Rethinking Industrial Heritage

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Introduction

While choosing a graduation studio around 5 months ago I had one thing in mind. I want to have the freedom to graduate on a subject which interests me the most, otherwise it is going to be a very long year. And this is actually the last time in my career (I think) where I have the possibility to completely create a project around my own fascinations. Quickly I stumbled on Architectural Engineering where there is a lot of freedom, except for one thing. Our design fascination should derive from a technical perspective. This technical approach onto a project goes hand in hand with pragmatic thinking[1] from my experience. Luckily pragmatic thinking has always been one of my better qualities.

On the course of the last 5 years of studying in Delft I have discovered that Architecture is a lot more then solving the puzzle of context, program and detailing. Let's call this the pragmatic side of architecture. Behind this side of architecture is also a more philosophical side.

Whether it is a football stadium, a library or a cottage. Every place we live, work and thrive in or around has a different feeling, a different character, or a different soul as Peter Zumthor would describe it (The National Gallery, 2014).

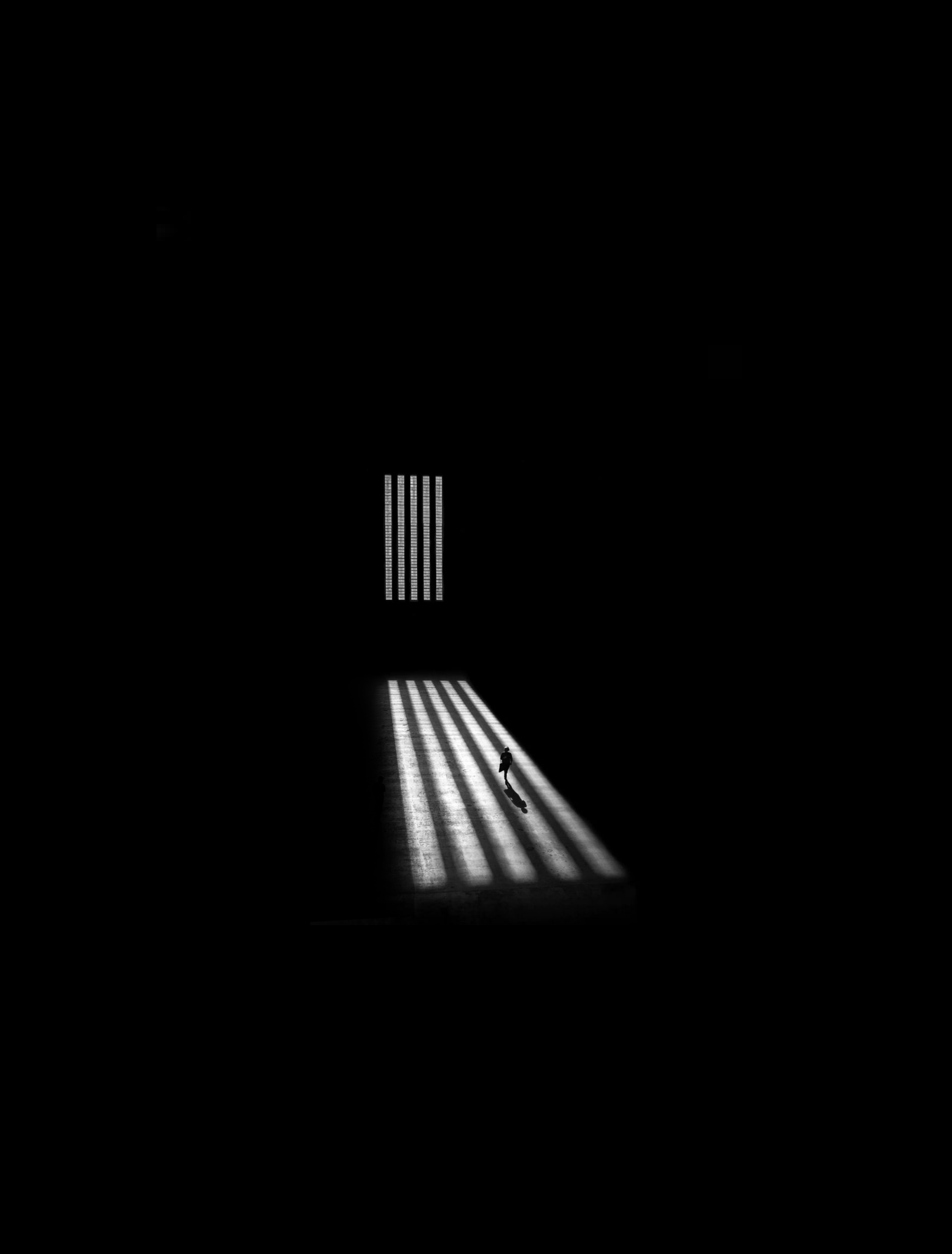
Imagine… Entering a wooden cottage somewhere high up in the Alps. You're welcomed by the warm scent of pine, the wooden beams overhead feel low and comforting. A stone fireplace crackles in the corner, casting a soft glow over the cozy space which makes the small wooden hut feel warm and inviting. And then, two weeks later …. You are stepping into a huge football stadium, the sheer scale of the space hits you immediately. The massive steel structure overhead feels intimidating and the endless rows of seats are rising steeply. As you walk into the stands, the space feels electric, built for wild crowds. Ready to support their teams to the fullest…

These two different buildings with each there very own character both evoke a complete different sensation. And it is exactly this side of Architecture what has been fascinating me more and more.

How does a space feel? With what character can the architecture be described? Why does it feel that way? And how do we translate this feeling, this experience into a tangible design?

During the exploration of what I want to research and design for my graduation I got stuck into a small dilemma. Since it is a technical studio I had the thought that I should design and research something purely from the pragmatic perspective of Architecture. I was imagining some sort of super-efficient modular building system. Which still is a subject I'm very interested in, but it feels like it loses the touch of the sensory perspective of Architecture. So it is my goal to combine these two fascinations into one project.

[1] *"Thinking pragmatically means making decisions based on available evidence towards applied outcomes. A pragmatic thinker is guided by practical considerations, what is immediately and realistically understandable or implementable." (DCF Lab, 2023)*



Entrance Tate Modern, London. (Polita, 2021)

1. General problem statement

The Netherlands faces a critical (affordable) housing shortage. Efforts to address these issues in the past have resulted in pragmatic, standardized designs that compromise architectural quality and individual customization.

