



FOLLOW THE GRAIN

ZERO-WASTE APPROACH & EXPLORATION OF
NATURAL-FORM WOOD IN ARCHITECTURE

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Machine cleft birch

The structure of a tree has evolved in response to the natural forces it was subjected to during its growth, by standardising and sawing wood for mass production, these qualities and natural intricacies are lost. I believe a more natural approach to wood is needed - preserving fibres, understanding its properties and how each part can be used for different purposes.

Should we look at each tree individually, harvesting only what we need, instead of clearing whole forests? This thesis explores a method of 3d scanning three particular trees and using them as efficiently as possible in order to incorporate them into a holistic structure.

The focus is also on challenging the conventional approach where wood is being treated as a generic substance. The project takes the point of departure by criticising paradoxes of engineered timber, where we take a natural material, saw it into small pieces, glue it back together, to then only take it through a complex digital manufacturing process in order to use it in organic and geometrically complex structures.

Techniques like cleaving, instead of sawing were used for hundreds of years in boat building, to produce wood that was extremely strong, flexible and stable. These techniques were replaced by sawing wood into standardised stock, in order to get the most wood out of the tree. However, once the natural grain fibres, that are aligned to transmit force are cut, the material immediately loses strength.

The findings discovered during the exploration phase of this thesis, looked at the by-products produced, by some of the traditional techniques and how the whole tree could be utilised, using different parts for different purposes. These techniques were developed by also incorporating some of the advanced digital tools that we have today.

The final aim for this thesis is a design exercise that combines all the research and knowledge produced during the exploration into a 'Zero Waste Pavilion'. This pavilion uses real trees that were 3d scanned, showcasing a more natural approach to wood as a building material, using the whole tree, looking closely at its natural properties and how each part can be used optimally, not only focusing on functionality, but also challenging the flatness and lost sense of materiality in the conventional aesthetic of wood in architecture. The final result is not presented as some ultimate design for pavilions, but is more a tool for discussion on this approach and how it can be used in a holistic structure.

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Part 1
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INTRODUCTION



Scanned texture of cleft pine

CLT Panel
Image: flickr.com

Paradoxes of Engineered Wood

The development of engineered wood products has contributed to recent advances in the application of wood in architecture by providing stable, consistent material that can be worked with in complex ways. However, this development leads to the paradox of wood being factory-processed into regularised products only to subsequently undergo complex subtractive digital fabrication processes to allow that material to be incorporated in geometrically complex organic building forms and structures. Furthermore, wood in its natural form consists of chains of cells – its grain fibres – that are optimally aligned to transmit force. Once these fibres are cut, the material immediately loses strength, meaning that most fabrication processes act to compromise the existing natural capacity of timber (Desch & Dinwoodie, 1996).

Of course, the advancements in engineered wood and the benefits that it offers should not be overlooked. By glueing or laminating smaller pieces of wood together into large panels achieves mechanical consistency and stability, regardless of the specific properties of the species or natural 'imperfections' within the tree. This approach has contributed to the return of wood as a building material, since its decline during the industrial times, when it was challenged by synthetic materials like iron, steel, concrete and others. (Menges, Schwinn, Krieg, 2016) This approach of course makes sense in our current economic system, which encourages standardization, mass-production and consistency.

However, the paradox here is obvious. By standardizing wood for mass-production, the natural intricacies of the material and specific qualities of the different species are completely lost and reduced to a generic substance, that is used without trying to understand the true anatomy of this living material. Based on the fact that the structure of a tree has evolved in response to the natural forces it was subjected to during its growth, it really is a shame that the majority of the wood industry today does not take into account wood's natural environmental credentials. This also leads to mono-culture within forestry and loss of diversity in our forests, at the same time reducing robustness towards disease and climate change. (Menges, Schwinn, Krieg, 2016)

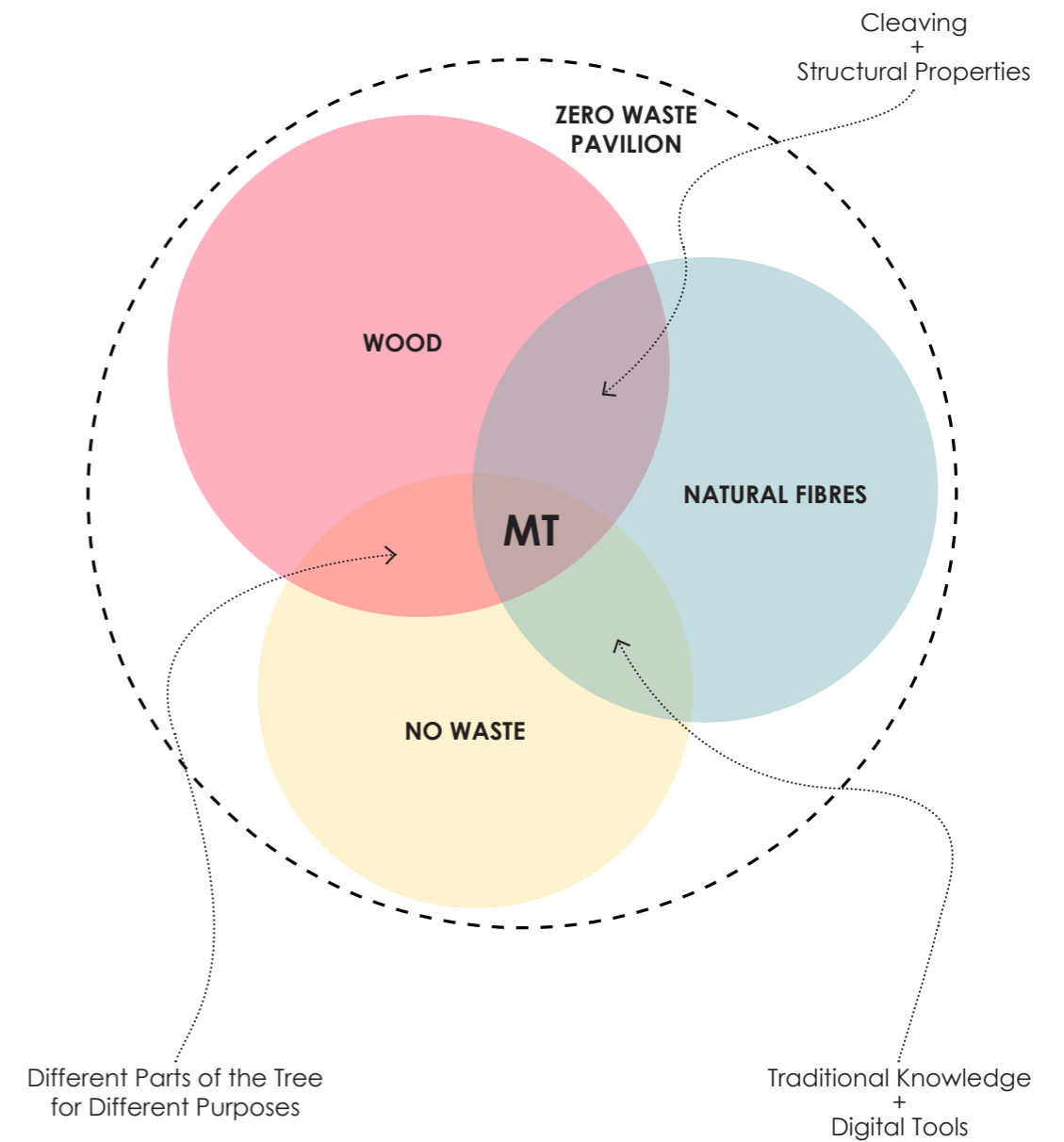
This thesis is somewhat a follow up on the exploration and own general fascination of natural form wood. It goes into investigations of structural properties of cleft wood and defining specific architectural use cases for different parts of the tree. The exploration also continues into less explored areas like bark, small branches and other by-products that are less commonly used in the architectural context. I am generally passionate and curious about wood in any form, though this thesis offers an alternative position to the conventional approach and to the current direction of the development of engineered wood.

Working with the actual material - wood, means that most experiments are 1:1 scale and my approach consists of research, immediate trial, then defining and conceptualising the discoveries afterwards. The tools for cleaving wood cannot be scaled down, therefore the smaller design models will use alternative techniques to represent those ideas.

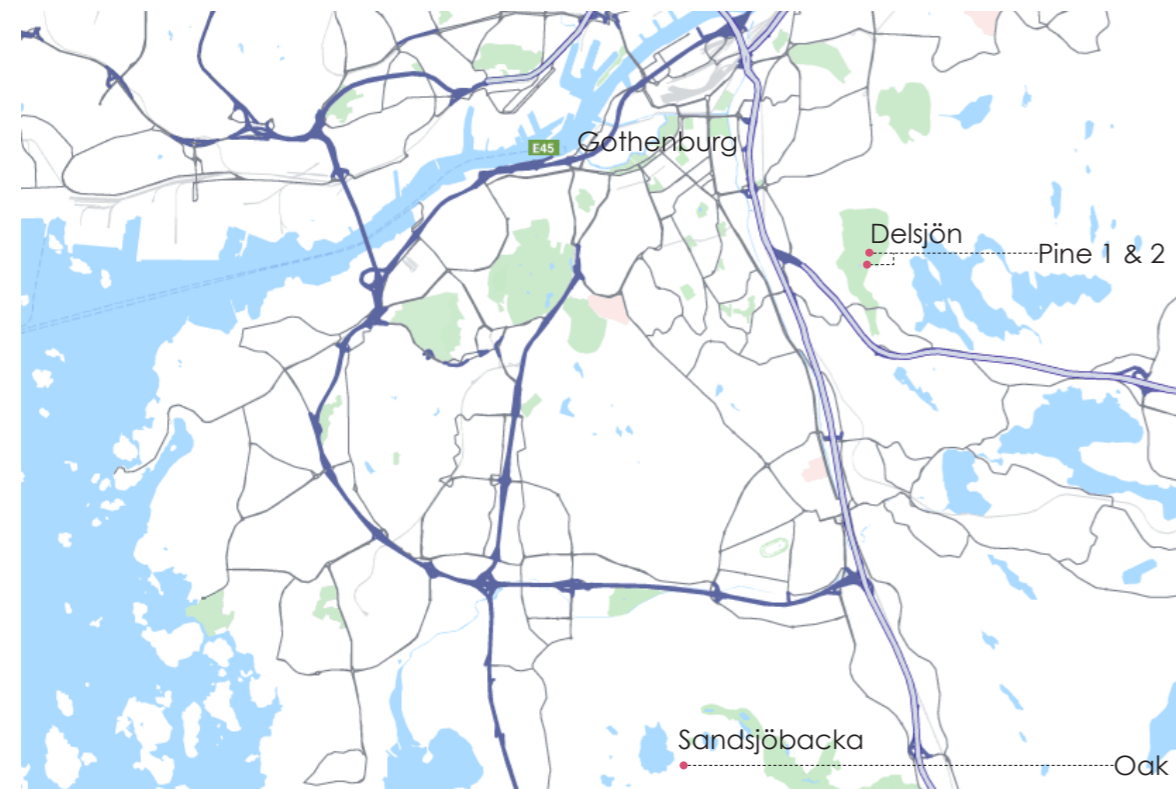
The design exercise of the 'Zero Waste Pavilion' is a way to conclude the research and exploration into a holistic structure, that offers real examples of how this approach can be used in architectural environments. However, the final result is more a tool for discussion on this approach, and is not proposed as an ultimate design for a pavilion.

The developed techniques for this approach are a combination of traditional knowledge and my own small scale experiments performed with relatively basic tools. The cleaving experiments explore the properties of wood and its natural behaviour, this does not necessarily mean that these methods would scale up in the same way without developing new tools to deal with whole logs that are several meters long. It does however show what is possible if each part of the tree is treated individually with care and willingness to adapt a different technique for each.

As of limited time, digital tools like 3d scanning, modelling and coding are only used as proof-of-concept and are not developed to the level where it solves all of the practical issues. The aim is to inspire and conceptualise a different way of working with wood and my approach is one of many potentials that could be developed further.



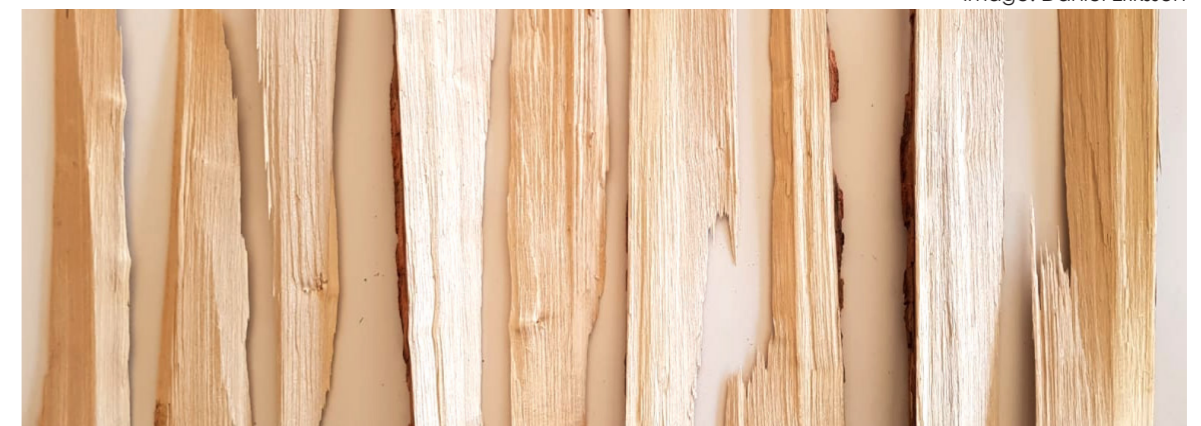
Looking at actual trees is an essential part of this project, especially when talking about natural intricacies and 'imperfections'. The choice of these specific trees was rather arbitrary on purpose, in order to challenge myself to deal with the unpredictable nature of this material. It was important to choose a species that is very common in this part of Europe (pine) and also another species which has different cleaving properties (oak), that generally has very straight fibres.



Another part of the process is 3d Scanning the specific trees and estimating the amount of the most valuable structural wood that can be extracted, but also in relation, looking at the proportions of the by-products, such as split-off panels, bark and even small branches, and how to use as close to 100% of the tree as possible.



Image: Daniel Eriksson



Own cleaving experiments



Image: crinklecrackle.com

Part 2

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NATURAL FIBRES & FORGOTTEN KNOWLEDGE

Natural Approach to Wood

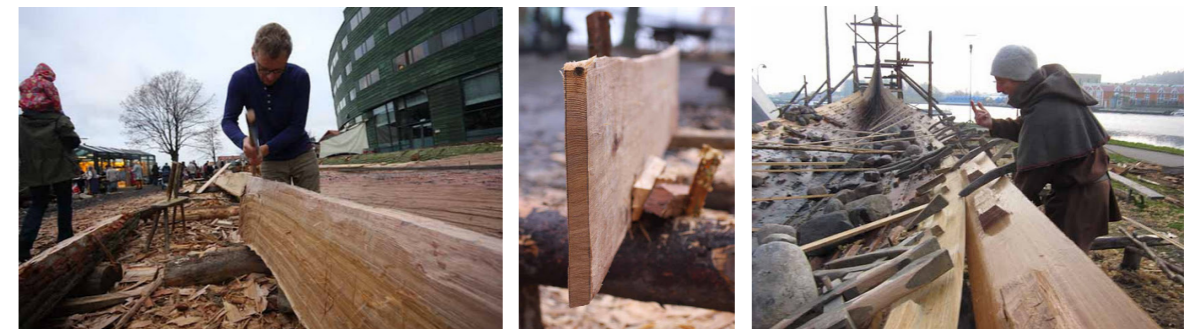
Oseberg ship reconstruction in Tønsberg, Norway was a project that attempted to build an exact replica of the iconic ship, using the same techniques and tools that would have been used originally in the 9th century. This means that the replica was built entirely out of cleft and hewed/riven oak, no saws were used. This technique preserves the fibres along the whole tree that are optimally aligned to transmit force and the boards produced this way are structurally superior compared to any sawn boards. The downside of this technique is that compared to sawing you get about 50-60% less boards out of a tree, which would be considered wasteful by any modern standard.



Source and Images: www.robin-wood.co.uk/



Diagonal oak cleaving, with control wedges along the length of the tree to ensure a continuous split

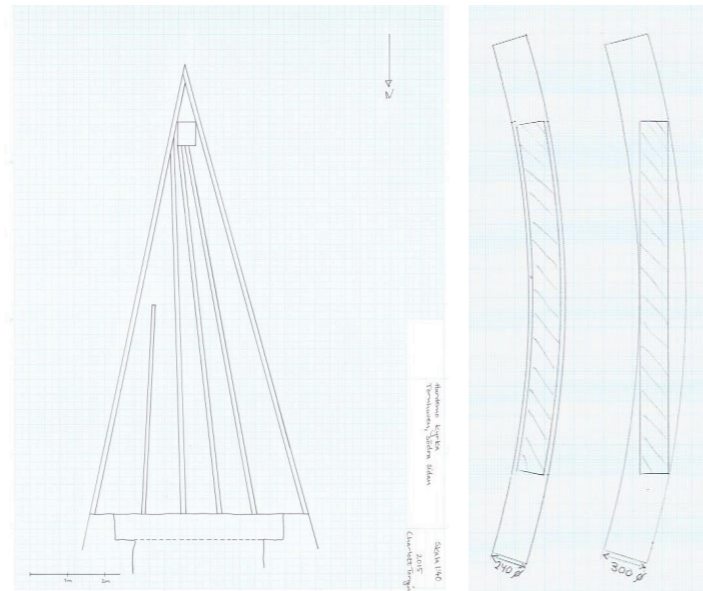
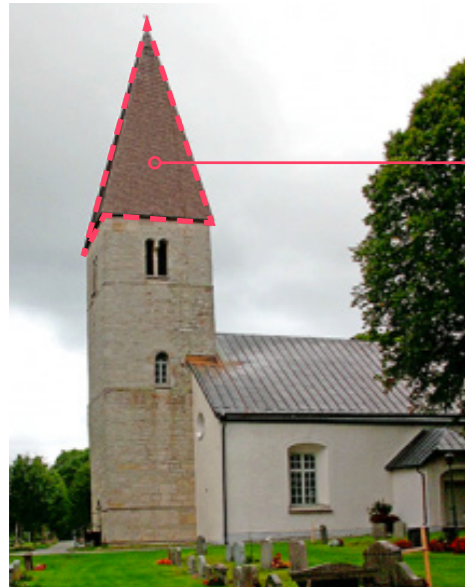


Flattening and bending of boards

Source and Images: www.robin-wood.co.uk/

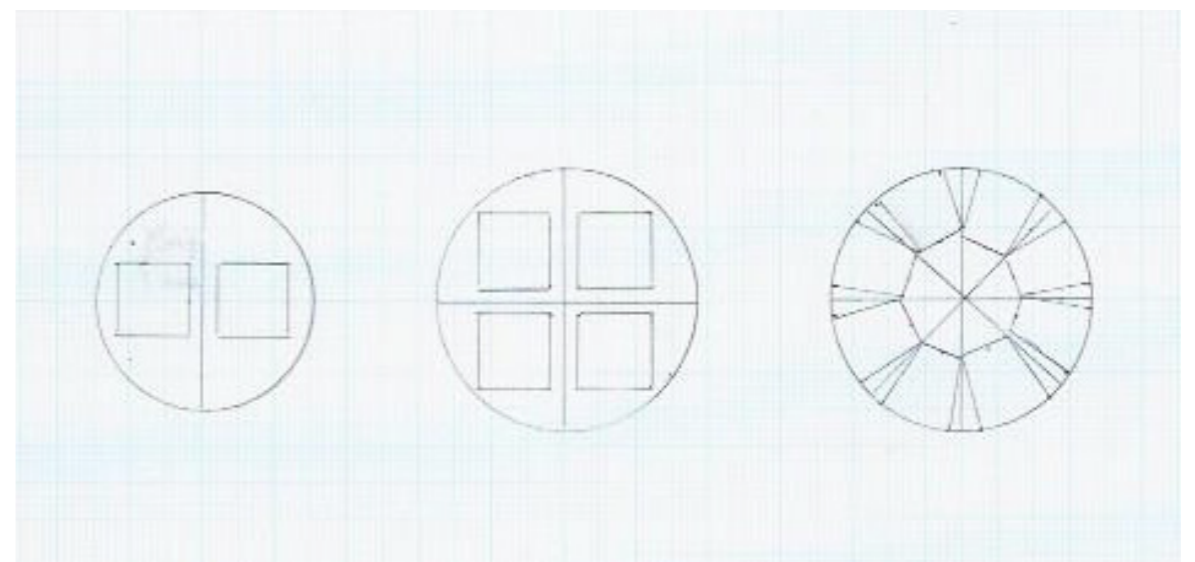
Sap-Wood in Architecture

Raw sap-wood rafters found in Hardemo Church Tower, Närke, Sweden



Visible curvature in tower, as a result of rafters bending after cleaving, because of shorter fibres on the outside of the tree

Örebro läns museum. (2016)
(Retrieved from report by Daniel Eriksson and Charlott Torgén)



Conventional way to produce square rafters compared to conical rafters taken from sap-wood. According to this report, rafters taken from sap-wood are more flexible, stronger and can produce 8 conical instead of 4 square rafters.

