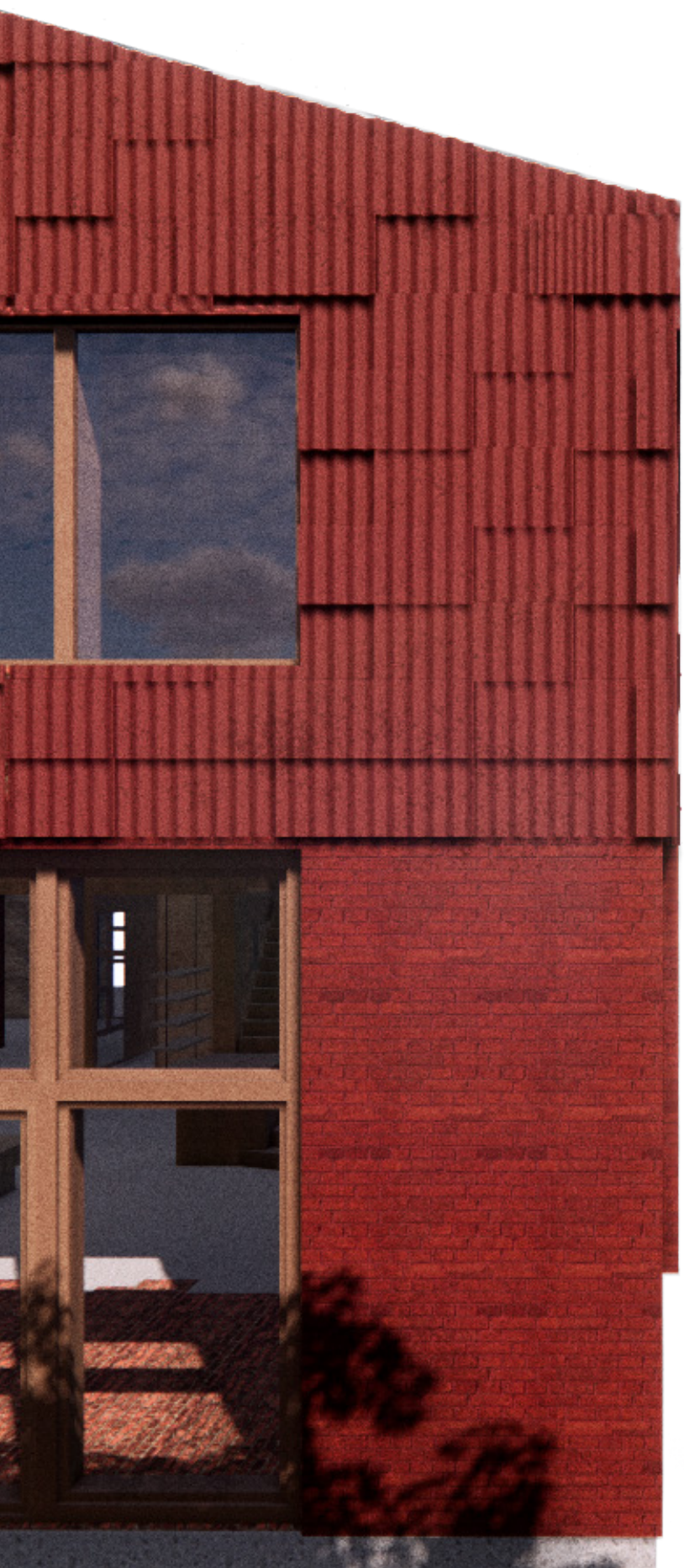
Reused materials

- in a design approach



MSc02
Explorations and Experiments in
Sustainable-tectonic Architectural Design

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Abstract

In this semester project, the objective was to transform a building using reused materials. Circular thinking is integrated a theme to embrace current trends and contribute to the sustainable agenda in the building industry. The project aims to explore challenges and possible solutions when it comes to reuse materials in a transformation project.

Based on a specific case concerning a future development plan of Hjulmagerkvarteret in Aalborg, limitations, challenges and potentials were identified. The project was shaped from two buildings intended to demolition as a critical reply giving a circular exemplary building in the area. Additionally, the design considered available materials from the demolishing plans of the area. From here the challenge was to convert these materials into a new, transformed building for the future Hjulmagerkvarter, aligned with the municipality's vision of creating a public "gate" in this location.

The design process therefore began with a *generator* – the materials available from Hjulmagerkvarteret. The various design studies aimed to solve specific challenges or propose possible solutions, but often, the outcomes also enlightened new challenges. The iterative approach of the design process allowed for a holistic and integrated design proposal, where functionality, materiality, atmosphere, and a sustainable agenda came together to form a cohesive whole. The design proposal establishes a place for small startup businesses to thrive, while also providing a vibrant meeting place that serves as a hub for the area. The design combines old and new elements to create an engaging spatial architecture. By preserving the existing structure and using reused materials, the new identity is built upon the existing. The building reflects a circular, innovative and creative atmosphere that aligns with the future vision of Hjulmagerkvarter and a sustainable suture.

By approaching the design in a different way through various studies, the project is driven by the potential and challenges of incorporating reused materials in a transformation.

Reusing materials, Transformation, Meeting point, Start-up community, Circular thinking

Title paper

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Ill. 1: Factory in Hjulmagerkvarateret

01 Introduction

The following section provides an overall introduction to the project, including the methodology of the design process and motivations. It is be followed by an exploration of selected themes and conditions that form the framework and the direction for the following design development.

Reading guide

This report introduces a process, and its challenges and potential, when reusing materials and incorporating them in a transformation project. Furthermore, it presents the design proposal for how the transformation of the building into a meeting point can take shape.

The report guides the reader through the process from project brief to the design outcome. It is divided into 6 chapters. Firstly, an introduction including methodology and themes, will explain the motivation and factors that formed the framework. The second chapter is a run-through of the relevant theory, analysis and methods used in the project. The third chapter accounts for the project's drivers and scope – Visions, problem, and criteria. The fourth chapter communicates the design process, in a non-chronological order. The knowledge gathered from the different methods and studies led to new studies and informed each other throughout the process. The design proposal will be presented in the fifth chapter and the report will be concluded in the sixth chapter in an epilogue.

Ill. 2: Location in Denmark

Ill. 3: Location in Aalborg, Hjulmagerkvarteret, an industrial area outsite the city center

Ill. 4: Location in Hjulmagerkvarteret, two existing buildings, currently functions as car mechanics

Introduction

This project has been developed in relation to the second master project, *Explorations and Experiments in Sustainable-tectonic Architectural design*, spring semester 2023. The report portrays the process from the project description to the design solution and the challenges encountered and processed. The primary focus of the project is to incorporate limited re-used materials available from the nearby context, to transform a building. The ultimate outcome includes both the design solution achieved and the comprehensive process of designing with re-used materials and managing the associated challenges.

"...embodied carbon emissions are locked in place as soon as a building is built. It is critical that we get a handle on embodied carbon now if we hope to achieve zero emissions by 2040"

(Architecture 2030, 2021)

Given the current critical state, there is a pressing need for a new approach in architecture and the building sector. This approach could call for a fundamental rethinking of how the existing building stock is perceived and utilized. It could emphasize the importance of retrofitting, reusing, and redesigning these structures, harnessing the embodied carbon they already possess. This strategy avoids contributing to the escalating emissions caused by demolition and new construction. The project has been driven by these tendencies and themes from the analysis stage to the final design stage.

The project is informed and limited by a presentation and report presented by Aalborg Municipality, envisioning the development of a vibrant neighborhood that combines the unique characteristics of both the current and historical elements and the character of old and new. They recognize the value of existing characteristics and buildings in elevating the area and creating a unique atmosphere. This project focuses on developing the desire for a gate in the Hjulmager neighborhood, serving as a meeting point and promoting reuse. In the municipality's ambitions of the new neighborhood, they seek showcases and methods on how to develop it, with environmentally friendly aspects in mind. Furthermore, the municipality presented an extensive demolition plan to realize their visions. However, we see a potential in the building as a transformation and reuse project, to question the municipalities intentions of demolishing numerous structures.

The project is not only about transforming a building into a meeting point. For us, it has represented an opportunity to find a different position and approach, leading us towards an explorational and methodological framework that emphasizes the weightage of material and reuse. A project where the materials, to a greater extent, shape the design, and determine the challenges.

Methodology

Integrated Design Process

The structure of this project is based on Mary-Ann Knudstrup's theory *Integrated Design Process, IDP* (ill. 5). Here different phases occur and form each other in an iterative process going back and forth between the different phases. In that way the potential of ensuring an integrated design where both architectural and engineering aspects are a part of the design development. (Knudstrup, 2004). This approach has been used as the framework for the project development.

Since this project has a different approach to the design development than previous projects in terms of Problem Based Learning, PBL, where a certain problem raised in the beginning shapes the direction, this project has a particular case involving a specific material bank. Therefore, the following methodologies are applied to explain the different design process, when comparing to previous semester projects.

Generator - Conjecture - Analysis

In Bryan Lawson's book *"How Designers Think"* a diagram by Jane Darke, a research student, propose a map of the design process consisting of three stages: *generator, conjecture, analysis* (ill. 6). She suggested that designers first should identify what they believe to be an important aspect of the problem, create an initial design based on this idea, and then examine it to gain further insights into the problem. (Lawson, 2006)

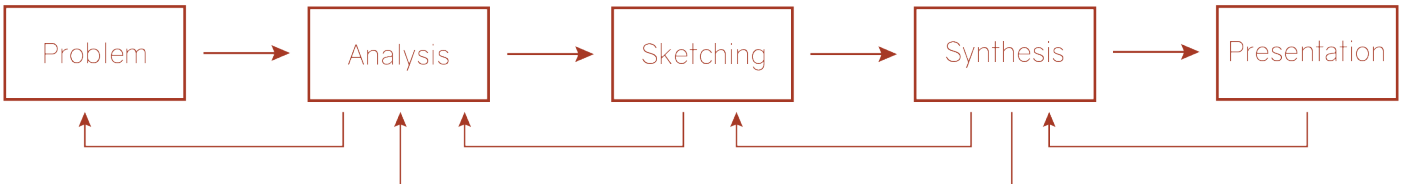
This process can be seen as an interpretation of the method used in our design process, where the potential use of reused materials serves as a generator that leads to further exploration and challenges. Additionally, instead of having the problem statement drive the process from the beginning, the process repeatedly utilizes challenges in implementing reused materials as drivers to guide the process.

Divergent, Emergent, Concergent

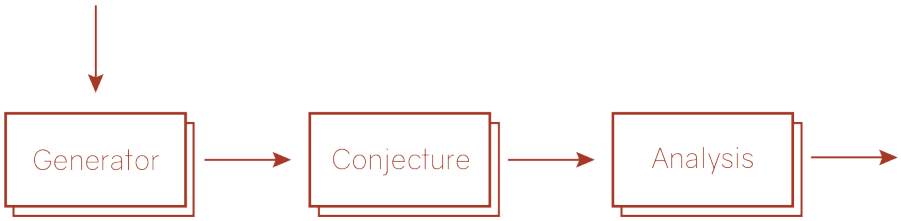
When discussing the use of a generator to initiate a project, Jane Darke's concept aligns with Charles Leons' three thinking modes: *Divergent, Emergent, and Convergent (ill. 7)*. These modes can effectively describe the design process and provide an understanding of how new possibilities led to further exploration and how selected opportunities were evaluated and narrowed down.

During the design development, the process involved exploring new possibilities, initiating studies, and adapting through the Divergent mode. *Divergent thinking* embraces the generation of a wide range of ideas, allowing for exploration and potential discoveries. *Emergent thinking* arises when unforeseen possibilities emerge through the comparison and combination of generated ideas. It helps in identifying and utilizing opportunities, refining understanding, and generating new ideas or challenges. The studies conducted in this design process have led to new insights or altered the direction of the project. The *Convergent* mode gradually narrows down the range of possibilities and directions. It requires a more analytical and critical approach to evaluate and select options and solutions. (Charles Leon, 2020)

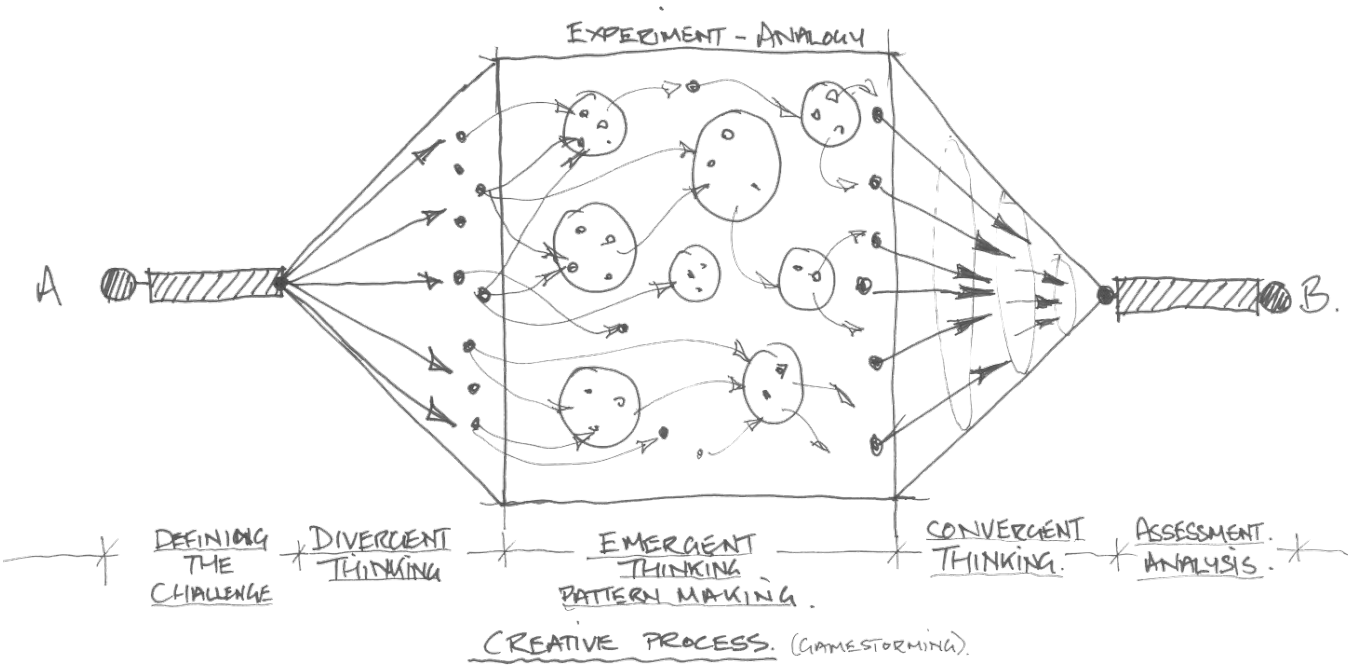
In the design process, where the goal is to establish an iterative process that ensures continuous learning and informative outcomes, the thinking modes of *Divergent, Emergent, and Convergent* matches our process starting with a *Generator*.



Ill. 5: Integrated Design Process. Illustrates an iterative process, where different phases inform each other



Ill. 6: Diagram illustrating Jane Darke's map of the design process



Ill. 7: Illustration by Charles Leon showing the three thinking modes: Divergent, Emergent, Concergent

Ill. 8: Construction site, Aalborg

Environment

Today, the construction industry is responsible for approximately 50% of the materials produced and accounts for over 35% of the waste generated in the EU (Frederikshavn Boligforening a.o., 2021). Additionally, building materials and processes contribute to 10% of Denmark's CO2 emissions (Climate Partnership, n.d.) Therefore, the construction sector is in t need to rethink its approach to architecture and implement measures to minimize its climate impact. It is crucial to reconsider the material usage, prioritize sustainable alternatives, and embrace circular thinking in both the design and construction processes.

From the 1st of January 2023, new climate regulations will be introduced in the building industry to reduce CO2 emissions from constructions. This means that all new constructions will be required to provide documentation of their climate impact through a Life Cycle Assessment. These regulations will gradually become stricter leading up to 2030, with a target of reducing the CO2 equivalent limit value by 40% per square meter per year. (Bolig og Planstyrelsen, 2022)

Additionally, the Danish government aims to incentivize the use of recycled materials in construction by exempting them from CO2 emissions tax starting from the 1st of January 2024. (Holt, Julie R. H., 2023) By implementing these changes, the Danish government hopes to drive the building industry towards more sustainable practices, encourage innovation, and explore new approaches to construction for a better future.

"It is an industry that doesn't do anything until it has a gun to its head, so there is a need for a measure like this."

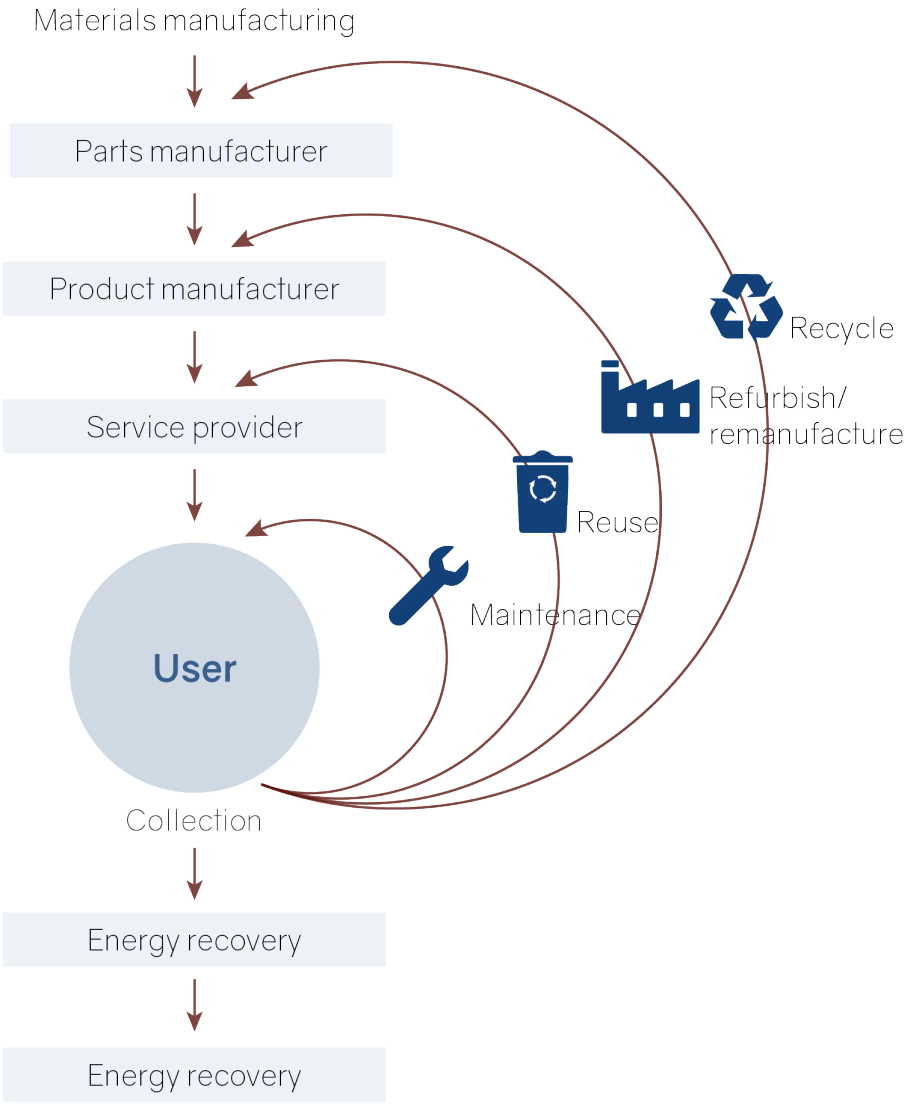
(Holt, Julie R. H., 2023)

By implementing these changes, the Danish government hopes to drive the building industry towards more sustainable practices, encourage innovation, and explore new approaches to construction for a better future.

Circular economy

Circular economy could be a part of the answer when it comes to climate crisis and lack of materials and is about a more environmentally sustainable approach to the building sector. The long-term vision for a circular economy in the construction industry is that the sector is driven by regenerative energy sources and solutions. It involves harnessing the resources available within existing buildings and avoiding primary production of materials and products. This contribution aims to address current climate challenges, resource scarcity, and the biodiversity crisis. (Realdania, 2023)

The circular economy diagram (ill. 9) illustrates how the flow of materials in the construction industry is circular. In the cycle products and materials are kept in circulation due to processes as recycling, remanufacturing, repair and reuse.



Ill. 9: Circular economy. Diagram showing how products and materials are kept in circulation through different processes

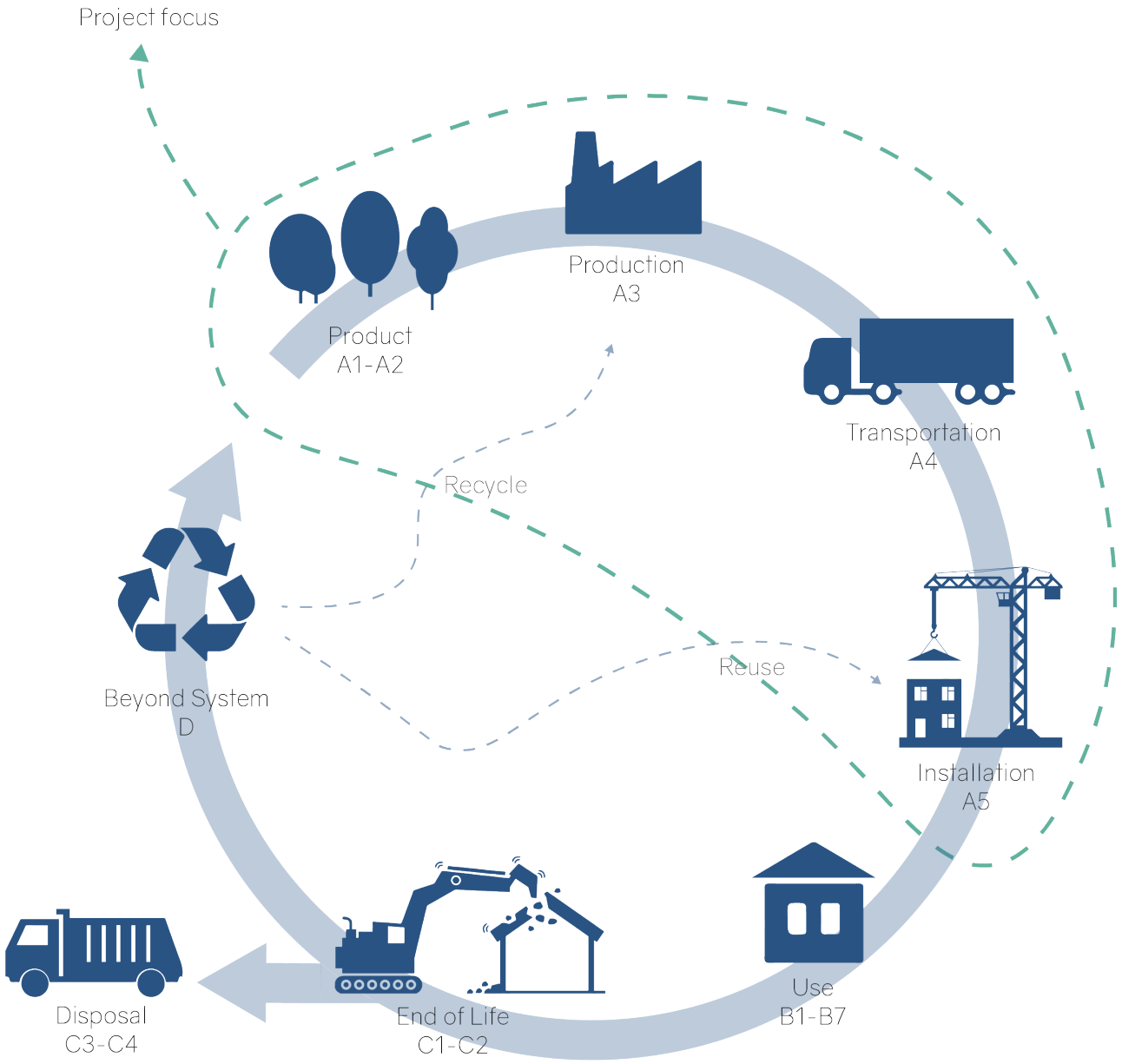
Aalborg Municipality aims to develop a circular city area in the former industrial Hjulmagerkvarter. Thus, the objective is to implement a circular and holistic approach to the design, reusing materials and transforming a building. An aim could be to introduce methods and a more circular building in Hjulmagerkvarteret by giving an example.

Life Cycle Assessment

To analyse and assess the environmental impact of the buildings or products over its entire life cycle, a *Life Cycle Assessment* (LCA) can be developed. LCA is a standardized method for evaluating potential environmental impacts of products and services. The method involves quantifying resource use and environmental impact, enabling quantitative comparisons between different solutions. (Kanafani, Kai, 2019)

The LCA analysis is divided into several stages (ill. 10). The main stages are product, construction, use, end of life and beyond the system boundary.

In this project, which focuses on reusing materials and transforming existing buildings, there will be a specific emphasis on Stage A. During this stage, conceptual *Environmental Product Declarations* (EPDs) will be developed, taking into account the specific conditions and necessary treatments and processes required for different materials. By employing this approach, the circular economy can be assessed and compared based on its Global Warming Potential and thereby evaluating its environmental impact.



Ill. 10: Life Cycle Assessment diagram illustration the different stages in the life time of a material

Product
A1: Raw material supply
A2: Transport
A3: Manufacturing

Construction process
A4: Transport
A5: Installation process

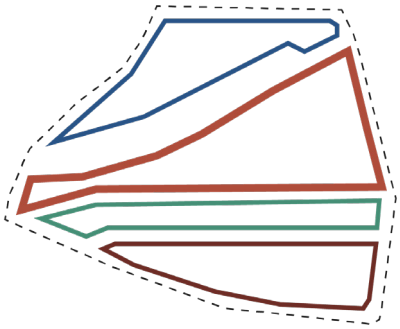
Use
B1: Use
B2: Maintenance
B3: Repair
B4: Replacement
B5: Renovation
B6: Operational energy use
B7: Operational water use

End of life
C1: Deconstruction demolition
C2: Transport
C3: Waste processing
C4: Disposal

Beyond the system boundary
D: Reuse, recovery, recycling potential

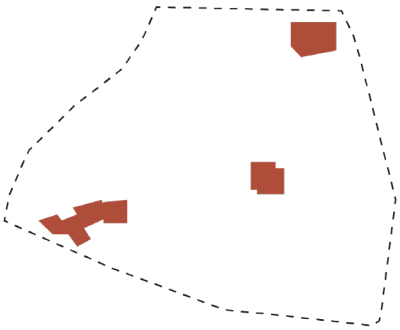
Aalborg Municipality

Aalborg Municipality is planning to develop Hjulmagerkvarteret in Aalborg in the future. They have drawn some initial iterations and thoughts on the vision, identity, and functions for the area. The entire neighborhood should contain a variety of urban qualities, dwellings, and businesses (Aalborg Municipality, 2018). The vision aims to preserve the existing identity of the area by maintaining and reusing existing structures and buildings instead of introducing new materials, thereby contributing to a more sustainable city development.



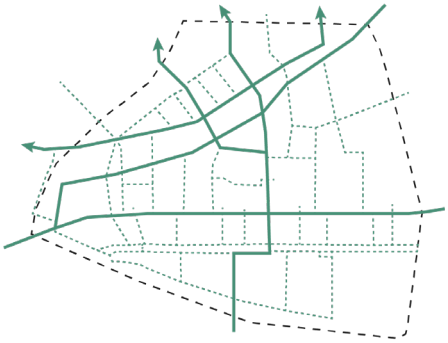
Ill. 11: Future subareas

The plan involves dividing the area into four different zones, each with a unique identity and set of characteristics. Additionally, the intention is to establish gates in each subarea, serving as attractive points for people functioning as public meeting places.



Ill. 12: Placement of gates or attractors in the future Hjulmagerkvarter

This project will focus on developing one of the gates in the future Hjulmagerkvarter, specifically the one located in the middle in the subarea called Hjulmager Nord. The building should serve as a meeting point for the neighborhood residents and also draw people in from the rest of the city, creating cultural experiences and bringing attention to the area. The identity of the building must align with their aspirations of circular thinking and reuse. In the presented plan, the municipality states the specific subarea as a thriving primary business area complemented by smaller residential units. This subarea becomes a part of the broader plan to further develop a mixed-used neighborhood incorporating businesses, housing, public functions, and liberal professions. (Aalborg Municipality, 2018)



Ill. 13: Paths and flow of pedestrians

Ill. 14: Visualization of an urban buisness area in future Hjulmager Nord

Summary

Through an iterative design process, the development of the design proposal aims to utilize the reuse of materials as a design generator. By exploring the potentials and challenges, the design process will proceed in a different sequence than we are used to in semester projects, focusing on how the materials can shape the design.

By adopting a circular thinking approach in this project, the process and design proposal not only align with current trends but also embody the municipality's vision. Through the transformation and utilization of reused materials, the project facilitates the exploration of methods and tools that are relevant to the building industry and architecture. These efforts are crucial for reinventing and reimagining processes in a sustainable future.

The following section will begin by analysing the materials available and the conditions of the existing building as a basis for the following design development.

Ill. 16: Hjulmagervej

02 Analysis

This section introduces the process of mapping materials from Hjulmagerkvarteret, identifying potentials and challenges in order to establish a material library for the design development. Furthermore, analysis of the existing structure, identity of the area and relevant theory are explored.

Tools

In this phase, various methods and tools have been employed to analyse both the existing building and the materials available in Hjulmagerkvarteret. Different potentials were showcased, but at the same time, challenges related to the approach of reusing and transforming were identified.

Furthermore, theories concerning a sustainable-tectonic approach were investigated to guide the direction of the design development and provide a theoretical perspective on how to create architecture that is not only aesthetically pleasing but also adopt the principles of circular thinking.

The analysis formed the foundation for the subsequent design process and led to the establishment of design criteria, which will be presented in *03 - Design Drivers*.

Material mapping

Analysing and mapping material properties of materials available in the demolishing plan presented by Aalborg Municipality. Through this method, amount, accessibility, new purpose, physical properties and lifetime associated with these materials was explored and established a framework for integrating them into the design solution.

Existing building

Through an analysis of the conditions of the existing buildings on the project site, potential opportunities for preserving and transforming the existing structural elements and materials were discovered. This analysis provided insights into the structural principles and revealed potentials and challenges according to the use of the existing buildings.

Phenomenological

Considering Aalborg Municipality's visions for the future identity of the entire Hjulmagerkvarter, an exploration of the existing identity in terms of spaciousness, materiality, and function was conducted. This process aimed to gain a deeper understanding of the current atmosphere in the area, which would subsequently influence the creation of a new identity that builds upon the existing.

Theories and case studies

Our discipline touches a broad spectrum of our daily lives, and encompasses more than just form, function, and techniques. It entails an awareness of the reality we build into, as well as the affect it has on individuals residing within it. Through theories and case studies we seek knowledge through solutions and challenges. In this project we use case studies to establish limitations when framing and designing our functions and typology. *Where has it worked, and what where the challenges?* By examining professional positions in, for example, sustainable tectonics we can make design choices based on a professional argumentation, that align with our own position.

Sustainable - tectonic

Tectonic in architecture refers to the study of the relationship between the structural and constructional systems of a building to create and form a whole. The Austrian architect and architectural historian Eduard Franz Sekler (1920-2017) explored the importance of tectonics in architecture. Based on the history of architecture, Sekler tried to understand the spatiality that is created through architecture, urban design and engineering, in relation to the human scale and perception (Hvejsel & Foged, 2018). In his paper *Structure, Construction, Tectonics* published in 1965 Sekler distinguishes between the terms structure, construction and tectonics. He writes about structure and construction:

"Structure as the more general and abstract concept refers to a system or principle of arrangement destined to cope with forces at work in a building, such as post-and-lintel, arch, vault, dome and folded plate. Construction on the other hand refers to the concrete realization of a principle or system – a realization which may be carried out in a number of materials and ways" (Sekler, 1965, p. 72)

Where structure and construction are generic, Sekler describes tectonics as being what happens when structure and construction presupposes a spatially experienced architecture that touches people empathically.

"... the tectonic statement: the noble gesture which makes visible a play of forces, of load and support in column and entablature, calling forth our own empathetic participation in the experience."
(Sekler, 1965, p. 77)

Sekler argues that tectonics should be a fundamental concern for architects, as it is through the integration of construction and structure that a building can achieve both functional and aesthetic coherence. He emphasizes the importance of a building's structure being expressed through its form and underlines the need for architects to consider the constructional methods and materials used in a building's design.

In 1981 the Italian architect and architectural theorist, Marco Frascari (1945-2013) published his essay *The Tell-The-Tale Detail*, in which he discusses the notion tectonics implicitly and the role of tectonic thinking in architecture (Hvejsel & Foged, 2018). Frascari's essay explores the idea that tectonics can be seen as a form of storytelling within architecture. He argues that the details of a building's construction and structure can convey meaning and narrative, and that architects should aim to create a sense of continuity between the building's form, structure, and construction.

"...study the detail as a joint. Architecture is an art since it is concerned with not only the original need of shelter, but in putting together in a meaningful manner spaces and materials." (Frascari, 1981, p. 93)

Frascari suggests that one examine the meeting between volume and surface through his own idea of the junction, the collection, in interaction with Sekler's gesture and principle (Hvejsel & Foged, 2018).

Both Sekler and Frascari highlight the importance of tectonics in architecture, emphasizing the need for architects to consider the relationship between a building's structure, construction, and form. What Sekler and Frascari does not discuss in their respective books is the sustainability aspect of the construction, structure and details in architecture. When those texts were written, sustainability were not a topic being discussed in the field of architecture.

The future of architecture will require us to think and build in a more sustainable and circular way. Contemporary architects and theorists are now coming up with new ways to manifest and add notions such as sustainability as an essential part of contemporary tectonic thinking and architectural practise. Anders Lendager's book *A changemaker's guide to the future* from 2018 and Anne Beim's *Circular Construction* from 2019 are both examples on how current architects manifest themselves in the field and how they suggest we start to think and build architecture. They both explore the importance of sustainable and circular approaches to architecture.

"... we must work actively to minimize the consumption of resources in the building industry and make sure that existing resources re reused at the highest level in the biological, technical, and cultural value chain."
(Beim, 2019, p. 26).

Beim manifests the idea of designing buildings that can be deconstructed and the materials reused or recycled. She emphasizes the importance of designing buildings with modular and flexible systems, so that they can be adapted to changing needs over time.

Likewise, Lendager argues that the future of architecture must be based on a circular economy model, where resources are used in a closed-loop system, minimizing waste and reducing the environmental impact of the building industry. They emphasize the impor-

tance of designing buildings that are not only energy-efficient but also made from sustainable and recycled materials.

"Circular design is about changing our methods. We need to rethink our products and our business models. We need to completely disable the connection between the individual citizen, company and society from the consumption of virgin resources and materials. And we must do so without compromising on aesthetics, quality, economy or our environment." (Lendager, 2018, p. 56)

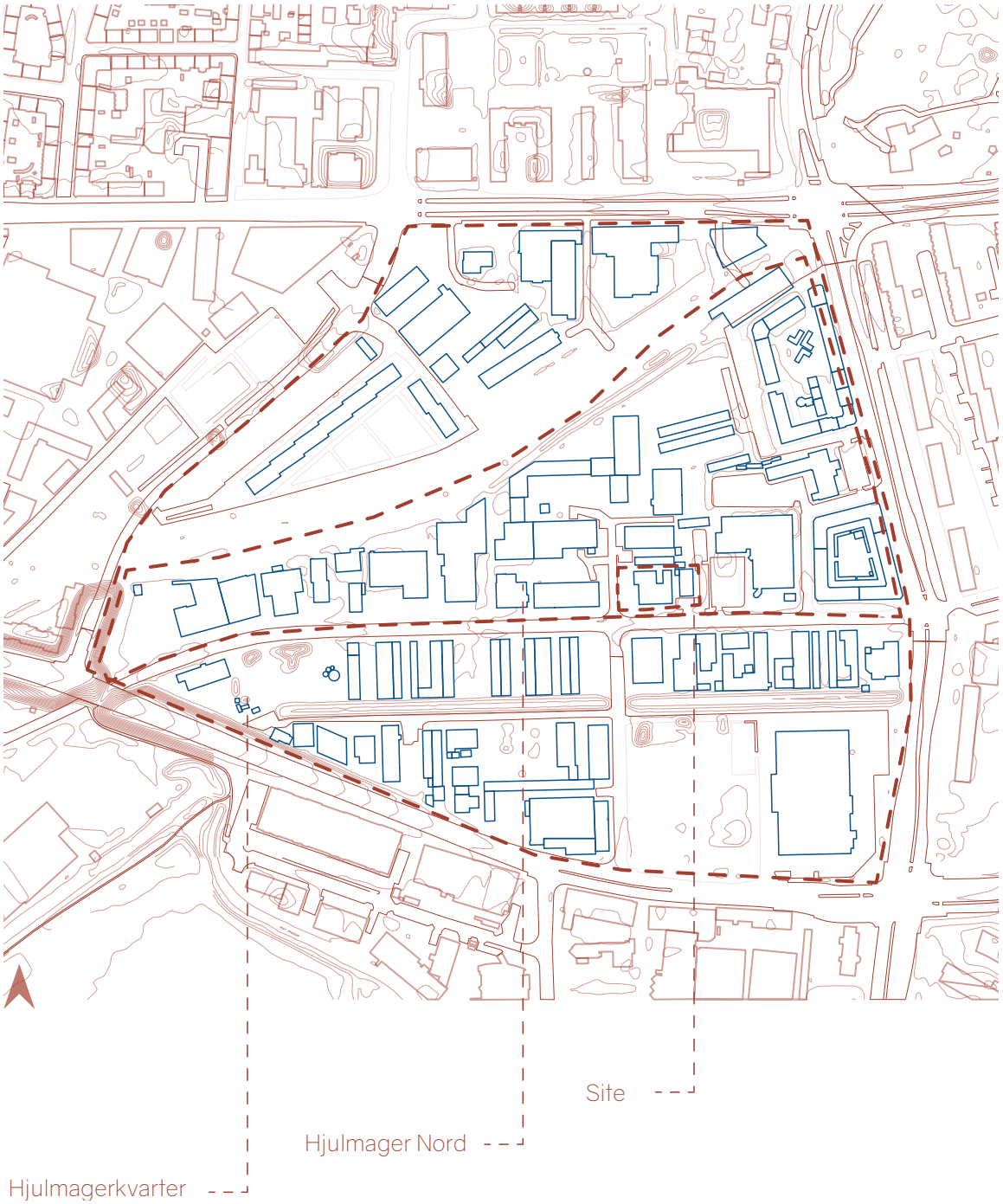
Both Lendager and Beim highlight the importance of considering the entire lifecycle of a building, from construction to eventual deconstruction, in order to minimize waste and maximize sustainability.

In this project the arguments presented by Lendager and Beim about sustainability in architecture can be combined with Sekler's and Frascari's definitions of tectonics to create buildings that are not only visually and functionally compelling but also environmentally sustainable. By combining these principles, architects can create buildings that are not only visually interesting but also environmentally responsible. This integrated approach to architecture can help reduce waste, minimize environmental impact, and create buildings that are adaptable to changing needs over time, where everything comes together in the final design; function, materiality, atmospheres and tectonic approaches and sustainable agenda; together forming a bigger whole.

How can this project create spacious architecture with an attractive and vibrant atmosphere using reused materials for people to gather?

"Design the world of tomorrow with the waste of today. While working towards designing a world without waste"

(Lendager, 2018, p. 58)



Ill. 17: Hjulmagerkvarteret, 1:4000,The map illustrates the whole Hjulmagerkvarter , the subarea Hjulmager Nord, and where the project site is placed

Site

At the project site today, the Municipality envisions creating a remarkable *"Gate"* that serves as a hub for public functions and spaces for people to gather. Within this site, several existing buildings currently stand. These buildings serve as car mechanics and polisher. They consist of two main structures and two smaller extensions (ill. 18-19). While the Municipality's initial plan suggests demolishing these structures, this project strives to embrace a sustainable approach and honour the circular identity the municipality desires. Therefore, the aim is to transform the existing buildings, preserving as much of their original character as possible, while incorporating reused materials sourced from Hjulmagerkvarteret.

By adopting this approach, the project seeks to challenge the current plans for Hjulmagerkvarteret and to demonstrate a more visionary way forward. It aims to exceed expectations by presenting a heightened level of transformation and utilization, thereby setting a new standard.

Ill. 18: Hjulmagervej 14

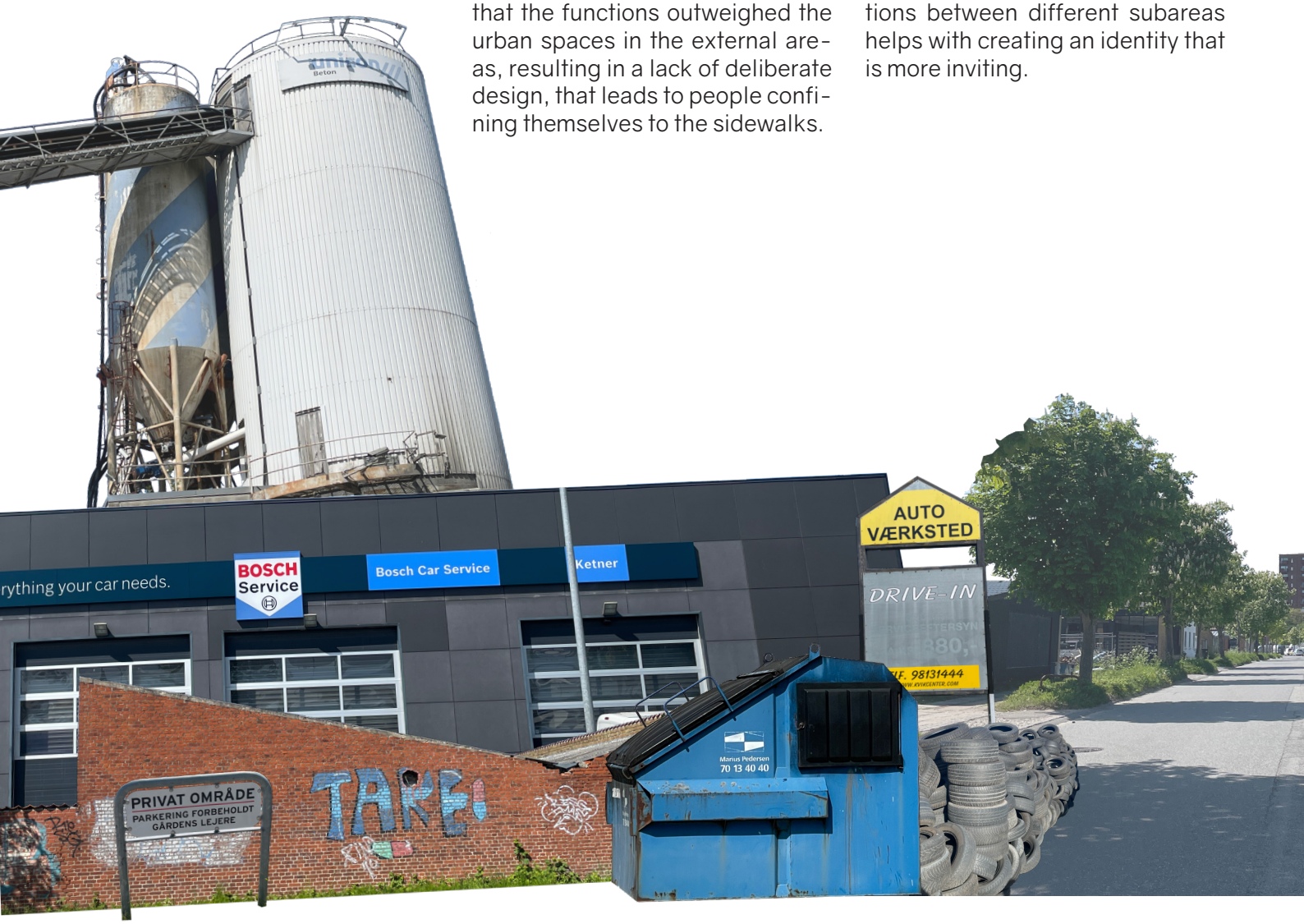
Ill. 19: Hjulmagervej 16

Identity

The buildings within the site and its near surroundings convey a narrative and distinct identity through the present materials and the way functions are prioritized. The area is considered to be the first business district of Aalborg, which brings a historical trace evident in its built environment. The buildings reflect a sense of rationality, a well-defined infrastructure and a homogeneity and is accommodating various crafts, car workshops, and small businesses. The buildings are experienced as immovable and static where their predominant use of bricks, concrete, and steel panels is experienced as the defining elements of their aesthetic.

