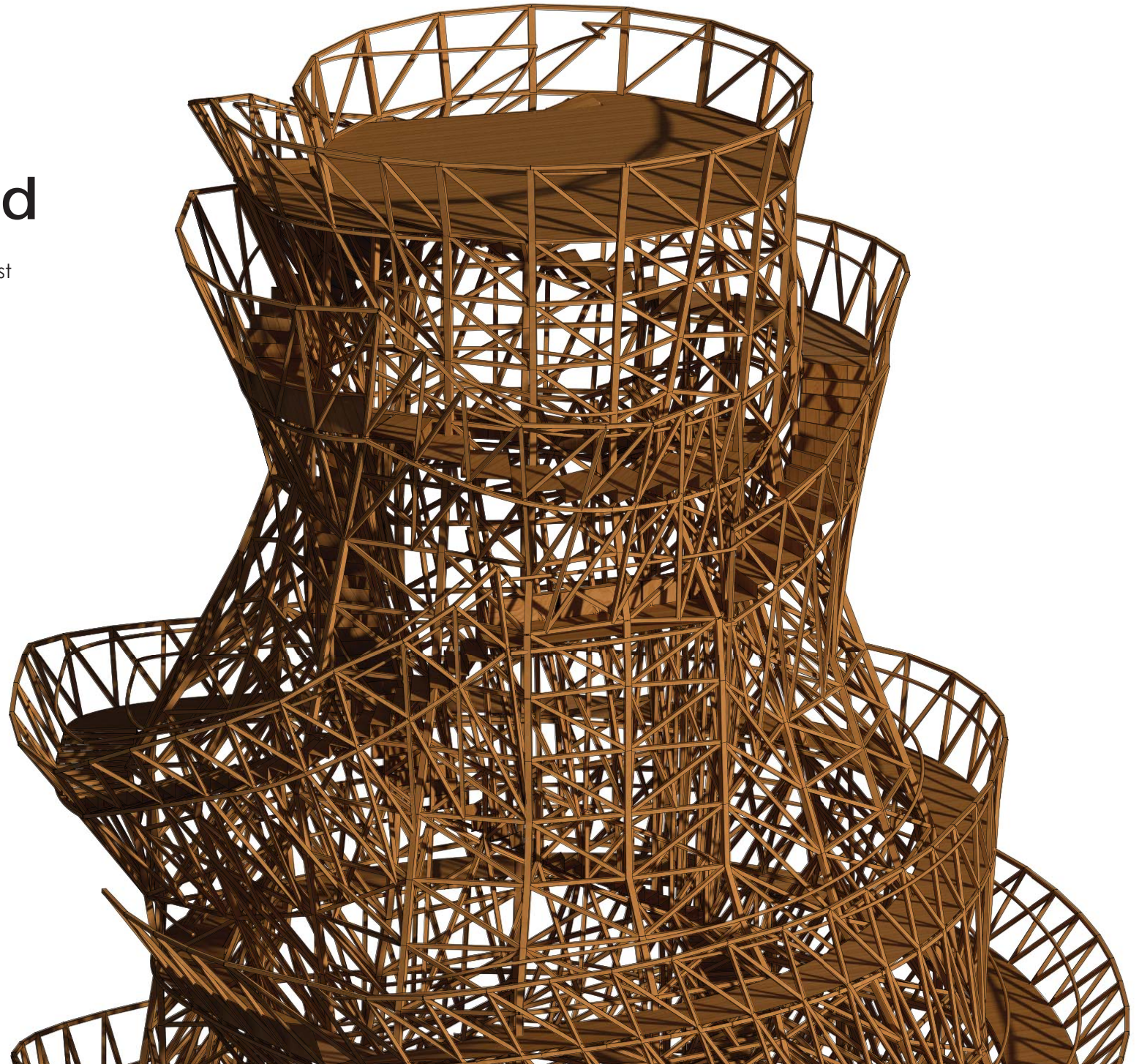


# View of Wood

Experiences and Perspectives of Forest  
and Timber in an Observation Tower

by Karin Cajmatz



*Chalmers School of Architecture*

*Examiner: Morten Lund*

*Tutors: Jonas Carlson and Kengo Skorick*



# CHALMERS

## VIEW OF WOOD

-Experiences and Perspectives of Forest and Timber in an Observation Tower

Master's thesis 2016

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# ABSTRACT

In modern times, timber building has been limited to the benefit of steel and concrete. This thesis aims at creating a new interest for, and to draw attention to, timber building. Though timber is on the rise again, many new timber structures do not utilize the material to the best of its potential and part of the problem is a lack of skilled carpenters. From this came the idea to create this timber tower that is meant to be built as part of an educational process to teach carpentry.

