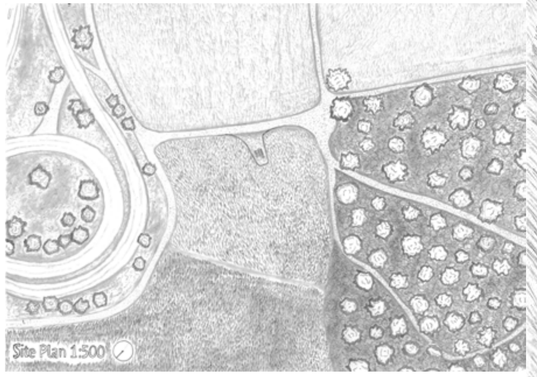
Sound Pavillon

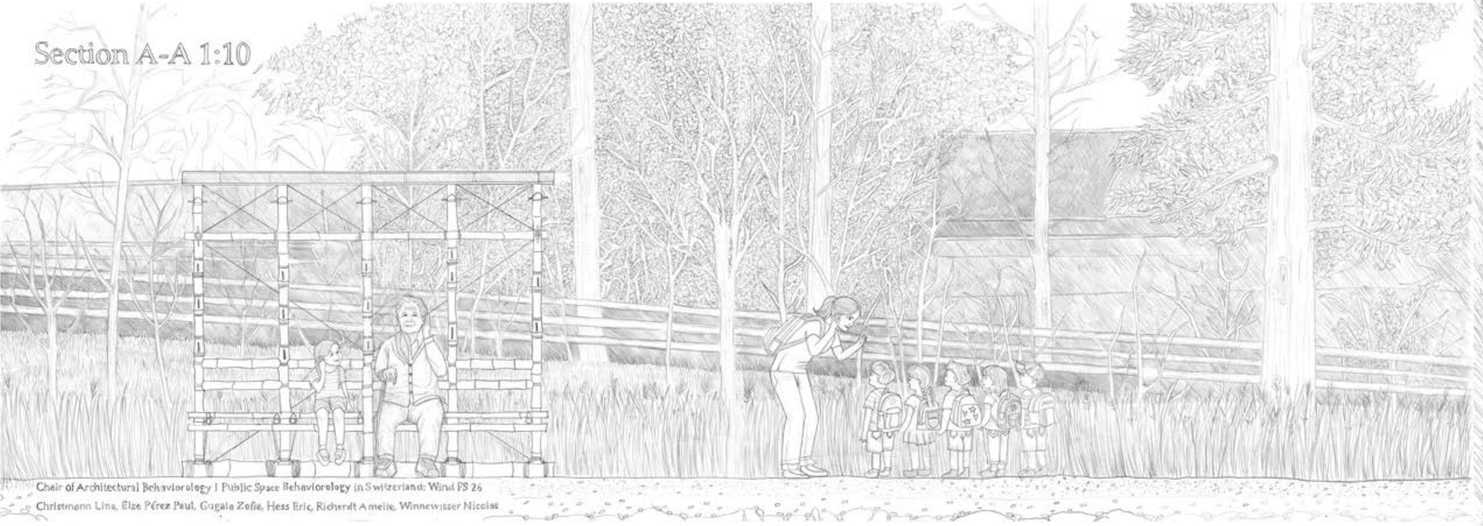
Site 1: Watertank

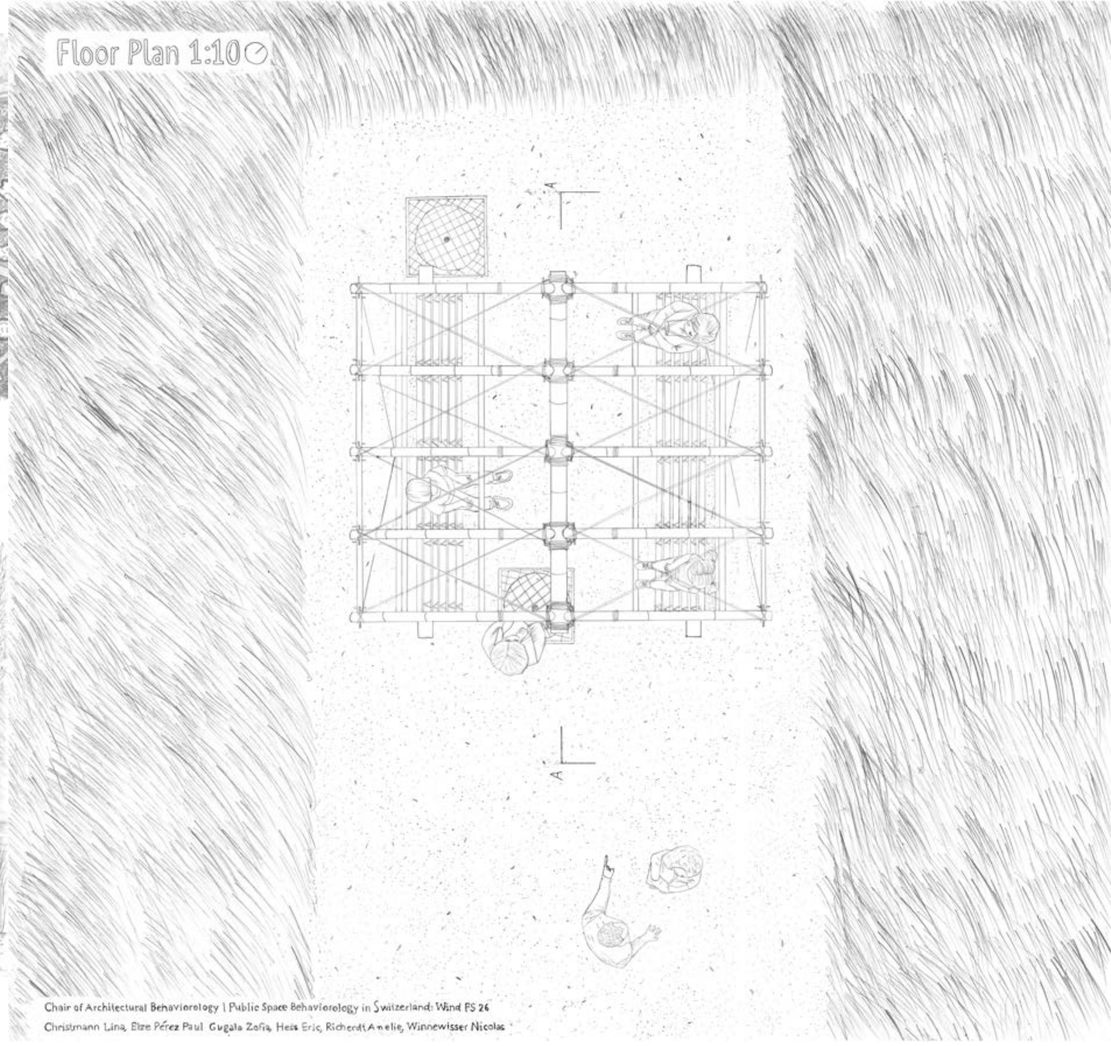
Lina Christmann, Elzé Perez Paul, Gugala Zofia,
Hess Eric, Richerdt Amelie, Winnewisser Nicolas

Public Space Behaviourology FS26: Wind
Chair of Architectural Behaviourology

Situated in an open field between the ETH campus and the forest, our bamboo sound pavilion offers the wind a voice. A structure formed by aeolian flutes and integrated seating shapes a calm gathering space for children, students, and adults. Colored strings framing the flutes reveal wind direction, making air currents audible and understandable. Constructed with bamboo and traditional joinery techniques, the pavilion creates an experience where sound, movement, and space are shaped by the wind.

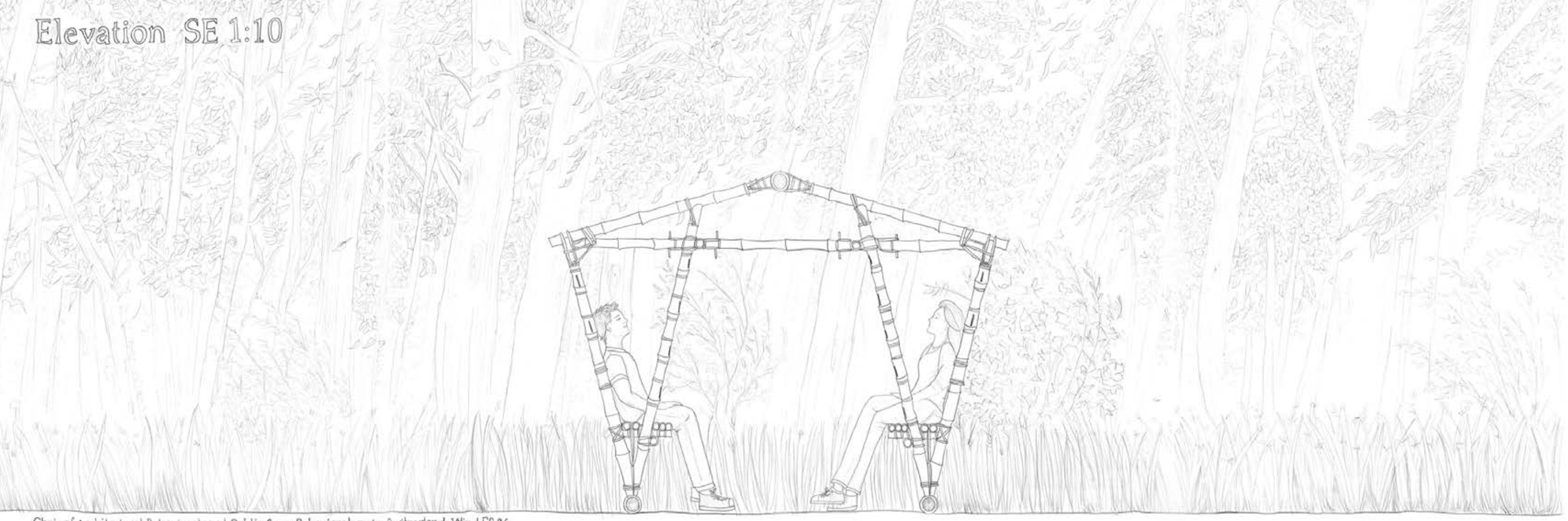






Chair of Architectural Behaviorology | Public Space Behaviorology in Switzerland: Wind FS 26
Christmann Lina, Elze Pérez Paul, Gugala Zofia, Hess Eric, Richerdt Amelie, Winnewisser Nicolas

