Final Report

A STRATEGY FOR INDIGENOUS WOOD IN ARCHITECTURE

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5254485
24-06-2025

Colofon

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P5 Date	24-06-2025
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Delegate	Mo Smit
	Stefano Corbo

Preface

Before I report and reflect on my entire graduation project, I have a few people to thank for their effort and support during this passt year. After this preface, I will elaborate on my process in chronological order.

Firstly, I would like to thank my tutors, Stephan Verkuijlen, Lex van Deudekom and Mo Smit, for their enduring enthusiasm for my project, even when I myself lost faith in it sometimes. They have helped me tremendously to remain structured, to apply simple solutions for many architectural problems, and to find the right people to talk to and the right reference projects to study, so that I was able continue my research and design properly.

One of these people I was introduced to is Max Salzberger from Cologne University of Applied Sciences, with whom I have had several chats about my project. His knowledge and passion for wood in architecture were inexhaustible and very valuable for both my research and design. Besides that, Max was also kind enough to assist me in finding specific materials for a model I wanted to make. I am very grateful for his involvement and his time.

Lastly I want to thank my family members for their support this past year, and especially my father, who has spent several days assisting me in the difficult process of creating two scale models of hardwood construction nodes. Without him and his tools and skills, I would not have been able to complete these models in time, if at all.

Thanks to everyone involved.

Content

P1

Introduction

In the first two weeks of the Architectural Engineering studio, we were asked to discover and define our fascination through two assignments. This quick start, although uncomfortable, did rejuvinate an idea that I have had for years: a new function for the vast amount of excess agricultural land in the Netherlands.

I combined this idea with my fascination for the wood architecture narrative. My graduation project would then be focussed on boosting the Dutch wood production chain by transforming dairy farms into production forests and complementary facilities.

A few weeks later however, I stumbled upon the inconspicuous problem of the declining resilience of already existing production forests. The wood we produce in the Netherlands originates from exotic species that are not fit for our climate. This discovery would define the rest of my project.

Eventually this led me to research the wood we find in our own local ecosystems, and how we can, or should, apply these wood types in construction. My design would be focussed on regaining the public's attention for the wood production chain, in order to avoid systematic missteps in its future.

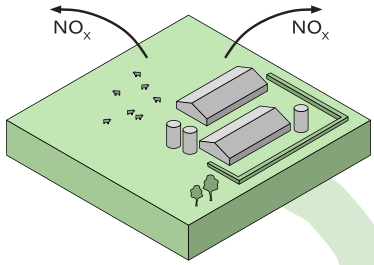
The poster on the next page was made, not knowing where my research would take me. Looking back, it was the first step towards what would become my graduation project.

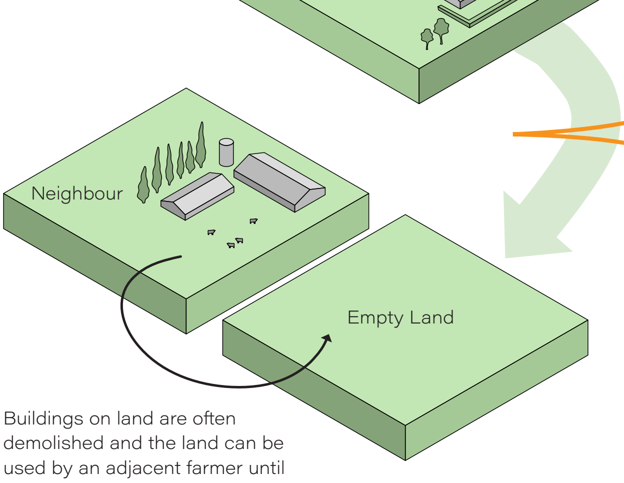
GROWING AN ALTERNATIVE

A generic strategy to repurpose bought out farmland real estate as a catalyst for a local wood production industry

OPPERTUNITY

Farmland Real Estate of Peak Polluters is voluntarily bought out by the province.





Buildings on land are often demolished and the land can be used by an adjacent farmer until a new purpose is found.

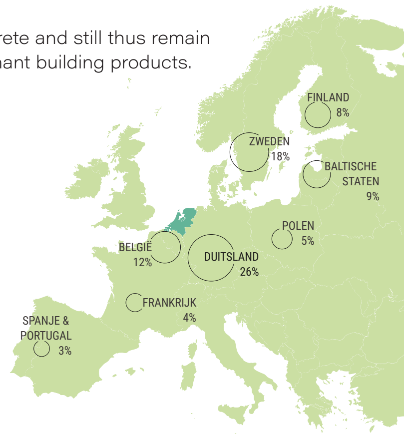
INTERVENTION

PROBLEM

Degree of self-sufficiency in material wood production in the Netherlands is only **5,8%**.

Wood construction therefore relies on import:
- from within Europe (86%)
- from outside Europe (14%)

Concrete and still thus remain dominant building products.



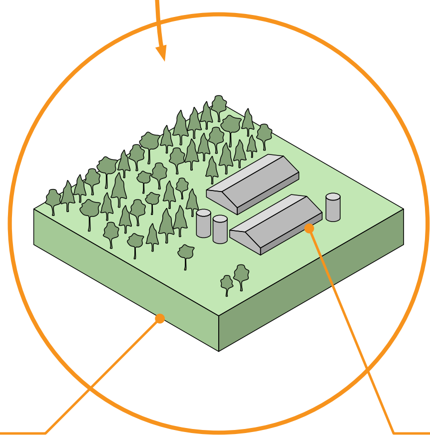
(Probos & Centrum Hout, 2023)

RESEARCH

To what extent can bought-out farmland real estate be transformed into an engineered-wood-product (EWP) industry?

Can the land be repurposed as sustainable production forests for a local FLOW of industrial wood?

Can the existing STOCK of buildings be repurposed as a factory or sawmill?



DESIGN

A generic set of principles must be found and tested with a PILOT DESIGN, converting the typical farmland real estate of a peak polluter into a typical sawmill or wood factory.

Centraal Bureau voor de Statistiek. (n.d.). *Voorraden staand hout*. Centraal Bureau Voor de Statistiek. https://www.cbs.nl/nl-nl/maatschappij/natuur-en-milieu/groene-groei/natuurlijke-hulpbronnen/voorraden-staand-hout

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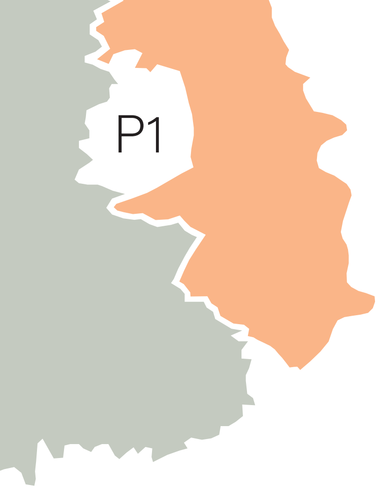


SUMMARY

Problem
The unilateral standardization of the wood value chain, resulting in:
- degrading ecology
- declining production
- low-grade application

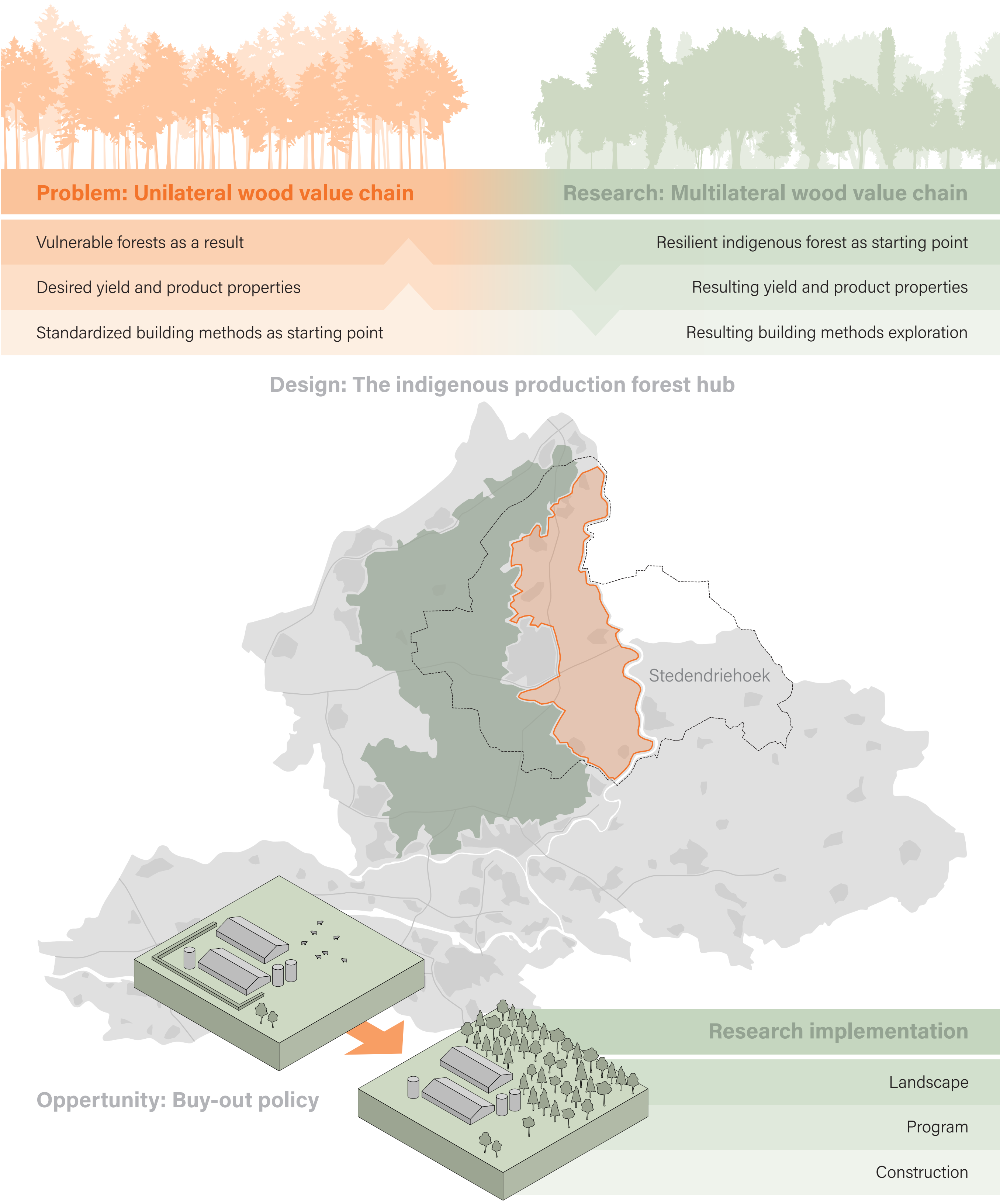
Research Questions
How can we reinvent wood construction as a multilateral practice, adapted to the properties of indigenous wood species in the Netherlands?

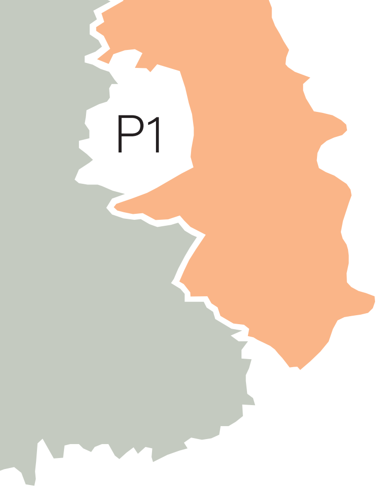
1. What would be the ideal composition of an indigenous forest in Gelderland, considering species, spatial distribution and landscape qualities?
2. What are the characteristics of such an indigenous forest in terms of yield and product properties?
3. How can these characteristics efficiently relate to tectonics, focusing on mechanical properties in relation to placement, and harvest rotation in relation to the value chain?

Oppertunity
- The voluntary buy-out policy for peak polluters
- The resulting unallocated estates
- Policy document stating desires for pilots and experiments

Design Question
How can bought-out farm real estate in Gelderland be repurposed as indigenous production forest hubs with building systems adapted to indigenous wood species?

VISUALIZATION





P1

Graduation Plan

The first concept for the research and design assignment had to be finalized in a formal document: The Graduation Plan. Of course, in a later stage of the graduation process, the questions and design assingment were further developed and finetuned.

The general idea however remained the same. I was going to design an innovation center in the midst of a production forest. This center, which in this stage I called the ‘forestry hub’ or ‘indigenous wood production hub,’ would serve as a link between the general public and the Dutch wood production chain. Proximity to the chain would in turn result in more understanding and innovation in the wood architecture narrative.

The hope is that this would contribute to destandardizing the production chain and limiting its dependence on coniferous wood species. In such a world, it is possible, perhaps even preferable, to revitalize indigenous ecosystems.

While writing this graduation plan, I was already working on the thematic research paper. This will be further discussed in the P2 section.

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
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Studio		
Name / Theme	Architectural Engineering	
Main mentor	Stephan Verkuijlen	Architecture
Second mentor	Mo Smit	Research
Argumentation of choice of the studio	I wanted the freedom to explore a subject of my own interest, within realistic and pragmatic limits and demands that I expect from a technically-oriented studio. I had no specific ideas for a graduation project at the start, but I was quite sure that I wanted to incorporate technical aspects, especially concerning materials and structures.	

Graduation project	
Title of the graduation project	A Strategy for Indigenous Wood Architecture
Goal	
Location:	Klarenbeek, Gelderland, Netherlands
The posed problem,	Wood construction reduces carbon emissions of the building sector. The current wood chain framework however impedes the aspirations to upscale wood production and shift to higher-value applications. Most Dutch wood construction is adapted to coniferous wood, provoking local forestry of exotic species. As a consequence, Dutch forests are less resilient in the face of climatic extremes and more susceptible to calamities (Van Kemenade et al., 2021). In addition to the ecological impact of poor resilience, annual reports by Oldenburger et al. (2022; 2023) and Teeuwen et al. (2024) show a declining national production, which can be attributed to drought and disease (Staatsbosbeheer, 2022). Moreover, our forests yield lower quality coniferous wood, as these species are not adapted to the climate (Fraanje, 1999). Being only 6% self-sufficient in its material wood production, the Netherlands relies on import (Probos, n.d.). Meanwhile,

	there is little attention for production of quality indigenous deciduous wood, making high-value application difficult. Approximately 80% of Dutch deciduous wood is used as firewood (Oldenburger et al., 2020). To conclude, within the existing wood chain framework, upscaling local production is undesirable and a shift to higher-value applications is unlikely. To overcome this obstacle, it is necessary to rethink the framework and to explore the potential of indigenous wood.
research questions and	To what extent is there potential to create new production forests with an alternative strategy for wood production and - application, adapted to the properties of indigenous tree species? Sub-questions: 1. What are the parameters of a desirable indigenous forest on the project location? 2. What are the appropriate management methods for such a forest? 3. What types, volumes and dimensions of wood can such a forest yield, and in what timespan? 4. How can these wood types be efficiently utilized in load-bearing constructions?
design assignment in which these result.	The goal of this project is to design a wood production hub within a new indigenous production forest. The *national termination policy of livestock farms with peak loads* is proposed as an opportunity to acquire real estate for this purpose. This wood production hub will consist of a mixed program that complement the production facilities, including recreational and educational functions. The challenge is to create a feasible, phased plan which aligns with the lifespan and material yield of the production forest. The research will contribute to this project in different ways. Firstly, it will determine the qualities of the surrounding production forest (the context). Secondly, resulting rotation periods will help to indicate phasing possibilities for the program (e.g. production facilities may only be required after a few decades, depending on when the forest be thinned or felled). Thirdly, this also helps to determine gaps in financial or temporal feasibility of the plan, resulting in an additional challenge for the design. Lastly, the research results in clear directions for materialization of the wood construction.

	This will result in a phased design for a forestry hub, aimed towards a new strategy for indigenous wood production and architecture.

Process

Method description

The ideal composition of an indigenous forest on the project location will be determined by a comparative analysis of inventories en documentations on old forests in proximity, including the *Beekbergerwoud* and the *Veluwe*. Sources include Weeda (2013; 2014), Maes & Van Loon (2011), Rövekamp & Maes (2002) as well as atlas material from (Stichting Wetenschappelijke Atlas van Nederland, 2001). This literary research will help to prototype the forest system(s), considering species and abiotic qualities.

The management methods and yield will be based on existing literature and silvicultural guides, that discuss forests that are comparable to the prototype forests from sub-question 1.

Finally the efficient application of the resulting wood types in construction will be studied. The book *Natuurlijk bouwen met hout* by Peter Fraanje (1999) will be the starting point for this query. Complementary articles on mechanical performance and archeological discoveries concerning the resulting wood types will be studied as well. Lastly, an analysis of the mechanical properties will be made, based on data from the Granta EduPack 2024 by ANSYS (2024) and the wood database of Centrum Hout (n.d.). This research will culminate in a matrix, stating efficient applications for the resulting wood types in specified elements of load-bearing constructions.

Literature and general practical preference

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Additionally, I will have personal communications with Max Salzberger about wood properties, yield, dimensions, applications and perhaps programmatic demands for production facilities. I hope this will strengthen both my research and design.

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

This graduation project relates to Architectural Engineering, because it is aimed at exploring the capacity of different wood types in load-bearing constructions of buildings. The hope is that this exploration will result in architectural expressions within this construction (e.g. different wood types in different parts of a truss construction), so that a new kind of architectural tectonics is created. The project does not necessarily relate to the rest of my master programme, other than the fact that I have often shown interest in wood construction and material efficiency. This graduation project can be considered a further advancement of those interests, which also explains the choice for my graduation studio.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

My goal is to tackle problems associated with current wood production and construction methods, such as forest depletion, monocultural plantation-style forests, loss of biodiversity, soil degradation, poor residence and low wood quality. In this project I try to explore the potential for a new strategy within the wood construction narrative, centred around indigenous deciduous wood types in the Netherlands. This will hopefully add new insights in current architectural advancements in the societal goal to battle climate chance, by lowering carbon emissions and allowing for more efficient and location-true material use.

Similar research already exists, and there are advancements and innovations aplenty in the general field of wood construction, however when it comes to deciduous wood, the practical applications and examples are relatively limited. Peter Fraanje (1999) already highlights the lack of appreciation for these wood types compared to standardized applications of coniferous species. This is why I believe that this graduation project is valuable in the scientific field, and especially in architecture.

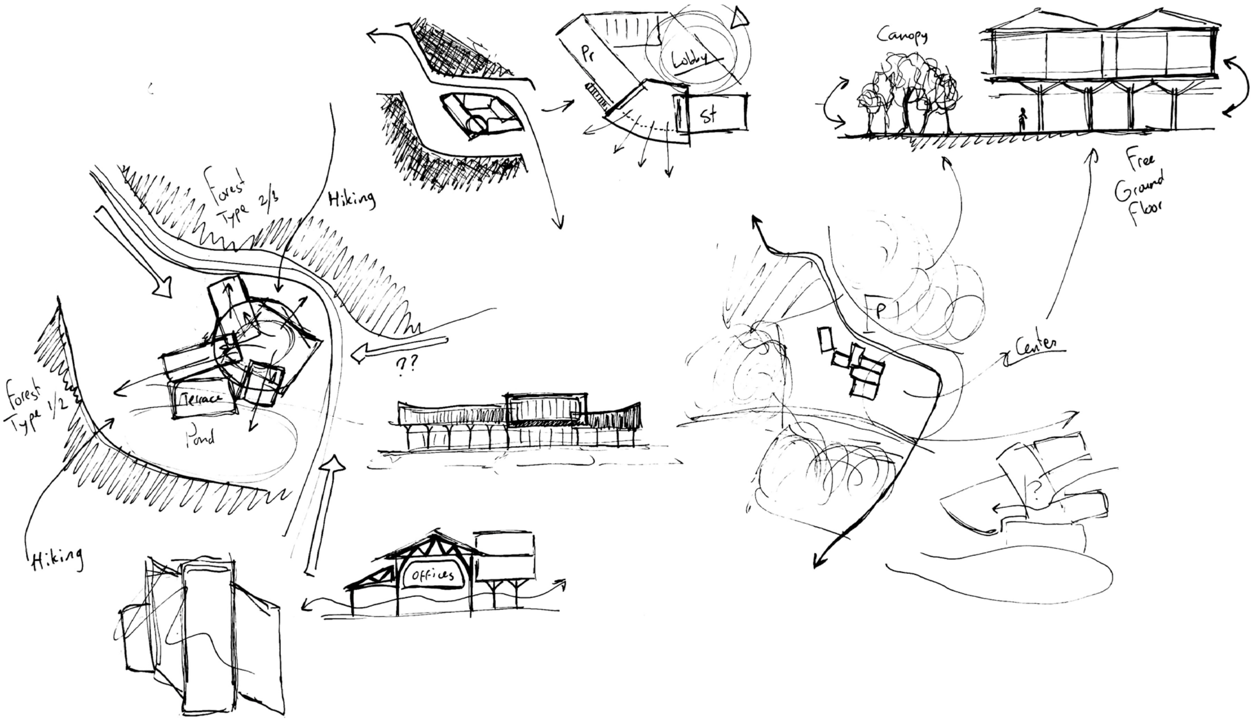
P2

Introduction

In the preparation for the P2 presentations, I was finishing my research, and starting my design phase. Up until this point, my plans were somewhat vague and conceptual. That is why my tutors challenged me to further clarify my plans by composing a program of requirements for the design. What was I going to design? And why? How would I combine such a diverse mix of functions in one building?

So far, I only used terms such as 'educational and recreational functions.' For the P2 however, I needed to define these phrases, and translate them into spaces. With these spaces I could start making conceptual floorplans and routing diagrams that would serve as a good starting point for the rest of the graduation project.

In this chapter I will present my thematic research paper, my program of requirements, and I will eleborate on some sketches, diagrams and reference projects.


Forest Type 2/3
Hiking
Forest Type 1/2
Terrace
Pond
Hiking
??
Pr
Lobby
St
Canopy
Free Ground Floor
P
Center
Offices

P2

Thematic Research

The next few pages are dedicated to my thematic research paper on indigenous wood in architecture. The paper I present here has been slightly altered after the P2 presentation, based on the feedback of my tutors.

In the next chapters I hope to illustrate how this research has helped me during the design process, especially whilst designing the load-bearing construction for my innovation center.

A STRATEGY FOR INDIGENOUS WOOD ARCHITECTURE

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ABSTRACT

The wood architecture narrative is an important link in carbon reduction of the building sector. However, upscaling wood production and shifting to high-value application is impeded by poor resilience and quality of coniferous production forests in the Netherlands. This research aims to explore the potential for indigenous deciduous wood production and application in load-bearing constructions. A pilot location was chosen, for which through a literature study, an ideal indigenous forest prototype could be theorized. Recommended management methods helped to infer the resulting yield and wood dimensions for such a forest. With technical literature and a comparative analysis of mechanical properties, the resulting wood types (Black Alder, European Ash, European Beech, Hornbeam and Summer Oak) were attributed various possible applications in construction. It was concluded that there is potential for a strategy for indigenous wood architecture.

KEYWORDS: *Timber construction, Indigenous trees, Production forestry, Deciduous wood, Architecture*

I. INTRODUCTION

1.1. Problem Statement

Wood construction is an important pathway to reduce the carbon emissions of the building sector. The unilateral standardization of the wood chain however impedes the aspirations to upscale wood production and shift more resources to high-value applications.

Most wood construction methods in the Netherlands are adapted to coniferous wood, provoking local forestry of exotic tree species such as spruce, douglas and larch. As a consequence, Dutch forests are less resilient in the face of climatic extremes and therefore more susceptible to calamities (Van Kemenade et al., 2021). In addition to the resulting ecological impact due to poor resilience, annual reports by Oldenburger et al. (2022; 2023) and Teeuwen et al. (2024) show a 35% decline in national wood production since 2016, which can partly be attributed to drought and disease (Staatsbosbeheer, 2022). Moreover, our forests tend to yield lower quality coniferous wood, as such species are not well adapted to the Dutch climate (Fraanje, 1999), which may also explain why the Netherlands is barely 6% self-sufficient in its material wood production, and relies mostly on import (Probos, n.d.). Meanwhile, there is little attention for production of quality indigenous deciduous wood, making high-value application difficult. For example, approximately 80% of locally cut deciduous wood is currently used as firewood (Oldenburger et al., 2020).

To conclude, within the existing wood production framework, upscaling local production is undesirable and a mass shift to higher-value applications is unlikely. To overcome this obstacle, it is necessary to rethink the framework and to explore the potential for indigenous wood production and - construction.

1.2. Scope

This thematic research is part of a larger graduation project. In this project, the *national termination policy of livestock farms with peak loads* is proposed as an opportunity to increase local wood production, create public recreational space and simultaneously regenerate nature. The *Stedendriehoek* region in Gelderland was chosen as a pilot location, because its policy documents (Regio Stedendriehoek, 2023) align with the scope of this graduation project and because of its proximity to vulnerable Natura-2000 reserves, where by definition most peak polluters reside. The thematic research is also limited to this location, although the methodology ought to be replicable in other locations.

The goal of this thematic research is to investigate the potential of an alternative strategy for indigenous wood production, suitable for implementation on the project location, based on an ecosystem-to-building-system approach. Firstly it is essential to know the parameters of a desirable ecosystem for the location, which will be the starting point for this approach. From this, it should be possible to infer productive qualities, such as rotation period, and product volume. This would contribute to resolving the problems associated with upscaling national wood production. Finally, the possible applications for the resulting wood products in construction will be explored, in order to illustrate the potential for a high-value indigenous wood chain. Engineered wood products (EWP) are left out of scope.

One dilemma in this project is the slower growth-rate of some indigenous tree species compared to exotic species, limiting the feasibility of an alternative wood production strategy. This obstacle will not be ignored in this paper, however the exact solution, if there is one, will be further developed in the overall design. This paper will focus mainly on the production and use of quality indigenous wood.

1.3. Research Questions

To what extent is there potential to create new production forests with an alternative strategy for wood production and - application, adapted to the properties of indigenous tree species?

This research question can be divided into four sub-questions, each representing a link in the wood chain:

1. *What are the parameters of a desirable indigenous forest on the project location?*
2. *What are the appropriate management methods for such a forest?*
3. *What types, volumes and dimensions of wood can such a forest yield, and in what timespan?*
4. *How can these wood types be efficiently utilized in load-bearing constructions?*

II. METHODS

2.1. Developing the Forest

The desired composition of an indigenous forest will be derived from a comparative analysis of field research and inventories on old indigenous forests close to the project location. The first referenced source is a review of historical documentation of plant findings in the last primeval forest of the Netherlands, the *Beekbergerwoud*, by vegetation scientist Eddy Weeda (2014). Secondly, Maes & Van Loon (2011) inventoried seed sources of indigenous species within proximity of the former *Beekbergerwoud*. Rövekamp & Maes (2002) previously did a similar inventory across the *Veluwe*. Both reports were aimed at exploring the potential for reinstating indigenous nature close to the project location, and thus provide valuable recommendations on forest recovery and - management. Lastly a map from the *Atlas van Nederland* shows the potential natural vegetation through succession (Stichting Wetenschappelijke Atlas van Nederland, 2001).

Species that were mentioned in at least three of the referenced sources are labeled as characteristic species for the desired indigenous forest prototype. If useful, these species can be felled as part of the new strategy. Species that were mentioned in only two of the sources, or deemed threatened by an attention list by Van Kemenade & Maes (2024), are included solely for ecological purposes. Herbaceous plants, grasses and mosses are mostly left out of scope for this research. The origin of all species is double-checked with an online tool by Royal Botanic Gardens Kew (n.d.).

With a list of indigenous species, it is possible to construct a forest complex suitable for the project location. The encyclopedic website of Ecopedia (n.d.a; n.d.b) and additional sources are consulted to determine the required abiotic factors and landscape qualities. This section concludes with an indigenous forest prototype as an answer to the first sub-question.

2.2. Finding Appropriate Management Methods

In this section, appropriate management methods will be selected for the prototype forest, taking into account the desired multifunctionality for the graduation project. Methods for stocking, thinning and harvesting, will be chosen based on literature by forestry experts such as Simon Klingen (2021), as well as other complementary sources and silvicultural guides.

2.3. Inferring the Yield and Dimensions

The yield and dimensions of the different wood types that result from the chosen management methods are hard to determine accurately, as they depend greatly on environmental qualities. Therefore, assumptions will be made, based on literature by Peter Fraanje (1999), data from the wood database of Centrum Hout (n.d.), and other sources. Through the theoretical mean annual volume increments (MAI) and the rotation periods of the tree species, the yield in cubic meters usable wood can be calculated. Additionally, several forestry reviews were found that give insight into the dimensions of the felled trees.

2.4. Wood Application in Construction

Peter Fraanje (1999) ends his book, *Natuurlijk bouwen met hout*, with a matrix for possible applications of 33 types of wood. Construction is mentioned as a relatively unspecified option in this matrix. The goal of this last section is to expand upon this matrix, and add more specific load-bearing construction applications for the different wood types.

To this end, the literature by Fraanje (1999) will be used alongside complementary research on wood application, archeological research, and an analysis of mechanical properties based on data derived from the Granta EduPack 2024 by ANSYS (2024) and the wood database of Centrum Hout (n.d.). Mechanical properties taken into account for this analysis are: Young's modulus, bending -, tensile -, compressive - and (parallel and perpendicular) shear strength. This analysis will indicate what loads the different wood types can or cannot resist, which in turn implies specific applications in construction. Limitations such as durability and dimensions, will also be considered.

III. RESULTS

3.1. Forest

The former 1,5 km^2 *Beekbergerwoud* is a reliable source for selecting truly indigenous vegetation for the project location, as it reached its climax ecosystem isolated from human intervention (Weeda, 2013). Weeda (2014) categorizes the collected documentation into three forest systems: Alder swamps, humid deciduous forests and dry deciduous forests on horsts. Species within these systems comply with theorized climax systems on the project location as mentioned in *Atlas van Nederland* (Stichting Wetenschappelijke Atlas van Nederland, 2001), as well as more modern inventories by Rövekamp & Maes (2002) and Maes & Van Loon (2011). By comparing these sources, a list of species could be created for an indigenous forest on the project location.

The characteristic species that have been selected for production purposes through the criteria mentioned in paragraph 2.1 are: Black Alder (Alnus glutinosa), European Ash (Fraxinus excelsior), Hornbeam (Carpinus betulus), European Beech (Fagus sylvatica) and the Summer Oak (Quercus robur). These species can be categorized with affiliated species, into three forest types, ranging from wet, light forests (Type 1) to dry, shady forests (Type 3), similar to the structure by Weeda (2014). These systems, summarized below, can also be found in the appendix (appx. A).

Type 1
Forest type 1 is characterized mostly by Alder. Due to similar growing conditions, the Ash, the indigenous Bird Cherry (Prunus padus) and the Black Currant (Ribes nigrum) are found there as well. This system is preferably situated near flowing water, on lower rich soil types (Ecopedia, n.d.a; n.d.b). Alder and Ash, both fast-growing and light-demanding species, can be felled for production (Fraanje, 1999). Black Currant can be harvested in early stages of development.

Type 2
The Ash is also found in forest type 2, in combination with the Summer Oak. This forest is mostly a gradient between forest type 1 and type 3. It also houses Bird Cherry, as well as Ivy, Honeysuckle, and the Hazel from the dryer forest type 3. Other species include Dogwood, Hawthorn, Spindle, and Guelder Rose. The soil must be humid, rich and well-draining (Ecopedia, n.d.a; n.d.b). Ash and Oak can be felled for production (Fraanje, 1999) and hazelnuts can be harvested in earlier stages of development. The European Maple (Acer pseudoplatanus) may also belong in this forest type, although due to its disputable origin (Weeda, 2014; Royal Botanic Gardens Kew, n.d.) it will not be further included in this research.

Type 3
The dry deciduous forest consists of Oak, Beech and Hornbeam. The Winter Oak (Quercus patraea) is also added to this landscape as recommended by Rövekamp & Maes (2002), although this threatened species will not serve for production. Other species include the Hazel, Ivy, Holly, Honeysuckle and Dog Rose. The forest is situated on higher, dryer grounds, as in the *Beekbergerwoud* (Weeda, 2014; Ecopedia n.d.a; n.d.b). A high density is recommended for tall and straight Beech trees (Fraanje, 1999). The Summer Oak, Beech and Hornbeam can be felled, and hazelnuts can be gathered in earlier stages.

3.2. Management

Development
Veen & Berris (1994) reviewed the approach of *Natuurmonumenten* for the recovery of two reserves on farmland, including the new *Beekbergerwoud*. Although *Natuurmonumenten* prefers spontaneous development from nearby seed-sources, they do not rule out planting when necessary. The Common Ash (Fraxinus excelsior) for example has insufficient seed-sources in proximity to the project location, and must be gathered elsewhere (Maes & Van Loon, 2011). Additionally, undesirable species or varieties may naturally spread into the forest (Veen & Berris, 1994), which can be another reason to prefer planting over spontaneous development. Other than that, *Natuurmonumenten* limits its intervention to the creation of appropriate abiotic qualities, by damming up draining ditches and removing fertilized topsoil (Veen & Berris, 1994).

Stocking
Production forests are stocked with thousands of stems per hectare and thinned until only a hundred *potential crop trees (PCTs)* remain before felling. PCTs are selected for their health, vigor and form, ensuring optimal qualities for the final harvest (Short & Radford, 2008). Ash and Alder can be initially stocked with 2500-3300 stems/ha, Oak with 2000-5000 stems/ha, and Beech around 4400-6600 stems/ha (Löf et al., 2015; Short & Radford, 2008; SWS Forestry Services, 2016). No information could be found on Hornbeam stocking (or thinning).

Thinning
Thinning limits natural losses (Tomter et al., 2016), benefits the health of the stand, ensures optimal conditions for the PTCs, promotes diameter growth, and provides periodic income (Short & Radford, 2008). Tending (removal of unfavorable trees) takes place when a stand reaches an average height of 8 meters. Thinning occurs upward from 10-15 meters (Short & Radford, 2008), or at 30-40 years old (Fraanje, 1999), depending on the species. After about 40 years and several

thinning operations, at least for Oak species, only around 500 stems/ha should remain (Löf et al., 2015). Before the final felling, 60-80 Ash (and probably Alder) and 100 Oak (and probably Beech) stems should remain. (Dobrowolska et al., 2011; Löf et al., 2015).

Cutting
Selective cutting is often deemed the most ecologically friendly method compared to clearcutting. Simon Klingen (2021) however poses that group-cutting may offer the best of both worlds, as it negates organizational complexities of selective cutting, whilst limiting the negative ecological impact of areal cutting. Additionally, this method mimics the naturally occurring landscape due to windthrow or disease. Mohren et al. (2015) analyzed different cutting methods, and drew similar conclusions. They claim that cutting groups of >0,25 hectares results in rejuvenation of more light-demanding species, whilst smaller groups result in rejuvenation of shade-demanding species. Due to its flexibility, this cutting method is chosen as an appropriate method for the indigenous production forest prototype.

3.3. Yield

Ranges for productive qualities and dimensions of the five different tree species were retrieved from several sources, and compiled into Table 1. These values will vary greatly based on growth conditions in practice.

Table 1. Rotation period, volume increment and dimensions for five wood species

Species	Rotation period	Increment	Stem height (m)	Diameter (m)
Black Alder *A. glutinosa*	40-60 [y] [1]	6,0-8,4 [m^3/ha/y] [1]	15-25 [1,6] Clear: 6-12 [1,6]	0,3-1,2 [1,6]
European Ash *F. excelsior*	60-75 [y] [1,2]	7,4-8,6 [m^3/ha/y] [1,2]	20-30 [1,2] Clear: 15-20 [1]	0,3-0,6 [5]
European Beech *F. sylvatica*	50-80 [y] [1]	5,0-5,7 [m^3/ha/y] [1,4,5]	20-30 [1,5,6] Clear: 9-15 [1,6]	0,2-0,5 [1,5,6]
Hornbeam *C. betulus*	30-80 [y] [1]	4,4-6,8 [m^3/ha/y] [5]	10-25 [1,5,6] Clear: 5-13 [1,5,6]	0,2-0,4 [1,5,6]
Summer Oak *Q. robur*	120-150 [y] [1,3]	4,0-6,3 [m^3/ha/y] [1,4]	25-30 [1,3,6] Clear: 6-8 [3]	0,6-0,7 [1,3]

Note: 1. (Fraanje, 1999) ; 2. (Dobrowolska et al., 2011) ; 3. (Löf et al., 2015) ; 4. (Baeté et al., 2002) ; 5. (Iliev et al., 2022) ; 6. (Centrum Hout, n.d.)

The *increment* in Table 1 refers to stemwood with bark, measured from ground level to the end node, excluding branches (Lerink, 2023). These numbers likely refer to the final felling volume, divided by the rotation period. Given the stem dimensions, this roughly complies with the approximate 100 PCTs after all thinning operations (Short & Radford, 2008). The Gross Annual Increment (GAI) consists of the final felling, thinning operations and natural losses. Natural losses can be kept as low as 5% of the GAI, with heavy thinning of 35% (Tomter et al., 2016). This means that the volume of the final felling, the *increment* in Table 1, is around 60% of the GAI.

With the numbers above, it is possible to estimate the yield per tree species per hectare of our forest prototypes. This yield also depends on the share that each tree species has in the total area. The formulas and an example calculation will be presented below.

$V_F = I \cdot t \cdot A_{sp}$ & $V_T = V_F \cdot 35/60$

Where V_F is the volume of final felling in [m^3], V_T is the volume of all thinning operations in [m^3], I is the annual increment in [m^3/ha/y] (see Table 1), t is the rotation period in [y] (see Table 1), and A_{sp} is the share of that species in the total area in [%]. The term *35/60* (may also be *35/55*) is derived from the share each volume has in the GAI, as stated by Tomter et al. (2016).

Example
Given forest type 2, with an assumed 50% Ash and 50% Oak under optimal growing conditions, the yields can be estimated. After 75 years, 320 m^3 (V_F = 8,6·75·0,5) Ash wood can be felled, which is approximately 60-80 logs with a diameter of 0,55-0,6 m, and a length of 17-19 m. In those 75 years, thinning resulted in another 180 m^3 (V_T = 320·35/60) Ash wood with smaller dimensions. After 150 years, 470 m^3 (V_F = 6,3·150·0,5) Oak wood can be felled, which is roughly 100 logs with a diameter of 0,7 m, and a length of 12 m. Thinning operations resulted in another 270 m^3 (V_T = 470·35/60) Oak wood with smaller dimensions. With a sustainable management cycle, this would result in an annual yield of 6,7 m^3/ha Ash wood, and 4,9 m^3/ha Oak wood. Similar calculations with other assumptions can be found in the appendix (appx. B).

A sustainable management cycle takes time to establish, as the time for rejuvenation should be considered. If harvests in forest type 2 take place every 25 years, then each harvest only 1/3 of the Ash area and only 1/6 of the Oak area can be felled to allow for the required regrowth time before the next felling. This limitation should be carefully considered in the planning of the project, as it affects the timespan for the return of investment.

3.4. Application

As mentioned in paragraph 2.4, the goal is to explore potential applications of the resulting wood types in construction. The matrix by Fraanje (1999) is taken as a starting point, and expanded upon with newer literature and a comparative analysis of mechanical properties. For this analysis, data from ANSYS (2024) and Centrum Hout (n.d.) is plotted in graphs (appx. C), together with the Eurocode strength classes retrieved from an information sheet by Centrum Hout (2017). These classes define property values based on rigorous testing and appropriate safety margins. The raw test data from ANSYS (2024) and Centrum Hout (n.d.) merely serves to compare individual properties of the wood types. They are by no means suitable as design guidelines. The findings are presented per wood type below, and compiled in a matrix in the appendix (appx. D).

