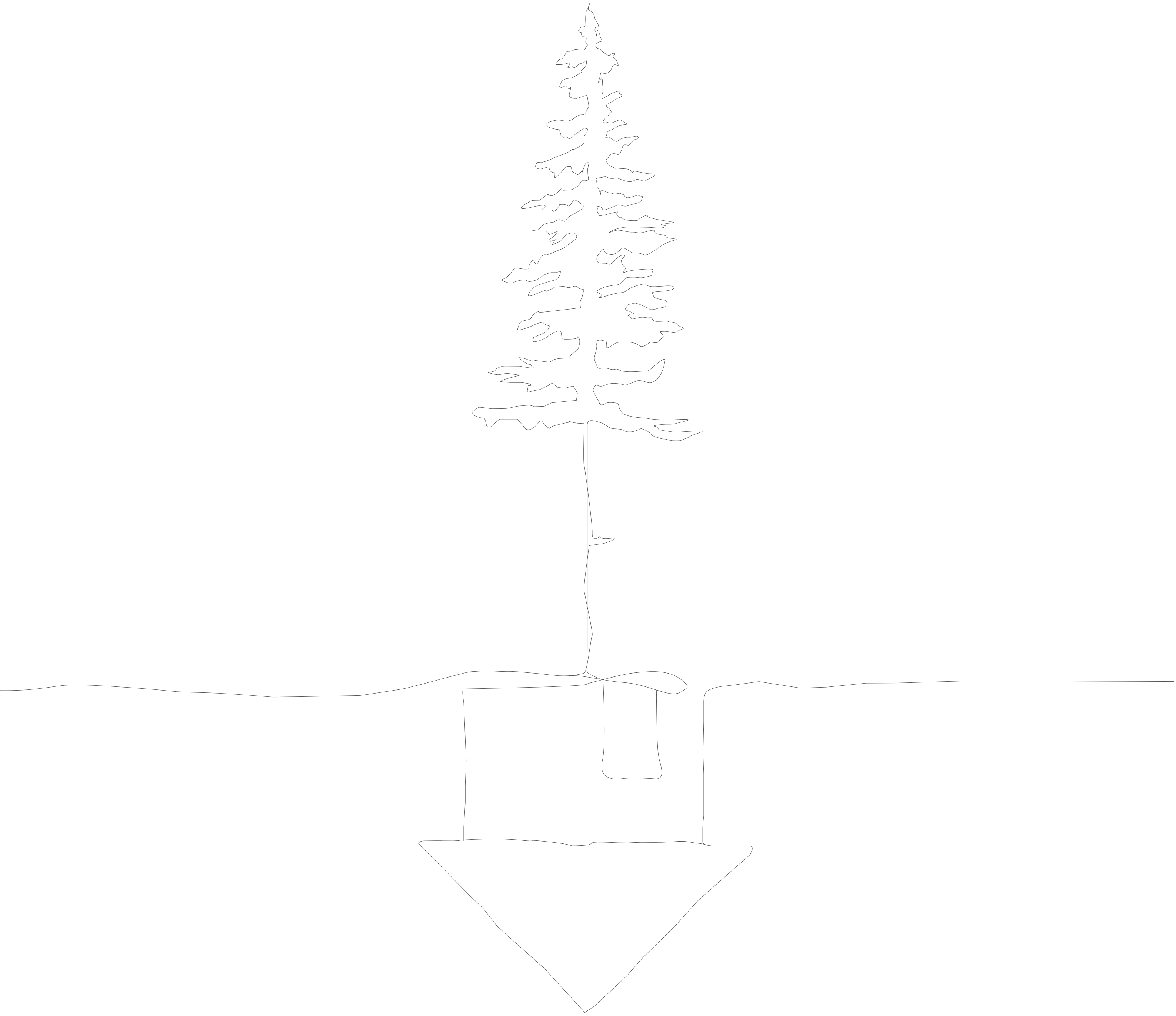
One Tree, One Building

Exploring the architectural potential of a single pine.



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Thank you,

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One Tree One Building

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Abstract

The role of the architect has nuanced over the past decades in tandem with the environmental crisis that the built environment has propelled substantially. Architecture, as a discipline, must address its environmental impact and promote sustainable practices. Resources effectiveness and a vernacular design approach are critical components of sustainable architecture. By embracing these ideas, architects can play an essential role in mitigating the environmental damage caused by the built environment and help break the downward spiral of environmental degradation.

One Tree - One Building explores the architectural potential of a single pine tree and proposes a design for a biodegradable forest cabin made entirely from this material. The study is grounded in a desire to challenge conventional building materials and methods and their often heavy baggage of environmental impact, and instead widen the view to find innovative solutions or rediscover forgotten techniques.

The research methodology involves a contextualization of the issues handled, looking at neighbouring research and concepts to position the investigations in a larger context.

Subsequently, a thorough investigation of the properties, quantities and characteristics of the Scots pine's various components was conducted prior to material investigations of how these components could be refined into building materials. The material experiments focus on three areas: boards, joinery and carbonization. The material findings are evaluated on perceived aesthetical and functional attributes.

The results of the investigations are then applied in a conceptual biodegradable forest cabin consisting solely of material descended from one exemplary pine tree - established from literary investigations. The proposed design serves as a vessel for the material findings and a precedent for future research. It does not deal with economic, regulatory or commercial feasibility.

Components interlock through intricate joinery and rely on the inherent strength of the pine tree, eliminating the need for metal fasteners or chemical adhesives. The carbonization strengthens the wood's resistance and enables a contrast and hierarchy in the design languages when interacting with the untreated heartwood.

The design exemplifies the potential of using local, renewable resources to create structures that are not only functional and aesthetically pleasing but also ecologically responsible. A enhancing link between the occupant and the surrounding forest environment.

Keywords

Pine Tree, Vernacular, Micro Architecture, Biodegrade, Resource Effectiveness, Material Investigation, Forest Cabin

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INTRODUCTION

On my first day of preschool, a tree was planted for each student. The trees grew together with us over the years. Before I left the school my tree had grown several meters high. I can still remember the juvenile ideas and plans I had for my tree. Growing it to the biggest tree in the world! living inside it?

Problem statement

Living Outside our Boundaries

The predicament of unsustainable exploitation of our planetary resources continues and the non-circularity within the building industry accelerates the environmental challenges that our planet faces. The building sector is responsible for over one third of the world's CO_2 emissions, with an all time high in 2021, breaking the previous peak right before the pandemic in 2019. This indicates that the sector is off track from the goal to be decarbonized by 2050 (UNEP, 2022).

Break the Trend

Historically, living standards has increased in tandem with environmental impact (Li, Chen & Zhu, 2021). If the planet is to sustain and prosper, this trend has to be broken. The average person's unwillingness to let living standards suffer to a meaningful degree in exchange for environmental benefits has proven itself globally over the last decades (Sörqvist & Langeborg, 2019). This leaves us with two primary options to move towards a more sustainable future without straining our living standard.

Innovative Solutions

By creating sustainable solutions that are economically competitive to the traditional method, the transition towards them will have a stronger motivation. The benefits are twofold as it can lower the threshold for developing countries to skip or shorten the time in which they are reliant on for example, fossil fuels, as other fuels become more economic and the incentive to utilize fossil fuels vanishes (WWF, 2017).

Back To the Roots

Another strategy is to rediscover forgotten, or underutilized building techniques and materials. Pre industrial times, the annual CO_2 emission globally was less than 2 billion ton. in 2021, it was over 40 billion ton (Ritchie & Roser, 2023). When the vernacular building practice was the only one around, and globalization wasn't a reality yet, the environmental impact of our buildings was a fraction of what it is today. By looking at any project through a vernacular lens where local environment and conditions guide the development of the project and the principles of traditional architecture are blended with contemporary building practices, a more sustainable practice can, in many instances, be achieved (Mohson & Ismael, 2021).

The Architect's Responsibility

I believe we, in the role of architects, have an important role to play in all of this. Technical developments and sustainable building practices can exist without any environmental benefit. This is of course if no one adopts these developments or practices. If innovations don't get adopted and sustainable building practices get forgotten, they do not make an impact. It is therefore an architect's responsibility to engage with the developments and integrate the best practices for each project they are involved with, to the best of their ability.

Thesis Framework

Aim

The thesis aims to showcase the versatility and possibilities of the pine tree in the building industry and give architects and other professionals within the built environment a toolbox of innovative and traditional ideas that pushes resource effectiveness and applications of material innovations forward.

Thesis Questions

- What design opportunities does the different components of a pine tree present?
- How can these opportunities manifest themselves in the built environment?

Scope and Delimitations

The core of the thesis lies in investigating and pushing the boundaries of what can be accomplished with a single pine tree at your disposal.

The tree that is being investigated is an example tree where the dimensions and component proportions are derived from literature studies. Other materials can be used during material experimentation but not in the final building material that is proposed in the building designs.

Evaluations of experiments are based on estimated and personal opinions, and are assessed mainly from an aesthetic and functional point of view.

The design proposal is a conceptual design that aim to showcase possible implementations of pine materials. The focus lies in highlighting the possibilities of each component and the building design acts as a vessel for that. The focus is not the program or commercial potential of the building. Furthermore, economy and regulatory perspectives are not entertained in it.

Material Choice

Wood

Wood has been used as a construction material all over the world for thousands of years. To this day it is a frequently used material, and on the rise. New innovations in wood technology gives it increased versatility and application areas. Engineered wood enables timber as a structural element in large projects while the traditional techniques still are relevant to this day in house building (Snow & Smith, 2008).

The Scots pine (Pinus Sylvestris) together with Spurce has a long tradition as the backbone of most buildings in Sweden throughout history (Swedish Wood, 2023). The long building tradition with wood and the techniques that follows that tradition risks slowly fading with the introduction of materials such as concrete and steel, and the pre- and massfabrication of building elements from these materials. With the increased need for sustainable buildings, the importance of keeping these techniques alive is clear.

Environmental Benefits

One of the most prominent benefits of building with timber is the environmental benefits that often follows. It is a local material in the context of Sweden, which entails reduced transportation costs and emissions. It is also an abundant material in many places. Sweden's total land area consists of 69 percent woodland, and 39 percent of all those trees are Pinus Sylvestris. Important to note is that the woodland has steadily increased over the last century as a result of sustainable forestry policies (SLU, 2022).

Moreover, it is a renewable as well as biodegradable material. The trait combination of local, abundant, renewable and biodegradable is a promising starting point for a material in these day and age of environmental threats.

Untapped Potential

If wood can match its competing materials in cost, preformance and aesthetics, which the developments in wood technology seems to indicate, the adoption of the material can reach new heights.

When wood as a building material is discussed it is typically the bark free trunk that is really discussed, but the tree is so much more than that. I believe that there is untapped potential in the other components of the tree. The bark, roots, cones, needles and branches can all be used as successful building materials, I believe.

Method

Literature Studies

Literature studies has been utilized as a part of the initial phases of the process. This has involved analyzing publications, books, articles and webpages in order to position the presented work within a larger scientific context, gain an understanding of the role of the relevant materials within the building industry, and identify concepts related to designing a building from a single tree.

Built References

I have delved into built references, encompassing both historical and contemporary projects with the objective to gain insight into the design intentions and execution of similar projects that share ambitions akin to the proposed design and gain an understanding of where the profession has positioned itself historically - currently - as well as potential future directions. Through this process, I have examined overarching design intentions, as well as the finer details of solutions.

Material Research

The material research has been an integral aspect of the work. Through investigation of a range of books, publications and articles, a thorough understanding of the Scots pine and all of its constituent components has been developed. The result is a comprehensive mapping of the Scots pine, which has subsequently enabled the formulation of an exemplar tree to serve as the foundation for the material constraint of the thesis.

Furthermore, the properties and potential applications of the materials have been studied both through literary research in tandem with material experimentation.

Material Experimentation

In the beginning of the thesis all the components of a pine tree were obtained. Pine resin was bought. A trunk was gathered and delivered to a local sawmill where it was sawn into heartwood, sapwood and bark. Cones, needles, branches and roots were gathered from a local forest. More complex materials derived from a pine tree were also obtained. Filament was bought, lignin was donated by Södra, and different boards were bought to act as a baseline for the assessment of the corresponding material experiments.

Various experiments were conducted, constrained by only natural pine components being present in the final product. The result was then assessed from a percieved functional and aesthetical perspective.

The experiments were conducted at Bjarke Ingels Groups office in Copenhagen, in Chalmers facilities and at home. The process of the experiments has been derived from studies of industry standard manufacturing methods as well as traditional techniques, adopted to function within the criteria of only pine derivatives in the final material samples.

Material Application

The result of the material experimentation acts as a catalogue of building materials that the building proposal in turn put to the test. These results together with the volume constraints the material research established creates the framework the building proposal have to be situated within.

Design Program

The demanding constraint of only having one pine tree at disposal is at the core of the design and the overarching principle that guides the design process. Furthermore the development of the proposed building design utilizes the notion of vernacularity, biodegradability, material efficiency and zero waste as supplementary guiding design principles. The focus of the design is to showcase the possibilities the different pine components possess and how they can manifest themselves in the built environment.

The function of the cabin is of secondary importance - but can be imagined as a forest retreat with a malleable function. Possibly a get-away, mindfulness space, hunting cabin or just a shelter, to name a few.

The design is only site specific in the sense that it sits on the trunk of the tree that was fallen to create the building. The idea is that the design, with smaller adaptations, can be deployed on a variety of sites.

Interior perspective of design proposal.

B A C K G R O U N D

Scots Pine

Overview

Pinus Sylvestris, commonly known as Scots pine, is the most common pine species in the world. It is prevalent all throughout Eurasia, and especially in central and northern Europe. It can grow under harsh conditions on poor soil. The main threats to the success of a pine stand development is local competition from other species and a too hot climate, since the Scots pine needs a winter chilling to break dormancy and successfully grow over the spring (Durrant, et al., 2016).

Scots pine occupies 28 million hectares of woodland in Europe alone, which accounts for 20% of the total productive forest area (Ibid.). In Sweden, that number is doubled, and forthcoming climate changes likely leads to an even larger presence in northern europe as opposed to southern Europe where the prevalence is expected to decrease (SLU, 2022).

A typical Scots pine grows roughly 23-27 meters high and over a century old, but can in some conditions stand for the better part of a millenia and grow over 40 meters high (Durrant, et al., 2016).

Properties

The Scots pine is of cultural and economic importance to many countries, especially in northern europe. Sweden exported wood products to a value of 164 billion Swedish crowns in 2021 (SkogsIndustrierna, 2023) and the Scots pine accounts for roughly 1/3 of the export (SLU, 2022). The cultural importance stems from a long building history with the tree. Not only in building projects but also in furniture and other woodworking areas.

Pine wood is a softwood, light in color with a fine texture and straight grains. It is an easy material to work with compared to hardwood due to its lower density, but still has good structural properties. It is also a relatively cheap material, which makes it a competitive alternative in the building industry (Svenskt trä, 2023).

It has seen an upswing in usage in the latest decades due to the renewability of the material as well as the carbon storing capabilities, which in many cases makes it the best option for the environment. The innovations with engineered wood and cost competitiveness as it becomes more mass produced snowballs the usage even further (Hart & Pomponi, 2020).

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Vernacular Architecture

Overview

Vernacular architecture describes the architecture that is developed by local communities through resources and constraints that the specific area presents. Building methods that have evolved over time in a specific region or culture, low-tech and problem-solving approach to the building construction and use of local materials that often carry a cultural heritage, are corner stones in that it means to build vernacular (Oliver, 2006).

If we go back far enough in history, all buildings were constructed through vernacular architecture. Before the globalisation and the exchange of ideas that it entailed, every region's building techniques, materials and designs were a result of the constraints and possibilities of the region. Granted, the exponential growth in knowledge and resources that paradigm shifts like the industrial revolution and the globalisation created propelled building efficiency, cost, etc. to new heights. However, in the process of all the growth and optimization, the building's connection and utilization of its surroundings fades (Oliver, 2006).

Adaptive design

The buildings constructed with these ideas are often adaptive. They are adaptive in the sense that they draw inspiration and respond to specific environmental and cultural conditions. In some areas it is desirable to minimize heat gain, in others to protect from heavy snow. The materiality featured will naturally have strong local availability, good climate performance and better reintegration to the environment when the lifecycle comes to an end, since it relies heavily on natural materials such as wood, stone and earth (Fuentes, 2023).

Trial and Error

Vernacular architecture is not something static, the local building techniques have been passed down through generations in an iterative process that has refined them over time through trial and error. The buildings were often built without formal architectural plans or blueprints, instead the builders problem-solved on the spot and continuously learned from their mistakes, and evolved together with the community they served. This process and engagement often creates an environmental and cultural resilience in the architecture, also in a long-term perspective (Oliver, 2006).

Examples

Four examples of vernacular architecture is presented to the left.

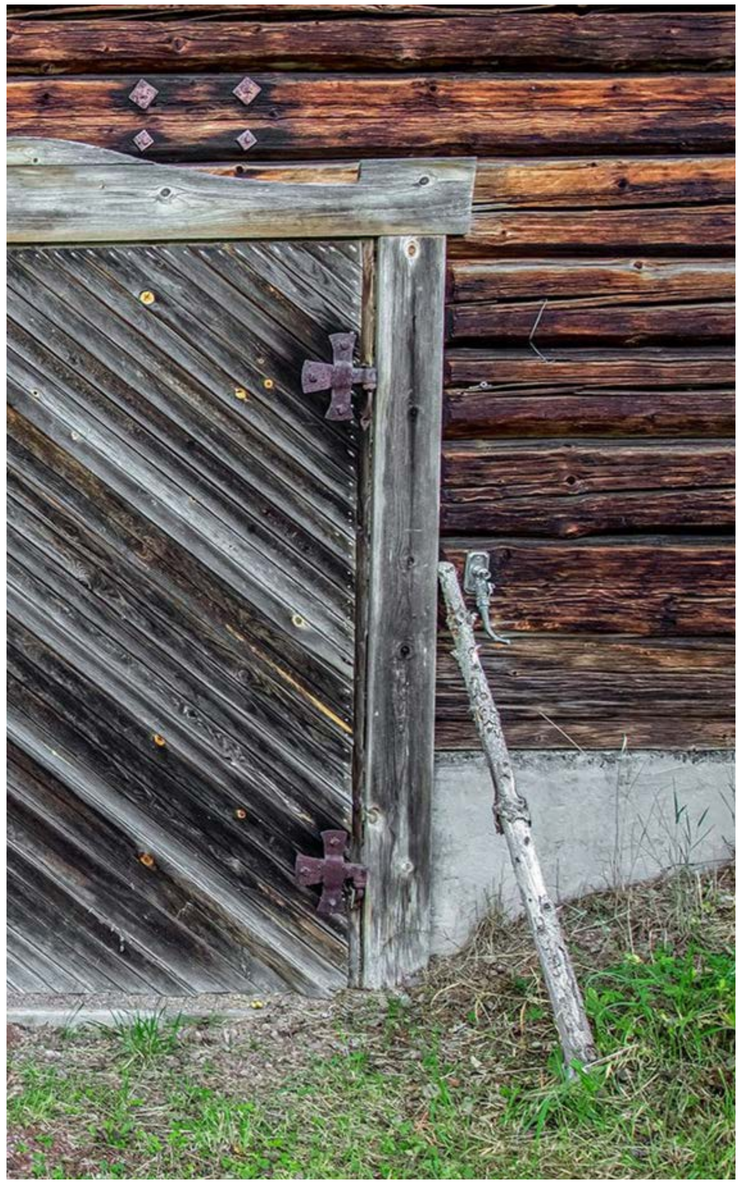
1. Beehive Houses of Harran, Turkey - Historical dwellings built rapidly like tents using sun-dried bricks (Özdeniz et al., 1998).

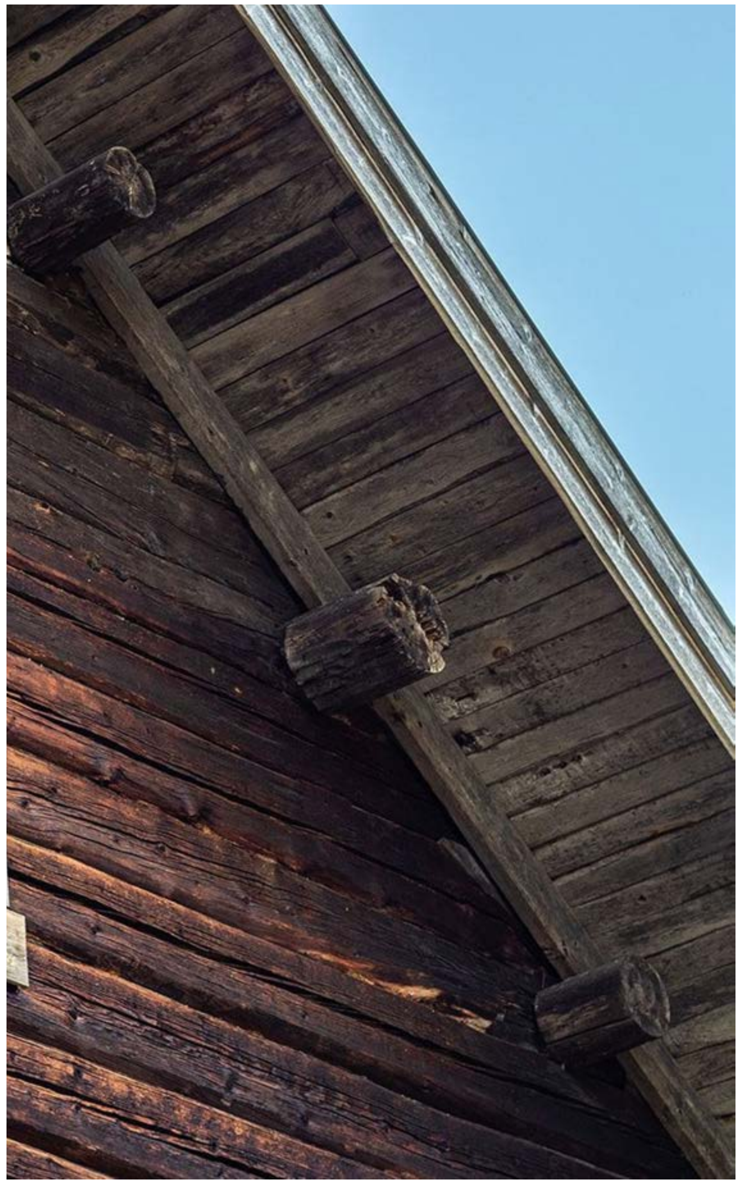
2. Wadden Sea Centre, Denmark - A modern example of vernacular architecture, merging traditional building techniques with modern aesthetics (Archdaily, 2017).

