From HOSPITAL to HOUSING

[A radical transformation of a former hospital building]

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"The problem with architecture is that it is allergic to time, because architects keep being asked to create lasting monuments, frozen in time. But buildings have no such presumption. Buildings live in time, the same way we do. In time, we learn. **In time buildings learn**."

-Stewart Brand

A guide for you, reader...

The following thesis is a collection of conducted investigations within the field of transformation and habitation, starting from an existing building. The investigation encompasses theoretical studies, registration, analysis, and valuation of the existing structure, selected material from the design process, and studies of transformation principles. The enclosed presentation contains a final design proposal.

Literature and illustrations not produced by the project group are referenced using the Harvard reference method, listed in the outro. Maps and illustrations not facing true north are accompanied by a north arrow, while the scale is provided in a description of the illustration on the page.

The report is divided into eight chapters and can be read depending on the desired level of understanding. Chapter 1 serves as an introduction to the project, aiming to frame the design task, the motivation behind the project, the approach undertaken, and the context in which the project figures.

Chapter 2 can be read for a deeper understanding of the theoretical background of the project.

Chapter 3 consists of registrations and analysis of the physical context and the building itself, concluded with a valuation and delimitation in chapter 4.

Chapter 6 covers the design process, which is concluded with a selection of transformation strategies in chapter 7. Chapters 4 and 7 can thus be read separately for a basic understanding of the program and strategies.

Chapter 5 presents the final design proposal, which is to be considered an answer to the thesis statement posted in chapter 1. Chapter 8 provides a conclusion on the project followed by a reflection positioning the project in a wider technical, historical, and architectural perspective.

Abstract

In 2007, a national structural reform led to the consolidation of the Danish hospital system, leaving some former local hospital buildings empty of functions. This situation prompts a need for a strategy to address the abandoned building mass. This thesis focuses on a specific hospital building in the city Aalborg, and aims to explore how the buildings formerly used as hospitals can be transformed into a new housing typology resting on the existing structure. The project relies on current methods for assessing and valuing existing structures, as well as best practices and references in the field of building transformation and habitation.

Given the challenges posed by global population growth and limited resources, the project argues for a shift in focus towards the potential of existing buildings, moving away from the developer-driven construction sector. In addition, changing family structures necessitate a reconsideration of how we design and inhabit spaces. In conclusion, the project demonstrates that energy optimising post-war buildings, while considering the impact on indoor climate of such, can significantly reduce transmission losses to meet present standards. This approach represents an environmentally and socially sustainable design strategy.

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Chapter 01: **Intro**

Motivation

[The wild urge to build during the economic boom is dangerous. Too much is being built, too big and ostentatious, too irrelevant. Without a special narrative, without connection to the place. It is in times of crisis that we reconsider and make the best decisions. Austerity is good for the way we build]

- Anna Mette Exner, 2003

The building industry is globally responsible for 30-40 percent of carbon emissions. To reduce this number significantly, actors of the building industry must break with indoctrinated values and look beyond the prevalent building system. The embodied CO2 of our existing building mass might be part of the solution and hold the potential to change the status quo on the necessary scale if the building industry is to move on the green agenda. In addition, existing buildings hold cultural heritage and architectural merits that new developments cannot provide.

During the post-war period (1950-1980) more than 1,5 million buildings were constructed in Denmark as a result of newly invented building techniques. These represent a significant section of our existing building mass. The buildings include residential constructions as well as public facilities, and are characterised by rationality and efficiency. Today, post-war buildings rouse disgust rather than nostalgia, which increases the probability of these buildings being demolished. However, it can be argued that the industrialised building system holds great transformation potentials (Cool, K. et al. 2023).

In 2007 a national structural reform was enacted in Denmark, resulting in the development of new centralised hospitals, leaving some former local hospital buildings empty of functions, many of which are well preserved and centrally placed (Jensen, L.B., 2021). This calls for a strategy on how to treat the large abandoned building mass, taking into account the specific architecture of such facilities. A growing interest in and shortage of rental accommodations, especially in urban areas, could make an argument for a transformation from hospital to housing (EjendomDanmark, 2022).

Designing architecture for habitation requires an understanding of current trends within the field. Two points deserve special consideration in this regard. Firstly, the dissolution of the nuclear family and rise of new family structures speak against a one-size-fits-all approach towards housing architecture. Secondly, the fact that during the last 100 years, the average housing area has quadrupled and is continuously growing, which increases the carbon footprint of our homes. Environmental challenges in addition to changing family structures therefore calls for a rethinking of the way we build and inhabit our homes.

Problem:

Can a new housing typology arise from the structure of former hospital buildings and manifest transformation as a sustainable design approach in a developer-driven building industry?

A sustaninable design approach?

If this thesis is to promote transformation as a sustainable design approach, indicating a need to look back upon the past in an otherwise developer-driven building industry, a definition of the sustainability strategy is necessary.

Sustainability has become a broad term often used widely to outline the goal of having no- or a positive impact on the natural and social environment.

Born in the Brundtland Report the definition often distinguishes between economic-, social-, and environmental sustainability, however, these are difficult to segregate. The following seeks to identify themes of the thesis touching upon sustainability in relation to the three aspects.

Transformation of existing structures itself encompasses all three aspects. By utilising the materials of these structures, embodied CO2 is retained, promoting an environmentally conscious and circular building sector. The social impact of transformation lies in preserving the cultural heritage associated with these buildings, while the economic effects are of course dependent on the specific transformation strategy, however it can be argued that utilising existing structures holds potential cost savings in construction.

The thesis presents an energy optimisation strategy aimed at reducing energy consumption, thereby benefiting the environment and minimising economic expenses. The strategy involves principles to reduce the transmission losses, and integration of renewable energy sources ensuring a sustainable approach to meet the current energy frame.

While implementing strategies for energy optimisation, the indoor climate impact of these are assessed to ensure a strategy that in addition to environmental challenges includes the health and wellbeing of the habitants. Passive strategies are integrated to ensure atmospheric and thermal comfort without increasing the energy demand.

manifesto!

01_let be what is.
revolt against a developer-driven building industry and consider the existing building mass a manifestation of our history and a potential resource of the future.

02_let the building do the talking.
design with respect for the existing, but transform what needs renewed. be brave enough to intervene but clever enough to know the effects of interventions.

03_allow alteration.
we cannot foresee the needs of the future, but we can design for change by incorporating essentials and allowing the inhabitant ownership of the layout.

04_live better together.
design around human needs, but question what must be rethought. consider the well-being of the inhabitant, but reduce the habitation-area by means of sharing.

05_care for detail.
do not reduce humans to observers of nature from their building or vice versa but design with humans as the focal point by detailing architecture in human scale.


Festsal
Restaurant Terrassen
Motionsinstitut
Foyer-Information
Gellerup center
Hotel Gellerup
Skægstubben
Bibliotek
Teater

1


SNOEP
KRAAM

2

Design Scope

§ 280: The following applies to the use of renovation class 1 for existing buildings:

1. *The energy demand must be reduced by at least 30,0 kWh/m² per Year.*
2. *The inspection must take place in accordance with SBI 213.*
3. *There must be a share of renewable energy in the total energy supply.*
4. *The following requirements for the indoor climate must be complied with*

§§382-384: Daylight

- *Adequate access to daylight can be documented by a total glass area corresponding to at least 10 percent of the relevant floor area.*
- To ensure visual comfort, calculations on the daylight factor will be performed, striving for an average of minimum of 2 percent in addition to the 10 percent. rule.

§386: Thermal indoor climate

- *(...) a maximum of 100 hours per year, where the room temperature exceeds 27 °C and 25 hours per year when the room temperature exceeds 28 °C.*
- To ensure thermal comfort, strategies on natural ventilation will be incorporated, assuming that a ventilation rate of 1,8 l/s can be obtained by an opening of 4 percent (SBI 213).

§§ 443-449: Atmospheric indoor climate

- *In living rooms as well as residential buildings, there must be an outside air supply of at least 0.30 l/s per m² heated floor area.*
- To ensure atmospheric comfort, ventilations rates are calculated in relation to emissions, category 2, taking into consideration the pollution from the building.

(Bygningsreglementet.dk, n.d.)

1. Example of careful approach; Kollektivbyen, Anna Mette Exner

2. Example of radical approach; apartment building, Lucien Kroll

This thesis seeks to define a new housing typology from the structure of a former hospital building located in Aalborg, Denmark. Focusing on this specific case, the thesis aims to propose a strategy on how to approach function-empty hospital buildings on a national plan.

Aesthetic scope

When transforming existing structures, architects tend to undertake a consistent position. Danish architect Anna-Mette Exner addresses transformation with a fondness for modernist buildings, departing in a valuation of the existing elements, while Belgian architect Lucien Kroll undertakes a more anarchistic approach, distancing the building from its original style. The aesthetic position of this thesis is less consistent. It undertakes a careful attention towards the architectural- and social history of the buildings but leans against present-day values by adding and subtracting structures while creating a contrast between the existing and the new.

Technical scope

The design process is based on an investigation of possibilities and limitations within the field of structural transformation and energy optimisation. As the hospital is constructed on different terms than what applies today, no passive strategies or renewable energy sources are integrated in the existing building mass, and will therefore be incorporated in new elements. Different interventions are proposed and tested in regards to energy demand and indoor climate impact, striving for renovation class 1 in relation to present Danish building regulations.

§ 281: residential buildings can be classified as renovation class 1 when the total energy demand for heating, ventilation, cooling, and hot water per m² heated floor area does not exceed 52,5 kWh/m² per year plus 1.650 kWh per year divided by the heated floor area.

Functional scope

The program is based on a historical review as well as case studies within housing architecture with a pronounced focus on social housing. Recognising present day changes within family structures and the evolving needs that follow, the thesis strives to define various housing typologies for a multitudinous user group. In the final design proposal, the housing units and related common areas are placed in one building, while another will host public functions derived from a vision program for the area in addition to an analysis of existing functions in the context.

Methodology

Placing itself in the intersection between architecture and engineering, this thesis leans towards a holistic approach to sustainable design. Aalborg University has an embedded foundation in the integrated design process, modelled by Mary Ann Knudstrup, which is applied and reimagined in this thesis as well. In the model, different components of architecture and engineering disciplines are combined in a method of five phases; problem, analysis, sketching, synthesis and presentation in an iterative process of interrelated actions informing one another (Knudstrup, 2014).

While ideas of integrated design provokes an interrelation between architecture and engineering, the method is however developed for designing new structures. This thesis focuses on an existing structure, calling for a reinterpretation of the integrated design process. Within the field of transformation, architect Nicolai Bo Andersen has developed five individual methods to study the physical characteristics, architectural history, and experienced qualities of existing structures. In combination the following five methods ensure site-adapted and contemporary architecture (Harlang, 2015).

Technical - historical - phenomenon based

A technical, historical and phenomenon based method entails an intellectual and emotional understanding of the building in all design phases. It considers the isolated elements and overall architectural style of a building, as well as the sensory perception of space and atmosphere. In addition the cultural-historical context is studied and considered a continuous source of inspiration (Harlang, 2015). In this thesis a theoretical framework outlines the technical, historical and experienced context of the existing structure. This three-legged focus will be undertaken when analysing the existing structure and context as well as when developing architectural interventions.

Landscape - still life - portrait

Inspired by photography, the method of Landscape, still life and portrait defines different scales from which a building should be studied, designed and presented. It affords an understanding of the building as a figure in the physical context and as a composition of spaces and details (Harlang, 2015). While the method suggests the scales 1:500, 1:50 and 1:5, this thesis defines varying relevant scales for analysing the existing structure, designing and presenting the final design, ensuring awareness of the details as well as the totality in all phases.

Skin - meat - bone

In this method, Skin, meat and bone are metaphors to describe the tectonic articulation and hierarchy between the facade, the spaces and the construction of a building. While the facade holds energy optimisation- and aesthetical potentials, the structure entails limitations and potentials within transformational interventions (Harlang, 2015). In this thesis, the structural limitations and potentials are outlined as part of the analysis, from which different interventions are proposed, followed by an iterative investigation of the energy-, indoor climate- and spatial effects of the proposals.

3. Hospital buildings observed from Skt. Jørgens Gade, 1976-1990

Look - throw - project

Unlike the other four methods, the Look, throw and project method is used to describe a design process. This method proposes a subdivision of the design process in an initial registration, analysis and valuation phase, a sketching phase and a projecting phase (Harlang, 2015). As the method is comparable to the integrated design process, a new method, combining the two, is developed and illustrated on the side. Being an integrated design task utilising engineering as well as architectural disciplines, this thesis implies submethods with both measurable and non measurable effects.

The goal of the first phase is to identify, analyse and value the historical, technical, and architectural conditions of the existing situation (Harlang, 2015). One way of doing so is by the use of SAVE, which is an acknowledged method to value historical buildings, however not performed on buildings constructed after 1940 (Slks.dk 2011). An analysis combining disciplines of SAVE with technical, historical, and phenomenological studies is developed and concluded in a valuation of the existing structures, framing the building program.

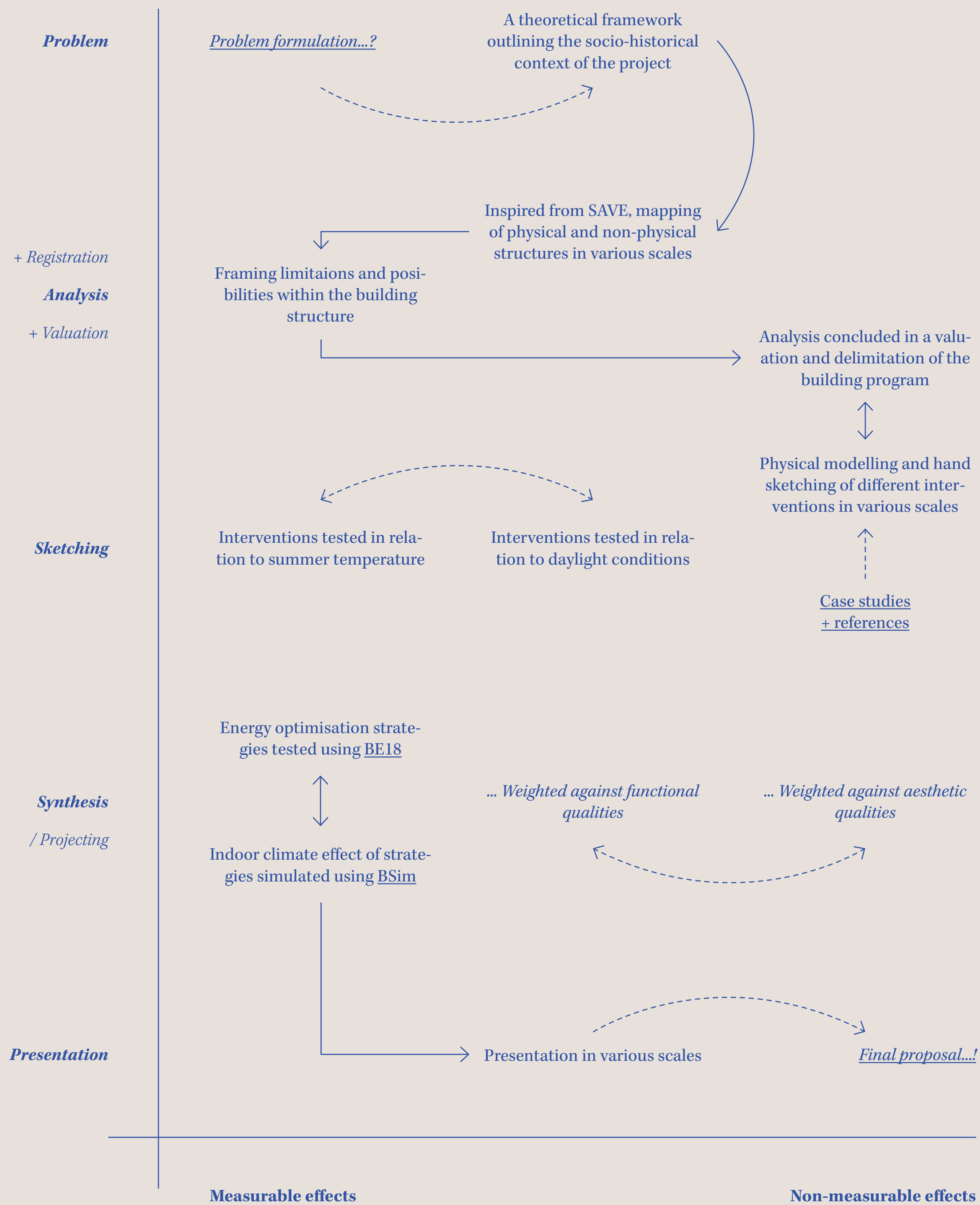
The second phase is an idea development, where different solutions are proposed, tested upon, further developed or rejected (Harlang, 2015). The idea generation is performed using traditional architectural disciplines of hand sketching and modelling, both physical and using 3D softwares. During this phase, the building program is continuously modified, and static calculations on daylight conditions and thermal comfort are used to identify potential challenges within proposed layouts.

The goal of the third phase is to develop the project, specify the intentions and tighten up the effects in a coherent architectural proposal (Harlang, 2015). In this phase an extended focus on energy optimisation and its indoor climate effects is undertaken, supported by dynamic softwares. The measurable effects are weighted against functional and aesthetic qualities, from which a final strategy is chosen and integrated. The final proposal is evaluated in relation to energy consumption.

Subtract - reconstruct - repair - transform - add

… Describes different acts of interventions in an existing physical situation. This thesis focuses on transformation rather than demolition but does not take an a priori subjective stand on which type of intervention to prefer. The design process is therefore not influenced by a certain normative standpoint in this regard. Different interventions are proposed and evaluated in relation to measurable and non-measurable effects to facilitate an argument based approach, where both quantitative and qualitative features are considered. Case studies and references are used as inspiration and assessment of different interventions in relation to transformation disciplines, user perspectives, material proportions etc.

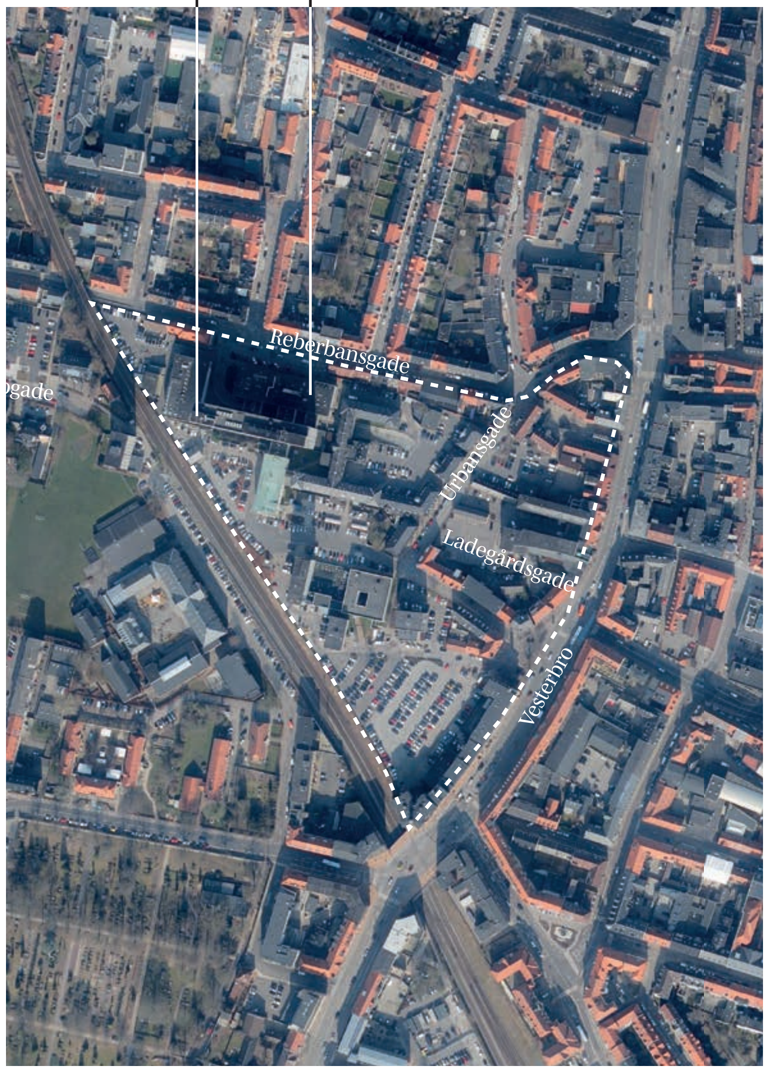
4. IDP combined with look, throw project and sub-methods of measurable and non-measurable effects


Problem
Problem formulation...?
A theoretical framework outlining the socio-historical context of the project
Inspired from SAVE, mapping of physical and non-physical structures in various scales
+ Registration
Analysis
+ Valuation
Framing limitaions and possibilities within the building structure
Analysis concluded in a valuation and delimitation of the building program
Physical modelling and hand sketching of different interventions in various scales
Sketching
Interventions tested in relation to summer temperature
Interventions tested in relation to daylight conditions
Case studies + references
Energy optimisation strategies tested using BE18
Synthesis
/ Projecting
... Weighted against functional qualities
... Weighted against aesthetic qualities
Indoor climate effect of strategies simulated using BSim
Presentation
Presentation in various scales
Final proposal...!
Measurable effects
Non-measurable effects

4


Project area

5


Building P
Building B
Reberbansgade
Urbansgade
Ladegårdsgade
Vesterbro

6

Project Location

The project area is located in Aalborg in the district Vestbyen and functions as a serving hospital area. This will soon be history, as the current sporadic hospital functions are relocated to a unified building situated in eastern Aalborg (Østergaard, n.d.). The total plot area is around 26.000 m2, and concludes today 16 buildings and sheds, that in total constitutes 44.450 m2 of building area. Unbuilt area on the site currently accommodates around 350 parking spots on ground (Nordud.com, n.d.).

The project enters an ongoing municipal development, currently composing a unified strategy for the hospital area:

» 2019: Aalborg municipality composes a vision for the area, which is purchased by Nordud, a newly founded real estate and development company.
» 2021: Norud organises a vision competition, which is won by a team comprised of SLA, TRANSFORM, Bertelsen & Scheving, Friis & Moltke and Sweco.
» 2023: In cooperation with the municipality, the competition winners develop an overall plan for the area, which is submitted for hearing.
» 2025: The project is to be fully treated.
» 2027: The hospital vacates the buildings.
»

Due to the central placement, the municipality's vision is to design a district that connects soft road users and re-establish the square structure that characterises the western part of the city. The district is to offer green areas and mixed living arrangements to ensure community across generations and blend the identity and history of the area with a new built environment. The current overall plan from which the project is developed is available in appendix. A (Aalborg kommune, 2023).

As no overall plan is finally enacted, the project includes following elements from the vision plan (Nordud.com, 2021):

» A tunnel below the railroad connecting Saxogade to the project area, allowing Reberbansgade to be converted to a one way street.
» A multi storey car park in continuation of the Saxogade-tunnel and additional underground parking below the B-building and the square.
» A large recreational structure for movement and stay stretching along the railroad from Vesterbro to the square in close relation to the P-building.
» A day care centre ~ 500 m2.
» A hotel/hostel ~ 3000 m2.

While the project area forms the context of the architectural intervention, the design proposal constitutes building P and building B, which will prospectively be referred to as the project buildings.

5. Aalborg 1:50.000

6. Project area 1:5.000

Chapter 03:

Theoretical framework

Technical

Architecture can be understood as the spatial composition of physical material. According to Nicolai Bo Andersen, the technical perspective on architecture entails recognizing the fact that materials, in the form of various building components, are systematically assembled using specific construction techniques (Harlang, C. et.al. 2015). A term often used to describe building components and their composition is tectonics. The modern definition of tectonics is ascribed to architect Gottfried Semper, who argues that the structural organisation of physical material itself is the object of tectonic form.

Modernist architecture, which adheres to the principle of 'form follows function' is in pronounced contrast to Sempers definition. Architect Le Corbusier is known for exemplifying this modernist position, as his architecture demonstrates the fact that the prevailing building techniques and associated materials provide artistic form-freedom (Danielsen, 2015). In a Danish context, this freedom was however replaced by industrial construction techniques resulting in mass production of concrete structures that does not align with present architectural values and preferences.

Continual flow in architecture

The changing needs that habitants have had throughout history in relation to their housing tendencies creates a continual need for an adaptation of our buildings. Unfortunately, buildings are rarely built to adapt, but instead to create a monumental impression of the stylistic period in which they were built. Many architects mistake architecture for something immortal, while few buildings will in fact last long if not able to adapt to modern tendencies. Attempting to define a model on how buildings change and what happens after they are built, writer Stewart Brand uses the term 'flow' to describe this continuous shift in tendencies (Brand, S. 1994).

Brand argues that mainly three forces change the building industry; technology, economy, and fashion. In terms of technology, the forces originate in the building regulations, which throughout history have changed simultaneously with an increased focus on health and well-being. The economic influence relates both to the inhabitants themself, where wealth often induces change, as well as the economic inflation in the given time. Fashion on the other hand changes at a fast pace, influencing the interior and stylistic perception of a building (Brand, S. 1994).

Changes can be observed in different forms throughout a building's lifespan. From smaller interior changes that can happen rapidly to greater changes in relation to functions or structures, which happens rarely. An understanding, not of the building itself, but of the elements that it is composed of, can provide information on possibilities and limitations related to transformation. Nikolai Bo Andersen covers this to some extent with the skin, meat and bone- method. Brand, however, expands his models to 'the six S's', containing knowledge on several components and their general lifespan, listed on the side. This reflects the challenges of transforming a building, as it is composed of several layers (Brand, S. 1994).

time

Space plan
3-7 years

Service
7-10 years

Stuff
Around 20 years

Skin
Around 20 years

Structure
Around 50 years

Site
Eternal

7

8

7. *Koldinghus renovated by Inger Exner in 1970, interior*

8. *Koldinghus renovated by Inger Exner in 1970, exterior*

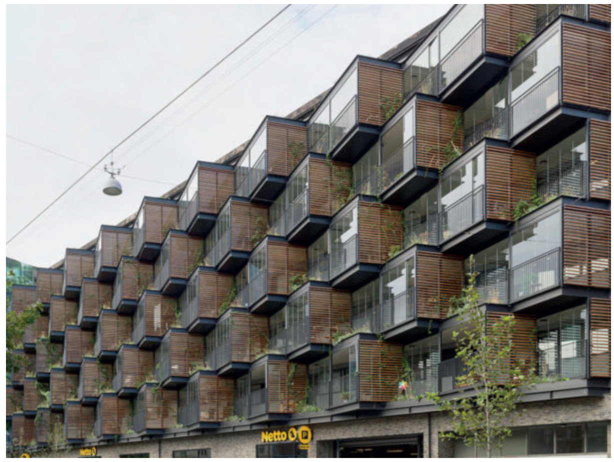
Considering these challenges one might wonder if preservation and transformation is worthwhile - a question often referring to the economic perspective. However, an assessment of such should likewise reflect the social and environmental advantages. Fortunately, preservation of historical buildings is a growing tendency, but buildings of the post-war period are rarely objects of attention. Though it can be argued that these hold to a greater extent potentials for an energy efficient renovation compared to historical buildings. Brand states that there are two roads in preserving and transforming buildings; buildings of high-road, and buildings of low-road (Brand, S. 1994).

Example of high road preservation

Buildings of high road entail a classic-historical imprint from a significant architectural period, and are generally considered of high preservation value due to their architectural expression. An example of such transformation is Koldinghus castle in Kolding, Denmark, designed by architect Inger Exner. Originally a border defence and later a royal castle, Koldinghus has undergone various expansions and transformations throughout its history, reflecting different architectural styles such as Renaissance and Baroque. Due to a fire in 1808 leaving the castle in ruins, a restoration began in the 20th century, preserving the historical phases of the building. Today, it serves as an art and cultural history museum (Dansk Arkitektur Center, n.d.)

A renovation of this calibre requires a large economic influence, but is considered worthy of preservation due to the cultural and historical heritage.

9



10

Transformation strategies

Buildings of the post-war period have been criticised almost ever since their construction, and the first wave of transformation took place as early as the 1980s. The renovation originated in constructional problems, but since the fashion had changed, the renovation strategy was often impacted by a desire to change the expression. A colourful facade was added to conceal the grey concrete, presumably provoked by ideals of equality being replaced by diversity. This strategy changed the architectural style without addressing the structure, and though new materials were added, these were subordinated to the original tectonic expression (Danielsen, C.B. 2015).

Facing the second renovation during the early 2000s, new structural principles formed the basis for the transformation strategy. Facing walls were added, allowing the structure to be radically changed, illustrating that it is possible to break with the architectural concept of industrialised constructions. However, this is challenging as different layers interfere, demanding a fundamental understanding of the building. One might also argue that the new facades appeared as a one-dimensional imprint of the original, suggesting that a break with the original architecture of a building requires a greater architectural care (Danielsen, C.B. 2015).

In contrast to the former, the third strategy does not reject the architecture of industrialised constructions, but departures in the well-being of the inhabitants. The primary goal is not to change the expression, but to offer new spatial experiences, improved daylight conditions and so forth. The strategy does not seek to reset history but introduces new interpretations of the structural and spatial composition, which appear like new layers on top of the existing (Danielsen, C.B. 2015).

Given the prevailing sentiment towards post-war buildings, they are commonly considered as low-road transformation projects. The position of this thesis elaborates on the third strategy aiming to unlock the potentials of preserving these buildings.

9. Ørsted Haver before renovation, designed by Ole Hagen Arkitekter in 1968

10. Ørsted Haver after renovation, designed by Tegnestuen LOKAL, 2020

Example of low-road preservation

Ørsted Haver, built in 1968 and renovated in 2020, is an example of a low road transformation. Initiating the renovation, the building and apartments were still structurally sound. However, the walkways were in need of replacement due to wear and damage from rainwater. Rather than opting for the easy solution of implementing new concrete facades, Tegnestuen LOKAL introduced a three-dimensional climate shield with staggered bay windows. The strategy not only improved light conditions and retained heat but also created new living spaces and meeting areas. While the facade underwent transformation, the rest of the building was preserved, emphasising both historical value and environmental sustainability (Cool, K et. al. 2023).

"From being the street's ugliest building in pragmatic concrete, Ørsteds Haver in Frederiksberg has become a school example of how a renovation project can be thought out of the box - quite literally. An innovative facade lift of the building has both strengthened the community, beautified the facade and made an unloved building warm and alive." (Cool, K et. al. 2023)

Energy optimisation and indoor climate

In addition to revitalising old buildings through the integration of alternative uses or new expressions, there is also a necessity for these buildings to comply with contemporary energy and indoor climate standards. Careful consideration must be given to upgrading and transforming the buildings to meet current requirements while simultaneously preserving their original architectural values. Buildings of the post-war period are constructed with less concern for renewable energy and passive strategies compared to contemporary architectural structures. As a result, these buildings rely on technical solutions, which are now outdated. In terms of integrating new systems in existing buildings, restoration architect Søren Vadstrup introduces three principles (Vadstrup, S. 2014).

» Keep the buildings values: Preserve the original architectural expression as it entails environmental, cultural-historical, and technical values.

» Change the form of heating: Replace the existing system with modern technology with heat recovery and implement renewable energy sources.

» Create energy and indoor climate improvements: integrate energy improvements considering elements of preservation value and indoor climate.

Referring to the principles, Vadstrup emphasises the importance of prioritising the act of interventions. He introduces three overall categories of transformation according to the architectural expression:

Category 1 | interventions that do not influence the preservation values.

Category 2 | visible, but architecturally acceptable interventions.

Category 3 | Architecturally unacceptable interventions.

Acknowledging that Vadstrups theory departs from a position of careful preservation of historical buildings, while this thesis does not take a critical position on transformation, the principles and categories are reinterpreted. The categories are used to describe different acts of interventions, however distancing from the notion of any interventions being unacceptable. The three principles will be combined with a transformation strategy focussing on the well-being of the inhabitants rather than undertaking an opinion on the intervention strategy.

Historical

The consideration of architectural history implies two primary purposes. Firstly, it enables one to describe and comprehend the present situation within a broader architectural and historical context. Secondly, architectural history serves as a source of inspiration for contemporary architecture (Harlang et.al, 2015). In this thesis, the relevant architectural history consists of two key aspects. The first relates to the history of residential architecture, exploring the evolution of housing architecture and changing living needs. The second aspect focuses on the history of hospital architecture, particularly the architectural compositions that have been employed over time.

History of hospitals and habitation

In the late 20s, the modern breakthrough in Denmark brought with it an international, functionalistic style inspired from the German Bauhaus Movement and French architect Le Corbusier's ideas on a 'habitation machine'. The style was later reinterpreted in a Danish functional tradition, mixing the form and function of modernism with a national building code and traditional materials (Nygaard, E. 1984). Post Second World War Denmark was facing housing shortage, making the home a political issue, which resulted in the implementation of social housing legislation that offered cheap government loans to houses of smaller scale. This quickly resulted in a shortage of materials in the late 40s, triggering the establishment of Statens Byggeforskningsinstitut with the intention of reforming the building industry (Danielsen, C.B. et. al 2018).

Prior to the modern breakthrough, hospital constructions were built based on the belief that infections were transmitted through contaminated air. Consequently, significant attention was given to ventilation and air circulation. To combat the spread of infections, hospitals were designed as separate pavilions. It later became evident that managing pavilion hospitals was space-consuming and required extensive logistical support. As a result, new hospitals were concentrated in large compact structures. The block buildings are characterised by a rational layout typically consisting of a centralised corridor with wards and associated administrative functions positioned on either side are prevalent in many hospitals today (Dsr.dk, n.d.)

Throughout the 50s storey-housing evolved, drawing on modern ideas of the 20s and 30s. As a result of shortage of masons as well as houses, architecture was standardised and structures became element-based. In 1958 the building boom was sparked by a liberalisation of the housing market. Some buildings from the late 50s are in situ cast load bearing structures with element based flooring structures and facades, while others have load bearing walls across the building. Both types have static plans and monotone facade rhythms. The modular style of building culminated in the 60s, reaching beyond residential constructions (Nygaard, E. 1984).

Architecture of the 70s is characterised by low-dense developments with vernacular idioms - low to offer contact with nature, dense to promote social contact. In 1974, the state of the market took a turn, sparking new ideas on how to construct and inhabit our homes. User involvement and cohabitation were keywords in 1971 when Statens Byggeforskningsinstitut organised a competition on alternative housing (Boligviden, 2021).

11. Tinggården, social housing by Vandkunsten 1971-1978

12. Tinggården, social housing by Vandkunsten 1971-1978

11

12

Example of cohabitation in the 70s

The competition was won by a small studio, later known as Vandkunsten. Their proposal emphasised community and suggested offering the future residents influence on the architecture and the way of living. After the competition, a year-long democratic process was carried out in close cooperation with a group of future residents. The final project consisted of 78 housing units divided between six family groups with a commonhouse for each family group. Common areas were extended from 3% to 10% of the gross floor area of housing units, making it possible to reduce the floor area of the housing units to an average of 78 m² (Vandkunsten, n.d.).

Not far from the building system of the 60s, the project is constructed from an element based building technique. However, the architectural expression is far from its predecessor. A patchwork of wood and bricks reflects the variation of the interior. The housing complex offers five different housing units with 1-6 bedrooms in one to two storeys. The plan is flexible, made possible by a system of spatial components assembled in various ways. The flexibility in addition to an extended planning process and residents involvement ensured that the incorporated sharings practices suited the future residents (Dansk Arkitektur Center, n.d.) *(Olesen, M. 2023).*

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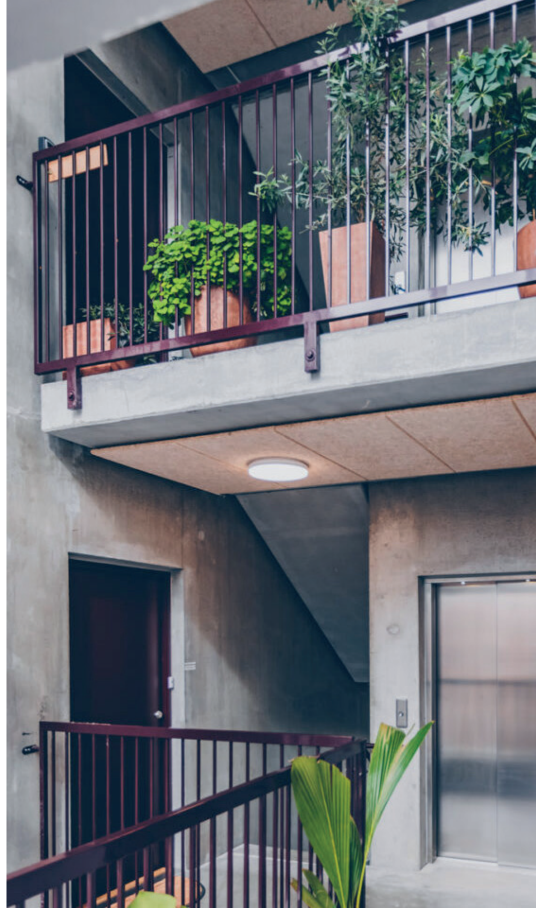

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Modern tendencies

Tinggården became a source of inspiration for the architecture that followed in the 80s. However, monotone architecture of the 60s and collectivism of the 70s was quickly replaced by ideals of individualism, sparking a new, postmodern architectural style. Architecture of the 90s is pragmatic, inspired by Dutch architects like Rem Koolhas. The traditional sense for craftsmanship is replaced by conceptualised, big scale architecture, in Denmark best represented by Bjarke Ingels Group. This was later assisted by a pronounced focus on the environmental impact (Danielsen, C.B. et. al 2018).

Since the start of the 21st century, new ways of habitation have emerged as a result of evolving family structures. Single houses, network housing and senior homes are just some examples of the new types of accommodations. Some mix the residents across generations, while others host a specific demographic group. Cohabitation experiences a renaissance, still present and relevant today, where the demand is increasing. In cooperation with the Danish Architecture Center and Utzon Center, Vandkunsten curated an exhibition in 2020 that linked their 1970s visions with contemporary challenges. The exhibition served as a testament to ways in which we can live improved and more sustainable lives, encapsulated in the following manifesto (Vandkunsten, n.d.).

**”Lad os bo mindre og bedre!
Lad os dele mere!
Lad naturen flytte ind!
Lad os gøre det selv, sammen!
Lad det være og se skønheden!”**

“Let’s live smaller and better!
Let’s share more!
Let nature move in!
Let’s do it ourselves, together!
Let it be and see the beauty!”

(Tegnestuen Vandkunsten, 2020)

Example of modern cohabitation

While Tinggården was created with the users, Fællesbyg Køge Kyst is created by its users. Future residents have immediate influence on their housing unit as well as common areas. Through an established association the residents have hired an entrepreneur, saving the cost of a developer. The project is not developed as social housing, but during the design process, a desire for 'everyday communities' arose amongst the residents. This is met by common houses, roof gardening, green houses and workshops, accounting for 10% of the gross floor area of the housing units (Vandkunsten, nd.).

Fællesbyg Køge Kyst illustrates that time has matured towards community-oriented housing. The housing project consists of 45 housing units from which the smallest is 65 m2 and the biggest 170 m2. Like Tinggården, Fællesbyg Køge Kyst is constructed from industrialised building modules and the facade is clad with colourful metal sheets. Despite savings in the development phase and the industrialised building system, the economic scope is high with an apartment price between 2.678.500-4.930.000 dkk. This indicates that the idea of co-living is expanding across demographics, however creating a paradox in new, private co-housing establishments not being affordable for everyone (Dansk Arkitektur Center, n.d.) *(Olesen, M. 2023).*

A socio-historical approach

Even being a simplified resume of architectural styles throughout history, which in reality was way less continual with different styles evolving simultaneously, the brief walk through history illustrates a tendency: a thesis is followed by an antithesis. The industrialised architecture of the 50s and 60s, which was inspired from a previous style valuing rationality, was met by romantic ideologies in the 70s and 80s characterised by collectivism. This was then met by the individualised society emerging in the 21st century. Until now ideas of co-living have been latent, but pressing environmental challenges and changing family structures have made it a desirable way of living, diversifying the demographics of residents in such arrangements.

There is currently a growing recognition of the possibilities inherent in existing building structures, however, when changing theses in regard to functionality an extended focus on the spatial layout is essential. This perspective is relevant for this thesis as it seeks to transform a hospital building into a housing complex, indicating an attention towards the substantial interior volume and its implications for creating suitable living spaces.

"Architects have cultivated abstraction, coolness and icon effects throughout the modernist period. Often in conflict with the body's need for sensory experiences and design that is legible and meaningful to the users. We want to give cosiness and well-being a greater place in modern architecture and urban planning" (Søren Nielsen, Architect and partner, Vandkunsten)

This thesis investigates the possibility of combining rational, modernist architecture with collective housing tendencies in an individualistic society in the quest towards a more sustainable building industry. Through the case studies, it is illustrated that user involvement is a successful tool to design co-housing with extended and used sharing practices. The limited time scope of this thesis however complexifies this practice. To overcome this challenge, an extended focus on flexibility will be undertaken..

13. Fællesbyg Køge Kyst, social housing by Vandkunsten 2017-2021

14. Fællesbyg Køge Kyst, social housing by Vandkunsten 2017-2021

Phenomenon based

In addition to the technical and historical perspective on architecture, Nicolai Bo Andersen argues that an architectural intervention should consider the experience-based interpretation of space. This approach originates in phenomenology (Harlang, C. et.al. 2015). A leading figure within phenomenology is French philosopher Maurice Merleau-Ponty (1908-1961). Merleau-Ponty rejected traditional distinction between consciousness, the body and the physical world. We exist in the world with our body, and we sense and experience the world through it. Sensation is basically our approach to the world (Dansk Arkitektur Center, n.d.).