Black Alder (Alnus glutinosa)
Alder wood is best suited for production of particle boards or poles and foundation piles. For millennia, it was used in mines, foundations and waterworks (Fraanje, 1999). Round and square piles up to 35 cm have been found on Roman military sites (Hänninen, 2019). In Ireland, fish-weirs were made from 40 year old Alder (Daly, 2024). Alder should be cut in winter and ventilated in storage. Its lack in strength can be compensated by making plywood (Reh et al., 2024). The wood itself is soft, has a high moisture content, and is quickly affected by fungi and insects, ruling out exterior application (Centrum Hout, n.d.). However, Alder can be watered for up to a year after felling, resulting in easier processing, increased durability and hardness, and fewer defects after drying (Fraanje, 2000). Results from the comparative analysis (appx. C) show that Alder has the worst mechanical values of the five wood types. Especially bending - and shear strength are low. Tensile - and compressive strength are comparable to Ash wood. For functions subjected to bending - and shear loads, such as for long-spanning beams or joints, Alder wood is not an ideal choice. For smaller elements in trusses, loaded in pure tension or compression and especially for zero-force members, Alder seems a fine option.

European Ash (Fraxinus excelsior)
The European Ash can be felled with large dimensions, although a short rotation period is recommended to prevent defects (Dobrowolska et al., 2011). The wood is underappreciated in construction, as its potential, especially for joists and beams, was surpassed by steel. In fact, metal

parts of tools and vehicles were previously often made from ash wood (Fraanje, 1999; Medović, 2021). It is also relatively affordable and easy to process, although it is less durable and susceptible to fluctuations in humidity and exposure to sunlight (Elkhaddar, 2024; Lignoma, n.d.). These issues depend on the drying process, the time of cutting, and may be overcome by watering the Ash first (Fraanje, 1999; 2000). The comparative analysis (appx. C) shows that the tensile - and compressive strength of Ash wood is comparable to that of Oak and Beech. Ash however excels in its elasticity, bending - and shear strength. It therefore seems ideally suited for long-spanning beams, lintels and floor joists, as well as for joints and dowels.

European Beech (Fagus sylvatica)
The comparative analysis (appx. C) shows that Beech wood performs well in all mechanical properties. It can be labeled as a universalist, although its utility is limited by low durability and high deformation (Pramreiter & Grabner, 2023). Both issues can however be avoided by steaming or watering the wood for up to a year after felling in the winter (Fraanje, 1999; 2000). It is also possible to improve the properties of the wood with high pressure and temperature (Centrum Hout, n.d.; Fraanje, 1999). It was used by the Romans in construction and shipbuilding as a lighter and more regular alternative to Oak (Medović, 2021). For good quantity and quality, Beech should be quarter-sawn or cant-sawn (Popadić, et al., 2014; Vilkovský, et al., 2023). Beech may be especially suitable for elements loaded in compression, for which a slenderness ratio of 1:50 (radius / effective length) is recommended (Koczan & Kozakiewicz, 2016).

Hornbeam (Carpinus betulus)
Before iron and steel, Hornbeam was used in parts for machinery and vehicles. It is still used as dowels and joints, however its use in construction is up for debate. (Fraanje, 1999). The analysis of mechanical properties (appx. C) shows that Hornbeam is tougher than the other wood types, especially excelling in bending, compression and tension. Moreover, it does not split or splinter easily (Centrum Hout, n.d.). Hornbeam however is claimed to be of poorer quality than Beech or Oak, due to its twisted trunk and many branches (Medović, 2021; Fraanje, 1999). Tests with representative samples resulted in mechanical performances slightly below that of Beech wood (Taj et al., 2009). Nevertheless, Hornbeam was used in the structure of a Roman theater (Medović, 2021), in traditional Romanian timber frame houses (Dutu, 2021), and as floor joists and bearers in 19th-century houses in Istanbul (Ergun & Schuller, 2021). It is concluded that Hornbeam is suitable for heavily loaded elements of small dimensions.

Summer Oak (Quercus robur)
Of the five wood types, Oak is the most common in foundations and construction. This can be attributed to its aesthetics, low number of defects and high durability, which can increase even further by watering for up to four years (Fraanje, 1999; 2000). Oak was used often in corbels and (curved) beams in floors, trusses and roof construction. Many examples exist in monumental buildings in Amsterdam. However, the wood was partly outcompeted by Pine (Van Tussenbroek, 2022). Quarter-sawing Oak wood with the Slovenian method offers the best value yield (Smajic et al., 2023). Pre-drilling is recommended, and in contact with metals, corrosion can occur. According to the comparative analysis (appx. C), Oak, just like Beech, slightly outperforms most coniferous wood types. It is universally suitable for many applications (Centrum Hout, n.d.).

IV. Conclusions

4.1. Answering the Research Questions

There appears to be great potential for an alternative strategy for wood production. Comparing historical and contemporary documentation and inventories proved to be a successful method to identify a list of indigenous species and landscape types. Additional atlas material, articles and online encyclopedias helped to describe the species combination and abiotic qualities for three forest prototypes (appx. A). It was concluded that five tree species would exist within these forests, that can be felled for production: Black Alder, European Beech, European Ash, Hornbeam and Summer Oak. Based on further research into silvicultural literature, it was possible to select appropriate management methods and to theorize the rotation period, dimensions and maximum yield for each tree, and thus for each forest prototype (see Table 1 and appx. B). The resulting numbers are slightly proud of current gross volume increment of existing forest stands in the Netherlands. An explanation is that these maximum yields (appx. B) simulate pure production forests with 100% felling. In reality, to be considered a multifunctional forest, these yields need to be reduced to 80% felling (Schelhaas et al., 2018).

Efficient theoretical construction applications were found for each resulting wood type, based on extensive technical and archeological literature and a comparative analysis of the mechanical properties (appx. C). The results were compiled in a matrix (appx. D), which can be seen as an expansion upon an already existing matrix by Peter Fraanje (1999). It can be concluded that Beech and Oak wood can be applied relatively universally. Ash and Hornbeam perform exceptionally well in joints or as elements under bending loads, although the Hornbeam will most likely not produce large dimensions. Alder wood is most suitable for foundation, waterworks and sheet material. Additionally it was suggested that Alder may be a good candidate for elements in trusses.

4.2. Discussion and Recommendations

Qualities and applications of several wood types, especially Hornbeam, were hard to determine for construction purposes. It can be concluded that there is a knowledge gap and lack of appreciation for Dutch deciduous wood in construction, which can for a great part be attributed to low durability and high warping and shrinkage. Processing methods such as watering and steaming however are claimed to significantly limit these problems (Fraanje, 1999). Watering would also reduce cracking whilst drying the wood, resulting in a higher valued yield and possibly in better characteristic mechanical properties (Fraanje, 2000; Van Benthem & Teeuwen, 2018). Thorough testing of this method is therefore recommended. Perhaps it is even desirable to include a new strength class category, similar to the category for laminated wood, for watered wood in the Eurocode.

Another aspect that can be considered when applying indigenous hardwood species in construction is the time factor. In order to be fully circular, the lifespan of the structure should ideally match or exceed the increment of the forest it came from. For example, if a structure contains 240 m^3 processed Ash wood (final felling), milled with 80% efficiency, originating from a small 5 hectare Alder swamp forest Type 3 b (appx. B), this wood should be in use for at least 27 to 32 years, (300 m^3 divided by 5 times the annual increment of 1,9-2,2 m^3/ha). During that time, the forest would theoretically be able to re-accumulate that material. If this lifespan cannot be reached, the designer ought to think about challenges such as disassembly, reuse and the possible cascading pathways of the material.

When designing a load-bearing structure with indigenous wood species, Table 1, Appendix B and Appendix D can be used as a guide. From these matrices it is possible to derive indicatory dimensions, increments and suggestions for the efficient application for the five wood species that were studied in this research.

Lastly, due to time constraints, this research was focused on one specific area within the Netherlands. Analyses of other areas will likely yield different results, based on their respective desirable indigenous forests and the qualities of the resulting wood. My hope is that, in the future, other areas will be studied in a similar way. Additionally, this research remains purely theoretical, based on existing literature and data. Due to the many variables within wood production, processing and utilization, more practical studies are required to assess the potential for large-scale implementation of this new strategy for indigenous wood architecture.

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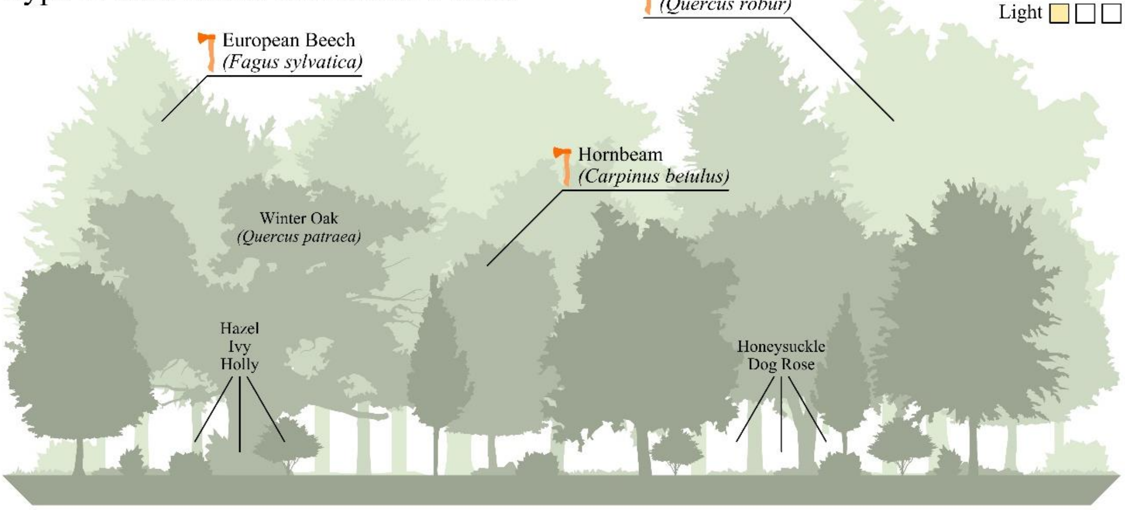
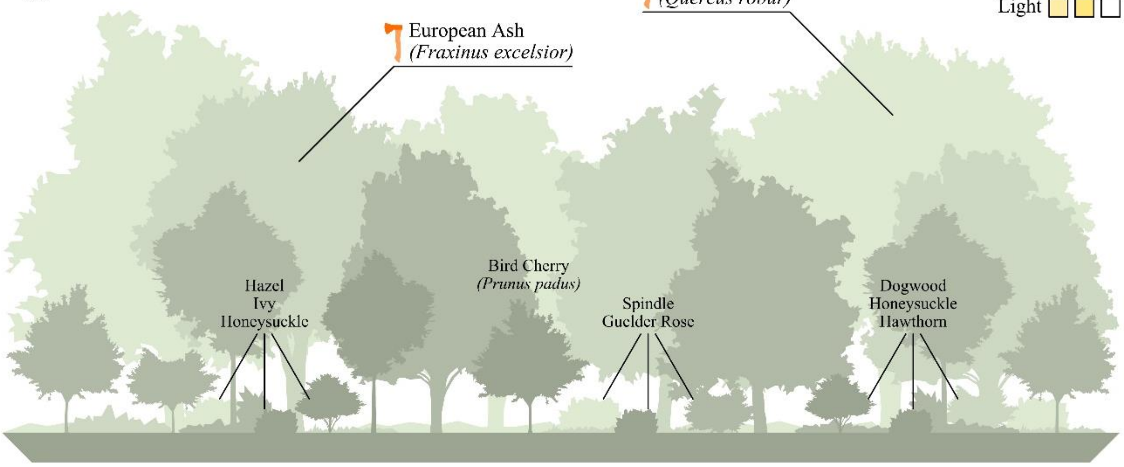
APPENDIX A

Forest Prototypes

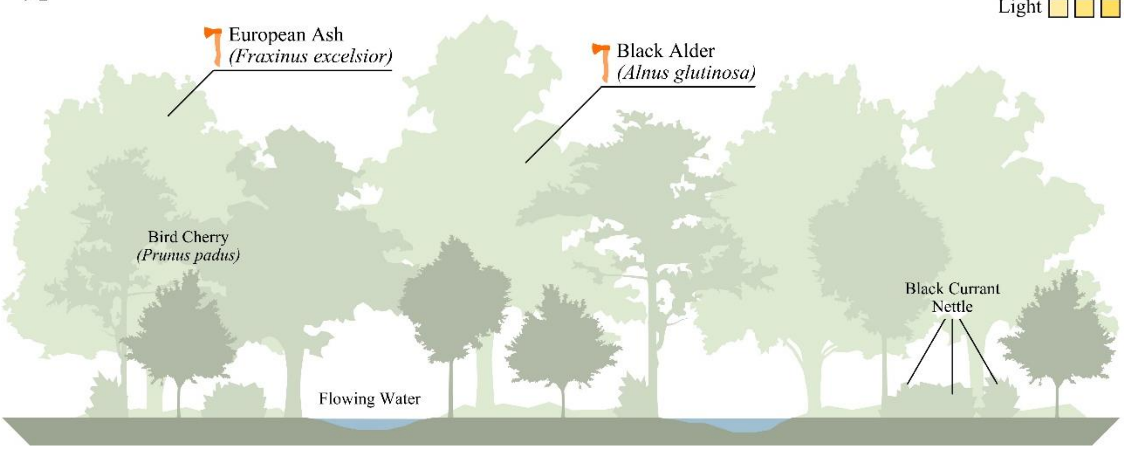
Type 1: Oak-Beech-Hornbeam Forest



Type 2: Ash-Oak Forest



Type 3: Ash-Alder Forest



APPENDIX B

Theoretical yield per forest prototype

Prototype *Share in area* *V_T/V_F = 35/60*	**Yield V_F** [m³/ha] *(at rotation period)* 60% of GAI	**Yield V_T** [m³/ha] *(at rotation period)* 35% of GAI	**Annual yield** Felling & Thinning [m³/ha]
Type 1 a: *Cb/Fs/Qr* *30/30/30%*	Cb: 106-163 *(at 80 y)* Cb: 44-68 *(at 30 y)* Fs: 120-137 *(at 80 y)* Fs: 75-86 *(at 50 y)* Qr: 180-284 *(at 150 y)* Qr: 144-227 *(at 120 y)*	Cb: 62-95 *(at 80 y)* Cb: 26-40 *(at 30 y)* Fs: 70-80 *(at 80 y)* Fs: 44-50 *(at 50 y)* Qr: 105-166 *(at 150 y)* Qr: 84-132 *(at 120 y)*	V_F Cb: 1,3-2,3 V_T Cb: 0,8-1,3 V_F Fs: 1,5-1,7 V_T Fs: 0,9-1,0 V_F Qr: 1,2-1,9 V_T Qr: 0,7-1,1
Type 1 b: *Cb/Fs/Qr* *50/25/15%*	Cb: 177-272 *(at 80 y)* Cb: 73-113 *(at 30 y)* Fs: 100-114 *(at 80 y)* Fs: 63-72 *(at 50 y)* Qr: 90-142 *(at 150 y)* Qr: 72-114 *(at 120 y)*	Cb: 103-158 *(at 80 y)* Cb: 43-67 *(at 30 y)* Fs: 58-67 *(at 80 y)* Fs: 37-42 *(at 50 y)* Qr: 53-83 *(at 150 y)* Qr: 42-66 *(at 120 y)*	V_F Cb: 2,2-3,8 V_T Cb: 1,3-2,2 V_F Fs: 1,3-1,4 V_T Fs: 0,7-0,8 V_F Qr: 0,6-1,0 V_T Qr: 0,4-0,6
Type 2 a: *Fe/Qr* *50/50%*	Fe: 278-323 *(at 75 y)* Fe: 222-258 *(at 60 y)* Qr: 300-473 *(at 150 y)* Qr: 240-378 *(at 120 y)*	Fe: 162-188 *(at 75 y)* Fe: 130-151 *(at 60 y)* Qr: 175-276 *(at 150 y)* Qr: 140-221 *(at 120 y)*	V_F Fe: 3,7-4,3 V_T Fe: 2,2-2,5 V_F Qr: 2,0-3,2 V_T Qr: 1,2-1,8
Type 2 b: *Fe/Qr* *75/25%*	Fe: 417-485 *(at 75 y)* Fe: 333-387 *(at 60 y)* Qr: 150-237 *(at 150 y)* Qr: 120-189 *(at 120 y)*	Fe: 243-282 *(at 75 y)* Fe: 195-227 *(at 60 y)* Qr: 88-138 *(at 150 y)* Qr: 70-111 *(at 120 y)*	V_F Fe: 5,6-6,5 V_T Fe: 3,2-3,8 V_F Qr: 1,0-1,6 V_T Qr: 0,6-0,9
Type 3 a: *Ag/Fe* *50/50%*	Ag: 180-252 *(at 60 y)* Ag: 120-168 *(at 40 y)* Fe: 278-323 *(at 75 y)* Fe: 222-258 *(at 60 y)*	Ag: 105-147 *(at 60 y)* Ag: 70-98 *(at 40 y)* Fe: 162-188 *(at 75 y)* Fe: 130-151 *(at 60 y)*	V_F Ag: 3,0-4,2 V_T Ag: 1,8-2,5 V_F Fe: 3,7-4,3 V_T Fe: 2,2-2,5
Type 3 b: *Ag/Fe* *75/25%*	Ag: 270-378 *(at 60 y)* Ag: 180-252 *(at 40 y)* Fe: 139-162 *(at 75 y)* Fe: 111-129 *(at 60 y)*	Ag: 158-221 *(at 60 y)* Ag: 105-147 *(at 40 y)* Fe: 81-94 *(at 75 y)* Fe: 65-76 *(at 60 y)*	V_F Ag: 4,5-6,3 V_T Ag: 2,6-3,7 V_F Fe: 1,9-2,2 V_T Fe: 1,1-1,3

Note:

Own work, based on (Baeté et al., 2002; Dobrowolska et al., 2011; Fraanje, 1999; Iliev et al., 2022; Löf et al., 2015; Tomter et al., 2016)

Ag = Black Alder ; Cb = Hornbeam ; Fe = European Ash ; Fs = European Beech ; Qr = Summer Oak.

V_F = Volume (yield) of final felling. V_T = Volume of all thinning operations up to the final felling.

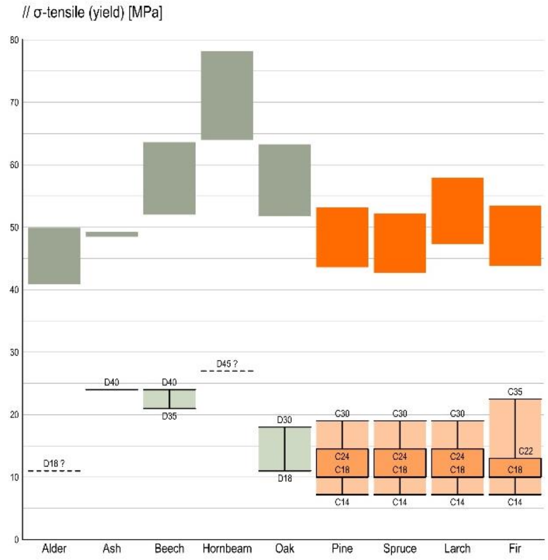
Calculations were based on the range of increments for each species as given in Table 1, thus results are presented in a range as well. The results simulate a production forest with 100% felling. In reality, to be considered a multifunctional forest, felling must be reduced to 80% (Schelhaas et al., 2018).

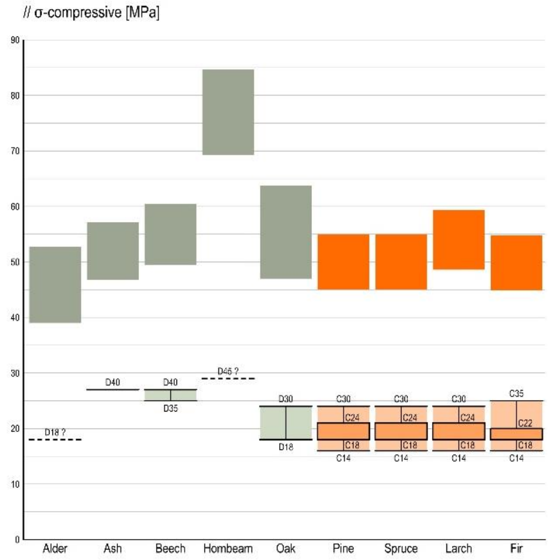
For forest type 1, 10% of the total area is reserved for the threatened Winter Oak (Q. patraea), the yield of which is not included in calculations.

APPENDIX C

Comparative analysis of mechanical properties for nine wood types

Continue on the next page…





Note:

Own work, based on (ANSYS, 2024; Centrum Hout, 2017; n.d.)

Raw test values (the higher, darker-colored values) for all properties are retrieved from Granta EduPack 2024 by ANSYS (2024) and complemented with values retrieved from the wood database of Centrum Hout (n.d.). These tests were performed under ideal circumstances with close-to-perfect wood samples. Characteristic values, such as those provided in the Eurocode, may be as low as 20-50% of the test values (ANSYS, 2024).

The Eurocode strength classes (the lower values in labeled boxplots) were retrieved from an information sheet by Centrum Hout (2017) as well as the wood database of Centrum Hout (n.d.).

Missing Eurocode strength classes for Alder and Hornbeam wood (dotted lines) were estimated by lowering the lowest mean raw test value by the same factor as the other wood types, for the worst of the six mechanical properties. These estimations should by no means be relied upon, because they did not result from rigorous research like the Eurocode (NEN-EN)

Appendix D

Application ranking matrix for five wood types in load-bearing constructions

		Black Alder	**European Ash**	**European Beech**	**Hornbeam**	**Summer Oak**
Truss construction	Top chord (rafter)	B	G	G	M (limited size)	G
	Bottom chord (tie)	M	G	G	M (limited size)	G
	Web member (strut)	M	G	G	**E**	G
	Web member (tie)	G	G	G	**E**	G
	Zero-force members	G	G	G	G	G
	Nodes, joints, pegs	B	**E**	G (as dowels)	**E**	G
Post & beam constr.	Posts & columns	B	G	G	M (limited size)	G
	Beams & purlins	B	**E**	G	M (limited size)	G
	Braces	B	G	G	M (limited size)	G
	Knee braces	B	G	G (universalist)	G	G (universalist)
Platform-frame construction	Sills or Soles	B	G (if durable)	B (moisture)	M (limited size)	**E** (durability)
	Studs (vertical)	M	G	G	M (limited size)	G
	Top plates	M	G	G	M (limited size)	G
	Headers & lintels	B	**E**	G	**E** (short span)	G
	Floor joists	B	**E**	G	**E** (short span)	G
	Rim joists	M	G	G (universalist)	M (limited size)	G (universalist)
	Sheathing	**E**	G	G	G	G
Misc.	Foundation piles	**E**	M	B (moisture)	M	G
	Foundation beams	B	M	B (moisture)	M	**E**

Note: **E** = Excellent ; G = Good ; M = Moderate ; B = Bad

The appreciations in the matrix are based on the literature as discussed in the thematic research paper (paragraph 3.4), the comparative analysis of mechanical properties (see appx. C), as well as personal communications with Max Salzberger from Cologne University of Applied Sciences (M. Saltzberger, personal communications, January 7 2025).

P2

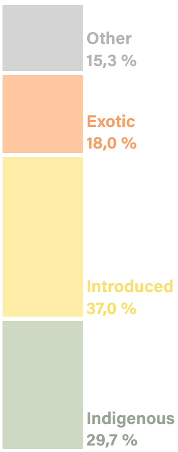
Concepts and Aim

As stated before in various other documents, the problem I want to solve with my graduation project is the declining national wood production and degrading ecology as the result of plantation-style forestry of exotic tree species in the Netherlands. To achieve this, I want to repurpose a dairy farm as a wood innovation center, and its surrounding grassland into an indigenous production forest.

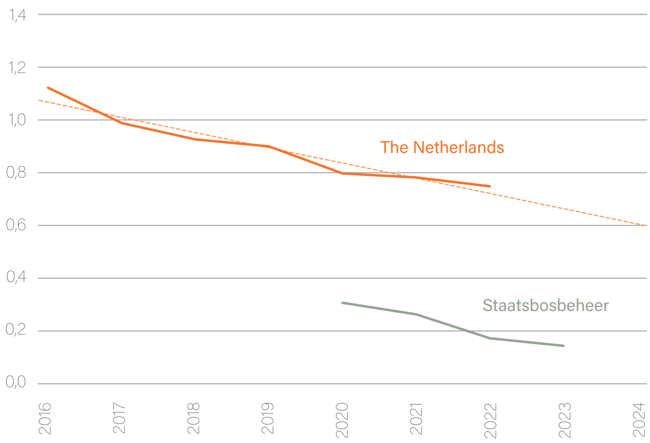
A pilot location was selected, based on the proximity of vulnerable Natura-2000 reserves and the alignement of regional policy documents with this graduation project. A dairy farm was found in the crossing of the A1 and A50 highways, in Klarenbeek, Gelderland. This farm, and the approximate 25 hectares of grassland, would become the subject for further study.

PROBLEM

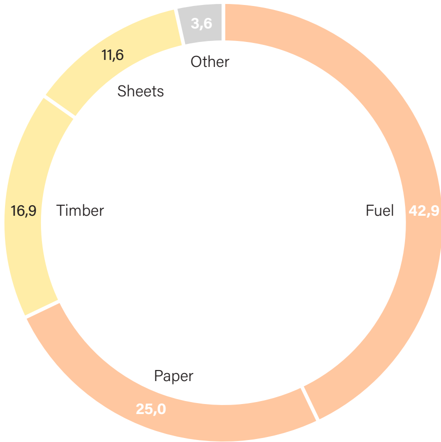
Tree origin [%]



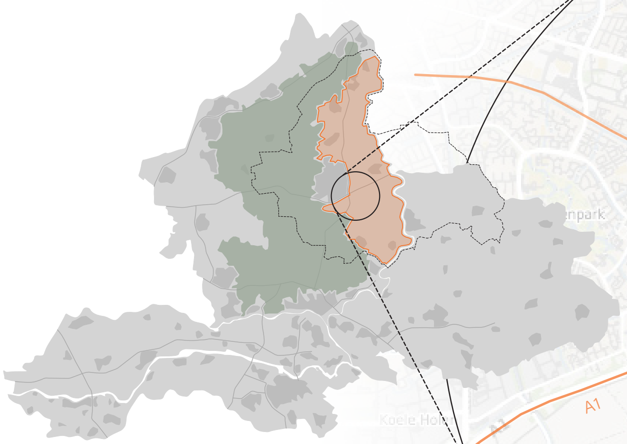
Wood production [x 1.000.000 m³]

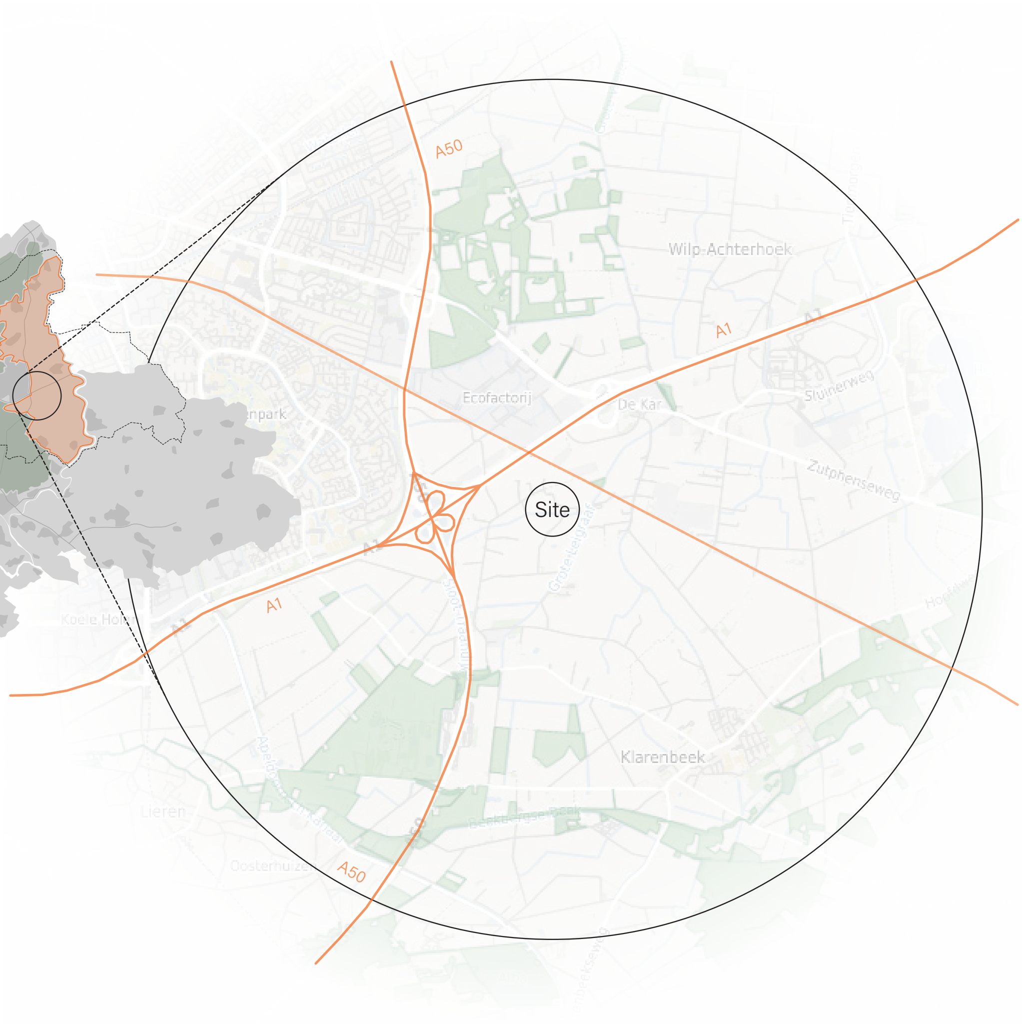


Wood application 2022 [%]



LOCATION





Location Choice

- proximity to Natura-2000 areas
- high potential for peak polluters
- alignment with regional policies

The essence of this project can be best explained by dividing the project into two distinct parts: the research and the design.

In the research I focussed on the ideal ecosystem, and the resulting indigenous wood production chain. Through a literary study, I could conclude what an ideal ecosystem should be composed of in the pilot location, as well as what wood types this system would yield. The research concluded with an application matrix for these wood types, based on historical and technical literature and data from two databases.

The vision behind this wood production - and application strategy is explained by the diagram below: to revitalize the main ecological structure of the Netherlands, by connecting century-old forest complexes with a resilient production forest, supported by a businesscase for indigenous wood in architecture.

The second part, the design, will focus on attracting the general public to the project site. As dairy farms are often located in isolated agricultural vacuums, this design goal was quite a challenge.

A solution was formulated, using the existing national recreational network as a driving force behind the urban planning. This plan was illustrated in the diagram below. Hikers and cyclists will be directed towards the site using both existing and new infrastructure.

This does however mean that the innovation center should include a small recreational program on top of the production, management and educational program. It was also concluded that, as a part of this recreational program, an exhibition space would be a suitable addition to the design.

P2

Program

The program of requirements was written with the help of two reference projects:

Firstly, the WIDC (Wood Innovation and Design Center) by Michael Green Architecture taught me that it is important to display the subject of innovation within the building. This means that I would have to use my wood application matrix to design wooden structures that play a big role in the architecture of the building. Additionally, this reference project contains offices, a lecture room and tenant spaces, as well as a restaurant; functions that I added to my own program to a certain extent.

Secondly, the Park Pavilion of 'De Hoge Veluwe', by De Zwarte Hond, emphasized the importance of anchoring the project in its context, and referencing the landscape in its architecture. In a sense, this project thereby also displays the subject of its function: recreation in the surrounding landscape. Thus, in many ways this project is quire similar to the previous reference. Besides also containing a restaurant and an exhibition space, this building is also equipped with a small shop.

The program of requirements to the right was subdivided into its various target audiences. The result is a mixed program with overlapping and flexibly used spaces and seasonal fluctuations.
This chapter will conclude with some preliminary sketches, conceptual routing diagrams and floorplans that I used to finalize my P2 presentation. The following chapters will eleborate on the continuation of the design process.

<table>
<tr><th>Function Group</th><th>Function</th><th>Area (m^2)</th><th colspan="2">Requirements & comments</th></tr>
<tr><td rowspan="6">Wood Production</td><td>Storage for machines/vehicles (mobile band saw, harvester, excavator, forwarder, skidder)</td><td>220</td><td colspan="2">Four spaces of 11,0 x 3,5 m and a free height of 4,0 m. One space for mobile band saw (20,0 x 2,5 m).</td></tr>
<tr><td>Log processing (debarking, sorting, sawing etc.)</td><td>400</td><td colspan="2">A hall of at least 40,0 x 9,0 m and a free height of 4,0 m. In use for (at least) 1 or 2 weeks each year, so flexible use of this space is desirable.</td></tr>
<tr><td>Storing and air-drying timber</td><td>180</td><td colspan="2">Enough space for at least 400 m^3 of stacked sawn timber at a maximum height of 4,0 m. Vehicles must be able to maneuver. Good (natural) ventilation required.</td></tr>
<tr><td>Steam chamber</td><td>20</td><td colspan="2">Size of a small container</td></tr>
<tr><td>Watering logs</td><td>1.200</td><td colspan="2">A body of water of 600 m^2 at a minimum depth of 0,6 m. Preferably flowing at 6 m^3/h. A paved terrace 40,0 x 15,0 m, bordering the body of water for logistics.</td></tr>
<tr><td>Sub-Total:</td><td>2.020</td><td colspan="2">(of which 1.200 m^2 is exterior)</td></tr>
<tr><td rowspan="4">Other Production</td><td>Storage for machines/vehicles (shaker and/or manual nut collectors)</td><td>40</td><td colspan="2">One space of 11,0 x 3,5 m and a free height of 4,0 m.</td></tr>
<tr><td>Nut processing (separating, washing, drying, cracking, sorting, pressing)</td><td>30</td><td colspan="2">Space for at least 3 machines of approx. 3,0 x 1,5 m. And additional kitchen area.</td></tr>
<tr><td>Nut storage</td><td>30</td><td colspan="2">Controlled climate.</td></tr>
<tr><td>Sub-Total</td><td>100</td><td colspan="2"></td></tr>
<tr><td rowspan="9">Management & Logistics</td><td>Offices for management</td><td>50</td><td>Three offices of 3,0 x 5,0 m.</td><td rowspan="4">Suitable indoor climate</td></tr>
<tr><td>Dressing room</td><td>10</td><td rowspan="4">For employees only.</td></tr>
<tr><td>Sanitary facilities</td><td>10</td></tr>
<tr><td>Cantina</td><td>40</td></tr>
<tr><td>Installations</td><td>30</td><td></td></tr>
<tr><td>Employee parking</td><td>150</td><td colspan="2">10 parking spots for authorized personnel (covered).</td></tr>
<tr><td>Loading/unloading</td><td>80</td><td colspan="2">In proximity to storages. At least 4,0 x 18,0 m (for truck).</td></tr>
<tr><td>Small storage</td><td>20</td><td colspan="2">For tools and equipment for forest management and safety.</td></tr>
<tr><td>Sub-Total:</td><td>390</td><td colspan="2">(of which 230 m^2 is exterior)</td></tr>
<tr><td rowspan="9">Recreation</td><td>Visitor center and museum</td><td>200</td><td colspan="2">Space for both permanent and temporary exposition, related to the established landscape and the resulting wood chain. Includes small reception/information point.</td></tr>
<tr><td>Lobby</td><td>50</td><td colspan="2">Visible and inspiring.</td></tr>
<tr><td>Lecture room</td><td>50</td><td colspan="2">May be situated in flexible used space.</td></tr>
<tr><td>Café-restaurant for cyclists, pedestrians and other visitors. Also acting as resting point.</td><td>200</td><td colspan="2" rowspan="3">Suitable indoor climate required.
Sanitary facilities kept apart from employee facilities.</td></tr>
<tr><td>Mini shop for local products</td><td>30</td></tr>
<tr><td>Sanitary facilities for visitors</td><td>10</td></tr>
<tr><td>Outdoor terrace</td><td>50</td><td colspan="2">In use in summer and spring, flexible use desirable.</td></tr>
<tr><td>Parking for cars and bikes</td><td>200</td><td colspan="2">10 car parking spots and 30 bike parking spots (covered).</td></tr>
<tr><td>Sub-Total:</td><td>790</td><td colspan="2">(of which 250 m^2 is exterior)</td></tr>
<tr><td rowspan="7">Education & Innovation</td><td>Lobby</td><td>50</td><td colspan="2" rowspan="3">May be situated in flexible used space.</td></tr>
<tr><td>Lecture room</td><td>100</td></tr>
<tr><td>Workshop area</td><td>100</td></tr>
<tr><td>Inspiring space for creators, innovators and partners</td><td>200</td><td colspan="2">At least four individual workshop spaces. May be situated in flexible space.</td></tr>
<tr><td>Storage for shared machinery and tools</td><td>50</td><td colspan="2">May be used by recreational and educational workshops and/or by creators and innovators.</td></tr>
<tr><td>Parking for cars and bikes</td><td>200</td><td colspan="2">Shared with recreational parking facilities.</td></tr>
<tr><td>Sub-Total:</td><td>700</td><td colspan="2">(of which 200 m^2 is exterior)</td></tr>
<tr><td colspan="2">TOTAL:</td><td>4.000</td><td colspan="2">(of which 1.880 m^2 is exterior)</td></tr>
<tr><td colspan="5">Challenges:
- The functional and spatial contrast between production functions and small recreational functions.
- The flexible use of space, both periodically and considering future adaptations and deviations.
- The spatial coherence of the project and its functions.
- The temporal implications of a forestry project.</td></tr>
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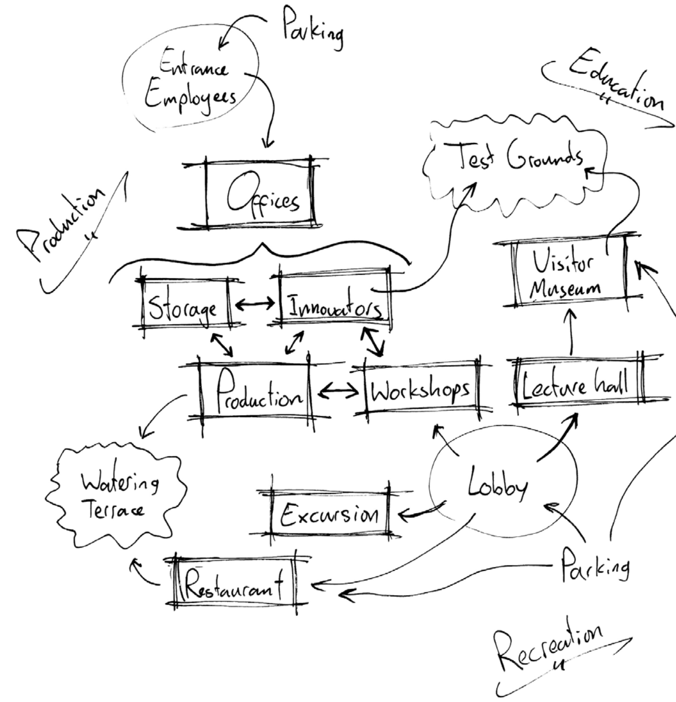
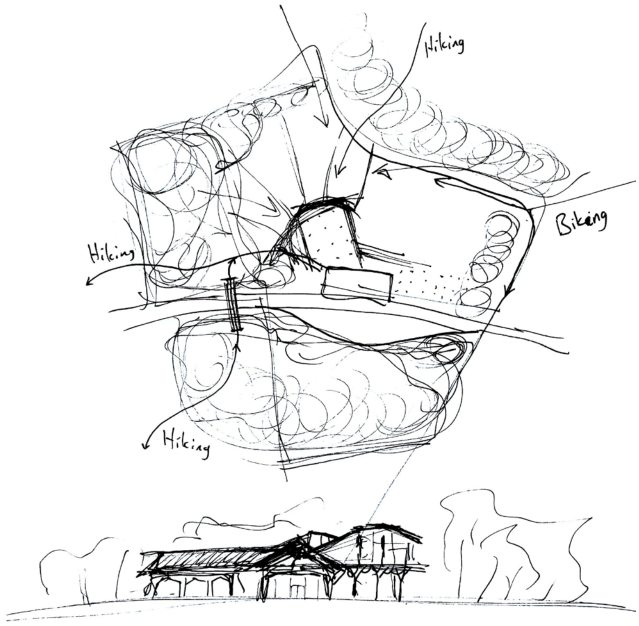
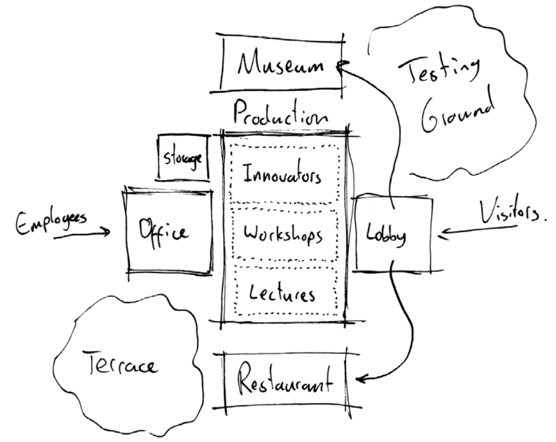
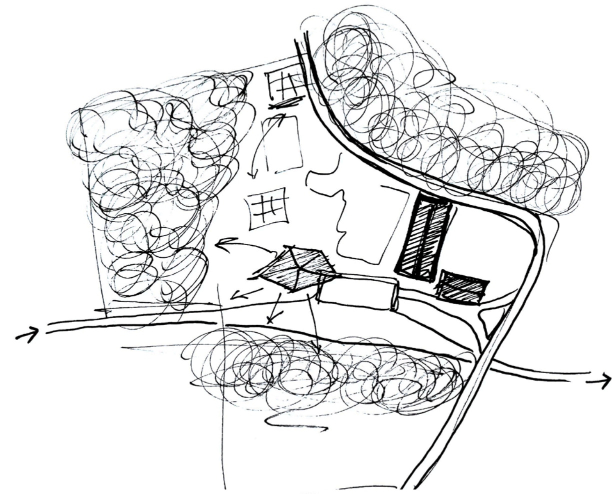
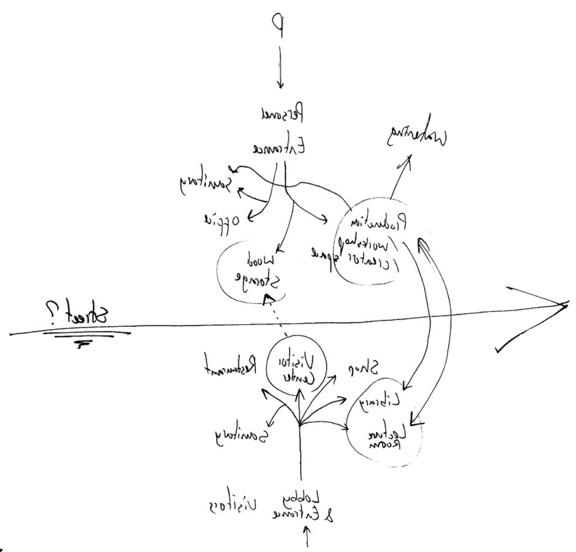
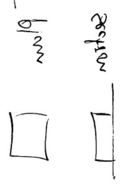