Örebro läns museum. (2016)
(Retrieved from report by Daniel Eriksson and Charlott Torgén)

Traditional Method to Cleave Sap-Wood

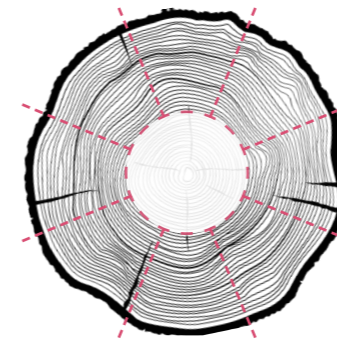
Process recorded during the on-field experiment to reproduce sap-wood rafters seen in the Hardemo Church tower, using traditional techniques and tools that were based on archaeological findings.



Örebro läns museum. (2016)
(Retrieved from report by Daniel Eriksson and Charlott Torgén)

Sap-Wood as Structural Material

As opposed to cleaving flat boards out of a log, conical stock taken from sap-wood is a more efficient way of getting large, structural material from a tree. Since you are not trying to extract square stock from a log, you end up with twice as many pieces and very little waste. Of course sap-wood has its specific properties and there is a reason why it is not favoured in conventional architecture. However, when adapted for an appropriate use, like the Hardemo Church tower, where it is required to have greater flexibility due to lateral wind loads, it can be superior to conventionally processed wood. Another reason, why sap-wood is not commonly used in architecture is its moisture content and susceptibility to decay. An argument could be made, that cleaving sap-wood works as a kind of treatment against decay, since the fibres are preserved and would improve the moisture repelling qualities.



Images: Daniel Eriksson. (2016)
(Retrieved from report by Daniel Eriksson and Charlott Torgén)

Part 3

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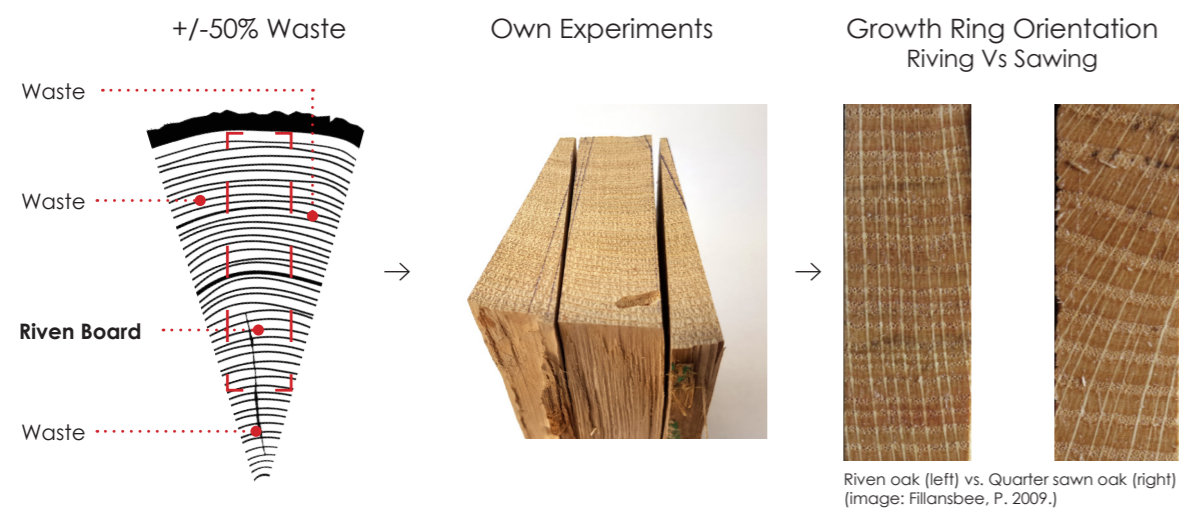
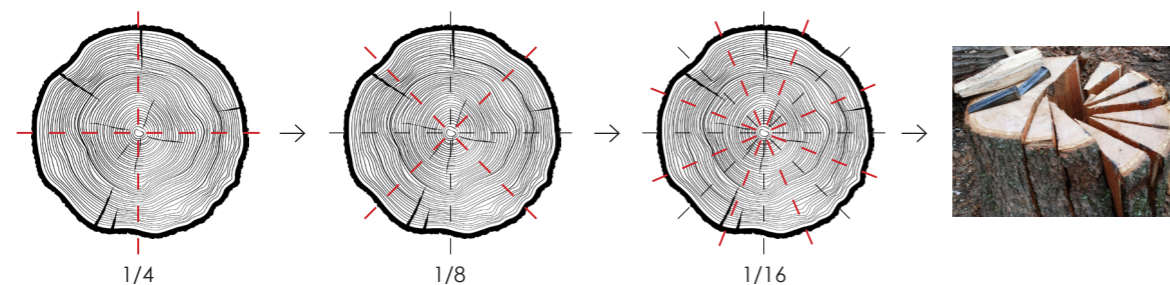
MY STRATEGY, EXPERIMENTS & DEVELOPED TECHNIQUES

Cleaving Wood

My Strategy

To produce riven boards in a traditional way, the log is split in half again-and-again, until wedge shaped pieces are produced. They are then straightened with an axe to create flat boards and the wood that surrounds the central board is wasted. I thought it would be interesting to not only focus on the boards, but also on the waste produced. During my own splitting experiments I found that the irregular or 'waste' pieces were the ones that created the most interesting combinations when it came to light and texture.

Traditional way to produce riven boards



Own Experiments

The tools and techniques for wood cleaving have not been developed for hundreds of years and most of the knowledge has been forgotten. Compared to wood sawing technology there is a clear gap, that makes one wonder where would we be if we chose to develop these techniques to the level of sophistication that we have in the wood milling industry today. A very clear observation from splitting wood by hand is how much easier it is, compared to sawing along the length of the fibres (by hand), it feels much less forced, as if the wood wants to be split that way. An argument can be made that the development of new tools could be a potential to reduce energy consumption within the wood industry, if we decided to take another approach, understand and treat wood as a truly organic material.

Log splitting with pneumatic machine



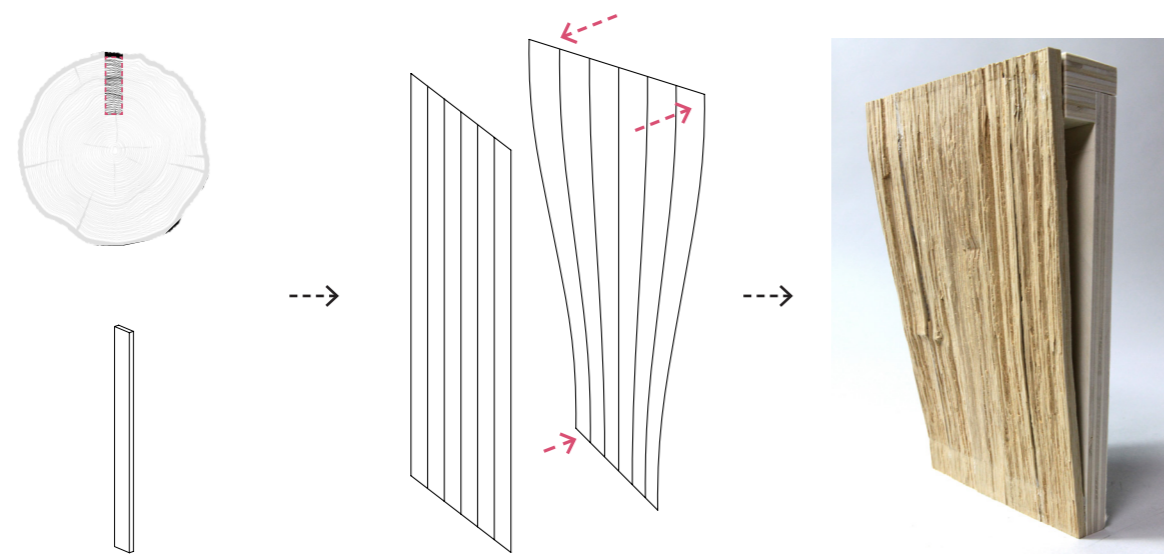
Machine splitting is relatively easy and less physically demanding, but the size of the blade does not provide a lot of accuracy or control. The split also happens very quickly and does not give you an opportunity to look at the length of the log and control the split line.

Log splitting with hand tools



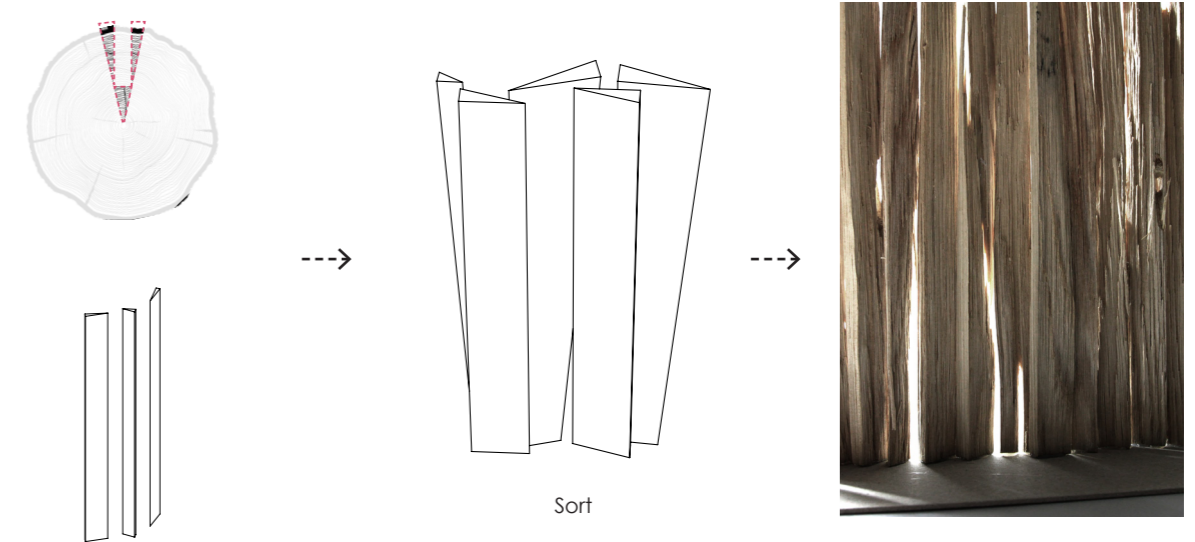
Splitting with hand tools allows for very accurate split lines. Since the process is quite slow, there is an opportunity to control the split pattern along the length of the log, with additional wedges.

Structural Boards - Bending/Flexibility



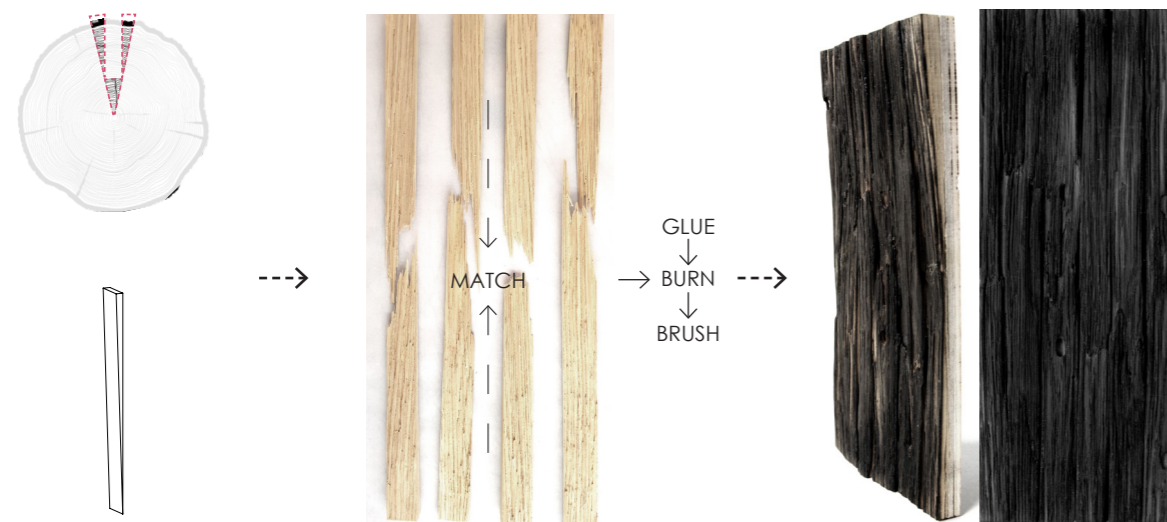
Soaked in hot water, the cleaved wood pieces are bent into a panel structure with clamps. As the wood dries, the clamps can be removed and the wood stays in the position. After the wood is bent, it will eventually want to go back to its original position, because of the pre-tension in the wood fibres, therefore the pieces are glued together to keep a uniform structure, however there is a potential to develop joining techniques that do not require the use of glue. Wood bent in this way creates a continuous form with a tactile surface, but can also be used in a structural way because of its strength and flexibility.

Secondary Boards/Wedges - Wall Panelling



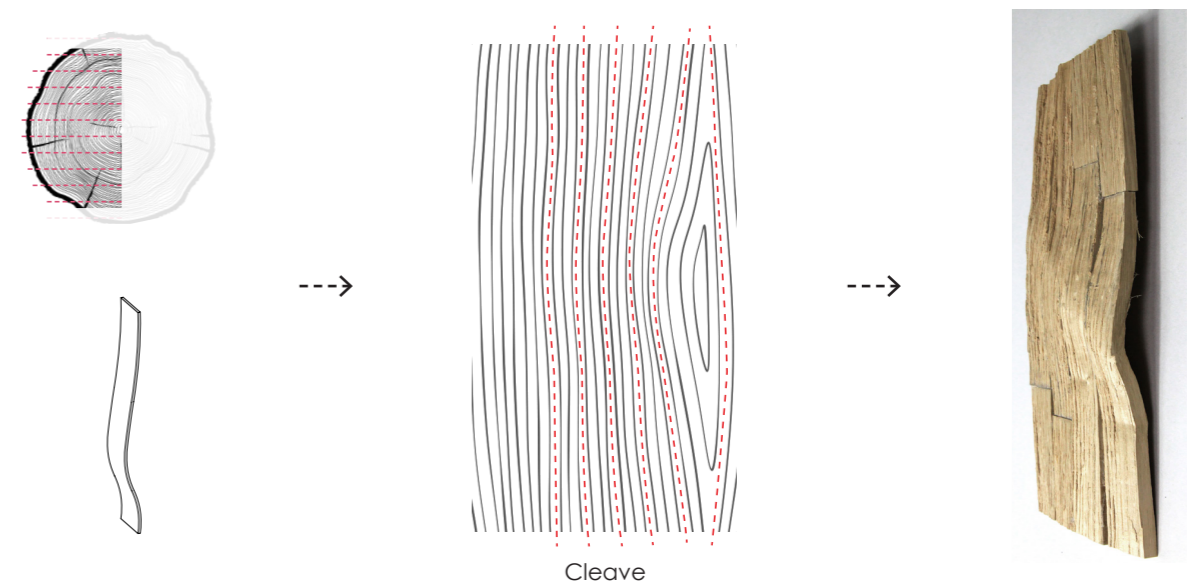
Wood surrounding the very valuable structural boards can be cleaved away, creating triangular wedges that from first sight could be seen as waste. However, as a result of my experiments, I found that they can be arranged in panels creating very interesting combinations in regards to light and texture.

Secondary Boards/Wedges - Floor Panelling



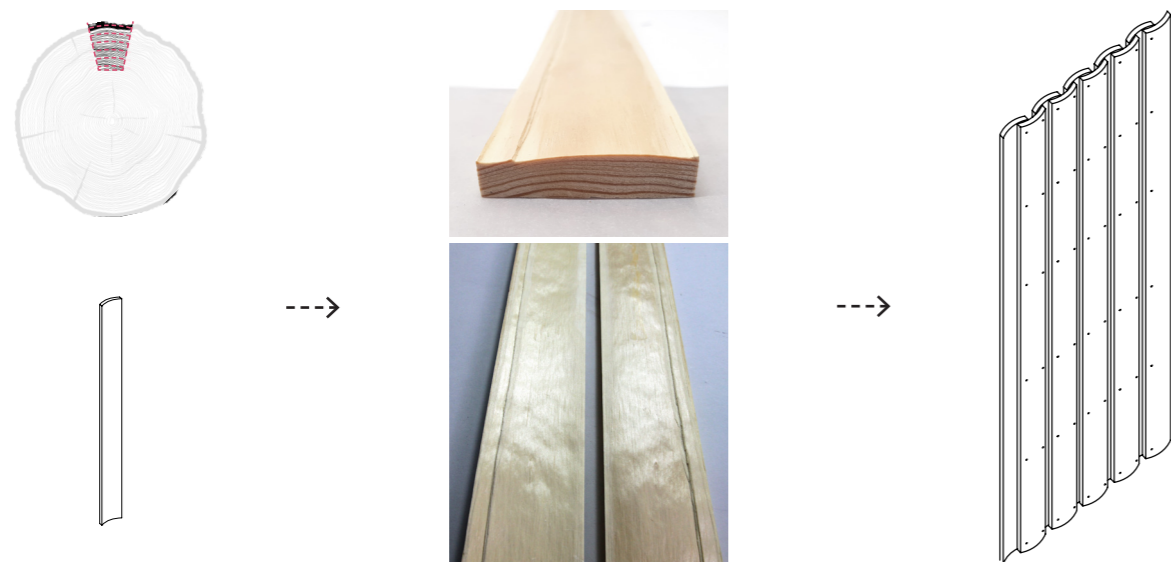
Many of the cleaving attempts do not produce continuous pieces, a lot of them taper off, especially with dry wood. These pieces maintain all the qualities of cleaved wood, like flexibility and water repelling, but they are quite rough to the touch and have splinters. With this experiment I tried to match the pieces with a similar taper angle together, glueing them into continuous panels, then burning and brushing them to take away some of the roughness and splinters. The result is a relatively smooth and safe to the touch panel, with a fall in the middle, that can be used to direct water when used on a floor.

Natural Pattern Cleaving - Wall Panelling



Cleaving wood along natural patterns separates boards along these fibres and can be re-arranged in a planar way to create a continuous curved surface.

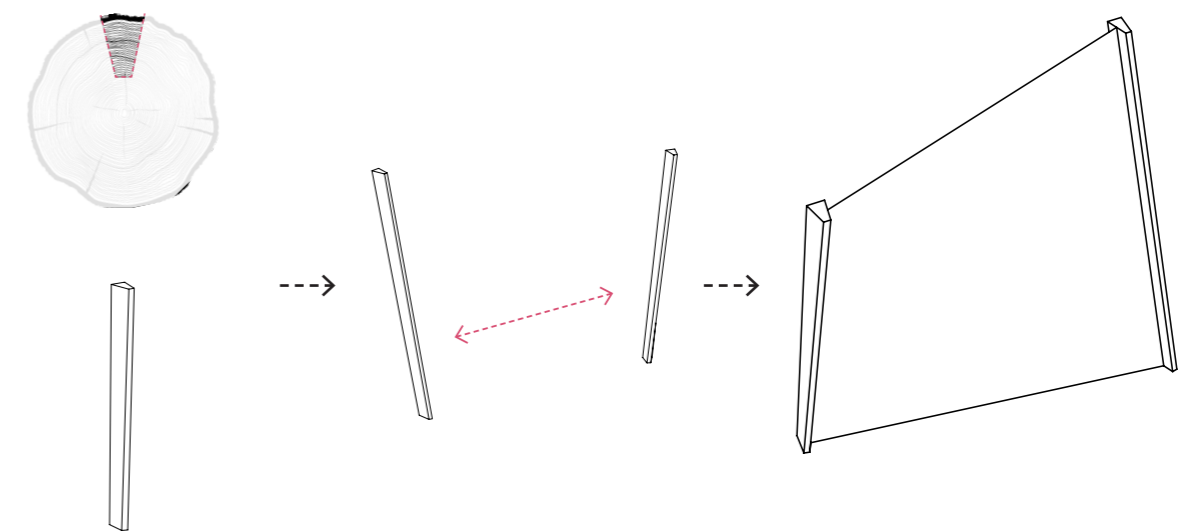
Cleaving Along Tree Rings - Roof Cladding



Wood cleaved along the curvature of tree rings has a smooth, glossy finish with great water repelling properties and could be arranged into panels for outdoor use or as roof cladding.