3. Living Root Bridges, Meghalaya, India - Built as an answer to the violent monsoon seasons that the previous bridges couldnt withstand. The roots only grow stronger over time (Zilliacus, 2017).

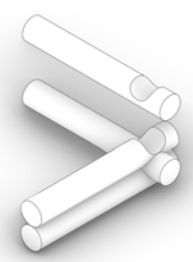
4. Wattle and Daub Houses, Brazil - A typology with roots from the colonial era. Building technique in which bamboo sticks act as a form work for clay that hardens in the sun (Daudén, 2019).

Photo credit: 1. Morgan Stone Grether
2. Adam Mørk
3. Ashwin Kumar
4. Pedro Levorin

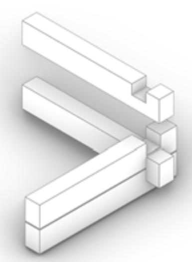




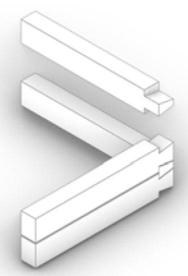
X-Joint Log House



Gutter X-joint



Single notch X-joint



Dovetail X-joint

History

The X-joint, or Cross-joint log house has a long tradition in Sweden, dating back to the 13th century at the very least. The building technique is a prominent example of vernacular architecture in the context of Sweden. The technique gained popularity quickly and was the dominant method of house construction before the end of the 13th century (Högman, 2017).

Building Technique

Due to its abundance as a material and its resilience to rot and twisting in comparison to spurce, pine was the primary type of wood used for X-joint log buildings in Sweden. To make the dwellings tight and stable, a groove was cut below each log and a scribe, a tool called a scribe, was used to notch two neighboring logs together (Högman, 2017).

The wood between notches on the bottom for the higher log was then carved out to fit nicely on top of the log below, and eventual gaps between the logs was typically filled with moss or tarred flax. Dowels were also utilized to secure the logs (Högman, 2017).

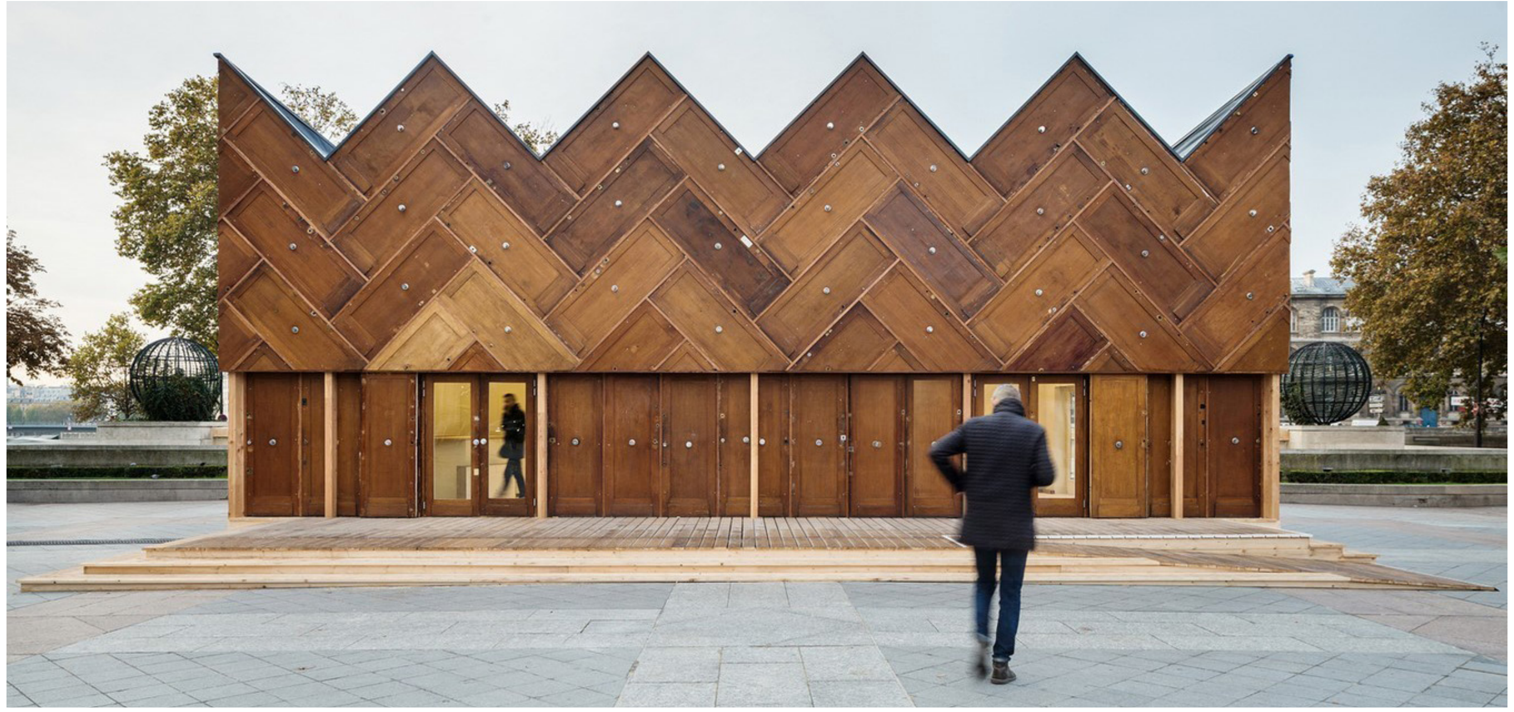
Joinery Variations

The joinery method varied greatly throughout time and between areas. The "rännknut" (gutter joint) is the oldest X-joint known. The top log is beveled and placed in the slanting-walled notch of the log below, known as the saddle joint. The oldest variants featured simply a half-round hollowness at the top of the log and were employed in smaller log houses (Andersson, 2016).

The late Middle Ages saw the addition of a carved threshold known as the "dubbelhaksknut" (double notch X-joint) or "enkelhaksknut" (single notch X-joint) depending on its placement within the notch. The double chin knot became the most frequent X-joint throughout the 18th century as this joint provided a tighter and more secure structure (Andersson, 2016).

Older X-joints with protruding heads were replaced by smooth corner joints in the late nineteenth century. During this time, the "laxknut", or dovetail joint, became the most prevalent X-joint (Andersson, 2016).

Photo credit: HusmanHagberg (2023)



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Circular Economy & Zero Waste

Overview

Robert Crocker and Steffen Lehmann argue that most efforts taken place currently to improve the sustainability of products, systems and environments are target towards their role in the consumption and use ecosystem. The cycle of extraction, refinement, use and discarding waste of natural materials is optimized more and more in the pursuit of sustainability. This ecosystem distances us from our local environments and the responsibility we have towards it. The things that fall out of this cycle becomes somebody else's problem (2012).

If we can not optimize the current model into a sustainable one, a shift has to happen. This is where the concept of zero waste and a circular economy model emerges. Instead of the linear economys model of take - make - use - dispose, which presumes infinite resources, a circular economy loops the line through concepts like transformation, reuse and repair. To achieve this there has to be a mentality shift and awareness for consumers, producers and designers (Ellen MacArthur Foundation, n.d.).

Zero Waste in Architecture

The Zero Waste International Alliance (ZWIA) Defines zero waste as:

> "The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health." (2023)

This definition can be encapsulated in 4 R's: Rethink, Reuse, Reduce and Recycle that architects should be aware of and integrate in their design process. For example:

Rethink how we perceive and think about things, include new materials, find innovative solutions or view precedent through a critical lens.

Reduce the material needs through optimization, or reduce urban cities, densify for efficient transportation systems and concentration of diversity and opportunity.

Reuse materials, refurbish buildings instead of demolition and modularity in the design to promote flexibility.

Recycling material at the end of their lifecycle and creating another product from that material, ensuring in the production of material that recycling the material is effortless (Souza, 2019).

Examples

Four examples of zero waste initiatives in different sectors are presented to the left:

1. The Circular Pavilion - A building project that aims for circularity. Doors in the facade saved from a building at the end of its lifecycle, the insolation from a supermarket roof (Frearson, 2015).

2. An exploration of how chemistry can be applied to recycle fabric while maintaining its structural properties (Notman, 2020).

3. Restaurant Rest in Oslo - Turn food waste into a fine dining experience

4. Drinking straws from hay - Eliminates the use of plastic with a low-tech approach of cleaning and cutting hay.

Photo credit: 1. Cyrus Cornut
2. Lisa Sheehan
3. Local Traveller
4. Jenny Andersson

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Biodegradable Design

Overview

In a circular economy the goal is in part to minimize waste and repurpose what would be waste into something different. A lot of materials are however tough to find applicable use for when a building for example gets demolished, and the process to recycle those materials are not always set in place. A biodegradable material will by nature not be waste for long, as it naturally decomposes into natural elements after its life cycle has ended (Sassi, 2006).

Biodegradable Building Materials

The building industry can learn from nature, in which plants grow, die and biograde into material that gives life to the next generation of plants in a constant loop. By integrating biodegradable materials into buildings demolition waste can be negated (Ibid.). cork, sand, bioplastics, mycelium and timber are all examples of biodegradable materials that can be used in the building industry to a much wider extent than it currently is (Thorns, 2018).

Each year, over 100 million tonnes of waste is created from demolishing buildings, in the UK alone. The part of the waste that is biodegradable is less than 20%, and that fraction is not fully biodegradable as it includes treated timber, etc. There are however biodegradable alternatives for virtually all building elements, so change can be made. Cost and reassurance of performance are two main points that stand in the way of mainstream adoption of biodegradable materials in the building industry (Sassi, 2006).

Examples

Four examples of innovative biodegradable initiatives are presented to the left:

1. Balena - Developed a thermoplastic that fully biodegrades at the end of its life cycle, the material can be 3D-printed or injection molded for flexibility (Balena, 2023).

2. Hemp-based bioplastics - Hemp is being explored as an alternative to petroleum based plastics. The image shows a 6 month breakdown of a plastic bottle made from hemp (Serisier, 2019).

3. Cork furniture - Cork finds its way into more and more sectors and applications. The sculptural ability of the material can be utilized to make furniture (Ganea, 2022).

4. Decomposable food bowl - One-time items like utensils and packaging has seen lots of regulations in recent years. This food container takes it one step further. It is fully biodegradable and comes with seeds to plant (Lindquist, 2013).

Photo credit: 1. Balena
2. Geocopure
3. Alessandro Isola
4. Michal Marko


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Small-Scale Architecture

Overview

Small-scale architecture typically ranges from just a few square meters to a small villa. This approach enables more attention to detail and a more personalized space as it is typically targeted towards individuals or small groups of people. The limited space to work with often calls for innovative design solutions that maximizes the functionality of the space. Multifunctional furniture, built-in solutions and creative ways to solve storage are all examples of this (Anderson, 2020).

Prefabrication and modularity are often discussed in regard to small scale architecture as it can speed up the construction process and reduce cost. Applying these ideas enables efficient manufacturing at scale which in turn could address the affordable housing crisis in both the cities and in the countryside (Ibid).

Test Ideas

Another use-case for small-scale architecture is to test ideas efficiently and iteratively. The vernacular architecture did this continuously whereas we now often settle for standard details and doing it the way we did before. The small-scale projects can act as a breeding- and test ground for new solutions without the intimidation and pressure innovative ideas can have in larger projects where more is at stake (Ibid).

Examples

Three examples of small-scale architecture are presented to the left:

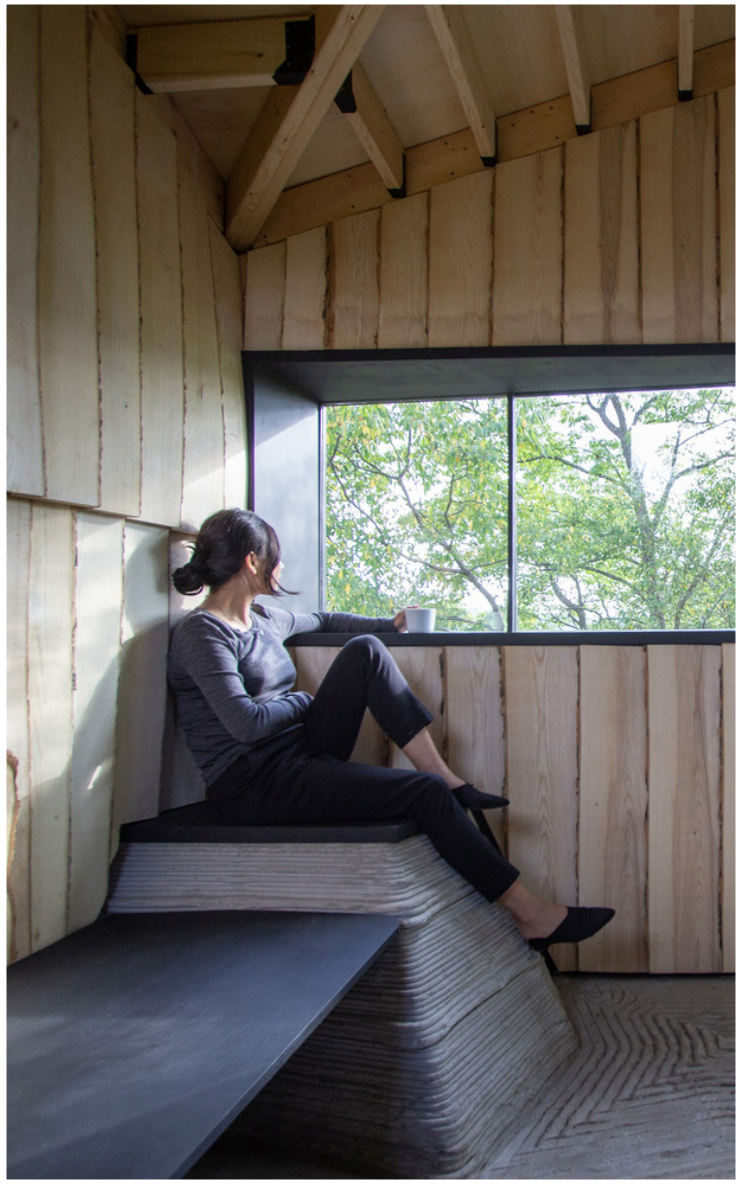
1. Hut on Sleds - This project by Crosson Clarke Carnachan Architects is built on a sled due to a planning condition on site that states that all buildings must be removable (Frearson, 2012).

2. Readline between the Lines - A church that is perceived as a solid object or almost entirely transparent depending on the view from which you perceive it (Lau. 2012).

3. ELDMØLLA Sauna - The Inspiration for this sauna is taken from the local typology "Kvern-hus". The building was designed and built by an international student group at NTNU over a two month period, two weeks of which for construction (Archdaily, 2017).

Photo credit: 1. Crosson
2. Filip Dujardin
3. ELDMÖLLA

BUILT REFEFERENCES



Ashen Cabin - HANNAH

Year - 2021 | Country - United States | Area - 9 m²

The Ashen Cabin project was designed by HANNAH, in collaboration with the College of Architecture, Art and Planning at Cornell. The conceptual cabin design developed as a response to the environmental crisis caused by the Emerald Ash Borer beetle, which has affected native Ash trees across the United States. The project applied robotics and 3D-printing technologies in both timber and concrete construction to combat this issue (Pintos, 2021).

They are able to cut down and recycle ash trees that aren't straight by using a specially designed robotic arm. The arm is programmed to saw and shape the wood at a scale that is appropriate for structural design features. The team also created a 1:1 3D-printing technology for the concrete foundation that eliminates the need for formwork, and uses the least amount of materials during production, reducing the building's carbon footprint (HANNAH, 2019).

The Ashen Cabin project promotes a vision for the future of environmentally friendly house design and construction, identifying an environmental concern and finding a way to turn it on its head through use of advancing technologies. It rethinks the use of concrete and timber and enhances their capabilities, demonstrating a new way of sustainable housing design and construction (Pintos, 2021).

In essence, the project sheds light on technological advances and the possibilities they create in an actual project. It proves the practical capabilities of advances in digital manufacturing, iterative testing and speculative designs that often don't reach past the academic sphere. It shows that adopting these emerging technologies can improve material efficiency, cut construction time, and increase customization (Pintos, 2021).

Photo credit: Andy Chen (2021)

Forest Retreat - Uhlik Architekti

Year - 2013 | Country - Czech Republic | Area - 16 m²

Uhlik Architekti's Forest Retreat is a small 16 m² refuge in the countryside of the Czech Republic. It was developed for a client as a personal get-away from his busy career in Prague. The site sits in a secluded area between central and south Bohemia and is surrounded by fields, woodlands and meadows filled with irregular boulders. The unique landscape and the client's vision immediately won over the architects and they took on to both design and build the project together with their client (Pintos, 2014).

The retreat is a humble building, measuring roughly 3 by 6 meters. The adaptation to the site is clear as it rests freely on boulders, with a stern raised on a particularly huge boulder. The outside is covered with charred boards connected through rabbet joints, and the interior is coated with OSB boards. A joist construction that was developed in collaboration with nearby carpenters serves as the supporting framework (Pintos, 2014).

The hideaway consists of a single, connected space with a flat platform at the entrance and a view through a large glass wall. The remaining portion progressively rises towards another window facing the three crowns and functions as a resting space. There is storage beneath each step, and each step can be utilized as a sleeping area. The flexible space can be used for informal meetings, performances, or meditation. Both glazed openings can be closed by large shutters using a manual winch or a pulley. (Pintos, 2014).

The wood used in the project was sourced from local fallen trees, gathered from the owner's land, and the building was built by local craftsmen together with the architects on the weekends over a few months time (Uhlík, 2013). The Forest Retreat is a strong testament to an architect's ability to adapt a design to the specific possibilities of a site and create a unique and functional space that seamlessly co-exists with its natural surroundings by actively engaging in the whole building process and engaging with local craftsmen that have a deeper understanding of the site and its possibilities.

Photo credit: Jan Kuděj (2014)

The Cabin - Jan Tyrpekl

Year - 2017 | Country - Czech Republic | Area - 12 m²

The Cabin is an innovative wooden structure situated on top of an existing concrete bunker near the Czech-Austrian border. These bunkers were constructed before World War II as a safeguard against Nazi Germany, although they were never used. In the Czech and Slovakian landscape, thousands of these bunkers exist to this day, posing a questions about their future use. The Cabin was designed as a light-weight wooden structure that can be effortlessly removed, with minimal impact on the pre-existing bunker. The architect argues that by doing so, he addresses the difficult issue of repurposing these bunkers (Hernández, 2018).

As a counterpoint to the landscape's horizontal aspect, the Cabin was created as a dominant vertical volume. The most interesting views are framed by two large windows. One faces east, towards Austria's borders, and the other, towards the church of the nearby community. Despite the small area of 12 m², the interior of the shelter conveys a generous atmosphere. In part thanks to a third window - a rooftop window that enhances the natural light (Hernández, 2018).

The building idea was to minimize material, cost and time. The design is simplistic, and can be built entirely by hand using common tools, without any modern technology. Friends, relatives and architectural students with an interest in the project came together to fund the project. Jan Typekl, the architect, claims that anyone can build a cabin of this sort. As a testament to this, the project was assembled twice. Once on a farm 200 kilometers away from the site, then disassembled and transferred to the permanent location to be reassembled. Currently, the cabin serves as a sanctuary where anyone is welcomed (Hernández, 2018).

Photo credit: Antonín Matějovský (2017)

Tree Hotel - Tham & Videgård

Year - 2010 | Country - Sweden | Area - 16 m²

Tham & Videgård Arkitekter developed the Tree Hotel project in 2010 as an original and mature homage to the tree house concept. The hotel is situated in Sweden's far north - close to the polar circle, in a small village called Harads. The design is a perfect cube in 4x4x4 meter dimensions clad in mirrored glass. The glass reflects the surrounding forest and sky, creating a disguised refuge for visitors. The cube is supported by a lightweight aluminium structure that is suspended above ground, attaching itself to a tree trunk (Saieh, 2011).