This thesis consists of a series of investigations into how modern timber architecture can offer new perspectives on the timber material as well as the forest landscape, the source of the material. The investigations have had different focuses. One group of investigations is aimed at spatial aspects, experiences and circulation logic, completely separate from the timber material and building techniques. Another group is about the overall concept of the structure and how it relates to the walk paths up and down the tower. The outcome of these investigations has been applied in the design of an observation tower in Bengtsfors, Sweden. A final investigation into materials and joinery that would enable the tower to be built by inexperienced workers concludes the thesis and suggests the next iteration of the design.

Along with a parallel thesis in structural engineering, this thesis is a part of this tower project. Throughout the whole process, a combination of physical and digital models has been used and the alternations between them have been important in order to always find the most effective way to investigate matters. At the beginning the work was focused on spatial experiences, but early on the collaboration with structural engineering became very important. An example is the idea of two separate walk paths that led to the concept for the structural system.





# CONTENTS

INTRODUCTION	7	Sequences in space on site	60
DISCOURSE	9	The Adventurous path	62
Local conditions	9	The Inspiring path	64
Material references	10	Material	66
Spatial reference	12	Timber	66
SPATIAL INVESTIGATIONS	13	Steel	68
Certain parameters affect the perception of your position	13	Joinery	70
Over	14	Alternative 1	72
Inside	15	Alternative 2	74
Near	16	CONCLUSION	76
Outside	17	Reflections	76
Under	18	To consider in future work	76
Below	19	REFERENCES	78
Between	20	Written references	78
On top	21	Other references	78
Above	22	Figures	78
Different path types have different consequences	23		
Different types of path offer different physical and mental preparation	23		
Path type defines path length	24		
Combining parameters into Events	26		
Combining path types is necessary for Events	28		
STRUCTURAL INVESTIGATIONS	30		
Structure and movement	30		
Intertwined is the best alternative for two paths	32		
Intertwined paths as a structural concept	33		
Further concept sketches	35		
The selected concept	37		
The paths define the structure	38		
Discovering possibilities and opportunities for structure and spatial experiences	38		
Different options have different interesting aspects	41		
SEQUENCE INVESTIGATIONS	42		
Sequencing Events	42		
Important Events	42		
Established sequences	44		
CONTEXT	45		
A small town with an industrial heritage	45		
The museum area and the site	48		
The view from the tower	52		
FORMATION	54		
The structure defined by the paths	56		
The structure that carries the paths	58		



# INTRODUCTION

My name is Karin Cajmatz and you are reading my master's thesis *View of Wood - Experiences and Perspectives of Forest and Timber in an Observation Tower*. I got my bachelor in Architecture and Engineering at Chalmers University of Technology in 2012. Since then I have studied two master's programs at Chalmers; MPARC Architecture and Urban Design and MPSEB Structural Engineering and Building Technology.

Before starting my thesis work I knew I wanted to work with wood and that I wanted a project that would include both architecture and structural engineering. When I came across the opportunity to work on this observation tower it felt completely right. So during the past year I have been working on this tower project for my theses within both master's programs. This is my master's thesis in architecture, but this work is very closely linked to my thesis in structural engineering and the two have been written in parallel.

Every now and then I have been asked these questions: "Are you an engineer or an architect?" and "What is architecture and what is engineering within this project?". My answer is always the same. I am both and I can not separate architecture from engineering. Sure, I can say that a certain image is purely about architecture and that in doing a certain structural analysis I wasn't concerned with architecture, but I can never answer what I would have done if I was just an architect or just a structural engineer. Just like everyone else, I carry all of my personal experiences and previous education with me and it influences my work. In my case it just so happens to be that I am educated in both architecture and structural engineering and hence my work is always influenced by both.