Elevation SE 1:10



Chair of Architectural Behaviorology | Public Space Behaviorology in Switzerland: Wind FS 26

Christmann Lina, Elze Pérez Paul, Gugala Zofia, Hess Eric, Richerdt Amelie, Winnewisser Nicolas

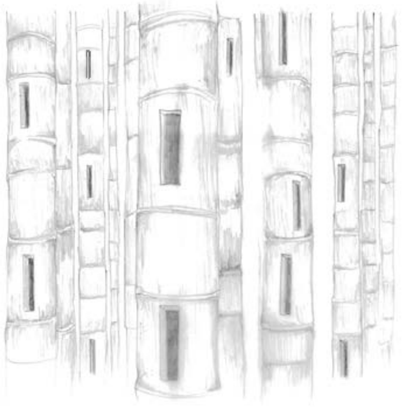
Elevation NE 1:10

Chair of Architectural Behaviorology | Public Space Behaviorology in Switzerland: Wind FS 26

Christmann Lina, Elze Pérez Paul, Gugala Zofia, Hess Eric, Richerdt Amelie, Winnewisser Nicolas

Sound in Aeolian Bamboo Flutes

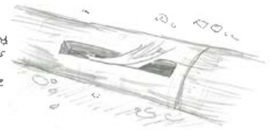
The aeolian pavilion investigates how sound is generated through precisely designed slits in bamboo tubes. The geometry of the slit and its sharp edge control the activation of sound by guiding airflow into vibration. Tube diameter defines pitch, while flute orientation determines how effectively wind interacts with each opening. Together, these elements shape a responsive acoustic system. Material performance, including protection from water, cracks, and UV exposure, ensures consistent sound production and long-term functionality in outdoor conditions.



Ilias Christmann - Chair of Architectural Biomimetics, Studio Kanjima

Slit Geometry

The sound of aeolian bamboo tubes is generated when wind passes over a slit and interacts with a sharp edge, causing the air column inside the tube to vibrate. At least one sharp edge is necessary, while the slit geometry controls how clearly and strongly the sound is produced.



Type 1 - Straight Slit — Sound Quality

Activation: ●●●●○
Stability: ●●●●●
Clarity: ●●●○○

- no angled
- neutral reference condition
- no proper windedge
- not suitable

Type 2 - Inward facing slit

Activation: ●●●○○
Stability: ●●○○○
Clarity: ●●○○○

- converging slit profile
- leaning towards center
- more focused stable tone
- more consistent acoustically

Type 3 - Outward facing slit

Activation ●●●●○
Stability: ●●●●○
Clarity: ●●●●○

- diverging slit profile forming
- works when wind comes from left and right
- clear tone, more variable

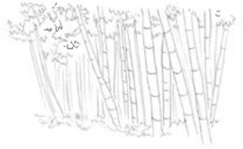
Type 4 - Parallel offset slit

Activation: ●●●○○
Stability: ●●●○○
Clarity: ●●●○○

- both edges from the same side
- airflow is strongly guided
- even and predictable tone

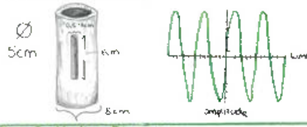
The outward-facing slit increases acoustic activation by exposing two wind-attacked edges in opposite directions. This allows sound generation from multiple wind directions, making it particularly effective in changing outdoor airflow conditions. Although the angle of attack must remain within a limited range for stable resonance.

Tube Diameter



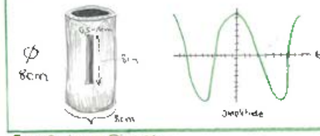
The sound of aeolian bamboo tubes is determined by the resonance of the air column inside. Where tube diameter influences the vibrating air volume. The Pitch is determined by the frequency of air vibrations: smaller tubes produce faster oscillations (high pitch), while larger tubes generate slower oscillations (low pitch)

Type 1 - Small Diameter — Vertical Pitch Scale



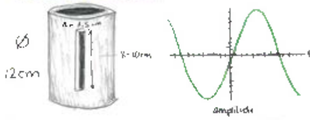
- High pitch / High Frequency
- sensitive to wind
- produces whistle like tones

Type 2 - Medium Diameter



- Mid range pitch / frequency
- stable sound production
- moderate wind required

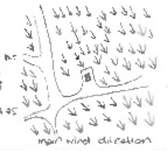
Type 3 - Large Diameter



- Low Pitch/Frequency
- deep hum
- requires stronger wind

The medium diameter bamboo tubes (ø 8 cm) are selected as the primary sound element, as they provide the most reliable and stable sound production under varying wind conditions. Their mid-range pitch is perceived as the most pleasant and balanced for human hearing, avoiding both the sharpness of smaller tubes and the heaviness of larger ones.

Flute Orientation



For Aeolian Bamboo flutes can produce sound, wind must hit the windward edge at a specific angle to create oscillation. If the orientation is wrong, the airflow passes without generating sound. The orientation of the flutes relative to the wind direction therefore determines the sounds intensity as well as stability.

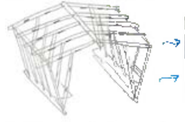
Option 1 - Two-Axis Orientation

- flutes face 2 main wind directions
- better acoustic variation
- site specific orientation

Option 2- Uniform Orientation

- all slits facing exactly main wind direction
- strong wind attack
- less variation

Option 3 - Distributed Orientation



- flutes face different directions
- ensures activation under changing wind conditions
- some flutes not perfectly

The dual-directional orientation makes sense because it responds to the site's two main wind directions instead of relying on only one. By dividing the flutes across two axes, the installation increases the chance of wind activation and sound production under changing conditions, making the system more efficient and adaptable. To visualize this, two different colors were used to distinguish the flute groups for each wind direction.

Material and Acoustic Challenges

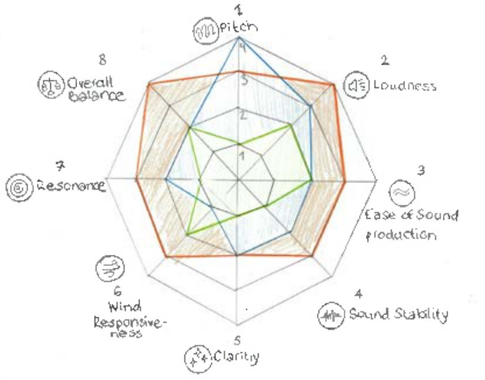
Problem 1: Rainwater inside the Tube — **Solution: Slit above node**

Problem 2: Cracks in the Bamboo — **Solution: Filling crack with epoxy**

Problem 3: Sun damage to bamboo — **Solution: UV Coating**

The performance of aeolian bamboo tubes is influenced by both environmental conditions and precise construction details. Issues such as water accumulation, air leakage through cracks, and incorrect slit geometry can prevent proper sound generation, making it essential to carefully design and protect each tube for reliable acoustic performance.

Graph : Accoustic Performance

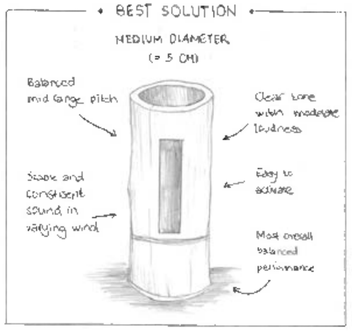


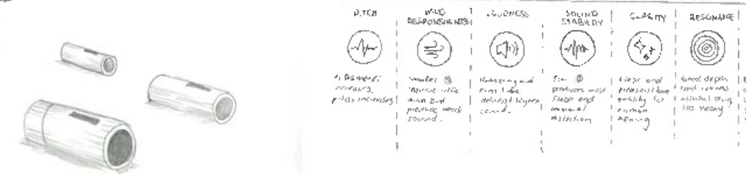
Diameters compared

- Medium Diameter
- Small Diameter
- Large Diameter

Conclusion

Accoustic Performance



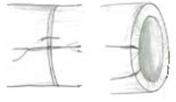


Observation

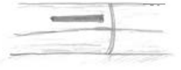
1 Observation - Tools for Carving Bamboo Flutes

The flute slits were carved using an oscillating tool to create straight angled openings. However, using the same tool on the small slit edges produced rough and imprecise cuts, reducing craftsmanship quality and negatively affecting sound performance.

2 Observation - Bamboo Cracks



During testing, bamboo developed small cracks that expanded over time, causing air leakage and reducing resonance. Epoxy filling was found to be expensive and difficult to use wisely.