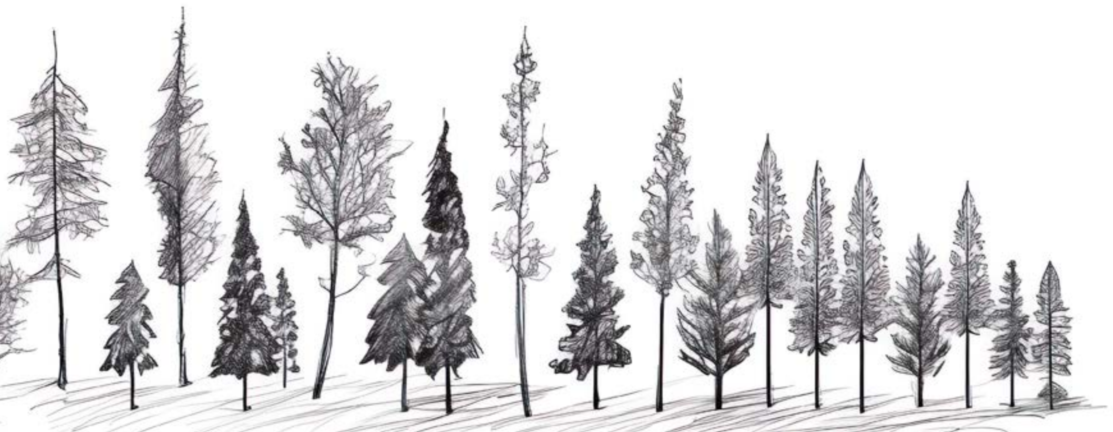
The interior is entirely made of light plywood, which the architects argue creates a natural and varm atmosphere for the guests. The room is equipped with a double bed, a small bathroom and a living room. The roof is accessible through a stair that leads up to the terrace with a panoramic view of the surroundings. To access the cabin, a rope bridge spans from the sloping ground to connect to the elevated building (Tham & Videgård, 2010).

The hotel's design is a nod to how we interact with nature in recent times - the desire to enjoy nature while having the conveniences of the modern man at your fingertips. The material choices are inspired by the products used for exploring remote places in harsh climates. Materials such as Gore-tex, Kevlar and composite materials are prevalent throughout the design, and highlights the advancement of technology and the effect that has had on our relationship with the environment (Tham & Videgård, 2010).

The Tree Hotel is a unique project in many ways that showcases the fusion between technology and nature. The innovative design creates a unique experience where a modern structure is placed in the ancient forest without disturbing the atmosphere of the environment. The project exemplifies how architecture can create a connection between humans and nature while promoting sustainability.

Photo credit: Åke E:son Lindman (2011)

THE EXAMPLE TREE




1


2


3


4

The Example Tree

Age - 75 years | D.B.H - 48 cm | Height - 26 m

No Tree Is Created Equal

Pine trees, much like any other tree, comes in many different sizes and shapes. Every tree is unique. Different growth rate, branch development, seed production and longevity all vary to a high degree. Much like for us humans, DNA from parent tree, climate, diseases and local competition all affect the growing of the tree (Kozniewski et al., 2022).

The Age

With the *old forest* (forest over 160 years) as well as preserved forests excluded, the average stand age of Sweden's productive woodland is roughly 100 years. The lowest age before deforestation is allowed in pine-dominated forests is between 45-100 years, depending on the county (SLU, 2022).

If pine trees avoid logging they can grow for the better part of a millenia. The oldest swedish pine tree is located in Hälsingland and is at least 770 years old. Interesting to note is that the tree only reaches 9,2 meters of height and a diameter at breast height (D.B.H) of 36 cm (Andersson & Nicklasson, 2004).

For this investigatiion a 75 year old Scots Pine will be studied.

The D.B.H and Height

The age of a tree and its D.B.H and height is of course correlated. Determining a reliable growth factor has however been proven difficult. Climate, local competition etc. has to be taken in to account in the model and the matrix of data becomes so complex that meaningful templates are challanging to extract (Pukkala & Kolström, 1987).

A more straightforward approach is to meassure the D.B.H and height at different stands. In a polish study, the mean D.B.H of four 80-year old Scots pine stands was 30,1cm (Kozakiewicz et al., 2020). In a study from Michigan, a *74-77* year old, unthinned pine stand averaged 48cm D.B.H and 26 meters of height (Rudolph & Lemmien, 1959). In Sweden, 4,7% of the total Scots pine population exceeds 45cm D.B.H (SLU, 2022).

For this investiagation a 48 cm D.B.H and 26 meter high pine will be studied.

1. Most mass in Sweden - 19.98 m³ (Glad, 2022).
2. Higest in Sweden - 40,6 meters (Reuter, 2018).
3. Oldest in Sweden - 770 years (Andersson & Nicklasson, 2022).
4. Largest circumference in Sweden - 523 cm (Glad, 2022).

The Sum

Weight - 1318 kg | Mass - 2,886 m³ + Foliage | Carbon - 645 kg

Selection of pine components.

The Parts

Heartwood

Weight - 190 kg | Volume - 0,404 m³ | Biomass - 14,5%

Sapwood

Weight - 702 kg | Volume - 1,494 m³ | Biomass - 53,8%

Bark

Weight - 54,39 kg | Volume - 0,20 m³ | Biomass - 4,6%

Branch

Weight - 133 kg | Volume - 0,35 m³ | Biomass - 10,1%

Cone

Weight - 11,7 kg | Amount - 589 pieces | Biomass - 0,9%

Needle

Weight - 21,02 kg | Surface area - 158,38 m² | Biomass - 1,6%

Root

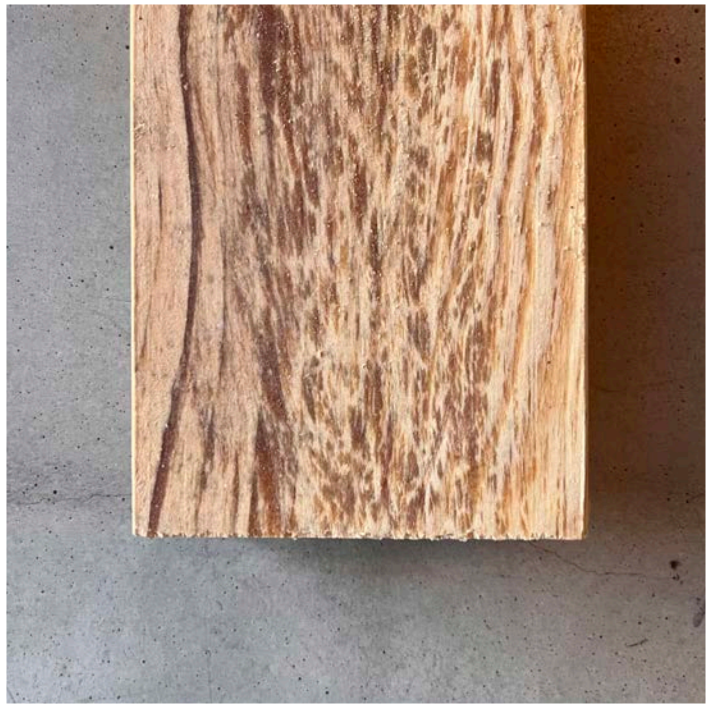
Weight - 203 kg | Volume - 0,436 m³ | Biomass - 14,5%

Resin

Weight - 3 kg | Volume - 0,0028 m³ | Biomass - 0,01%

Heartwood

Weight - 190 kg | Volume - 0,404 m³ | Biomass - 14,5%



Properties and Usage

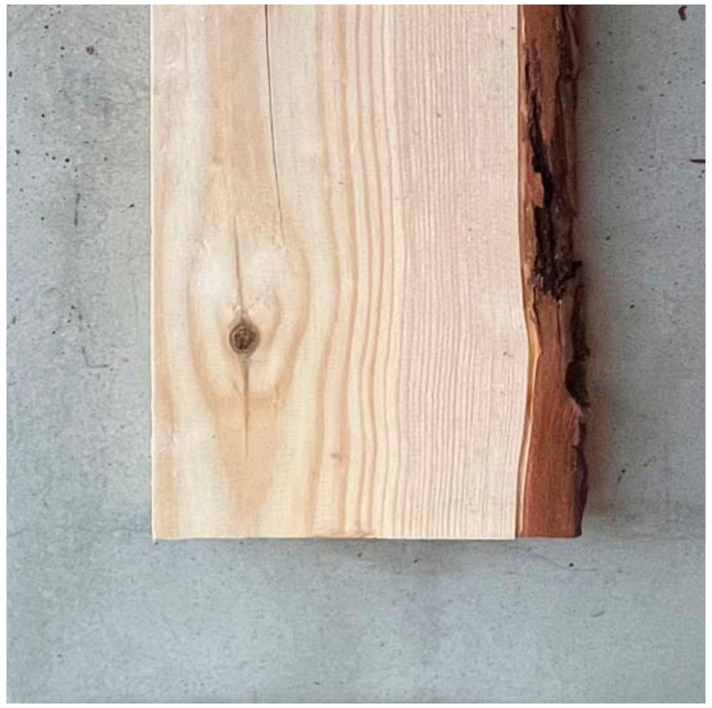
Heartwood is the innermost, oldest and dead part of the pine tree which creates the best conditions for structural performance due to a lower moisture content and more durability in comparison to the sapwood, although both materials have widespread use as structural elements with success (McLean, 2019).

Quantity

The Trunk of a Scots pine accounts for 74,4% of the total biomass of a mature tree according to a biomass equation formulated by Jaakko Reopla (2009). 24,4% of the volume of that fraction consists of heartwood (Kozakiewicz. et al., 2020). The bark free volume of that amounts to 1,898 m³ (Petras & Pajtik, 1991) When discounting for the bark the, the heartwood make up 29,5% of the mass in the trunk (Kozakiewicz. et al., 2020). Since there is no notable difference in density between heartwood and sapwood (Jelonek, et al. 2005), and the wood has a density of around 470 kg/m³ (Svenskt trä, 2023), the example tree has 190 kg and 0,404 m³ of heartwood.

Sapwood

Weight - 702 kg | Volume - 1,494 m³ | Biomass - 53,8%



Properties and Usage

Sapwood sits between the heartwood and the bark and has a lighter color due to a higher moisture content. Sapwood has a wide range of applications, often overlapping with the applications of heartwood. Many wood products consist of a combination of both wood types. Applications include facade, structure, walls and floors within the building industry. It is also used to great extent in the pulp and paper industry, furniture making and packaging (Svenskt trä, 2023).

Quantity

Sapwood occupies 58,3 % of the total trunk volume. When discounting the bark, the sapwood makes up the remaining 70,5% of the trunk volume, which amounts to 1,494 m³ of barkfree trunk (Kozakiewicz. et al., 2020). With the same density of 470 kg/m³, the example tree has 702kg and 1,494 m³ of sapwood.

Bark

Weight - 54,39 kg | Volume - 0,20 m³ | Biomass -4,6%

Properties and Usage

The bark has less fibers compared to the wood, which means the strength is somewhat lower. It does however conduct less heat which indicates that it can serve as a successful insulation board. Examples of boards with upwards of 40% bark has been proven successful in Scandinavia and publications indicate that it can be successful in a variety of boards (Harkin & Rowe, 1971).

Quantity

The bark makes up the remaining 17,3% of the trunks volume (Kozakiewicz. et al., 2020). Due to a lower density than heart- and sapwood, it does however only make up 6,1% of the trunks mass. It is important to note that bark amount and characteristics has a high variable with twofold differences of volume between trees in the same stand (Berendt, et al., 2021).

Branch

Weight - 133 kg | Volume - 0,35 m³ | Biomass - 10,1%

Properties and Usage

The non-linear shape of the branches coupled with their lower density and much higher holocellulose content (roughly 70% in branches, 20% in wood) compared to the wood, makes them unsuitable for structural applications (Suansa & Al-Mefarrej, 2020). They do however show good promise as boards, and have ornamental capabilities (Wronka & Kowaluk, 2022).

Quantity

The branches of a scots pine constitute 10,1% of the total biomass according to Jaakko Reoplas biomass equation (2009). Another study comes to a similar conclusion with the branches making up 7-14% of the above ground biomass (Chmura, et al., 2021). With a density of roughly 380 kg/m³ (Gort, et al., 2010) the branches of the example tree are 133 kg and 0,35m³.

Cone

Weight - 11,7 kg | Amount - 589 pieces | Biomass - 0,9%

Properties and Usage

Pine cones has been used historically for insulation, but can not compete with modern insulation materials (Bozsaky, 2010). Research does however indicate that pine cones can be utilized successfully in particle boards. It shows environmental benefits and lowers the amount of formaldehyde emissions from boards significantly (Ayrilmis, Et al., 2009).

Quantity

The cones make up the smallest fraction of the total biomass with only 0.9% (Reopla, 2009). This is supported by McNeil (1954) who gathered 589 cones from a 72 year old Scots pine and the mean weight of cones from such a tree being roughly 20 grams each (Hauke-Kowalska, et al., 2019). For the example tree the weight is therefore 11,7kg. Important to note is that cones add up to a larger fraction of the biomass when the whole life of the tree is accounted for. For a 75 year old tree it is estimated that over 15% of the biomass comes from cones, from a life-cycle perspective (Xiao, et al., 2003).

Needle

Weight - 21,02 kg | Surface area - 158,38 m² | Biomass - 1,6%

Properties and Usage

Research argues that pine needles as an insulation material is both innovative and rational. The thermal conductivity is similar to already existing alternatives but the environmental benefits of this forestry residue compared to most material on the market is clear (Muizniece, Et al., 2015).

Quantity

The needles make up around 1,6% of the total biomass (Reopla, 2009). This is supported by another study where the needles are 2% of the biomass (Durkaya, et al., 2016). The weight of the needles in the example tree is 21,02kg with a surface area of 158,38 m² (Sporek, et al., 2022). When accounting for the full life-cycle of the 75 year old tree the needles account for over 22% of the total biomass instead (Xiao, et al., 2003).

Root

Weight - 203 kg | Volume - 0,436 m³ | Biomass - 14,5%

Properties and Usage

The root system serves two primary functions for the tree, to anchor it in the soil and to absorb water and minerals so that the tree can grow. The anchoring mechanics of the root system has inspired research on how mimicking it can be used as a framework for foundations, which showcases the structural potential of the root system (Stachew, Et al., 2021). Architectural projects have also experimented with attaching structures to the trunk, which by extension uses the root system as the foundation (Pintos, 2021).

Quantity

The roots comprise the remaining 14,5% of the total biomass according to Reoplas biomass equation (2009). Which is supported by one study where they weighed the roots of a 73 year old Scots pine stand and that accounted for 12,6% of the total biomass (Xiao, et al., 2003) And another study of trees with a DBH of 25cm, in which the mean biomass was 15,29% (Durkaya, et al., 2016). With a density of 470kg/m³, our example tree has a 203 kg and 0.09m³ root system.

Resin

Weight - 3 kg | Volume - 0,0028 m³ | Biomass - 0,01%

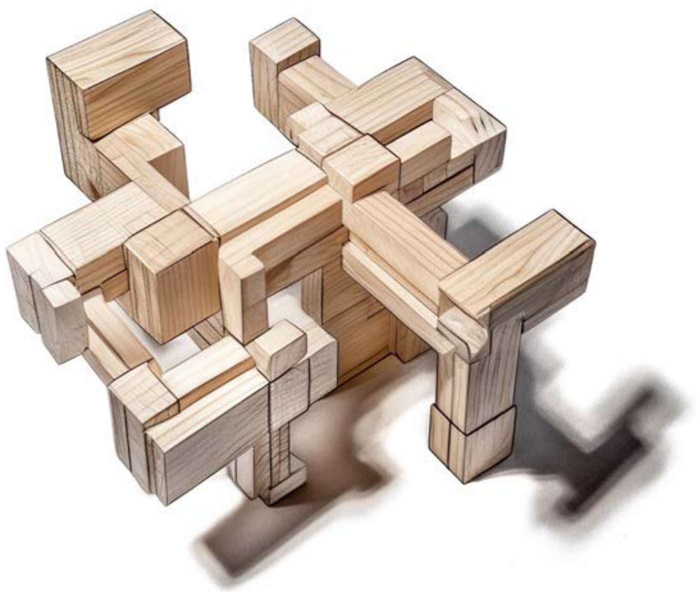
Properties and Usage

Pine resin was tested as an alternative to traditional adhesives in a study where they joined two planks with a dowel joint and applied different adhesives and then measured the force required to break the planks. Pine resin performed better than most glue alternatives which proves the adhesive capabilities of the material (Bouder & Yau, 2019). Pine resin consists of roughly 70% rosin, which is commonly used as an adhesive in the construction industry (Zaoui, Et al., 2020).

Quantity

Since pine resin is a product released from a tree to defend itself it is not possible to quantify at any given point. When tapping a tree for resin extraction however, the yield is roughly 3 kg per year with a tree having roughly 20 years of production (Cunningham, 2012).

MATERIAL INVESTIGATION



Boards

Selection of board samples.

Process

The first examples.

Method

All the materials were granulated in a food processor (sawdust collected from a local sawmill). The materials were then weighed to desired amount before being put in a skillet over medium heat. Water was added to prevent the materials from burning. After roughly 10 minutes the resin and the granulated material had bonded into one combined material and was put into silicone molds and pressed into a flat board. The boards solidified in a matter of seconds so the timing to press the material was urgent. The resin is naturally water repellent so there was no drying process after the pressing of the material.

Aim

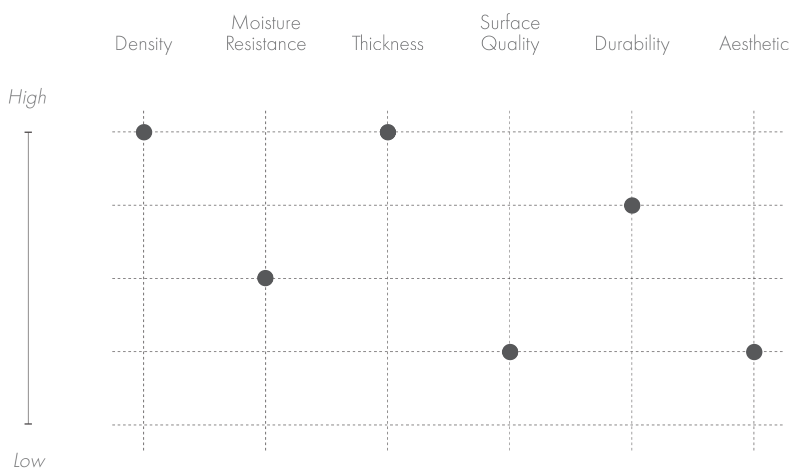
These investigations aim to examine possible applications for pine components that don't have a place in the current building industry. All the material samples are made completely out of pine tree components.

Evaluation

The evaluation of the material samples are based on estimations and are subject to personal bias.

Sawdust Board

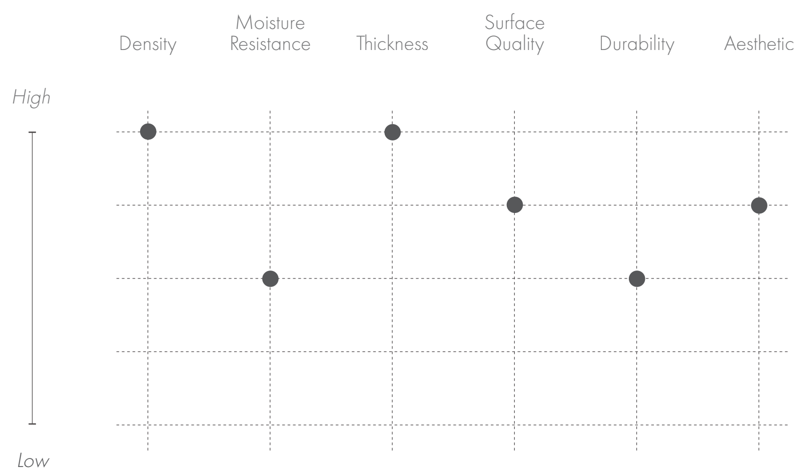
Sawdust - 88g | Resin - 44g | Water - 20 ml



Notes: *The resin doesn't bind 100% of the sawdust which gives the surface a grainy finish. Roughly 6% of the timber becomes sawdust in the saw mill process, so turning that portion into boards can increase resource effectiveness.*

Bark Board

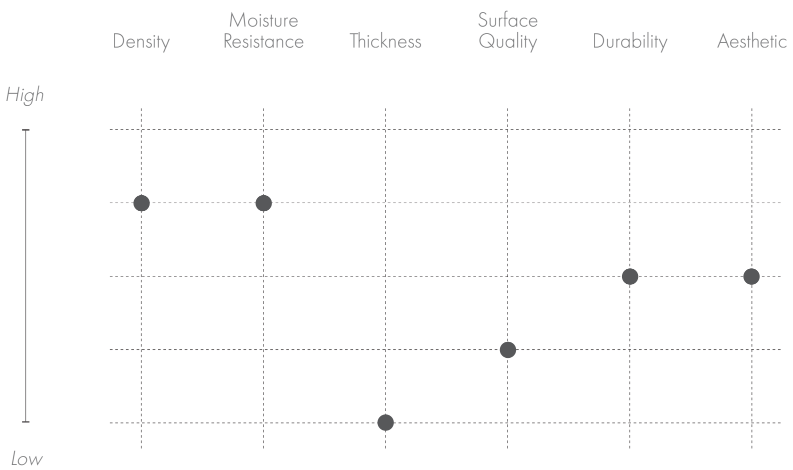
Bark - 130g | Resin - 65g | Water - 20 ml



Notes: *The granulated bark gives the board a rich color. The easiest and most forgiving material to manufacture. Different ratios are successful.*

Needle Board

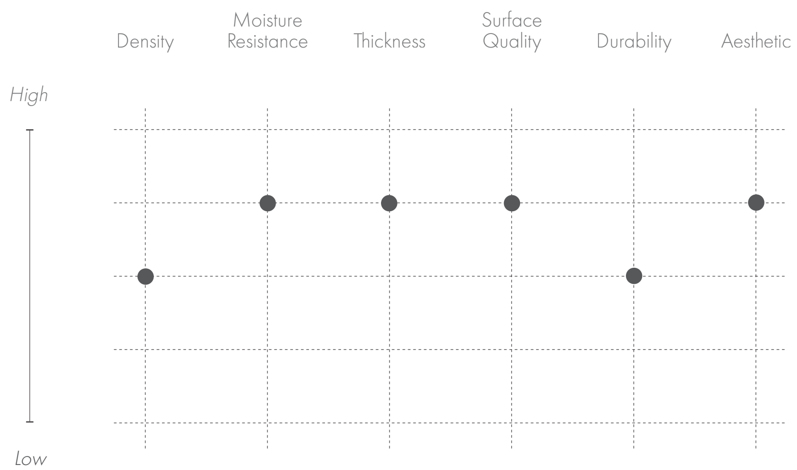
Needles - 76g | Resin - 38g | Water - 20 ml