This applies to this project of course. To simplify, one could say that the thesis in architecture has had a focus on spatiality and experiences, while the structural engineering thesis has focused more on the structural concepts and the construction. However, the idea from the beginning was to work closely together within the two disciplines and therefore the two theses are one project and hence a clear distinction can not be done.

The starting point for this thesis and the questions that it aims to answer has been the following:

- How can an observation tower be built to raise interest for timber as a construction material?
- How can the observation tower add value to its context, besides providing a widespread view?
- How can an observation tower be constructed in a way so that it can be built within the framework of the local adult education by students with no or limited experience in construction and carpentry?

You are now about to read my master's thesis in architecture. To get more information about the structural concepts and the reasoning behind choices regarding those, I suggest reading the thesis in structural engineering. But for now, sit back and let me take you through the series of investigations that, starting from the discourse, will take you through both spatial and structural investigations to finally end up in a design proposal for an observation tower in Bengtsfors, Sweden.

Karin Cajmatz  
Göteborg, January 2017

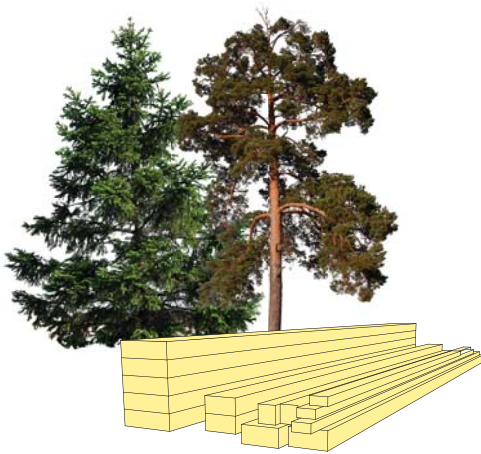




# DISCOURSE

## Local conditions

This thesis takes off from a desire to use more timber in construction in the region of Dalsland, which has a lot of forest. That requires an increased interest for the material, which requires attention. A way to draw attention to timber building and the forest, the local resource, is to build something public to show what the local high quality material can actually be used for and enhance the experience of the forest. From there came the idea of building a wooden observation tower in the forest landscape. There is also a desire to use the tower project to build knowledge and skill locally. That way future timber buildings could be built with both local material and local workers. The hope is that the tower will be something that draws attention, both as a project and as a built object.



### **Local quality material**

*The area has a lot of forest that can be used to produce high quality construction material. That is also what is done today, but a lot of the timber leaves the area. Instead, the forest could become a local resource that stays in the area and that is used for local construction projects.*



### **Eye opening effect**

*The tower shall be something else, something unpredicted. The goal is not merely to provide a way to get up above the treetops and see far, but something that is worth visiting for other reasons. The tower should be something for the town and the municipality to be proud of.*



### **Education and integration**

*Building in timber requires knowledge and skill, something that is becoming increasingly rare in Sweden. The town has unemployed inhabitants and a need for integration of newly arrived immigrants into the society as well as the labor market. The idea is to bring these groups together in courses aiming at developing skills and building a tower.*



### **Skilled workers and educators**

*There are some people who know how to build, who have experience and who can teach. The intention is to let these people and the companies and schools they belong to be involved in courses and in leading the work towards a built tower.*

# Material references

Historically, timber has been a very important construction material. So building in timber is not something new, yet the modern timber industry offers great possibilities compared to what was possible before engineered timber products and digital fabrication. Still, what is being done today doesn't always utilize these possibilities, or they are being utilized but not in the best way. At the same time there are projects that show that there is potential in standardized timber products, if we just think a step further. And thinking a step further is something that has to be done today, to ensure an environmentally friendly construction industry.