3 Observation - Slit Geometry

Earlier inward-facing slits designs showed limited sound activation in changing wind conditions. Testing revealed that outward-facing slit edges improved airflow interaction and increased sound production.

4 Observation - Flute Orientation

Flutes were initially placed in random directions, but testing showed that they did not respond efficiently to the site's main wind direction. This caused inconsistent sound production and left some flutes inactive.

Reflection

1 Solution - Tools for Carving Bamboo Flutes

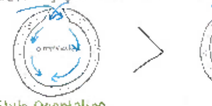
By improving the oscillating tool with a holder and trimmer, the small slit endings could be shaped more precisely, leading to cleaner cuts, improved craftsmanship and better sound quality

2. Solution - Bamboo Cracks

Small cracks were filled using a natural mixture of wood glue and bamboo dust, to seal openings & prevent further cracking. In addition, a traditional threading technique was wrapped around the bamboo to stabilize the tube and reduce splitting under stress.

3. Solution - Slit Geometry

The outward-facing slit increases acoustic activation by exposing two wind-attacked edges in opposite directions. This allows sound generation from multiple wind directions, making it particularly effective in changing outdoor airflow conditions.

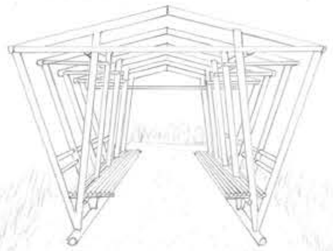


4. Solution - Flute Orientation

Flutes were adapted to the site's wind data instead of placed randomly. Multiple flutes were rotated either individually or in small groups, improving sound production

The Activated In-Between

This research aims to bring the act of sitting in our project closer to its full spatial and atmospheric potential. It explores how seating elements can invite people to remain within the pavilion and experience it over time, rather than simply passing through.
The investigation is centered on bamboo as the primary material, testing different variations to understand not only structural possibilities but also how people behave in the space and how it affects them. Bamboo becomes both structure and seating surface, forming a continuous system that shapes space, supports the body, and responds to environmental conditions. In particular, the interaction with wind is essential: the bamboo moves subtly and produces sound, activating the pavilion and enriching the sensory experience.
At the same time, we studied how seating can provide comfort and encourage people to settle in, creating a balance between physical ease and sensory awareness. The positioning of the seating was also carefully analyzed to understand how people relate to one another spatially without weakening the overall concept. In this way, social interaction, material behavior, and spatial intention come together to form a cohesive and immersive environment.



SEATING SURFACE

The key decision is whether the chair behaves as a rigid object or a structure responsive to the body. A boxed system saves space, stores rigid movement, secures body shape, and translates wind into visible movement. It feels safe, calm, and alive, but is less precise, and requires careful tension to remain stable.

A closed system with drilled stools is rigid and stable. Every part stays in place, creating a clear structure, but it feels more detached and less responsive. Bound systems respond to body and environment, while fixed systems remain independent.

For a project focused on silence, wind, and perception, the best solution is the system with a stable main structure and lightly bound bamboo elements, where adjusting the tightness allows material flexibility that balances stability with subtle movement so the body can sense wind and space.

Varying the bamboo elements in size and position transforms the grid from a simple surface into a kind of topography that actively shapes the body. Differences in diameter create natural pressure points: thicker bamboo carries more load and defines the main support areas, while thinner elements become more subtle and less dominant. As a result, the body informally finds its balance points and adjusts to the structure.

This can be organized in different ways. A random mix creates a very lively and irregular surface. A gradual transition from thick to thin elements introduces a clearer direction and supports the body in a more guided way.

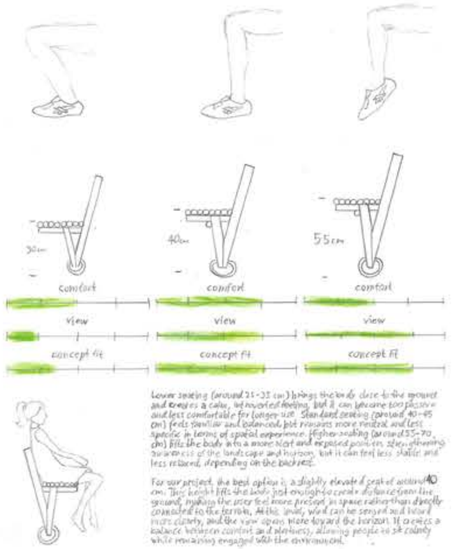
Small height differences between the bamboo elements create a gentle micro-relief, which keeps the body slightly present without touching discomfort, as long as transitions remain soft and not too abrupt.

Overall, this variation prevents the seat from becoming overly big. Instead, it keeps the body subtly engaged, enhancing awareness without overwhelming it. When combined with a slightly flexible structure, the result is a stable yet living surface where the body is grounded but still sensitive. The goal is for the person to sit down easily, remain relaxed and comfortable while also becoming curious or feeling asleep, while staying subtly alert, engaged with the space, and attentive to listening.

1/4

SEAT HIGHT

Sitting height is one of the most powerful design parameters in our project, because it influences far more than comfort—it directly shapes behavior, attention, and the emotional relationship to a place. In a project focused on silence, wind, and perception, it becomes almost more important than form itself, because it defines how the body enters the environment.



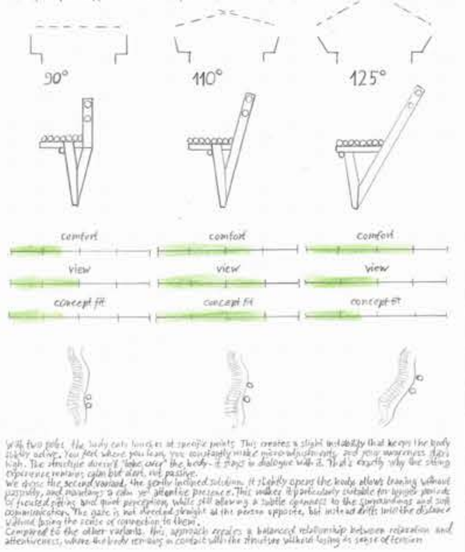
Lower seating (around 25–35 cm) brings the body close to the ground and creates a calm, withdrawn feeling. But it can become too passive and less comfortable for longer use. Standard seating (around 40–45 cm) feels familiar and balanced, but remains more neutral and less specific in terms of spatial experience. Higher seating (around 55–70 cm) lifts the body into a more alert and exposed position, strengthening awareness of the landscape and horizon, but it can feel less stable and less relaxed, depending on the backrest.

For our project, the best option is a slightly elevated seat of around 40 cm. This height lifts the body just enough to create distance from the ground, making the user feel more present in space rather than directly connected to the terrain. At the same time, it can be sensed and heard more clearly, and the view opens more toward the horizon. It creates a balance between control and alertness, allowing people to sit calmly while remaining engaged with the environment.

2/4

BACKREST ANGLE

With two poles, the body rests on pressure contact points, creating slight instability that keeps it subtly active and aware. The user continuously makes small adjustments, maintaining a balance between calmness and alertness. Adding a third pole increases stability and distributes pressure more evenly, but reduces sensitivity. The body relaxes more fully, shifting the experience from active perception to passive comfort. In short, two poles support awareness and presence, while three poles promote stability and relaxation.

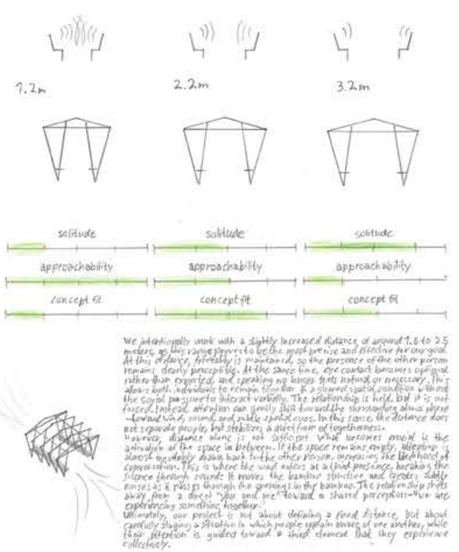


With two poles, the body rests on specific points. This creates a slight instability that keeps the body subtly active. You feel where you lean, you constantly make micro-adjustments, and your awareness stays high. The structure doesn't "take care" the body—it stays in dialogue with it. That's exactly why the sitting experience remains just alert, not passive.
We chose the second variant, the gently inclined solution. It slightly opens the body, allows breathing without passivity, and maintains a calm yet attentive presence. This makes it particularly suitable for longer periods of focused silence, wind and sound perception, while still allowing a subtle openness to the surroundings and social communication. The gaze is not directed straight at the person opposite, but instead drifts into the distance without losing the sense of connection to them.
Compared to the other variants: The upright one creates a balanced relationship between relaxation and attentiveness, where the body remains in contact with the structure without losing its sense of tension.

3/4

SEATING DISTANCE

We are searching for a spatial condition that enables something seemingly paradoxical: proximity as a form of connection, without it automatically turning into conversation. What matters is not just geometry, but the interplay between distance and other aspects in the space between people.

