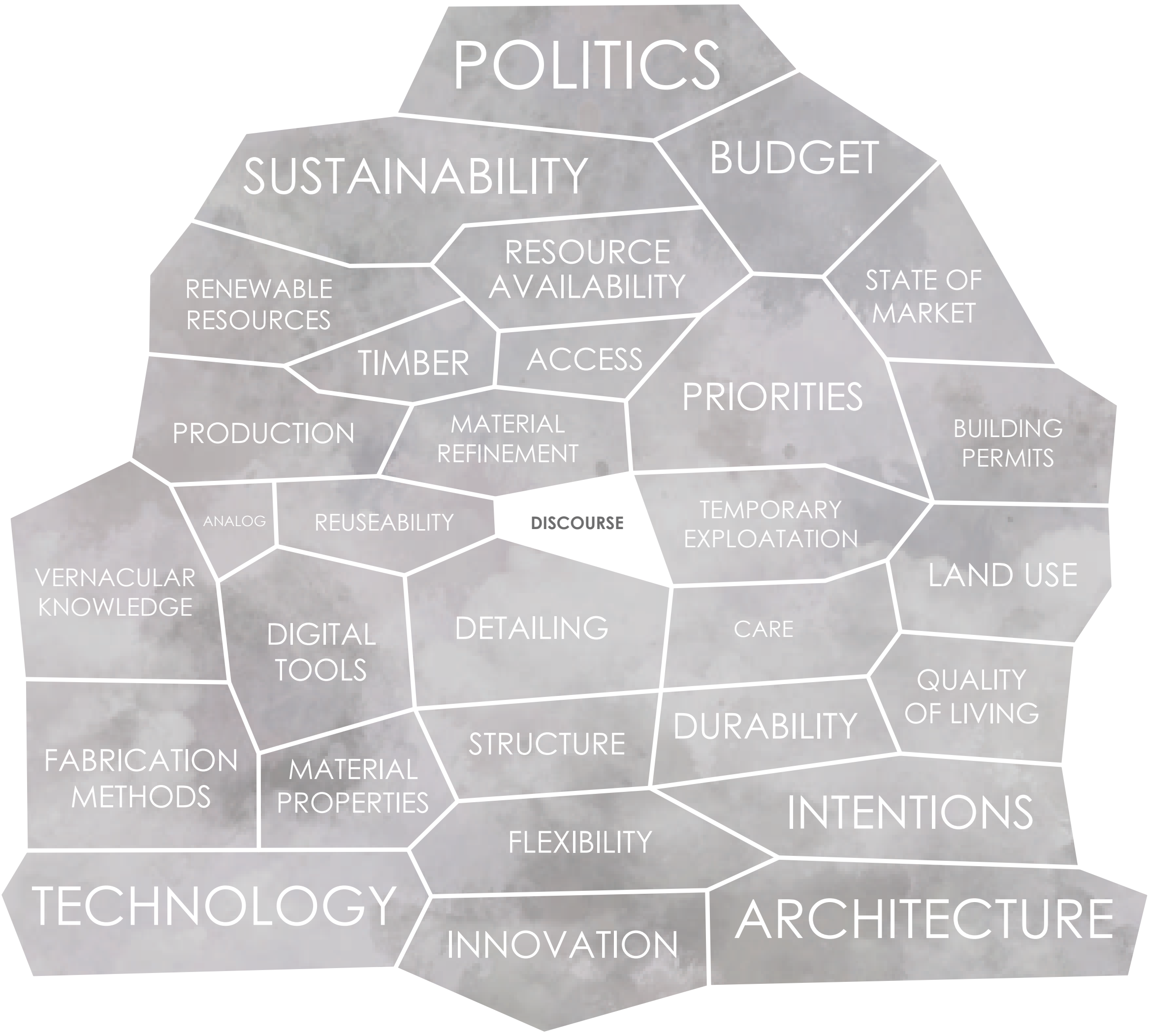
EXPOSED ORIGIN

A STUDY ON INTERLOCKING UNREFINED TIMBER ELEMENTS
– BASED ON THE PRINCIPLE OF LOG NOTCHING

2018 Ossian Quigley-Berg
Examiner: Daniel Norell
Tutors: J. Runberger,
J. Lundberg, K. Skorick

2018
Exposed Origin
Ossian Quigley-Berg
Chalmers School of Architecture
Examiner Daniel Norell
Tutor J. Lundberg, J. Runberger, K. Skorick
Architecture and Urban Design



Discourse diagram describing related subjects, spreading out to the more general domains of architecture, politics and technology.

Abstract

Timber construction is in a renaissance where new projects feature solutions that before seemed impossible to achieve with its physical restrictions. Everything from tall buildings, complex shapes and intricate prefabricated systems is boosted by the demand for more sustainable alternatives and made more efficient by digitally aided tools.

Today engineers and architects generate shapes and joinery no human could render by hand within reasonable time. Wood has been proven to be a suitable material when transferring analogue tool technology to be operated by robots with nearly impeccable precision. However, the often hands-on and verbal passing of knowledge regarding vernacular skills and wisdom about the material and its properties in different stages of refinement is regarded as nostalgia and never adapted to modern fabrication methods of the industrial and digital era. When evaluating the traditional skill and care for the resource, the criteria play well with that of sustainable values of today; a local and renewable source of material that more unrefined and untreated have less impact on the environment and climate. Furthermore, log houses, or more generally- notched timber constructions is based on a modular concept, making it moveable, easy to disassemble, reconfigure or extend without major destruction of components – arguably an asset as situations change. There are projects exploring new ways to handle imperfections that come with unrefined material for construction. Laser scanning and software get more efficient in helping to bring the inherited properties of the raw material into new light. Nevertheless, these experiments often end up more oriented towards optimizing material and tool methods whereas concepts for architectural purpose and typology is lacking in the discussion.

Taking these aspects into consideration, this thesis have investigated the elemental qualities of unrefined timber by synthesizing knowledge from both the vernacular and contemporary spectrum in regards to the notched timber technique. In context to the modern refinement process as a key source of reasoning, the work presented state the log as its physical limitation yet main element of focus for the design proposal. By adopting old- and creating new techniques, the findings from studies and tests conducted has aided the re-imaginative approach towards finding other properties of the interlocking raw timber concept. By reinterpreting the log building technique the proposed design, situated in connection to a temporary preschool in Gothenburg, showcase architectural possibilities with a contemporary profile and highlight the variance of the concept with pivotal points in spatial qualities as well as the appearance and esthetics.

Contact information

Ossian Quigley-Berg
Born 30th January, 1989
q.ossian@gmail.com
+46 739 84 76 72

Relevant Education

Chalmers University of Technology
Gothenburg 2012-15, 17-18

Norwegian University of Technology
Trondheim 2016-17

Relevant Work

Erseus Arkitekter
Gothenburg 2015-16

Student background

As part of a growing interest for timber architecture I went to Trondheim, Norway to study courses better oriented in the subject. The goal was to increase my skills by for me the best learning method – 1:1 construction combined with verbal learning. I had the opportunity to learn from one of the best Scandinavian architect and carpenter; Sami Rintala with colleagues. Also working closely with engineering professor Jan Helge Siem to realize a project in Orkanger, close to Trondheim I learned a lot through communicating detailing through drawings and testing. Exposing myself to these people that possess a deep knowledge within the field my confidence was boosted and has abled me to enlarge my library of tools and basic knowledge regarding architecture with a timber driven approach.

Originally I've been raised and part of a family business where the trait is photography and graphic design. I believe in a position as an architecture student this have helped me to communicate ideas better, being selective and clear about material that I produce. However, I've currently noticed that my focus is more honed towards tectonics and materiality, trying to better understand what make up our physical world through architecture, where wood has become the medium. My grandmother and her siblings where part of a family company that owned a lumberyard so maybe this is a subconscious way for me to close the loop and connect to my roots.

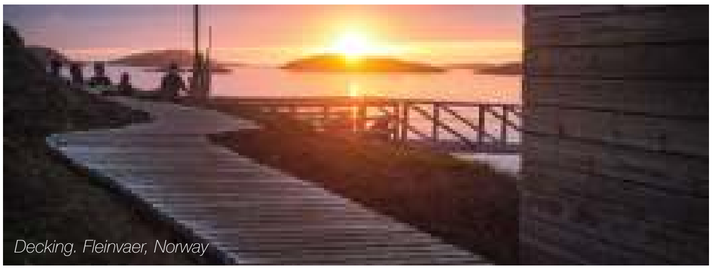

Debarking and cutting logs
Valsoya, Noray


"Wood masonry" fire house
Valsoya, Norway.

Framing- river tide observatory
Orkanger, Norway


Glulam steel plate fitting, Trondheim, Norway


Pine furniture. Private project


Decking. Fleinvaer, Norway


Cladding for river tide observatory
Orkanger, Norway


Building decking from context.
Fleinvaer, Norway


Laminated and treated birch frame for
Hessdalen hut. Trondheim, Norway.


Curvy plywood staircase mockup lamination.
Trondheim Norway.


Larch shingled hut for Hessdalen
UFO-observers. Trondheim, Norway

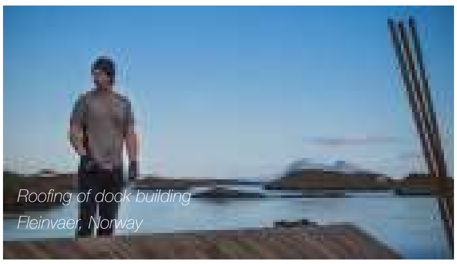

Roofing of dock building
Fleinvaer, Norway

Table of Content

KEY WORDS

Lumber / Timber
Interlocking
Contemporary
Modular

Introduction

Wood – a material that is present in everyday life, from the frame of your bed to constructive components in the buildings where we experience our contemporary reality. The name encircles a wide range of products and entities that is subcategorized due to the way it is configured, used or made (or not made). The collective we call forest is constructed by the individual – the tree that we perceive as living until the intersection that severs the trunk from the roots that provide nourishment. In a way the tree is neither alive nor dead as its anatomy rules out the other at the same time, only dependent on what the observer decide what is living apart from dead. A fallen tree decaying in the forest is still alive in the sense that it provides for other forms of life and the next generations to come. We mammals do not do this to the same way as we mostly trade consumed energy for heat and the ability to move. When our time is up there is little stored energy left for others. Even if part of our expiration is used in the trees' photosynthesis we do not share the same way of life. So who are we to decide when it is ended?

The tree is in many cultures a valued symbol of a religious or metaphorical narrative. But in a time where this type of outlook on life is becoming rarer, the symbolism of trees and wood becomes one of the last fingers we still have on the hand that is grasping on to a world drifting into a semi-digital cosmos. Meaning it being a strong link to nature in contrast to materials we do not possess any personal relation to how they were made or what they are composed of. Wood also being a hygroscopic* material; it shrinks, swell, twists and skew long after the day of supposed death, changing color and texture making it alive in some manner for us due to its ability to display time, context and use.

From the moment of the thud from a fallen tree hitting the ground we change the name and call it lumber. As soon as we know what to do with it, it's called timber and from there on the subtraction, division and addition of the material index the category and the use. Beams, planks, veneer etc. speak for the capacity, size and suitable use.

This thesis explores the future use of the log (the individual that composes lumber) rather than the historical aspects of it. The term 'log building' is weighed down by its heritage and traditional values revolving around activities that are linked to the historical and modern function. Words like skiing, hunting or hiking is rigidly connected to the structural system of the log building, something that other ways of building generally do not have. This blocks an important vain to innovation that helps look forward by looking backwards which this thesis is attempting to high light. By diversifying the discussion through an architectural design process this thesis intends to question this categorization and show a variety of ideas regarding the typology made from interlocking logs.

Background

Scandinavia and Russia a couple of thousand years ago - the people of the land where more reliant on their surroundings to survive. Where to secure food, water and shelter was a greater challenge in everyday life of that time. But this life also gave you a type of knowledge that we do not have to rely on today. Awareness of your surroundings especially what resources that can be found and how they can be used. The building style based on notching timber dates back to even prehistoric times as it is a very efficient way to shape space and shelter in this part of the world where tall, straight trees are thriving. Since then the skill has evolved, passed on through verbal and practical channels, resulting in many styles, variations and traditions based on the local material and access to tools. What the styles and different sizes of this typology have in common is that every log and bit of wood used has been carefully selected and shaped to fit and to perform. Awareness of climate, weather and the care needed to maintain the buildings have resulted in a rich heritage of everything between churches and cabins with a life span exceeding a millennia or even more sometimes.

The constructive system of log notching where one element is places on top of the other and then interlock can be classified as a non-permanent structure. This was key in a pre-industrial setting when depleted farmlands was left and storage and safe keeping facilities could be brought along to new places. Families in search for prosperous land could reuse the parts of an old log house to build up a new one on site without wasting energy on finding and felling suitable trees. As time progressed and the industrial revolution caused rapid urbanization, more and more people started to fit together in a smaller space. A lack of the regulations and fire preventing design in combination with heating and cooking on a direct source of heat, many fires broke out and spread to wipe out entire districts in cities. This resulted in regulations that prohibited wood as main material in buildings set in urban context. As Larsson (2016) describes the Swedish timber construction regulations before restricted the height of wooden buildings to two floors in height. After this was revised in 1995 the chances for architects and developers to realize larger projects with focus on invention was better. Although projects using laminated wood and other newer products emerged long before this, the trend of tall structural timber buildings is still present today.

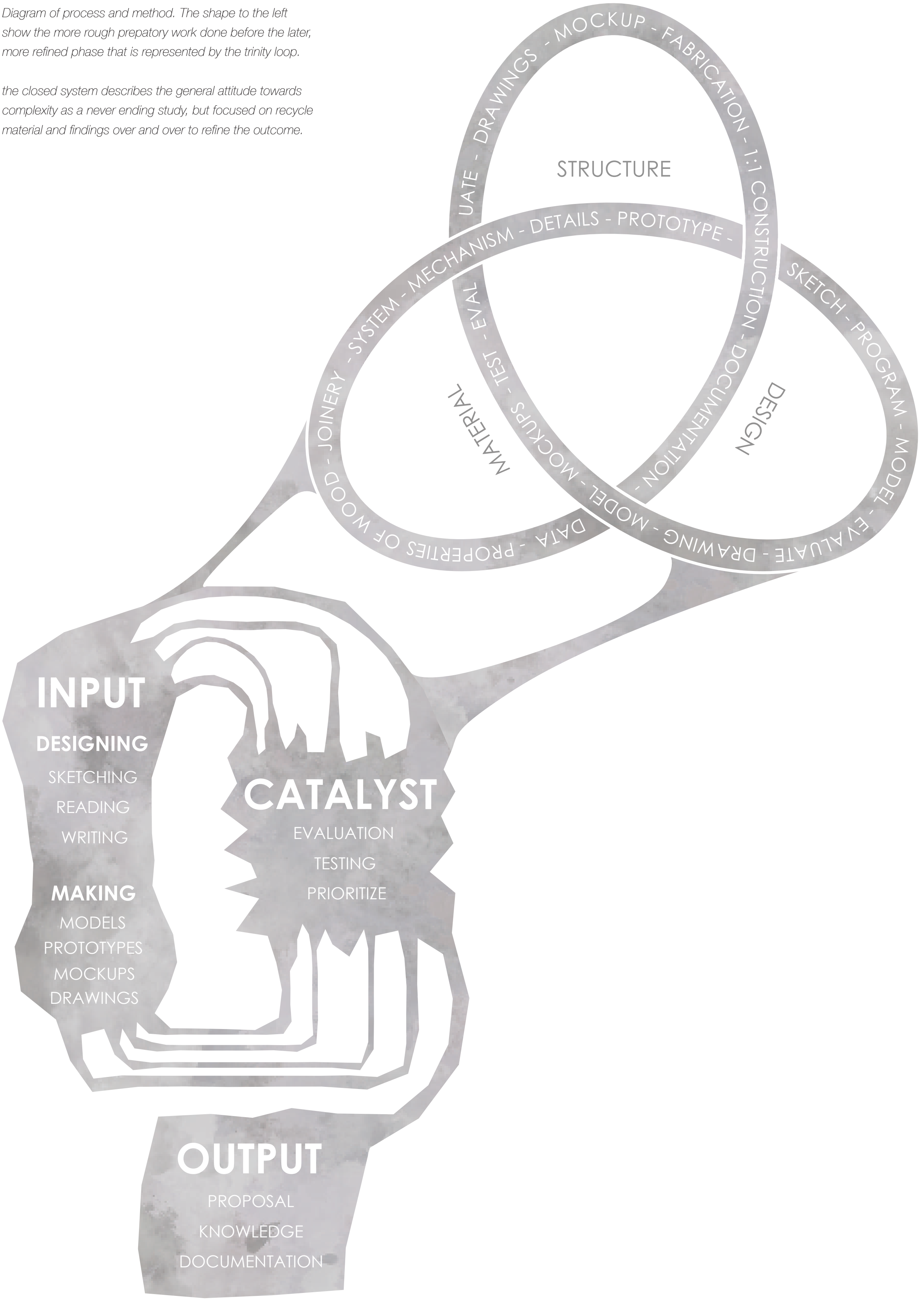
Furthermore the debate regarding sustainable development and the emission of carbon dioxide from the construction sector has weighed in favor for the use of wood as Oliver et al. (2014) confirm. This has boosted investment in the field making forest and timber industry lobbyism stronger, resulting in a greater use of wood products in buildings. The industry is and has for many hundreds of years mainly been based on plantations as a reliable method to control the resource. Both larger industries and smaller business rely on this method. Despite the fact that the harvest amount and period is regulated by laws and restricted by seasons and growth rate, inclination in economic value is the main driver for the volume of harvested trees at a certain point. Meaning; when the price goes up, more trees are cut- if it goes down, the land owner can wait for a swing in the market to increase profit. Another major part of harvesting is rejuvenating patches of forest, removing trees to create better circumstances for the ones left. (Sveaskog, n.d.). All of these aspects has together with more modern harvesting methods and the ability to analyze larger data resulted in a process where trees precisely harvested in mass with up to 90 trees per hour and then sorted and cut with the purpose to optimize the output after current price and demands. Even if the Nordic countries has a higher regeneration of planted forest than what is being harvested, the method has been criticized by environmental protection agencies for impairing biodiversity and affect species that will have a negative impact on forestry in the future. (Naturskyddsföreningen, 2014)

The market oriented process has also driven the cultivation of fast growing species of trees that have better protection against deceases and grow straighter with fewer knots. But this has been dependent on the quality of timber, creating a greater percentage of sapwood that is not as resilient as heart wood which is found in great proportion in slow growing trees. More slow growing species that historically where used had a greater variance but was then selected and planned for in context to their use. The general selection of material today is followed by classification that is based on a strict visual assessment. Knots, faults in grain and color are dominant parameters when deciding the quality of wood, something that a lot of carpenters and smaller manufacturers are aware of and do not agree upon. Instead they do an internal assessment of quality and buy smaller quantities of material from local suppliers, looking at the amount of heart wood and other parameters that can tell about the quality of the material when relying on quality in the unrefined wood itself for structural purposes. The lower quality timber is part of the reason for the increase of engineered wood, taking low grade wood, cutting into short pieces that has less flaws and gluing together in a controlled order to create massive elements that has a wider range of usability. But this is on the expense of energy and waste that is the back side of any refinement process.

Digital fabrication used by both small and big manufacturers is increasing speed, precision and amplifying creativity by interdisciplinary work with robotics and material research. Having the output of a skilled carpenter at the tip of your hands has only quite recently liberated designers by access to digital aid, sharing skills and not limit the design to standardized wood products and fittings. The industrial refinement process is also relying more on robotics and digitalized systems to sort and create dimensional material but the aim is rarely to try new creative solutions but to increase value and efficiency, which cancels out the opportunity to deeper knowledge about the raw material that in fact is the shape, origin and growth of the tree.

Diagram of process and method. The shape to the left show the more rough prepatory work done before the later, more refined phase that is represented by the trinity loop.

the closed system describes the general attitude towards complexity as a never ending study, but focused on recycle material and findings over and over to refine the outcome.



Purpose

The purpose of this thesis is to innovate and test a new way of designing with unrefined timber in the realm of contemporary architecture. Additionally, it poses a questioning of the prejudices about “log buildings” and their image. Lastly by critically reviewing the quality of refined wood today, the thesis aspire to transmit knowledge of the material to other architects and designers.

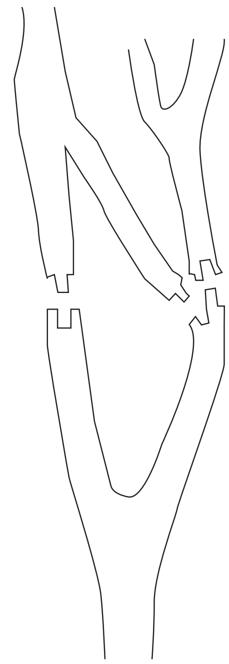
Thesis question

In what way can an interlocking building system based on raw timber elements, with limited refinement make use of digitally aided design tools and vernacular knowledge to add to the diversity among the typology of massive timber constructions?

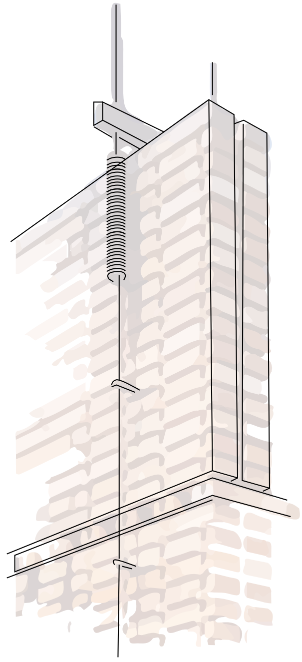
Additional question:
What type of innovative transformation of the design criteria can challenge the perceived architectural identity of log based constructions, without losing the functionality of the element?

Method

The work flow of moving back and forth between making and reflection as shown in the diagrams cyclical momentum has contributed to the wholeness of the thesis. The tools contributing to the appearance of the design proposal is general digital modelling, in combination with geometry based computational scripting, using knowledge about material and the refinement process as parameters. Models and mockups have been more focused towards testing fabrication methods, to see consequences of certain design features.



Concept diagram of the principle used in the wood chip barn. Non- uniform pieces of trees are mapped ,catalogued and then put togehter to create the structure.



Tension spring detail that keeps unfixed wood pieces together, allowing for movement in the material even though compressed down.

Built references

At a macro perspective the whole refinement process is well documented as both research as industry representatives are keen on displaying their knowledge bank in public. The reason for this openness is not certain but the forest industry is a big part of the national identity among Scandinavian countries and taking pride in it boosts awareness and there by economic influence. This thesis rely on these references in combination with experience, notes by the author and documented knowledge about wood and log notching.

The first reference, the wood chip barn (2016) that was designed and fabricated by tutors and students at the satellite campus 'Design+make' of the AA was useful for the thesis with the intention being a use of the inherited properties of wood – and the log in particular. It is a progressive and inventive project that uses 3D scanning and scripting to join the crooked geometry of the trees as components for the grand truss that carries the roof. As computation to fabrication is of importance to this thesis it is on target with the precision in joinery and assembly aspects. With the proposal in mind, the Swiss pavilion, or 'soundbox', designed by Peter Zumthor was used for this study to extract the prototypical quality of the joinery method. Using this influence, prototypes and testing of a new design to fit the interlocking logs that is part of the proposal. A second prototype extracted is the fact that the pavilion later was demolished, but that the wood could be sold as a product with patina. This aspect of not putting permanent pieces of metal or other materials fixed to the wood is something that was the goal for this project.

Swiss pavilion - Peter Zumthor (2000)

Image 1, Wood chip barn by Design + Make (2016)

Map of Europe, highlighted area of delimitation, together with irrelevant species of trees.

Delimitations

This thesis context and questioning is mainly based on a general perspective on the refinement process in Scandinavia, taking in to consideration both current methods and old that are to some extent still in use. It will not research deep into the industry abroad with the intent to limit the focus with local timber supplies and placing a smaller target to enable core questioning. Furthermore, the products in focus are that of industrialized fabrication of material from Pine and Spruce for construction. The log is the yardstick that defines the main elements used, so other solutions for example laminated and treated timber is part of the design but more as content of compliment.

Regarding sustainability and CO2 emission the thesis will not clarify or argue for or against despite beneficial pros in comparative studies with other materials. It might occur phrasing that can be interpreted as a pro-ecological or environmental friendly under tone. It is an important topic and in a best case scenario something that is strengthening our civilization's progress but will not be treated as a case here, leaving that to expert with a clearer stated objective approach that provide data.

Fire hazard is always prominent when discussing combustible material choices, especially wood with its history. This topic has a clear division of its own with many aspects to consider, but since numerous massive wood building have been erected proving its solutions and can tackle the problem satisfactory this topic will not be part of this thesis.

Glossary

To justify the explanations about the material this thesis will be consistent with the terms that follows:

Wood:	The material as a name - can be used as prefix for example "Wood Products"
Forest:	A human planted collection of trees used as resource bank, not being old natural forests.
Log:	Fresh or dried tree trunk that has not been shaped.
Lumber:	Collective name for logs or other raw material.
Timber:	Collective name for logs that have been sawn or shaped with an intention for construction.
Notch:	Joint cut from wood with the intetion to fit next or on top of another joint.

Terminology regarding engineered timber products will commonly be used in form of abbreviations:

CLT:	Cross laminated timber
ICLT:	Interlocking Cross Laminated Timber
xSL:	Laminated/Parallell Strand lumber
LVL:	Laminated veneer lumber (plywood)
NLT:	Nail laminated Timber
DLT:	Dowel Laminated Timber

PROPOSAL

A COMPLEMENTARY STRUCTURE FOR A PRESCHOOL AND ITS LOCAL CONTEXT.

The Exposed Origin Conservatory

A conservatory, a two level pathway with an en¬closure and a noise barrier form the proposal is the result of this investigation of interlocking timber. The outcome speak for the potential to create freeform timber structures with robust strength and potential to be produced through the fabrication techniques explored in this thesis.