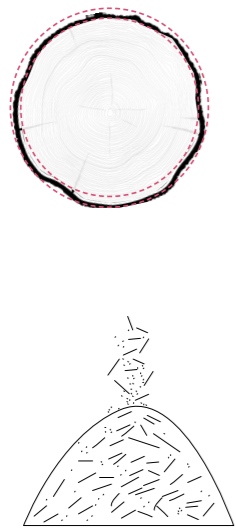
A similar technique was used traditionally for making barrels, due to the curvature of these boards and of course for their water resistant qualities.

Structural Sap-Wood Posts



Conical sap-wood slices taken from the cross-section of a tree can be used as structural posts. Sap-wood is not commonly used for this purpose, but there are examples of medieval buildings like Hardemo Church tower in Örebro, that are still standing to this day. Sap-wood is not generally desirable in conventional wood working and construction, because of its moisture content and susceptibility to movement and decay. Therefore, the overall design and structure needs to account for this. However, if used in the right way sap-wood can be excellent in construction because of its flexibility and ability to deal with tension. An argument could be made, that cleaving sap-wood works as a kind of treatment against decay, since the fibres are preserved and would improve the moisture repelling qualities.

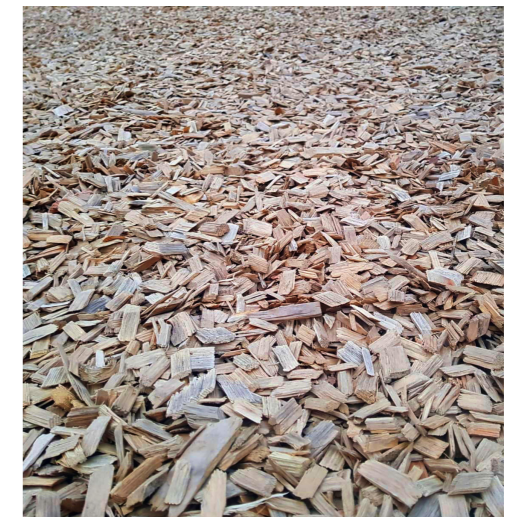
By-Products - Bark Composite



Moberg, Eliasson, 2019

In conventional wood processing, bark is usually seen as waste or is burned as bio-fuel. Recent developments in sustainable materials shows great examples how by-products like bark can be used in a composite material, using cellulose adhesives, as seen in the thesis work by Sandra Moberg and Josefin Eliasson.

By-Products - Loose Wood Chip Floor



Own photograph of wood chip floor

In commercial wood harvesting, branches are usually cut-off and left in a forest to make it easier to transport logs. With a more careful approach, where the tree is selected specifically and used very efficiently, means that it would require only a small scale operation - the whole tree can be used, even small branches. These are perfect for creating wood chips for flooring, that is pleasing to walk on and has good drainage properties.

CLT & Cleft Wood

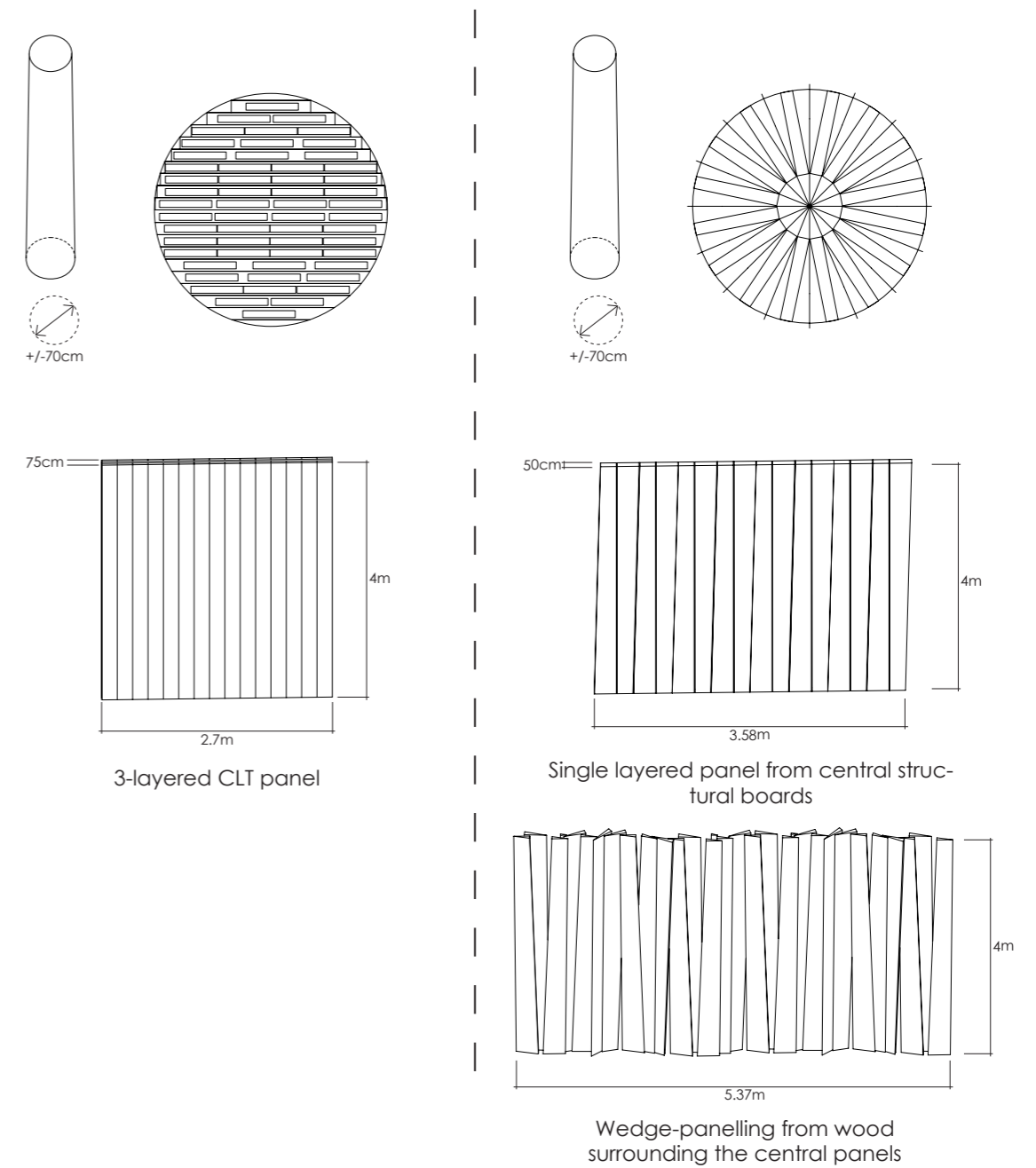
This exercise is a comparison and an estimation of how much wood is used to produce a simple, 3-layer CLT panel and how much surface area can be covered with cleaved wood panelling, since there is no waste produced by sawing and planing boards. These two types of materials of course have different properties, but I think it is important to mention how much wood is lost by trying to make it into standardised stock, in order combine it into a cross laminated panel.

Based on 25mm x 150mm boards, with estimated waste for sawing (4mm), planing (10mm) and thickening (varies). Production methods and amounts vary significantly manufacturer to manufacturer. Figures are estimated and based on averaged data from CLT standards in Austria. (Brandner, 2013)

Cross laminated timber gains its structural strength through numbers - generic wood planks combined into a single panel. Even though the natural fibres are cut, this process ensures strength and stability. However, most modern construction regulations do not allow the use of CLT as structural material and in most cases it needs to be supplemented with steel and concrete. If this was not the case, a discussion and critique of cross laminated timber, could potentially be very different.

Therefore, the main purpose of this comparison is purely based on how we process an organic material like wood and the effect on efficiency when standardising a material that has many natural intricacies.

4m long pine log comparison



Part 4
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THE PAVILION

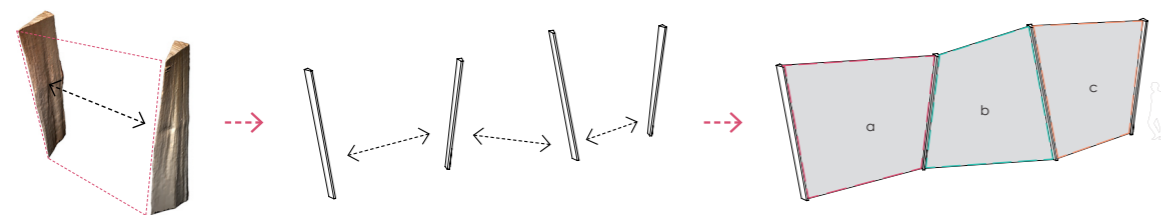
Introduction

'Zero Waste Pavilion' is a design exercise where the afore described techniques, research and knowledge produced during the exploration process are showcased. Part of the narrative and also a limitation to myself is to only work with actual trees. Therefore, I 3d scanned 3 trees from the surroundings of the city of Gothenburg, using a drone and photogrammetry. I took the data and based the proportions and design of the pavilion on the available wood and the amount of by-products produced as a result of the cleaving techniques. I chose to work with 2 different species - oak and pine, in order to explore the different properties of these trees.

The pavilion works as a tool for discussing different techniques, details, joinery, sensory experience and designing principles when working in this particular approach. Before starting to discuss those principles, the overview is meant to give an overall image of the pavilion and the first visual reference of how the afore mentioned techniques come together.

Structural Concept

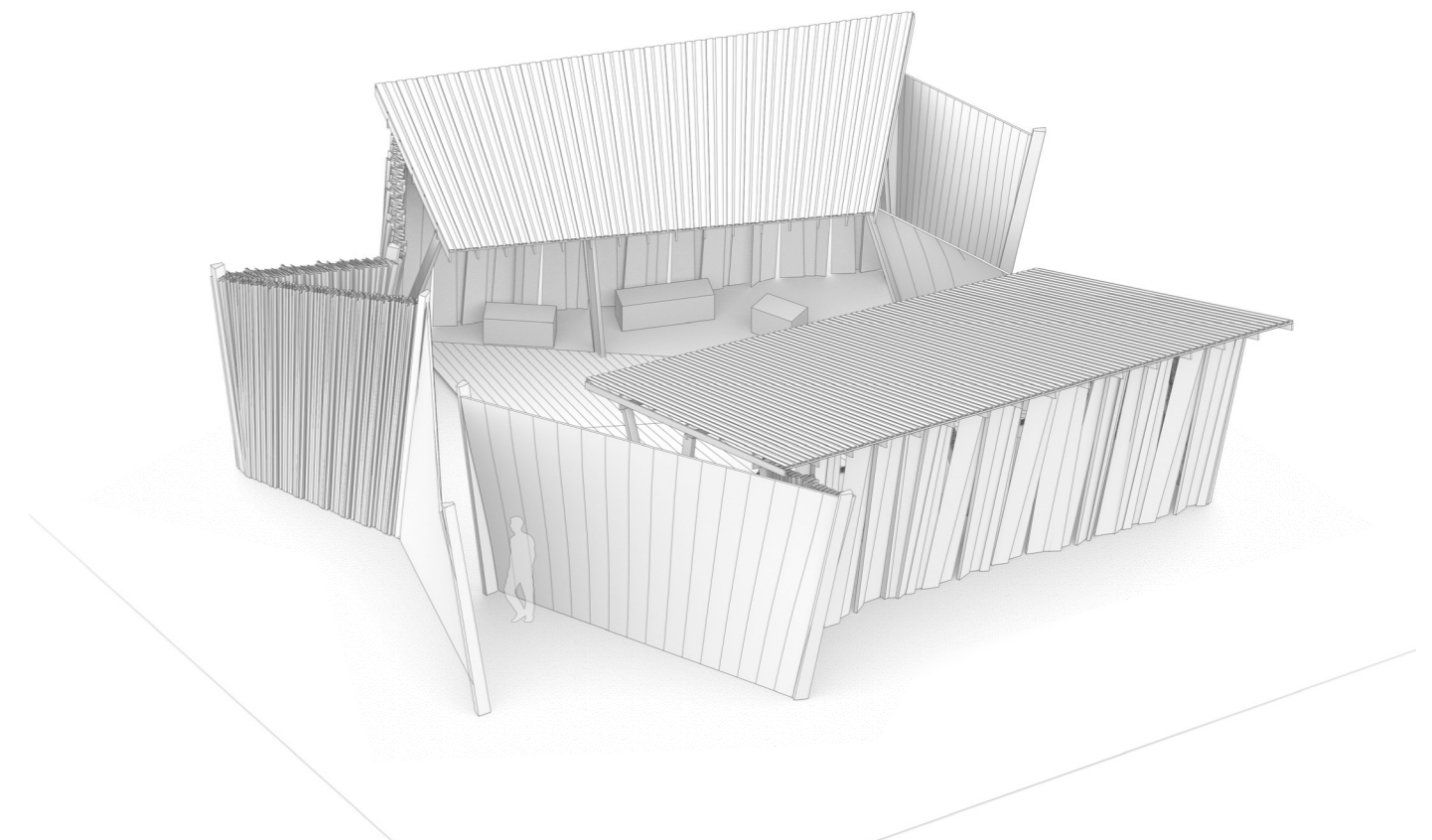
When cleaving boards out of a log, many of them end up having a natural twist. The design of the structure, uses the natural twist in these boards not as a problem, but as a design element, with the structural posts being placed out in different/ undulating angles and the previously described panelling techniques making the connections between them. For instance, there would be a panel where boards are bent to explore form and flexibility, another area would look at the natural patterns, the shelters would focus on the water resistance and the side panels would utilise the secondary pieces and by-products, but also highlight the light and textural properties.



Architecture

The overall architectural language of the pavilion is somewhat inspired by the geometry of the structural sap-wood used in previously described historical examples. Sap-wood generally performs better when subjected to tension forces, rather than compression, therefore there are almost no 90° angles within the structure. Since, one of the aims of this project is to highlight structural capabilities of cleft wood, the structure might also appear rather ambitious, borderline between viable and not, in order to really push the limits suggesting the structural efficiency of cleft wood.

Overview

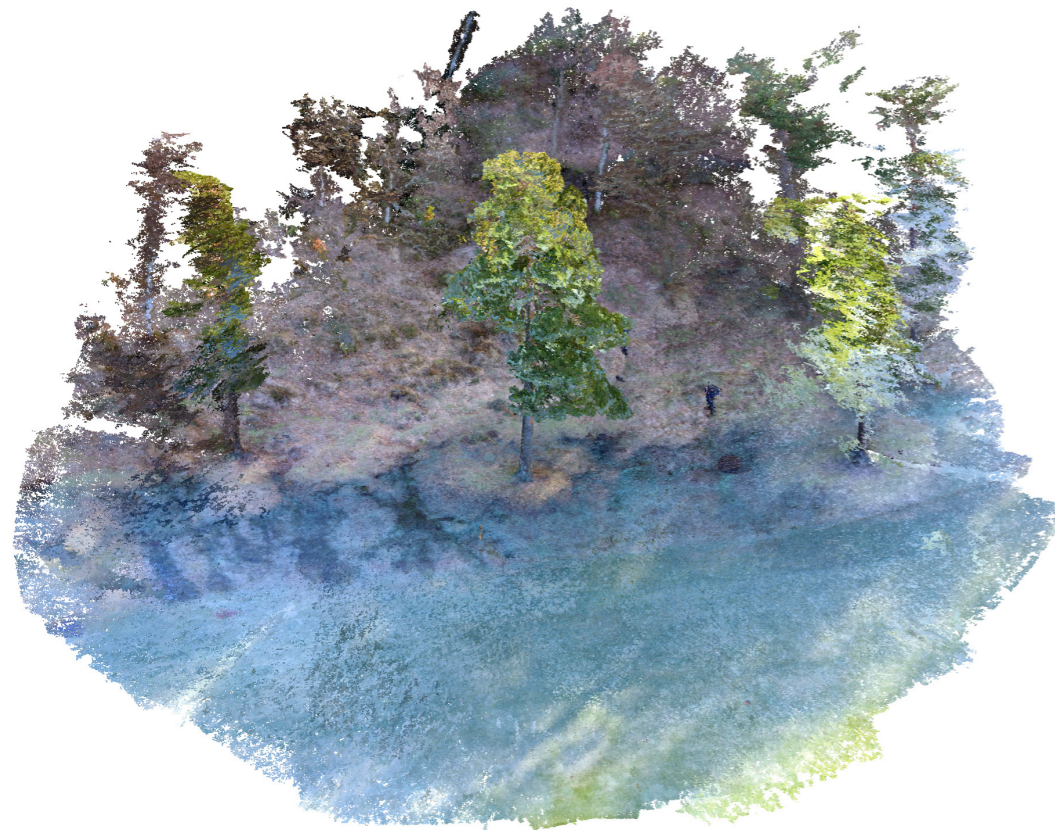


Tree Scanning

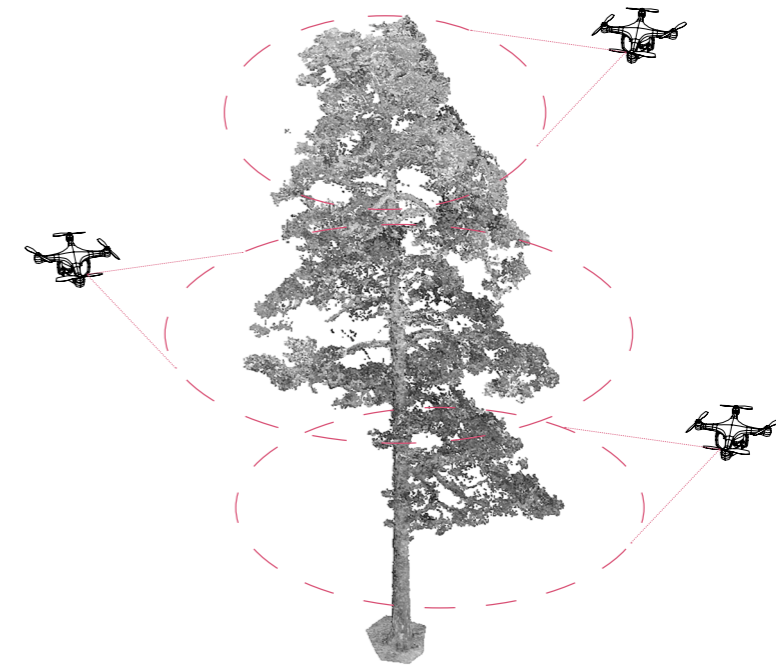
Equipment



3d Scanned Area

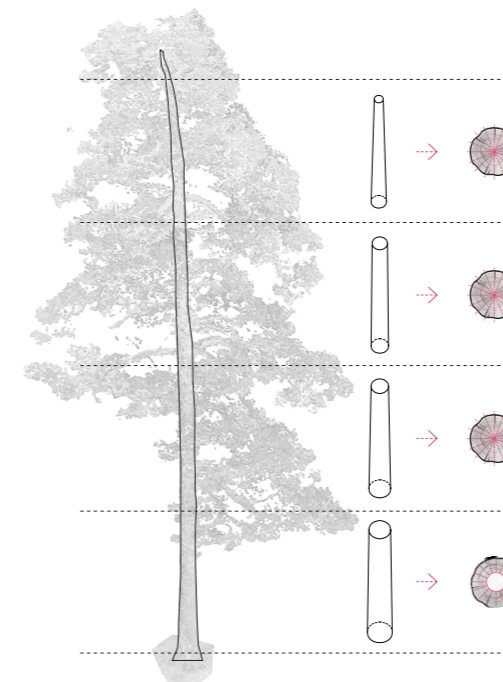


360 ° Drone orbit at 3 or 4 different heights



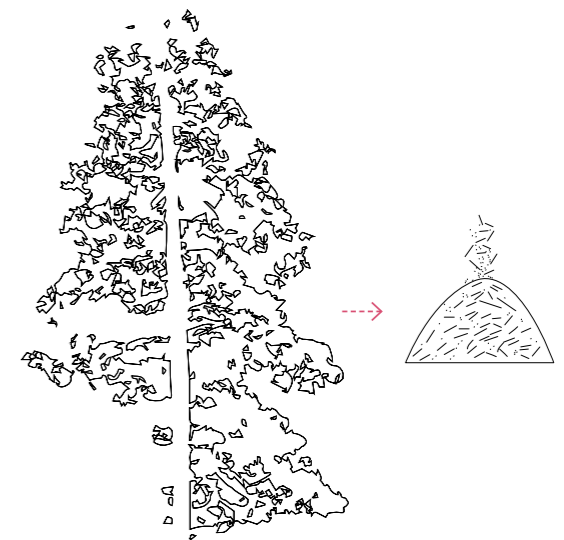
Drone Photogrammetry - 3d Scanning of Trees