Parking
Entrance Employees
Education
Test Grounds
Production
Offices
Visitor Museum
Storage
Innovators
Production
Workshops
Lecture hall
Watering Terrace
Lobby
Excursion
Parking
Restaurant
Recreation

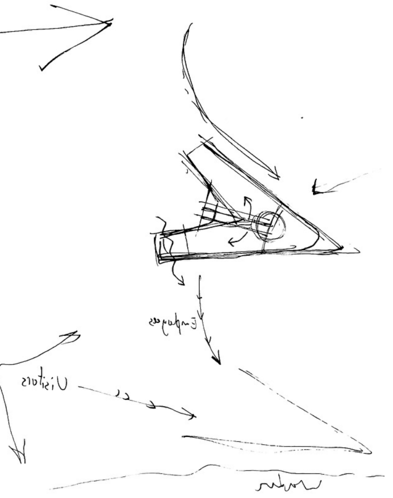

Hiking
Biking
Hiking
Hiking

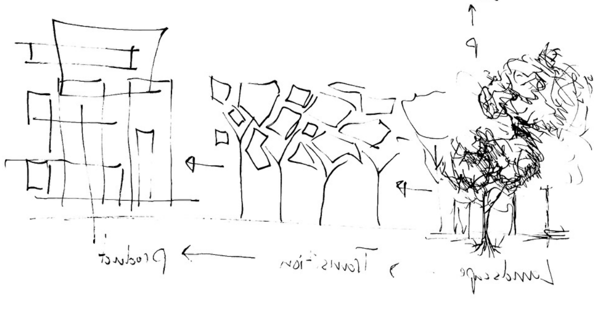

Museum
Testing Ground
Production
Storage
Innovators
Employees
Office
Workshops
Lobby
Visitors.
Lectures
Terrace
Restaurant

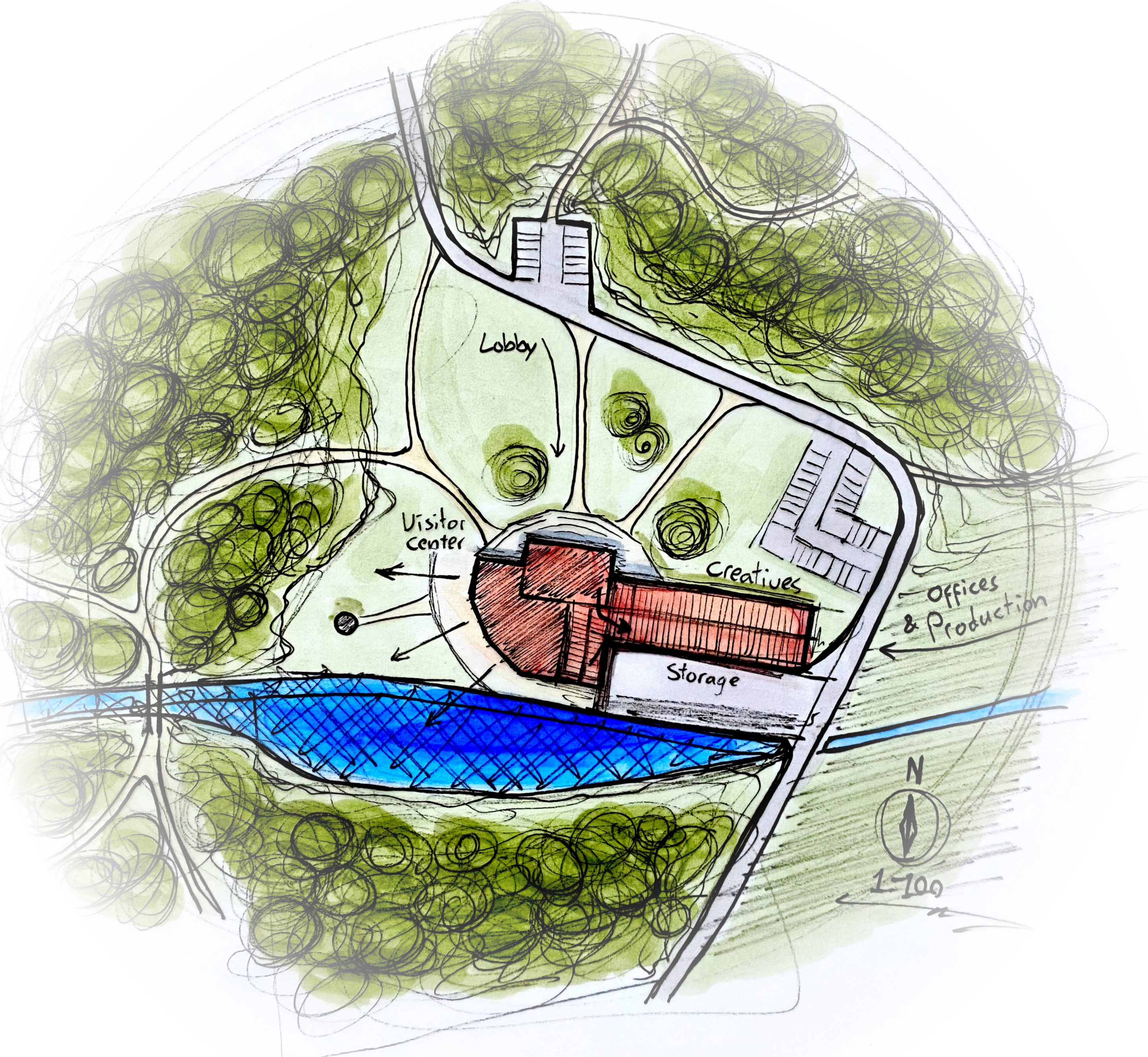


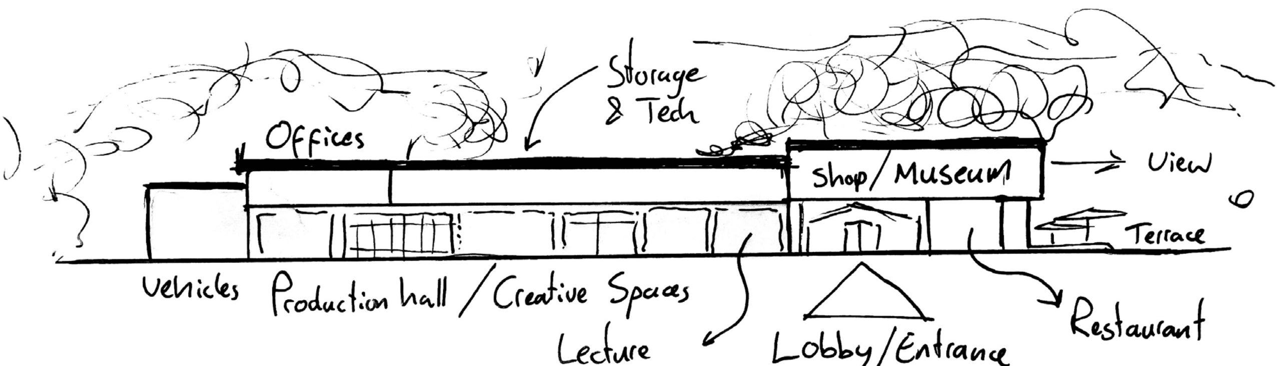









Lobby
Visitor center
Creatives
Offices & Production
Storage
N
1:100


Storage & Tech
Offices
Shop/Museum
View
Terrace
Vehicles
Production hall / Creative Spaces
Lecture Room
Lobby/Entrance
Restaurant

P3

Introduction

After the P2 presentation I was given some feedback on how to continue my design process. All my tutors in fact agreed that it would be better for the project if I worked with the existing dairy farm structures rather than building next to it. This would give me a more clear yet challenging framework during the design process.

A major piece of advice was to set up a site visit, to better understand the existing structures. Whilst there, I took a look at the surroundings to find inspiration for the project, however limited. Additionally I was told to look into the site from a historical perspective, as agricultural land often offers limited present context apart from the plot structure.

A few questions were asked regarding the architecture in relation to the landscape and the material. I had shown a financial feasibility diagram with a conceptual phasing for the project during my P2 presentation. Now it was up to me to show how this temporal perspective would influence design decisions in the project as well. I could either add a section to my research, explaining this relation, or I could eleborate on it in my design. In the end, I did both.

In this chapter I will discuss my design process up and until my preliminary design for the P3 presentation.

P3

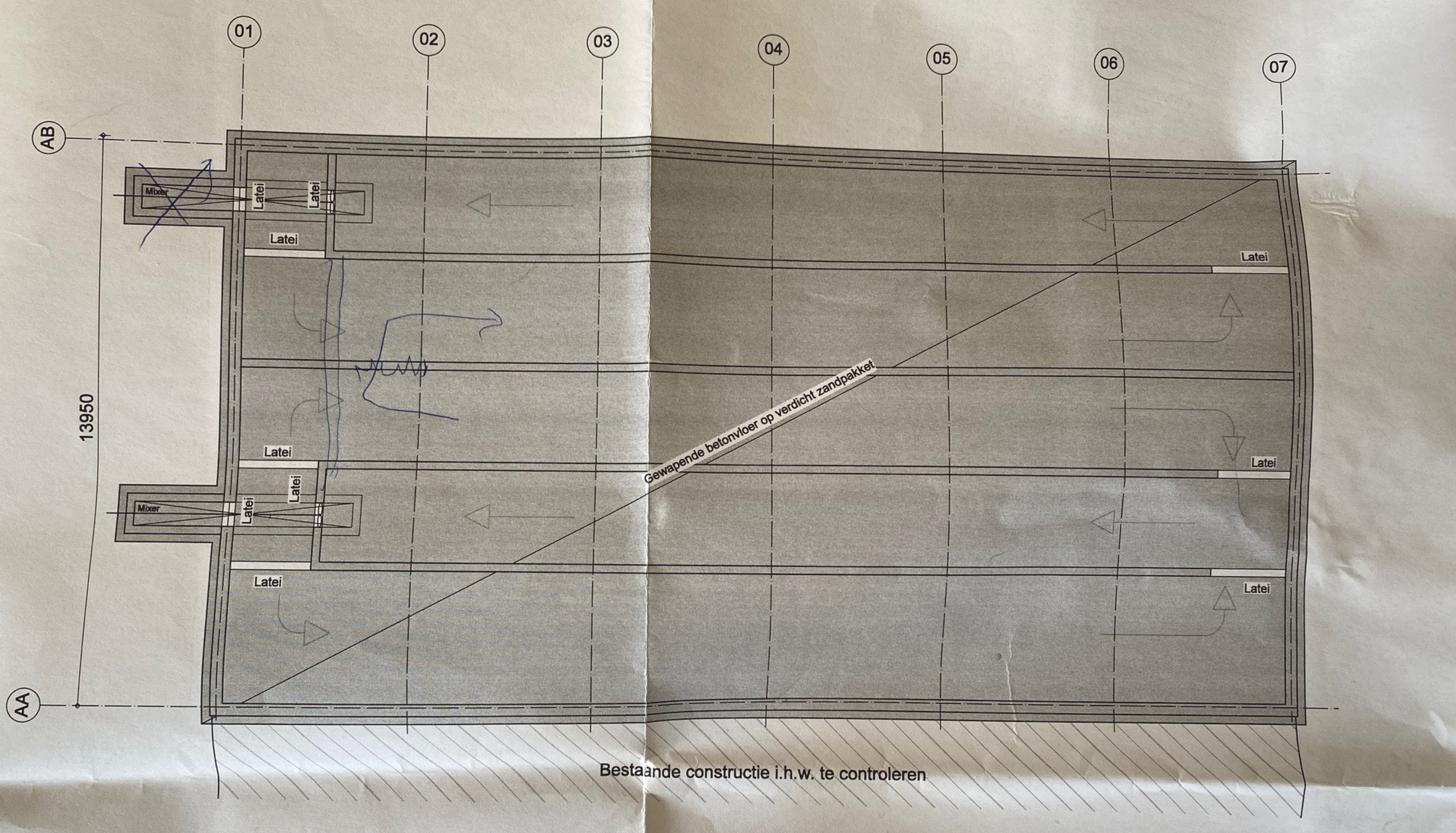
Site Visit

When reaching out to the farmer that runs the dairy farm on my pilot location, the conversation was somewhat rusty. Logically, the farmer did not perfectly understand what I was talking about. Nevertheless, it was quite easy to pick a date to come and visit. On wednesday, the fifth of March, I was welcomed by the farmer's wife, as the farmer himself was still in conversation with the veterinarian.

Once he returned, he could hardly stop talking passionately about his profession. He was happy to answer all questions that I had, also about his buildings and his land. He even was so kind to search for the technical drawings and explain the workings of manure cellars below the cow stables. It also turned out that my initial guess of the farmer owning 25 hectares grassland was correct, although he owns an additional 15 to 20 hectares elsewhere. There was nothing that this farmer wasn't willing to tell me about.

I was allowed to take as many pictures as I wanted. Thus, I noticed how the tunnel below the A1 highway, an important point of access to the location was clearly visible from the site. The scale of the site itself was also inspiring. Lastly, the farmer informed me that he extracts heat from the cooling process of milk, to heat his own house. This inspired me to work on a similar approach for my design: extracting waste heat from my own wood production process.

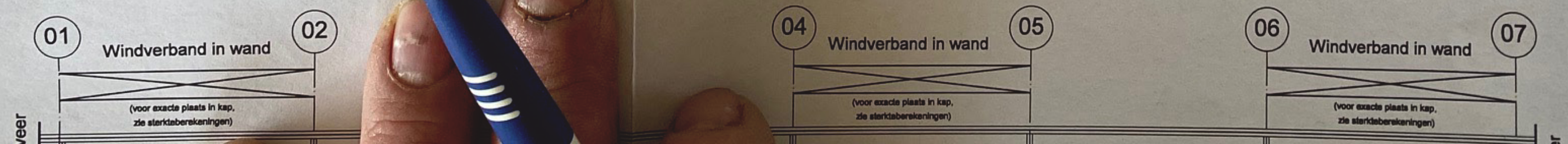
All in all, this was a succesful site visit, well worth the 2 hour drive.



Kelder

Definitieve posities en afmetingen mixputten …t.b. i.o.m. opdrachtgever

Voorzieningen t.b.v. ondersteuning bestaande …structie tijdens het aanbrengen van de kelder en staalconstructie te bepalen e… …form opga… …ructeur!

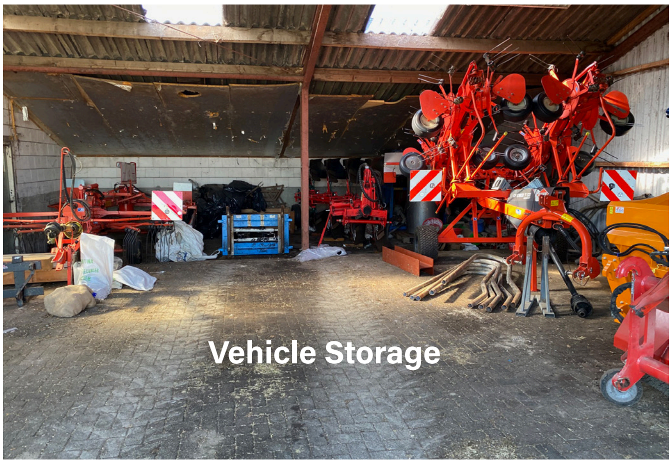



Heat Extraction


Grid Floors


Mix Pit


Milking


Vehicle Storage


Voorgevel (noordgevel)
Rechter- zijgevel (westgevel)
Linker- zijgevel (oostgevel)
Doorsnede A-A
Brandcompartimentering
BC2:1278 m2
BC1:398 m2
Gebruiksfuncties
Plattegrond
Kelder
Vorm spant as 01
Vorm spant as 02 t/m 06
Detail 3
Detail 2
Detail 1


Tunnel

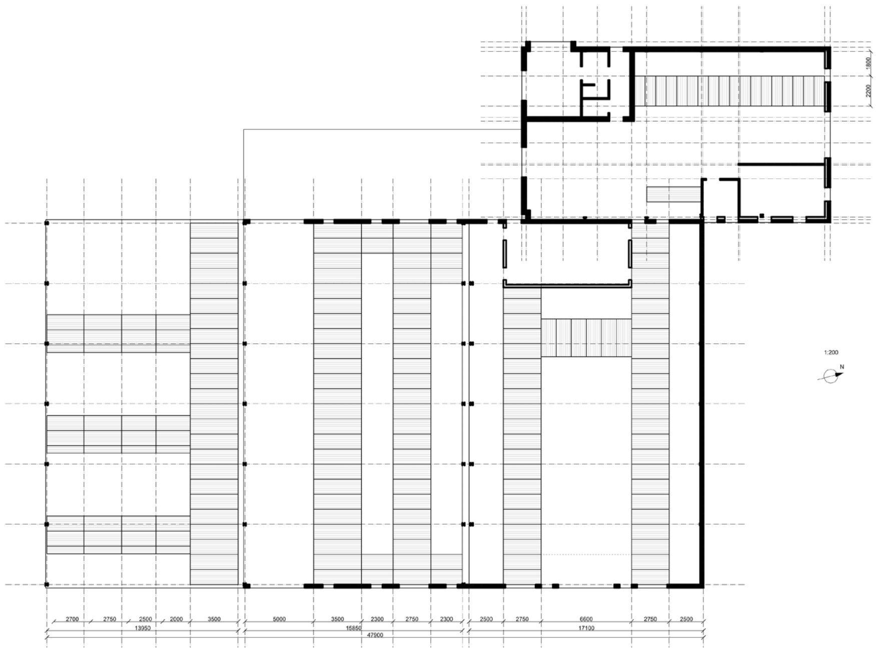
P3

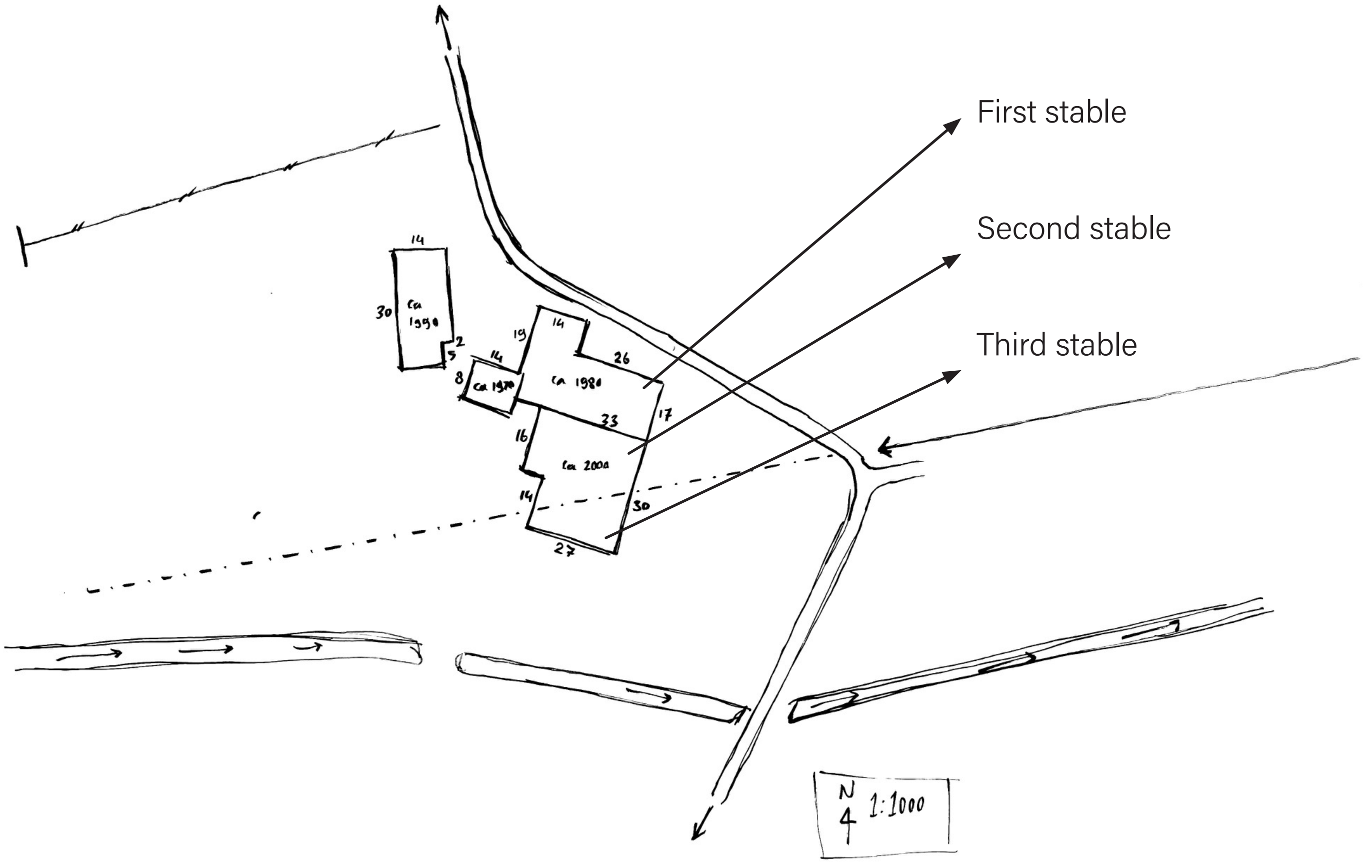
Design Process

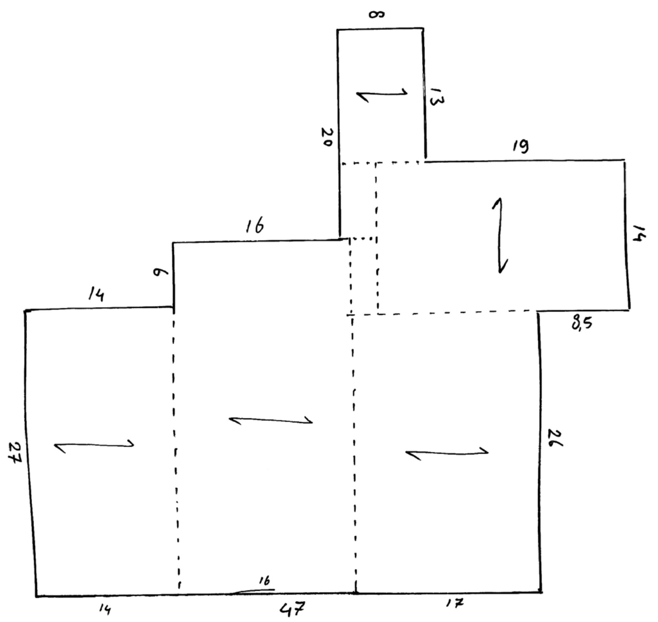
Understanding the existing situation:

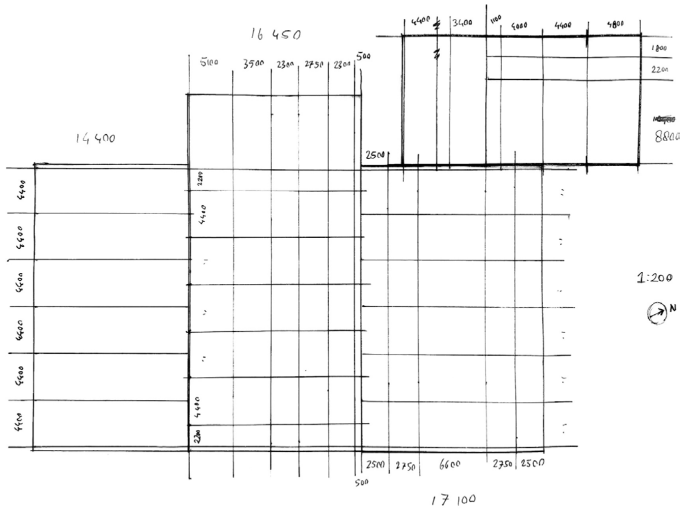
The first weeks after the p2 presentation I worked on my understanding of the site and the buildings. Through archival materials that I requested, I was able to get a good sense of the building's dimensions and structure. The most southern stable and the western extension however were not present in this archive. On my site visit, the farmer was able to fill those gaps for me.

It turned out that manure cellars ran everywhere beneath the third stable. They were organized differently as well, as opposed to the information in the archival materials. The same goes for the grid structure. The archive suggested an offset in the load-bearing elements between the second stable, and the first and third stable, probably to allow for the construction of a new foundation. In practice however, the structure of all three stables was aligned. The drawing below was the final conclusion for the existing situation.




First stable
Second stable
Third stable
ca 1950
ca 1970
ca 1980
ca 2000
N
1:1000



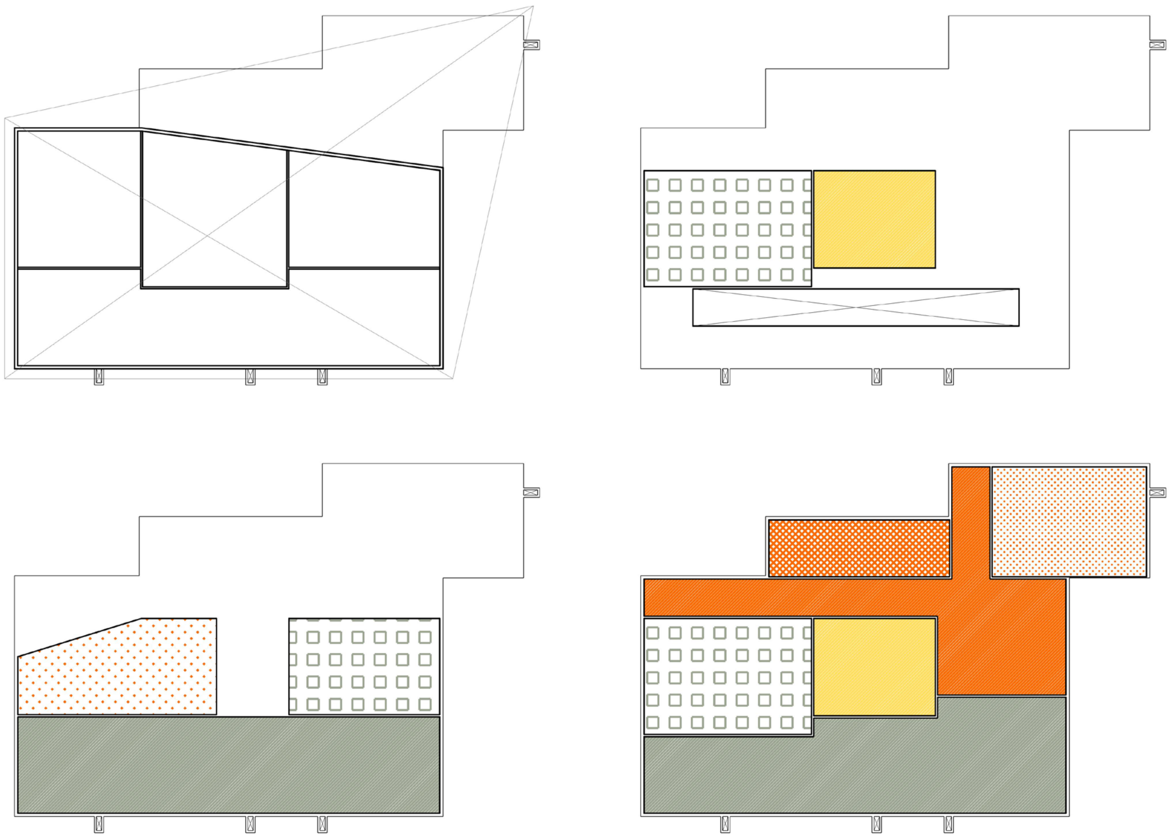

16 450
14 400
17 100
1:200
N

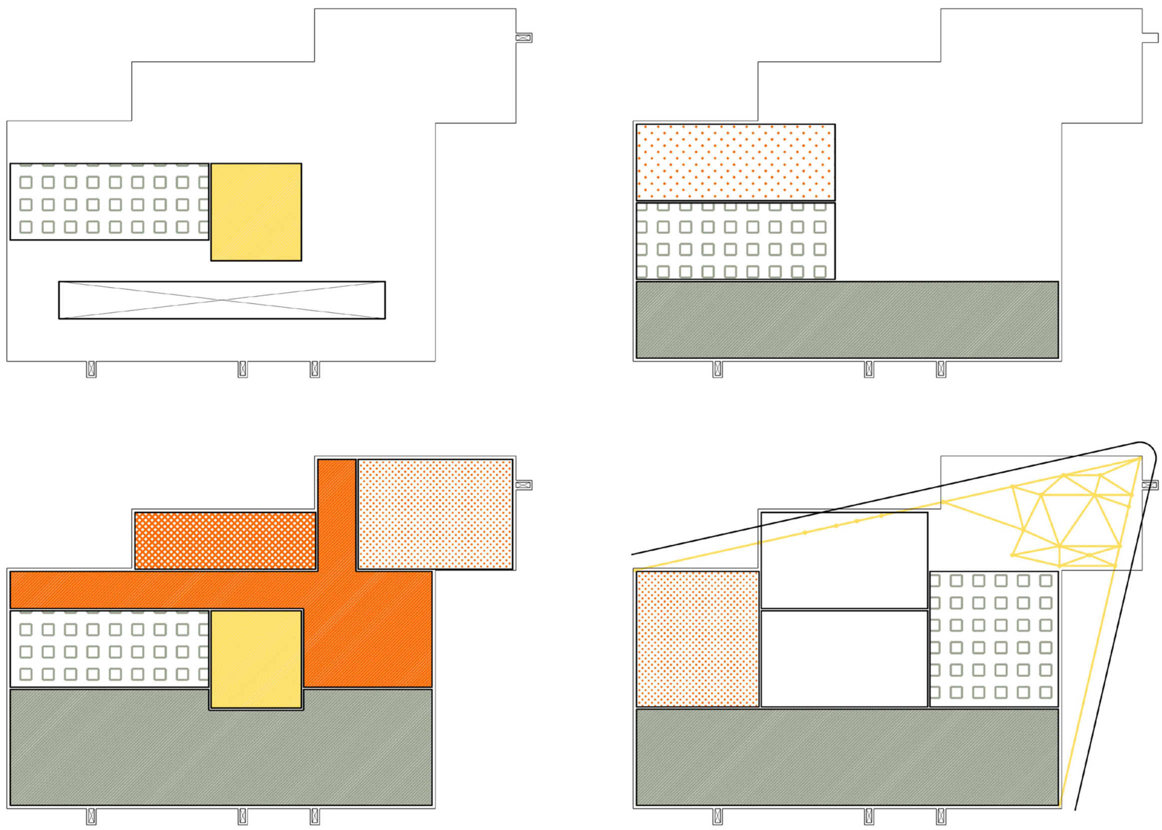
Organizing the program:

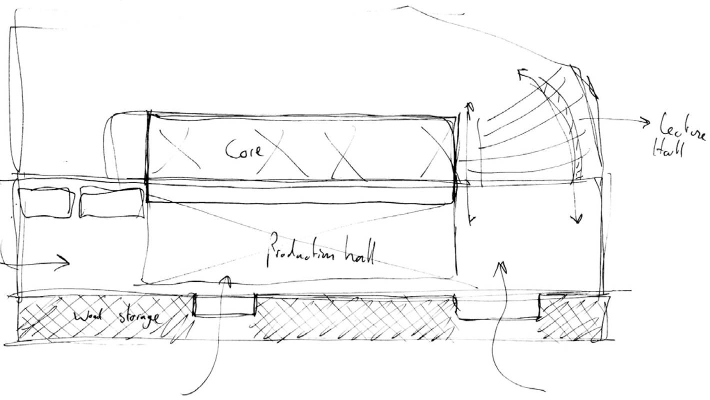
The most time, by far, was spent on organizing the program on top of the existing foundation. Some functions, such as the production hall (green rectengular surface on the right), were easily situated with clear argumentation for daylight, space and logistics. Others, such as the restaurant, lobby, and other recreational or educational functions, were harder to process.

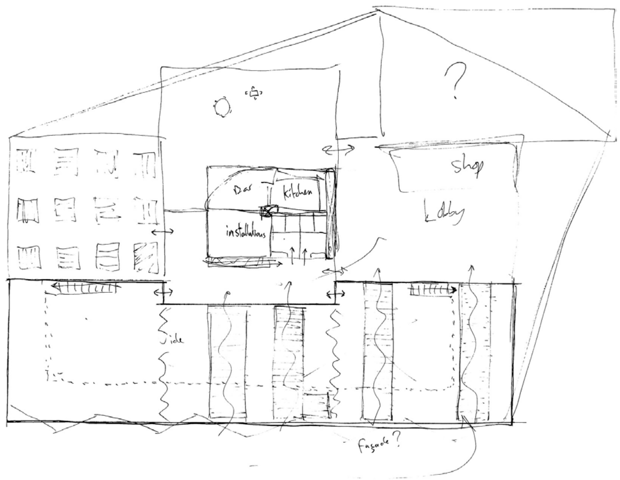
Some choices eventually led to a working floorplan. Firstly, the decision was made to not air-dry the timber on the interior, but rather on the exterior, as a part of the eastern facade. This opened up more space on the interior of the building, though it meant that I had to design for a cantelever to shade the timber. Secondly, I discovered a historical pathway which would mark the central points of access to the site, and to the building. A circular walkway would define the entrance of the building, and thus create a more logical routing structure throughout the design. Lastly, I decided to structure the floorplan more rigorously, after studying the uncompromising design approach in reference projects by Herzog & de Meuron.

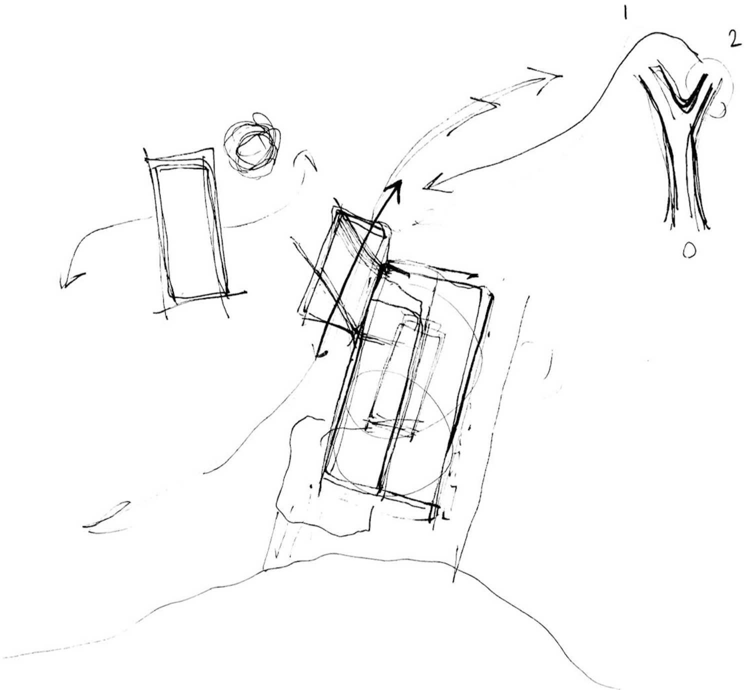
On the next few pages, you will see sketches with which I attempted to find a balance in a functional program as well as the massing, the elevations, and the accessibility. I was unable to complete this process before the P3 presentation, leading me to present a completely rectangular design with a flat roof. I will eleborate on that presentation in the section on the P3 preliminary design.