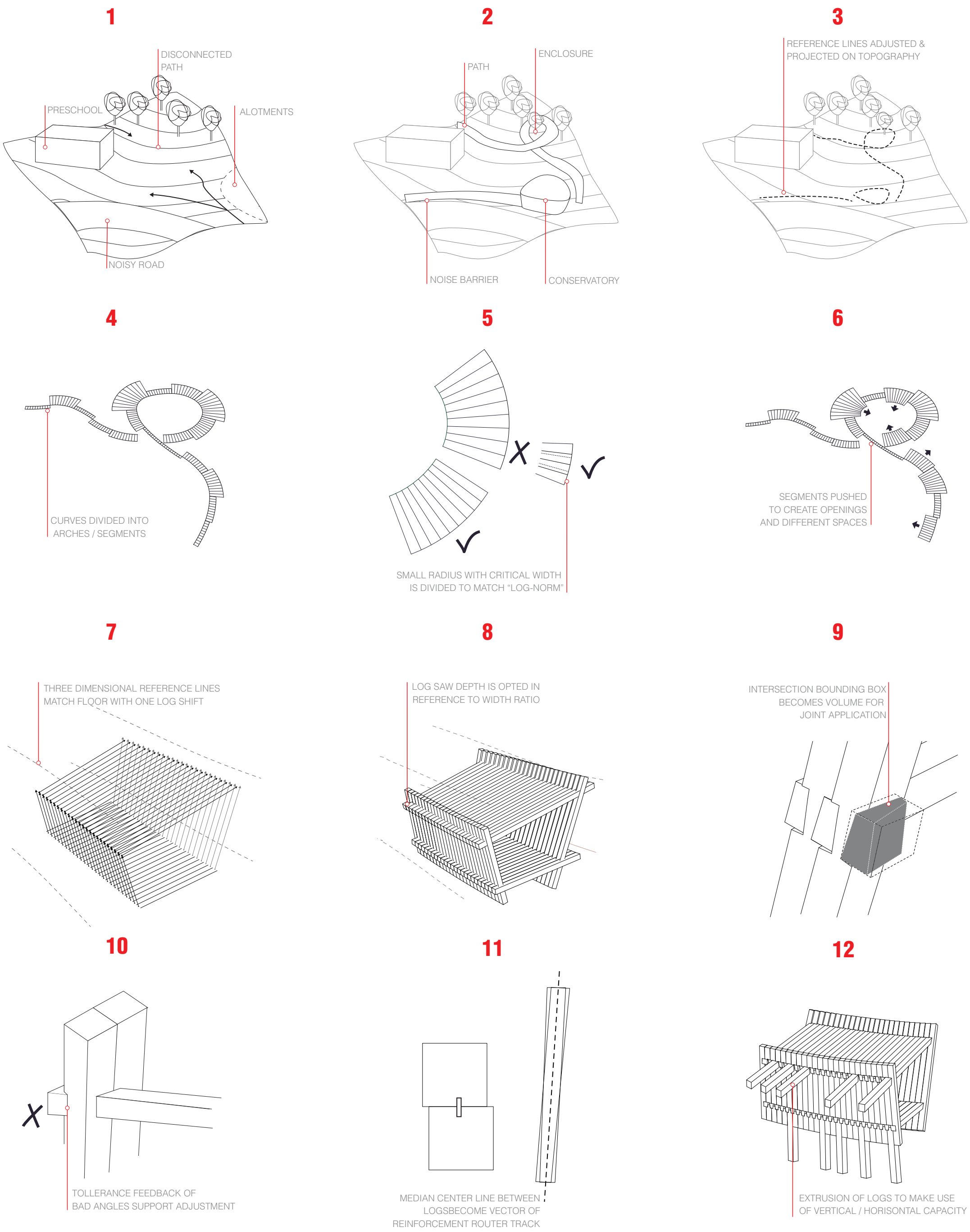
The key aspects of the design challenge was to find a system that could overcome the topography of the steep hill on the site and at the same time connect to the low-rise and sensitive area counting the urban context as a parameter.

The design is inspired by the log building principle but instead of a horizontal frame concept where the pieces are arranged as four walls this concept relies on a inde¬pendent-from-gravity system using compressed springs to keep the pieces interlaced as they are oriented horizontally. The strength of the interlocking mechanism that come with the high friction between multiple surfaces allow great torque forc¬es. This gives the opportunity to twist and curve the form but still making sure that every knot share the force in the entire span of the structure.

The connected paths creating a walk on the hillside between the trees, landing next to the conservatory that enclose a courtyard is divided into segments that are moved by crane onto foundation fittings on the ground, to later be complimented with pieces that are fitted between them.

The conservatory (the lower part) is acclimatized, meaning it can be used all year around as an indoor space. The interior areas of the pathway is mostly usable during spring, summer and fall, but works as a path all year round and protects against rain- and snowfall. The spatial and tactile experience is made to be used by both the everyday users like the children of the preschool and others passing by, walking to or from the great park next to the site.

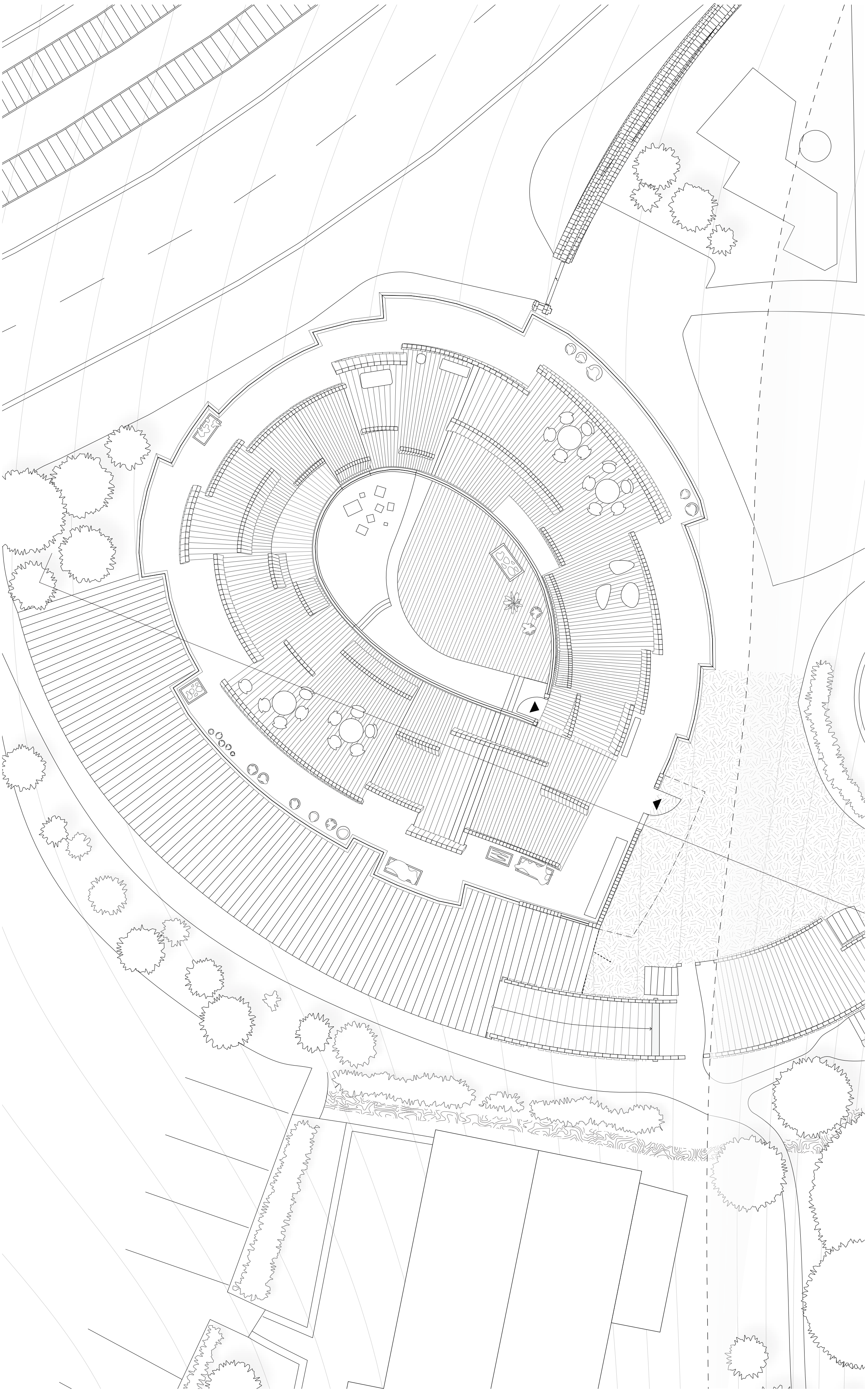
Altogether, the proposal only shows one possible result. Further on, you as the reader will be able to discover the process behind it, with that being both the design process as well as the studies done on fabrication and experiments. Feel free to copy, be inspired or ask questions by contacting me at any time.

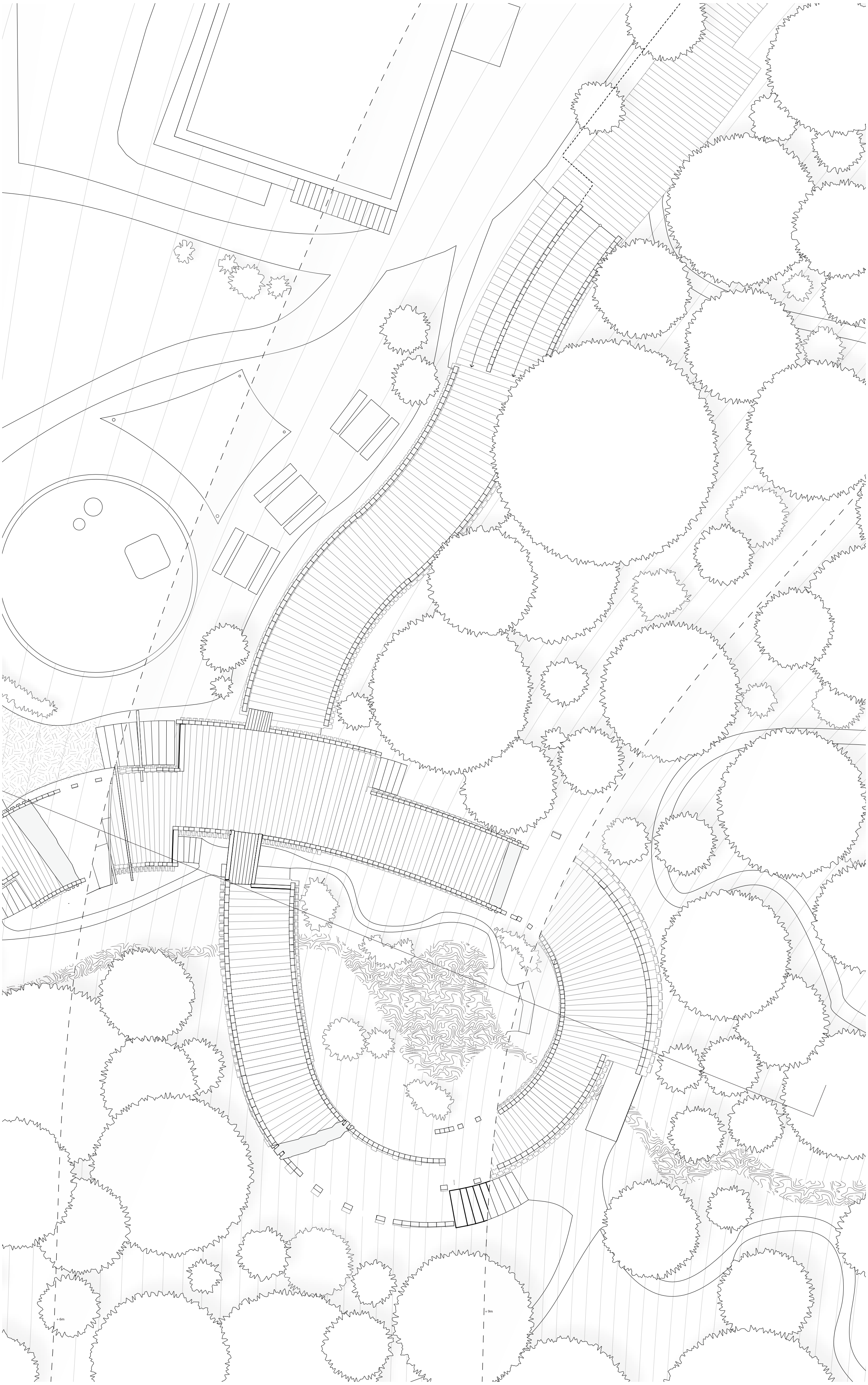


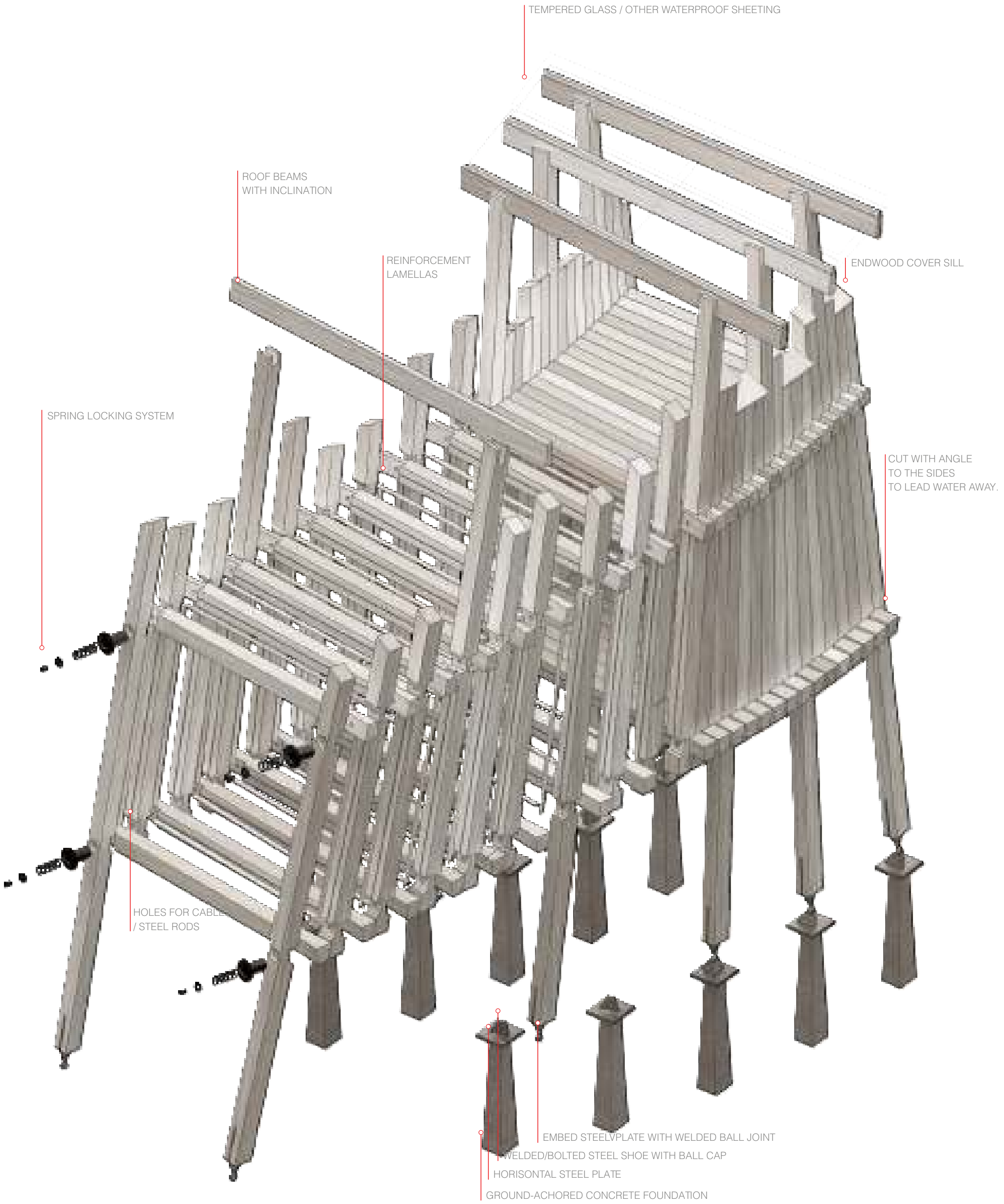
Throughout the project interpretations derived from the initial iterations of design has been supported by the analysis of different processing methods of the material and together formed the proposal all considering the raw esthetical qualities of unrefined wood. The freeform style is a product of the amount of control and precision that increased during the process of designing. By applying algorithmic modelling through 3D software, together with collected knowledge about the material and the building style of notching every joint is confidently shaped to supply a creative yet sophisticated and over seeable design.

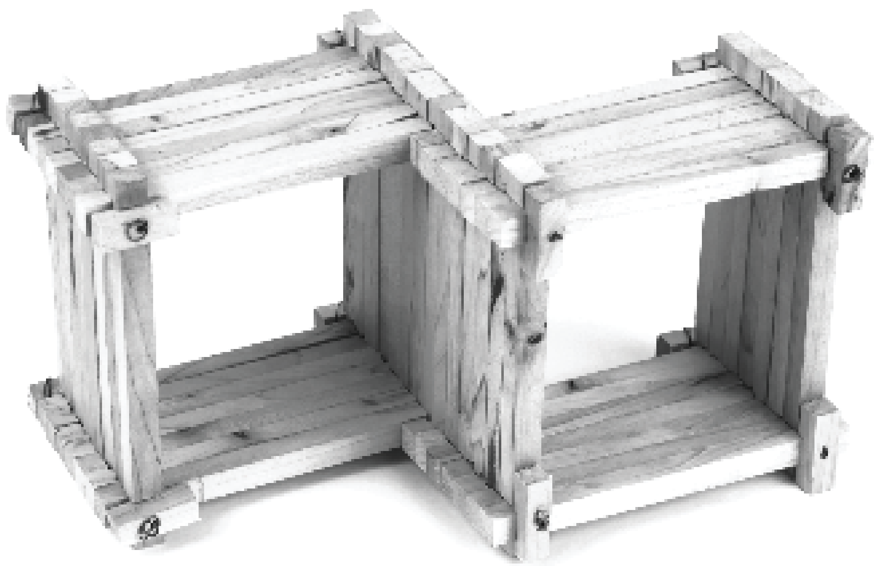

View of the interior donut-shaped space inside, looking out onto the courtyard of the lower structure seen in the previous page.

An overview from the hill next to the site. The protective appearance is countered with the soft form of the structure making it not too dominant.



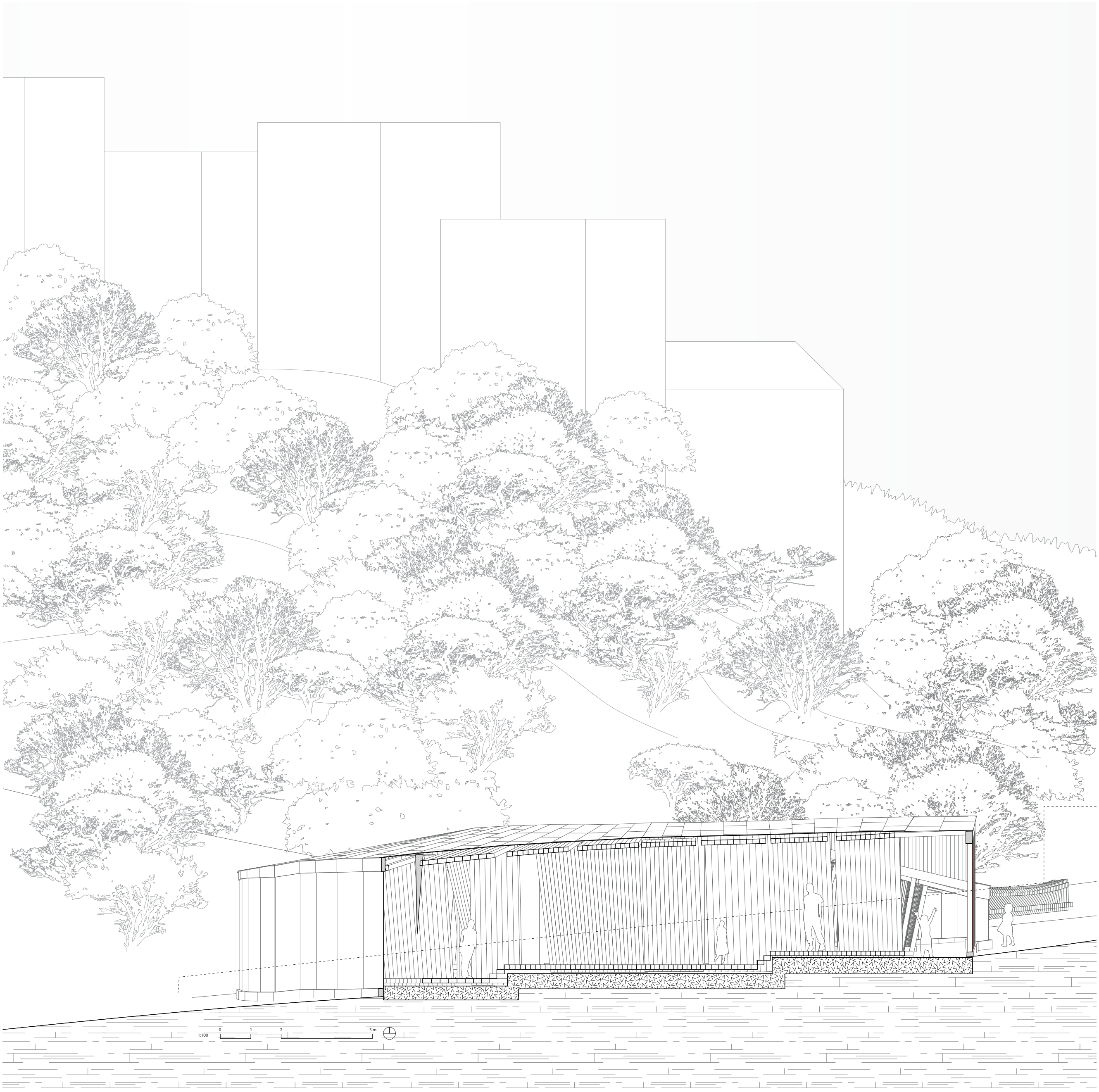


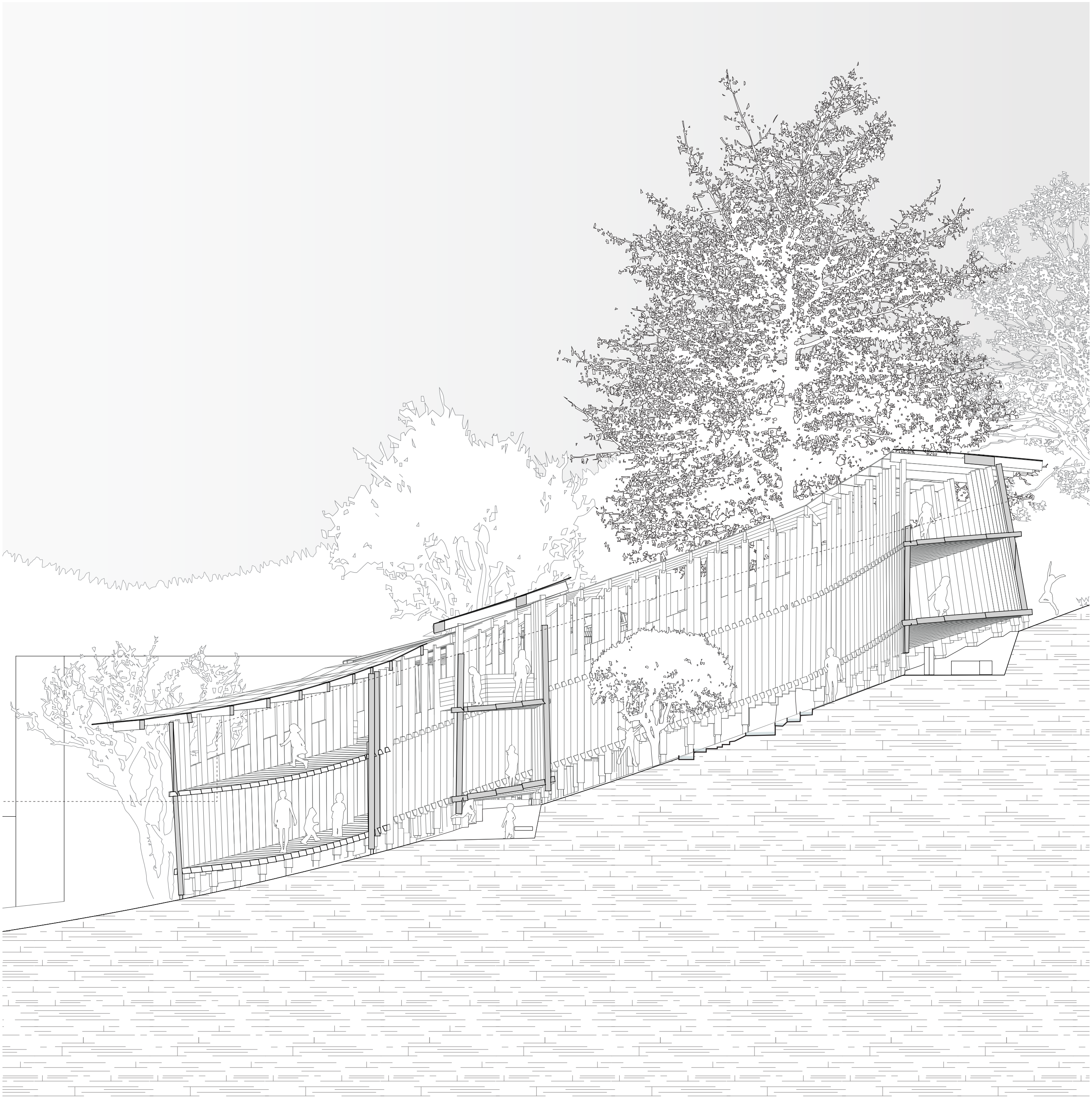

TEMPERED GLASS / OTHER WATERPROOF SHEETING
ROOF BEAMS
WITH INCLINATION
REINFORCEMENT
LAMELLAS
ENDWOOD COVER SILL
SPRING LOCKING SYSTEM
CUT WITH ANGLE
TO THE SIDES
TO LEAD WATER AWAY.
HOLES FOR CABLE
/ STEEL RODS
EMBED STEELVPLATE WITH WELDED BALL JOINT
WELDED/BOLTED STEEL SHOE WITH BALL CAP
HORISONTAL STEEL PLATE
GROUND-ACHORED CONCRETE FOUNDATION



Method

The work flow of moving back and forth between making and reflection as shown in the diagrams cyclical momentum has contributed to the wholeness of the thesis. The tools contributing to the appearance of the design proposal is general digital modelling, in combination with geometry based computational scripting, using knowledge about material and the refinement process as parameters. Models and mockups have been more focused towards testing fabrication methods, to see consequences of certain design features.


1:100
0
1
2
5 m



MATERIAL KNOWLEDGE

RESEARCH REGARDING WOOD AS MATERIAL AND ITS PROPERTIES RELEVANT FOR DESIGNING AND DETAILING.

The Architecture of Trees

The science of genetics and biology has allowed us to better understand and manipulate organisms such as trees in changing their 'codes' similar to redesigning a building through drawings. But beyond our control is the many factors that can play a role in the trees actual geometry. The 'perfect tree' exist only as a template within diffuse threshold limits that we know from years of data collection by measuring.

Forests are today more tamed to our benefit as we can have been breeding species over time, creating improved material as an outcome. But there is still irregularities in the geometry of the logs when handling an organic material that cannot be calculated, depending on everything from what affected the tree in its youth. Disease, poisoning, changing surroundings or damage inflicted by animals or machinery. Even though technology allows for better tracing and monitoring there is simply too much complexity in the anatomy of the tree to measure correctly on site as for now. Historically a good eye, experience, and patience was enough to decide if a tree was suitable, but even though we still have the first two mentioned there is a different volume and speed to what the market is demanding today.

The industry is and has been taking advantage of technology in scanning, x-raying and surveying trees with the purpose to have a better turn over in material sales. However, purpose driven selection and harvesting is almost limited to traditional associations connected to the experience of building a log house as a hobby and the history of tools and styles as their reference framing their interest. This knowledge is key in order to create authentic restoration to old timber buildings but has limited input to the discussion today.

Coastal pine bent by wind, Vilshärad Halland, Sweden. (Courtesy of Stewen Quigley)

Pinus Sylvestris

Picea Albis

Pine

Spread to northern Europe and Scandinavia around 12000 years ago. Thrives partly because of its resistance to cold climate. It's sensitive to pollution but also resilient to storm felling due to its shaft-like root system. Perfect conditions allow a lot of light and to be able grow tall and thick it prefers lean and relative dry soil. Composes around 4o% of the total stock in Sweden, with around 13 million cubic meters of material. The main uses is material for construction and the paper industry. Other products that make use of the pine are refined chemicals such as tar, alcoholic detergents, glue and acetone among other.

Spruce

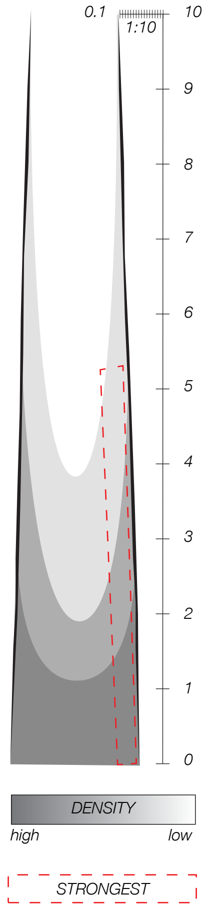
Relatively new to Scandinavia, spread from the north east 3000 years ago. Now the most common tree making up 41% of the stock in Sweden. Thrives in damp and nutritious soil and doesn't require as much light as pine but has shallow roots making it less resistant to storm felling and also sensitive to drought. Commonly used wood in construction material. Better for example cladding than pine because of pores closing upon drying than keep water out better but is also softer, making it weaker in compression. Chipping occurs on edges more easy. Other products extracted are different types of paper, fibers and chemicals.