A continuous, spacious road lined with chestnut trees follows the southern border of the sites, establishing a pleasant rhythmic atmosphere. This could potentially contribute to a recreative area with more activities in future developments. However, it is evident that the functions outweighed the urban spaces in the external areas, resulting in a lack of deliberate design, that leads to people confining themselves to the sidewalks.

In relation to Aalborg Municipality's envisions the new area's identity is to reflect the areas business and historical history by building upon existing structures. A part of this contains an architecture, with re-use, large footprints and orthogonality. They desire the subarea to be known as a thriving district with a unique character, highlighted by thoughtfully designed urban spaces between existing buildings and small businesses. The re-designing of Hjulmagervej to be a more human-centric space and establishing smooth transitions between different subareas helps with creating an identity that is more inviting.



Ill. 20: Collage of images from Hjulmagerkvarteret - identifying the identity and materiality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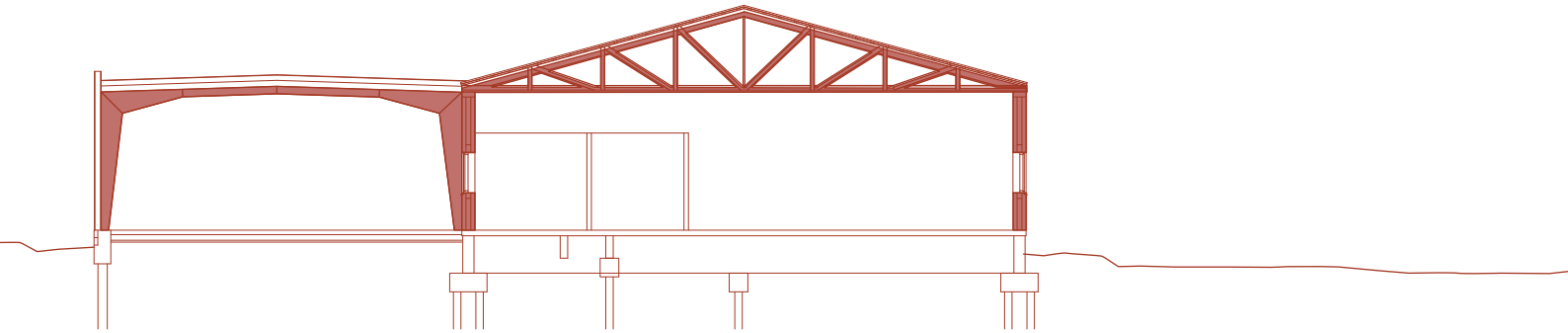


Ill. 21: Section of the structural elements in the existing buildings, 1:200

Transformation

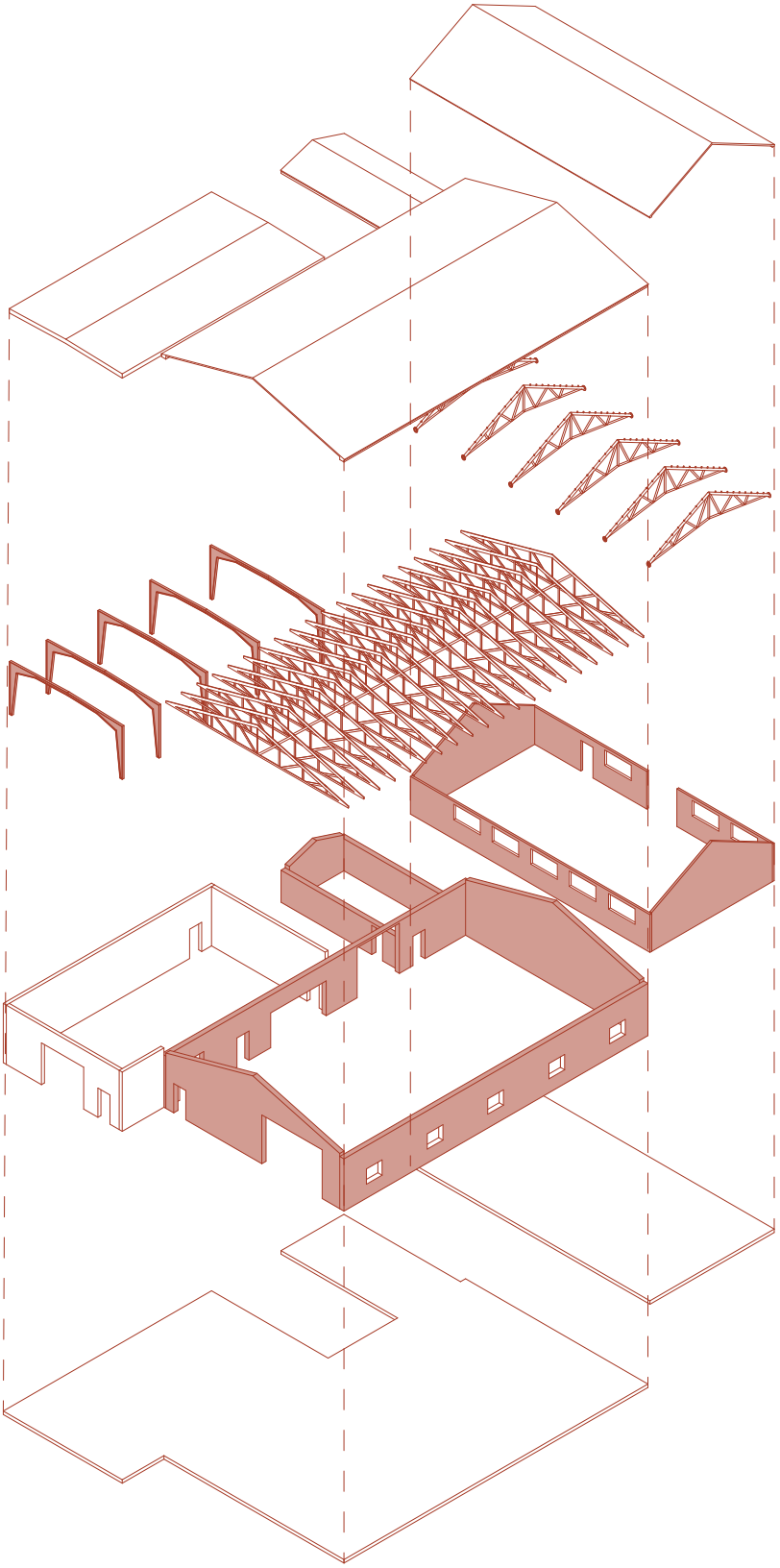
The existing buildings and their potential for transformation have been thoroughly analysed and evaluated (Analysis based on available drawings, Appendix 1). Each building varies in terms of age, materials, and structures.

The red brick building is supported by 0.35 m load-bearing brick walls. These walls consist of two layers of bricks with a 0.05 m rock wool insulation layer between. The interior walls are covered with a plaster layer. The roof is upheld by wooden trusses with a span of 1.45 m. Corrugated steel boards directly attached to the trusses serve as the roof covering. The trusses are concealed by a double layer of 0.05 m rockwool insulation and plaster, secured with formworks. The building rests on deep foundations, with a continuous concrete beam measuring 0.6 m to 1 m in height supporting the walls. Footings are placed beneath the building at a relatively consistent distance from each other, and depending on the size of the footing, one to two concrete piles are attached to them.

The extension of the red brick building is sustained by 13 steel frames. The external walls consist of a 0.15 m insulation layer and an inner cladding of plaster. The extension features a flat roof supported by a steel roof deck, which in turn is carried by the steel frames. The roof is insulated with a 0.14 m thick layer of rockwool. Similar to the other buildings, footings are constructed beneath each column of the extension, with one concrete pile attached to each footing.

The yellow brick building shares similarities with the red brick building. Its load-bearing structure comprises two layers of brick with a 0.05 m insulation layer. Iron trusses support the roof, which is covered on the inside by a low hanging ceiling. Like the other buildings, the yellow brick building also rests on deep foundations.

Due to the current use of the buildings as car mechanics, the project will proceed under the premise that all existing load-bearing structures and walls are to be retained. This implies that the inner walls, cladding, and roofs will be removed due to their conditions. Additionally, in order to ensure an acceptable u-value and indoor comfort, insulation needs to be added. Therefore, the project aims to preserve and build upon the existing constructions, maximizing their potential for transformation.



Ill. 22: Isometry of existing buildings, illustrating the existing structure

Existing buildings
Reuse potentials

Building	Materials	Reuse potential	Main Value
	materials, elements, objects etc.	• condition/quality • amount/availability • preserve • repurpose	☐ environmental ☐ social ☐ economical
1. 396sqm	Concrete floor	• amount • preserve *[if sanded = simple aesthetic concrete floor]*	environmental *[concrete has a high GWP value]*
	Ventilation pipes	• condition/quality • preserve	social *[identity]*
	Carports [all three buildings]	• preserve *[transparent, kept for the history and cost saving, but has low u-value]*	economical *[not considering the high u-value]*
	Bricks	• condition/quality • amount • preserve	environmental *[well conditio-ned durable brick walls]*
	Concrete plaster	• preserve *[plaster on loadbearing brick layer needs treat-ment.]*	environmental *[well conditio-ned durable brick walls]*
	Wood truss	• condition/quality • preserve *[high quality aesthetic strucutral elemtents]*	environmental *[replacement not needed + aesthetic value]*
2. 157sqm	Wall Construction	• preserve • repurpose *[Keep walls or reuse insu-lation + steel boards]*	environmental *[insulation and steel has high pro-duction GWP]*
	Metal structural elements	• preserve *[could be treated for aesthetic reasons, but not needed]*	environmental *[well conditioned structural ele-ments]*
3. 195sqm	Metal truss	• preserve *[treated for aesthetic rea-sons, not needed]*	environmental *[well conditioned elements]*
	Acoustic panels	• amount • repurpose *[place them differently to improve the acoustics]*	social *[improve indoor climate, reduce nuicances]*
	Bricks	• condition/quality • amount/availability • preserve *[keep the walls as they are]*	environmental *[well conditioned durable bricks]*
	Car lift	• preserve *[to indicate the use of the building before]*	social *[identity]*

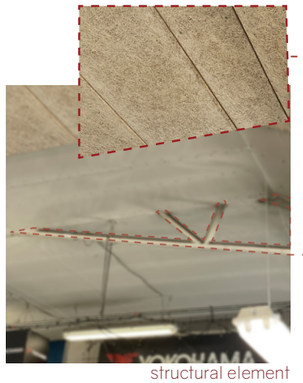
Ill. 23: Existing buildings, floor plan 1:200. Pictures illustrates, what the existing building looks like and where different materials are placed in the buildings

walls
Concrete plaster

interior
Ventilation pipes

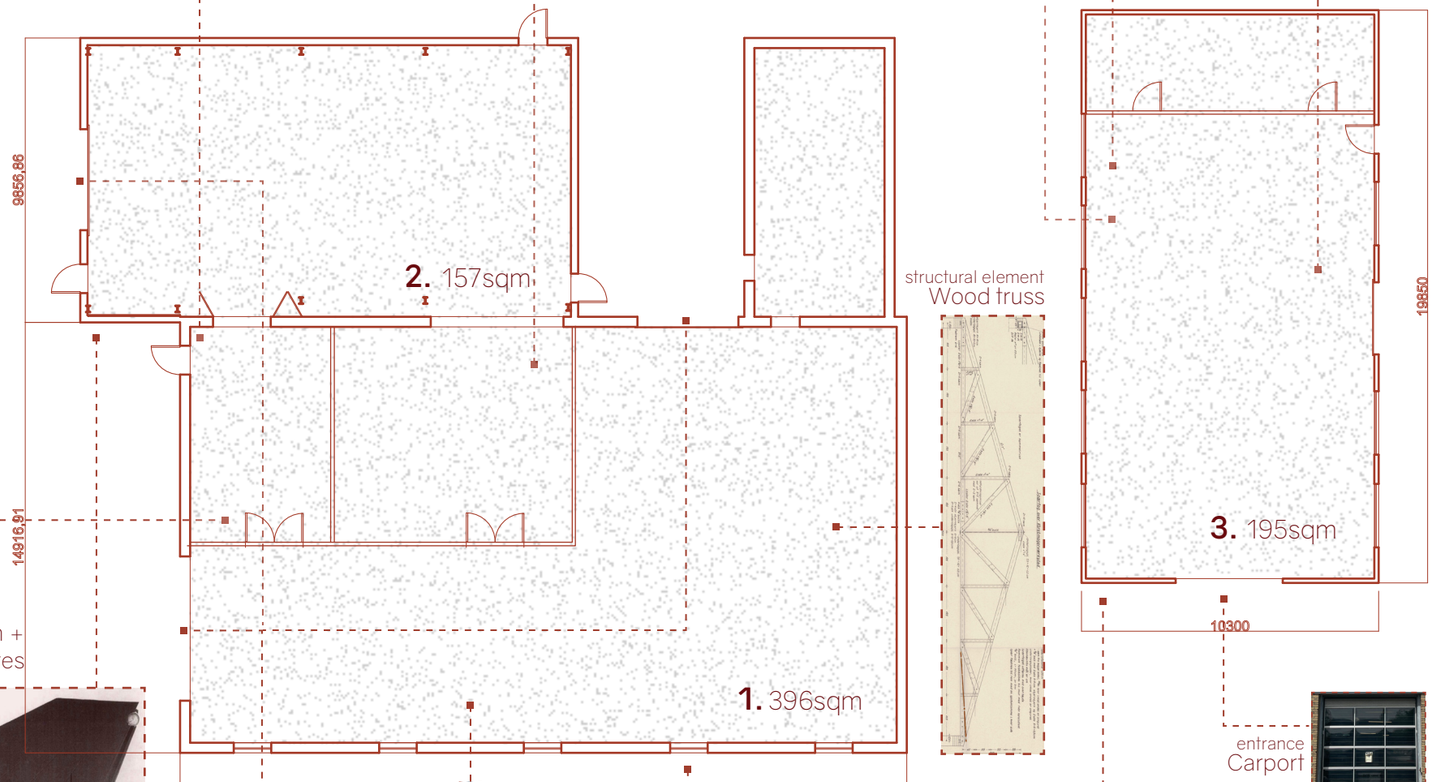
interior
Concrete floor

ceiling
Acoustic panels



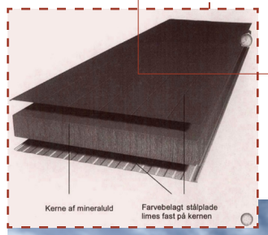
structural element
Metal truss

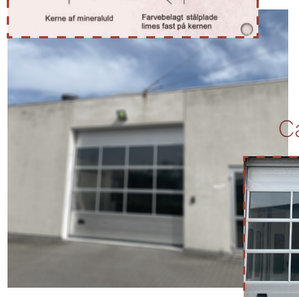
interior
Car lift



structural element
Wood truss

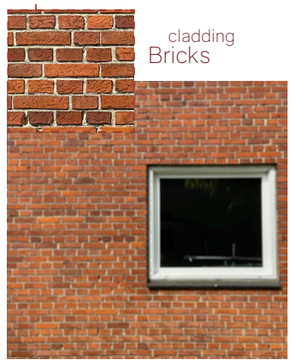
Insulation + metal plates





Carports

cladding
Bricks



entrance
Carport

cladding
Bricks

Material mapping

Ill. 24: Hjulmagerkvarteret, 1:4000, illustrating which buildings are going to be preserved, transformed and demolished

Steel


1.


2.


3.


4.

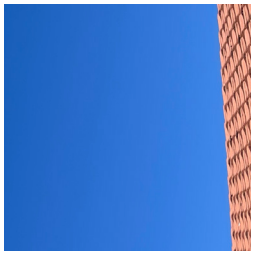

5.

Brick


6.


7.


8.


9.

Wood


10.


11.

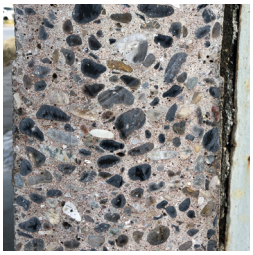

12.


13.

Slate


14.

Concrete


15.

Window


16.


17.


18.

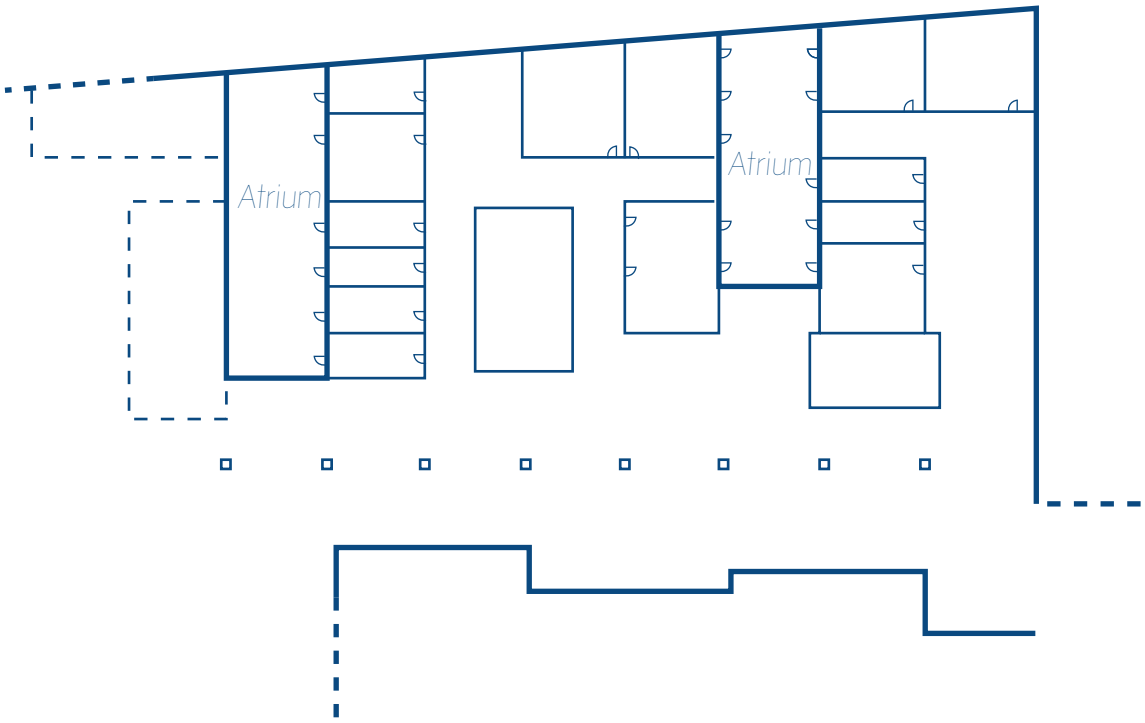

19.

Ill. 25: Pictures of selected materials available in Hjulmagerkvarteret, with further explanations of their properties on the next pages

Type	Material	Properties	Current use	Reuse potential parameters			
				Cleanliness + condition (would it need cleaning or treatment before use?)	*Amount: (not considering waste from demolition)*	*Availability*	*Quality: age, strenght etc. (would be investigated further in the reuse process part)*
Steel	1. Steel board squares 60x60cm	Durability, Easily reused, diffusion closed, weather profness	Cladding	Aesthetic treatement (painting)	+/- 15m²	Easily accessible	lifetime: atleast 69 years (100 years from new)
	2 - 4. Steelboards (2m x 5m) 18mm sinusplate	Durability, Easily reused, diffusion closed, weather profness	Cladding applyed only using screws	Aesthetic treatement (painting)	Material > 500m^2	Easily accessible	lifetime: atleast 69 years (100 years from new)
	5. Steel beams/coloumns	Structural elements, outside structure (weather proof)	structure for a shelter	Painting and probably weather protection	5	out of the building but heavy and fixed to concrete foundation	lifetime: atleast 100 years
Bricks	6. Red Bricks	Durability, weather profness	cladding (Bearing wall ?)	Treatment to increase lifetime (more mortar)	Material > 500m^2	composed with mortar, maybe bearing wall -> difficult to access	lifetime: atleast 100 years
	7. Yellow Bricks	Durability, weather profness	cladding (Bearing wall ?)	Treatment to increase lifetime (more mortar)	200<x<400m²	composed with mortar, maybe bearing wall -> difficult to access	lifetime: atleast 100 years
	8. Painted White Bricks	Durability, weather profness	cladding (Bearing wall ?)	Treatment to increase lifetime (more mortar)	200<x<300m²	composed with mortar and painted, maybe bearing wall -> difficult to access	lifetime: atleast 100 years
	9. Roof tiles	Durability, weather profness	roof cladding	clean for mold and replacement of the felt underlayment	200<x<300m²	easy to access	Lifetime: whithout felt underlyament: at least 50 years; otherwise: 20-40 years
Timber	10. Wood planks	Weather proofness	cladding	weather proofing maintenance	10<x<100m²	easy to access	Lifetime: atleast 10 years left (from new 25 years)
	11. Timber Frames (glulam 13,8 * 57 cm) 30,7m of span	Structural Elements	roof structure	structural checking	10	inside the building and heavy	lifetime: atleast 100 years if maintained throughout the years, dating from 1961 (62 years old)
	12. Wood trusses + steel columns	Structural elements	structure for a bike shelter	Need to be tested and cleaned/painted	34	out of the building but heavy and fixed to concrete foundation	Lifetime: 100 years but wood requires more maintenance if used outside
	13. Troldtekt (wood wool boards) white or natural	Acoustic qualities, light	interior ceiling, acoustic panels	Need cleaning (without the use of water), repainting	Material > 1500m²	small size and light unit + outside layer, no use of glue just screws	Lifetime: 80 years
Other	14. Fiber-ciment eternitskifer	Insect and Flame resistant, moisture and UV resistant	cladding	cleaning by pressure washer but should be painted/ finished	x>50m²	outside layer, put on the wall with tiny angled metal connectors	Lifetime: at least 100 years if well maintained, but the finish lasts at least 10 years - Dating from 1992
	15. Concrete wall (urban)	Strong at reciving compression, loadbearing	Urban area wall , avoid visual connections between areas and divide them	would need cleaing and treatment before reuse	120<x<200m²	Outside wall detached from any other material except the ground	at least 100 years
	16 - 19. Windows (All)	wood = +/-thermal insulating, Aluminum= stress and weather resistant	External windows	Aluminum and PVC doesnt need a lot of maintenance but wood does		Glued to the wall	Glass has long lifetime but depending on the frame, the lifetime may vary: wood=20 years, aluminum=45 years, PVC= 25 years

Function potentials				
Envelope: outer layer, inner layer, vapor barrier, wind barrier	*Structural element: (÷weather proffness properties)*	*Interior use: (÷weather proffness properties ÷structural properties)*	*Urban use: (U-value not important, temporarity as a quality)*	*Deconstruct: (÷weather proffness properties ÷structural properties)*
Outer layer (walls)		inner layer (needs to be able to breath)		
Outer layer (walls or roof)		Inner layer (walls or ceiling)	Wind barrier	Cut in smaller elements for furhter exploration of expression
Main strucutral elements in the construction	beams and/or column	aesthetic objects, exhibition framing/indicating,	shelter structure, framing/indicating purpose, identity indicator/landmark	cut in smaller pieces for more optimal use, seperate beam and column, seating
Outer layer (walls), inner layer	Loadbearing wall Roof arches Columns inside	inner walls, room divider, floor, seating	sheltering walls, framing elements, pavement, seating, greenery boundaries	Brick elements 1x1m, 1x2m etc. if mortar has cement, crushed and put in concrete, smaller bricks
Outer layer(walls), inner layer, roof		inner walls, room divider	sheltering walls	crushed and put in concrete
cladding(only 10 years), inner layer		Ceiling, inner wall cladding, acoustic panels	Sheltering walls, benches, tables, railing	
	loadbearing construction, beams, columns,		shelter structure, framing/indicating purpose (if weather proof coating)	Cut into: smaller beams, smaller columns, flooring, staircase, ceiling, wall cladding, furniture etc.
	Structure for low roof, structure for extension of roof, structure for floating building parts	room divider, function indicator, room inside of room, wood for railing		seperate truss from steel
inner layer		wall cladding, ceiling, room divider		Cut in smaller elements for furhter exploration of expression and acoustic qualities
Cladding (could be painted), inner layer, roof		Ceiling, inner wall cladding	Sheltering wall/roof cladding,	
		floor, room divider	sheltering walls, plinth, pavement	
windows, buffer space, roof windows		room divider, windows	greenhouse	seperated from current frames, and constructed into 2 or 3 layered windows with addition of new frame

III. 26: Table identifying the properties of the materials shown on previous page. Reuse potentials and function are evaluated



Ill. 27: Extract of floor plan of Spinderihallerne, 1:500. Illustrates the placement and size of the studios and furthermore the space in between the studios for workers to gather and guests to visit

Spinderihallerne

In 2010, the former cotton factory, Spinderihallerne, located in Vejle, reopened as a vibrant hub dedicated to design-driven innovation and business development within the creative industry. The transformation of the buildings not only reflects the history of Vejle's shift from an industrial society to an experiential and knowledge-based society but also creates an inspirational area of creativity and new innovative ideas. (Spinderihallerne, n.d.).

"We are a community-creating, creative, and vibrant house where people come together around a wide range of communities and activities."
(Spinderihallerne, n.d.)

At present, Spinderihallerne serves as a dynamic and creative community for smaller companies operating at the intersection of design, art, and business development. The diverse composition of these emerging companies is crucial in fostering synergy within the building, enabling individuals to inspire and engage with one another, as well as with visitors to the building. (Spinderihallerne, n.d.)

These upcoming companies have the opportunity to rent a studio space and benefit from shared resources, such as workshops, exhibition areas, and social event spaces, further enhancing collaboration and networking opportunities. The functions of Spinderihallernes and the spatial composition of the studios serve as our inspiration in developing the typology and functional requirements for our project.

"And just like the Spinderihallerne provide us with some to spar with and celebrate with, the place also gives a fantastic sense of belonging - and as new and small, it's a nice starting point when the big wide world is to be conquered."

(Spinderihallerne, 2011, p. 20)

Ill. 28: Spinderihallerne. Picture illustrating the open, flexible space between the studios. Furthermore, the rough, authentic and creative atmosphere in a transformed building.

Ill. 29: Spinderihallerne, studios. The picture illustrates how the internal walls in the studios are transparent in order to establish social interactions and thereby social relations.

Ill. 30: Werkraum, Andelsbuch. Looking from the outside it is noticeable that the building appears transparent which allows the surrounding context to be in focus even though one is looking at the building.

Werkraum - Peter Zumthor

Werkraum Bregenzerwald is an Austrian craft and trade association established in 1999. In 2013, the Swiss architect Peter Zumthor designed Werkraum Haus, located in Andelsbuch. It serves as an innovative platform where different local craftsmen exchange and exhibit ideas and work (Werkraum, n.d.). Zumthor's vision for the building was based on two main ideas: first, it should be a meeting place for people in the neighbourhood as well as for visitors from abroad, and second, it should showcase the local culture of craftsmanship in the Bregenzerwald region.

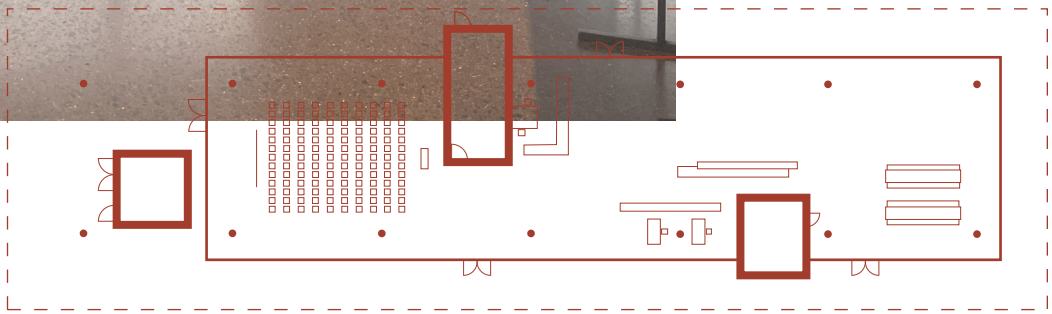
"'The result reflects our values and suits our purpose very well - to be a meeting point for the people of the valley and for people from abroad, for crafts and culture. Zumthor brings together the rural context with the world, the local qualities and spirits with the international.'"

(Stathaki, E., 2022).

By using wood, a local material, the building reflects the cultural building techniques of the area and utilizes the region's long history of craftsmanship. The large glass façades eliminate the distinction between inside and outside, allowing the landscape and village to flow through the building. A significant overhang extends the building's functions outside, such as exhibitions and gathering spots. Inside the building, a large, open, and flexible floor plan provides space for changing exhibitions, events, a shop, and a restaurant. Here, the craft and trade association Werkraum can tell their story, showcase their work, and inspire each other and the guests. By keeping the materials inside dark, the focus is on the surroundings rather than the building itself, contributing to the narrative of telling the local story and culture of craftsmanship.

Werkraum Haus is an example of how architecture can bring people together and showcase local history, identity, and culture. Incorporating some of the principles into this design proposal can help create spaces that foster a sense of belonging, promote cultural appreciation, and connect people with their surroundings.

Ill. 31: Exhibition space showcasing how the dark material choice and large windows reflect the surroundings from the inside. It is clear that the neighbourhood and its culture and identity which are important.



Ill. 32: Werkraum, 1:500. The floor plan features a large open, flexible room that accommodates various functions and events.

Typology

The building's typology has been developed by considering the needs of the new Hjulmager area. Since the design proposal itself is just one aspect of the overall project solution and receives less focus, the typology is determined by selecting limitation based on the existing buildings capacity, its contextual placement and the municipality's vision for the site, as guidelines. With that said, the typology aims to be expressed as a gathering place where people come together, share knowledge, and shape a meeting point.

The meeting point should emerge from the local context, taking into account both the past and future of the area. It should provide frames that encourage people to gather, actively participate in its functions, or simply inhabit the space – contributing the overall hub. Considering the functions and wishes for the area, we have identified three user groups – The ones we prioritize are creative small start-ups to benefit the area and the individuals, the other are visitors to the area and inhabitants from the near context.

Drawing inspiration from Spinderihallerne in Vejle, the building aims to set a framework for start-ups, to benefit from mutual sparring and shared resources. Therefore, the functions of the building should include workshops, a shared workspace, exhibition areas, studios, and a café for immersive and creative work. It should serve as a meeting point on various scales. Start-ups, the Studio renters, would benefit from networking opportunities and collaboration. A flexible exhibition space should facilitate the showcasing of their work, creating connections between the start-ups and the visitors from both Hjulmagerkvarteret and the rest of the city. The café and the open, flexible floor space should offer an inviting and vibrant environment for gatherings and small events. Thus, the different relations constitute the building as a space for dynamic meetings and social interactions.

Defining functions

Since our project's focus lies more on the process of incorporating reused materials and preserving existing structures in a transformation, rather than the building's design as the primary solution, we drew inspiration and established limitations based on the cases and early functional iterations. The successful concept observed in Spinderihallerne creates a central meeting point for both the city and the business community, which matched our interest. Listed below are requirements and conditions derived from these cases and function iterations, which we later utilized as guidelines during the design process.

Studios
- 12 sq m
- 1 occupant

Open studios
- 12 sq m
- 40 sq m
- 4 occupants

The studios should accommodate approximately 20 people.

Workshop
- 90-110 sq m
- Sheltered outside area.
- Space for tools and workbenches.

Adminstration
- 20-30 sq m
- 2-3 occupants

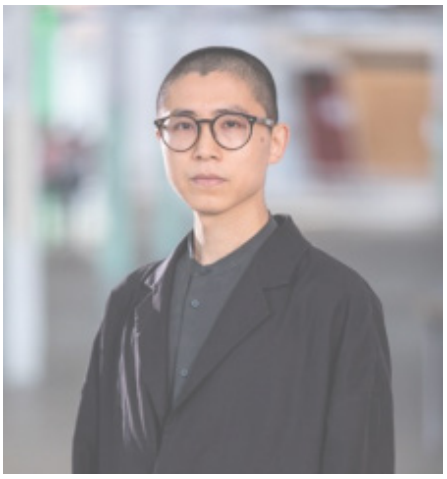
Café and exhibition
- Work as a meeting place for people who are located or live in Hjulmagerkvarteret.
- Should have an outdoor area drawing people in and meeting the main flow.
- It needs to work as a transition between the exhibition space, studios, and the neighbourhood's recreative activity.

Overall, the layout should have a gradually transition between functions to ensure coherence in the building.

Studio users

MaStudio

Graphic designer, Creates distinctive designs and connects brands to audiences, Exhibit graphical art.



Studio Innové

Fashion Designers, specializing in clothing, Can benefit from participating in fashion events, pop-up shops, or fashion showcases.

North Furniture

Furniture designer, Background as a furniture carpenter, Spends equal amount of time between the workshop and the studio, Exhibit designs.

Ill. 33: Studio users

The creative business community requires innovative frames and creates a professional energetic work environment for start-ups. The renters have 6 months renting period at a time, and their work should touch the aspects – creativity, innovation, and sustainability. Shown here are examples of start-ups that the building could accommodate.

Summary

To ensure a cohesive and integrated design proposal, the design development operates at the intersection of engineering, architecture, and sustainable thinking, forming a bigger whole. A sustainable-tectonic approach will ensure that the design proposal not only possesses visual and functional appeal but also embodies environmental sustainability.

By building upon the existing structure and repurposing materials from Hjulmagerkvarteret, the project can infuse the site with traces of its historical narrative. To steer future developments in line with the municipality's vision for the area, it is crucial that the project's identity reflects sustainable practices and serves as a source of inspiration and knowledge. Additionally, the identity should manifest through lively recreational activities that enhance the site's role as a vibrant gathering place.

The reuse of materials and transformation of the existing buildings will provide the design process with distinct materials and structures. These elements should play a central role in shaping the form, while ensuring the preservation of the site's identity and sustainable approach.

In alignment with the municipality's aspirations and potential in the placement of the project site, the building is intended to serve as a public "gate", attracting people and providing spaces for gatherings. By incorporating studios inspired by Spinderihallerne, the building can support smaller businesses while maintaining an innovative and creative identity. In addition to the studios, the building should offer the public a meeting point centred around an exhibition space for visitors to engage with and a café to enjoy.

The following chapter will summarise the design drivers based on the knowledge found in this and the previous chapter.

03 Design drivers

This section will present the design drivers, which include the main focus points of the design process and the final design proposal. They are derived from prior knowledge and conclusions drawn through the analysis of current conditions, future plans, and an investigation of relevant themes and theories.

Vision

The project aims to contribute to the ongoing transition towards a circular thinking in the building industry. Recognizing the need for change in current processes, the project explores an alternative approach to integrating the unique shapes and properties of reused materials throughout the design phases. By reusing locally available materials to transform existing buildings, the project intends to provide Aalborg Municipality with an example of how to build sustainable in the future development of Hjulmagerkvarteret. By prioritizing circular thinking in the design process, the building will minimize its environmental impact and serve as an inspiration for future projects to employ reused materials in architecture.

Furthermore, the design aims to establish a vibrant meeting point that accommodates new, innovative, and creative emerging businesses, fostering interaction among them and visitors. The project takes the opportunity to engage the community in the circular approach by combining a sustainable design with an appealing atmosphere. Considering the site's identity, the design aims to create a strong communal atmosphere between emerging start-ups and the future neighbourhood that will arise with the development of Hjulmagerkvarteret.

Problem

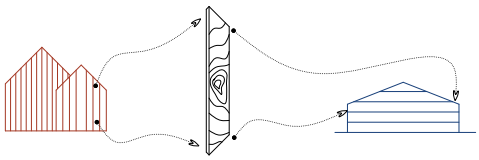
How can the utilization of local reused materials be incorporated to transform a building?

Additionally, how can the building be transformed into a vibrant meeting point that both reflects and enhances the identity of Hjulmagerkvarteret?

Design criteria

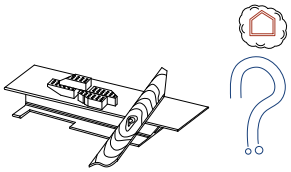
Transformation

The existing buildings should be preserved as much as possible in order to build upon existing materials, structure and identity in the transformation process.



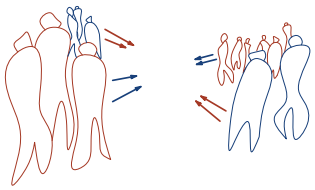
Reuse

To minimize the environmental impact, the transformation should utilize and implement the reused materials available from the demolished buildings. This approach will not only respect the current identity but also reflect the future circular and vibrant atmosphere.



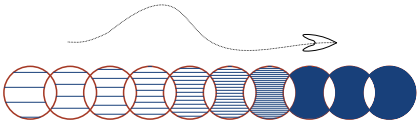
Sustainable-tectonic

The design proposal should showcase the potential and challenges associated with incorporating reused materials. It should emphasize the visible connections between different construction elements, highlighting their characteristics and contributing to the identity.



Space and atmosphere

The building should afford communal interaction and a sense of belonging, providing a creative and inspiring workspace for startups. Additionally, the space should serve as a meeting point, encouraging people to come together and find inspiration. Visual interactions among the studios, café, exhibition space, and urban areas should therefore be designed to invite and attract visitors, encouraging them to explore the work of the startups and gathering.



Transistion

A gradual transition between functions should be implemented to ensure coherence within the building, and to enhance interaction between users. The exhibition space should serve as a visible connection and transitional zone between the different functions.

Ill. 34: Design process

04 Design process

This section will present the design process, starting with a description of the tools and methods employed, followed by an exploration of various design studies that led to the final design proposal. While the design process was iterative, this report aims to present it chronologically, allowing the reader to understand and get an overview of the different phases in the process.

Introduction

When choosing a project direction aimed at transforming existing buildings reusing a limited number of materials, the design approach and process will differ from previous semester projects. Instead of adopting a Problem Based Learning approach, where an overall problem frames the direction of the project development from the beginning, this project took a different approach. It began with a *generator* for the project (see Methodology, p. 10), which specifically focused on reusing materials. As a result, the entire project was in a different sequence, starting with the materials as limitations from which the building should be designed.

Therefore, the design process takes its starting point from the identified challenges and potentials of the existing buildings and available materials. These led to different design studies, each with a specific focus point, where various tools and medias were used to investigate the topic. The design studies aimed to solve specific challenges or propose possible solutions, but often, the outcomes also revealed new challenges. The design drivers and overall potentials were then used to evaluate and select which challenges to further explore.

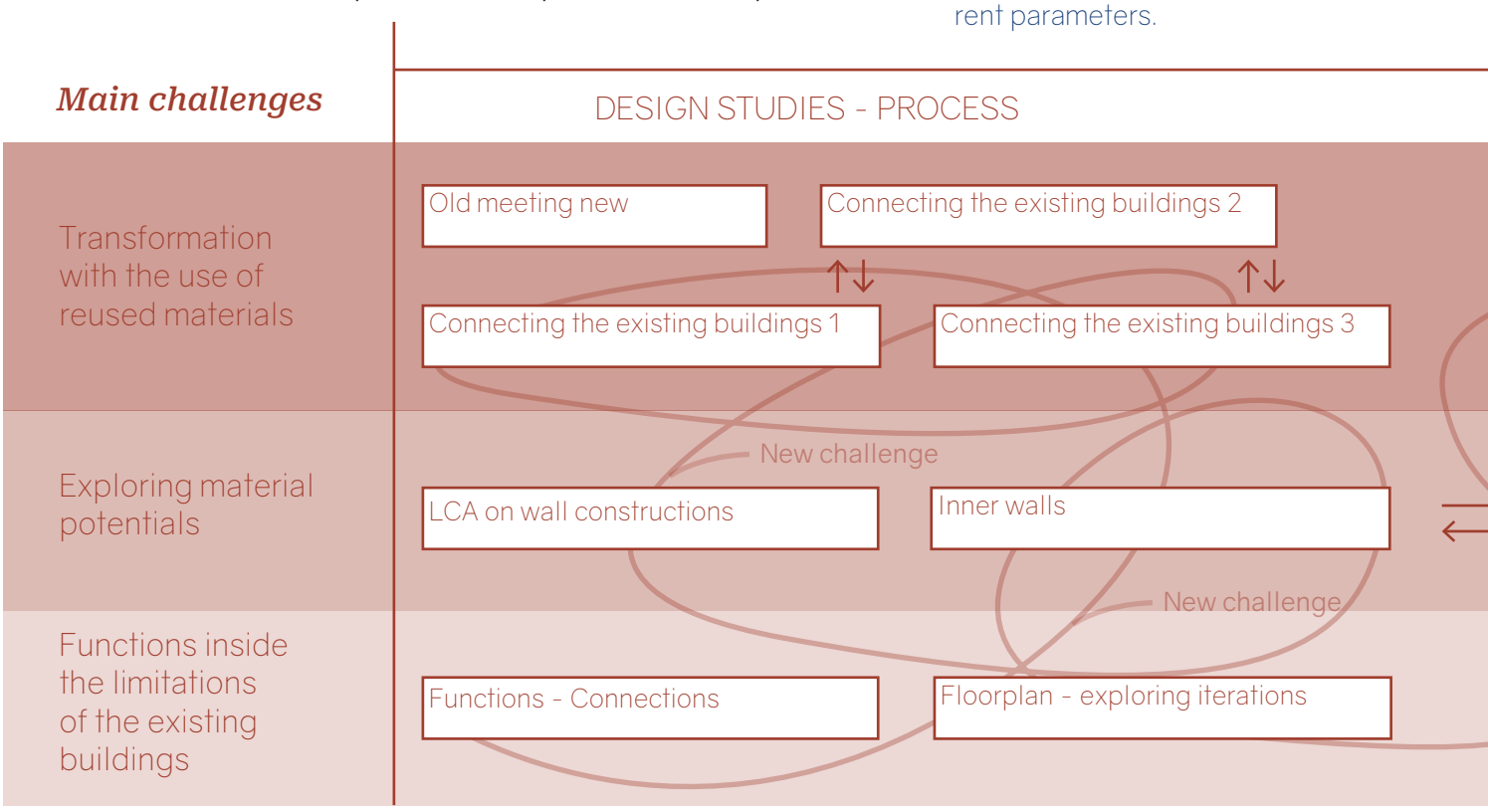
In the following presentation of the design process, the design studies will be presented as if they were developed chronologically. But some of the design studies were developed in parallel, which ensured, that the outcomes could be compared and inform each other. This iterative process resulted in an informed selection of solution suggestions and a guided design process where various aspects were considered simultaneously.
By exploring how the use of reused materials can be implemented in the design process, investigations of selected challenges and potentials were conducted through the studies. Some of these studies delved deep into creating solutions for the challenges, while other challenges were left open for future exploration in later processes.