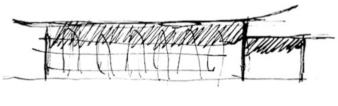


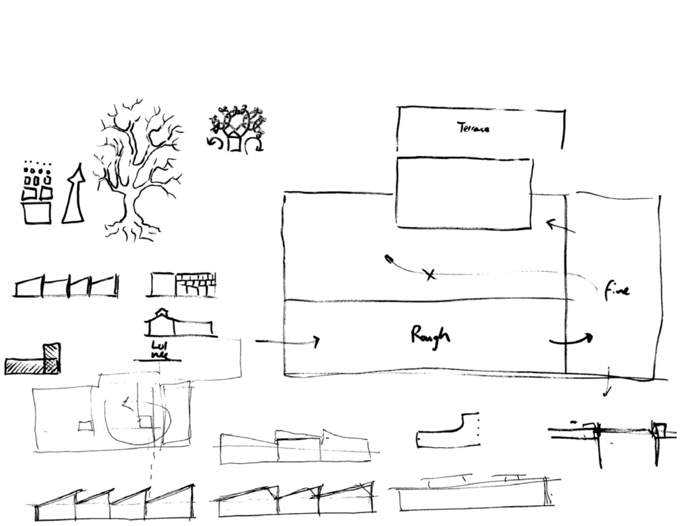


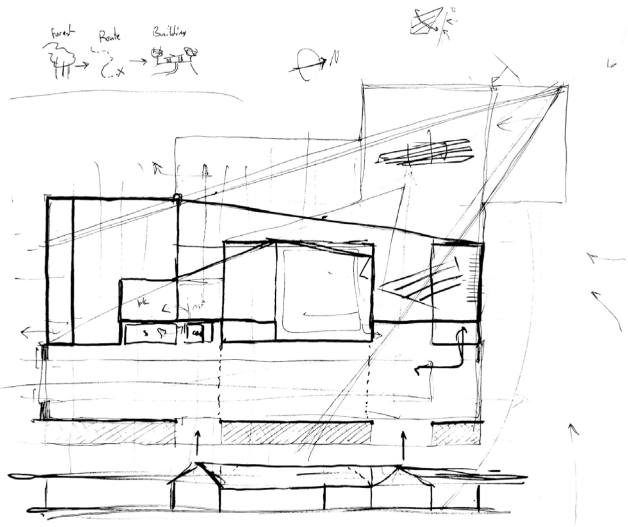

Core
Production hall
Lecture Hall
storage


?
kitchen
installations
shop
Lobby
Façade?

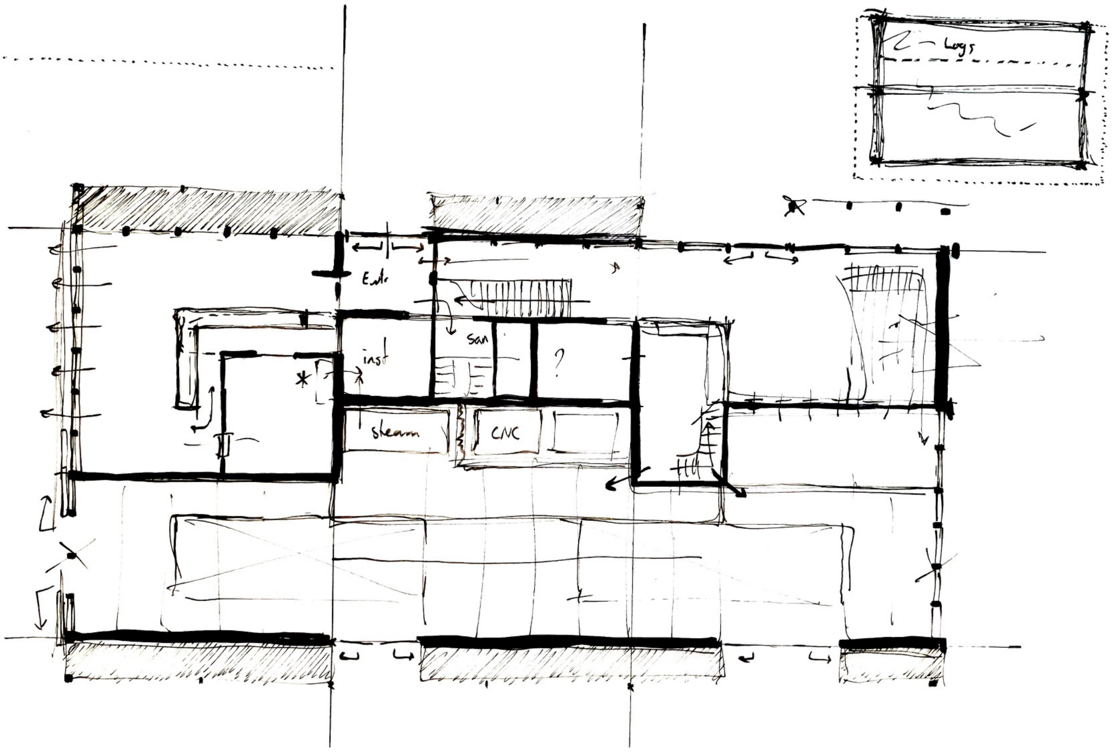

1
2
0

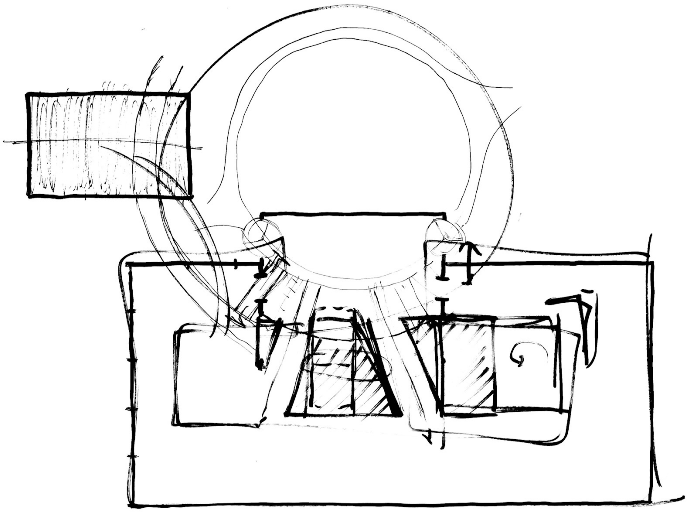


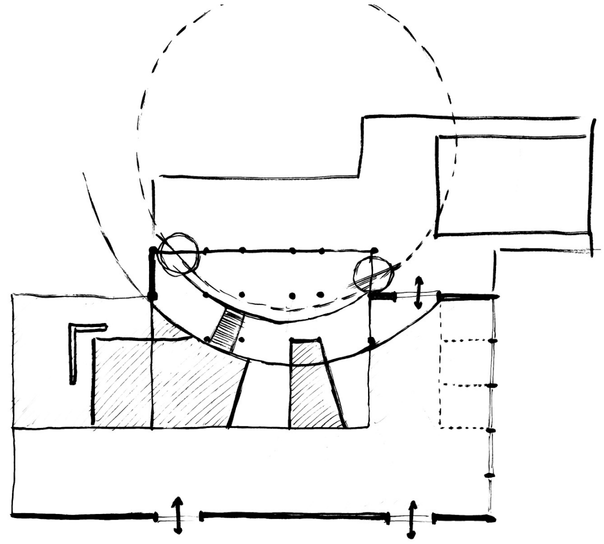




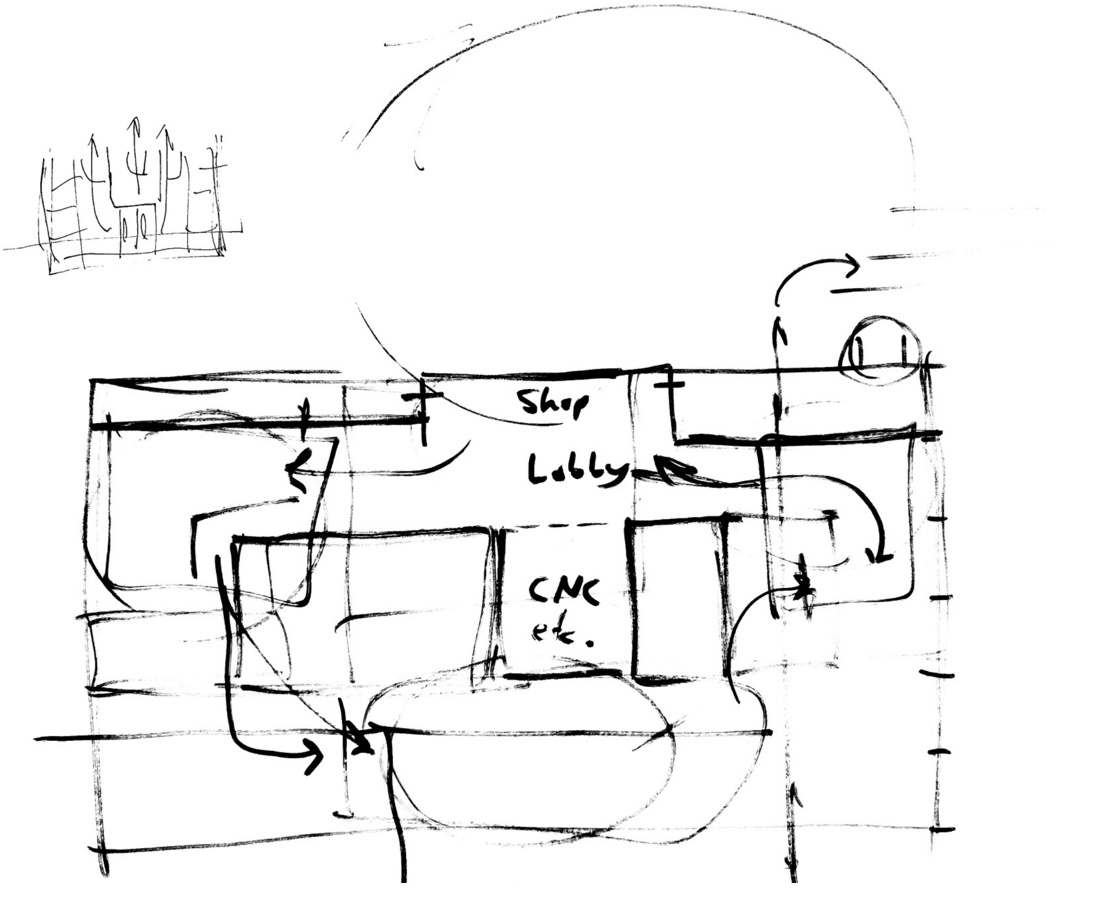
1:200

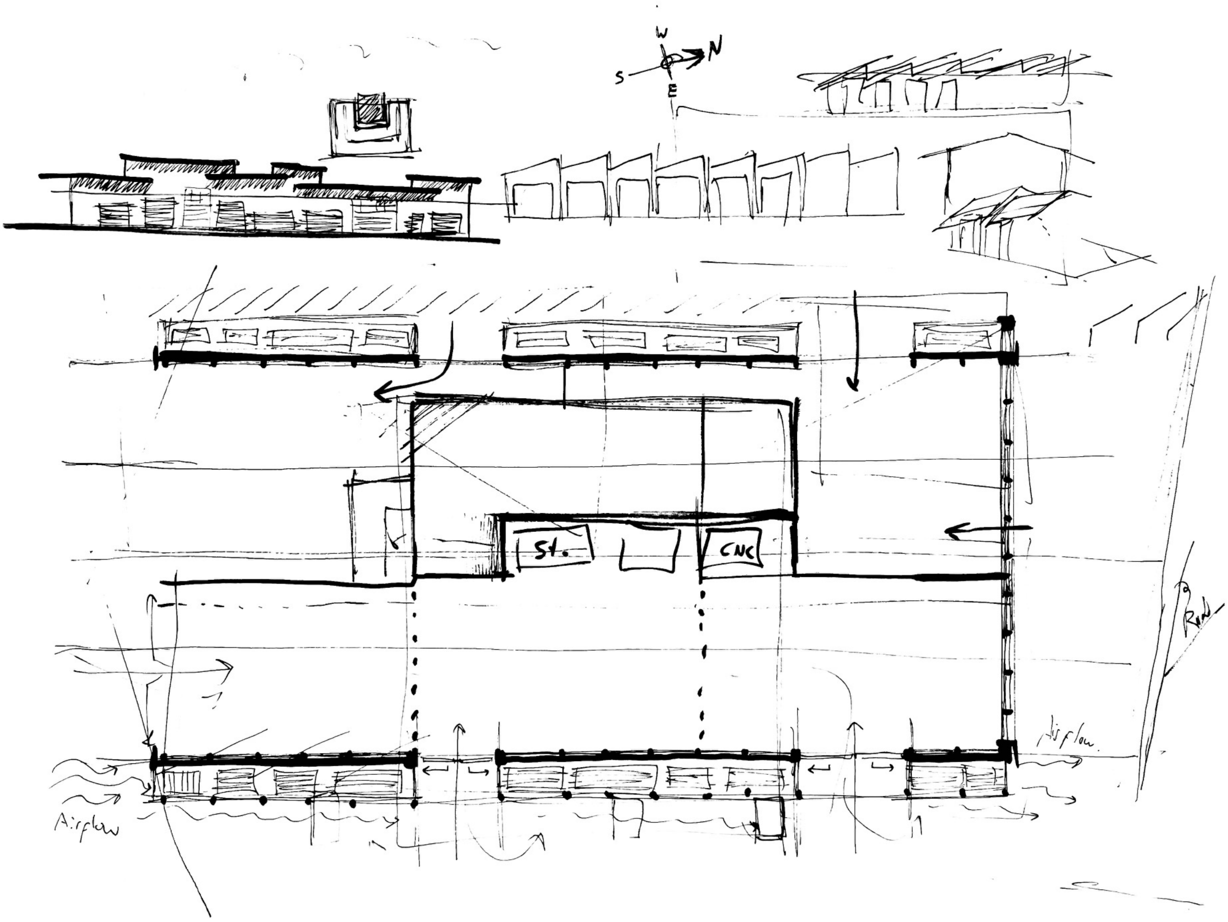




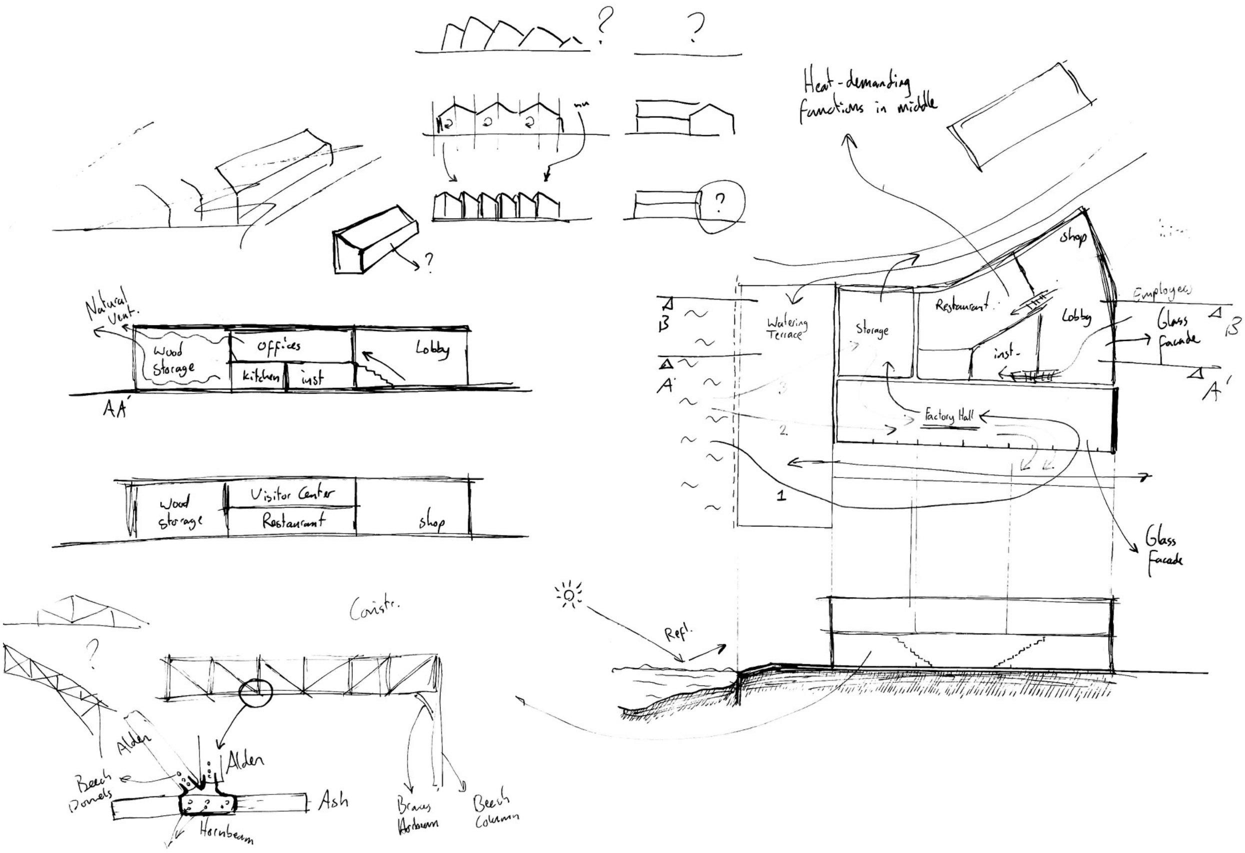


Door mestkelders veel vrijheid in ↕ richting.
Daardoor h.o.h. wel vastgelegd (beperkt).
Dat werkt goed samen met variabele vakwerkconstructies.

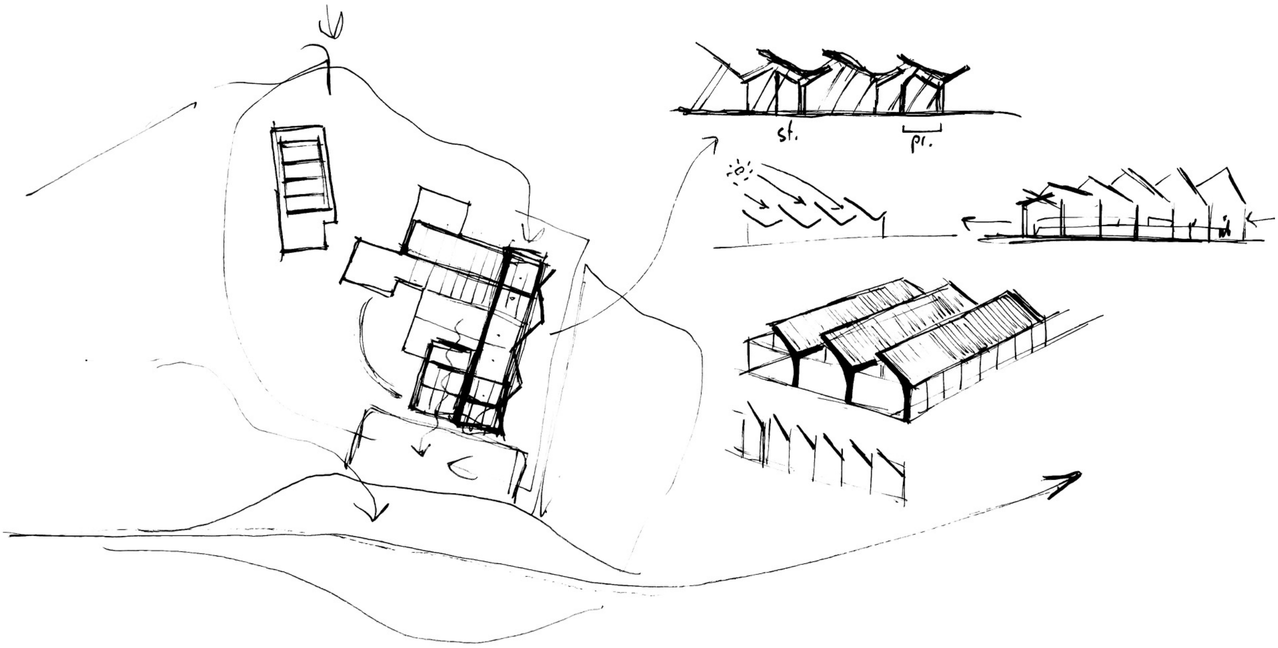




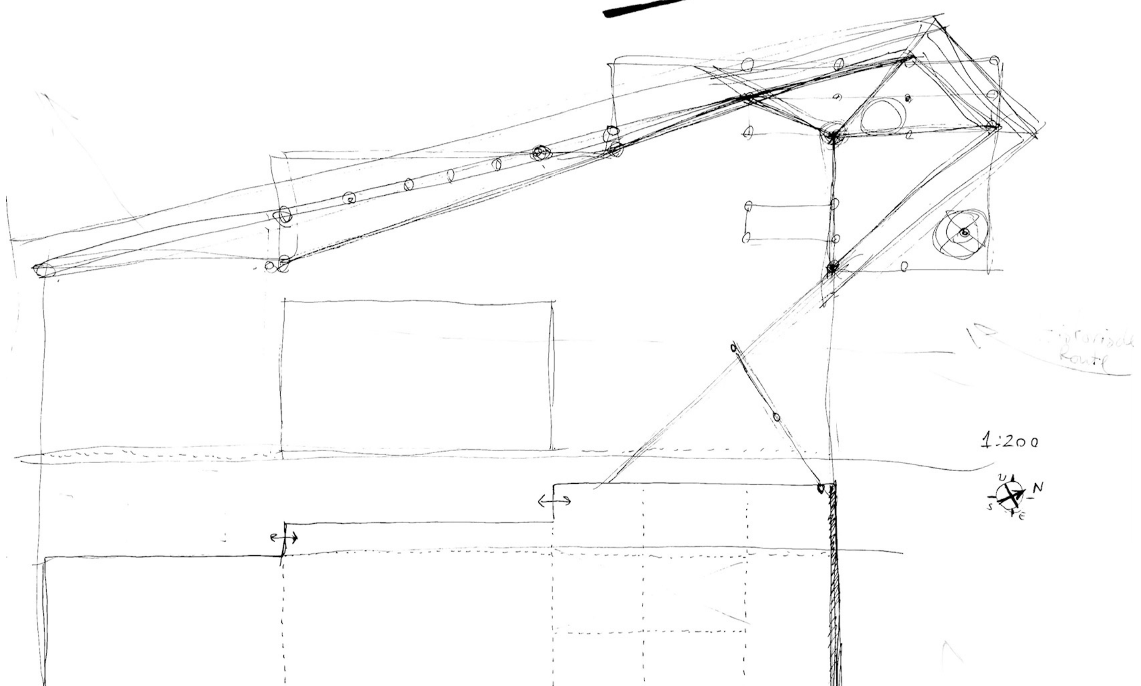
W
S
N
E
St.
CNC
Road
Airflow
Airflow

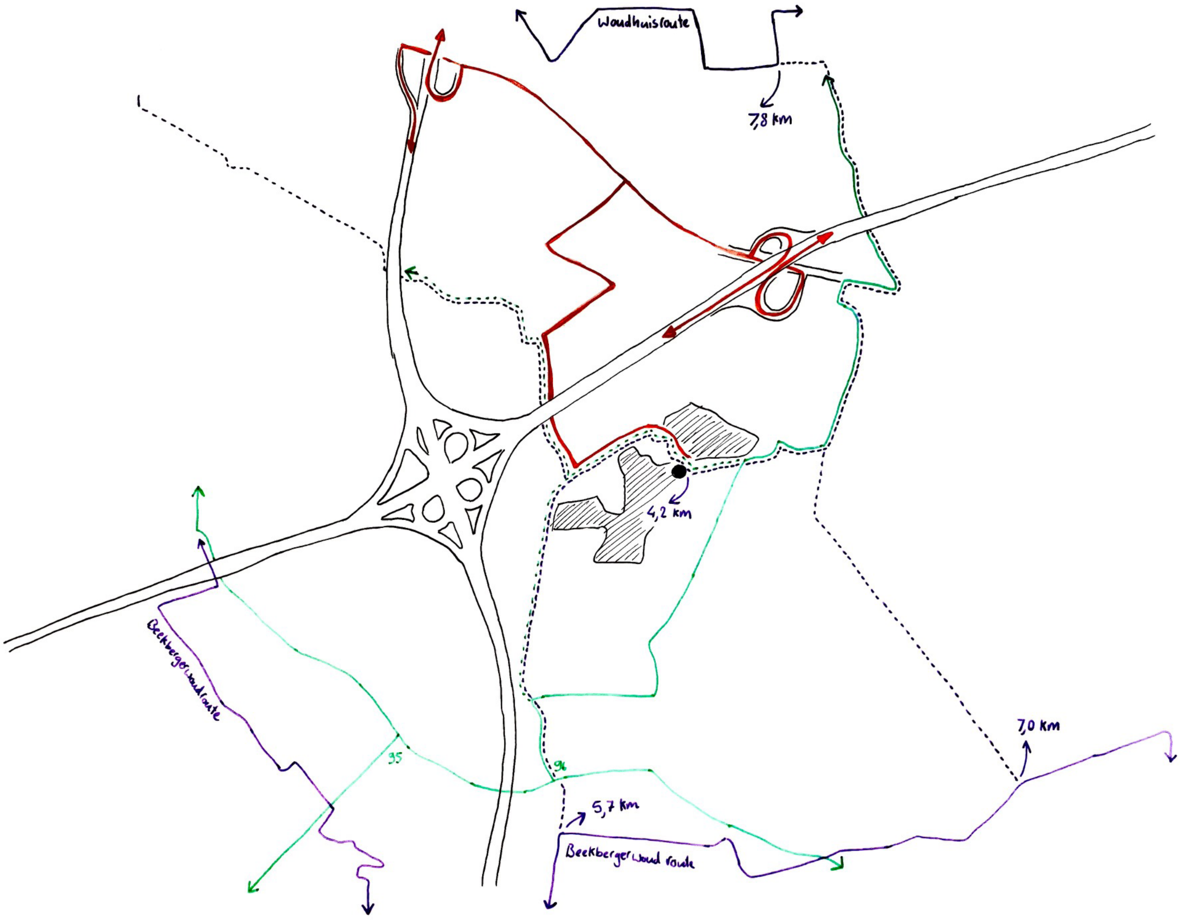


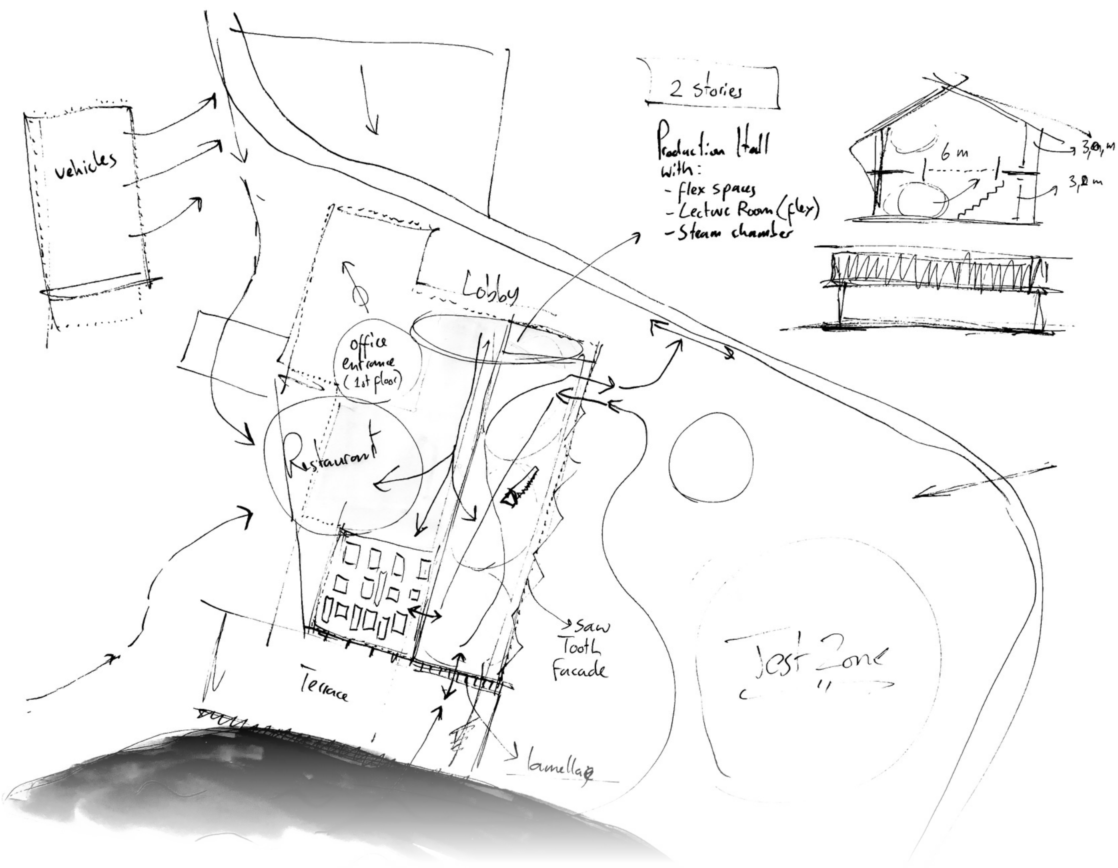
?
?
Heat-demanding functions in middle
?
?
Natural Vent.
Wood Storage
Offices
kitchen
inst
Lobby
AA'
Wood storage
Visitor Center
Restaurant
shop
Constr.
?
Alder
Alder
Beech Dowels
Ash
Hornbeam
Braces Hornbeam
Beech Column
shop
Employees
Watering Terrace
Storage
Restaurant
Lobby
inst.
Glass facade
Factory Hall
Glass facade
Refl.

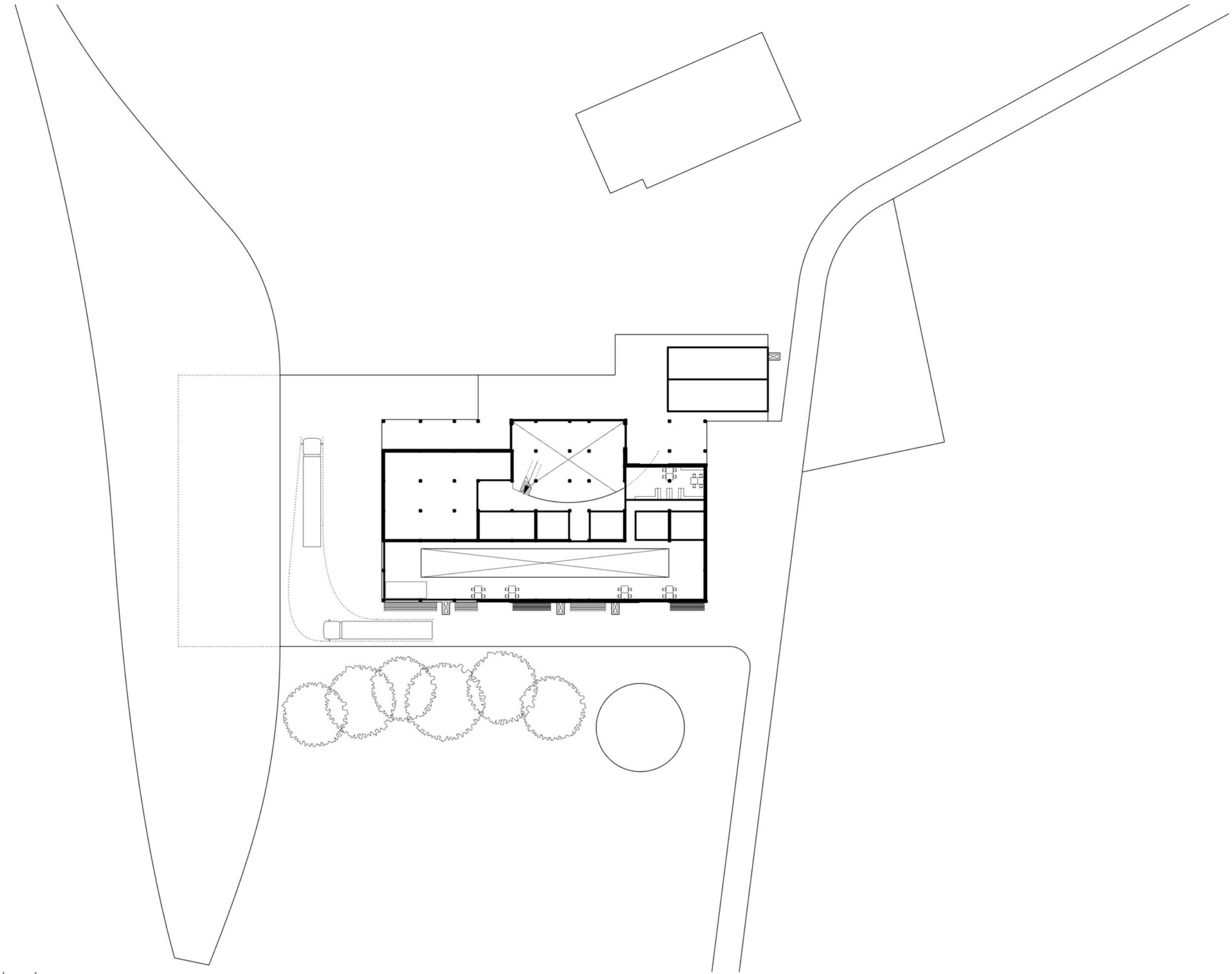


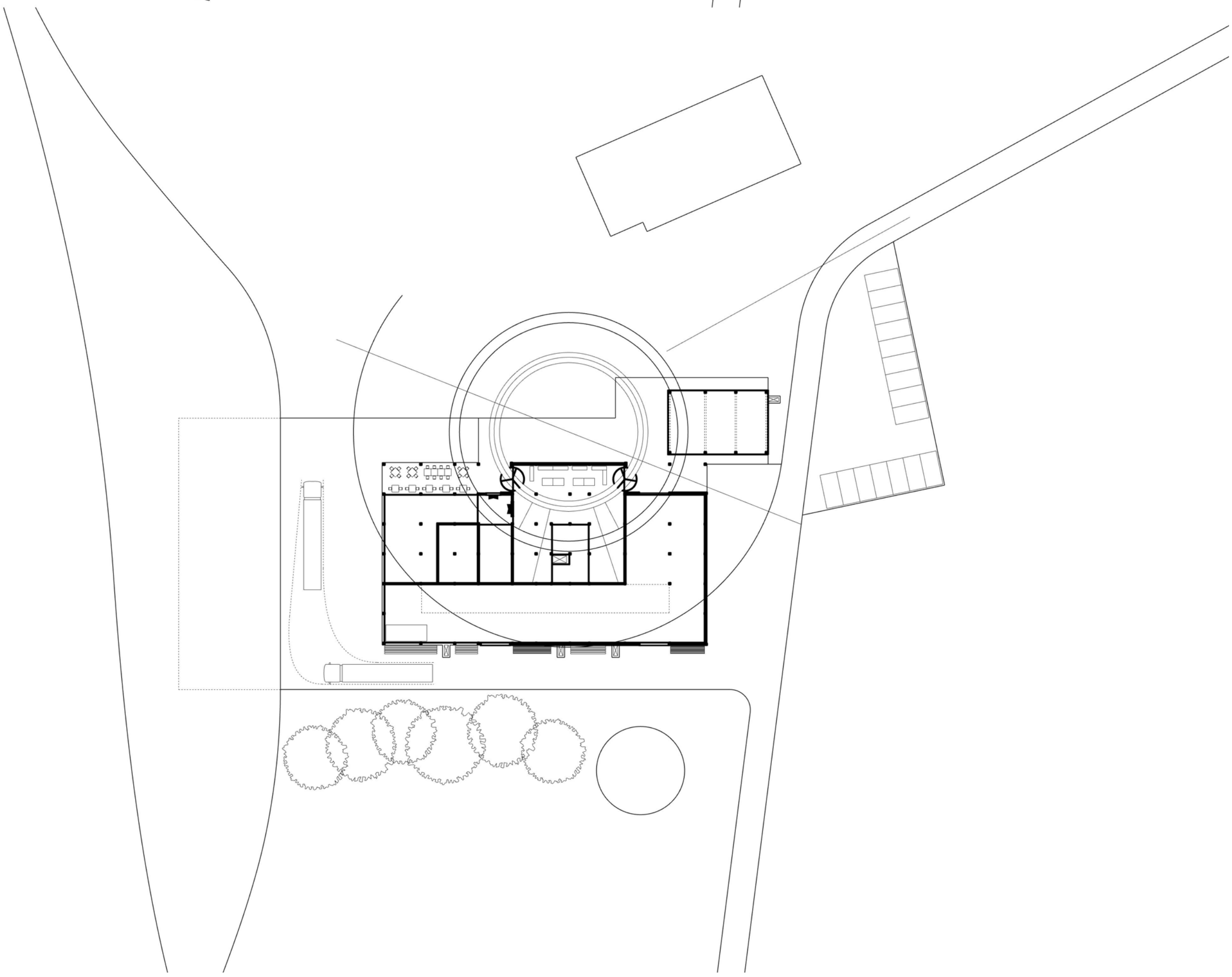
Plan Libre - Le Corbusier

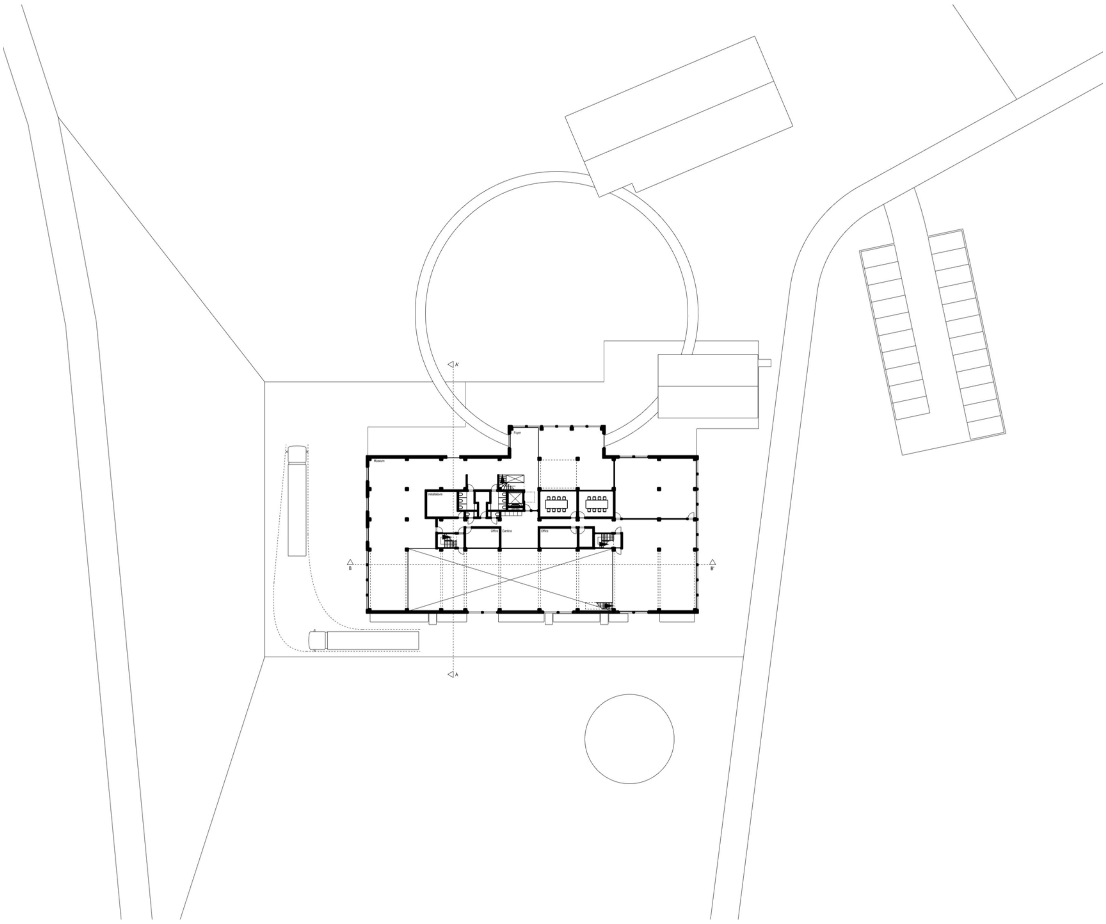


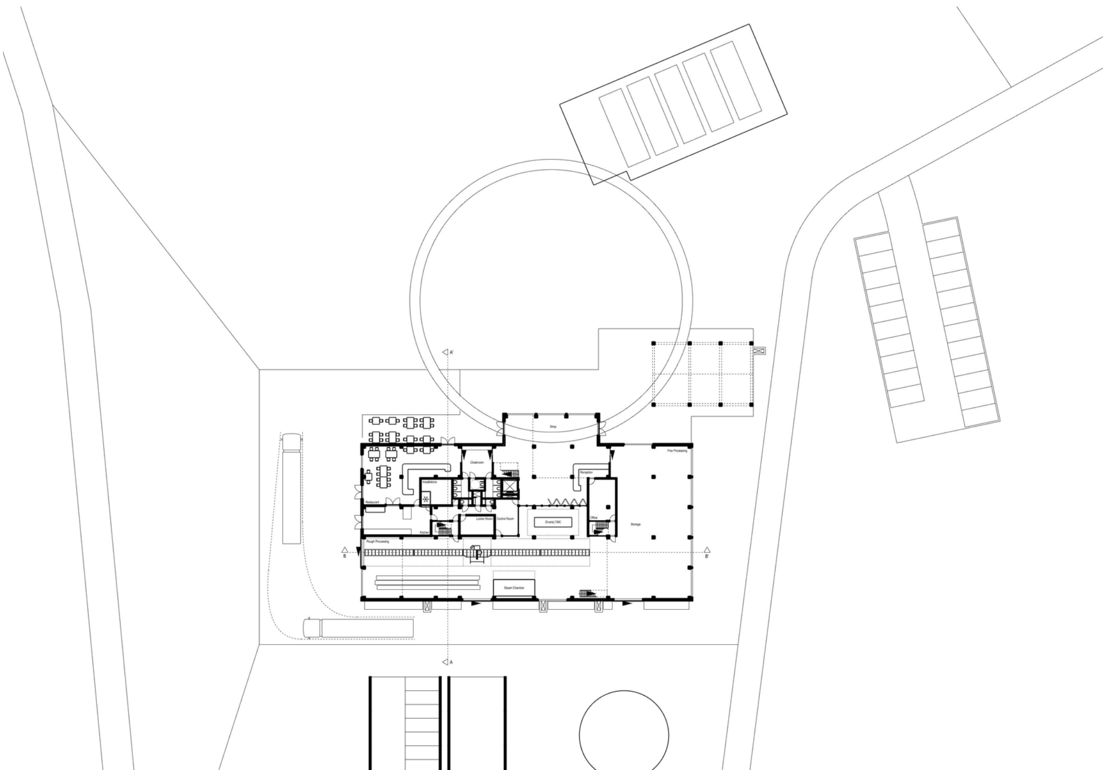

Woudhuisroute
7,8 km
4,2 km
Beekbergerwoudroute
35
96
5,7 km
Beekbergerwoud route
7,0 km


vehicles
2 stories
Production Hall
with:
- flex spaces
- Lecture Room (flex)
- Steam chamber
6 m
3,0 m
3,0 m
Lobby
office
entrance
(1st floor)
Restaurant
Saw
Tooth
Facade
Terrace
lamellas
Test Zone









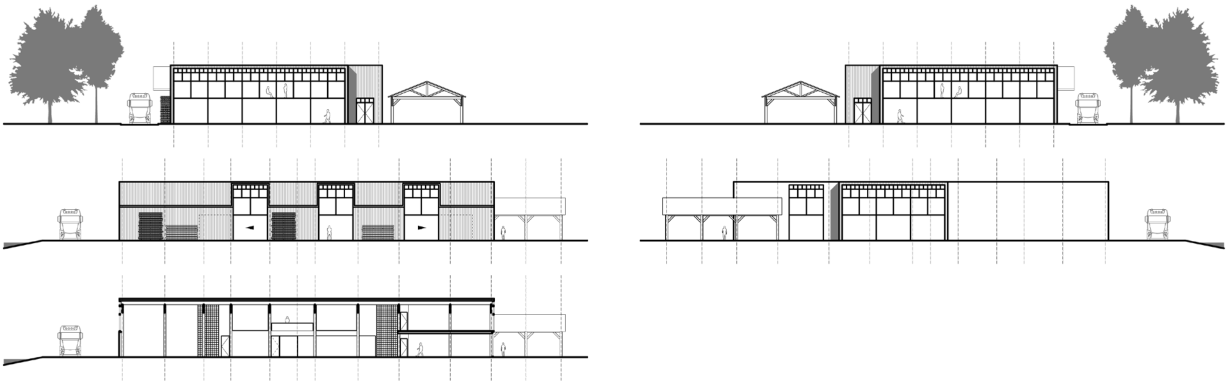
P3 Takaways:

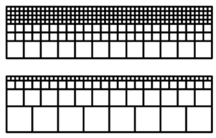
Some decisions I made during these weeks, remained a big part in my design. The facade system for example can still be found in my final products, although slightly altered according to the P3 feedback. This will be further explained in the P4 chapter.