Growth

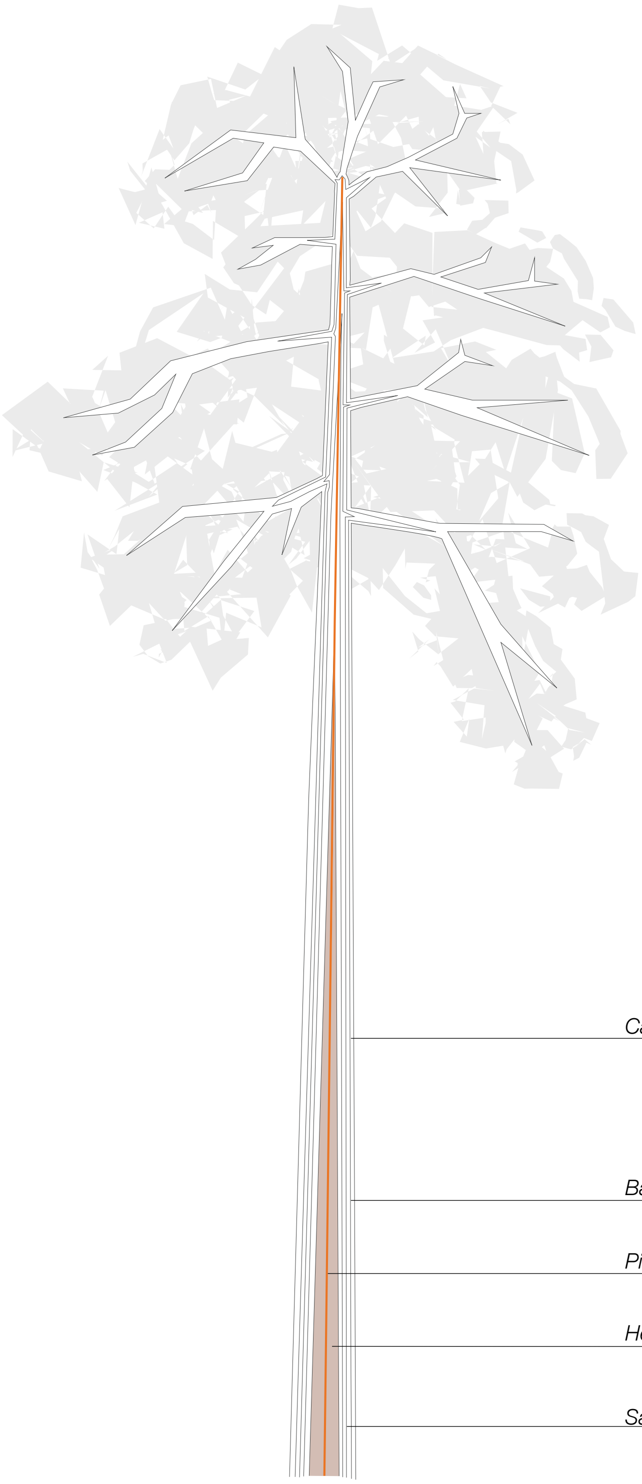
In context to growth linked to location there are extreme variations that has a higher complexity than these diagrams are able to show. Even though trees have a certain general geometry, the variation is immense when looking on different climate on a latitudinal level. Furthermore the quality of soil, light conditions and the impact of other species or topology will affect the growth. For example the "martall" (dwarf pine) which are pine trees growing on northern mires, can reach just over a meter tall even after 150 years of growing, with a microscopic resolution of the compact annual rings as a result.

Structure

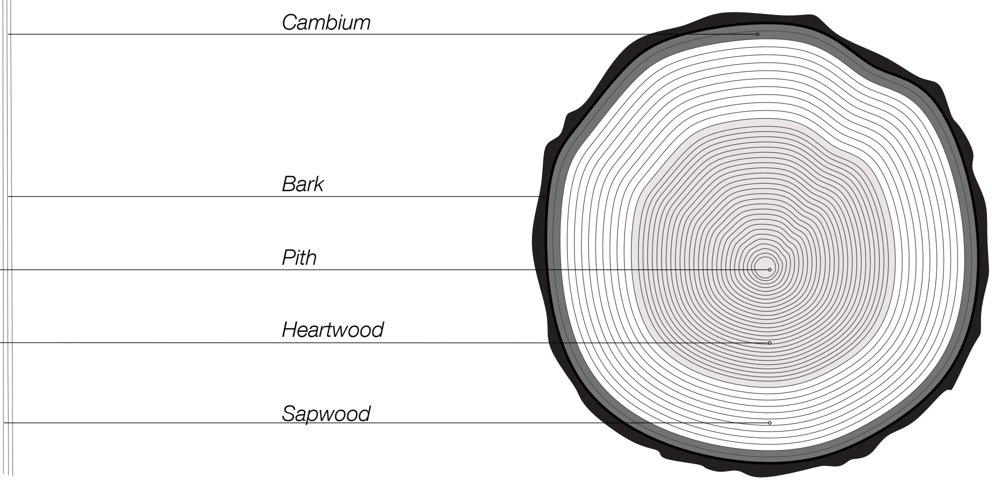
The inner anatomy of the tree is almost similar to human anatomy. It has a skin, blood and bone but in a different way. The bone is hard and dead wood at the inner core full of resin that protects it against rot. The bark covers the cambium, the living tissue of the tree that transports nutrients to the top. The tree bleeds when hurt and the nerves that is the roots can communicate with other trees and fungi to share “food” and information about the environment. The tree is rigid yet very flexible to take wind when storms blow. The structure is divided so that the lower parts are harder and more flexible the higher on the trunk you look. Having this in mind, a tree is as strongest at the bottom but also more breakable and frigid. The best part of trees are taken care of, but trees are also individual making them vary in their structure, so there is no template tree or rules that cover every field of assessment when cutting them down.



Average tapering
and desity map



Growth map of
a pine tree



Cross section of
a log of pine

Dynamics of wood

Wood is anisotropic, meaning it has different properties depending on direction of the grain. This cellular structure in trees have evolved from the race for sunlight against other plants and getting away from animals that wants to eat the nutritious foliage, but also to be able to sway and bend instead of snapping right of when the wind is blowing strong. Since the height add a lot of weight the trees centre, the branching is balanced, spreading the distribution of knots that interferes with the grain. A slight helix revolve clockwise when looking from the top, following the sun path leaving a slight reinforcement for the knots in the vertical plane to prevent splitting. This highly complex inner structure affects the dimensioned material depending on what part of the tree it comes from.


Split larch shingles, Trondheim, Norway. 2016

Straws packed together

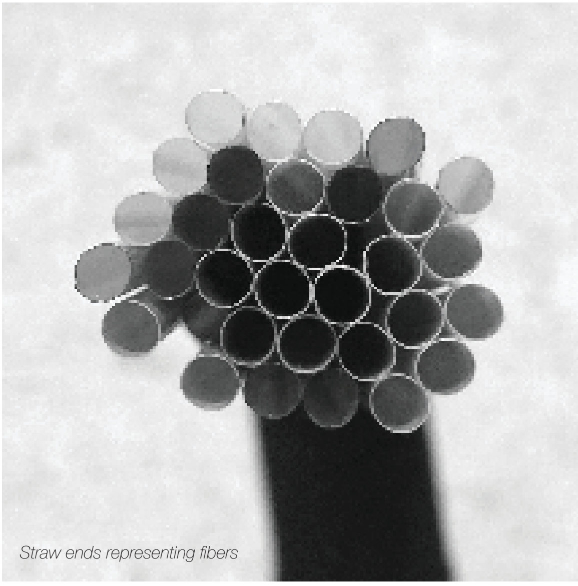
Packed straws supporting a brick

Consistency

Different species' fibers look differently in a microscope. Spruce and pine has less interruptions in the length of the fiber, resulting in the ability to extract long even pieces of wood that sometimes can be hard for other species. Both spruce and pine are on average quite bendy in relation to for example oak. This means it's softer when compressing, making it a bit weaker in that sense, but more resistant to shock and lateral forces as it is more flexible. The consistency in the fibers in these two species from bred forest is highly calculable giving a good turn over when harvesting.

Endurance

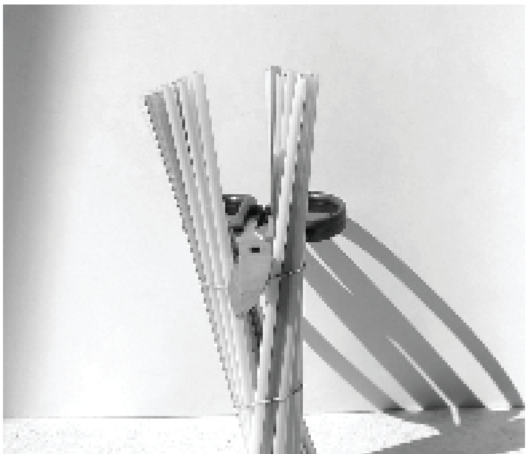
The structure of wood fibers can be simplified by being viewed as a bunch of straws packed together. The fibers grow in this vertical direction to be able to use the capillary force to transport nutrients and sap through the whole tree. This gives the strength in the vertical direction but still bendability to the sides. Every surface of these "straws" is in reality more glued together resulting a lot of friction on a microscopic level. This can be well presented in the model made from straws as the capacity to carry weight vertically is highly efficient, but also across, even though bending occurs as it have toughness not like a frail material.



Straw ends representing fibers

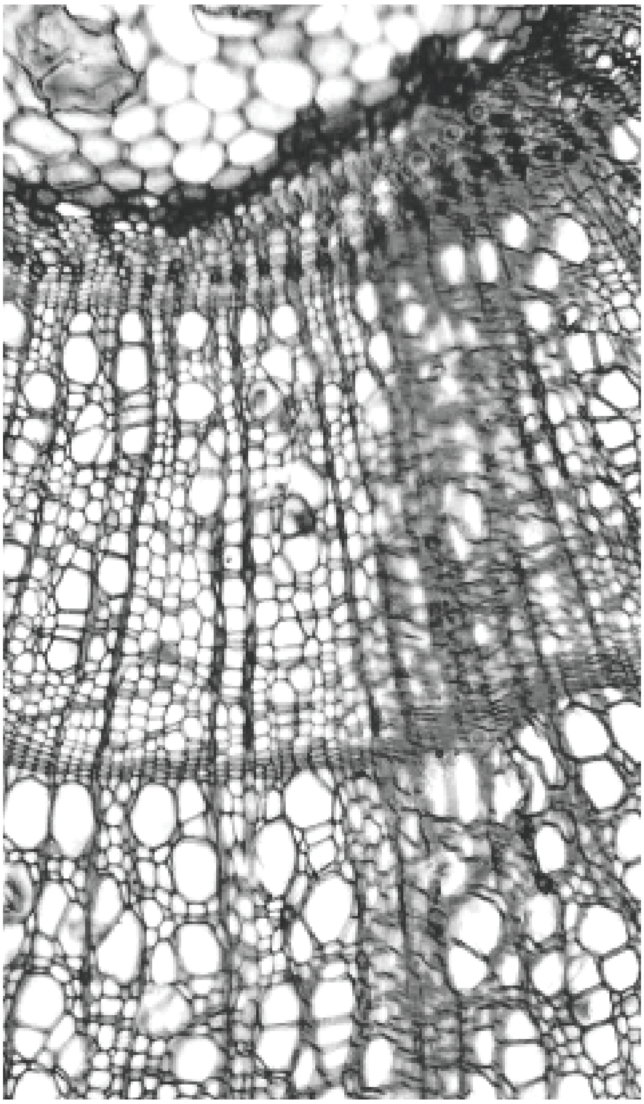
A beam of straws carrying an avocado

A beam of straws with a cut is less strong. Only the profile of the carrying beam can be counted with.



A verry narrow field of force splits the wood easily as only the bond between a few "pipes" can help to withhold the piece.

Wood taking load at bad places and from bad objects like sharp edges onto it in the wrong direction.



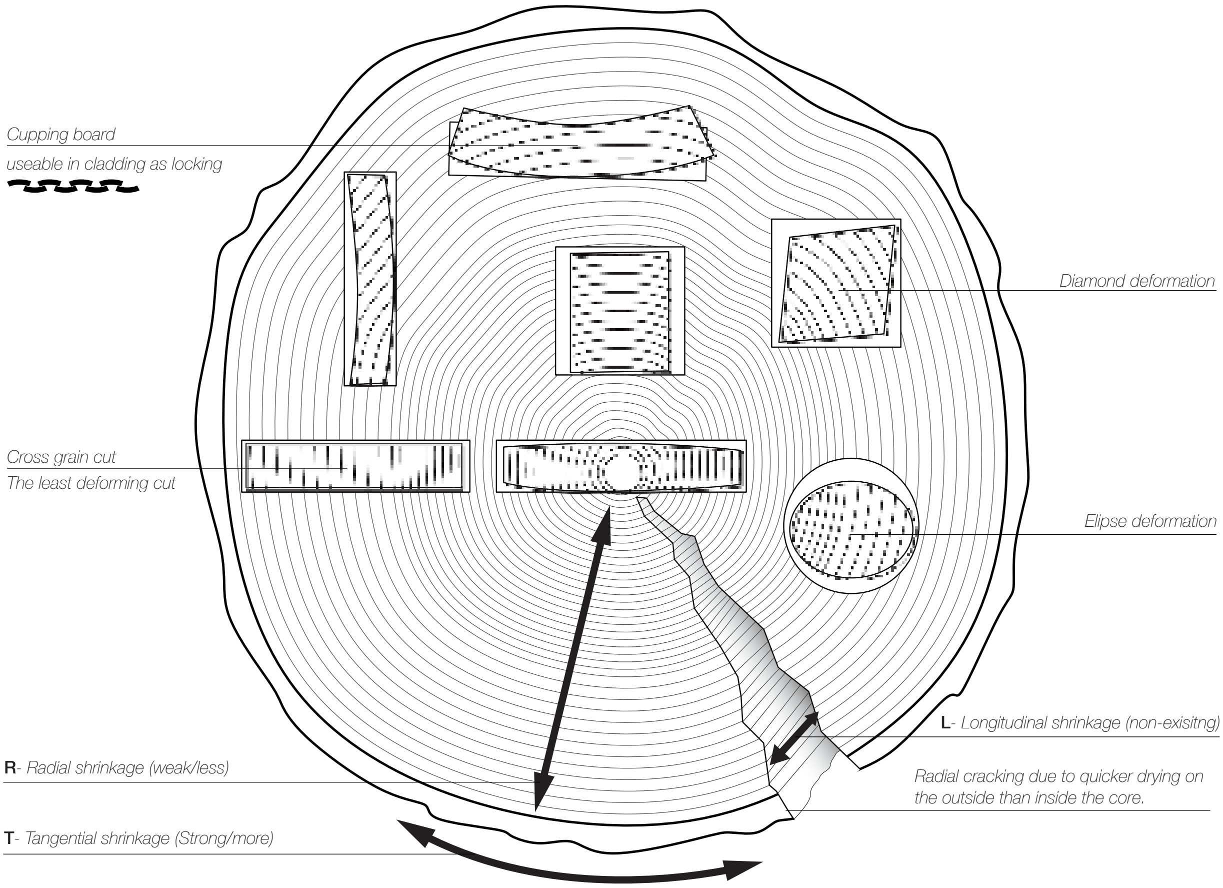
Wood taking load at bad places and from bad objects like sharp edges onto it in the wrong direction.

Weakness

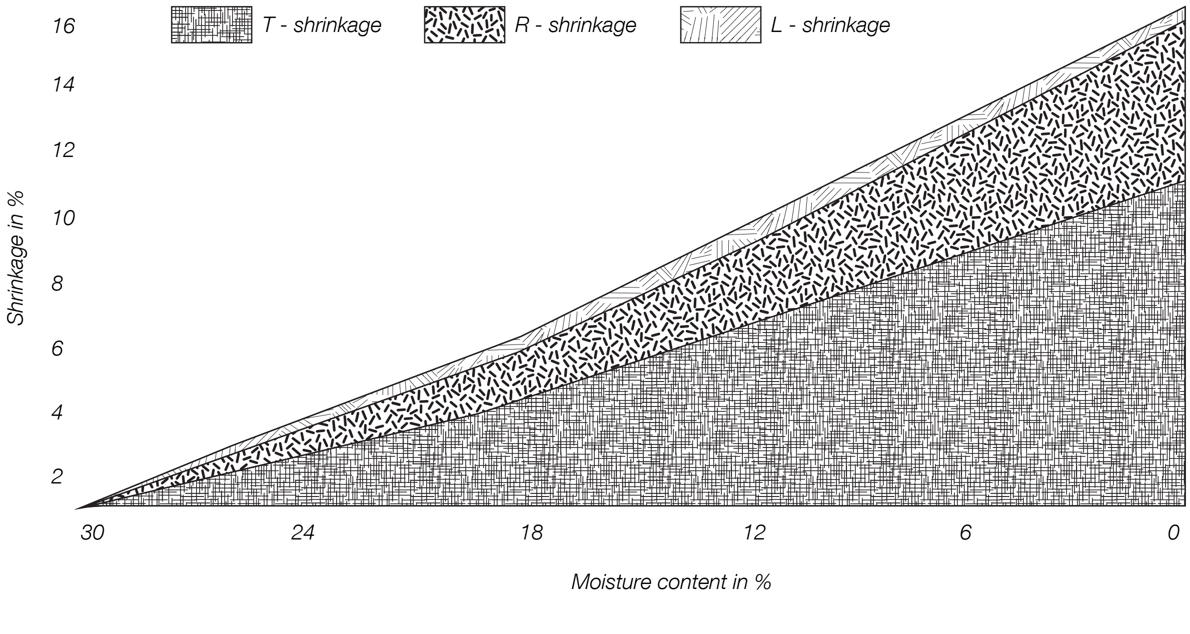
Different species' fibers look differently in a microscope. Spruce and pine has less interruptions in the length of the fiber, resulting in the ability to extract long even pieces of wood that sometimes can be hard for other species. Both spruce and pine are on average quite bendy in relation to for example oak. This means it's softer when compressing, making it a bit weaker in that sense, but more resistant to shock and lateral forces as it is more flexible. The consistency in the fibers in these two species from bred forest is highly calculable giving a good turn over when harvesting.

Effects of Drying

Moisture content matters a lot when using wood for building material. Indoor dried wood needs to reach below 8% moisture quota sometimes, and that can be going down from over 100% since the tree drink more water to store if needed. Drying too fast, it cracks, too slow it can rot so this is a science field of its own, where both air dried and kiln dried methods still are being tested in different ways. Depending on how the wood is cut deformation because of the molecular structure of the wood. For log notching the join can either be cut fresh or dry but you have to consider movement both between the surfaces but also the outer layer of the log where they meet. Slow drying and adding the right pressure is the best way to keep tension out of the material and prevent cracks. But a log could take years to dry so research combining long term drying and kiln drying at certain points in time could boost the quality of the end product



Cupping board
useable in cladding as locking
Diamond deformation
Cross grain cut
The least deforming cut
Elipse deformation
L- Longitudinal shrinkage (non-exisitng)
R- Radial shrinkage (weak/less)
Radial cracking due to quicker drying on the outside than inside the core.
T- Tangential shrinkage (Strong/more)



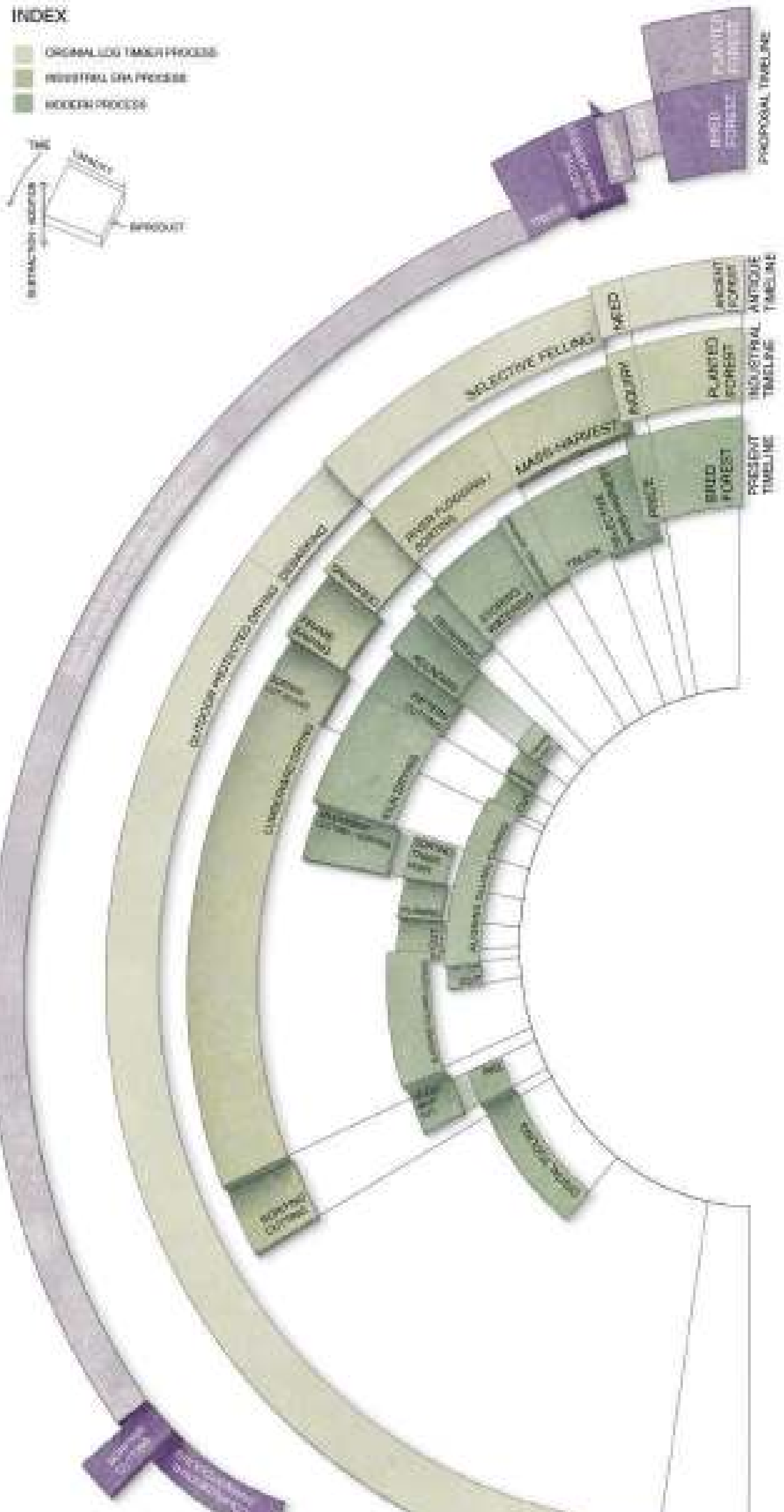
T - shrinkage
R - shrinkage
L - shrinkage
Shrinkage in %
16
14
12
10
8
6
4
2
30
24
18
12
6
0
Moisture content in %

Refinement process

From forest to finished building there is a long line of refinement taking place. Everything in the process is being used, leaving almost no by-products without use. The century long development of the Nordic timber industries have resulted in a proportionally big export compared to the amount of inhabitants in the countries around the Baltic Sea. Currently the amount of timber product produced each year is 18 million cubic meters which in comparison is the volume of roughly 18 empire state buildings including all the building material and the space inside. More than 75% of this amount is exported abroad to countries like Great Britain, Egypt and Norway who are the three largest recipients. Sweden and Finland are the third and fourth largest producers in the world after Canada and Russia.

De-barked logs at Bravikens Sågverk, Sweden. (Courtesy of Linnea Danielsson)

A diagram showing the refinement processes in a historical context, in relation to the process of the proposal (purple) borrowing from theese timelines.



Comparing methods

The context linked to the thesis questions is revolving around the refinement industry and the processes to engineer wood. CLT and other products have a great capacity as it creates a homogenous and stable material. But it also drives the breeding of fast growing species of trees, erasing a great amount of diversity in types of construction wood that the market offers. 70% of the raw material is not used for the final product when producing engineered wood while at least the majority of the logs possess great structural capacity as they come. One of the main reasons for this refinement is also the problems arising when drying the wood, as it deforms and cracks logs, but when looking at older vernacular methods drying can, if given longer time, produce logs that have very little cracks that doesn't affect the capacity.

The main issues would be storing the logs in a dry place for years, but this aspect could pay off in the long term as the life span of a good and cared for log could exceed one thousand years in life time, as seen in many existing historical buildings throughout the Nordic countries and Russia. The proposal is based on this long term drying followed by steps already existing in the refinement industry today, but combining them in another order to enable the potential of the log and notching principle as a contemporary way of processing wood for architectural purposes.

Today almost every step of the refinement is monitored and the shaping of logs to wood products is completely robotized, and optimized for demand inquiry. The investments made to monitor and manufacture with the use of a large amount of collected data means that there is potential to make use of this data for other ways of manufacturing. In the future, more of the already existing techniques and tools can become useful not just for increased profits but also architectural and design oriented challenges in using the material. As for the log it has its limitations regarding length and size, but other ways of connecting the material using hybrid systems and combining engineered wood with unrefined wood and other materials has yet to be explored.

This part explains the logic of material refinement in different steps where the common practice is presented in position to another older or just different technique that could be beneficial for the material in the use of full timber elements.

Conditioning

HARVEST

Common:

Automated harvesting, branches removed and log cut to length on an instant. Up to 90 trees a minute.

Options:

Cut and long-term dry on site for some years. Reduces weight. Or cut crown to increase self-preserving chemicals and leave to “die” and dry.

SORTING

Common:

Unrefined sorting followed by storing and watering to prevent cracking (Uses a lot of fresh water). Later sorting through strainer-like machine by diameter.

Options:

Reinstate flogging in rivers, to keep wet and lower transport emission and cost. Sort along the way by using automation and robots/drones instead of people.

DEBARKING

Common:

Debarking and rounding to an even diameter resulting in loss in material due to smallest diameter is ruling the outcome.

Options:

Cut small strands along the bark to slow down drying, releases tension and prevents cracking. Then easy to debark as it losens easily. More of the log can be used.

DRYING

Common:

Pre-dried logs are not common practice. See post-treatment.

Options:

Se harvesting and de-barking.

Subtraction

SAWING

Common:

Band saw with pre-set width. Some laser guided adjustments of the logs are done. Quick but lots of spillage.

Options:

Splitting logs gives better surfaces protecting against water. Also “show” the weakest part and removes it. Efficient but slow and unprecise.

DRILLING

Common:

Drilling- or routing out shapes is mainly done in CLT products in 2D manor, like a printer removing material.

Options:

Scanning and using the logs structure as guide to how a piece could be shaped or where joints could be cut. Carving is slow but the best way to inspect the material and grain direction and other irregularities as the procedure is ongoing.

PLANING/SHAVING

Common:

Planing done from present, not taking in to account irregularities. Almost always orthogonal corners. Also shaving to create layers for LVL, plywood etc.

Options:

Using the natural tapering of the log as angular reference, planing it even so that less grain lines are broken, that weakens the wood.

MILLING

Common:

Wood is grinded down to create fibre for glued components like MDF.

Options:

Growing wood from cells onto premade structures. This is not researched on to the extent that it can be done.

Addition

GLUING

Common:

CLT, Glulam etc. Also lengthening by finger joining.

Options:

Making saw tooth like joints tensioning the long side of pieces together with threaded bolts. The friction between all the tiny surfaces makes a strong connection that increases due to the woods’ shrinkage.