Outline / Simplify → 3d Volumes → Cleaving Technique



Outlining and extracting average wood volumes from digital point-clouds

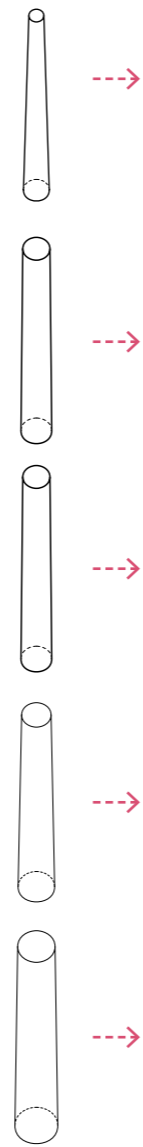
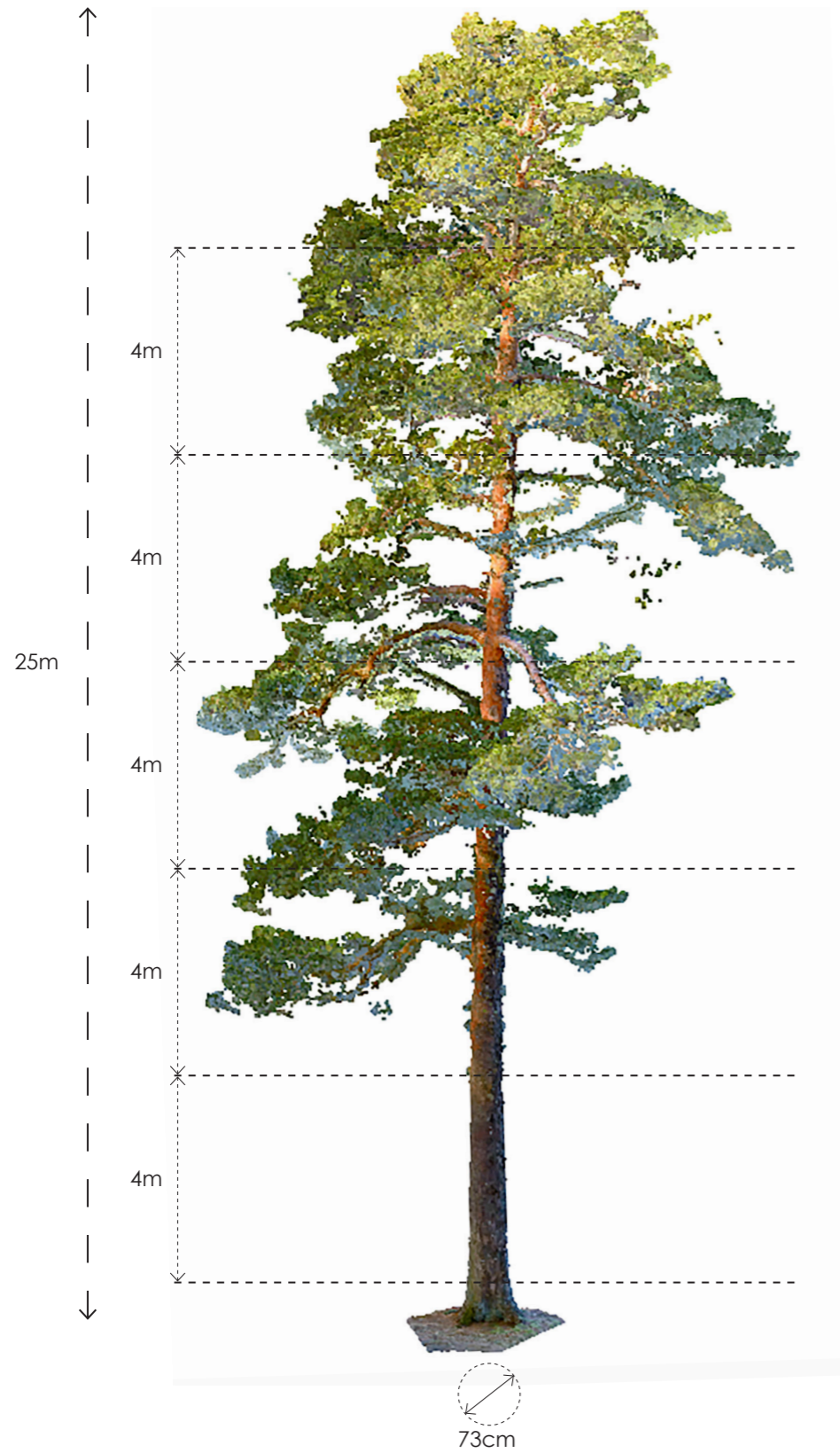
Outline / Simplify → Estimate Volumes after processing



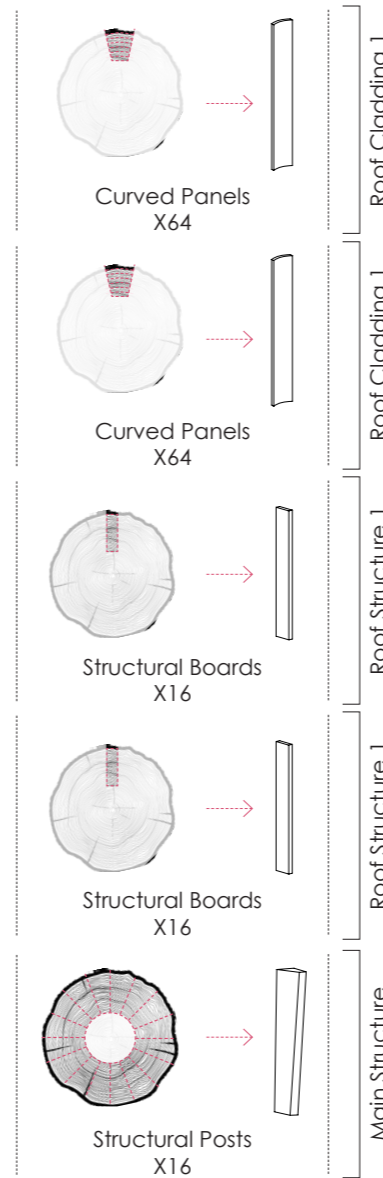
Estimating amount of by-products from digital point-clouds

Techniques Applied

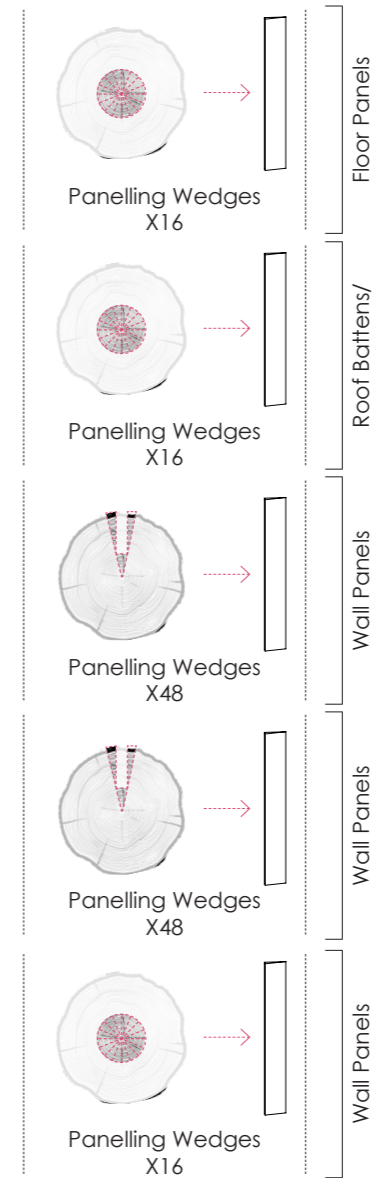
3d Scanned Pine 1 - Delsjön Forest
(RGB Point Cloud)



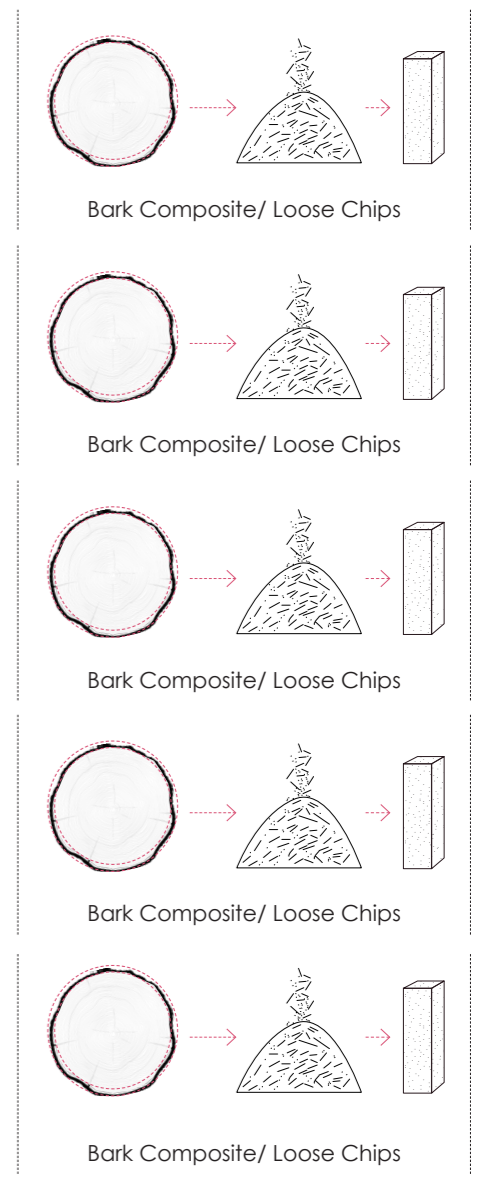
Primary Use



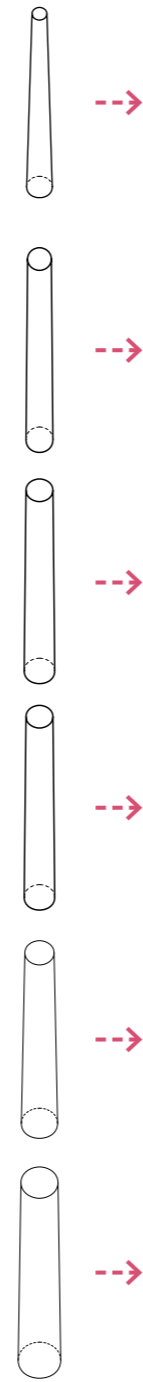
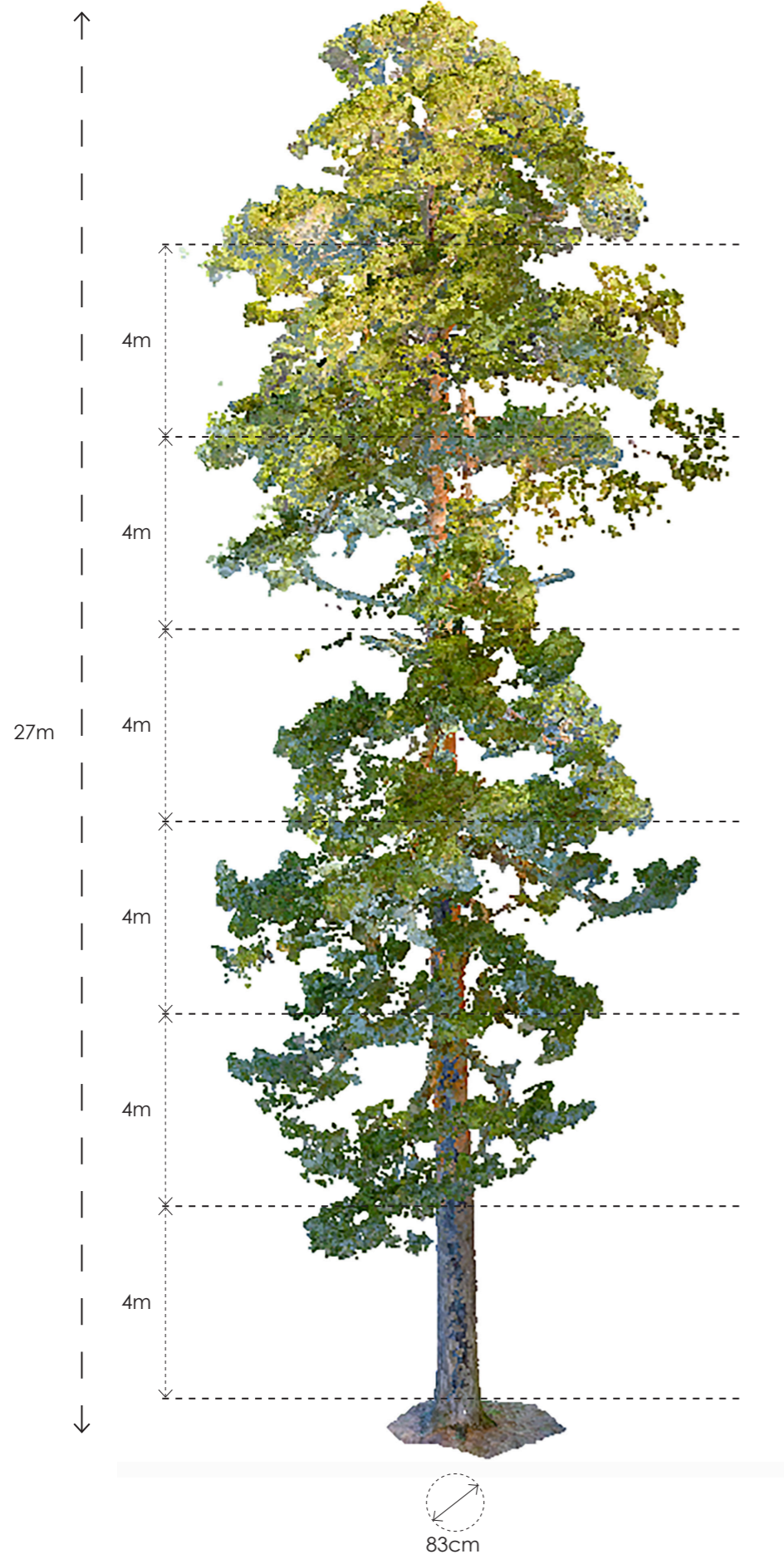
Secondary Use



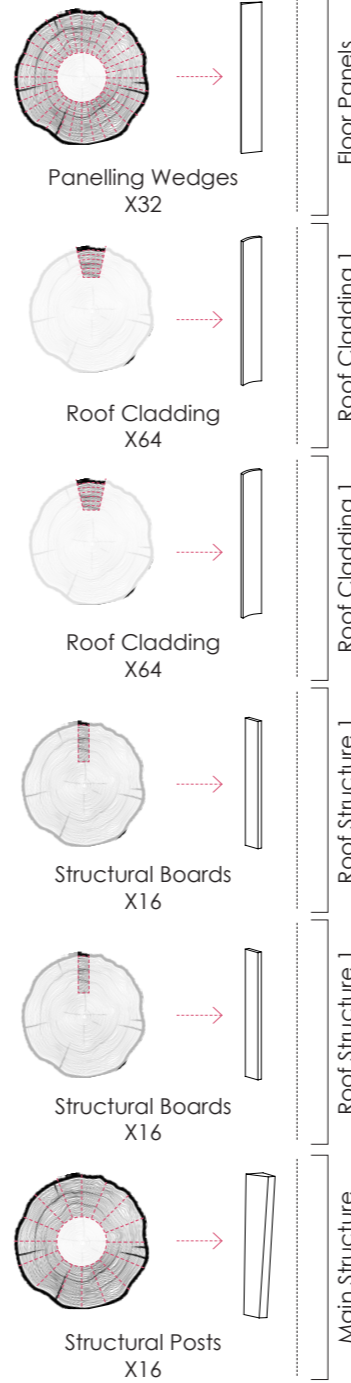
By-Products



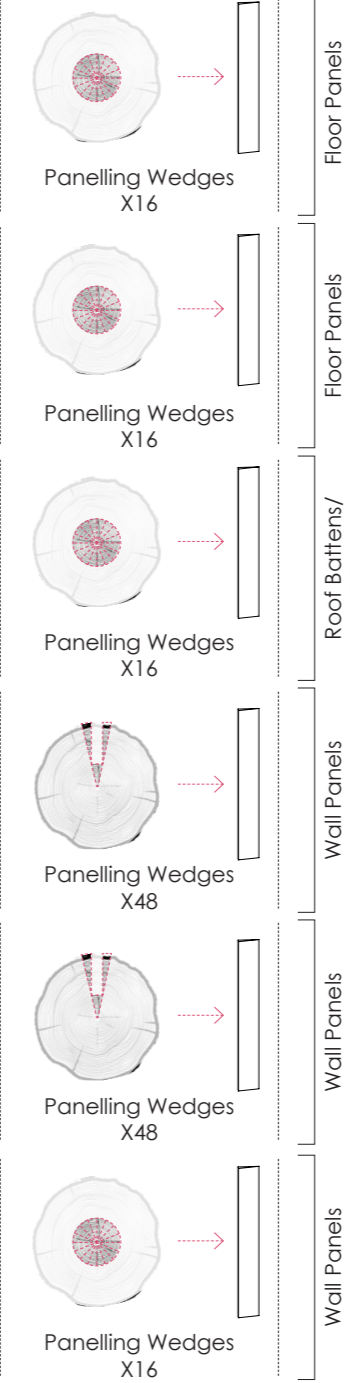
3d Scanned Pine 2 - Delsjön Forest
(RGB Point Cloud)