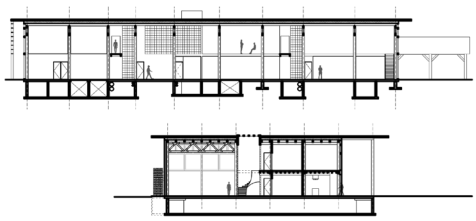
Additionally, the idea for the wooden truss and post and beam construction remained. After the P3 period, I started to finetune these construction details, for a great part with the help of Max Salzberger. For this detailing, I continuously referred back to my research, making sure my design decisions could be justified according to my wood application matrix.

Lastly, the reuse of the manure cellars for various functions was further developed after the P3. I even left bits of these cellars in sight in the final design, and I articulated their existance with the ventilation shafts rising from the mix pits.

In the next paragraph, I will present my preliminary design as it was at my P3 presentation.







P3

Preliminary Design

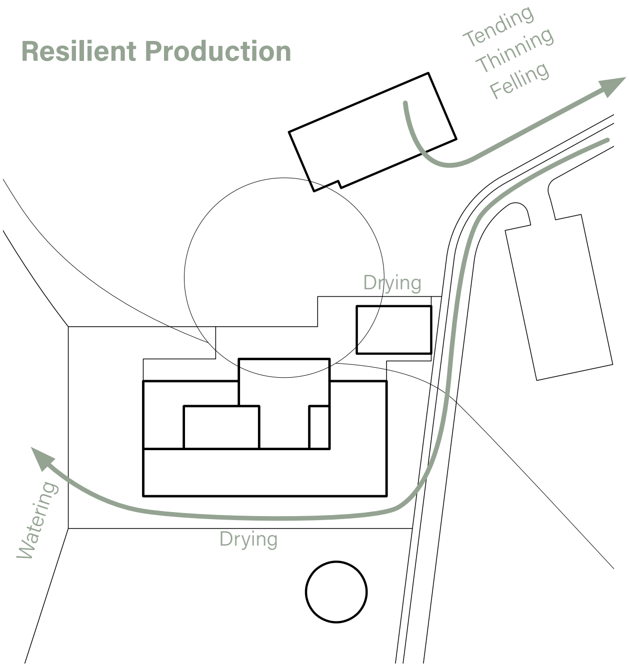
As I rushed a bit before the P3 presentation to complete all necessary drawings, many design decisions were not yet made. The materialisation of the facade, the roof shape, and the details are some examples of this. In this chapter I will show some products that I did have, what feedback I recieved on them, and in the P4 chapter I will show how I used that feedback in the final design.

To the right, you can see a diagram that attempts to illustrate how my design achieves its main goal: to get people closer to the production chain. This diagram is rather complex, and shows a seperate exterior and interior route that takes the public on a tour alongside the production chain. In later renditions, this diagram is somewhat simplified.

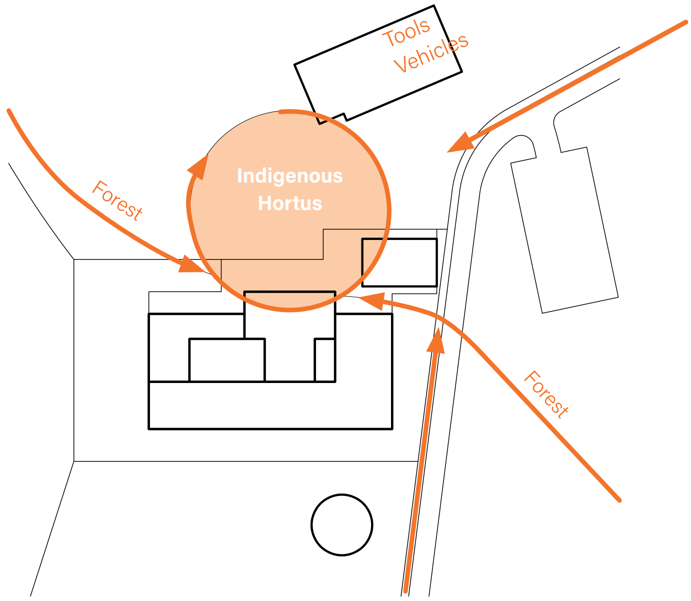
The same goes for the floorplans that result from this main design goal, which can be seen on the next pages. My P3 floorplans felt somewhat cobbled together, because I completely overanalysed each aspect of the program. I forgot to take into account the larger architectural gestures, something on which I was critiqued after the P3 presentation.

This eventually led me to overhaul my floorplans, based on what I learned from studying some Herzog & de Meuron projects; advice given by both fellow students and my tutors. This overhaul will be discussed in the P4 chapter.

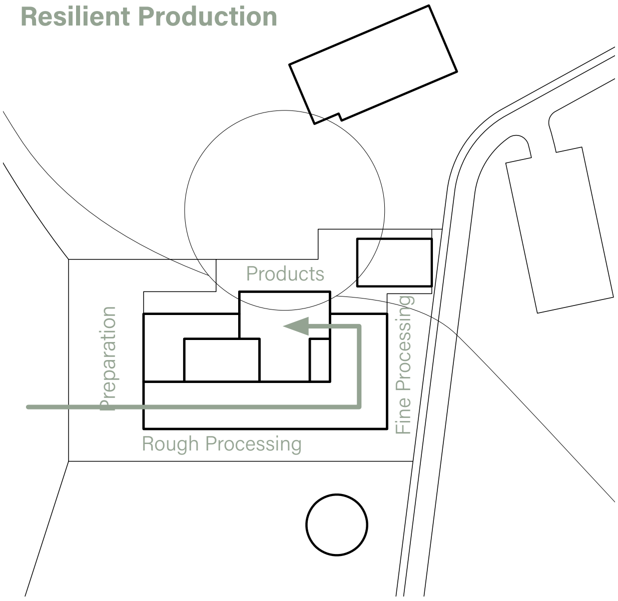
Resilient Production



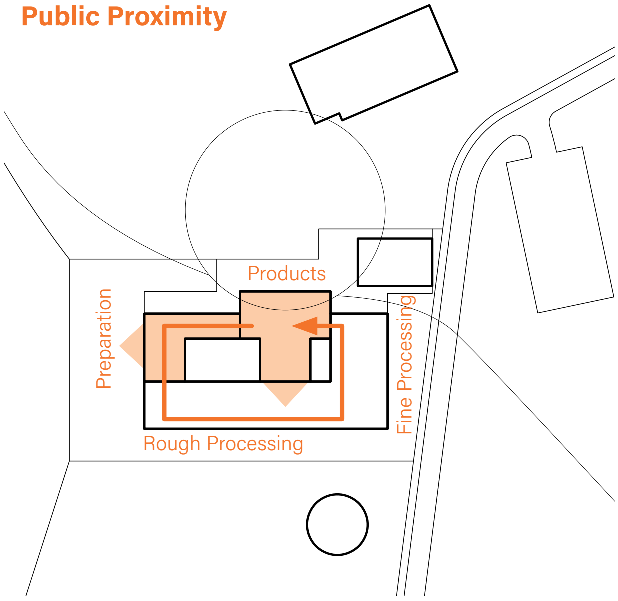
Public Proximity

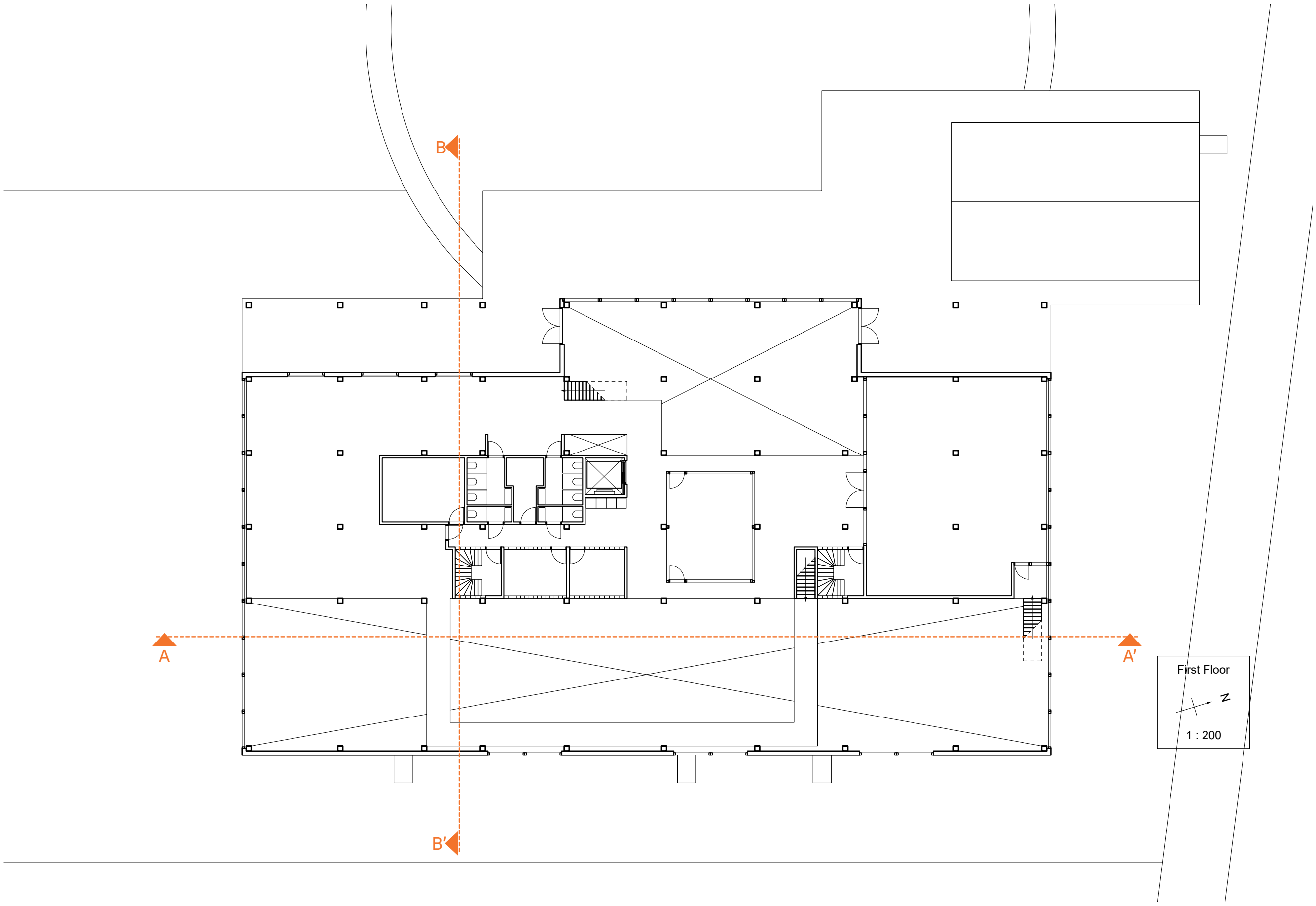


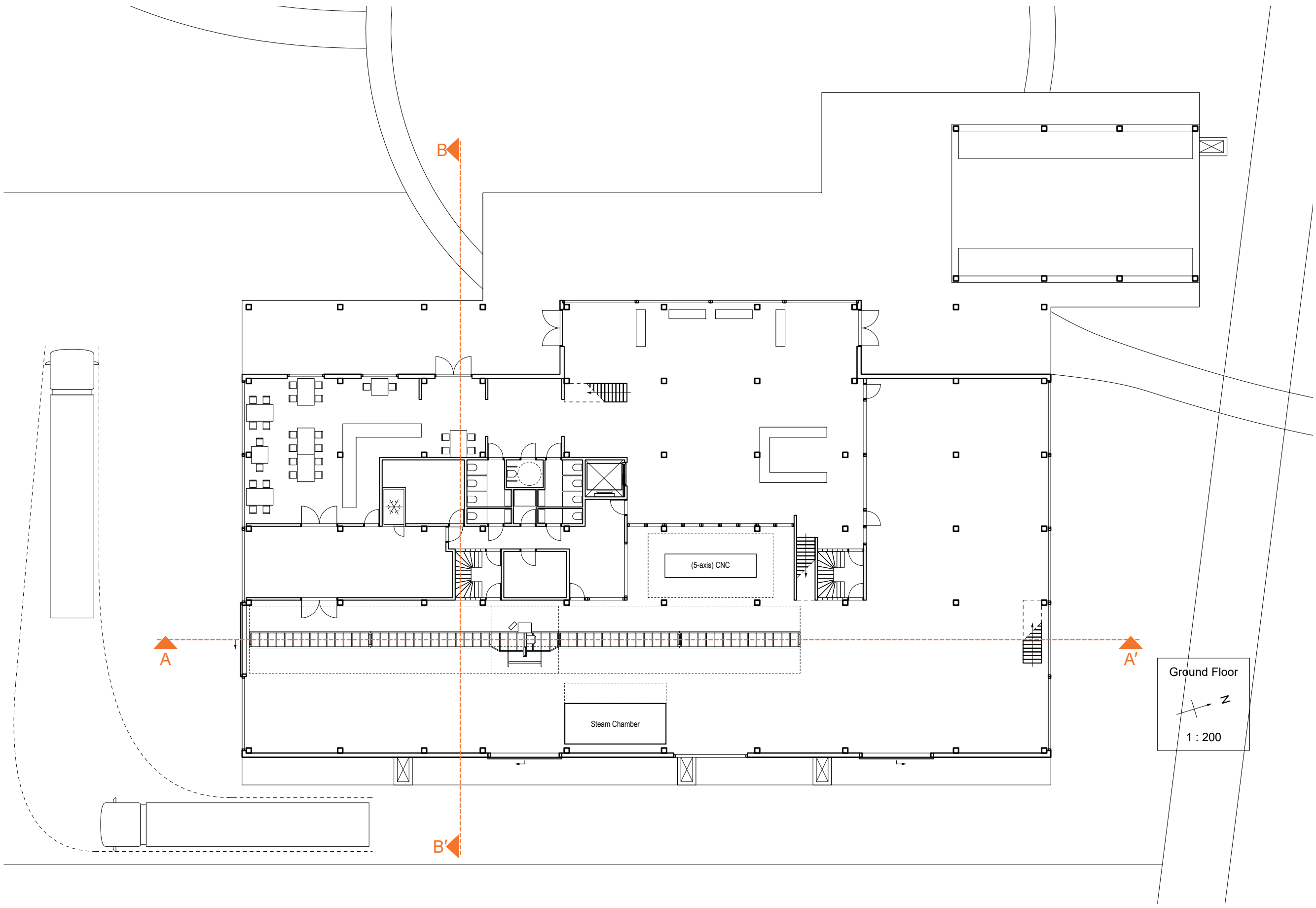
Resilient Production

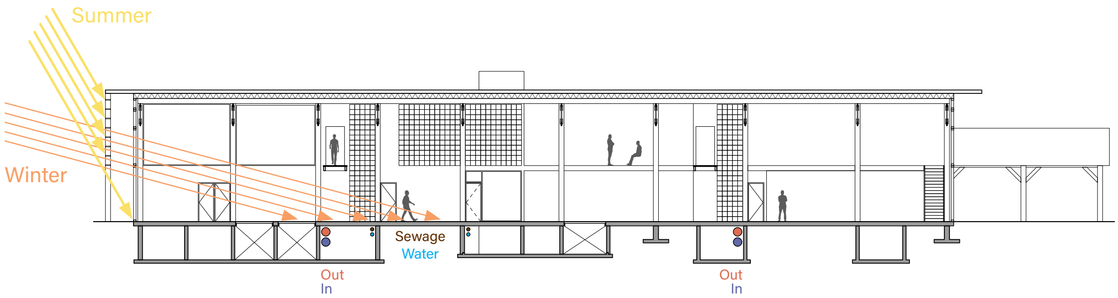


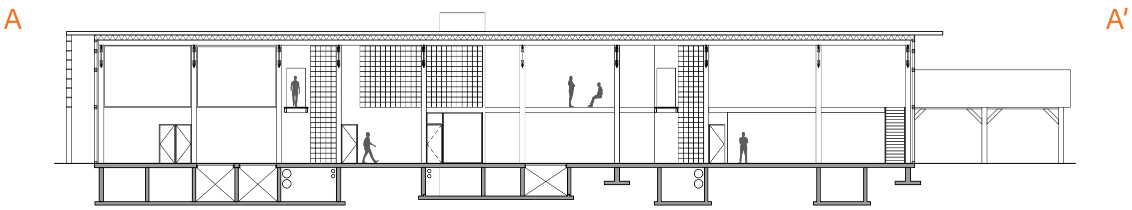
Public Proximity

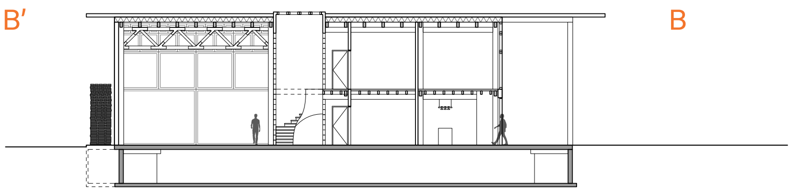


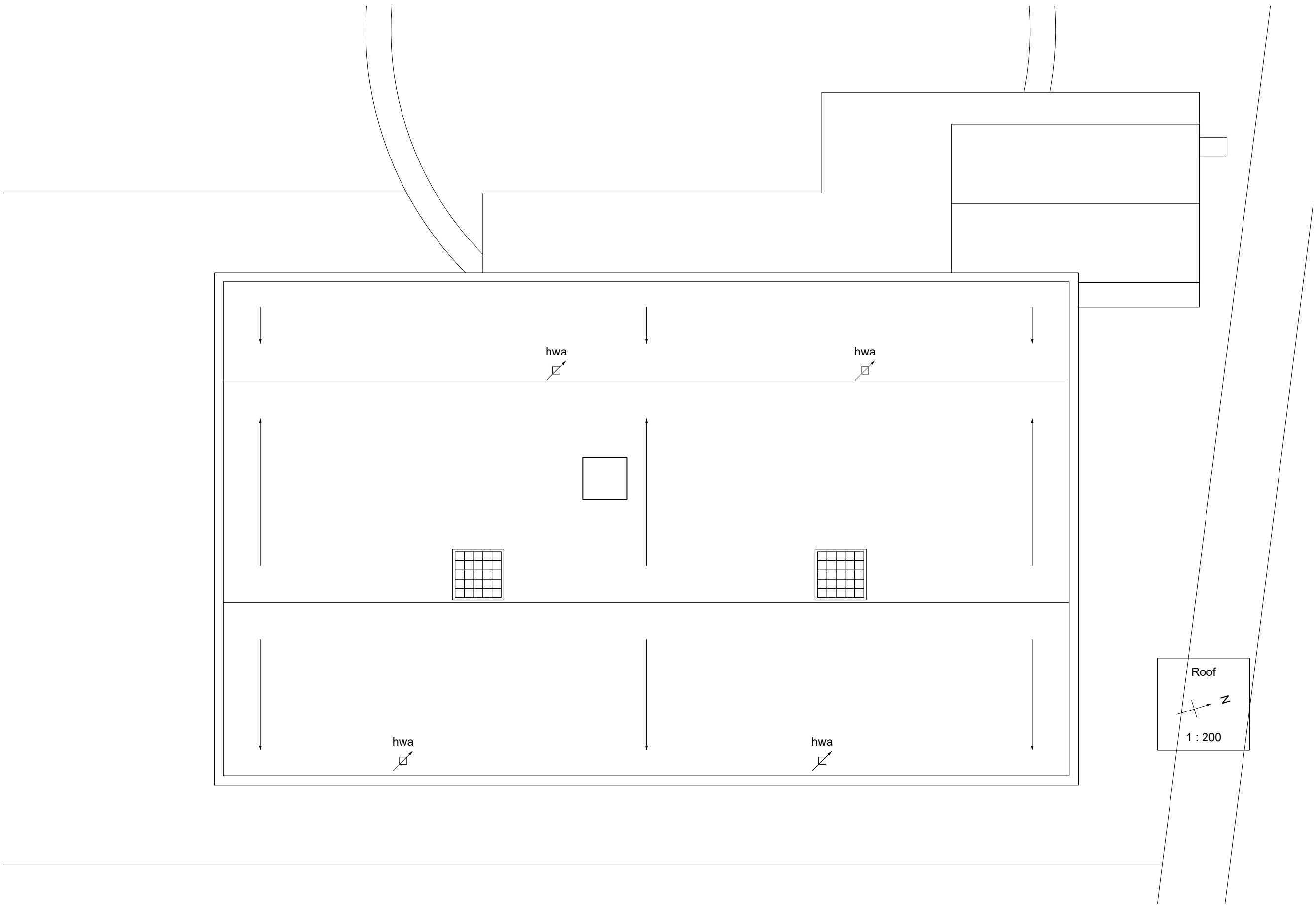

B
B'
A
A'
First Floor
N
1 : 200


B
B'
A
A'
(5-axis) CNC
Steam Chamber
Ground Floor
N
1 : 200


Summer
Winter
Sewage
Water
Out
In
Out
In


A
A′


B′
B

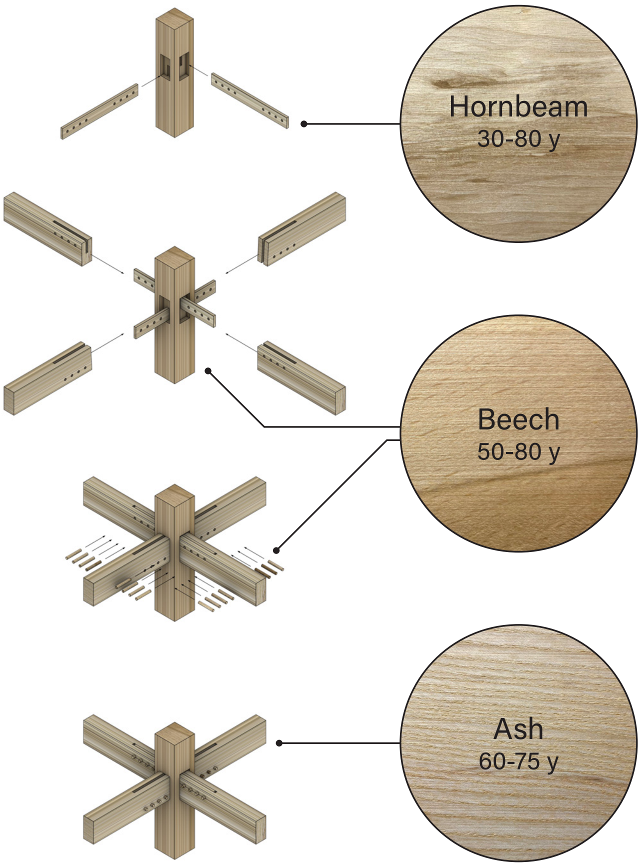

hwa
hwa
hwa
hwa
Roof
N
1 : 200

An important aspect in the design, is the visual representation of my research in the load-bearing construction of the building. This was one of the main takeaways from reference projects I studied during the P2 period. I made two sheets, illustrating how I combined different wood species in construction nodes, according to the application matrix that I concluded my research with. These nodes would add a tectonical expression to the architecture, because each color, grain pattern and texture would directly indicate a specific function within the structure.

For example, in both the truss and the post and beam construction nodes, I use Hornbeam in the joints. Hornbeam is the toughest wood species that naturally belongs in the Netherlands. It would be a perfect candidate for large-spanning beams, were it not for the fact that it is hard to get large dimensions of straight timber from a Hornbeam tree. Therefore I only used the wood in small spans, such as lintels, pegs and joints.

Another example is the use of the Black Alder wood in the truss. Alder is by far the weakest of the five wood species I studied, with an exception for pure tensile and compressive forces, where Alder performs quite similar to the other species. Thus, I concluded that it would be the ideal wood for web members and zero-force members in a truss.

Many such decisions were made, but due to time constraints, not all nodes could be fully developed.



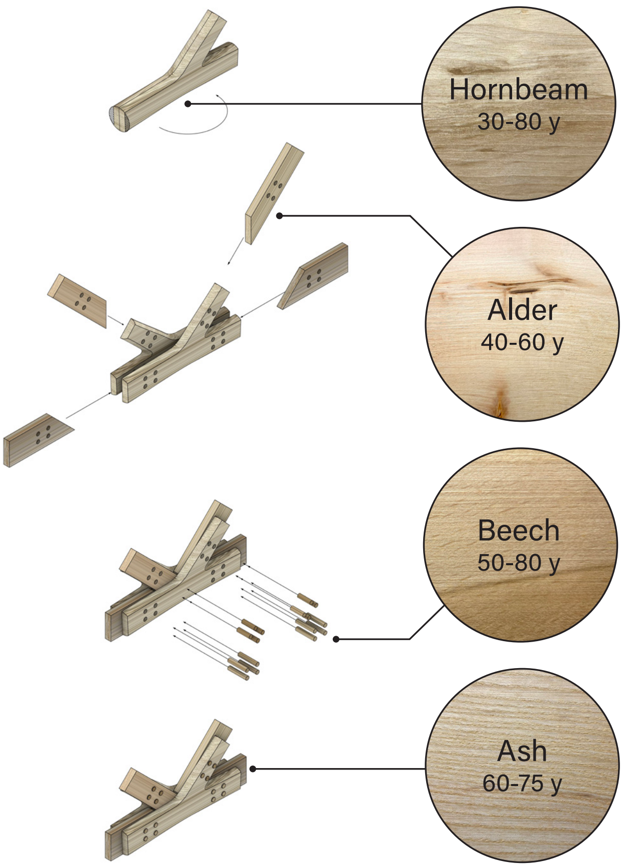
Appendix D

Application ranking matrix for five wood types in load-bearing constructions

		Black Alder	European Ash	European Beech	Hornbeam	Summer Oak
Truss construction	Top chord (rafter)	B	G	G	M (limited size)	G
	Bottom chord (tie)	M	G	G	M (limited size)	G
	Web member (strut)	M	G	G	**E**	G
	Web member (tie)	G	G	G	**E**	G
	Zero-force members	G	G	G	G	G
	Nodes, joints, pegs	B	**E**	G (as dowels)	**E**	G
Post & beam constr.	Posts & columns	B	G	G	M (limited size)	G
	Beams & purlins	B	**E**	G	M (limited size)	G
	Braces	B	G	G	M (limited size)	G
	Knee braces	B	G	G (universalist)	G	G (universalist)
Platform-frame construction	Sills or Soles	B	G (if durable)	B (moisture)	M (limited size)	**E** (durability)
	Studs (vertical)	M	G	G	M (limited size)	G
	Top plates	M	G	G	M (limited size)	G
	Headers & lintels	B	**E**	G	**E** (short span)	G
	Floor joists	B	**E**	G	**E** (short span)	G
	Rim joists	M	G	G (universalist)	M (limited size)	G (universalist)
	Sheathing	**E**	G	G	G	G
Misc.	Foundation piles	**E**	M	B (moisture)	M	G
	Foundation beams	B	M	B (moisture)	M	**E**

Note: **E** = Excellent ; G = Good ; M = Moderate ; B = Bad

The appreciations in the matrix are based on the literature as discussed in the thematic research paper (paragraph 3.4), the comparative analysis of mechanical properties (see appx. C), as well as personal communications with Max Salzberger from Cologne University of Applied Sciences (M. Saltzberger, personal communications, January 7 2025).



Appendix D

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	Bottom chord (tie)	M	G	G	M (limited size)	G
	Web member (strut)	M	G	G	**E**	G
	Web member (tie)	G	G	G	**E**	G
	Zero-force members	G	G	G	G	G
	Nodes, joints, pegs	B	**E**	G (as dowels)	**E**	G
Post & beam constr.	Posts & columns	B	G	G	M (limited size)	G
	Beams & purlins	B	**E**	G	M (limited size)	G
	Braces	B	G	G	M (limited size)	G
	Knee braces	B	G	G (universalist)	G	G (universalist)
Platform-frame construction	Sills or Soles	B	G (if durable)	B (moisture)	M (limited size)	**E** (durability)
	Studs (vertical)	M	G	G	M (limited size)	G
	Top plates	M	G	G	M (limited size)	G
	Headers & lintels	B	**E**	G	**E** (short span)	G
	Floor joists	B	**E**	G	**E** (short span)	G
	Rim joists	M	G	G (universalist)	M (limited size)	G (universalist)
	Sheathing	**E**	G	G	G	G
Misc.	Foundation piles	**E**	M	B (moisture)	M	G
	Foundation beams	B	M	B (moisture)	M	**E**

Note: **E** = Excellent ; G = Good ; M = Moderate ; B = Bad

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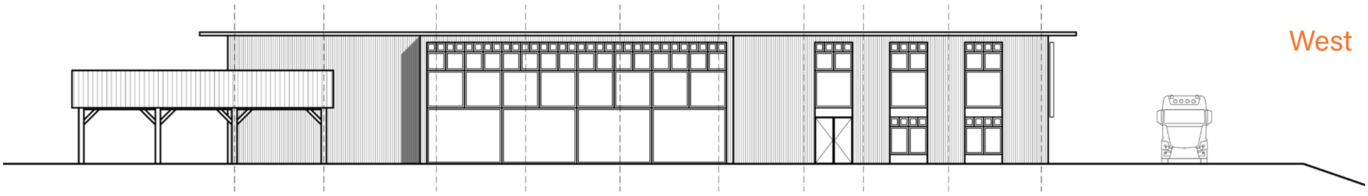
Although there were some construction drawings as well, I would like to conclude this chapter with my elevations, the preliminary render, and the feedback I recieved.

The main comment was that the design at this stage did not represent the research that I did, and the goal that I tried to achieve. From a distance, pedestrians would not recognize this building as a wood innovation center. Instead, they would see a steel construction box with a thin flat roof, most often found in cheap structures such as distribution centers and purely functional production halls. Something was missing.

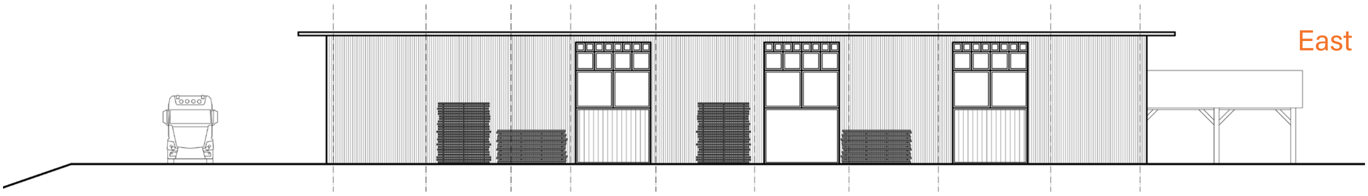
For starters, I was questioned on my choices for materials in the facade; something I had not yet thought about much. The roof shape and thickness was critiqued as well, as it did in no way resemble any sort of wood construction. I was advised to rethink the massing and the materials, and I was asked to further develop the window system, to more resemble the idea of a wooden curtain wall facade.

Moreover, I recieved feedback on my floorplans and elevations. At this point, they were all too compromising. A bigger gesture was missing from my architecture. As said before, I was told by several people to look into Herzog & de Meuron for inspiration.

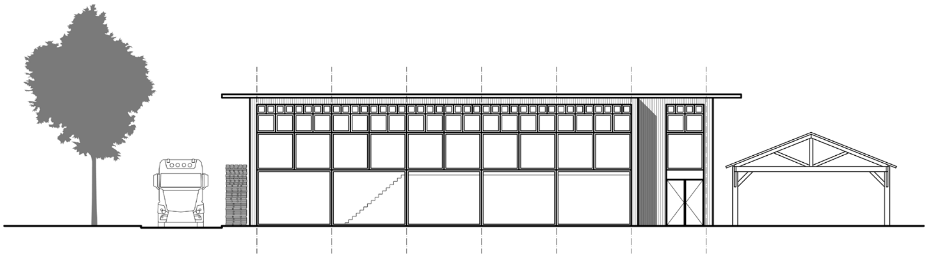
Although somehwat disappointed about my own P3 performance for a few days, I was finally able to regain motivation and continue working towards my P4 presentation.



West



East



North

P4

Introduction

After the P3 period, it took me a few days to find motivation to continue the design. I decided to name the design 'Silvae', which is Latin for 'from the forest'. This was meant as a reminder of what the goal of the project was; to design something that clearly results from the surrounding forest, and that reconnects people to the landscape and the production chain.

The final product can be seen to the right, and it clearly contrasts with the P3 design found on the previous page. In the coming chapter I will briefly discuss some key moments in the design process between the P3 and P4 presentation. I will also show a bit of the process of modelling the construction nodes, and I will conclude the chapter with the mandatory P4 reflection document.

In the last chapter I will write about the last few weeks, up to the final public presentation. I will eleborate on the extra products I made, changes I made in the already existing products, and on another model that I constructed during this time.