Sketching and modelling

In developing the design proposal, a change through various scales, mediums, drawing techniques, and calculations where used. Through the use of sections, plans, perspectives, and 3D modelling, the aim was to ensure that the design became a comprehensive solution that integrate spatial progressions, functionality, construction considerations, texture and aesthetics.

Design studies

Through studies we have tried to structure the design process around our specific approach focused on reusing and transforming. Various methods and mediums have been used to explore these approaches. Each study begins by identifying a potential or problem encountered during the process, leading to further knowledge, as well as uncovering new potentials and problems. The studies are investigated through different aspects, such as structural, aesthetic, and functional considerations, by applying different parameters.



Ill. 35: Design process. Diagram illustrates an iterative process with different studies affecting eachother

STUDY: Exploring the expression of old meets new

STUDY: LCA on wall constructions

STUDY: Functions

STUDY: Connecting the existing buildings 1

STUDY: Connecting the existing buildings 2

STUDY: Connecting the existing buildings 3

STUDY: Roof lift

STUDY: Roof shape

STUDY: Roof lift structure

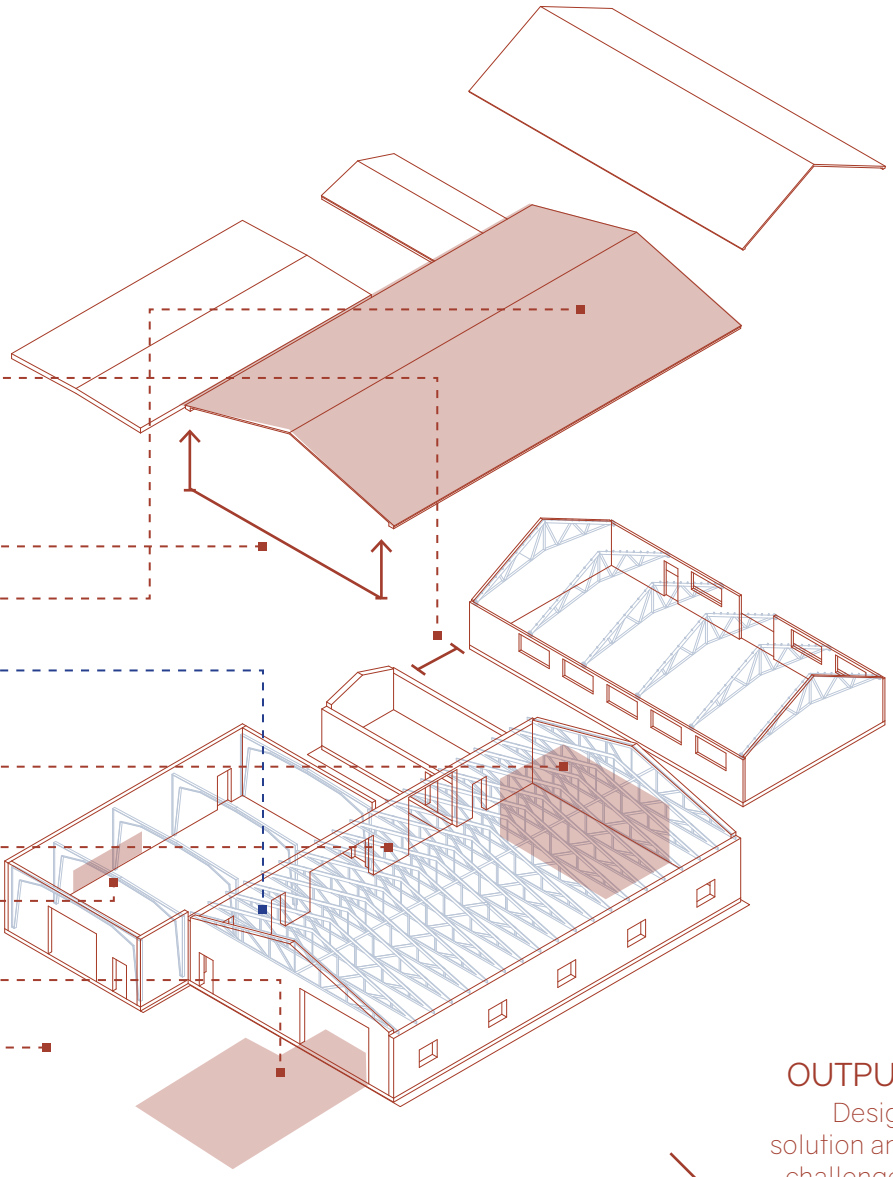
STUDY: Intermediate floor construction

STUDY: Inner walls

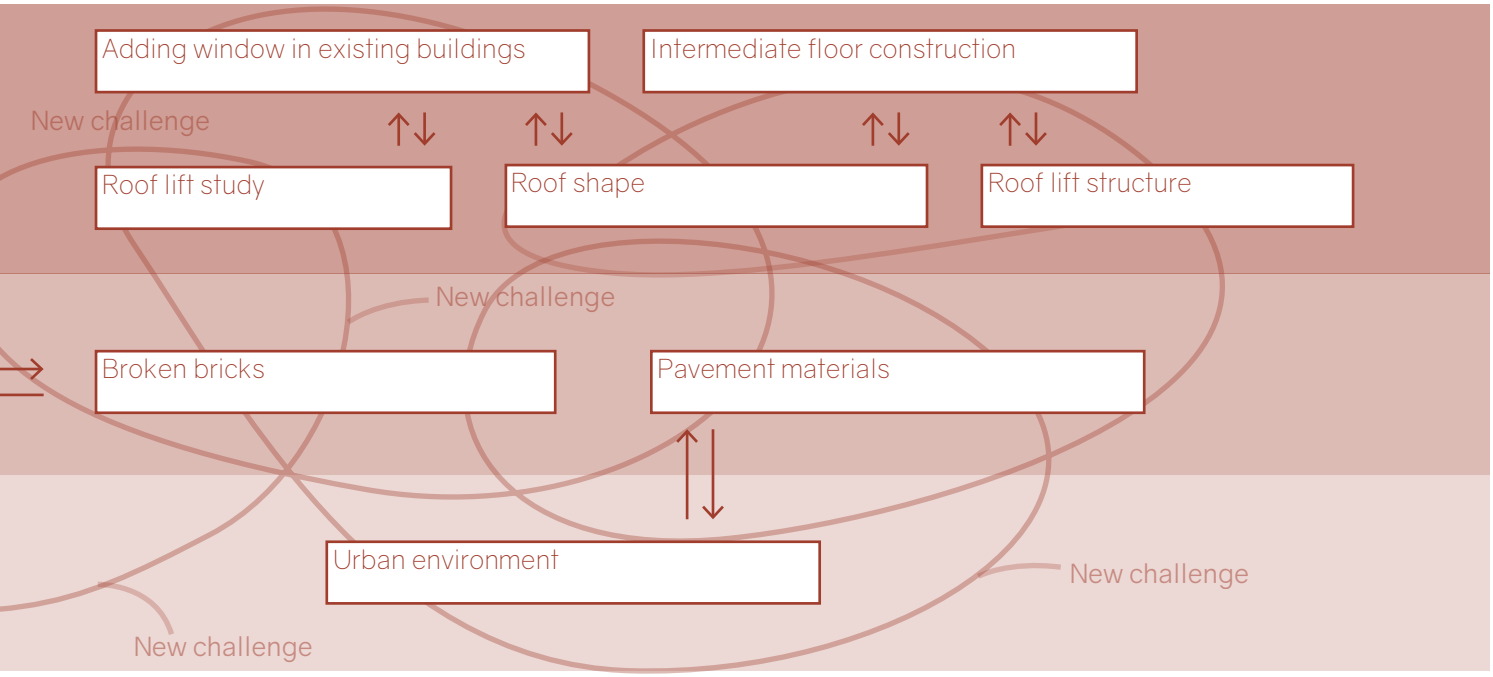
STUDY: Broken bricks

STUDY: Pavement/ floor

STUDY: Urban areas



OUTPUT
Design solution and challenges



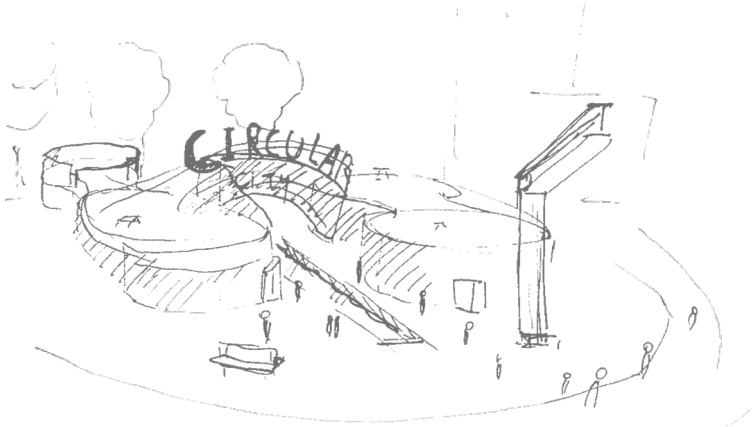
Early design iterations

At the outset of the project, the initial focus was primarily on establishing the framework for the following design process. This phase encompassed defining the typology, identifying the project site, and developing the design scope.

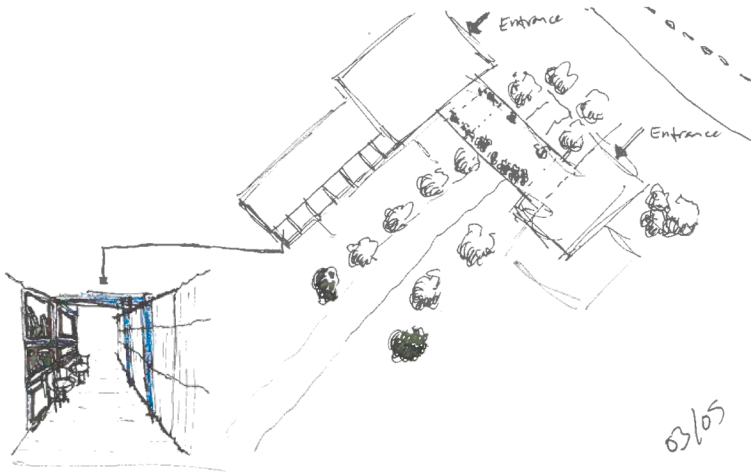
Following a presentation by Aalborg Municipality regarding their future plans for the development of Hjulmagerkvarteret, it became evident that the project was poised to embrace a direction centered around the reuse of materials, with a specific emphasis on incorporating materials sourced from Hjulmagerkvarteret.

Therefore, the early design ideas and iterations focused on how to implement existing materials and maybe give them a new function.

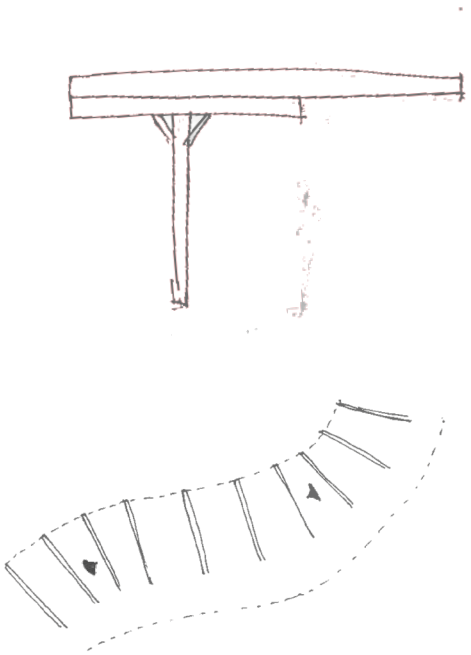
Ill. 39: Museum LAB, early iterations of the creation of an experimental museum about reuse and circular thinking



Ill. 37: Building as a gate-entrance, site placed at the corner of Hjulmagerkvarteret

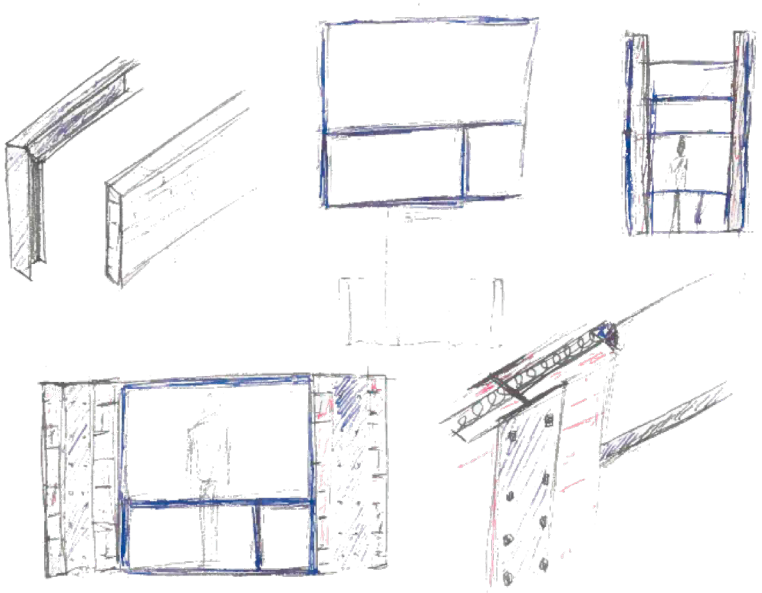


Ill. 38: Building as a gate with urban connection, project site is here at the corner of Hjulmagerkvarteret

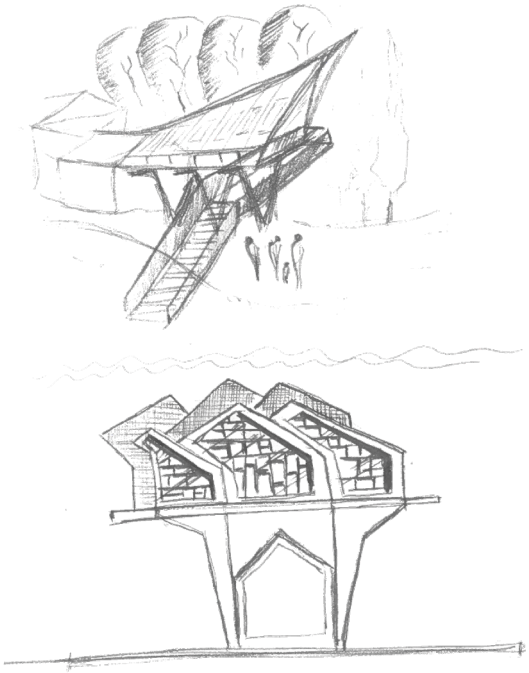


Ill. 40: Reuse steel structure in urban context

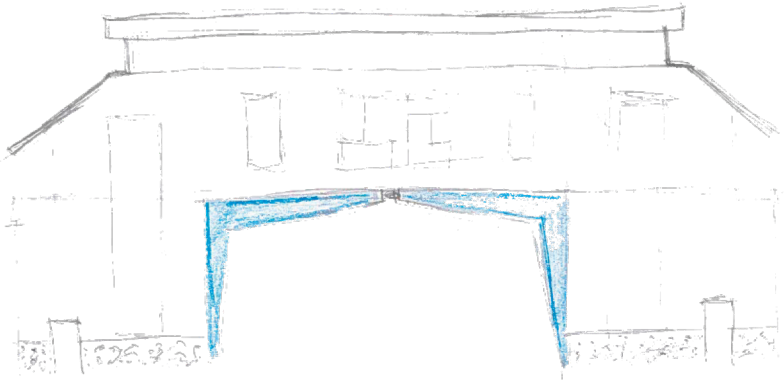
How to design with reused materials?



Ill. 42: Wall constructions with incorporation of reused materials

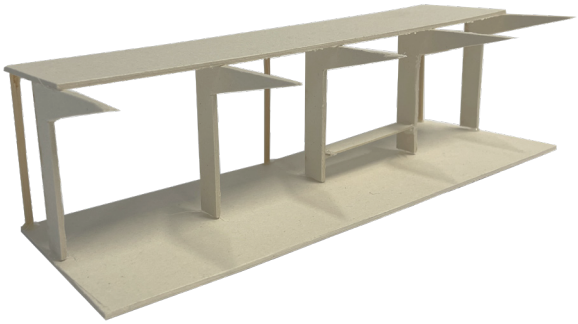


Ill. 41: Sketches of building high in order to design a landmark which attracts people

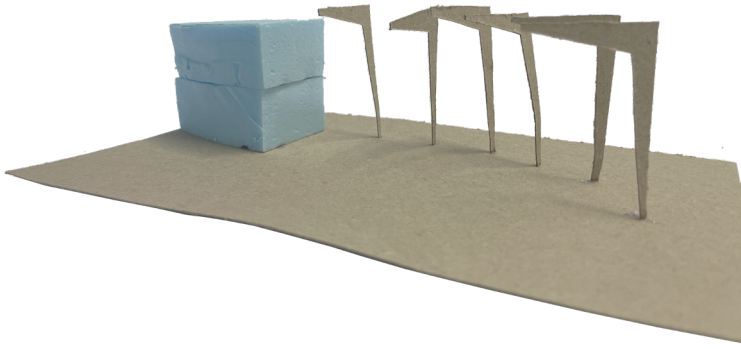


Ill. 43: Incorporating reused structure to shape a "gate"

During these early iterations, it became evident that the framework and scope of the project were still not sufficiently defined. The necessary limitations and criteria were unclear, making it challenging to evaluate the design ideas. Throughout the process, various project sites and typologies were explored, including an extension of Råt og Godt, a new experimental museum and a new building at the entrance to Hjulmagerkvarteret. After another site visit and a review of the Municipality's plans, the project ultimately evolved into a transformation of existing buildings focusing on reused materials within Hjulmagerkvarteret.



Ill. 44: Model, using reused structural elements

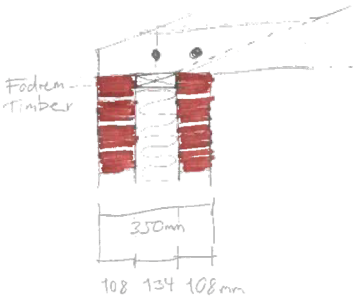


Ill. 45: Model, using reused structural elements, in relation to a building

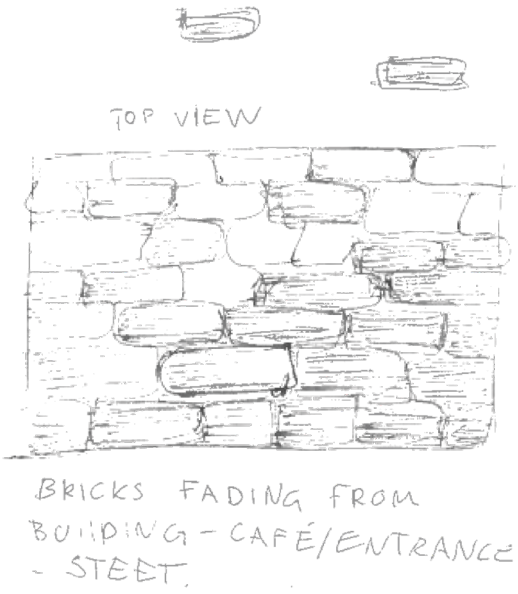
Old meeting new

Study: *How should and can new and old materials meet?*

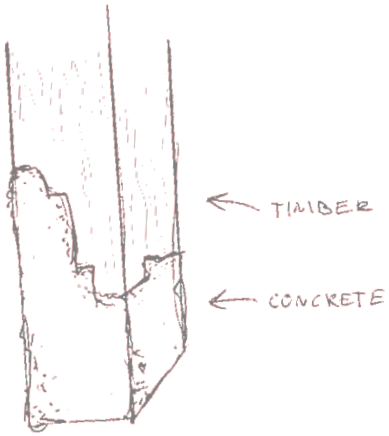
After taking the decision to do a transformation project using locally sourced reused materials, the design process dug into exploring the diverse possibilities for their utilization. Questions arose regarding how the materials could be reused, transformed, or given new functions. Furthermore, the process focused on how the existing materials and the new materials could be put together. *How could a harmonious and coherence integration of the new and old be achieved? And should it be clear what materials is old, new-old or new?* The look, shape and conditions of the different materials were known beforehand and thereby taking into account when visually putting together materials or letting reused elements give shape.



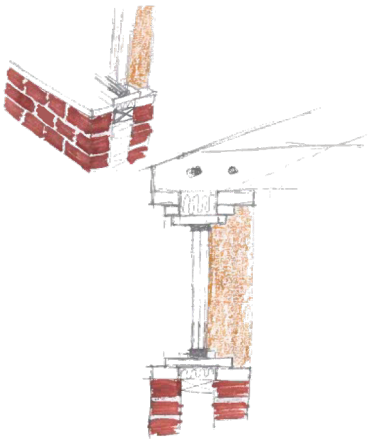
Ill. 46: Brick wall



Ill. 48: Bricks fading together

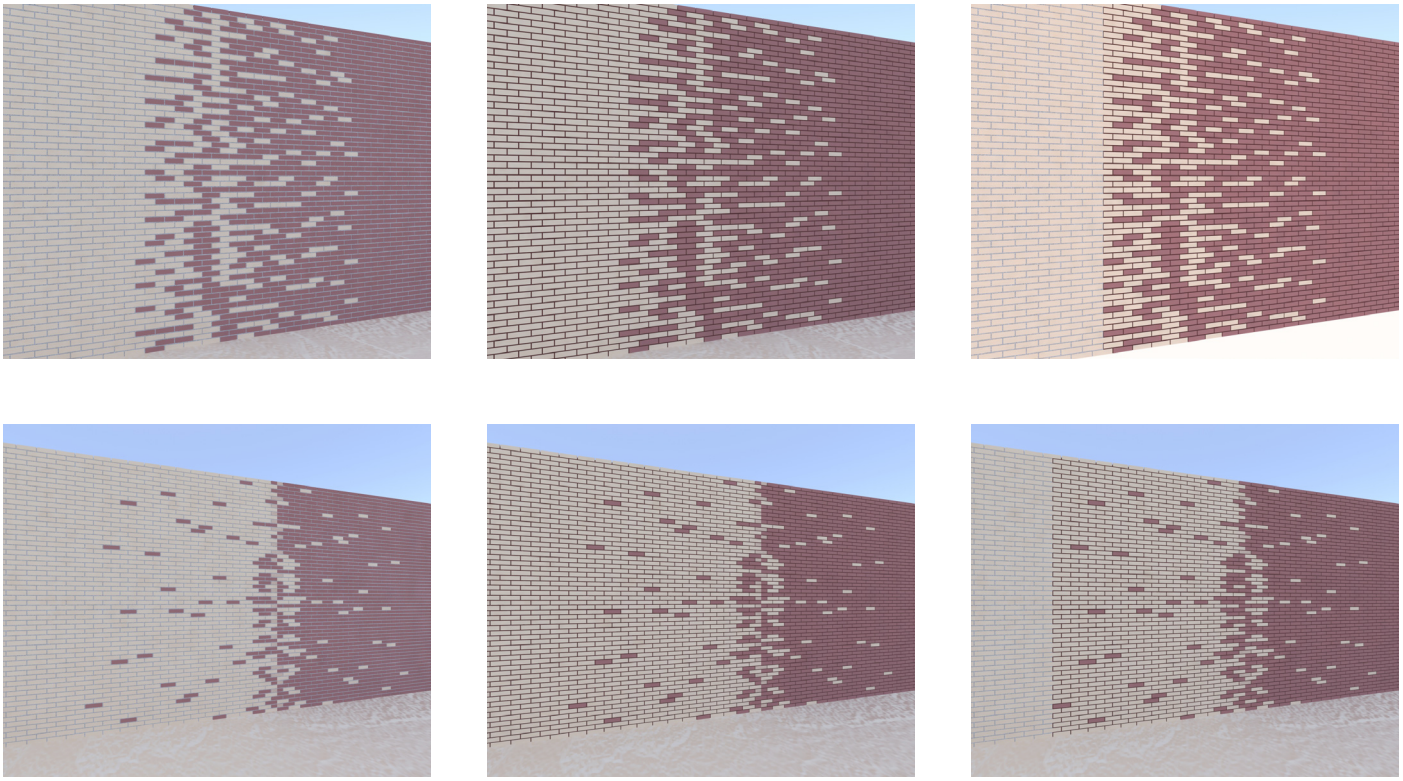


Ill. 47: Timber and concrete meeting



Ill. 49: Brick and timber wall

Grasshopper brick study



Ill. 50: Grashopper brick /mortar study. Iterations of how different bricks can gradually blend together, and how the mortar will be affected

Physical brick study

Ill. 51: Brick wall collage. Trying to put different reused bricks together in different ways and patterns

Ill. 52: Process

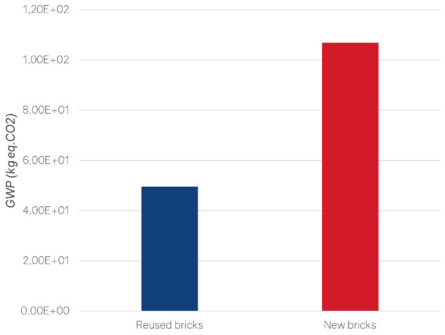
In this phase, it became clear that the design process, with its emphasis on reusing materials, presented different challenges and potentials, about incorporating materials and their unique properties, than in previous semester projects. *How to evaluate the conditions of the different materials? What materials are possible to reuse? Can the destroyed materials be used for something new instead of thrown out?* On the other hand, the use of existing structures and materials ensure a certain shape, identity and atmosphere. By using old materials with its own patina, it allows the design to be playful, unique and authentic.

Life Cycle Assessment

Study: *What is the effect of using reused materials when looking at GWP?*

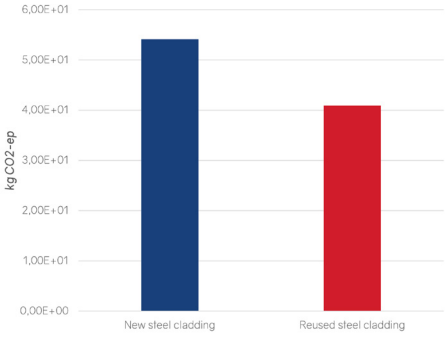
To ensure an environmentally sustainable design proposal, *Life Cycle Assessment* (LCA) was used during the early design process to examine the construction's impact on the climate, specifically focusing on *Global Warming Potential* (GWP). A comparison was made between 1 m² of various construction types (Appendix 2), and thereafter, selected elements of the construction were replaced with reused materials to evaluate the environmental effects.

Bricks



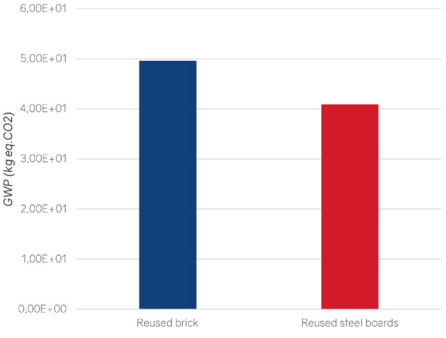
Ill. 53: GWP Brick

Steel



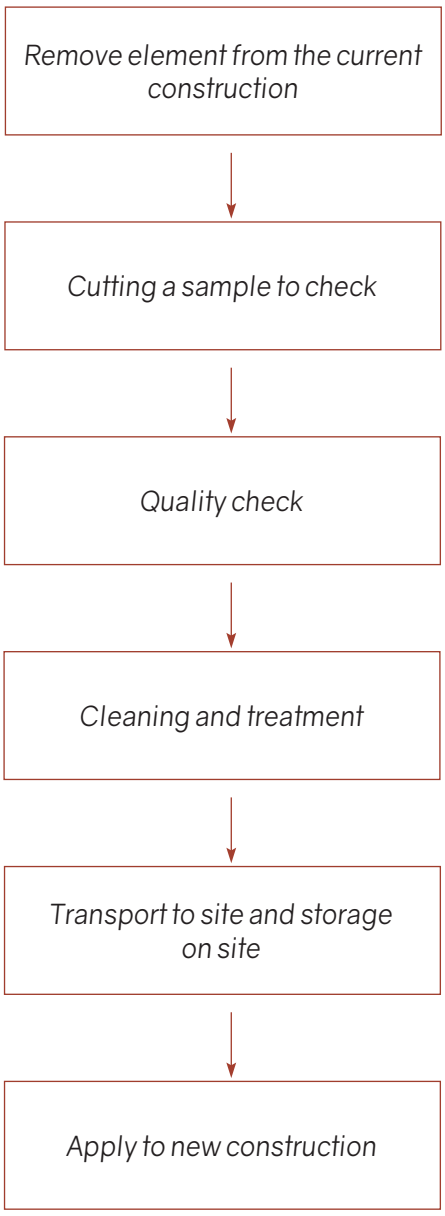
Ill. 54: GWP Steel

Comparison



Ill. 55: GWP Comparison

Conceptural EPD

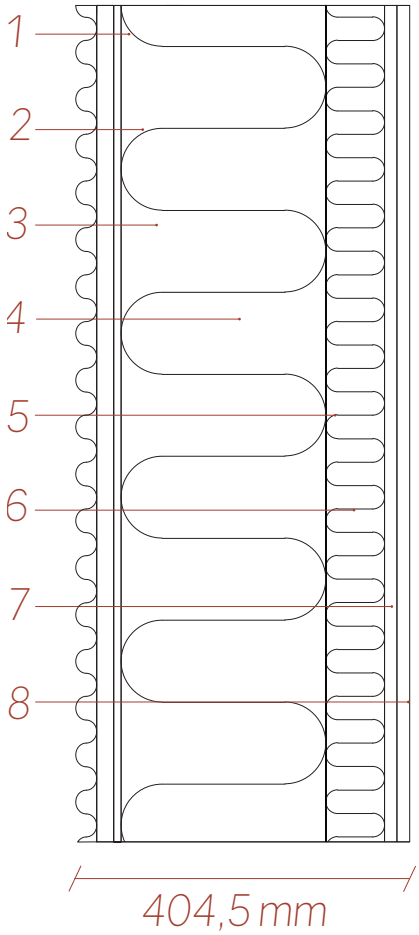


Ill. 56: Conceptural EPD

EPD

When integrating data into LCA-Byg, an *Environmental Product Declaration* (EPD) for the A1-A3 stages of a product is required. Therefore, conceptual EPDs were created for the reused materials to be able to compare with virgin materials. Illustration 56 show the contents of the developed conceptual EPDs, for the investigation of the different reused materials.

Steel cladding construction

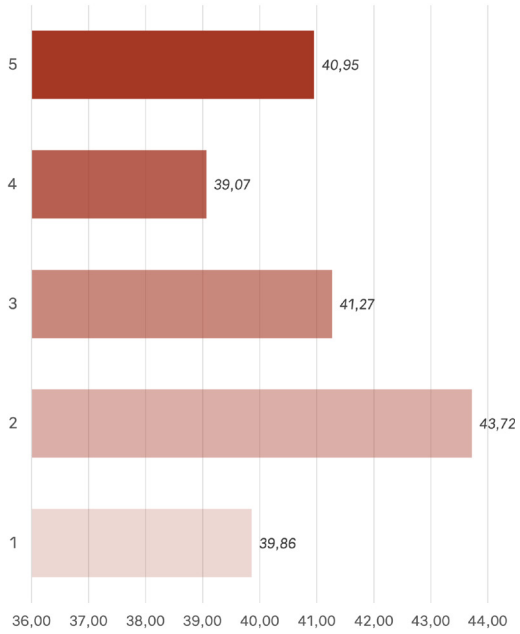


Ill. 57: Detail, 1:10

Reused steel board cladding	1.
20 mm air	2.
9 mm OSB	3.
245 mm insulation + timber construction	4.
Vaper barrier	5.
70 mm Insulation + timber spruces	6.
2 x 15 mm gypsum boards	7.
5 mm finish / painting	8.

Furthermore, in the process of comparing different constructions in LCA, the reuse of an existing steel structural element was implemented. Through various iterations exploring the placement of the structure, the GWP results were compared. The different iterations explored the effect of the treatment of the steel structure, and the position of structure taking into account the temperature and amount of insulation needed to achieve a u-value of 0.12 W/m²K. It also appeared from iterations on the GWP value from different insulation layers, that the wood fibre was the best choice when considering reuse after end-life. This choice makes sense for our building, as the insulation layer needs to be new and will therefore probably live for a longer time than most reused materials. this means that its end life should be anticipated.

Comparison



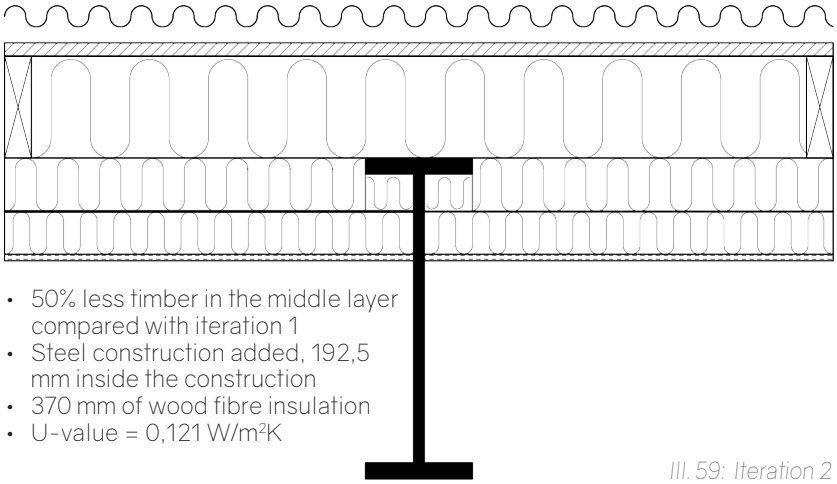
Ill. 58: GWP Comparison of 5 iterations

Based on the LCA study examining the environmental effects of different constructions and materials, it is evident that by reusing materials for both the cladding and structural elements, it is possible to reduce the GWP. By decreasing the use of virgin materials, the design proposal will demonstrate how to construct a more sustainable building and minimize its environmental impact.

Iteration 1

- Timber construction with reused steel cladding, ill. 57
- 360 mm of wood fibre insulation
- U-value = 0,119 W/m²K

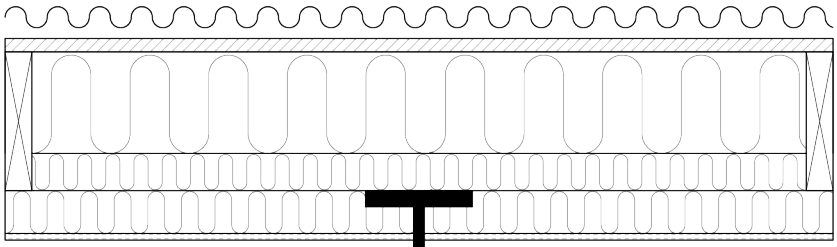
Iteration 2



- 50% less timber in the middle layer compared with iteration 1
- Steel construction added, 192,5 mm inside the construction
- 370 mm of wood fibre insulation
- U-value = 0,121 W/m²K

Ill. 59: Iteration 2

Iteration 3



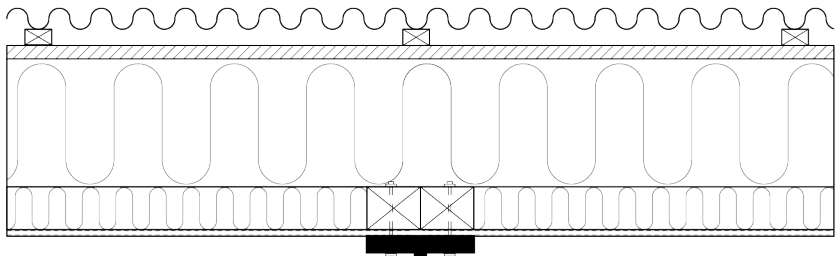
- 50% less timber in the middle layer compared with iteration 1
- Steel construction moved, now 90 mm inside the construction
- 340 mm of wood fibre insulation
- U-value = 0,122 W/m²K

Ill. 60: Iteration 3

Iteration 4

- Same construction as iteration 3
- But no added treatment on the steel construction (powder coating)

Iteration 5



- 50% less timber in the middle layer compared with iteration 1
- Steel construction moved out
- 320 mm of wood fibre insulation
- U-value = 0,122 W/m²K

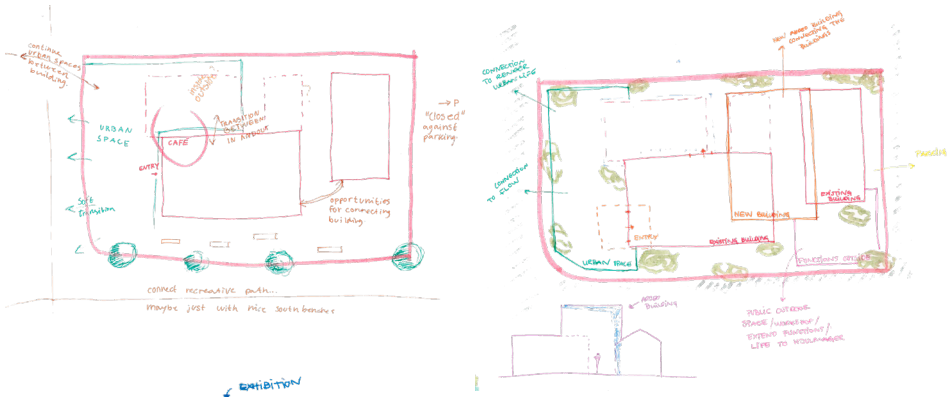
Ill. 61: Iteration 5

Functions

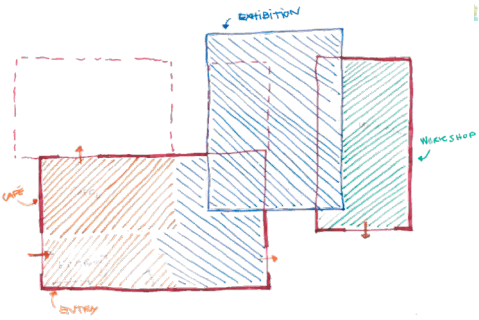
Following the establishment of a clear vision for the building's function as a hybrid space, serving as both a workspace for emerging, creative, and innovative businesses and as a central meeting point for the local community, an initial design study was initiated to explore the functional aspects in greater detail.

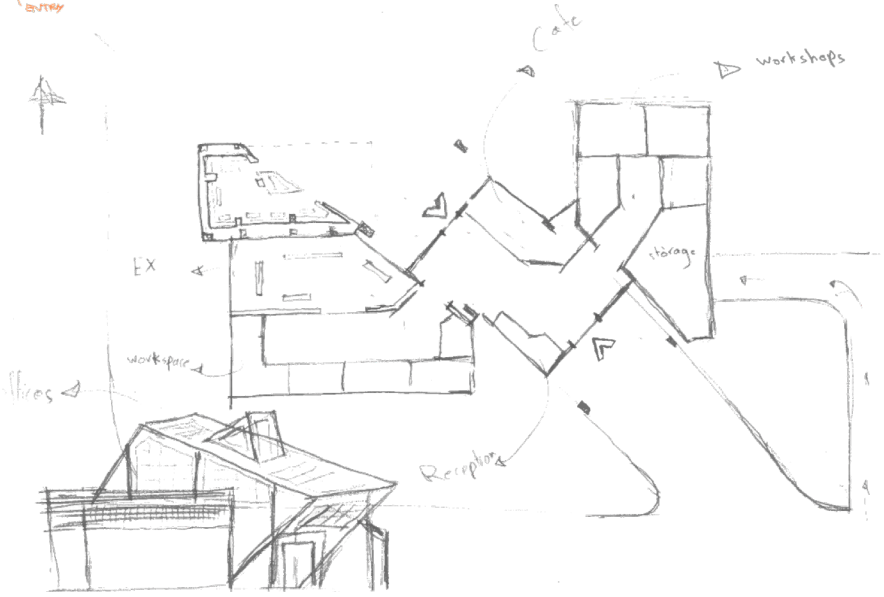
The study focused on exploring the relationship and placement of the three main functions: studios, flexible exhibition space, and a café. Consideration was given to the urban context and future flow lines, with iterations strategically positioned to examine the interplay between functions within the building and their connection to the surrounding outdoor spaces.

In terms of function placement, the iterations aimed to preserve existing walls and openings as much as possible, allowing the existing identities to influence the new design proposal. By filling out the existing floor plan, insights were gained regarding the number of studios and whether an extension would be necessary.