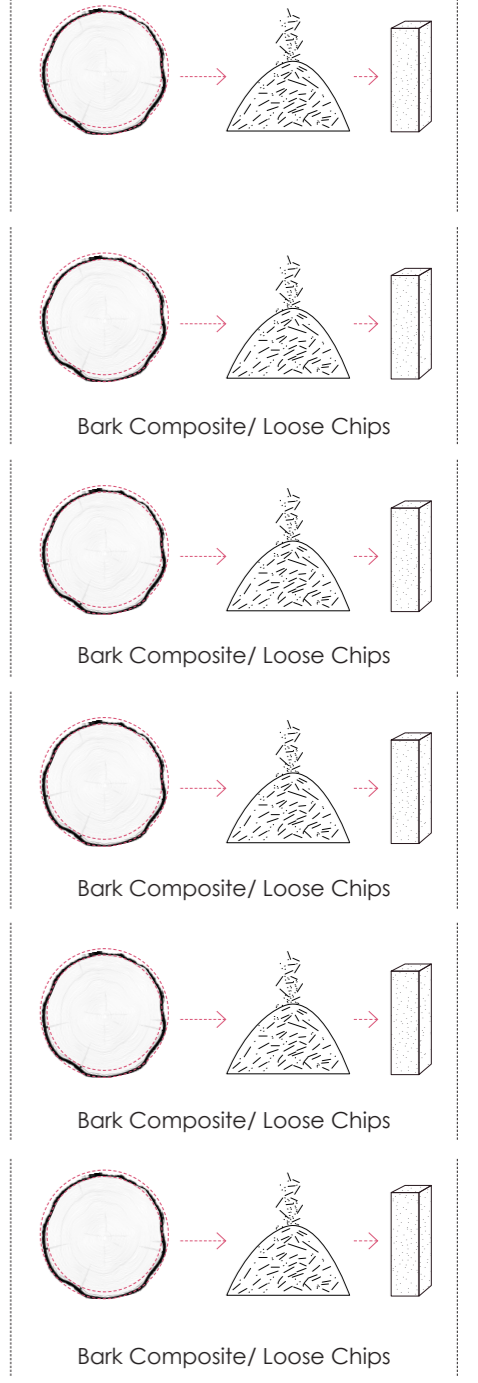
Primary Use



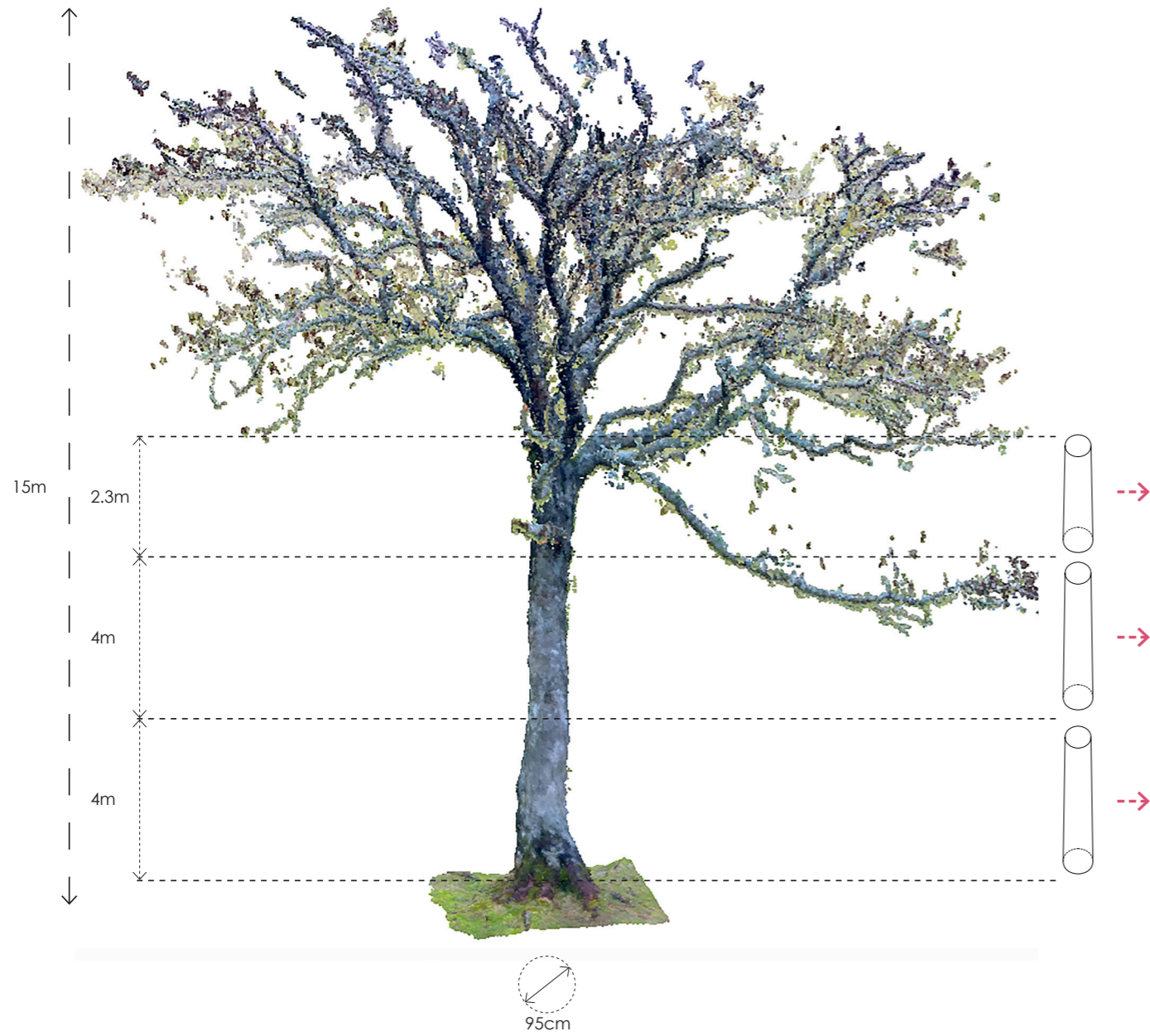
Secondary Use



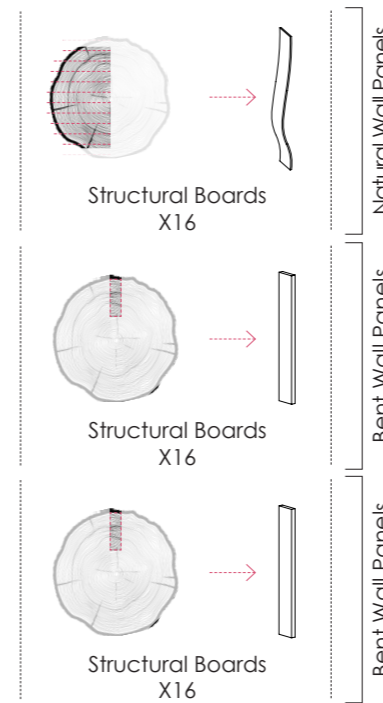
By-Products



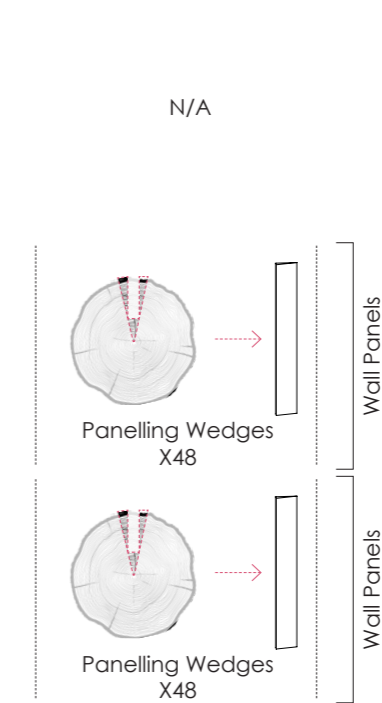
3d Scanned Oak - Sandsjöbacka
(RGB Point Cloud)



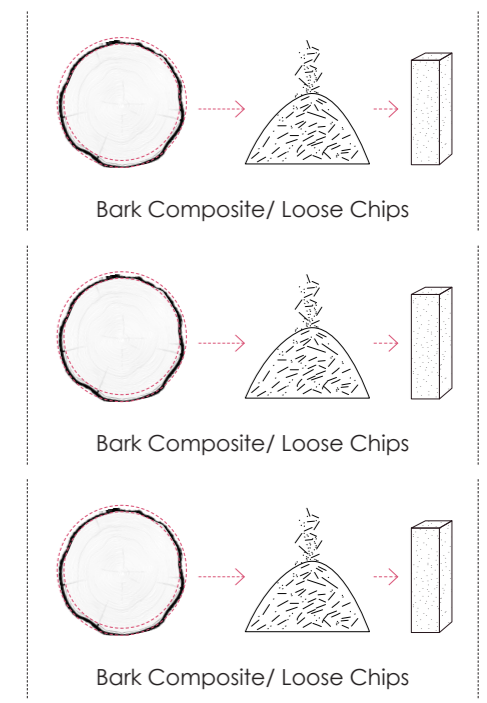
Primary Use

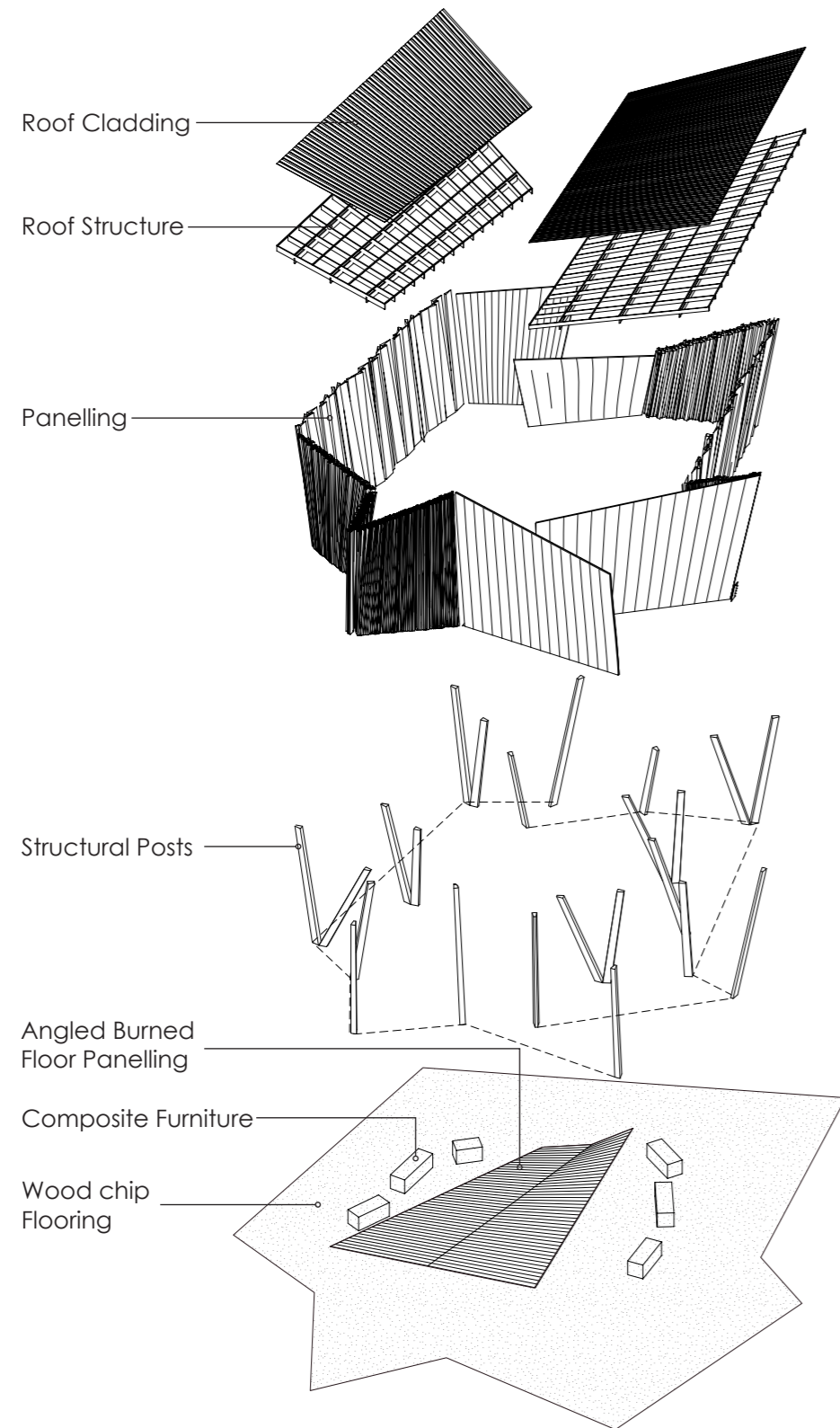


Secondary Use



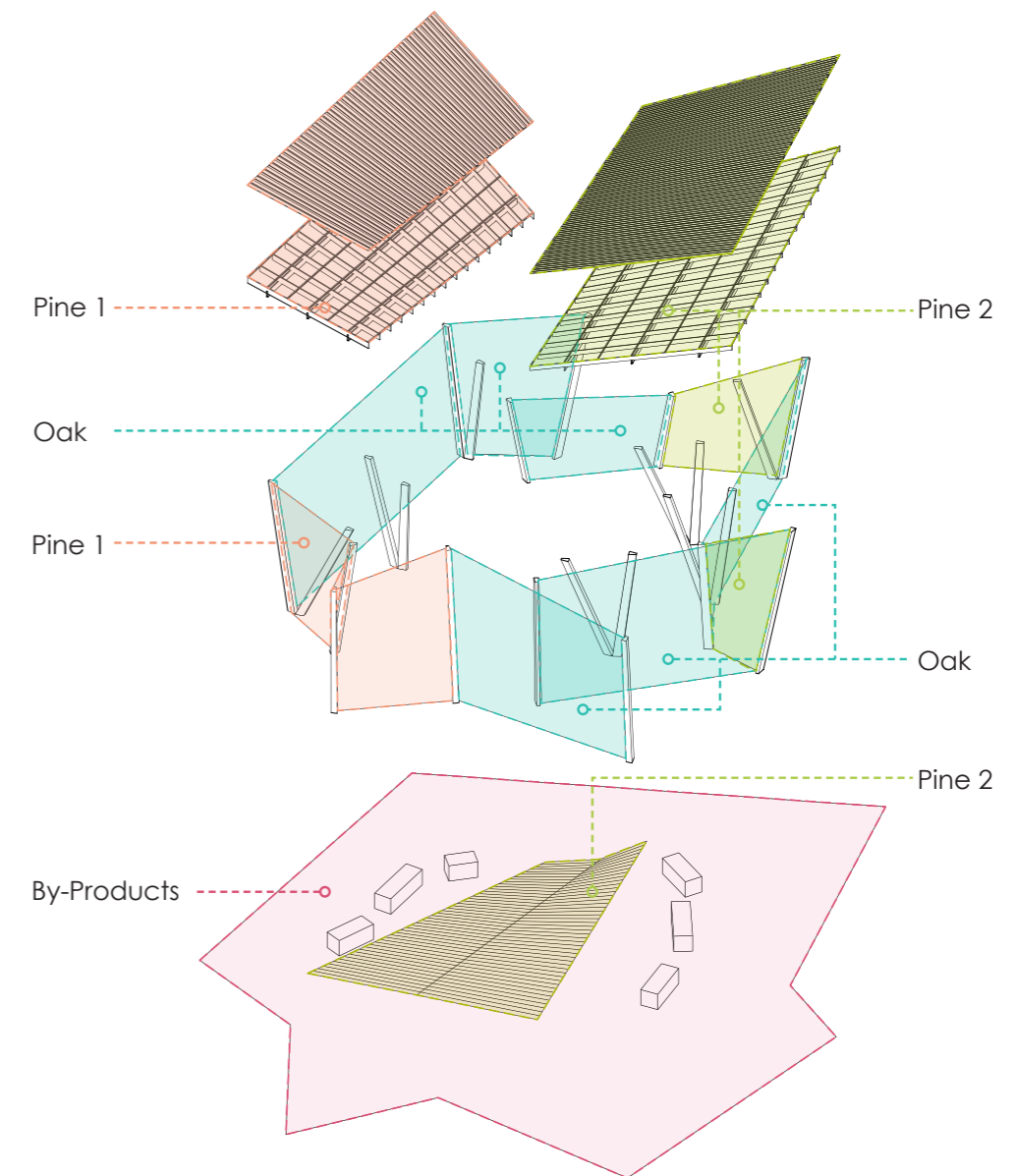
By-Products





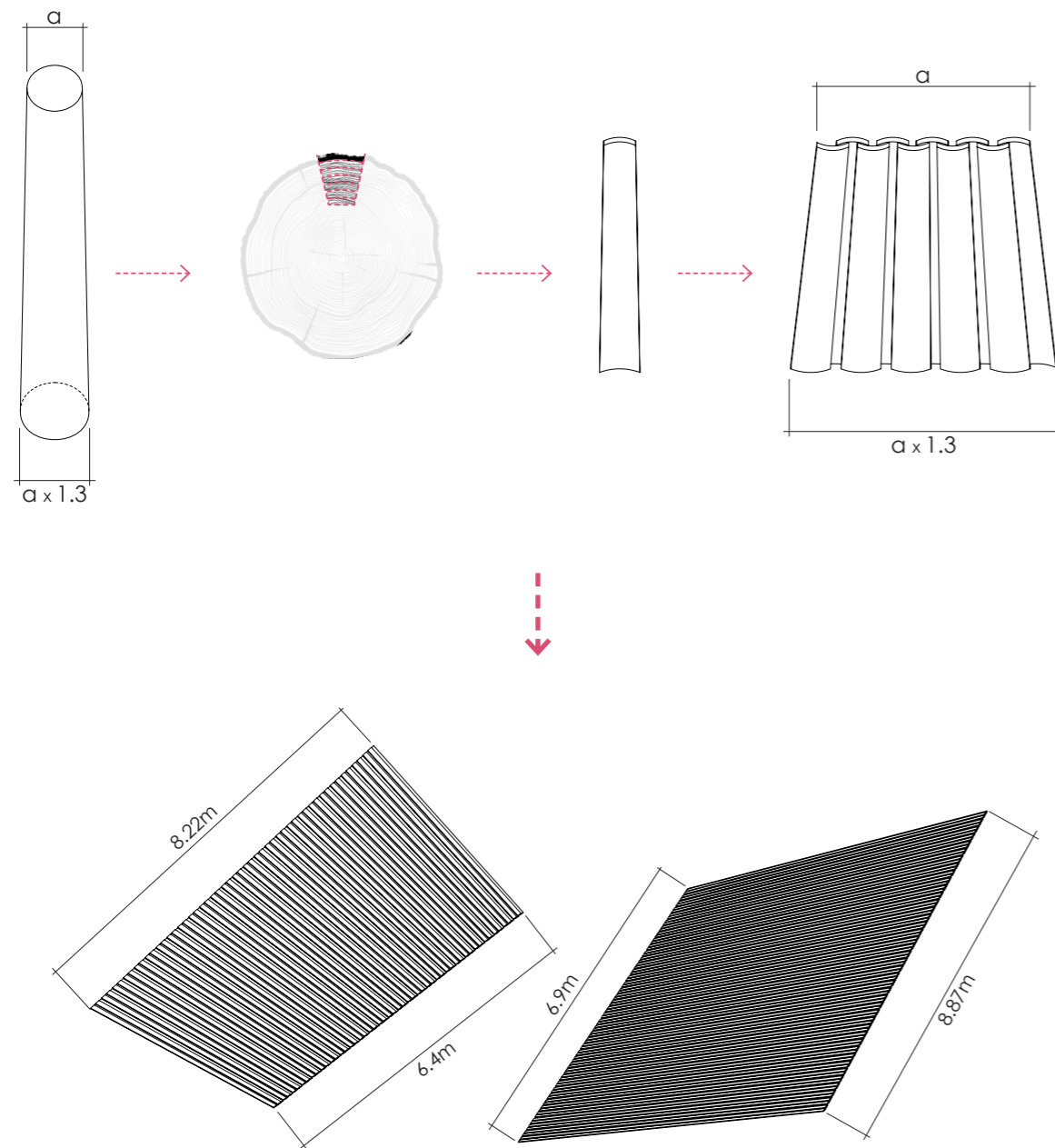
The locations of different trees used in the construction of the pavilion are based on their specific properties. First focus is to get the most valuable structural boards out of a log and then finding the right location and purpose for the secondary boards produced during that process. Since oak has relatively straight fibres, it is used to get large, structural boards that can then be bent into position for the entrance panels.