1.1 Affordable housing crisis

The Netherlands is facing a significant housing crisis, with a shortage of 401,000 homes, approximately 4.9% of the total housing stock (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2024).

The issue is not just about the lack of homes available but also about their affordability. Even if enough units existed, high prices would still prevent many people from accessing them (Tarne, 2023).

The crisis began with policy changes in the 1990s that restructured the Dutch housing sector. Previously, municipalities controlled land markets, which helped develop and regulate affordable housing. Reforms shifted the focus to private ownership and reduced municipal control, allowing developers and investors to dominate and increase land values (Buitelaar, 2024). In 1995, the "bruteringsoperatie" further separated housing corporations from government support, forcing them to operate without state subsidies (Buitelaar, 2010). This weakened national housing policies and removed essential support for affordable housing development (Buitelaar, 2024).

More recent policies under former Minister Stef Blok worsened the situation. His initiatives encouraged private investment by increasing rent flexibility, introducing temporary contracts, and reducing tenant protections. While aiming to boost the housing market, these measures prioritized investors over affordability. Landlords were allowed to raise rents and engage in buy-to-let schemes, significantly affecting low- and middle-income households. Housing costs rose, especially in cities, as investor demand pushed rents beyond what many could afford (Hochstenbach, 2023). Investors also bought many properties, removing lower-priced homes from the market for first-time buyers and lower-income individuals (Tarne, 2023).

To solve the housing crisis, the Dutch government plans to build 900,000 homes in the next eight years. Though according to the Economic institute for construction, the cabinet will not meet this target (Endhoven, 2022). Besides by solely focusing on new construction the affordable housing crisis will not be solved. (Tarne, 2023)

An approach to easing the Dutch affordable housing crisis is the strategic repurposing of underused or vacant buildings. Converting existing structures, such as former offices, schools, or warehouses, into residential spaces could offer a faster, more cost-effective alternative to new construction, if done right.

Estimated housing shortage 2024-2039. (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2024).

1.2 Standardization vs customization

In the 1960s, rationalization in the field of architecture emerged. An industrial approach completely changed the way we were building our houses. The goal was to streamline construction through mass production and standardization. (Bundgaard, 2013) It was all about speed, building faster and cheaper to meet the enormous demand for housing. (Priemus, 1987) While this method was very efficient, it led to a loss in architectural diversity. The result? Endless rows of rigid, monotonous, uniform buildings that lack individualism. Which turned cities into bland landscapes, still visible in todays cityscapes.

Mass-standardization fails to support a dynamic society. Uniform, "one-size-fits-all" designs lack the flexibility to meet varying needs. As a result over 60% of building production in the Netherlands involves the partial or full demolition of existing structures, generating significant waste as rigid designs are torn down to meet new demands. (Elma, 2006)

In a diverse society with many personal spatial requirements, buildings should be able to adapt, allowing for customized solutions that suit individual needs. As Stewart Brand (1994) put it, "All buildings are predictions. All predictions are wrong." Buildings must anticipate on the ever changing demands, driven by shifts in the economy, diversity in working and living patterns, and constant migration of populations. (Elma, 2006) Instead of mass-standardization, we should embrace mass-customization. A more sustainable approach to the current housing shortage in the Netherlands.

Mass-customization finds the balance between standardization and customization in architecture. This approach combines the

Voorhof, Delft. (Voorhof2West, 2011)

Gijsinglaan, Rotterdam. (platform wederopbouw Rotterdam, z.d.)

Alexanderpolder, Rotterdam. (Pinterest, z.d.)

Bijlmer Amsterdam. (Bijlmer museum, z.d.)

efficiency of standardized system with the with future flexibility. This customization concept operates on the principles of the open building approach, allowing for adaptable, flexible designs that separate the base structure from the infill. This enables buildings to adapt to occupant needs over time, minimizing structural alterations and accommodating diverse spatial solutions. (Kendall, 1999) With mass-customization, we can create buildings that are more resilient and responsive to future needs.

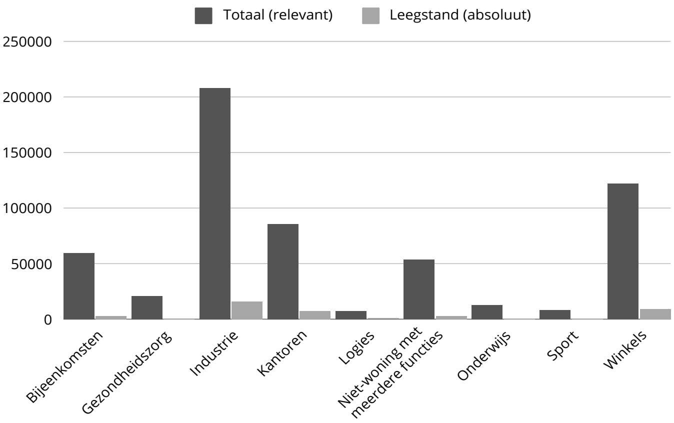
Mass-customization is still focussed on mass-construction. We shouldn't make the same mistake of constructing repetitive and monotonous buildings, as we did during mass-standerdization. Instead, we should create architecture that is more considerate of its context. This implies on the importance of an architect still adapting the design to its physical, historical and cultural context. Situated architecture. In a way also customization, but then applied to the design phase instead of the post-construction phase.

1.3 Pressure on land

The pressure on the available land for suburban expansion in the Netherlands is increasingly intensifying, leading to significant challenges in housing, infrastructure, and the preservation of natural and agricultural areas. Particularly within the Randstad, spatial pressure is exceptionally high. This region faces considerable spatial challenges due to limited available expansion space and the necessity to balance urbanization with landscape preservation (de Nijs, 2005).

Several factors intensify the pressure on land use in the Netherlands.

1. Restrictive policies and designated bundling areas in the Randstad and surrounding provinces limit expansion space. These measures aim to concentrate urbanization within specific zones but further constrain the available land (de Nijs, 2005).
2. National landscapes like the Groene Hart are protected under the "Nota Ruimte," which imposes stricter restrictions to safeguard landscape and ecological values. (de Nijs, 2005).
3. Population and economic growth intensify the issue. The "High Spatial Pressure Variant" report predicts that an economic growth of 2.1% and a population nearing 20 million by 2040 will lead to significant spatial pressure, necessitating concentrated urbanization mainly in Central Netherlands (Kuiper, 2007).
4. Climate change and associated flood risks contribute to land-use pressures. Reserving areas for water storage, especially in low-lying regions like the Delta area, the river region, and the Ijsselmeer area. This reduces the space available for urban development, as these areas must be kept free for future water management adaptations (Kuiper, 2007).