Within architecture, the inspiration from phenomenology has led to an extended interest in the relationship between the surroundings, the place and the senses. Architects have become more interested in the physical sensation of a building. The interest in phenomenology is to a large extent a break with the international style, which focused on technology and industrial processes, differing from local building traditions (Dansk Arkitektur Center, n.d.).

Architecture and the senses

The Norwegian architect Christian Norberg-Schulz is one of the first architects to stress the importance of place for its architecture and vice versa.

"A concrete term for environment is place. (...) What then do we mean with the word place? (...) We mean a totality made up of concrete things having material substance, shape, texture and colour. Together these things determine an environmental character" (Architect Christian Norberg-Schulz, 1979).

Norberg-Schulz voiced criticism, specifically targeting the perceived "loss of place" caused by modernist buildings. He argued that industrial construction relied on a universal mindset, resulting in a homogenisation of spaces. Architects should preliminary to designing localise the environmental character of the project area. What is the mood, rhythm and atmosphere of the place? Further, architects must be responsive to the inherent qualities of a place, in order for the building and the area to mutually offer each other something new. Architecture should interpret the area's characteristic features, and through form, space, materials and colours enhance the user's attention to the area. An authentic architecture is an interpretation of human life in a specific place (Norberg-Schulz, C. 1979).

"Modernist design at large has housed the intellect and the eye, but it has left the body and the other senses, as well as our memories, imagination and dreams, homeless" (Architect Juhani Pallasmaa, 2012).

Another architect who is inspired by phenomenology in his buildings as well as his architectural criticism is Finnish architect Juhani Pallasmaa. In his book 'The Eyes of the Skin – Architecture and the Senses', he argues that modern architecture is inhuman. It lacks materiality, and this has created an imbalance in our emotional system. Architecture should mediate between ourselves and the world through the senses, firstly by understanding the world, then turning it into a meaningful and humane place (Pallasmaa, J. 2012).

“We must be better at acknowledging the value of the things we already have and that the used can be used again”

Senseless architecture?

Danish architect Anna Mette Exner disagrees on the depreciation of sensory experiences in modern architecture, claiming that Gellerupparken is indeed a sensoric place. She posts against a general public sentiment associating the architecture with polarisation, suggesting that we remove the ‘ghetto-glasses’ to unbiasedly see the beauty of the concrete. Exner argues that by demolishing, we are not just erasing buildings, but our history (Pind, A. 2018).

When approaching transformation, Exner considers the elements of the building doing something good for the users, and how the building’s history can continue to be experienced when a new function is added. She studies context, atmosphere and usability and takes pride in not removing anything that still works. When renovating concrete visible and close to the human body, it must be done carefully. By refining the detail and adding warm materials such as wood or leather where people touch the building, poetry and beauty can arise in the interaction with the raw concrete (Cool, K. et al. 2023).

“We must stop demolishing and stop believing that because something is worn, out of fashion or so-called ’ugly’, it has no value. We must be better at acknowledging the value of the things we already have and that the used can be used again” (Architect Anna-Mette Exner, 2023)

Describing the architecture of Gelleruparken, Exner uses terms like monumental, referring to the infinite grid from foundation to rooftop. Despite the immediate expression, this is an intentional architectural choice, expressing the social equality dominating the area. Internally, the architecture is in pronounced contrast to the exterior. The apartments are beautifully programmed with sliding doors offering the inhabitant ownership of the plan, illustrating a social consciousness. Form and spaces are proportioned for humans, materials and colours are warm and light rolls in (Pind, A. 2018).

Experience of monumentalism

To assist in describing the experiences embodied in the project buildings, three terms introduced by art historian Alois Riegl are used. These terms, namely ‘nearsightedness’, ‘normal vision’, and ‘farsightedness’, are relevant in understanding the built environment. When we encounter large-scale buildings in the cityscape, they often fall into one of the categories, which can be used to describe their spatial perception and impact on the surroundings. Essentially, it questions whether a building appears disproportionately larger or smaller, or perfectly proportioned, relative to its actual size (Lægring, K. 2022).

In the present context, most buildings can be categorised under ‘normal vision’. These houses conform to the standard perception of what a building should look like, often constructed as squared block buildings in bricks. Buildings that deviate from this norm tend to catch the attention of the passers-by as the architecture associated with the ‘normal vision’ has become the prevailing standard, particularly in city centres (Lægring, K. 2022).

The term ‘nearsightedness’ describes a spatial experience that demands closer proximity for full recognition. It emphasises surface-level experiences, and Riegl associates it with the haptic nature of perception, which encompasses the senses of touch and sensation (Lægring, K. 2022).

The antithesis to the concept of ‘nearsightedness’ is ‘farsightedness’. Buildings characterised by ‘farsightedness’ exhibit a significant spatial extent and offer clear visibility across the visual field. In this case, visual perception takes precedence, according to Riegl (Lægring, K. 2022).

Overall, Riegl’s framework provides a valuable perspective for analysing the spatial qualities and perceptual impact of buildings, considering their relationship with the surrounding urban fabric.

A phenomenological intervention

Even if born from an antithesis towards modern architecture, a phenomenological approach to architecture is continually relevant, independent of the architectural style. When approaching a design task, an awareness of the physical and atmospheric place must be undertaken. The environmental character and qualities of a place are read and understood through our sensory system. From these understandings, meaningful architecture can emerge through form, space, and materials, adapted to- and co-existing with a specific place. This does not make phenomenology less important when approaching a transformation task. Quite on the contrary, It can be argued that sensory experiences are embedded in historical buildings.

The qualities are discovered when observing and experiencing existing buildings unbiasedly. However, memories shaped by former experiences affect our sensory system, making it difficult to break with pre-constructed associations. As opposed to Juhani Pallasmass distinction between modernist architecture and senses, Anna-Mette Exners vivid description of a modernist building demonstrates that sensoric experiences co-exist with concrete and modularity. Even posting as opposites, the position of Pallasmaa and Exner together form a design strategy, stressing the importance of localising elements that affect the body positively and refine these. This is not always a logical process, but one based on intuition, which is an important skill within architecture, especially when approaching existing buildings.

15. Gellerup Bibliotek, 1990-2002

Chapter 04:

Registration and analysis

Big scale

City of smokestacks

Preliminary to investigating the project area, a brief walk through the city history is to frame the overall context in which the architectural intervention is performed. Aalborg emerged as an urban community and trading post around the year 1000. Due to the key location in relation to sea carriage, the city experienced growth and wealth during 16th and 17th centutury, which reached a vertex in the 18th century resulting in an economic drop. This was turned by the establishment of several industries during the 19th century, including a large alcohol- and tobacco factory.

Due to the chalk deposits in the underground, Aalborg became the capital of cement factories, known as the city of smokestacks, while the textile industry was likewise a considerable trade. In the 1860s, two key infrastructures were developed: the railway in 1869 and the first bridge connecting Aalborg and Nørresundby in 1865 (Danmarkshistorien.dk, 2012).

During the industrialisation, Reberbansgade and Urbansgade, former field roads marking the transition from mediaeval town to agricultural land, were laid out as streets which led to the development of Vestbyen. The former hospital was constructed in 1879, and expanded in the 1930 with a pavilion building relating well in terms of scale to the urban structure of the area. As the hospital system evolved, the hospital facilities were outdated, resulting in the construction of a new, larger hospital facility in 1961, constituting the project buildings (Flyvbjerg, B. et.al. 1991).

In 1960, around 50% of the population were employed in industrial- and craftsmanlike trades, while by the millennium, 60% of the workforce was employed in service- and education, sparked by the establishment of Aalborg University in 1974 (Danmarkshistorien.dk, 2012).

Despite the change towards a cultural- and educational city, hosting students instead of smokestacks, the city has preserved its industrial heritage, with the cement factory Aalborg Portland and Textile factory Gabriel still being significant operators. The industrial identity and history of Aalborg is a continuous inspiration for the project.

16. Project location 1847

17. Project location 1885

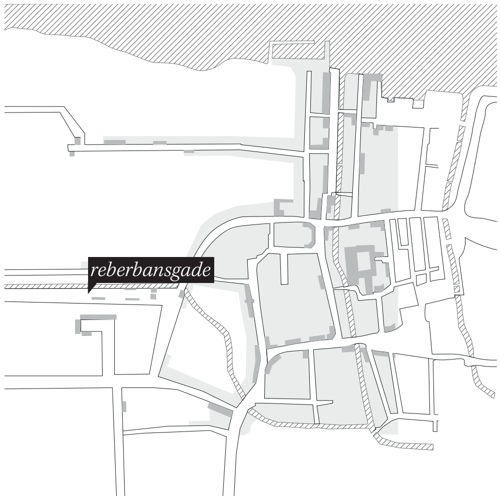
18. Project location 1937

19. Project location 1968

20. Project location 1979

21. Project location today

16



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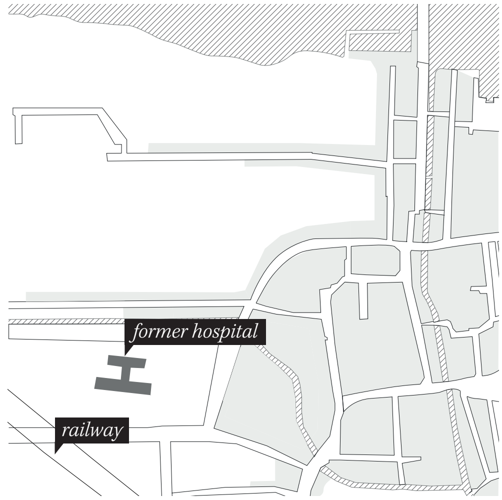

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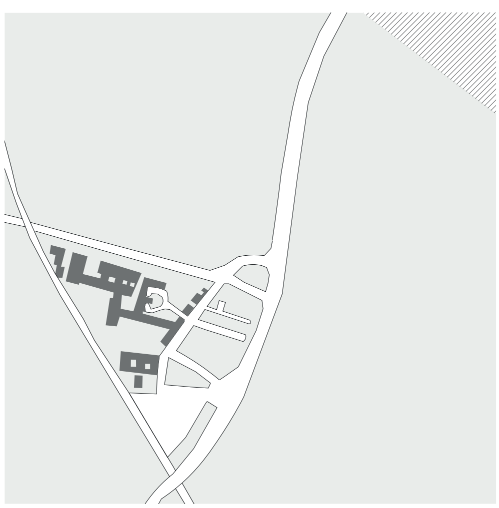

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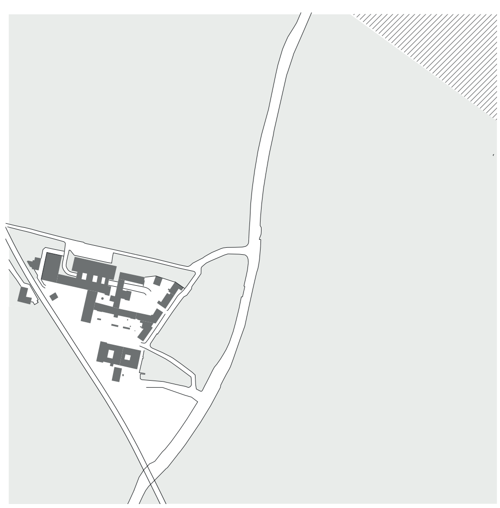

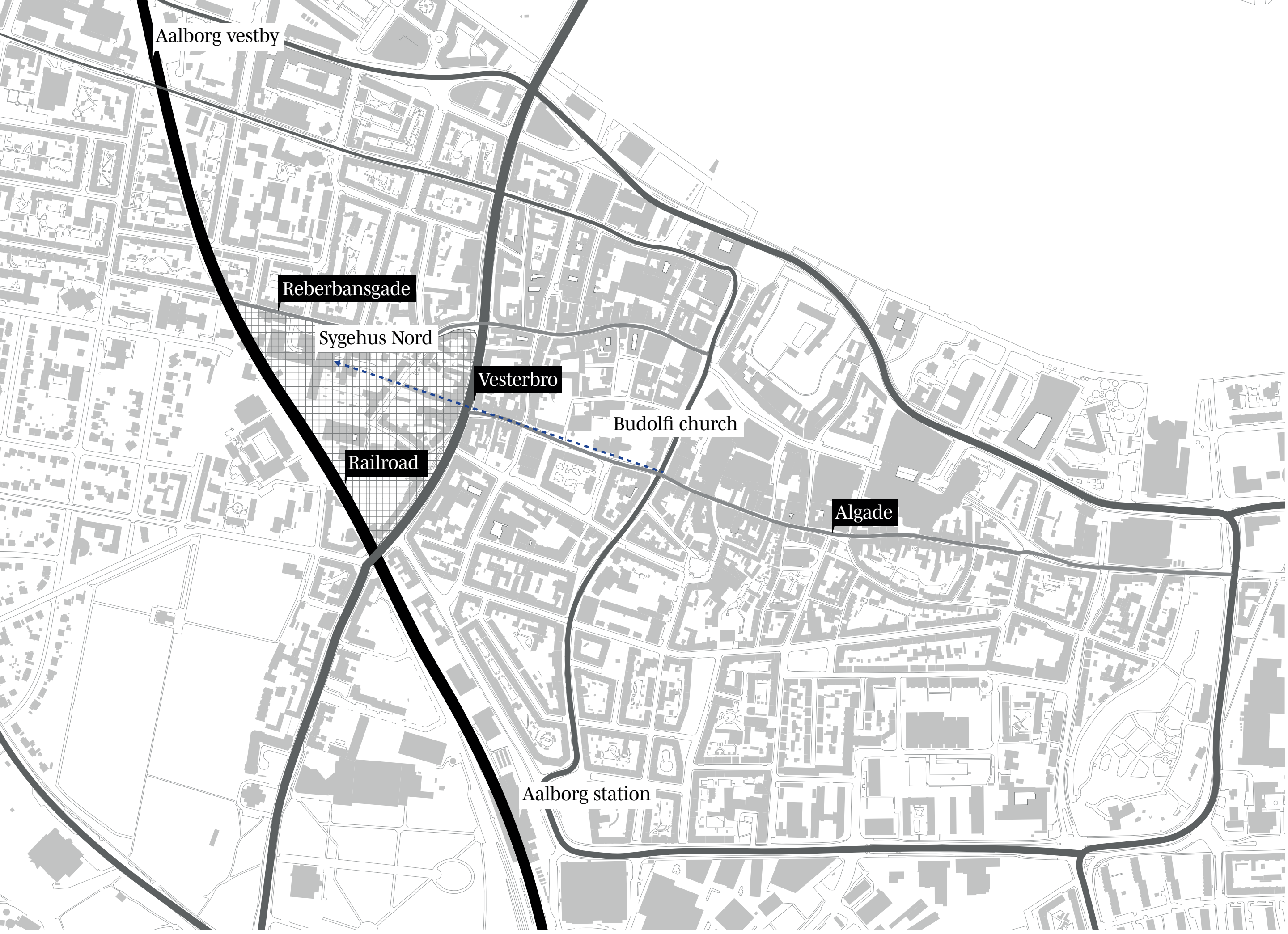

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Dominating structures

The project area is framed by three main infrastructures; the railroad, Vesterbro, an artery of the city and Reberbansgade, a lively street closely related to the project buildings. Along with the railroad, the project area constitutes the western boundary of the central city. The project area is located between two train stations, which can be reached within fifteen minutes by foot. As a tunnel is established connecting Saxogade to a multi storey car park in addition to basement parking to be established, it is assumed that the residents' need for car parking is met. To preserve Reberbansgade as a takeaway spot, short time parking will be implemented along the one way street, but designed as an integrated part of the square.

Due to the central placement, an extended focus on connections for soft road users will be undertaken. Bicycle parking will be integrated on both sides of the project buildings, accommodating the public, while residents' bike parking will be incorporated within the building.

Monuments

The scale of building P makes it a recognisable monument in the cityscape, visible from various locations, making it a landmark, serving as a reference when navigating through the city. Moving along the pedestrian street Algade, the eastern gable of the tall building mass reaches above the surrounding rooftops, framed by the town structure. The building figuring in the dominating structures of the city contributes to its preservation value.

22. Dominating structures 1:10.000

23. Hospital buildings observed from the central city

23

Fjordparken
Sct Mariæ (State school)
Reberbansgade // Foods-shops
HHX (Gymnasium)
Klostermarkskolen (State school)
Katedralskole (Gymnasium)
Aalborg theatre
Cemetery
Kildeparken

User perspectives

Although not typically not included in a SAVE registration, an examination of the nearby offerings is conducted, encompassing green structures, educational institutions, and cultural establishments. This in addition to a demographic definition aims to assess the existing functions and identify areas where improvements can be enacted. The close context is primarily characterised by residential buildings, in many cases hosting liberal arts in the ground floor. Reberbansgade accommodates a sequence of different food-shops making the street a well known- and used location of the city, especially among younger residents. The project area is encircled by two primary and lower secondary schools and two gymnasiums, contributing to the clientele.

The project is located close to the city centre with its related cultural facilities and Vestbyen with maritime offers such as Vestre Fjordpark - a significant force of attraction during the summer. South of the project area, larger green structures offer spaces for walks and runs. However, the close area is rather empty of functions offering longer stays, especially during the colder months. To accommodate the young residential group, after school activities will be considered in the program, while enclosed public spaces will offer places to stay during the winter.

Demographics

As Aalborg has transformed into an education-city, young people between the ages of 18-30 represent a significant section of the population. Past 25, the population curve is slowly declining, indicating that part of the students chose to stay in the city after finishing their studies. More than half of the population are single and close to half live alone (Aalborg Kommune, 2022). In a strongly individualised society where the amount of persons living alone is increasing, co-housing or shared facilities might be a tool to overcome loneliness, which is an emerging problem, especially among young people. The project will include student housing and address singles as well as families of different constellations.

24. Functions 1:5.000

Next page: Photo registration from- and around the project area


Pita Mix


LÆSEHESTEN
BYTTER BEDST OG BILLIGST!


Burger

Medium scale

Building patterns

Towards the west, the building structure is mainly formed by detached house neighbourhoods and related institutional buildings. These continue towards the south in the residential area Hasseris, and are weaved into squared tenement blocks towards the north. Further east, the building structure is mediaeval consisting of mixed architecture, including half-timbering houses. While the detached houses come with a private garden, enclosed by hedges, the squared housing blocks frame a common courtyard, rarely used for garden purposes. Given that the options for nearby lifestyles are limited to either suburban living without shared amenities or apartments sharing walls, but rarely more than that, the project aims to provide accommodations with a range of shared facilities.

Elements

Buildings along Vesterbro represent Danish functionalism of the 1930s. The material is primarily red/brown bricks, with a few examples of coloured concrete. The apartments are well-lit, and characterised by a balcony/bay-window solution. The pavilion buildings along Urbansgade in yellow bricks with black tile roofs from the late 19th century are assessed to a high preservation value. The scale is small, and the level of detail high, enhancing the contrast to the project buildings. In continuation of the project buildings on the south side, a building in yellow bricks disrupts the contrast by featuring functionalistic design with fewer details in a larger scale. Around the area, buildings with similar modes of expression as the project buildings can be observed, many of which are to be torn down.

25. Project buildings and surrounding structures

26. Central city towards the east

27. Housing blocks towards north west

28. Detached houses towards south west


25


26


27


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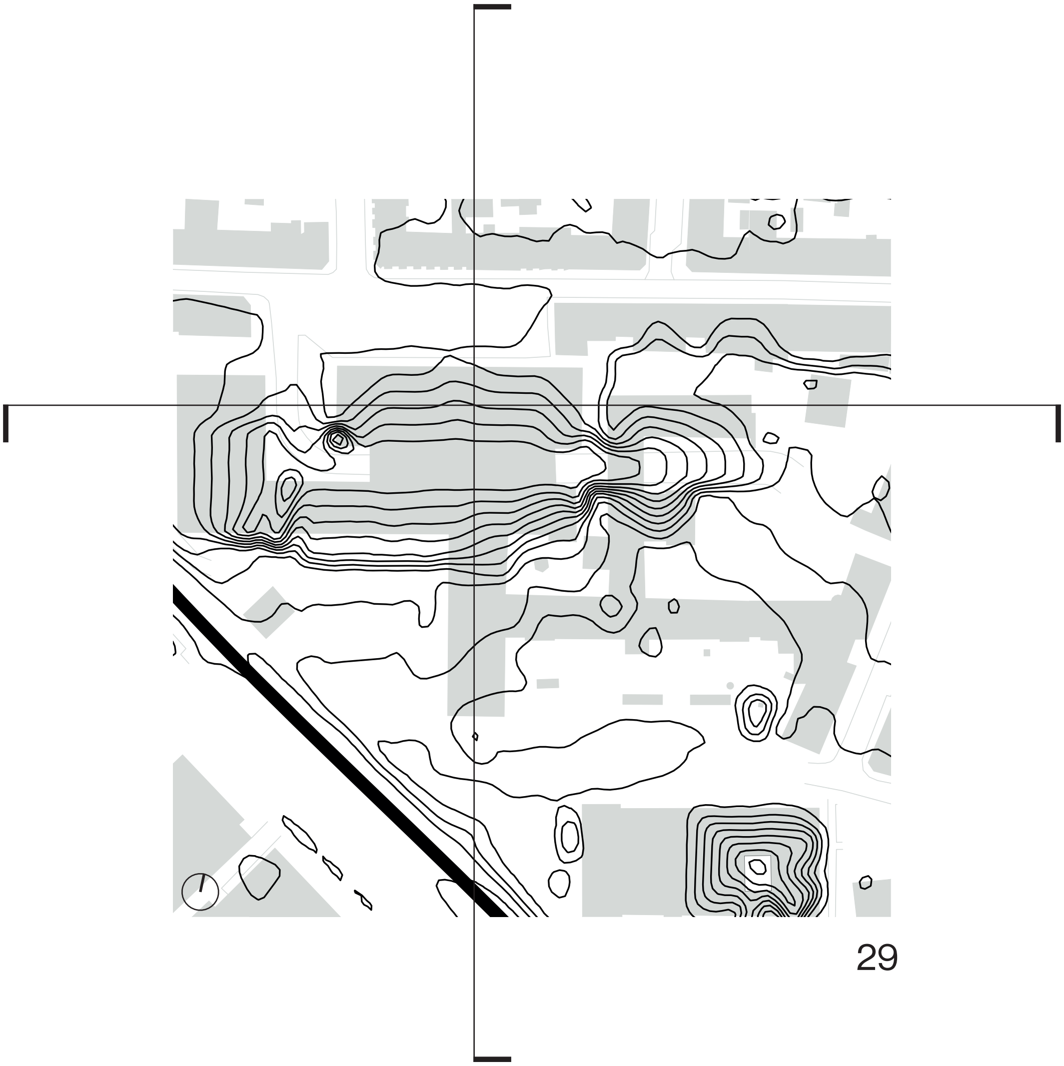

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Topographic analysis

The project area is relatively flat with the exception of the ambulance ramp around the project buildings, which descends to a network of basement floors, making this a critical area in relation to blue spots (Miljøgis, n.d.). The vision program suggests to fill in the ramps as well as the gap towards the south, creating a relation between the ground floor and the terrain. This approach will be undertaken and supported by a transparent ground floor, breaking down the boundary between the square and the green area towards the south, and inviting bypassers to stroll through the buildings.

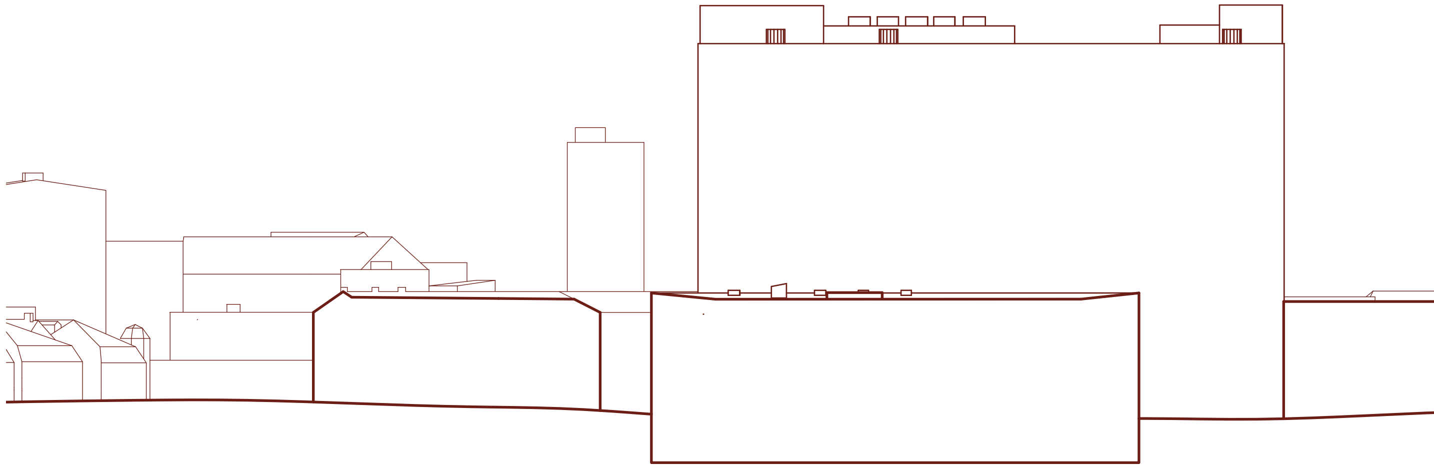
The eastern and northern side of the project buildings are slightly dislocated in the vertical direction, which will be approached in the design.

The project buildings rise in the centre of the project area, offering a view over Aalborg and Limfjorden, otherwise restricted by the dense urban environment. As a way of giving back to the city, the rooftops will be utilised for recreational purposes.

29. Topography map 1:2000

30. Longitudinal section 1:1000

31. Latitudinal section 1:1000



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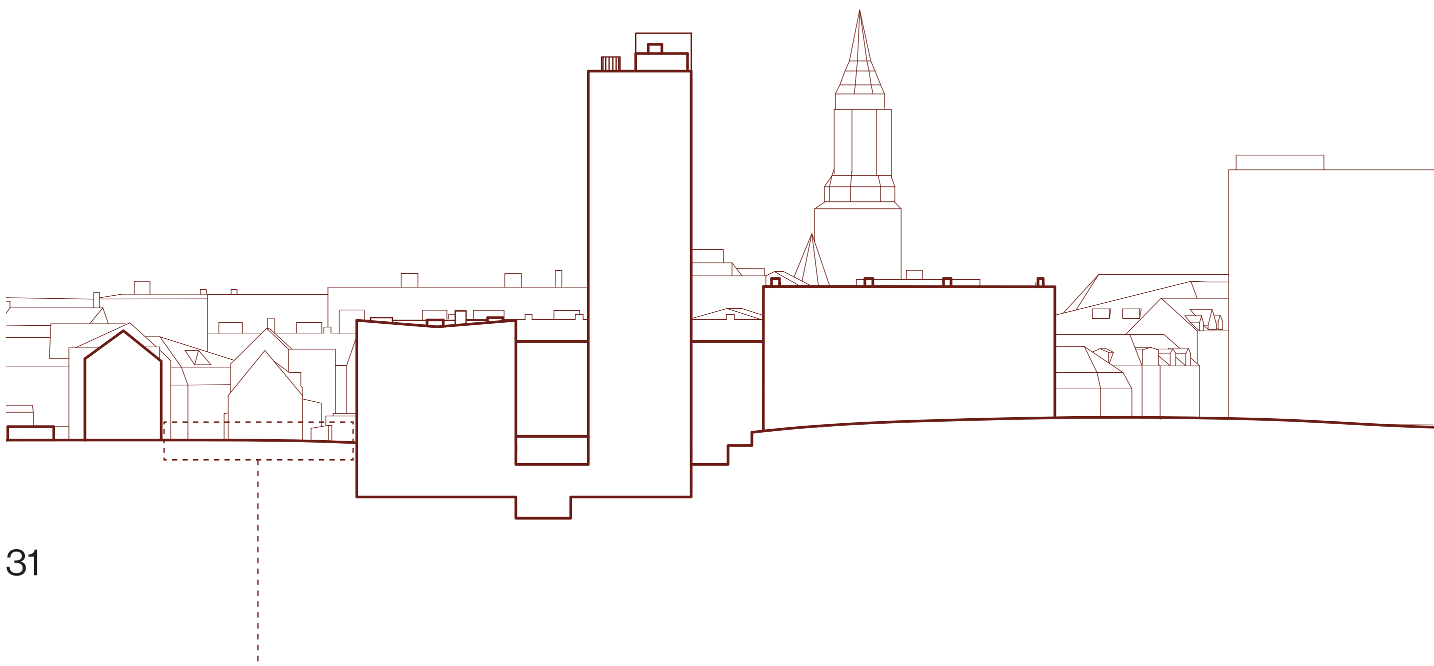

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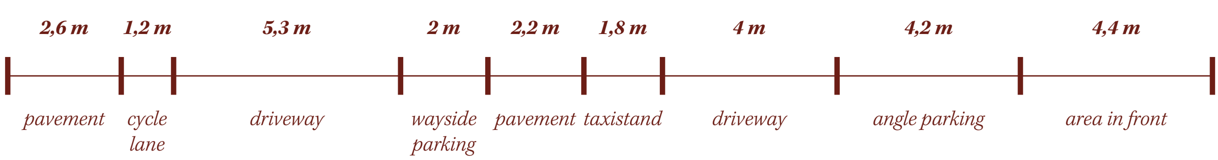
Road section :



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32. Foto from the preserved canteen on the 13th floor

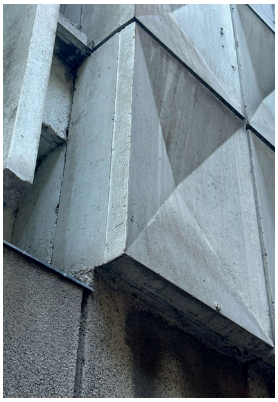
Atmosphere of the space

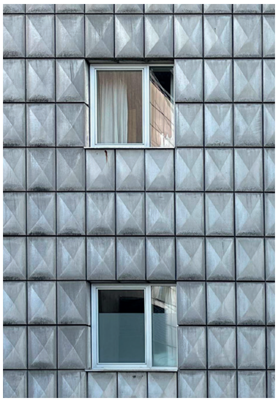
While a SAVE analysis typically does not incorporate a description of spatial experience, this thesis adopts a phenomenon based approach that involves studying the atmosphere of the project area. The close area is characterised by asphalted parking lots and the arrival towards the project buildings is dominated by cars, a massive arrival hall and an ambulance ramp connecting to the square. The atmosphere is a chaotic encounter between users of the hospital and visitors of Reberbansgade.

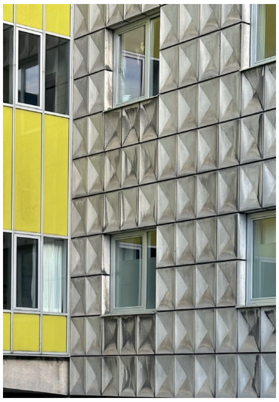
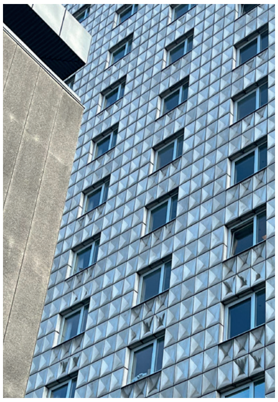
The project buildings themself stand out from its neighbours due to their pronounced scale. The late modern concrete hospital is stereotypical for the uncomplicated style of the post-war period. It was born around the same time as the term volume-sickness, triggered by an unconscious production of rigid box architecture. However, the delicate sense of detail present in the relief on the facade tiles illustrates a building that - in contrast to big scale architecture of today - addresses the human body. Through this detail, the building affords an intimate distance to be fully acknowledged. in terms of experience the building appears larger than it is, but appeals to a tactile perception.

When standing on the square, all surrounding surfaces are of hard, cold materials only with the exception of a few buildings in red bricks, adding warm colours. This in addition to the contemporary use, contributes to a raw, informal atmosphere. The informality is distinctly present in the graffiti on the facade of 'Læsehesten', a well visited entertainment shop. While improving the arrival experience and integrating areas for stay, an attention towards preserving the raw atmosphere is undertaken.



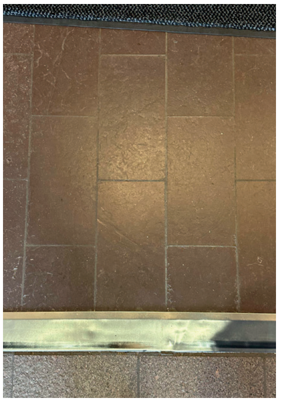





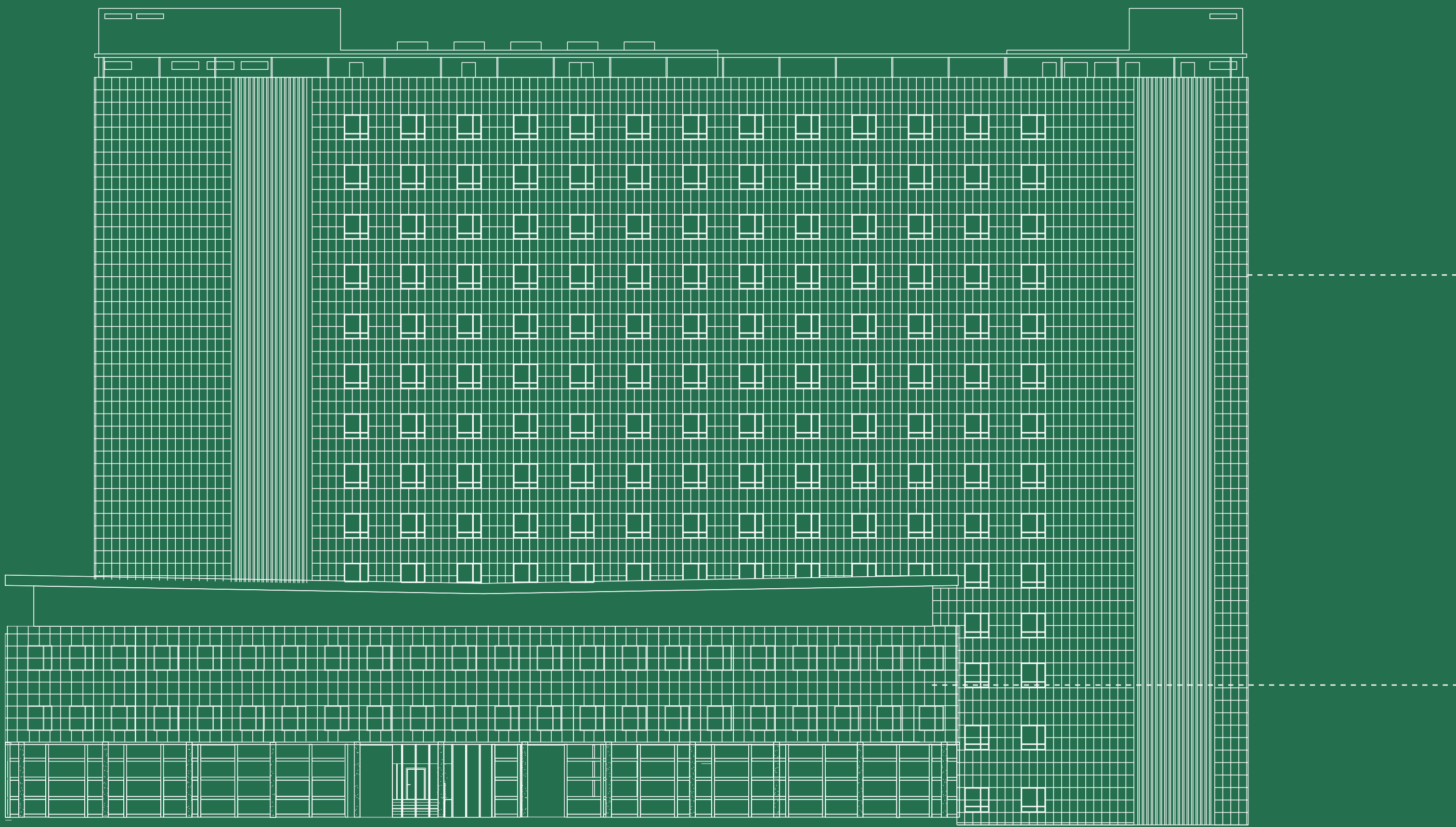




Trappe


Reserveudgang
Trappe



Small scale



Architectural characteristics

Building P has a monumental quality, but despite the noticeable height and heavy concrete facades, it appears elegant in the cityscape as it constitutes a tight, rectangular shape. The facades are covered with tiles in a light grey concrete, of which the centre is oriented inward, forming a relief. The facades demonstrate the art of repetition with a rhythm of perforations in a network of orthogonals lines. The systematic expression reflects the rational composition of the interior. Symmetrical corridors separate the wards on one side and administrative facilities on the other a layer of uniform floors, of which most have been renovated to a pristine white appearance. On the top floor the original canteen is preserved offering a pocket of a time where colours were an integral part of architecture.

Building B has a similar expression of rhythmic facade elements. The building forms a square towards the north, decreasing the tall body of building P to the level of the eye. The transparent ground floor of building B indicates a public transit area, with an overhang from the first and second floors, marking the entrance. The two buildings are currently connected on three floors, as is building P connected to a building towards the south. The connections will be removed and closed by a new facade (Nordud.com, 2021).