Pine sap-wood is used to create structural posts, due to their flexibility and structural properties. It is possible to cleave out rectangular structural boards from pine as well, though they are not as large, therefore, they are used in combination with each other to create the structure for the roof. The roof is then clad in radially cleft pine planks. All other by-products are combined into composite furniture or wood chip



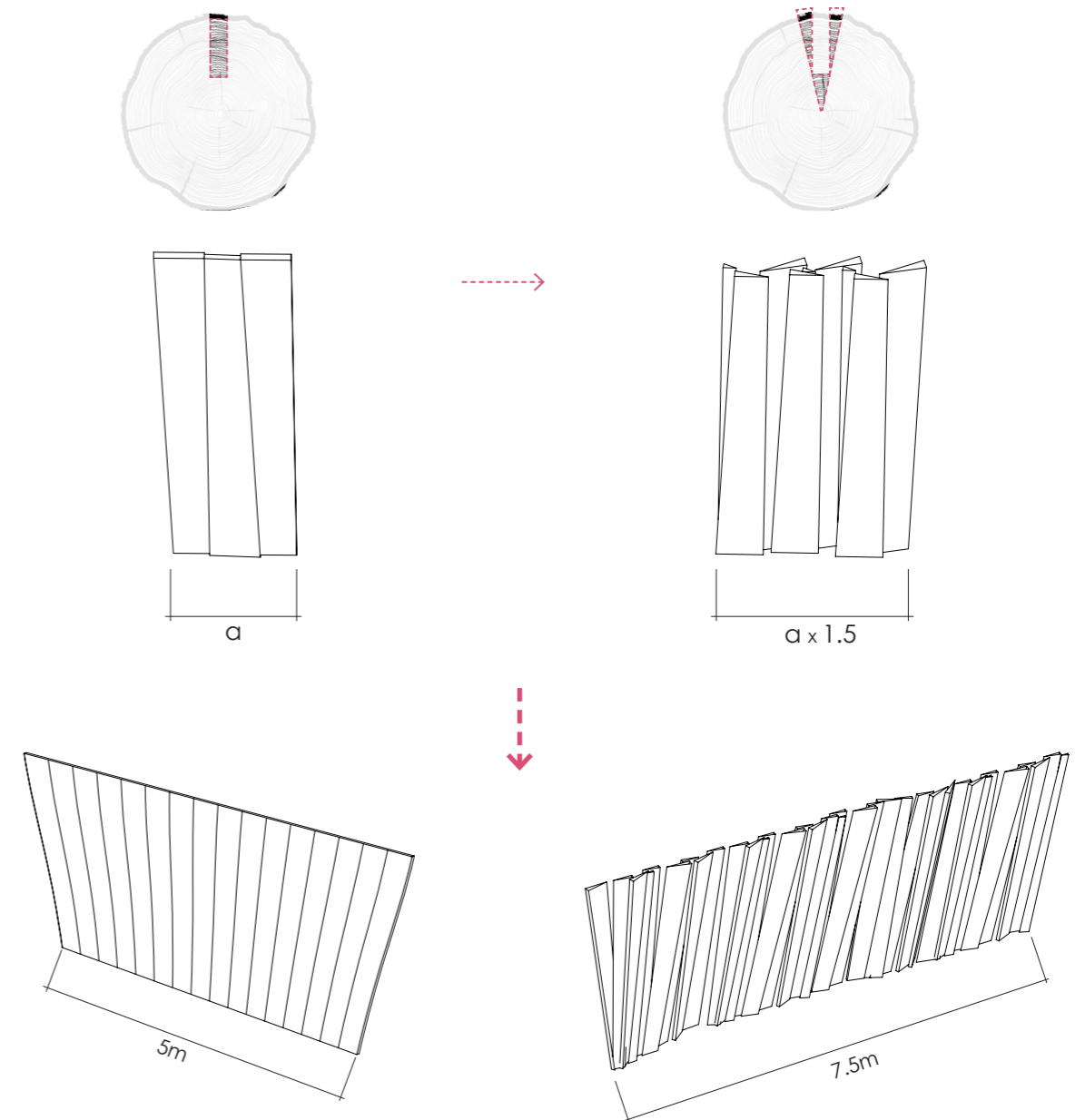
Roof Cladding Example

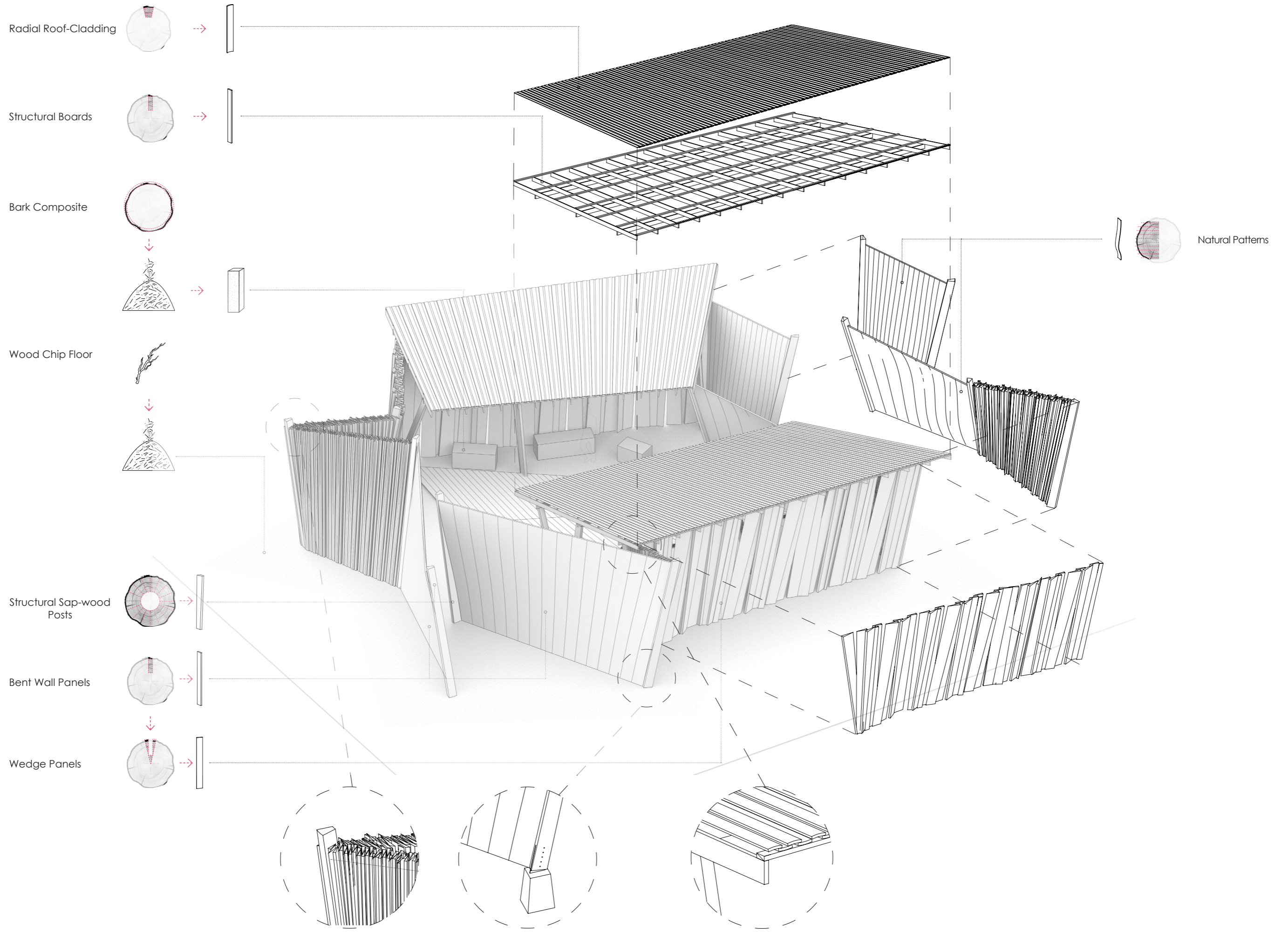
The design principles behind the proportions and sizes of all elements, are based on specific parameters. For example, the lower part of the tree is narrower than the top, which means that all cleft parts will have one dimension at the top and another dimension at the bottom. This translates into the panelling as well and their proportions are based on this ratio.



Wall Panelling Example

A certain ratio applies when working with primary and secondary boards as well. When a rectangular board is taken out of a wedge, the wood that surrounds it can be arranged into panels in a few different ways and that will have a ratio in relation to the structural boards, therefore the dimensions of the continuous panels are also based on this principle.





A simplified overview diagram of interior shows the natural factors that you might expect from this type of construction.

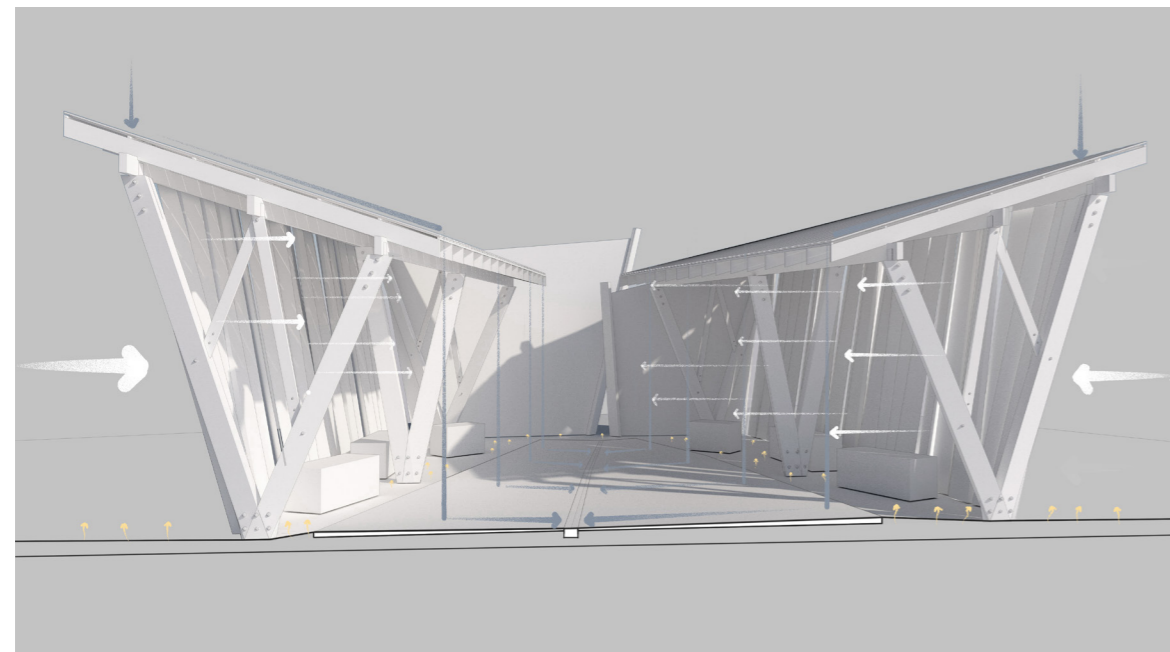
First and foremost, tactile experience almost comes a given, just by cleaving wood, separating the fibres and exposing the texture and patterns, one will experience wood in its flesh and its rawest form. It is the opposite of trying to polish, flatten and hide the natural qualities. Due to the unpredictable nature of cleaving, textural properties can vary from smooth/glossy to intensely textured with varying depth within fibres. Same goes to the touch of these surfaces, some can be smooth to the touch and some can be rough, even splintery.

Wood is cleft while it's still wet and green, it is also not treated in any way, one can expect the smell of wood being quite prominent within the structure, of course diminishing as the wood dries and ages.

The gaps in the panelling allow the wind to come in and enhance the smell of wood inside.

The structure also interacts with water, when it rains, the water runs off the roofs into the central area and the angled floor directs the flow of water through the pavilion, before it is drained.

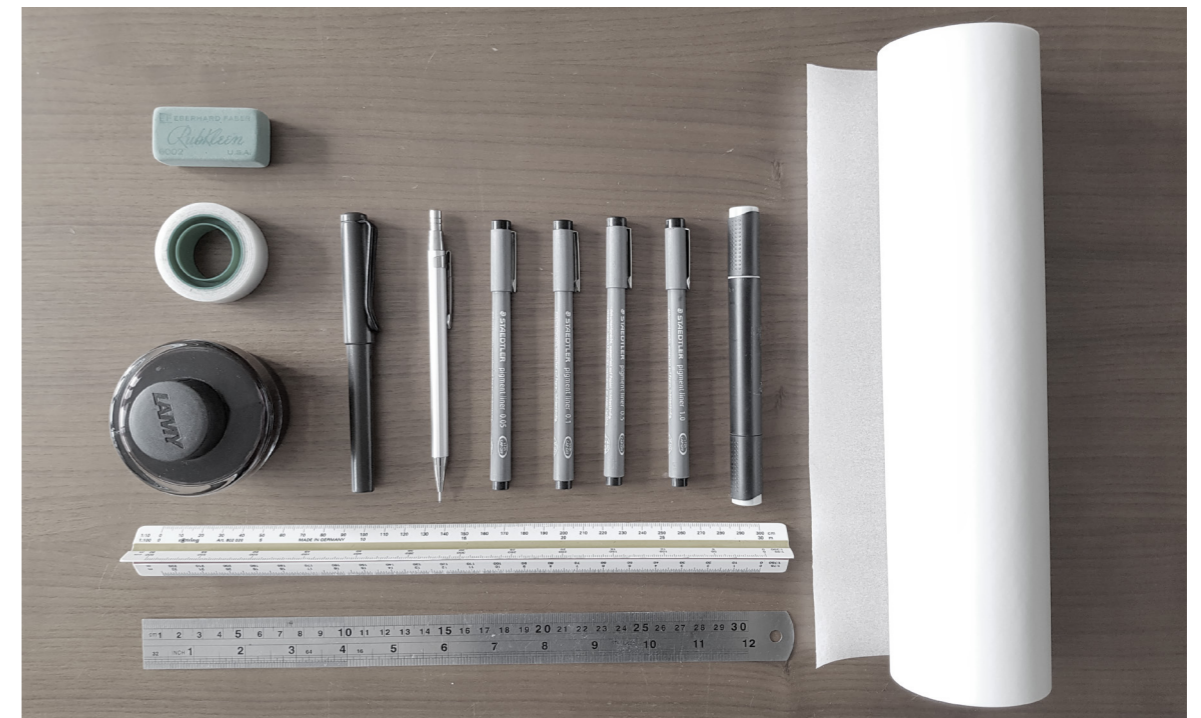
When walking on the wood chip floor you will experience movement, sound and a sense of walking on a forest floor.



TEXTURE WIND SMELL WATER MOVEMENT

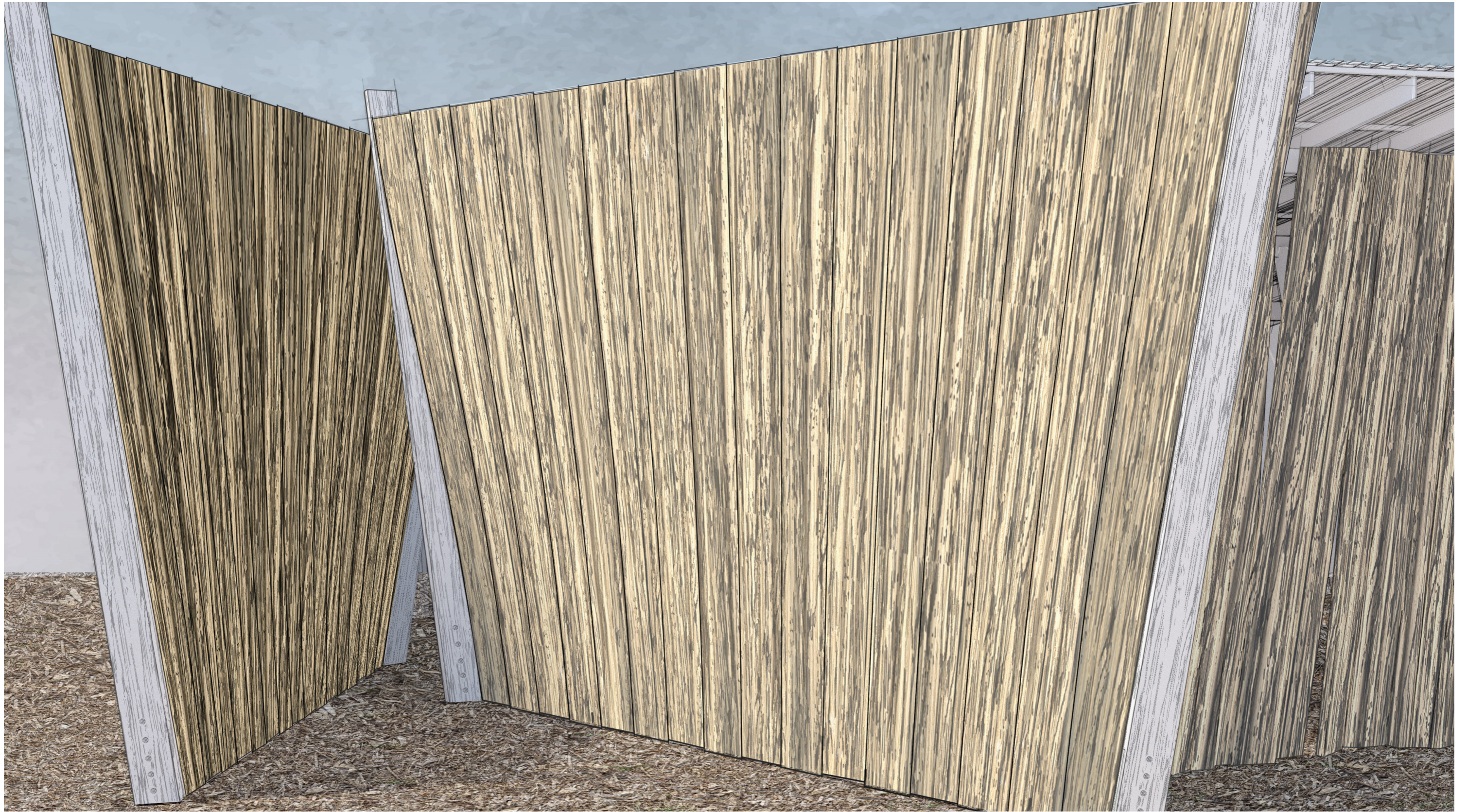
When visualising such a heavily material based project, there is a risk of overwhelming the drawing with intense, deep textures and taking focus away from important details and design elements. My chosen drawing technique is a hybrid between 3d rendering, hand drawing, scanning and also hand drawing over real textures. This technique aims to retain control and subtlety, while still emphasizing certain areas of sensory and architectural importance.

Hand Drawing Tools



Scanned Textures





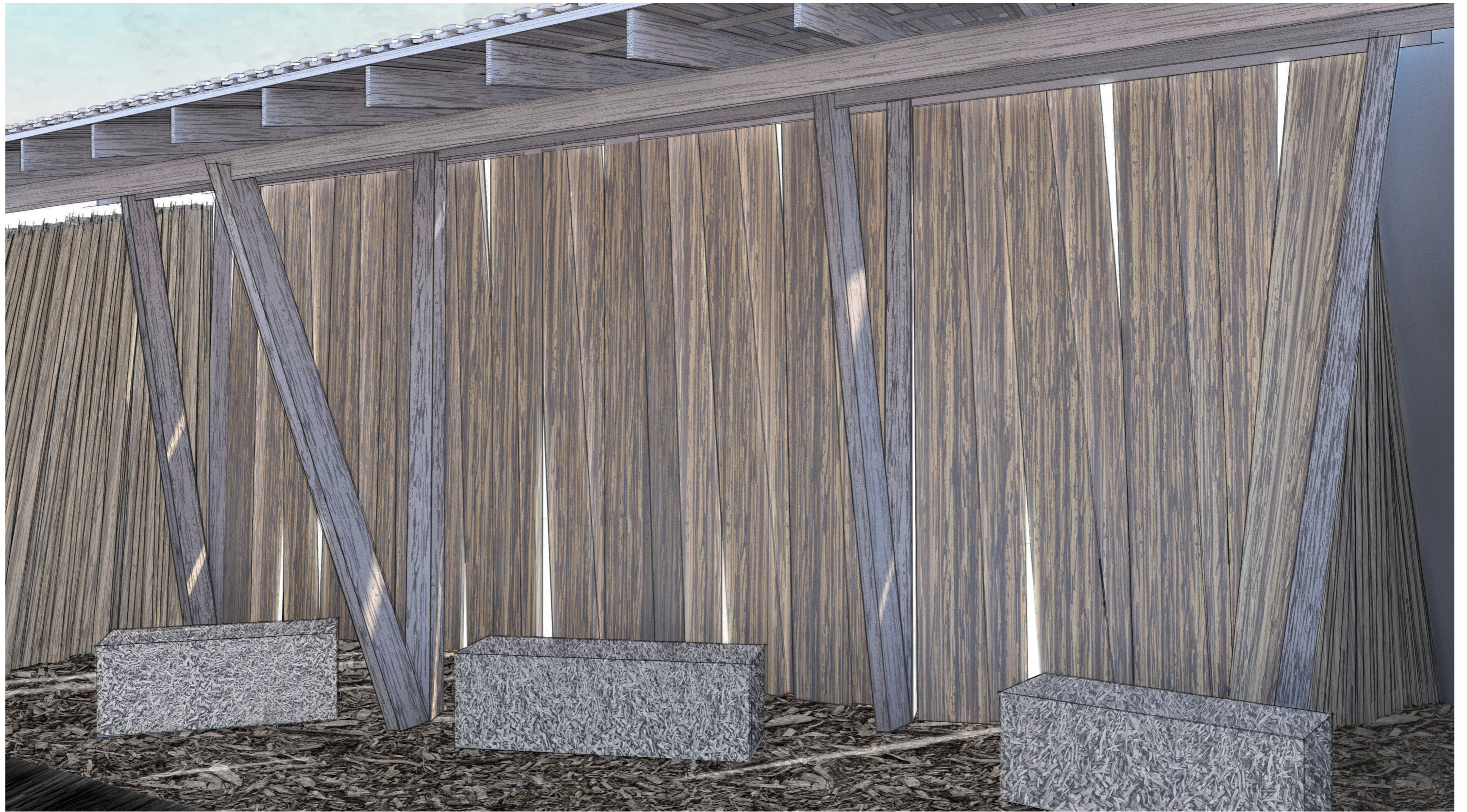
Entrance

Bent structural panels making a narrow point of entry, encouraging you to get close to the wood and even touch it.