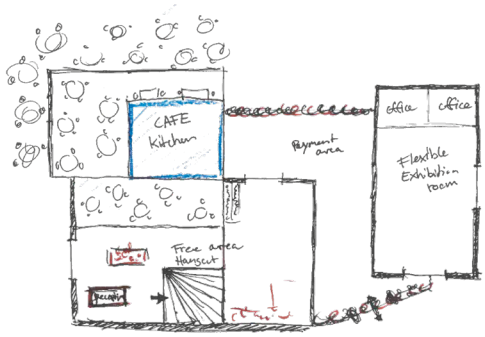


Ill. 63: Plan zoning iterations

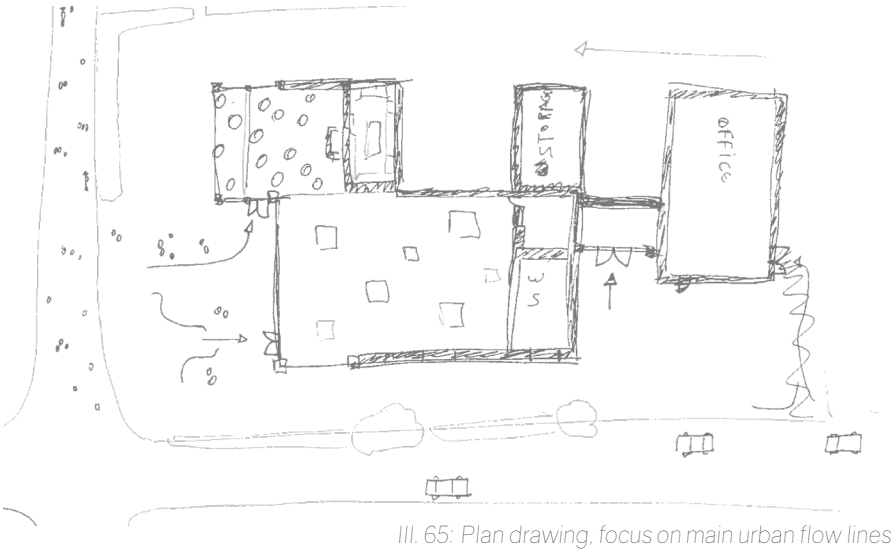




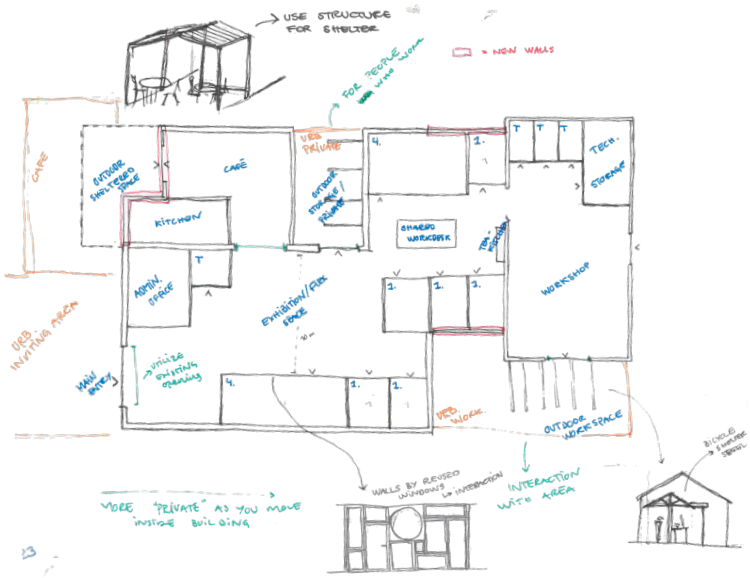
Ill. 64: Plan drawing, cutting in existing building to make a extension which pops out. Different in style and shape



Ill. 62: Plan drawing of a circular museum

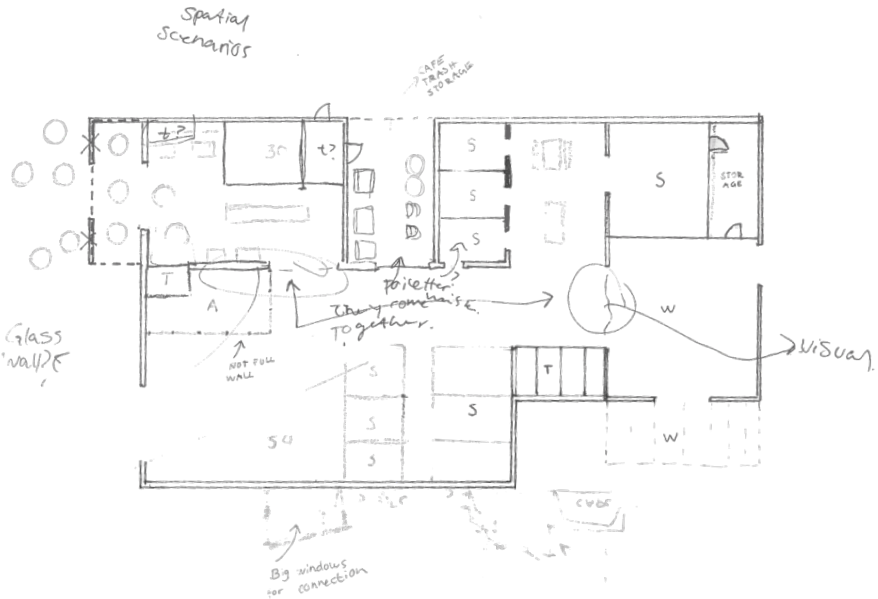


Ill. 65: Plan drawing, focus on main urban flow lines

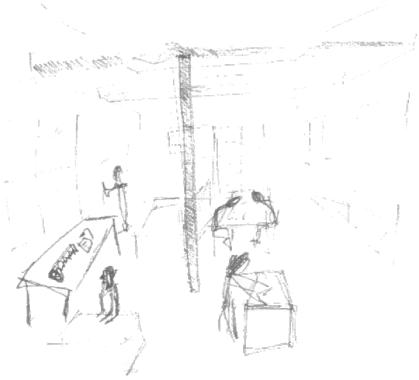


Ill. 66: Plan drawing with illustrations. focus on extending functions outside to smoothen the transistions

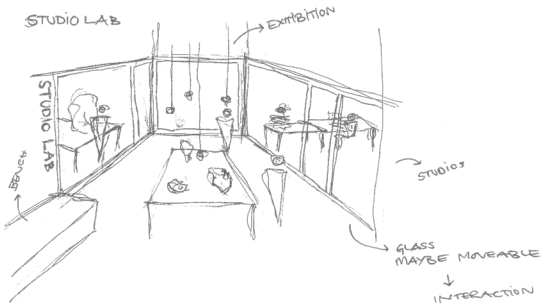
Ill. 67: Plan drawing with focus on the movement inside the building



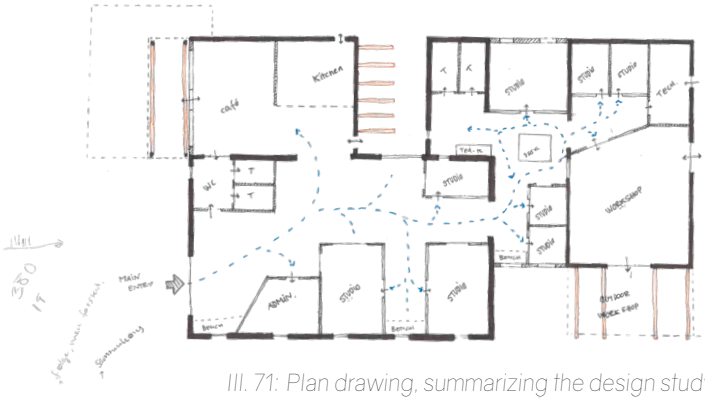
Ill. 68: Plan drawing, focus on visual connections a gradual transistion between functions



Ill. 69: Shared workshop, for startups to use and interact with each other



Ill. 70: Studio workspace with transparent walls to ensure interactions



Ill. 71: Plan drawing, summarizing the design study

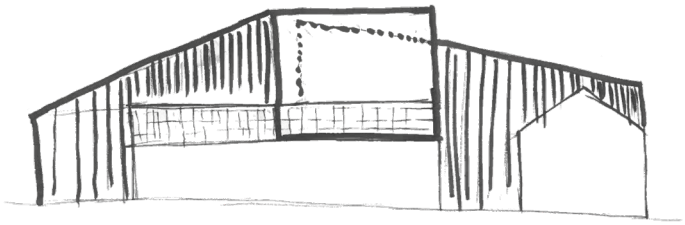
Based on the study, a gradual transition between functions should be established to ensure coherence within the building. The integration of a flexible exhibition space with an inviting main entrance will help attract and guide people towards the studio area and café. Additionally, selected functions such as the café and workshop should extend some of their functions to the outdoor areas, creating an inviting and urban atmosphere that engages with passersby.

The studios should offer a variety of sizes to accommodate shared and individual workspaces, while also incorporating gathering spaces for the people working there.

Connection - Extension

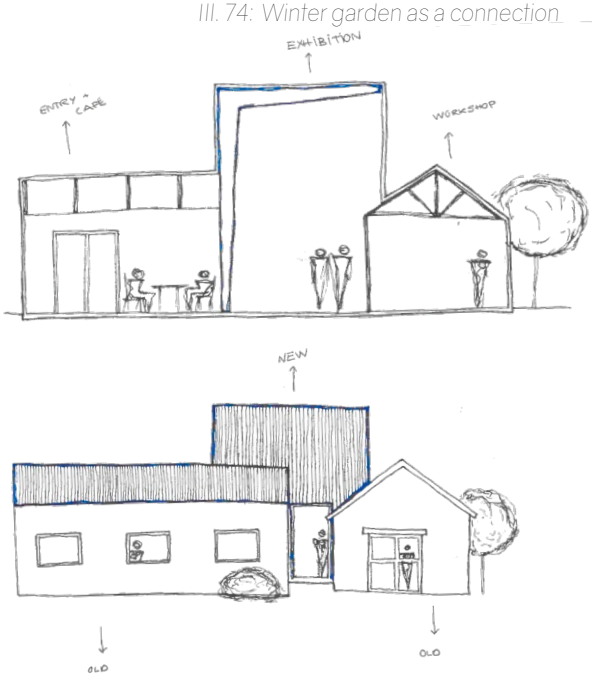
The project site contains two different buildings, and as a result, the following design studies will focus on how to establish a connection between them to achieve coherence and a sense of belonging. Furthermore, the created typology would require more surface, and a connection of the spaces in the two buildings. The initial study explores various iterations of how an additional building volume can effectively connect the existing structures. This involves sketching and creating 3D models to evaluate different possibilities.

Ill. 72: Extension



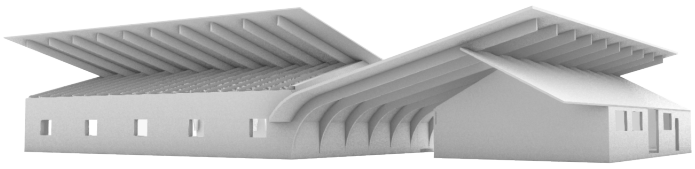
Ill. 73: Extension, change the existing shape and aesthetics

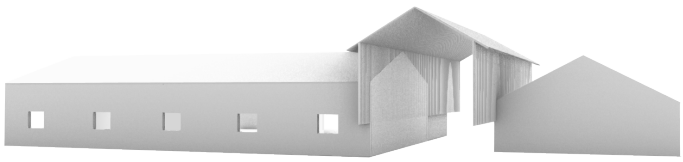
Ill. 74: Winter garden as a connection

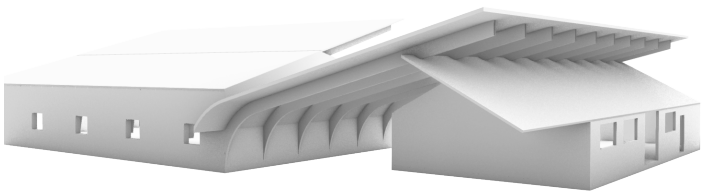


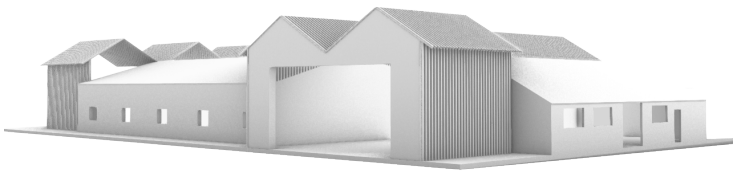
Ill. 75: Extension, with reused structure

Rhino modelling





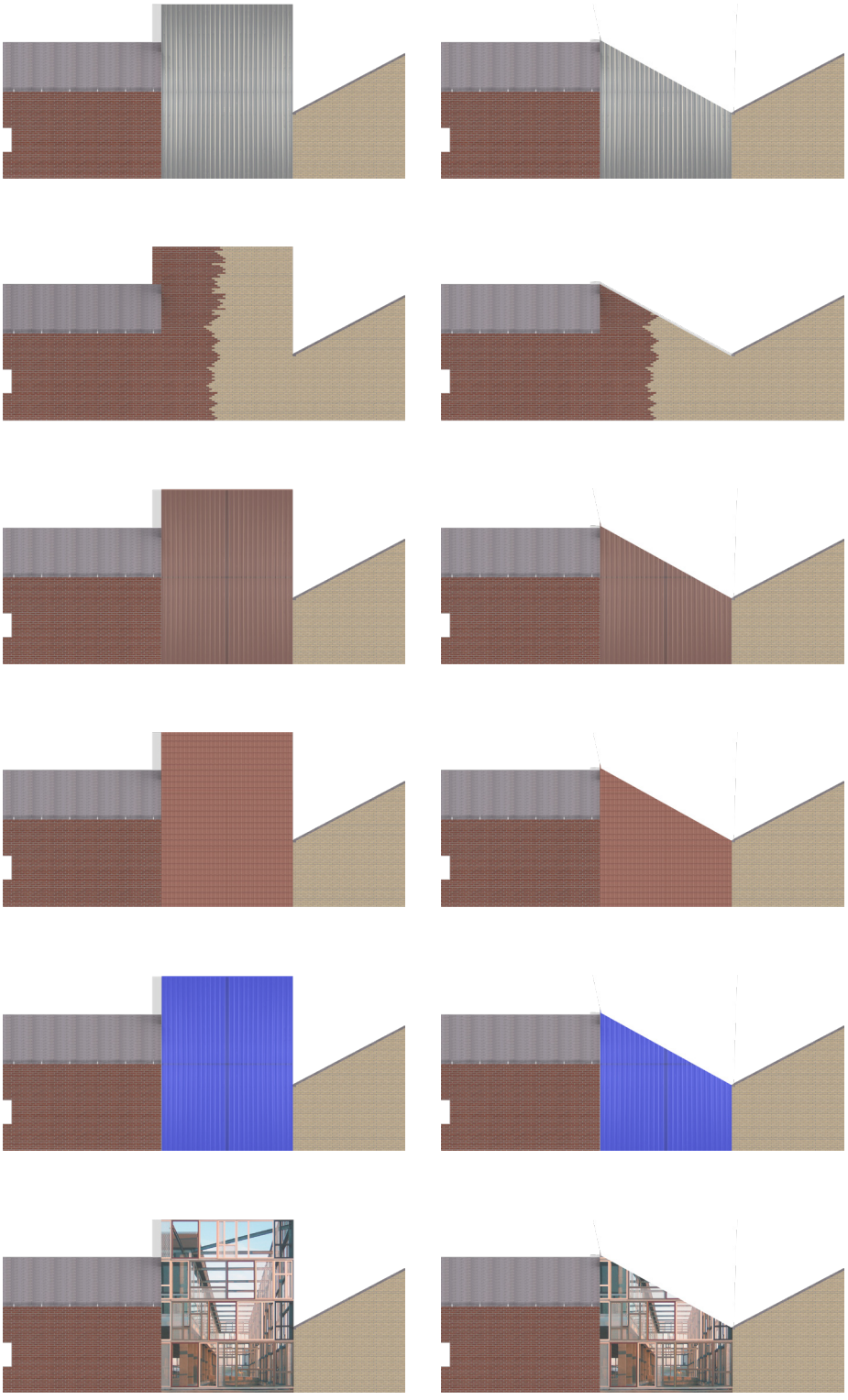




Ill. 76: Rhino iterations using reused glue laminated timer beams to create a connecting roof construction

Ill. 77: Rhino iterations adding building volume to connect the buildings

Materials and shapes



Ill. 78: Material and shape study

Silver steel boards

- The material and its colour stand out compared to the existing. However, it blends in with the industrial look. The meeting is sharp.

Bricks

- The material blends the two facades into one, while the intersection still highlights two facades meeting. The concept could have potential to be a soft transition, iterating on the pattern.

Red steel boards

- The colour blends well with the red bricks but stands in contrast to the yellow building. It gives a subtle industrial atmosphere.

Roof tiles

- The colour blends well with the red bricks but stands in contrast to the yellow building. It gives an Urban and reuse-friendly atmosphere, and fits with the current look of the red building.

Blue steel boards

- The material and its colour stand out compared to the existing. It exudes that is wants to be seen.

Windows

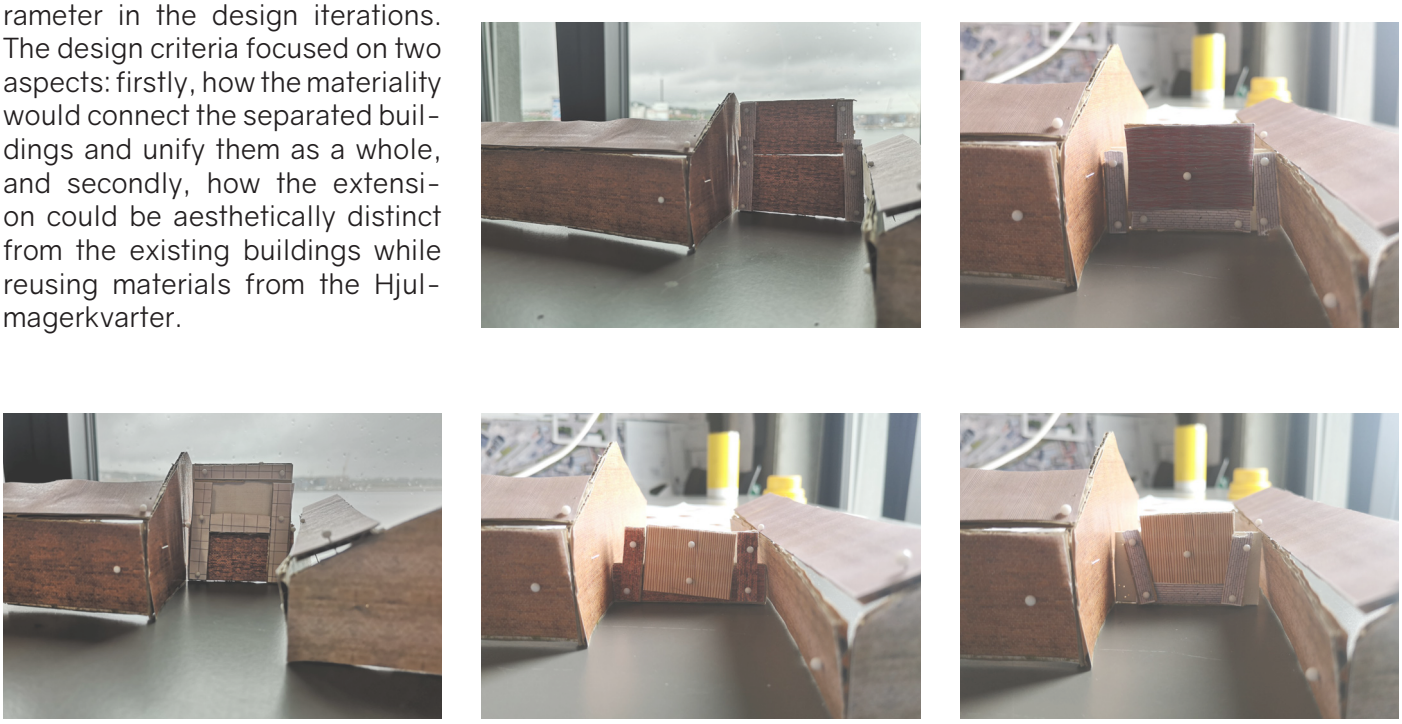
- Highlights the function inside. Allows an indoor/outdoor relation. Interaction to the outside.

Based on the findings of the study, additional aspects of the connections emerged as important considerations. Investigations are being conducted to determine how materials can serve as connecting elements. Should the extension stand out or blend in with the existing buildings? Furthermore, the challenge of expanding the building envelope while maintaining sustainability-related aims is being addressed.

Connection - Materiality

The aim of this study was to investigate how the materiality of the extension could harmonize with the existing buildings. However, the study did not consider the shape of the buildings as a parameter in the design iterations. The design criteria focused on two aspects: firstly, how the materiality would connect the separated buildings and unify them as a whole, and secondly, how the extension could be aesthetically distinct from the existing buildings while reusing materials from the Hjulmagerkvarter.

Physical models



Ill. 79: Texture and materiality study. Exploring with different textures, how the materiality can connect the buildings

In the initial stages of the study, a method using physical models with textures was chosen. By incorporating various textures using materials from Hjulmagerkvarteret, it was possible to observe the interplay of materials. Based on this study, it became evident that incorporating too many materials would result in a chaotic and messy appearance from the outside. Additionally, it was determined that the extension did not effectively serve as a connecting element.

A follow-up study was conducted to explore selected materials and examine their combinations from another perspective using Photoshop as a design tool. In this study, fewer materials were included.

Photoshop iterations

Bricks

- Sober look but not aesthetically different from existing envelopes.

Orange steel boards and bricks

- Aesthetically different from existing buildings but looks like a garage door and not an appealing entrance.

Tiles and bricks

- Aesthetically different from existing buildings but too different geometrical motif from the existing bricks.

Tiles and bricks

- Clear separation between existing buildings and new extension but steel plates are too large and take too much space. In addition, the bricks from the extension are not really aesthetical different from the existing buildings.

Tiles and bricks

- The bricks from the extension and the red painting of steel boards remind the existing envelopes while being aesthetically different from them.

Ill. 80: Material connection study. Exploring in Photoshop how selected materials can connect the buildings from another perspective

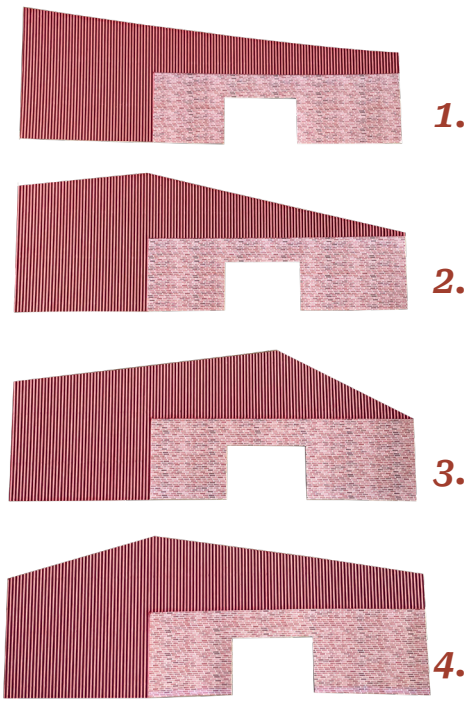
This material study revealed the potential of using materials as an element to achieve a coherent appearance. To avoid the façade cladding from becoming overly dominant, it was concluded that a limited number of different materials and colours should be used. In relation to this, it was decided to insulate the yellow building on the exterior to optimize the building envelope and to allow the building to have another look.

Connection - Structural element

The objective of this study was to explore the possibilities of reusing a steel structure from Hjulmagerkvarteret as the structure for the extension while also shaping the extension itself. The goal was to preserve as much of the existing buildings as possible, with the steel structure being repositioned to establish a connection between them.

Throughout the iterations, the study focused on assessing the practicality of incorporating the steel element into the construction. Questions such as how the construction would appear with the inclusion of the steel element, or how the walls should be extended, and the load-bearing capacity of the steel structure, were addressed.

Ill. 81: Existing steel structure



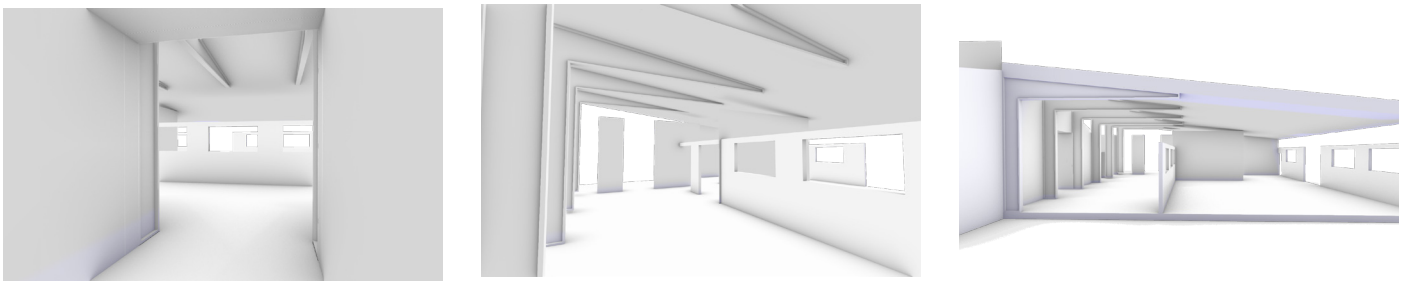
Ill. 82: Iterations

1.

- Blue structure placed on the outside of the red brick wall.
- Roof angled - but straight
- Timber beam added
- Light construction extend the yellow brick wall

Ill. 83: Iteration 1

Iteration 1



Ill. 84: Rhino models of iteration 1

2.

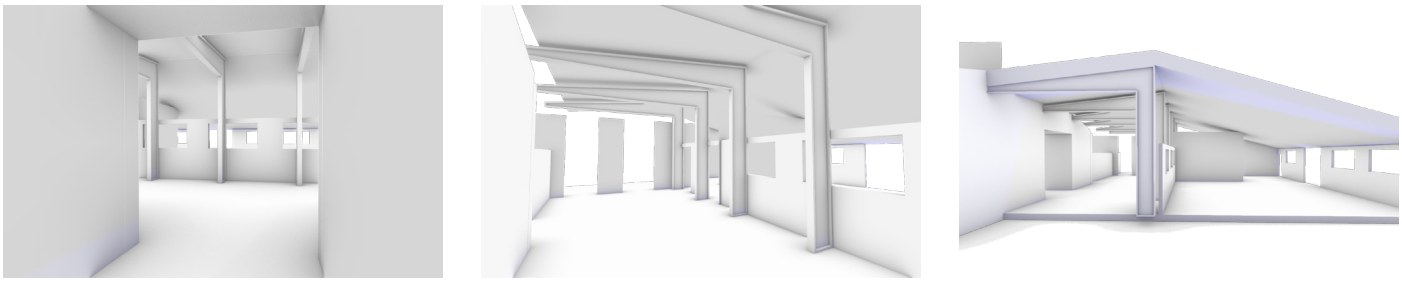
- Blue structure placed on the outside of the yellow brick wall (facing red bricks)
- Extend red brick wall to attach blue structure
- Middle wall extension needed
- No need for extended wall on the east wall (yellow)

Ill. 85: Iteration 2

After conducting the study using physical models, iterations one and two were rendered in a 3D program to examine the shape and connection from a different perspective. Iteration two showcased the steel structure prominently from the inside, while from the outside, it formed a saddle roof that complemented the red building's roof. As a result, it was concluded that the blue steel structures would be utilized as the connecting element, encompassing the building volume it generated.

Hereafter, investigations into the structural principles and capacities of the blue structures were undertaken.

Iteration 2



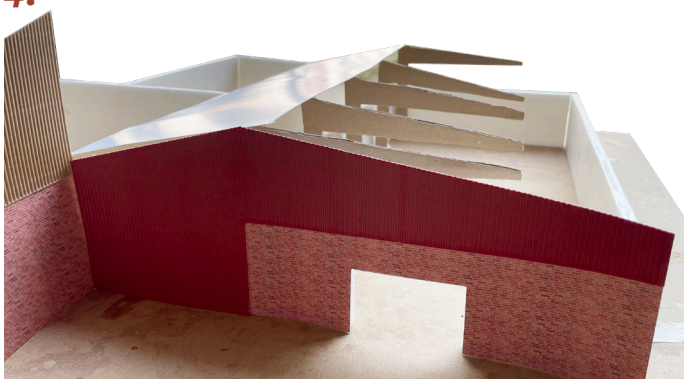
Ill. 86: Rhino models of iteration 2

3.

- Blue structure placed on the middle of the yellow building
- Need beams on both side of the blue structure to carry the roof
- No extension of east wall needed
- Effects the workshop floorplan a lot

Ill. 87: Iteration 3

4.



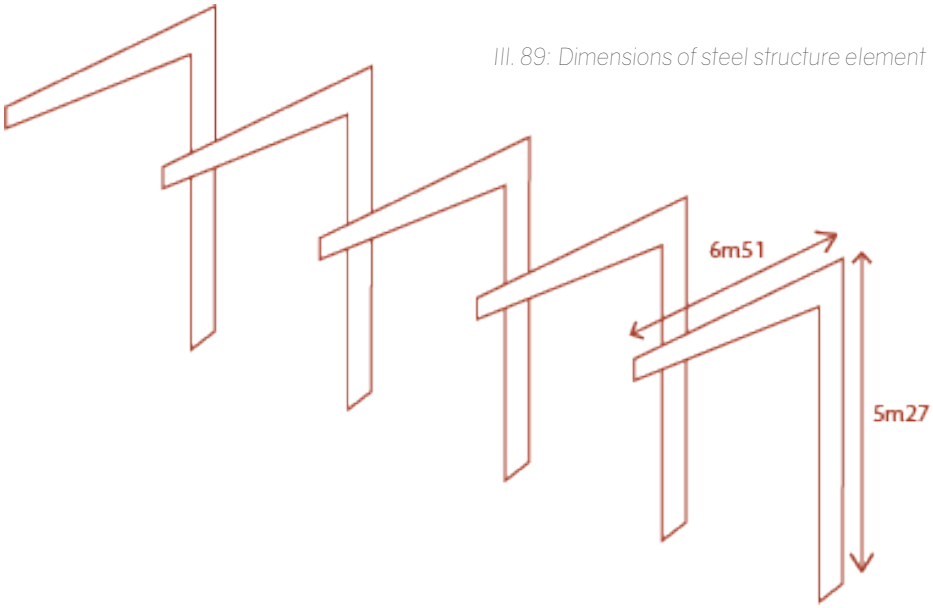
- Blue structure placed inside the yellow building
- Need timber extensions for the roof
- Need extensions on all walls

Ill. 88: Iteration 4

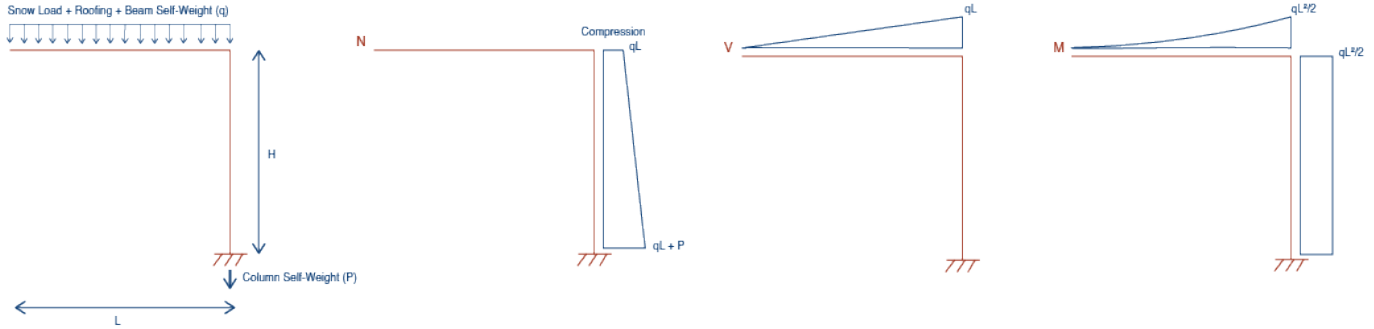
Blue frame load bearing capacity

There are only five blue frames available on the site. Therefore, it is required to calculate their load bearing capacity to know whether they are enough to carry the whole roof's extension. Their dimensions and the loads applied on the roof are known, the only missing data is the maximum spacing distance between each of them. (For calculations see Appendix 3)

Based on the calculations, it could be concluded that the maximum distance between the frames was 4.2m. However, it is important to notice that this value is based on the maximum deflection and can be increased or decreased depending on the appreciation of the client. Therefore, it was possible to include the steel structure in the development of the design proposal.



Ill. 89: Dimensions of steel structure element

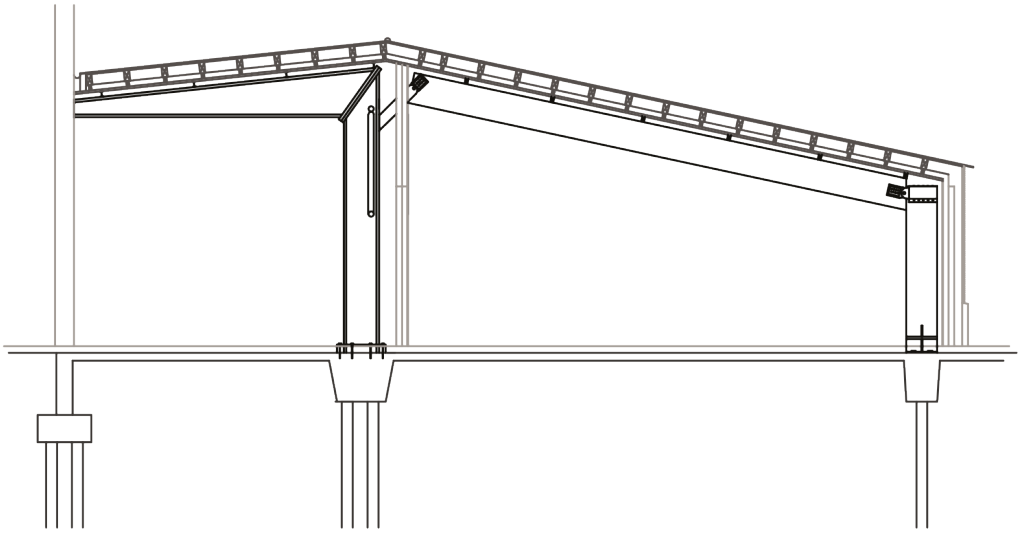


Ill. 90: Static diagrams

Construction iterations

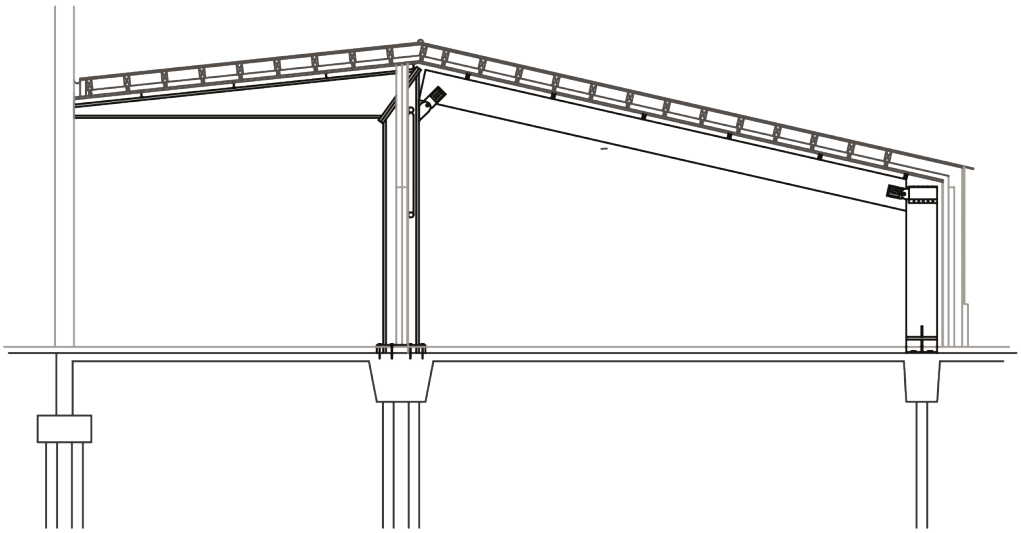
This study focuses on the joint between the structure of the extension, happening in the connection of the buildings, and the structure of the eastern existing building. At first, the two structures were separated from each other, this means that the structure would require more materials, foundations and more working time. Therefore, in the second iteration, the beam from the existing building is designed to lay on the steel frames instead of a new column. The new challenge was to connect both structures through the wall. The first idea was to include the steel frame in the wall in a way that the column is visible from both rooms. Nevertheless, it involves deconstruction of the existing brick wall placed close to the structure before reconstructing them. Thus, in the last iteration, the steel frame placed away from the existing wall and only a smaller connection goes through the wall to carry the beam. This way, it only requires intervention on the extension of the wall which does not currently exist.

Iteration 1



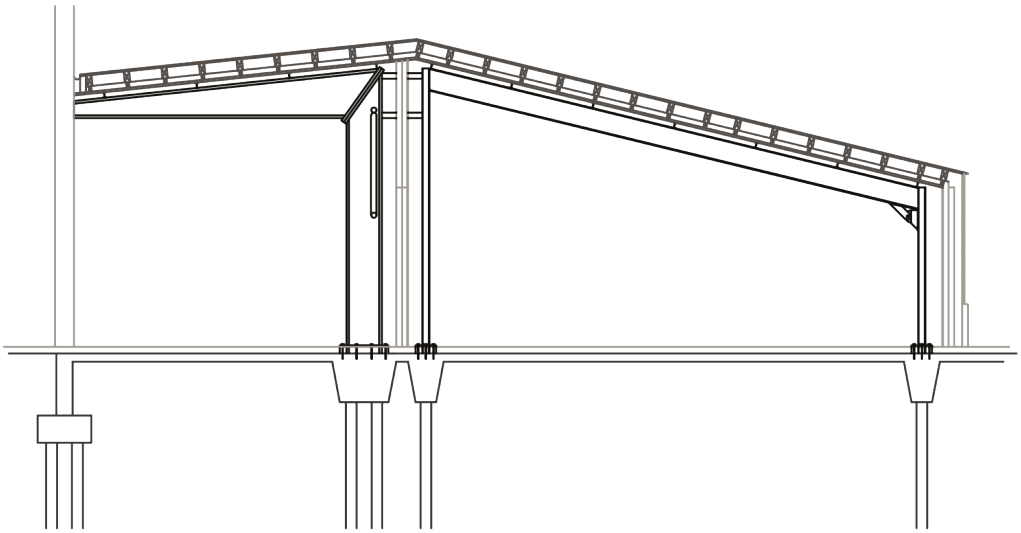
Ill. 91: Detailed section in the building extension and eastern building with both structures separated from each other.

Iteration 2



Ill. 92: Detailed section in the building extension and eastern building with the structure from the existing building laying on the steel frame which is included in the existing wall.

Iteration 3



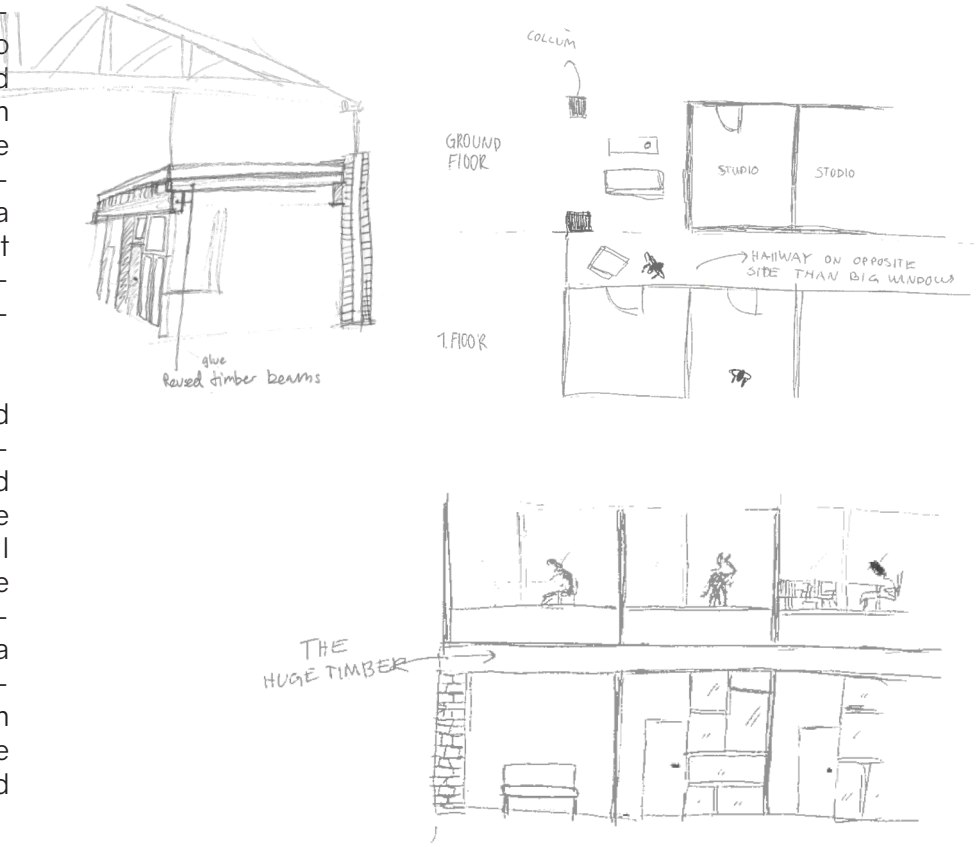
Ill. 93: Detailed section in the building extension and eastern building with the structure from the existing building laying on the steel frame which is place away from the existing wall.

Study: *Where to place the café, flexible exhibition space and the studio based on previous studies?*

Floor plan

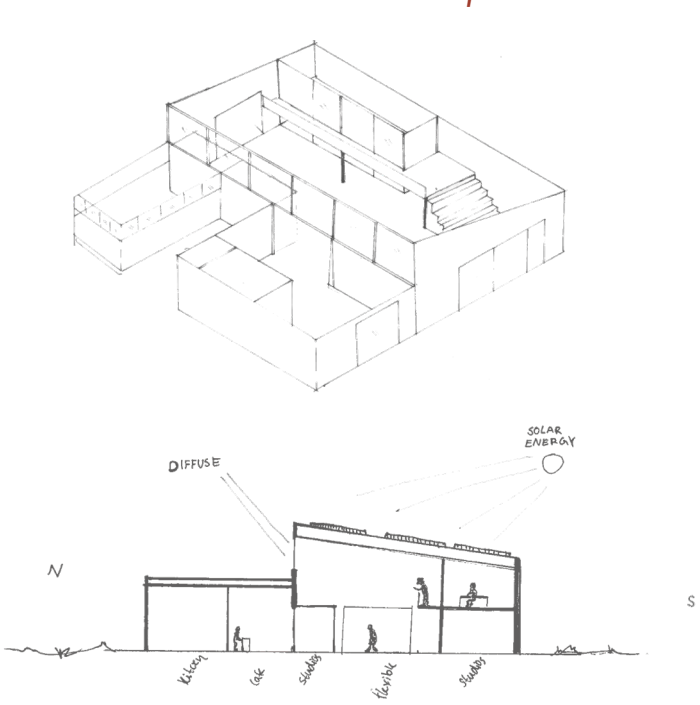
Following the design of the extension, a study was conducted to explore the detailed floor plan and experiment with the addition of an extra floor. Previous knowledge and conclusions regarding the floor plan were incorporated, with a particular focus on the placement of the studios and the space between them for the upcoming businesses to gather and interact.

During the study, ideas emerged regarding the possibility of raising the existing roof on the red brick building. This concept gave opportunities to add an additional floor where more studios could be accommodated. By intentionally not covering the entire floor, a unique, open, and enhanced atmosphere was created. The design study includes the detailing of the existing floors, the extension, and the added floor.



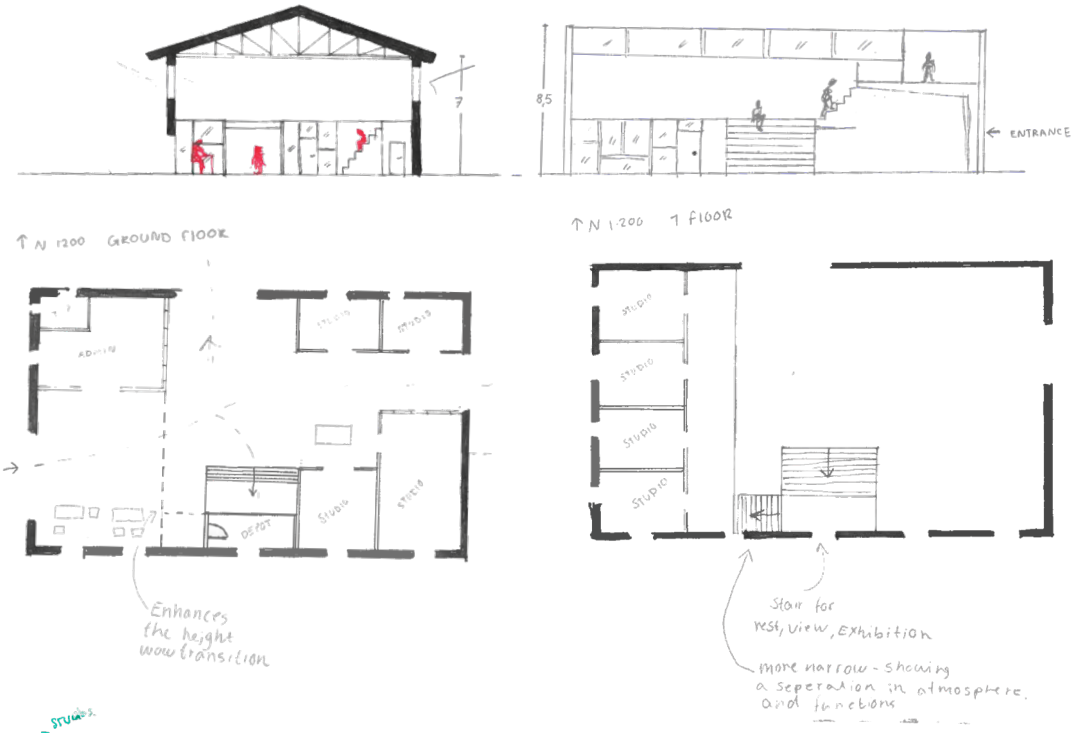
Ill. 94: Iterations of additional floor in the red brick building

Study: *Where to place the added floor while ensuring a welcoming atmosphere and interactions between the two floors?*

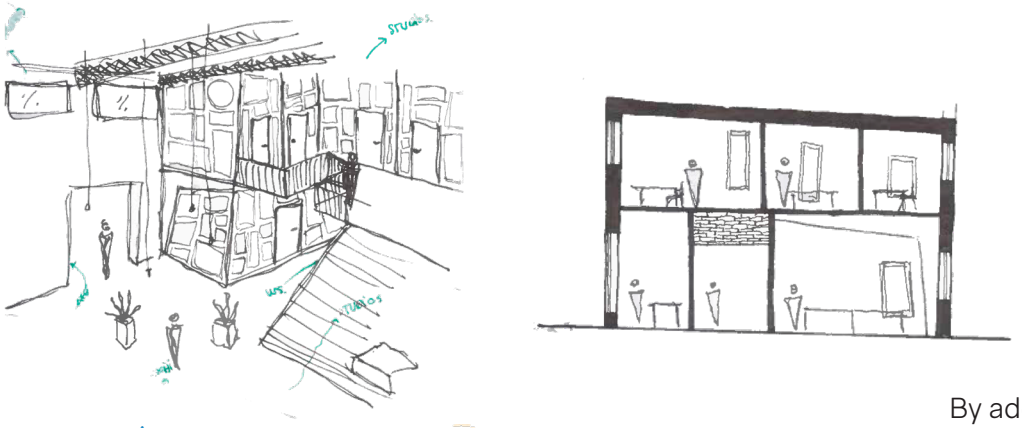


Ill. 95: Adding a floor in the southen part of the red building, illustrated through section and isometric drawing

Ill. 96: Adding floor in the south part of the red building, illustrated in section and plan drawing



Ill. 97: Adding floor in the west part of the red building. Exploring how the stair can be an integrated part of the floor plan and spacious apperiance



Ill. 98: Adding floor in the east part of the red building. Illustrated through perspective drawing, section an plans.