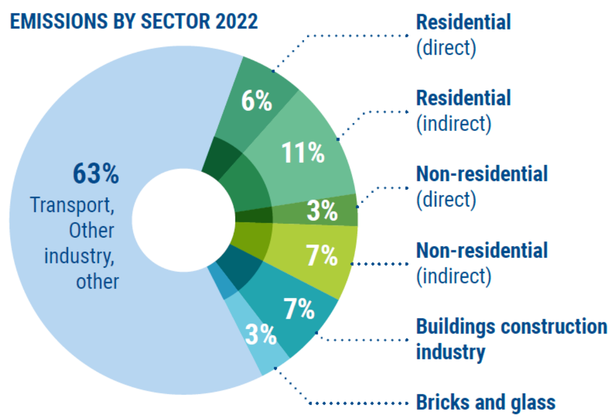
Total number of (relevant) buildings and associated vacancy. (Own work, data source: Centraal bureau voor de statistiek, 2024)

A sustainable solution to these challenges lies in focusing on the transformation of vacant existing structures rather than expanding cities into surrounding rural or green spaces. As shown in the diagram, industrial buildings have a relatively high vacancy rate, totaling 16,040 vacant units. This significant amount of unused industrial space offers an opportunity to reduce the pressure on available land. By repurposing these vacant industrial buildings into housing or mixed-use developments. This approach efficiently uses existing structures, preserves industrial heritage, and supports sustainable urban development.

1.4 Excessive CO_2 emissions

The excessive emission of carbon dioxide is a critical global issue contributing to climate change. One of the most significant contributors is the building and construction sector. According to the Global status report for buildings and construction, this sector accounted for nearly 37% of energy and process-related CO2 emissions worldwide in 2022. This includes emissions from the production of building materials like cement and steel, the construction process and the energy consumed by buildings during their operation.

To reduce the high CO2 emissions associated with building construction, one promising approach involves the use of locally sourced bio-based materials. These materials actively absorb CO_2 during their growth, storing carbon over their entire lifespan. Furthermore, the production and processing of bio-based materials require significantly less energy than traditional materials like steel and concrete, resulting in a lower embodied energy footprint (UNEP, 2024).



Emissions by sector 2022. (United nations environment program, 2024)

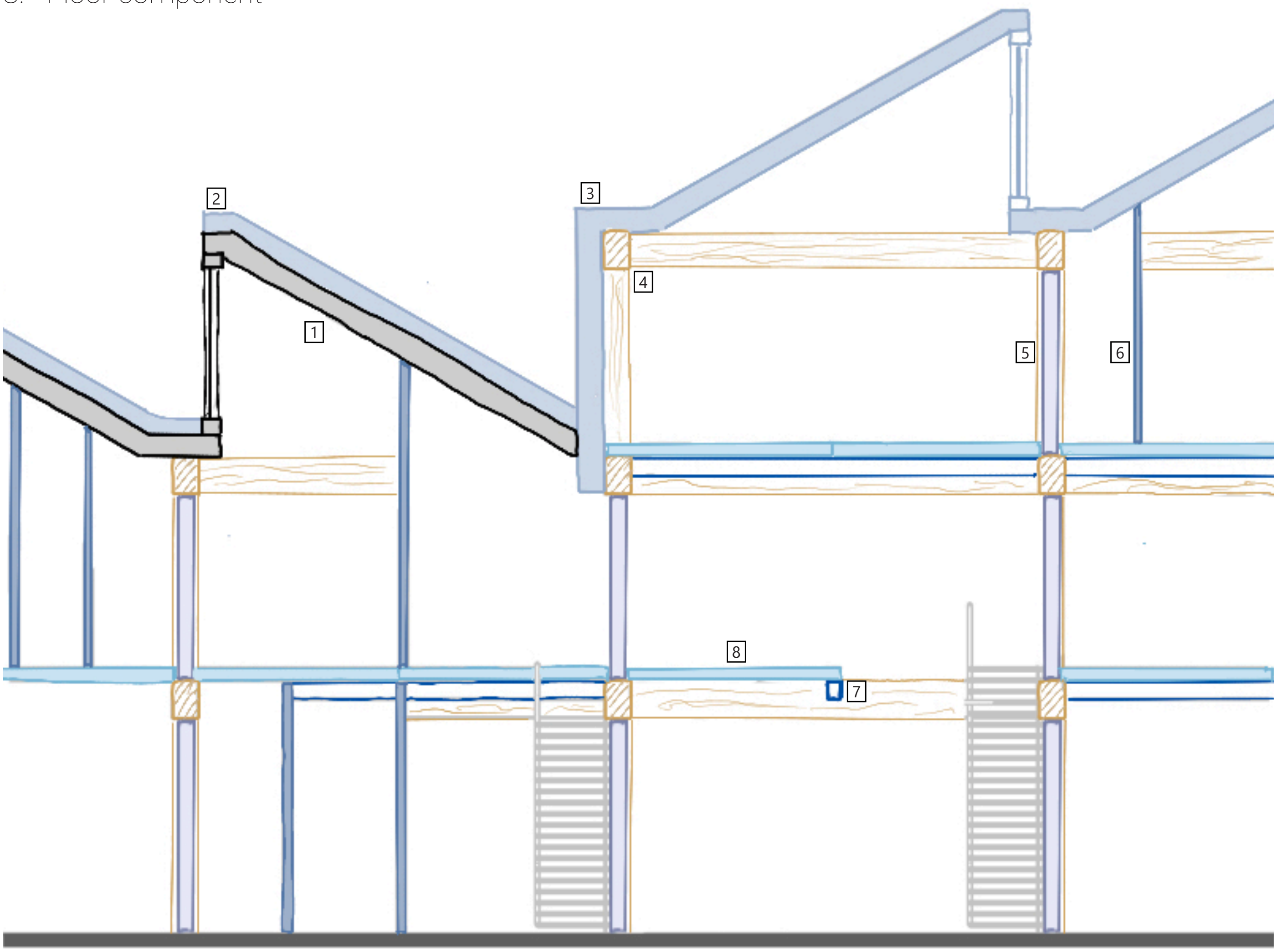
2. Design

2.1 Overall design question

How can a building system existing of a standardized main structure created out of LVL transform an existing industrial building into affordable housing that offers future adaptability through the substructure that is made from as much bio-based materials as possible?