Internal space

The perspective section shows the overview of the internal space, also beginning to suggest some technical information and how the structure is constructed.



Sheltered space

Being inside the pavilion, the texture of the panelling, the contrast and shadows formed, by light coming in through the gaps between panelling.

Approach to Detailing

An attempt to combine the best of both Digital and Analogue

My approach is an attempt to combine the best of both digital and analogue. Due to the complex and organic nature of the cleft wood geometry, I envision using 3d scanning and 5-axis robot fitted with a chainsaw in order to make precise cuts for the joinery. However, the joining itself is somewhat inspired by the simplicity of traditional boat building - down to earth, not over-engineered, visible fixings, not being obsessed with hiding things and being able to adjust things on site as you go along.

Working with green wood, movement of wood as it dries is one of the key things that needs to be accounted for. Proposed steel fixings aim to have holes for bolts and screws that are slightly oversized and will allow for that movement of wood, without it resulting in cracking.

Another important factor is to allow air circulation between boards and other building elements, therefore, the detailing tries to avoid butting things flat together in order to allow for that air circulation and even drying of wood.

Untreated Wood

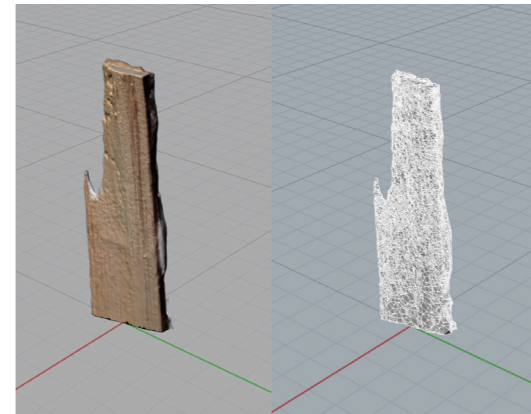
Choosing not to treat wood in any way was a conscious decision. An assumption can be made that cleaving wood and preserving fibres in itself is a type of treatment, since the water runs off the wood easier and the moisture does not penetrate the wood as much. A comparison can be made to cleft shingle roofs that last more than a hundred years and after some maintenance, even longer. Therefore, there is no concern in regards to panelling wood within the pavilion.

When talking about wood that is structural, without doing real scientific testing, we can only make assumptions and look at historical examples. Looking at examples like the Hardemo Church tower, where untreated sap-wood was used, the rafters were covered with a roof and allowed to dry, the tower has been standing for hundreds of years without any problems. The structural wood within the pavilion is somewhat covered, but it is not a weather-proof structure. Detailing, using steel plates would also prevent the wood from cracking to the extent where the structure would be compromised.

Another reasoning for not treating the wood is the typical lifespan of a pavilion. Pavilions such as this would be best suited for short-term exhibitions, like an expo or a Serpentine type of arrangement that would last a couple of months. If used in different set of circumstances, the treatment of cleft wood needs to be further investigated. Burning technique that is used for flooring could potentially be used as a treatment to preserve the wood in other areas,

Digital

3d scanning and 5-axis robot cutting of joints, to handle complex angles and geometry



Own 3d scanning experiments



Image: Hooke Park

Analogue

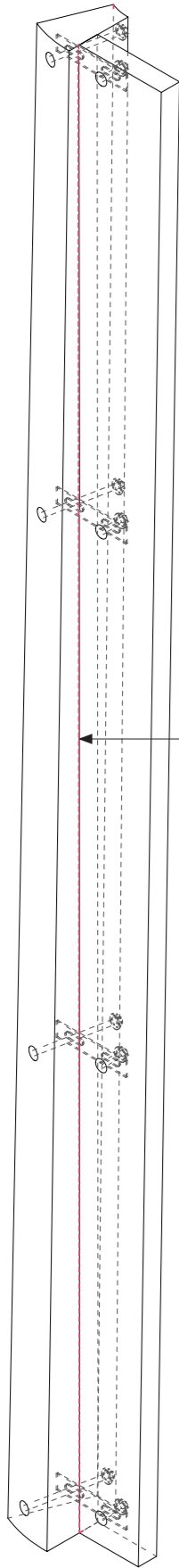
Straight-forward, pragmatic, methodical approach to joining. Down-to-earth and not over-engineered



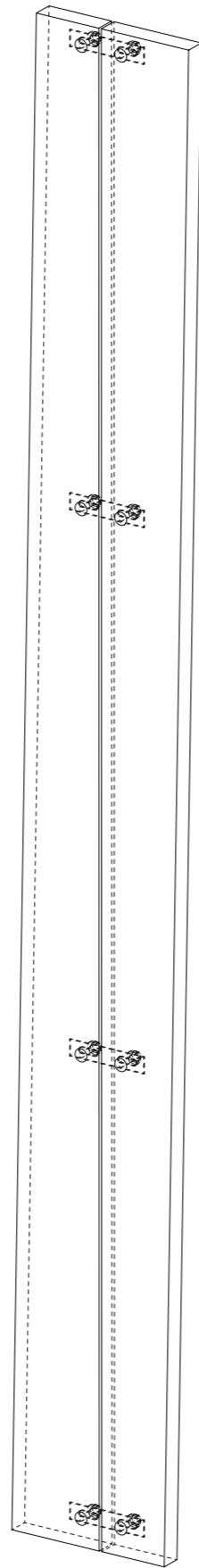
Images: robin-wood.co.uk

Joining of structural boards

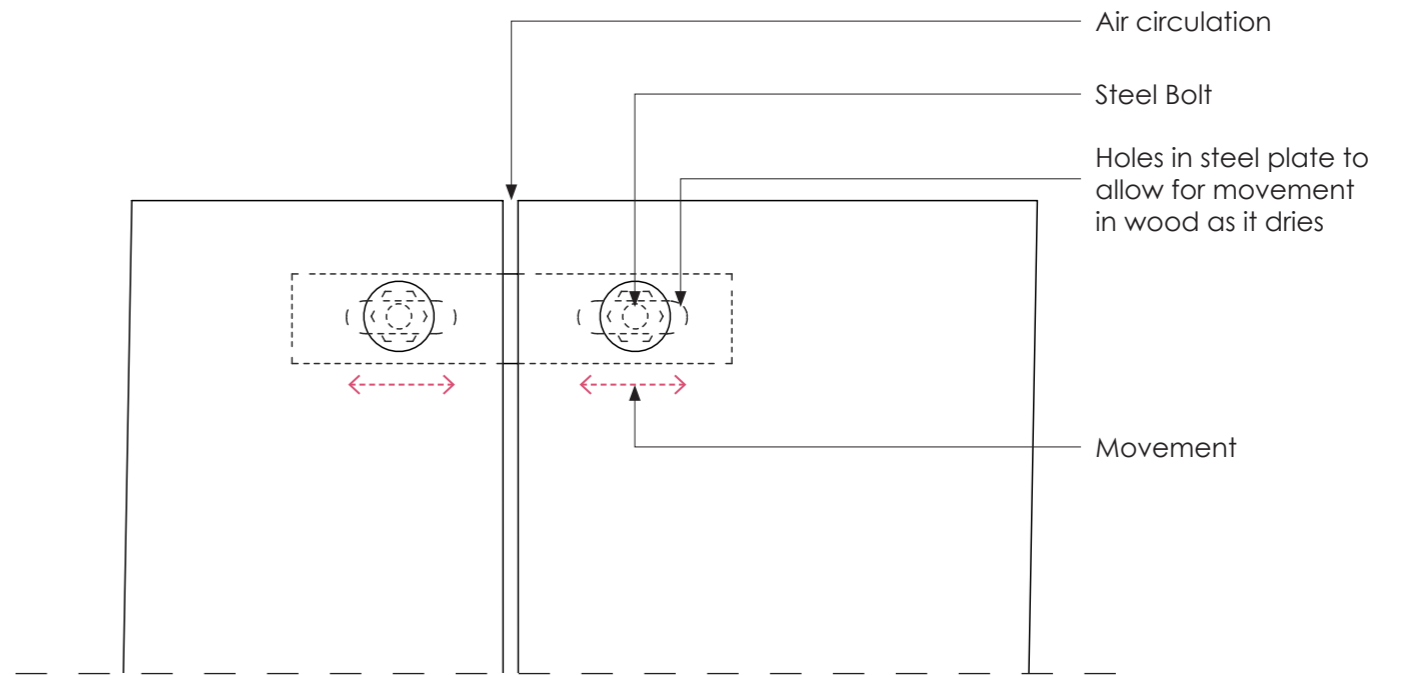
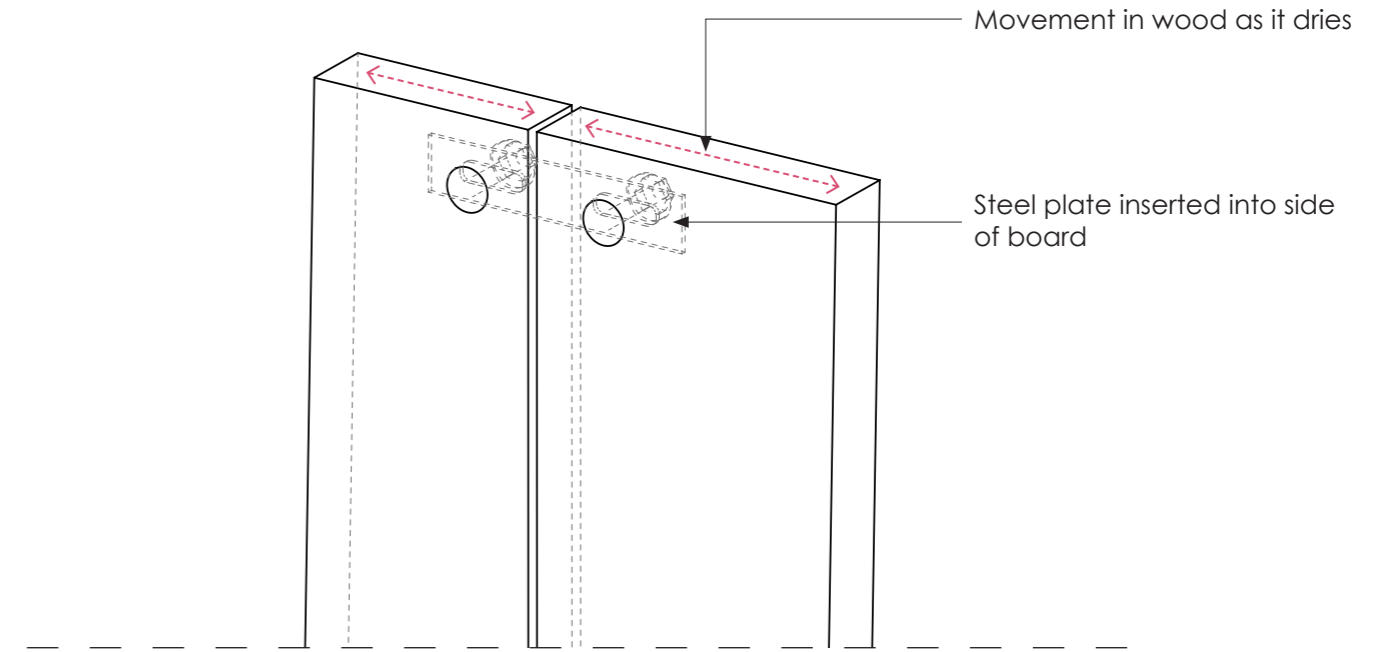
Sap-wood post to Structural Board



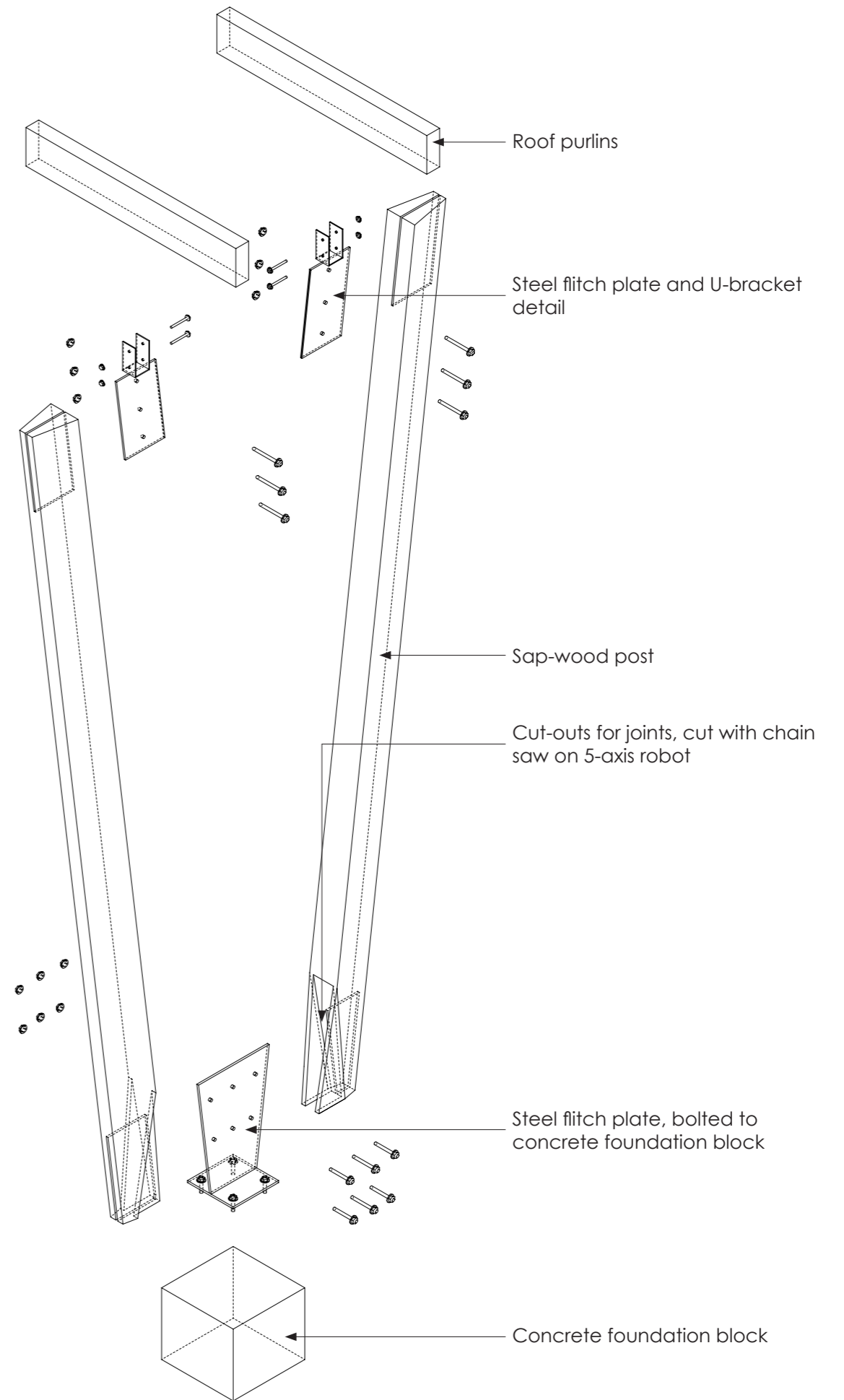
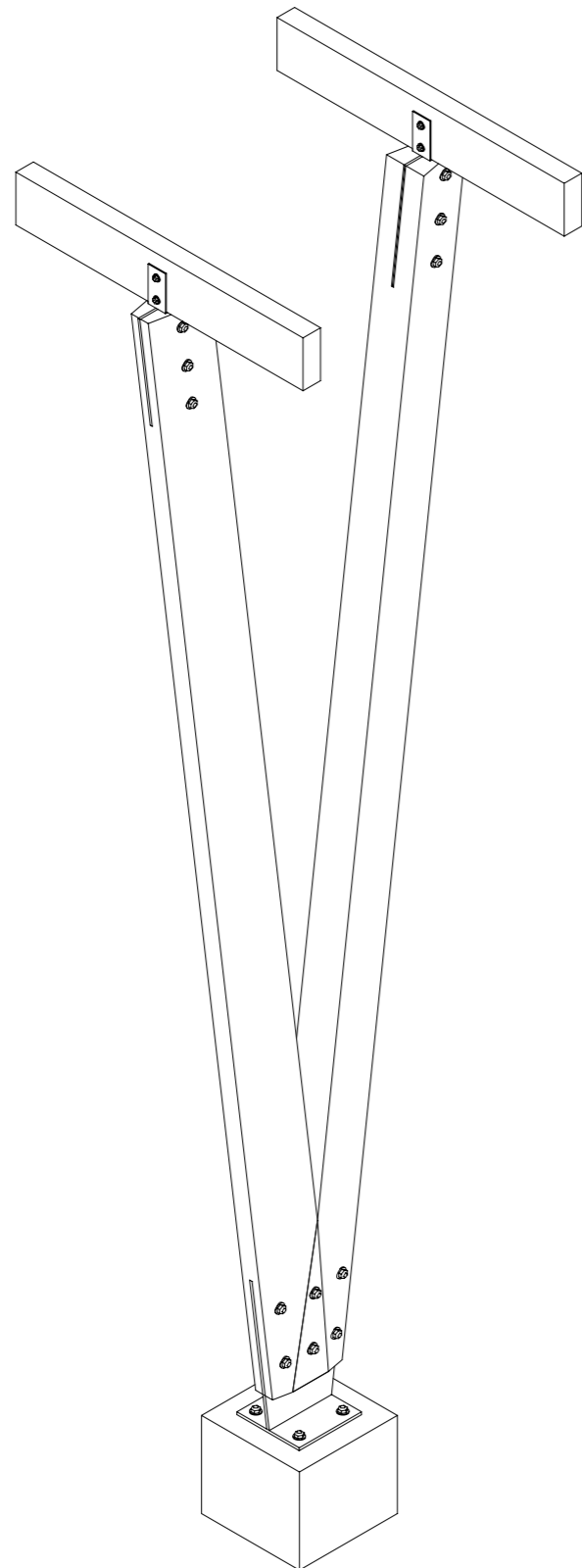
2 Structural Boards