SCREWING

Common:

Steel screws treated if outdoors. Expensive in relation to the timber.

Options:

In many cases screws don’t last forever due to rust and erosion. Dowels and joinery could replace screws in many cases.

CONNECTING

Common:

Steel plates outside or embed into the wood that with high precision is bolted with metal dowels.

Options:

As the proposal shows notching in combination with this as ball joint foundation connectors could be useful to leave the wood a bit away from the ground and moisture.

JOINING

Common:

Mostly jointed by steel connectors that are screwed into place, like beam shoes and such.

Options:

The trust in the wood is overseen because of the fear of failure. But if the background of the material is known the risk would be minimized.

Post treatment

KILN DRYING

Common:

Post cutting procedure. Warping is minimized but not eliminated.

Options:

In small scale saw mills the whole log is first cut into slabs then tensioned back into its original shape but with air gaps between the slabs. Then it is slow dried in a kiln reducing movement.

IMPREGNATION

Common:

Chemicals are pumped into the wood making it resilient to rot, with different degrees. Bad wood can become good, but not so environmentally friendly.

Options:

Damaging the tree where it stand in a certain way can make it self-impregnate with natural protective chemicals before cutting it.

THERMAL

Common:

Baking the wood products in a big oven. Requires no chemicals and makes it more resilient because of the surface is now toxic for fungi.

Options:

Not so efficient but making a fire around a tree every winter for a long time doesn’t kill it but dries it out very slow. This means less trapped moisture for the rot to use.

COATING

Common:

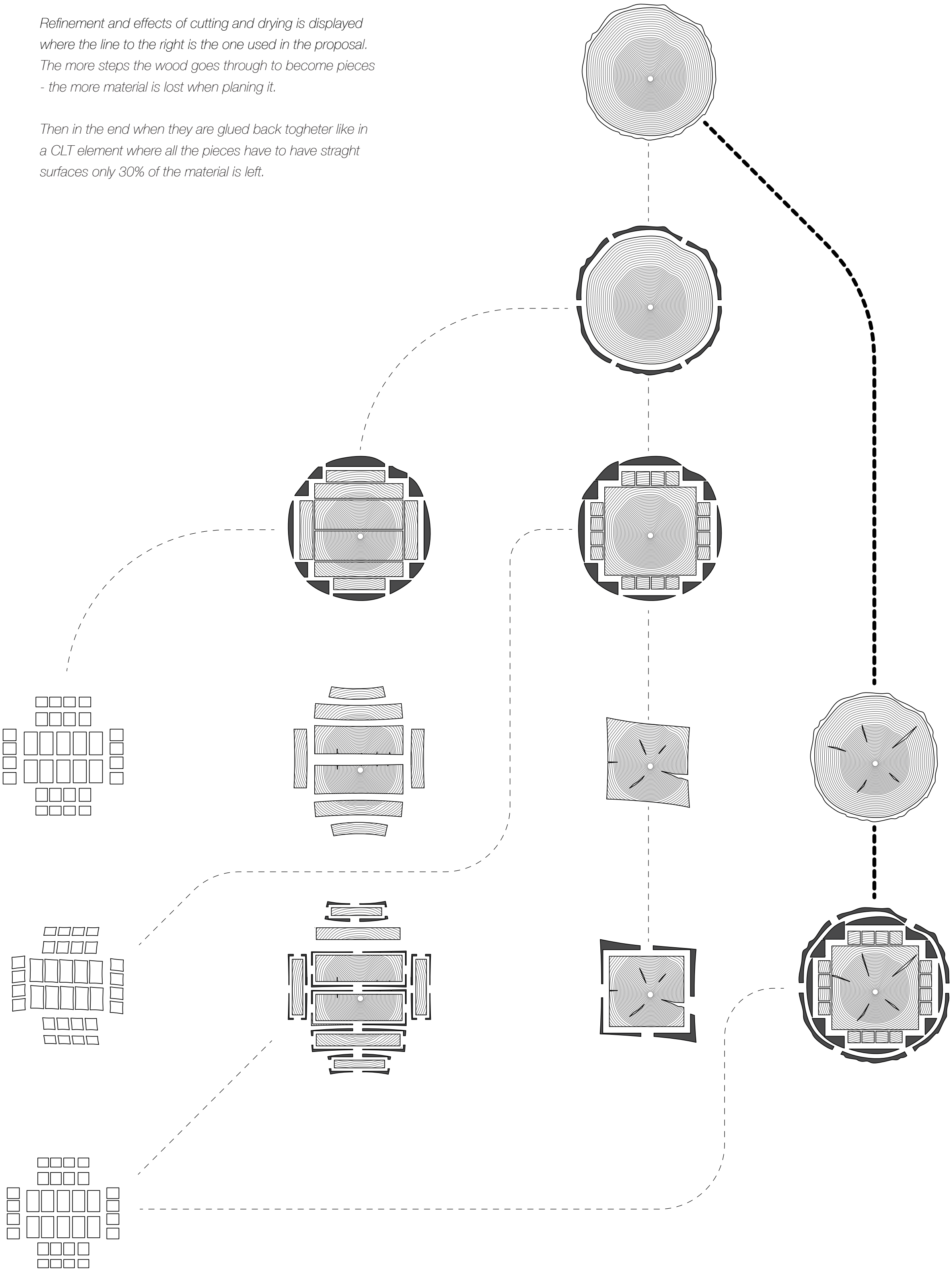
Paint, lacquer and staining to protect the wood. Useful but has to be done over and over again.

Options:

Building so that the wood has a great chance to dry out well then it doesn’t require so much paint. For some areas where this is not possible, other species could be selected for cladding.

Refinement and effects of cutting and drying is displayed where the line to the right is the one used in the proposal. The more steps the wood goes through to become pieces - the more material is lost when planing it.

Then in the end when they are glued back togheter like in a CLT element where all the pieces have to have straght surfaces only 30% of the material is left.



Quality assessment

To have a unified quality assessment, a set of general classification method has and are being implemented that evaluate the material through certain parameters. This is most commonly through visual inspection in correlation to use and post treatments. The user can ideally trace the material from the source and fabrication method to construction, to make sure no confusion or mix up is involved when following building codes or other regulations that put trust in the capacity of the material. Unknown irregularities that isn't calculated with that makes the wood weaker or more prone to rot can have devastating consequences for people's safety and health. Even though engineers have the responsibility for this area, architect and designers need to base decisions from this knowledge in order to design resilient architecture in wood.


Freshly cut logs, Valsoya, Norway.

Visual assessment

In Sweden most timber products that are used for building are those for example carpentry and casting molds. These types of product are classified by appearance rather than strength, which means that they solemnly are reviewed and priced according to parameters, such as:

- Knots
- pitch pockets
- skewed fibers
- discoloration
- fungi staining
- cracks
- bark damage
- compressed wood
- deformation
- insect damage
- harvest damage
- measurement faults

Among others. The classification goes from 0 to 4 where 0 is the best type. This is based on the fact that the more visually equal the piece is the better meaning that knots and stains are seen as ugly. This is of course a subjective classification even though a lot of "bad" knots can be a problem when building. There are wood that is simply discarded due to its ugliness, even though it could function well as material for some purposes.

CLT and other fined products are very dependent on homogenous wood because of difficulties in controlling movement with irregular pieces. This drives the industry to discard wood that could've been used, grinding it down and making it into products with a lot of glue and heat treatment.

Visual assessment is also used for construction wood but it requires knowledge to detect for example bad knots or cracks. Even if a camera connected to a computer could do most of the raw sorting an experienced inspector is today still unbeatable since the time spent reviewing each plank, board or beam is a couple of seconds and requires the person to imagine faulty outcomes of the specific piece of wood.

The wood can vary from log to log and even within a tree a lot of variations can occur. This is means that the classification cannot be guaranteed above a certain level of resilience.

Machine assessment

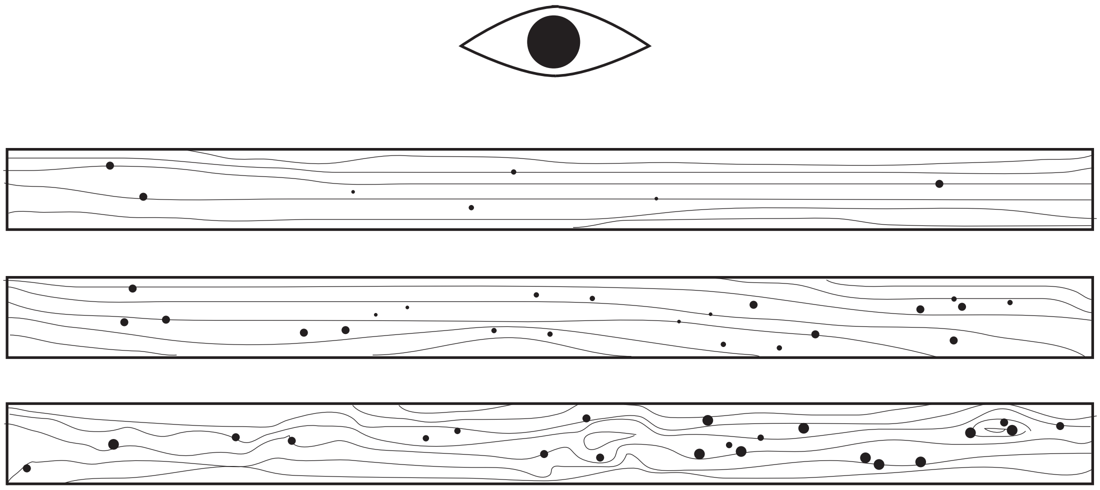
To easier find invisible faults or damage one can assess the wood using a hydraulic press connected to a computer. Without destroying the wood, pressure is put upon the element making it slightly bend which will feed the computer with information with elastics data. This is then calculated to give the piece an elastic modulus that defines its capacity when it comes to load bearing capabilities.

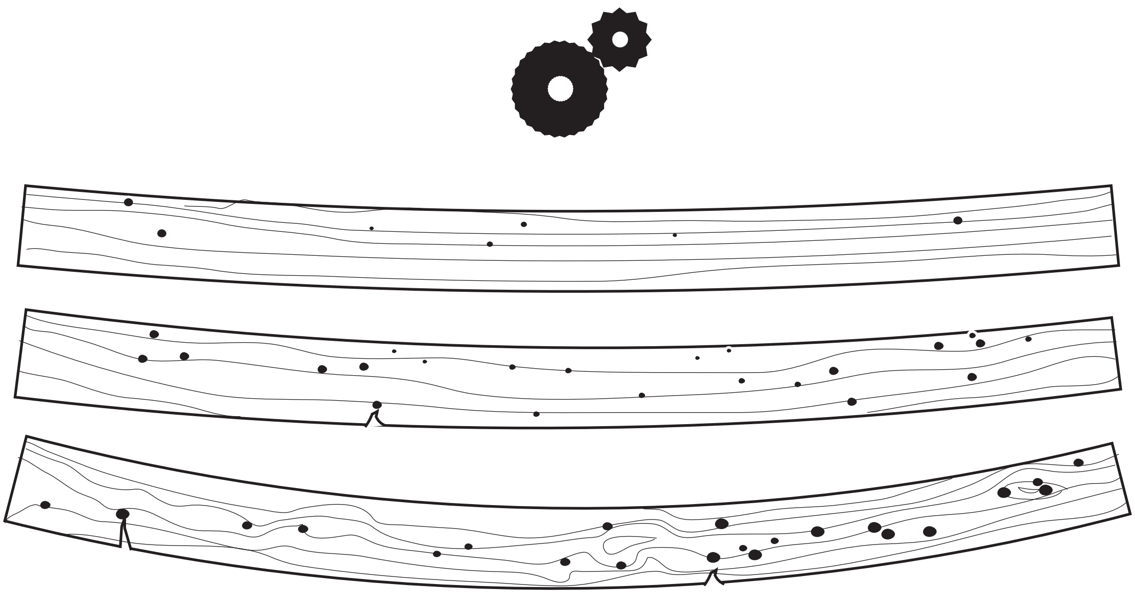
Other assessments

There are small scale assessments using x-ray and MRI scanning that renders an image of the trees full anatomy. This is very time consuming and expensive to apply to big scale, but it has given researchers the chance to fully understand how parameters that affect the quality are formed and how it can be linked to the outside of a tree trunk.

Comments

Looking at log houses and the technique of notching there is not many common factors or logic of structure that is equal to the common style of building. Frame work construction have to rely on that the piece itself have to be strong enough to carry the load that it is assessed for. But combining them into a larger surface, like in the case of CLT et al means the requirements could be lowered. This implies that knots, cracks or any other unwanted damage is less important when creating strong and reliable building material.
There is also some assessment being done at the point of harvest. This is done by the harvester digitally but it is very crude data. Historically trees where often assessed on site using knowledge and parameters of the trees surrounding as to how well it is. This is something that could be implemented again with drones and artificial intelligence. It would be too time consuming for experienced people to walk around inspecting trees and marking them. With complex mapping capabilities and big data handling forests could in the long run be harvested more selective than mass harvesting. This would allow trees to grow more natural and thereby stronger and bigger than farmed trees.

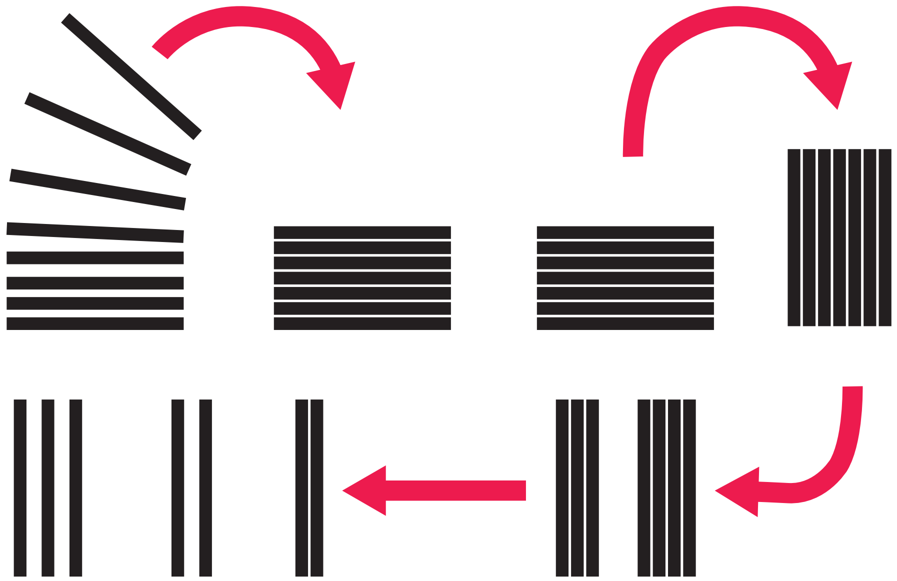




Notched and stacked wood

Log notching dates back thousands of years. The technique is a combination of man's curiousness and skill to craft using tools and the properties of the material that is found in the local environment. It has been a game of trial and error leading to the point where industrialization and denser cities have pushed out the log building both geographically to the country side and as function of everyday dwelling and building style. Today they mainly are used as a recreational facility for hikers, fishers and skiers. New log houses are erected in many ski resorts and they function well as housing in cold areas and they are quick to manufacture. But the visual link is still connected strongly to nostalgia and nationalism giving no room for the actual structural purpose of notching as a method for building today.

A log cabin being build iin Norway n a historically correct way using axes and other remade tools from the 17th century.



Principle

The principle of notching is quite simple. A joint that is similar to the next fitted together. Either ornamentation or practical variations occur depending on culture, climate and type of wood. Logs are selected, carved and cut to fit together stacked horizontally where the corners of the house make up the locking mechanism. It is of high importance that the top and bottom log are full length so that door and window openings are not "unconnected" and become a weakness. The two ways of making a log house is either build with wet wood and letting it shrink and compress down as gravity presses the logs together, tightening the structure, or drying the wood first to have less shrinkage and deformation. IN either case lining with insulation creates a tightly sealed room that can withstand both cold and heat just as well as an insulated wall depending on the log thickness.

Movability

Due to the easy disassembly procedure log buildings could be moved around from time to time to better suit the needs of the farmer using it. It sometimes also occurred splitting of houses a s children grew up and married off to other families. The siblings could inherit part of the house to bring along to their new family to combine with other logs or just create a new building with the help of the inherited pieces. This is done by marking the logs so that they always carry their instructions with them. Rotten logs can therefore also be changed, either by disassembly or just cutting a piece out and replacing it using dowels. Today a lot of buildings are moved when for example private buyers like the house but not the plot or when historical buildings move to outdoor museums to be better taken care of. Due to the high friction and interlocking corners whole buildings can be moved in one piece. This is not cheap but the time it can save can be beneficial.

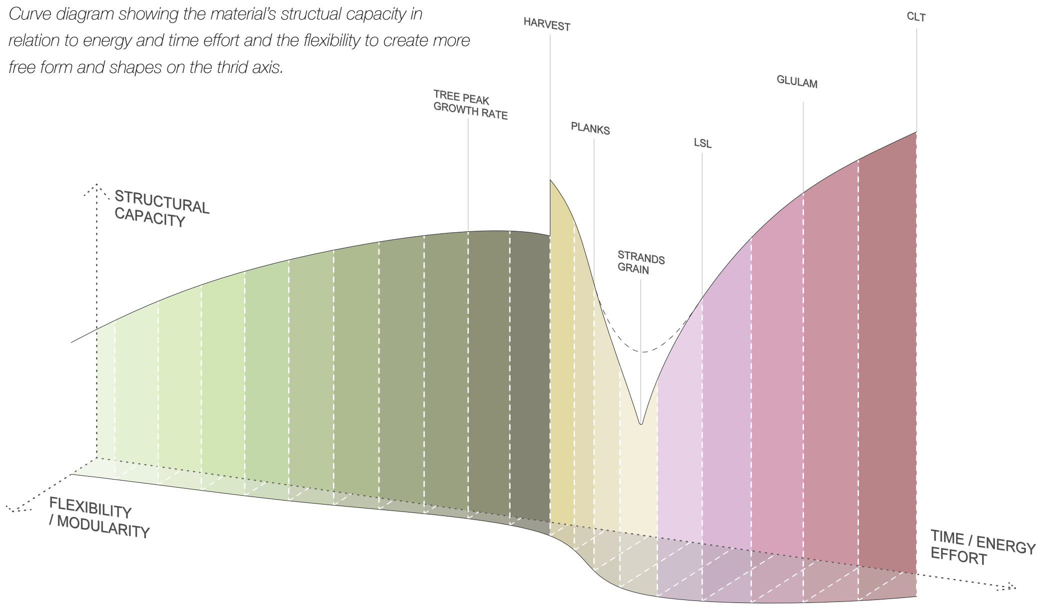
Representation of log house being moved in Åre, Sweden.

Representation of log building being moved near Lugnet, Sweden.

DESIGN CONTEXT

THE CIRCUMSTANTIAL DATA DIRECTLY AFFECTING THE DESIGN OUTCOME.

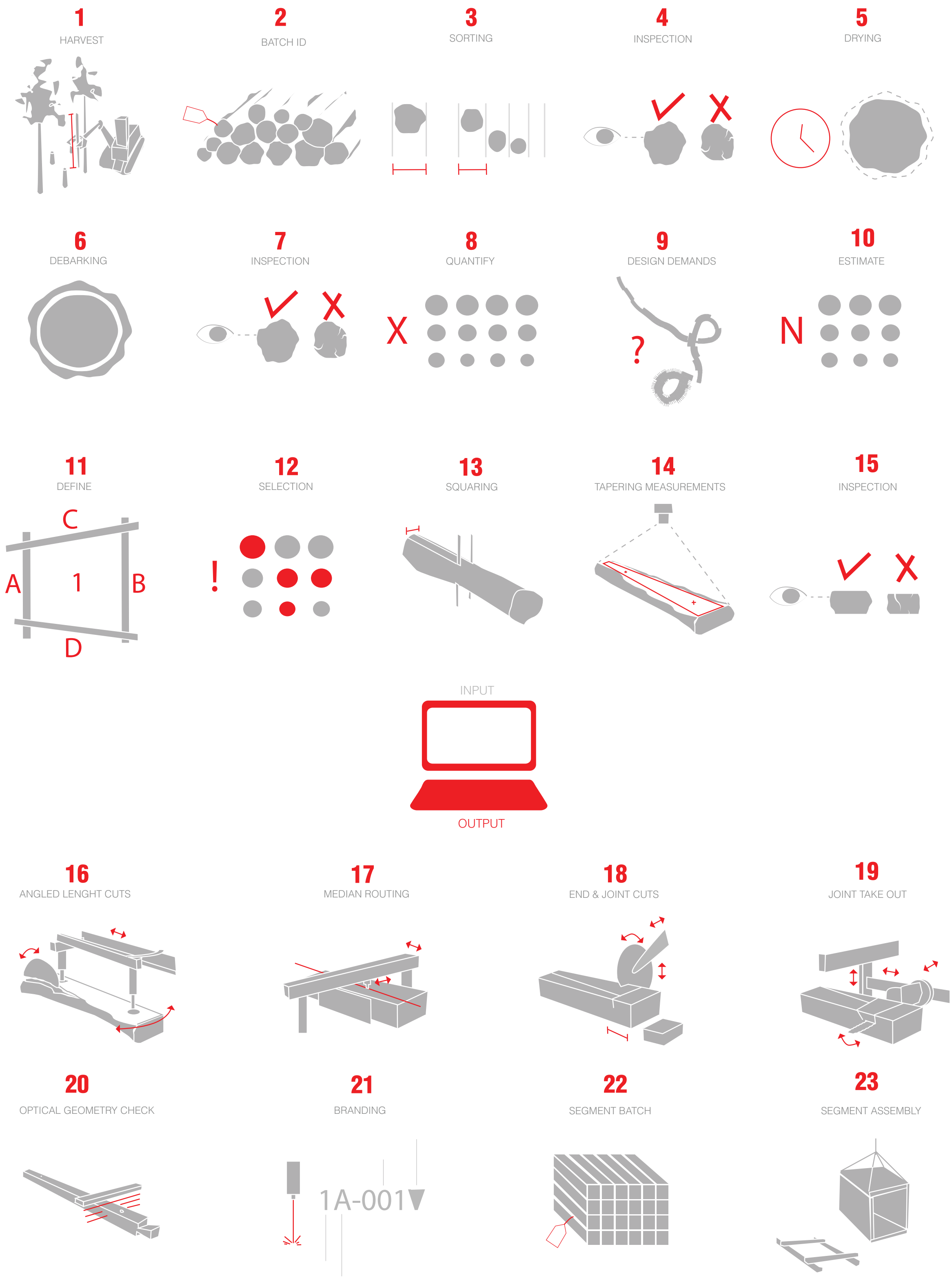
Curve diagram showing the material's structual capacity in relation to energy and time effort and the flexibility to create more free form and shapes on the thrid axis.



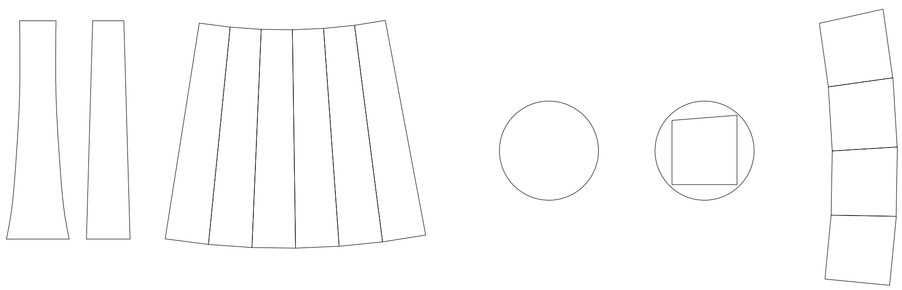
Refinement approach

Referring back to the chapter about the refinement process the intention of the approach is basically using the full capacity of the tree as it comes when harvested. All the drying and processing that is common today can be used as is, but a new approach would be influenced by old techniques that are better linked to the resource as a prime product of nature. Together with this mind set about the material – new technologies involving parametric design and algorithmically altered sawmills could produce high end product with high precision, taking raw material that is very cheap compared to engineered wood, and creating high end products that can compose tailor made, freeform architecture with as little cutting and destruction as possible. The appearance is the least controllable thing but materials that reflect life and inconsistency is to many a beautiful aspect of the experience and narrative of the buit environment.

The main goal for the industry is of course money making. But diversifying the line of products is in many cases successful as it creates a demand that wasn't there before. All the byproducts of today's processes are used because it creates capital. If that could be a case for waste then any form of refinement also could be that. The sustainable approach is also an aspect that is becoming more and more relevant. Using energy and resources is more demanded by the consumer today. In most cases, also for this one - less treatment and refinement means less negative impact on the climate and pollution of chemicals.

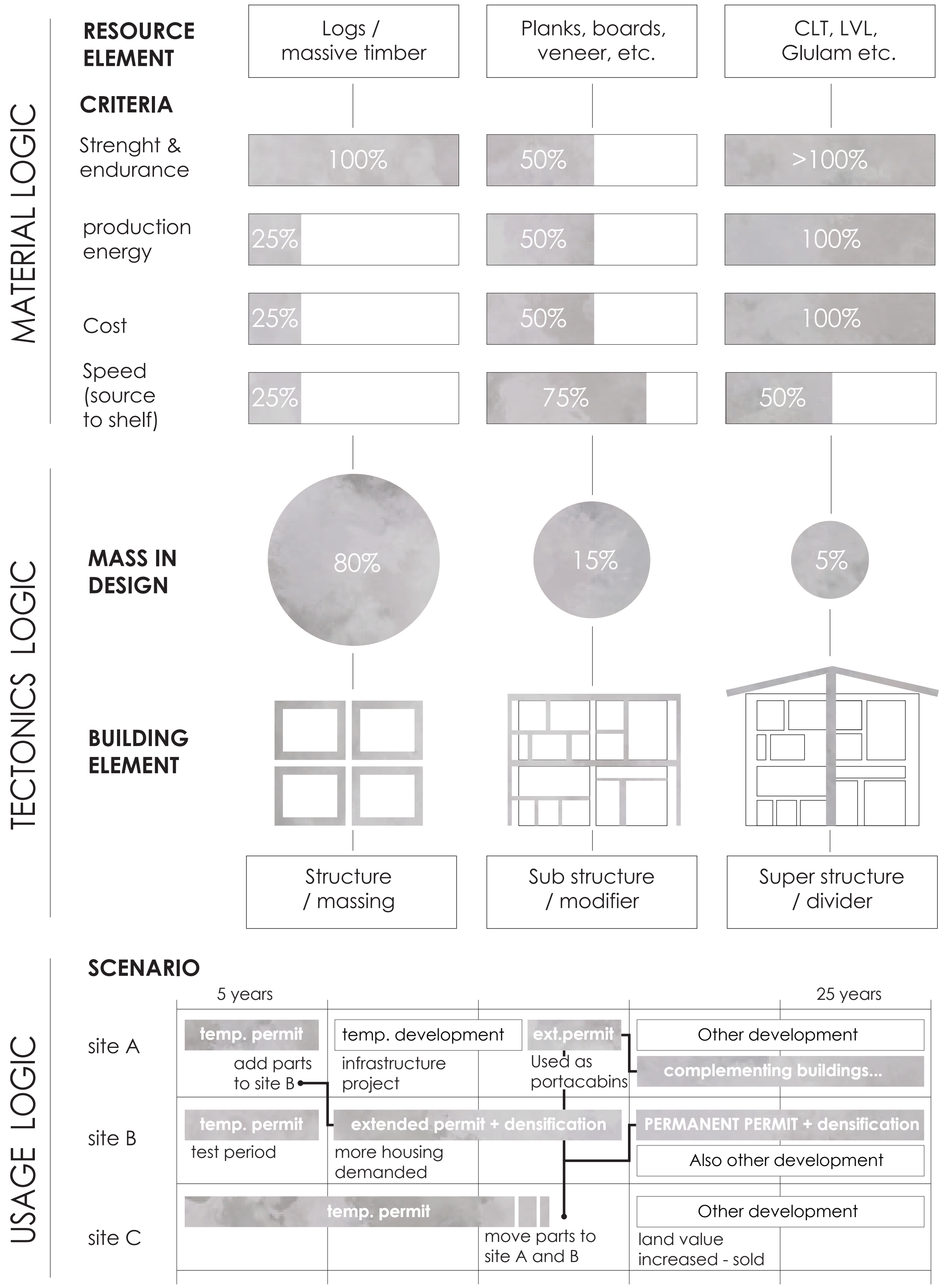


The path from tree to building showing that the data handling and digital processing as the key to keep the flow of input and outputs in order. From physical to digital and then from digital to physical.