## ***Modern timber building is similar to concrete and steel building***

*Modern industrialized timber building tends to look like modern steel and concrete building. Many of the nice qualities of the material are lost when the timber is joined together with steel brackets and covered up in gypsum boards.*



## ***Digital fabrication offers possibilities for standard timber products***

*Modern production techniques offer possibilities. Camilla Schlyter's facade system is based on standard timber boards that in combination with digital production techniques offers variability and individualized patterns without the costs that were previously associated with such a one off production (Schlyter, 2016).*





### ***Steel in moderation is good for structures***

*In order for a structure to be perceived as wooden, the amount of steel must be limited. If only for example the columns are wooden, then the structure isn't perceived as wooden. On the other hand, thin steel elements can enhance the wooden elements and make them clearer, if used carefully and in moderation. Making everything out of wood isn't necessarily the right answer as it can mean that very large dimensions are required.*



### ***Steel in moderation is good for connections***

*The most effective and easy way to transfer forces in a node may be by making the entire node out of steel, but that also has a big influence on the visual aspects of the joinery. By utilizing slotted steel plates and recessed screws the load transferring capacity can be obtained in a more elegant way with the impression of wood maintained. Connections can also be created out of only wood, but in order to achieve the required capacity the joint may become chunky and also require excessive precision work and combinations of different wood species.*



# Spatial reference

The tower is intended not only as a means of transportation to a certain height, but to add value to its context. The question of what there is to experience on the site and as you ascend the tower was raised and a reference project found. The Bostoren tower in the Netherlands is an example of how a structure that may traditionally be just a staircase with a platform on top can offer something more. This tower lets you experience the site in new and unexpected ways in a number of pavilions along the way to the top.



## *Experiences and new perspectives*

*The experiences along the height of the tower are like added pavilions that become elective experiences. You can choose to stop at them or just pass by. They are different in character. Some are thrilling and really uncomfortable, like the one where you step out onto a net 27 above ground. Others are really calm and safe, like the box that frames a view straight into the trees.*

## *Contrast and sequence*

*The character of an experience is either enhancing or diminishing the following experience. For example, when a calm experience is followed by a thrilling one, the latter seems even more thrilling. On the other hand, when a thrilling experience is followed by an experience that is slightly less thrilling, the effect of the latter is diminished.*



# SPATIAL INVESTIGATIONS

## Certain parameters affect the perception of your position

Aside from just a way to get from the ground to above the treetops, what can an observation tower offer? Where can your focus be and what can you experience along the way?

With the Bostoren tower reference project as a starting point a number of prepositions came to mind as positions in which you could be. These were considered Spatial situations that you could be in and the parameters that define these situations and that affect how you experience them were investigated. The Spatial situations are defined by parameters that can be used to direct the attention of the visitor.

In order to make the experiences part of a path up the tower, and avoid the elective pavilions of the reference project, they were considered as part of a path and designed with spatial qualities in mind. The resulting spaces turned out to be best experienced either in motion or from making a stop there. The experiences were also considered based on the feelings they trigger. Some experiences are thrilling, while others are calm.



Journey

### ***Journey***

*Experience as you move along at your own pace.*



Thrill

### ***Thrill***

*An experience that is perceived as uncomfortable and unsafe.*



Pause

### ***Pause***

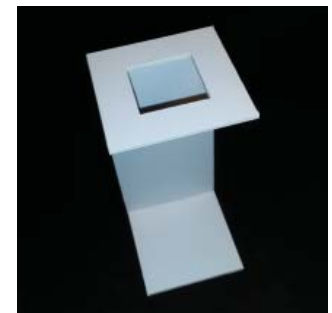
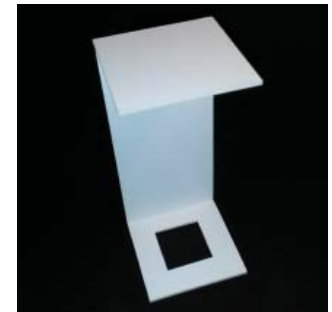
*A stop along the way where you let the experience take its time.*



Calm

### ***Calm***

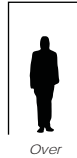
*An experience where you feel safe and that suits everyone.*



### ***Initial models to investigate the Spatial situations***

*One model per Spatial situation was built to visualize and help in defining the parameters to describe them. From left to right, top to bottom, the models represent Over, Inside, Near, Outside, Under, Below, Between, On top and Above.*