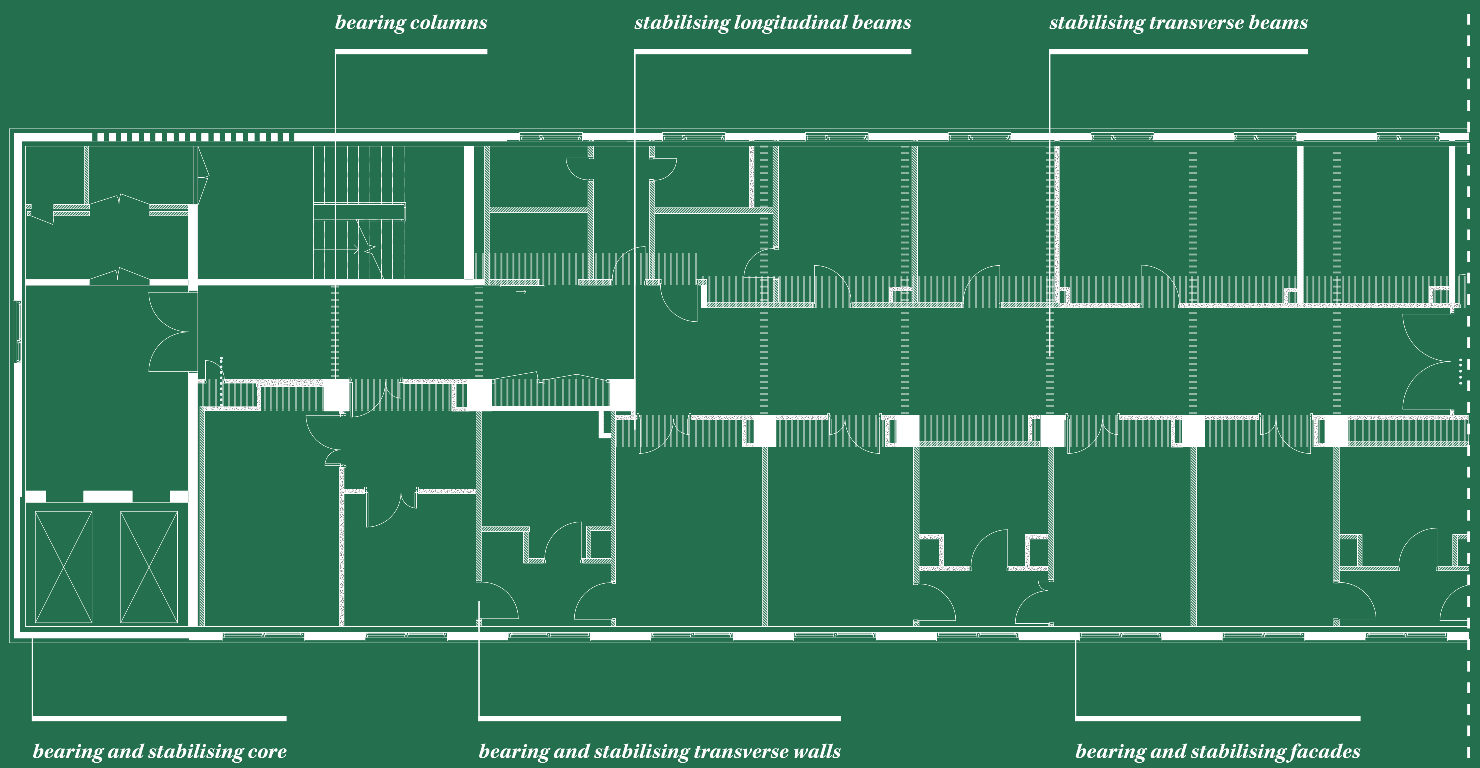
33. Elevation north 1: 500

Building P

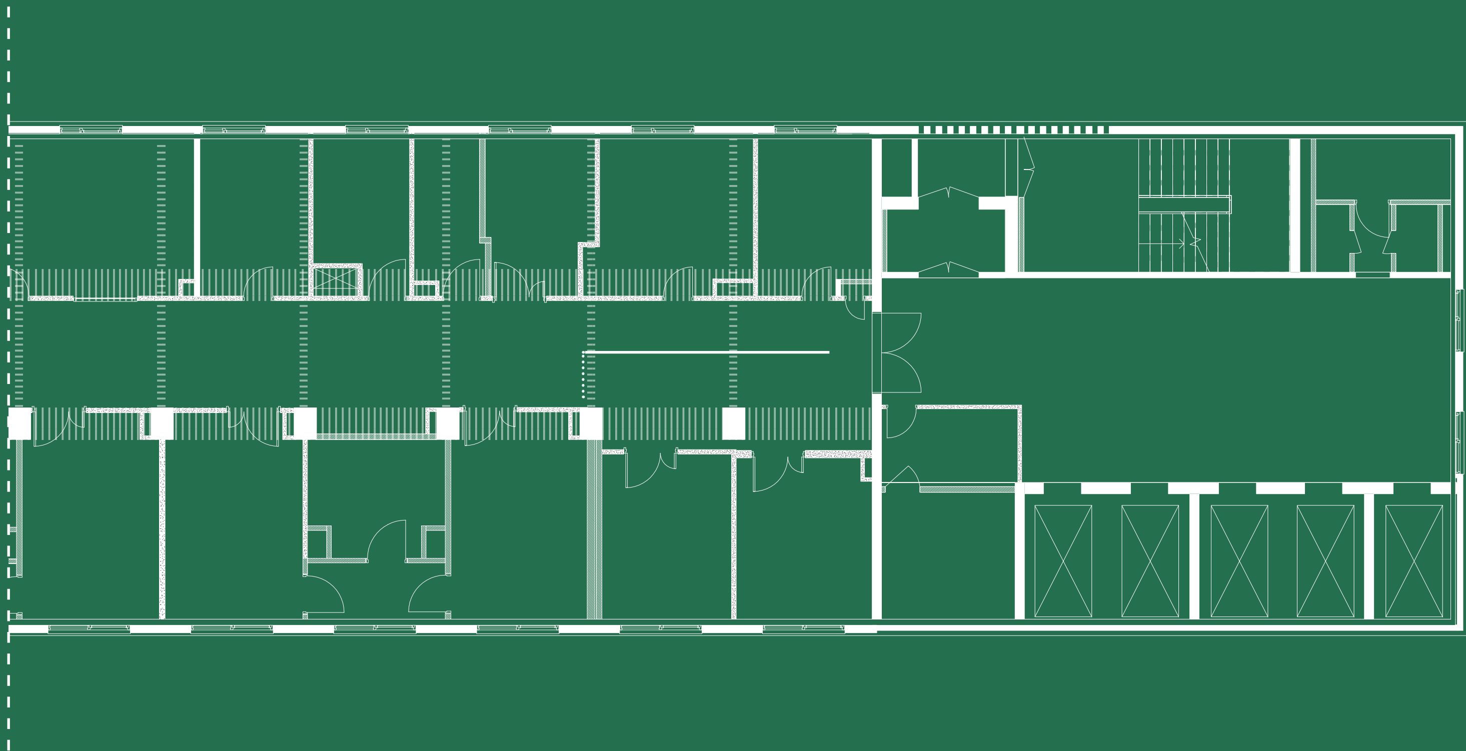
Year of construction:	1959
Latest reconstruction:	2007
Build area:	1.170 m^2
Total area:	16.380 m^2
Levels above terrain:	14
Levels below terrain:	2

Building B

Year of construction:	1959
Latest reconstruction:	2007
Build area:	1.642 m^2
Total area:	4.926 m^2
Levels above terrain:	3
Levels below terrain:	1
Total area:	*21.306 m^2*


bearing columns
stabilising longitudinal beams
stabilising transverse beams
bearing and stabilising core
bearing and stabilising transverse walls
bearing and stabilising facades

34



34. *Load bearing and stabilising system, P-building 1:200*

Structural system – Building P

The building consists of fourteen more or less repeated levels above terrain and two basement floors, all constructed from in situ cast concrete. The overall building system is a slab construction with supporting floors and walls. The load-bearing elements in the building consist of centrally placed columns of various dimensions and wall-columns between the window openings in both facades.

In addition, the system is carried and stabilised by transverse walls towards the south, with various placements throughout each floor. Transverse and longitudinal beams in the northern side allow an open plan, where the transverse beams are exposed while the longitudinal beams are hidden in the floors. The bearing and stabilising walls consist of either reinforced concrete or clay brick walls, while non-bearing walls are constructed from plasterboards (Niras, 2021).

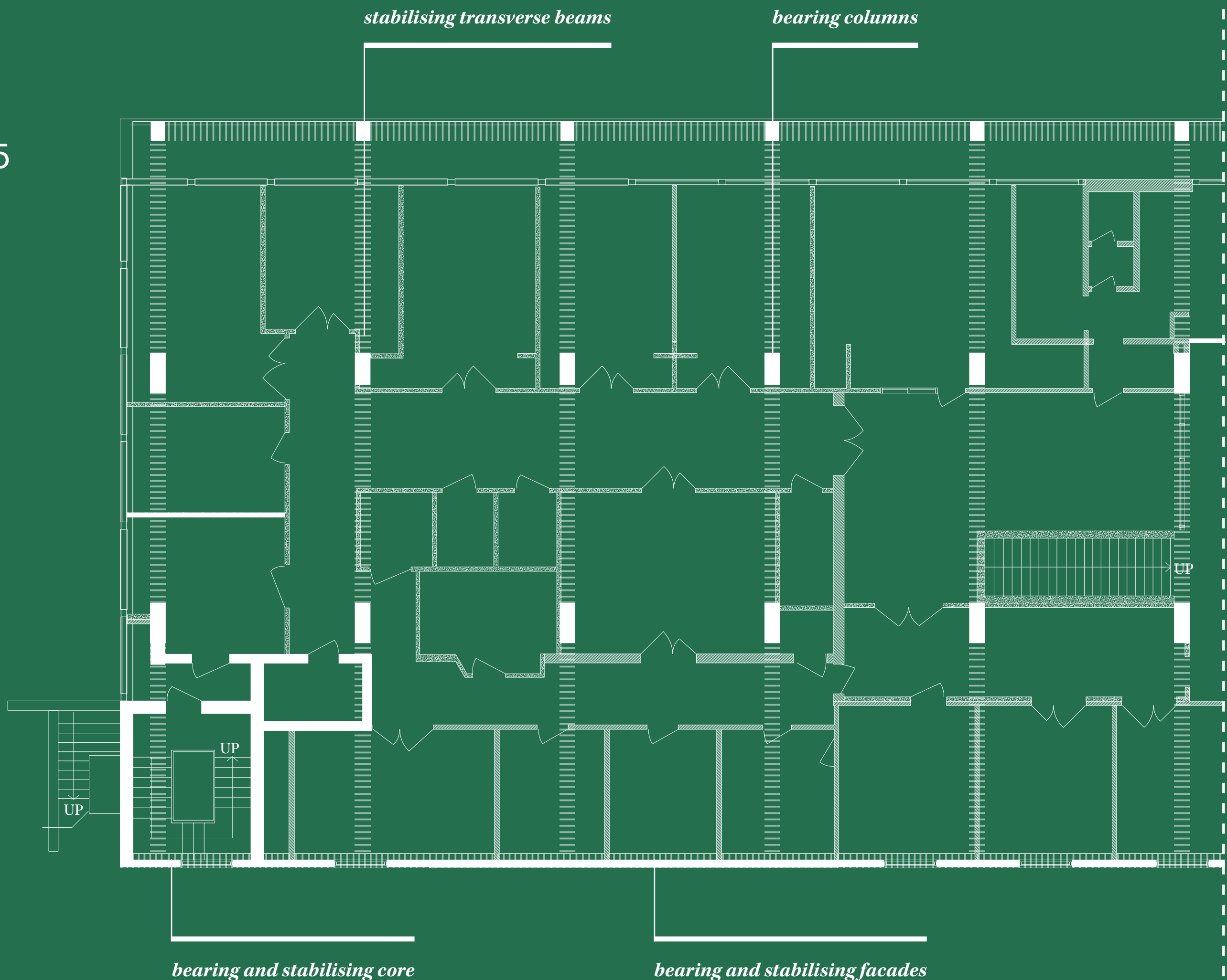
Limitations

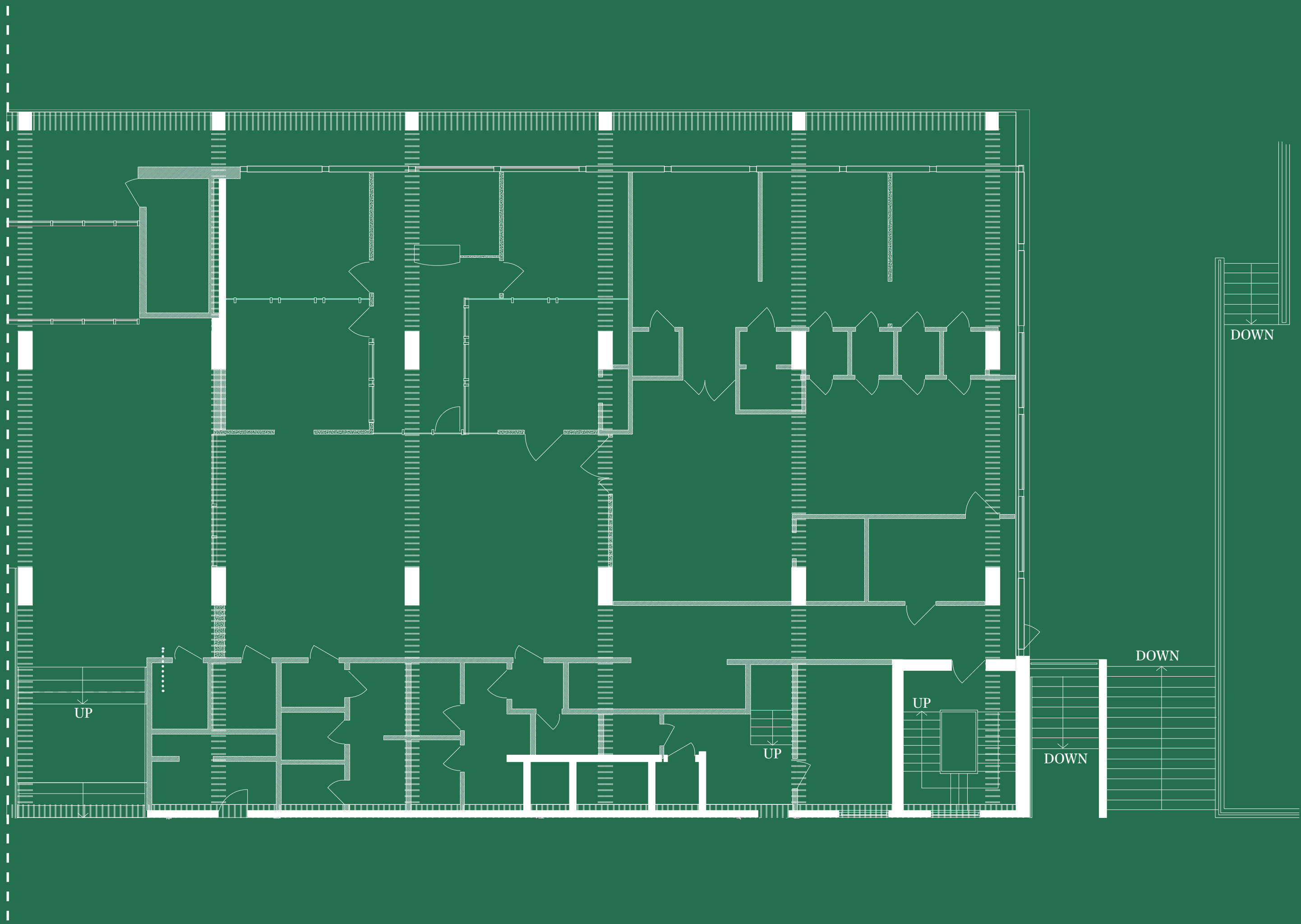
» The centrally placed bearing columns vary in dimensions throughout the floors and can not be reduced or replaced.
» The facade columns between windows are bearing and can not be reduced, limiting enlargement of windows to the vertical direction.

Potentials

» The northern part of the building being carried by beams creates possibilities for an open and flexible layout.
» The number of transverse walls on the southern part of the building can be reduced, creating possibilities for room widths of 3780 mm to 7410 mm.

35


stabilising transverse beams
bearing columns
UP
UP
UP
bearing and stabilising core
bearing and stabilising facades



35. *Load bearing and stabilising system, B-building 1:200*

Structural system –Building B

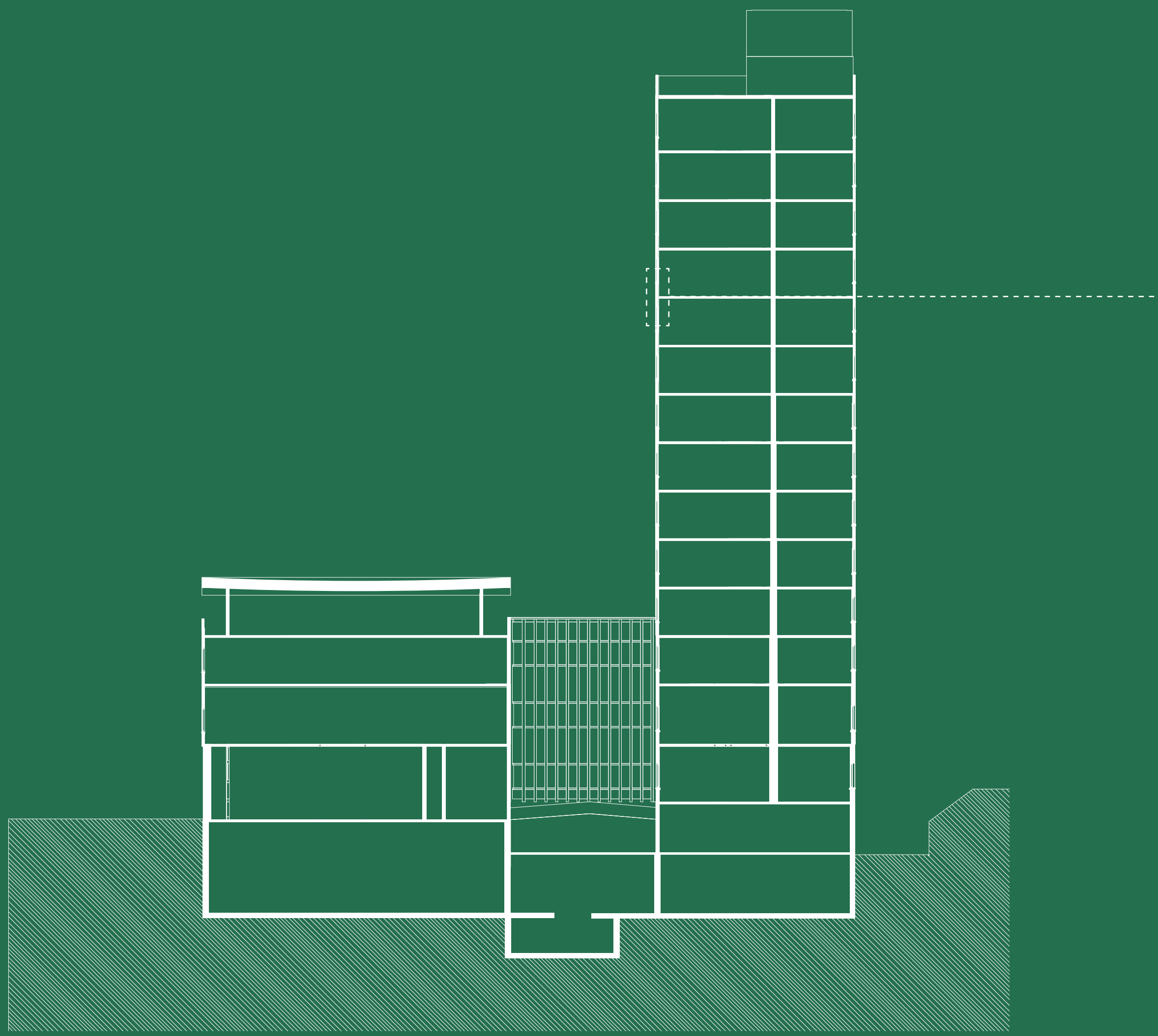
Building B consists of three levels above ground and two basement floors, which is likewise an in situ cast concrete slab construction. The load-bearing elements are three rows of columns, two of which are centrally placed, while the third is placed towards the north, exposed on the ground floor. The south facade functions as a stabilising longitudinal wall. The open ground floor indicates that northern, western, and eastern walls are non-bearing, while transverse beams resting on the columns constitute the stabilising system. Two bearing and stabilising cores of staircases are placed on the gables towards the south (Niras, 2021).

Limitations

» The deck being a stabilising element implies stabilising beams if principles of double height are to be implemented.
» The south facing facade and rooms are bearing and stabilising and can not be reduced or replaced.

Potentials

» The external walls facing north, east and west are non-bearing creating opportunities for a transparent facade.
» The deck being supported by columns, the building can be designed as a semi-open space with rooms within the room.



36

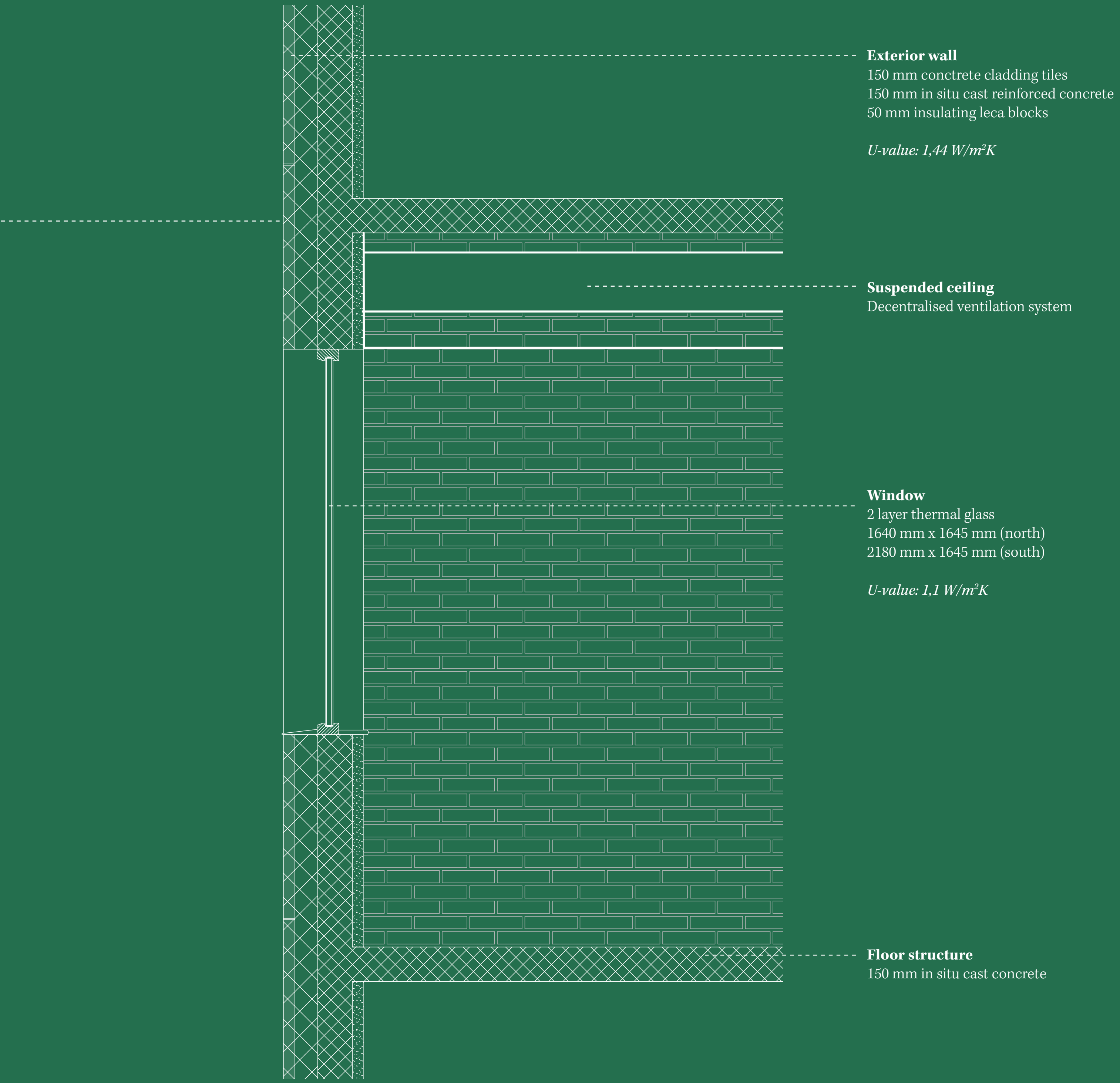
Energy optimisation

With the goal of optimising the project buildings to energy demands of today, a pronounced focus on re-insulations is undertaken. The project focuses on transmission loss through the external walls, ground deck, and roof. Considering the proportions, the external walls hold the largest optimisation potentials, and will therefore be the starting point for studying different re-insulation methods. The construction of the existing ground deck and roof is unknown and an assumed construction is therefore based on similar buildings of the time period (Jensen, RL et.al, 2011).

As a result of the slab construction, a main issue is thermal bridges along the slabs contributing to the transmission loss. Examinations of thermal bridges are often limited to explicit demands, taking only linear thermal bridges along the foundation, windows and doors into consideration. However, this particular construction indicates a focus on implicit demands, integrating the thermal bridges of the slabs by correcting the u-value calculations.

36. Section 1:500

37. Detail section 1:25


Exterior wall
150 mm conctrete cladding tiles
150 mm in situ cast reinforced concrete
50 mm insulating leca blocks
U-value: 1,44 W/m²K
Suspended ceiling
Decentralised ventilation system
Window
2 layer thermal glass
1640 mm x 1645 mm (north)
2180 mm x 1645 mm (south)
U-value: 1,1 W/m²K
Floor structure
150 mm in situ cast concrete

37

Chapter 05:

Valuation and Delimitations

Elements of <u>preservation value</u>?

The valuation process, derived from the SAVE-method, entails two components: evaluating the built environment in the project area and assessing the preservation value of the project buildings. The assessment of the project buildings involves ranking them on a scale of low, medium, or high based on five parameters outlined in the SAVE-valuation.

The project area is a well known and used location among especially younger residents of the city. Interventions in the area are to respect the existing functions and atmospheres, influenced by the take-away spots along Reberbansgade. The temporary feel resulting from the functions can be challenged by means of recreational purposes, however, the raw atmosphere characterising the close context should be preserved. The area around Reberbansgade is a significant section of the city history implying an awareness of the lines in the built environment.

The project buildings, being well preserved examples of architectural structures of the post-war period, and contemporary typical elements should therefore be preserved. This includes the <u>structural system</u> and related <u>materials</u>. In addition, the architectural expression resulting from the <u>proportions</u> and rhythmic facade <u>composition</u> is an identifiable motive in the cityscape. The <u>degree of detail</u> in the facade elements has a positive influence on the sensoric perception of the buildings, and should therefore be preserved or introduced in an architectural reinterpretation.

Though assessed to a high preservation value, the position of this thesis is not careful, as new structures may be added without conflicting with the abovementioned elements. On the contrary, new structures can enhance the elements, either by creating a contrast or undertaking the same form principles as the existing.

valuation !

01_architectural value.
the architectural value of the project buildings are rooted in the proportions, the facade composition, and the detailing of the facade elements. valuation: high

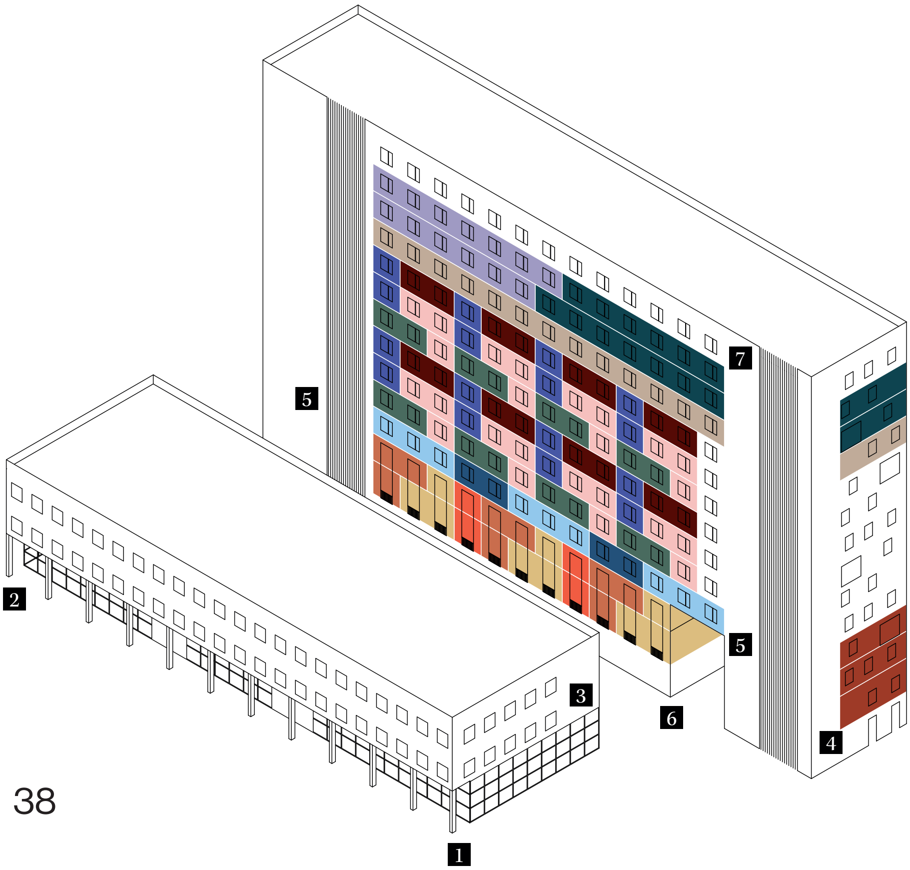
02_culture-historical value.
the buildings are part of the cultural heritage of the specific place and of a general architectural style period, characterised by repetition and rationality. valuation: high

03_environmental value.
on a big scale, building P performs as a landmark in the cityscape while building B forms a central place for the close context experienced in human scale. valuation: medium

04_originality.
the structural system of the buildings are a manifestation of a time-typical way of constructing, which is distinctively present in the external expression. valuation: medium

05_condition.
The materials of the buildings are resistant and with no to few damages on the construction, however outdated in relation to thermal properties. valuation: low

Project program



38

1. Street sport facilities
2. Café and bakery areas
3. Hostel and student housing
4. Bicycle parking
5. Circulation
6. Kindergarten
7. Canteen

Building P features collective housing, while building B offers public functions in relation to the existing structures along Reberbansgade. A square, which can be adopted for market days, exhibitions or events, is established in continuation of building B. To break down the barrier between the square and the green structure towards the south, an open ground floor and connections across the building volumes is integrated.

On the ground floor Building B is a square hall occasionally inhabited by small delicacy shops in addition to permanent café areas. Part of the ground floor is ascribed to after school activities enhancing the raw atmosphere of the area by offering street sport facilities within and outside the building. On the 1st and 2nd floor a combination of student housing and hostel is implemented with shared facilities. The rooftop is accessible from the square, and used for recreational purposes.

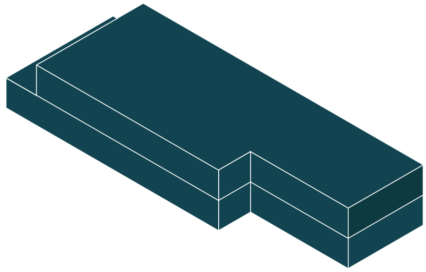
The collective house constitutes housing units of varying sizes and layouts. Different common areas are incorporated throughout the floors, including living- and work spaces. The ground floor will house a daycare facility, and covered bicycle parking to accommodate the habitants. On the 14th floor the existing canteen is preserved, serving as a common dining space. In relation to the canteen a roof terrace will be designed offering a place for neighbours to socialise around gardening.

38. Diagram of project program

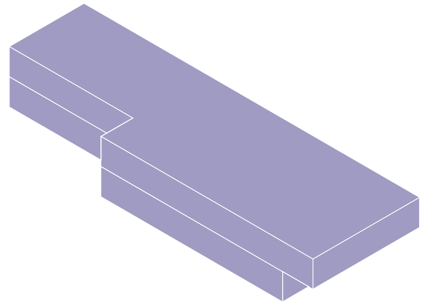
39. Diagram of varying apartments

39

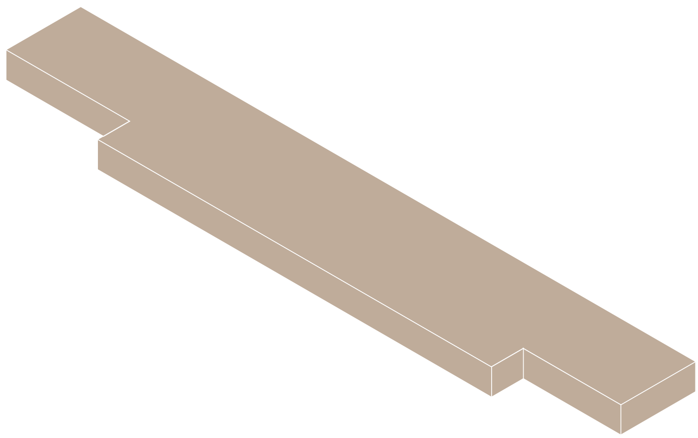
Co-housing in two levels / 20 rooms
~ 880 m²
20 rooms



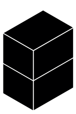
Co-housing in two levels / 20 rooms
~ 880 m²



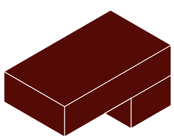
Co-housing in one level / 14 rooms
~ X m²



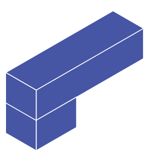
Studio
~ 50 m²



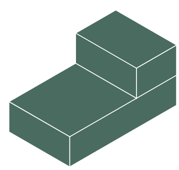
unit c.4 / 3-4 rooms
~ 120 m²



unit c.3 / 1-2 rooms
~ 70 m²



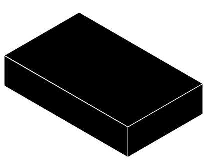
unit c.2 / 4-5 rooms
~ 140 m²



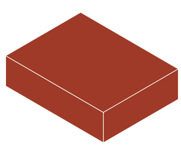
unit c.1 / 2-3 rooms
~ 90 m²

Focused

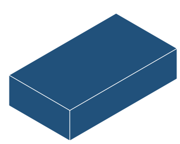
unit b.4 / 3 rooms
~ 105 m²



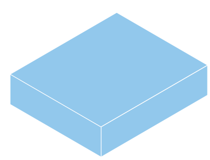
unit b.3 / 2 rooms
~ 85 m²



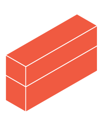
unit b.2 / 1 room
~ 85 m²



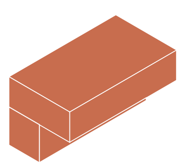
unit b.1 / 2 rooms
~ 125 m²



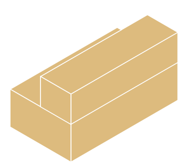
unit a.3 / 1 room
~ 85 m²



unit a.2 / 3 rooms
~ 125 m²



unit a.1 / 3 rooms
~ 125 m²



Delimitations

The project revolves around building P and building B, and constitutes in addition the edge zones around the project buildings. As the basements might be utilised for basement parking, these are left out of account. Concluding a total of 21.306 m2, a varying degree of attention will be given to different aspects of the project. While the ground floor of building B is designed in relation to building P and the edge zones, the 1st and 2nd floor are conceptually programed. To create an inclusive habitation community, building P houses a range of different apartments, of which selected are thoroughly designed. The lower floors will house private units while the top floors are programmed as co-housing. These sections are designed, but will be subject to additional development. The intermediate floors offer a varying degree of shared facilities, and are the primary focus of the design task, as they to a greater degree represent the organisational aspects of the hospital structure. The roomprogram relates to this section.

Energy optimisation and indoor climate aspects relate exclusively to building P, while the selected strategy will be transferred to Building B. The energy frame is calculated on building level, while a critical room is evaluated in relation to indoor climate.

Aesthetic parameters

- Allow all housing units access to both diffuse and direct light.
- Add new structures to enhance the existing expression.
- Replace the existing systems and integrate new in the design.
- Implement a transparent ground floor and connections across buildings.
- Preserve the raw, industrial atmospheres characterising the project area.

Technical parameters

- Ensure an average daylight factor of minimum 2% in all living spaces.
- Combine a new mechanical ventilation system with natural ventilation.
- Implement renewable energy sources in the form of photovoltaics.
- Preserve the structural system and let new structures be subject to it.

Functional parameters

- Utilise the existing canteen and by so reduce the kitchen area in the units.
- Implement common areas, including workspaces.
- Integrate bicycle parking for residents and the public on the ground floor.
- Offer different ways of living for families of varying constellations.
- Implement a daycare facility and after school activities.

Apartment ~ 70 m²

Room	Nr. of rooms	Area	Capacity	Daylight		Ventilation		Windows		Set temperature	
				Aesthetic	Ammount [%]	Strategy	Rates [l/s]	Opening area [m²]	Glass area [m²]	Heating [°C]	Venting [°C]
Dining room	1	~ 20	6	Direct light	2	Hybrid	56	0,8	2	20	20
Living room	1	~ 15	4	Diffuse light	2	Hybrid	39,5	0,6	1,5	20	20
Bed room	1-2	~ 15	2	Diffuce light	2	Hybrid	24,5	0,6	1,5	20	20
Bath room	1	~ 5	1	-	-	Mechan-ical	10,5	-	-	20	20

Apartment ~ 90 m²

Room	Nr. of rooms	Area	Capacity	Daylight		Ventilation		Windows		Set temperature	
				Aesthetic	Ammount [%]	Strategy	Rates [l/s]	Opening area [m²]	Glass area [m²]	Heating [°C]	Venting [°C]
Dining room	1	~ 20	6	Direct light	2	Hybrid	56	0,8	2	20	20
Living room	1	~ 15	4	Diffuse light	2	Hybrid	39,5	0,6	1,5	20	20
Bed room	2-3	~ 15	2	Diffuce light	2	Hybrid	24,5	0,6	1,5	20	20
Bath room	1	~ 5	1	-	-	Mechan-ical	10,5	-	-	20	20

Apartment ~ 120 m²

Room	Nr. of rooms	Area	Capacity	Daylight		Ventilation		Windows		Set temperature	
				Aesthetic	Ammount [%]	Strategy	Rates [l/s]	Opening area [m²]	Glass area [m²]	Heating [°C]	Venting [°C]
Dining room	1	~ 20	6	Direct light	2	Hybrid	56	0,8	2	20	20
Living room	1	~ 15	4	Diffuse light	2	Hybrid	39,5	0,6	1,5	20	20
Bed room	3-4	~ 15	2	Diffuce light	2	Hybrid	24,5	0,6	1,5	20	20
Bath room	2	~ 5	1	-	-	Mechan-ical	10,5	-	-	20	20

Apartment ~ 140 m²

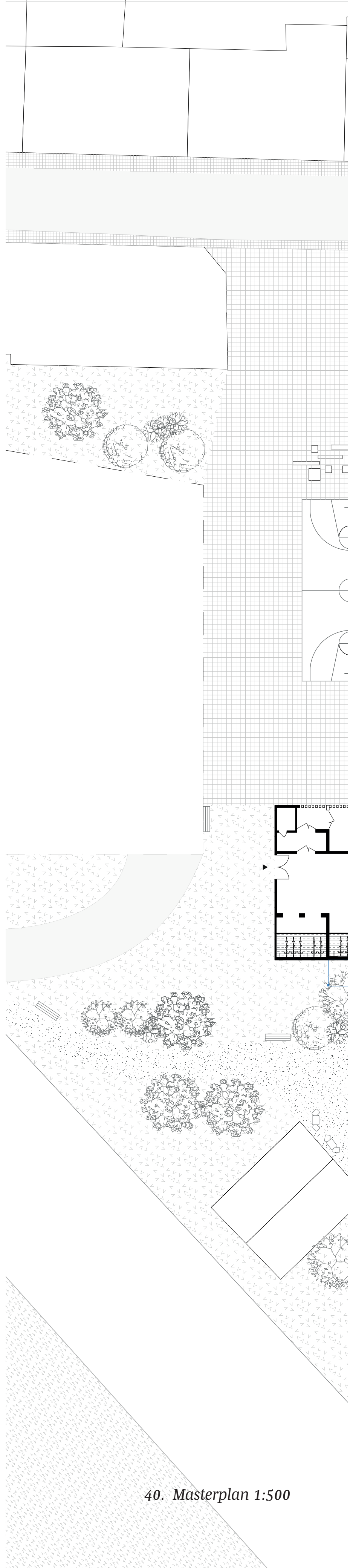
Room	Nr. of rooms	Area	Capacity	Daylight		Ventilation		Windows		Set temperature	
				Aesthetic	Ammount [%]	Strategy	Rates [l/s]	Opening area [m²]	Glass area [m²]	Heating [°C]	Venting [°C]
Dining room	1	~ 20	6	Direct light	2	Hybrid	56	0,8	2	20	20
Living room	1	~ 15	4	Diffuse light	2	Hybrid	39,5	0,6	1,5	20	20
Bed room	4-5	~ 15	2	Diffuce light	2	Hybrid	24,5	0,6	1,5	20	20
Bath room	2	~ 5	1	-	-	Mechan-ical	10,5	-	-	20	20

Room program...

Chapter 02:

Presentation

40



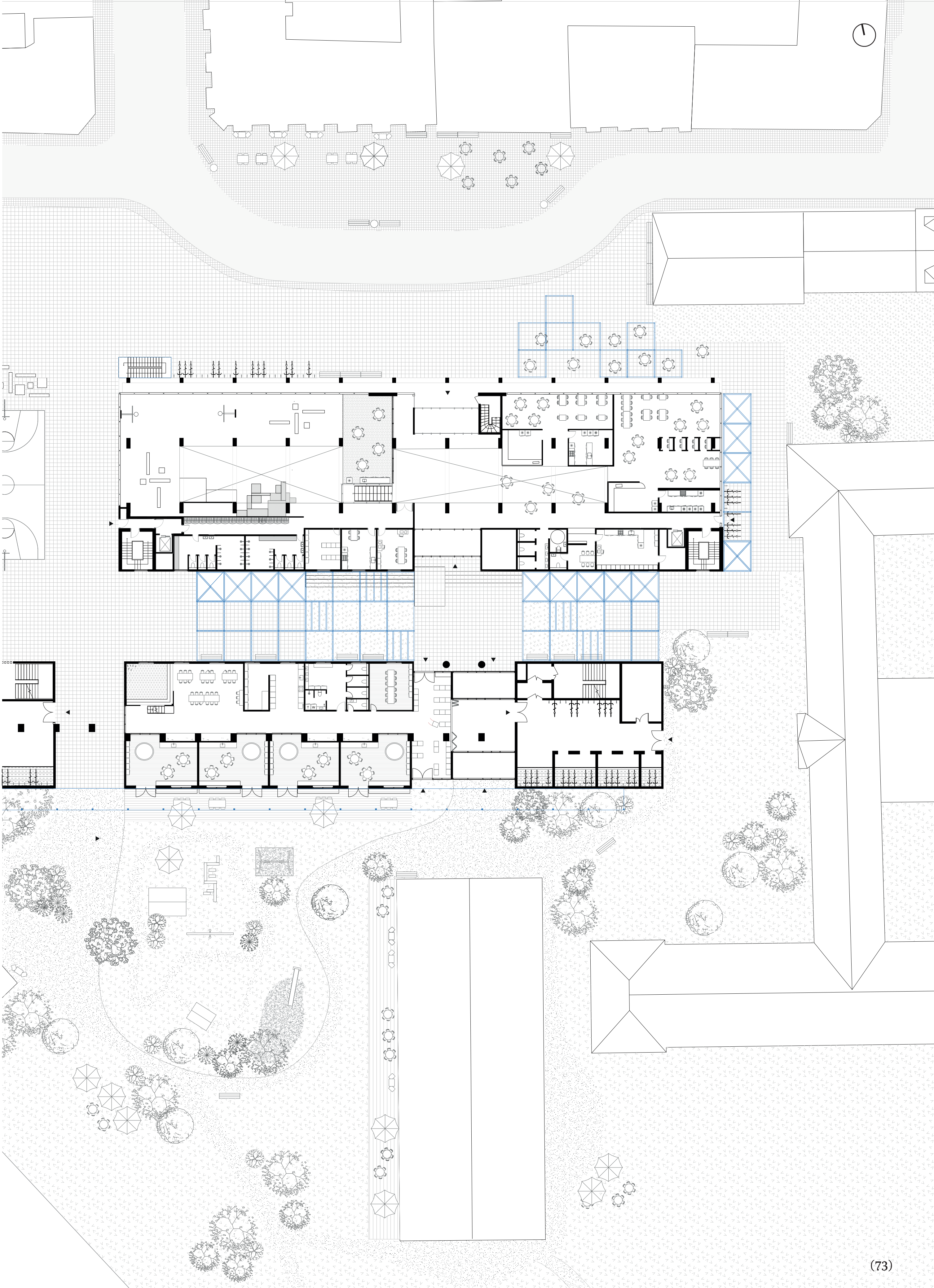
Masterplan

The transformation of the hospital buildings P and B inwrites itself in an ongoing development of the hospital area. It emphasises the importance of preserving the contemporary atmosphere in an urban space undergoing radical functional changes. A town square that can be utilised for market days, exhibitions and events strengthens the temporary feeling present on Reberbansgade, while a green, recreational area towards the south provides a space for leisure activities.