Arguing for singularity

On top you see the detailed refinement logic where as much of the log as possible is used as the natural tapering and the roundness is optimized to become part of the end product. The schedule to the right is an older plan on how the argument for using different refinement grades on different parts of the building would look like. The argument is that the more energy you put into creating for example a glulam beam the more strength and consistency you get. But to a certain level it is unnecessary if you consider using cheap massing materials like logs to create other architectural elements. Complementing with “normal” sawmill produced planks and boards together with engineered wood and logs could in the right proportions both give a new type of architecture and at the same time challenge the use of multi-material constructions that mix plastic, plaster, wood, stone and metal without arguing for what this recipe means for perception and also cost.


MATERIAL LOGIC
RESOURCE ELEMENT
Logs / massive timber
Planks, boards, veneer, etc.
CLT, LVL, Glulam etc.
CRITERIA
Strenght & endurance
100%
50%
>100%
production energy
25%
50%
100%
Cost
25%
50%
100%
Speed (source to shelf)
25%
75%
50%
TECTONICS LOGIC
MASS IN DESIGN
80%
15%
5%
BUILDING ELEMENT
Structure / massing
Sub structure / modifier
Super structure / divider
USAGE LOGIC
SCENARIO
5 years
25 years
site A
temp. permit
add parts to site B
temp. development
infrastructure project
ext.permit
Used as portacabins
Other development
complementing buildings...
site B
temp. permit
test period
extended permit + densification
more housing demanded
PERMANENT PERMIT + densification
Also other development
site C
temp. permit
move parts to site A and B
Other development
land value increased - sold

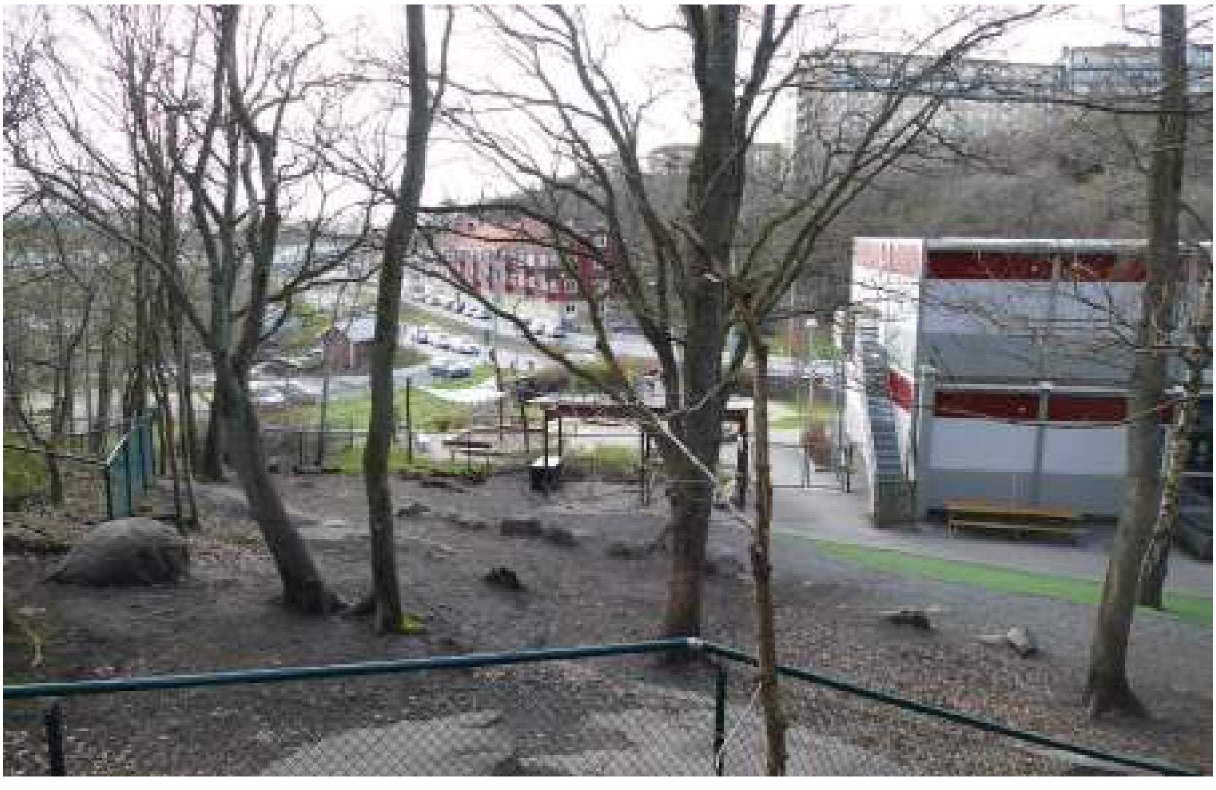
Map over Gotherburg

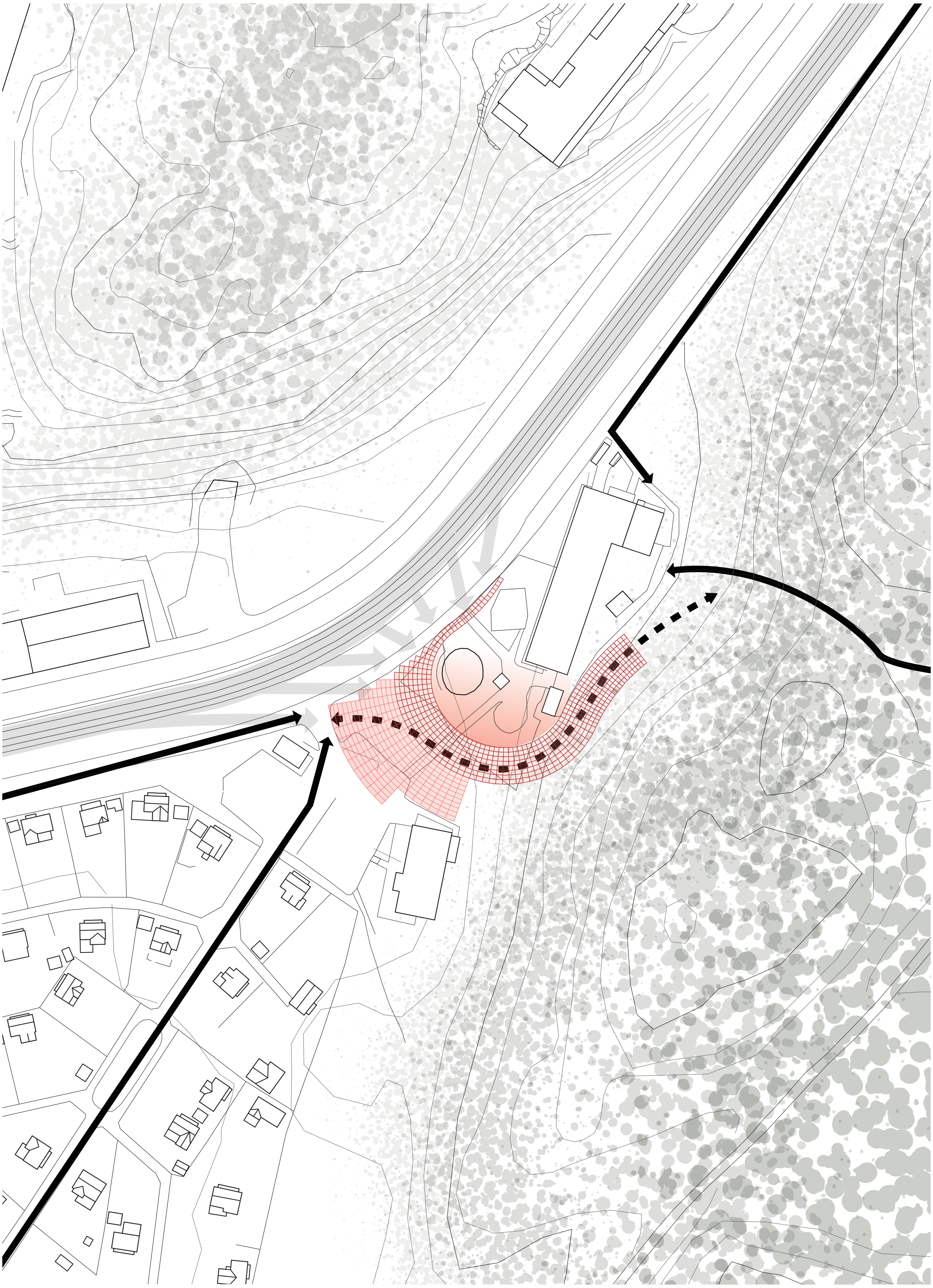
Site

The site chosen for the proposal is located in the western parts of Gothenburg, where a temporary pre-school composed of porta-cabin containers has been erected. This type of solution has become a more frequent way for municipalities in Sweden to meet the space requirements of the fluctuant group sizes of children in need of daycare each year. Apart from the primary objectives of this thesis, this choice of site reflects the intention to high light the flexibility of the assembly logic of the interlocking notch timber method, adding to it, without questioning or proposing to change the preexisting function. The plot in question is not registered as a permanent plot therefore the proposal comply with this condition and aim to be available to disassemble if needed, without greater demolition and waste construction material.

Pictures overlooking the sight from different angles.

The topography is steep and filled with both small and big trees.





Potential key aspects that was considered during designing.

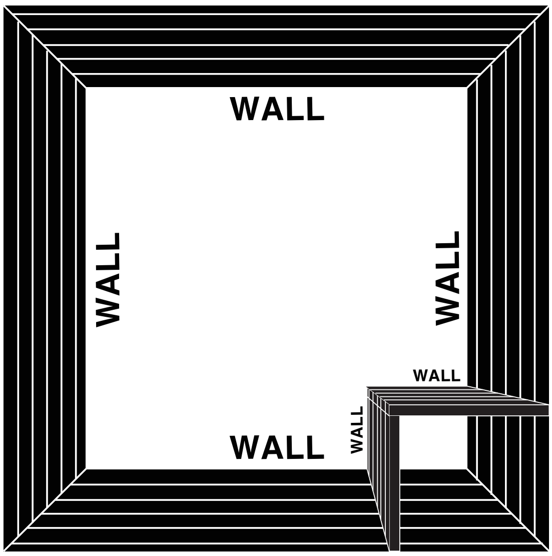
DESIGN STUDIES

THE STEPS AND SIDE TRACKS LEADING TO THE PROPOSAL

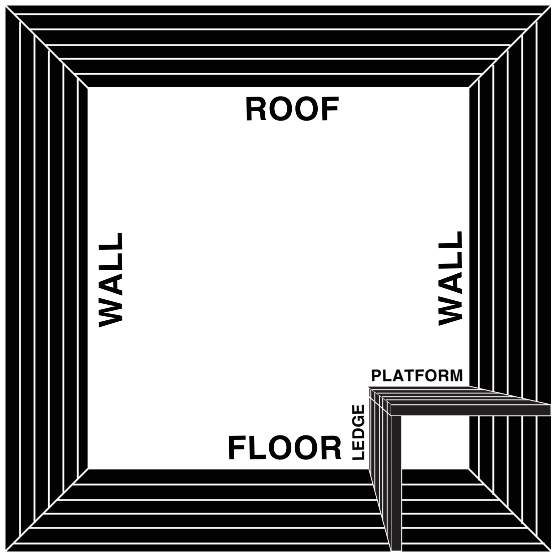
Initial concept

Vernacular buildings are the base for the emerging ideas about the concept. They performed as visual proof of belief in the unrefined material. Skilled craftsmanship is proudly represented in both the precision of building and ornamentation that together with the hierarchy of the types of material for different uses paint a holistic narrative image of the concept. This wholeness is key to their century long survival as both the embed design quality and later maintenance derive from people caring about their existence, allowing us to even experience them today.

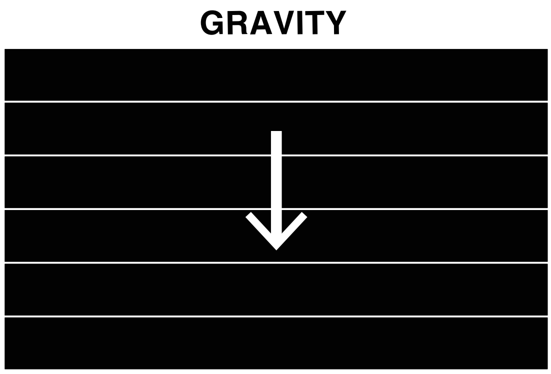
Performance wise the log house has played out its roll, as it is too unsophisticated and more shelter oriented than our sought after qualities demand in today's urban development. However, the material selection, and construction method of interlocking raw timber elements have somehow followed down the same neglected path together with the use. This is the seed that grew to become the concept: An interlocking framing principle that reflect a more contemporary approach towards the use, creating independence from the closed four-wall orientation.



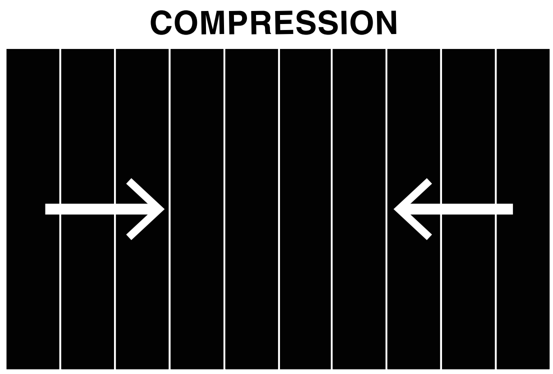
Plan



Section



Wall of plan



Wall of section

The vernacular log building

As described in the chapter about log buildings the vernacular style log buildings are dependent on gravity to keep the structure intact. This principle is dependent on openings for access and views. The space is closed and the horizontal size of the room is determined from start, creating a locked situation leaving the options of doors and windows left for transformation.

The contemporary log building

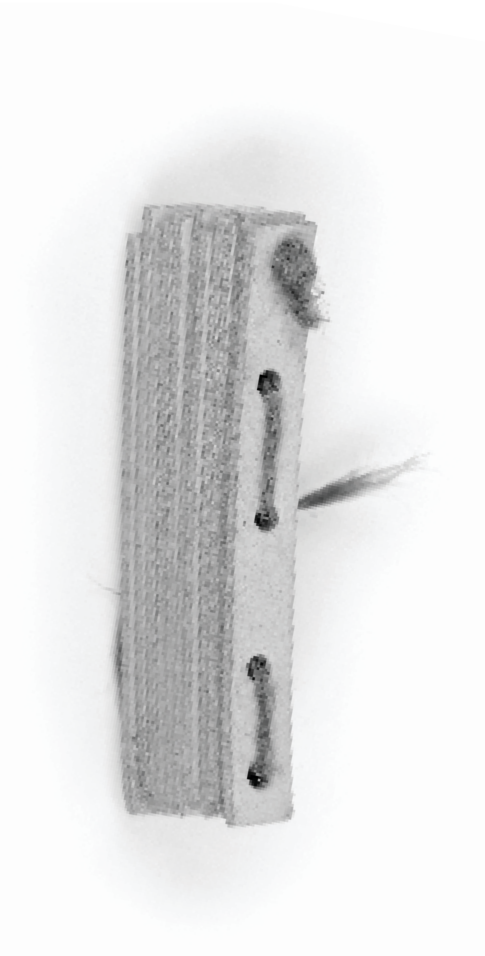
The frame principle changes the orientation of the space, with vertical elements and interlocking 'seams' running horizontally instead of vertical. This means the gravity is switched to compress along the fibres of the wood which is the stronger direction. The forces that used to keep the notches together are gone and therefore need to be countered with compression.

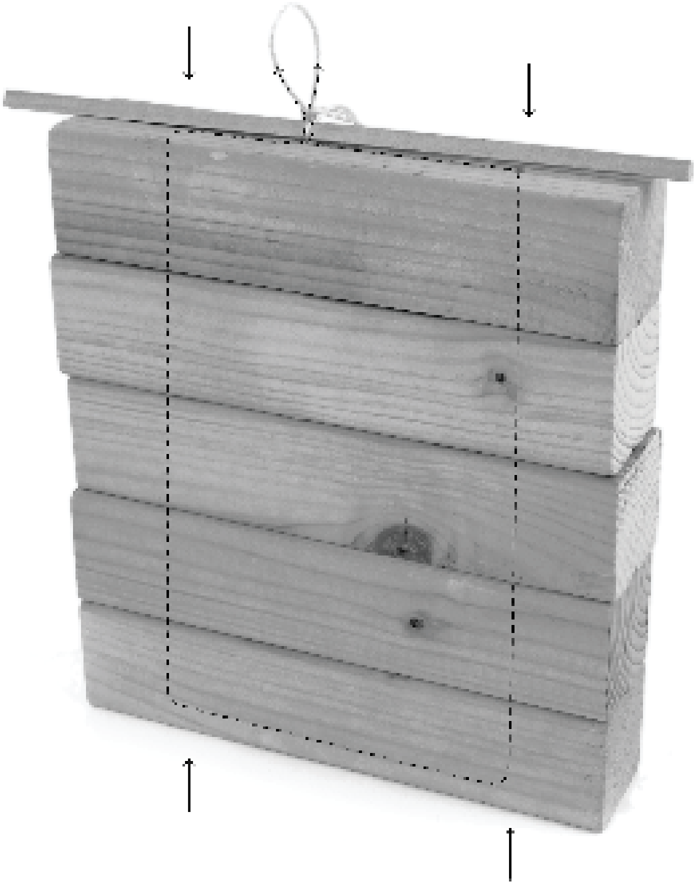
Assembly

Vernacular buildings are the base for the emerging ideas about the concept. They performed as visual proof of belief in the unrefined material. Skilled craftsmanship is proudly represented in both the precision of building and ornamentation that together with the hierarchy of the types of material for different uses paint a holistic narrative image of the concept. This wholeness is key to their century long survival as both the embed design quality and later maintenance derive from people caring about their existence, allowing us to even experience them today.

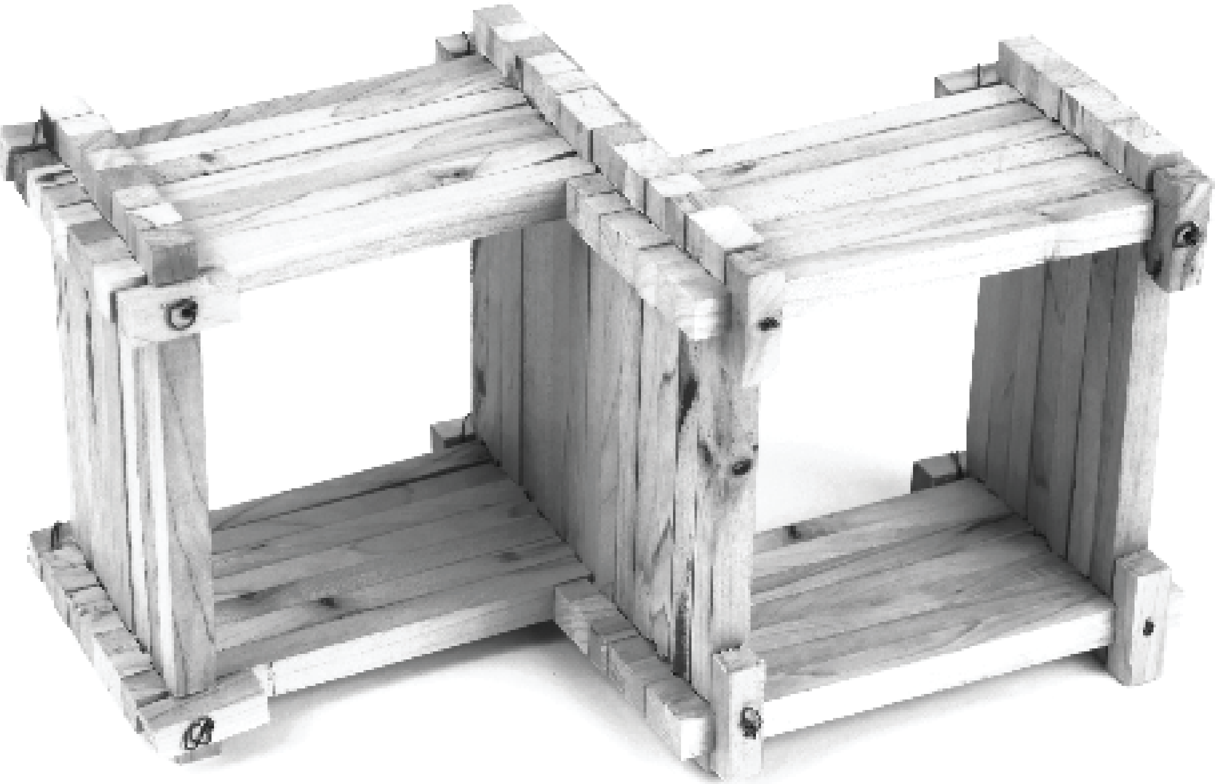
Performance wise the log house has played out its roll, as it is too unsophisticated and more shelter oriented than our sought after qualities demand in today's urban development. However, the material selection, and construction method of interlocking raw timber elements have somehow followed down the same neglected path together with the use. This is the seed that grew to become the concept: An interlocking framing principle that reflect a more contemporary approach towards the use, creating independence from the closed four-wall orientation.

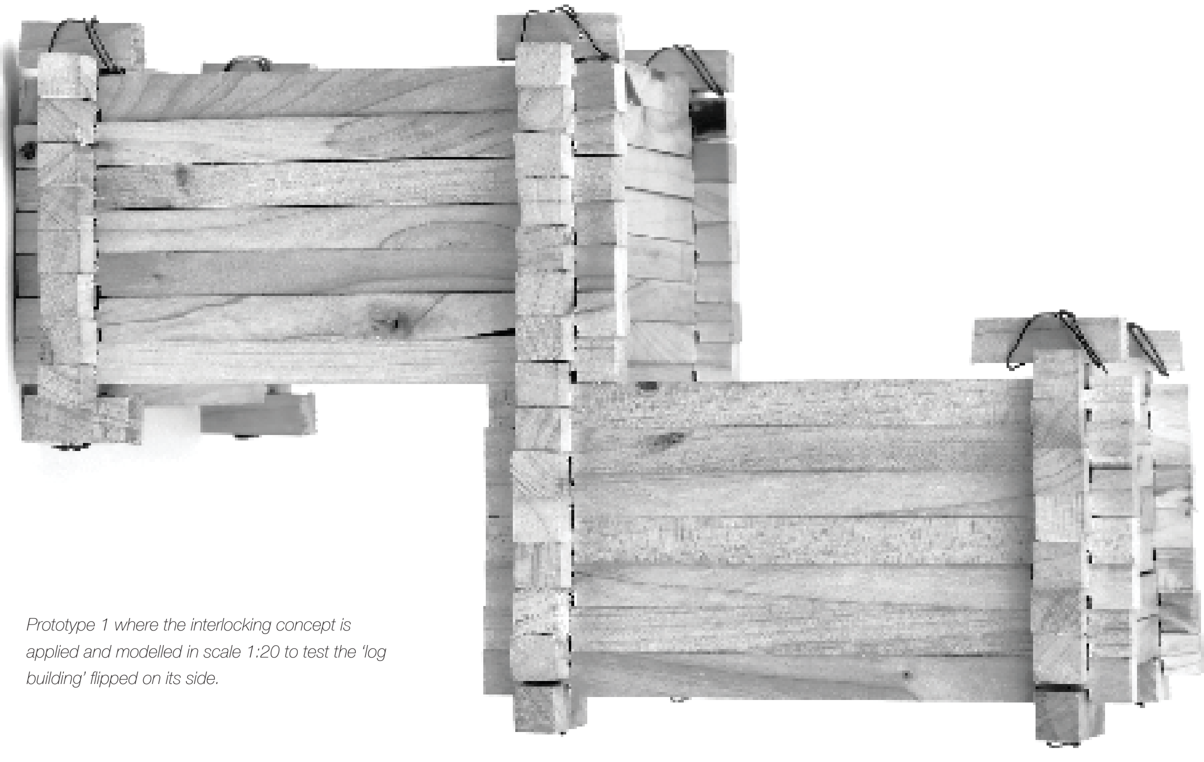
1:1 mockup of connection fully mounted.



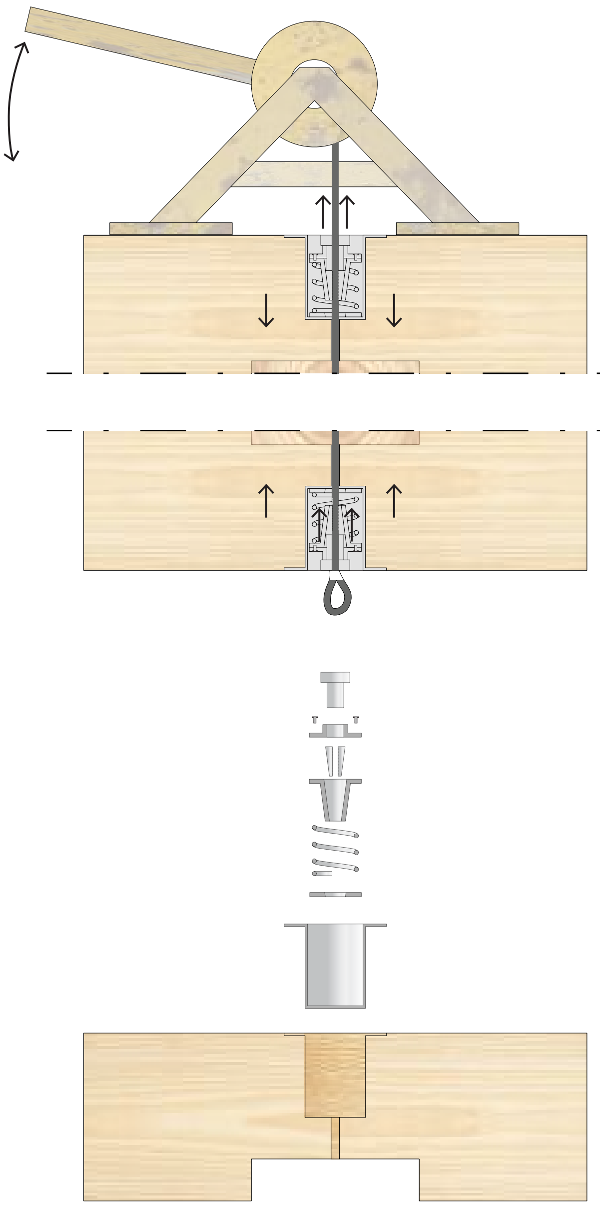


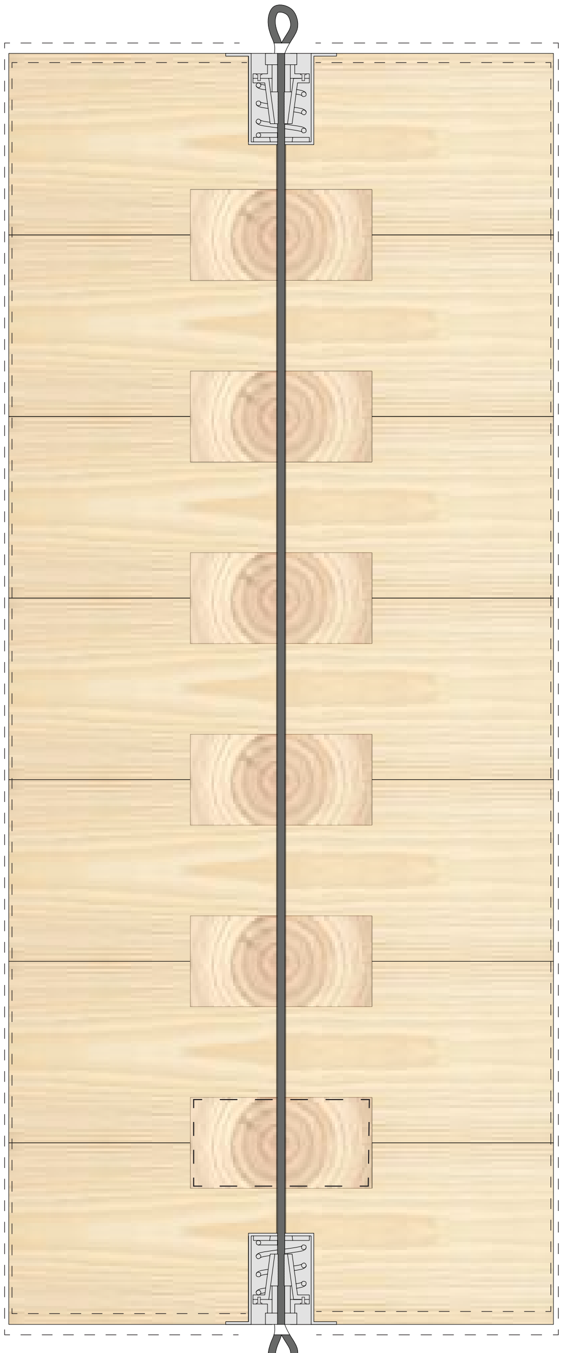
Inital models exploring the principle where tension and compression is replacing gravity as force of keeping elements intact.