By adding an additional floor above the studios located on the east side of the red brick building, an open space with a double-height ceiling at the entrance was created. This area serves as a flexible exhibition space, forming a meeting point where the public could interact. A spacious staircase provided a place for relaxation, offering an elevated view of the room and exhibits.

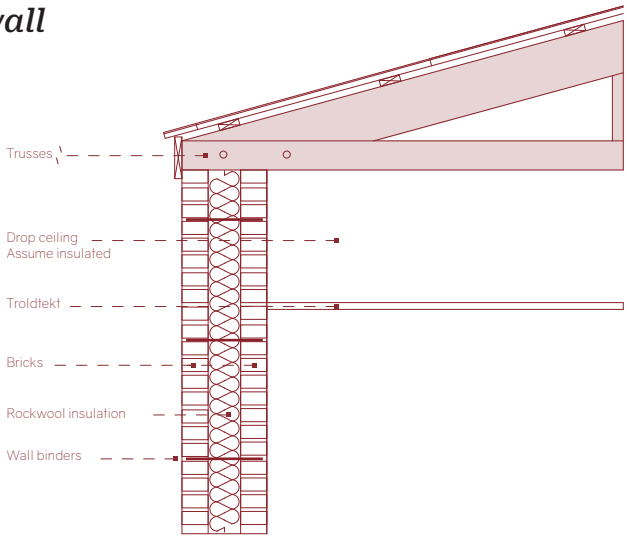
From the spacious exhibition space, visitors could be guided towards the café or the studios. As one moved closer to the studios, the floor plan gradually narrows down, creating a more intimate atmosphere. Open spaces between the studios allows for collaboration and interaction among the people working in the building, while also providing guests with the opportunity to observe and engage with the innovative and creative processes taking place.

Lifting study

This study was made to explore how the use of reused materials could enable a 2-meter lift of the roof, allowing for the addition of an extra floor and a double-height ceiling in the exhibition area. The primary objectives were to enhance spatial qualities and maximize natural light within the space.

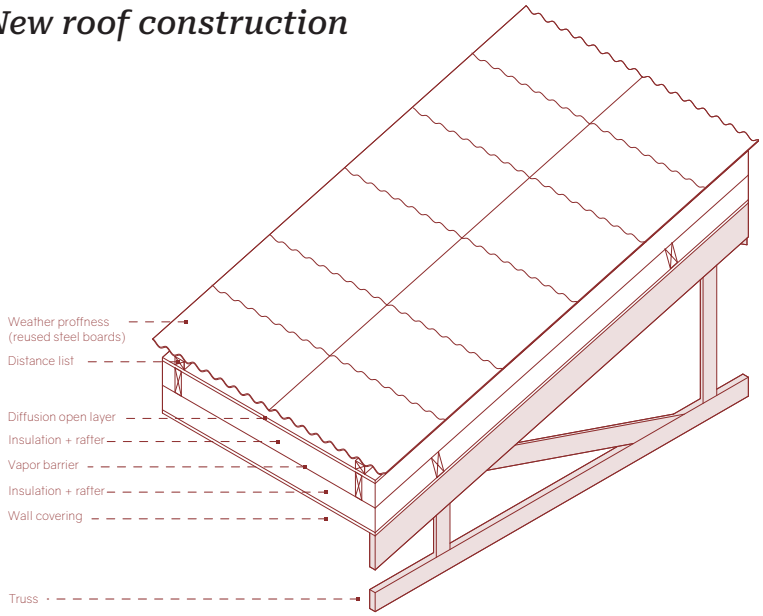
Several parameters were examined during the study. This included finding ways to showcase the existing trusses from the interior, optimizing the wall's capacity in relation to adding insulation to lower the u-value, and considering the structural properties of both the old and new wall constructions. Additionally, the study focused on achieving an aesthetically pleasing expression of the meeting points and joints between the existing building and the added construction using reused materials. The external appearance of the construction was also considered in terms of its overall aesthetic appeal.

Exising wall

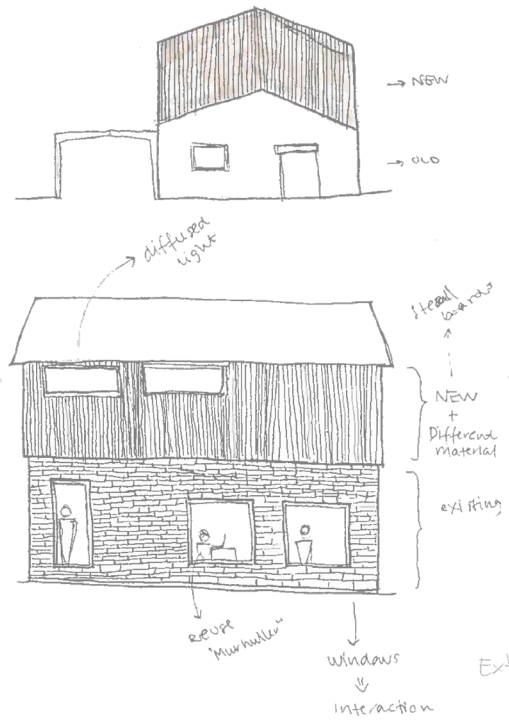


Ill. 100: Detail, 1:30

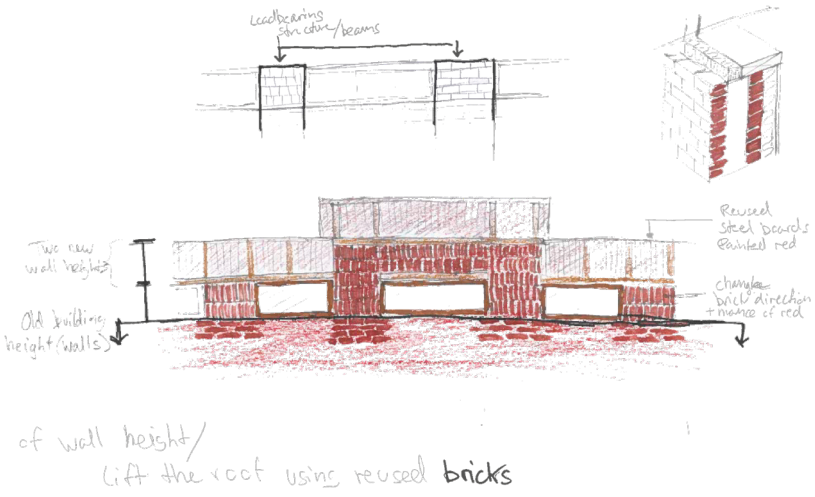
New roof construction



Ill. 101: New roof construction

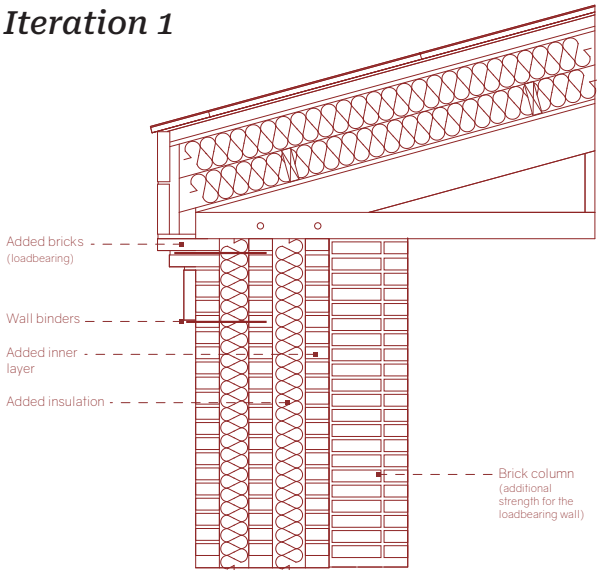


Ill. 99: Lift iteration, clear difference between new and old



Ill. 102: Lift with bricks, continuing same materiality, but horizontal

Iteration 1



Ill. 103: Wall detail added brick layer on the inside

Aesthetic:
- The extension looks similar to the existing, creating a cohesion between the old and new.

Construction(Approach + GWP):
- Traditional brick laying method
- Reinforce the wall to make sure it can hold when it becomes taller than 4 meters.

Virgin materials needed (GWP):
- Mortar(facade and column), insulation, wallbinders

Elevations made in Enscape

Ill. 105: Red reused bricks - horizontal

Ill. 106: Red reused bricks - vertical

Ill. 107: Red reused bricks - transition layer between existing and new

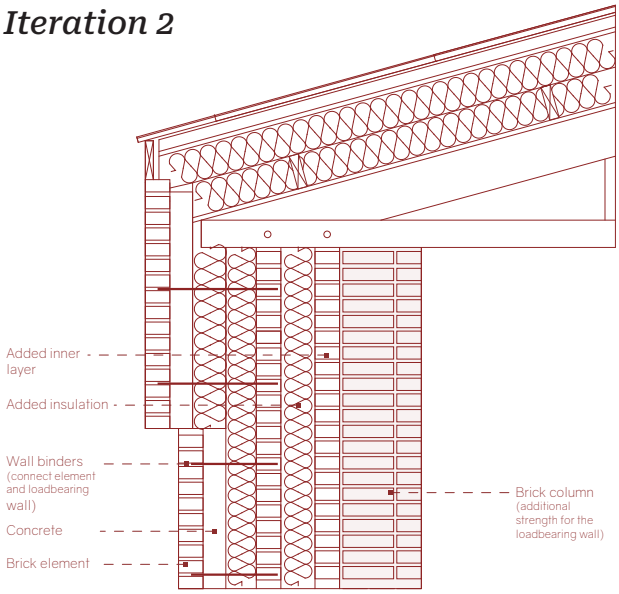
Ill. 108: Red reused bricks - transition layer between existing and new

Ill. 104: White uncleaned bricks - rotated for diffused sunlight

Ill. 109: White uncleaned bricks - rotated for diffused sunlight

Visualization method compared to real life photo of existing wall. In the render the bricks from the site has been used to create a material inside the software. The colour difference is due to there being additional daylight on the facade than in the photo.

Iteration 2



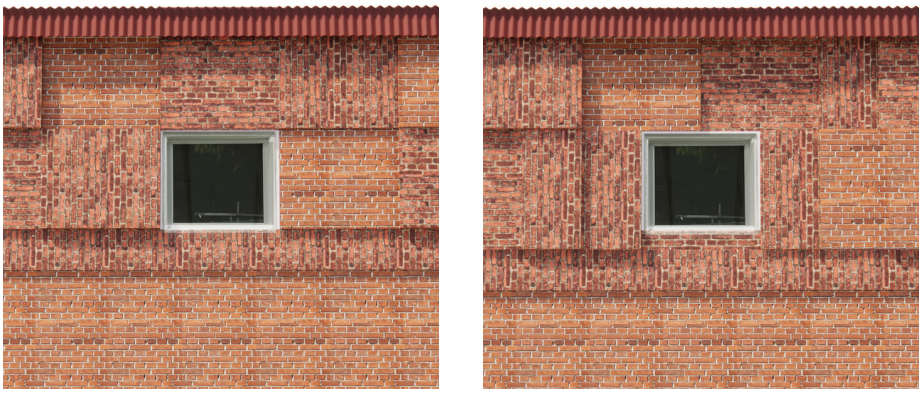
Ill. 110: Wall detail, brick elements as cladding on the extended facade

1 m x 1 m brick elements

Aesthetic:
- The extension is attatched with clear constrast to the existing

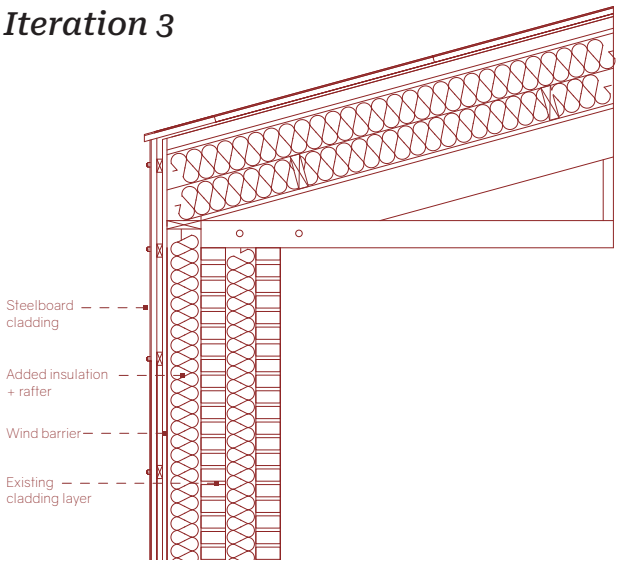
Construction(Approach + GWP):
- New mortar needed to realize this construction.
- The new extension is a very heavy structure, which challenges the existing walls.

Virgin materials needed (GWP):
- Mortar, concrete, insulation, construction wood, wallbinders



Ill. 111: Elevations. Brick elements implemented as facade cladding on the extended wall

Iteration 3



Ill. 112: Wall detail, steel boards as cladding on the extended facade

Light timber construction and steel cladding

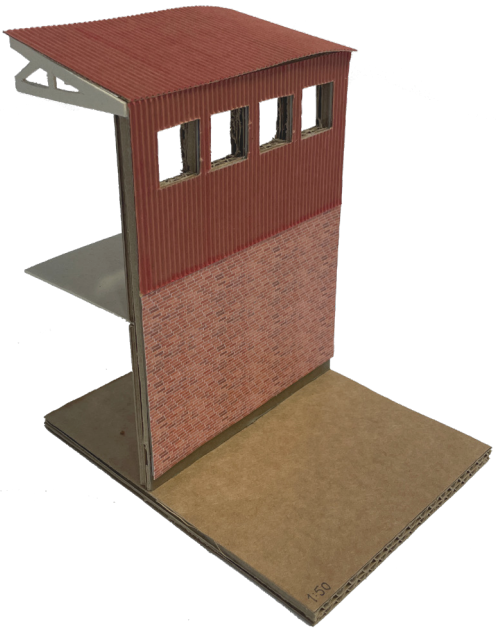
Aesthetic:
- The extension is attatched with clear constrast to the existing.
- New texture + shapes added to the wall

Construction(Approach):
- Light construction - preferable when adding to a loadbearing brick wall.

Virgin materials needed (GWP):
- Construction wood, insulation, screws

Ill. 113: Elevations. Steel boards as cladding on the extended facade. Iterations on colour.

Ill. 115: Facade steel board cladding iterations. Exploring colour and sizes of the applied boards to investigate the potentials of a pattern.



Ill. 114: Model of the lift focusing on the cladding

After conducting initial studies on the structural lifting of the roof and the materiality of the extended wall, further investigations took place. These subsequent studies revealed that the existing load-bearing brick walls were unable to support the extension and the roof. As a result, an additional construction was necessary, and this aspect will be explored in the following studies.

It was decided that steel boards would be the material choice for the extended wall. They offer a lightweight construction, reducing the load borne by the new structure. Additionally, they provide the opportunity to paint them in a red nuance arose. This approach allows the extended wall to blend in with the existing building while clearly distinguishing between the new and old elements through the choice of materials.

Consequently, studies were conducted to examine both the construction and aesthetics of the structural elements of the intermediate floor and the roof looking from the inside.

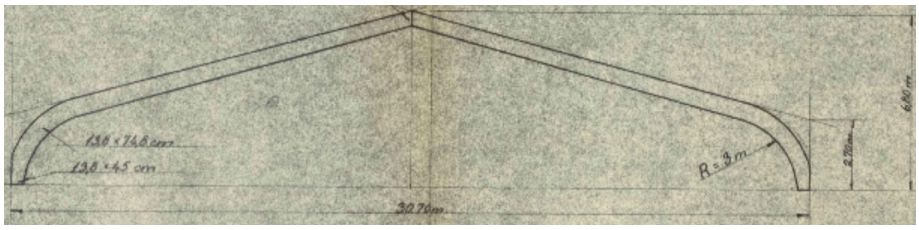
Construction

This study aimed to explore the construction and design possibilities of the intermediate floor using reused materials. The additional floor does not span the entire footprint of the red building, thereby allowing variation in the construction of the intermediate floor and the double-height room.

Three primary approaches for the intermediate floor were investigated: one involving the attachment to the existing structure, another relying on the support of the existing structure, and finally, the addition of a separate structure within the existing building.

Additionally, the study incorporated references to inspire the design development and evaluations.

Glue laminated timber beams from Hjulmagervej 12

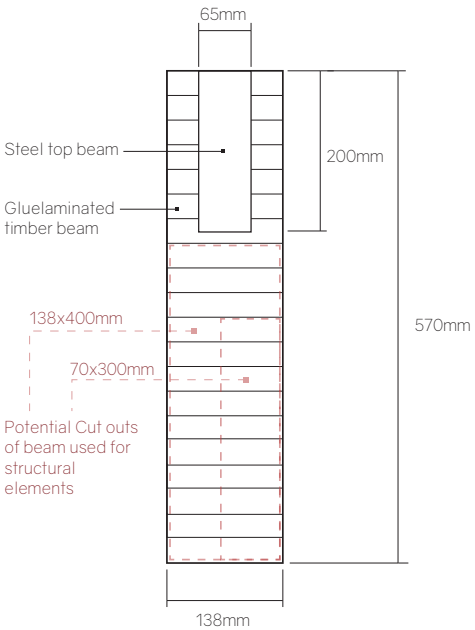


Ill. 116: Construction drawing, Hjulmagervej 12

Ill. 117: Glue laminated timber, patina

Ill. 118: Glue laminated timber

Reuse timber principle



Ill. 119: Glue laminated timber

Aarhus School of Architecture

- Libary
- Seperate timber structure inside concrete envelope

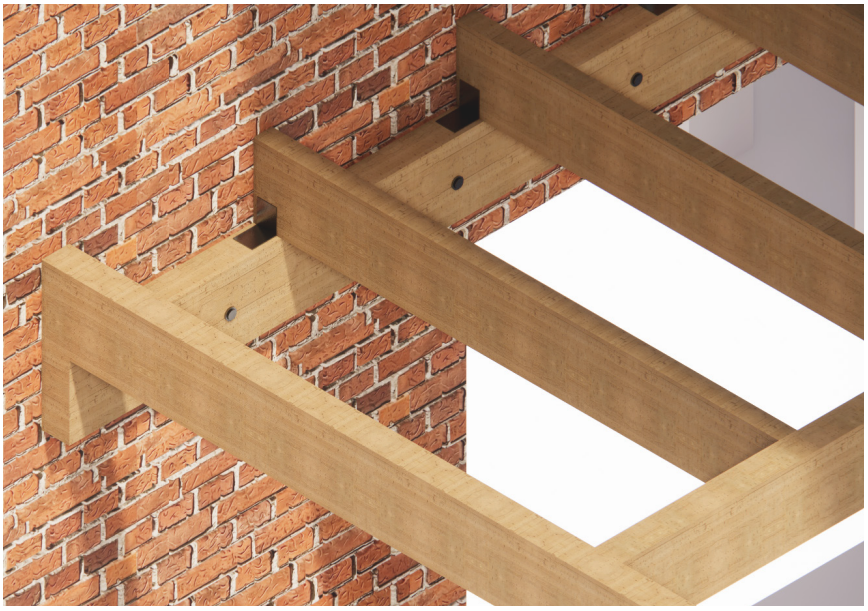
Ill. 120: Aarhus School of Architecture

Muuratsalo Experimental House

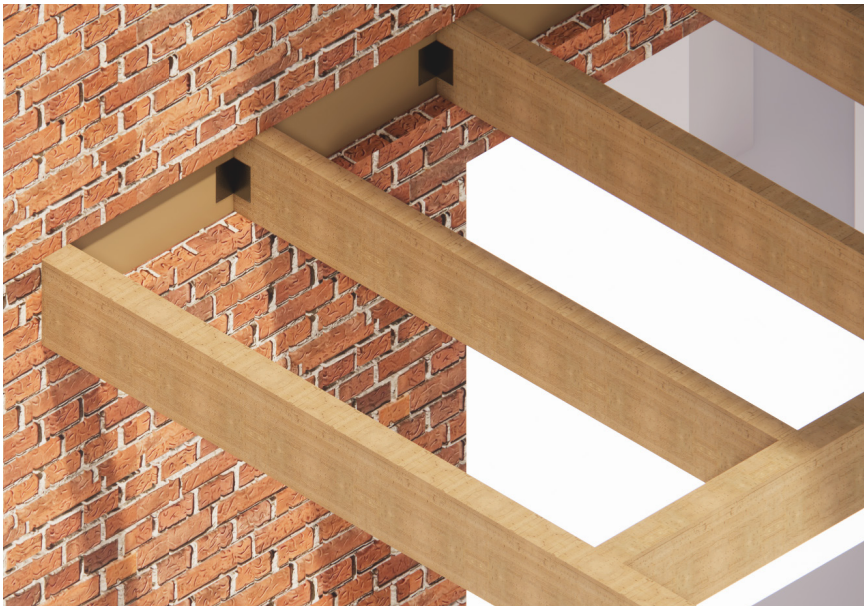
- Summerhouse
- Timber beams resting on brick wall

Ill. 121: Alvar Aalto summerhouse

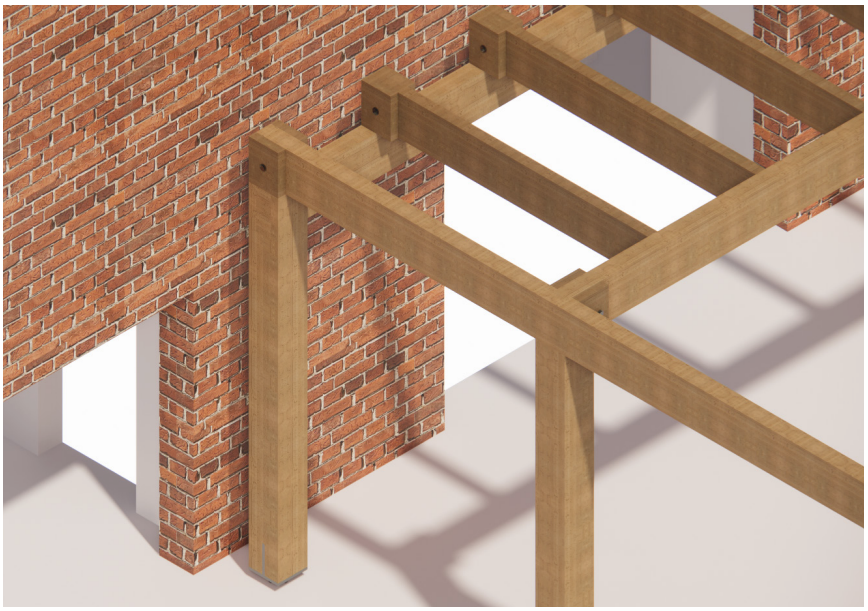
Attached



Resting



Seperate



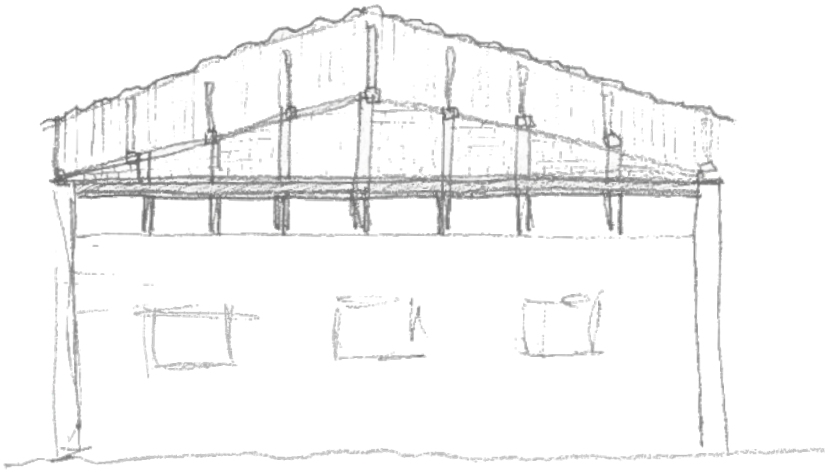
Ill. 122: Construction iterations

It was determined that glue-laminated timber beams would be utilized to construct a separate framework for the additional floor. This separate structure was designed in a way that did not impact the existing walls. The visual distinction between the existing and additional structures, achieved through their separation, reinforced the concept of differentiation between new and existing materials. However, further design studies were required before deciding whether this approach should be implemented throughout the entire building.

During these studies, iterations on the roof design took place. Consequently, the final iterations on the construction will be presented after the following study of the roof design.

Roof

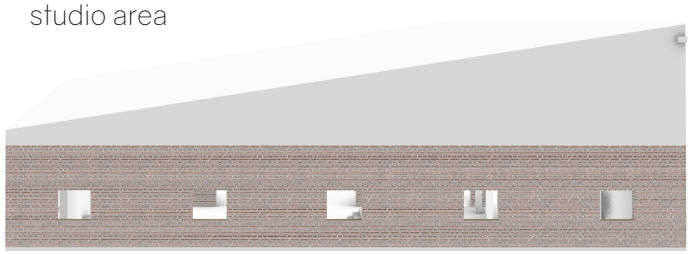
Since the additional floor does not span the entire room, it was necessary to consider whether the entire roof needed to be lifted or only a part of it. To assess the spaciousness and aesthetic impact, 3D modelling was employed to examine the perspectives from both the interior and exterior.

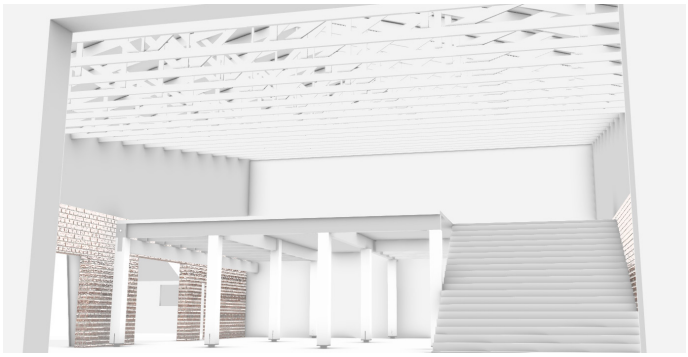


Ill. 123: Lift sketch

Iteration 1

- The roof slope draws the attention towards the second floor/upwards
- Less ceiling height in the entrance area, more in the studio area

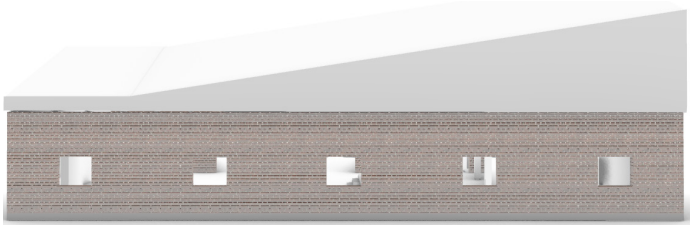


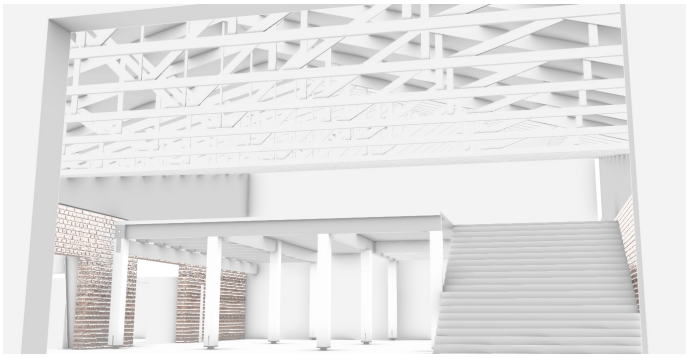


Ill. 124: Iteration 1, rhino model

Iteration 2

- Less visual connection between floors
- Less ceiling height in the entrance area, more in the studio area
- Gradual reveal of the slope

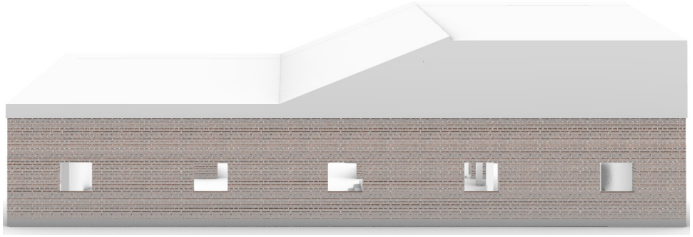


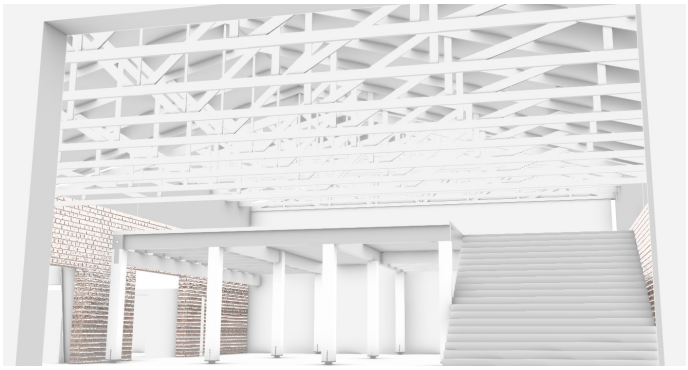


Ill. 125: Iteration 2, rhino model

Iteration 3

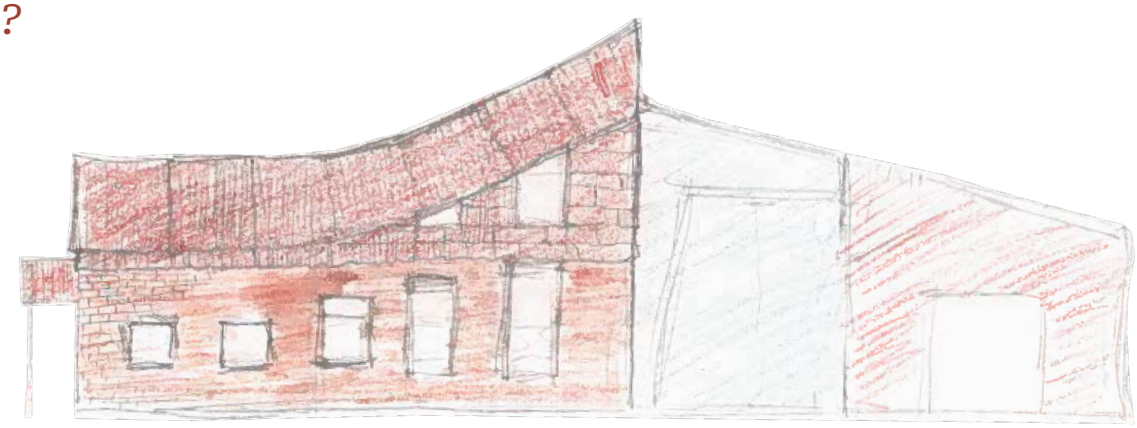
- Less visual connection between floors
- Less ceiling height in the entrance area, more in the studio area





Ill. 126: Iteration 3, rhino model

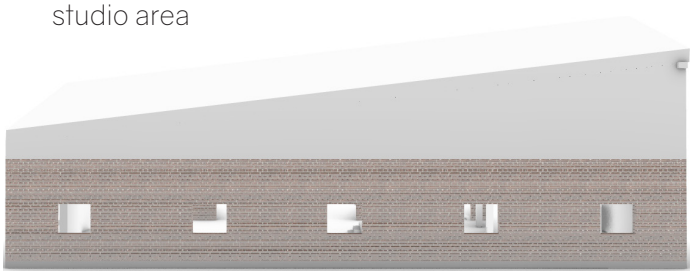
Study: *How should the roof be lifted? Should it be the whole roof or gradually lifted?*

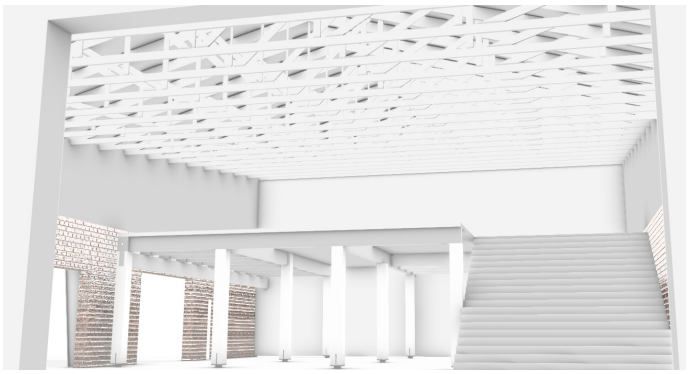


Ill. 127: Lift sketch

Iteration 4

- The roof slope draws the attention towards the second floor/upwards
- Less ceiling height in the entrance area, more in the studio area

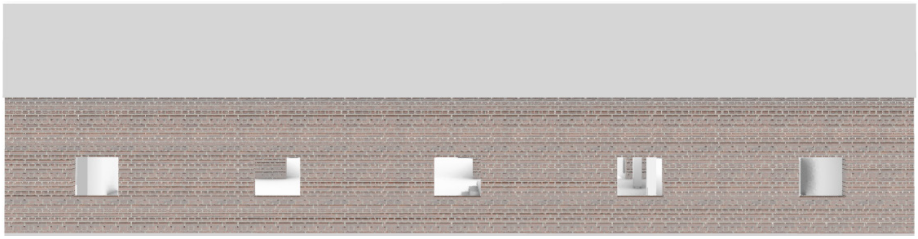


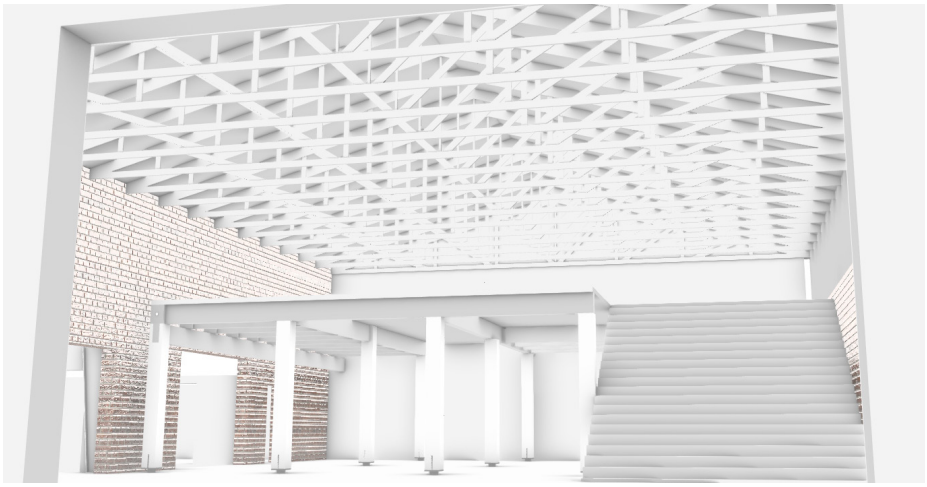


Ill. 128: Iteration 4, rhino model

Iteration 5

- Extension: Traditional saddle roof - allow more ceiling height in 2. floor and entrance exhibition





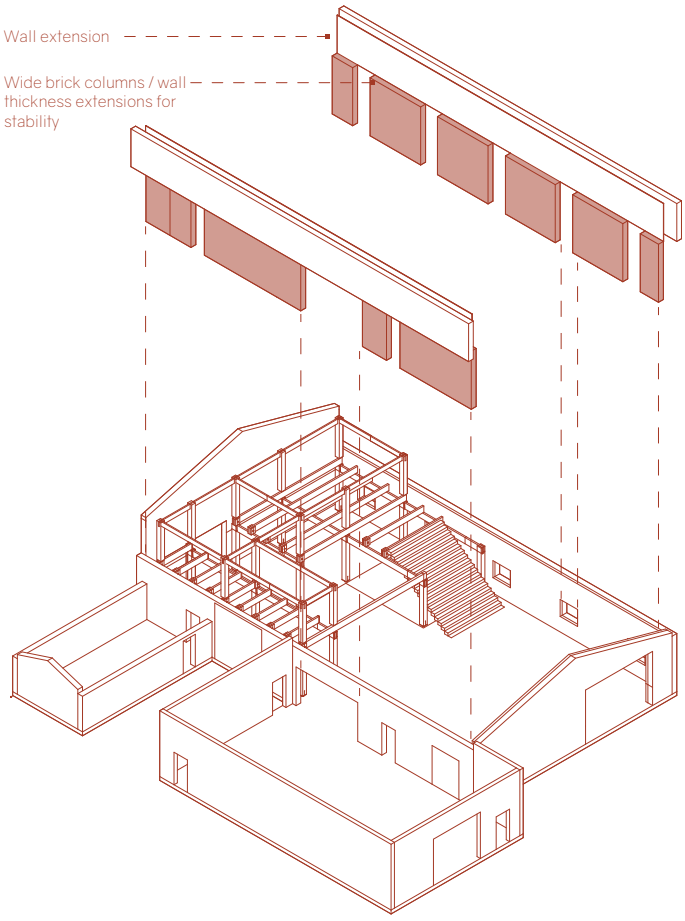
Ill. 129: Iteration 5, rhino model

To ensure a spacious entrance for people entering the building, iteration 5 was further developed. This design allows the trusses to remain visible, enhancing the visual connection and open atmosphere. Furthermore, the interaction between the two floors was maintained.

Roof construction

Building upon the previous studies, which concluded that the additional floor would be constructed using reused glue-laminated timber, this study explored the design of the roof construction. Two primary approaches were explored: one entailing the utilization of the same timber beams as the intermediate floor, and the other involving the implementation of brick columns.

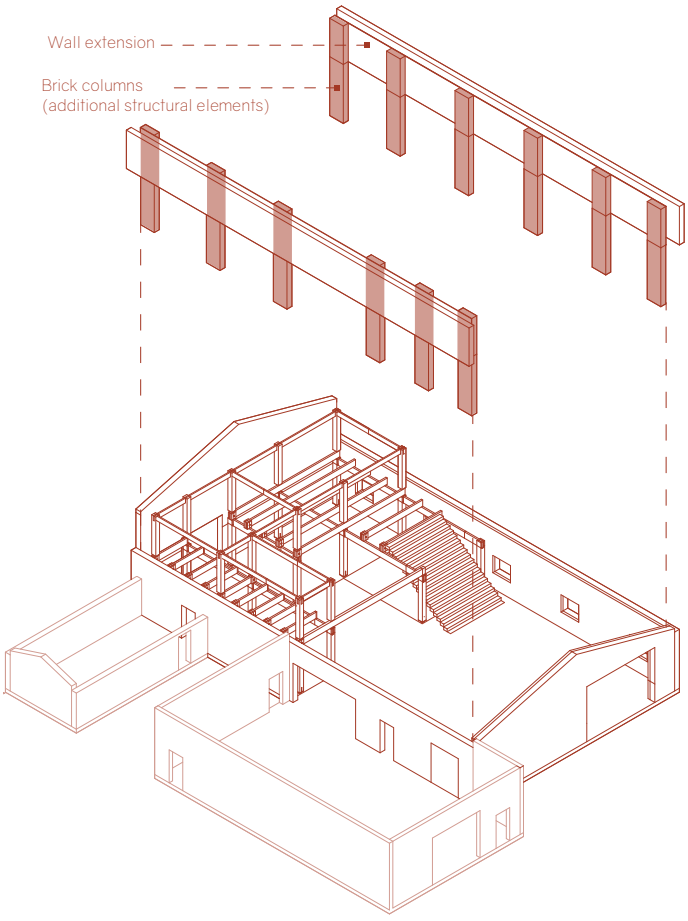
Iteration 1 - Brick columns



Ill. 130: Iteration 1 - Brick

- Wide columns added to the existing envelope to add stability and allow the 2,3 m lift of the roof.
- The added structure frames the windows and openings inside the building.

Iteration 2 - Brick columns

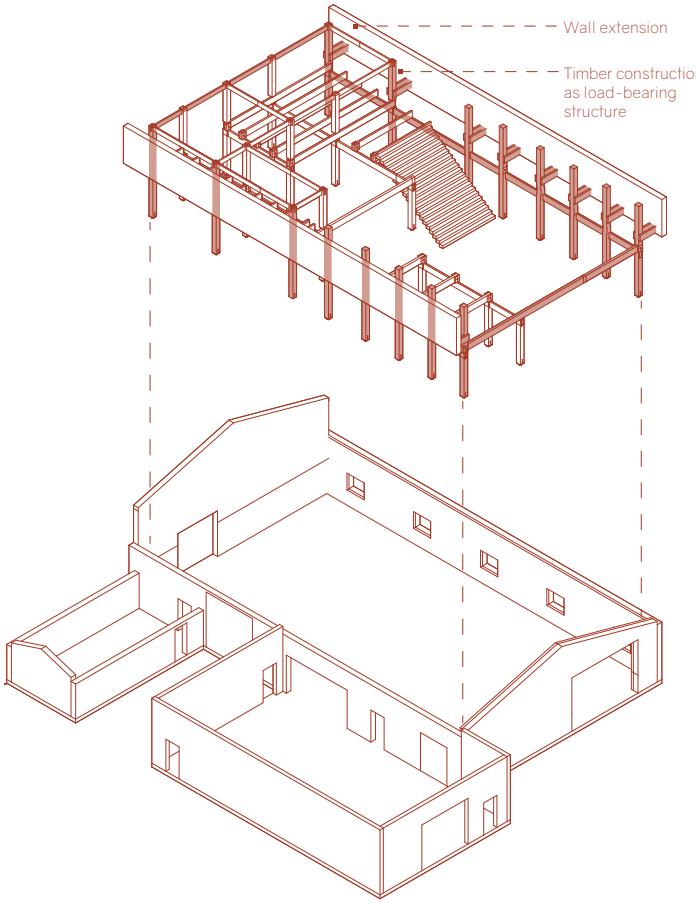


Ill. 131: Iteration 2 - Brick

- Wide columns added to the existing envelope to add stability and allow the 2,3m lift of the roof.
- The added structure frames the windows and openings inside the building.