Notes: *The most visually distinct board together with the coal board. The grinded needles release resin which makes them bond together without additives. Adding extra resin strengthens the board however.*

Cone Board

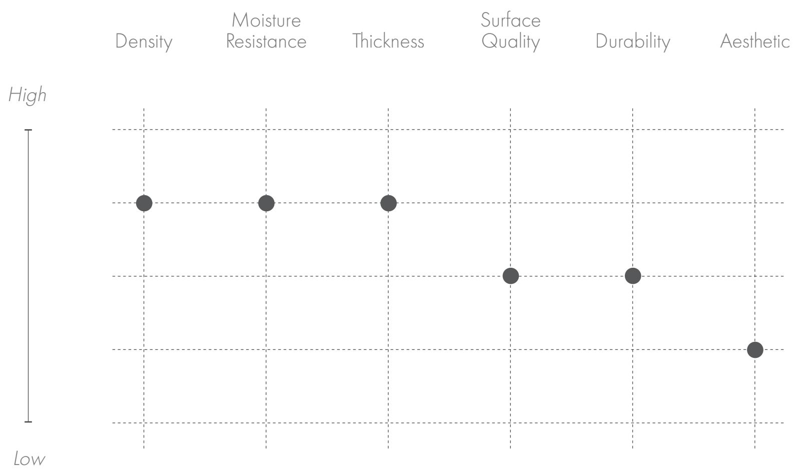
Cone - 118g | Resin - 59g | Water - 20 ml



Notes: *Tougher to get to a fine granulation compared to the other materials. Even with bigger pieces the board feels strong.*

Mixed Board

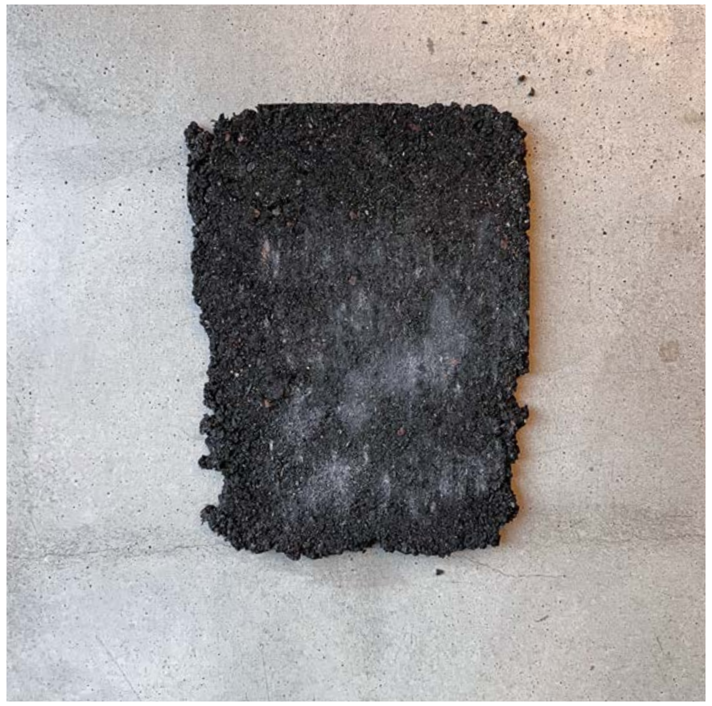
Sawdust/bark/ cone/needle - 72g | Resin - 36g | Water - 20 ml

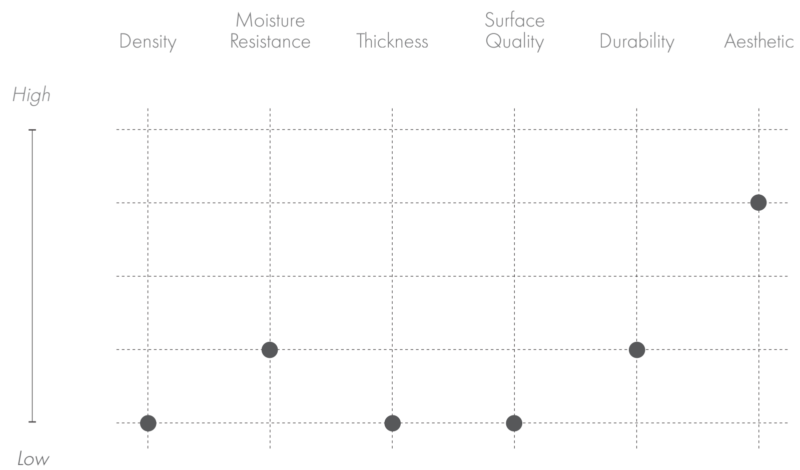


Notes: *Creates a strong earth aesthetic, but loses the clear identity the other samples showcase.*

Charcoal Board

Charcoal - 96g | Resin - 48g | Water - 20 ml



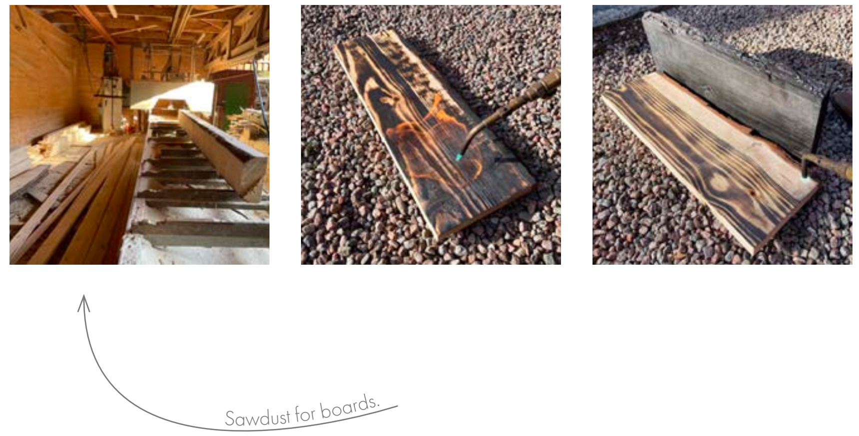


Notes: *The most brittle sample. Needs some sort of coating to stop the surface from contaminating on contact.*

Carbonized Wood

Samples of wood carbonization.

Process



Method

A local sawmill cut a bunch of planks to be used in this investigation. The planks were freshly cut from a tree with no drying so the moisture content was quite high. After drying the planks for one day, they were torched with an acetylene torch until desired carbonization point was reached.

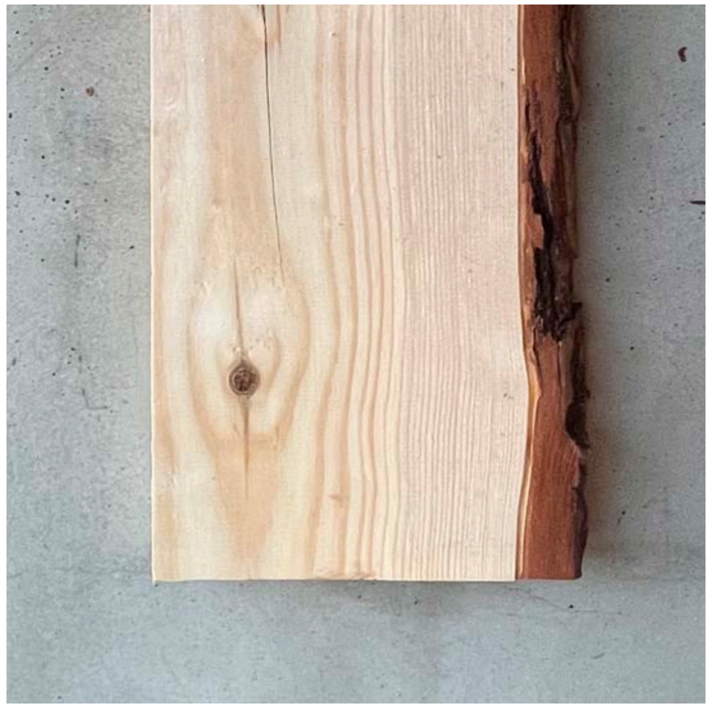
Aim

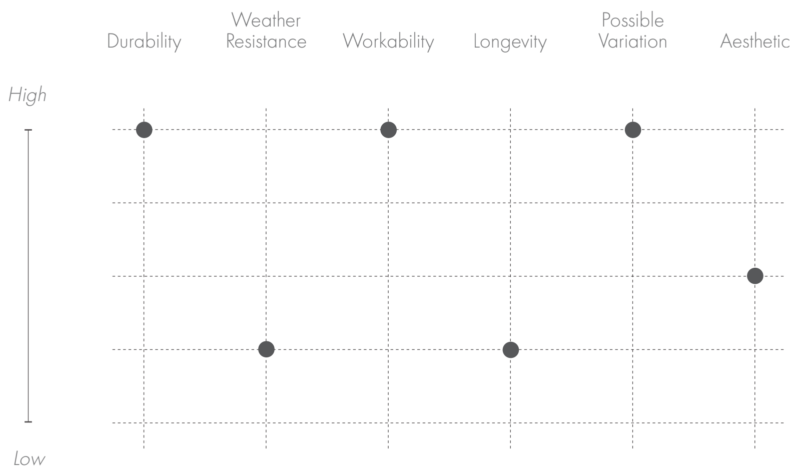
When a building design is limited to the use of only one tree, and no manipulation of materials through conventional methods like painting is within the scope, The design risks lacking contrast and could become dull. By burning the wood, no other material is added but it can give variation to the expression of the design. The burnt wood also has several benefits as an exterior material compared to the untreated wood.

Evaluation

The evaluation of the material samples are partially based on estimations and are subject to personal bias.

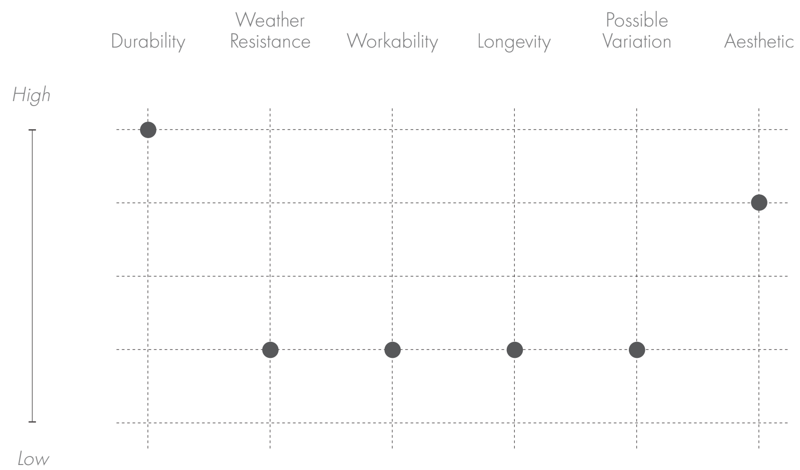
No Carbonization





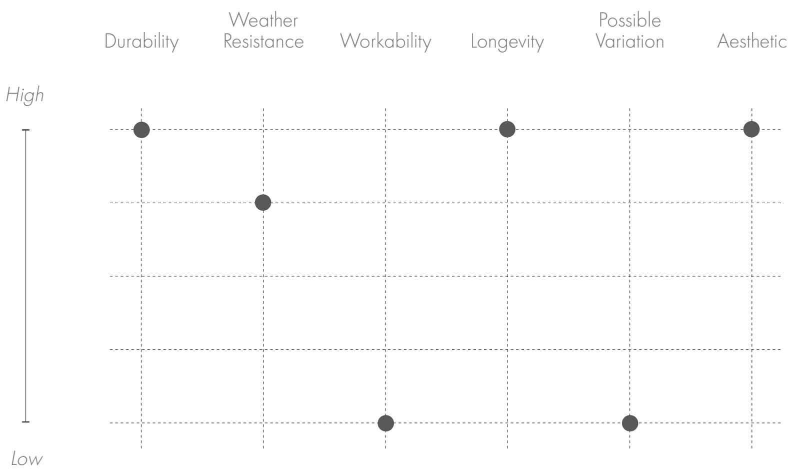
Notes: *Creates a strong earth aesthetic, but loses the clear identity the other samples showcase.*

Grain Carbonization



Notes: *The drier heartwood carbonizes much quicker than the sapwood. The lower workability only applies if the carbonization happens before assembly.*

Shou Sugi Ban Carbonization



Notes: *The lower workability only applies if the carbonization happens before assembly. The process of this level of carbonization was 10 fold the time of the grain carbonization.*

Shou Sugi Ban is a building technique originating from Japan. The technique is over three hundred years old and was developed in coastal Japan as a way to combat wood damage caused by the sea. At that time they used an open fire to burn the outer layer of the wood, whereas it now usually is done with a torch. The effect the burning has is that the external fibers that are exposed to the fire are forced to react which leaves the untreated wood underneath immune to fungi and other natural forces - enhancing its rot resistance (Pereira, 2021). Since only the external fibers are carbonized that strength and durability loss of the process is negligible, as long as appropriate amount of torching is applied (Svenskt trä, 2023).

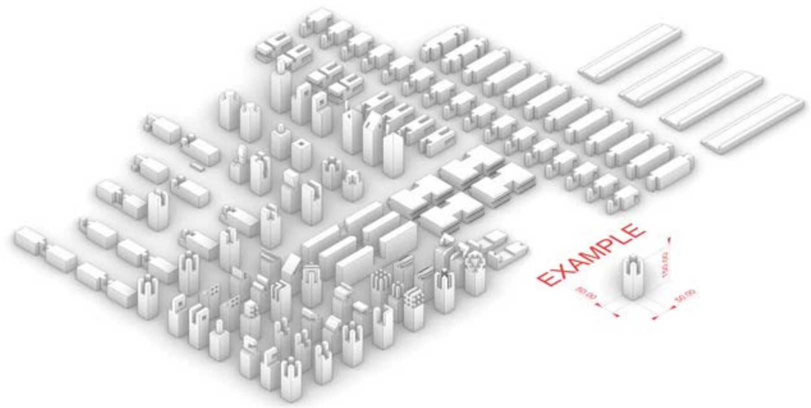
The four steps of shou sugi ban is:

- Burning the wood
- Brush of the top layer of carbon
- Waterproofing with cedar oil
- Applying a layer of sealant to avoid stains upon contact with the facade

Joinery

Samples of wood joinery.

Process



Method

First, the connections were developed and modelled in Rhino. When the catalogue of digital joints were developed they were assessed to determine which manufacturing method was most suitable for each individual joint. Two manufacturing methods were used, CNC-milling and 3D-printing. In general the more complex joints were 3D-printed and the joints that could be milled on a 3-axis CNC machine were manufactured with that technique.

Aim

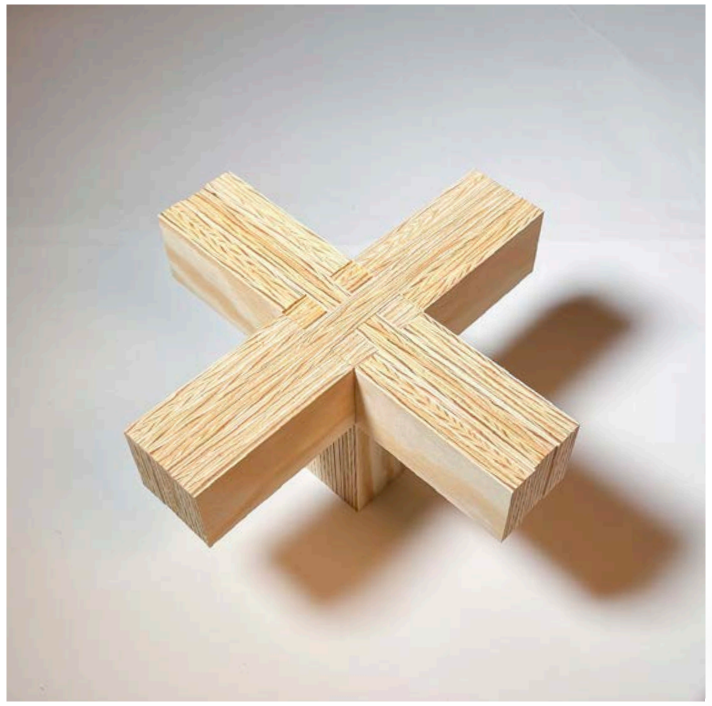
Since no other materials than pine derivatives can be used in the building design, these interlocking joints can eliminate the need for metal fasteners, chemical adhesives or any other material that is used conventionally.

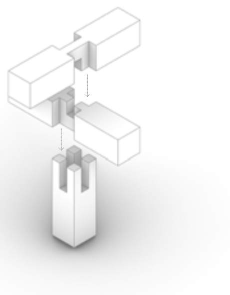
Evaluation

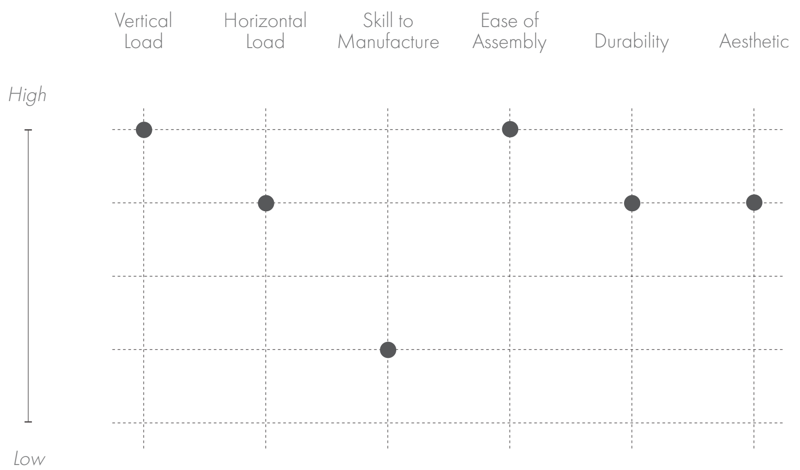
The evaluation of the material samples are partially based on estimations and are subject to personal bias.

Castle Joint 5-way

No. 1



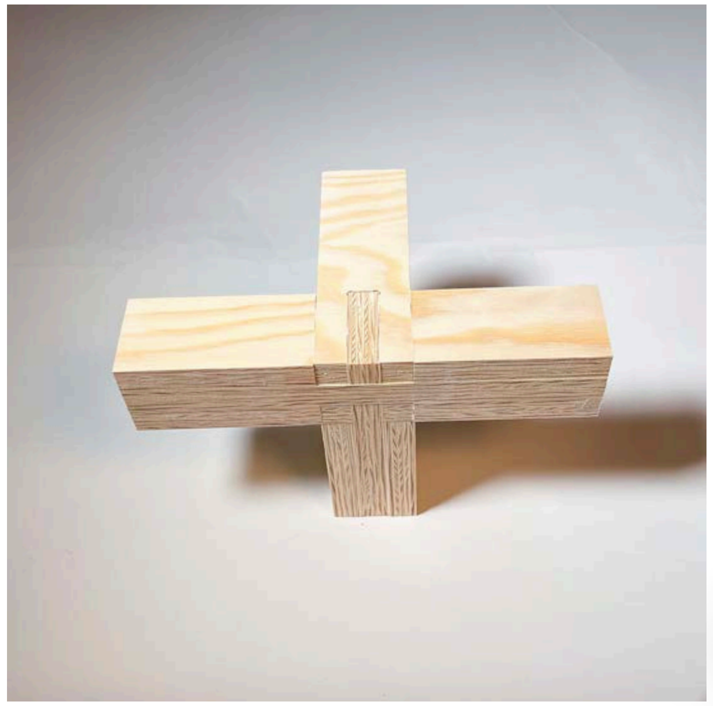


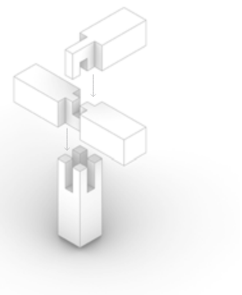


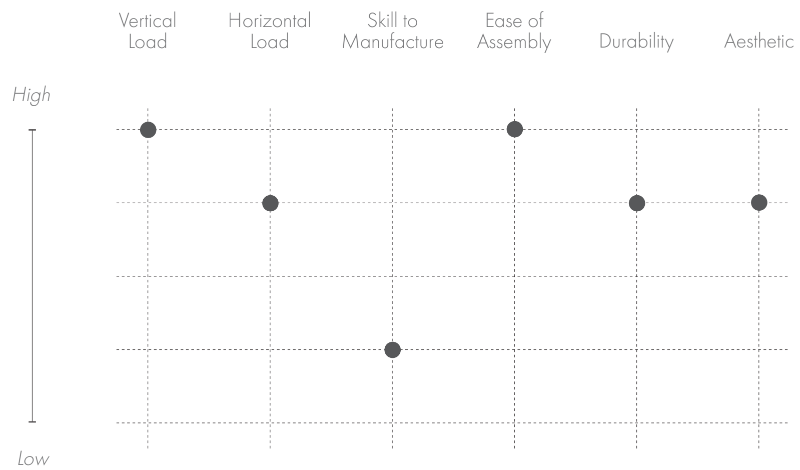
Notes: *The strongest 3-way joint since the uniformed dimensions means there is no obvious weak point.*