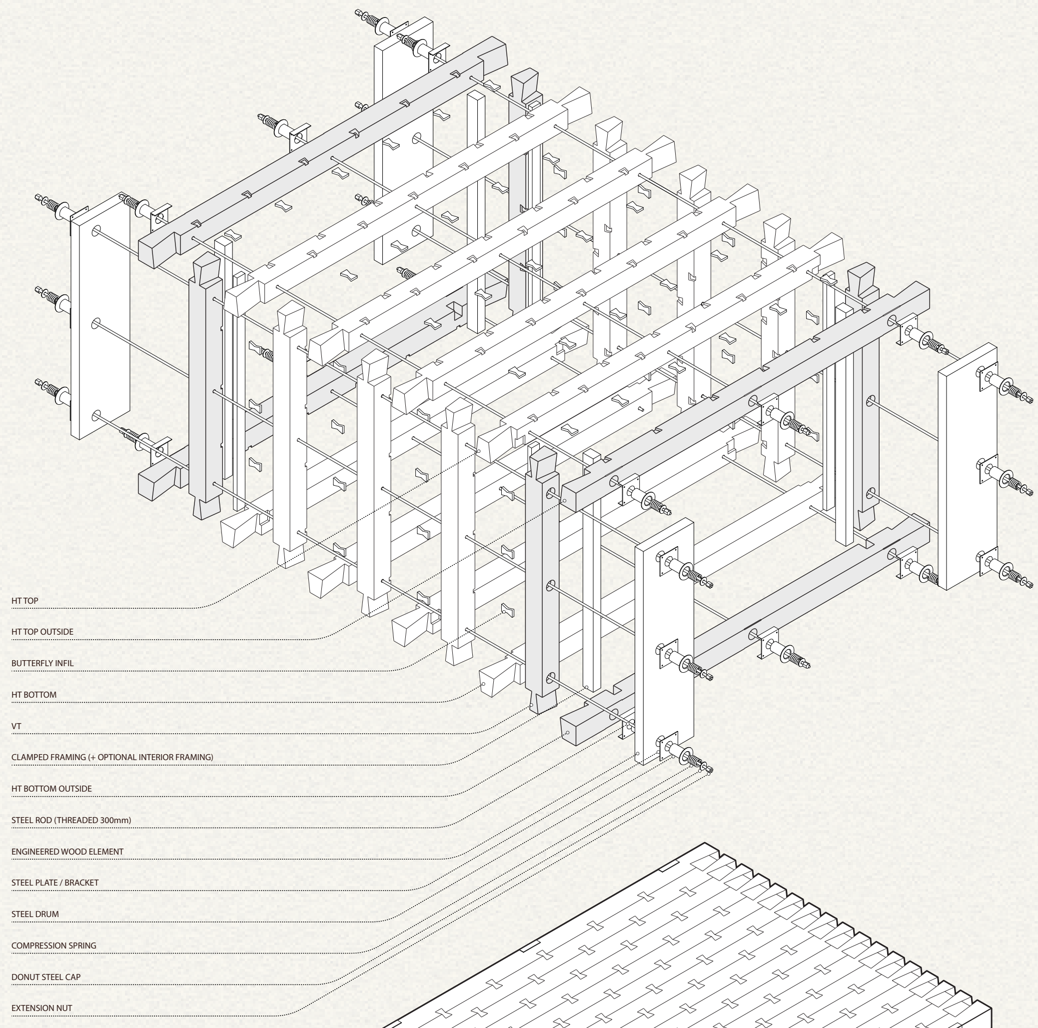
Prototype 1 where the interlocking concept is applied and modelled in scale 1:20 to test the 'log building' flipped on its side.

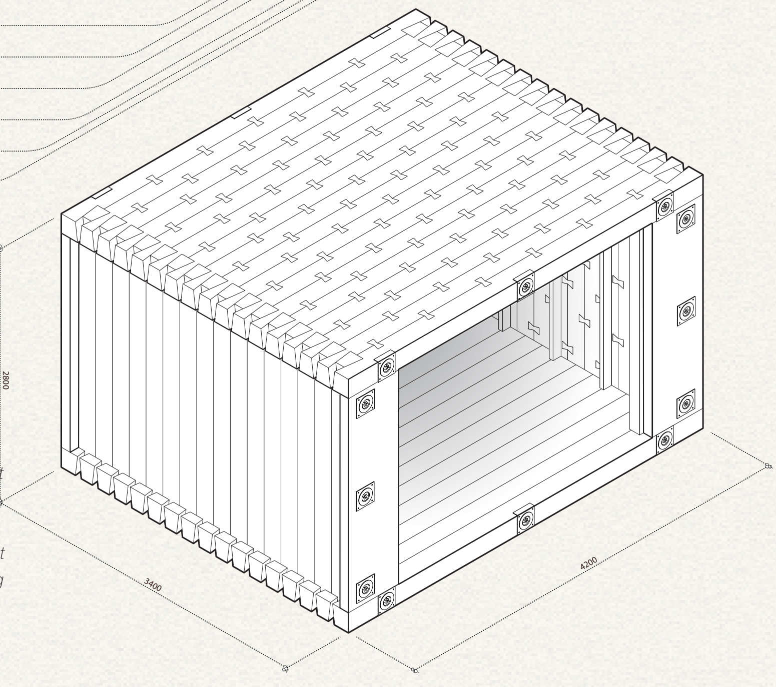




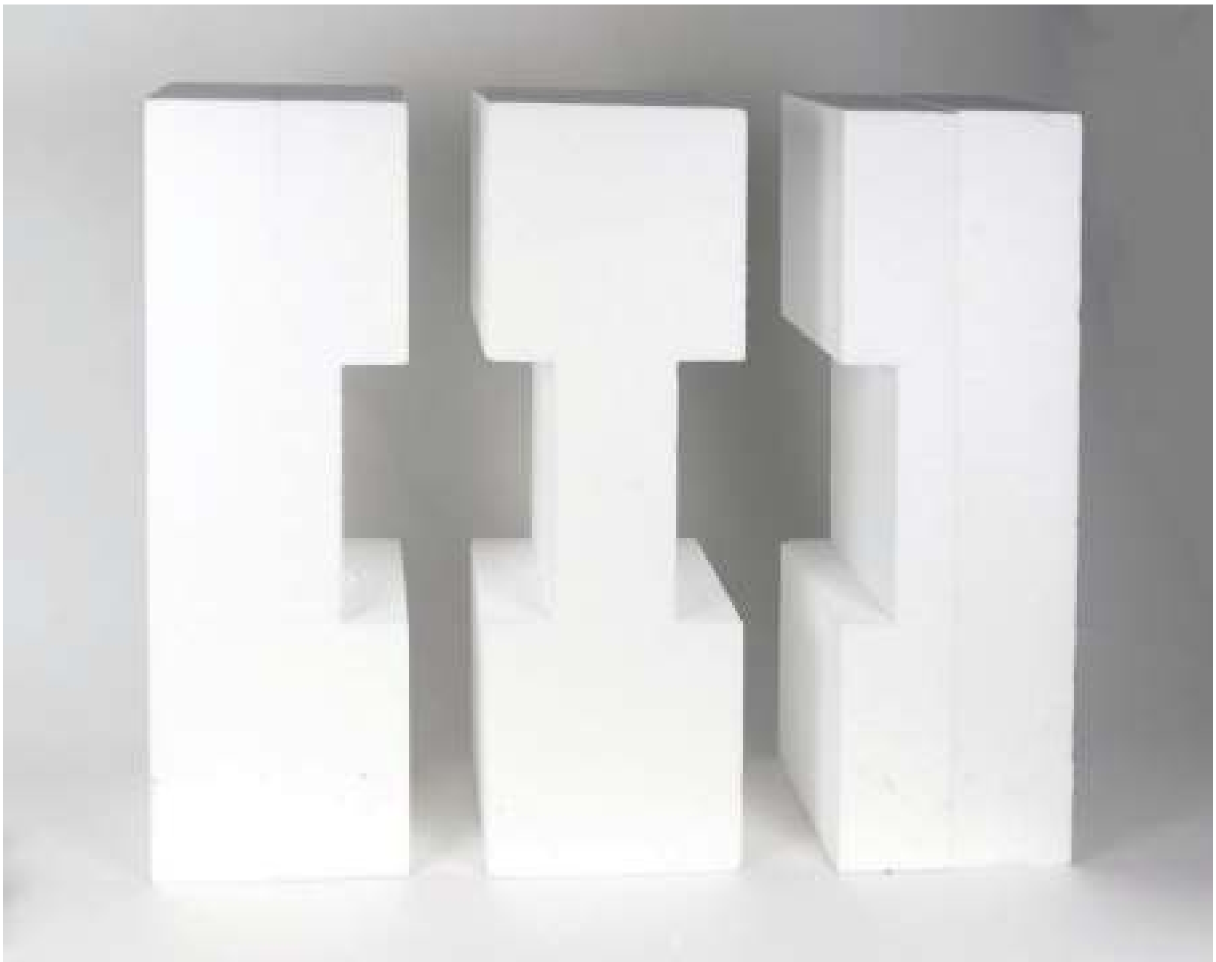
Fitting and assembly design for prototype 1. On each side a spring is fitted and compressed by a jack to connect the joints of the logs. The cable or steel rod runs through minimizing the cut away that could weaken the timber.

As the wood swells and shrinks the springs keep the compression even with their stored energy. The fit would be effected over time but as viable if the friction area is greater than forces acting on it.

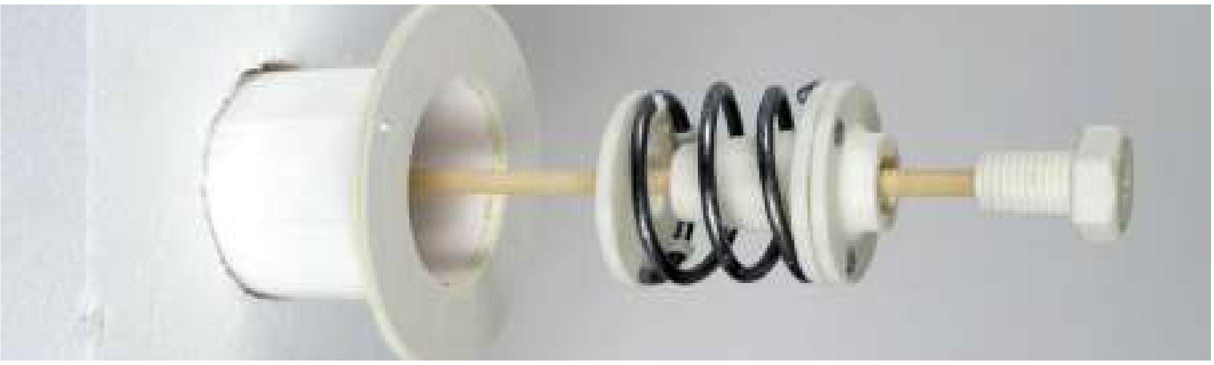




An assembly principle that rely on CLT elements for stiffening and bow tie plugins that secure side movement of the logs. The fittings are complemented with a plate to spread out the force acting on the outmost log. This is not necessarily a good solution but rather showing the concept of what to take into consideration in the system.



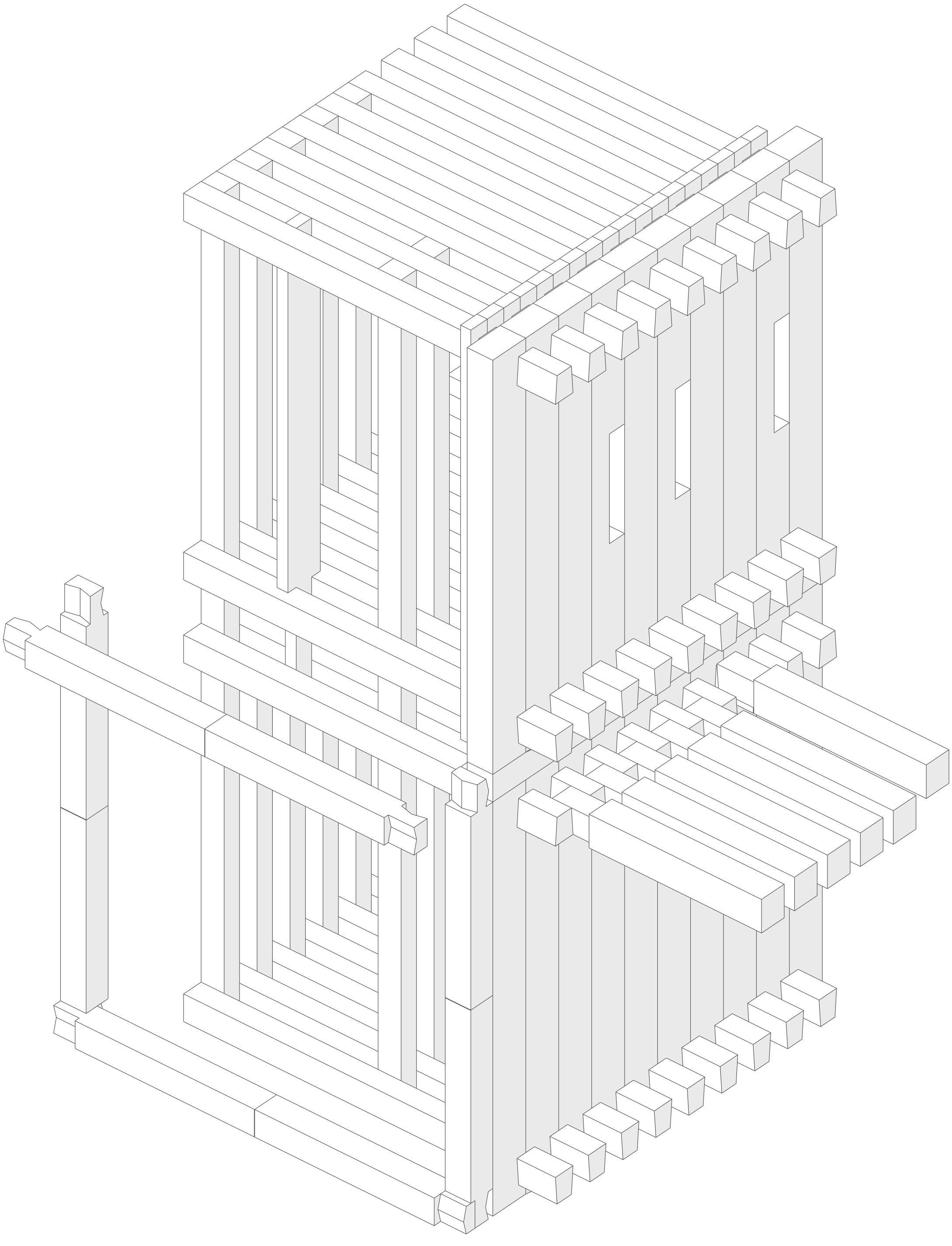
1:1 mockup of spring connector.



1:1 mockup of connection half-way demounted.

Joinery and the element

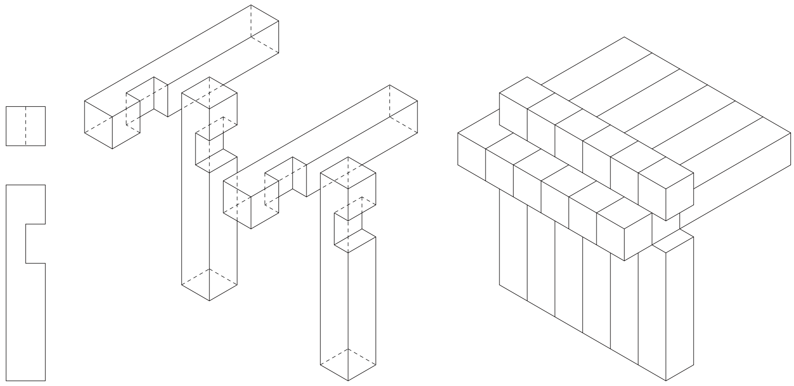
The interlocking joint of the elements is the most important design feature as it represent the strength of the system but also the appearance that creates the unique appearance. This chapter starts of by displaying some main principles of joinery used in this thesis. Iterations where made according to certain parameters, ruled by thresholds that is limited to the size and dimensions of the log and the weakening factors of the joint. There are countless ways to iterate a joint, and some types are not suitable for interlocking or functional for massive timber use, so they will not me treated in this thesis. This will be further explained.



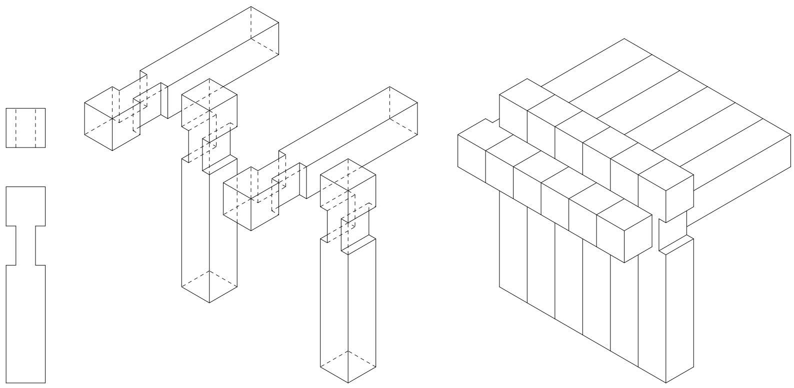
One of many joinery experiment using different joints to create unprogrammed spaces and unintentional functions to see what conclusions could be made.

Different flooring principles and extentions that create room for new joinery was the outcome of this.

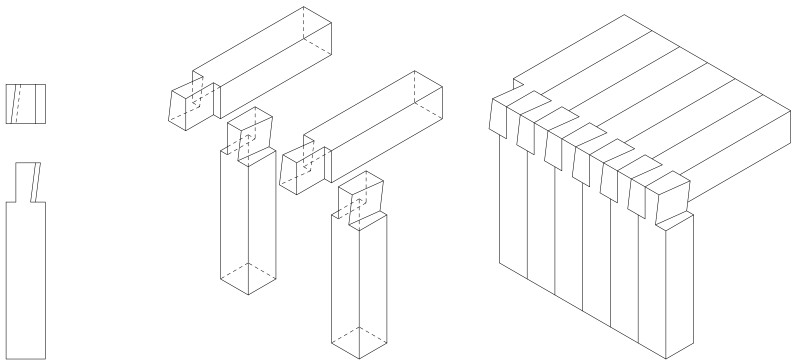
Chin notch



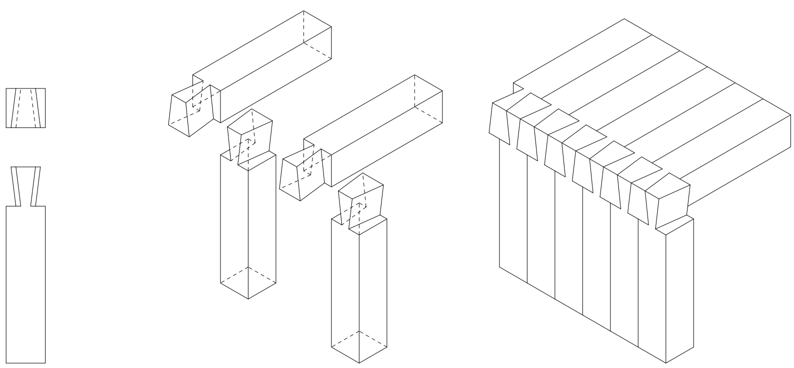
Double chin notch

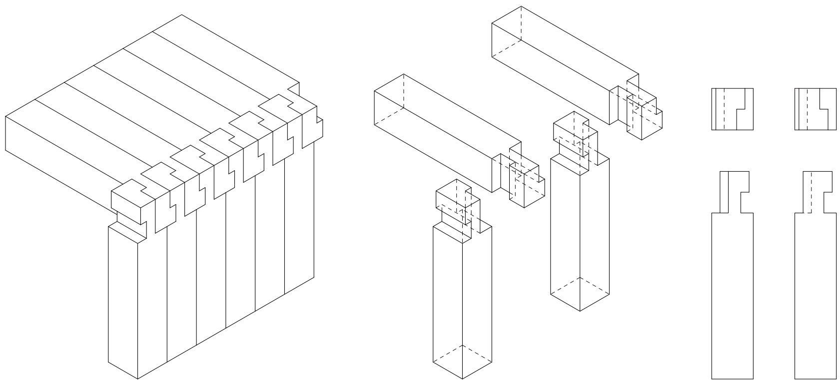


chinked dove tail

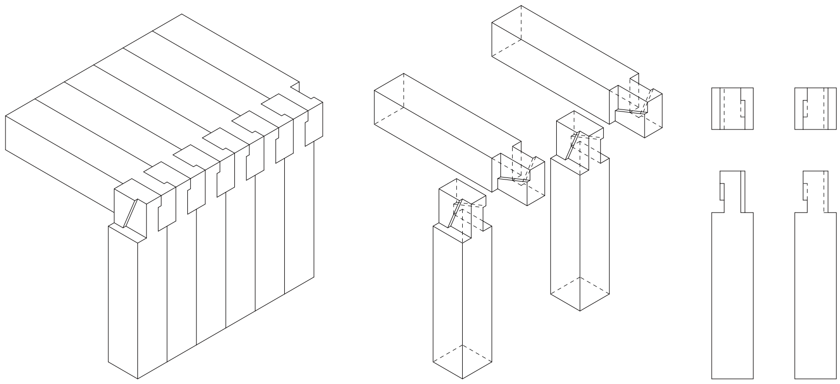


double chinked dove tail

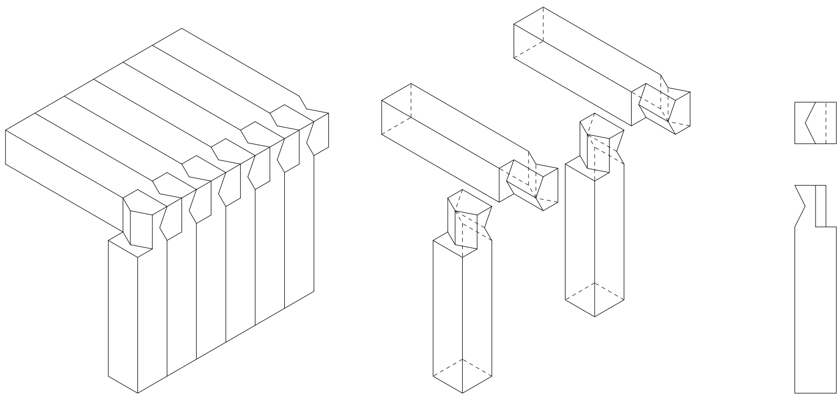




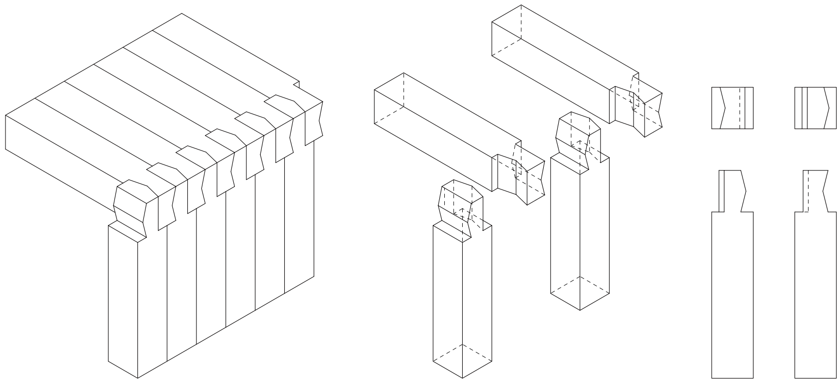
Diced chin notch



sleeved chin notch



saddle & roof notch



twin saddle & roof notch

The V type is symmetrical and work both before and after itself.

The A type is asymmetrical but still works before and after itself.

The AV combination has to follow the same order.

The mirrored AV has to follow a shifted pattern.

The AV principle

The AV principle was invented during the classification for the joints. It represents the different ways joints can be configured in relation to each other. A or V represent for example the end of a log where the joint is.
V is symmetrical – A is asymmetrical. As seen in the chapter notched and stacked wood, the overlapping principle rules the next joint to fit onto the first. This means that the geometry of the meeting joint surface has to match the opposite. A gives the opportunity to have two similar, but different types of geometry on each side of the axis of the element. The benefit of this principle is that if the element size, angle or proportions changes during designing, there are more options to create a suitable joint for the situation. To some extent this could be a factor for the choice of appearance for the sequence of joinery, not considering strength but rather the holistic aesthetics that a joint pattern could produce.

At least 50% of the profile need to be removed from the log in order for it to fit snug to the adjacent one. Keeping the centre line intact and preferring symmetry increases the strength as it is more core material present.

A chinked surface is better than a flat one due to its potential to act as a wedge when forces act upon the joint. A slanted cut surface is more prone to deform, since it is cutting more fibers off, but with pre-dried material it's close to 0.

Heavy detailing and small pieces of wood in proportion to the wholeness are more fragile and break off easier. Also pockets are formed where moisture can penetrate and stay, destroying the fibres

The number of cuts should be reduced due to time efficiency but also deep angles that might result in unreachable areas. Faults in the wood like knots and disrupted fibres might also cause problems if they meet unfortunately over a ridge.

The height of the profile seen from the side should be kept intact because of the forces that more often act together parallel with gravity. Weight put on top of these might cause rupture if if the profile height is decreased

Very sharp angles might cause problems for tools to reach, disrupting saws or milling tools to reach all the way. Except for the blade or tool head itself the machinery supporting it might bump in to other parts of the log.

An atempt to create a joint that fulfill the criteria put up. Its based on the double chinked dovetail joint but with room for a milling tool with smooth transitions.