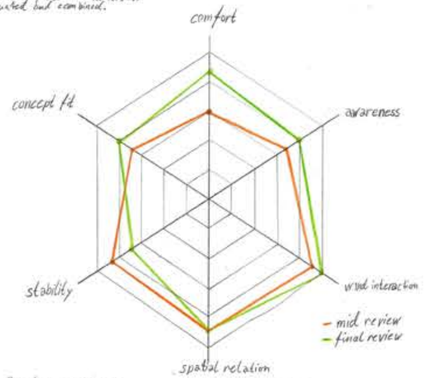


We intentionally work with a slightly increased distance of around 1.8 to 2.5 meters, as this range proves to be most precise and effective for our goal. At this distance, perceptibility is maintained, so the presence of the other person remains clearly perceptible. At the same time, eye contact becomes optional rather than expected, and speaking no longer feels natural or necessary. This allows both individuals to remain fully in a relaxed spatial condition, to enjoy the social presence to interact verbally. The relationship is held, but it is not forced. Instead, attention can gently drift toward the surroundings, always aware of the other person, but shielded, a distribution of togetherness.
However, distance alone is not sufficient. What becomes crucial is the activation of the space in between. If the space remains empty, attention is almost inevitably drawn back to the other person, increasing the likelihood of conversation. This is where the wind enters as a third presence, breaking the silence through sound. It moves the bamboo structure and creates subtle noises as it passes through the grooves in the bamboo. The person may drift away from 2 shared "you and me" toward a shared perception—"We are experiencing something together."
Ultimately, our project is not about defining a fixed distance, but about carefully staging a situation in which people remain aware of one another, while their attention is guided toward a third element that they experience collectively.

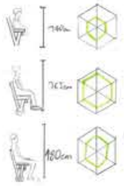
4/4

GRAPH

The rating of all three actors was evaluated and combined.



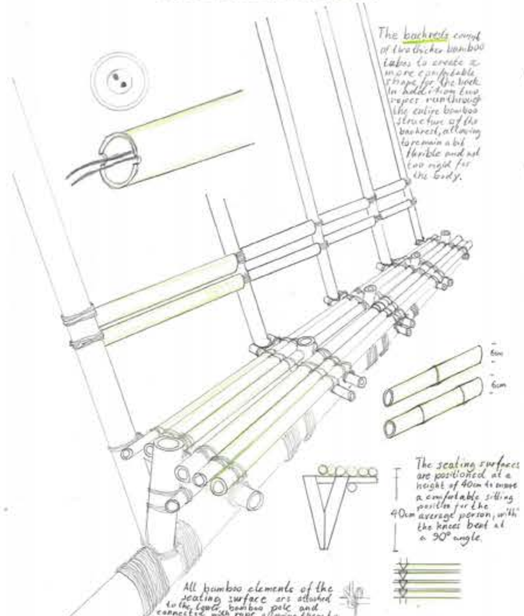
3 actors - 3 heights



We want to include people of all ages and sizes in order to provide everyone the best possible experience of the pavilion

CONCLUSION

The backrest consist of two inches bamboo tubes to create a more comfortable shape for the back. In total, 4 cm two layer runs through the entire bamboo structure of the backrest, allowing to remain a bit flexible and not too rigid for the body.

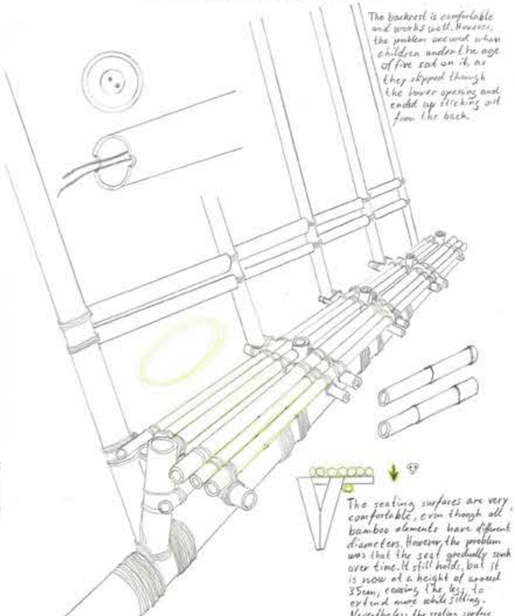


The seating surfaces are positioned at a height of 40cm to make a comfortable sitting position for the average person, with the knees bent at a 90° angle.

All bamboo elements of the seating surface are attached to the front bamboo pole and connected with rope, allowing them to function as a single unit rather than as independent elements, to create a more comfortable seating surface.

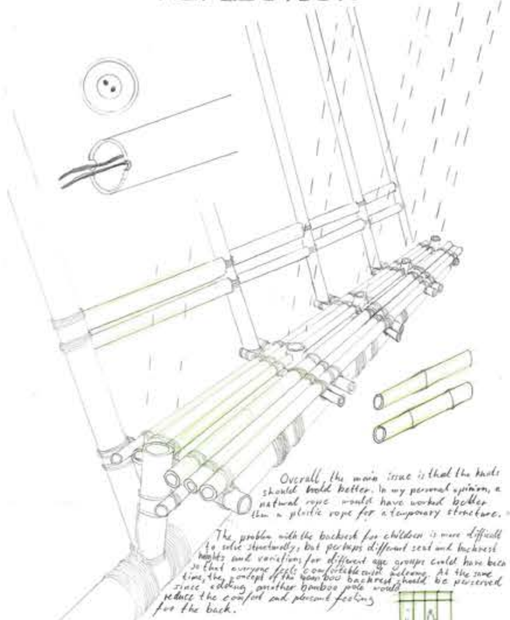
OBSERVATION

The backrest is comfortable and works well. However, the problem occured when children under the age of five sat on it, as they slipped through the lower opening and ended up sticking out from the back.



The seating surfaces are very comfortable, even though all bamboo elements have different diameters. However, the problem was that the seat gradually sank over time. It still holds, but it is now at a height of around 35cm, causing the legs to extend more while sitting. Nevertheless, the seating surface remains comfortable and still stays parallel to the ground.

REFLECTION



Overall, the main issue is that the backs should hold better. In my personal opinion, a natural rope would have worked better than a plastic rope for a temporary structure.

The problem with the backrest for children is more difficult to solve structurally, but perhaps different seat and backrest heights and variations for different age groups could have been so that everyone feels comfortable and belongs. At the same time, the concept of the bamboo backrest should be preserved since adding another bamboo pole would reduce the comfort and pleasant feeling for the back.

BAMBOO
BEHAVIOROLOGY

Choosing the right material is an important step in the design process. Our group selected bamboo because of its ability to act as a flute and produce sound with the wind. This report explores how bamboo is structured, which types are most suitable, how it behaves outdoors and how it can be processed. By understanding its characteristics, we can avoid problems. This knowledge helps us work with bamboo more confidently and use it effectively in our project.

Behaviorology Studio Zofia Gugala Research Report Sound Pavilion

Bamboo Anatomy

1. Stem
2. Stem base :
3. Stem wall :
4. Stem cavity :
5. Internode :
6. Node :

Holds upright, important for Photosynthesis

Top → thinner walls

Bottom → thicker walls

Allows faster growth

Prevent cracking along stem

Reinforcement

Prevents fire spreading

- Walls of vessels made of cellulose fibres

A. Outer skin:
Fibres concentration towards outside
↳ stronger

B. Inner skin:
Weaker

- Compared to wood:
  - Wood fibres more irregular and heterogenous uneven distribution of thick and thin walls
  - ↳ Both different structure of fibres which contributes different mechanical behaviour

- Components of bamboo:
  - lignin, cellulose, hemicellulose

Bamboo Species

Bamboo belongs to the Graminae family and consists of two large groups of species:
- Woody bamboo Bambúsoideae (1250 species)
- Herbaceous bamboo Olyrae (115)

For our project we need the woody bamboo as it is more stable and larger.

For that below is a comparison table of various species and how well it would suit our project.
D: Diagram W: Wall thickness S: Sound quality C: Construction A: Availability in Switzerland

Chusquea
D: 0.5 - 15cm
W: Solid
S: Impossible
C: Weak
A: Available
Solid

Gigantochloa
D: 3 - 20cm
W: Thick
S: Bad, low sensitive
C: Strong
A: Expensive import
Hollow

Bambusa
D: 2 - 20cm
W: Medium
S: Good
C: Good
A: Available
Hollow

Guadua
D: 5 - 23cm
W: Thick, dense
S: Deep tones only
C: Strong
A: Available
Hollow

Phyllostachys
D: 2 - 18cm
W: Thin - medium
S: Very good
C: Good
A: Available
Hollow

Dendrocalamus
D: 8 - 30cm
W: Very thick
S: Poor
C: Strong, heavy
A: Very expensive import
Hollow

Conclusion:
The characteristics we need in a bamboo species suitable for our project are: not too large diagram, middle thick walls, good sound qualities, strong construction and available in Switzerland. Therefore Phyllostachys is the best choice.

Environmental Behavior

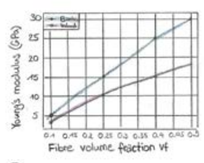
Since our project takes place outdoors, potential risks and their possible solutions must be carefully analyzed.