Castle Joint 4-way

No. 2



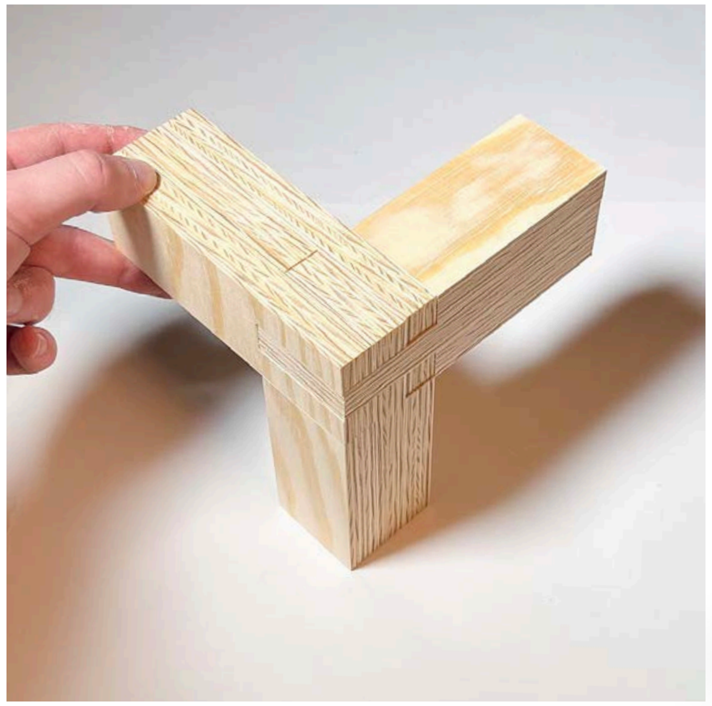


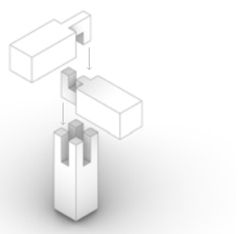


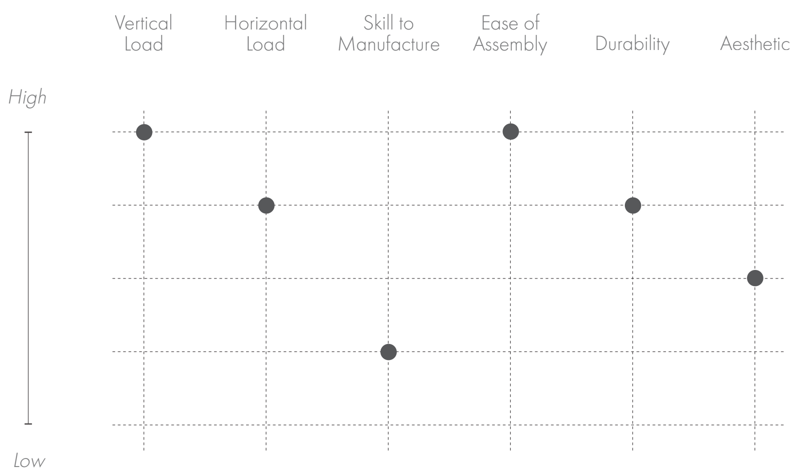
Notes: *The castle joint is flexible since it can change number of connections.*

Castle Joint 3-way

No. 3

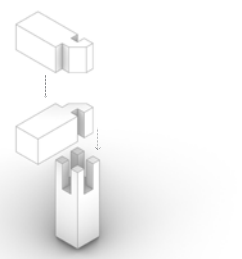


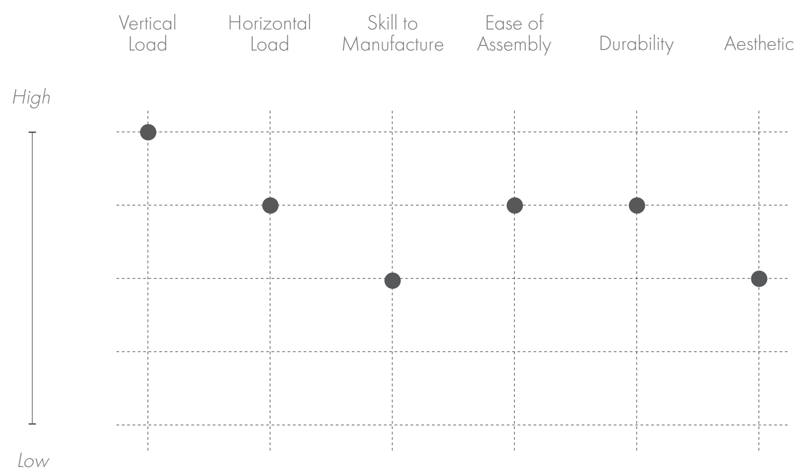




Castle Joint Flexible Direction

No. 4

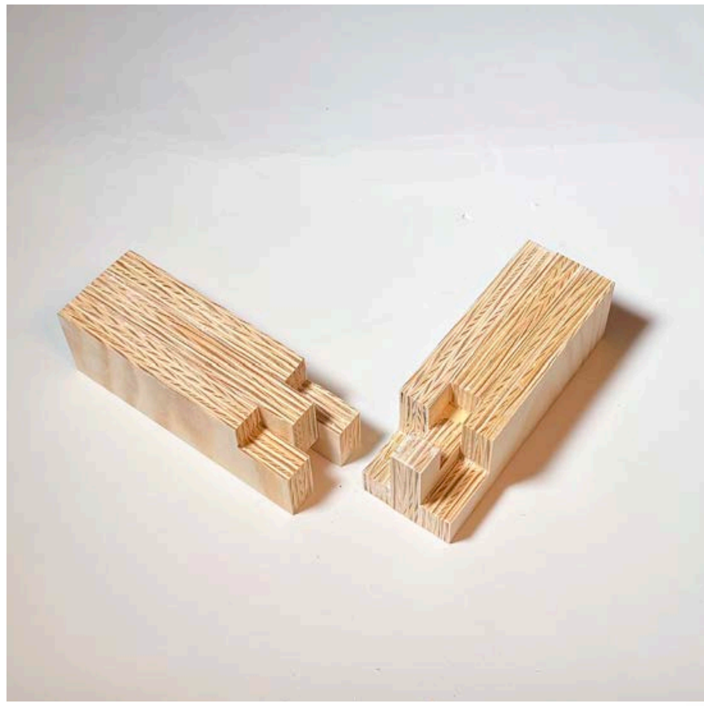


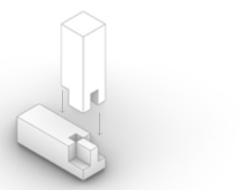


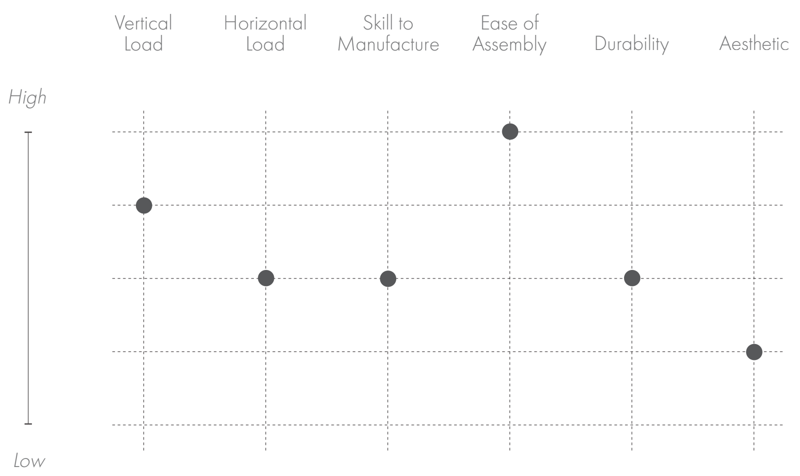
Notes: *The joint can also be assembled in a 90 degree angle.*

Voxel Joint 1

No. 5

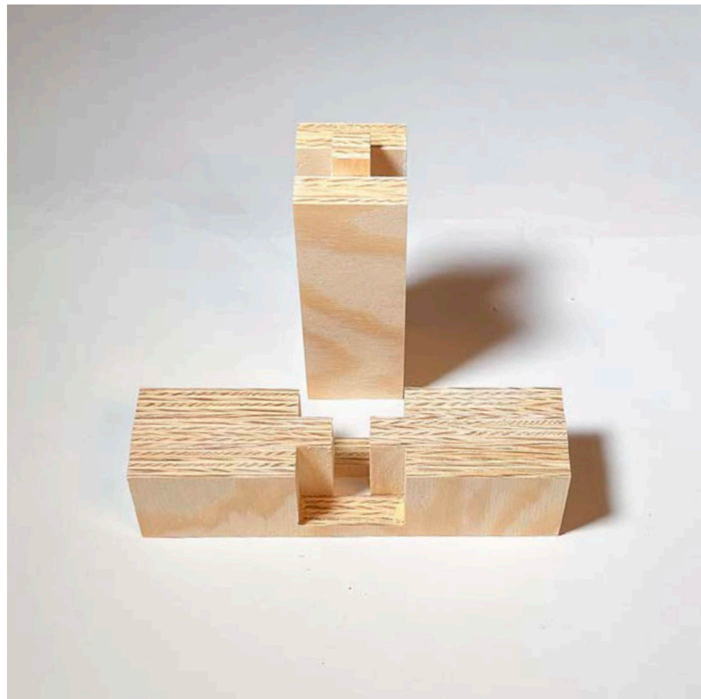


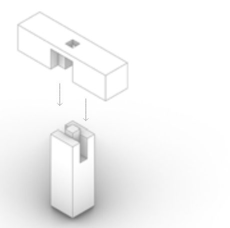


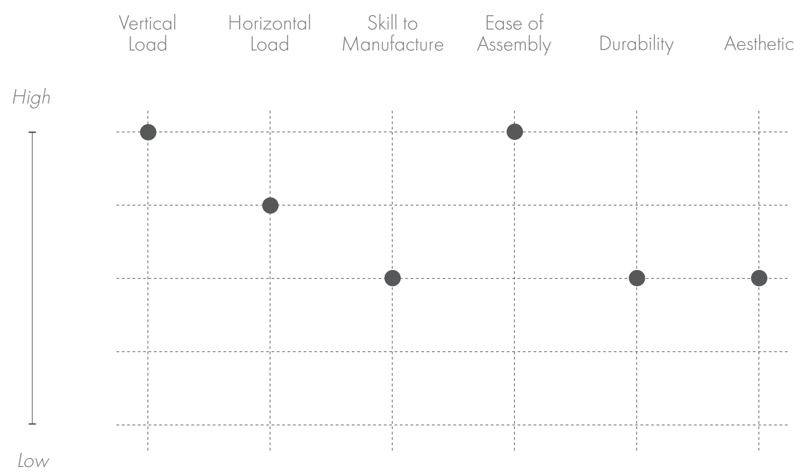


Voxel Joint 2

No. 6







Gooseneck Joint

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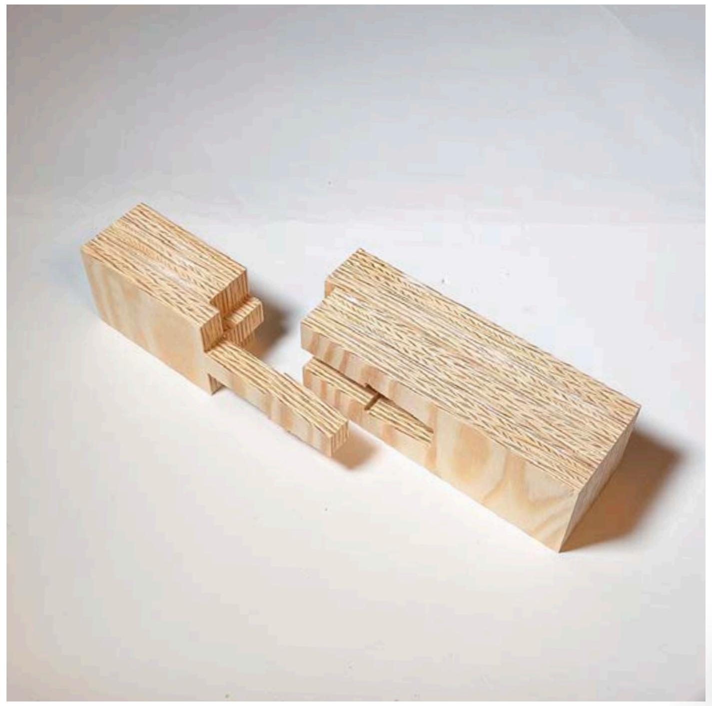
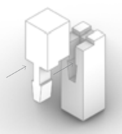
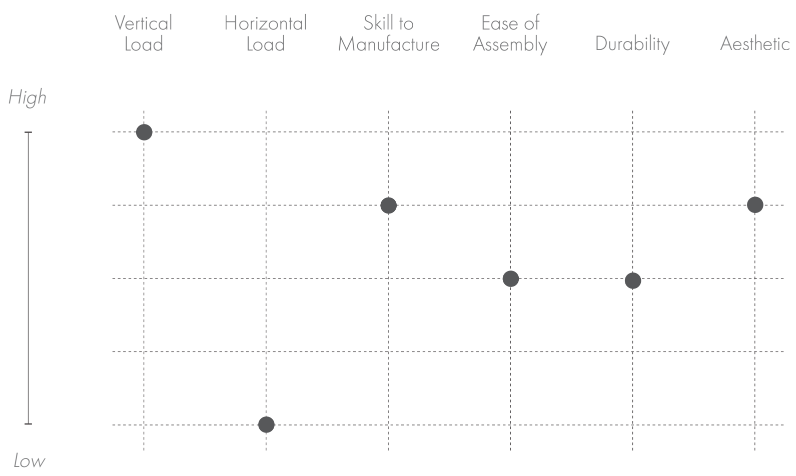
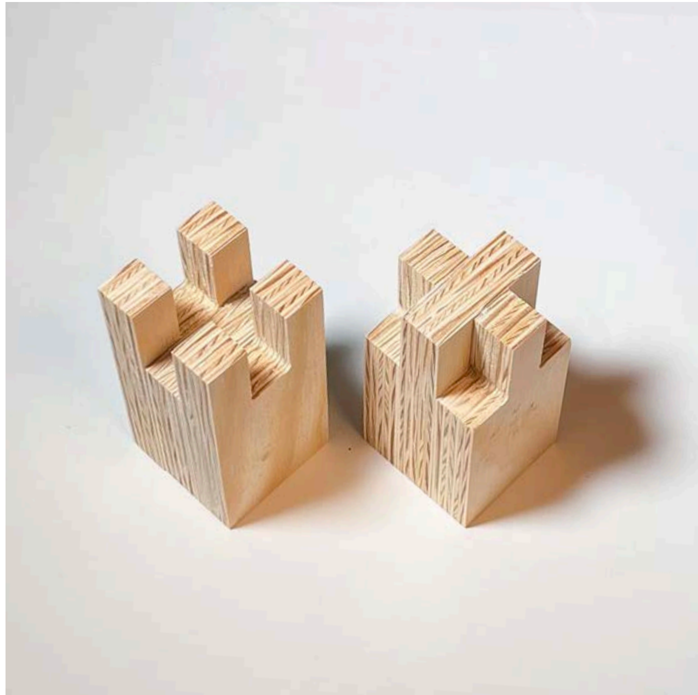