Facing the square, building B houses public functions and administrative facilities on the ground floor. Towards the west, street sport facilities cater to after-school programs in the area. Adjacent to this, a town hall separates a space designated for a bakery and a cafe in continuation of the square and administrative functions related to a hostel. Overall, Building B fosters interactions between permanent residents, guests, and city users.

To accommodate the increased number of residents in the area, a day care facility is situated on the ground floor of building P. During the day, it utilises a section of the recreational area, while the public can enjoy the playground outside of operating hours. The mixed functions within the area contributes to a diverse user group and a vibrant atmosphere throughout the day.

40. Masterplan 1:500



41

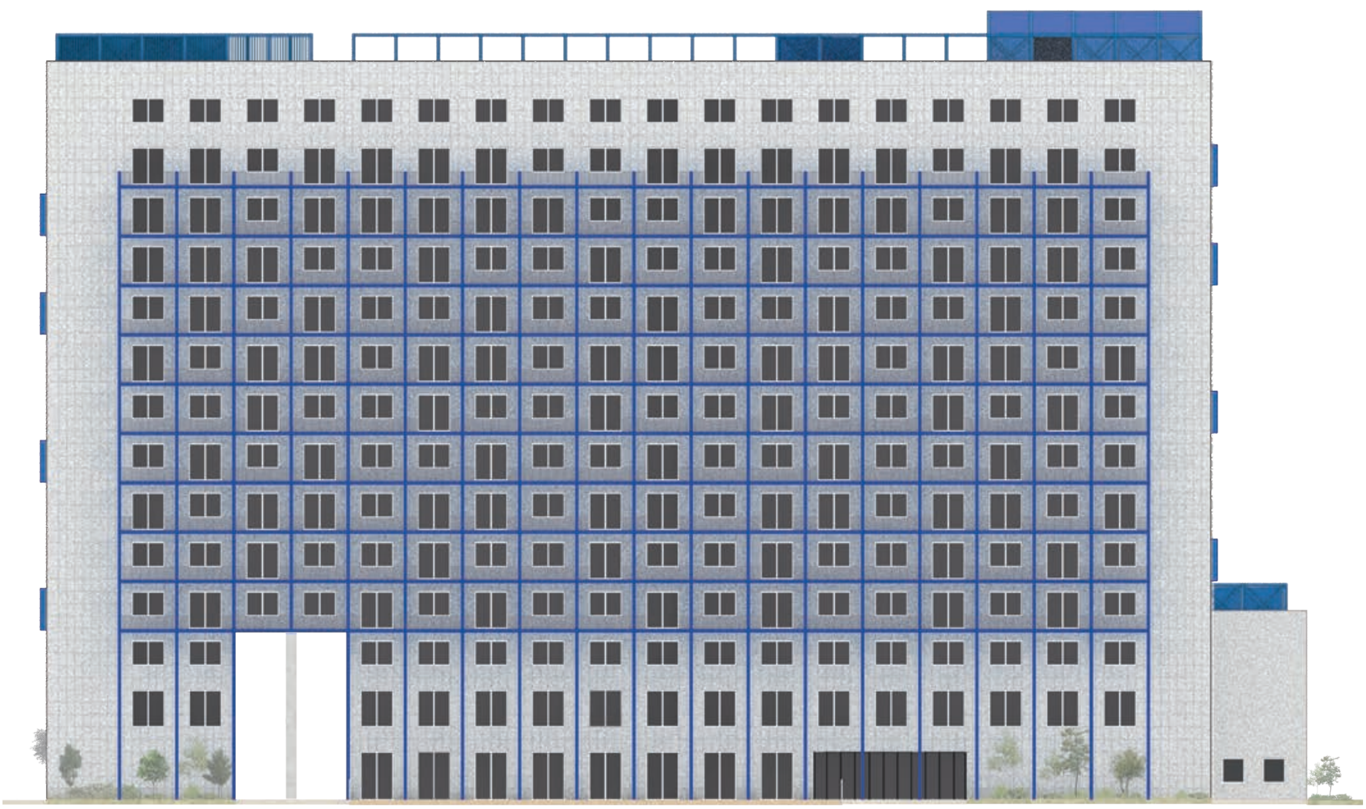
41. Exterior observed from the city

42. The square on Reberbansgade

The exterior of the hospital buildings tells a tale of transformation through the use of colour, emphasising the contrast between the existing structure and the new elements. The distinctive character of the facades is preserved, while the introduction of new structures in the same mode of expression enhances the rhythmic composition. As a result, the recognisability in the cityscape is maintained throughout interventions.

42

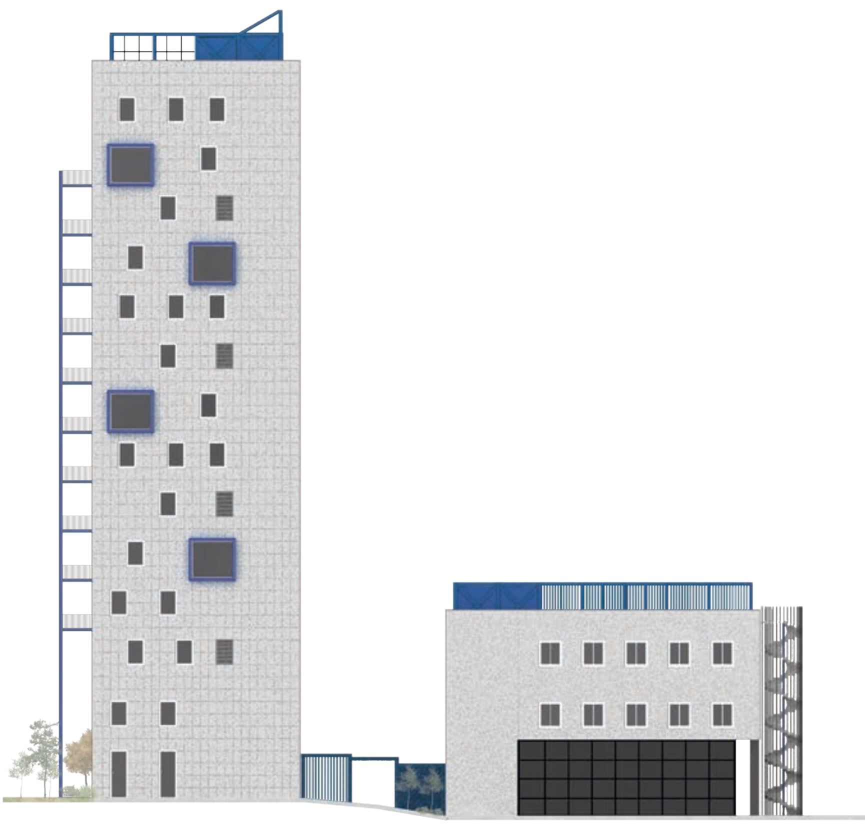
43



44

Elevations

45



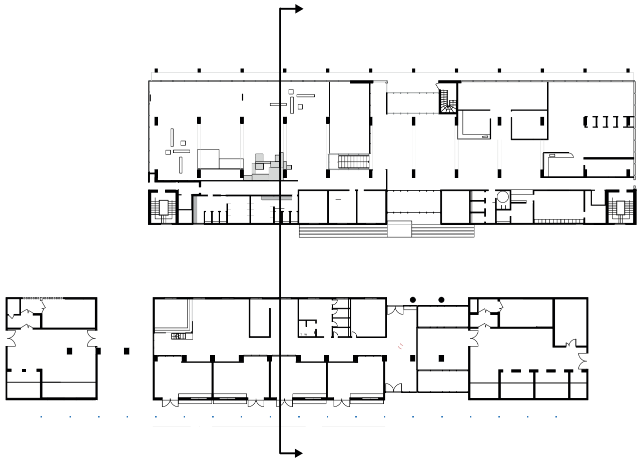
46

43. Elevation, north 1:500

44. Elevation, south 1:500

45. Elevation, west 1:500

46. Elevation, east 1:500

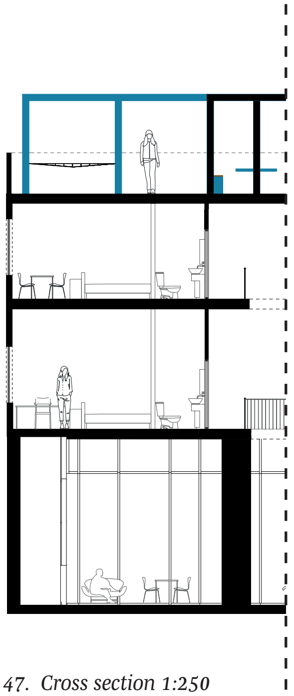


Section

The upper floors on building B serves as a hostel and student housing both benefiting from common facilities and thereby promoting relationships across city boundaries. The student housing accommodates permanent residents as well as semester students in furnished units.

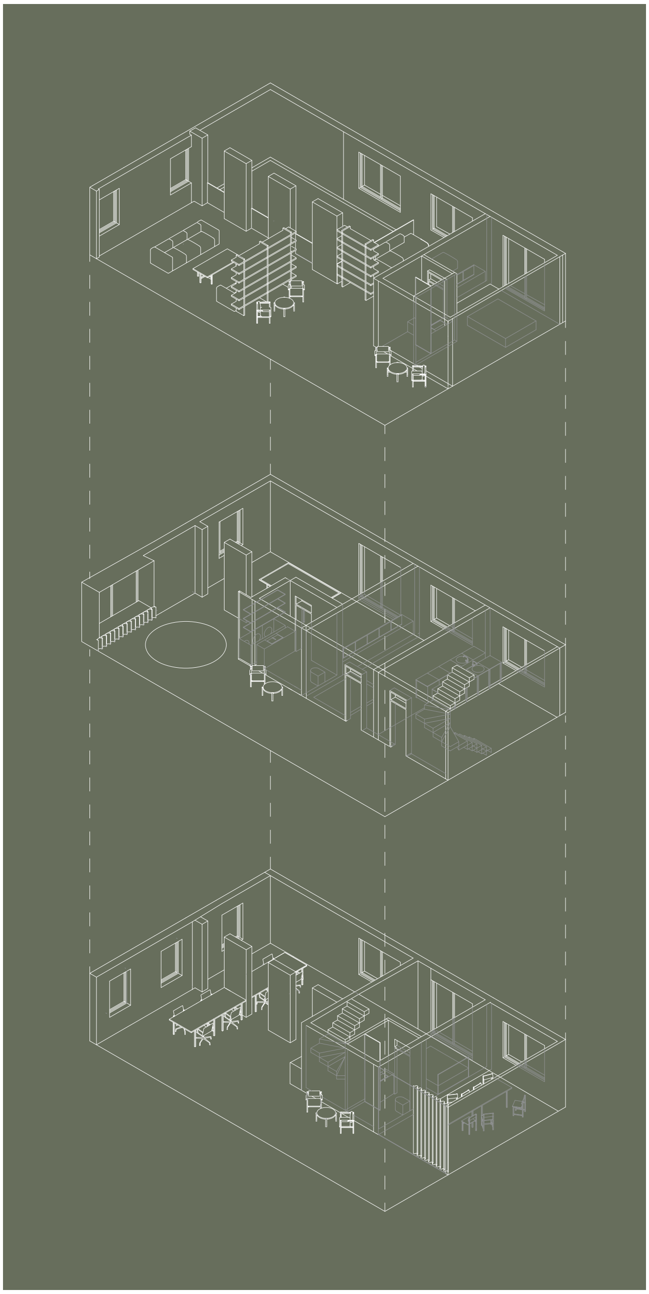
In building P, a sense of collectivism graduates vertically. The lower floors consist of private housing units, while the top floors are designed as co-living arrangements, where the private area is reduced to a single room. Housing units in between follows a 'tetris' principle, allowing units of varying sizes to open up to the common areas to varying extents. Living- and working spaces are situated on individual floors, while the existing canteen is preserved on the top floor. This caters to the larger community while also fostering smaller communities between close neighbours.

New elements are incorporated on the rooftops, providing spaces for leisure activities and acting as a shelter from wind and rain. The rooftop of the B building is accessible to the public, while the rooftop of the P building is exclusive to residents and includes gardening facilities.



47. Cross section 1:250

47



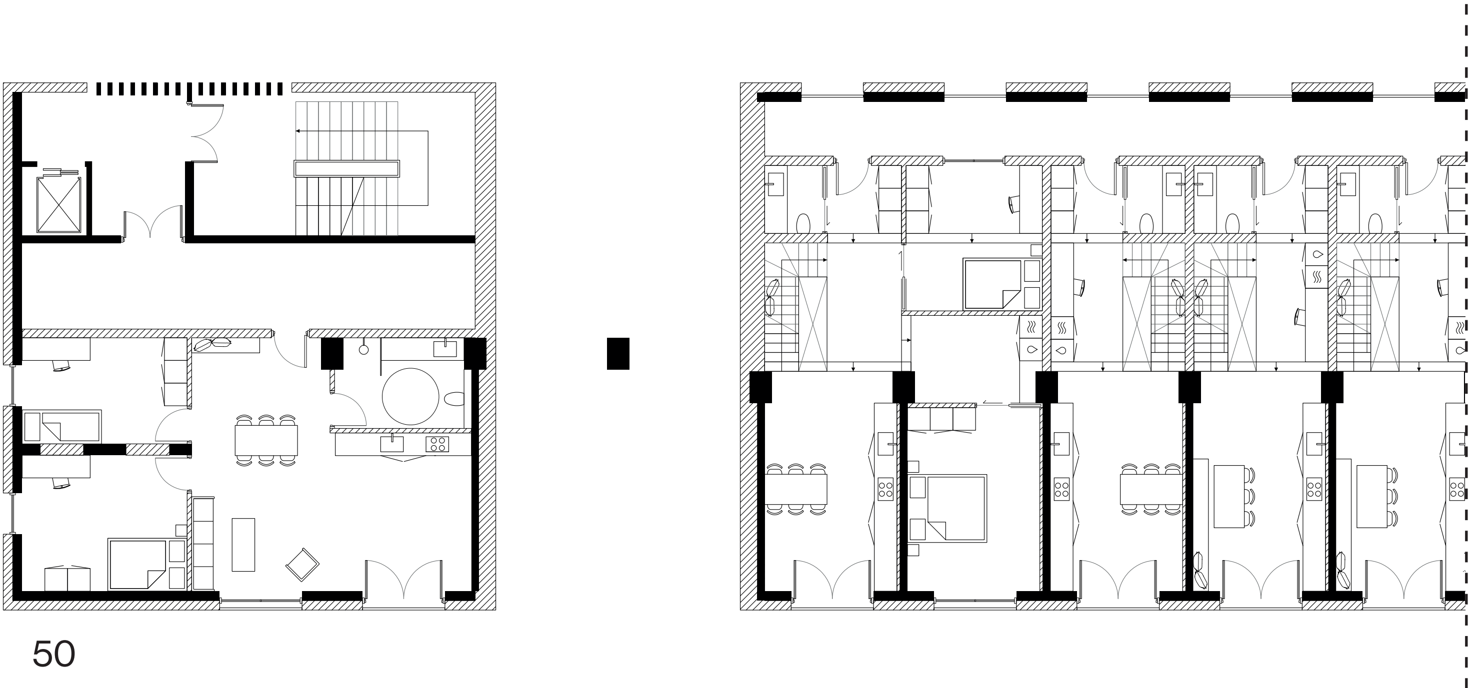
48

Common areas

The project incorporates workspaces in proximity to the housing units, adapting to contemporary lifestyles and enabling residents to work from home. Furthermore, living spaces and laundry areas encourage informal interactions among neighbours and allow the private area to be reduced. The common areas are situated at the gables of the 4th to 9th floors and accessed through the primary circulation system.

48. Diagram, living- and work spaces

49. Common areas, P-building



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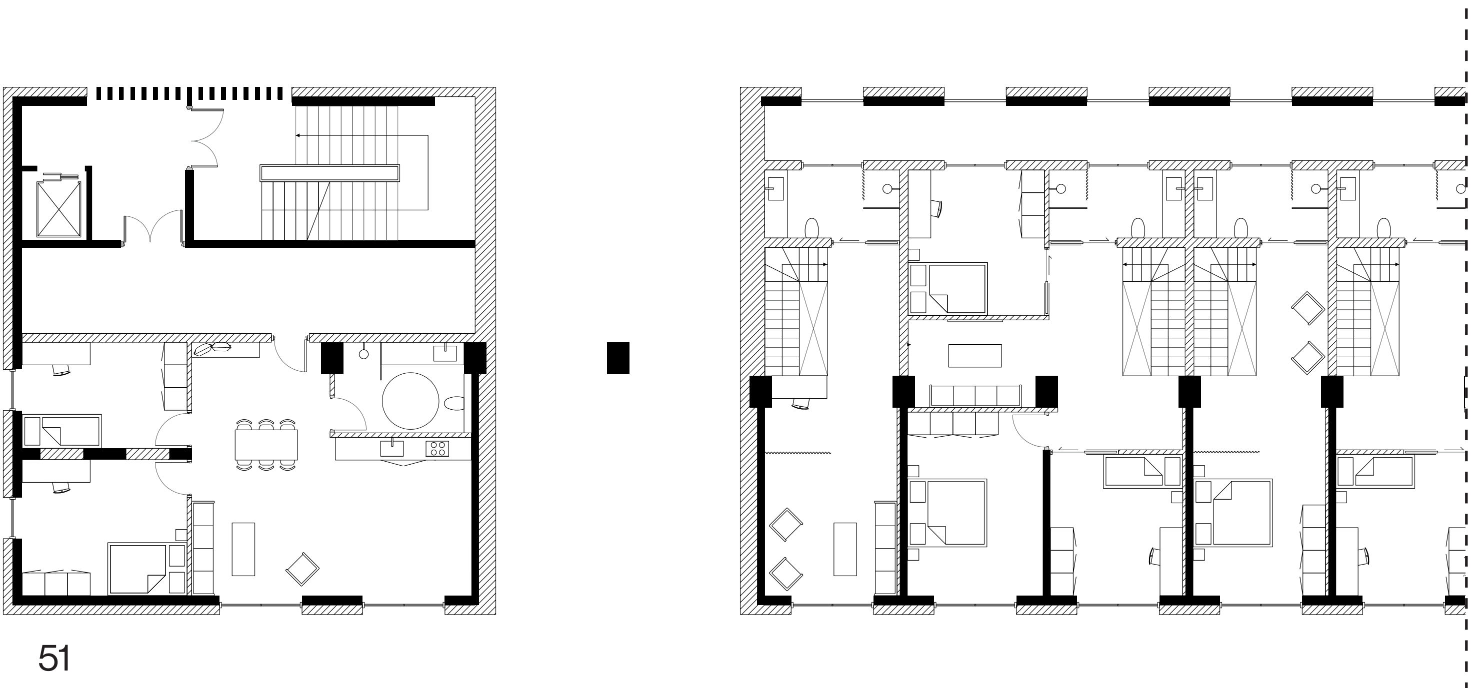

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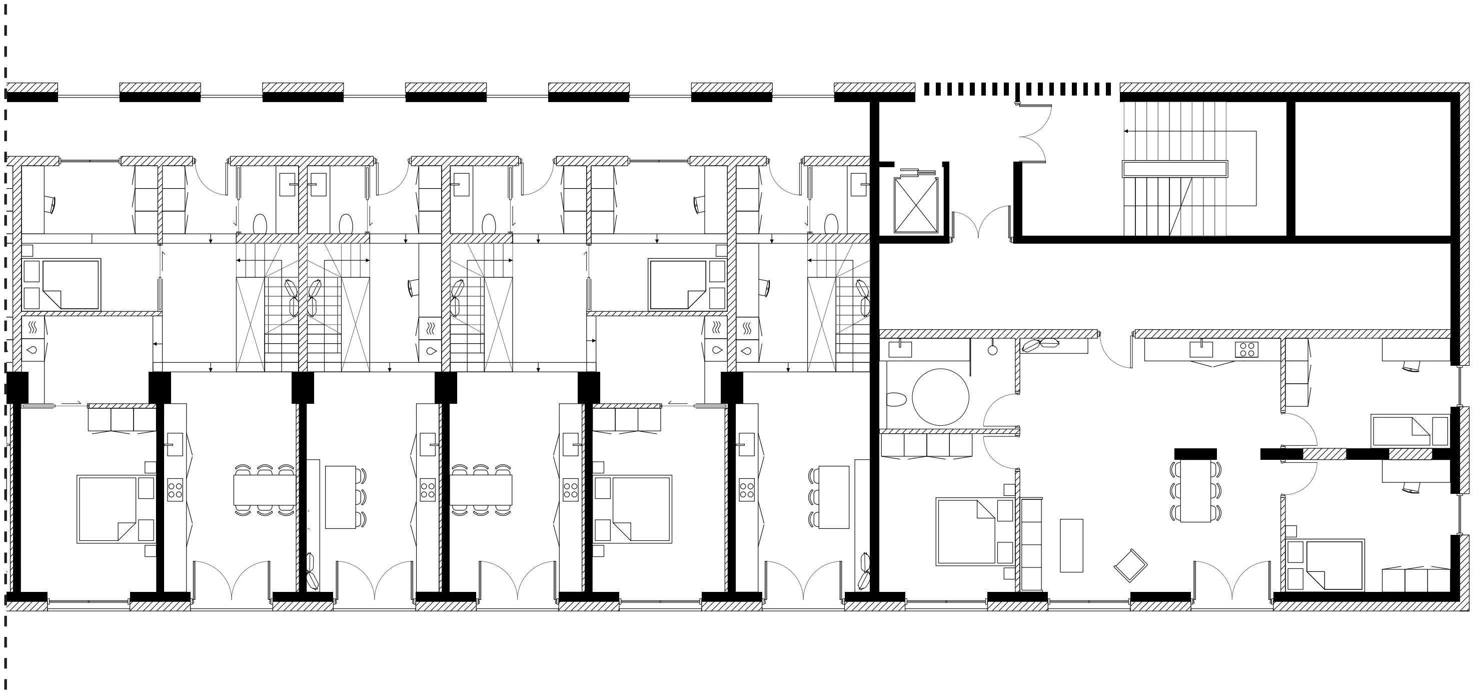
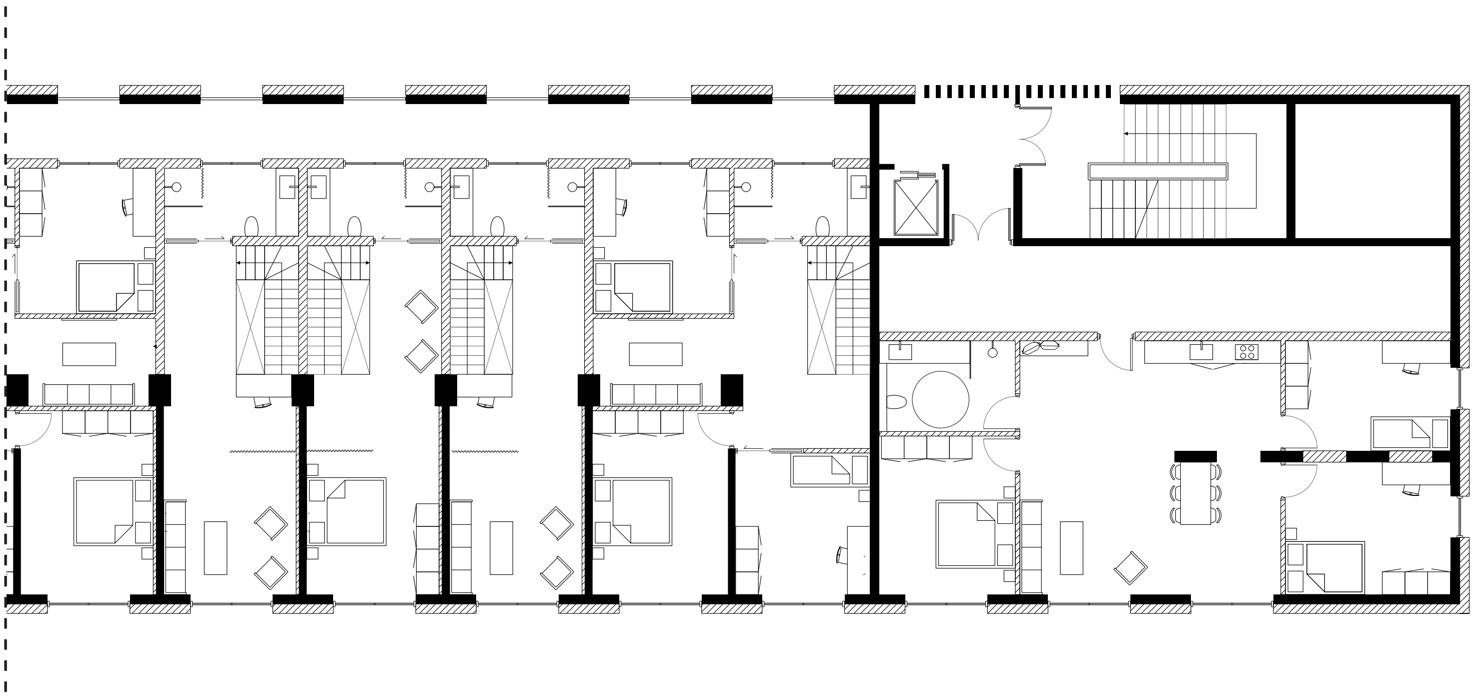




Private housing

The private housing units on the 1st and 2nd floor are accessed from a balcony on the northern side. With the exception of the apartment located at the gables, these housing units are designed as two stories of 125 or 85 m2. Taking advantage of the greater room height on the 1st floor, the design incorporates different levels within the units, effectively establishing different zones within an otherwise open layout. The layout of the 3rd floor consists of accessible private housing units, although not presented in this thesis.

50. 1st. floor, P building 1:200

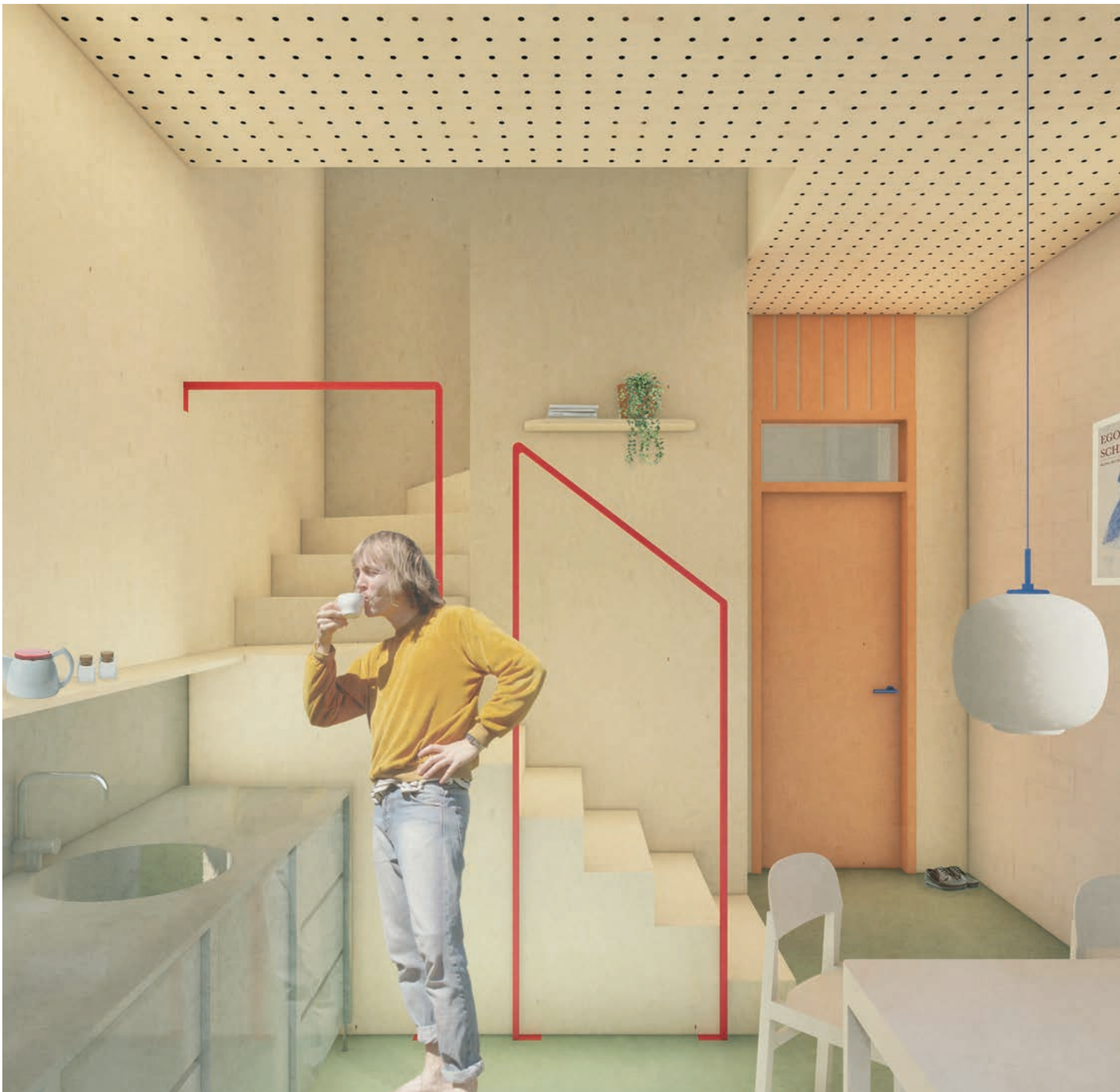
51. 2nd floor, P building 1:200

52

52. Kitchen on ground floor in 70 m²
apartment

53. Living area on 1st floor in 70
m²apartment

The 4th to 9th floor constitute housing units of various sizes that can be opened to the common areas to different degrees. Access to the housing units is provided through a central corridor, and the design features two-story units, all with access to both facades. Upon entering, you encounter the kitchen, and then have the option to go either up or down a staircase to reach the private living spaces, bedrooms, and bathrooms.



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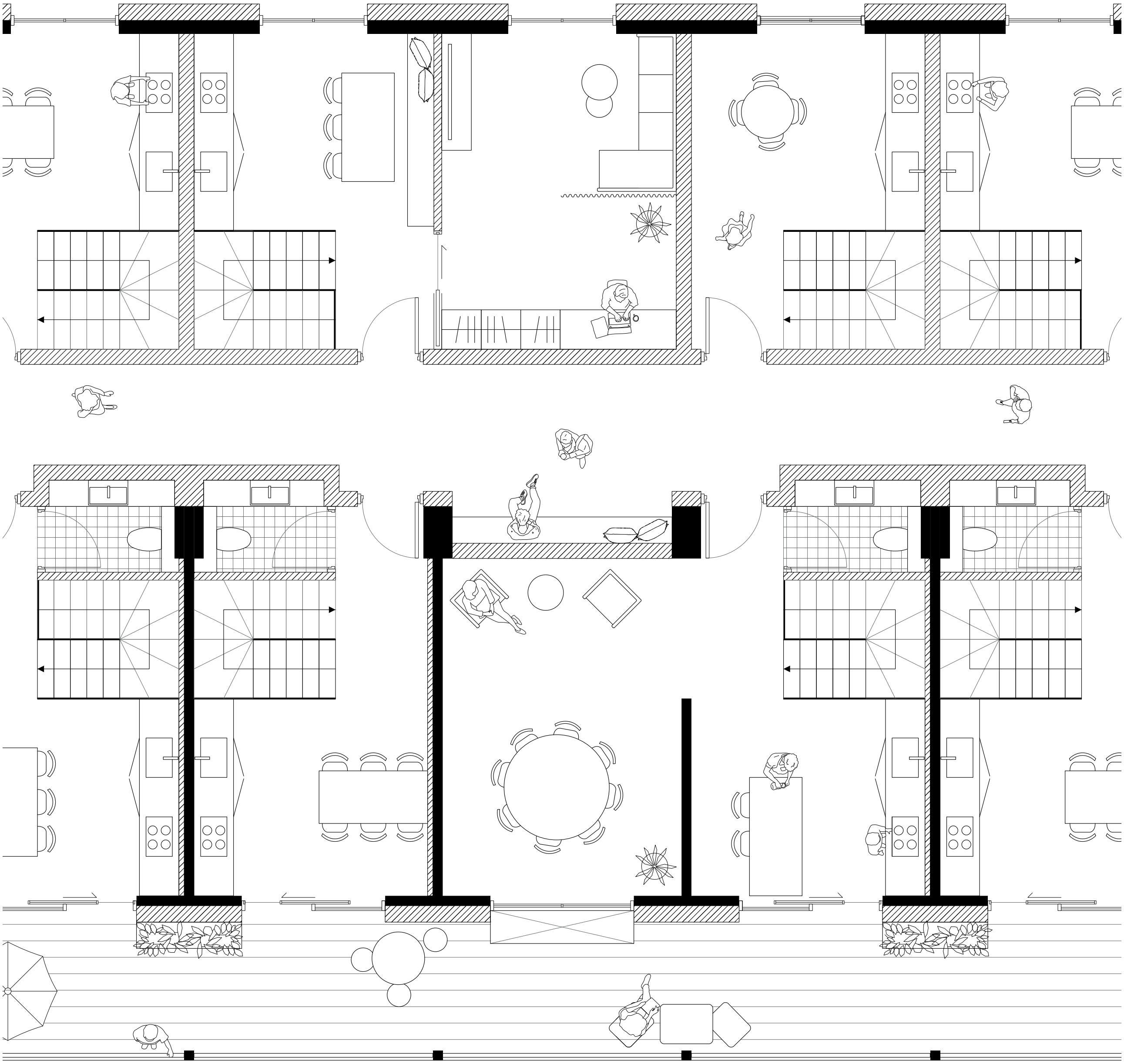

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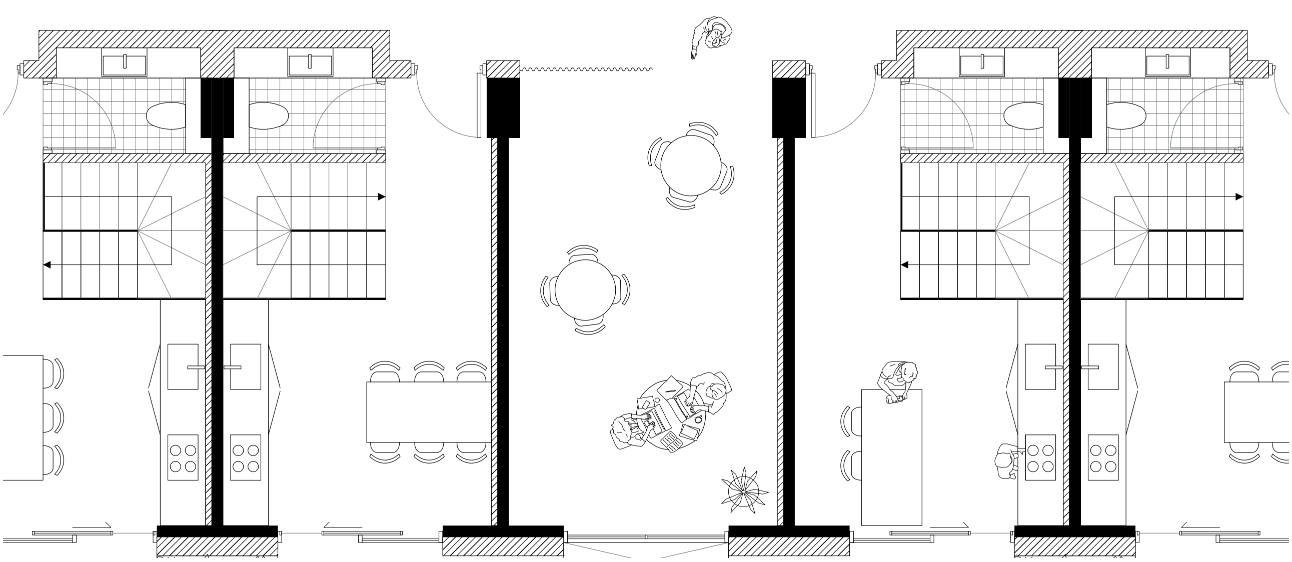

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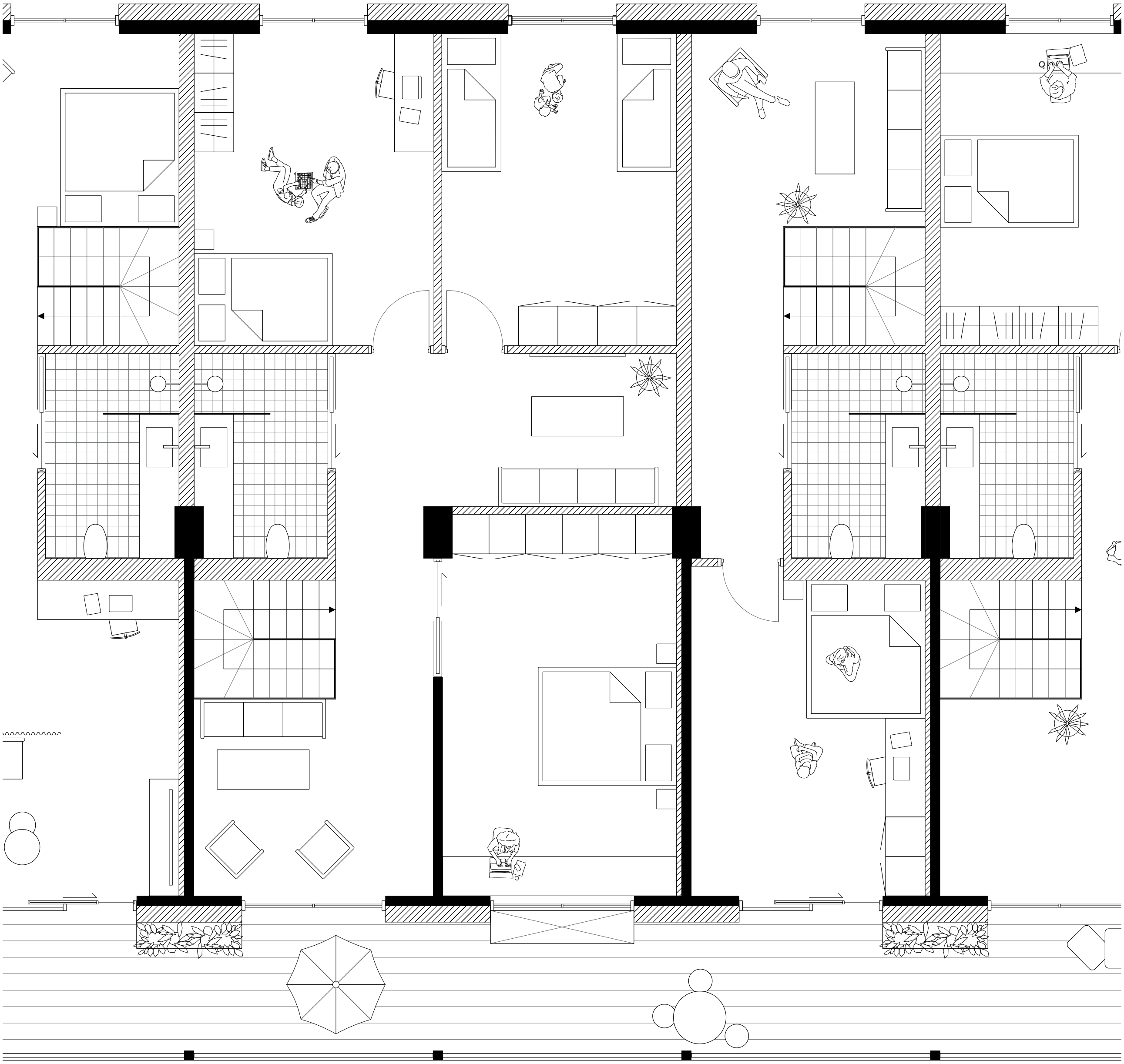