The final choice based on an intuitively look on the structural properties led toward the second brick column iteration. Despite its involvement of a different material, from the new intermediate floor structure, and the bricks are less flexible, brick columns allow more space in the exhibition room and still allows a view of the wooden trusses under the roof. In addition to this, it can highlight the windows between them and fits well with the brick materiality on the interior walls. Further calculations on the brick column construction and the timber construction will be presented on the following page.

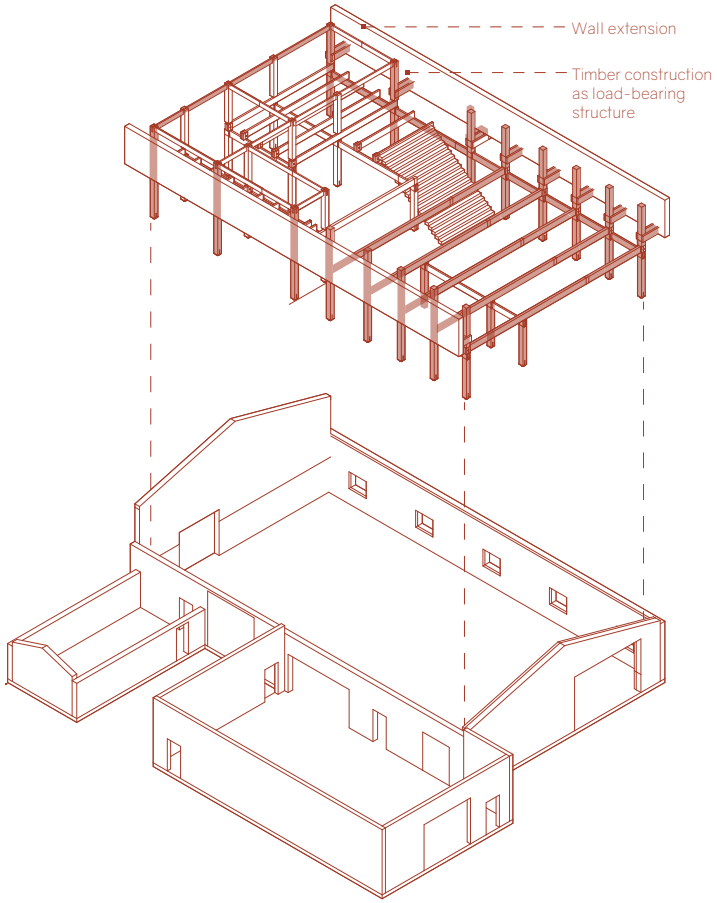
Iteration 3 - Timber columns



Ill. 132: Iteration 3 - Timber

- Wood structure added as an envelope inside the existing walls that carry roof lift.
- Combination of utilizing the existing brick walls loadbearing properties with the addition of wood beams and columns.

Iteration 4 - Timber columns



Ill. 133: Iteration 4 - Timber

- Wood structure added as an envelope inside the existing walls that carry roof lift.
- Combination of utilizing the existing brick walls load-bearing properties with the addition of wood beams and columns.
- Long beams added for extra stability in the wood structure

Structural calculations

Purpose

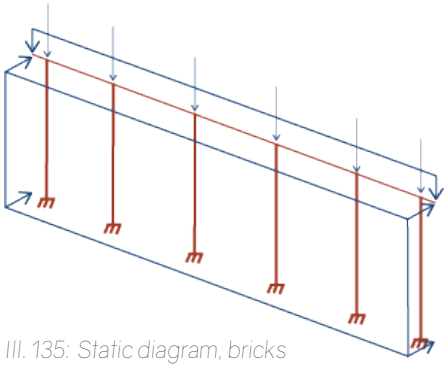
Before choosing between timber structure and new masonry to carry the wall extension, it is important to evaluate the feasibility and the implications on the indoor space of such structures.

Load case

The loads applied on the structure are the roof load, the snow load, the structure self-weight, and the wind load. The loads are based on Eurocode and Danish standards. (Appendix 4)

New masonry

The new masonry is composed of both one brick layer on the existing walls and brick piers spaced at regular intervals of 5 meters. To stay in a feasible timeframe, the structure has been assumed as a beam-column structure with fixed connection where the columns are the brick walls. The only unknowns are the brick columns dimensions.



Ill. 135: Static diagram, bricks

The Eurocode 6 mentions the verification of the normal stress, the shear stress and the flexural stress when designing a brick wall. Below are the formulas allowing to calculate resistance values.

Maximum normal force (Nrd):

$$Nrd = \phi * t * fd \geq N_{Ed}$$

Where Φ is the capacity reduction factor which considers the eccentricity caused by horizontal loads, t is the thickness of the wall increased by the piers' thickness, fd is the design compressive strength and N_{Ed} is the design normal force in the wall.

Maximum shear force (Vrd):

$$Vrd = cv\left[\frac{l}{2} - e_{Ed}\right] * t * f_{vd0} + \frac{0,4N_{Ed}}{\gamma M}$$

$$\leq 3 * \left[\frac{l}{2} - e_{Ed}\right] * t * f_{vdu} \geq V_{Ed}$$

Where cv is 3 for masonry with filled perpend joints, l is the length of the wall in bending (here it is the height), e_{Ed} is the eccentricity due to horizontal load, f_{vd0} is the design initial shear strength, γM is the safety factor (in the case of brick of class 1 and category II, the value is 2), f_{vdu} limit shear strength, and V_{Ed} is the design shear force.

Maximum bending moment (Mrd):

$$Mrd = f_{xd} * Z$$

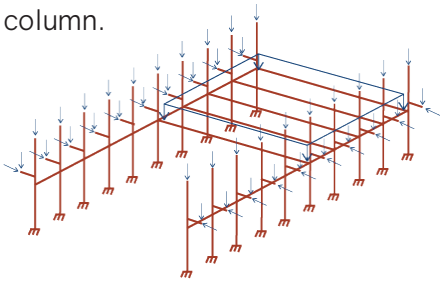
Where f_{xd} is the flexural strength increased by the design compressive stress and Z is the elastic section modulus considering the section in bending and the brick column section.

The design forces in the structure have been computed with Robot Structural Analysis (Appendix 5).

According to the resistance value, the flexural stress is the most restrictive and lead by iteration to a brick column of 0.97m wide and 0.36m deep. (Appendix 5)

Timber structure

The timber structure is made of glulam columns assumed to be GL28c connected to timber beams carrying the wall extension on one side and the studios on the other side. This means that load case is different from the masonry: the self-weight and the wind load of the existing wall is not considered anymore but a surface load from office is added. The unknown is the side dimension of the timber column.



The Eurocode 5 mentions the verification of the combined bending and compressive strength, the shear strength, and the buckling. Below are the formulas allowing to calculate resistance values.

Bending and Compression (the moment in y direction is negligeable):

$$\frac{\sigma_{c0d}{}^2}{f_{c0d}} + \frac{\sigma_{mzd}}{f_{mzd}} \leq 1$$

Where σ_{c0d} is the design compressive stress in the column, f_{c0d} is the design compressive strength, σ_{mzd} is the bending stress and f_{md} is the bending strength.

Maximum shear stress (τ_{max}):

$$\tau_{max} = f_{vd} * A_{ef} > \tau_{Ed}$$

Where f_{vd} is the design shear strength in the column, A_{ef} is the efficient area, and τ_{Ed} design shear stress on the efficient area.

Buckling (the moment in y direction is negligeable):

$$\frac{\sigma_{c0d}}{f_{c0d} * k_{cz}} + \frac{\sigma_{mzd}}{f_{mzd}} \leq 1$$

Where k_{cz} is a factor related to the relative slenderness of the column.

The design forces in the structure have been computed with Robot Structural Analysis (Appendix 5).

According to the calculation the buckling is the most restrictive and has led by iteration to a column with a 26cm square section. (Appendix 5)

Conclusion

Both structures are feasible and do not affect the indoor space too much. It means that the structure limitations are not defining the final design solution.

Ill. 134: Static diagram, Timber

Interior materials

Study: *How to incorporate reused materials in the interior walls while ensuring a visible, dynamic, and creative atmosphere?*

A building on Østre Allé 104, that is included in the municipality's demolition plan, have windows that can be utilized with the dimensions of 1x1 meter and 2x2 meter (Appendix 5). The glass can be utilized by re-framing them and integrate them in the inner walls. This would allow a visual connection between the studio renters and the visitors as well as creating a community feeling between studio renters.

Interior walls and window frames from plywood would add a soft texture and in coherence with the window make out a bright room for a creative workspace. The warmth and natural tone of plywood can contribute to the sense of belonging in the workspace community. The material affords a different atmosphere than the surrounding bricks, that creates a contrast and highlights the old meeting new.

Using brick as interior studio walls can contribute to a gritty and raw ambiance in the studio spaces as it is associated with the industrial identity. In connection to the work within the studios the unrefined texture of the brick walls complements a vibrant artwork and decorative elements, resulting in a visually dynamic and creative atmosphere.

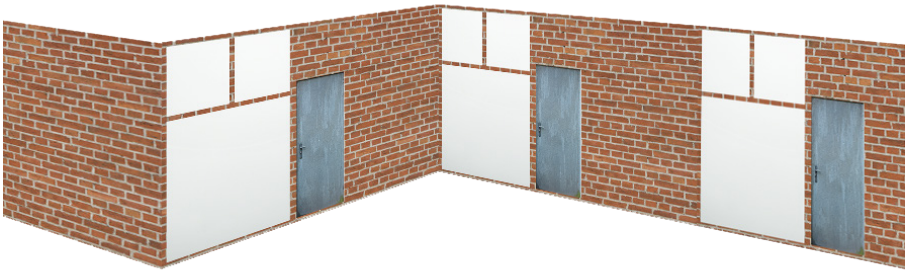
As well as interior brick walls, plywood can in the combination with the surrounding brick walls create an atmosphere that feels playful, artistic, and expressive. When plywood is left raw it can also contribute to an industrial aesthetic, similar to exposed brick walls. Furthermore, when plywood and bricks are combined, they enhance and illuminate each other, creating an atmosphere that embodies the historical identity and new synergies of a space situated in a new neighbourhood and consisting of a startup community. The plywood will blend in with the timber structure from the studios and intermediate floor and together enhance the brick envelope surrounding them.

Plywood

Ill. 136: Plywood, perspective

Ill. 137: Plywood, elevation

Brick



Ill. 138: Brick, perspective

Ill. 139: Brick, elevation

Broken bricks

This study was made to investigate how to use broken bricks. The re-use of these broken bricks will still require cleaning, and new mortar when assembling. The walls or elements designed with these bricks are not loadbearing.

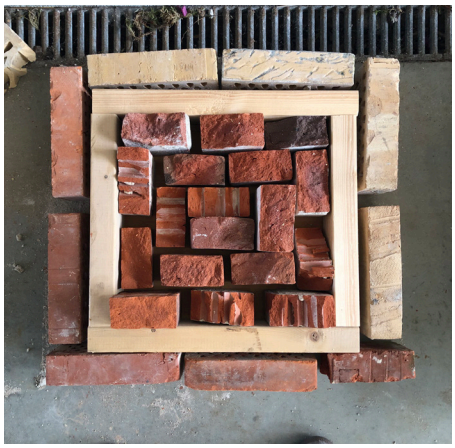
Use of material

- Bricks - broken bricks allow for a more dynamic expression,
- Wood - added to allows easier transportation, reduce the chaotic expression, cohesion in the design
- Mortar - added for stability and connection between bricks, should keep the amount as low as possible

Element qualities

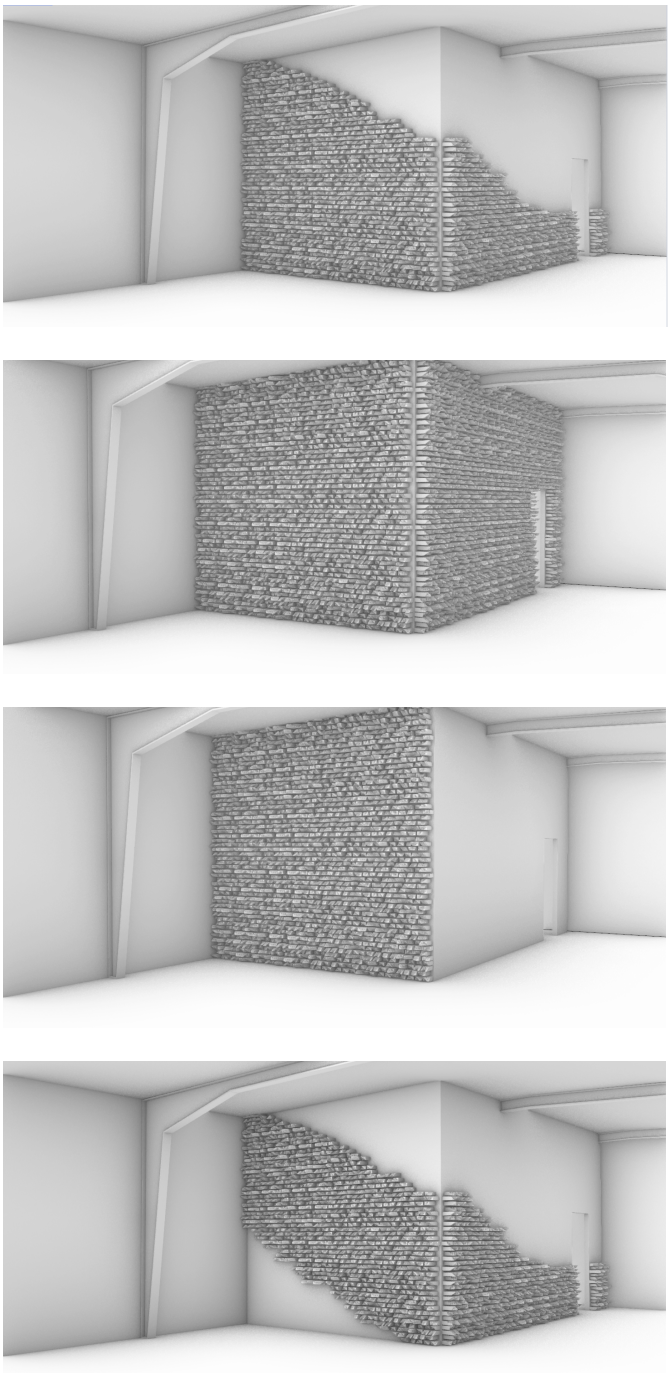
- *Acoustics* - the increased surface area and its shape capture soundwaves
- *GWP reduction* - reusing the broken bricks without having to crush them further
- *Expression* - Element changes expression as the light hits them differently.
- *Aesthetic* - expresses the idea of reusing in a more raw and playful way
- *Interactive* - the dynamic facade invites users to approach and touch the elements

Physical brick collage

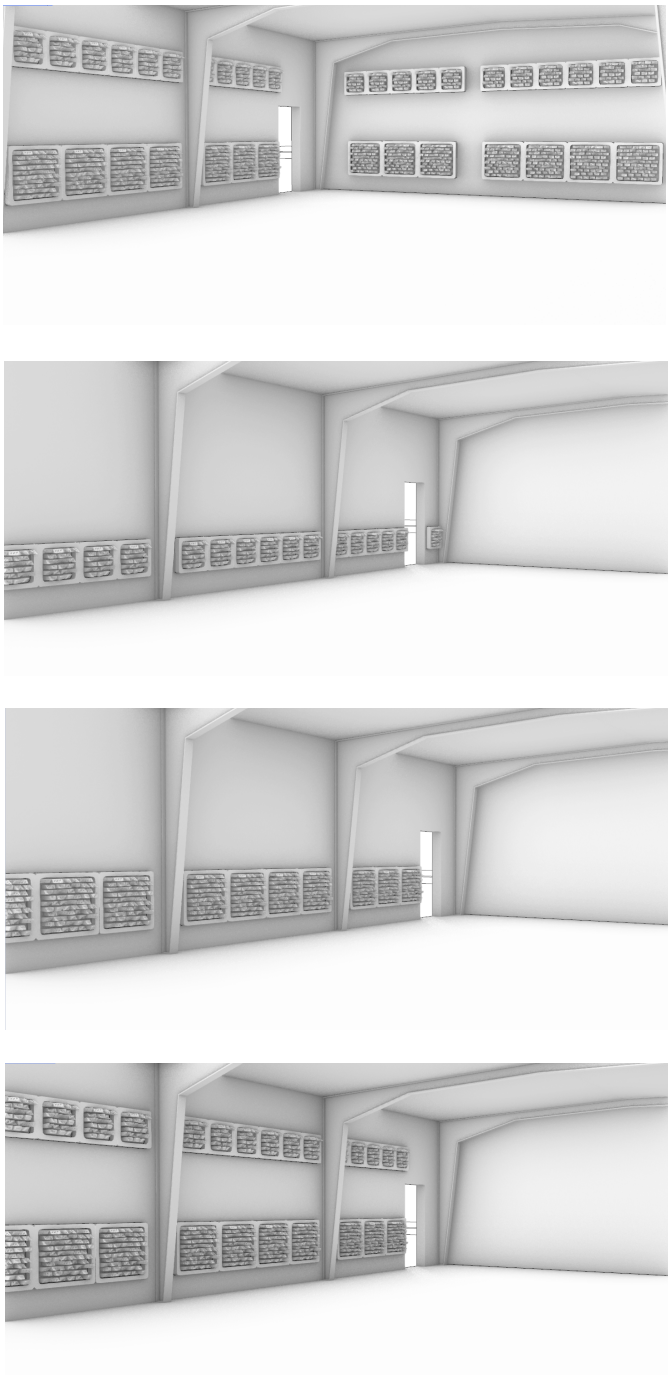


Ill. 140: Broken brick study. Exploring the placement of broken bricks within a frame, to be used as cladding on interior walls

Rhino modelling



Ill. 141: Broken bricks as cladding explodred in Rhino. Implemented on interior walls.



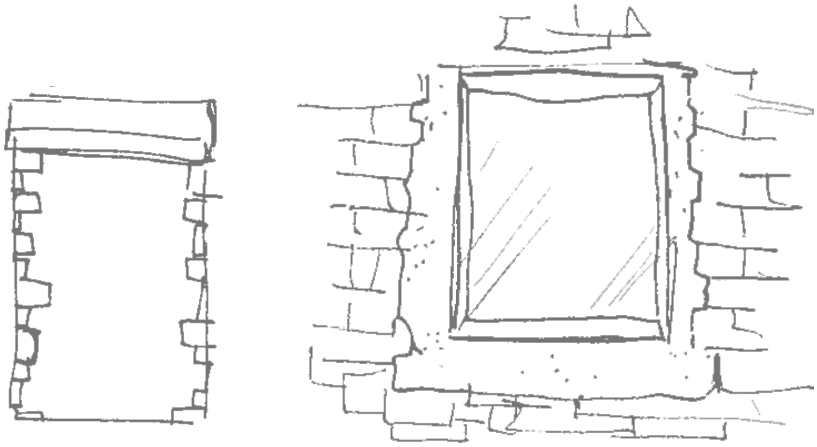
Ill. 142: Broken brick as cladding in frames of timber. Implmented as panels on interior walls

By exploring the possibilities of reusing broken bricks instead of recycling or crushing them, several suggestions emerged. One suggestion involved using the bricks as cladding on selected interior walls, creating a rough, tactile, and authentic atmosphere in the room. Another suggestion involved using timber frames to create elements that could serve as cladding. In both cases, these materials could be used for interior cladding to create a distinctive focus or feature on a wall within a room.

Windows

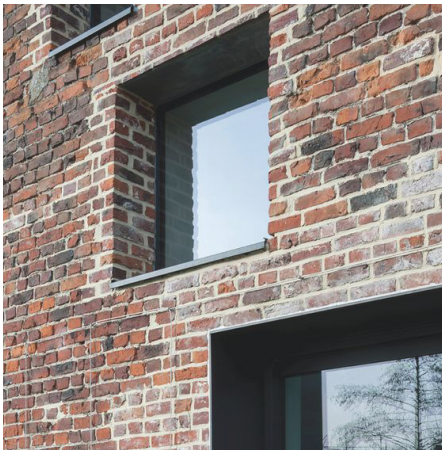
Study: *What to do with the interior and exterior finish when cutting holes for windows and such in the exisiting brick wall?*

This study aimed to address the challenges associated with achieving a cohesive wall expression when cutting openings in the existing brick wall for windows and doors. Various design solutions were explored, drawing inspiration from different references, with the goal of integrating the changes in the old brick façade while preserving its atmosphere, history, and identity.



Ill. 143: Bricks around window, sketches

References



Ill. 144: Studio Farris

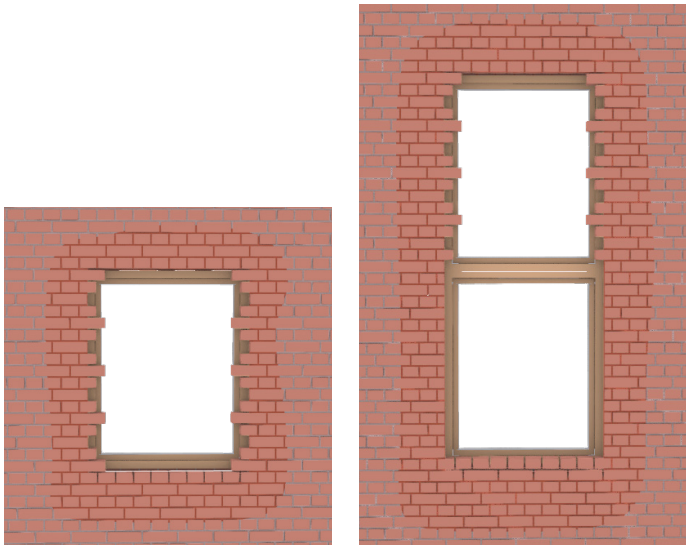
Larger windows are incorporated in an old brick facade. The old morter is kept as a contrast to the new mortar around the window holes. This solution enhances the transformation, and gives an understanding of the history and identity in the meeting between old and new - past and future.

Ill. 145: Walter Francl Architects

An old exterior wall kept in its preserved state as an interior wall - keeping the identity of the place and its previous function.

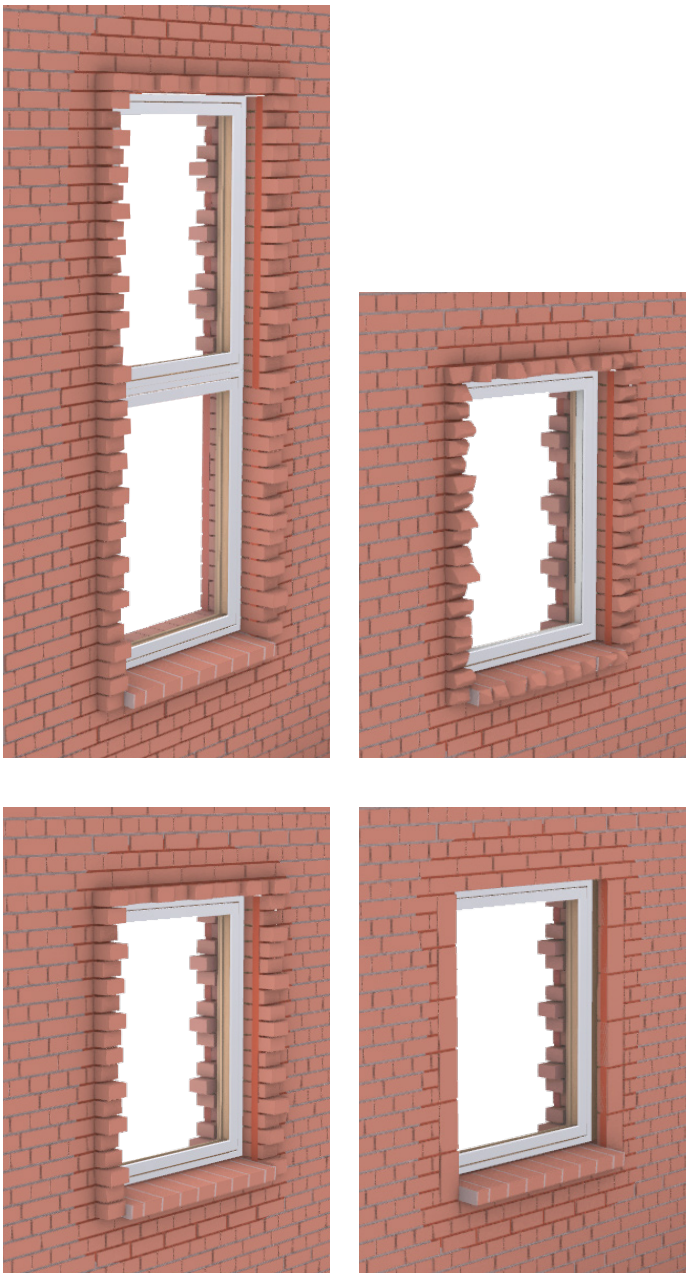
Ill. 146: HVH Architecten

Changing the brick pattern around the window openings, to highlight the tranformation and the meeting between the new re-used material and the old wall.



Ill. 147: Inside iterations. Exploring how a rough finish where new window is placed inside, can create a rough and unique look and clearly illustrate, where new elements are added

Inside



Ill. 148: Outside iterations. Exploring how bricks can highlight or frame a window with the placement and orientation of the reused bricks.

Outside

Through the exploration of different techniques for removing and installing bricks within the existing wall, it was determined that on the external walls, the old mortar should be replaced with a new mortar colored in a shade of red, mimicking the red bricks and red coloured steel boards. This approach creates a clean visual expression for the external façade, where the differentiation between materials is achieved through distinct materialities and textures.

On the interior side, the envelope can contribute to an authentic and dynamic atmosphere by allowing the bricks surrounding the windows to stand out and appear rough, creating an playful and clear expression of old-meeting-new.

***Study:** Can reused materials be used for pavement in the design?*

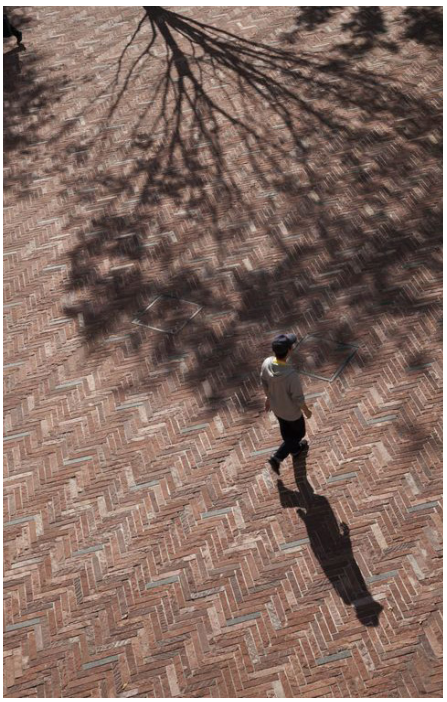
Pavement

Currently, the existing buildings have concrete floors. However, there is an opportunity to explore various treatments that can be applied to concrete floors, allowing for the consideration of different types of concrete flooring in the design.

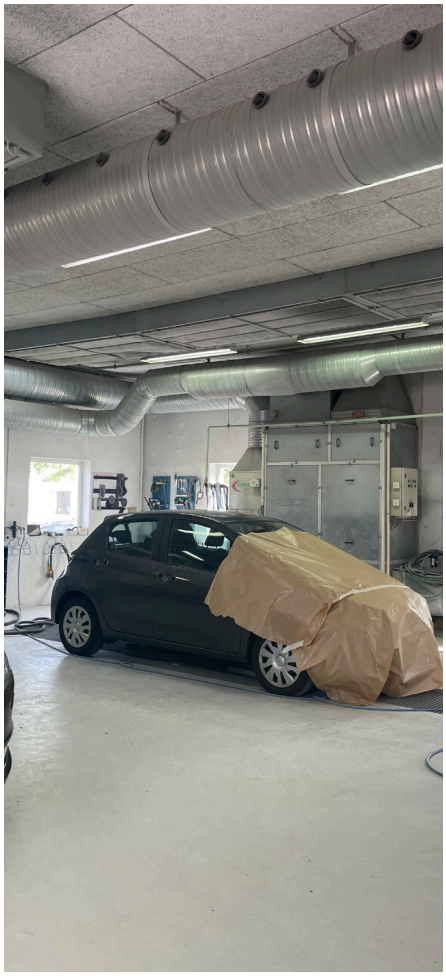
On the same time, the connection to the exterior pavement was examined to determine whether it should have a distinct appearance or gradually blend together.

By utilizing old reused bricks as urban pavement in relation to the red brick walls, visual continuity can be created, establishing a harmonious connection between the ground plane and the building. This approach enhances the overall aesthetic appeal. Additionally, using bricks of the same color for both the pavement and exterior walls can contribute to a timeless and elegant aesthetic.

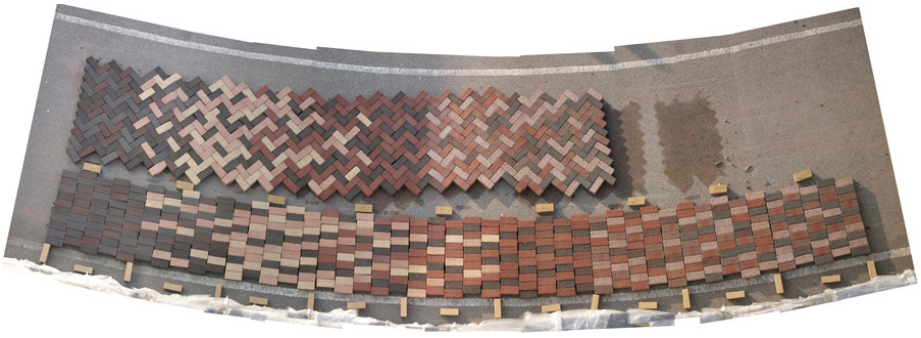
Allowing the red bricks in the urban areas to blend with the concrete floor inside the building's entrance will ensure a smooth transition between the interior and exterior spaces.



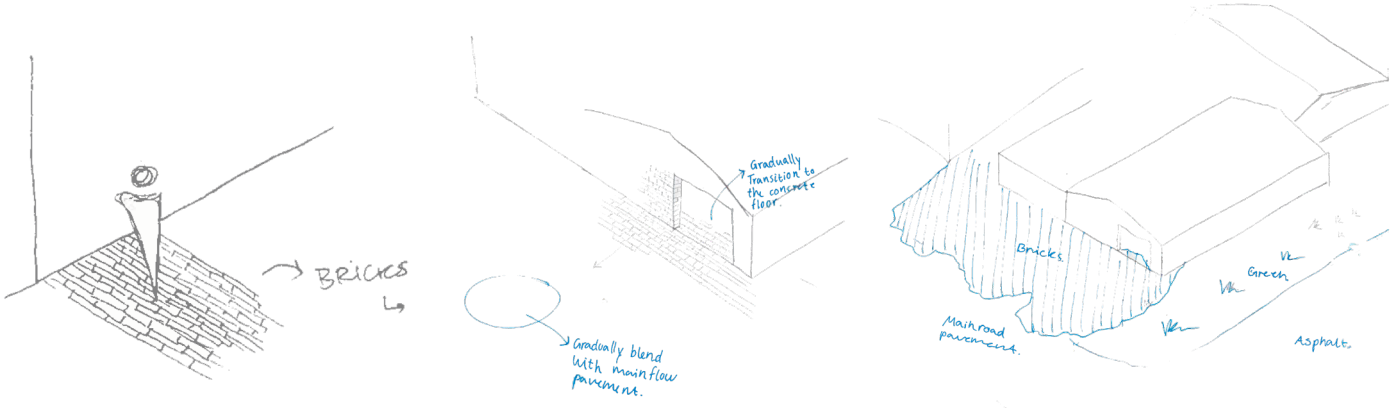
Ill. 149: Brick pavement, reference



Ill. 150: Existing floor



Ill. 151: Brick pavement, reference



Ill. 152: Brick pavement iterations

Ill. 153: Brick pavement iterations

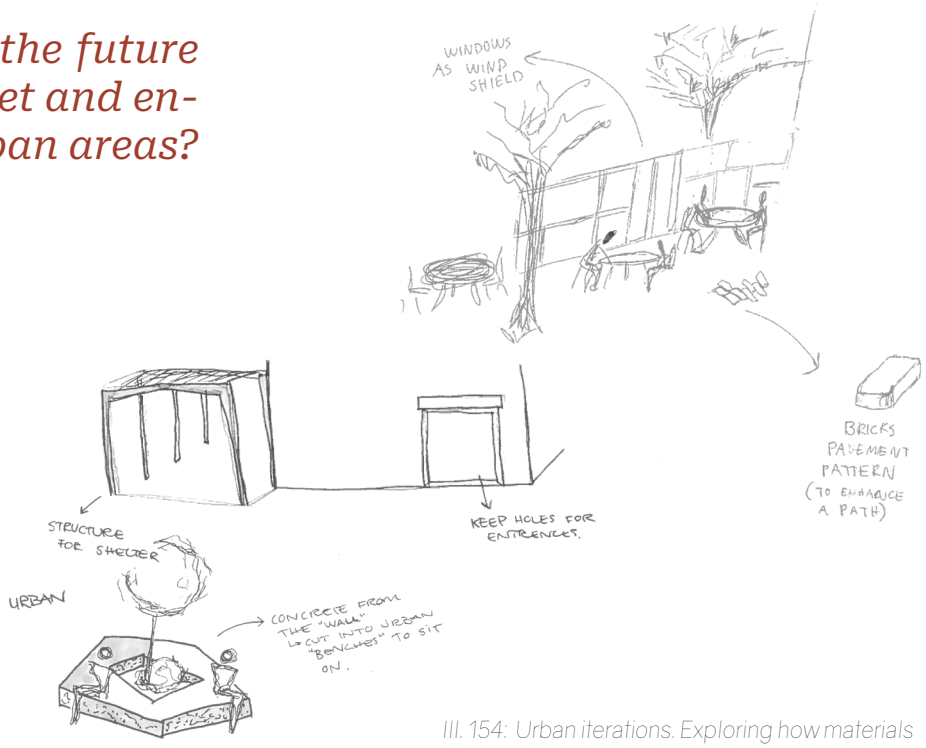
***Study:** How to connect to the future plans of Hjulmagerkvarteret and ensure interactions in the urban areas?*

Urban study

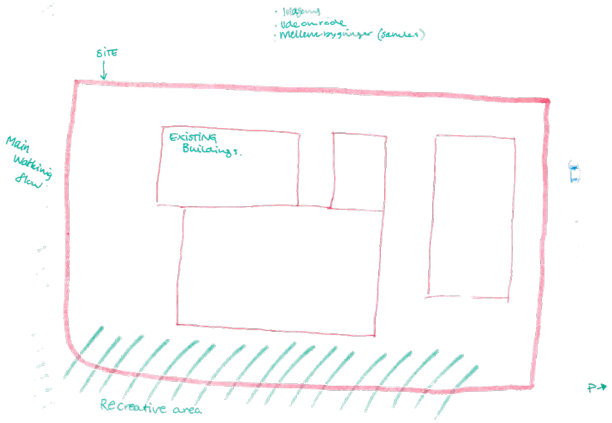
The Municipality's plans for future development were taken into account in the development of urban areas and connection to the surrounding context. A main flow line coming from the south, passing along the western edge of the project site, while a main street is situated in the southern part. Additionally, a parking lot is located on the eastern side of the building. Furthermore, urban areas with smaller businesses and gathering spaces will be placed near the project site, and therefore, the design process of the urban areas focused on how to relate to the future plans of Hjulmagerkvarteret.

Additionally, studies were conducted to determine how to extend interior functions to the outside in order to facilitate interactions between the activities taking place inside the building and the people in the surrounding area. Functions such as an external workshop area, café, and gathering spaces were iterated upon during this process.

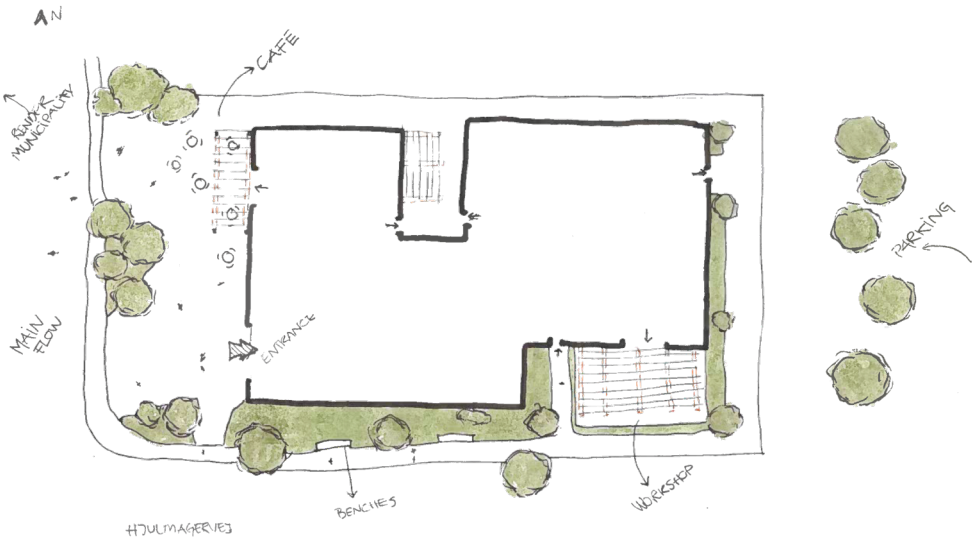
Furthermore, the study explores how to reuse materials from the area for purposes where the properties of the materials are not relevant, such as load-bearing capacity and thermal properties. These materials can be given a new function in the design and furnishing of the urban areas.



Ill. 154: Urban iterations. Exploring how materials can have a new function in the urban areas



Ill. 155: Zoning the urban areas in relation to the floor plan



Ill. 156: Urban design iterations. Focus on smooth transistions, interactions and invitations

05 Presentation

In this section the final design proposal will be presented using visualizations, plan drawings, text and diagrams.

Ill. 157: Visualization arriving from the main pedestrian flow.

The meeting point

The dynamic yet coherent exterior creates an attractive atmosphere that invites people into the site, where both the building and its urban areas are oriented towards the main flow of the future circular Hjulmagerkvarter. The composition and its materiality exude an identity that harmoniously blends the industrial heritage of the area with the dynamic spirit of the new development where old meets new.

Floor plan

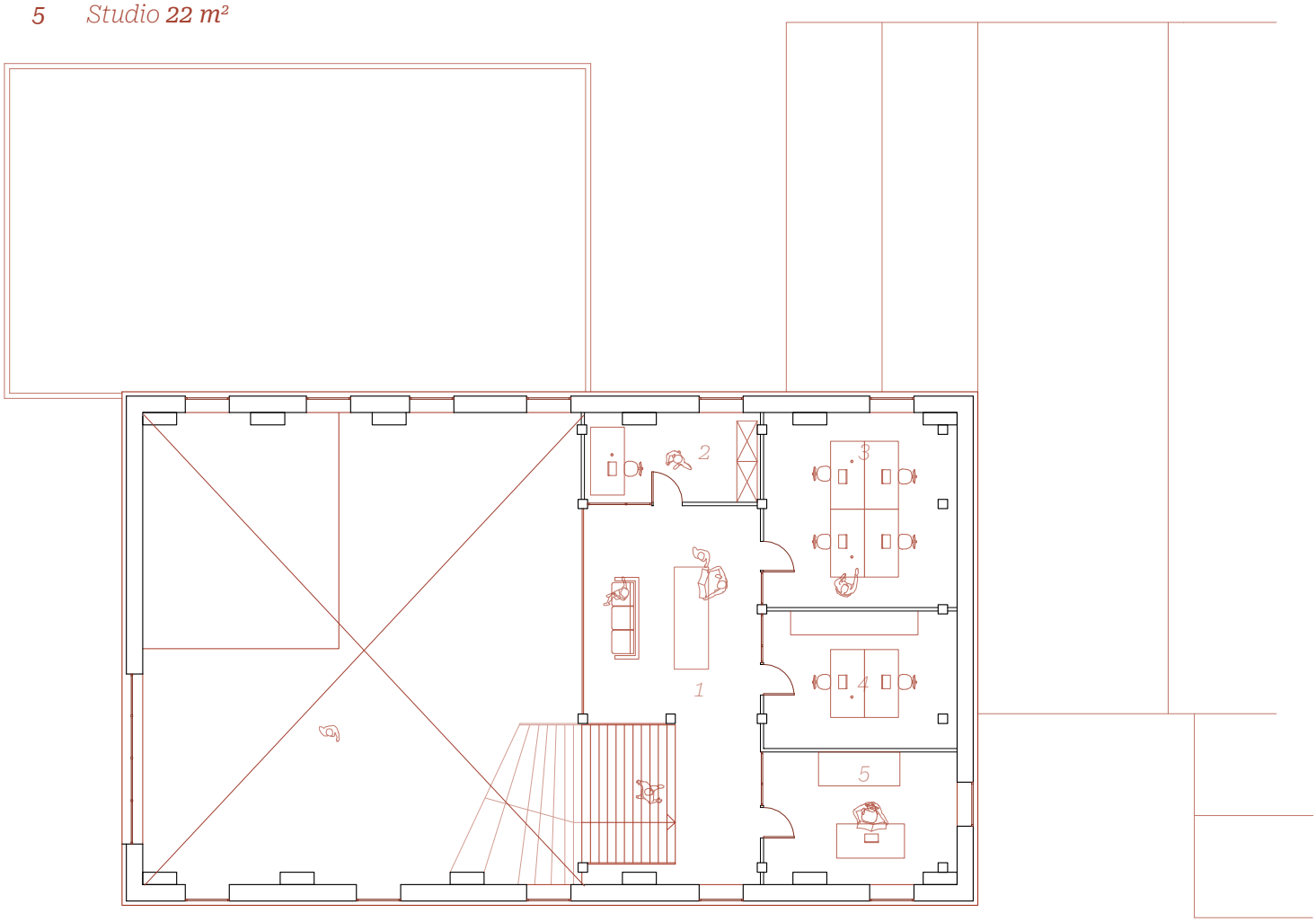
Ground floor, 1:200

1 *Flexible exhibition and work space* **324 m²**
2 *Administration* **20 m²**
3 *Bathroom* **18 m²**
4 *Café* **125 m²**
5 *Studio* **13 m²**
6 *Studio* **16 m²**
7 *Studio* **23 m²**
8 *Studio* **46 m²**
9 *Studio* **13 m²**
10 *Bathroom* **9 m²**
11 *Studio* **15 m²**
12 *Studio* **12 m²**
13 *Studio* **12 m²**
14 *Studio* **38 m²**
15 *Workshop* **125 m²**

Ill. 158: Ground floor plan, 1:200

1 st floor, 1:200

1 *Flexible work space 58 m²*
2 *Studio 14 m²*
3 *Studio 33 m²*
4 *Studio 22 m²*
5 *Studio 22 m²*



Ill. 159: 1st floor plan, 1:200

The design combines old and new elements to create an engaging spatial progression. The composition opens towards the west and southwest corner, inviting the main flow of the new area into a vibrant and inviting environment. The flexible floorplan accommodates exhibitions, events, and collaborative workspaces, creating a dynamic atmosphere. The studios serve as creative spaces for individuals and offer a visual connection with the surrounding spaces. Together, they frame the common floor, inspiring interaction and sparring among the occupants to establish a sense of community and collaboration. This vibrant hub merges the urban landscape with the building, and by integrating old and new, invites innovation and creates an inviting meeting place.