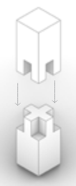


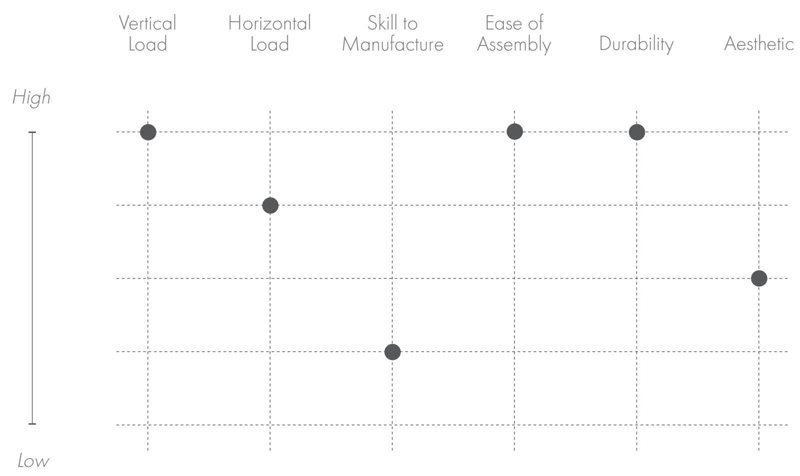


Socket Joint

No. 8

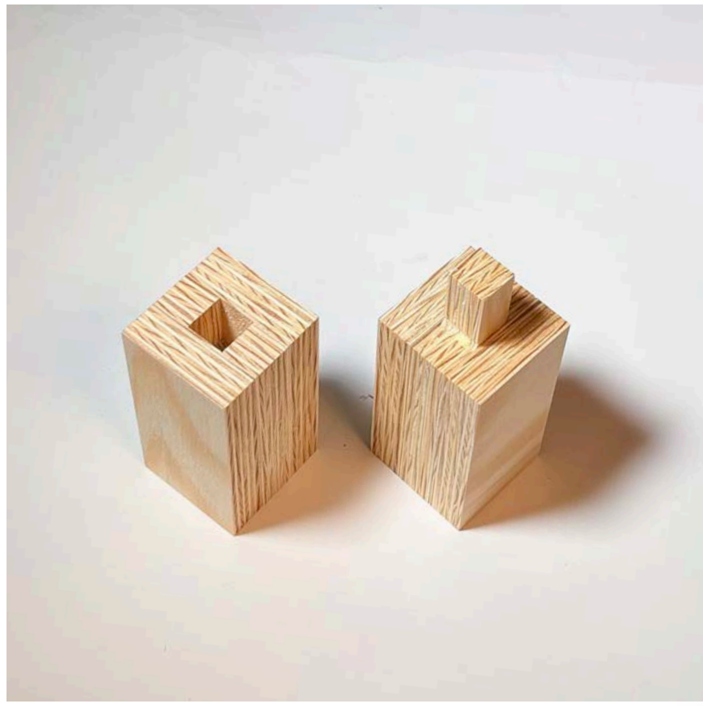


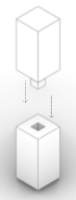


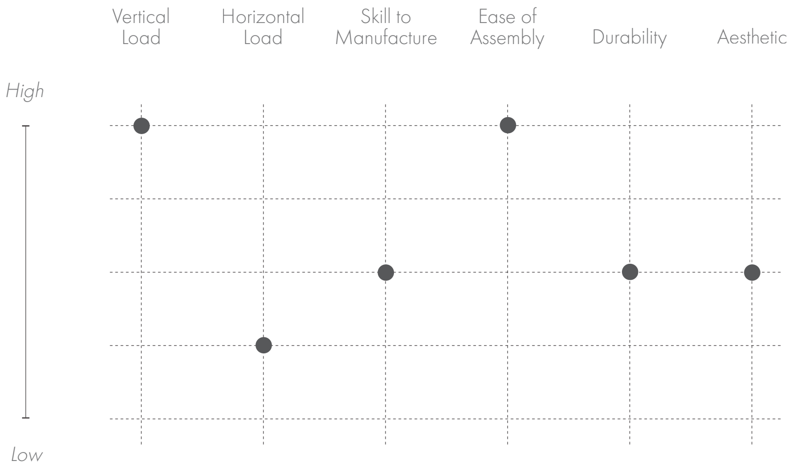


Mortise & Tenon Joint

No. 9

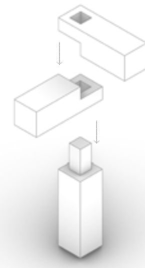


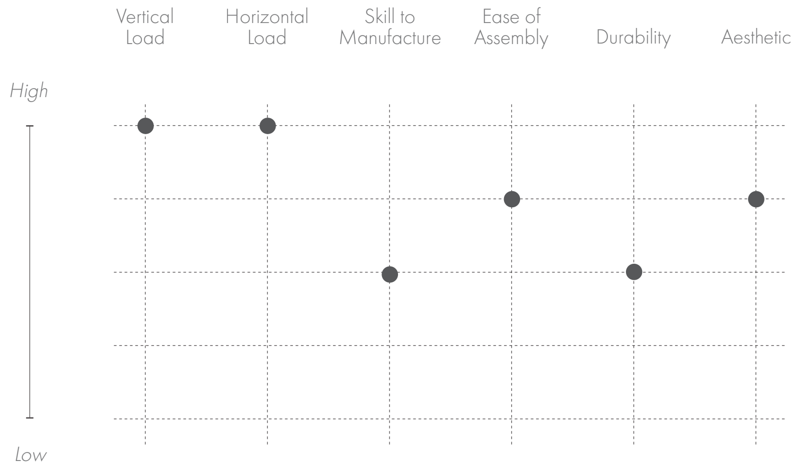




Double Mortise & Tenon Joint

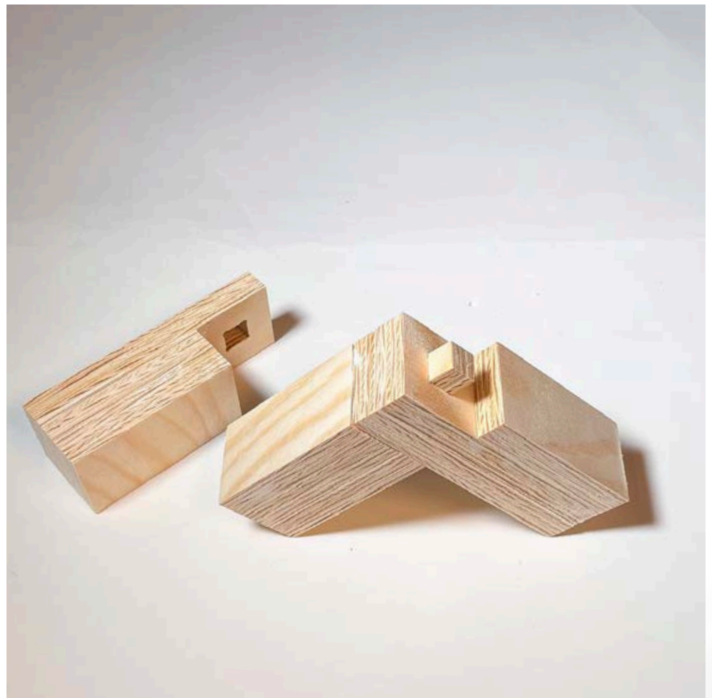
No. 10

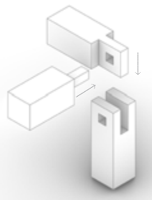


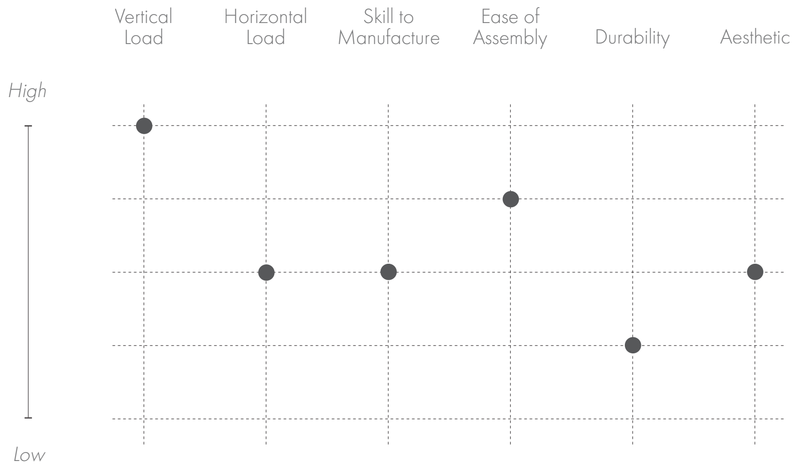


3-way Mortise & Tenon Joint

No. 11



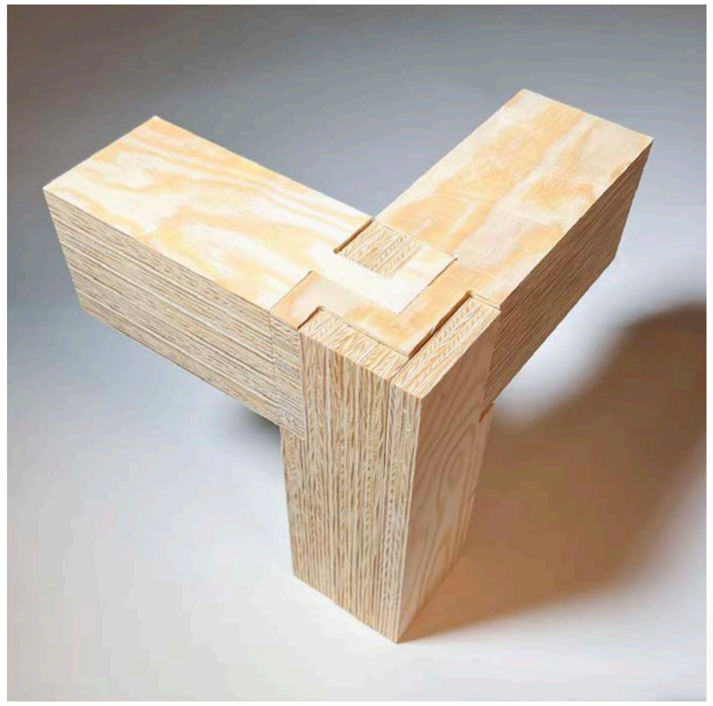


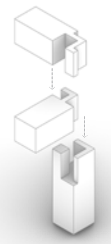


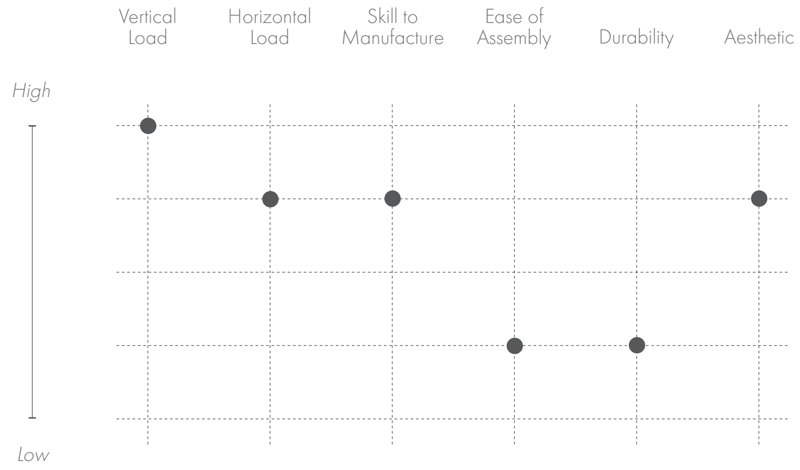
Notes: *Can be assembled in multiple directions.*

3-way Joint

No. 12

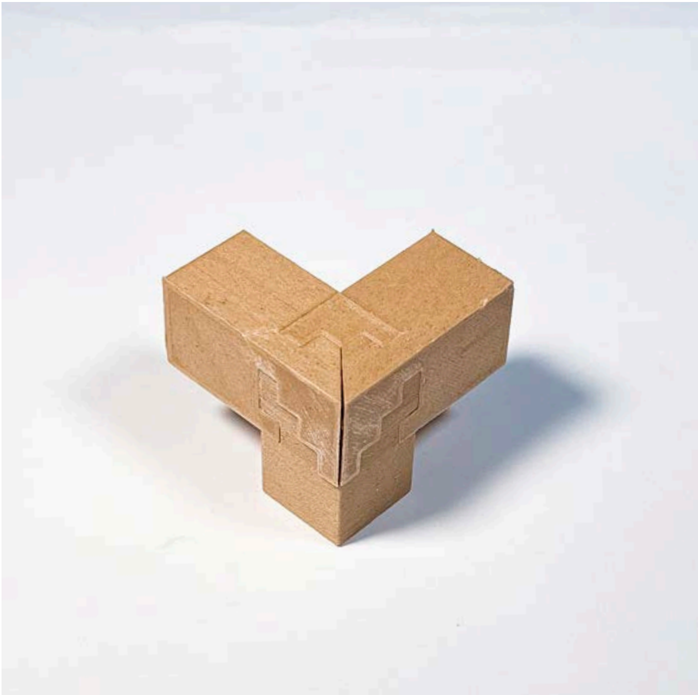


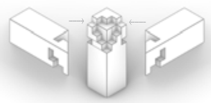


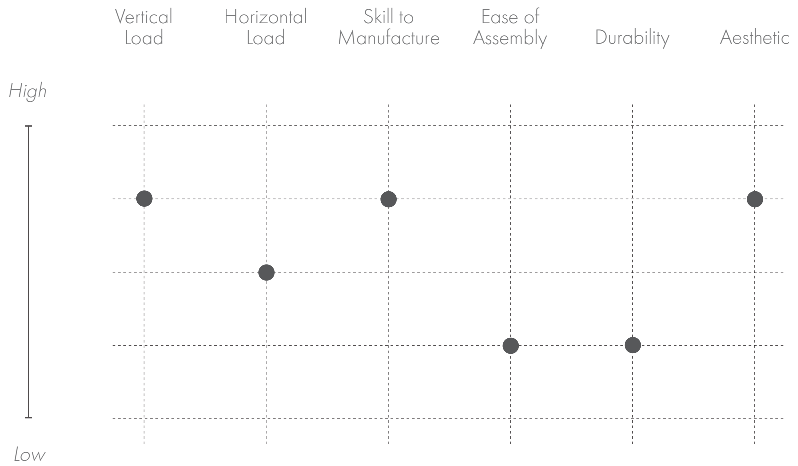


Experimental Joint 1

No. 13

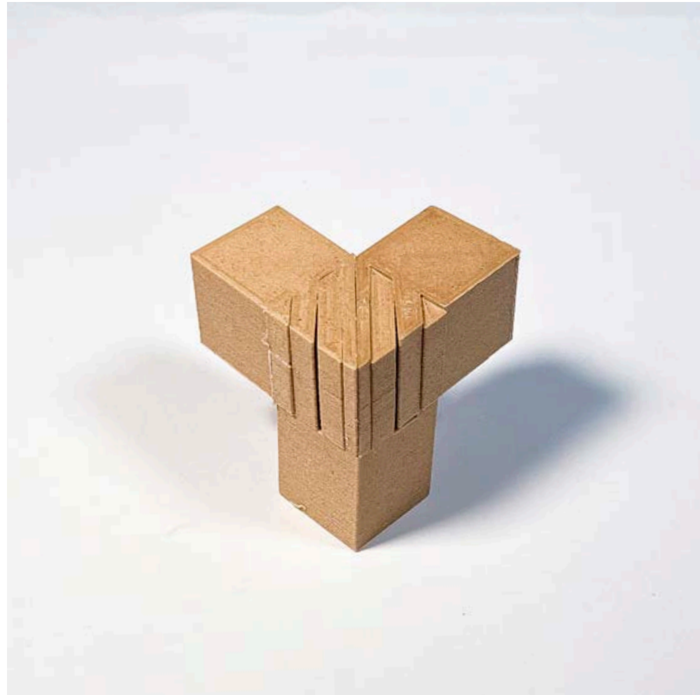


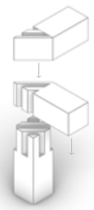


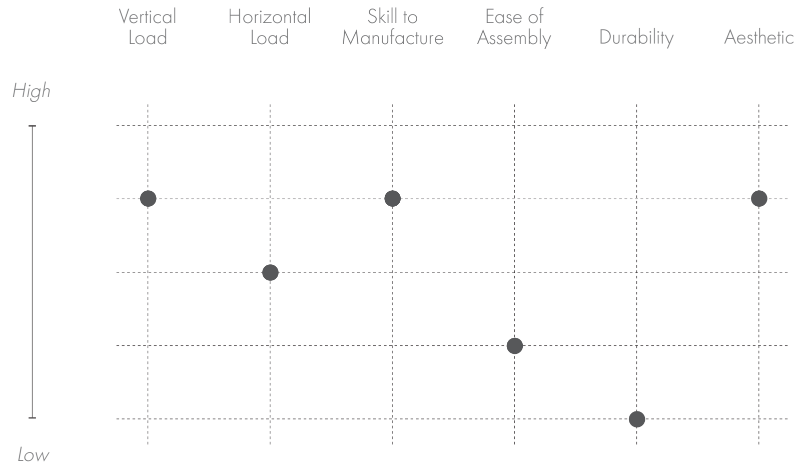


Experimental Joint 2

No. 14

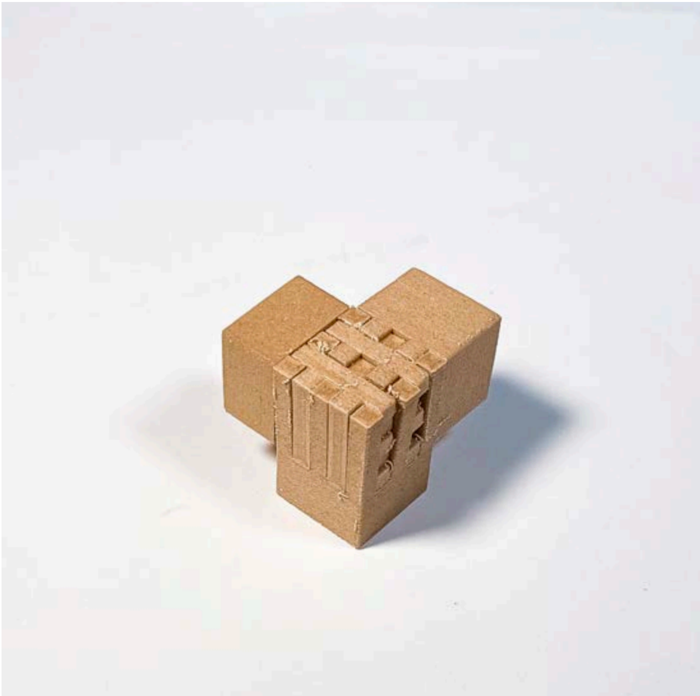


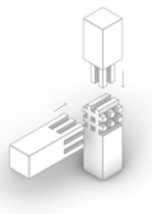


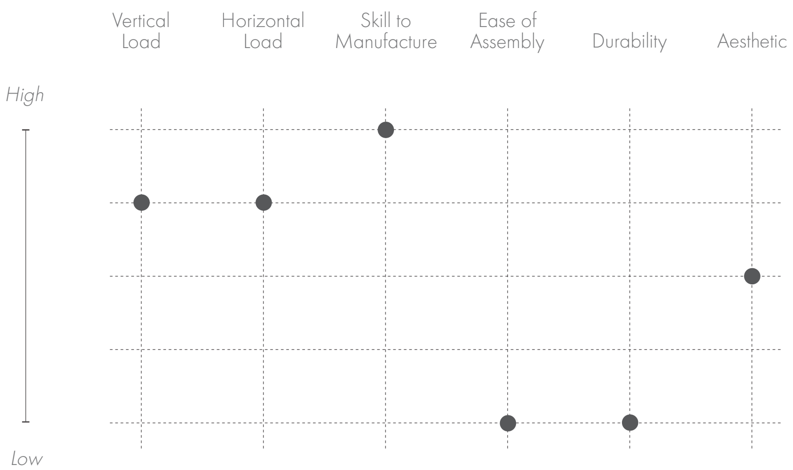


Experimental Joint 3

No. 15

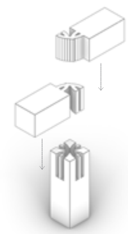


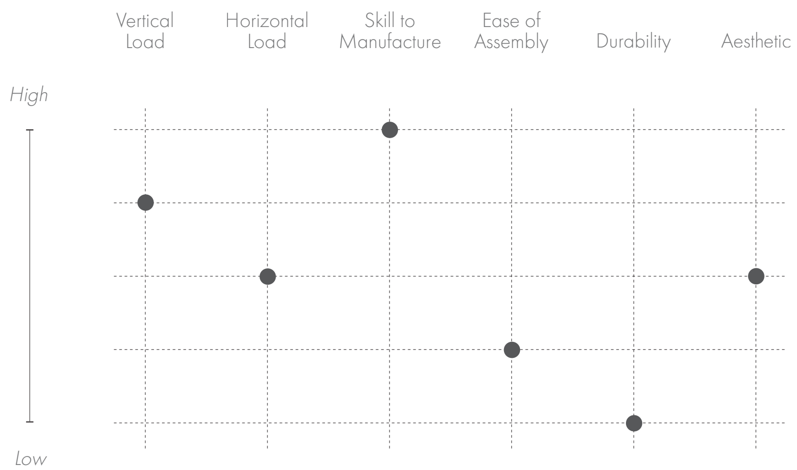




Experimental Joint 4

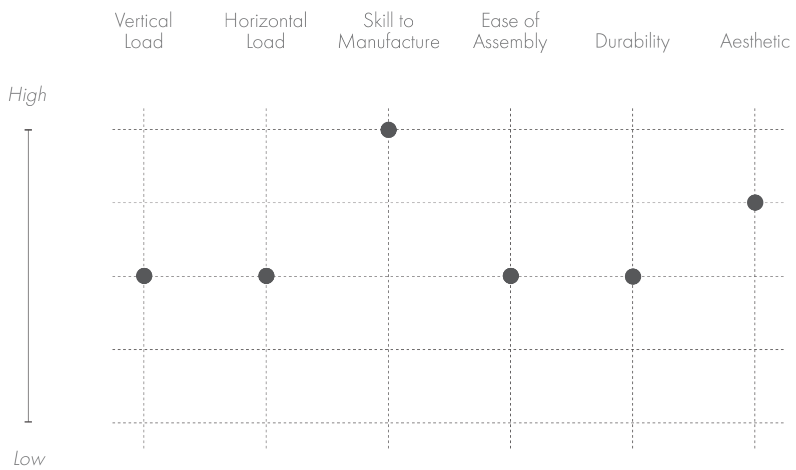
No. 16





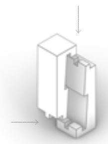
Kawai Tsugite

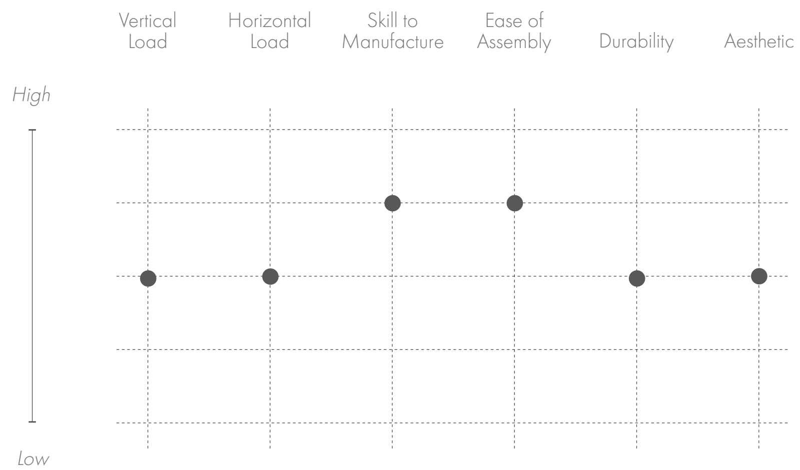
No. 17

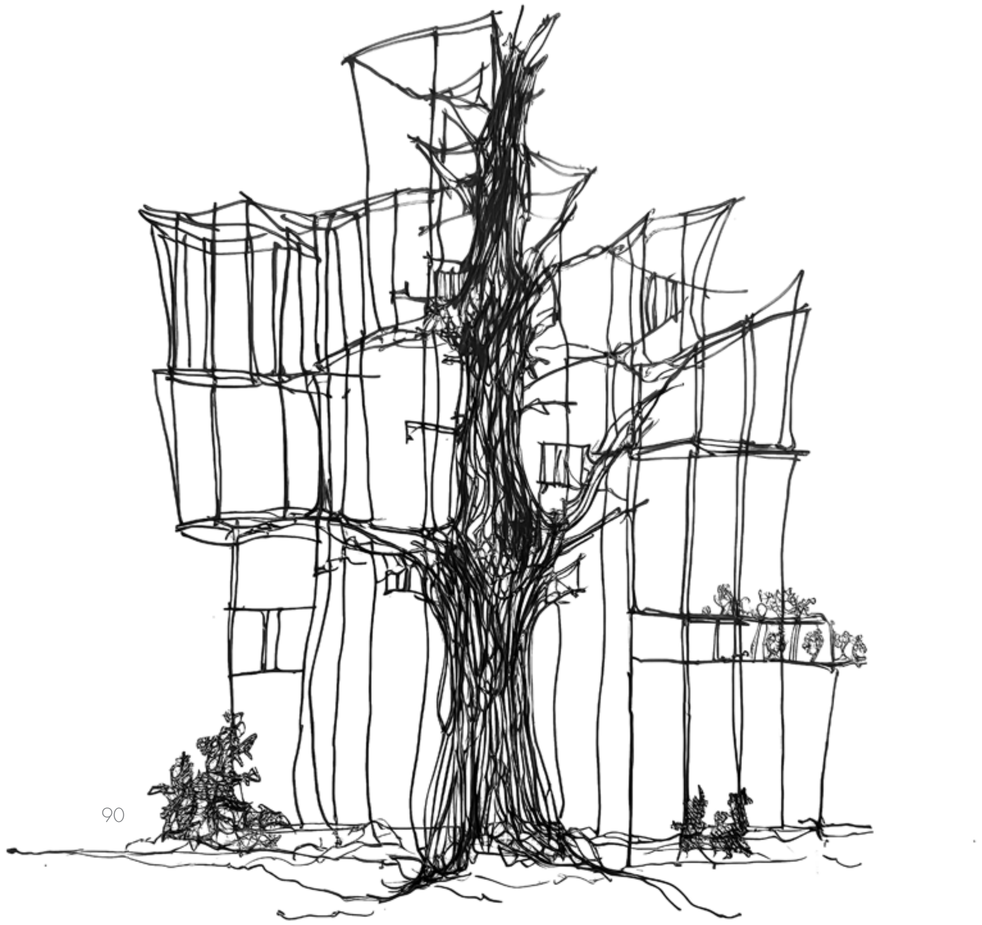


Okkake Daisem Tsugi

No. 18

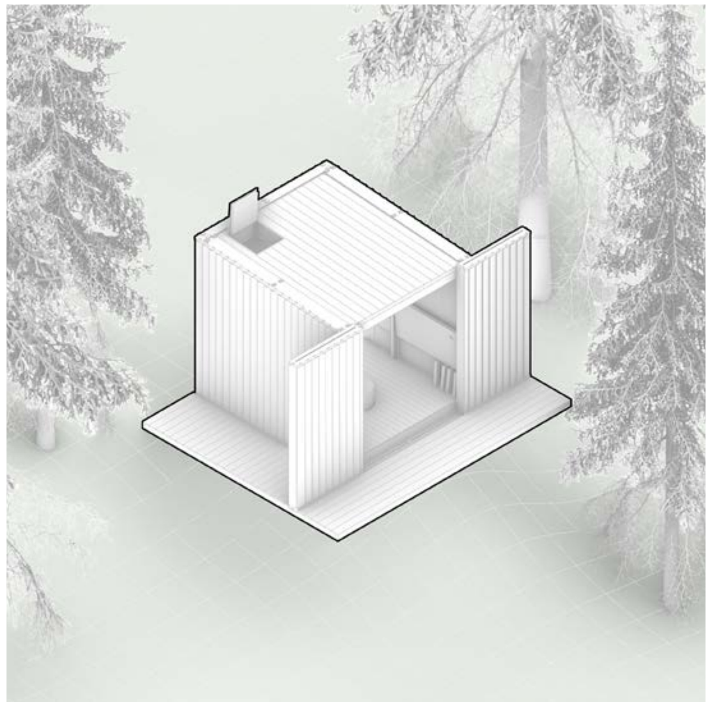






T H E C A B I N

The Cabin



Material Application

A selection of the findings from the material research and investigations, combined with conventional building materials derived from scots pine is integrated and showcased in a conceptual forest cabin. The example tree determines the material budget of each pine component that the cabin can consist of.