Different elements within the building system

1. Existing structure
2. Outside or inside cladding for necessairy insulation
3. New exterior wall
4. Main structure
5. Seperating wall component
6. Wall component
7. Floor component support
8. Floor component

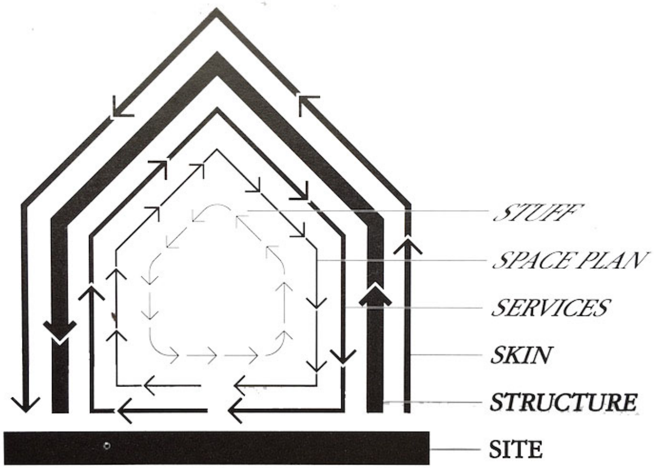


Different component typologies, test sketch (own work)

2.2 Overall design objective

In this graduation, I will be transforming an existing industrial building by the use of a flexible building system. This system balances the concept of standardization and customization. Looking at the shearing layers diagram we can see 6 different layers: site, structure, skin, services, space plan and stuff. These layers form the basis for determining which parts of the system are standardized and which are customizable.

Standardization will be found in the structure, providing a constant framework over time. Customization will be found in the substructure, which refers to the skin, services and space plan. This customization will be applied within two phases of the building-process, the design phase and the post construction phase.



Shearing layers diagram. (Brand, 1994)

Standardization

The standardized elements follow the construction principles of Laminated Veneer Lumber (LVL). This main structure provides various dimension options, forming a stable framework that supports the customizable substructure. The standardized structure serves as a constant layer over time, which means it is intended to remain largely unchanged, even as spaces within the building may shift, expand, or contract. However, the LVL framework is designed to be demountable, allowing beams and columns to be reused.

Customization

Customization within this system occurs in two phases of the building-process, the design phase and the post-construction phase.

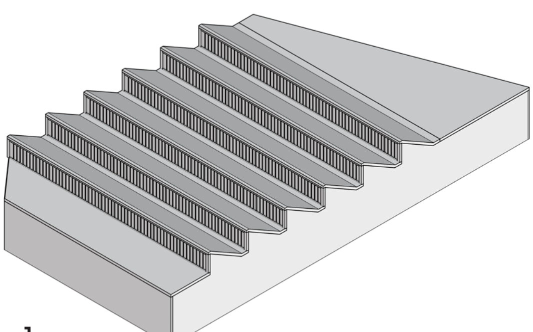
1. Design phase: Situated architecture

During the design phase, the system is based upon the principles of situated architecture. Situated architecture refers to design that responds to the specific environmental, cultural, and historical context of a site. (Frampton, 1983) Each site presents unique characteristics, ranging from intangible qualities such as atmosphere and character to physical attributes like materiality, structure, lighting, grid size, and orientation. The system needs to be able to adapt itself to physically connect itself to the existing site. To achieve this, bio-based components that form the substructure are customized during the design process. This refers to the skin, services and the space plan.

2. Post-construction phase: Open building concept

Adaptability in the post-construction phase is based on the concept of open building. This refers to the future flexibility in the space plan. The main structure defines specific design rules that allow for different possibilities in the space plan. The future residents can remove, change, or add components to modify the layout. This flexibility gives them the possibility to design and personalize interior spaces according to their needs. The essential infrastructure (gas, water, and electricity) and services must be easily adjusted as needed.

The skin layer, however, will remain fixed and non-adaptable after construction. Since this project focuses on transforming an existing industrial structure with a traditionally constructed façade, the external skin is intended to stay largely unchanged. This establishes a clear design rule: interior components must be removable, modifiable, or expandable without altering the building's exterior. Consequently, the focus of the open building concept is on the interior spaces, creating a dynamic and adaptable internal environment that respects the historic integrity of the outer structure.



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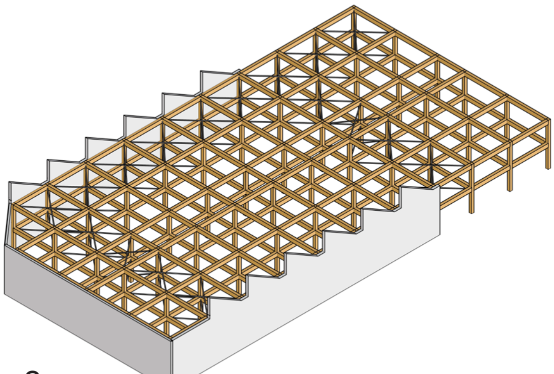

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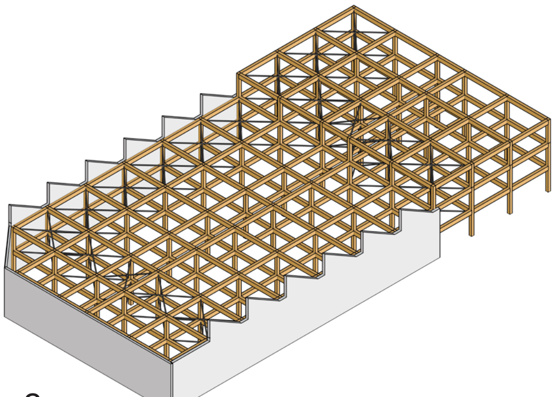