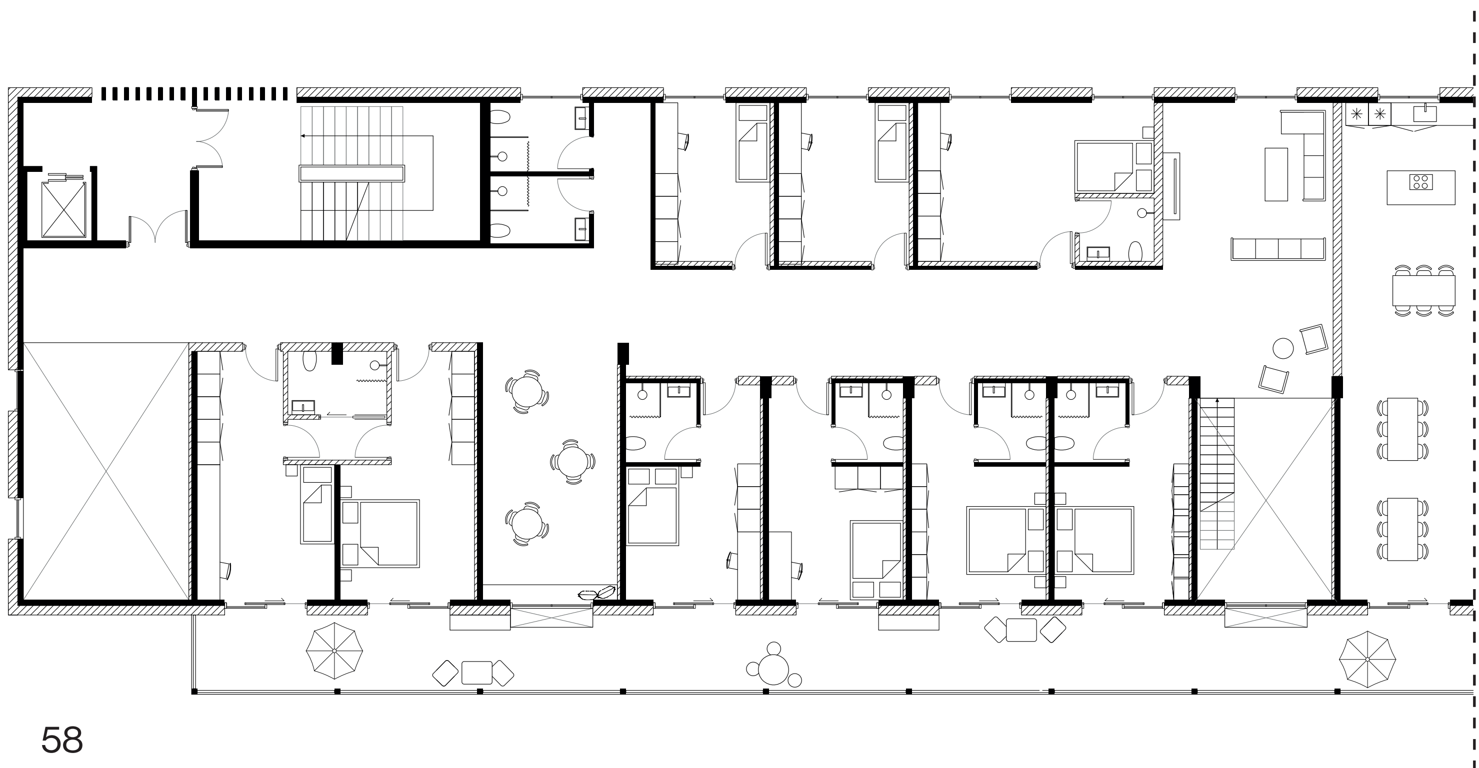
54. Housing units, entrance level 1:100

55. Housing units, alternative entrance level with shared spaces 1:100

56. Housing units, private level 1:100

Varying degree of collectivism

57



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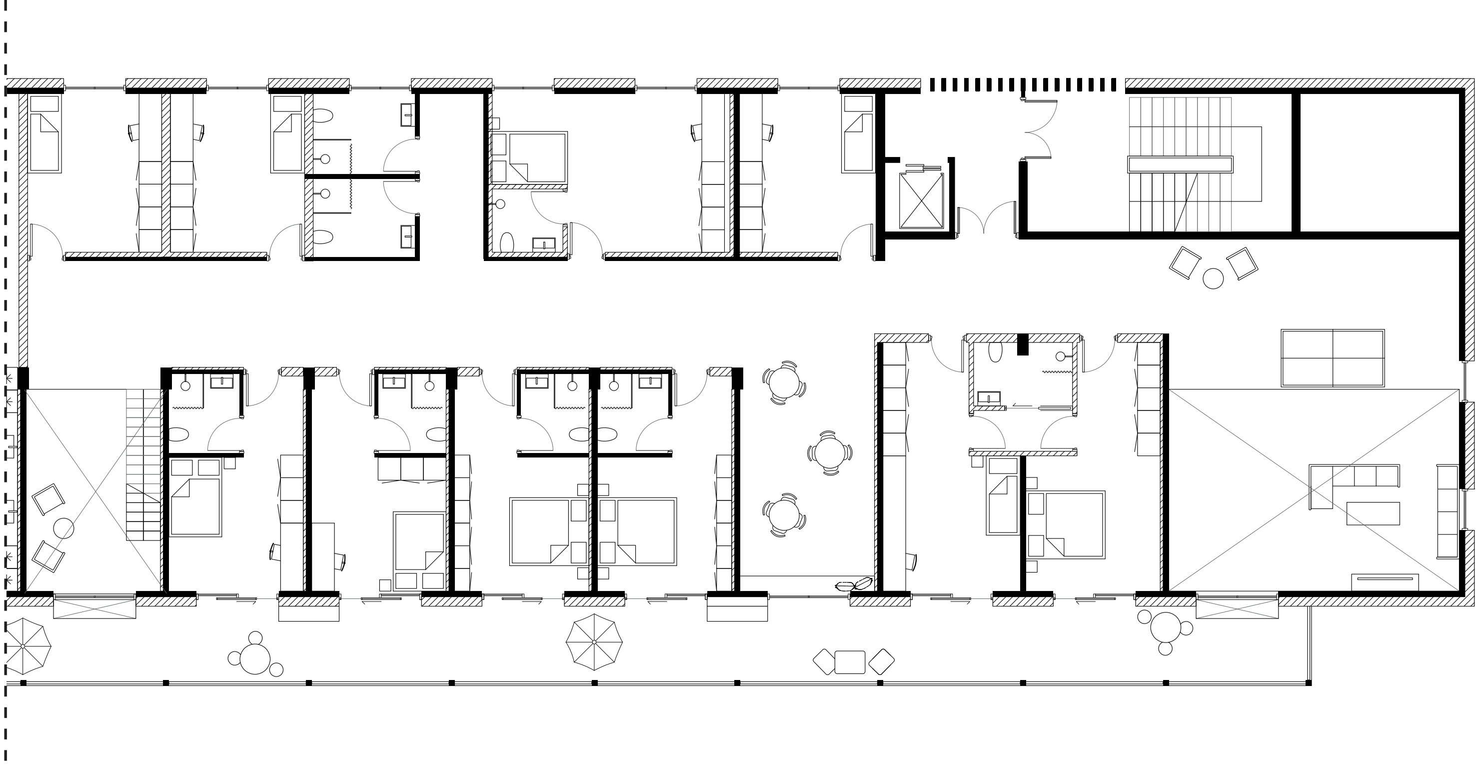
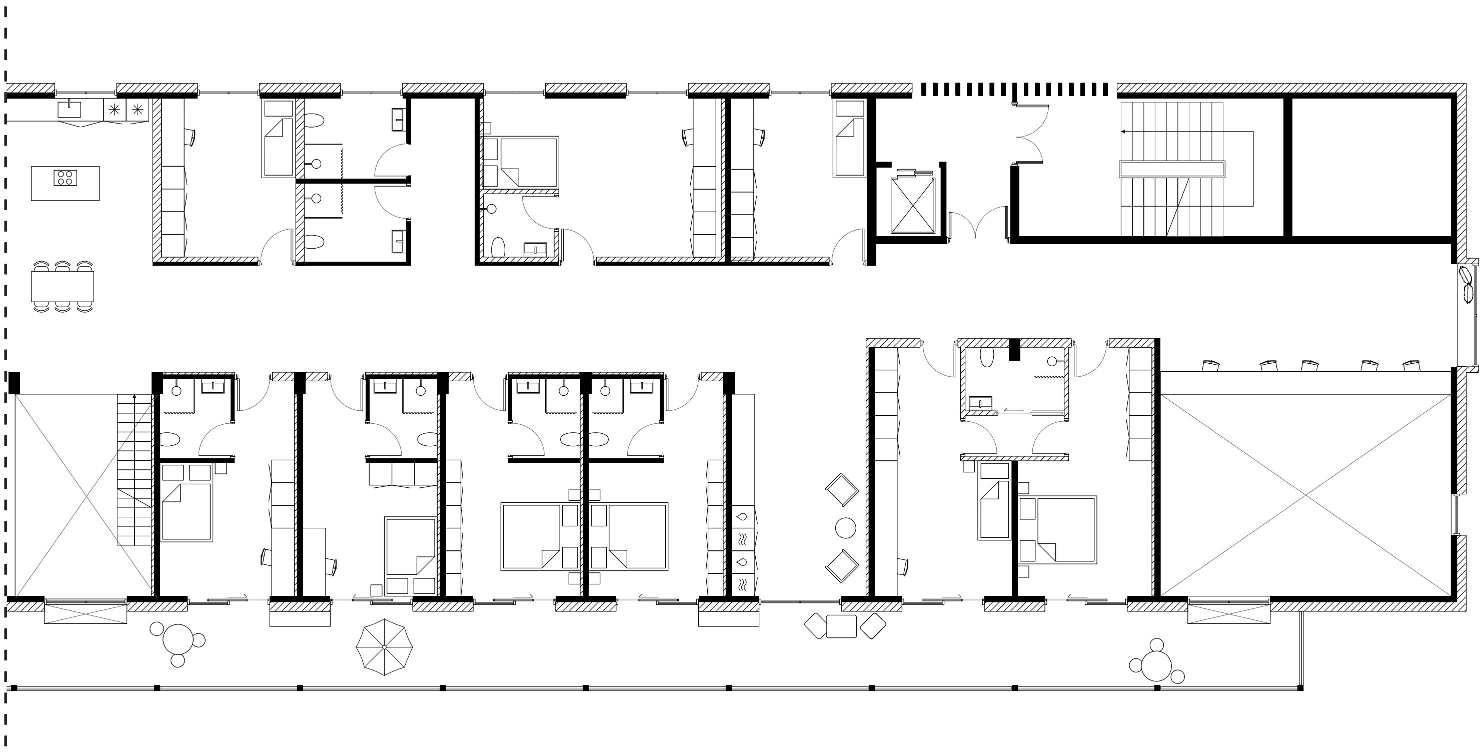




Co-habitation

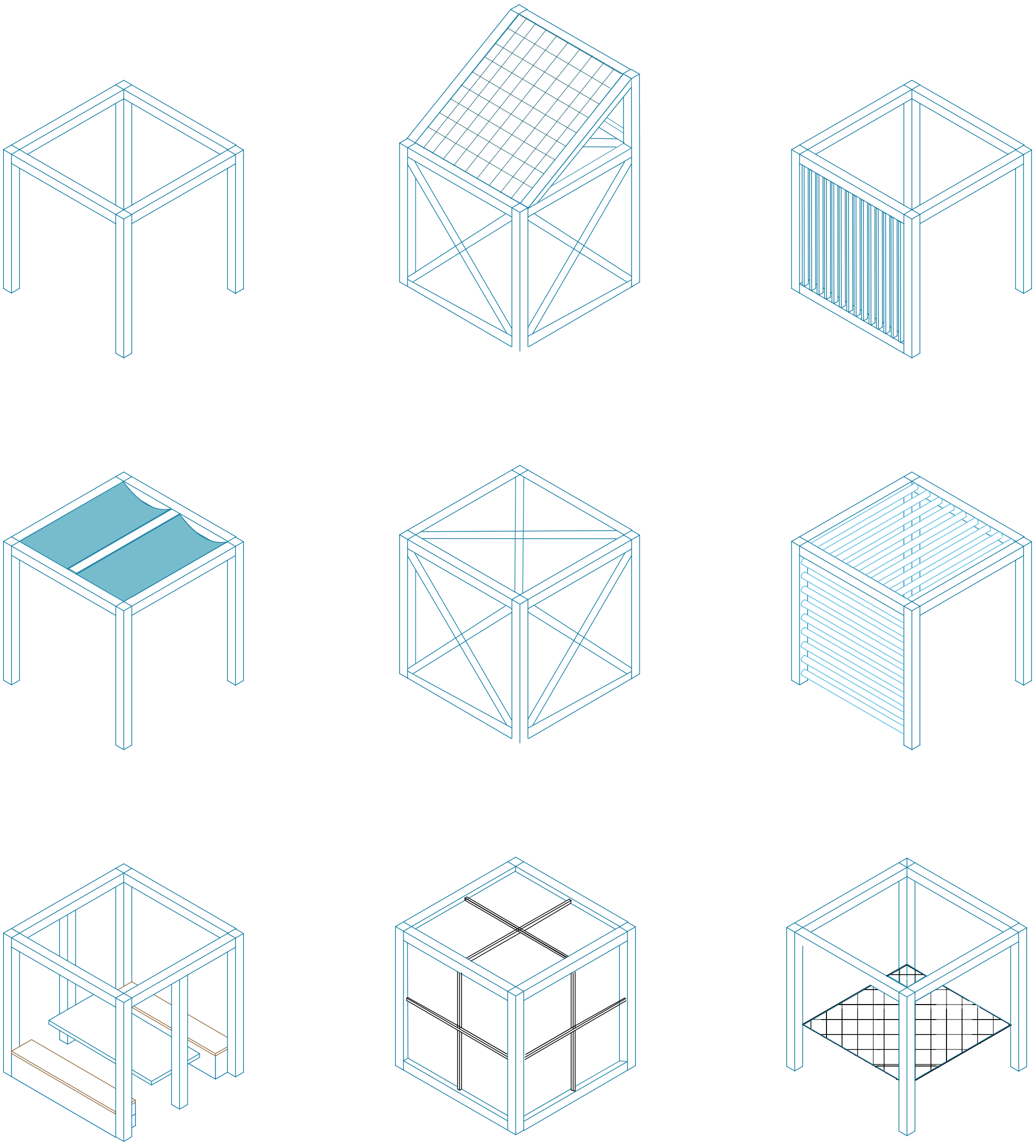
On the 11th and 12th floors, there are two collective houses, each of 19 rooms, some of which share bathroom facilities. By incorporating bedrooms of different sizes, the user group becomes more diverse, accommodating families of various constellations. The layout is designed in two stories, with one level housing a kitchen and the other featuring a living area, connected by a secondary staircase. The 10th floor is designed as an accessible collective house, although not presented in this thesis.

57. 11th floor P-building 1:200

58. 12th floor P-building 1:200

Small scale

60



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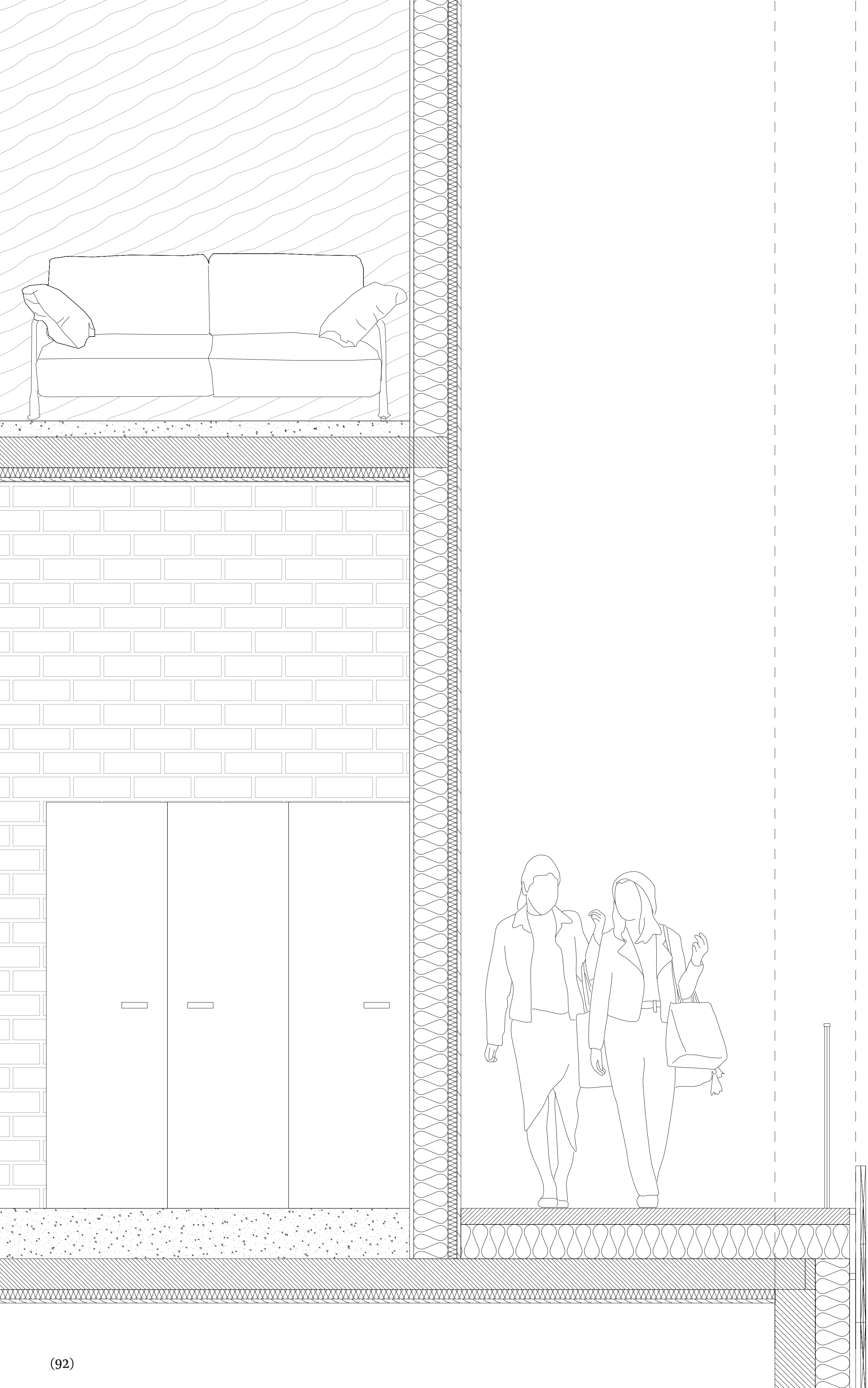
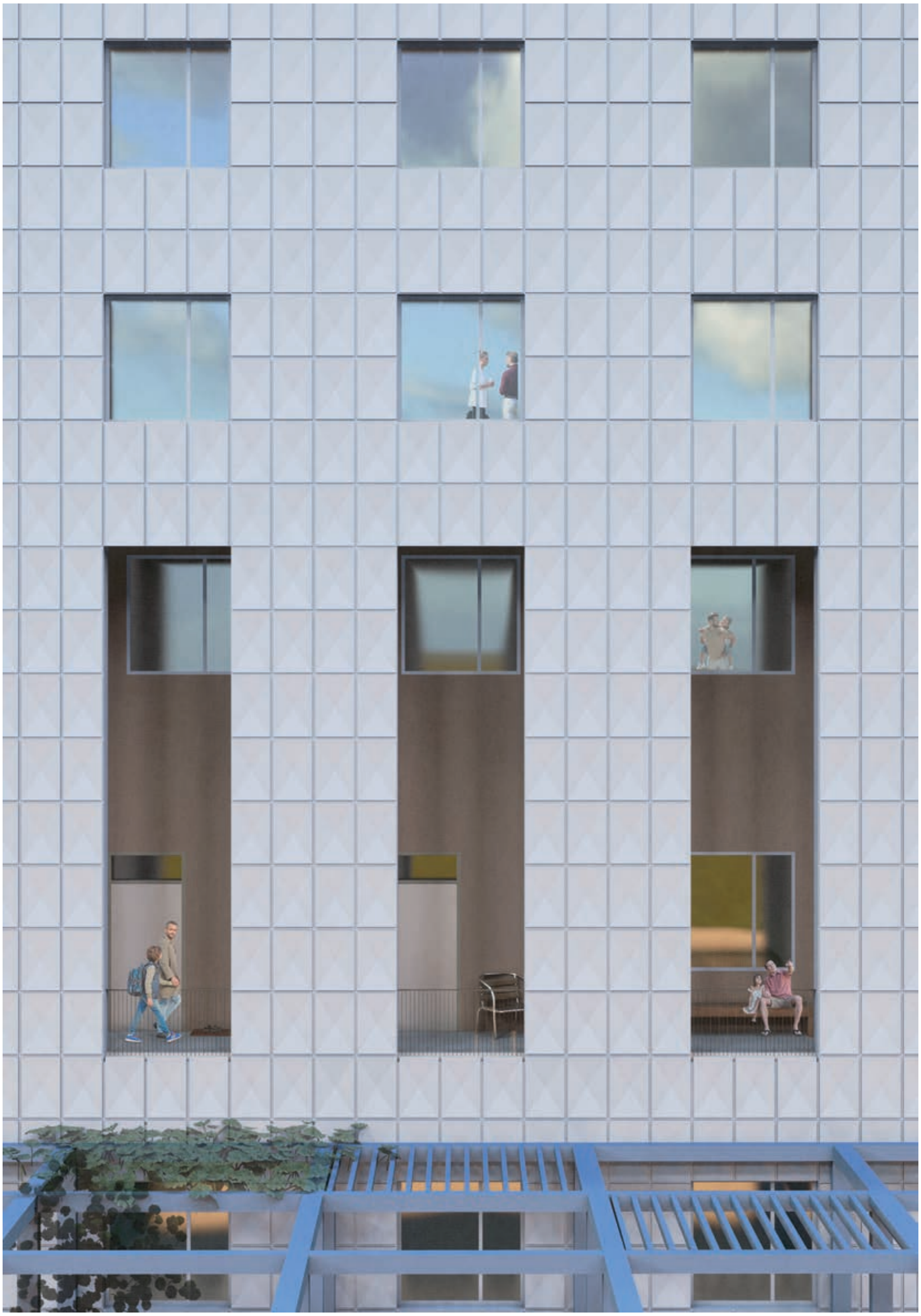
Rooftop

The rooftop of the P buildings is designed as an extension of the canteen on the 13th floor, providing outdoor cooking facilities and seating arrangements. Given that the housing typology lacks a traditional garden, the rooftop serves as a space for gardening activities. This is achieved through a modular system of cubes that can be arranged according to needs. The cubes are perforated to different extents, offering protection from wind and rain.

59. Diagram, modular cubes

60. The rooftop





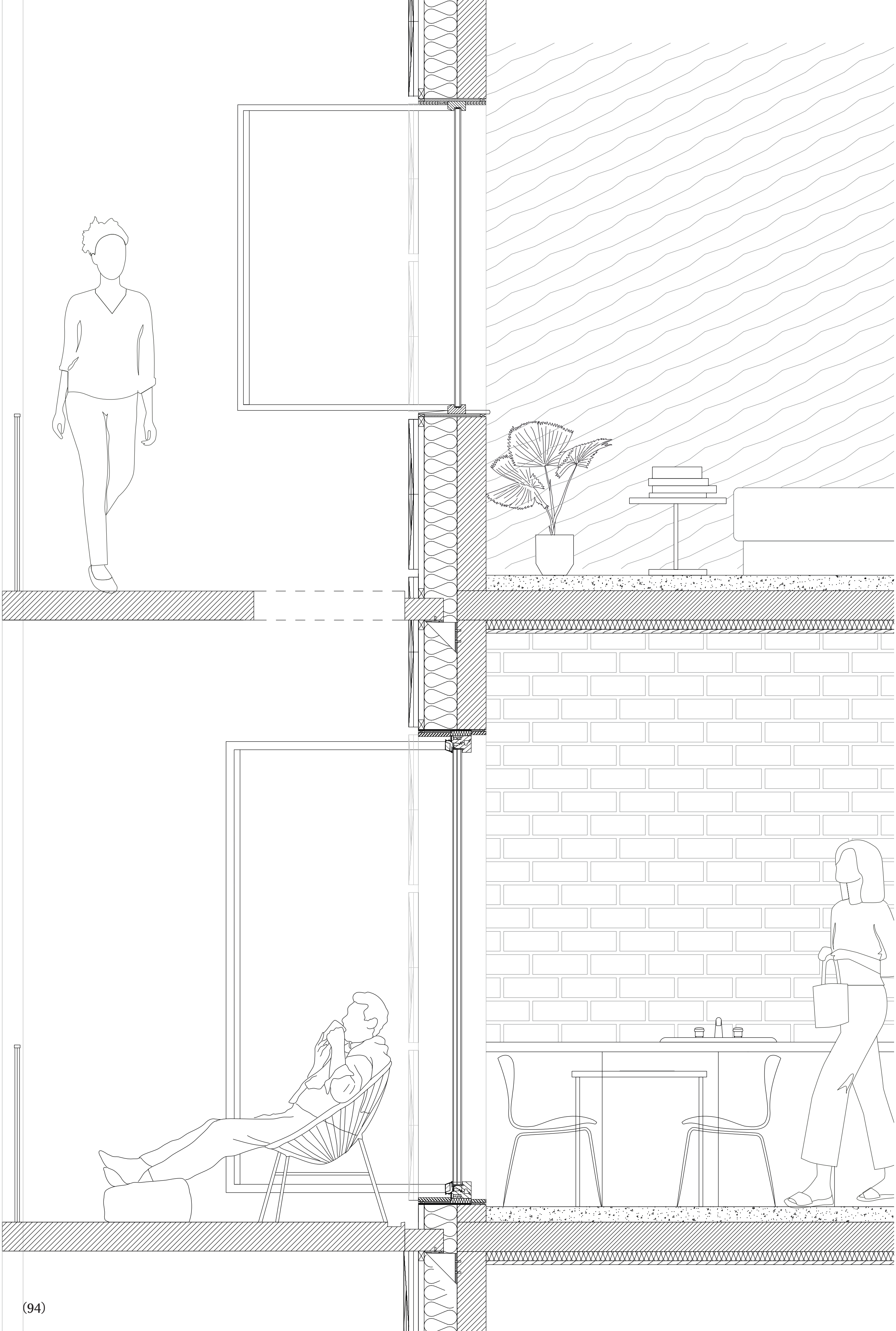
62

Balcony access

61. Detail section 1:25

62. North elevation, zoom

The north-facing balcony access acts as a buffer towards the B-building. It is open on the 1st floor, and can be accessed from the ground floor.



64

Balcony structure

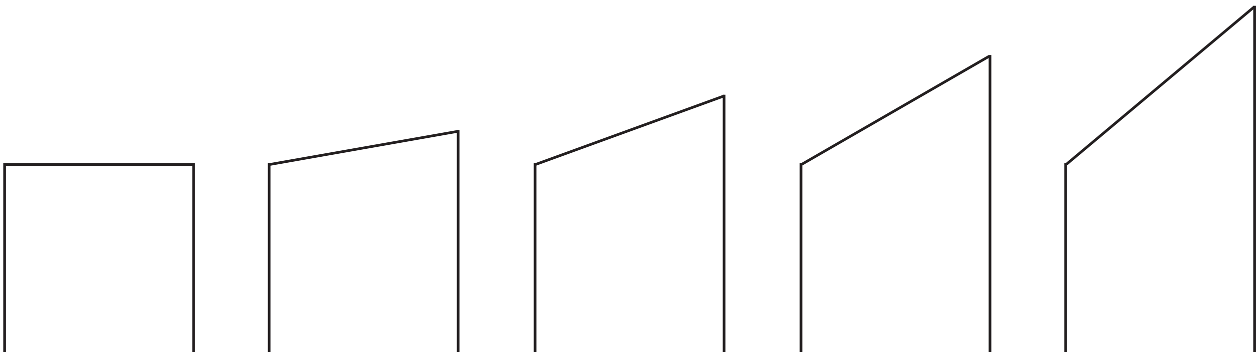
63. Detail section 1:25

64. South elevation, zoom

Towards the south, a structure of common balconies offers each housing unit access to outside while at the same time providing passive shading.

Chapter 06: **Sketching**

Big scale



Acts of interventions

Different interventions are performed on physical models, roughly divided into the act of subtracting from- or adding to the existing structure. The study seeks to examine interventions of radical character and evaluate their aesthetic qualities and energy optimisation potentials.

Subtraction

Two overall approaches emerged as a result of various subtractions from the existing structure: puncturing through the entire building mass or removing sections of the facade. Puncturing through the building at ground level creates connections that benefit the surrounding environment. On higher levels, creating connections allows for the establishment of smaller communities between different floors, where terraces and gardens can be integrated. By subtracting sections of the facade, it is possible to reveal different layers of the building envelope, thus creating a contrast between the existing and new constructions.

Addition

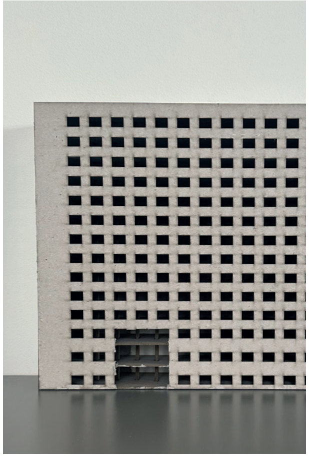
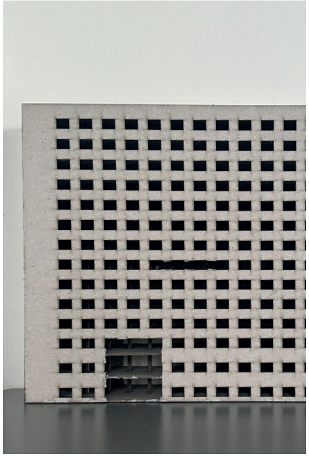
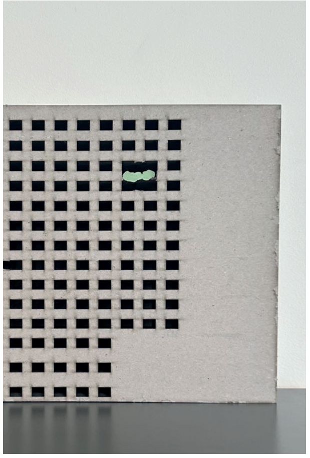
Similarly, the addition of elements to the building was categorised into two approaches: adding to the facade or adding to the roof. Adding to the building facade involves creating a new circulation system or implementing balcony solutions, which at the same time provides shade. Incorporating new elements on the roof can generate outdoor communal spaces or provide surfaces for renewable energy sources. If photovoltaics are to be integrated, it is important to consider the shape of the added structure accordingly. A study upon different degrees of roof angle in relation to radiation is completed.

Concludingly, a perforation on ground level is performed to break the boundary between the square and the green area. A structure of balconies is added to the south facade, while the expression is preserved on the northern facade. New structures on the roof generate common areas and surfaces for photovoltaics and will likewise figure on the ground floor.

65. Subtract from facade, model 1:200

66. Add on facade, model 1:200

67. Add on roof, model 1:200

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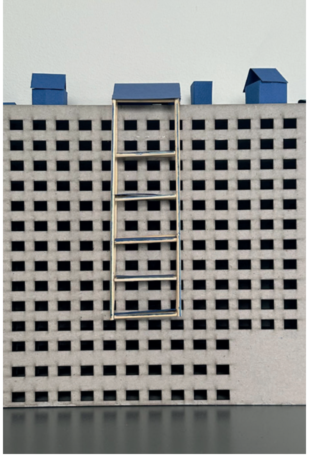
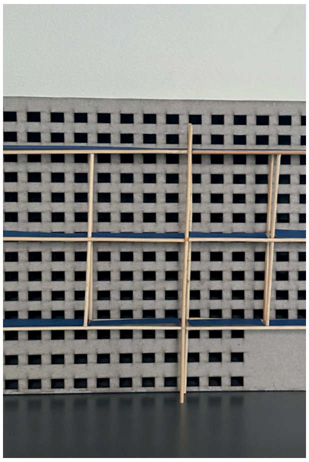
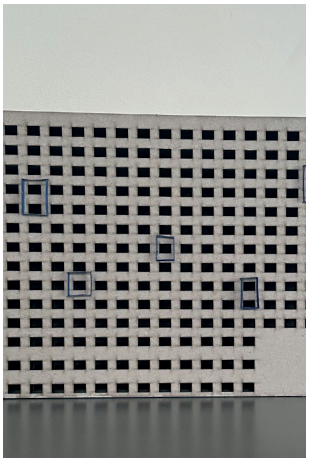

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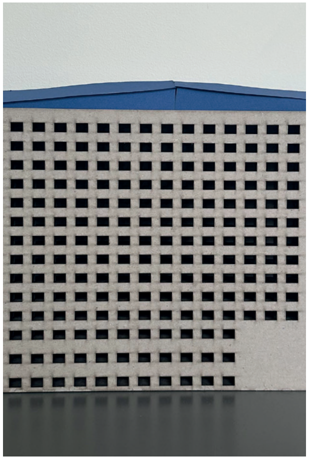
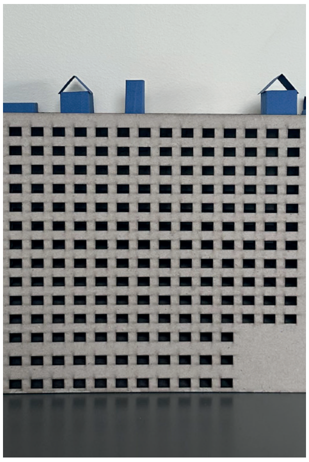
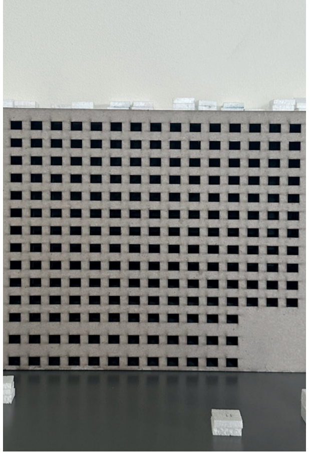

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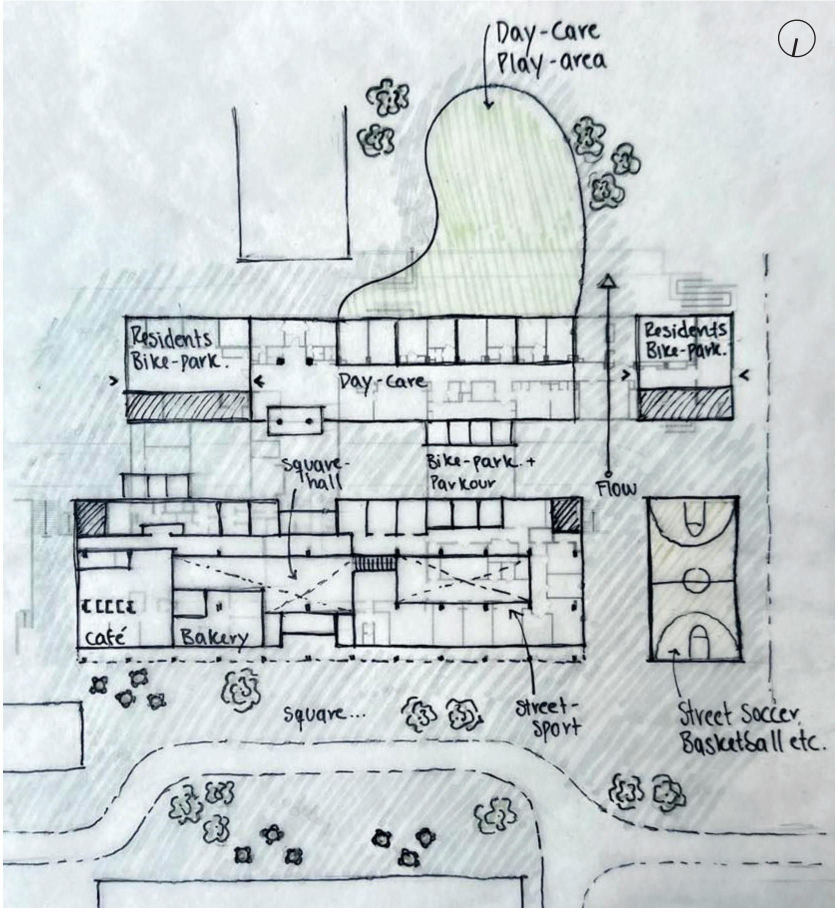

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69

Public spaces

The arrangement of public functions is organised in relation to the existing surrounding areas, taking into account a shadow study to guide the program. Due to the northern orientation of the square and the shading caused by building P, it is not ideal for extended stays. Instead, it is designed as a town square that can be utilised for various events and the pedestrian area in front of the take-away options is expanded to accommodate outdoor seating, providing a suitable space for people to enjoy their meals.

To the east of building B, an additional coffee shop and bakery that provides indoor seating are integrated. After-school facilities are positioned towards the west, benefitting from the evening sun during the summer. In building P, a daycare centre is established, which faces and occupies part of the green area during the daytime. The associated playground will be accessible to the public outside of opening hours, providing both children and adults with a space to play and relax in the evening sun.