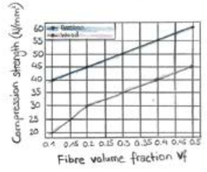
Risks	Solutions
• Humidity - Constant moisture exchange with air → dry bamboo 10-15% moisture content - Result: swelling, shrinkage and repeated stress - Diameter might slightly change	- Bamboo construction should avoid direct contact with the ground - Borax and boric treatment effective, however should be done before transportation abroad
• Rain - Rain entry through flute holes or cracks might cause swelling, splitting, mold or fungi and mosquito breeding	- The flute holes should be located above the node to avoid collecting water - Seal cracks with glue, resin or wax - Change angle of flute holes
• UV Exposure - Color changes: yellow → light brown → grey - Surface becomes rough and brittle, if temperature changes too fast, bamboo might crack	-Oiling might help slightly, but cannot prevent cracking fully
• Wind - Constant vibration can cause micro-cracks	- Does not affect or highly damage a temporary structure

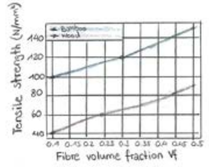
Conclusion:
Depending on where we buy the bamboo from, we might assume the anti-humid treatment was already performed. However, the foundation should avoid direct contact of bamboo with the ground. The flute holes should be above the node and in the correct angle.

Building Characteristics and Processing

Mechanical properties of bamboo compared to Wood (typical structural timber)

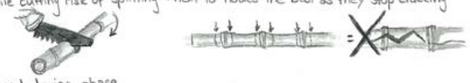






- Bamboo is stiffer than wood
- Bamboo resists compressive forces better than wood
- Bamboo is much stronger in tension than wood

- Cutting
  - Turn while cutting with saw to prevent fiber detachement in outer layer
  - While cutting risk of splitting → next to nodes the best as they stop cracking

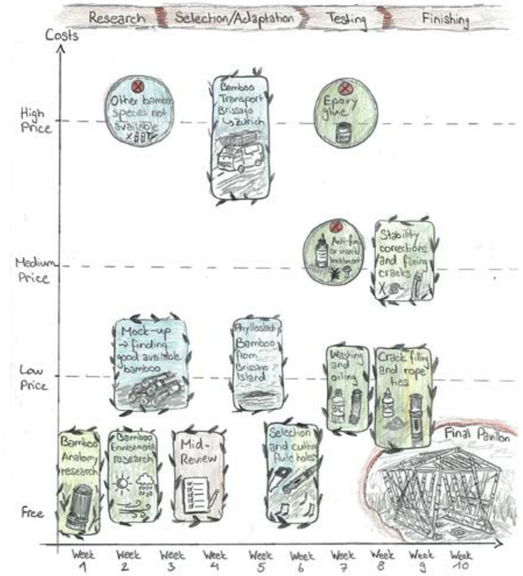


- Age and drying phase

Age	Use
< 30 days	Edible bamboo shoots
6-8 months	Weaving, basket decorations
2-3 years	Fiber for laminates and panels
3-6 years	Culms for construction
>6 years	physical properties gradually diminish

Conclusion: Bamboo is very stable and can be used after 3 years of its life for construction.

Graph



⊗ rejected plans/strategies ● Anatomy/Processing ● Treatment ● Species/Selection

Conclusion

The timeline graph shows the decision-making process throughout the whole project. Because the research report focused on the behaviorology of bamboo, it became clear that truly understanding a material takes time and cannot come from reading alone. It also has to be tested, built with, touched, and observed in real conditions. Working directly with the bamboo helped us recognize what it needed, what it lacked, and which new issues appeared over time. I chose to compare the price to our plans and strategies as it also had a great influence on them. Some needed to be changed, some fully rejected. The transport was at the end most expensive. When analyzing, I realized our strategies could be divided into several work stages:

Research
- Process began with gaining knowledge with research. Through this we formed our first expectations and plans, which led to more ideas on paper.

Testing
- By directly working with bamboo, touching it and testing new things, unknown issues occurred. Through this we had to change our plans and the design.

Research → Experience → Adaptation → Final decision

Selection
- Seeing all stages of bamboo, testing them made us understand which pieces fit our construction the best.

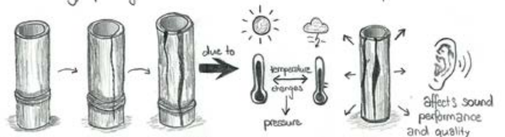
Adaptation
- We understood that some assumptions made during the research stage did not at all help us. → New strategies were introduced spontaneously.

Final bamboo behaviorology strategy

Concluding the graph shows how the research, before starting to build, helped us along the way. However, it alone is not enough; All research, testing, selection and adaptation created the final Pavilion

Observation

- Cracking/Splitting over time (Observed on the mock-up)



Day 1 - no cracks - stable
Week 1 - starts cracking - flutes still work
Week 2 - several bigger cracks - flutes don't work

- Different bamboo conditions (Observed during bamboo selection)

Older dry bamboo Younger partly green bamboo

- Transport, cutting and self-care

cut and transported by us, so no previous treatment → still necessary

- Ground contact

⊗ Ideally foundation should not touch the ground due to humidity

Reflection

- Contacted zeelian bamboo flutes specialists as well as bamboo experts about the splitting
  - ↳ cracking is a natural bamboo behavior

↳ cracking cannot be fully prevented, however treatment can stabilize bamboo slightly.

- Testing several glues before buying expensive and toxic epoxy.

↳ worked well with waterproof wood glue

- We filled the cracks with waterproof glue and bamboo powder that washed it once it's dry

↳ bamboo powder matches correct color

- Washing and oiling bamboo

↳ Oil stabilizes bamboo outdoors and gives right amount of humidity for too dry bamboo

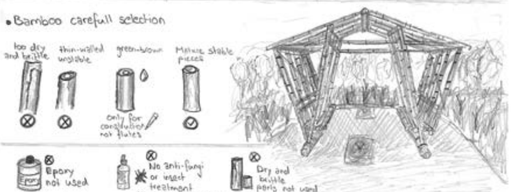
- Rope ties around bamboo

↳ Flute reinforcements stop cracking

- Foundation contact with the ground

↳ Does not harm bamboo if it's a temporary construction

- Bamboo carefull selection



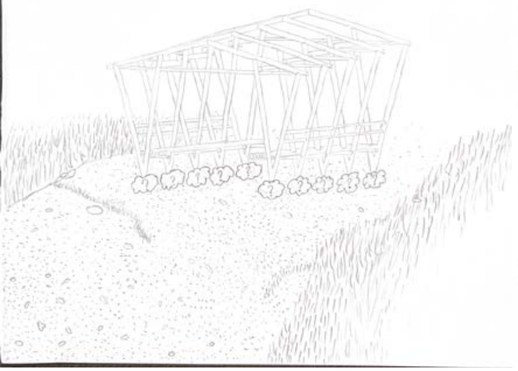
Eric Hess
Group 1

Chair of architectural Behaviorology FS26

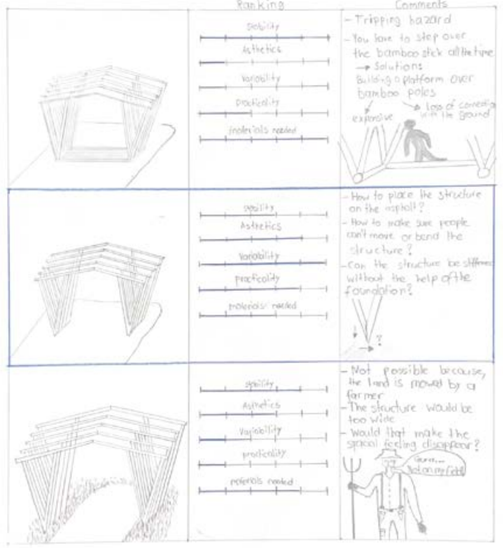
Foundations

Site 1: Water Tank

The foundation of a structure seems simple, but the question of anchoring a structure is key. In this research report I will start by approaching the question of "how to touch the ground?". Concluding on that I will show different ways to create the needed downward force by showing different typologies of possible foundations. In the next chapter the issue of transporting the structure from RIA to the site is being discussed. The last chapter deals with calculations related to the foundation.

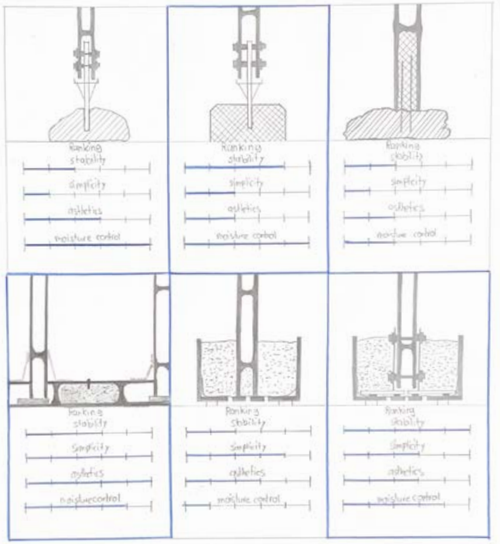


How to touch the ground?



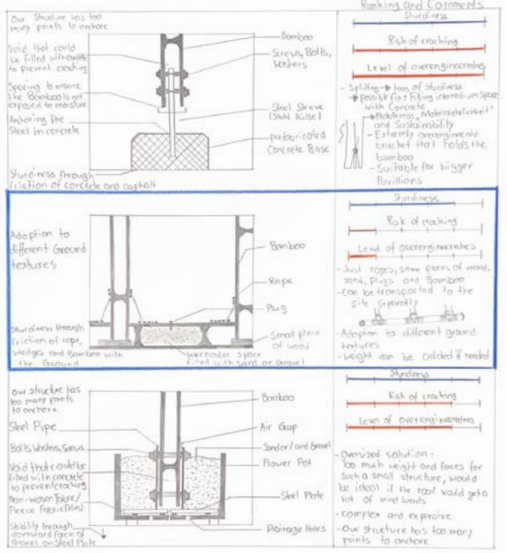
Conclusion: Only the version where the structure is placed directly on the floor and does not have a beam on the pathway is an option. A solution must therefore be found that allows the structure to stand on the ground without being physically anchored to it.