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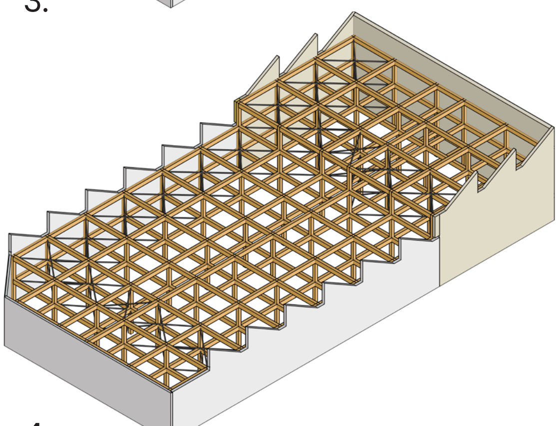

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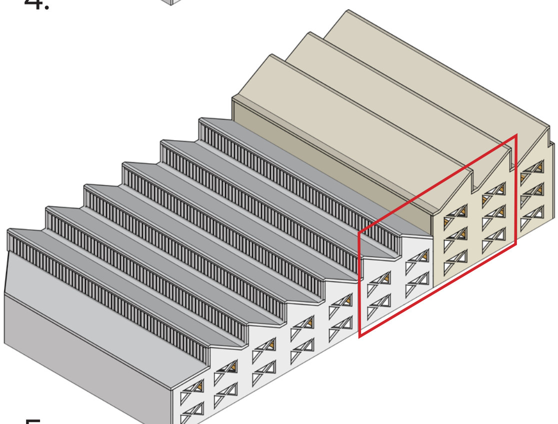

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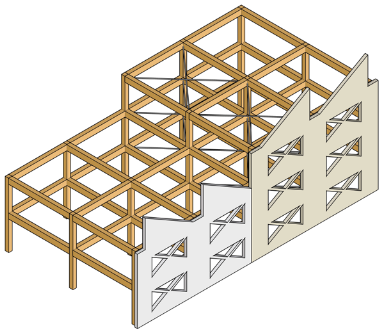
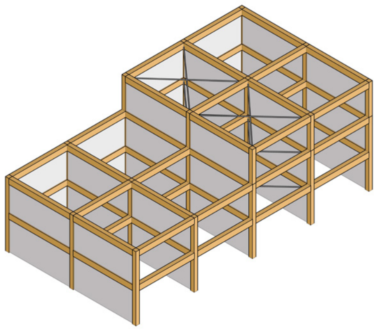
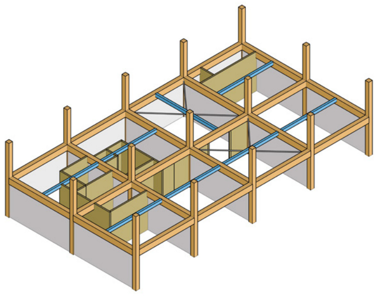
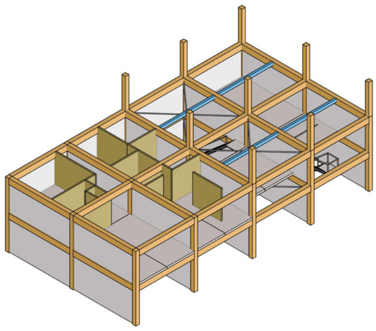
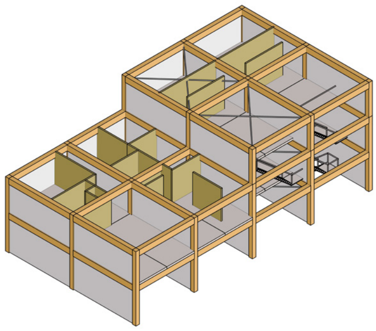
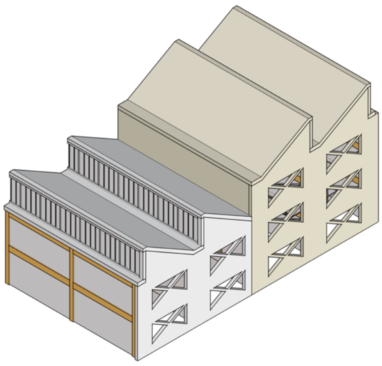