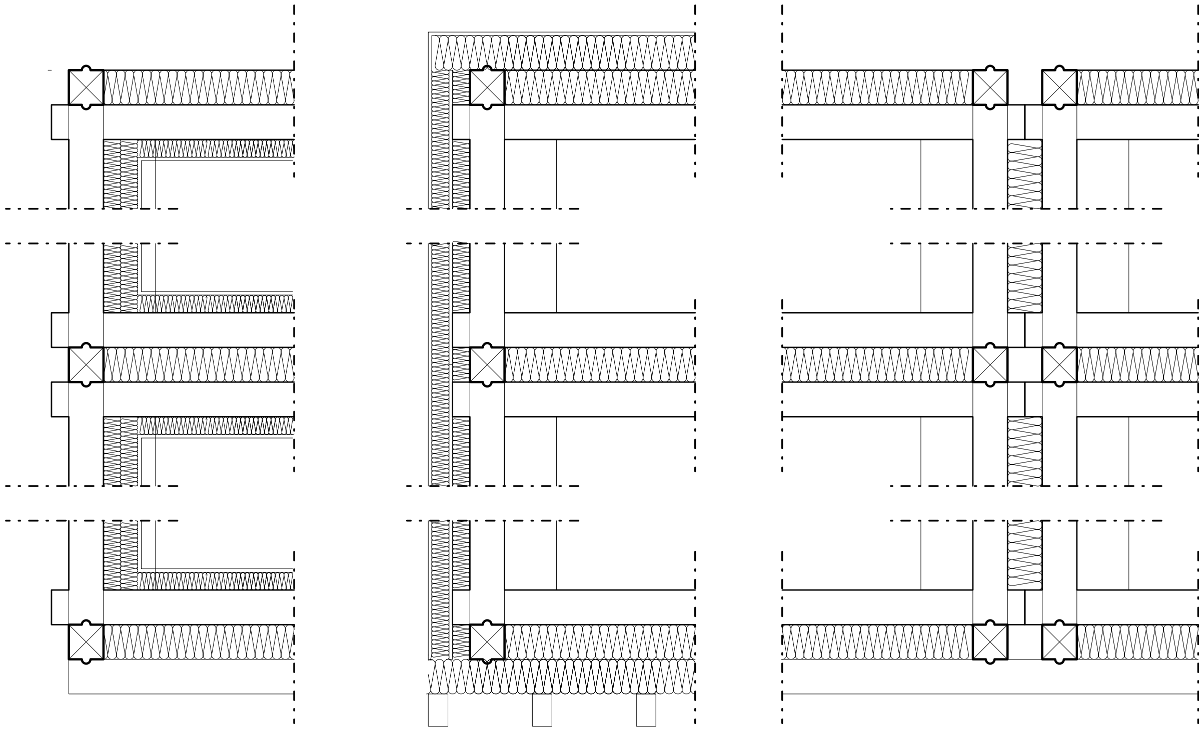
A set of rules

These sets of rules was brought into both modeling and algorithmic design tools and translated into geometric parameters. During design work a number of warning notifications was programmed to occur when limits where passed regarding measurements and proportions between the size of the log and the smallest cross section profile that occurred.Further on the style of the joint was kept to be the double chinked dovetail style mostly because of the difficulty to model and parametrize every iteration of styles. This could be challenged into a more detailed search for functionality in terms of weather proofing, strength, flexibility and expressive variation.

Configuration of elements and units

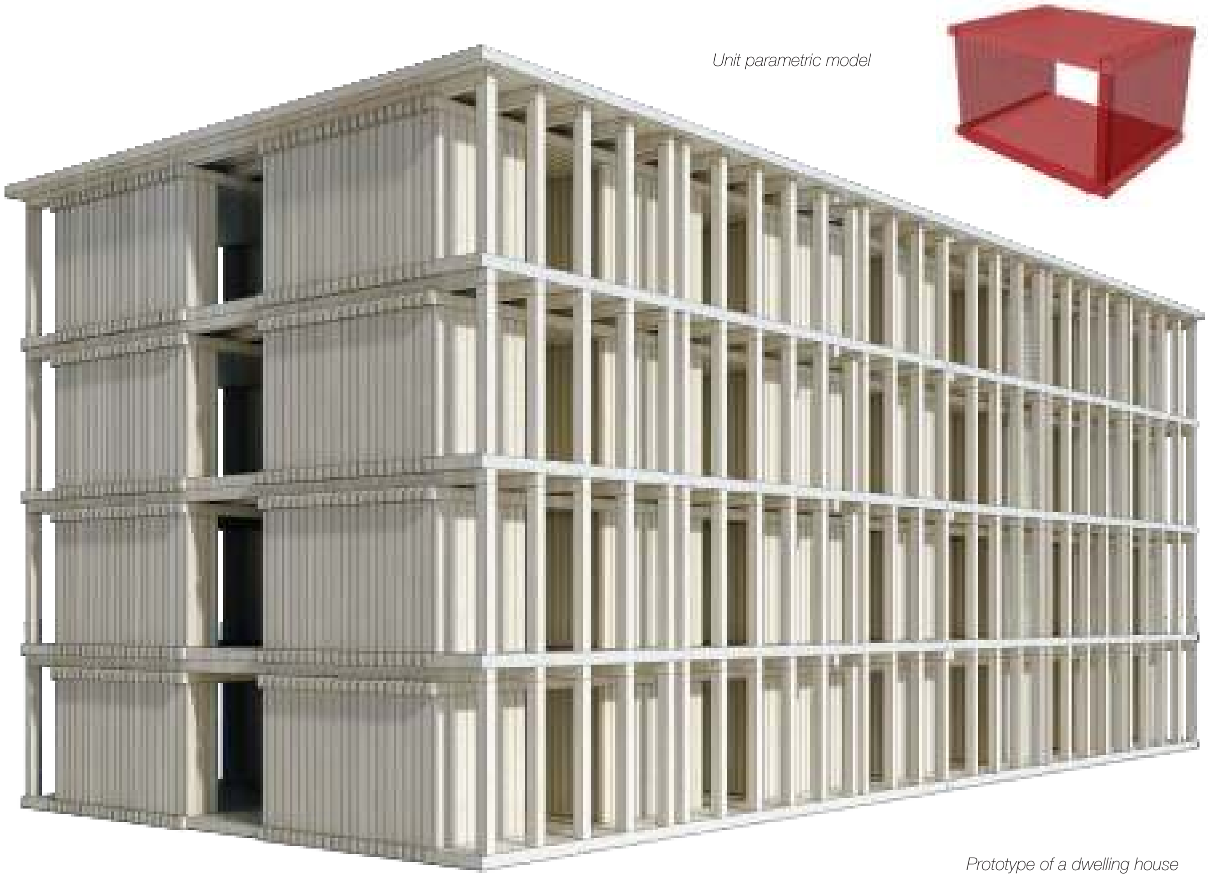
Since the frame of the notched square seen from above had become the frame seen as an elevation a number of framing iterations was conducted. Through evaluation the flexibility of either roofing, connected parts on the sides and sandwich elements showed promise to apply the frame principle onto three dimensional space, where units could be formed and then stacked. This line of thought was not sustainable since it was more about the space for dwelling that was in focus and not the possibilities of the technique to notch the wood and create form. It was therefore abandoned later on but the study also show what another approach could've been where lowering material cost and the mix of materials could've been the focus.

An early general study exploring the base frames for different types of units and spatial creation. The basics for all is that every connection is part of the structure and interlocks with joints in corners and meeting points. The most basic principles in the bottom are more similar to sandwiched slabs and the top ones are subdivided full size rooms with extended elements so that for example roof beams can be supported on top of the object.

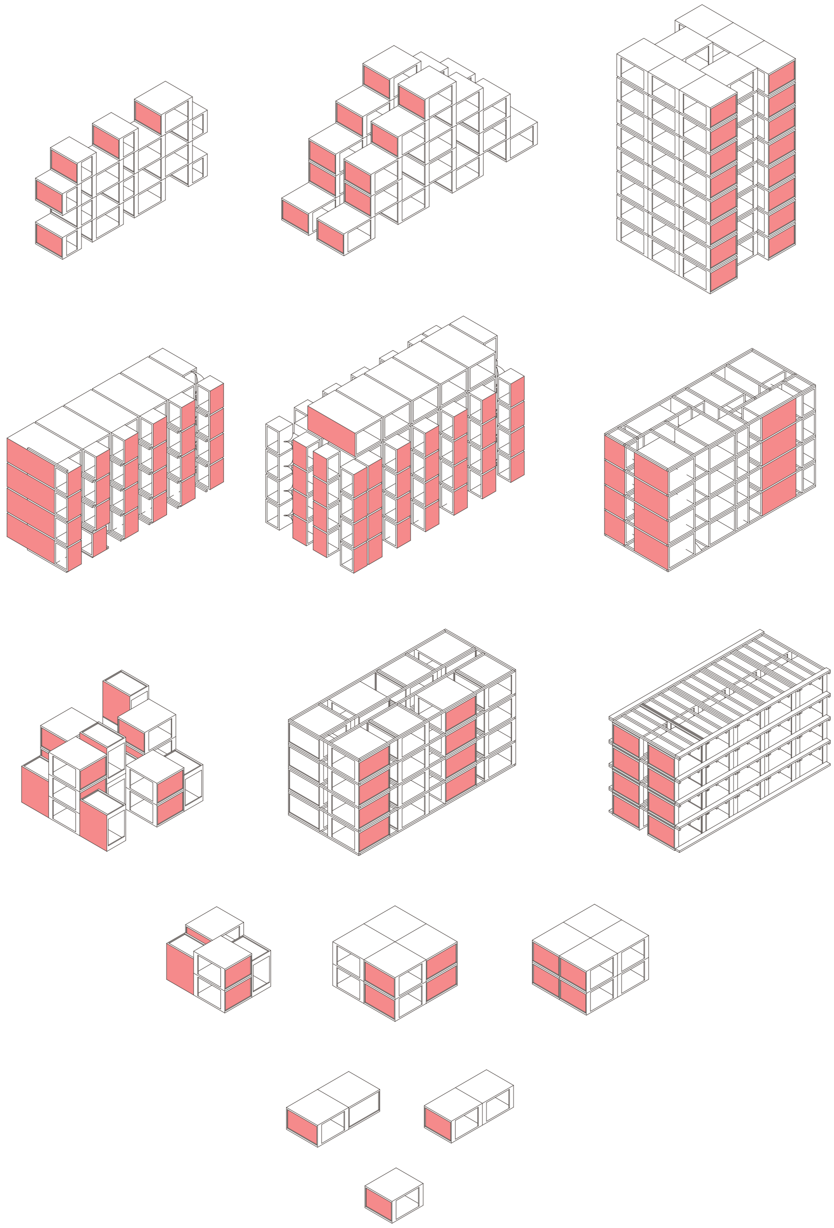


Details of insulation possibilities

Unit parametric model



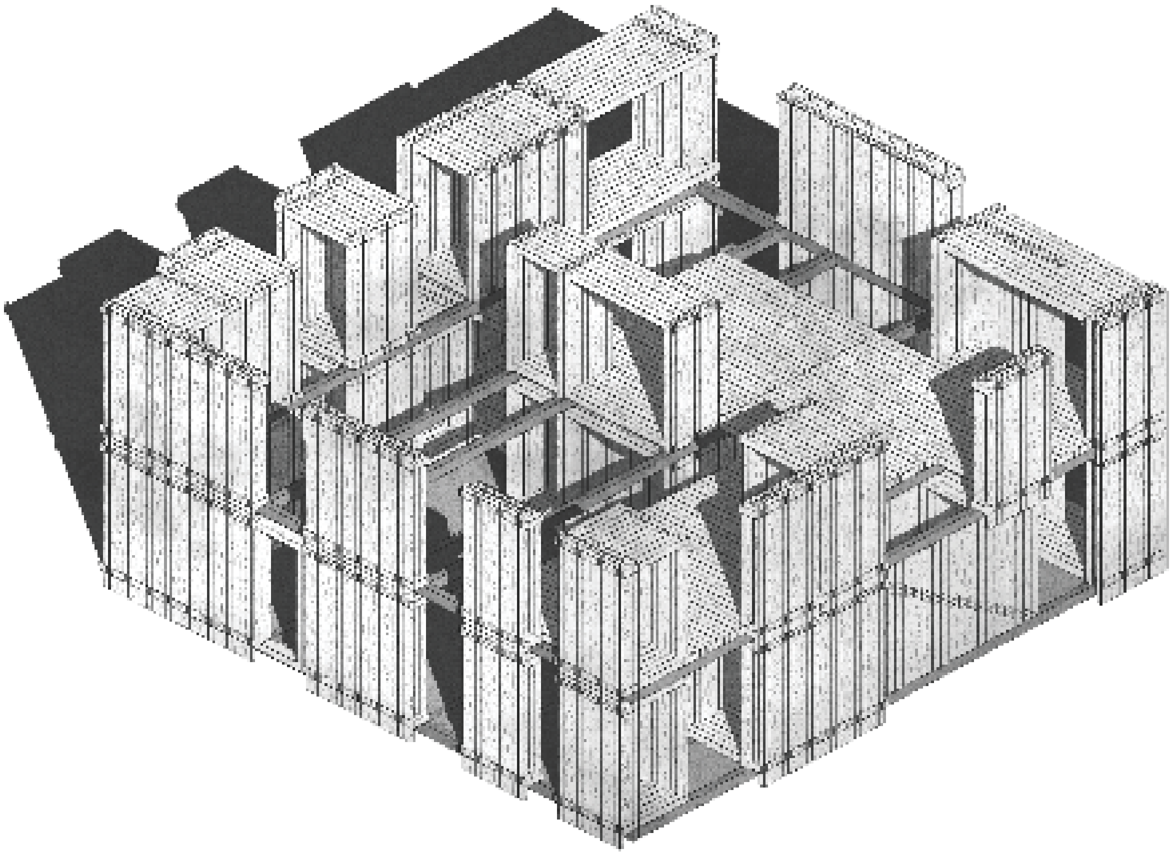
Prototype of a dwelling house



The typological tree of variation using the same unit

The unit

As a simple box but where every part is controlled by executive modelling tools took shape, and the configuration of the boxes and the elements that they are made from was iterated to find different architectural qualities. The open end box would have to be covered at the front and back and weather proofing and insulation would have to be applied. As a result a proto-typical dwelling structure was produced but it could not reach a level of complexity required to start answering the thesis question about diversity within timber architecture.



Exposed model of the first preschool design

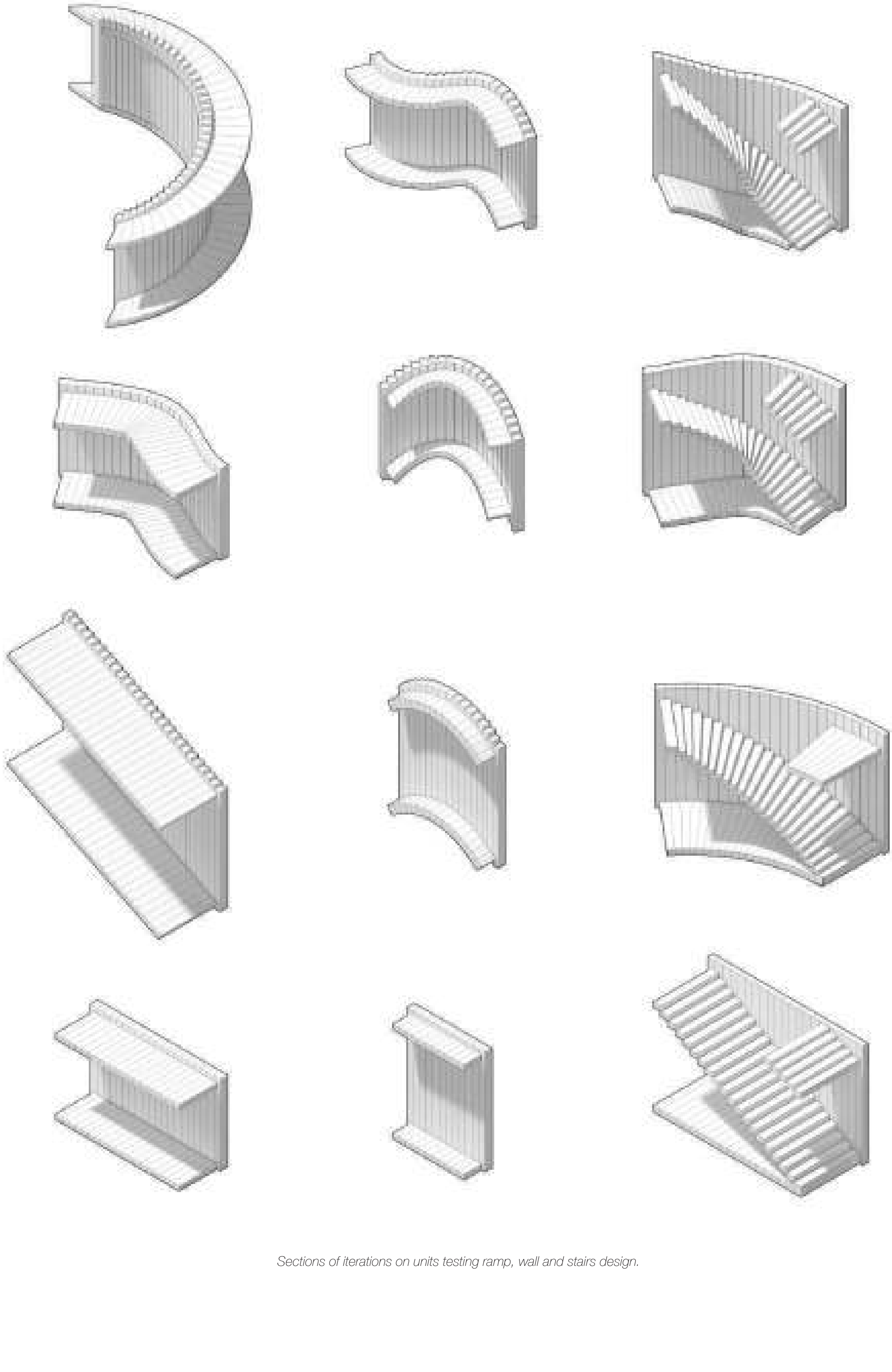
It's not a house

Moving on - the idea about a preschool emerged and different tests of a larger space but composed of smaller rooms became the design- influenced by Zumthor's Therm Vals. The differentiation of spaces did not affect the joinery other than the appearance of them and this in combination of a flat and non-challenging design led to the abandonment of this approach as well.

Prototype of stairs with combined units

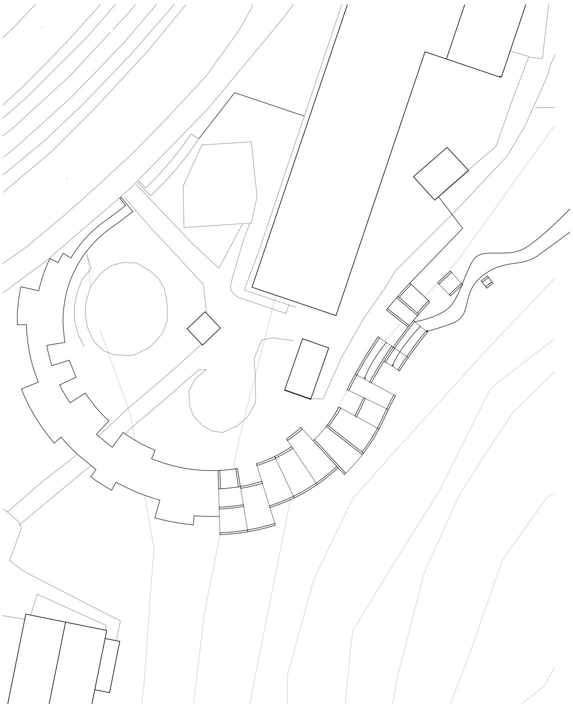
It’s not furniture

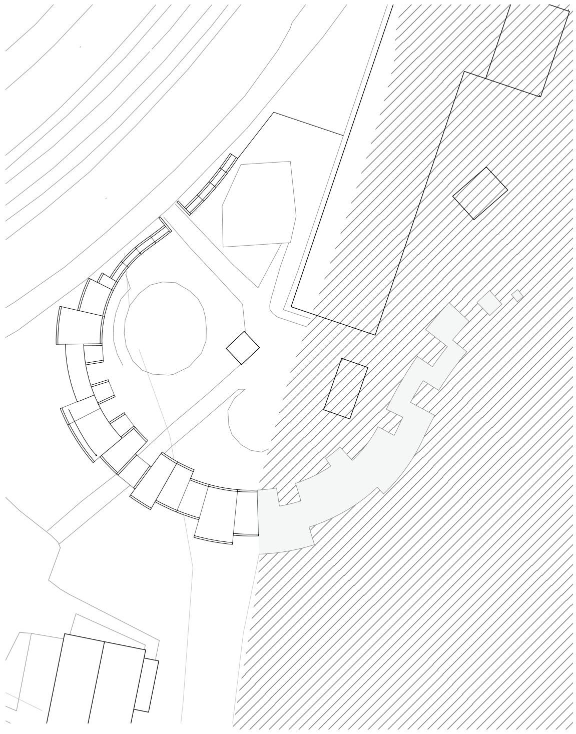
When more freeform algorithmic controlled parameters could be applied, test with different types of building components emerged from the design. But mostly this stayed within the realm of experimental and small scale prototypes. Using this knowledge the idea to apply the same method to a large scale building model was growing to become reality within the proposal.

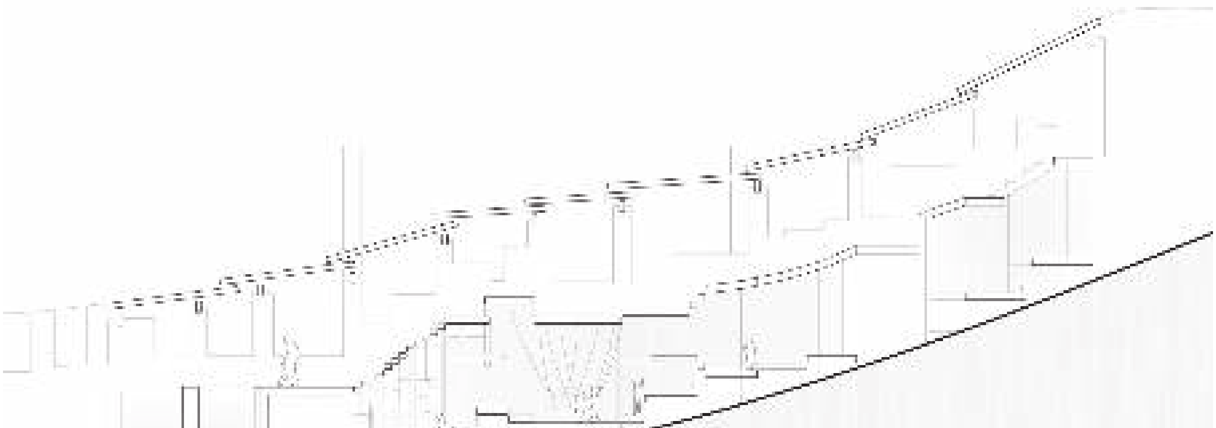


Sections of iterations on units testing ramp, wall and stairs design.

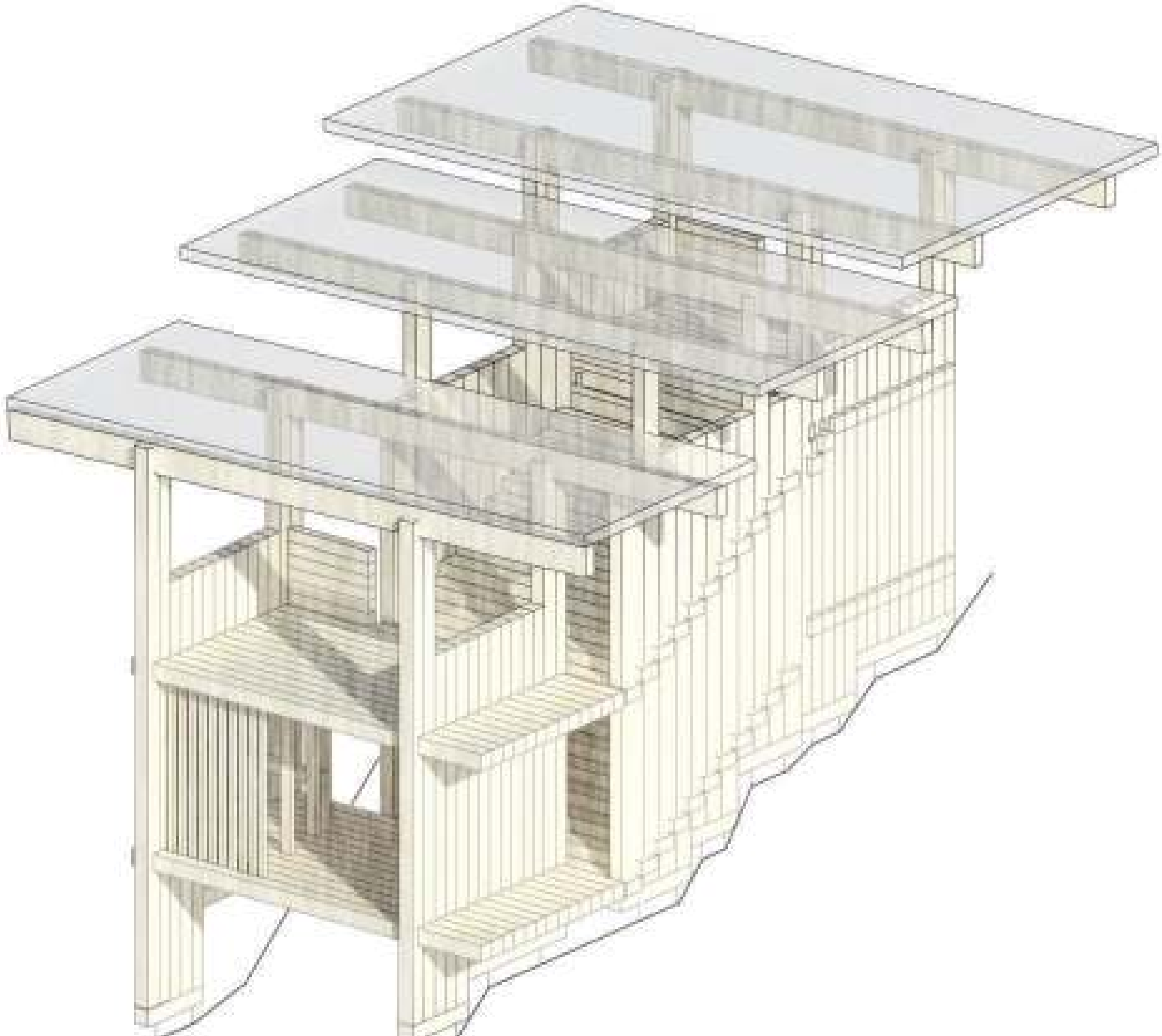
Free formed frame design using flat surfaces but with stepped inclination as tolerance.