Typologies



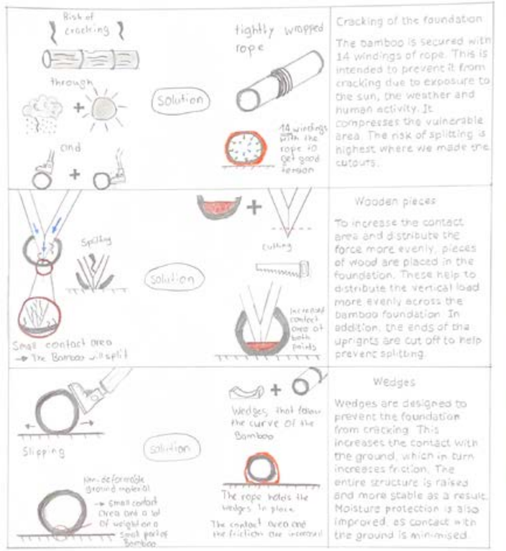
Conclusion: There are many possible solutions to the same problem. The three encircled ones are the best characteristics according to the four ranking categories. Especially the 3rd and 5th have a moisture problem due to the constant contact with the ground. And the disadvantage in the 1st option is its complexity without any benefits compared to the 2nd.

Sturdiness



Conclusion: Sturdiness is one of the most important characteristics a foundation must have. All three options presented offer sufficient sturdiness; however, the first and third options are overengineered for the loads acting on the foundation. Furthermore, these options carry a risk of the bamboo splitting. This could only be addressed using methods that are not compatible for our project.

Managing the forces



Cracking of the foundation

The bamboo is secured with 14 windings of rope. This is intended to prevent it from cracking due to exposure to the sun, the weather and human activity. It compresses the vulnerable area. The risk of splitting is highest where we made the cutouts.

Wooden pieces

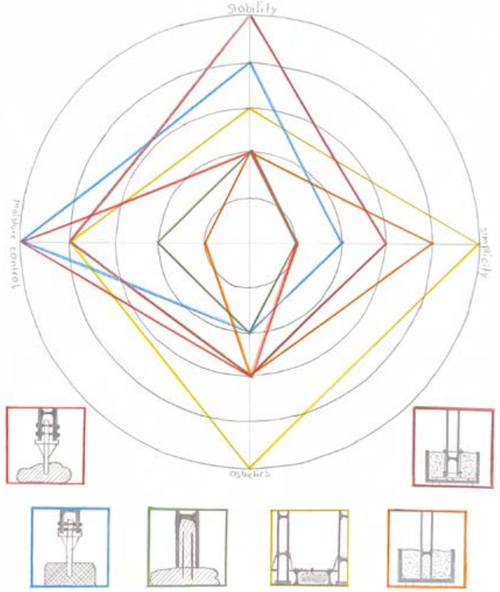
To increase the contact area and distribute the force more evenly, pieces of wood are placed in the foundation. These help to distribute the vertical load more evenly across the bamboo foundation. In addition, the ends of the uprights are cut off to help prevent splitting.

Wedges

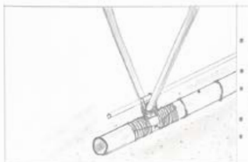
Wedges are designed to prevent the foundation from cracking. This increases the contact with the ground, which in turn increases friction. The entire structure is raised and more stable as a result. Moisture protection is also improved, as contact with the ground is minimised.

Conclusion: The foundation is subjected to a great deal of force. The wooden components in the foundation are designed to maximise the contact area with the bamboo. The lacing around the bamboo foundation serves to prevent it from splitting. The wedges serve to better transfer the force into the ground.

Graph

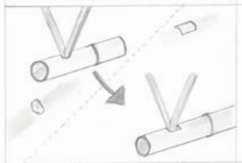


Conclusion



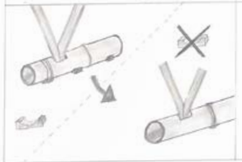
Foundation as implemented

- Rectangular cut-out instead of a perfectly fitted one.
- Wrapped with 14 rounds of rope
- Wood inside the bamboo to distribute the forces
- Intermodal space filled with sand
- Wooden plug



Cut-out

A rectangular cut-out was easier to create. Creating ten perfectly fitting cut-outs would have been very time-consuming. Moreover, it was practically impossible, as the pavilion was very flexible without the foundations. We also realised that the fitting cut-outs would have contributed very little to overall stability.



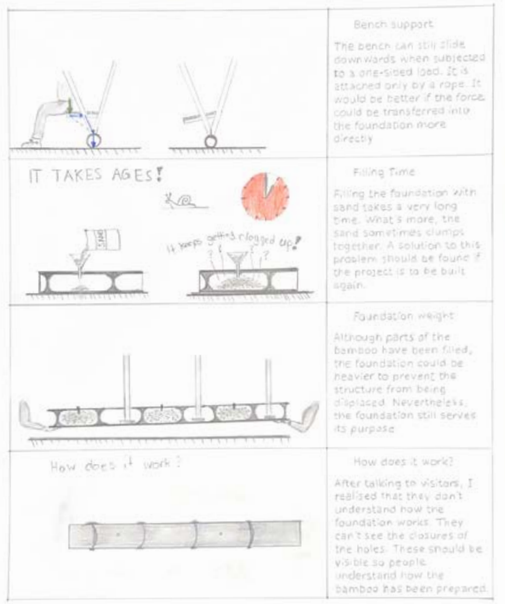
Ground contact

After several discussions and further research, I have discovered that ground moisture is a minor issue at our site. Furthermore, the structure is heavy enough that the additional friction on the ground caused by the wedges is unnecessary. The bamboo can withstand the load even without the wedges.

In this research report, I have examined the foundations of our structure. The report is divided into several chapters, in which various options are weighed up against one another. On page four, solutions were found for minor details.

Despite the research, the foundation was not built entirely as proposed in the research report. Protection against moisture proved not to be very important. During construction, we also found that creating the perfect recesses for the verticals was difficult and time-consuming to implement.

Observations



Bench support

The bench can still slide downwards when subjected to a one-sided load. It is attached only by a rope. It would be better if the forces could be transferred into the foundation more directly.

Filling Time

Filling the foundation with sand takes a very long time. What's more, the sand sometimes clumps together. A solution to this problem should be found if the project is to be built again.

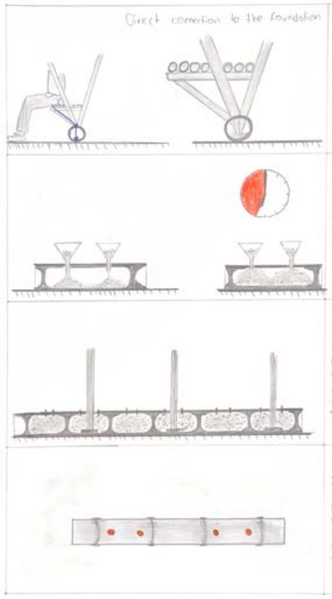
Foundation weight

Although parts of the bamboo have been filled, the foundation could be heavier to prevent the structure from being displaced. Nevertheless, the foundation still serves its purpose.

How does it work?

After talking to visitors, I realised that they don't understand how the foundation works. They can't see the closures of the holes. These should be visible so people understand how the bamboo has been prepared.

Reflections



Settling Bench

One solution for the settling bank would be a bamboo pole that transfers the force directly into the foundations. This would prevent the settling and strengthen the structure.

Two Holes

With two holes, the time taken to fill the foundation could be significantly reduced. This would also prevent clumping.

More weight

Filling the holes where the vertical supports are located could add more weight. It would probably also strengthen the structure. This would need to be tested.

Color coding

If the closures were marked in bright colours, it would be clear that the bamboo is filled. Visitors could then understand and learn for themselves all the things that can be done with bamboo.

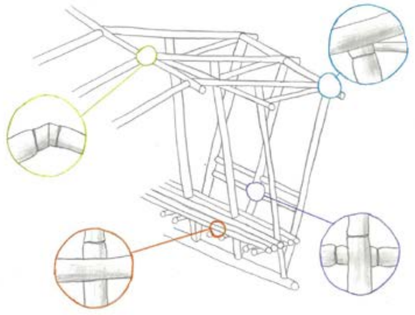
Amelie Richerdt

Group 1

Chair of architectural Behaviorology FS 26

BAMBOO JOINERY

Side 1: Water Tank

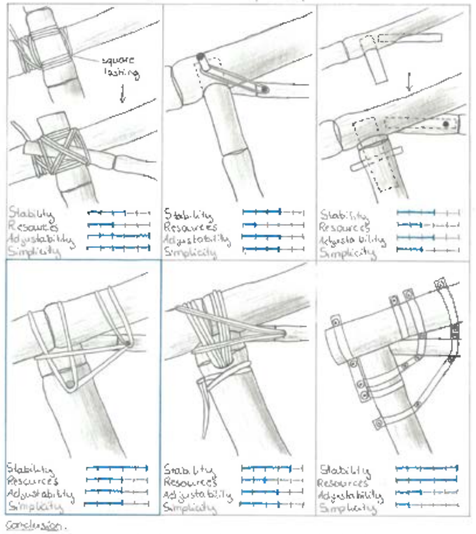


Joinery is a critical aspect of bamboo construction as joint failure can weaken both structural performance and user safety. This report investigates a series of joint typologies used within the project, evaluating them according to stability, resources, adjustability and simplicity. Multiple techniques were tested and compared through observation and construction, leading to informed decisions for each joint. The report concludes with a reflection on how context specific constraints shape appropriate structural solutions.