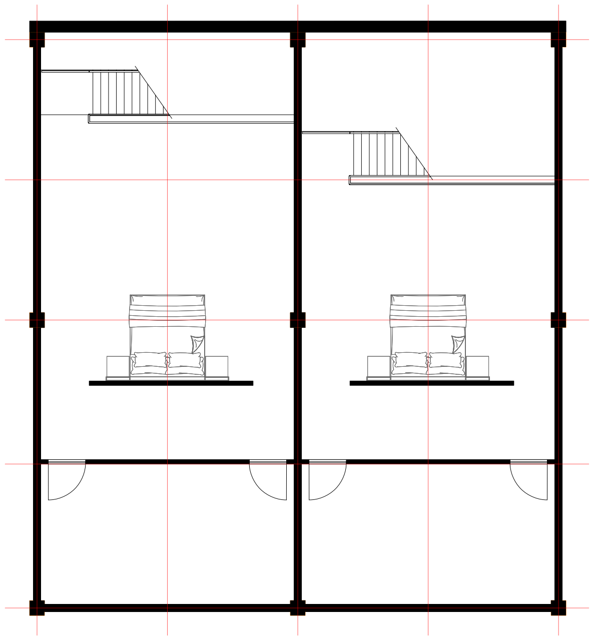


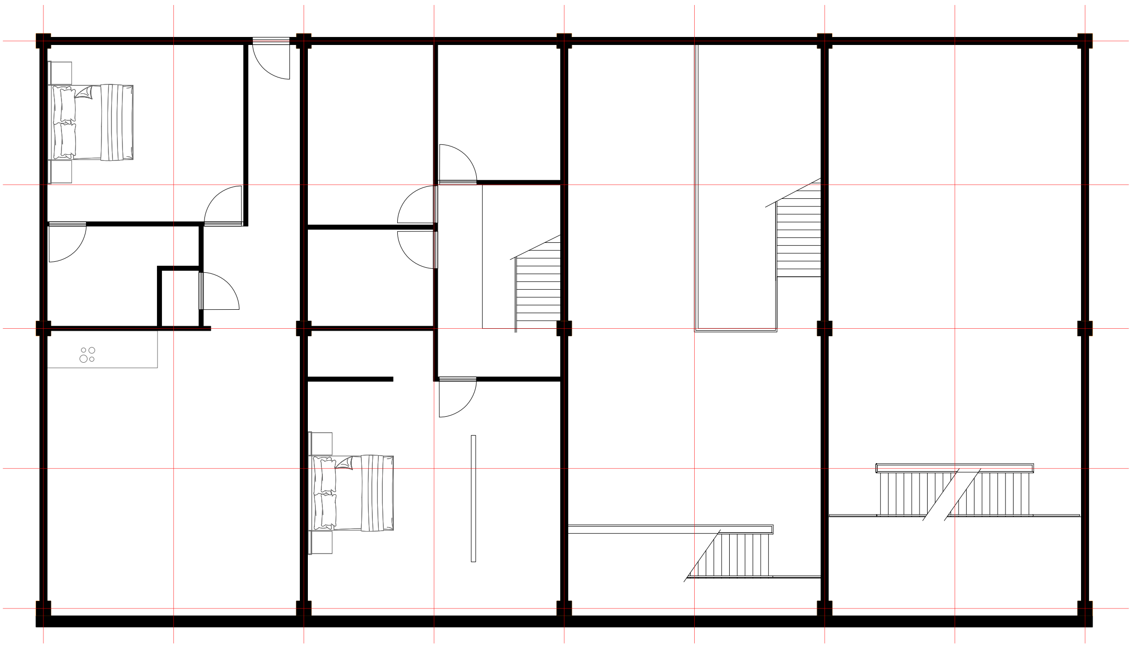


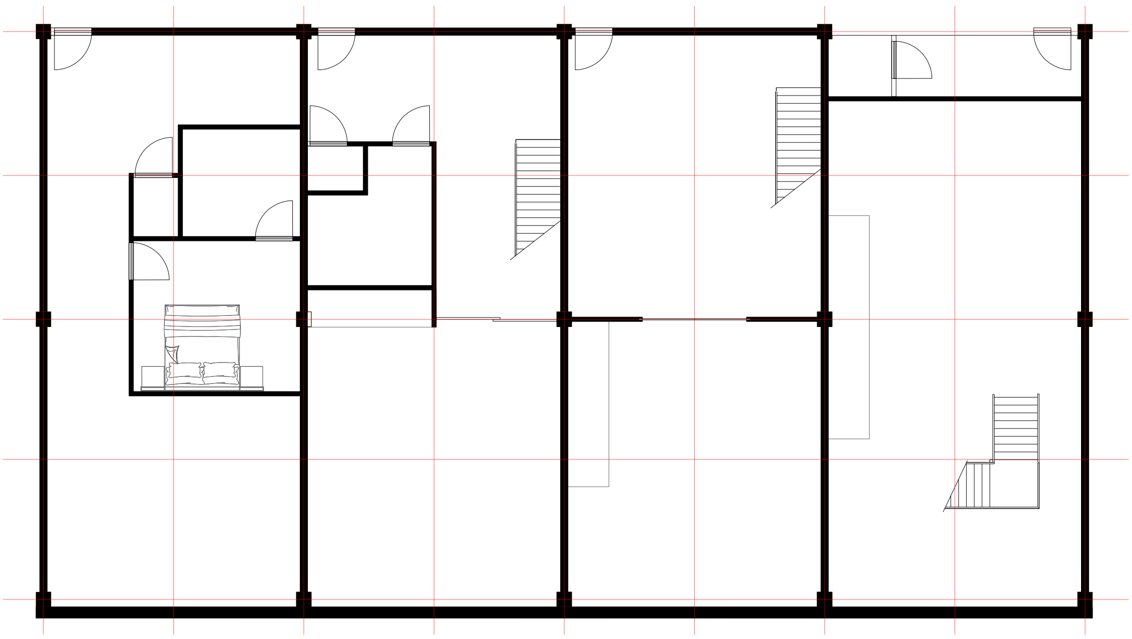


Concept study
In a quick design task, I transformed an existing industrial warehouse in Buiksloterham, Amsterdam, into housing using the concepts proposed for my graduation project. This exercise not only demonstrates my project intentions but also explains them through visualization.

Through this test, I've already gained several new insights. For this reason, these quick design tasks will serve as a key method throughout my project.







2.3 Location

While the proposed building system is designed to be applicable to various types of industrial buildings, the selection of a specific site for this graduation project is guided by several factors.

1. Firstly, the site should present a certain level of complexity to adequately challenge and demonstrate the system's capabilities. It is essential that the existing structure allows for the addition of multiple stories, enabling the exploration of vertical expansion within the design.
2. The existing foundation must be capable of supporting the Laminated Veneer Lumber (LVL) construction, ensuring structural feasibility without extensive foundation modifications.
3. The chosen site should possess a distinctive aesthetic or historical appeal, a 'wow' factor, that adds value to the transformation and highlights the potential of reusing industrial heritage.
4. The site should be well-accessible and easy to reach. Not only for the hypothetical future residents but also for myself, allowing for frequent visits and a better understanding of the site's conditions and context.

3. Research

3.1 Thematic research question

What are possible remountable bio-based components that form the substructure that functions as the infill elements creating the space plan within an open building system meant for transformation of industrial heritage?

Subquestions

The sub-questions are divided into literature, design, and realization stages, following the methodology structure.

Literature research

1. What are the design criteria for the standardized LVL main structure that will serve as the framework for the substructure components?
2. What are the different typologies of substructure components, and what specific criteria do each of these components require?
3. What are the material criteria for the bio-based materials that will be used for the components?
4. Which (local) bio-based materials are available, and how do these bio-based materials perform against the established criteria for the substructure components?
5. Which bio-based materials best meet the requirements for integration into the substructure components based on the comparative analysis?

Design research

6. How can the selected bio-based materials be applied in the design of specific substructure components to ensure seamless integration with the LVL main structure?
7. What sub-concepts can be developed for each aspect of the specific component and how do they address the component criteria?
8. How can the individual sub-concepts be combined into an overall concept for the component that meets all design and component criteria?

Realization

9. What are the optimal methods for prototyping the component, including scale, materials, and integration with a scale model of the main structure?
10. How does the prototype perform in terms of tactile qualities, functionality, and compliance with the established criteria when tested within the LVL main structure framework?
11. What technical insights and material considerations arise from the prototyping phase, and how can these inform refinements to the component and the development of other components?