The design is focused around highlighting the possibilities of the pine tree and being honest in its design. The intricate joinery structure, the utilization of the tree stump as foundation, the experimental boards as inner walls and the charred wood exterior is not hidden or downplayed. Instead, it is highlighted.

The concept - A tree is chopped down, the parts are refined to building elements without involving any new materials. The tree is then reassembled on top of its own stump, as a sort of frankenstein version of itself. When the lifecycle of the cabin is due, it degrades and the tree returns to the ground it came from.

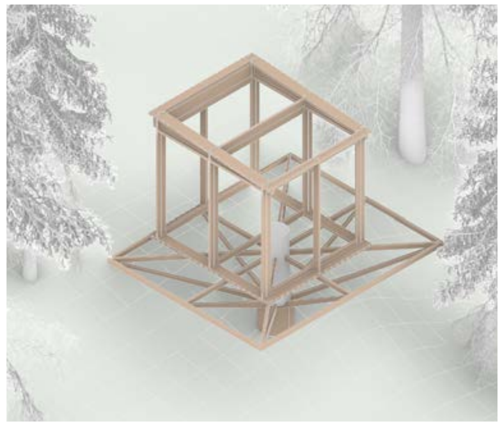
BUILD UP

MATERIAL BUDGET

1.

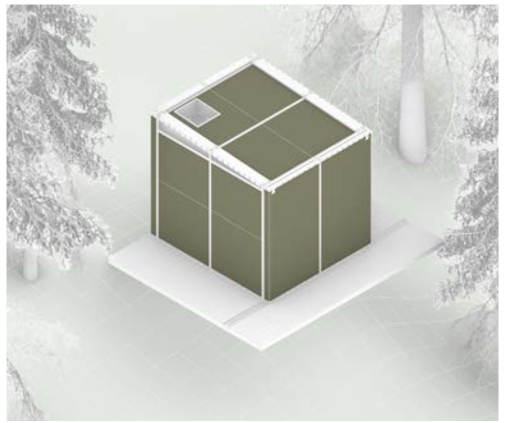
2.

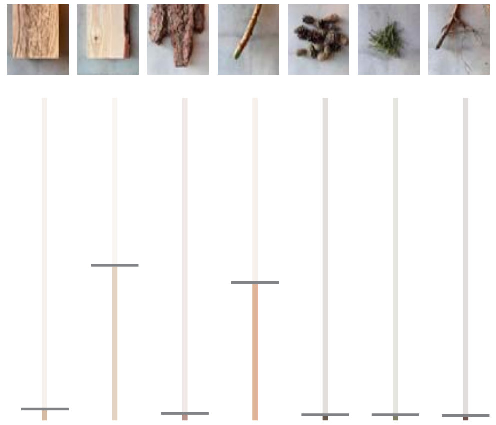
3.



4.

5.

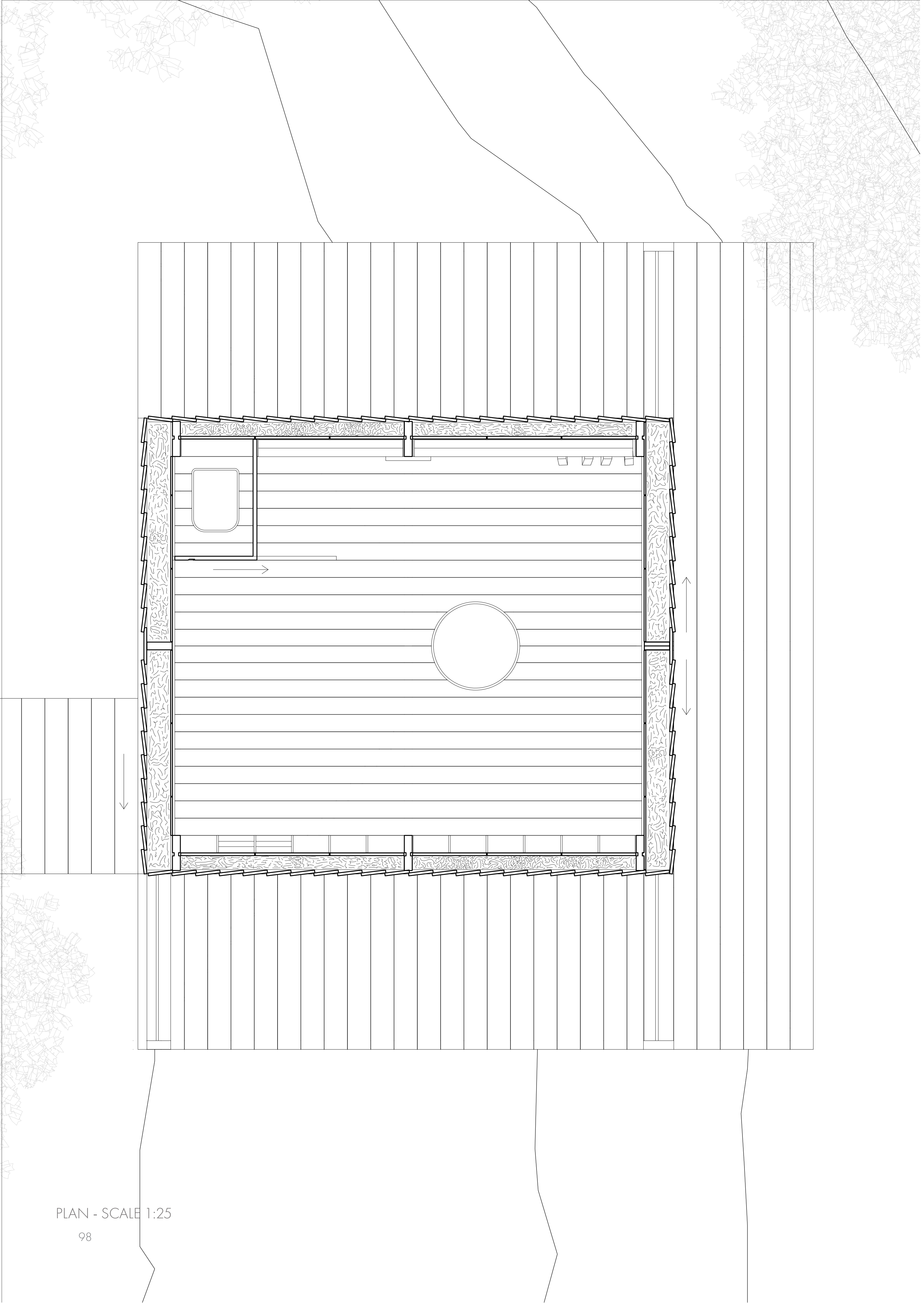




6.

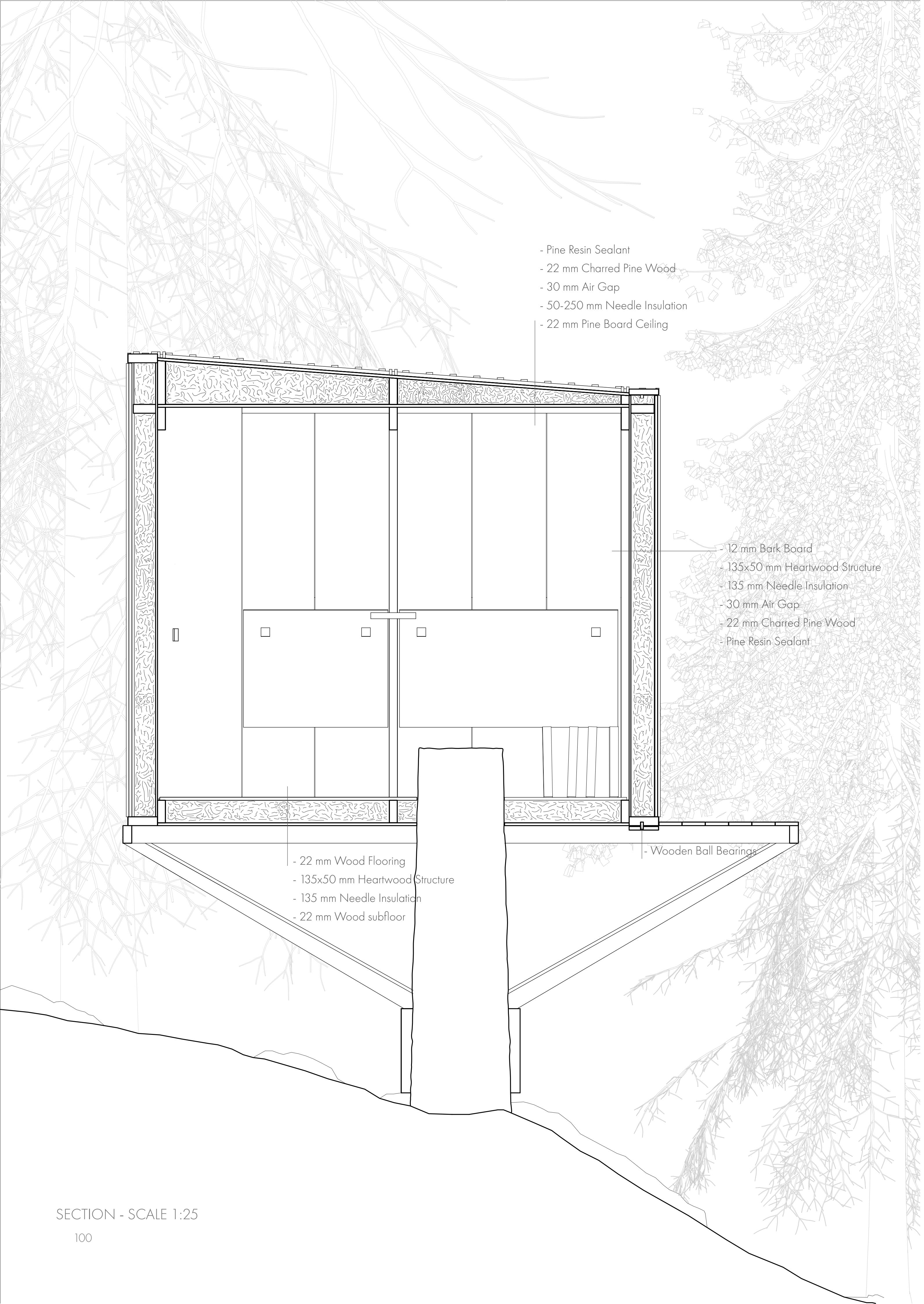
7.

8.

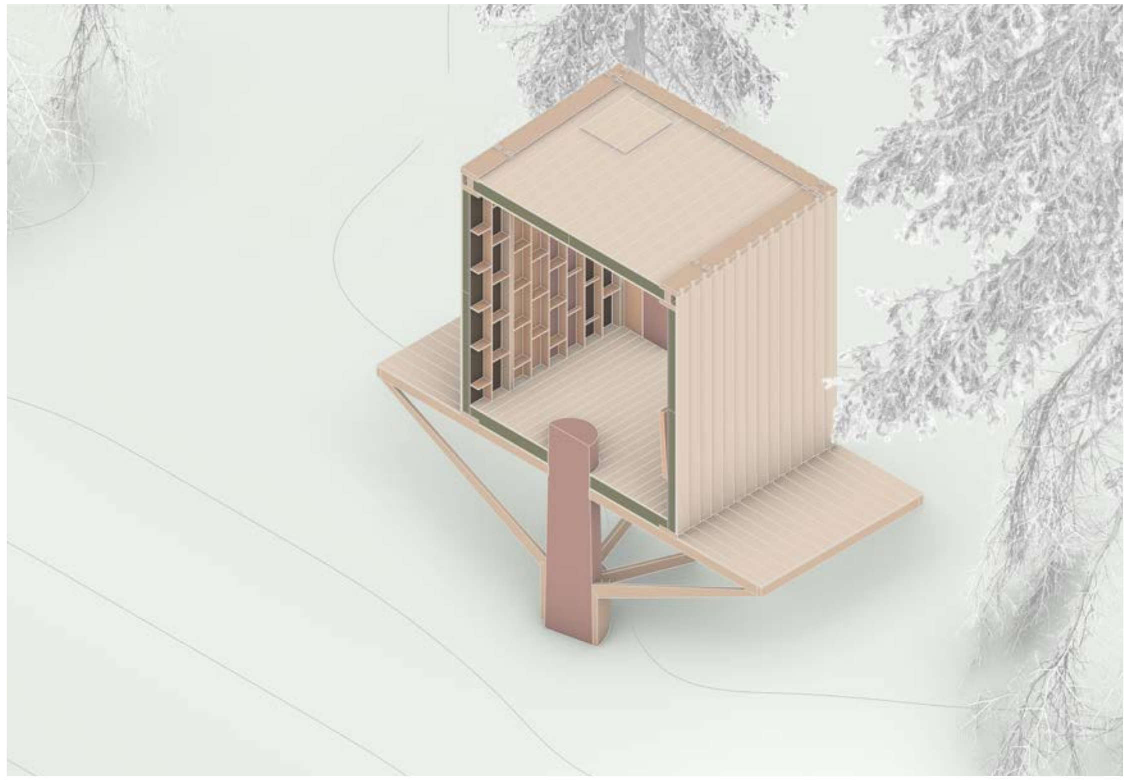


PLAN - SCALE 1:25

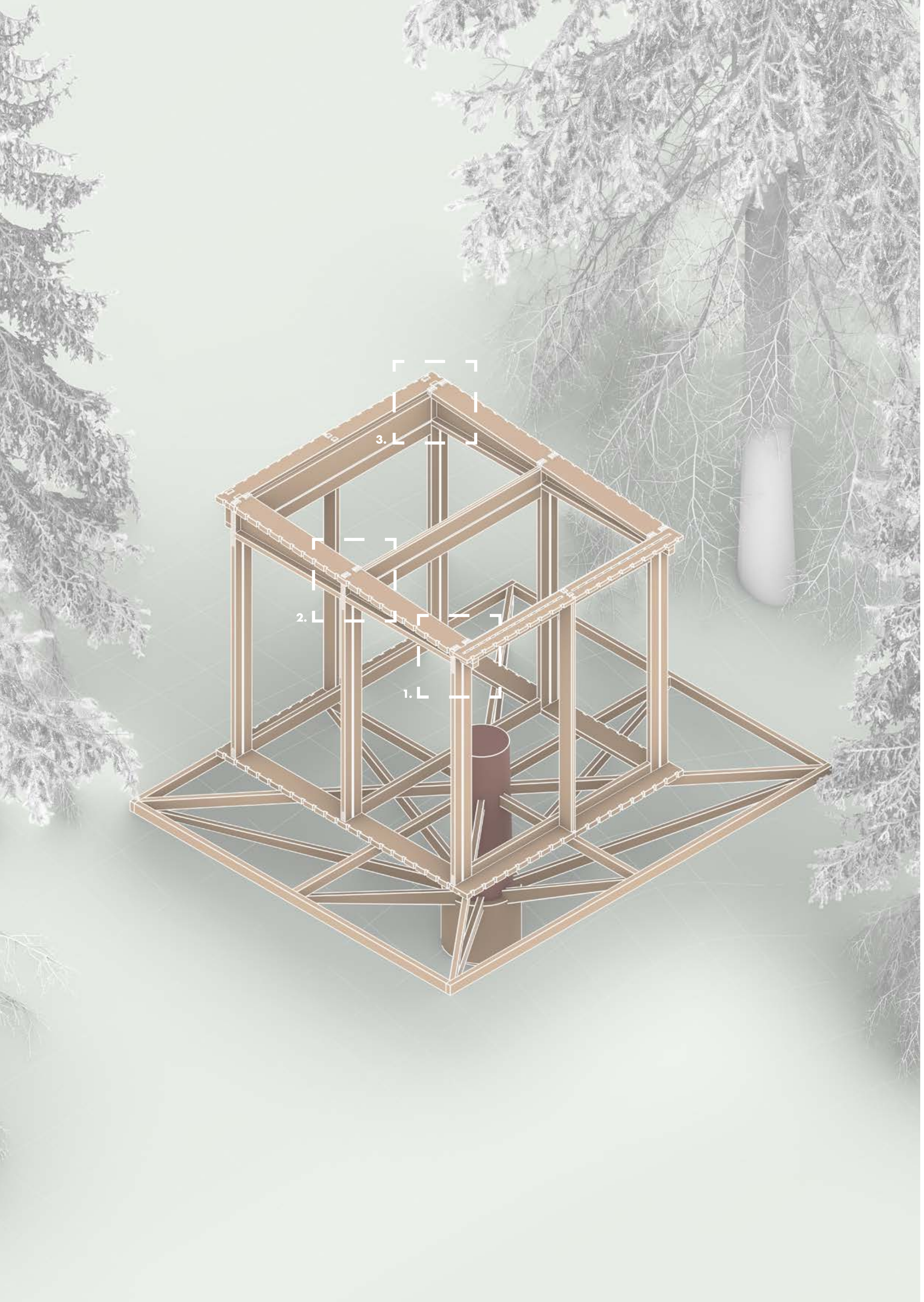
HORISONTAL CUTS



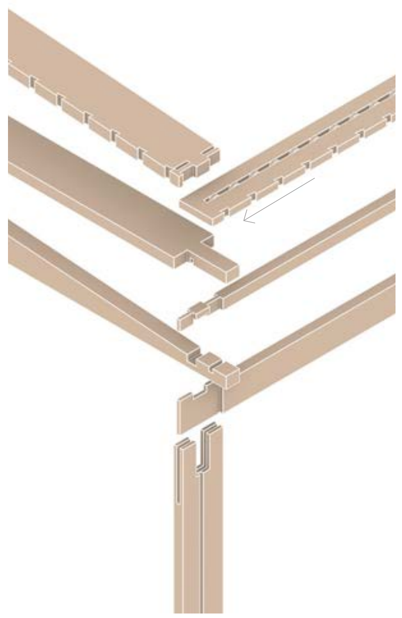
SECTION - SCALE 1:25



VERTICAL CUTS

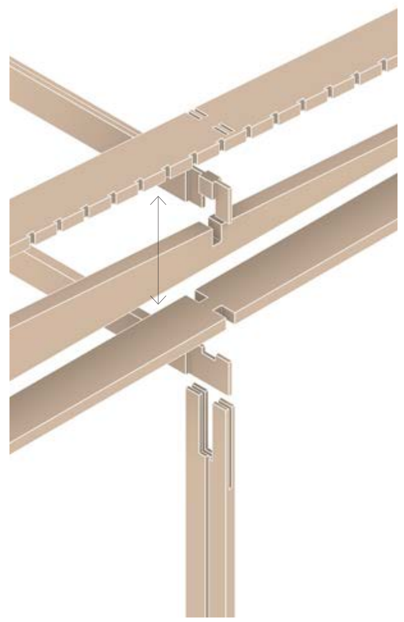


CONNECTION EXAMPLES



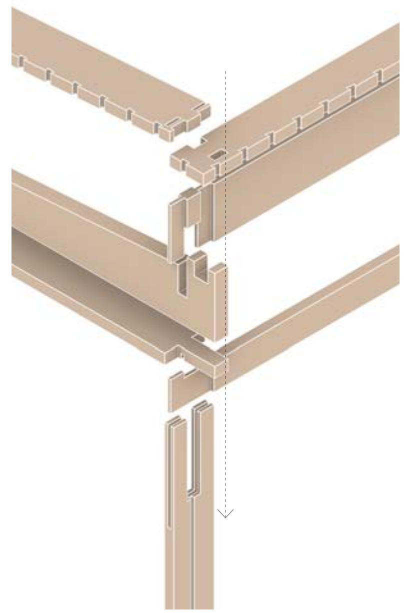
CONNECTION 1

The front walls have their own structure and only interact with the main structure at the top and bottom, where wooden ball bearings are attached to make the walls operable (see arrow).



CONNECTION 2

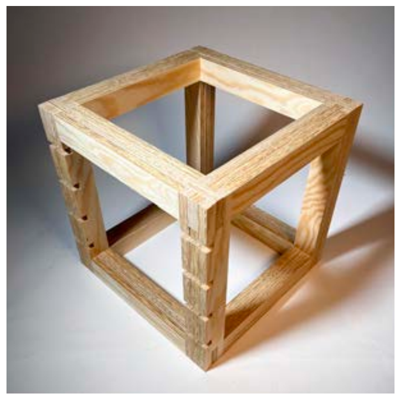
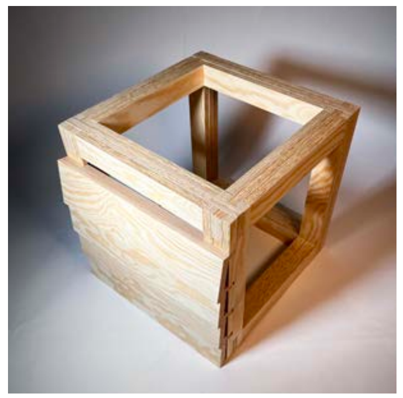
The double structural frame creates a void between the layers that is filled with insulation.