Amelie Richerdt
Bamboo Joinery

1/4

KNOT 1



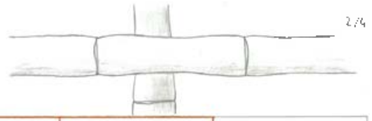
Conclusion:

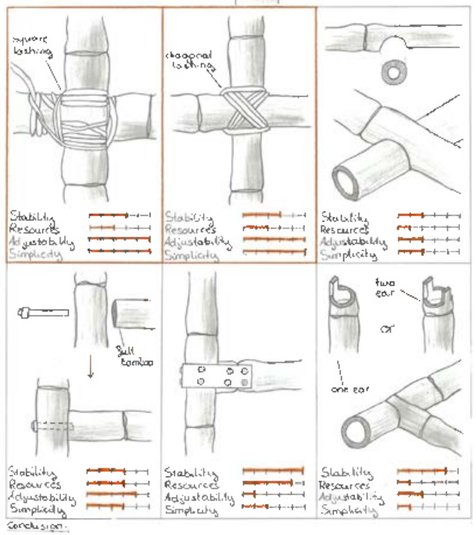
Friction based solutions proved insufficient for controlling the inclined load, while metal connectors required too many materials and precision. The plagged lashing was chosen as it provides good force transfer while remaining simple and adaptable for the project.

Amelie Richerdt
Bamboo Joinery

2/4

KNOT 2





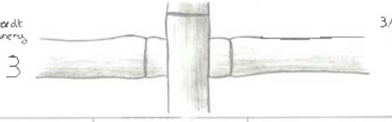
Conclusion:

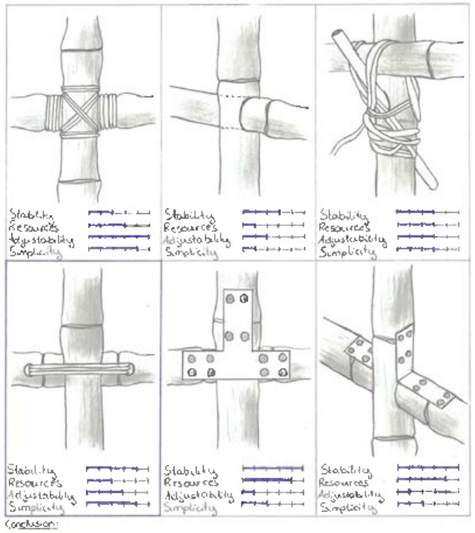
The joint is primarily required to stabilize the seating elements rather than high vertical loads. The combination of square and diagonal lashing was therefore selected, as it provides sufficient stability while remaining simple, repeatable and adaptable to bamboo geometry.

Amelie Richerdt
Bamboo Joinery

3/4

KNOT 3





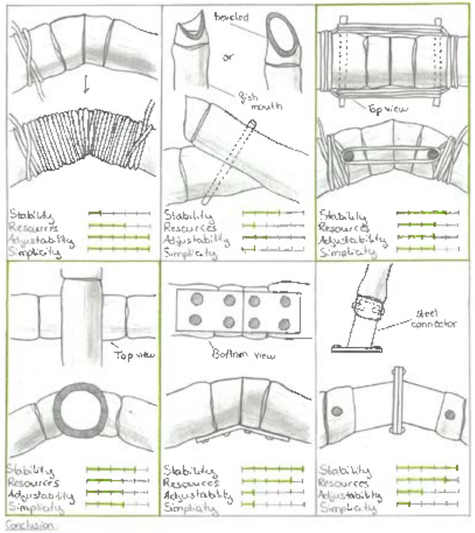
Conclusion:

The backrest joint prioritizes comfort, repetition and tolerance to movement rather than maximum structural capacity. The drilled lash rig was selected as it provides a compact, secure connection while remaining adaptable and resource efficient within the project context.

Amelie Richerdt
Bamboo Joinery

4/4

KNOT 4



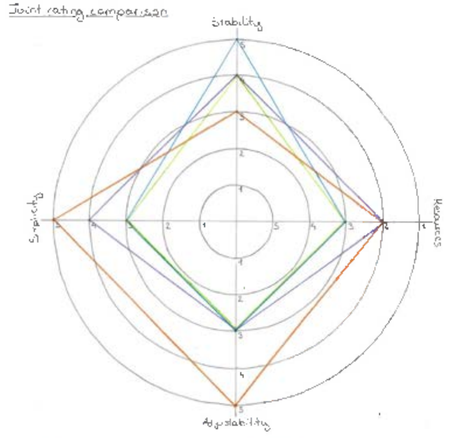
Conclusion:

Engineered steel and bolted joints offer high stability but exceed the project's constraints in resources and accessibility. Therefore, the double drilled pegged joint with an additional bamboo wedge element for improved stability was selected as the most balanced solution.

Amelie Richerdt
Bamboo Joinery

GRAPH

Joint rating comparison



Knot 1

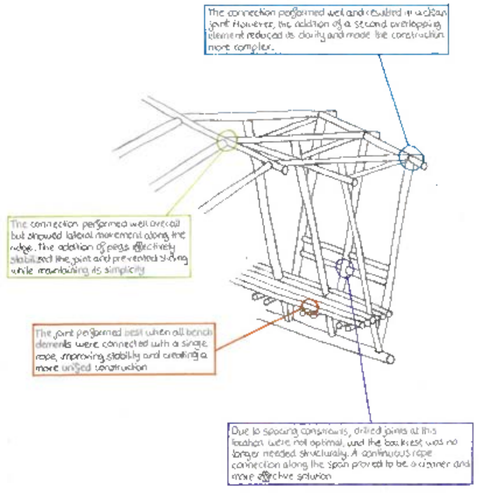
Knot 2

Knot 3

Knot 4

Amelie Richerdt
Bamboo Joinery

CONCLUSION



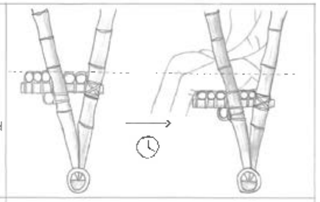
This research demonstrates how different joint typologies were explored, tested, and adapted throughout design process. Rather than aiming for maximum structural performance, the final solutions reflect a balance between stability, simplicity, resources, and adaptability, shaped by the specific constraints of the project and the material.

Amelie Richerdt
Bamboo Joinery

OBSERVATIONS

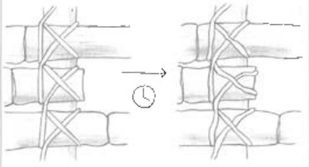
Seating height:

The seating height decreases over time with use, as the rope gradually loses its initial tension and settles under repeated loading. This causes the seating surface to become lower than originally intended after continued use.



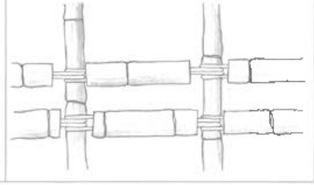
Rope:

At locations where knots overlap or are placed close to edges, the rope tends to slip and shift along the bamboo surface. In some cases, it can move into adjacent holes, which reduces tension and causes the joint to loosen.



Backrest:

The backrest joint resulted in a clean and visually minimal connection but allowed slight movement during use. This can lead to occasional misalignment, where the backrest shifts into unintended positions.

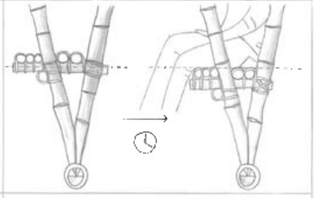


Amelie Richerdt
Bamboo Joinery

REFLECTIONS

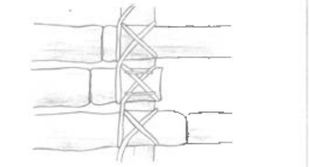
Seating height:

This behavior could have been anticipated and integrated into the design strategy from the beginning. Originally positioning the seating slightly higher, it would settle into the correct height over time.



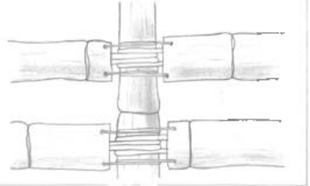
Rope:

To address this issue, additional thin rope windings were introduced to tie the main rope in position. This helped prevent unwanted movement and maintained the stability of the joint over time.



Backrest:

Additional small drillings combined with thin rope connections could improve the positional stability of the backrest. This approach would secure the element more effectively while maintaining the minimal and non-invasive character of the joint.