3.2 Thematic research objective

The objective of this research is to develop demountable bio-based substructural components that connect seamlessly within the framework of a standardized Laminated Veneer Lumber (LVL) main structure. These components will follow to the design principles of the open building concept, enabling future adaptability in the space plan of transformed industrial buildings. By integrating bio-based materials into the substructure, the research aims to balance standardization and customization within the building system, facilitating the transformation of existing industrial heritage structures into affordable, adaptable housing.

3.3 Theoretical framework

This research is grounded in the interplay between standardization and customization in architecture, drawing upon theories of open building, situated architecture, and sustainable design principles. By integrating these concepts, the study aims to develop a flexible building system that transforms existing industrial buildings into affordable, adaptable housing using bio-based materials.

Standardization versus customization

Historically, the push for mass standardization in the 1960s led to efficient but monotonous housing developments that lacked adaptability (Elma, 2006). Mass customization emerges as a response, combining the efficiency of standardization with the flexibility to meet individual needs (Pine, 1993). This approach allows for the creation of building systems that are both efficient and responsive.

Stewart Brand's (1994) concept of shearing layers divides a building into layers that change at different rates: site, structure, skin, services, space plan, and stuff. By identifying which layers to standardize (structure) and which to customize (skin, services, space plan), the building system can be designed for both stability and adaptability.

Customization can be recognized in two ways. Firstly the open building concept. The open building theory, developed by Habraken (1972) and expanded by Kendall and Teicher (2000), emphasizes the separation of a building's support (base structure) and infill (interior fit-out). This separation enables adaptability over time without altering the primary structure. Applying this concept allows future residents to modify their living spaces, addressing the need for housing that evolves with changing lifestyles.

This concept of open building is solely applied on the space plan and the service layer. The skin layer has a sense of permanence and is customized during the design phase of the project. This is based on the principles of situated architecture. Situated architecture focuses on a design that is responsive to its environmental, cultural, and historical contexts (Frampton, 1983). The main driver for this approach is that I strongly disagree with a concept where the appearance of the façade is a consequence of the building system. A concept where the appearance of demountable façade components shape the final layer of the building. The façade of the building is something personal, something that should take time and consideration while designing it. It should not be determined by a standardized system but should instead respond thoughtfully to its environmental, cultural, and historical context.

Sustainability and Bio-based materials

Sustainability is a critical aspect of modern architecture due to environmental concerns like climate change. Using bio-based materials supports a reduction in CO_2 emissions, as these materials store carbon and require less energy to produce compared to traditional materials (United Nations Environment Programme, 2021).

By incorporating bio-based materials into the system as early as possible, the final aesthetic can achieve a more refined look. By integrating bio-based materials from the beginning, rather than focusing on sustainability only at the end of the design process, the overall incorporation of sustainability within the design is much stronger.

By using the newest and most innovative applications of bio-based materials this project will try to create the most climate friendly design possible. References such as Naturbaustoffe by Sandra Hofmeister provide valuable insights into the potential of natural building materials.

4. Thematic research methodology

The research process is divided into three main stages: literature research, design research, and realization. This is an iterative process with the end goal of developing multiple components within a standardized system of Laminated Veneer Lumber (LVL). Developing a single component requires going through the entire process once.

Literature Research

The literature research starts by setting the design criteria for the main structure, this is the main structure development. These design criteria are a set of rules which the structure follows. Allowing it to function as a system while remaining adaptable to different dimensions. These set of rules also creates the basis for determining all the different component typologies within the sub structure.

Next, the sub structure development is conducted. Each specific component has its own properties and, therefore, its own set of criteria. In this step, the criteria for each component are established.

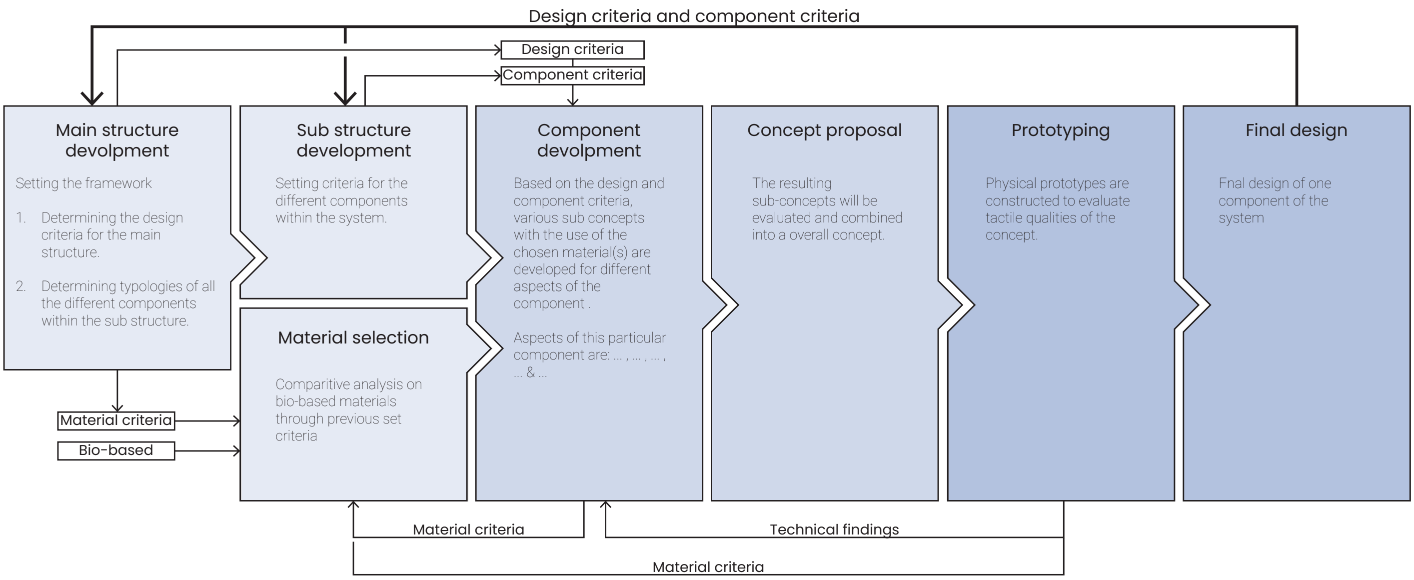
Simultaneously, research is conducted on material selection. A comparative analysis is used to systematically evaluate existing local bio-based materials. The goal is to gain insights into the range of available solutions and how different bio-based materials meet predefined criteria. By quantifying these criteria, a scoring system is developed to rank each bio-based material based on its performance. This enables a clear assessment of which bio-based materials are the best fit for the building system's needs.