68. Ground floor program

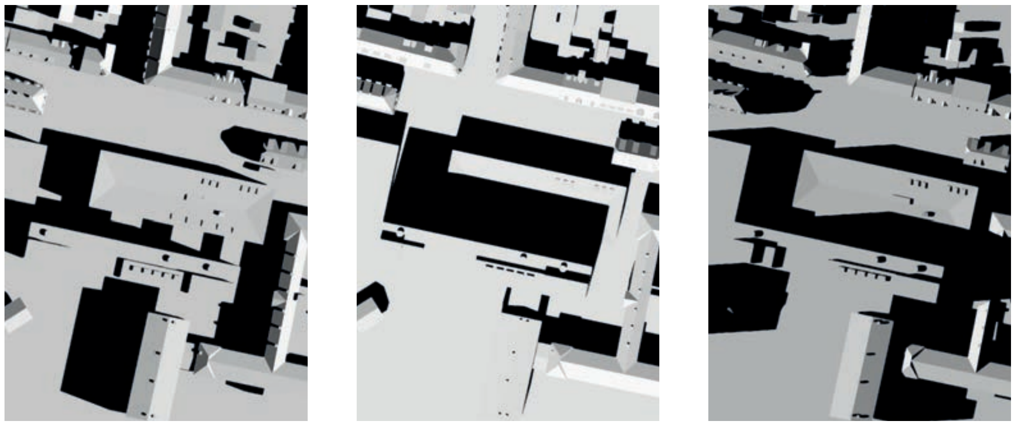
69. Mie enjoying a falafel in the sun on the pedestrian area 20.04.23, 15:41

70. Shadow conditions, summer solstice

71. Shadow conditions, equinox

72. Shadow conditions, winter solstice

08.00 **12.00** **16.00**



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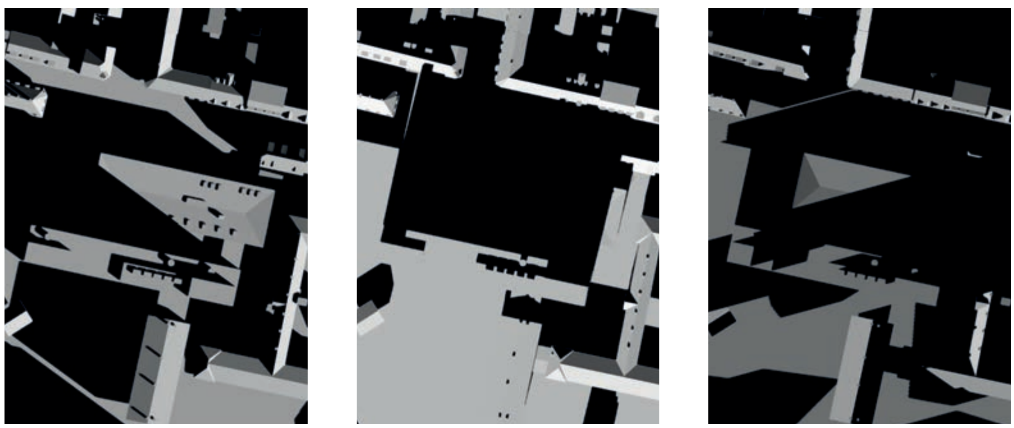

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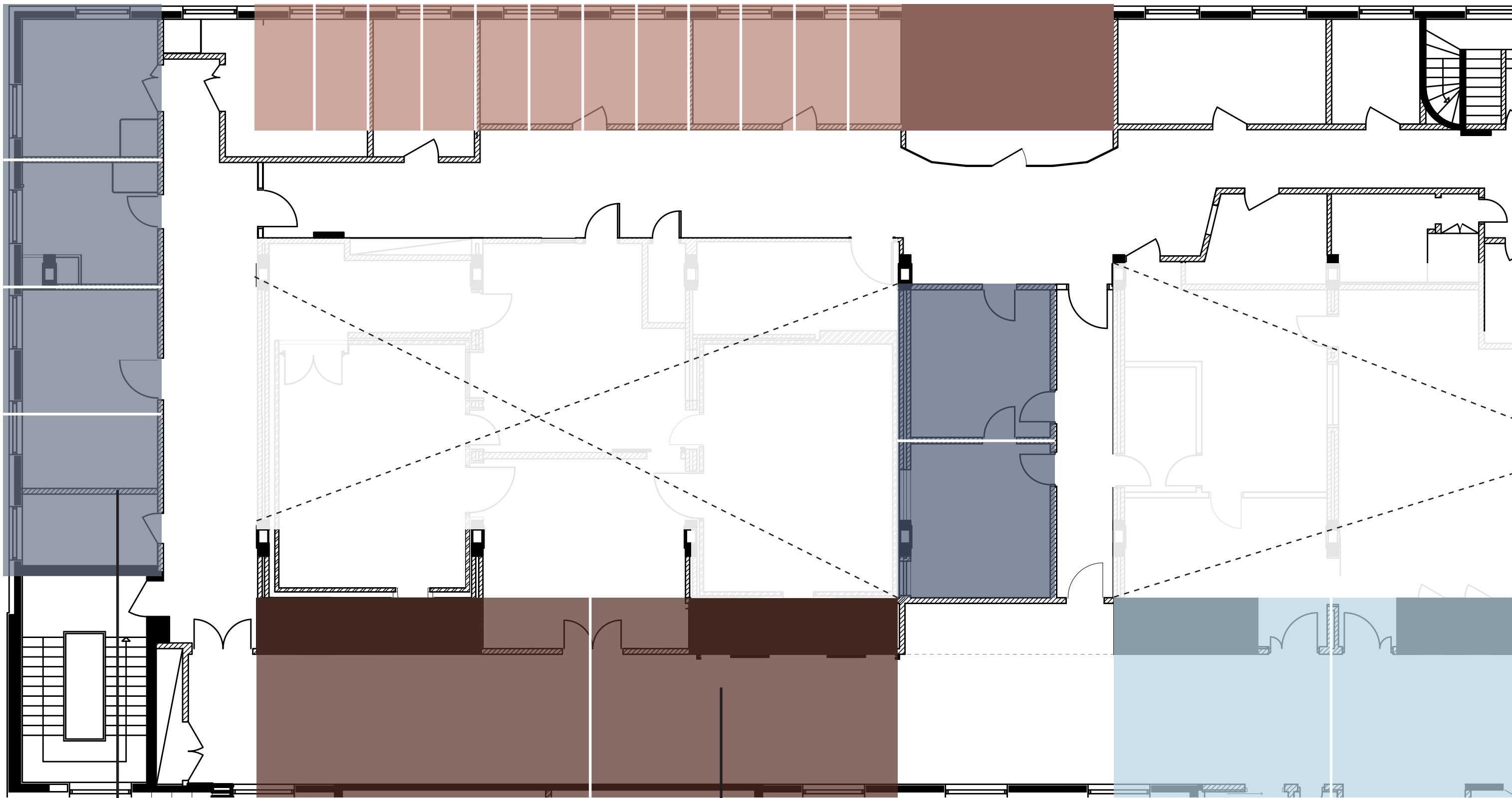

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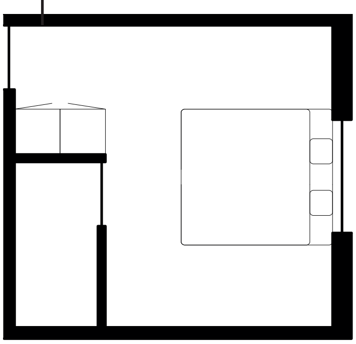

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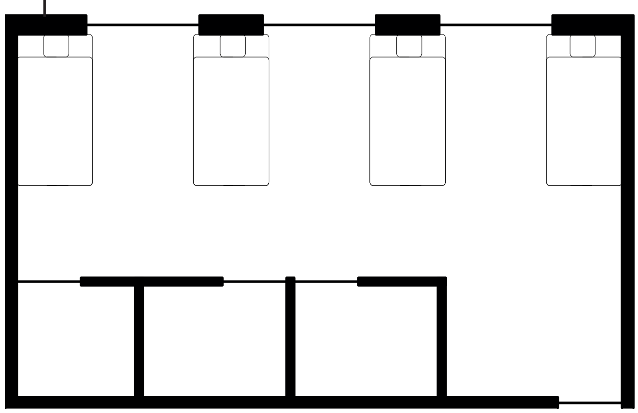
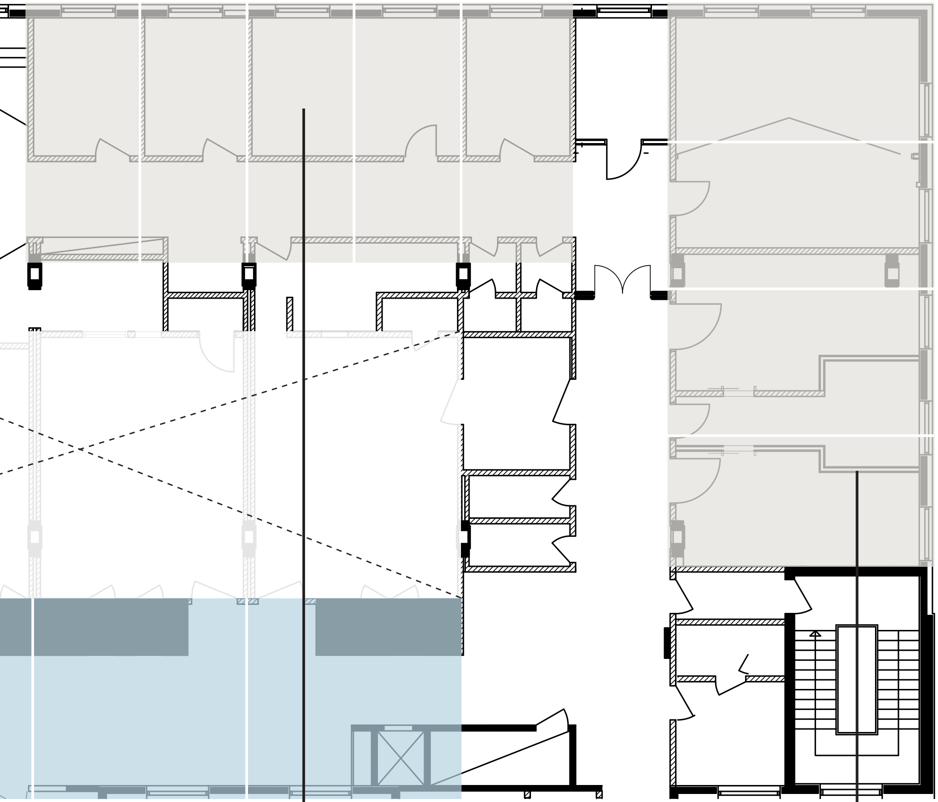


Hostel and student housing

Initially, the program requested a mix of housing facilities, including student housing in the P-building. However, as the design evolved conflicting interests between families and students became evident, while possible sharing potentials between students and hostel guests arose. This sparked the idea of programming a hostel, that in addition to short term stays houses students. Accommodations are designed for students who are in the city for a semester, as an intern or during a semester abroad, as well as students who live here during their entire education. Mixing these users and adding shared facilities fosters relations across guests and residents, advocating Aalborg as a cultural- and educational city beyond city- and country boundaries.

A program of student accommodations, hostel areas, and communal spaces is made for the 1st and 2nd floors of building B, but it has not been thoroughly designed.

77



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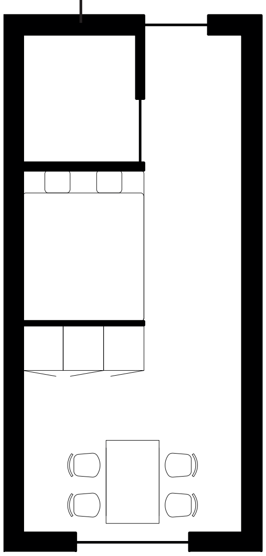

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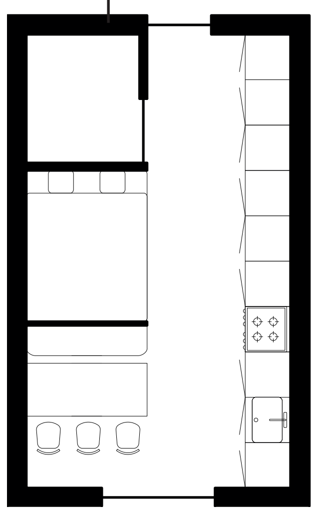


73. *Student apartment*

74. *Semester accommodation*

75. *Hostel dorm*

76. *Hostel private room*

77. *Program 1st floor B-building*

Unité d’Habitation

78

79

Case Study: Unité d’habitation
Architect: Le Corbusier
Site: Marseille, France
Year: 1952

Constructed in the aftermath of the second world war, Unite d’Habitation is a significant project designed during a period of high demand for housing. The design emphasises communal living, fostering a vertical community where habitants could live, shop, and work within the building. The large-scale apartment complex optimises the use of space by organising its layout as double-stacked corridors, enabling apartments to span from one side of the building to the other. This reduces the number of corridors to one on every third floor. The layout provides habitants with private spaces in their own apartments while offering public areas right outside their doors. The rooftop of the building features a garden, a gym, a pool area, and a kindergarten, effectively incorporating various facilities and services, transforming the building into a self-sustained “vertical city” (Krool, 2023).

The vertical city has been a reference throughout the project, as the shape of Unité d’Habitation is comparable to that of building P. The project draws on the distribution of public functions as well as composition of private units and is inspired by Le Corbusier’s visions.

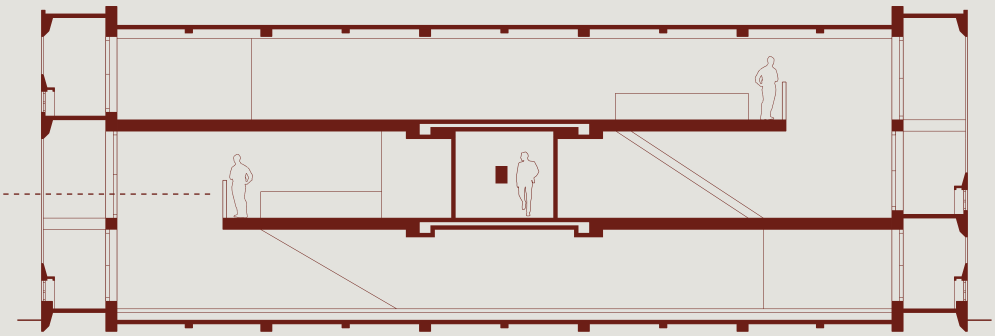
78. Unite d’habitation, Architect Le Corbusier, 1952, interior

79. Unite d’habitation, Architect Le Corbusier, 1952, exterior

80. Redrawn section 1:200

81. Redrawn plandrawings, 1:200

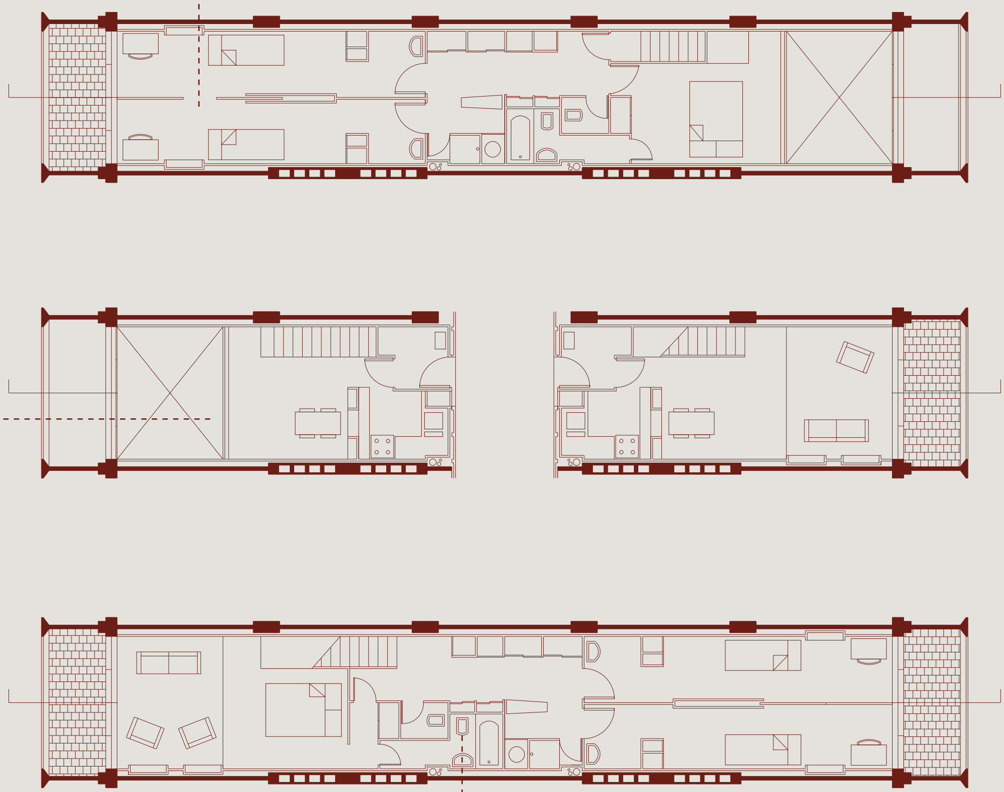
'Tetris principle' allowing all apartments access to both façades and reducing square meters used on circulation...



80

Smaller, flexible bedrooms

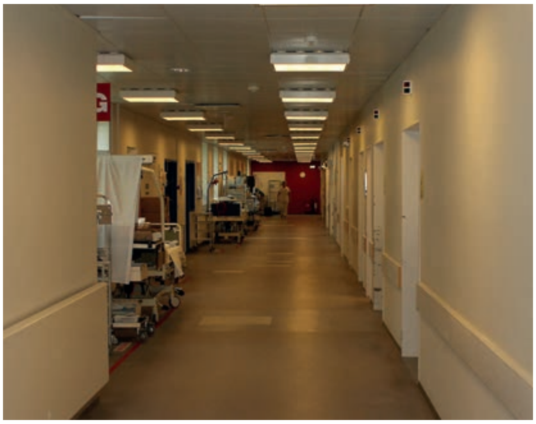
Double-high rooms improving daylight conditions and relations between different rooms in the apartments...



81

Separated toilet and bath

Medium scale



82

83

Circulation

As the building currently functions as a hospital, the existing circulation system is designed thereafter. A long distribution corridor separates the wards from serving functions and centres the circulation, which is accessible from staircases and elevators located at the gable ends. As the staircases are placed and designed as fire-escape routes according to present building regulations, it is considered beneficial to preserve these. The elevators on the other hand are outdated and can profitably be replaced and relocated in relation to the staircases. A study on different circulations is performed to investigate the potentials and challenges of the resulting apartment layouts. To ensure well lit apartments with thermal comfort, static calculations on daylight factor and maximum temperature have been performed

Internal circulation system

Preserving the internally located access road will result in apartments that are lit from one side. In addition, if not further iterated upon by integrating principles of units across storeys, the distribution creates an iniquity in apartments with only south facing spaces, risking thermal discomfort and apartments with only north facing spaces, without direct sunlight.

External circulation system

Integrating an external gallery allows apartments that are lit from both sides, however resulting in deep, narrow spaces with limited daylight. In addition, in compliance with fire regulations, and inclosed gallery limits the placement of enclosed spaces to the southern side, as each living room must be equipped with a minimum of one escape opening to the outdoors.

An alternative approach to the layout involves clustering a number of apartments around a separate circulation system. However, this option has not been extensively explored due to the additional cost associated with implementing multiple circulation systems. Instead, the focus has been directed towards an internal circulation system. This choice signifies a deeper examination of strategies to address challenges related to direct sunlight and thermal comfort.

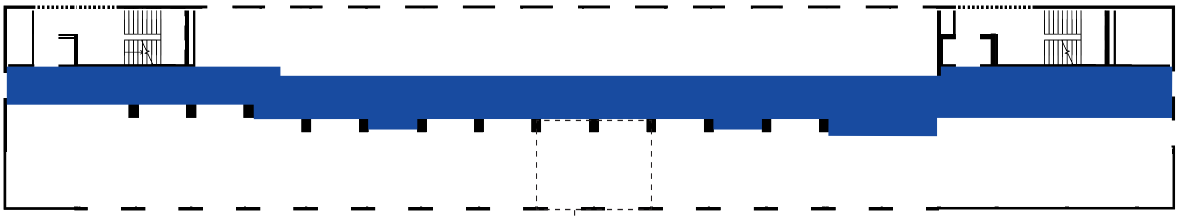
82. Existing hospital corridor

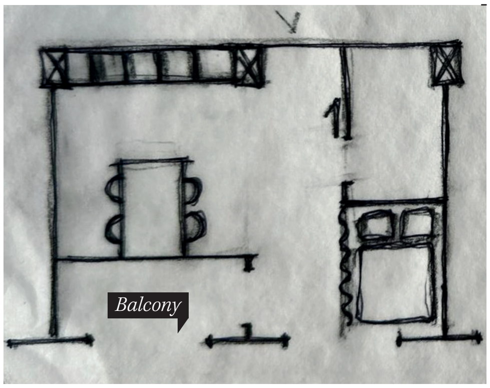
83. Jernstøberiet co-living from 1981, Internal circulation

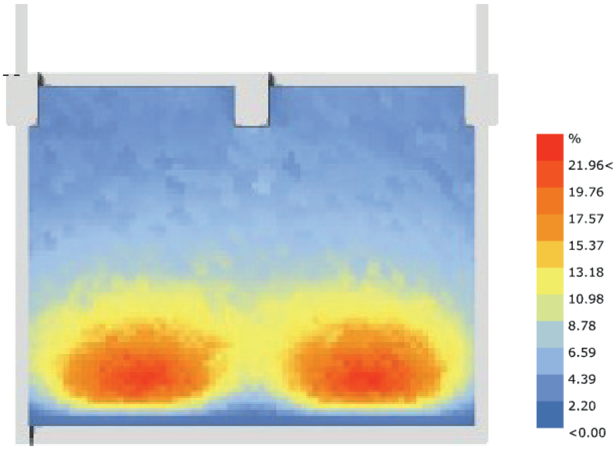
84. External circulation and apartment layout (early student apartment)

85. Internal circulation and apartment layout (early student apartment)

84

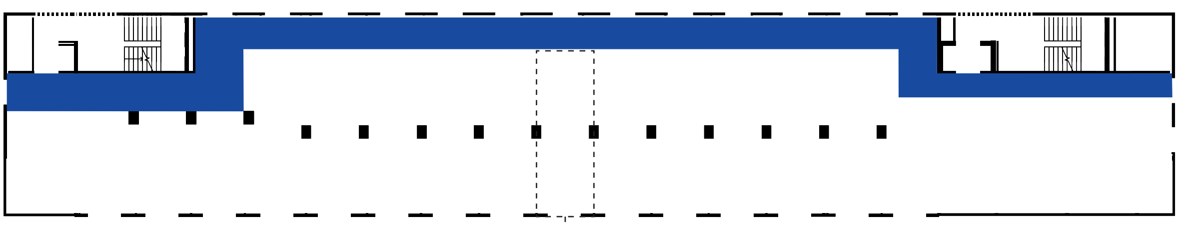


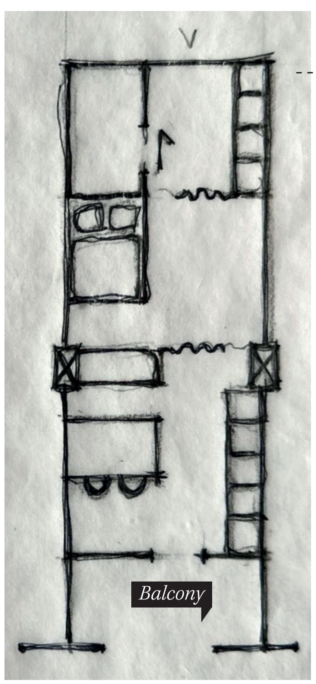


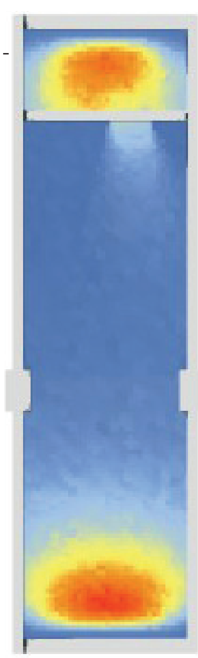


Daylight factor: 3,28 %
Max. temperature: 25,8°C

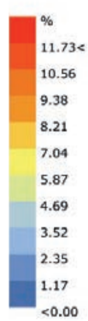
85

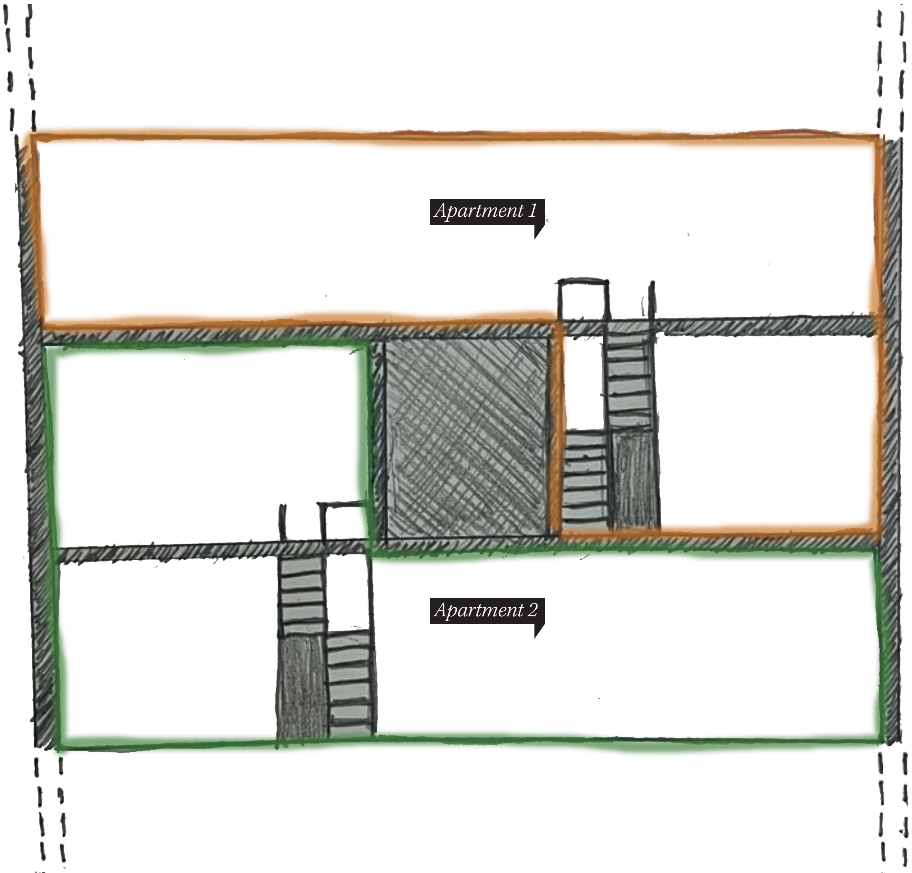






Daylight factor: 2,0 %
Max. temperature: 25,6°C





86

Housing units across storeys

The internal circulation system resulted in housing units either of smaller size or with an additional corridor within the unit. To overcome this, apartment layouts across storeys have been investigated in physical models. To minimise the circulation area and allow all apartments access to both facades, a principle inspired from Unité d'Habitation was investigated. This afforded an entrance level, in most iterations housing a smaller kitchen, and two levels with areas for restitution and hygiene.

The modular system present in the project building resulted in apartments of either one or two modules, with sizes of 70 or 140 square metres respectively. With the goal of providing apartments of varying sizes, a principle of overlapping apartments in the horizontal direction was likewise explored. Within three modules, this approach yielded four housing units with sizes ranging from 70 to 140 square metres, including options of 90 and 120 square metres.

A notion in relation to this layout is that the concept of housing units across multiple floors results in having a staircase within the unit, making them non-accessible. In order to address this concern and promote inclusivity, the implementation of accessible housing units on some floors is proposed.

86. Section drawing

87. Model 1:100, level +1

88. Model 1:100, entrance level

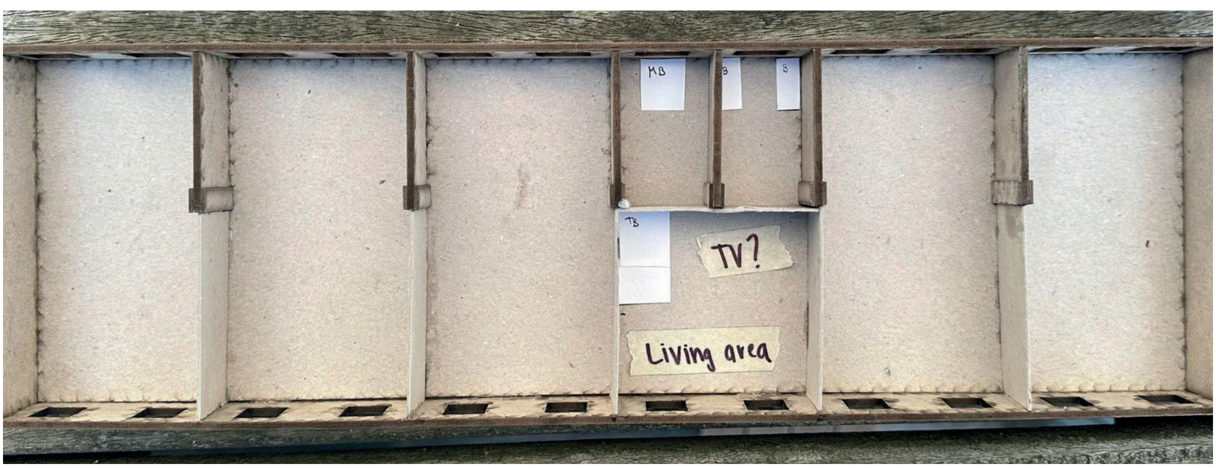
89. Model 1:100, level -1


Dining
Living
TB
TV?

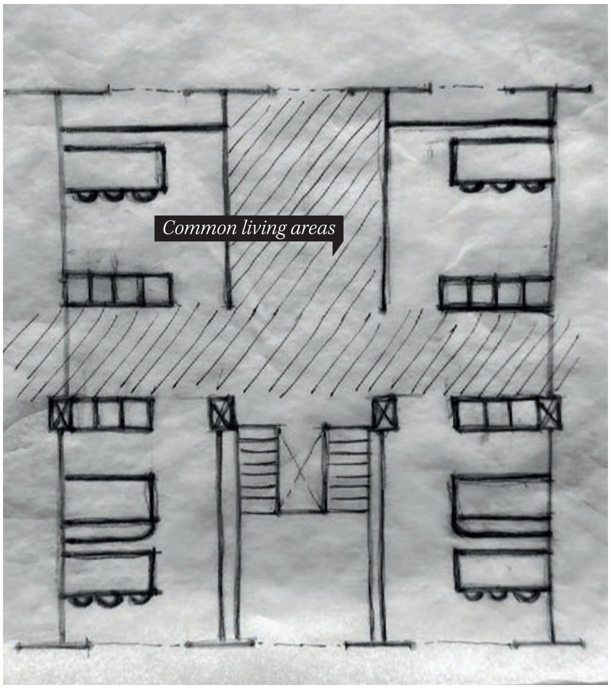
87


Dining area
Living area
Dining area
Living area

88


MB
TB
TV?
Living area

89



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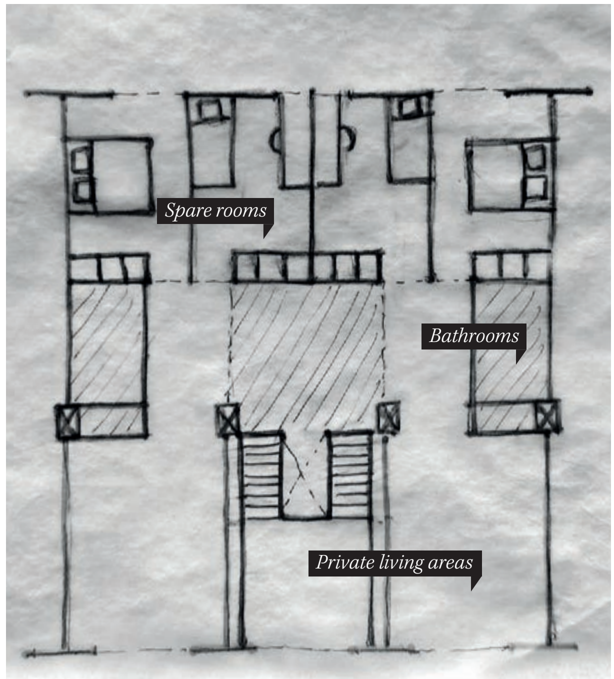


91

Collective housing

A study of different cohabitations was executed, illustrating that existing options were either a total dissolvement of the home or private housing units with additional common areas. In the attempt to define a new typology challenging existing cohabitation offers, layouts that opened some of the private functions to the community were proposed. The proposals included common areas on the circulation level and private areas either above or below the circulation.

The first iteration, illustrated above, introduced a secondary circulation system, shared between two apartments and allowing access to a deck, from which two or more spare rooms were accessible. This gave the habitants the opportunity to share the rooms between them as the need occurred. Separating the kitchen from the apartment further provoked an extended interaction between neighbours, however not allowing to deselect this interaction.

Another iteration where the circulation system and kitchen is part of the private housing unit provided the opportunity to withdraw from the community. In this layout, the apartment areas are minimised by opening the living areas, and the bathrooms are centrally placed above the circulation. During this study, it became evident that one housing typology, as flexible as it might be, would not be able to house the diverse habitant group of the project.

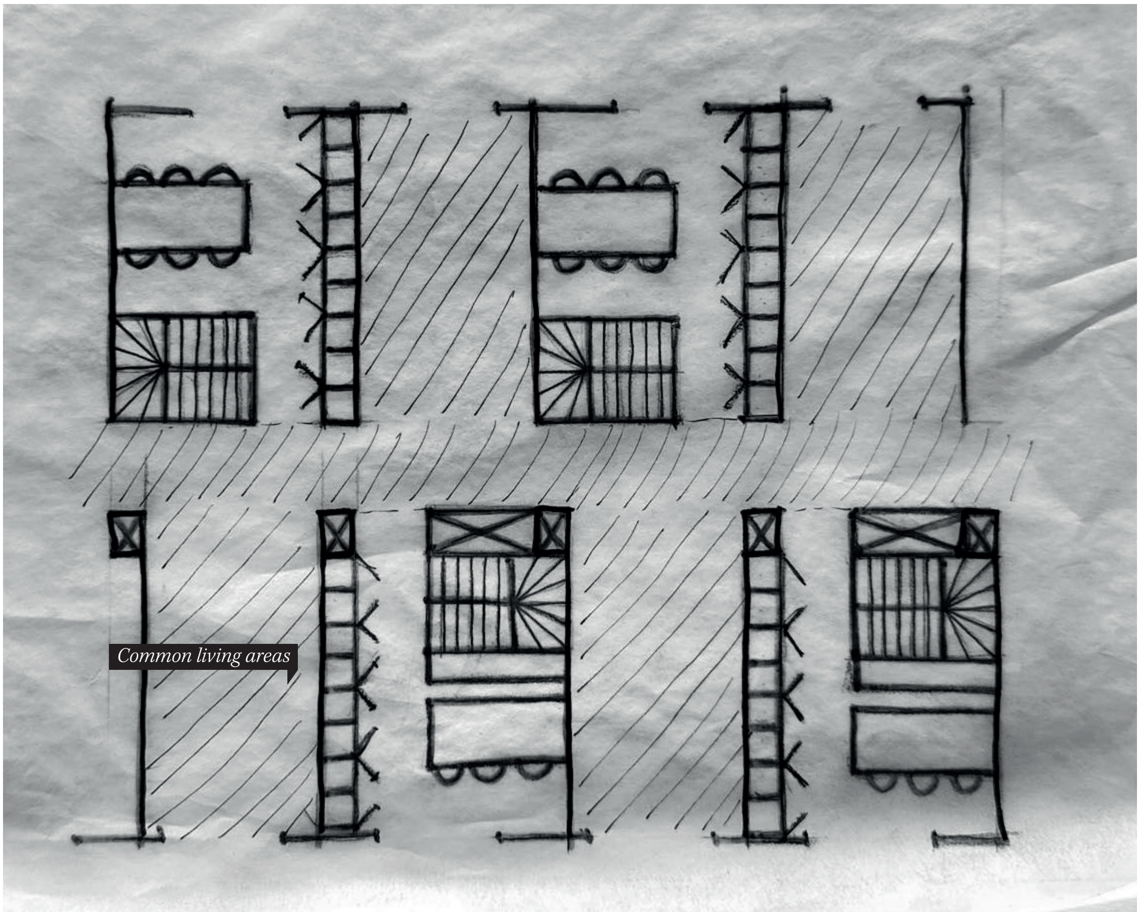
90. Collective housing with shared circulation, entrance level

91. Collective housing with shared circulation, private level

92. Collective housing with individual circulation, entrance level

93. Collective housing with individual circulation, private level

92



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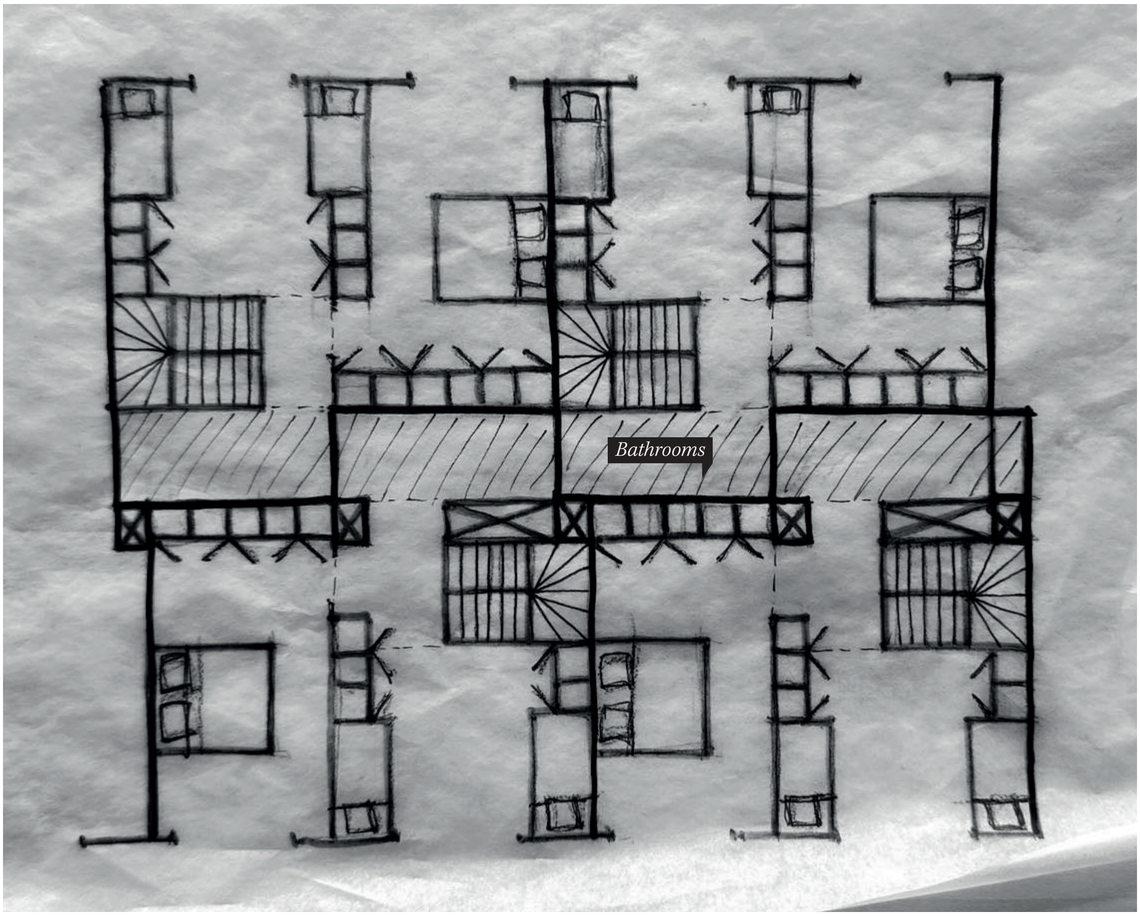
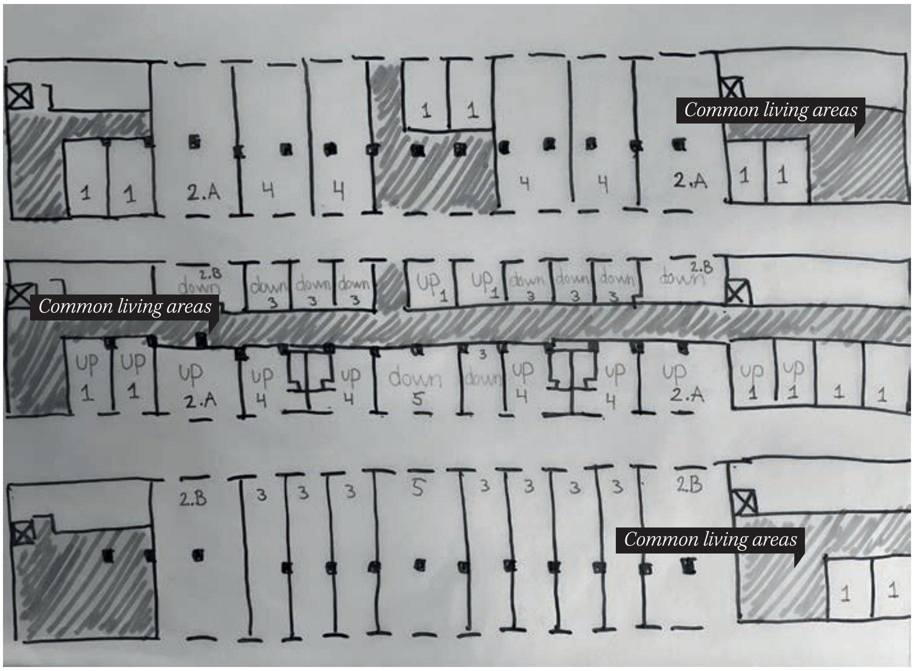




94

1: studio ~ 50 m²
2.a and 2.b: apartments ~120 m²
3: apartment ~70 m²
4: apartment. ~105 m²
5: apartment ~120 m²

Graduating collectivism

To embrace different family constellations, the concept of the project was altered. Rather than offering one type of dwellings, a concept of vertically graduating the degree of collectivism was enacted. The lower floors offer private apartments with access to larger communal areas such as a canteen and related rooftop terraces. Centrally placed housing units are smaller in size but with extended common areas such as workspaces and living areas while higher floors are co-living arrangements.

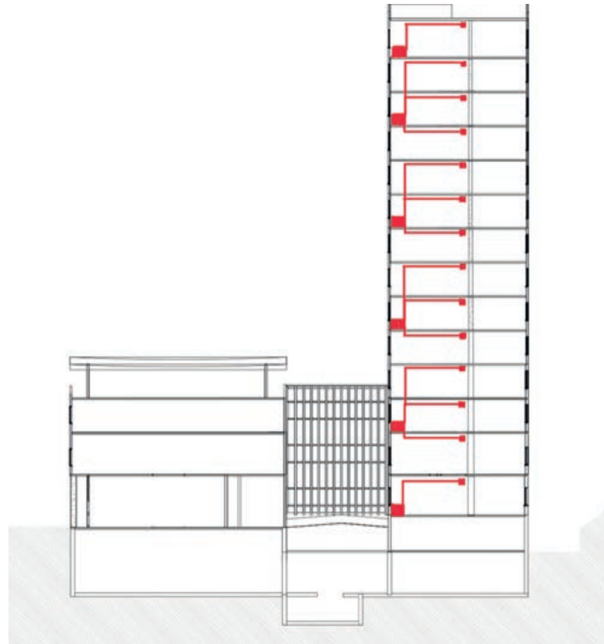
The overall division was informed by discoverings within the ventilation system. A calculation of the airflow rates showed that six air handling units were needed to deliver the total air volume (appendix. B). A placement of the systems in the basement, delivering the airflow vertically was tested, but rejected due to distribution challenges around the load bearing systems. Delivering the airflow level-wise claimed an area on every third level for technical installations, however making the building independent of the basements, if the basement parking is to be expanded.

» Finally, the building was layered as follows:
» A level housing a day care centre with its own central aggregate.
» Three levels of private apartments, one of them accessible, with a ventilation system on the middle floor.
» Three levels of private units with extended common areas, with a ventilation system on the middle floor.
» Three levels of partly private units with extended common areas, with a ventilation system on the middle floor.
» Three levels of co-living arrangements, one of them accessible, with a ventilation system on the middle floor.
» A level housing a common canteen with its own central aggregate.

94. Plan layout, 5th to 7th floor

95. Ventilation system located on every third floor

96. Ventilation system located in basement



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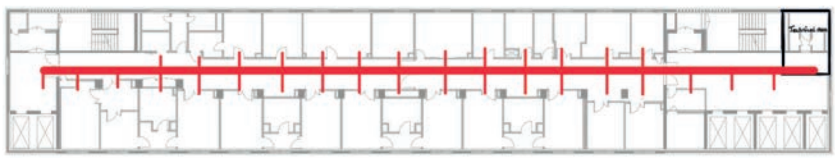

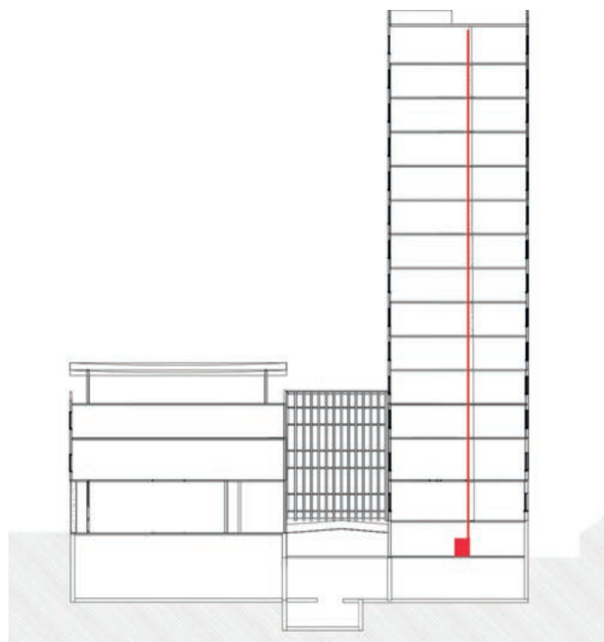

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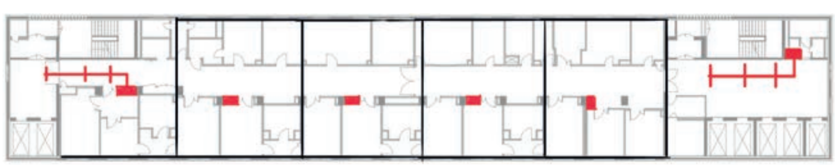


Lange Eng Cohousing

97

98

Case Study: Lange Eng
Architect: Dorte Mandrup
Site: Albertslund, Denmark
Year: 2008

Lange Eng is the largest modern co-housing community in Denmark. It constitutes 54 housing units and houses more than 200 residents. The complex is a square building circling a shared garden place where children can play safely, drawing parallels to a suburban street. However, in contrast to the suburban way of living, Lange Eng offers a number of shared facilities and activities. Dinner is served in a common house of 600 m2, where the habitants take turns cooking. Besides the kitchen and dining area, the common house offers places for play, relaxation and creativity, by means of which, the housing units have been reduced. The housing units vary in size from 69 to 128 m2, inducing diversity in family constellations (Lange Eng, n.d.).