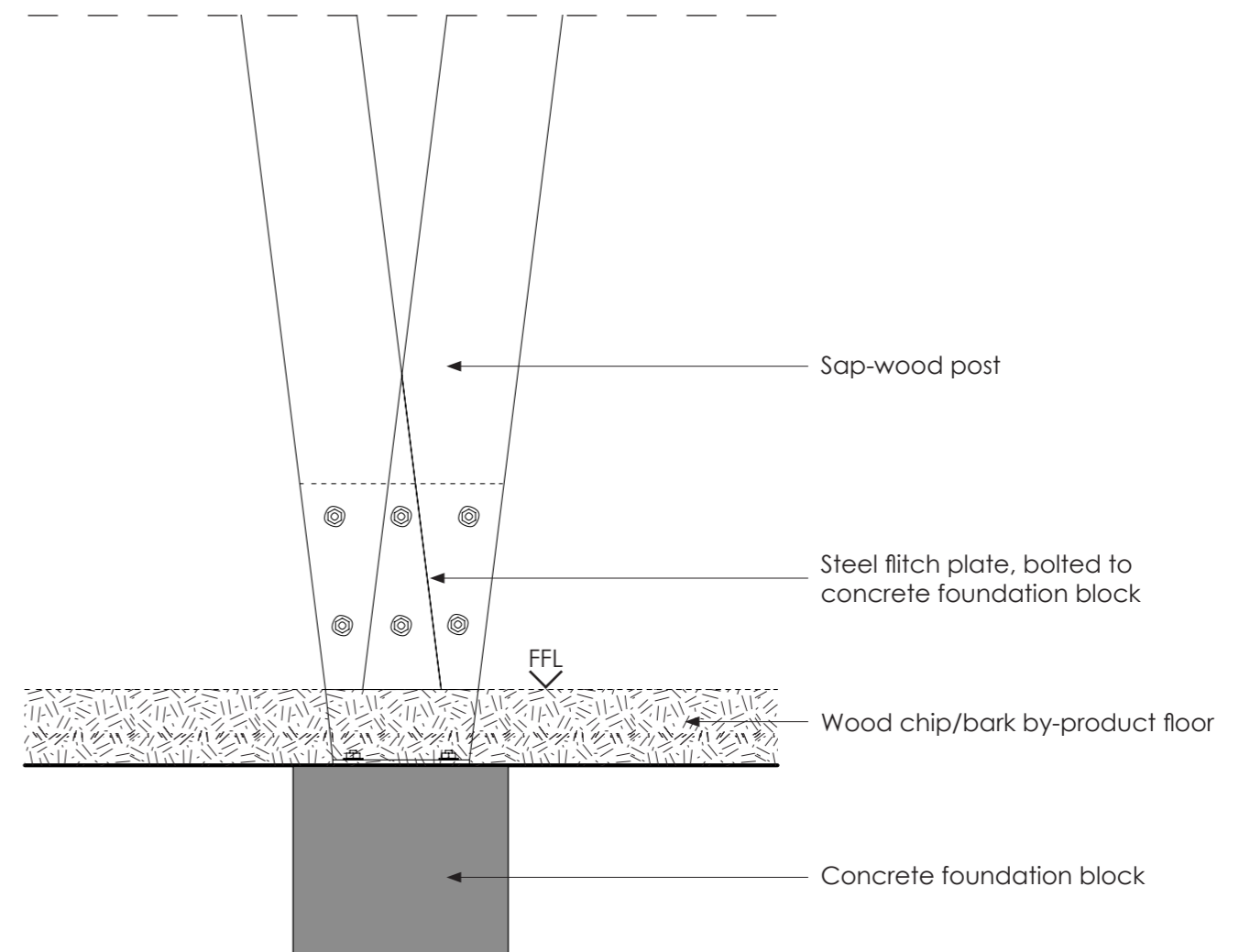
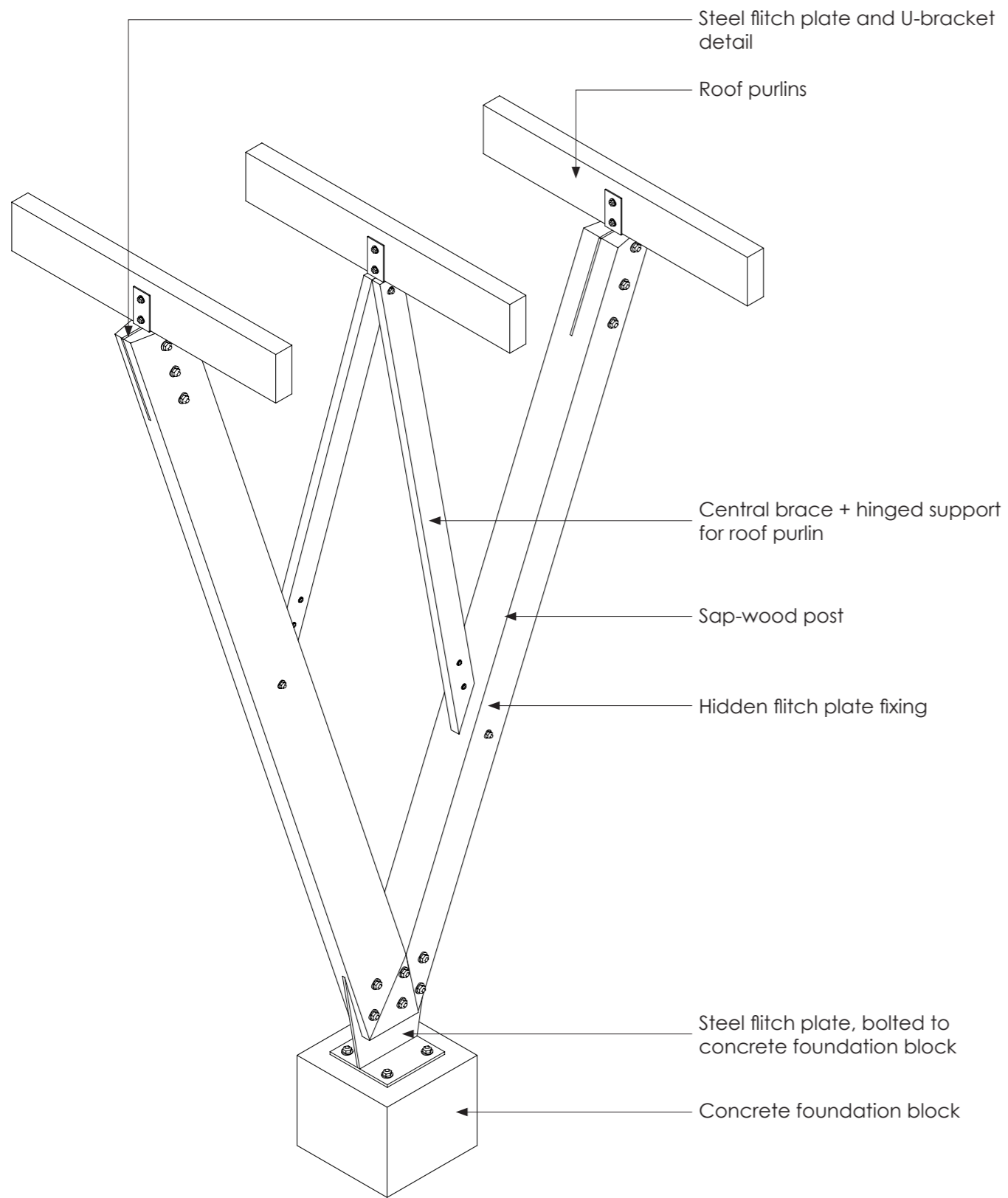
Steel plate positions to allow for board bending



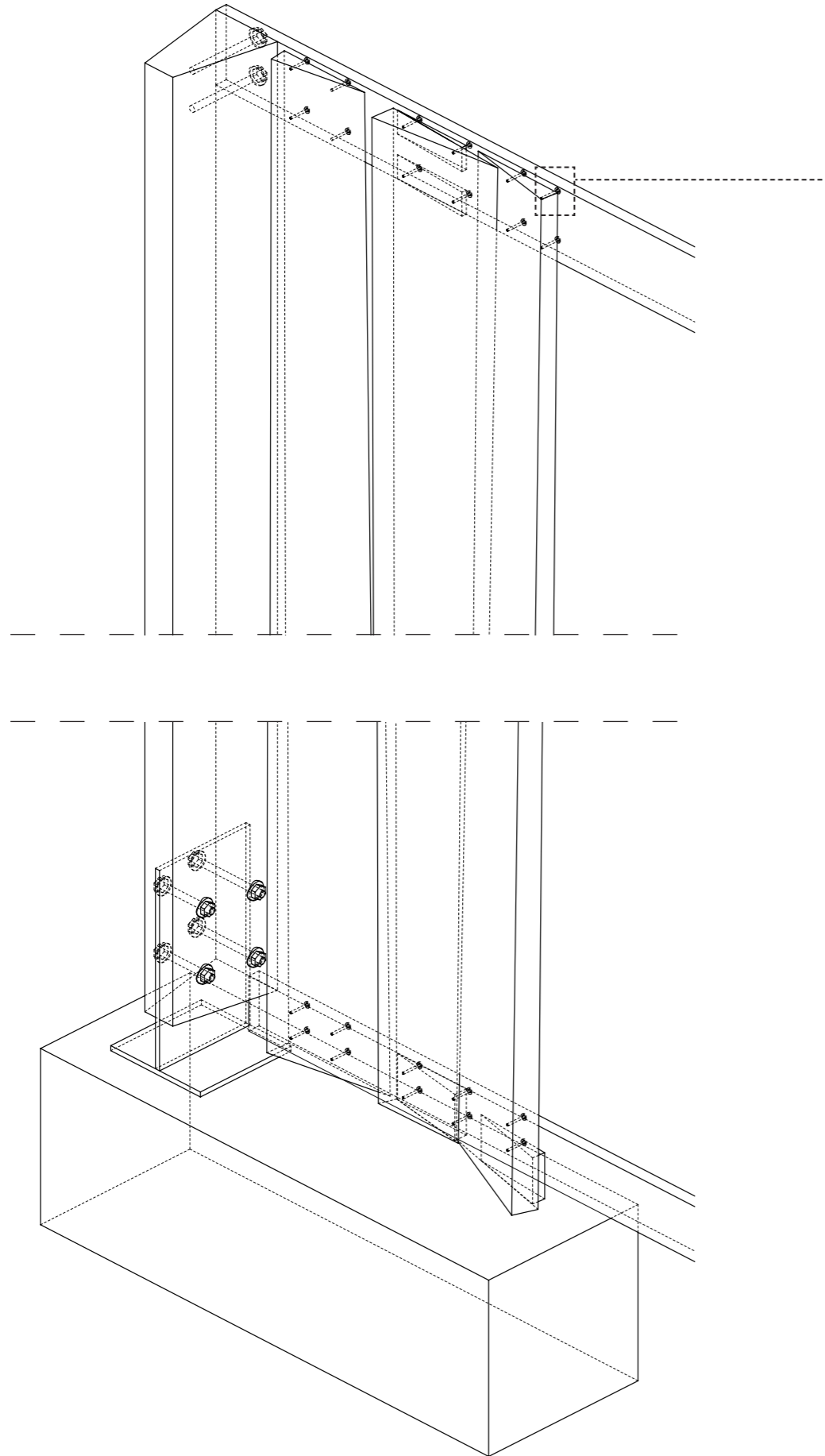
Joining of two sap-wood posts to create roof support structure



Joining of two sap-wood posts to create roof support structure
(3 purlins)



Triangular-wedge panelling between two structural posts



Supporting board for panelling, fixed to structural posts

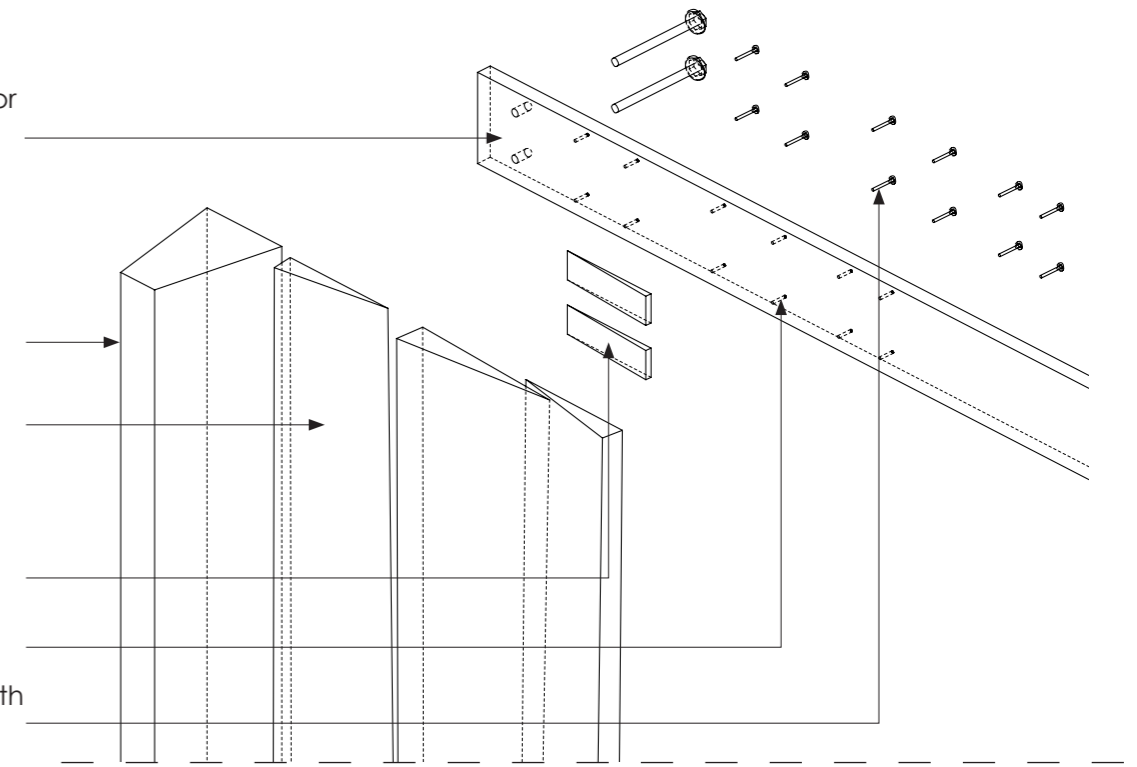
Sap-wood post

Triangular board panelling

Spacer wedges

Pre-drilled holes

Self drilling screw with washer

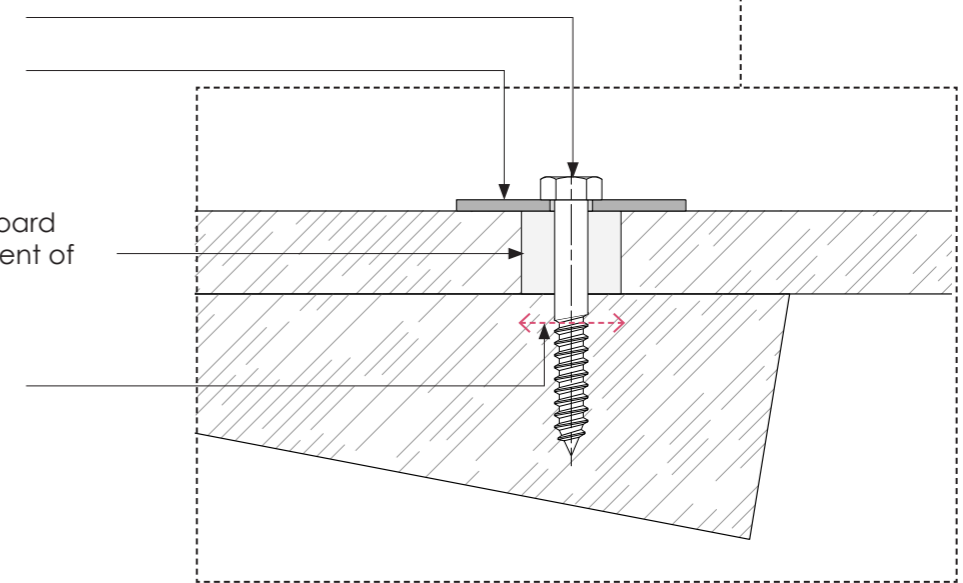


Self drilling screw

Washer

Pre-drilled hole in board to allow for movement of panelling boards

Movement



The discourse for this thesis developed through a general passion and curiosity for wood as a material and previous explorations looking into more natural aspects of it. While trying to investigate the specific properties and natural intricacies of wood, I was exposed to a very intriguing, but also immensely complex world of a material that has so many environmental credentials that seem to be overlooked by the industry and our current approach to working with wood. This led me on a journey and realisation that this subject was rarely explored and the traditional knowledge, cleaving techniques, that used different trees and different parts of the tree for different purposes, have mostly been forgotten.

It was somewhat surprising to me that this subject was not explored more within architecture, being able to find only very few references from the medieval times. Boat building techniques and some modern day reconstructions of medieval Viking boats worked as a starting point in order to better understand the more natural and careful approach to wood that our forefathers used. My own developed techniques looked at the traditional cleaving methods, but also at the inefficiencies within those methods. Based on some of those principles I was able to develop my own set of techniques that could be adapted in the architectural context, taking the best of the structural properties of the cleft wood, but also improving the inefficiencies, attempting to utilise as close to 100% of the tree as possible.

Employing some of the advanced digital tools that we have today, made these techniques and the idea of using them in today's architectural context, feasible. However, these were used only as proof-of-concept, there are still practical issues that would need further investigation into how these methods scale up or how to make it economically feasible to work with wood in this way.

Another important part of this approach is changing the way we harvest trees. Instead of clearing whole forests and taking all the wood as a generic substance, this thesis proposed a method of 3d scanning particular trees, that are suited for a particular purpose and then using them as efficiently as possible, in order to create a holistic structure. This resulted in a final design exercise of a 'Zero Waste Pavilion' and a showcase for this newly produced knowledge. The design principles were developed solely for this approach of working with wood, meaning that the proportions, angles and relationships between different elements were a result of an incremental process that implemented new knowledge and discoveries as the process went on, but still preserving the principles of a multi-sensory experience that come when working with wood in such a natural way.

It is important to note, that the overall design of the pavilion is not the focus of this thesis. The pavilion is a discussion tool and a result of an incremental process of discovering new methods, design techniques and directly applying them within a structure. It is also used to express some of the multi-sensory experience factors that come while working with wood in this particular manner, and arguably this is something that we are also gradually losing in our environments.

Now that I have a number of techniques that can work alongside each other and with the knowledge that I have built-up by the end of this thesis, the next hypothetical step would be to develop other ways of designing using this approach. Reflecting on the current design, one could argue that the design is very heavily driven by the material itself and the combination of structural and practical factors that come with cleaving wood instead of sawing it. It would be interesting to see how these methods could be developed, so that the architect takes back more control as we get more comfortable and knowledgeable while using this approach. It would also be interesting to see other species of trees explored and what could be built only using one tree or perhaps using only one or two techniques. Would that result in a more coherent design? What if a completely different architectural expression and language is used from the starting point?

A further investigation into the life-span of cleft wood and sap-wood, would also be very interesting. Generally, the life-span of a pavilion building is relatively short, as a result, this project did not focus heavily on this part. For using this type of wood in other contexts would require further study of how cleft wood and sap-wood behave when exposed to moisture and if needed, how to protect it. The Japanese burning techniques and using boiled down sap/tar that comes from the tree itself, could be rather interesting potentials.

My aim for this thesis was to hopefully inspire and conceptualise a different way of approaching this truly organic material. Even after this long process, I can't help but feel that this is only scratching the surface and my approach is only one of many potentials. I do hope sincerely, that we do not stop here and continue on the same path for the sake of convenience and that we do not balk here, just because we are faced with complexity. I believe the rewards are far too great, to ignore a material that has so many environmental credentials.

References

Brandner, R., (2013, May). Production and Technology of Cross Laminated Timber (CLT): A state-of-the art Report. Graz University of Technology. Graz, Austria

Desch, H.E. & Dinwoodie, J.M. (1996). Timber: Structure, Properties, Conversion and Use (7th edn, rev.). London: Macmillan Publishers Limited

Eriksson, D., Torgén, C., (2016:04). Medeltida taklag Örebro län, Strängnäs stift Etapp 2, 2015-2016. Örebro läns museum. Örebro, Sweden

Follansbee, P. (2009, October 18). 'There's oak, then there's riven oak'. Retrieved from <https://pfollansbee.wordpress.com/2009/10/18/theres-oak-then-theres-riven-oak/>

Menges, A., Schwinn T., Krieg, O.D. (2016). Advancing Wood Architecture, A Computational Approach. London: Routledge

Moberg, S., Eliasson, J., (2019). Tales of the Revived, an exploration of natural leftover resources. Master Thesis spring 2019. Chalmers School of Architecture, Department of Architecture and Civil Engineering. Gothenburg, Sweden

Örebro läns museum. (2018, March 19). Medieval wood riving – An attempt to recreate craftsmanship [video]. Retrieved from <https://www.youtube.com/watch?v=BE2klxBE8QM&t=924s>

Pallasmaa, J. (2012). The Eyes of the Skin. Chichester: Wiley & Sons

Wood, R. (2011, November 14). 'Building the world's most iconic Viking ship'. Retrieved from <http://www.robin-wood.co.uk/wood-craft-blog/2011/11/14/building-the-worlds-most-iconic-viking-ship-part-1/>

[@hookeparke]. (2020, March 30). 2016's is edition of @aavisiting_school's Robotic Fabrications saw our robot wield its first chainsaw. Since it's been upgraded to a large Logosol saw [Instagram photograph]. Retrieved from: https://www.instagram.com/p/B-XRCV9pqtH/?utm_source=ig_web_copy_link

[Crinklecrankle.com](2008, July 19). Shredded bark mulch [photograph]. Retrieved from: https://www.flickr.com/photos/garden_and_landscape_design_products/3428350011/



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