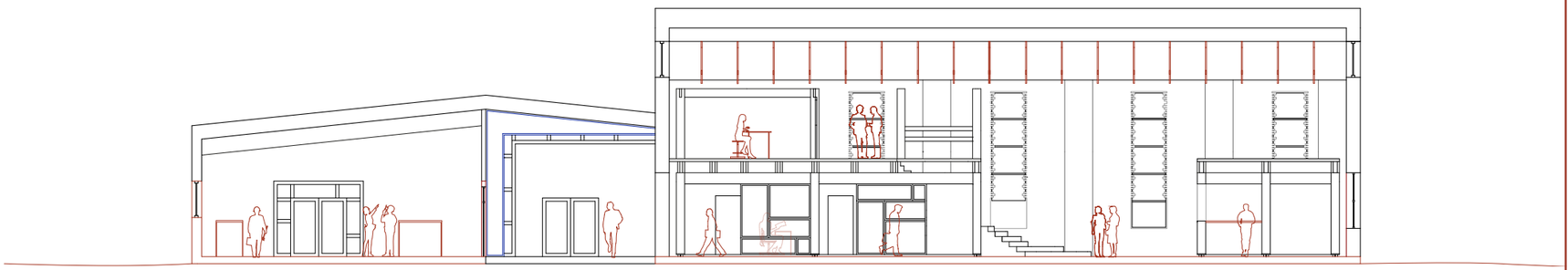
Ill. 160: Visualization of the flexible exhibition space then entering the the building

Inside

The intention with the interior was to keep as much of the old envelope and reuse its material when adding a new layer, to enhance the raw and honest expression. The additional structure made of primarily reused glue laminated timber contrasts the old walls, to indicate the act of adding "new". It is placed without touching the existing structure to express the idea of a new envelope inside an old envelope, showcasing how a transformation of an old envelope can house new functions, while contributing with historical values to the building/atmosphere.

Social interactions

The two buildings are integrated into one cohesive structure through a new construction. The visual and structural support of blue steel frames adds to the unique identity of the building. The design allows for various activities to take place in different areas throughout the building, while still maintaining a sense of smooth transition and coherence. This is achieved through visual connections and a layout that encourages social interaction. The overall design creates a vibrant environment with opportunities for interaction and collaboration, while also providing privacy by allowing the studios to be closed off with doors.

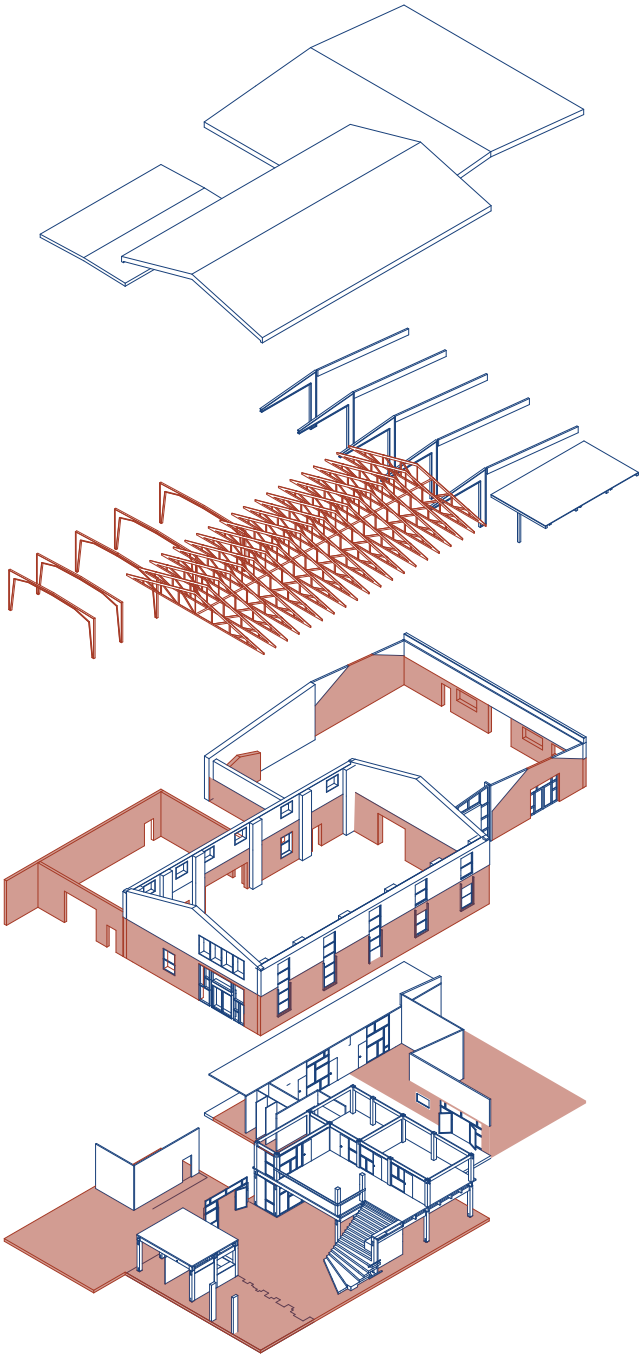


Ill. 161: Section A, 1:200. A section towards south through the entrance, extension and workshop, illustrates the double-height room, which creates an open, inviting and flexible atmosphere, with the remaining functions distributed throughout.

Preserved - Reused - New

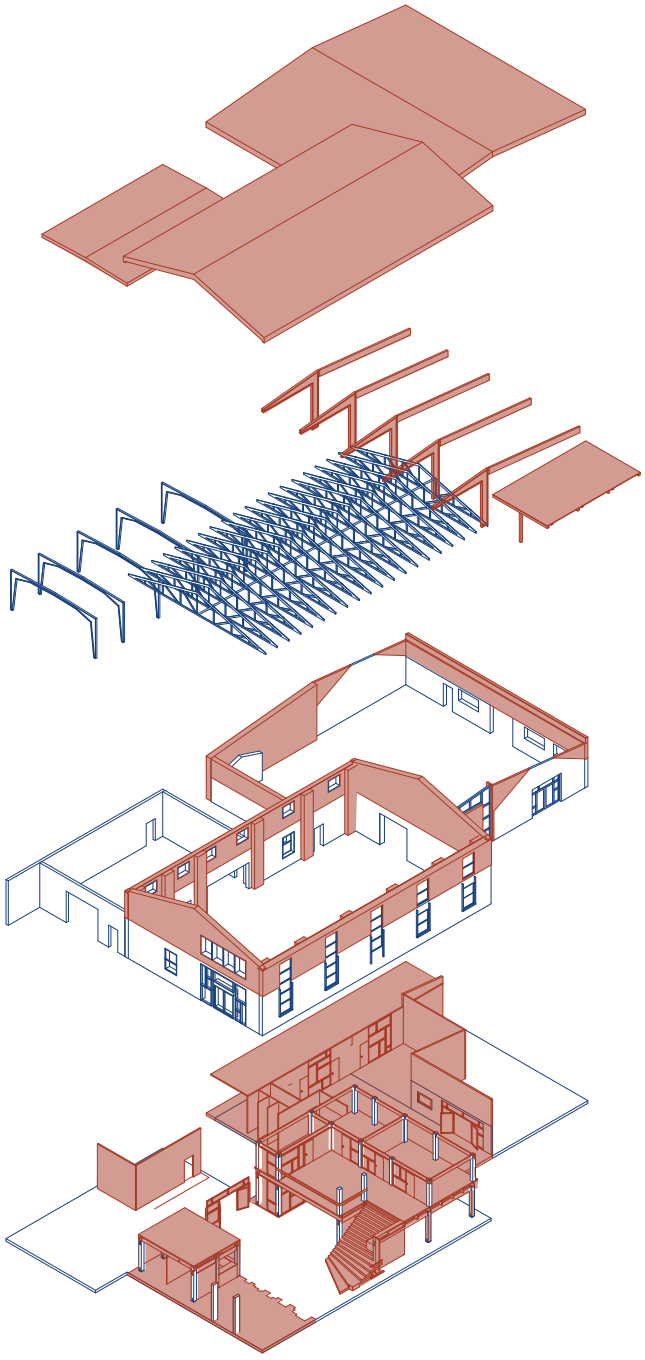
These diagrams illustrate the distribution of preserved materials, reused materials, and new materials used in the final design proposal, which aims to transform a building with reused materials. The objective is to preserve as much as possible of existing buildings and elements, including external walls, foundation, and trusses (ill. 162). To optimize the building envelope and create a meeting point and studio workspaces, additional reused materials from Hjulmagerkvarteret are incorporated (ill. 163). However, due to the limited availability of reused materials, new materials were necessary. These new materials include insulation and some of the structural timber elements (ill. 164).

Preserved materials



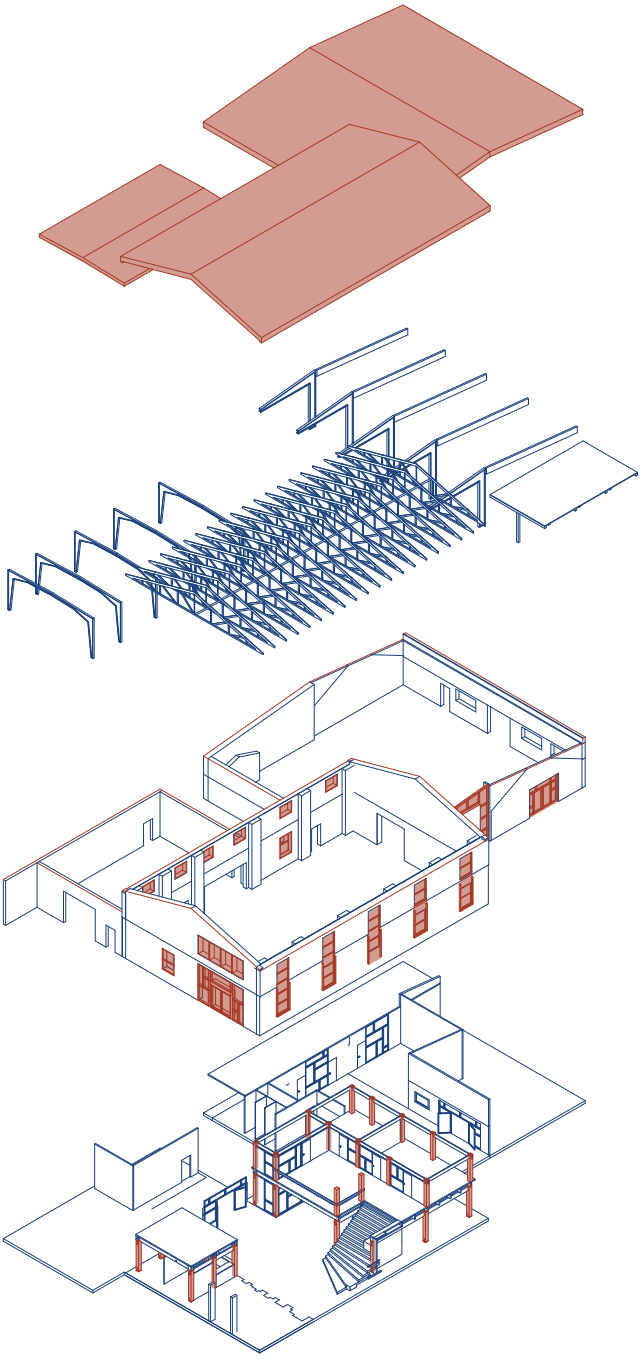
Ill. 162: This exploded isometry illustrates which materials are preserved in the final design proposal. Red = preserved, blue = other. Overall the preserved materials are the foundations, walls and structural elements.

Reused materials



Ill. 163: This exploded isometry illustrates which materials are re-used materials used to transform the buildings. Red = reused materials from Hjulmagerkvarteret, blue = other. The reused materials contains both facade cladding and strutural elements.

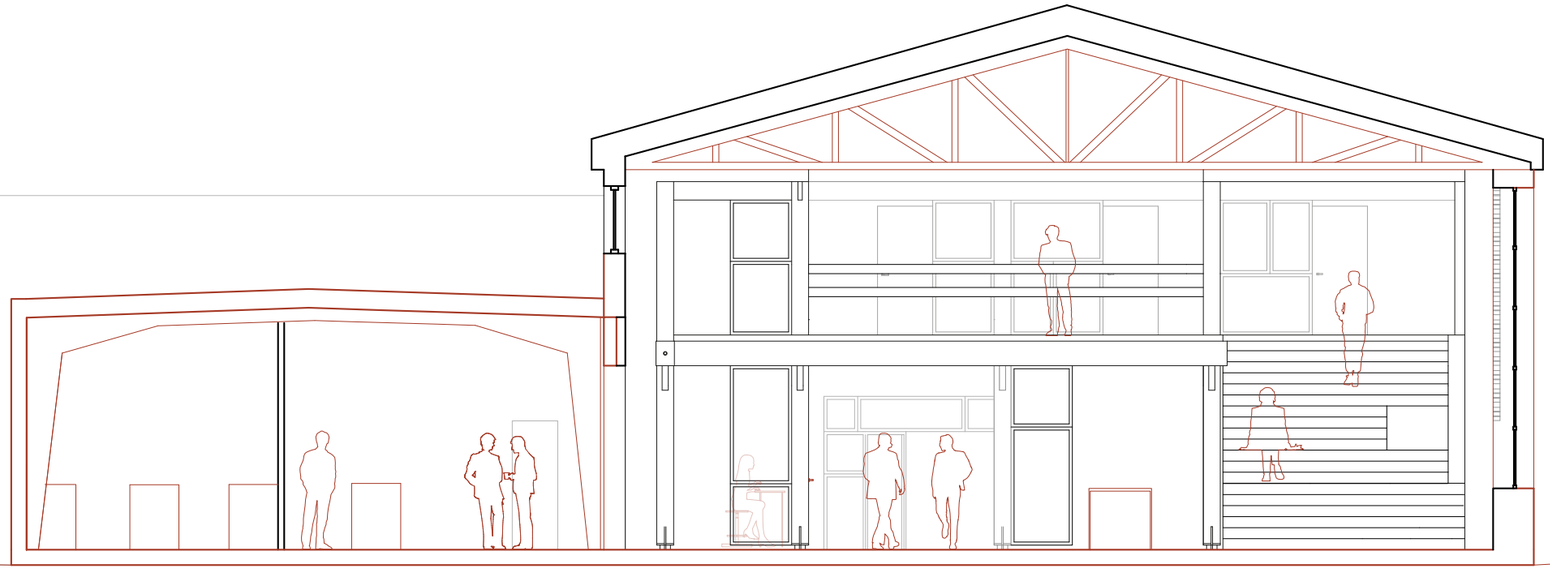
New materials



Ill. 164: This exploded isometry illustrates which materials are new materials applied in the final design proposal. Red = new materials, blue = other. Overall, the new materials applied contains external windows, insulation and some structural timber.

The node

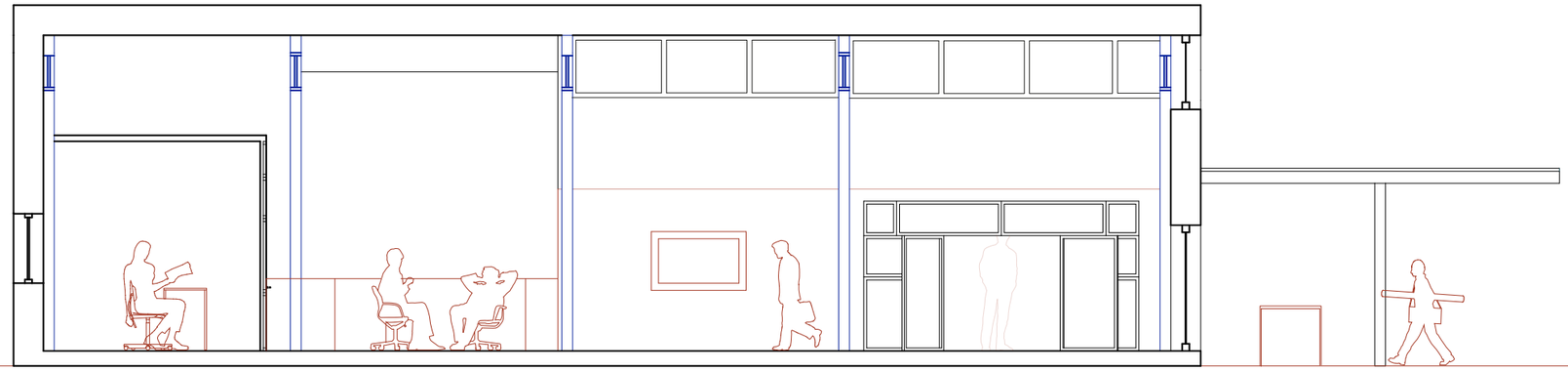
The open space functions as the central meeting point of the building, connecting its various functions and serving as a hub for social and spatial interaction. The café, studios, administration area, and exhibition/workspace converge here, taking advantage of the tall ceiling height and creating a distinctive atmosphere and identity. Visual connectivity is also established among these areas and the spacious staircase connects the two distinct zones, serving as a transition between different floor divisions. This space provides a resting place, a quiet spot for reflection and immersion, or a vantage point for an overview.



Ill. 165: Section B, 1:100. Section towards east through the café and the double-height room, accomodating a flexible floor plan for exhibitions and gatherings. Interactions between the two floors are ensured,

The extension

The spacious hallway and the area between the studios facilitate a collaboration space for social interactions. The former car workshop has been transformed into a creative workspace for various projects undertaken by creative start-ups. The workshop extends towards Hjulmagervej, by incorporation steel frames from a bike shed, creating a gradual transition between the indoor and outdoor spaces, as well as between the workshop activities and the recreational area that Hjulmagervej is set to become.



Ill. 166: Section C, 1:100. A section towards east through the extension between the existing building. Illustrates the transistion to the outside and the flexible spaces inside for interactions, gatherings and working.

Construction

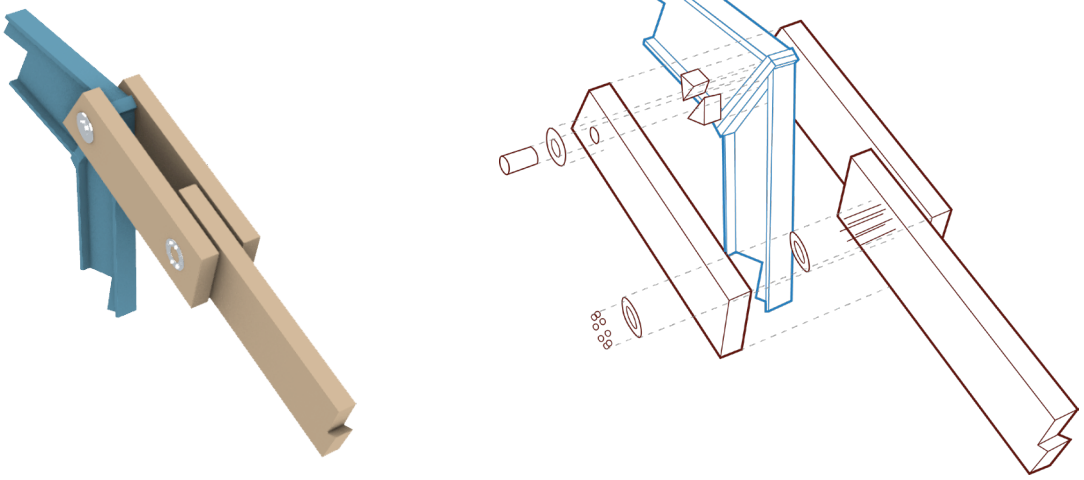
The detailed section shows the different materials used for the eastern existing building and the extension connecting the two buildings. The attention is focused on reusing existing construction or locally available materials from the site. Otherwise, the materials are selected to have the least environmental impact, such as wood fibre insulation.

The detail also shows the connection between the two buildings. Especially for the structural joint, the timber beam is designed to be carried by the steel frame thanks to a rotation free connection. In this way the less materials are used for the structure and the structure from the existing building acts as counterweight for the steel frame. Indeed, the steel beam is only carried by one column at its edge and thus is very sensitive to deflection at the other edge.

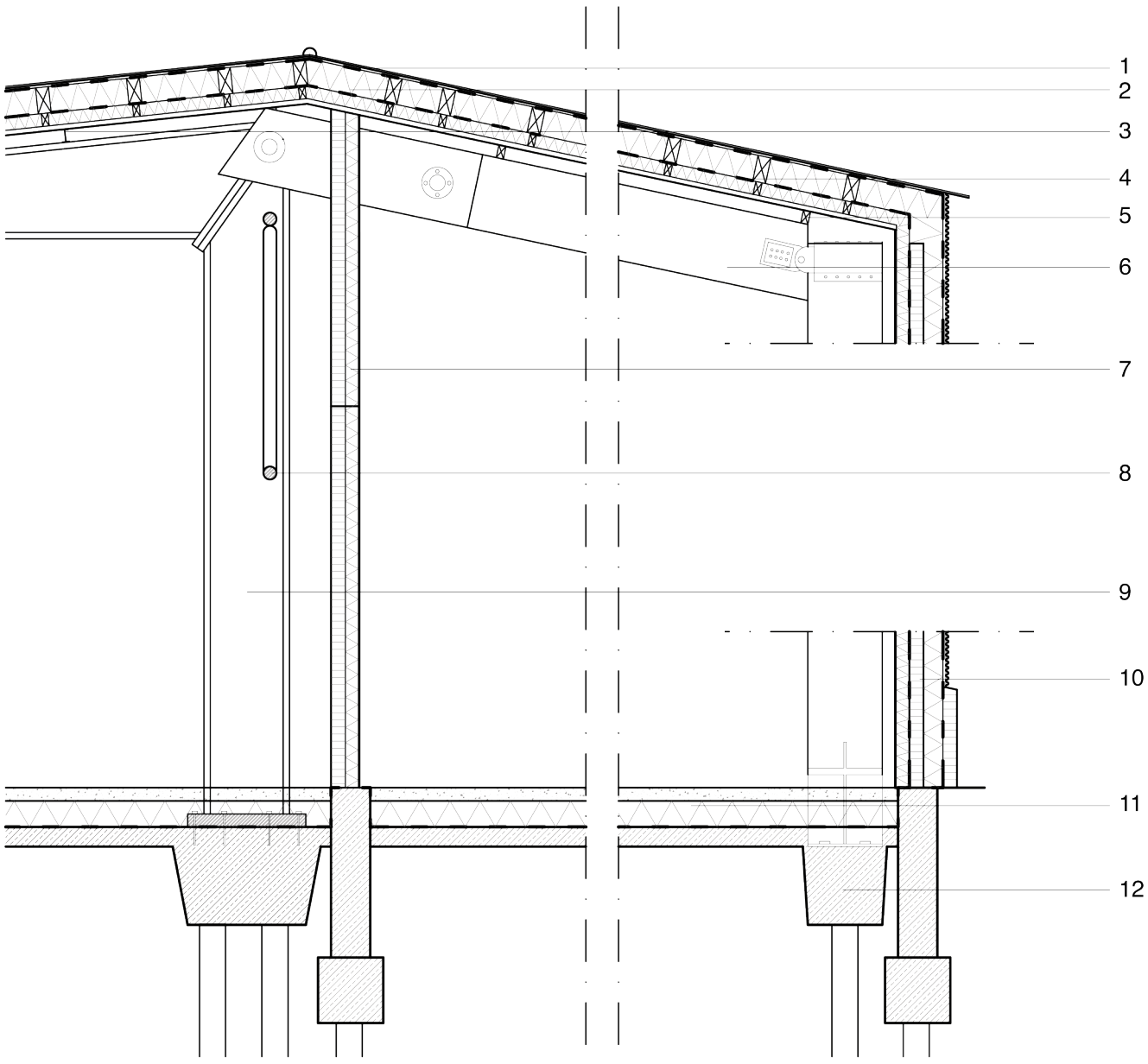
The connection is more detailed in the 3D view and exploded view. The timber beam is screwed to two segments of timber beam which are connected to the structure frame with a roll connection welded to the steel structure.

Ill. 167: Construction detail, 1:50. Showing how eastern building and the extension are connected

1. Damp proofness
2. Roofing (Roof structural deck, 300 mm wood fibre insulation, wooden lathing, reused corrugated steel)
3. Reused steel purlins
4. Vapor Barrier
5. Reused wooden purlins
6. Reused gluelam timber structure (57 x 13.5 cm)
7. Inner wall (existing 108 mm bricks, existing 100 mm Rockwool insulation, existing plaster)
8. Reused steel bracing
9. Reused steel frame (Column section: 65.5 x 18 cm, beam section: 85 x 18 cm)
10. Exterior wall (Existing plaster, existing 100 mm Rockwool insulation, existing 108 mm bricks, 150 mm wood fibre insulation, reused wooden lathing, reused corrugated steel)
11. Floor (200 mm wood fibre insulation, 100 mm concrete floor deck)
12. Concrete foundation on piles

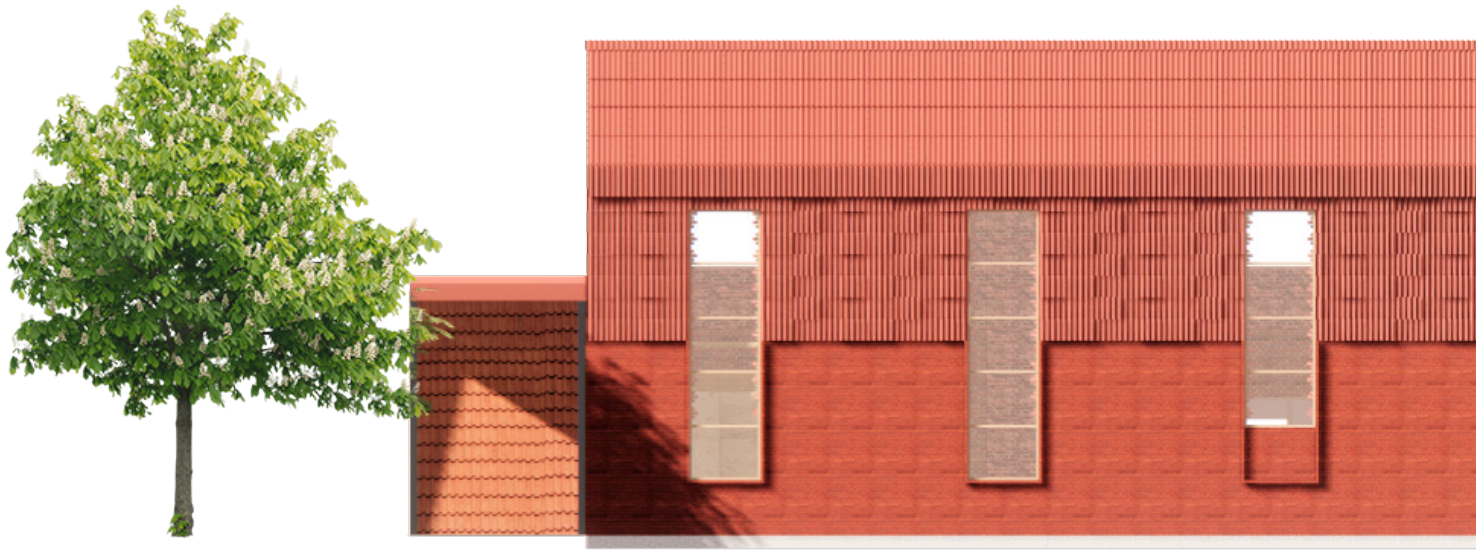


Ill. 168: Joint assembled

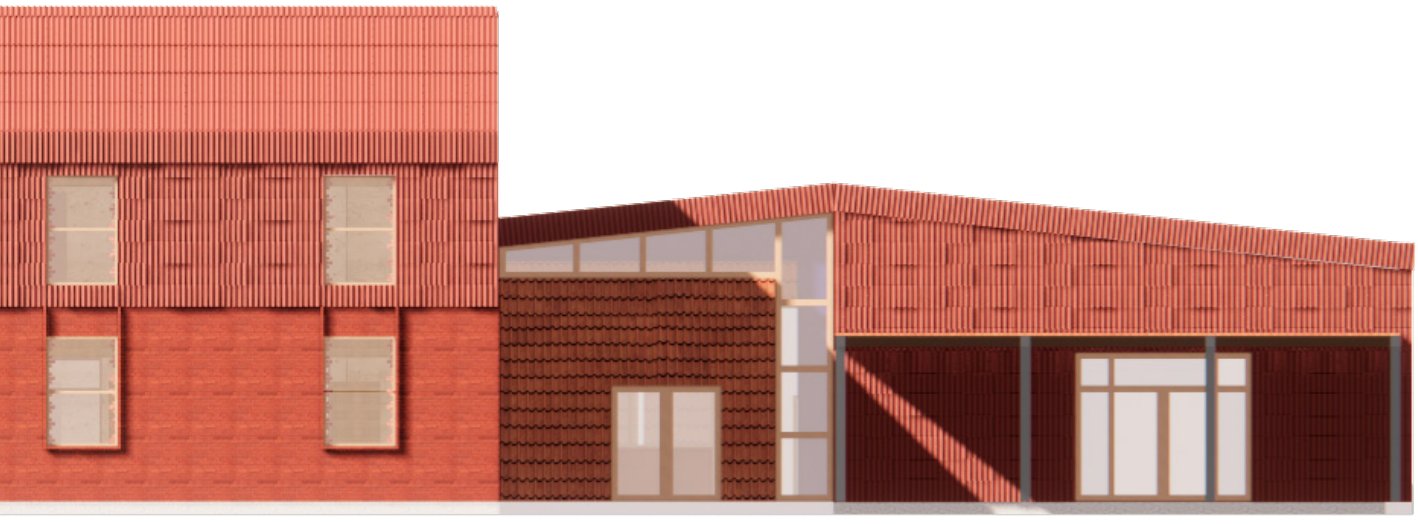


Elevations

The facade elevation of the building showcases a visually dynamic composition achieved through the use of different materials, all sharing a consistent color palette. The incorporation of reused materials adds a unique texture to the surfaces, creating a captivating interplay of elements. Despite the diverse materials, the design maintains a sense of visual continuity, offering a pleasant and cohesive aesthetic experience, and a continuity through different red shades referring to the brick from the local identity. The harmonious blend of textures and colors in the façade composition captures the essence of the building, reflecting the identity of reused materials in a transformation, integrated in its context.



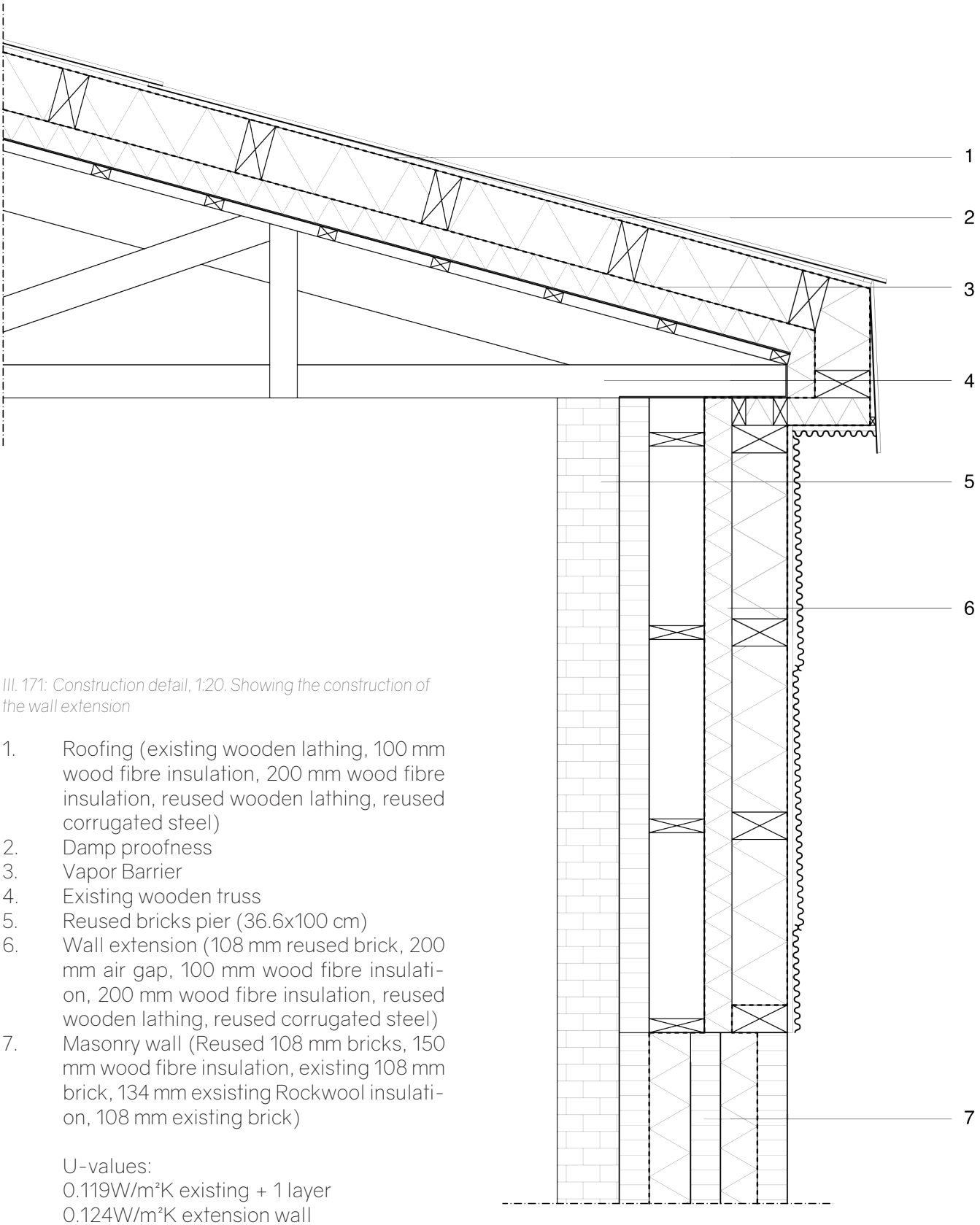
Ill. 169: Elevation west, 1:100



Ill. 170: Elevation south, 1:100

Construction

The detail for the roof lift shows the different layers used in the wall extension. The priority is set to existing and locally available materials such as the corrugated steel cladding. It also displays the joint between the existing wall and the new wall extension. A 200mm thick air gap is included to allow the extension to pop off the existing wall. An additional insulation and brick layer as well as brick piers have been added to the existing wall to avoid heat loss and increase the bearing capacity.



Ill. 171: Construction detail, 1:20. Showing the construction of the wall extension

1. Roofing (existing wooden lathing, 100 mm wood fibre insulation, 200 mm wood fibre insulation, reused wooden lathing, reused corrugated steel)
2. Damp proofness
3. Vapor Barrier
4. Existing wooden truss
5. Reused bricks pier (36.6x100 cm)
6. Wall extension (108 mm reused brick, 200 mm air gap, 100 mm wood fibre insulation, 200 mm wood fibre insulation, reused wooden lathing, reused corrugated steel)
7. Masonry wall (Reused 108 mm bricks, 150 mm wood fibre insulation, existing 108 mm brick, 134 mm exsisting Rockwool insulation, 108 mm existing brick)

U-values:
0.119W/m²K existing + 1 layer
0.124W/m²K extension wall

06 *Epilog*

In this final section the design proposal will be assessed through a conclusion, and a reflection will question selected aspects of the semester project in terms of the design process and contribution.

Conclusion

This project sets an example by demonstrating the creative reuse of existing materials, exemplifying how sustainability and creativity can transform a building into a meeting space. This project contributes to the exploration of reusing materials, particularly in the context of working with specific dimensions and the associated potentials and challenges. The focus is on the process in doing so. The project takes an exploratory and potential seeking approach, examining the possibilities for repurposing existing materials in the transformation of the building. By doing so, it not only offers the municipality a practical showcase on how to effectively reuse materials but also challenges the initial plan of demolishing the structure.

The design proposal establishes platforms for small businesses to thrive, while also providing a vibrant meeting place that serves as a hub for Hjulmagerkvarteret. We have worked with designing frames for the start-up's community, where the environment create space for collaboration and innovation. The design carefully balances the preservation of the buildings historic identity while incorporating new elements, resulting in a harmonious building of old and new. A contrast is found between the kept construction and the new. By not trying to imitate or compete with the existing expression the place's narrative is strengthened. The materiality shapes its inviting atmosphere, with attention to detail and meetings between old and new materials. By linking to the existing identity and flow of the surrounding area, as well as aligning with future development plans, the project integrates into its context, enhancing the overall urban fabric.

The project's emphasis on the work with reused materials serves as a testament to the benefits and possibilities of reusing, advocating for a more environmentally conscious and resourceful approach to construction and renovation projects. Instead of removing buildings in our cities and build new, we add another layer to its history. The contrast between old and new is a testimony of growth, respect and change.

Reflection

The process

Navigating the design process and shaping the drivers for the project.

Taking Jane Darke's and Charles Leons description of the design process into account, the described generators can both be beneficial and problematic. In our project such *generators* or potentials worked as drivers for the process, but that also entails the risk of selecting impractical or inappropriate ideas or directions that create more problems than they solve. Without certain limitations or evaluation points to guide the decisions, the solutions become based on unsubstantial opinions.

In the beginning stages of the project, we faced challenges in setting clear limitations and choosing the right direction. The design scope was vague, causing us to design in uncertainty. The main objectives were to design elements by reusing building materials for a museum at the chosen site – Råt & Godt, in an area that already serves as a material bank and runs reuse operations. Because of the lack of limitations and need for a building on the site, the project site moved to Hjulmagerkvarteret where there was a vision for a building, functioning as a 'Gate' or a node at an empty corner plot. However, building from scratch was inadequate considering the time allocated in this project course and the lack of a clear driver and problem. Finally, we chose a site to the centre of the area where the municipality plans to demolish existing buildings to raise another meeting point, or 'Gate'.

When the challenges where recognized, we took steps to address the issue. To establish boundaries and structure, we incorporated limitations based on the municipality's development plans for Hjulmagerkvarteret. Additionally, we chose a transformation project approach, utilizing an existing building shape, rather than starting the design process from scratch. These decisions allowed us to bring more definitions and direction to our process and overcome the initial challenges we faced.

A clearer direction took shape, when we made the conscious choice to prioritize reuse as our central focus. Utilizing the material available from the demolishing plan aligned not only with our focus within sustainability but also presented us with limitations and opportunities. The use of reused materials introduced dimensions and challenges that drove our studies and solutions. We worked within limited dimensions and utilized the potentials and challenges they presented. The approach sparked creativity and a need for adapting a different design strategy.

Incorporating reuse from the nearby buildings allowed us to add a sense of sustainability and authenticity to the project. It created a design process that implemented continuous learning, problem-solving and informational outcomes. Upon reflection, without a problem statement, or a clear driver, the project had a hard time to further design and find criteria.

Contribution

Assessing the outcome to guide the process.

By examining the project from a different perspective and focusing on the desired outcome, we can establish a clearer framework and identify key drivers throughout the entire process. *What should the project contribute with?* It is important to understand this, rather than fixating on finding the solution. This understanding allows us to determine a more effective way to achieve the outcome and navigate through the messy and complex design process.

The contribution, or the outcome can give guidance for decision-making. However, one of the challenges we faced, in the first part of the project, was defining the specific contribution of the project. *What does our report contribute with? In what context should it be read and provide knowledge? When it comes to reusing materi*als in buildings, there have been various approaches. It stills requires new ways of thinking, new methods, and alternative ways of approaching the topic. The lack of clarity and uncertainty regarding the project's contribution has played a role in the challenges we encountered at the beginning, and the time setback throughout the project. By defining and prioritizing the process of incorporating reused materials as the central contribution of the project, we established guidelines to try and succeed. Furthermore, it helped shape a process methodology for the project.

Assessing reused materials

A comment on assessing reused materials in the project context.

It can be a challenging task to assess the introduction of reused materials in a project. We knew from the beginning, which materials we could utilize and how they appeared – The question then is, how this knowledge could be used in our design process? Current software and modelling tools lack textures that illustrates the unique textuality and materiality caused by time effects. To address this, we explored different physical and numerical methods with different potentials and constrains. Therefore, it is important to be clear in what knowledge we seek and explore. However, none of these methods allowed us to evaluate the physical properties of materials, which is important considering potential degradation over time. Reusing materials from the existing buildings has benefits, such as fitting in with the aesthetic identity of the area, but it also has challenges such as a limited material library. Because the materials are limited in size, amount, and properties, we took assumptions when designing with them.

When introducing reused materials as the main driver in the design process, it is important to know why materials are or aren't deemed reusable. What hurdles occur when deciding to incorporate a material that once where part of another construction? We as architects needs to convey the potentials and possibilities of reused materials in new constructions, as the mentioning of this it currently tends to scare the clients away due to a long list of arguments against. That list is driven by economic challenges, lack of knowledge, certification limitations, lack of interest in the aesthetics and deviation from usual building process. These challenges will reduce with the increase of interest in reused materials as a market for reused materials is slowly growing and building up. Often, economic budgets can be challenged by innovative and aesthetically interesting solutions, which is where engineers and architects could benefit from collaborating with other branches of the industry for knowledge sharing and creativity. Generating interest in building elements that were once considered waste and identifying the wide spectrum of values and benefits of reusing them is essential for pushing the agenda of the industry in a more environmental friendly direction. Architects are usually the ones conveying the design solution, and in the case of reused materials there is an opportunity to showcase the solutions in a realistic way as the aesthetics of the materials are very specific and available to physically see and touch.

In each of our studies, we have tried to investigate different visualization methods e.g., creating our own materials in render programs, photoshop material pictures and physical models. The awareness of how we approach the visualization of the design solutions can help create models and visualizations closer to the end result. Furthermore, it can help bring the design solutions and aesthetics closer to the builders. The attention to detail in the visualizations helped us get closer to the materials available, pushing the design process in directions focusing heavily on the aesthetic values as well as the methods on how to reuse.

The desire to reuse in specific ways require in depth investigations of how these designs can be realised. Deeper understanding of the materials often leads to more limitations but can also inspire alternative ways of reusing. Limitations inspire potentials, and the potentials are often easier to discover when being able to work with them physically.

Prioritization in the design process

Prioritizing and focusing on different aspects of the project

Due to the time dedicated to defining the design scope, we had to narrow down the focus and prioritize certain aspects of the project and deprioritize others. For instance, the level of detail and focus, regarding the design and the plan have varied. The focus areas of what we then have detailed more, than other, have also been deliberate. We decided not to focus on designing the café area, although it presents interesting opportunities, such as engaging the indoor-outdoor relationship. The indoor climate is based on assumptions at this stage but could have been studied with numerical software. In the material mapping analysis, it became clear that a lot of materials from demolition sites have reuse potential but is deemed not usable, for the same purpose as its current function, due to lack of certification, interests and resources for quality checking. A potential further exploration we deprioritized were investigating how to reuse these disregarded materials outside of the building envelope, like in an urban setting. The uncertainty and apparent safety risks of reusing materials are some of the main reasons why there is such a low interest in implementing reused materials in new buildings. which is why seeking and identifying potentials of reusing where the builder doesn't put anyone at risk would be an interesting direction for further work.

Although several materials have been incorporated in the design, we could have explored a wider range of materials. These materials may have been less available on site but could have added further depth to the project. Overall, prioritization allowed us to focus on key aspects while acknowledging that certain elements could have been developed in greater detail given additional time and resources.