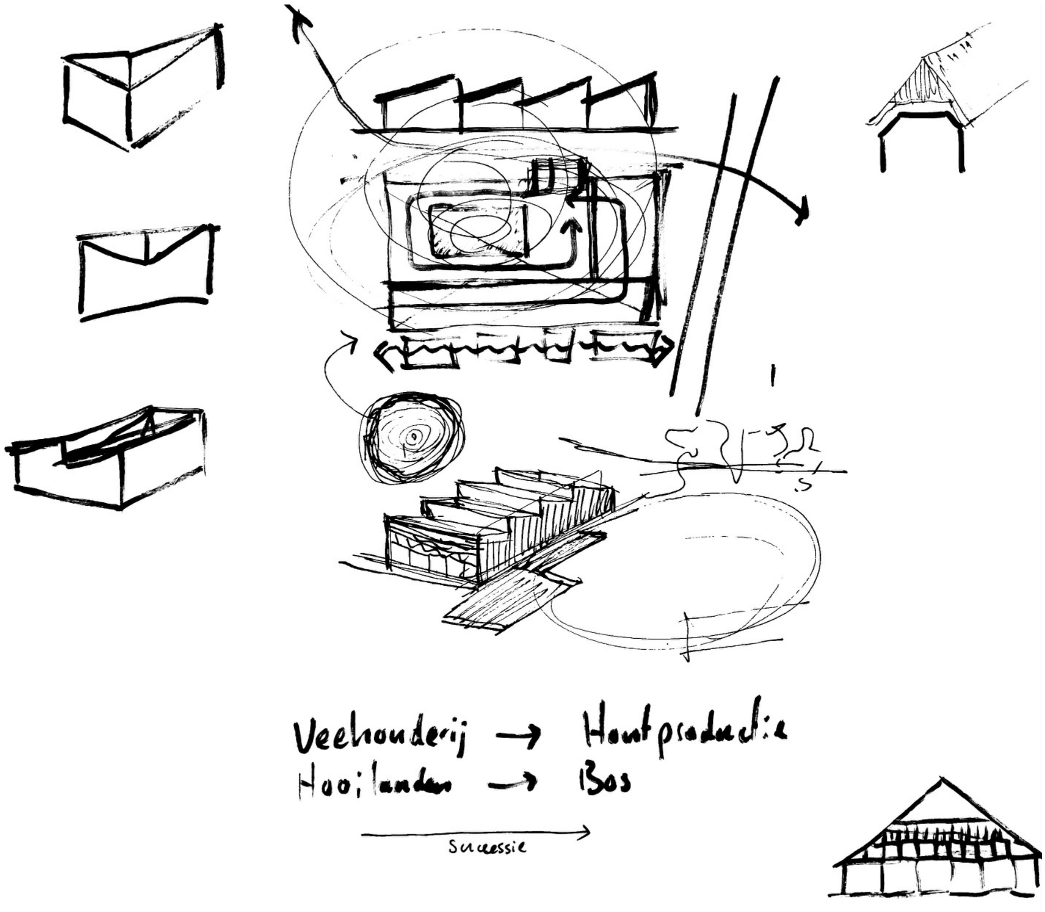
Situation 1:500

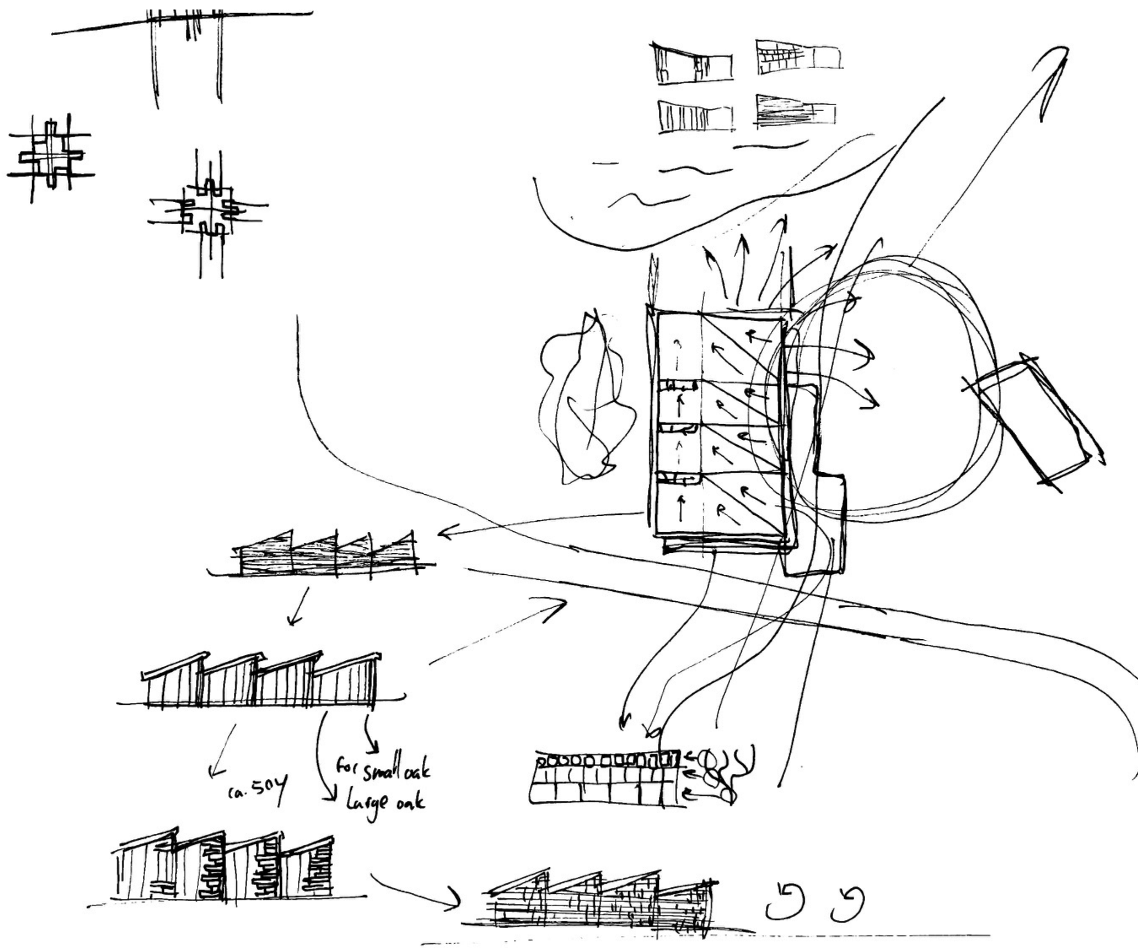
Design Process

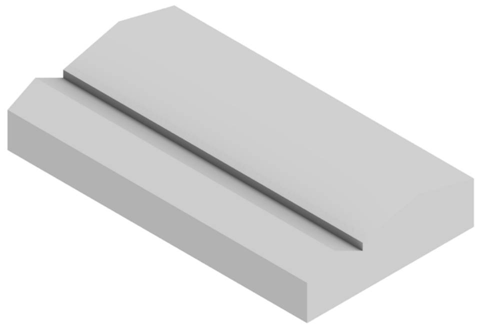
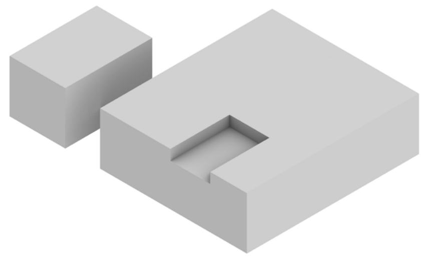
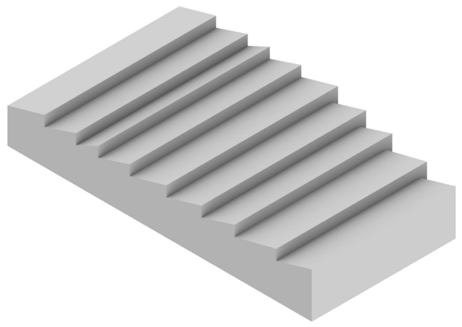
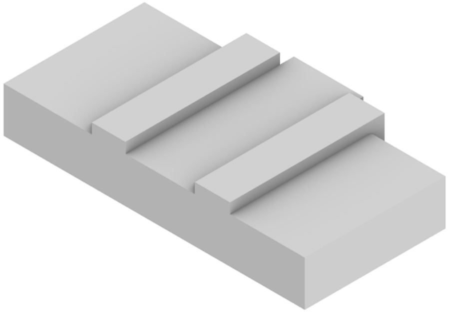
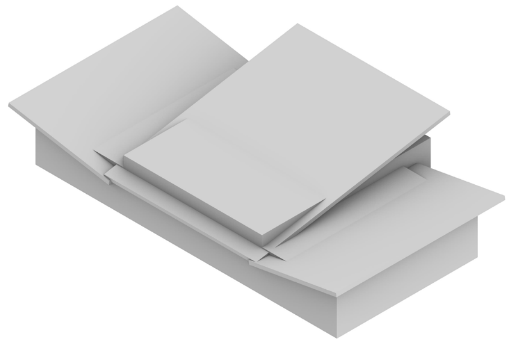
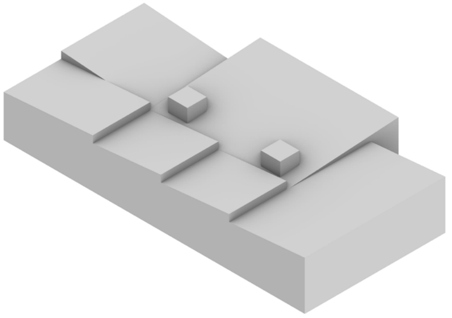
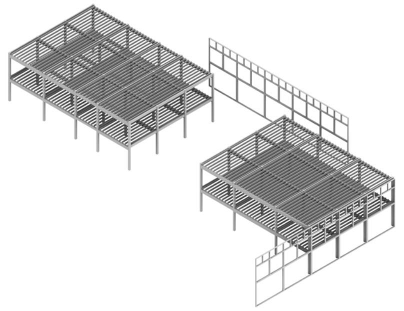
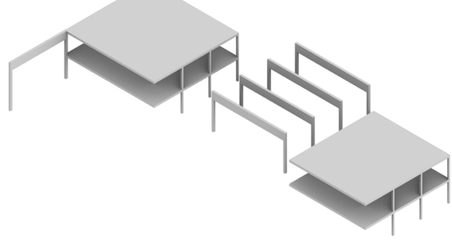
The first few weeks, I struggled to find a good massing for the design. I was told to look into what the typology of wood constructions in innovation centers would or should look like. On the other hand though, I was given the advice to try and make a connection with the previous function of the site: a dairy farm. This would mean a more historical approach.

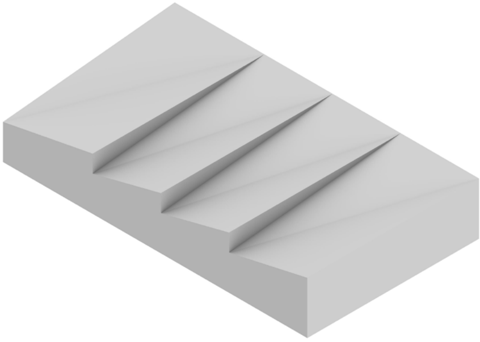
I later chose to drop this second approach, because it did not lead to any appropriate morphology for the design. Some of the masses in the next pages show my attempts for this historical strategy.

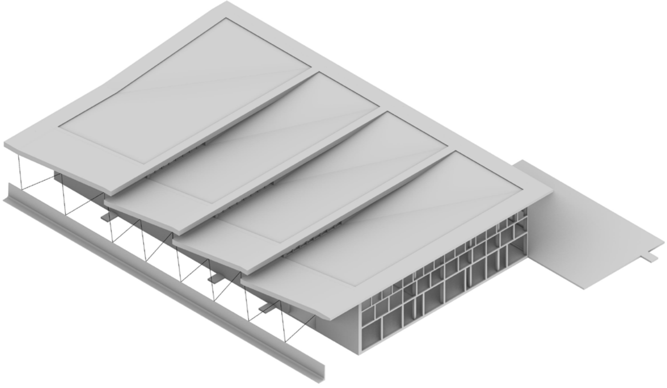
Instead I tried to find a new massing, based on the functions each facade should have. On the one hand, there is the more industrial function, which is often recognized by the typical factory-like slanted roof repetition. On the other side of the building however, we need an exhibit-like facade, meant to draw people into the building. This facade is all about transparency and attraction. I finally found a roof geometry that would allow for both facades to exist in the same building.

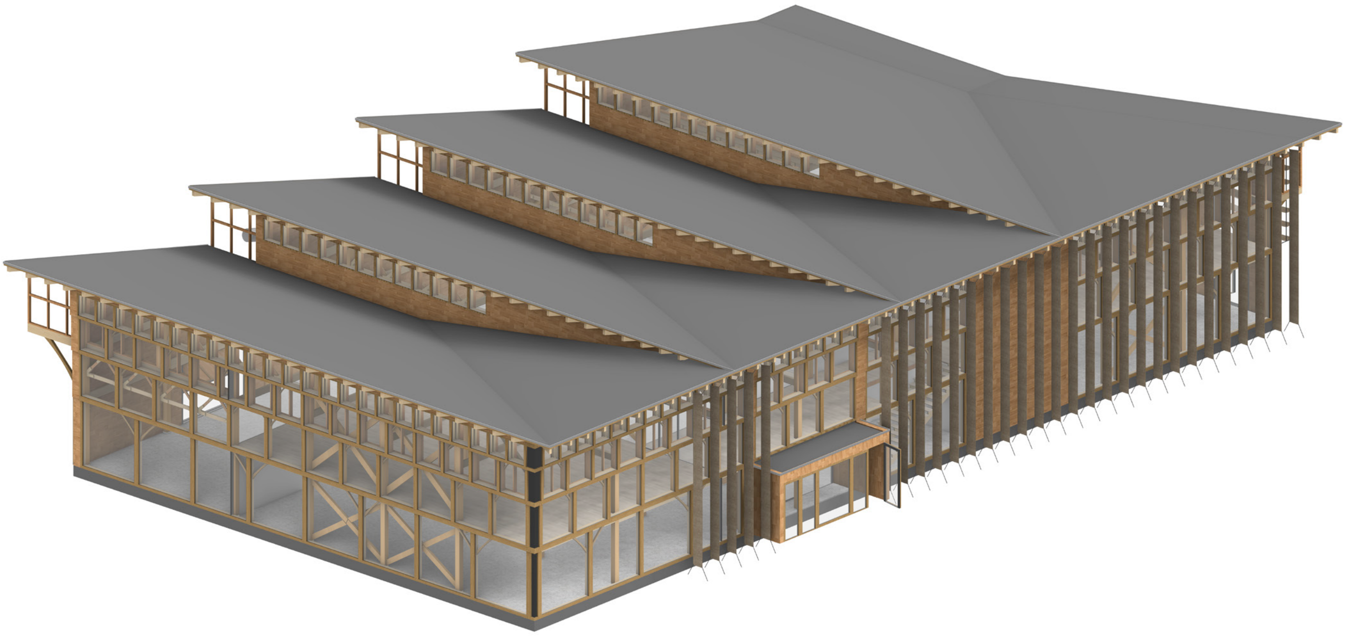

Veehouderij → Houtproductie
Hooilanden → Bos
Successie

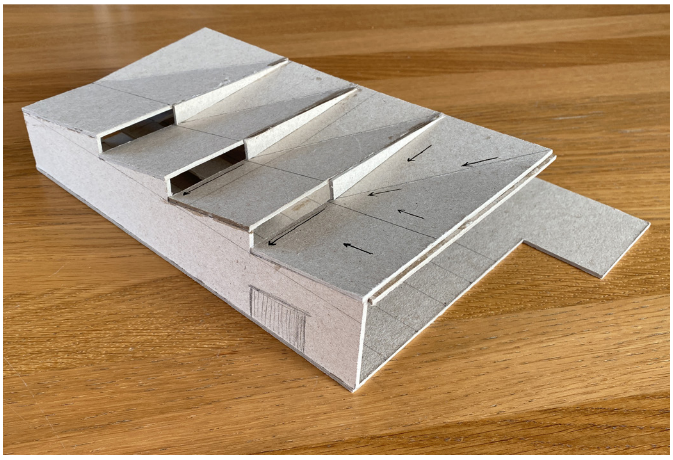

ca. 50y
for small oak
Large oak



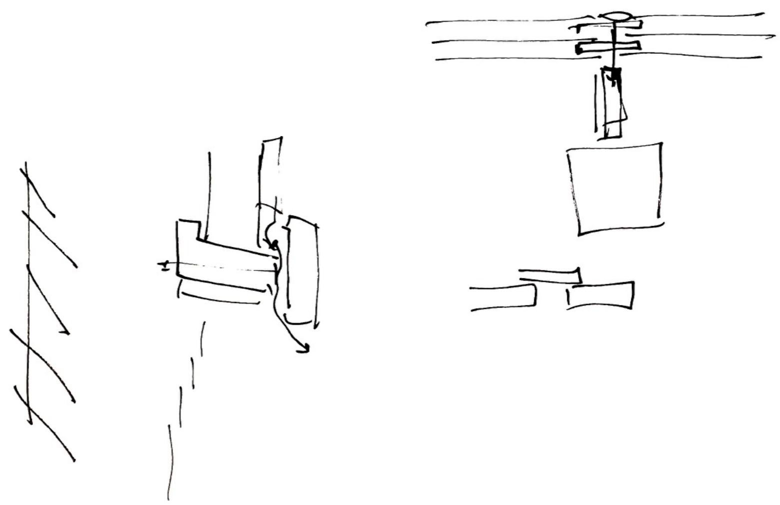


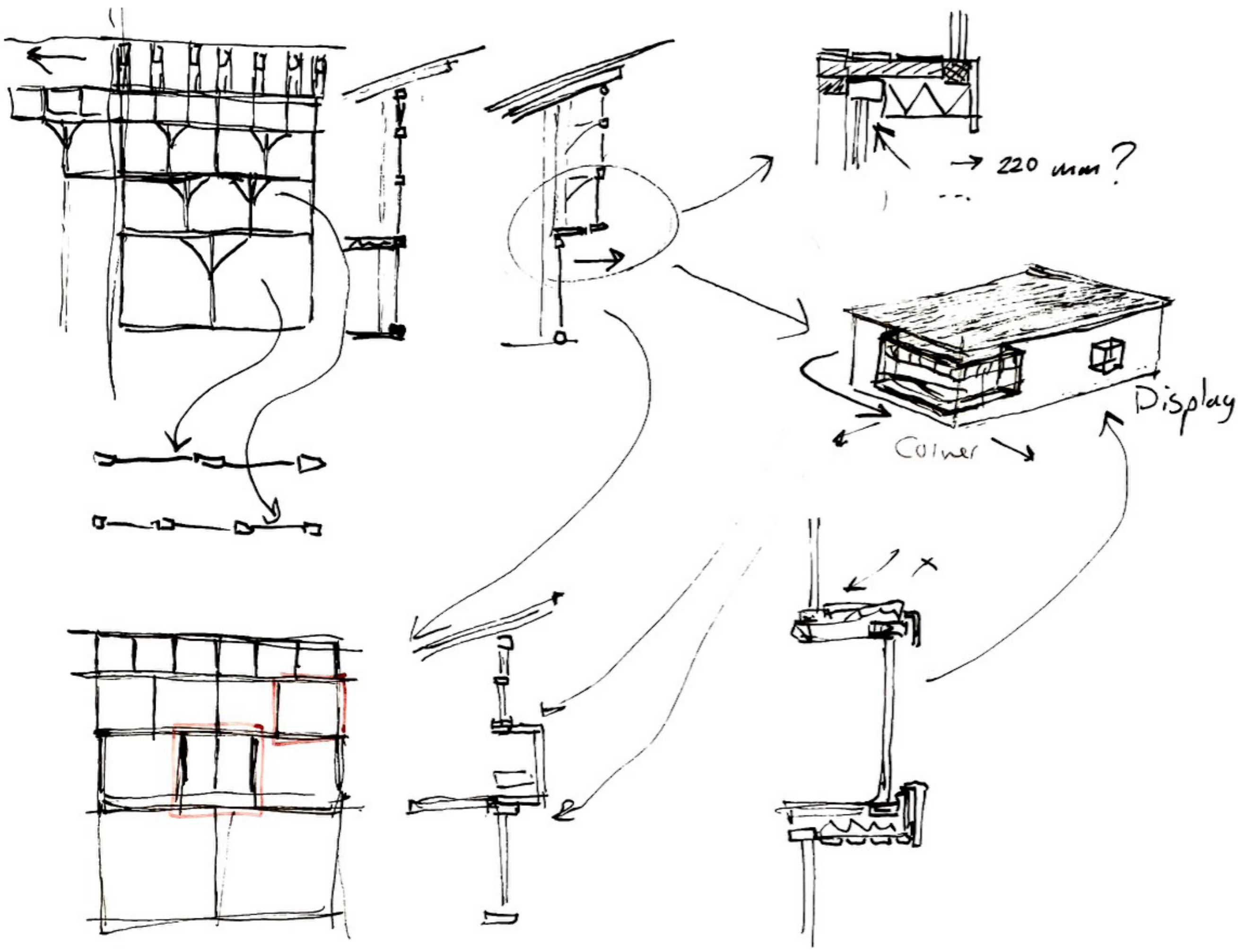




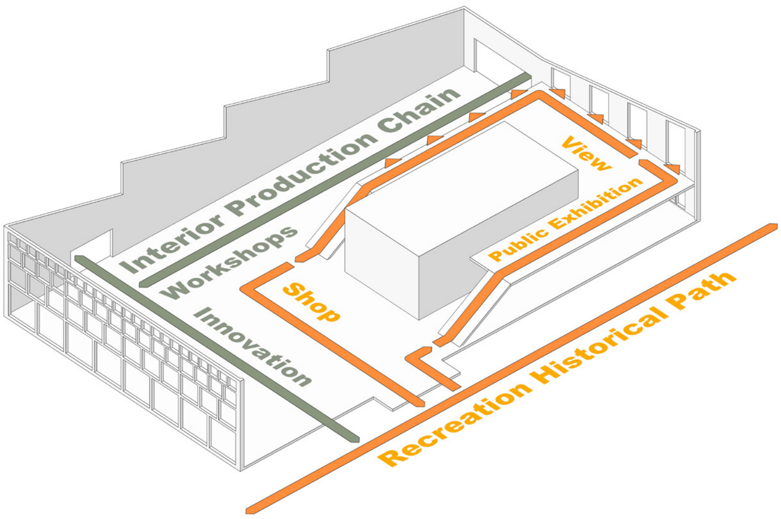
Even with the massing done, the facade remained an issue. It lacked depth and variety, even when I applied thinner pieces towards the top. Some variants were tested to make this facade more interesting, but eventually I settled for a stepped facade, extending further outwards towards the top, accompanied with some closed parts and vertical lamellae on the west side of the building.

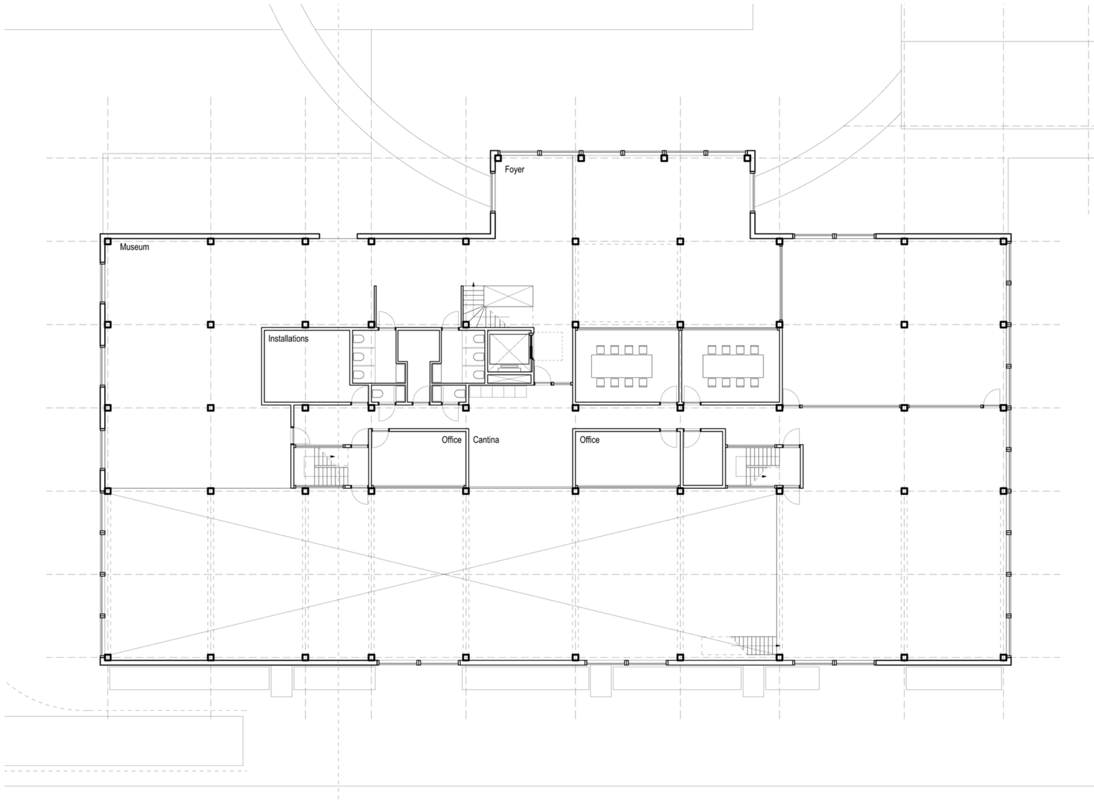
The final result can be best presented with the facade fragment and details. These will be presented in the paragraph showing the final design.

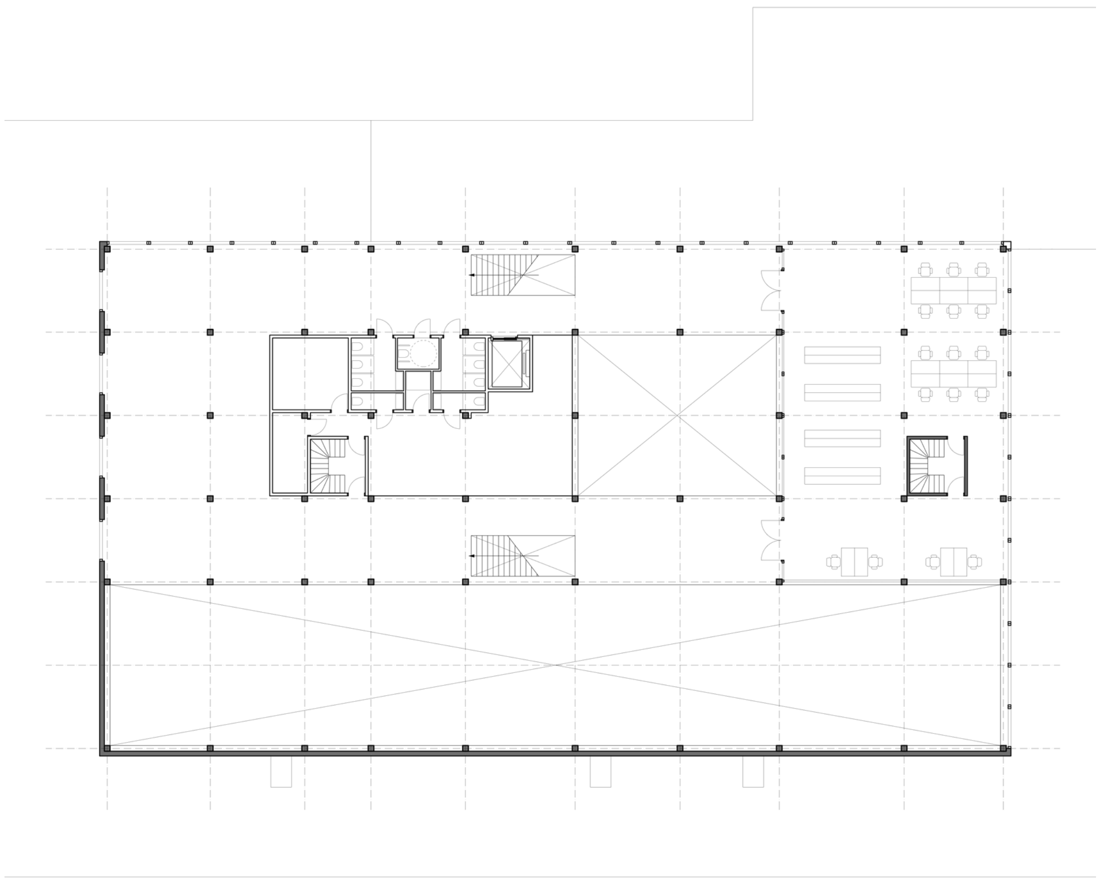



→ 220 mm ?
Display
Corner

Lastly, as stated before, I overhauled the floorplans. I chose to organize the service program into a single core, creating a clear pathway around the core, alongside the production hall, back into a big open lobby where the roof construction can be admired. The final floorplan is way more structured and logical; the experience of the visitors way less confusing and more pleasant.




Foyer
Museum
Installations
Office
Cantina
Office



Model 1

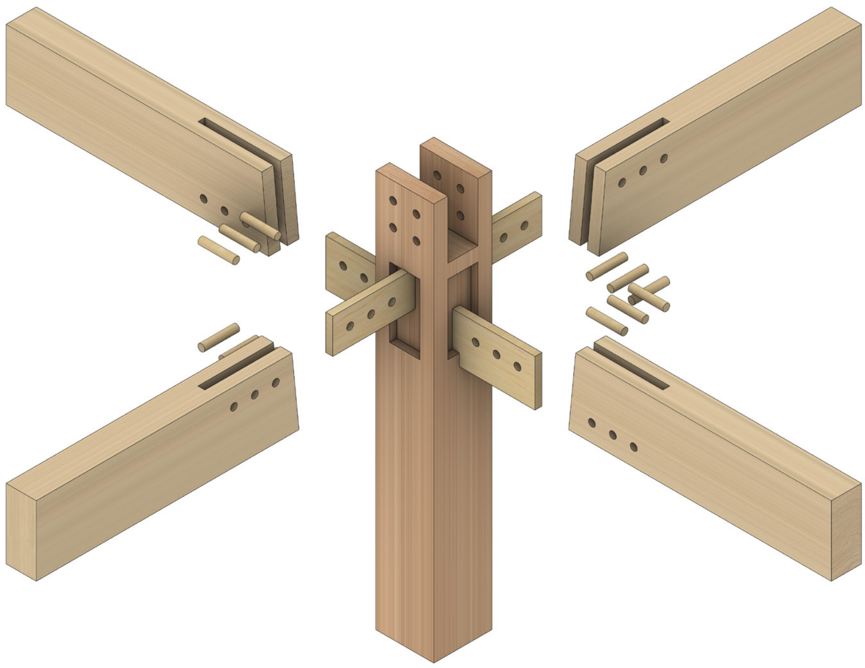
Another thing I did whilst finalizing my design, was building a 1:5 model of the principle post and beam construction node. I built this using the wood species discussed in my research. They were hard to aquire, but eventually I was able to find a company willing to sell a small amount of wood to me, a private consumer.

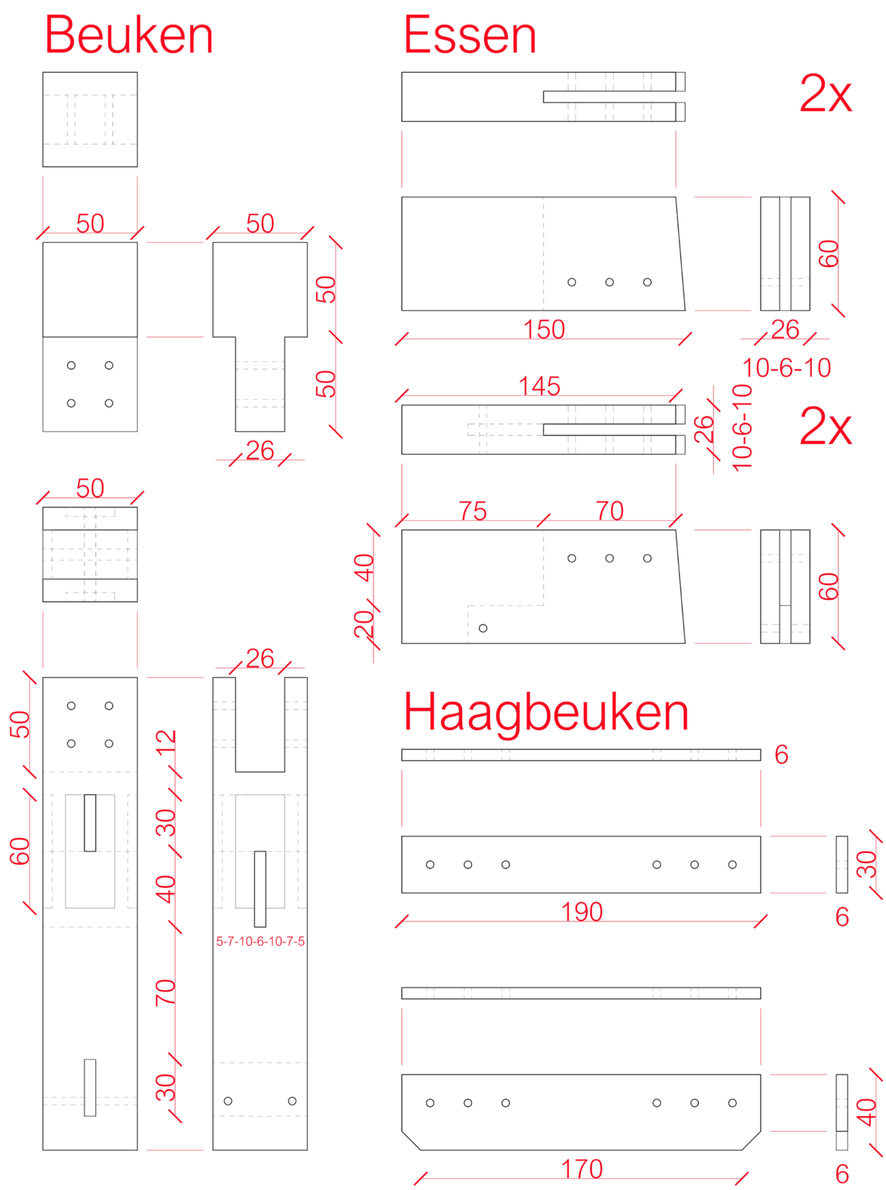
This node uses spline joinery to make sure the beams attatch to the column in the same plane, limiting floor thickness and resulting in a complex node that will remain visible in the design. I already discussed some choices for the wood species in this node previously.

In the P4 reflection I also briefly mention some of my experiences during the building process, such as the smell of the wood species, and the toughness when sawing or drilling through it. This model eventually took me and my dad, who helped me a lot, four full days to complete.

To the right you can see my 3D model and the drawings I made as a template. These drawings still assumed the use of Oak knee braces, however I chose to leave them out of the design eventually. On the next page you will find pictures of the process and the end result.

For the P5 presentation, another similar model was made for the truss node. This process will be discussed in the P5 chapter.




Beuken
Essen
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Haagbeuken
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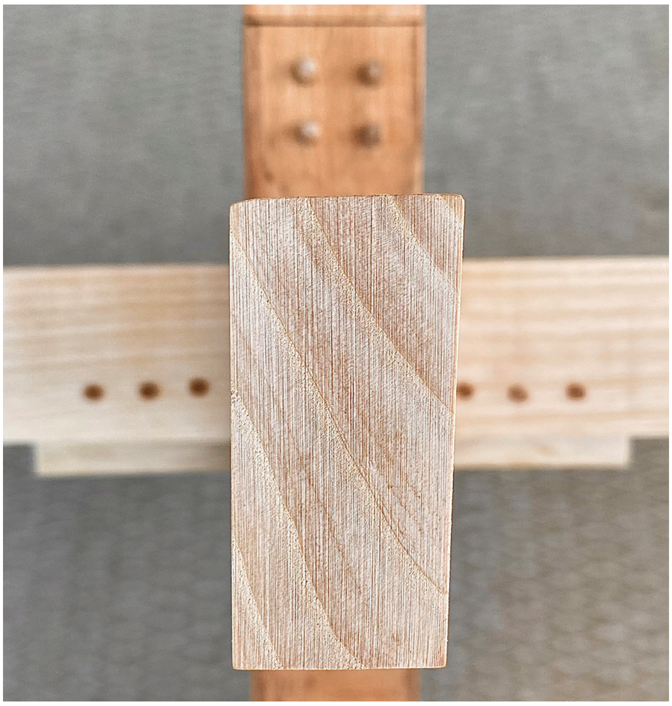
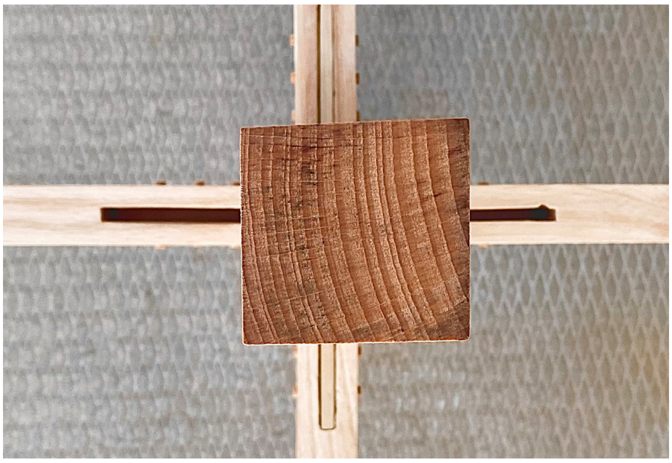
170
6




PLUS



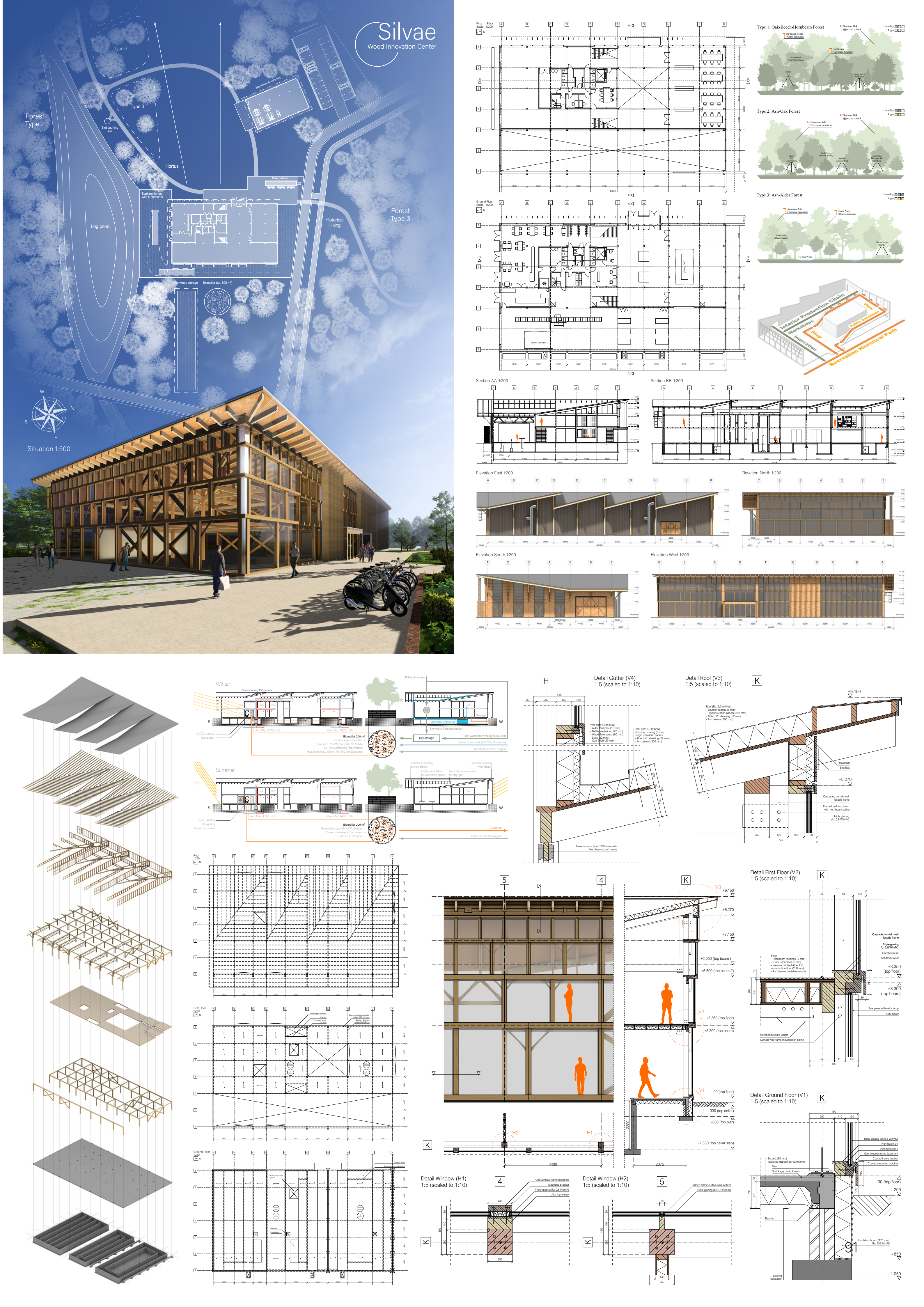





P4

Final Design

The two posters to the right contain most of the final products that I presented alongside my model during my P4 presentation. I will point some of them out to explain the most important parts of the design. I will also highlight some of my slides that did not make the poster. Lastly, the feedback at the end of my P4 presentation will be discussed.