The size and program of Lange Eng is comparable to that of the project, and has been used as a reference regarding the form and dimension of common areas. In addition, the uncompromising approach to coliving has been an inspiration. Even small in size, the apartments offer spatial experiences demonstrating that private areas do not have to suffer despite an extended collectivism.

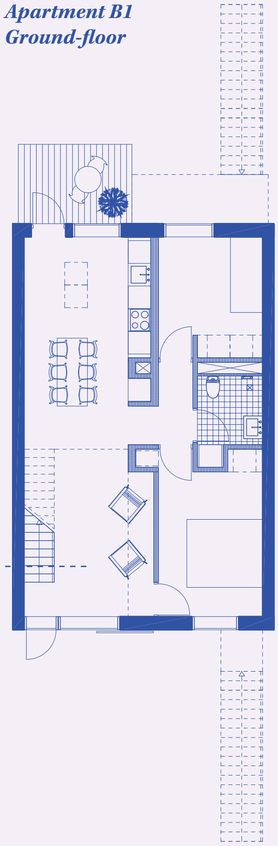
97. Lange Eng, Dorte Mandrup, 2008, exterior

98. Lange Eng, Dorte Mandrup, 2008, interior

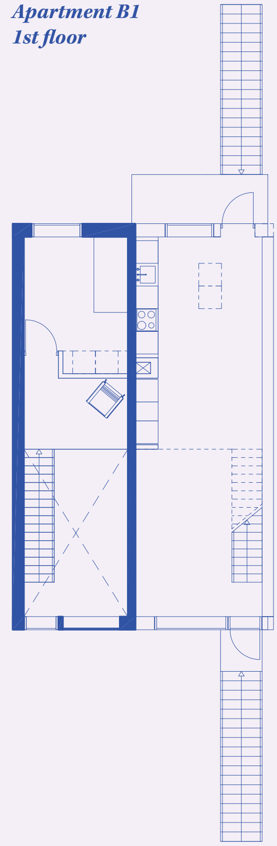
99. Redrawn plan drawing, Apartment B1

100.Redrawn plan drawing, Apartment B2

Apartment B1
Ground-floor



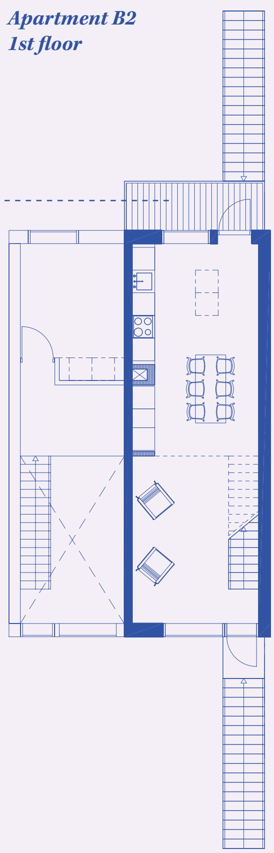
Apartment B1
1st floor



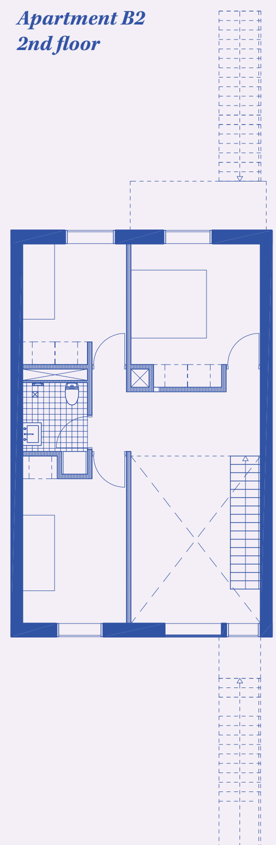
Double height rooms and windows from floor to ceiling contributes to well lit apartments...

99

Apartment B2
1st floor



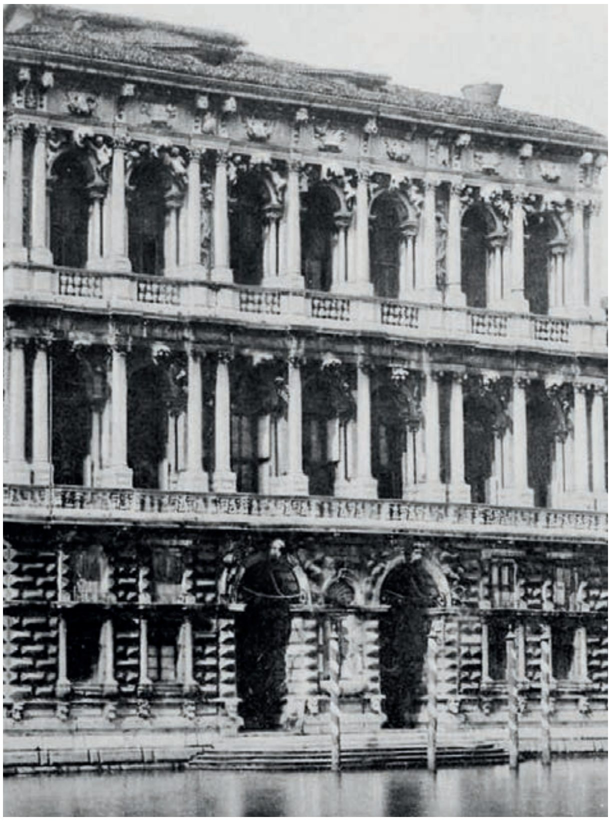
Apartment B2
2nd floor



Every housing unit has access to the shared garden space, and terraces along the façades...

100

Small scale



101

102

Facade composition

Attempting to articulate the stratification of the building in the facade composition, a reference to the renaissance house appeared. Ideas of varying the expression of different layers was iterated upon and carried a study on window alterations. The existing windows were replaced in 2007 and are therefore not necessary to replace from an energy optimisation perspective.

The design process was characterised by an inside and out approach, where different apartment layouts were to generate variations in the facade. As the facades are load bearing, perforations are limited to the window columns, allowing the windows to be extended only in the vertical direction. During the design process, a balcony solution was integrated, requiring an enlargement of some window sections to fit a door. In relation to areas without a balcony, an expansion of the window ledge can create a space that connects indoor living areas with the outdoor environment.

In addition to aestical qualities, different window solutions were tested in relation to daylight conditions and thermal comfort to detect potential problems. Concludingly, windows are preserved on the north facing facade while some of the south facing windows are replaced by a door. Window bays are incorporated on the gables in relation to common areas.

101.Reference, horisontal composition, Renaissance house

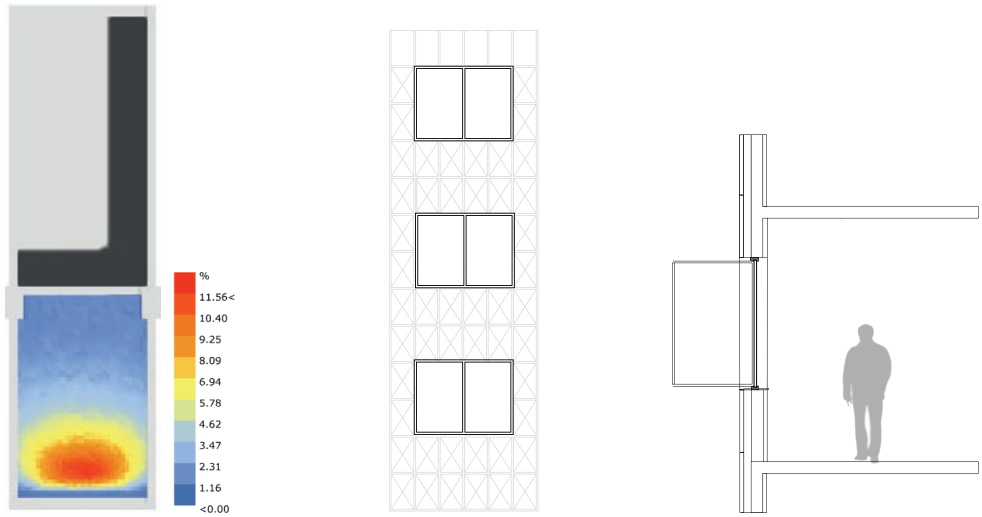
102.Reference, vertical composition, Aussenministerium

103.Existing window

104.Bay window

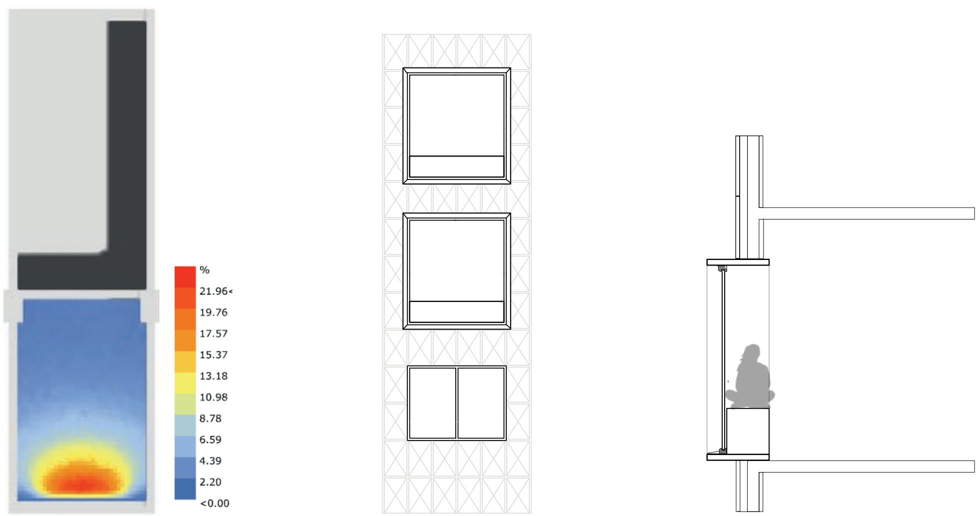
105.Balcony

Daylight factor: 3,36 %
Max. temperature: 27,3°C



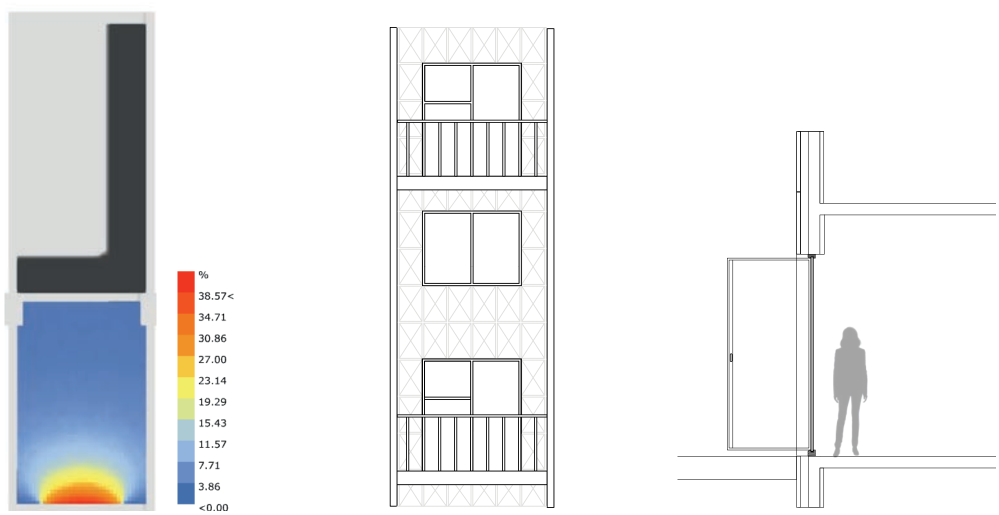
103

Daylight factor: 4,7 %
Max. temperature: 28,4°C



104

Daylight factor: 5,85 %
Max. temperature: 29,4°C



105

Systems

location. This showed that decentralised ventilation systems are scattered around the building, and the current airflow rates are therefore unpredictable. District heating is delivered through radiators with a two string system placed below the windows.

Ventilation

From the study, it was concluded that the ventilation system is outdated, calling for an integration of a new system with heat recovery, the placement of which have been touched upon in the big scale discoverings. On a small scale, the mechanical ventilation system can provide different aesthetics. Visible ventilation pipes carry an informal atmosphere that fits well with the raw materials preserved in the building, while the ceiling height can be preserved. In contrast, integrating a suspended ceiling reduces the room height, affording an intimate atmosphere. By integrating the ventilation pipes in furniture, this can be achieved without reducing the ceiling height.

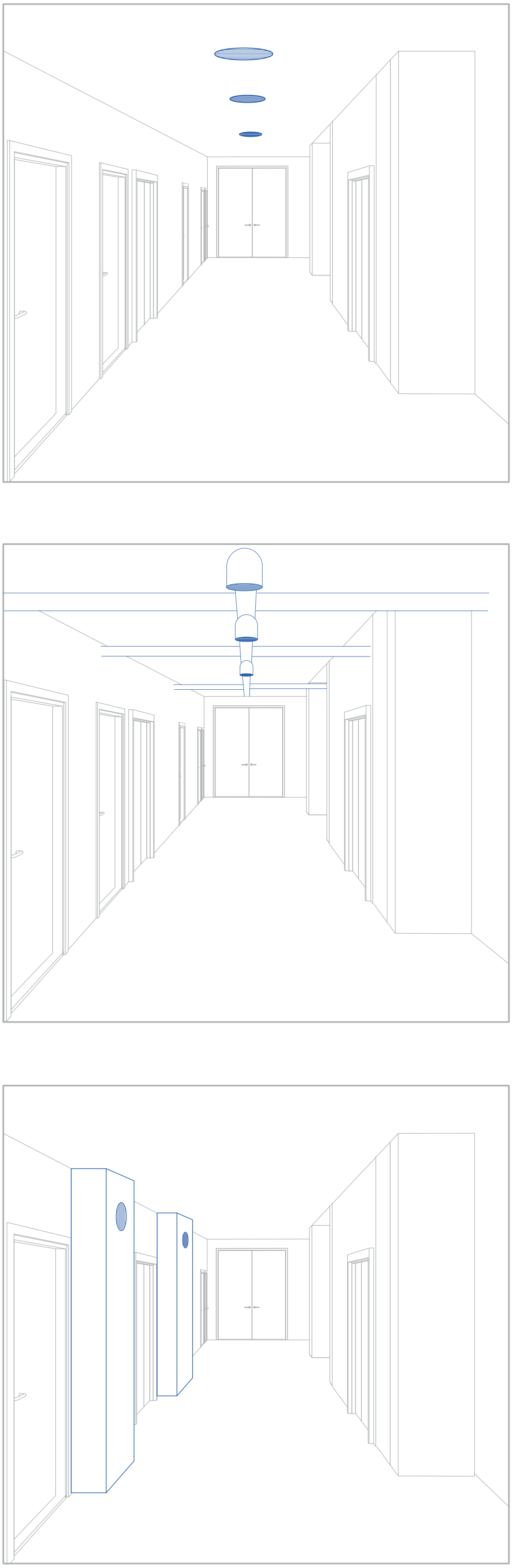
Heating

As the existing heating system meets current standards, principles of preserving the radiators have been investigated. Drawing on the implementation of colours as an architectural approach, the existing radiators could be, while concealing the radiators in a seating furniture affords a more refined space. However, as some windows are replaced with doors allowing access to the balcony, the radiators are removed and floor heating integrated in a concrete layer on top of the existing. Due to the shallow placement of pipes, the heating system is quickly adjusted to settings, and the incorporation of floor heating enables future modifications to the layout.

106.Ventilation principles

107.Heating principles

106



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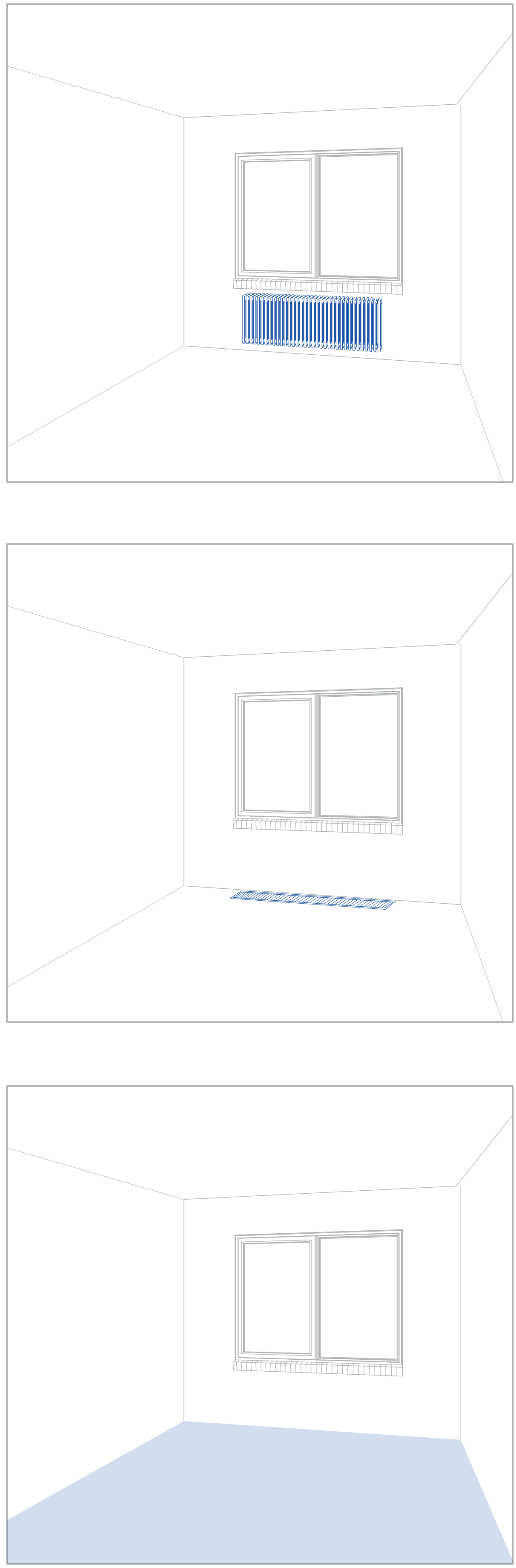


Exterior

Materials

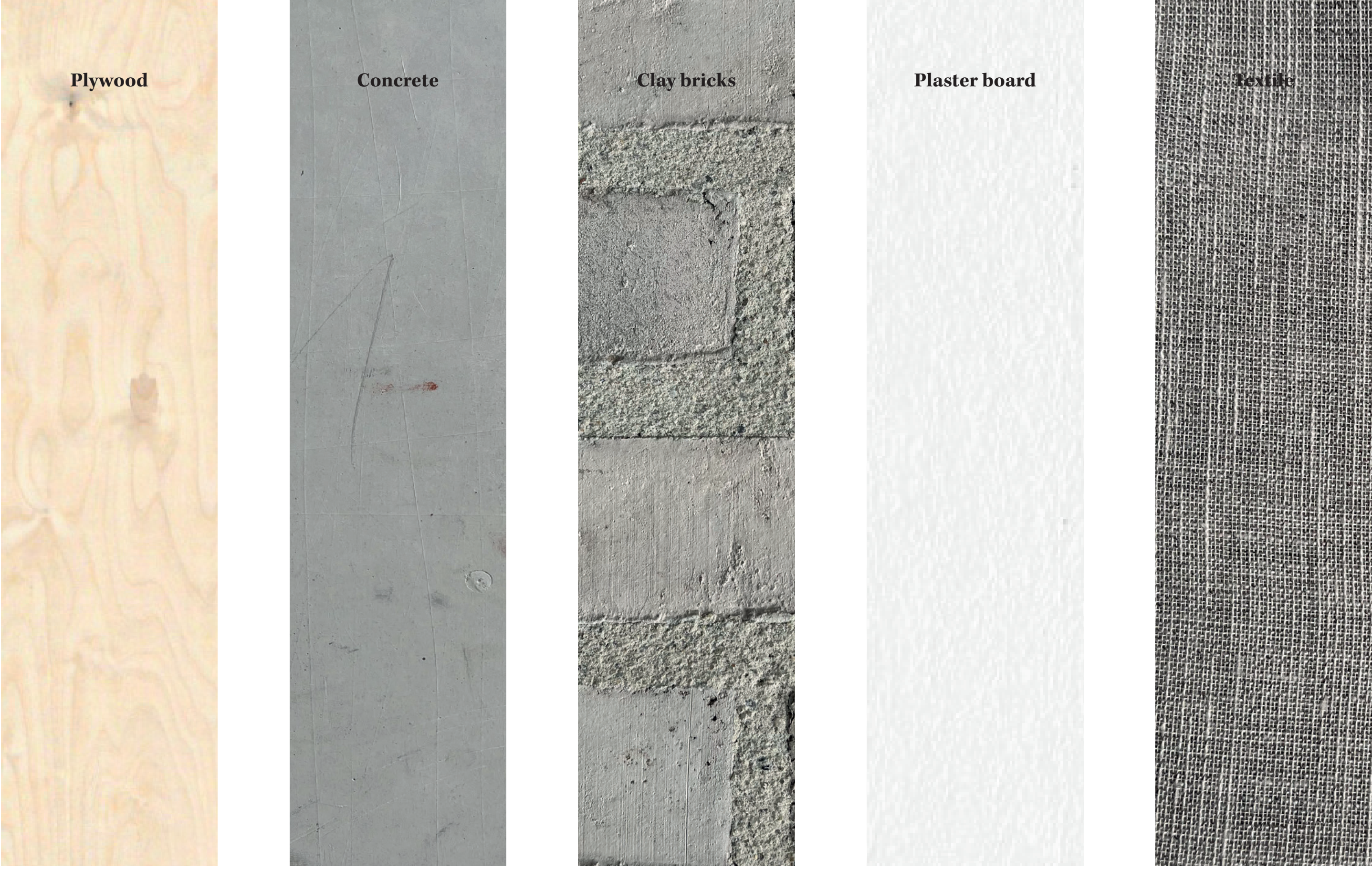
The existing walls are to the extent possible preserved in the new layout. Material properties of existing structures are studied to create an informed prioritisation of preservation in addition to studies on potentially added materials. As the structures are to figure as separation between housing units, acoustic properties are considered in addition to aesthetic qualities.

Acoustic comfort

As the project involves apartments sharing constructions, the focus is on sound insulation between units, where walls and floors are modified to meet current regulations. The existing deck consists of 150 mm reinforced concrete while 80 mm of concrete is added to enable floor heating entailing that additional insulation is placed below the deck. The roof is clad with plywood, perforated to reduce the reverberation time, while an installation gab is incorporated.

Studies on separating walls departures in sound insulation of the existing brick walls. To maintain the expression of the bricks, insulation is limited to one side and clad with plywood to add warmth to the otherwise raw aesthetics. This principle can be transferred to the concrete walls, while existing plaster walls are removed and replaced by new wall constructions, which meets the regulations.

The new floor and wall constructions are illustrated in appendix. C.



Interior

Material	Wood	Steel	Plywood	Concrete	Clay bricks	Plaster boar	Textile
Thermal mass *[kg/m²]*	*480*	*7850*	*480*	*2302*	*1650*	*800*	*-*
Global warming potential *[kg C02 eq/m³]*	*-670*	*1020*	*-599*	*84,5*	*2,7*	*22,4*	*-*
Reverberation time *[Short, medium, long]*	*Medium*	*Long*	*Medium*	*Long*	*Long*	*Medium*	*Short*
Maintenance *[Low, medium, high]*	*Medium*	*Low*	*Low*	*Low*	*Low*	*Medium*	*Low*
Adaptability *[Low, medium, high]*	*Medium*	*Low*	*Medium*	*Low*	*Low*	*Low*	*High*
Aesthetic qualities *[Key-words]*	*Warm, tactile, organic*	*Cold, robust, homogeneus*	*Warm, tactile, organic*	*Cold, raw, homogeneus*	*Warm, raw*	*Homogeneus*	*Tactile, change-ble, soft*

Chapter 07: **Synthesis**

Energy optimisation

For this thesis to be an applicable tool for energy optimisation of post-war buildings, different re-insulation strategies are proposed, from which one is chosen for this specific project, based on following studies in addition to the valuation of the project buildings. Due to the proportions of the construction, the strategies focus on transmission losses through the external walls, including thermal bridges along the slabs.

Different strategies are divided into three overall categories: external re-insulation, internal re-insulation and specific interventions, and tested in relation to u-value, transmission loss and relative humidity. The wall thickness and its consequences on daylight and net floor area is likewise considered. To create a basis for comparison, the amount and properties of added insulation is maintained throughout the studies, including 120 mm insulation with a thermal conductivity of 0,038 W/mK and an sd-value of 0,31 m. While the results are illustrated on the side, the related constructions and calculations are found in appendix D and E.

External re-insulation

Initially external re-insulation was rejected due to the valuation of the facades, however, being the only strategy interrupting the thermal bridges along the slabs and with minimal risk of moisture build up, this was reconsidered. Additionally, further studies of the facade revealed that the facade tiles were removable, thereby enabling their reinstallation. Three different principles are tested, listed on the side.

Internal re-insulation

Internal re-insulation requires a pronounced focus on build-up moisture as the dense part of the construction will be externally placed. To reduce the relative humidity, a vapour barrier is placed on the heated side of the construction. While this strategy allows the facades to be preserved, thermal bridges are likewise maintained, and the net floor area is reduced. Two different principles are tested, listed on the side.

Specific interventions

Optimisation potentials of interventions of more radical character have likewise been investigated. Since these strategies do not provide sufficient insulation to meet current standards, they are supplemented by internal insulation. Three different principles are tested, listed on the side.

The overall strategy chosen to be further examined in relation to indoor climate effects is an external re-insulation, where the facade tiles are removed, reduced and replaced. As studies on internal re-insulation showed that the Leca blocks could preferably be removed, this is likewise chosen. As it has not been possible to determine the construction of the ground deck and the roof, assumptions have been made based on references constructed in the same period (Jensen, RL, et.al 2011).

External re-insulation

1. Adding insulation directly on the existing construction, finished by a new cladding, which could be an architectural reinterpretation of the existing.
2. Removing the facade tiles, reducing them from 150 to 50 mm and replacing them on the insulation by means of an added mounting system.
3. Combining the two above by removing the facade tiles and replacing them with a new facade cladding.

Internal re-insulation

4. Adding insulation directly on the existing construction, including a vapour barrier, and finished by an internal cladding of plywood.
5. Removing the existing layer of Leca blocks, currently making up the insulation, but with a higher thermal conductivity compared to the added insulation.

Specific interventions

6. An open balcony access, preserving the existing structure, but removing the windows and, introducing a new external wall within the building mass.
7. A closed balcony access framed by the existing structure and a new external wall within the building mass.
8. Adding a double skin facade of glass, which is ventilated during the summer, but closed in the heating period, functioning as an insulating layer.

108.U-value

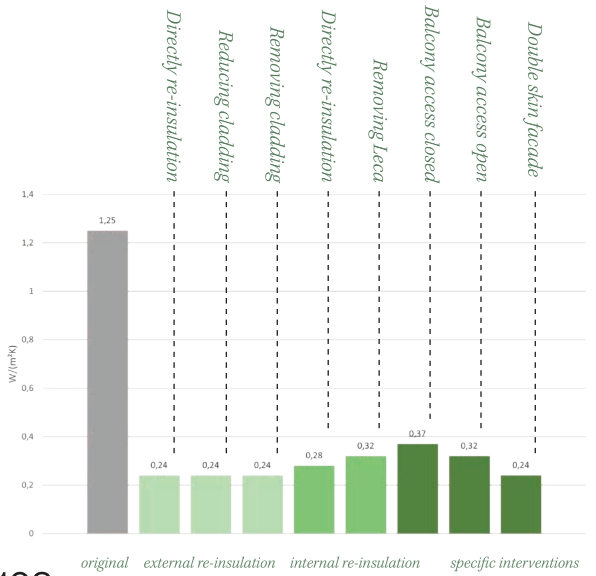
109.Transmission loss

110.Wall thickness

111.Daylight factor

112.Net floor area

113.Max. Relative humidity



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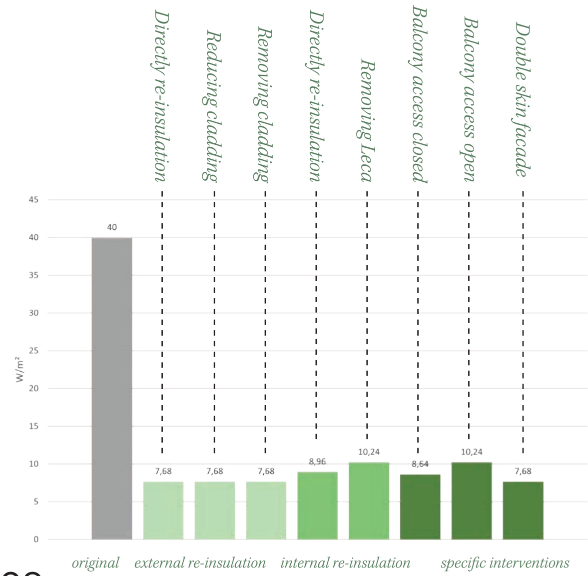

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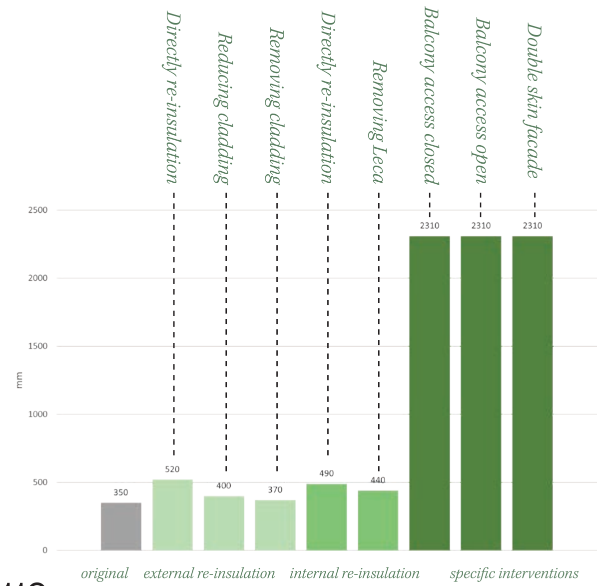

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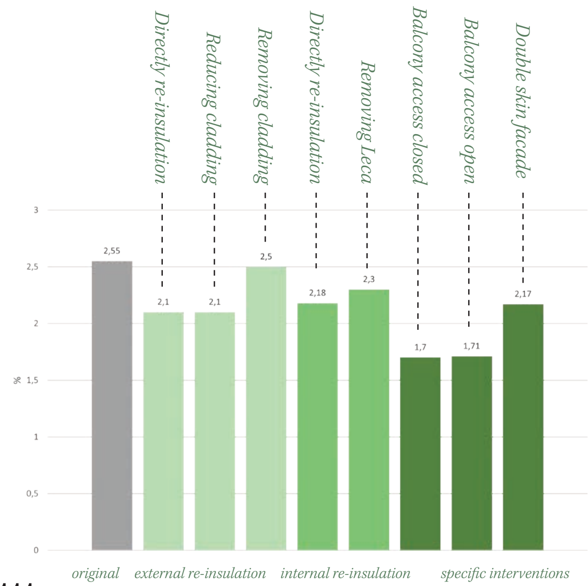

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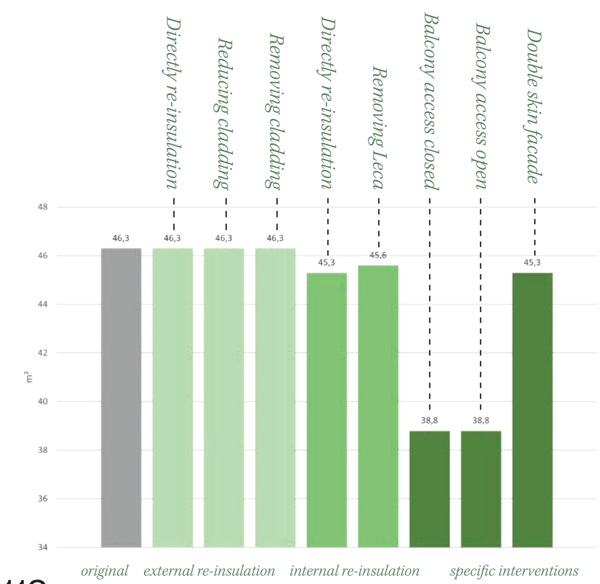

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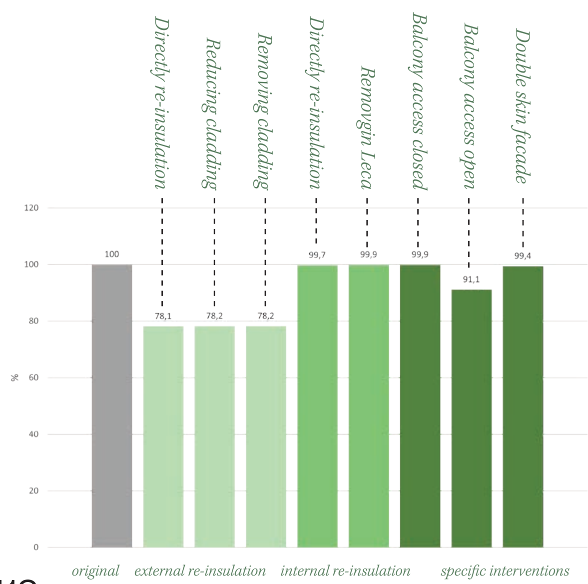


113

Indoor climate effects

To ensure thermal comfort, the maximum temperatures are examined in relation to building regulations, stating that the temperature in residential constructions are not exceed 100 hours above 27 °C and 25 hours above 28 °C. A critical room in relation to placement and proportions is modelled and dynamically analysed in BSim (Appendix F). Due to the reduction of infiltrations and transmission losses through the building envelope, the temperatures increase, causing risk of overheating. Passive strategies to reduce the temperature are examined.

Natural ventilation

A concept of hybrid ventilation, supplementing the mechanical ventilation system with natural ventilation during the warm season is incorporated to reduce the energy use for ventilation and the dimension of ventilation pipes. Window openings have been dimensioned on the assumption that an efficient opening area of 4 % of the relevant floor area will enable an airflow of 1,8 l/s pr. m^2 for single sided openings (Aggerholm, 2018). On the side a graph illustrates hours above 27 and 28 degrees respectively during a year, when the mechanical ventilation is supplemented by venting.

Passive shading

To further reduce the temperatures following passive shading strategies are investigated:

» An overhang of 2 metres, functioning as balconies
» Sidefins of 0,5 metres, functioning as bay windows

Asx both strategies affect the daylight conditions, a study on the consequences is performed showing that the overhang reduces the daylight factor. However, as it functions as balconies, the windows are replaced with doors increasing the window area.

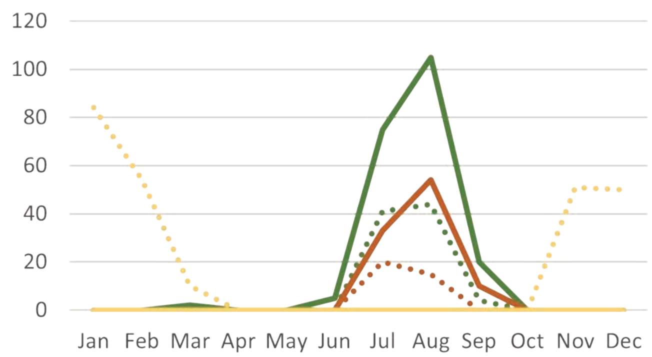
114.Original and renovated building

115.Natural ventilation

116.Passive shading, south facing window

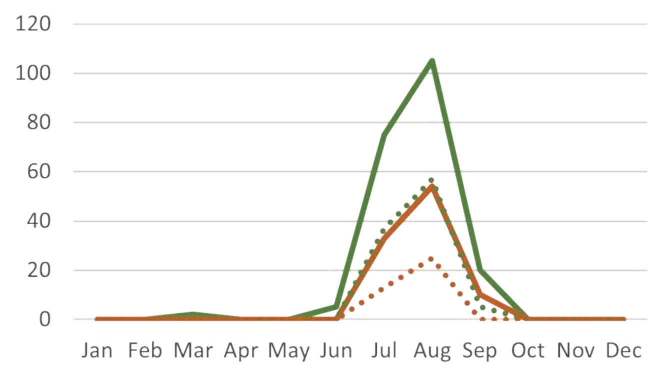
117.Passive shading, south facing dppr

hours > 27 ⁰C - original building
hours > 28 ⁰C - original building
hours < 18 ⁰C- original building
hours > 27 ⁰C - renovated building
hours > 28 ⁰C - renovated building
hours < 18 ⁰C - renovated building



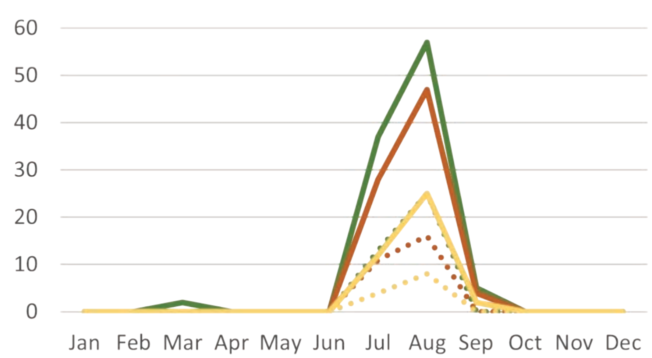
114

hours > 27 ⁰C - without natural ventilation
hours > 28 ⁰C - without natural ventilation
hours > 27 ⁰C - with natural ventilation
hours > 28 ⁰C - with natural ventilation



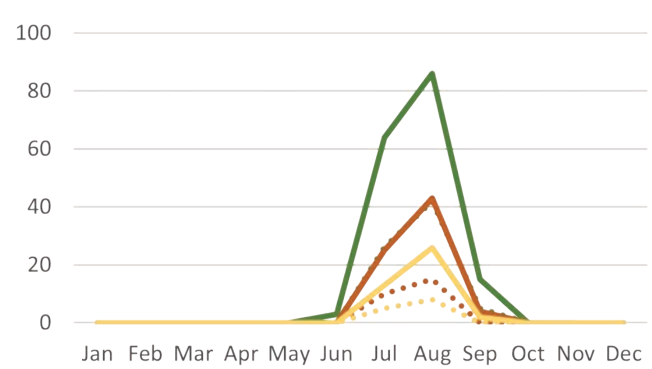
115

hours > 27 ⁰C
hours > 28 ⁰C
hours > 27 ⁰C - side fins and overhang 0,5 m
hours > 28 ⁰C - side fins and overhang 0,5 m
hours > 27 ⁰C - overhang 2 m
hours > 28 ⁰C - overhang 2 m



116

hours > 27 ⁰C
hours > 28 ⁰C
hours > 27 ⁰C - side fins and overhang 0,5 m
hours > 28 ⁰C - side fins and overhang 0,5 m
hours > 27 ⁰C - overhang 2 m
hours > 28 ⁰C - overhang 2 m



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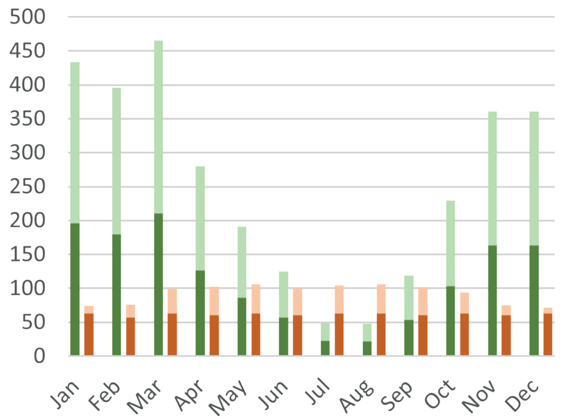
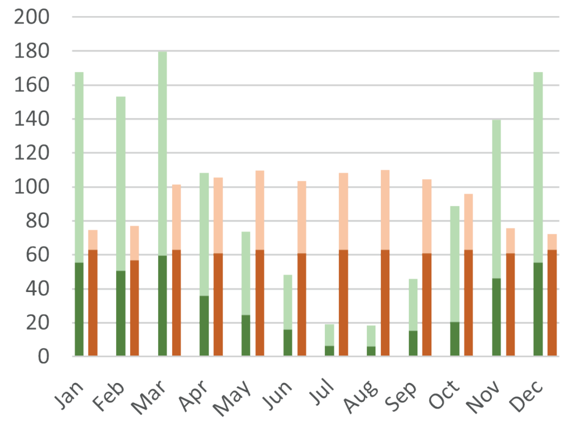
Architectural interventions



118



119

Transmission loss
Ventilation loss
Internal gains
Solar gains

Original building

Energy

Energy frame: 127,5 kWh/m^2 pr. year
Transmission loss: 23,5 W/m^2
Ventilation loss: 29,7 W/m^2

Renovated building

Energy

Energy frame: 46,4 kWh/m^2 pr. year
Transmission loss: 6,7 W/m^2
Ventilation loss: 14 W/m^2

Indoor climate

[south facing window]

Hours above 27 °C: 39 hours
Hours above 28 °C: 12 hours
Daylight factor: 2 %

[south facing door]

Hours above 27 °C: 41 hours
Hours above 28 °C: 13 hours
Daylight factor: 4,35 %

Concludingly a comparison between the existing and the transformed building is performed in relation to energy consumption using BE18 (appendix G). As the existing systems are not accounted for, ventilation and heating is maintained across models to create a frame of reference in relation to transmission losses. The interventions conclude as follows:

» An external re-insulation of the building envelope, reusing the existing cladding to preserve the architectural expression.