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Ill. 121: Sveiven, Megan and Photographer Saieh, Nico, n. d. AD Classics: Muuratsalo Experimental House / Alvar Aalto. Available at: https://www.archdaily.com/214209/ad-classics-muuratsalo-experimental-house-alvar-aalto?ad_medium=gallery (Accessed 8/6 2023)
Ill. 122: Construction iterations
Ill. 123: Lift sketch
Ill. 124: Iteration 1, rhino model
Ill. 125: Iteration 2, rhino model
Ill. 126: Iteration 3, rhino model
Ill. 129: Iteration 5, rhino model
Ill. 127: Lift sketch
Ill. 128: Iteration 4, rhino model
Ill. 130: Iteration 1 - Brick
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Ill. 135: Static diagram, bricks
Ill. 134: Static diagram, Timber
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Ill. 137: Plywood, elevation
Ill. 138: Brick, perspective
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Ill. 140: Broken brick study. Exploring the placement of broken bricks within a frame, to be used as cladding on interior walls
Ill. 141: Broken bricks as cladding explodred in Rhino. Implemented on interior walls.
Ill. 142: Broken brick as cladding in frames of timber. Implmented as panels on interior walls
Ill. 144: Mairs, Jessica, 2016. Stacked beams form Jenga-like workspace inside converted barn in Belgium, Available at: https://www.dezeen.com/2016/05/21/studio-farris-architects-barn-conversion-office-interior-design-jenga-staircase-west-flanders-belgium/ (Accessed: 03 June 2023).
Ill. 145: Lehoux, Nic (Photographs), n. d. Rennie Art Gallery and Offices / Walter Francl Architects with mgb. Available at: https://www.archdaily.com/160648/rennie-art-gallery-and-offices-walter-francl-architects-with-mgb (Accessed: 03 June 2023).
Ill. 143: Bricks around window, sketches
Ill. 146: HVH Architecten, n. d. Noors verband, Available at: https://www.hvh-architecten.be/projecten/woning-vt (Accessed: 03 June 2023).
Ill. 147: Inside iterations. Exploring how a rough finish where new window is placed inside, can create a rough and unique look and clearly illustrate, where new elements are added
Ill. 148: Outside iterations. Exploring how bricks can highlight or frame a window with the placement and orientation of the reused bricks.
Ill. 152: Brick pavement iterations
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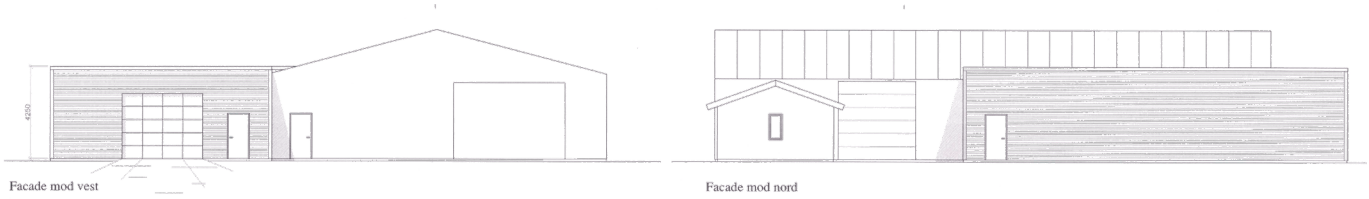
Ill. 150: Existing floor
Ill. 153: Brick pavement iterations
Ill. 156: Urban design iterations. Focus on smooth transistions, interactions and invitations
Ill. 155: Zoning the urban areas in relation to the floor plan
Ill. 154: Urban iterations. Exploring how materials can have a new function in the urban areas
Ill. 157: Visualization arriving from the main pedestrian flow.
Ill. 158: Ground floor plan, 1:200
Ill. 159: 1st floor plan, 1:200
Ill. 160: Visualization of the flexible exhibition space then entering the the building
Ill. 161: Section A, 1:200. A section towards south through the entrance, extension and workshop, illustrates the double-height room, which creates an open, inviting and flexible atmosphere, with the remaining functions distributed throughout.
Ill. 162: This exploded isometry illustrates which materials are preserved in the final design proposal. Red = preserved, blue = other. Overall the preserved materials are the foundations, walls and structural elements.
Ill. 163: This exploded isometry illustrates which materials are reused materials used to transform the buildings. Red = reused materials from Hjulmagerkvarteret, blue = other. The reused materials contains both facade cladding and strutural elements.
Ill. 164: This exploded isometry illustrates which materials are new materials applied in the final design proposal. Red = new materials, blue = other. Overall, the new materials applied contains external windows, insulation and some structural timber.
Ill. 165: Section B, 1:100. Section towards east through the café and the double-height room, accomodating a flexible floor plan for exhibitions and gatherings. Interactions between the two floors are ensured,
Ill. 166: Section C, 1:100. A section towards east through the extension between the existing building. Ilustrates the transistion to the outside and the flexible spaces inside for interactions, gatherings and working.
Ill. 167: Construction detail, 1:50. Showing how eastern building and the extension are connected
Ill. 168: Joint assembled
Ill. 169: Elevation west, 1:100
Ill. 170: Elevation south, 1:100
Ill. 171: Construction detail, 1:20. Showing the construction of the wall extension

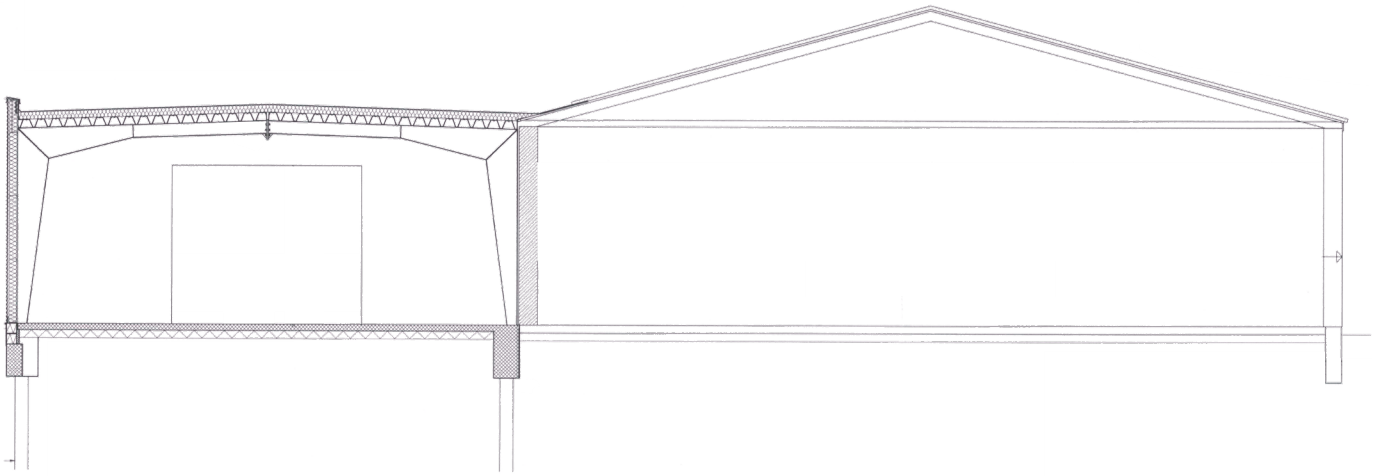
07 Appendix

Appendix 1

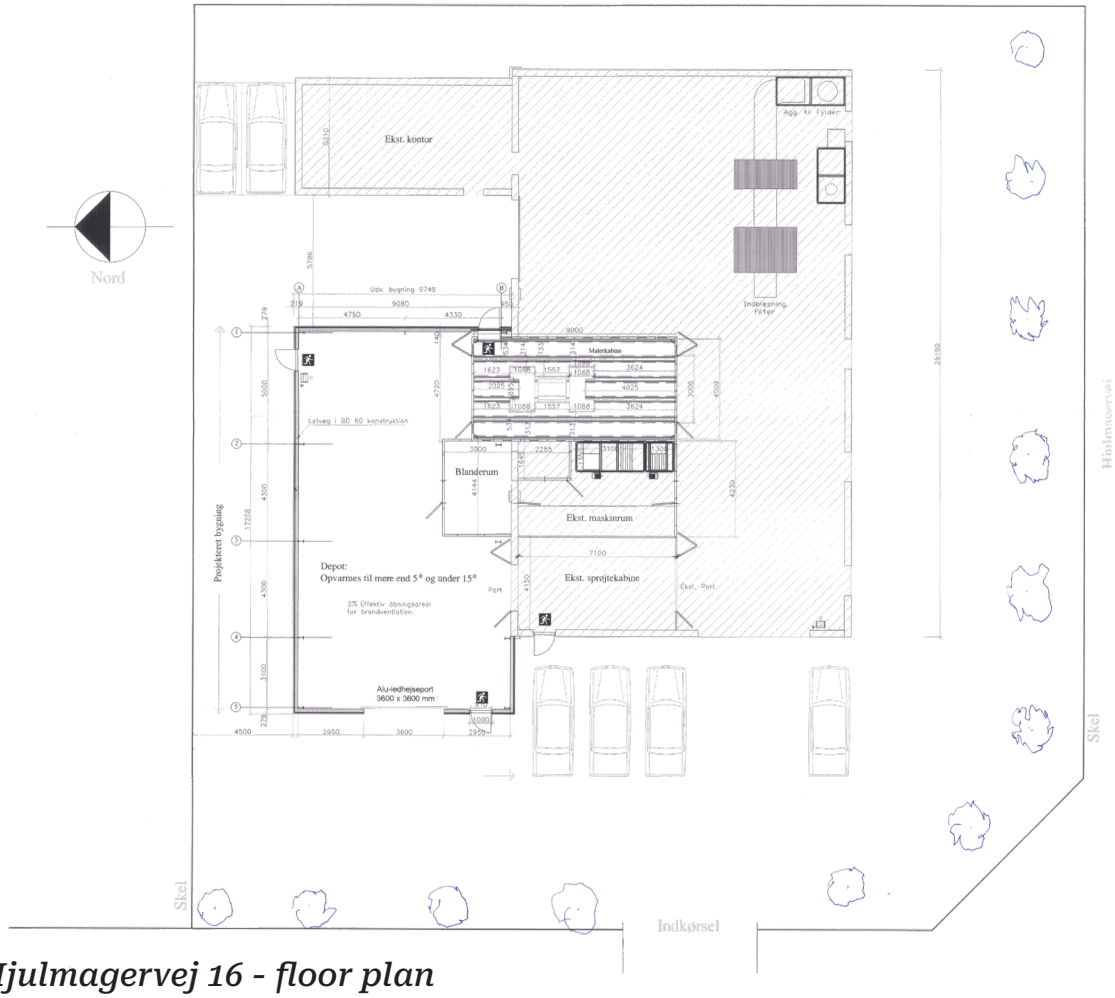
Drawings of existing buildins



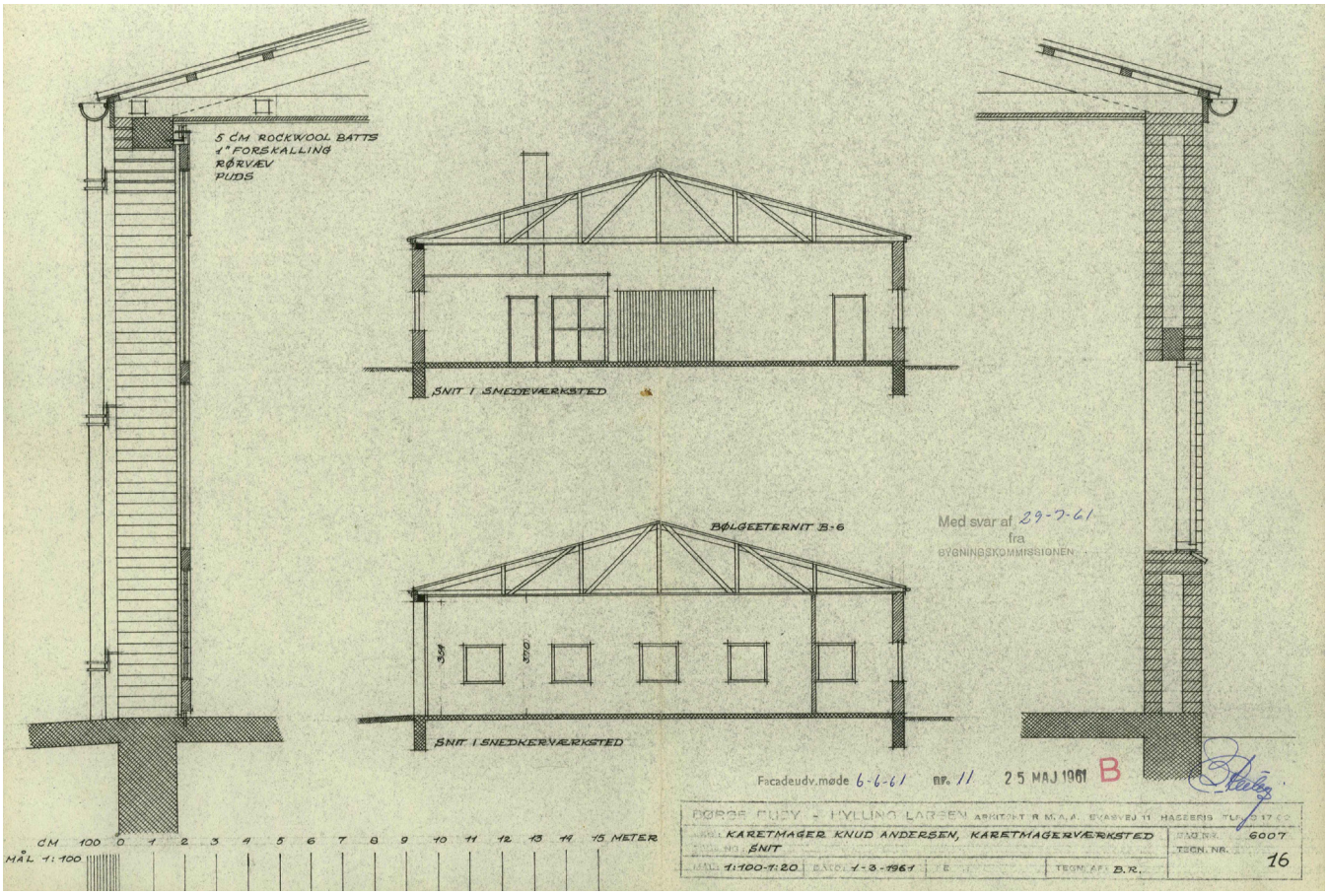
Hjulmagervej 16 - section



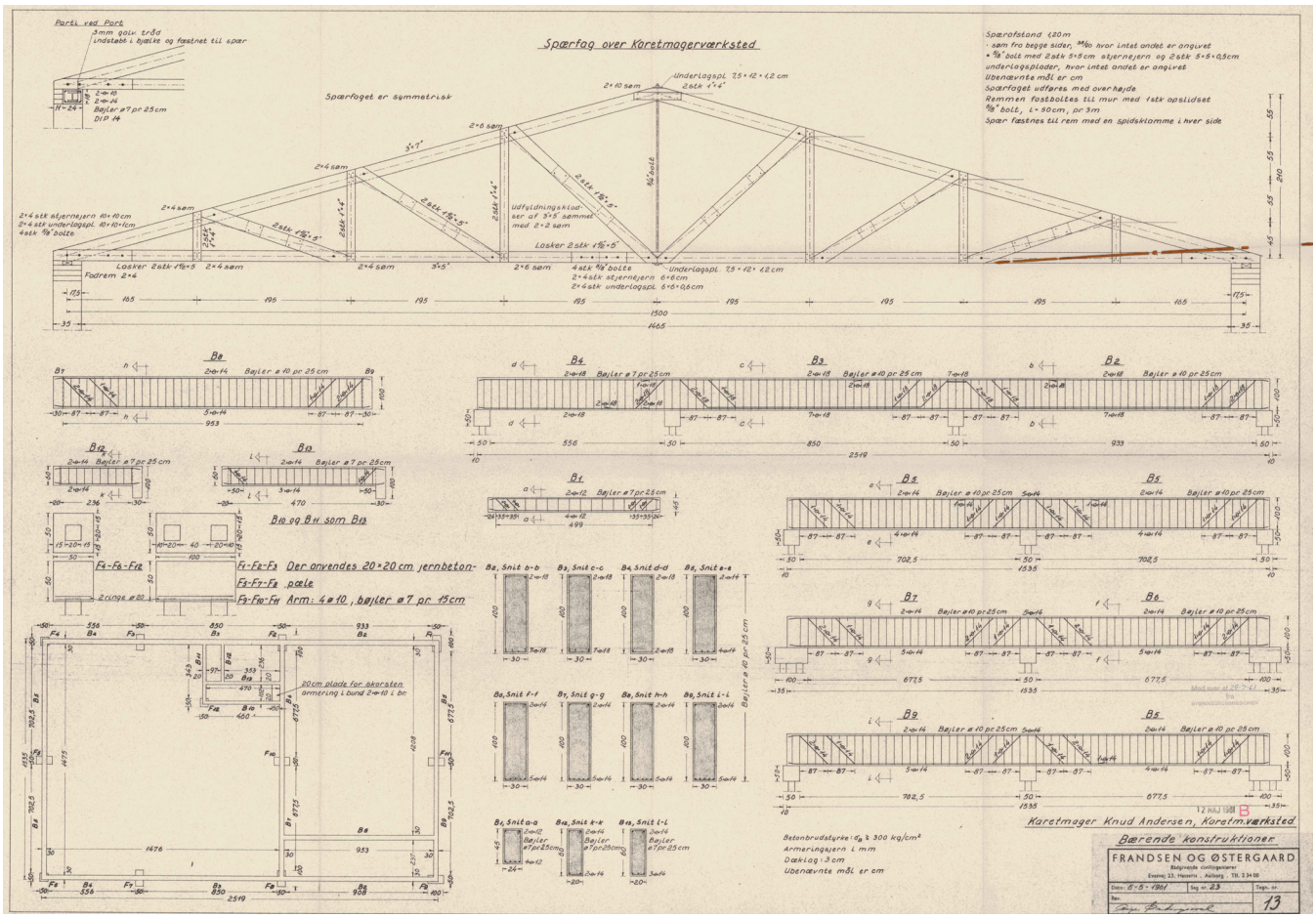
Hjulmagervej 16 - section



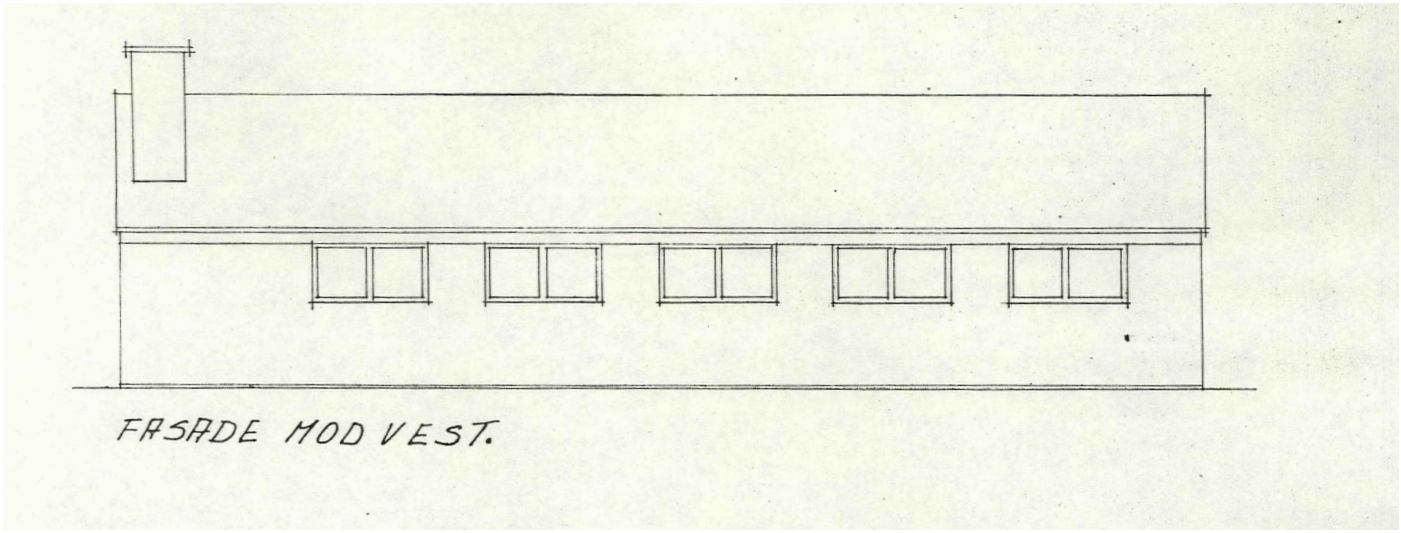
Hjulmagervej 16 - floor plan



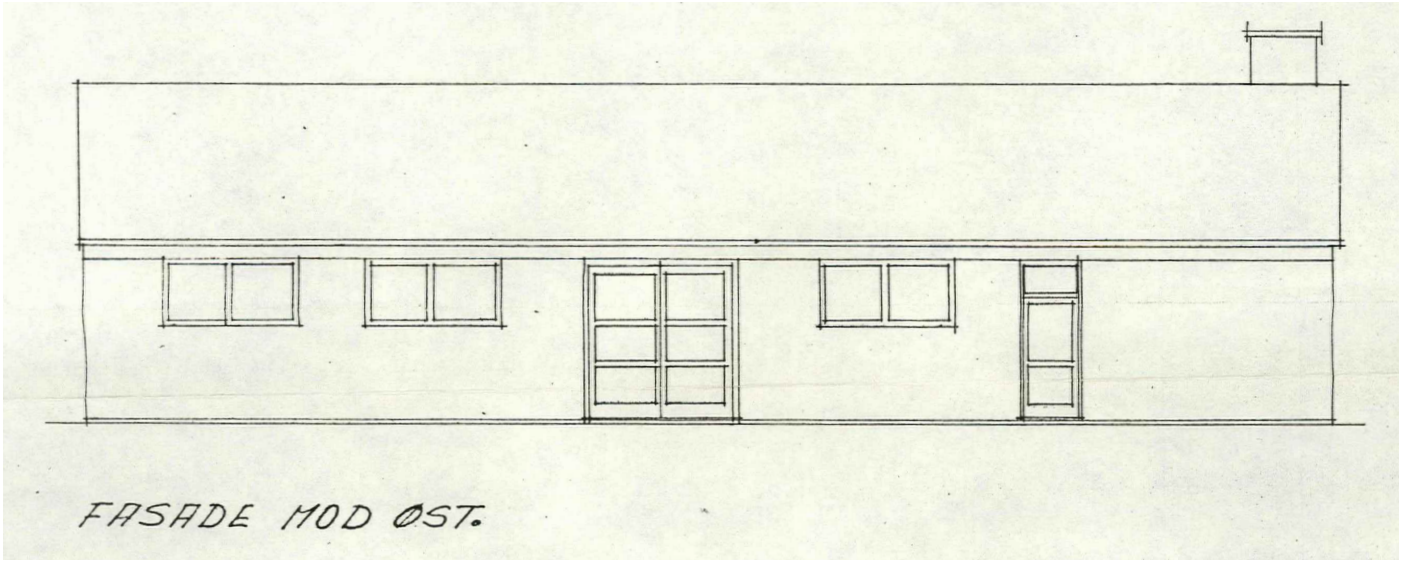
Hjulmagervej 16 - technical section



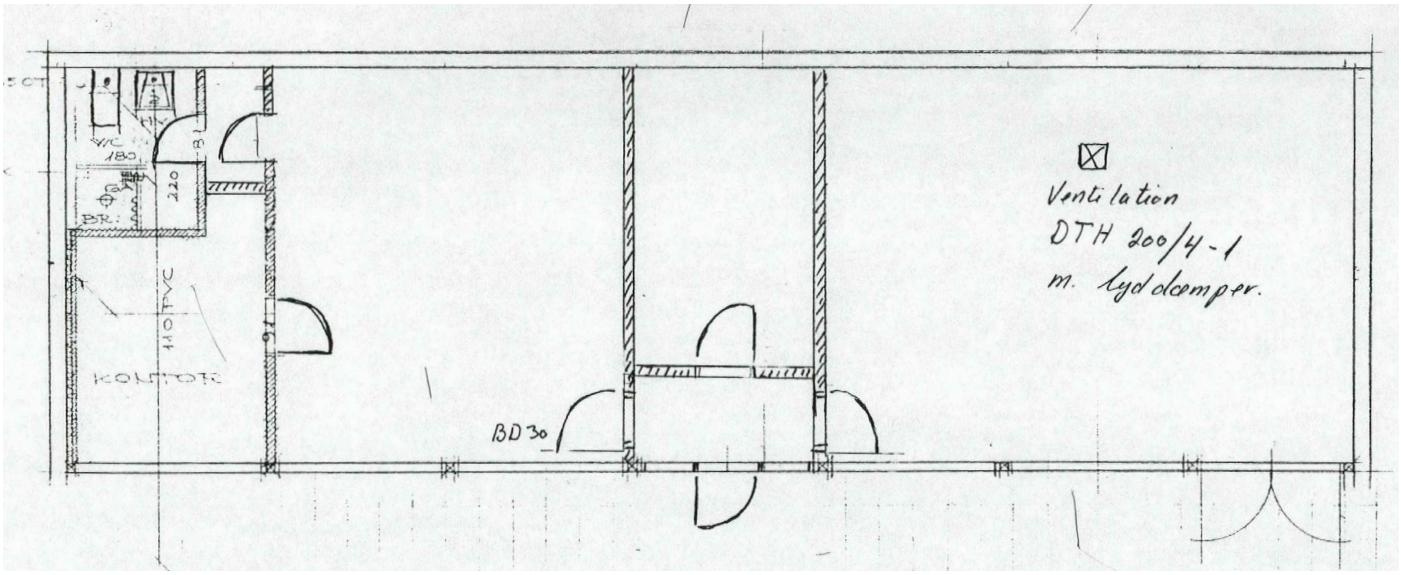
Hjulmagervej 16 - Trusses, walls and foundation



Hjulmagervej 14 - Elevation wast



Hjulmagervej 14 - Elevation east

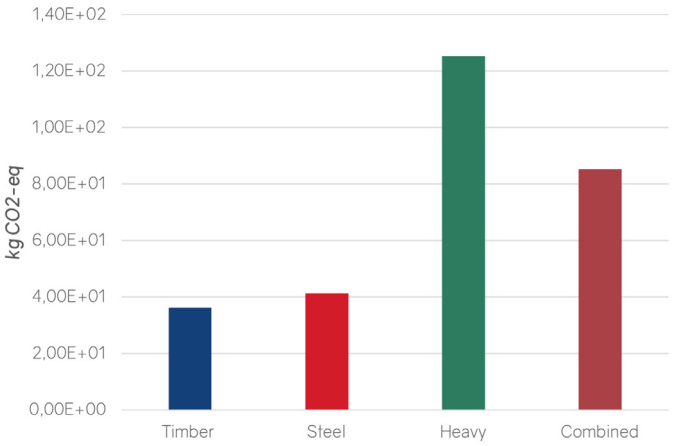


Hjulmagervej 14 - Floor plan

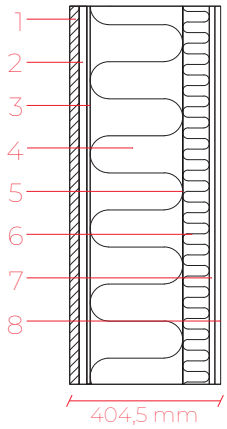
Appendix 2

LCA material, constructions

Comparison

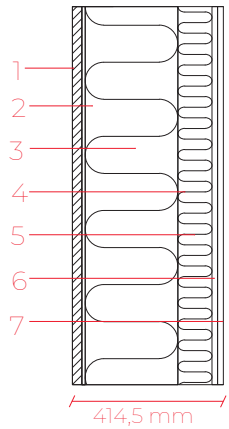


Timber



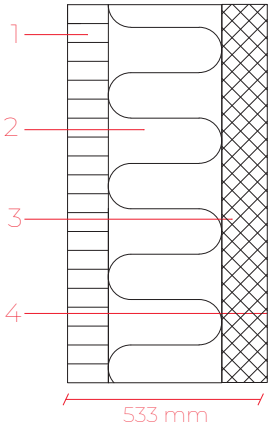
1. 25 mm wood cladding
2. 20 mm air
3. 9 mm OSB
4. 245 mm insulation + timber construction
5. Vaper barrier
6. 70 mm Insulation + timber spruces
7. 2 x 15 mm gypsum boards
8. 5 mm finish / painting

Steel



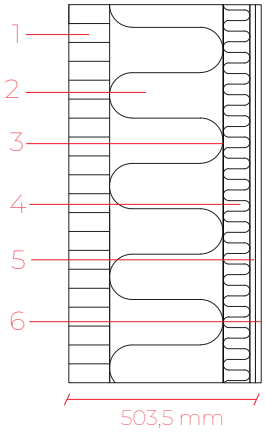
1. 25 mm wood cladding
2. 9 mm OSB
3. 245 mm insulation + steel construction
4. Vaper barrier
5. 100 mm Insulation + steel spruces
6. 2 x 15 mm gypsum boards
7. 5 mm finish / painting

Heavy



1. 108 mm brick cladding
2. 300 mm insulation
3. 120 mm concrete
4. 5 mm finish / painting

Combined



1. 108 mm brick cladding
2. 280 mm insulation + timber construction
3. Vaper barrier
4. 80 mm Insulation + timber spruces
5. 2 x 15 mm gypsum boards
6. 5 mm finish / painting

Appendix 3

Calculations on steel structure

There are only five blue frames available on the site. Therefore, it is required to calculate their load bearing capacity to know whether they are enough to carry the whole roof's extension. Their dimensions and the loads applied on the roof are known, the only missing data is the maximum spacing distance between each of them.

The first step was to determine the static diagrams of the structure affected by a horizontal distributed load on top of the beam and the structure self-weight. The wind load is not considered as the structure is not connected to outer wall influencing the spacing distance. The boundary reaction is considered fixed at the bottom of the column. It is also important to notice that as the frame is carrying the roof's extension, the length of the beam has been cut to 5m70.

The second step was to determine the limit resistance value for each element. As the beam is only affected by shear stress and bending moment, it is only required to calculate the maximum shear force (Vrd), the maximum bending moment (Mrd) and the deflection (δmax) at the end. According to Eurocode 3, Vrd is given by the formula:

$$Vrd = \frac{fy * Av}{\gamma 0 * \sqrt{3}} > Vmax$$

Where fy is the resistance value, which is assumed to be the standard value 235MPa, Av is the shear area, which is the web thickness times the flange thickness, δ0 is the safety factor which is 1 for steel and Vmax is the highest shear force affecting the beam.

Mrd is given by the formula:

$$Mrd = fy * \frac{W}{\gamma 0} > Mmax$$

Where W is the section modulus. In this case, the section is of class 1 and the Wpl should be used. Wpl is 2 times the Static Moment (S). Mmax is the highest bending moment affecting the beam.

δmax is given by the Mohr Integral of the beam and the column with a virtual force located at the end of the beam. In this case, the contribution of the beam is given by:

$$\delta = \frac{1}{4} * \frac{ql^2}{2} * 1 * l * \frac{l}{EI}$$

And the contribution of the column is given by:

$$\delta = \frac{ql^2}{2} * 1 * l * \frac{l}{EI}$$

Where E is the standard young modulus for steel structure 210GPa and I is the moment of inertia of the beam section. In this case, the beam section is not constant, but to speed up calculations, it has been assumed that the moment of inertia was constant over the beam and based on the average section area.

According to the Danish Standards, the maximum deflection for a beam between 4m50 and 6m is 30mm, but the Eurocode mentions that this value can be discussed with the client as it does not cause the collapse.

Now for the column, there is only compression force and bending moment. Therefore, it is required to calculate the maximum stress value related to combination of compression and bending (δcr), and the critical buckling force (Nbrd).

δcr is given by the formula:

$$\frac{\sigma cr}{\gamma 0} = \frac{N}{A} + \frac{M}{W}$$

Where N is the maximum compression force (ql + P), A is the area of the column, M is the moment located at the same place as N ($ql^2/2$) and W the section modulus. As for the beam, the section is of class 1 and therefore the plastic modulus should be used.

Nbrd is given by the formula:

$$Nbrd = \frac{\chi * A * fy}{\gamma 1} > Nmax$$

Where δ is the reduction factor depending Eulerian Critical Buckling Force (Ncr), the section area and fy, A is the section area of the column, δ1 is the safety factor for

steel structure affected by buckling which is equal to 1 and Nmax is the highest compression force in the column.

Then the formulas can be compared to evaluate what is the most restrictive for the distributed load. It should also be noticed that only the deflection is calculated under Service Limit State and should be compared to the distributed load anyway.

It can be seen that the bending and compression combination is the most restrictive at ULS and the deflection is the most restrictive at SLS.

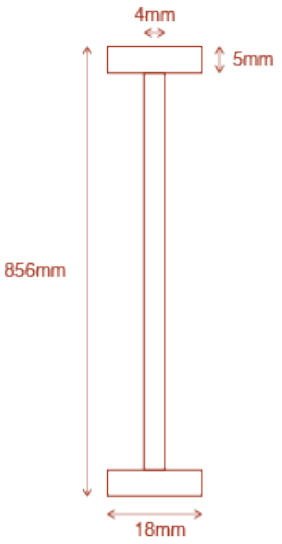
The final step is to determine the load applied on the structure in function of the distance between frames. Only the snow load and the roofing load which are applied on a surface, are depending on the distance. Therefore, the distance can be found by using the following formula for both limits as the self-weight of the column has already been included in the qmax calculation:

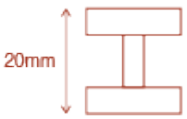
$$\frac{qmax - beam\ self\ load}{snow\ load + roofing} = l$$

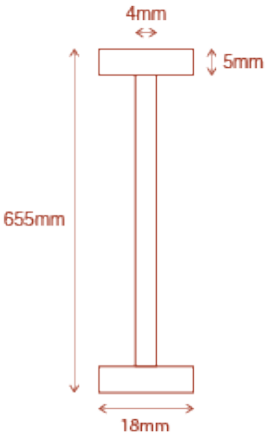
It can be concluded that the maximum distance between frames is 4.2m. However, it is important to notice that this value is based on the maximum deflection and can be increased or decreased depending on the appreciation of the client.

		Parameters	Limit Value	qmax (kN/m)
Beam	Shear Stress	Av = 0.34m²	Vrd = 4646kN	815
	Bending Moment	S = 0.0036m³ Wpl = 0.0073m³	Mrd = 1705kNm	105
	Deflection	I = 0.0013m⁴	Delta = 0.03m	13
Column	Bending + Compression	A = 0.0402m² S = 0.0027m³ Wpl = 0.0054m³	Sigma = 235MPa	75
	Buckling	A = 0.0402m² Buckling Length : Lk= 2*L Ncr = 41.43MPa Buckling Curve c : alpha = 0.49 X = 0.855	Nbrd = 8082kN	1418

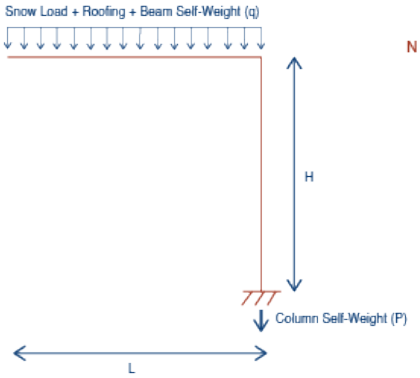
	Snow Load (Variable)	Roofing (Permanent)	Beam SW (Permanent)	Column SW (Permanent)	Factor	Distance max
Bending + Compression	1kN/m²	2kN/m²	Steel density = 7800kg/m³ 3.63kN/m	Steel density = 7800kg/m³ 4.15kN/m	Permanent = 1.35 Variable = 1.5	17m
Deflection					Permanent = 1 Snow = 0.5	4.2m

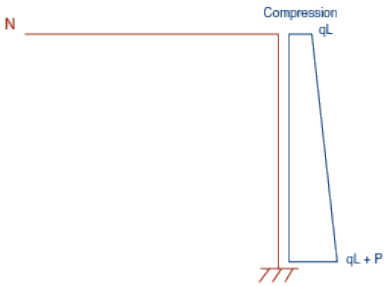


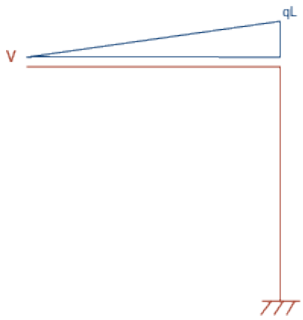


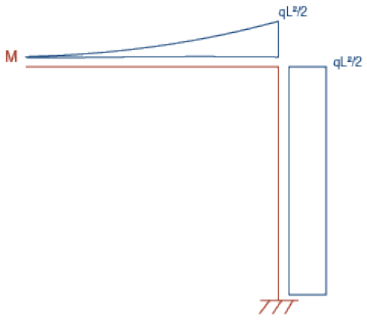


Highest Beam Section | Lowest Beam Section | Column Section









Appendix 4

Calculations - Wall extension

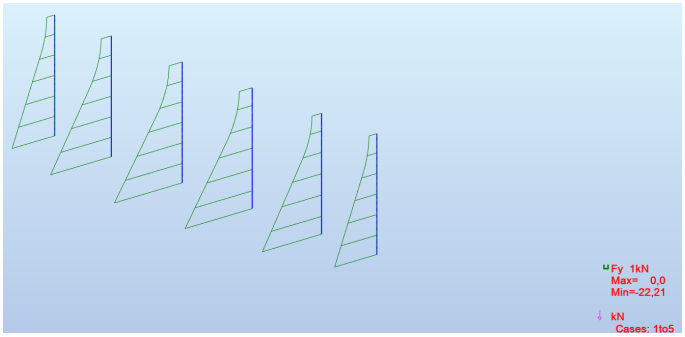
Load case

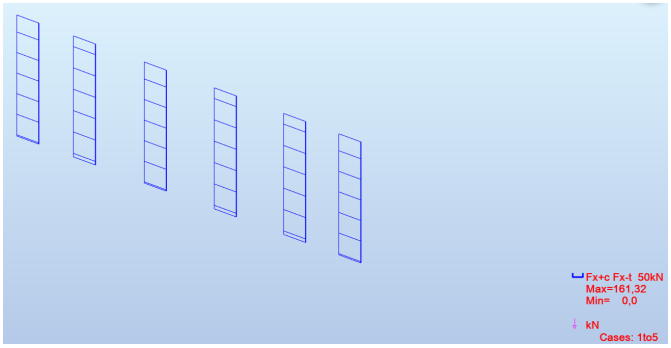
Wind Load (Variable)	Snow Load (Variable)	Roofing (Permanent)	Brick SW (Permanent)	Timber SW (Permanent)	Extension Wall (Permanent)	Studios (Permanent)
0.475kN/m²	1kN/m²	0,5kN/m²	16.19kN/m³	4.12kN/m³	2kN/m²	3kN/m²

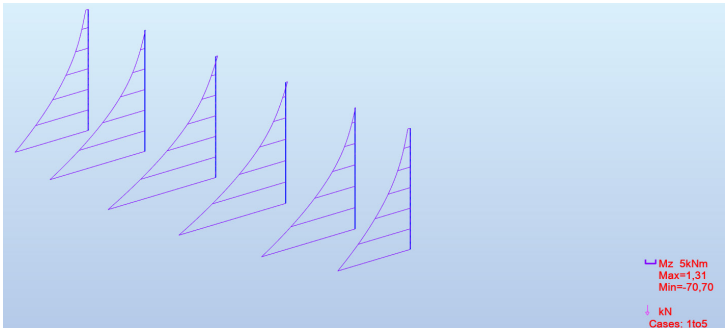
Brick calculation

	Design Forces	Parameters	Limit Forces	Dimensions
Compressive Stress	N_{ed}=161.32kN (Compression)	t_{ef}=0.29m phi=-0.38 fcd=-4MPa	N_{rd}=433.30kN	D=0.36m W=0.97m
Shear Stress	V_{ed}=22.21kN	c_v=3 l=6.2m e_{ad}=0.44m f_{vd0}=0.1MPa	V_{rd}=196.41kN	
Flexural Stress	M_{ed}=70.7kNm	f_{xd1app}=0.153MPa Z=0.464m³	M_{rd}=70,93kNm	

Brick - Robot



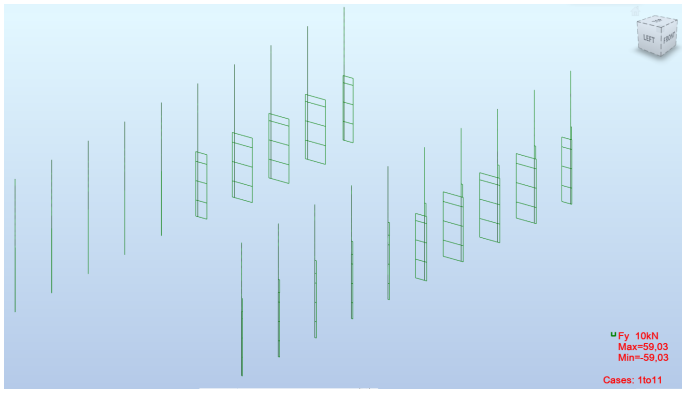


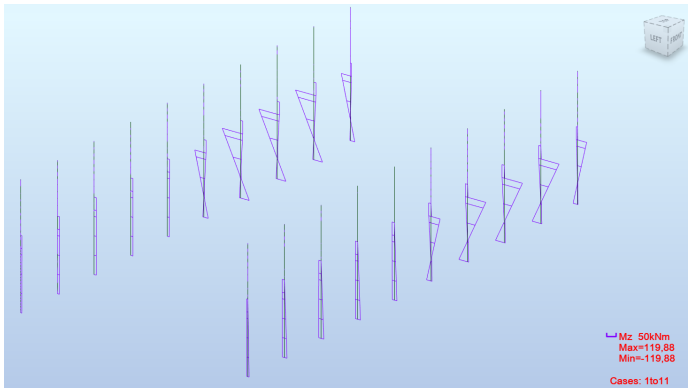


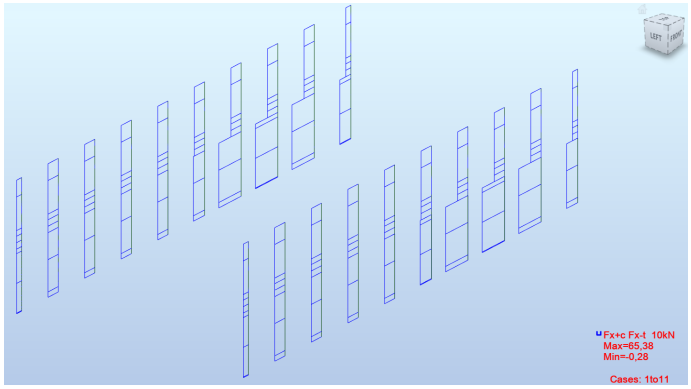
Timber calculation

	Design Forces	Parameters	Limit Forces	Dimensions
Bending & Compression	M_{ed}=119.88kNm	A=0.0676m² W=0.0059m³ SF=1.25	f_{c0d}=19.2MPa f_{md}=22.4MPa	c=0.26m
Shear Stress	V_{ed}=59.03kN	k_{cr}=0,67 A_s=0.030m²	f_{vd}=2.8MPa	
Buckling	N_{ed}=65.38kN (Compression)	k_{cz}=0.64 rel. slend.=1,15	f_{c0d}=19.2MPa	

Timber - Robot







Appendix 4

Windows - Østre Allé 104