After gathering the necessary data, the final step involves comparing and analyzing the materials using a matrix or chart. The matrix scores each material against the established criteria, providing a clear visualization of their performance. Organizing this information in a structured manner makes it possible to identify which bio-based materials best align with the system's requirements.

Design Research

After establishing the various component and design criteria and making material choices, the research proceeds to component development, focusing more closely on one specific component within the substructure. Based on the design and component criteria derived from the literature research, different aspects of the specific component are examined. For each aspect, a sub-concept is developed in this step. The different aspects are: compatibility with main structure, regulatory compliance, structural performance (if necessairy) and aesthetic qualities.

Subsequently, in the concept proposal, all these sub-concepts are combined into an overall concept. This overall concept is a theoretical proposal for one of the components to be applied as a substructure within the system.



Visualization methodology. (own work)

Realization
After establishing an overall concept, it is developed in the form of a prototype. Physical prototypes are built to evaluate the tactile qualities of the concept. This will likely be executed at a scale of 1:5 or 1:10. A scale model of the main structure will also be developed at the same scale to test the prototype within this framework. Technical findings and insights regarding material criteria are fed back to earlier steps in the research process during this stage.

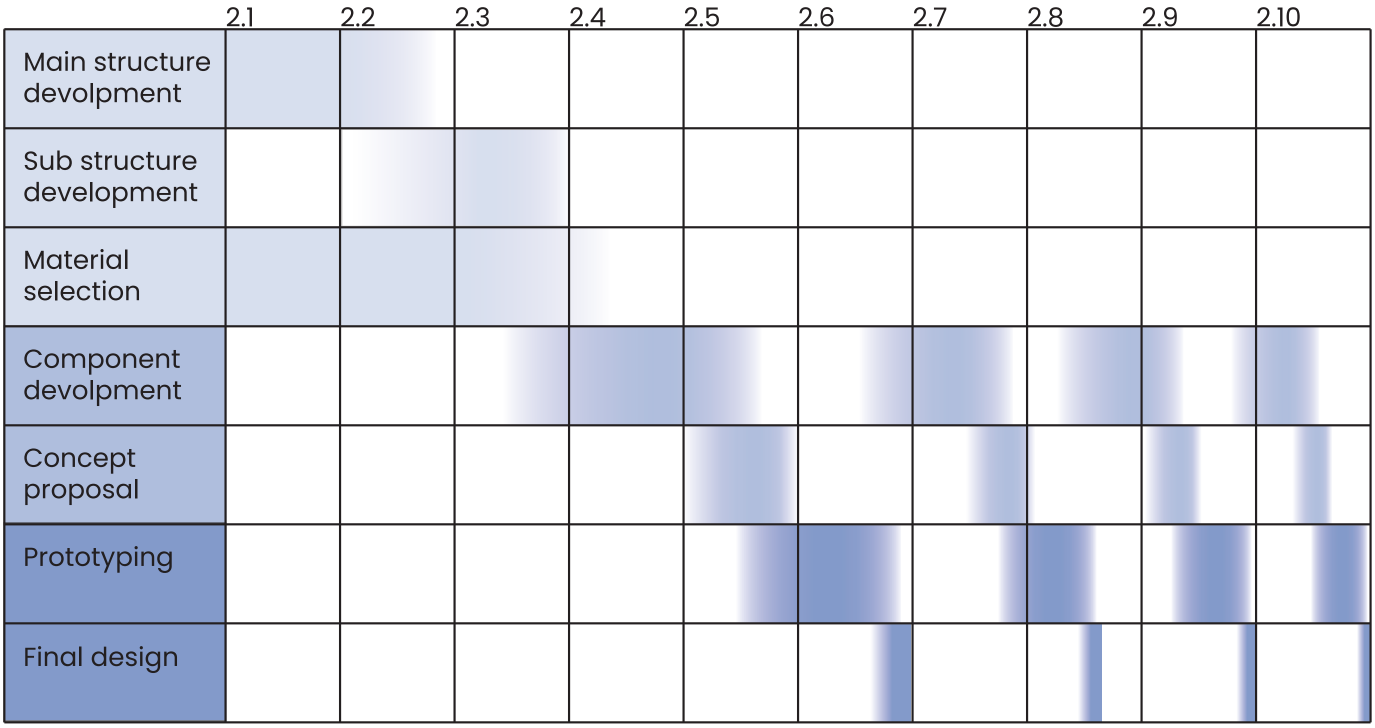
Once this phase is completed, a reflection on the final product is conducted. This reflection is incorporated into the development of both the main structure and the substructure. While this reflection is depicted here as occurring at the 'final design' stage, it may also occur earlier in the process, such as during component development, concept proposal, or prototyping. The insights gained throughout the process allow for further development of the component, and the knowledge acquired can also be applied to other components yet to be developed. The knowledge gained in each iteration of the process ensures that the process can be completed more efficiently each time.

5. Reflection on the relevance

The graduation project proposes solutions to issues related to housing shortages, land scarcity, environmental sustainability, and the need for adaptable architecture. By integrating standardized and customizable elements within a flexible building system and focusing on the transformation of existing industrial structures using bio-based materials, it aligns with goals for sustainable social, economical and ecological sustainable development.

By balancing standardization and customization, the project addresses historical issues of monotonous and inflexible housing designs that fail to meet diverse user needs (Elma, 2006). Implementing the open building concept allows residents to customize and modify their living spaces without altering the building's core structure, providing flexibility and personalization. Reusing existing structures not only preserves industrial heritage but also efficiently utilizes limited land resources, reducing the need for new construction and minimizing environmental impact. Embracing situated architecture ensures that designs respond to specific environmental, cultural, and historical contexts rather than relying solely on the aesthetics of systemic building principles. Additionally, developing remountable bio-based substructural components contributes to sustainability by using CO2 positive materials and enabling adaptability within the building system.

6. Planning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Main structure devolpment
Sub structure development
Material selection
Component devolpment
Concept proposal
Prototyping
Final design

Literature references

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