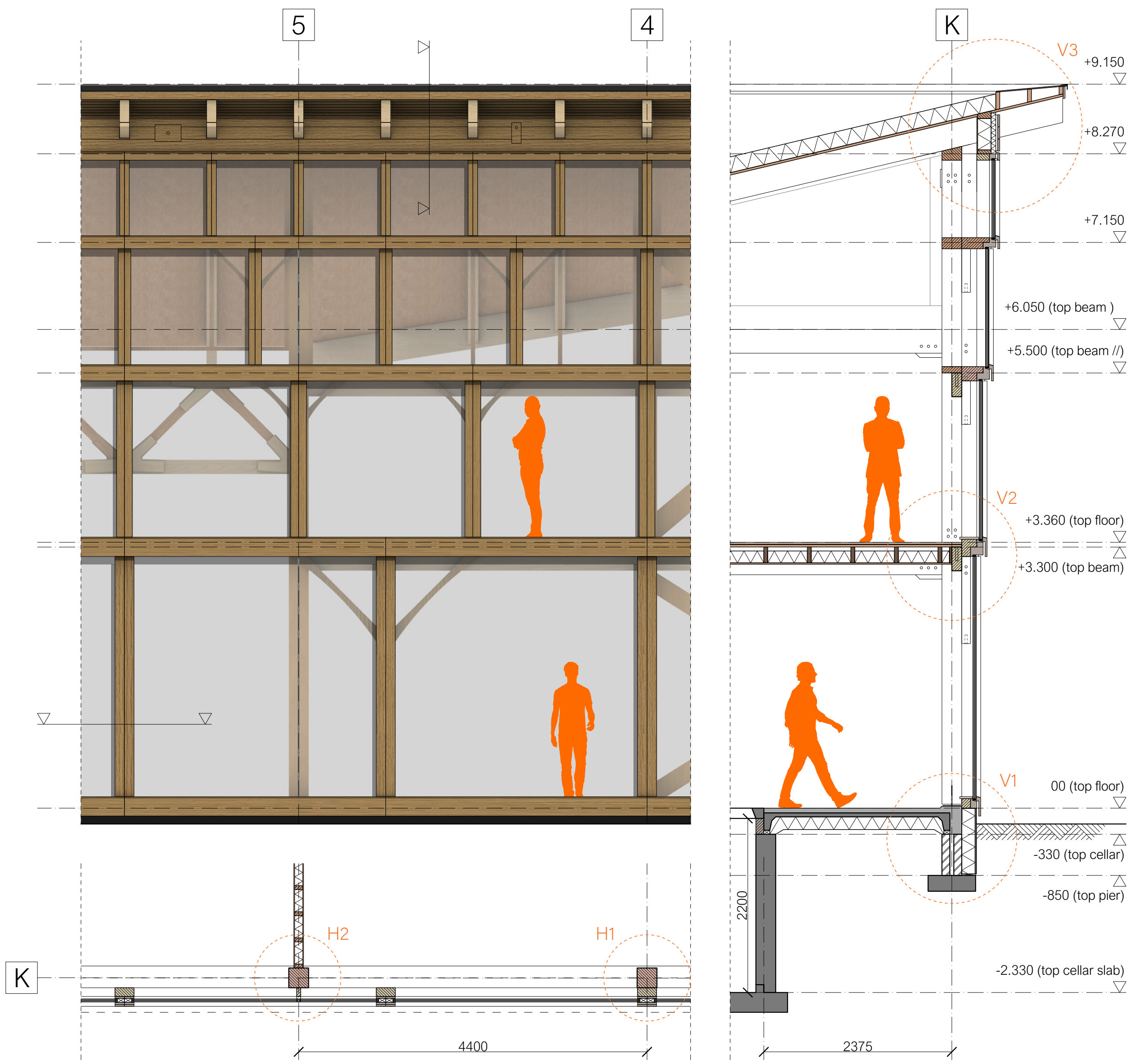

Silvae
Wood Innovation Center
Forest Type 2
Forest Type 3
Type 2
Type 3
Hortus
Log pond
Historical Hiking
Situation 1:500
First Floor Scale 1:200
Ground Floor Scale 1:200
Type 1: Oak-Beech-Hornbeam Forest
Type 2: Ash-Oak Forest
Type 3: Ash-Alder Forest
Interior Production Chain
Workshops
Innovation
Shop
Public Exhibition
Recreation Historical Path
Section AA' 1:200
Section BB' 1:200
Elevation East 1:200
Elevation North 1:200
Elevation South 1:200
Elevation West 1:200
Winter
Summer
Detail Gutter (V4)
1:5 (scaled to 1:10)
Detail Roof (V3)
1:5 (scaled to 1:10)
Detail First Floor (V2)
1:5 (scaled to 1:10)
Detail Ground Floor (V1)
1:5 (scaled to 1:10)
Detail Window (H1)
1:5 (scaled to 1:10)
Detail Window (H2)
1:5 (scaled to 1:10)

I had built my P4 story around three aspects in the design that symbolize the relationship between the landscape and the building material. One of those aspects was the dimensional aspect. The facade fragment is the perfect drawing to explain this principle with. Similar to how any tree would grow, this facade is built up with bigger pieces on the bottom, and smaller pieces towards the top.

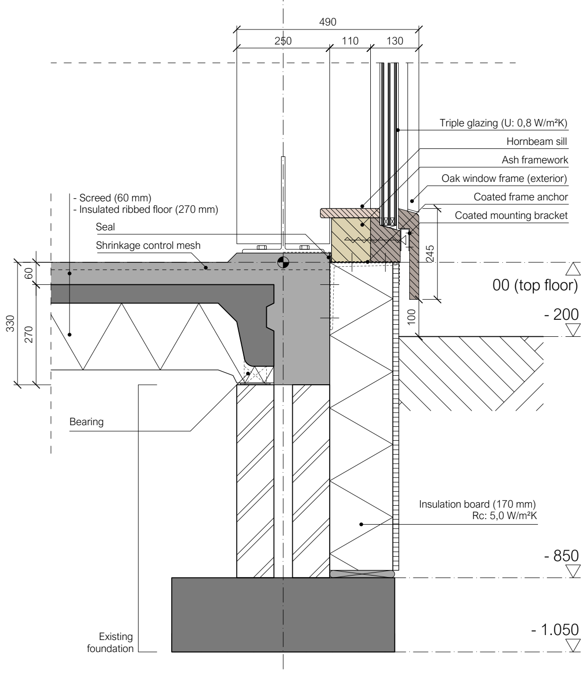
The window frames too become thinner the further up you go. They are made from the wood of the Summer Oak, as this is the only one of the five wood species that is naturally wheather-resistant. This is also one of very few places in the design where Oak wood is used. This has to do with the second aspect of the landscape-to-material relationship, the temporal factor, which will be eleborated upon later.

Another thing that stands out in this facade, is the offset of the higher windows with respect to the lower windows. This better aligns the slope of the roof with the facade, and it also creates a more durable situation for protection against water. In the detail you can see how an Oak board finish for the window frames directs the water away from the windows.

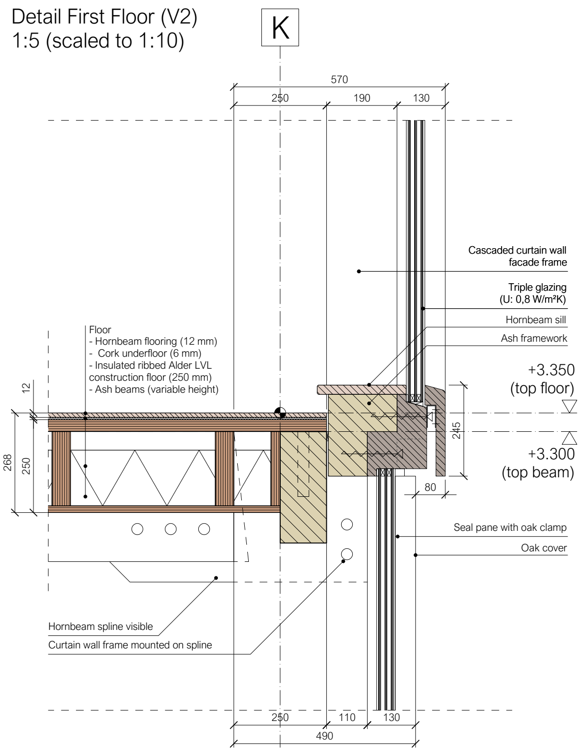
This, together with the cantelevering roof, should allow for the maximum life-span for the cladding.



Detail Ground Floor (V1)
1:5 (scaled to 1:10)

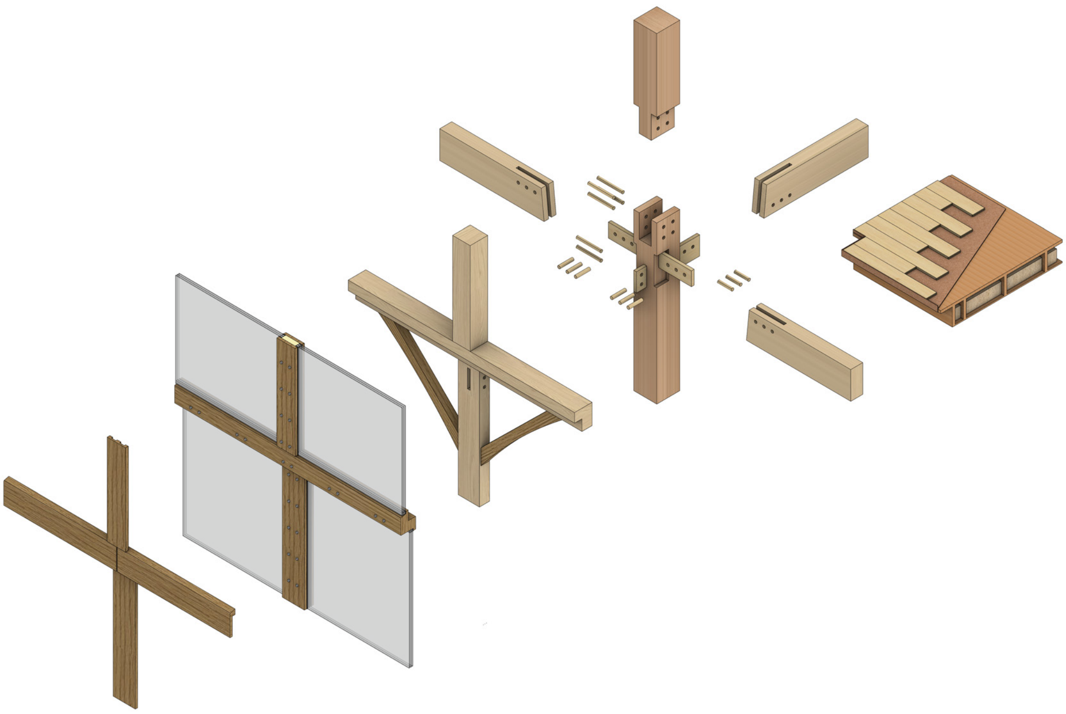


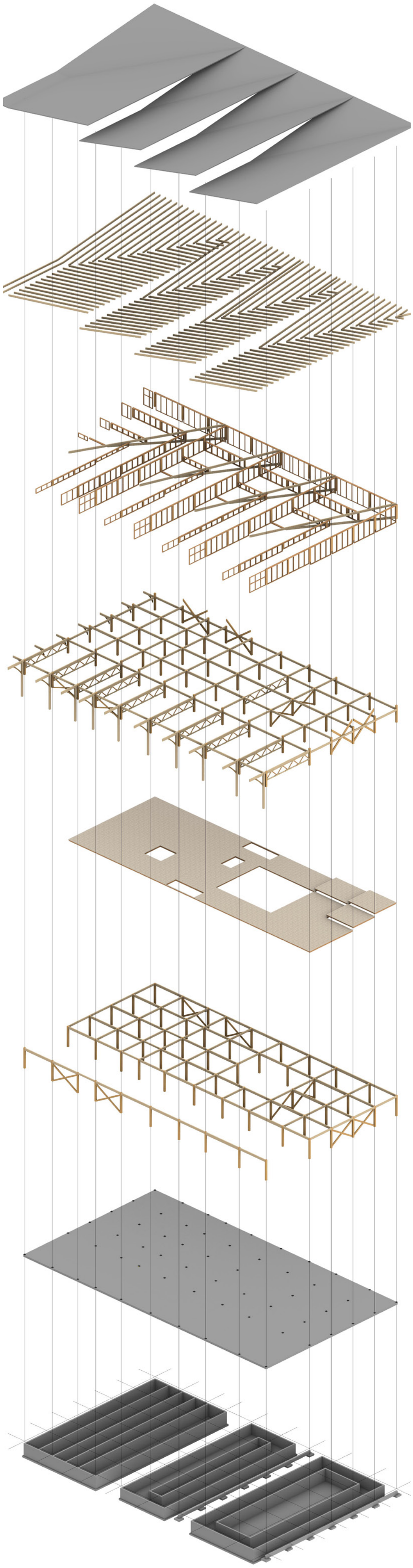
Detail First Floor (V2)
1:5 (scaled to 1:10)

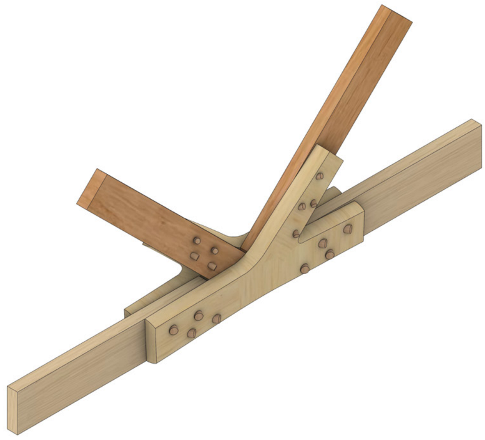


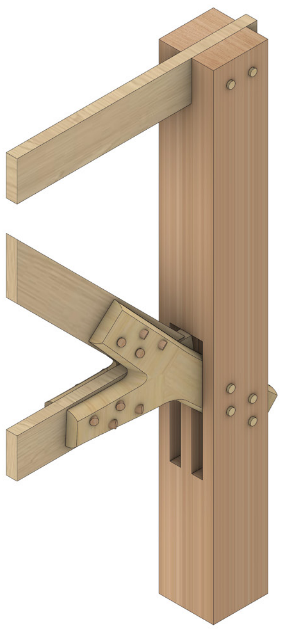
The second aspect I discussed in my presentation is the structural aspect. Through diagrams and matrices I derived from my research, I attempted to explain how I made certain design decisions in my construction nodes. In the feedback session however, this was described as too complex and abstract. During my P5 presentation I will therefore attack this subject from a different, more conceptual and visual angle.

This second aspect is essentially what my research was all about: the right wood, in the right place. I focussed much of my time on developing 3D details with the five wood species, some of which I present here. Based on technical and historical literature and data from performance tests, I made design decisions for the application of these wood species in specific parts of the construction. For example, Ash beams, Beech columns, Hornbeam joints and pegs, Alder truss webs and floor sheathing, and Oak cladding.







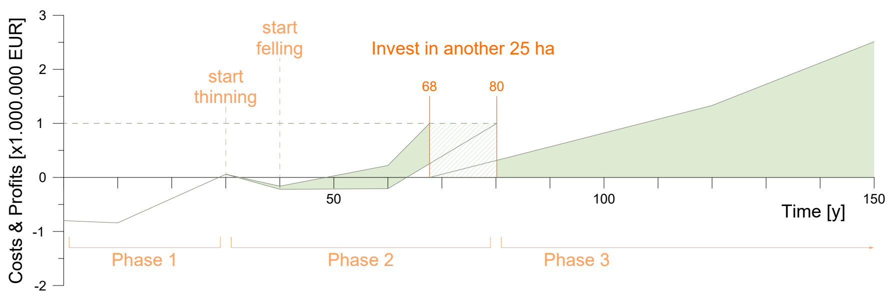


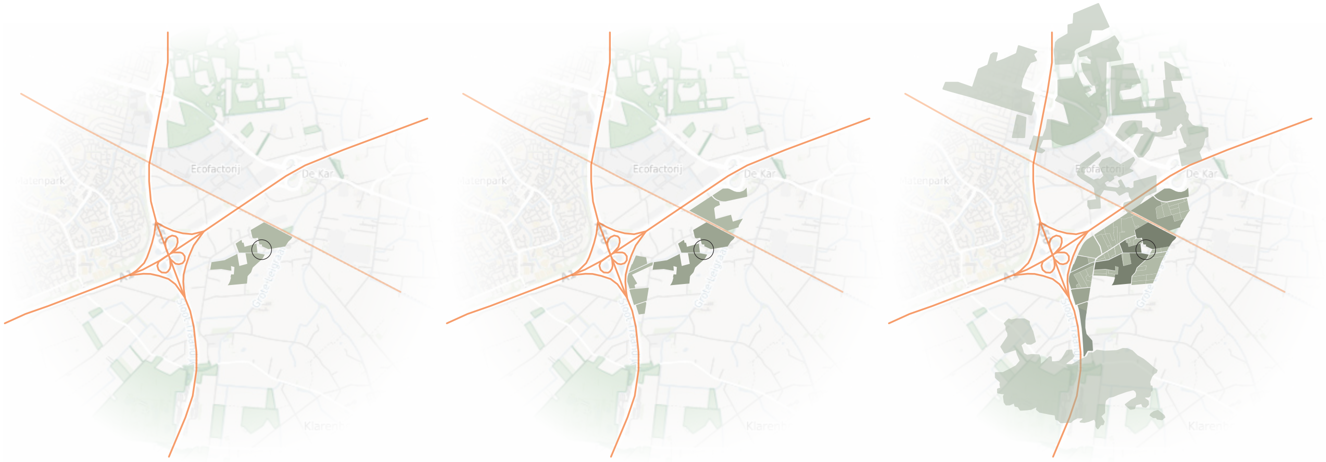
And then lastly, the temporal factor. Just as with the structural aspect, I described the temporal aspect of the design with way to many complicated diagrams and calculations.

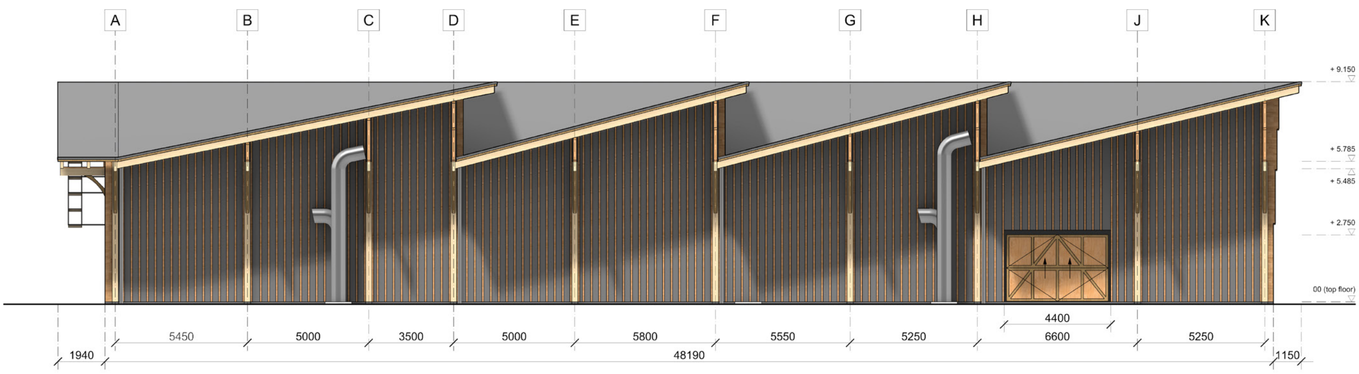
I explained the way in which my design would reflect the growth time of the surrounding forest in different ways. For starters, I tried to limit my use of Oak wood, because the rotation period of the Quercus robur is 130 to 150 years, and my project is realized after approximately 60 years. In my P2 presentation I referred to a diagram showing the financial feasibility of the project in time.

For my P4 presentation however, I had no such diagram. Instead I proceeded to numerically explain how the surrounding 25 hectares of forest would reaccumulate the used wood in approximately 7 years. This method too would need to be different at my P5 presentation.

Indication of financial feasibility





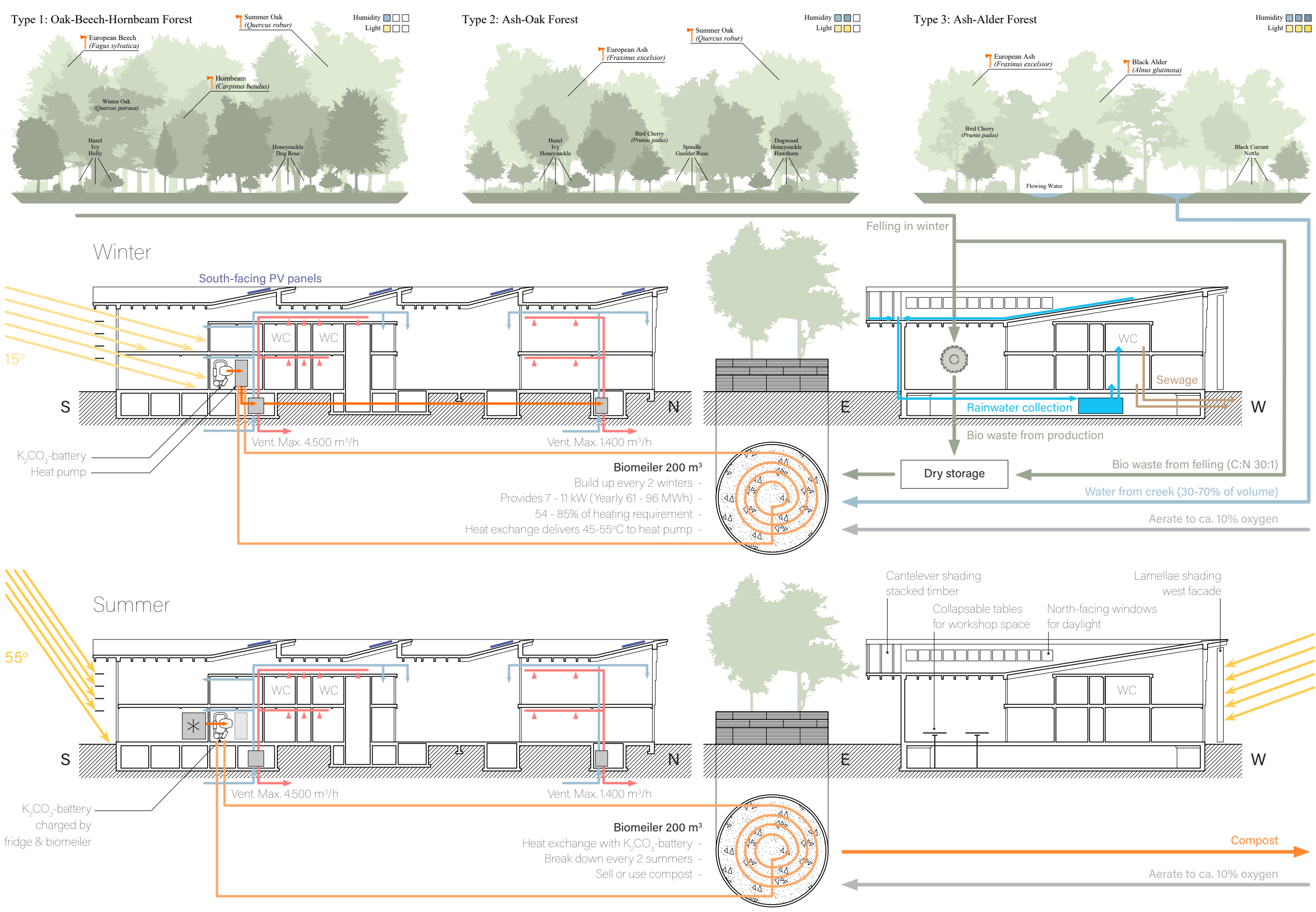


The eastern facade is left bare, as the Oak trees will take another 70-90 years to fully mature.

Two last things I want to highlight are the functionality of the floorplans, and my climate design.

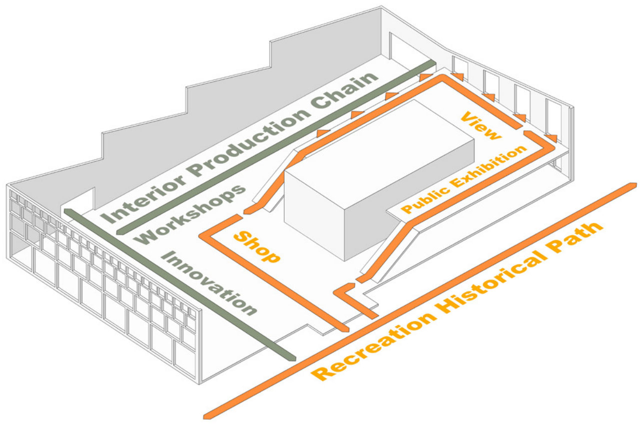
The climate design was based on a biomeiler system; a composting pile that would generate heat from waste flows of the production chain, that through a heat-exchanger would be fed into the ventilation system or a salt-battery, depending on the season. This way, the climate system of the building becomes part of the landscape too.

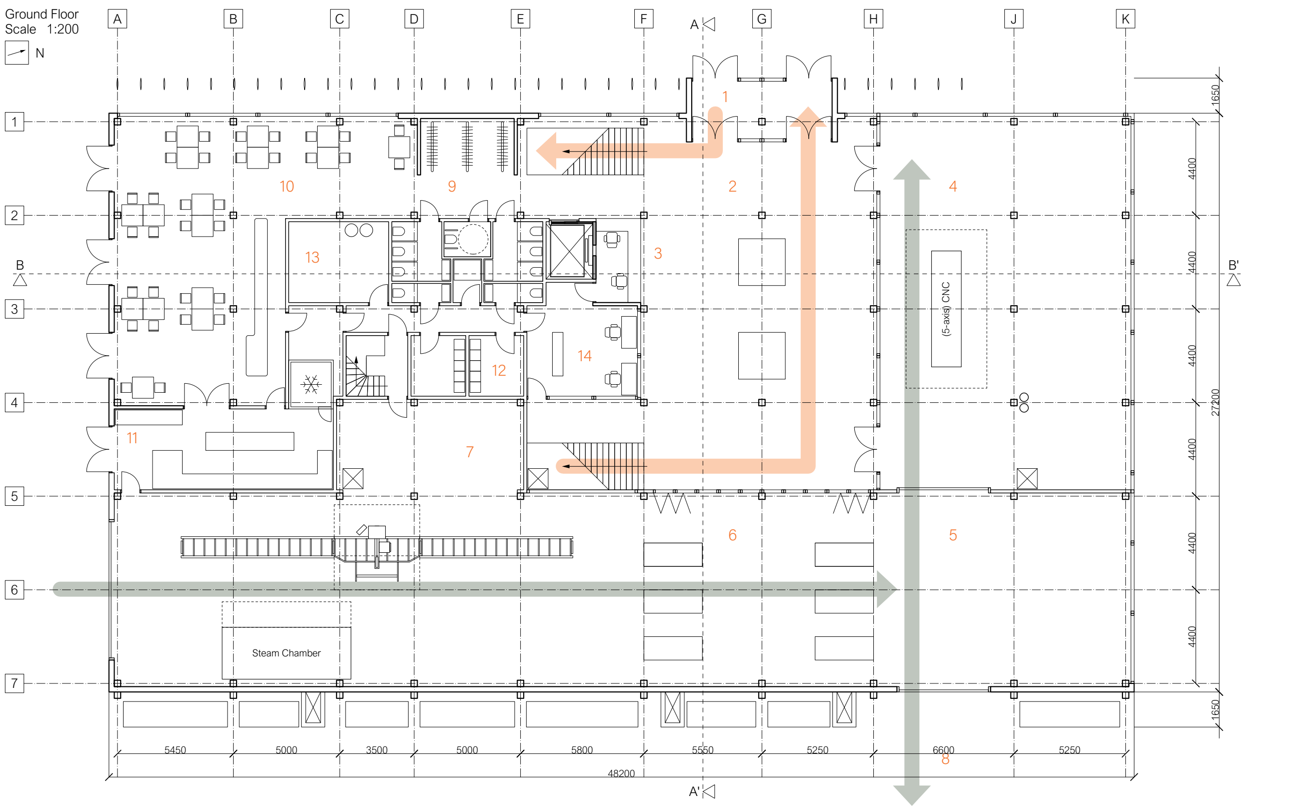
Besides that, the ventilation system is organized within the manure cellars of the existing foundation. The ventilation shafts, as can be seen on the elevation in the previous slide, poke out of the mix pits in the ground, articulating the fact that this project reuses parts of a previous function.



And lastly the floorplans, organized according to a big architectural gesture, making sure that an open sightline is created between the lobby and the production hall. These to spaces are only seperated by an accordion-like glass sliding door. Glass is used all around the lobby, encouraging conversations between innovators, students, personell and visitors.

Finally and most importantly, the exhibition route on the first floor will take visitors on a journy along the production chain, starting with a view over the log pond, running next to the production hall and ending back in the lobby, where people can see the finer production functions in the front of the building. To draw as many people in as possible, a small restaurant was added to the south-west corner of the center, connecting to recreational users of the multifunctional production forest.





P4 Reflection

P4 REFLECTION

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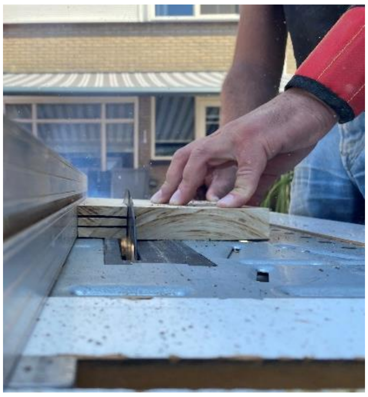
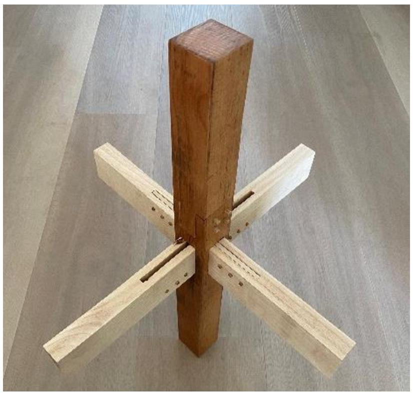
PREFACE

In this document I will be reflecting on the products, process and planning of my graduation project. This reflection will include an elaboration on the approach of my research, and its implementation in my design. I will also discuss the feedback given by my tutors, the way in which I translated that feedback into the project, and finally what I have learned from this project. Before I start however, I will take this opportunity to thank everyone who was directly or indirectly involved in my project this past year.

Firstly, I would like to thank my tutors, Stephan Verkuijlen, Lex van Deudekom and Mo Smit, for their enduring enthusiasm for my project, even when I myself lost faith in it sometimes. They have helped me tremendously to remain structured, to apply simple solutions for many architectural problems, and to find the right people to talk to and the right reference projects to study, so that I was able continue my research and design properly.
One of these people I was introduced to is Max Salzberger from Cologne University of Applied Sciences, with whom I have had several chats about my project. His knowledge and passion for wood in architecture were inexhaustible and very valuable for both my research and design. Besides that, Max was also kind enough to assist me in finding specific materials for a model I am planning to make. I am very grateful for his involvement and his time.
Lastly I want to thank my family members for their support this past year, and especially my father, who has spent several days assisting me in the difficult process of creating a scale model of a hardwood construction node. Without him and his many tools, I would not have been able to complete this model in time, if at all.

Thanks to everyone involved.



I. Introduction

At the start of the graduation year, I was not sure what to research. In the first two weeks however, we were forced to quickly come up with a topic. This fast start helped me to find an approach to deepen my own fascination for wood in architecture. After these two weeks I knew I wanted to create a method to boost production forestry using the termination policy of livestock farms in the Netherlands. After some preliminary research, I knew I would focus specifically on indigenous hardwood in architecture, solving the problem of local standardized plantation-style forestry of coniferous exotics.

II. Reflection on the approach

Explanation of my approach

The approach I came up with, was to separate this complex issue in two distinct parts. In the first part, which constitutes my thematic research paper, I would study literature and data in order to write a strategy for a new production chain, starting from the ideal indigenous landscape, finding the right management techniques and the resulting wood yield, and finally ranking these wood types in an application matrix for load-bearing constructions. This matrix would then function as a guide during my design process.

In the second part of my graduation project, the overall design assignment, I wanted to design the required facilities to put this new wood chain strategy into practice. The goal for this design was to bring the general public closer to the production chain. This resulted in a wood innovation center as a transformation project of a dairy farm in Gelderland. The innovation center would be situated in the midst of a new multifunctional production forest, connecting to a large recreational network to attract visitors. Knowledge derived from my research helped me in many aspects of the design, most important of which was the design of hardwood timber frame construction details.

The diagrams below illustrate the goal of the two parts of my graduation project.

This separation helped me to make a clear distinction between my research and design, which in turn made it possible to easily assess the relation between the two. In other words, my approach provided me with a clear method to apply my research in my design.

Mutual influence of research and design

First of all, the research directly determined the context of my design through the three landscape types that I was able to construct from literary studies. However, the most important contribution of my research to my design, was the knowledge of the specific properties of the different wood types. This enabled me to design interesting nodes and make specific design choices that, in the end, became a significant part of the story.

The design in turn made me aware of the limitations of my research. I could for example have included more studies on carpentry rather than fixating on history, silviculture and physical analyses and data. This would have given deeper insight into the practicalities of woodworking with uncommon wood types in construction. Moreover, whilst designing I was critiqued on a missing link between the temporality of the landscape in relation to my architecture. As requested by my tutors, this resulted in me adding a section to the discussion of my thematic research paper as well as an example calculation in my P4 presentation.

Assessment of my approach

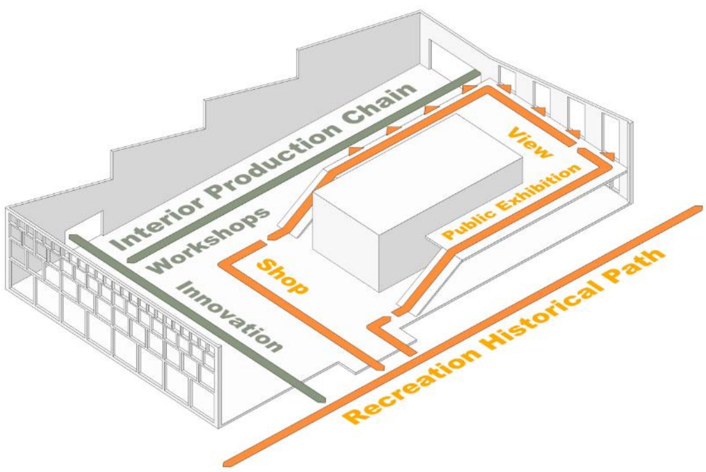
To conclude, although my design process was sometimes quite messy and slow, my approach to this graduation project allowed me to restructure and regain control over my actual goals and intentions. I often overthink my design choices, and I often get mixed up in details that are not necessarily essential to the goal of the project. My method enabled me to look back at my research and refresh the intentions that I had while writing it. Every time I reread my problem statement and looked back at my diagrams, I could continue designing with more clarity.

III. Reflection on the feedback

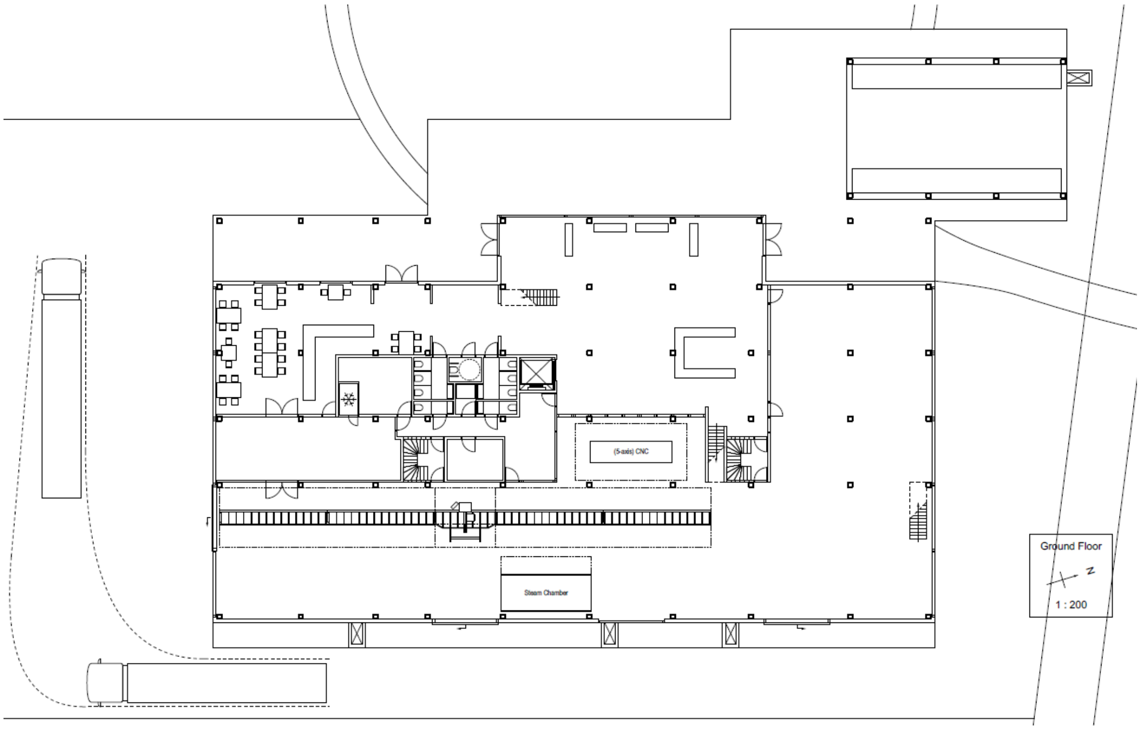
In this section I will reflect on the given feedback, I will explain how I processed that feedback, and what I have learned from the feedback and the design process as a whole. First of all, I will elaborate on some general feedback that I have gotten throughout the entire year.

Given feedback and translation into the project

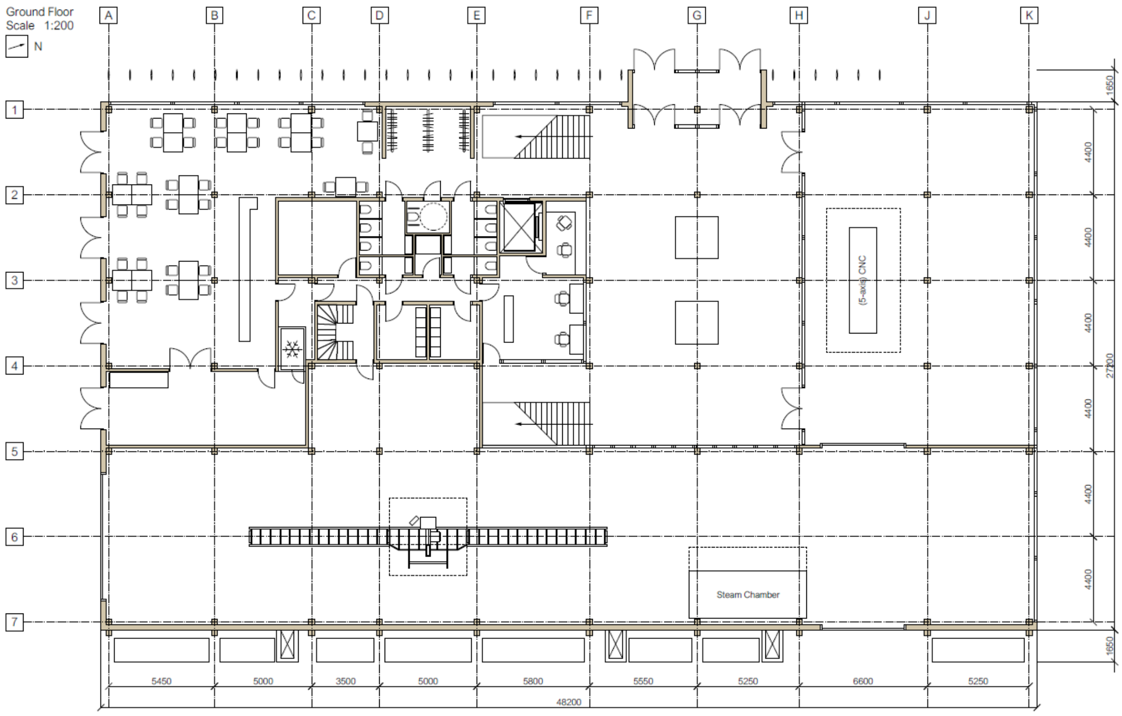
My tutors constantly had to remind me to stay focused and to retain some structure in my project. As said before, I easily lose myself in insignificant details. Having tutors around to keep me on track was very helpful. Especially Stephan Verkuijlen often reminded me to think about what I want to present. What is the thing that I am trying to achieve, and how do I get there? He, together with some fellow students also commented on the fact that I tend to make too many concessions in the design. Because I tend to lose structure, I lose the ability to make strong gestures in my project. For this specific issue, I was told to study the project library of Herzog & de Meuron, as they are known for their - what I call - architecture without compromise. This had a major impact on the functionality of my design after my P3 presentation. This evolution can be best explained by comparing floorplans of my P3 and P4 assessments (see next page), the latter of which shows a clear core, open sightlines, and simple routing that fits the function of the building, illustrated by the diagram to the right.