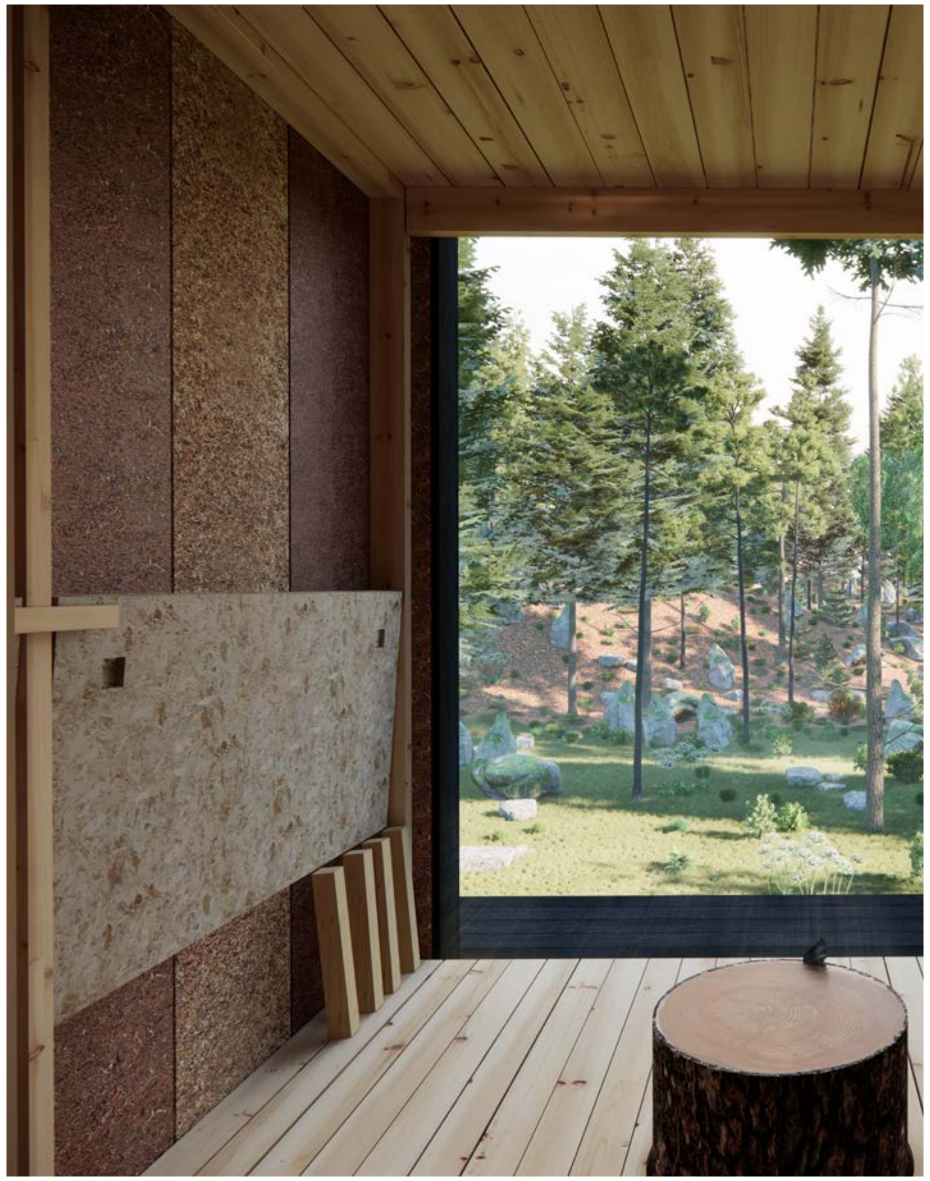
CONNECTION 3

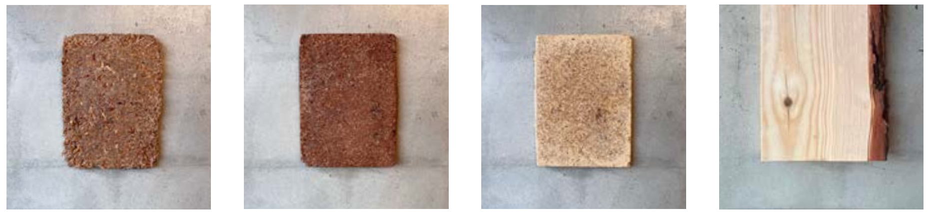
The column penetrates every element and connects them together.

PHYSICAL MODEL - PROOF OF CONCEPT


Pine wood structure assembled without any fasteners or adhesives.

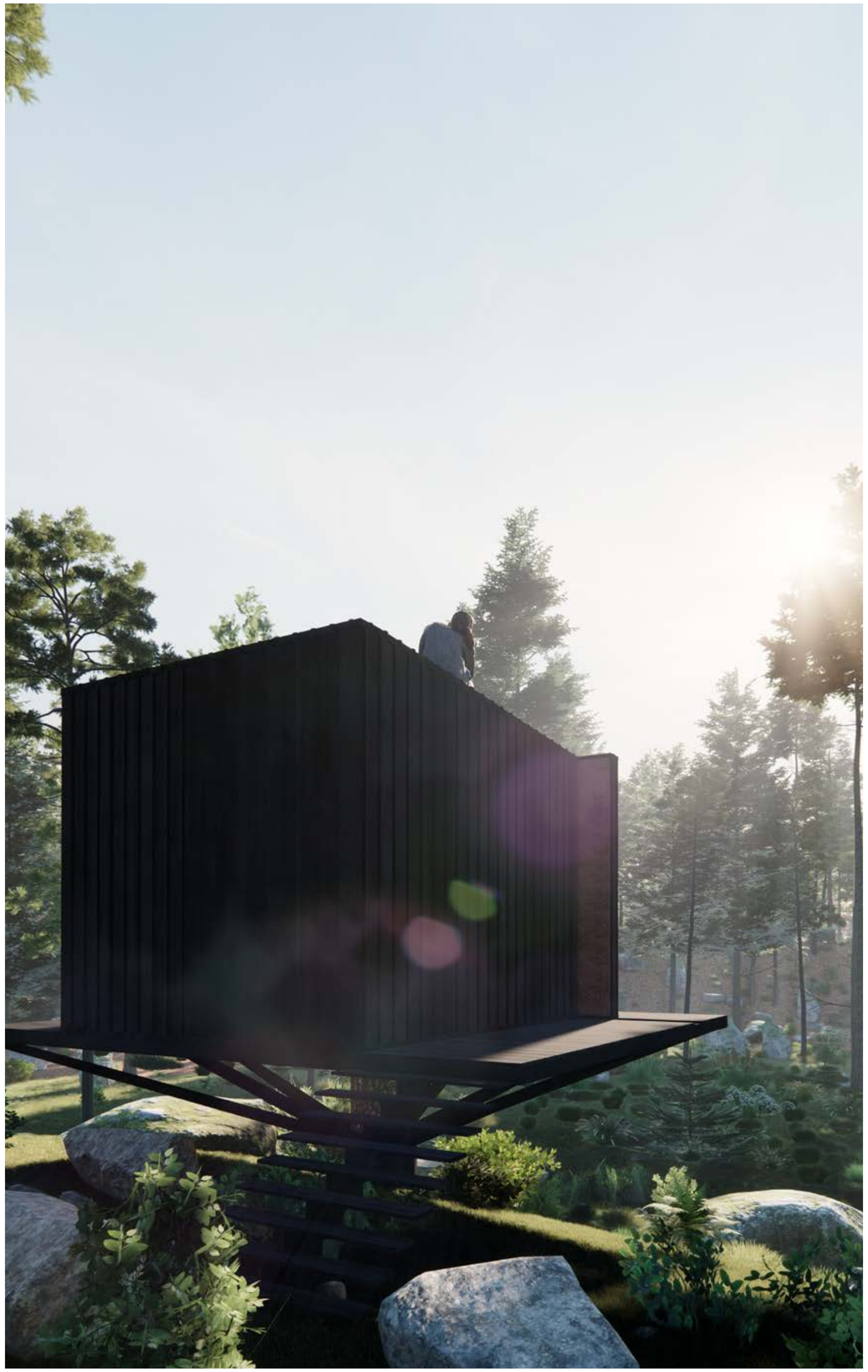




Material samples used in interior

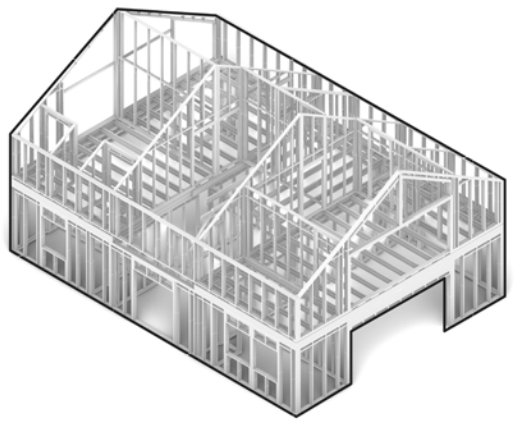
Material samples used in exterior

The Tree...

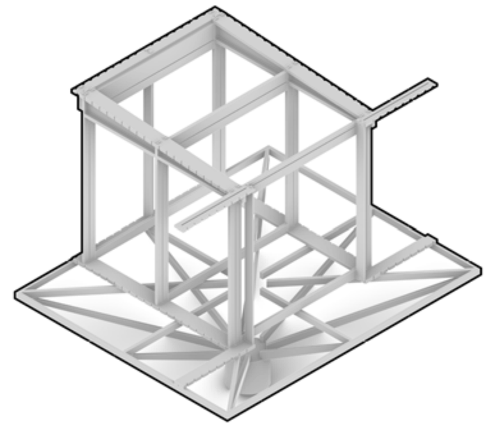


Becomes a building

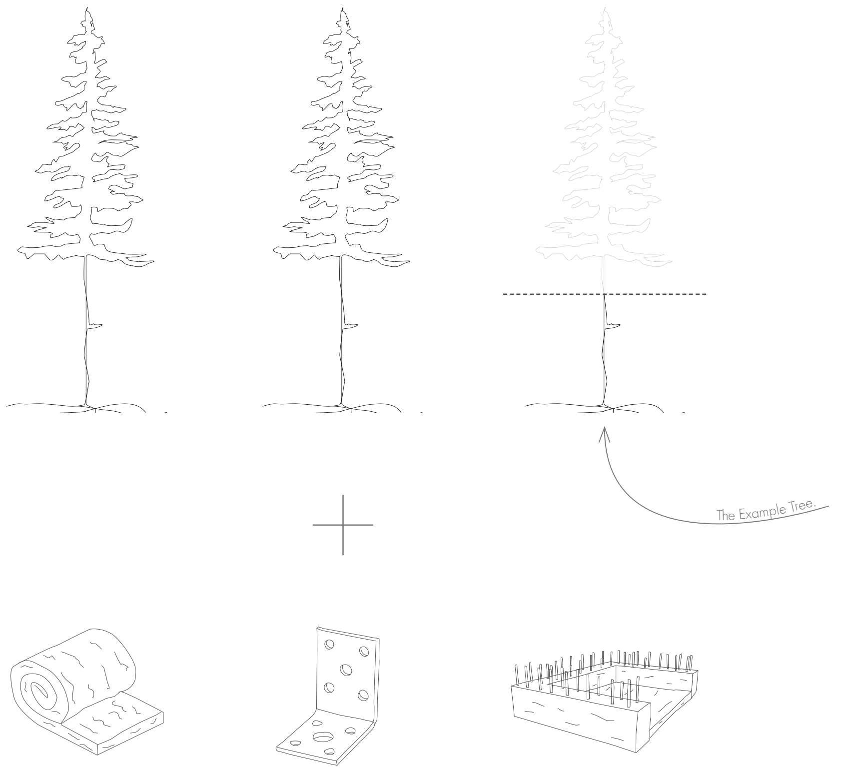
THE COMPARISON



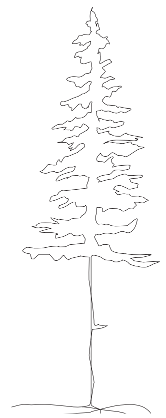
Typical wood frame building.



Design proposal.



Material usage for 7 m² single structure building.



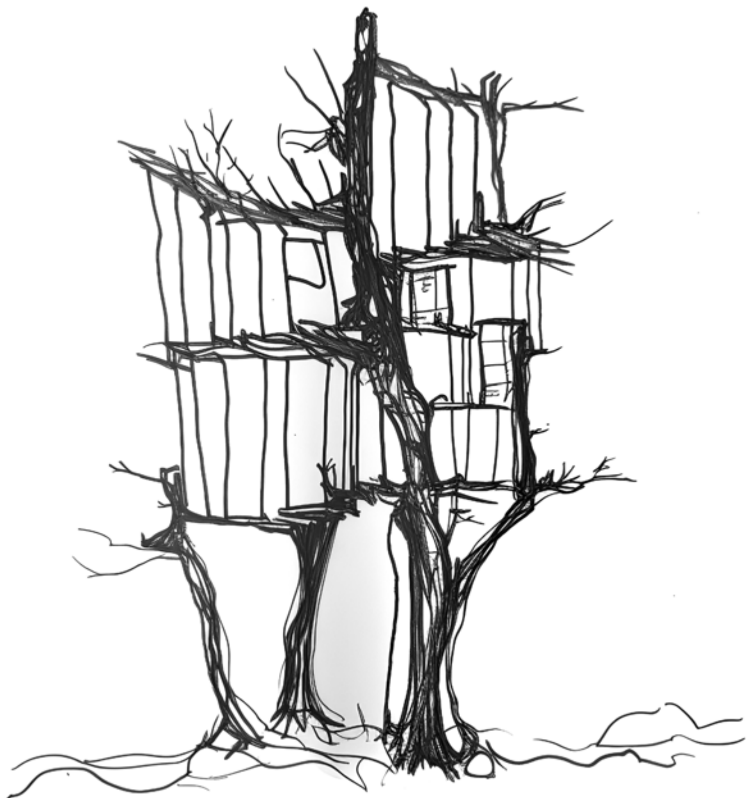
Material usage for 7 m² design proposal.

How many trees does it take to build a building?

The amount of trees of course varies depening on the size of the building, building technique, how big portion of the building that is made in wood, and so on. A typical villa of roughly 180 m² utilizes somewhere between 60-100 typical trees (Kilgore, 2023) whereas a 7-story mass timber building could use over 2000 typical trees to manufacture (Russell, 2022).

It is challanging to make a fair comparsion between the proposed building and a typical building of the same size, as other buildings are not limited to the use of only tree materials. In the illustrated examples the typical wood frame building is compared only in terms of the wood used, the non wood materials are left out of the comparsion. My example tree has a Board footage (amount of wood that can be extracted from the tree - 1 board is 13, 4 m² and 2,54 cm thick) of 490. A Typical single structure wood frame building of the same size would use roughly 1200 boards in its construction, which amounts to 2,44 times the example tree (Kilgore, 2023).

CONCLUSION



Conclusion

The aim to showcase the versatility and possibilities of the pine tree in the building industry and give architects and other professionals within the built environment a toolbox of innovative and traditional ideas that pushes resource effectiveness and applications of material innovations forward has been achieved through the development of the material catalogue and the proposed implementations of the findings in the building design.

What design opportunities does the different components of a pine tree present?

All the components of the pine tree can be utilized as building materials. The wood has conventional applications as planks, sheets or framework that can be a self-sufficient material through wood joinery - eliminating the need for fasteners or adhesives. The suitability of the wood as a exterior material can be enhances through carbonization of the wood. Cones, bark and the inevitable sawdust from the production of the hardwood can be bonded with pine resin to create board materials suitable for interior spaces. The branches are also apt to use as board material after being chipped down. Pine resin can be used as a alternative adhesive although it is not as bonding as other alternatives on the market. Another application of the resin is as a sealant to protect the pine from the environment, as it does in nature. The needles have insulating properties and the stump and roots can acts as a foundation for structures with a shorter life cycle.

How can these opportunities manifest themselves in the built environment?

In this thesis the opporunities are put to the test under the strict constraint of only using a single pine tree and refining the components in a way that enables a proposed building design within that budget. The ambition was to highlight the materials and their capacity by letting the components interact with eachother and not introduce conventional solution when faced with design challanges. This resulted in experimental solutions in some cases, for example the stump as a foundation or self-interlocking joinery as the main structure. These solutions may not be the most efficient or comercially viable, but they could help expand the view of what a material can become and not only see it for what it currently is. Some ideas in the thesis are more ready for a wider adoption, like charring the wood as an alternative to chemically impregnated wood, or utilizing the bark and branches for board production to reduce waste.

Reflections and future research

One important acknoledgement is that the example tree used as the basis for the design proposal was not a median tree, but still a size that can be found in most forests. This decision was make to ensure practicality and feasability of the proposed designs. Future studies could however consiter using a median tree to explore the implications that would have on the design, or do several designs with different tree sizes to gain a larger understanding of the limitations and opportunities that follows.

Another area for future investigation lies in the exploration of transparent wood and 3D-printing with wood. The topics was a resarched during the thesis but choosen to be left out due to the current limitations of the manufacturing process, which currently requires the introduction of materials other than pine deratives, although progress to move towards higher wood content in the materials are being made. Studying the possibilities and challenges presented by these emerging technologies could offer interesting avenues for further research.

In terms of methodology, full-scale testing is suggested as the next step to gather more reliable data on the performance of the materials in situations that more accurately resemble reality.

Additionally, a more technical approach to the evaluation of the material investigations could be adopted. For example stress testing the wood joints and measuring the u-value of a wall utilizing needle insulation compared to conventional insulation materials. These more rigorous testing methods would enhance the understanding of the proposed architectural solutions.

Finally, it should be clarified that this thesis does not aim to provide definitive answers or solutions. Instead, its purpose is to showcase possibilities and inspire the field for future research on the topic of integrating the full potential of the pine tree into the built environment. By highlighting the various components of the pine tree and their potential applications, this research intends to foster creativity and encourage further exploration in the realm of sustainable and resource effective architecture.

Student Background

ACADEMIC

MSc Architecture and Urban Design
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Internship, July 2021 -July 2022

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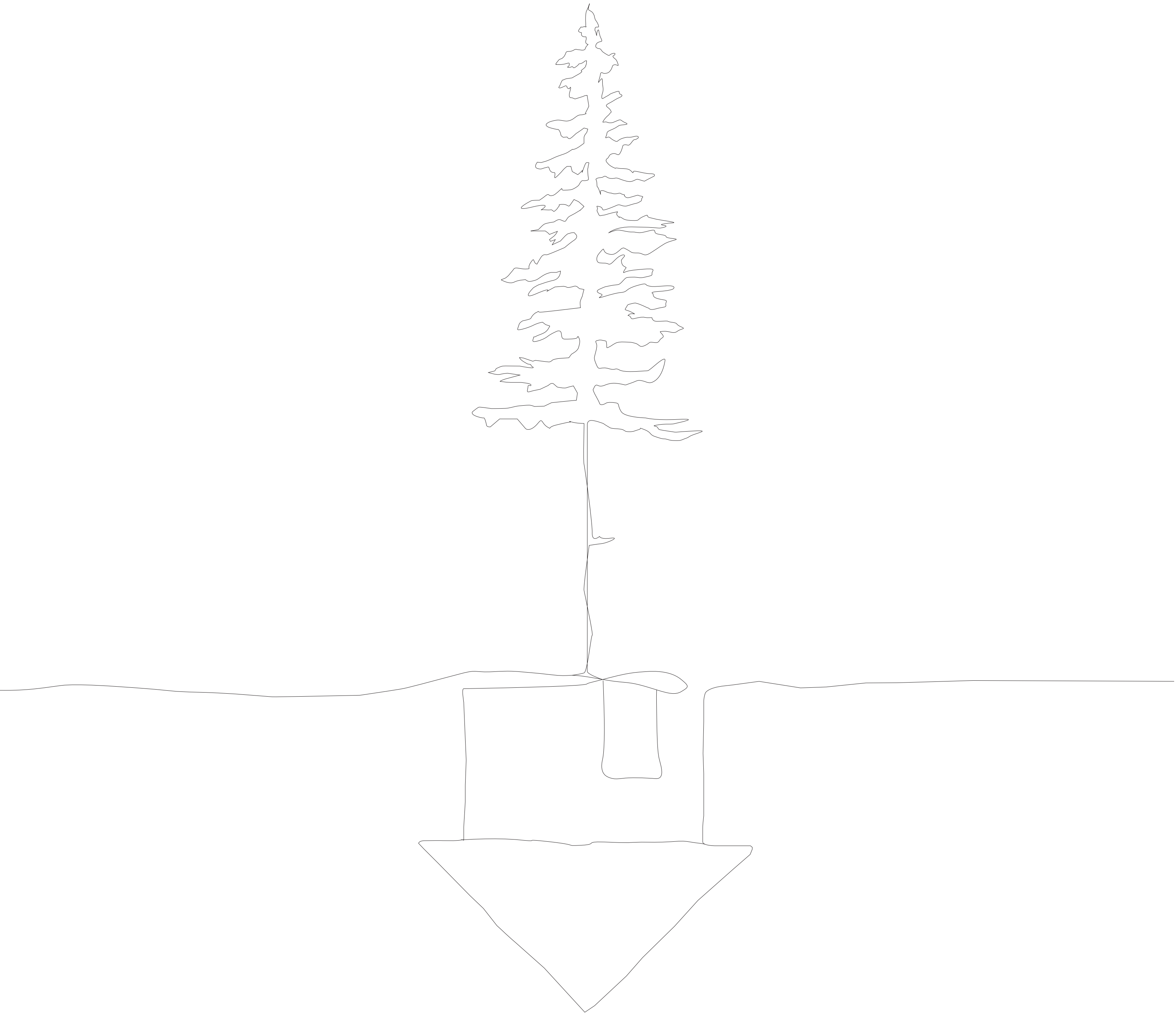

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