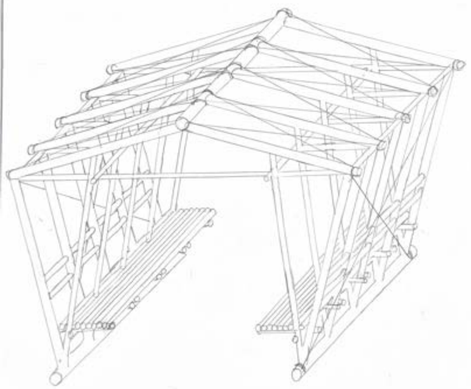


Structure & Stability

Chair of Architectural Behaviorology FS26

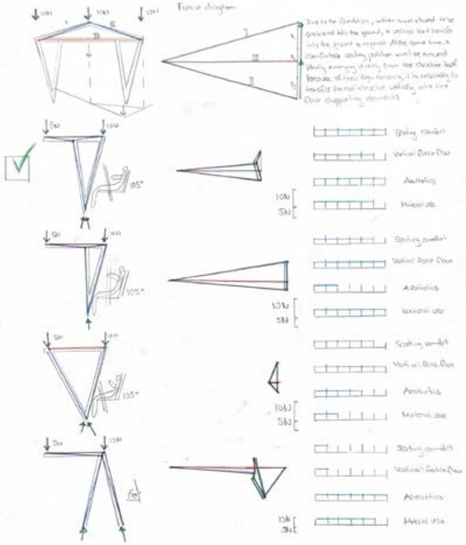
Nicolas Wimmelsser

Structural design defines how a project stands, carries loads, and remains safe, making it one of the most important aspects of any construction. In the following project, the structure fulfills several functions at once: it serves as the main load-bearing system, forms the framework for the seating areas, and also acts as a musical instrument. The focus of this structural investigation lies on the leg typology, the hinge system, and the bracing strategies needed to achieve overall stability.



Nicolas Wimmelsser

Leg Typology

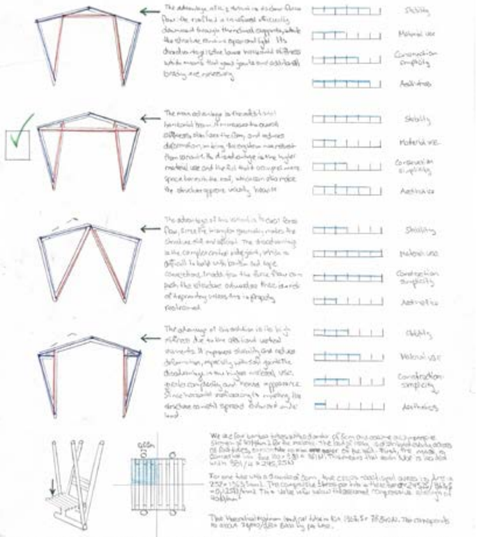


Conclusion: Version 1 is the most common approach, provides a vertical load transfer through the supports, offers a seating angle of 105°and presents a more material efficient variation of version 2. In contrast version 2 & 3 do not transfer the forces vertically and would therefore require a more rigid foundation. Version 3 is also unsuitable in terms of seating comfort.

Nicolas Wimmelsser

Hinge Systems & Stability

effect of hinges and stability of material



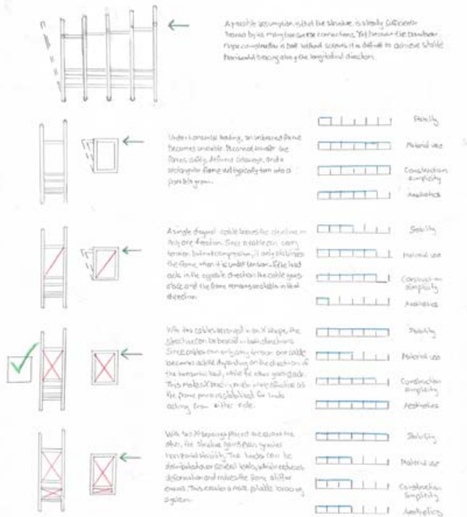
In conclusion, Version 2 is the best option since the most common bridge typologies and constructions. The additional hinge increases stiffness and reduces deformation, while especially angled hinges help to transfer forces more directly into the supports.

With a load of 100N per each the components stress in the chair has also been calculated. For both the selected composite designs of version 2. This shows the structure can easily carry the load.

Nicolas Wimmelsser

Stiffening

how to deal with vertical loads from both sides



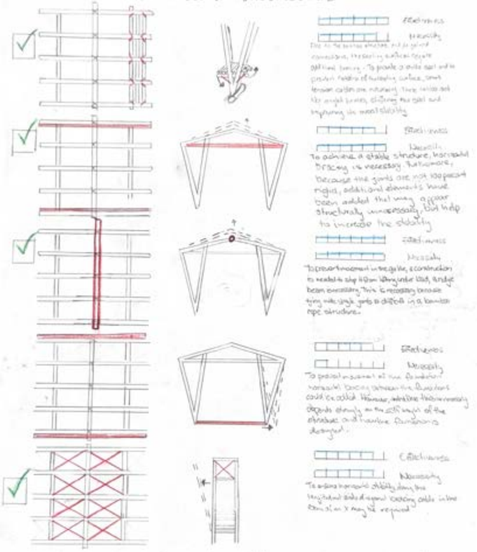
In conclusion: the version with no cable or any one diagonal does not stabilize properly, because they cannot provide stability in both directions at once. A single X function as both cable for tension and strut for compression, but only stabilizes the frame when it is under tension. Either load case in the opposite direction the cable goes slack and the frame remains unstable in that direction.

With two stabilizing elements in each direction, the construction becomes redundant. Since each cable only has to take tension, it can be made very thin and lightweight. Even if one cable goes slack during compression, the other one remains fully effective. This makes the system much more reliable and safer overall.

Nicolas Wimmelsser

Structural Add-Ons

how to deal with unstable details

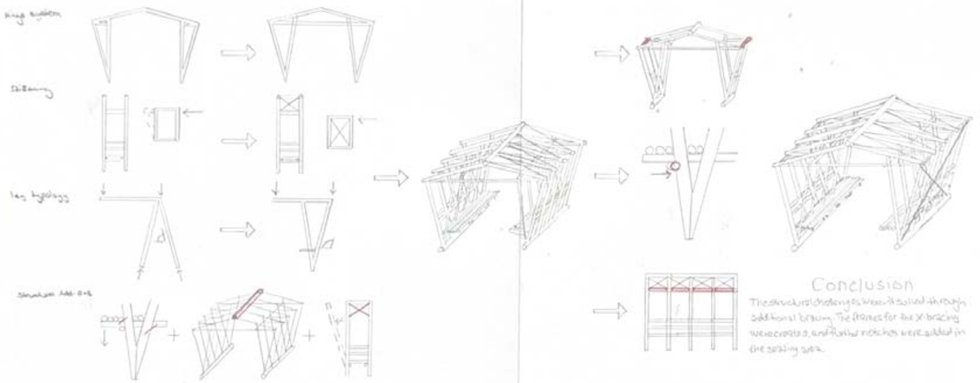


In conclusion: Proposal 1 and 2 are considered to be more effective in terms of stability and material usage. Proposal 3 is the necessary, but only in the external direction. Proposal 4 should not be considered at all. Proposal 5 needs to be tested although it is not strictly required from structural point of view.

Nicolas Wimmelsser

Nicolas Wimmelsser

GRAPH & CONCLUSION



Conclusion

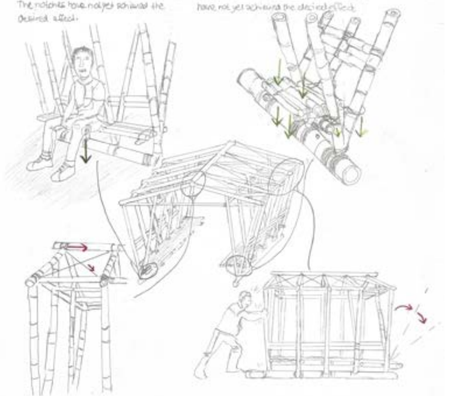
The structural challenges were successfully solved through additional bracing. The fixtures for the X bracing were welded, and drilled holes were added in the seating area.

Nicolas Wimmelsser

OBSERVATIONS

The seating surfaces did not yet sufficiently stabilized, as they flex downward under load. The notched tops, no yet achieved the desired effect.

The curve bench leans noticeably under load. The joints, in combination with the notches, have not yet achieved the desired effect.

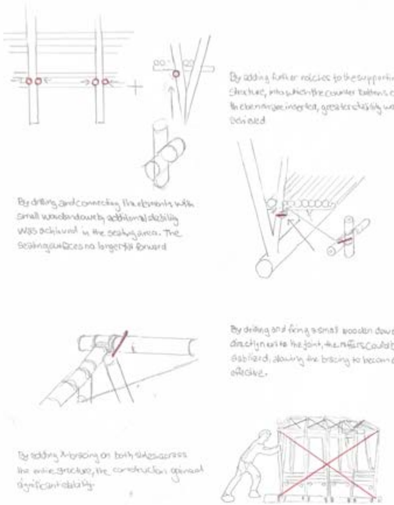


Due to the tension from the first and last X-connections at the gable, the respective rafters are pulled toward the center.

The multi-directional loads makes provisional, distinct horizontal bracing the most effective and practical.

Nicolas Wimmelsser

REFLECTION



By adding further notches to the supporting structure, which acts like counter battens, as the chair no longer moved, greater stability was achieved.

By drilling and connecting the elements with small wooden dowels, additional stability was achieved in the seating area. The seating surfaces no longer slip forward.

By drilling and fixing small wooden dowels directly next to the joint, the rafters could be displaced, allowing the bracing to become effective.

By adding X-bracing on both sides across the entire structure, the construction gained significant stability.

https://kaijima.arch.ethz.ch/wp-content/uploads/2026/05/260505_FS26_Final-Review_Water-Tank_Video.mp4