» An open balcony access facing north on the 1st and 2nd floor and a balcony structure facing south counteracting overheating.

» A hybrid ventilation system, where a constant mechanical ventilation is supplemented by natural venting during the summer.

» Integration of photovoltaics in new structures on the roof angled to a degree of 40 to maximise the effects.

» Replacement of some windows with new ones featuring lower U- and g-values, increasing the total amount of window area.

Collectively, these interventions have significantly reduced the transmission loss from 23,5 to 6,7 W/m^2, categorising it as a low-energy in relation to the transmission loss frame. The ventilation loss is likewise reduced caused by the minimisation of infiltrations. The energy frame of the transformed building, without the integration of renewable energy sources is 46,4 kWh/m2 pr. Year reducing it to renovation class 1. Depending on the amount of photovoltaics added to the roof, the energy frame can be reduced accordingly..

118.Heat losses and gains original building

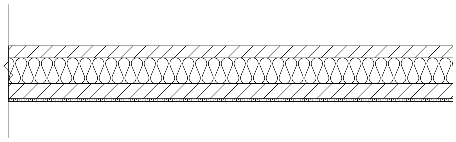
119.Heat losses and gains renovated building

120.New roof construction 1:50

121.New ground deck construction 1:50

122.New wall construction 1:50

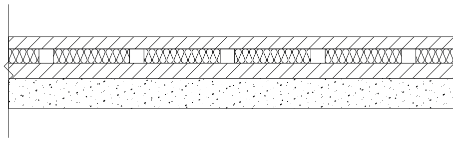
123. Mounting system



120

Roof
20 mm plywood
100 mm concrete
vapour barrier
170 mm insulation
80 mm concrete

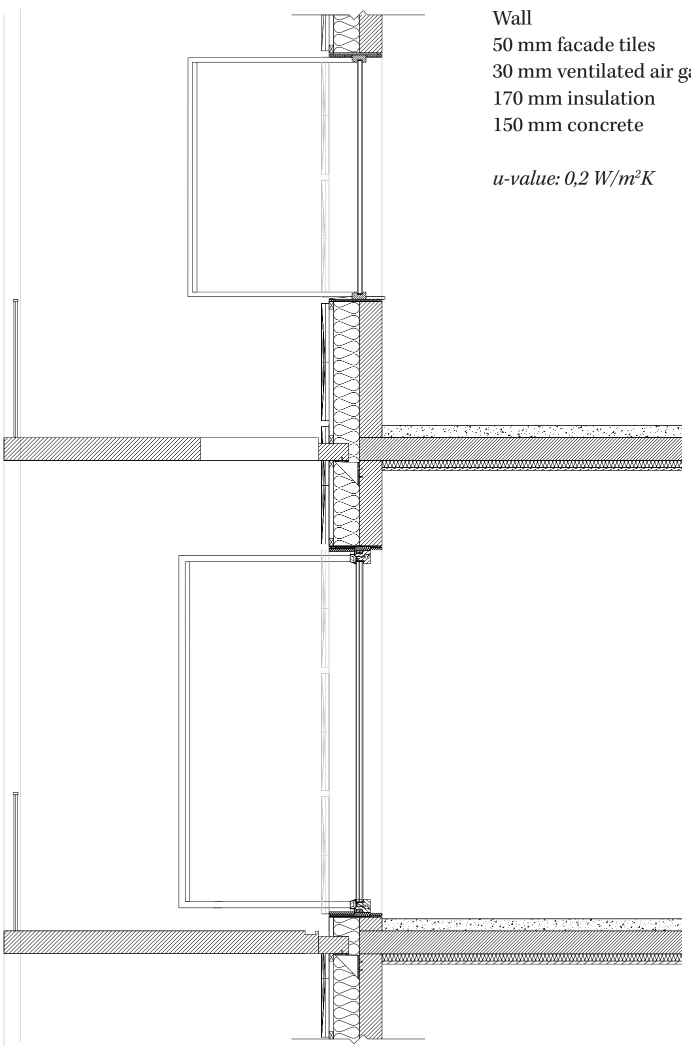
u-value: 0,2 W/m²K



121

Ground deck
200 mm lightweight concrete
100 mm concrete
120 mm insulation
80 mm concrete

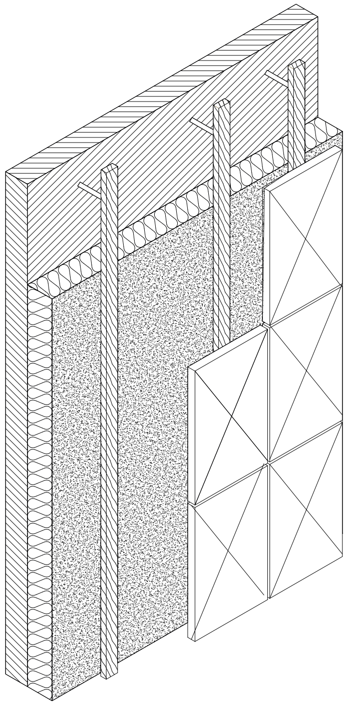
u-value: 0,2 W/m²K



Wall
50 mm facade tiles
30 mm ventilated air gap
170 mm insulation
150 mm concrete

u-value: 0,2 W/m²K

122



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Chapter 08:
Outro

Conclusion

The research question raised in this thesis is twofold. Firstly, the aim was to define a new, sustainable housing typology from the structure of a former hospital building. This necessitates an evaluation of whether the design proposal is sustainable.

Secondly, the thesis sought to develop a strategy on how to approach function-empty hospital buildings on a national plan with learnings from a specific case. This necessitates an evaluation of the scalability of the design proposal.

Sustainability

Sustainability is a broad term, and in this thesis it is used in a holistic definition whereby, in addition to the attention given to environmental- and economic savings, the wellbeing of the inhabitants is considered. Social-housing is an emerging tendency in residential architecture. However, it often takes form either as a total dissolution of the home or as private housing units with additional shared facilities. By offering different housing layouts with a varying degree of collectivism, the housing typology defined in this thesis appeals to a diversified group of residents promoting inclusivity and social responsibility.

From an environmental perspective, the biggest contribution of CO_2 from our buildings is when they are constructed. Thereby follows the fact, that preserving and utilising our existing building mass is environmentally sustainable, if the alternative is demolishing it to build a new. However, this approach is accompanied by some challenges. In this particular case, the available drawing material and information on the existing structure was limited and due to the time constraints of the thesis, assumptions based on examples of construction methods used at the time were made.

This indicates that the act of transformation is time- and thereby resource consuming. In addition, it can be argued that aspects of the design proposal are more cost related compared to new developments. For example, the design proposal includes preserving the architectural expression of the building, aided by the assumed possibility of removing the facade tiles. This allowed an external re-insulation, which proved to be more efficient, however does not consider the resources used, and potential damages related to the demonting procedure.

Concludingly, the design proposal can be considered socially responsible and environmentally sustainable, not taking into consideration the economic related costs of such a design approach, which are not accounted for in this thesis.

Scalability

Acknowledging that hospital buildings, like all constructions, are a result of the time in which they were built, the proposed strategy is mainly applicable for hospital buildings of the post-war period. However, as this period represents a significant section of our building mass, and one to a greater extent being demolished, the thesis is all the more relevant. Changing the function of any existing structure requires an understanding of the spatial composition, and how this might conflict with the new function. Hospital buildings of the post-war period are characterised by a deep volume with a central distribution corridor around modular spaces. Transforming such volume into housing implies an awareness of the indoor climate effects of the interventions applied.

If the proposed strategy is to be transferred to other constructions, it is important to remember that cultural heritage and the atmosphere of space are central aspects in any project, especially one concerned with transformation. These are related to the surrounding structures, and thereby differ, indicating that the act of interventions should likewise vary from one project to the other.

Concludingly, elements of the design proposal can be incorporated in other transformation projects dealing with comparable constructions. However, a transformation of such character should originate in a valuation of the specific building and its surroundings.

Reflection

This thesis, being concerned with the act of transforming existing structures, rouses a historical reflection, which sets our current way of building and inhabiting our buildings into perspective. In the developer driving building industry of today, buildings are constructed at a fast pace, and a lot of what is built in the urban scape falls into the same category of rigid box architecture.

Energy optimisation

Buildings constructed during the rise of the Danish welfare state are designed from ideals rather than constraints. Since then, architects have been concerned with the handling of and reaction to a series of crises: firstly the energy crisis in 1973 later the financial crisis, and distinctively present today, the climate crises. The consequences of the construction-boom and its industrialised building system are now being realised and are often met by demolition. But facing the lack of resources, this approach cannot be sustained long term.

When considering the utilisation of the existing building mass, an awareness of energy consumption is needed. Referring to energy in the building industry one often distinguishes between operational energy (energy used for heating, cooling and equipment) and embodied energy (the sum of energy used to extract, manufacture, transport and assemble materials into a building).

In the late 20th century, sparked by the energy crisis, the concerns of architects and engineers were put towards the first category. Ideas on passive strategies arose and renewable energy sources were integrated. However, the annual energy consumption of a building only covers part of the total footprint.

Today, sparked by the climate crises, the focus has shifted to the second category, carrying a distinct focus on CO_2 emissions. Software is being developed to aid in obtaining sustainable developments by evaluating the properties and performance of our building components. A common trait for these software is the focus on measurable effects, whereas the intention of architecture should be to create spaces of quality.

Designing for sustainability has thus become an act of checking boxes - disregarding the qualitative aspects related to the relationship between man and the built environment. Illustrated by the demolition of post-war constructions, however, the lifetime of a building is not simply equal to the lifetime of its components, but rather depends on people carrying out the necessary maintenance and/or transformation(s) through time. In this sense, a sustainable building is a building which human beings, who have the capacity to do so, are motivated to maintain.

Transformation and habitation

Today there is a national aversion towards post-war architecture due to its association with negative narratives on parallel societies. However, considering the fact that these buildings represent a significant section of our existing building mass, it is time to view them as a physical manifestation of the Danish welfare state and a valuable resource for the future.

Utilising post-war constructions does not mean reverting to the original visions associated with these buildings, but rather incorporating them with new trends and needs. These structures were initially constructed to promote equality by offering residents equal conditions and functionally separating different parts of the city. Drawing on lessons from their history, contemporary construction now provides a variety of apartment sizes within a diverse urban fabric. However, the ways of living afforded by architecture of the developer-driven building industry remain relatively monotonous.

This thesis demonstrates that post-war buildings can facilitate the emergence of new living arrangements, not only through varying layouts of housing units, but also by promoting varying degrees of collectivism. While the thesis introduces innovative ideas for building and inhabiting spaces, there may be concerns about the profitability of such an approach. However, as the building industry undergoes a paradigm shift, it is crucial to adopt a holistic approach to sustainability that in addition to economic considerations encompasses natural and social considerations.

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Illustrations

Appendix

App.A: Overall plan

Available at: https://www.aalborg.dk/om-kommunen/udvikling-og-planer/udvikling-af-kommunen/byudvikling/sygehus-nord-og-gaasepigen - Credit: Aalborg Kommune med rådgiverne SLA og Transform

App.B: Ventilation rates

Calculation of atmospheric indoor environment

The ventilation rates are calculated according to DS447:2013 in relation to category II with a maximum percentage of dissatisfied on 20€. Three different aspects are taken into consideration; Emission from people and the building, C02 pollution, and experienced air quality. Emissions from people and buildings are chosen as the dimensioning rates, despite experienced air quality representing a larger amount. However, it is noted that the experienced air quality is to a greater extent relevant when transforming existing buildings as the old building materials may liberate more obnoxious smells.

From emissions, the air flow is 1,4 l/s pr. m2.

$$21306\, m^2 * 1,4\, l/s\, pr\, m^2 = 29828,4\, l/s \sim 107416,8\, m^3/h$$

An indoor air handling unit from Systemair is chosen (Systemair.com, 2020), which can deliver an airflow of 17500 m3/h. The amount of units is calculated.

$$\frac{107416,8\, m^3/h}{17500\, m^3 h} = 6,1 \sim 6 \text{ air handing units}$$

Emission

Room	number of people	Area	Room height	Room volume	Outdoor air supplied pr. person	Outdoor air supplid - emission from buildings	Total outdoor air supplied
		m^2	*m*	*m^3*	*l/s pr. person*	*l/s pr. m^2*	*l/s*
Room facing south	*2*	*20*	*3,2*	*64*	*7*	*0,7*	*28*

Airchange	Flow rate	pr. m^2
h^{-1}	*m^3/h*	*l/s pr. m^2*
1,575	*100,8*	*1,4*

CO2

Room	number of people	Area	Room height	Room volume	Level of activity	Pollution load	Emission concentration, room
		m^2	*m*	*m^3*	*met*	*l/h*	*m^3/m^3*
Room facing south	*2*	*20*	*3,2*	*64*	*1,2*	*20,4*	*0,001*

Emission concentration, air	Total outdoor air supplied	Airchange	Flow rate	pr. m^2
m^3/m^3	*l/s*	*h^{-1}*	*m^3/h*	*l/s pr. m^2*
0,00035	*17,43*	*0,98*	*62,79*	*0,87*

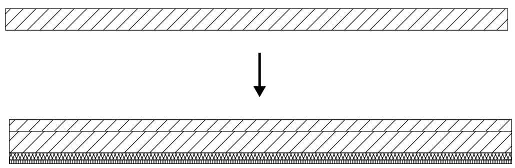
Sensory

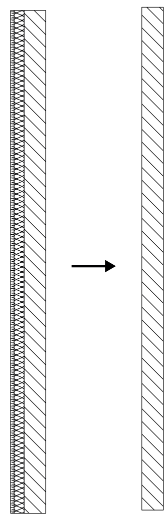
Room	number of people	Area	Room height	Room volume	Pollution from people	Pollution from building	Experienced air quality
		m^2	*m*	*m^3*	*olf pr. person*	*olf. pr. m^2*	*decipol*
Room facing south	*2*	*20*	*3,2*	*64*	*1*	*0,4*	*1,4*

Pollution from air	Total outdoor air supplied	Airchange	Flow rate	pr. m^2
m^3/m^3	*l/s*	*h^{-1}*	*m^3/h*	*l/s pr. m^2*
0,00035	*71,42*	*4,017*	*257,13*	*3,57*

App.C: New constructions

Interior wall and deck





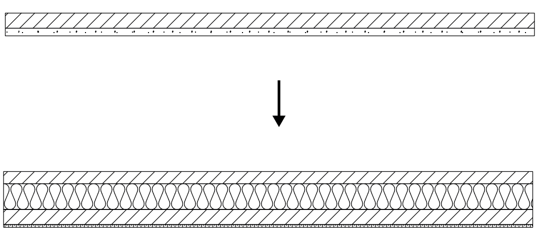
Existing deck constrruction:
150 mm concrete

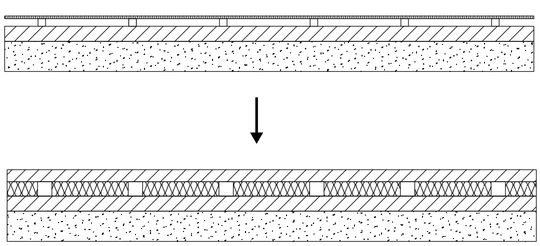
Transformed deck construction:
20 mm wood cladding
50 mm insulation (concerned footfall sound)
150 mm concrete
80 mm concrete (with heating)

Existing internal bearing wall:
150 mm brick wall or concrete

Tranformed internal bearing wall:
150 mm concrete or brick
70 mm insulation
25 mm wood cladding

Roof and ground deck





Assumed roof constrruction:
50 mm leca
100 mm concrete

Transformed roof construction:
15 mm plywood
100 mm concrete
vapour barrier
170 mm insulation
80 mm concrete

Assumed ground deck:
200 mm lightweight concrete
100 mm concrete
50 mm joists
18 mm floor

Tranformed ground deck:
200 mm lightweight concrete
100 mm concrete
120 mm insulation
80 mm concrete

App.D: Calculation of U-value

Example

The calculation for different transmission coefficient are calculated according to DS 418:2011. An example for calculating the existing wall are shown:

$$1/U = R_u + R_i + \sum_{i=1}^{n} R_{isolance}$$

R_u = inner thermal insulance m^2K/W

R_i = outer thermal insulance m^2K/W

U = corrected transmission coefficient W/m^2K

$R_{isolance}$ = isolance for layers $m^2\,K/W$

n = number of layers

The thickness, thermal conductivity are found for each material, and from here the isolance can be calculated:

$$s/\lambda = R$$

The corrected U-value can thereafter be calculated:

$$1/R = U$$

$$0,40 + \frac{0,150}{2,1} + \frac{0,150}{2,5} + \frac{0,05}{0,950} + 0,130 = 0,714\, m^2k/W$$

$$\frac{1}{0,714} = 1,40\, W/m^2K$$

To calculated the uncorrected U'-value where the thermal bridges in the construction are included the understanding of the transmission area and the heat flow is important. Each level in the construction form a linear thermal transmittance, and should be concluded in terms of calculating the u-value if a inner re-insulation are chosen.

$$U' = \frac{\sum_{i=1}^{n} A_i * U_i + \sum_{k=1}^{m} l_k \psi_k + \sum X_j}{A}$$

A = the total conctructions transmossions area m^2

A_i = part area m^2

U_i = part areas transmission coefficient for one − dimensional heat flow W/m^2K

l_k = length of each linear thermal bridge m

ψ_k = linear loss for each linear thermal bridge W/mK

X_j = point loss for each point thermal bridge W/mK

n = number of part areas

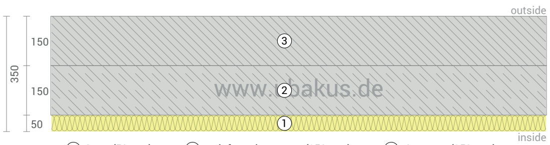
m = number of linear thermal bridges

For the existing external wall:

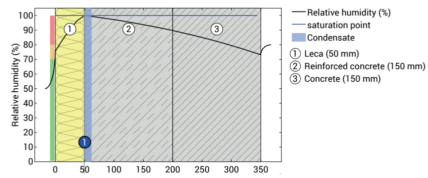
$$((163 * 1,4) + (50 * 0,13))/163 = 1,44\, W/m^2K$$

App.E: Wall iterations

Original wall

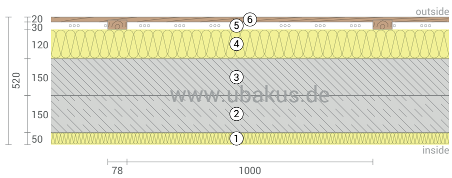


① Leca (50 mm) ② Reinforced concrete (150 mm) ③ Concrete (150 mm)

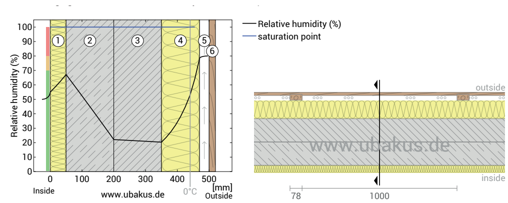


Outer re-insulation

Directly re-insulation (outer)

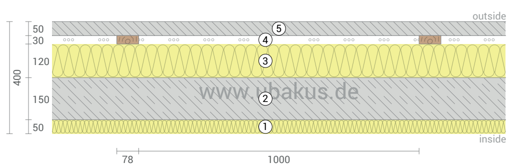


① Leca (50 mm) ② Reinforced concrete (150 mm) ③ Concrete (150 mm) ④ Hunton (120 mm) ⑤ Rear ventilated level (30 mm) ⑥ wood cladding (20 mm)

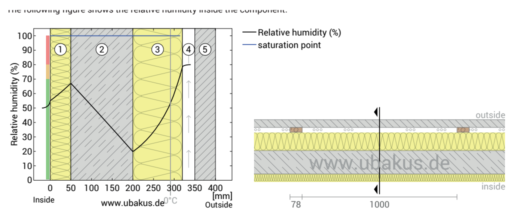


① Leca (50 mm) ② Reinforced concrete (150 mm) ③ Concrete (150 mm) ④ Hunton (120 mm) ⑤ Rear ventilated level (30 mm) ⑥ wood cladding (20 mm)

Moving and reducing cladding

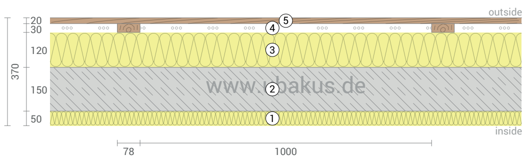


① Leca (50 mm) ② Reinforced concrete (150 mm) ③ Hunton (120 mm) ④ Rear ventilated level (30 mm) ⑤ Concrete (50 mm)

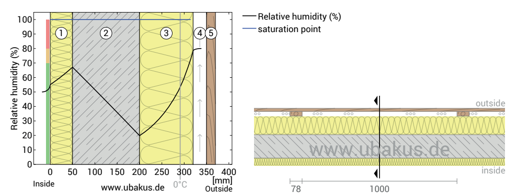


① Leca (50 mm) ② Reinforced concrete (150 mm) ③ Hunton (120 mm) ④ Rear ventilated level (30 mm) ⑤ Concrete (50 mm)

Removing cladding



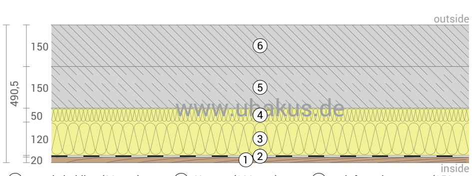
① Leca (50 mm) ② Reinforced concrete (150 mm) ③ Hunton (120 mm) ④ Rear ventilated level (30 mm) ⑤ wood cladding (20 mm)



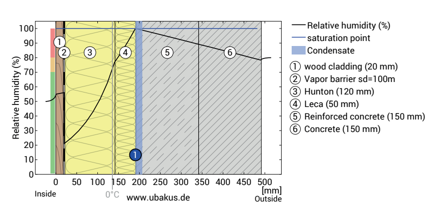
① Leca (50 mm) ② Reinforced concrete (150 mm) ③ Hunton (120 mm) ④ Rear ventilated level (30 mm) ⑤ wood cladding (20 mm)

Inner re-insulation

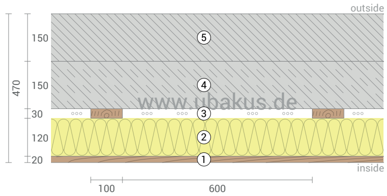
Directly re-insulation (inner)



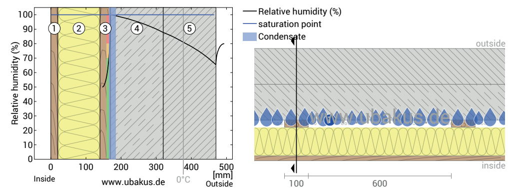
① wood cladding (20 mm) ② Vapor barrier sd=100m ③ Hunton (120 mm) ④ Leca (50 mm) ⑤ Reinforced concrete (150 mm) ⑥ Concrete (150 mm)



removing leca



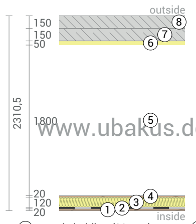
(1) wood cladding (20 mm)
(2) Hunton (120 mm)
(3) Rear ventilated level (30 mm)
(4) Reinforced concrete (150 mm)
(5) Concrete (150 mm)



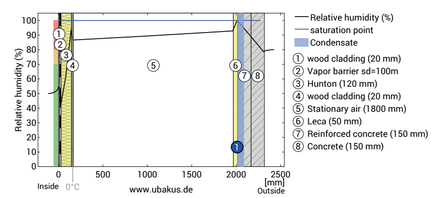
(1) wood cladding (20 mm)
(2) Hunton (120 mm)
(3) Spruce (30 mm)
(4) Reinforced concrete (150 mm)
(5) Concrete (150 mm)

Specific interventions

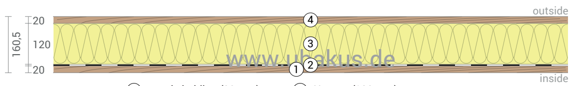
Balcony access closed



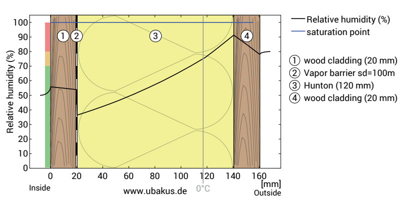
(1) wood cladding (20 mm)
(2) Vapor barrier sd=100m
(3) Hunton (120 mm)
(4) wood cladding (20 mm)
(5) Stationary air (1800 mm)
(6) Leca (50 mm)
(7) Reinforced concrete (150 mm)
(8) Concrete (150 mm)



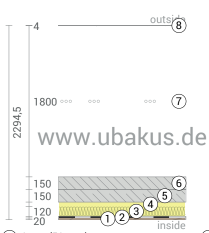
Balcony access open



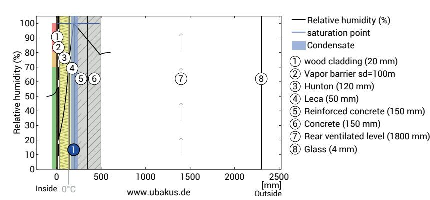
(1) wood cladding (20 mm)
(2) Vapor barrier sd=100m
(3) Hunton (120 mm)
(4) wood cladding (20 mm)



Double skin facade



(1) wood cladding (20 mm)
(2) Vapor barrier sd=100m
(3) Hunton (120 mm)
(4) Leca (50 mm)
(5) Reinforced concrete (150 mm)
(6) Concrete (150 mm)
(7) Rear ventilated level (1800 mm)
(8) Glass (4 mm)



App.F: Indoor climate effects

Condition for examined room in BSim

Existing condition for examinated room	Walls
East and west	*brick wall: 150 mm*
North	*Plaster wall: 100 mm*
South	*External wall: 50 mm leca, 150 mm reinforced concrete, 150 mm concrete cladding*

Existing condition for examinated room	Deck
Floor	*Concrete deck: 150 mm*
Ceiling	*Concrete deck: 150 mm*

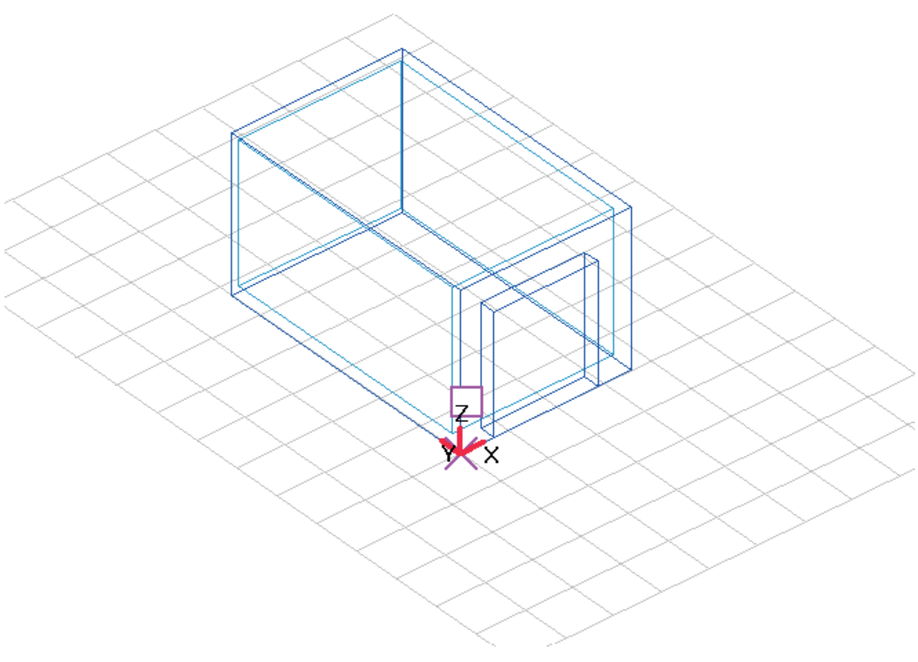
Existing condition for examinated room	System
Heating	*always*
Infiltration	*always*
Peopleload	*2 people - full load*
Ventilation	*always*

Final condition for examinated room	Walls
East and west	*brick wall: 150 mm brick, 70 mm insulation, 25 mm wood cladding*
North	*Leight weight wall: 25 mm wood cladding, 70 mm insulation, 25 mm wood cladding*
South	*External wall: 150 mm reinforced concrete, 170 mm hunton insulation, 30 mm venilated air gap, 50 mm concrete cladding*

Final condition for examinated room	Deck
Floor	*Concrete deck: 80 mm concrete, 150 mm reinforced comcrete, 50 mm insulation, 25 mm cladding*
Ceiling	*Concrete deck: 80 mm concrete, 150 mm reinforced comcrete, 50 mm insulation, 25 mm cladding*

Final condition for examinated room	System
Heating	*always*
Infiltration	*always*
Peopleload	*2 people - full load*
Ventilation	*Always*
Venting	*Summer*
Solarshading	*Balconies (south) and sidfins (east and west)*

Model



App.G: Energy optimisation

Original building

Bygning

Navn NORD_original

Etagebo — Fritliggende bolig (fritliggende enfamiliehus)
Sammenbyggede boliger (fx dobbel-, række- og kædehuse)
Etagebolig, Lager mv eller Andet (ikke bolig)

1 Antal boligenheder — 0 Rotation, °

16922,2 Opvarmet etageareal, m² — 17979,8 Bruttoareal, m²

2115,28 Opvarmet kælder, m² — 0 Andet, m²

1057,64 Bebygget areal, m²

250 Varmekapacitet, Wh/K m² — Start, kl. — Slut, kl.

168 Normal brugstid, timer/uge — 0 — 24

Beregningsbetingelser

BR: Aktuelle f — Se beregnings-vejledningen

Tillæg til energirammen for særlige betingelser, kWh/m² år

0

Kun mulig for andre bygninger end boliger og beregningsbetingelser: BR: Aktuelle forhold.

OBS: Ny reference for belysning i BR15: 300 lux.

Varmeforsyning

Fjernvarr — Basis: Kedel, Fjernvarme, Blokvarme eller El

☐ Varmefordelingsanlæg (hvis elvarme)

Bidrag fra (i prioritets-orden)

☐ 1. Elradiatorer ☐ 2. Brændeovne, gasstrålevarmere og lign.

☐ 3. Solvarme ☐ 4. Varmepumpe ☐ 5. Solceller ☐ 6. Vindmøller

Mekanisk køling

0 Andel af etageareal, -

Beskrivelse

Kommentarer

Samlet varmetab

Transmissionstab 417,5 kW 23,5 W/m²

Ventilationstab uden vgv 1261,3 kW 71,0 W/m² (om vinteren)

I alt 1678,8 kW 94,5 W/m²

Ventilationstab med vgv 527,5 kW 29,7 W/m² (om vinteren)

I alt 945,0 kW 53,2 W/m²

Transmissionstabsramme

Almindelig 12,4 W/m²

Lavenergi 11,4 W/m²

Nøgletal, kWh/m² år

Renoveringsklasse 2

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
70,1	0,0	70,1
Samlet energibehov		127,5

Renoveringsklasse 1

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
52,6	0,0	52,6
Samlet energibehov		127,5

Energiramme BR 2018

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
30,1	0,0	30,1
Samlet energibehov		127,5

Energiramme lavenergi

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
27,0	0,0	27,0
Samlet energibehov		127,5

Bidrag til energibehovet

Varme	118,9
El til bygningsdrift	13,9
Overtemp. i rum	0,0

Netto behov

Rumopvarmning	118,7
Varmt brugsvand	13,1
Køling	0,0

Udvalgte elbehov

Belysning	0,0
Opvarmning af rum	0,0
Opvarmning af vbv	0,0
Varmepumpe	0,0
Ventilatorer	13,9
Pumper	0,0
Køling	0,0
Totalt elforbrug	42,7

Varmetab fra installationer

Rumopvarmning	0,0
Varmt brugsvand	0,0

Ydelse fra særlige kilder

Solvarme	0,0
Varmepumpe	0,0
Solceller	0,0
Vindmøller	0,0

Heating demand

	MWh	Januar	Februar	Marts	April	Maj	Juni	Juli	August	September	Oktober	November	December	I alt
	Varmebehov													
+1	Trans.- og vent.tab	433,37	396,08	464,98	279,88	190,56	125,19	49,77	47,53	118,46	229,13	360,59	433,37	3128,90
2	Vent. VF (total)	39,80	36,83	45,81	11,97	0,00	0,00	0,00	0,00	0,00	0,94	27,33	39,80	202,48
3	Vent. VGV nedreg.	0.00	0.00	0.00	0.00	-6,40	-17,46	-33,19	-33,61	-18,74	0,00	0,00	0,00	-109,40
4	Varmetab	393,57	359,25	419,16	267,91	196,96	142,65	82,96	81,14	137,20	228,19	333,26	393,57	3035,82
5	Solindfald	10,98	19,10	35,81	41,43	43,13	39,10	41,62	43,35	40,58	30,81	13,84	8,84	368,58
6	Internt tilskud	62,95	56,86	62,95	60,92	62,95	60,92	62,95	62,95	60,92	62,95	60,92	62,95	741,19
7	Fra rør og VVB konst.	0.00	0.00	0,00	0.00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
8	Samlet tilskud	73,93	75,96	98,76	102,35	106,08	100,02	104,57	106,30	101,50	93,76	74,76	71,79	1109,78
9	Rel. tilskud, -	0,19	0,21	0,24	0,38	0,54	0,70	1,26	1,31	0,74	0,41	0,22	0,18	
10	Del af rumopv.	1.00	1.00	1,00	1.00	1,00	0,00	0,00	0,00	1,00	1,00	1,00	1,00	
11	Variabl. varmetilsk.	0.00	0.00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Tot. tilskud	73,93	75,96	98,76	102,35	106,08	100,02	104,57	106,30	101,50	93,76	74,76	71,79	1109,78
13	Rel. tilskud, -	0,19	0,21	0,24	0,38	0,54	0,70	1,26	1,31	0,74	0,41	0,22	0,18	
14	Udnyt. faktor	1.00	1.00	1,00	1,00	1,00	0,99	0,78	0,75	0,99	1,00	1,00	1,00	
15	Varmebehov	319,64	283,29	320,41	165,56	90,94	0,00	0,00	0,00	36,70	134,43	258,50	321,78	1931,25
16	Vent. VF (centralvarme)	39,80	36,83	45,81	11,97	0,00	0,00	0,00	0,00	0,00	0,94	27,33	39,80	202,48
17	I alt	359,44	320,12	366,22	177,53	90,94	0,00	0,00	0,00	36,70	135,37	285,83	361,58	2133,73

Renovated building

Bygning

Navn	NORD_Renovated		
Etagebo	Fritliggende bolig (fritliggende enfamiliehus) Sammenbyggede boliger (fx dobbel-, række- og kædehuse) Etagebolig, Lager mv eller Andet (ikke bolig)		
1	Antal boligenheder	0	Rotation, °
16922,2	Opvarmet etageareal, m²	17979,8	Bruttoareal, m²
2115,28	Opvarmet kælder, m²	0	Andet, m²
1057,64	Bebygget areal, m²		
250	Varmekapacitet, Wh/K m²	Start, kl.	Slut, kl.
168	Normal brugstid, timer/uge	0	24

Beregningsbetingelser

BR: Aktuelle | Se beregnings-vejledningen

Tillæg til energirammen for særlige betingelser, kWh/m² år

0

Kun mulig for andre bygninger end boliger og beregningsbetingelser: BR: Aktuelle forhold.

OBS: Ny reference for belysning i BR15: 300 lux.

Varmeforsyning

Fjernvarm | Basis: Kedel, Fjernvarme, Blokvarme eller El

☐ Varmefordelingsanlæg (hvis elvarme)

Bidrag fra (i prioritets-orden)

☐ 1. Elradiatorer ☐ 2. Brændeovne, gasstrålevarmere og lign.

☐ 3. Solvarme ☐ 4. Varmepumpe ☐ 5. Solceller ☐ 6. Vindmøller

Mekanisk køling

0 | Andel af etageareal, -

Beskrivelse

Kommentarer

Samlet varmetab

Transmissionstab 118,2 kW 6,7 W/m²

Ventilationstab uden vgv 982,8 kW 55,3 W/m² (om vinteren)

I alt 1101,1 kW 62,0 W/m²

Ventilationstab med vgv 249,0 kW 14,0 W/m² (om vinteren)

I alt 367,2 kW 20,7 W/m²

Transmissionstabsramme

Almindelig 12,4 W/m²

Lavenergi 11,4 W/m²

Nøgletal, kWh/m² år

Renoveringsklasse 2	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
	70,1	0,0	70,1
	Samlet energibehov		46,4

Renoveringsklasse 1	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
	52,6	0,0	52,6
	Samlet energibehov		46,4

Energiramme BR 2018	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
	30,1	0,0	30,1
	Samlet energibehov		46,4

Energiramme lavenergi	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
	27,0	0,0	27,0
	Samlet energibehov		46,4

Bidrag til energibehovet		Netto behov	
Varme	23,6	Rumopvarmning	23,3
El til bygningsdrift	13,9	Varmt brugsvand	13,1
Overtemp. i rum	0,0	Køling	0,0

Udvalgte elbehov		Varmetab fra installationer	
Belysning	0,0	Rumopvarmning	0,0
Opvarmning af rum	0,0	Varmt brugsvand	0,0
Opvarmning af vbv	0,0	**Ydelse fra særlige kilder**	
Varmepumpe	0,0	Solvarme	0,0
Ventilatorer	13,9	Varmepumpe	0,0
Pumper	0,0	Solceller	0,0
Køling	0,0	Vindmøller	0,0
Totalt elforbrug	42,7		

Heating demand

	MWh	Januar	Februar	Marts	April	Maj	Juni	Juli	August	September	Oktober	November	December	I alt
	Varmebehov													
+1	Trans.- og vent.tab	167,50	153,09	179,72	108,18	73,65	48,39	19,24	18,37	45,79	88,56	139,37	167,50	1209,34
2	Vent. VF (total)	39,80	36,83	45,81	11,97	0,00	0,00	0.00	0,00	0,00	0,94	27,33	39,80	202,48
3	Vent. VGV nedreg.	0.00	0.00	0.00	0.00	-6,40	-17,46	-33,19	-33.61	-18,74	0.00	0.00	0.00	-109.40
4	Varmetab	127,70	116,26	133,90	96,20	80,05	65,85	52,42	51,98	64,53	87,62	112,04	127,70	1116,26
5	Solindfald	11,62	20,33	38,32	44,75	46,83	42,46	45,32	46,90	43,50	32,81	14,67	9,35	396,85
6	Internt tilskud	62,95	56,86	62,95	60,92	62,95	60,92	62,95	62,95	60,92	62,95	60,92	62,95	741,19
7	Fra rør og VVB konst.	0,00	0,00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Samlet tilskud	74,57	77,19	101,27	105,67	109,78	103,38	108,27	109,85	104,42	95,76	75,59	72,30	1138,04
9	Rel. tilskud, -	0,58	0,66	0,76	1,10	1,37	1,57	2,07	2,11	1,62	1,09	0,67	0,57	
10	Del af rumopv.	1,00	1,00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0,37	1,00	1,00	
11	Variabl. varmetilsk.	0.00	0,00	0,00	0,00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Tot. tilskud	74,57	77,19	101,27	105,67	109,78	103,38	108,27	109,85	104,42	95,76	75,59	72,30	1138,04
13	Rel. tilskud, -	0,58	0,66	0,76	1,10	1,37	1,57	2,07	2,11	1,62	1,09	0,67	0,57	
14	Udnyt. faktor	1,00	1.00	1.00	0.90	0.73	0.64	0.48	0.47	0.62	0,91	1.00	1.00	
15	Varmebehov	53,13	39,07	32,65	0,24	0,00	0,00	0.00	0,00	0,00	0,28	36,45	55,40	217,23
16	Vent. VF (centralvarme)	39,80	36,83	45,81	11,97	0,00	0,00	0.00	0.00	0.00	0,94	27,33	39,80	202,48
17	I alt	92,93	75,90	78,46	12,21	0,00	0,00	0,00	0,00	0,00	1,22	63,78	95,20	419,70