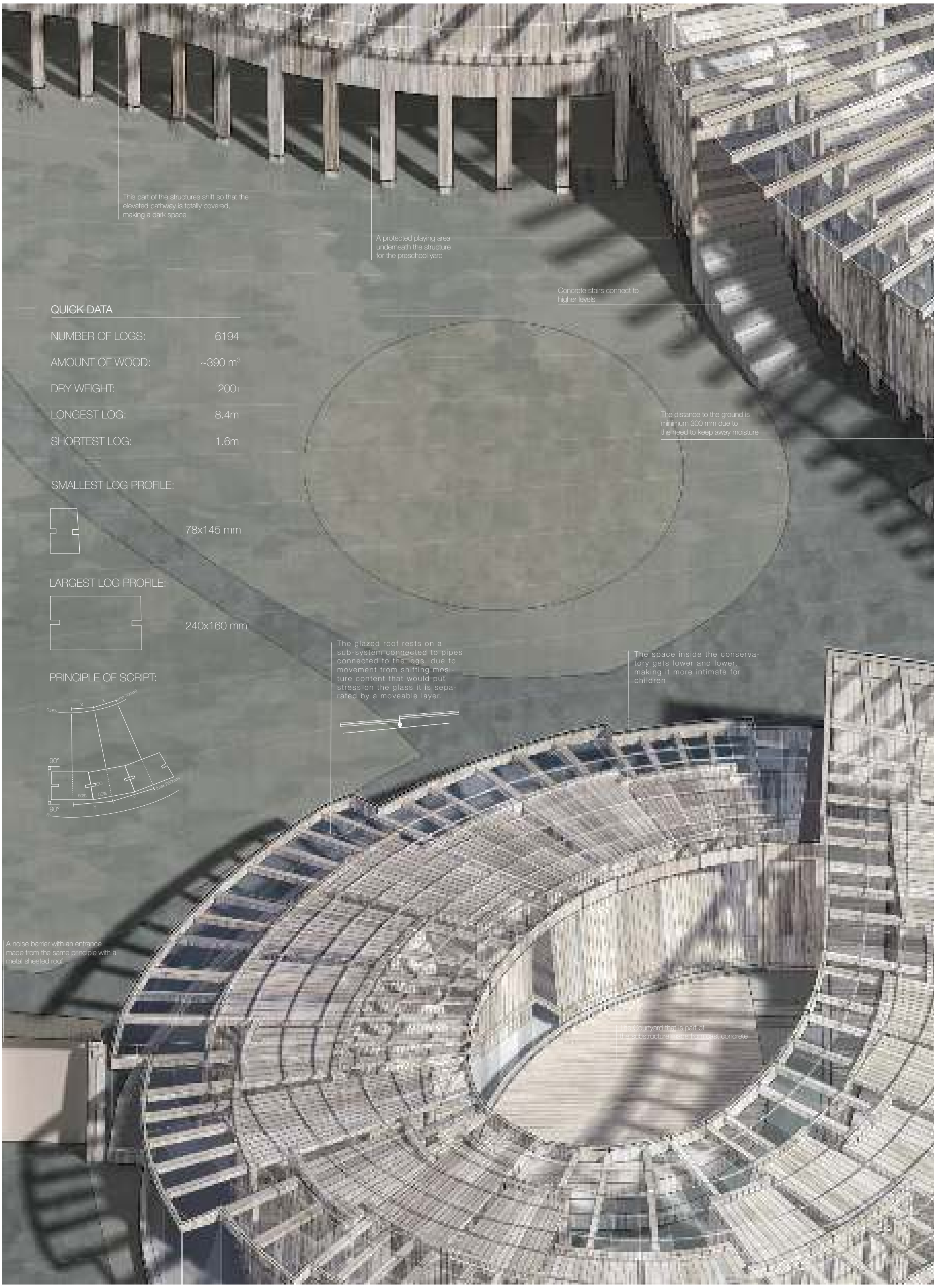


First sketches of plan and section on final site.



Part of the pathway as a first sketch.

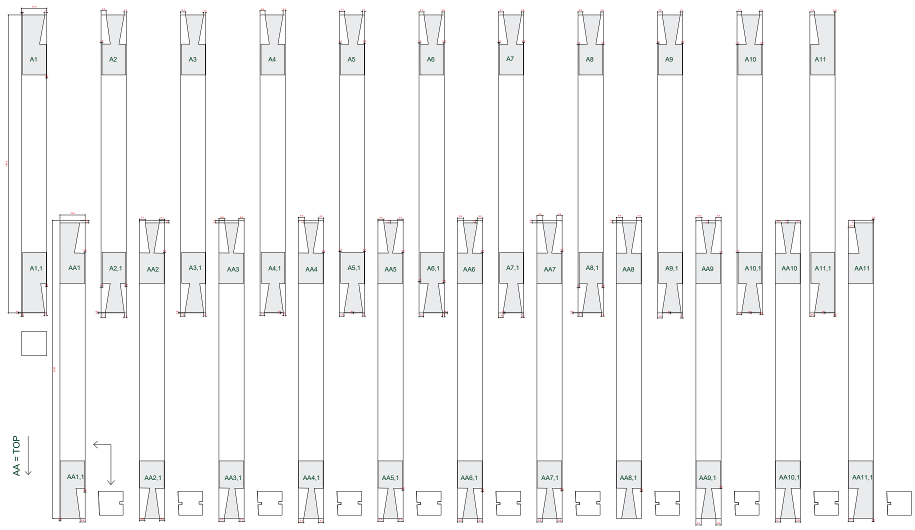
Overview of the first sketch on the site



Final proposal zoom in


The roof beams are halved logs that sits into a joint at the end of the vertical logs. The lenght extending out on the sides have the purpose to protect the end grain from rain.
To make sure that water doesn't interfere with the structure prepatory work includes leading water by a draining ditch that create a small oasis in the upper loop
A protected playing area underneath the structure for everyone

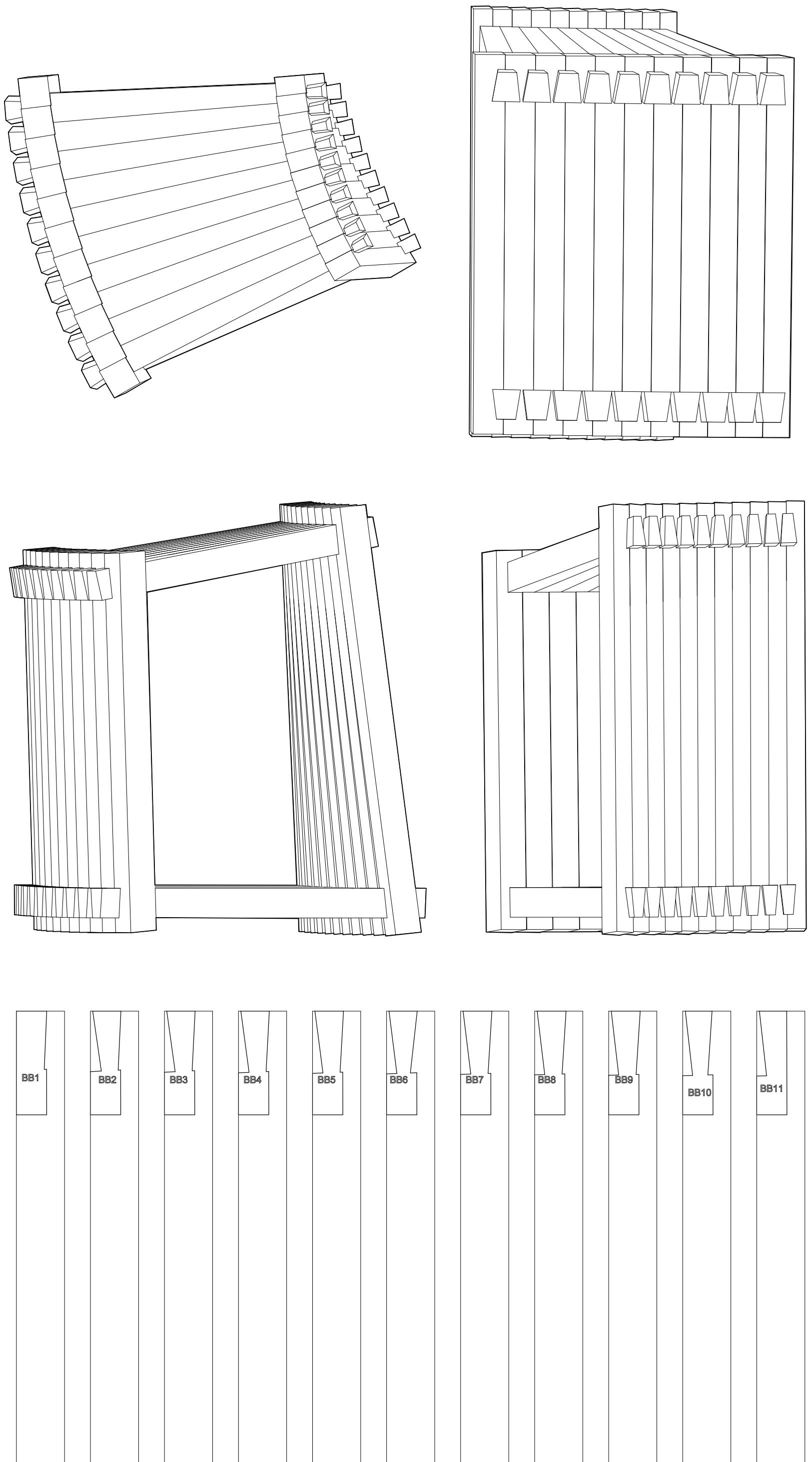
Link to folder where pictures of he final model of the thesis are uploaded, followed by any other experiments taking place on the subject.



Drawing template for the pieces of the final model that later was glued on the pieces to guide the saw. Every piece is based on the rules of the joint but vary in angle and length.

Fabrication experiments

The most truthful evaluation to any design is by testing in it model. It is not only the result that has been the point of evaluation in this thesis but the process behind it and the actual building that was key to understanding the fabrication process and what tools could be useful, but digitally aided and hand tools. By knowing about different types of robotic adaptation and sawing and milling rigs a simulation using hand guided tools could still be useful in understanding how the wood would act when altered by a blade, a rotor or any other tool.

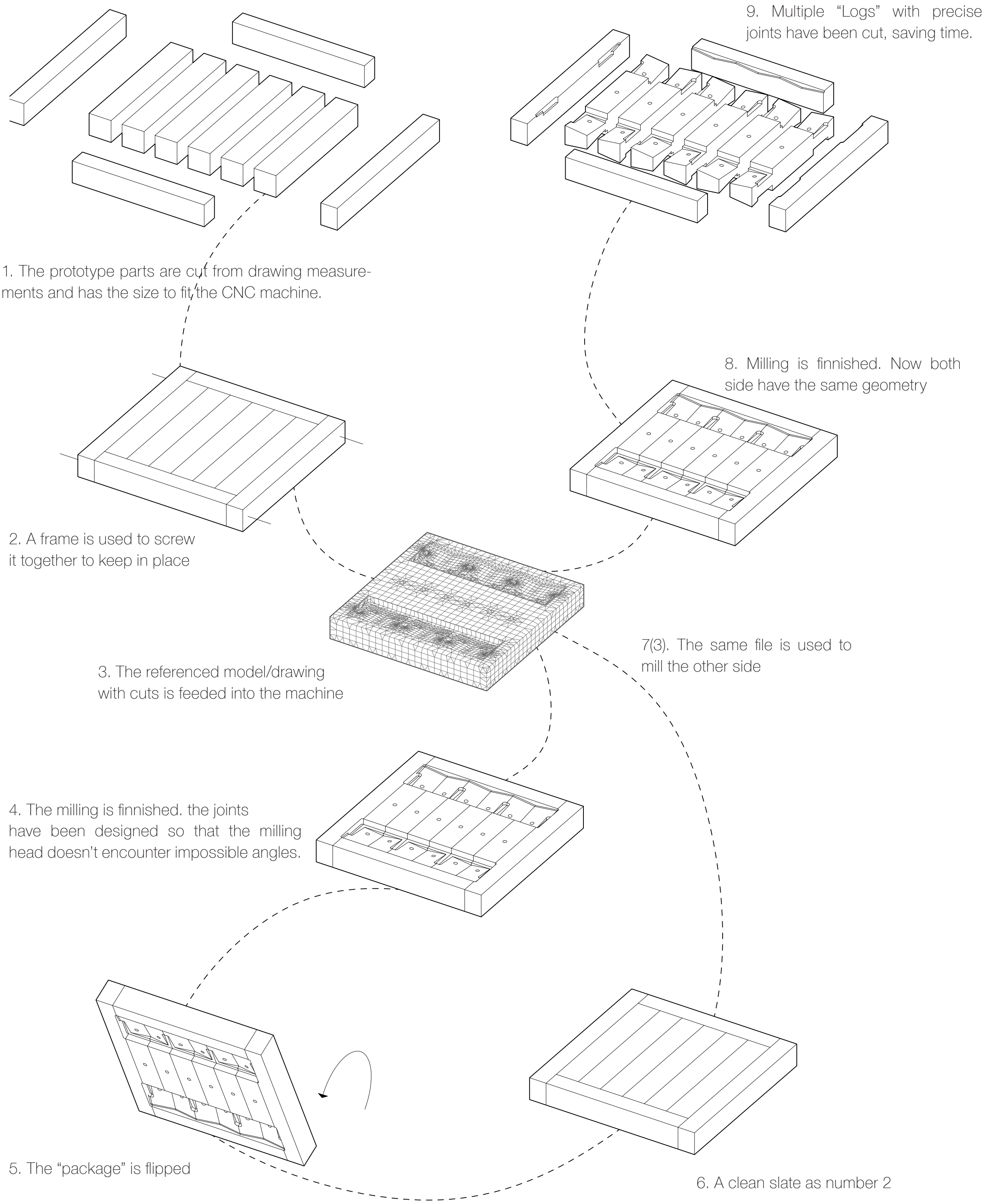


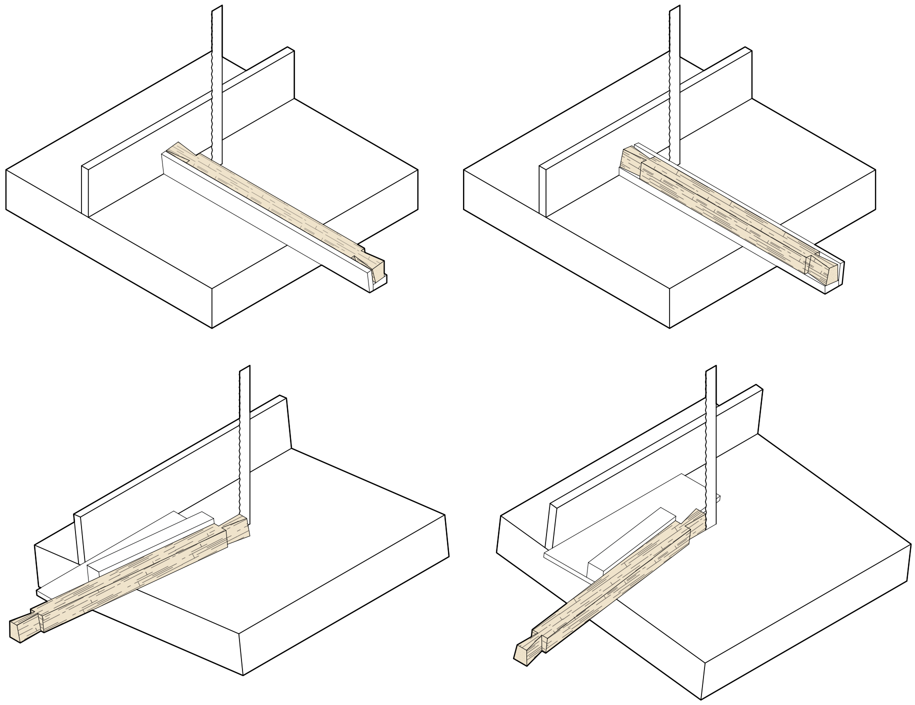
Fabrication drawing of log pieces in 1:5 using 2x2 wood to represent logs.




2D milling

A fabrication experiment using digital milling as tool of refinement was tested out with a principle of combining already cut pieces. This test was to see how a full scale production line could be worked out and what could go wrong when using milling. The result of the experiment was better than expected with very precise cuts on the surfaces. But putting the milling head in the same position for the next round was were the tolerance limit was crossed as the joint did not end up being cut on the same place. If the flipping of the pieces also could be controlled by a robotic feature, this mishap could be eliminated too. For other experiments the milling platform would have to be scaled up and different mill heads would have to be used as well as consideration when designing for their cutting profile.


9. Multiple "Logs" with precise joints have been cut, saving time.
1. The prototype parts are cut from drawing measurements and has the size to fit the CNC machine.
8. Milling is finnished. Now both side have the same geometry
2. A frame is used to screw it together to keep in place
7(3). The same file is used to mill the other side
3. The referenced model/drawing with cuts is feeded into the machine
4. The milling is finnished. the joints have been designed so that the milling head doesn't encounter impossible angles.
5. The "package" is flipped
6. A clean slate as number 2



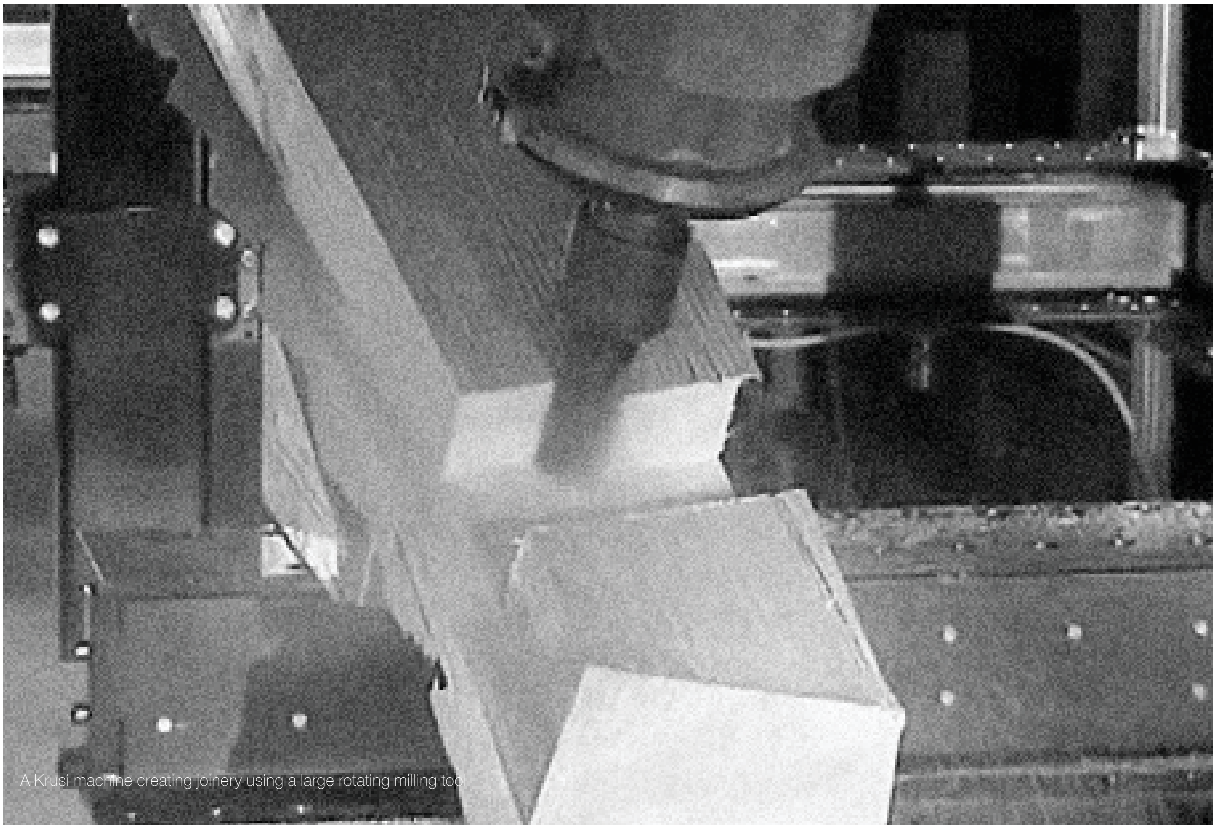
Back to basics

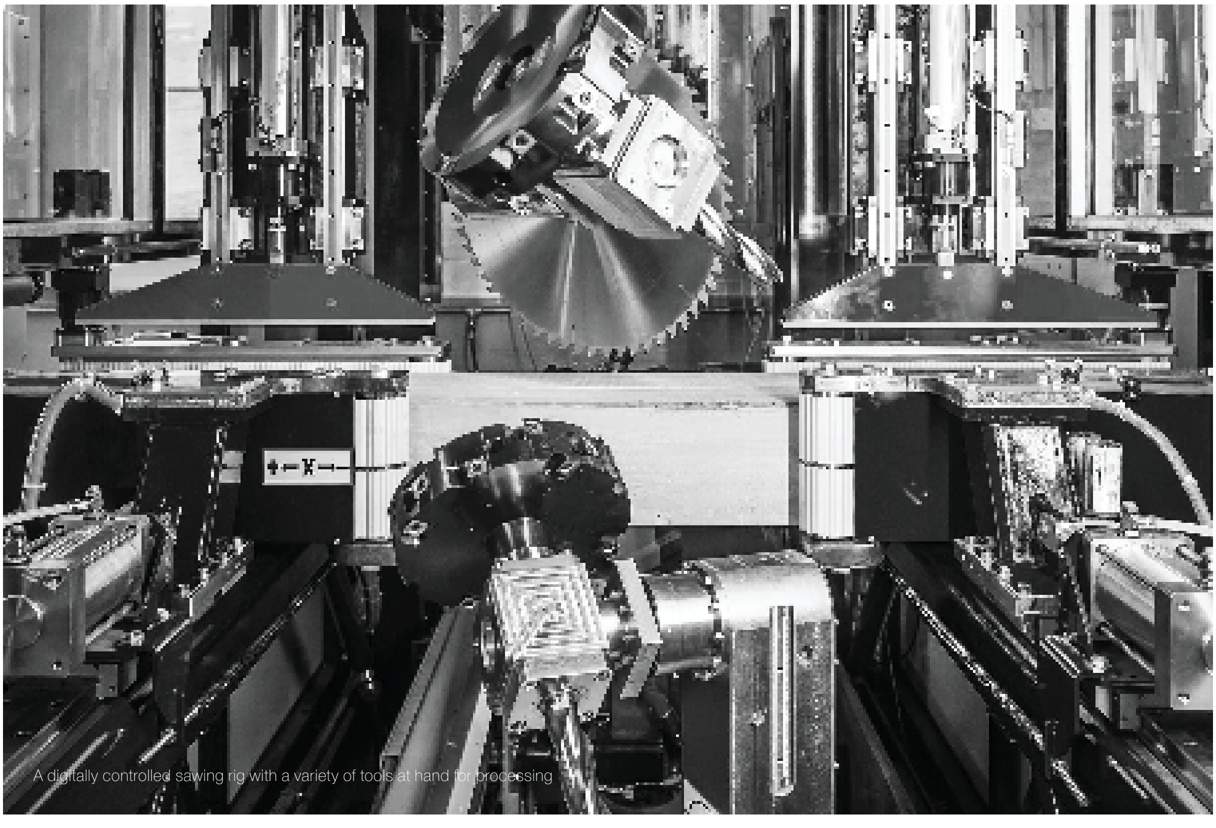
The final model had to be a mix between computer aided design and hand guided tools because of the lack of machining possibilities available. This is was a semi-simulated production line where the pieces represent logs in scale 1:5. The smaller pieces glued on the logs had to be placed by hand which in itself adds another risk for error in the production. But the laser cut pieces fit just right onto the planed-to-width log so no measurements had to be taken to place them on the right place. Between the template and "log" a piece of paper is glued on for easier removal of it. After sawing, some elements had to be planed for the floors and roof pieces that had to be curved ad there for altered so that one end is smaller. Saw and chisel could easy remove the material with two simple steps, but the most time consuming part is the planning of the sides which could be roughly sawed first using a band saw but is also skewed in the other direction. In this sense a preset-able machine could save time.

Author's comment

The whole process of writing this thesis have been a learning experience with emphasis on faults and errors. It's true that mistakes can lead to success. But success is a very loose word when speaking about architecture. Some measure it in how it is used, and other in the way the end result compared to the detailing of drawings end up. But in this case the success in not measured by great esthetics, environmental benefits or pride of design but as a seed of curiosity for others as a first step of looking at the old technique of log notching in a new light. The identity of the log house is strong and will not be changed unless architects can find another meaning for the use of raw material in this way, but it's not solemnly the architect who's responsible to skew it into something new. The old narrative and nostalgic should be able to exist too but in the same way that other materials like ceramics and stone have strong history and have been modernized so can raw timber. Architecturally it is not always important with the style or the ideology behind it but the mere functionality of it in combination with social values about how it's perceived that shines new light on it. The production of the material and the conscious selection of consumers can also play a role for the importance of innovative solutions to take place again and again with small steps towards something unexplored.

So in the end this small contribution to the topic of timber construction and the architectural questions that are risen in its name can be seen as a step towards new chances to experiment. In my view that could be to work with for example spans, using long extruded frames and curvature of the form that strengthens the structure using the collective force of all joints. Also sandwich elements that the thesis was considered earlier in the time line could be used with insulation and also be designed in a modular mode. More joinery on the side of the logs could create a fine mesh of elements creating a frame-like structure. But the future of using wood is also in combination with other materials like 3D printed metal or plastic connectors and even 3D printed wood. The hybrids will be more flexible and since wood is cheap and renewable the many options of combinations that could be invented are endless, meaning it will sustain for at least another thousand years as an important material for both our body and soul.


A Krusi machine creating joinery using a large rotating milling tool



A digitally controlled sawing rig with a variety of tools at hand for processing

Bibliography

Books

Håkansson, S. (2002). Från stock till stuga. (6., omarb. utg.) Västerås: Ica.

Jansson, J. (2005). Knuttimring: en arbetsbeskrivning steg för steg. Västerås: Ica.

Menges, A., Schwinn, T. & Krieg, O.D. (red.) (2016). Advancing wood architecture: a computational approach. London: Routledge.

Mayo, J. (2015). Solid wood: case studies in mass timber architecture, technology and design. London: Routledge.

Forest Products Laboratory (U.S.) (2010). Wood handbook [electronic resource] : wood as an engineering material (Centennial ed.) Madison, Wis.: U.S. Dept. of Agriculture, Forest Service, Forest Products Laboratory.

Riksantikvarieämbetet Nordiska museet (1982). Var virket bättre förr?: en orientering om traditionellt svenskt virkeskunnande : uppgifterna är hämtade ur Nordiska museets frågelista "Virke och virkesbehandling" samt ur äldre byggnadsläror. Stockholm: Nordiska mus..

Naturskyddsföreningen (2014). Ny vår för skogen: Naturskyddsföreningens förslag till ny skogspolitik och rättsliga förstärkningar : rapport. Stockholm: Naturskyddsföreningen.

Electronic

Föreningen Svenska Timmerhus. (2010) Kvalitetsnormer för FST:s industriellt producerade timmerhus: Timmerstommens kvalitet. Retrieved 18.03.11 from http://www.svenskatimmerhus.se/wp-content/uploads/2016/02/Kvalitetsnormer_industriell_tillverkning_20100126.pdf

Svenskt trä. (2016) Materialet trä. Retrieved 18.03.01 from https://www.traguiden.se/om-tra/materialet-tra/

Thörnqvist, S-A. (2006) Aptering och virkesmätning. Retrieved 18.04.03 from http://slojd-data.se/virke//

Skogsindustrierna. (n.d.) Produktion och export 1980-2016 av sågade barrträvaror. Retrieved 18.04.05 from http://www.skogsindustrierna.se/siteassets/dokument/statistik/svenska/2016/sagverksindustrin-2016.pptx

SDC virkesmätningsontroll. (2018) VMK:s Tillämpningsanvisning till Mätningsinstruktion för kvalitetsbestämning av sågtimmer av tall och gran. Retrieved 18.04.20 from http://www.sdc.se/admin/PDF/pdffiler_VMUVMK/M%C3%A4tningsinstruktioner/Till%C3%A4mpnanvisn%20M%C3%A4tningsinstr%20f%20kvalitetsbest%20av%20s%C3%A5gtimmer%202018-01-01%20slutlig.pdf

Oliver, C. D., Nassar, N. T., Lippke, B. R., & McCarter, J. B. (2014). Carbon, Fossil Fuel, and Biodiversity Mitigation With Wood and Forests. Journal of Sustainable Forestry, 33(3), 248–275. Retrieved 2018.04.20 from https://doi.org/10.1080/10549811.2013.839386

Sveaskog (n.d). Avverkning. Retrieved 2018.04.22 from https://www.sveaskog.se/om-sveaskog/var-verksamhet/produktion-och-skotsel/avverkning/?acceptCookies=true