Floorplan P3 (not to scale):

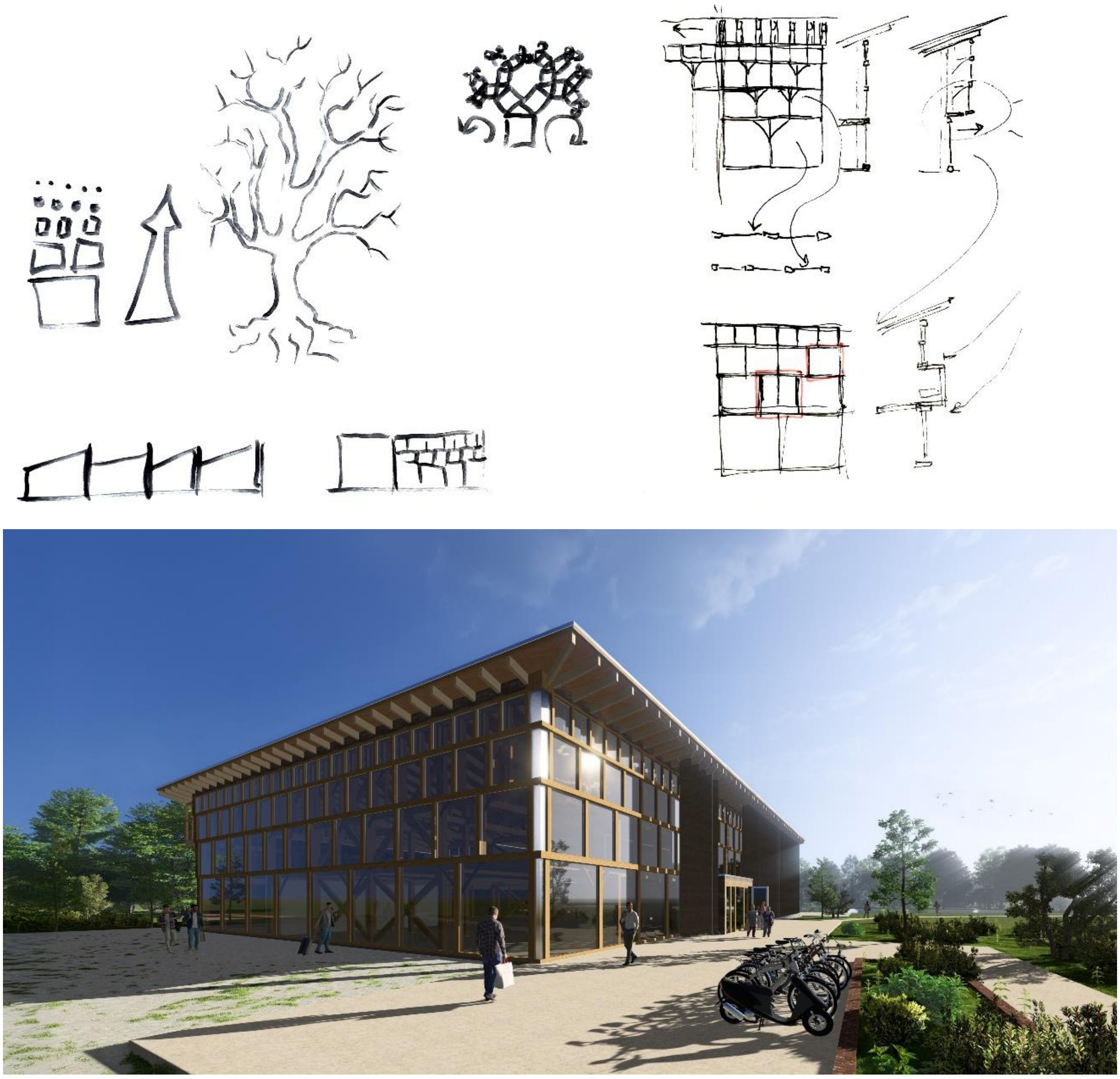


Floorplan P4 (not to scale):



Additionally, I benefitted greatly from the enthusiasm and confirmation that my tutors often gave me. I have discovered that whenever I work on one project for a long time, my motivation, appreciation and satisfaction decline exponentially. The same thing happens at my job too. I quickly lose sight of the aspects in my design that are rather special, resulting in a persistent imposter phenomenon (at least, that is what it feels like to me).

Therefore it was helpful to have tutors that point out the qualities in my design. My facade system for example is a direct result of this confirmation, as my tutors encouraged me to further develop one of my earliest sketches. This system later became an important part of my story, explaining the relationship between my architecture, building materials and the landscape.



Early sketches and final render

I will now mention some more specific pieces of feedback that I deemed important in my graduation project.

First of all, I was made aware of several reference projects, such as wineries and other industrial buildings. These references helped me especially during the massing phase of the design process, which took way longer than it should have, as I could not find a suitable morphology for the building.

Secondly, my delegate of the board of examiners, Stefano Corbo, advised me to look into public buildings, especially data centers, to see how they handle the interaction between production and people. This feedback eventually influenced my climate design of the building, as I was able to think about reusing flows of waste materials as a source of heat. This enabled me to integrate the climate design into the interaction between landscape and architecture, further strengthening my story.

Thirdly, as said before, I was also told to think about the missing link between the temporality of the landscape in relation to my architecture. This had an impact on my facade, as I imagined an incomplete system where the exterior finish, oak wood, would be missing due to its long rotation period (of 150 years).

Fourthly, my chats with Max Saltzberger, which in itself was an advice given by my main tutor, were helpful in designing my construction nodes, as I was able to tap into his vast knowledge on woodworking. Additionally, some of his comments made be confident that I was on the right track with my research and design. He for example proclaimed my application matrix (the conclusion of my research) valuable for the field of wood architecture, and he encouraged me to further develop details that I made, as he liked where it was going.

Of course, half a year of tutoring involves much more feedback than just that. For example, with feedback from my architecture tutor, Stephan Verkuijlen, I adapted my facade multiple times to give it more depth. My technical tutor, Lex van Deudekom, helped me to simplify details and to realize my inverse roof geometry. My research tutor, Mo Smit, encouraged me to build a physical model of a construction node, from which I learned a great deal. And finally, my tutors also advised me to visit the location, and talk to the farmer, to discover more about the existing structure on which I was designing my building. From this, I not only learned about the substructure of the cow stables, but also about the process of growing grass, milking the cows, storing the milk (even extracting heat from it), processing manure and more about the nitrogen crisis.

What I have learned from my own project

Besides learning how to run a dairy farm, I also learned a thing or two from my graduation project.

First of all, I came to realize that I tend to set the bar too high at the start. This causes me to drop ideas and intentions down the line, which in turn gives me a feeling of failure. Instead I should try to focus more on one specific target in a project. This would, I think, immediately result in stronger architecture (without compromise). For example, I intended at the start to also design bridges in the project, to design the entire landscape as well as the building in its direct context, or to research all indigenous wood types of the Netherlands. Of course, these ideas never made the final cut, due to time limitations and in order to retain some structure in my story.

Additionally, I learned a lot about wood. So much in fact, that I can consider it a new obsession. I am even considering making a few small furniture items for myself, when I finally have some time for hobbies. My own research, but also the talks with Max Salzberger, were eye-opening for me. From silviculture to architecture, from molecular structure to mechanical performance, I know so much more about wood production and application than before I started my graduation. I hope to further develop this knowledge in my career.

IV. Reflection on societal and academic implications

In this section I will reflect on how my project fits into my entire Bachelor and Master program, as well as how it fits into society as a whole, including some ethical aspects as well as the transferability of my research and design within the context of Dutch agriculture, silviculture and the wood production chain.

Relation to Bachelor and Master

During my graduation project I finally realized that I really love detailing, especially with wood. I have enjoyed making intricate details in previous projects too, and I have always been complimented on them. On the other hand, I never enjoyed the bigger picture that much, which is why I did not choose the Landscape Architecture or Urbanism track. Additionally, I always found myself designing with wood structures instead of steel or concrete, as I liked the aesthetics and the ecological benefits of the material. It therefore comes as no surprise that I took this opportunity to deeply study mechanical properties and wood joinery on a detail level. Considering that only a year prior to my graduation, I was picking all kinds of electives and topics to research, I think this really shows that I have been able to narrow down my own fascinations in the past year.

Societal implications and ethics

As stated in my research paper, my project intends to solve the issue of ecological degradation due to a standardized wood chain, by imagining a new wood construction strategy with resilient indigenous forestry as a starting point. This subject fits into a variety of contemporary societal narratives and crises, such as the nitrogen crisis, climate change, local material production, biobased building, political instability (and the reliance on import), biodiversity, and many more. I therefore think my project is a valuable contribution to the position that architecture has within these issues. Of course, due to time constraints, my research is fairly limited in some regards. In my paper I therefore suggest new directions of research for the future.

In terms of ethics, there is one subject that I want to highlight. When I started this project, my view on agriculture was somewhat negative, due to its portrayal in the media in discussions on nitrogen deposition. Therefore I thought I wanted to create a story, utilizing the voluntary buy-out policy of agricultural land as a driving force for a large-scale change that would positively impact the building sector; hence the idea of production forestry as a main topic of interest. I came to realize however, that this politically sensitive topic is much more nuanced than I thought.

The farmer I had the opportunity to talk to, pointed out that the Netherlands is the most advanced agricultural country in the world. Diminishing this sector will thus impact the importance of our country in the global economy. Additionally, according to him, the sector is being disproportionally blamed for nitrogen pollution. He mentioned Danish research, which supposedly concludes that nitrogen deposition does not reach as far as our official models would suggest. Moreover, he explained how the water system running through his land is polluted more by the drainage of the highway, than by his own activities. Lastly, he pointed out the hypocrisy of having to export manure (from his land), and import fertilizer, even though he would be perfectly able to create a closed cycle of food and waste on his dairy farm.

This has rendered me unsure whether utilizing the termination policy of livestock farms as an opportunity to advance the interests of the building sector is ethically correct. Actively attempting to profit from potential political missteps seems like a moral compromise. Therefore I am curious to see in what way the political climate is going to change in the coming years, regarding the subject of agriculture and the nitrogen crisis.

Transferability of results

As I mentioned before, my research is limited in many ways. I once had the intention to study all relevant indigenous wood types of the Netherlands, before demarcating a specific location (Gelderland). This however means that the results of my research and design are transferable to a certain extent. Research into wood types in other regions would result in a different application matrix, which would in turn result in different wood constructions, and thus, a different architecture. I envision a world in which there are several wood innovation centers scattered throughout the Netherlands, each specializing in the predominant local wood species. I believe the wood architecture narrative would profit from such a network of innovation, education and frankly, recreation.

On a smaller scale though, my project is directly transferable to any other project. Learning to design with wood can play a major role in any biobased project. With that comes an understanding of the subtle differences in performance of different wood species. Any designer can use my application matrix as a guide to design appropriate wood constructions for their project.

V. PERSONAL REFLECTION

What was left out?

Throughout my graduation year, I have come up with several ideas that I was not able to translate into my final project. For example, I wanted to see whether Beech leaves would constitute a suitable insulation material, considering that they were historically used in mattresses and they degrade slowly. I was planning on testing the heat conductive properties of Beech leaves myself, however, as this plan was not directly part of my scope, I chose to leave it.

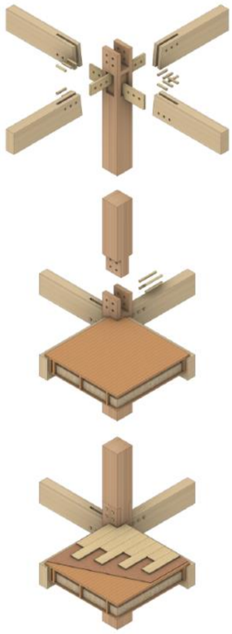
I also would have liked to spend another semester further elaborating my research. I could have gone more in depth on many specific wood-related issues, such as the effect of moisture or the best method of milling the logs. I could also have broadened the research, taking into account more wood types. Whilst designing I came to the conclusion that five wood types, of which one could barely be used due to its long rotation period, is a limited material library to draw from. If I researched more wood species, I would have had more variation in my final design.

Finally, I also was not able to fully design several secondary functions of my project. I already mentioned the idea to design bridges in the landscape plan, however I also planned on creating bird-spotting facilities in existing food silos. Furthermore, I was not able to complete the landscape plan and smaller satellite buildings to my own satisfaction. Nevertheless, this in my opinion shows personal growth in being able to regain focus on what is important for my project.

What am I most proud of?

I am most proud of the direct translation of the conclusion of my research into my design. I have used my application matrix to construct intricate timber frame details with different wood types, resulting in nodes that express the function of each part through the color and pattern of the wood. This, I believe, is a good example of the quality of architectural tectonics.

I am happy with the simplicity of the design, the clear proof of concept for my application matrix, and I am very proud of the 1:5 scale model I made together with my father, using the specific wood types that I researched.



Application ranking matrix for five wood types in load-bearing constructions

		Black Alder	European Ash	European Beech	Hornbeam	Summer Oak
Truss construction	Top chord (rafter)	B	G	G	M (limited size)	G
	Bottom chord (tie)	M	G	G	M (limited size)	G
	Web member (strut)	M	G	G	E	G
	Web member (tie)	G	G	G	E	G
	Zero-force members	G	G	G	G	G
	Nodes, joints, pegs	B	E	G (as dowels)	E	G
Post & beam constr.	Posts & columns	B	G	G	M (limited size)	G
	Beams & purlins	B	E	G	M (limited size)	G
	Braces	B	G	G	M (limited size)	G
	Knee braces	B	G	G (universalist)	G	G (universalist)
Platform-frame construction	Sills or Soles	B	G (if durable)	B (moisture)	M (limited size)	E (durability)
	Studs (vertical)	M	G	G	M (limited size)	G
	Top plates	M	G	G	M (limited size)	G
	Headers & lintels	B	E	G	E (short span)	G
	Floor joists	B	E	G	E (short span)	G
	Rim joists	M	G	G (universalist)	M (limited size)	G (universalist)
	Sheathing	E	G	G	G	G
Misc.	Foundation piles	E	M	B (moisture)	M	G
	Foundation beams	B	M	B (moisture)	M	E

Note: E = Excellent ; G = Good ; M = Moderate ; B = Bad

The appreciations in the matrix are based on the literature as discussed in the thematic research paper (paragraph 3.4), the comparative analysis of mechanical properties (see appx. C), as well as personal communications with Max Salzberger from Cologne University of Applied Sciences (M. Saltzberger, personal communications, January 7 2025).

VI. Planning the final steps

After my P4 presentation I have got exactly five weeks to finish my graduation project. From experience I know that this is not a lot of time, considering having to hand in physical materials such as posters and lasercutting templates well in advance. Therefore I will try to limit my goals and plan the required time to achieve these goals.

What to I plan on adding after my P4?

First of all, due to hardware limitations, I was not able to make as many renders as I would have liked. I will try again before my P5 to make renders, especially of important parts in the interior of the innovation center. Secondly, I will finish my final report, including hopefully all of my relevant sketches and drawings in chronological order. Thirdly, I am thinking of creating a small scale site model, with help of the lasercutter at the faculty. This means that I have to make a template file, and deliver that in time, taking into account the fact that I have to build the model afterwards. Finally, I want to make another scale model of a construction node, using a crotched Hornbeam branch that Max Salzberger was able to provide me with. This will take me at least 3 days to make, possibly including a day to drive to Cologne to retrieve the forked branch. Meanwhile, I will also (probably) have to process some final feedback of my tutors. Some of this feedback may have an impact across multiple drawings that I would therefore have to adapt.

P5

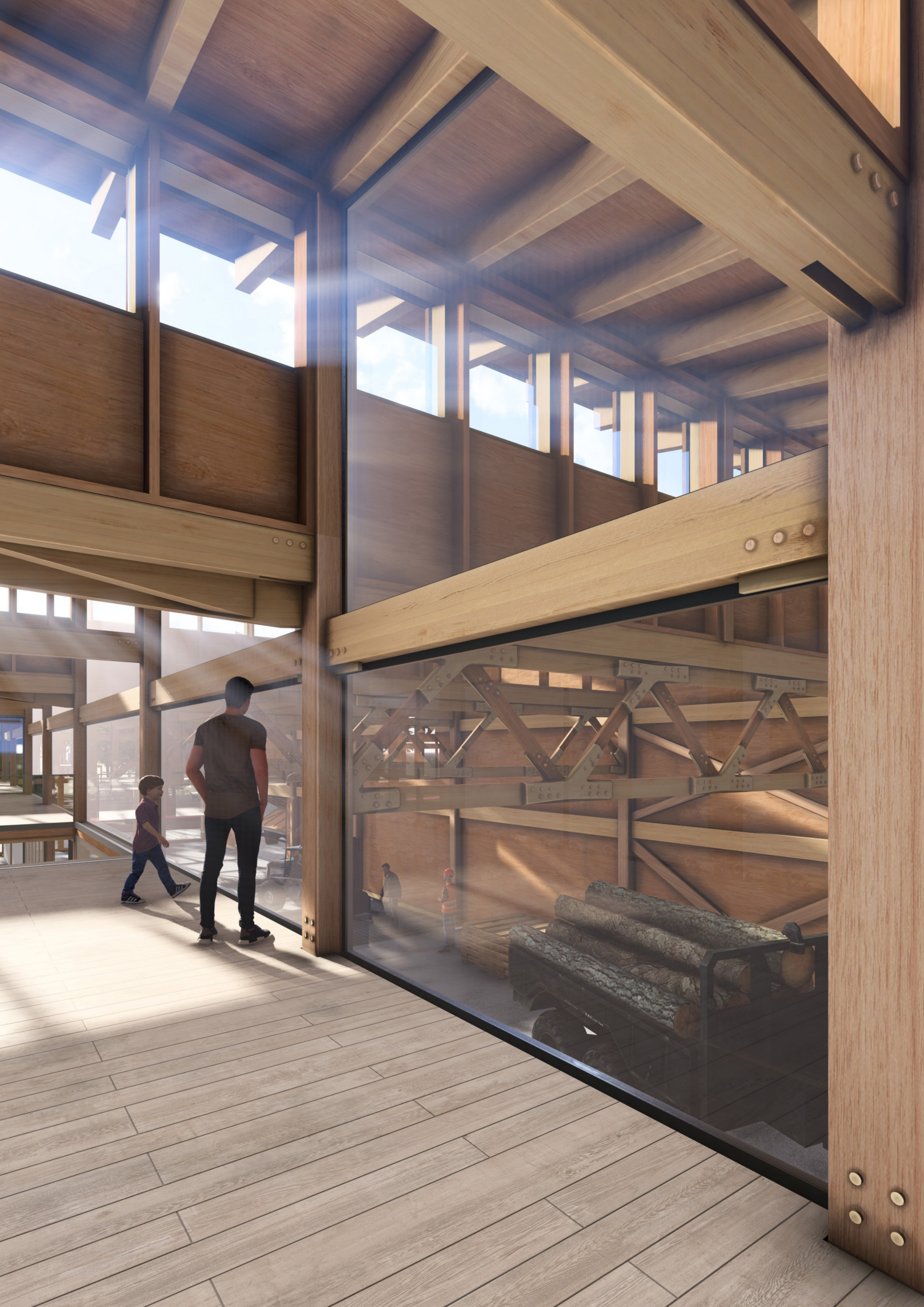
Introduction

In this final chapter, I will present the last products and changes I made for my public P5 presentation. The feedback at my P4 presentation served as a guideline for how to continue.

Most comments could be explained by me simply not showing what I was talking about exactly. Rather than diagrams, I used numbers. Rather than an eleborate routing scheme where I show how people and production meet one-another, I had an oversimplified isometric sketch. Rather than showing the construction in the building through nice interior renders, I only had 3D details of construction nodes.

The consequence was that the entire story stayed somewhat abstract. The challenge for me, besides completing more renders, diagrams and models, was to visually clarify the interrelationships between the different aspects of my design. And that is what I did the past four weeks.

But before I get into all the changes, first I would like to show you the process and finished product for my second construction node model: a 1:2 model for a truss joint.



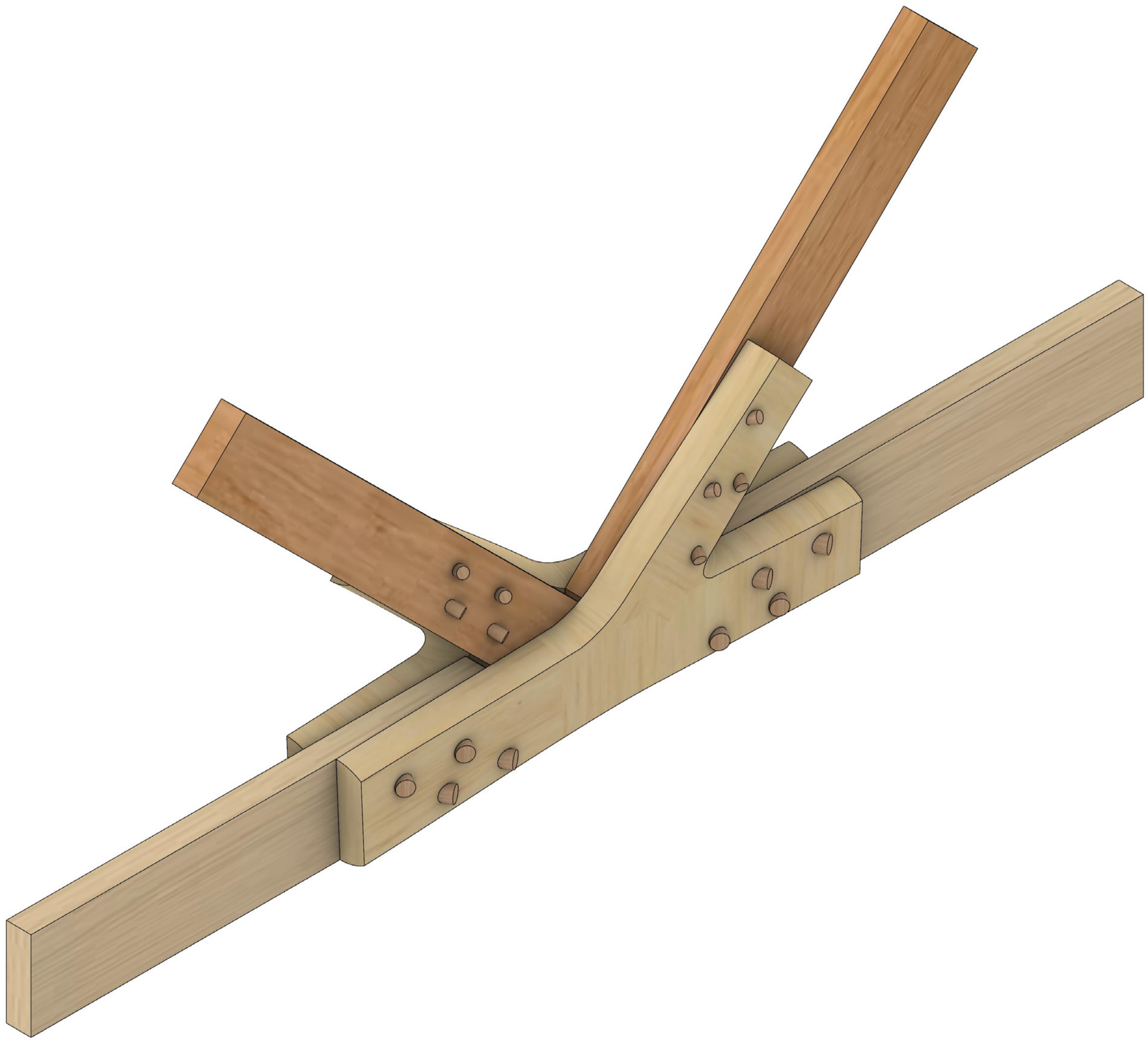
Model 2

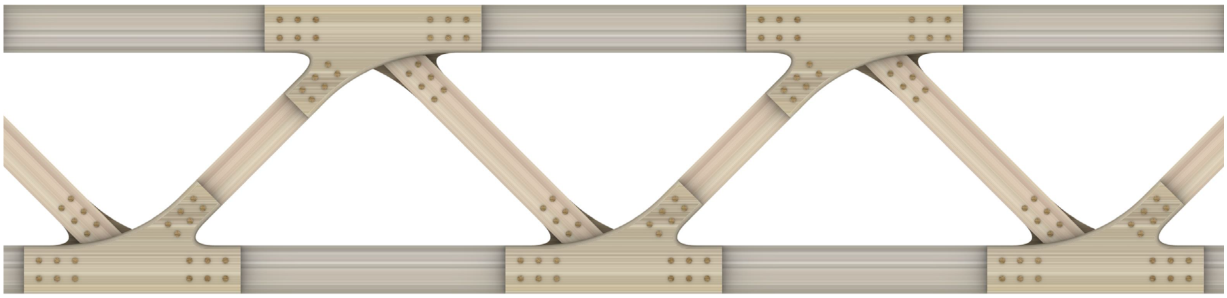
Before I started working on this model, I was sceptical whether I could pull it off. Aquiring the branches for the joint was hard enough already, and I could not have done it without the help of Max Salzberger (thanks again Max).

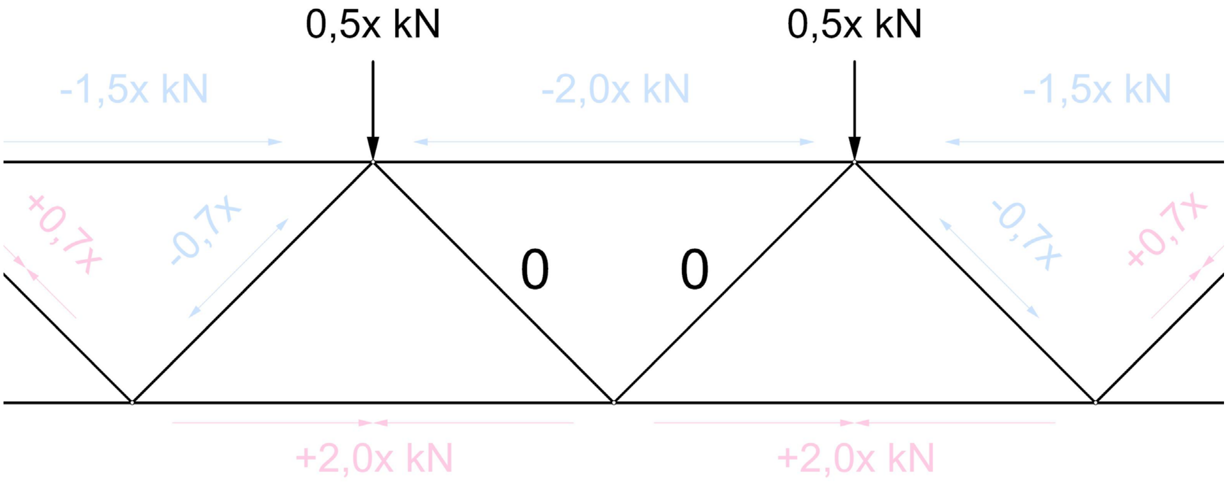
The branches were needed as an alternative to steel connection plates, which are usually used when making wooden trusses. Steel is a homogenous material, unlike wood, which means that it can easily take loads in varying directions. Wood can usually take loads best along only one axis. When however we take a branch, the wood fibres are weaved together in such a way that forces can also be applied under an angle. This is the main concept for this truss node.

For this to work, I had to cut a forked Hornbeam branch in half along its length axis. Together with my dad, we did this by hand, sawing through the toughest naturally occuring wood in the Netherlands with a meter long tree saw, after drawing a straight line across the fork using a laser as a guide. Two days it took us to complete this task, after which I could continue the rest of the process, such as sawing the chords and members, and drilling for dowels.

The total process took about a week, but I am surprisingly satisfied with the end result. The prototype did warp somewhat, however this does not seem to impact the strenght or constitution of the joint that much. I can actually say that I feel like this method might be applicable in practice, especially considering professional equipment.. and professional people.



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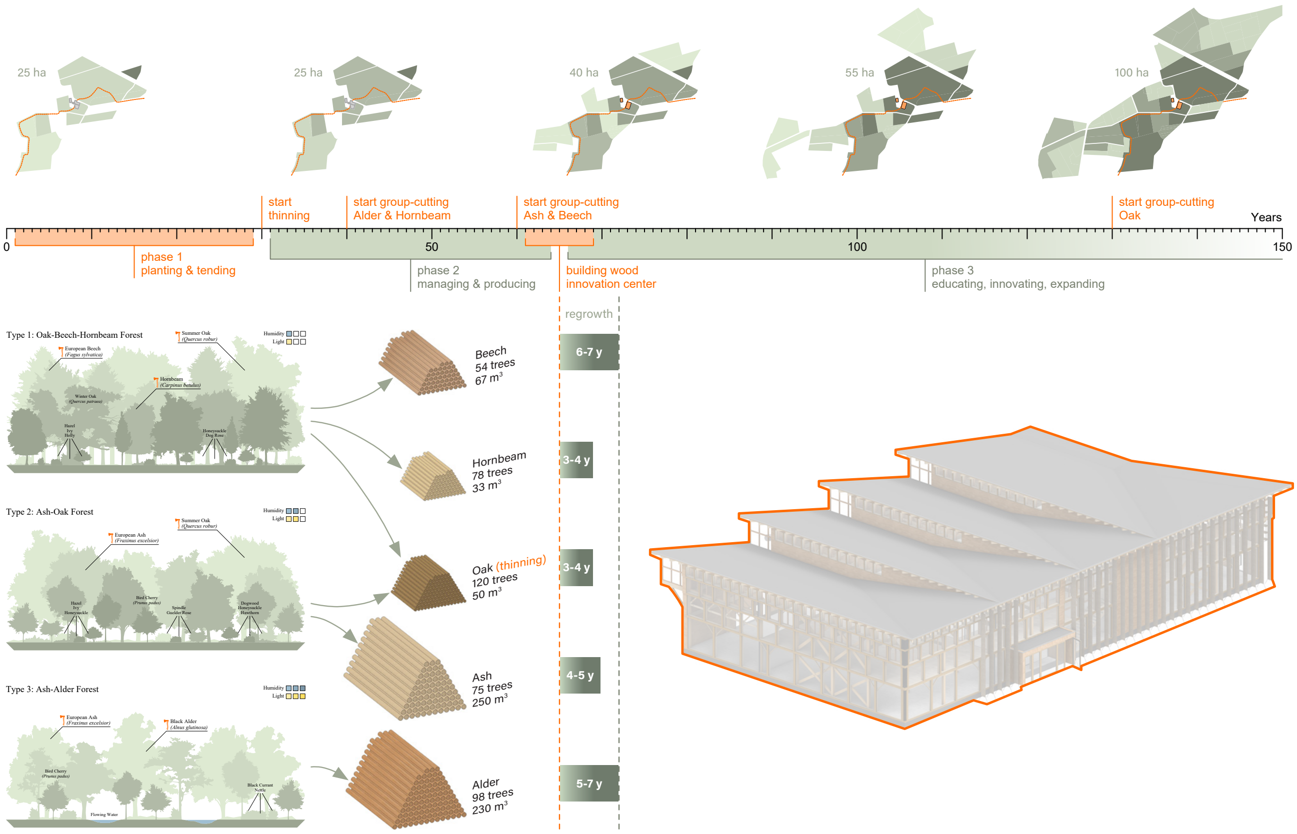
P5

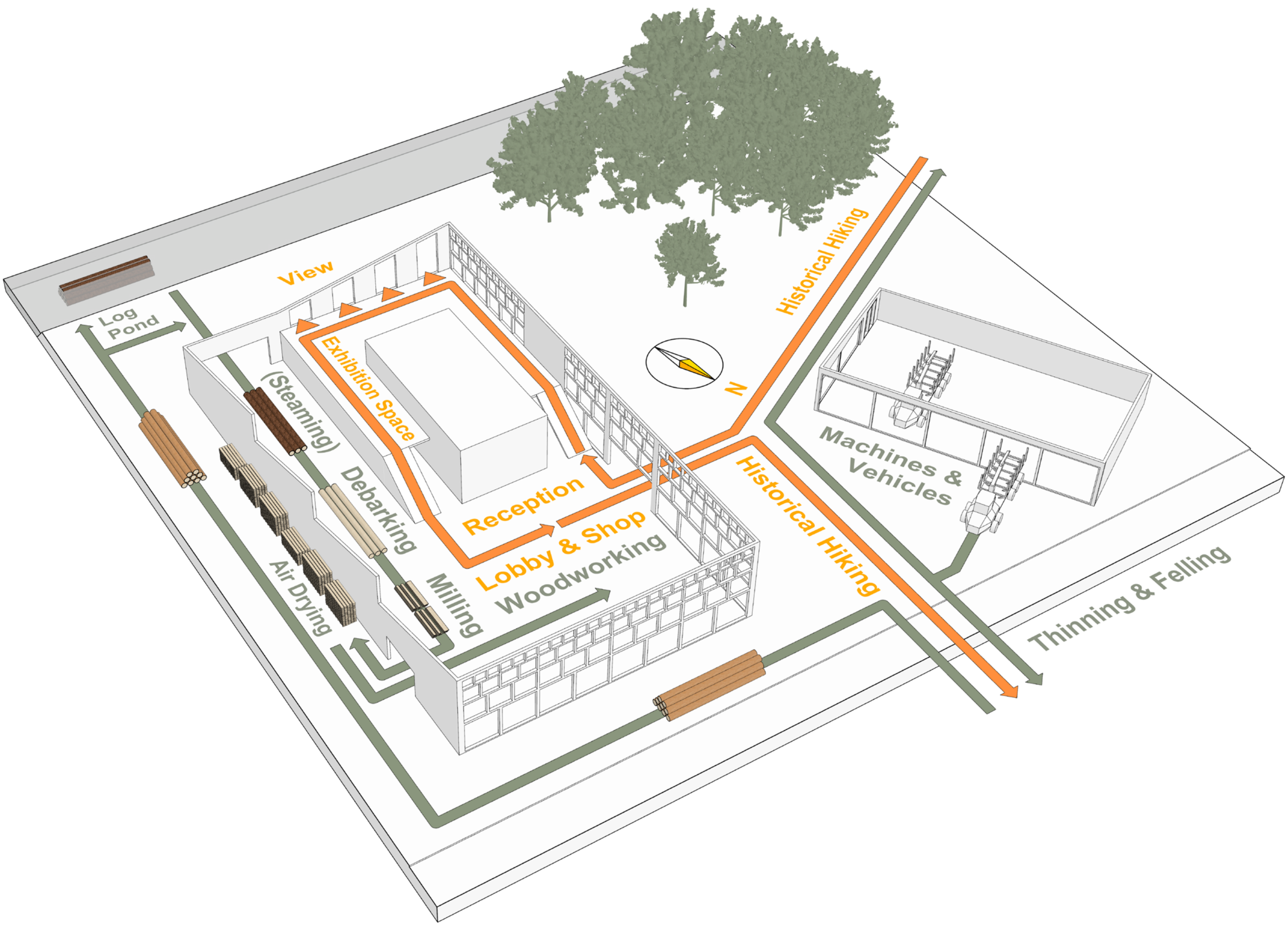
Final Changes

The first changes I made, was the way in which I explained either a very abstract theme, such as the temporality in my design, or a complex functionality, such as the way in which people are exposed to the production chain. I made two new diagrams to explain these matters more thouroughly and visually.

The top diagram to the right shows a timeline, with the landscape maturing and expanding above it. We read some important moments in time, such as key management decisions and the start of the building process of my innovation center. We can also see the three landscape types, and the amount of wood that was taken from these forests in order to construct the innovation center. Lastly, we can see how much time it takes for these forests to reaccumulate the used wood.

The bottom diagram shows the routing through the site and the building of people (orange) and the production chain (green). We see how people are directed through the exhibition space on the first floor, and how they have the ability to see each step of the production chain, of which some are mentioned.

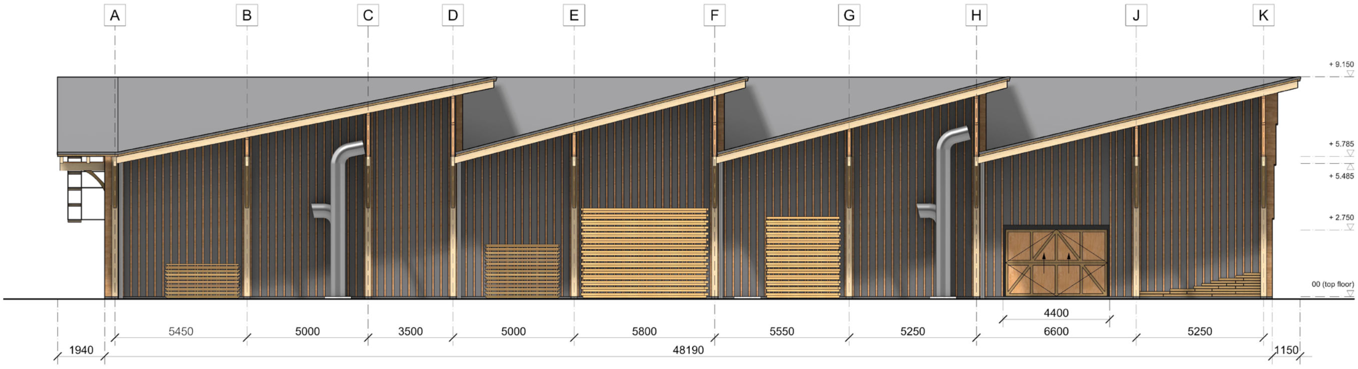

25 ha
25 ha
40 ha
55 ha
100 ha
start thinning
start group-cutting Alder & Hornbeam
start group-cutting Ash & Beech
start group-cutting Oak
Years
0
50
100
150
phase 1 planting & tending
phase 2 managing & producing
building wood innovation center
phase 3 educating, innovating, expanding
regrowth
Type 1: Oak-Beech-Hornbeam Forest
Type 2: Ash-Oak Forest
Type 3: Ash-Alder Forest
Beech 54 trees 67 m³
Hornbeam 78 trees 33 m³
Oak (thinning) 120 trees 50 m³
Ash 75 trees 250 m³
Alder 98 trees 230 m³
6-7 y
3-4 y
3-4 y
4-5 y
5-7 y


View
Log Pond
Exhibition Space
(Steaming)
Debarking
Air Drying
Milling
Reception
Lobby & Shop
Woodworking
Historical Hiking
Historical Hiking
N
Machines & Vehicles
Thinning & Felling

Another change I made was in the elevations. Previously, I did not show the stacked timber that was supposed to be there in front of the east facade, drying to the air, even though this was an important bit in my story. I also highlighted the idea of the Oak cladding expanding as the surrounding forest matures, with a simple diagram.

And obviously, the work did not end there. I would like to close off this final chapter with a line-up of my last three renders. These images were made to connect the final loose dots of my story. They should present the visibility of the architectural tectonics I introduced through my research and my construction nodes. They are meant to show the functional transparency between the visitors and the production chain. Lastly, they had to clarify the position of the building in its context.

These might not be my final drawings, but I will end it here as, ironically, I have to finish writing this final report at some point too. I hope my P5 presentation goes well. See you the 24th of June.


A
B
C
D
E
F
G
H
J
K
+ 9.150
+ 5.785
+ 5.485
+ 2.750
00 (top floor)
4400
5450
5000
3500
5000
5800
5550
5250
6600
5250
1940
48190
1150