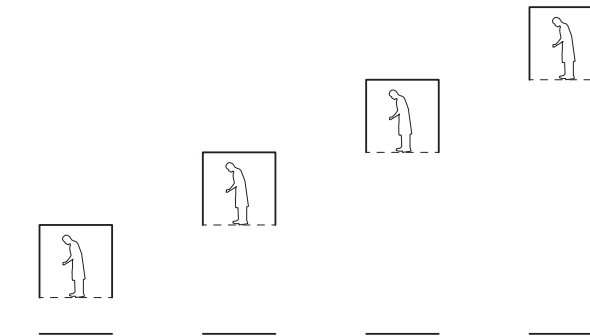
# Over



Being over means there is something below to look down at and experience from a new perspective. What do things look like from this perspective? How far up do you have to go? Is there a limit to how far up you need to be or how far up you can be? What effect does different sizes of the space have?

The higher up you get, the greater the experience of being over gets. Getting further up also widens the view, which may cause your focus to be less precise than if you are closer. Size matters too. A small peephole may rise curiosity, but a large open space triggers thrill and the feeling of unsafety. Regarding ceiling height, the most uncomfortable is probably when you can almost stand up straight.

## Parameters that define the Spatial situation



*Height intensifies sensation.*

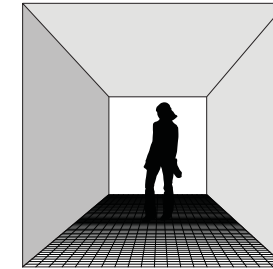


*Width increases sense of control.*

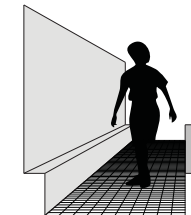
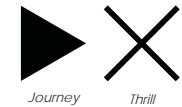


*Lower ceiling forces focus downwards.*

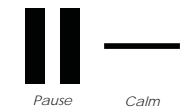
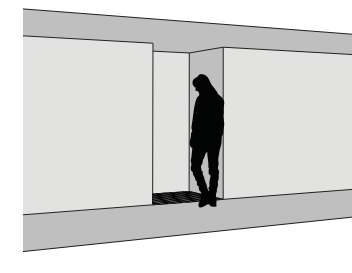
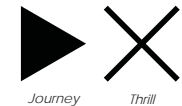
## The Spatial situation as part of a path



*Being able to see through the path is thrilling.*

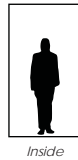


*Even with solid edges to step up onto it is thrilling.*



*Standing on a solid path and looking down through something beside you is calm and secure.*

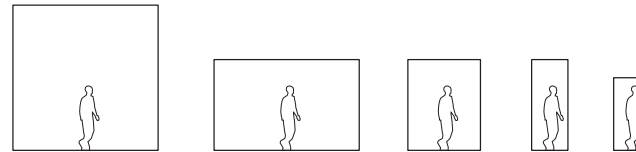
# Inside



Being inside means that you are surrounded by surfaces that limit the space. It may mean that you are safe, but can also mean that you are trapped. How is the experience affected by size? What difference does it make if it is completely closed? What about the relations between height, width and depth? Or if not all corners are right angled?

A big and closed space may leave you feeling small and lost, but a small opening directly gives the space a direction. Proportions can do the same thing. Being inside can mean being in a safe environment that frames a certain view, like a painting. Changing the proportions and tilting some surfaces can direct you, both emotionally and physically.

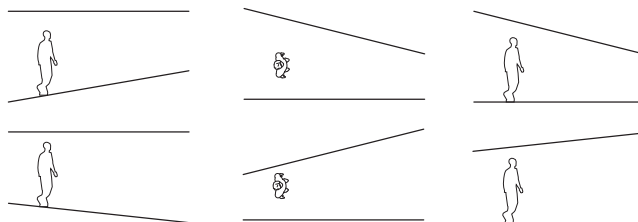
## Parameters that define the Spatial situation



*Narrower space increases sense of safety.*



*Openings can turn enclosed to exposed.*

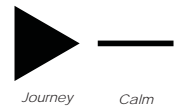
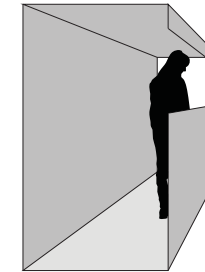


*The effect is largest for tilted floors and smallest for tilted ceilings.*

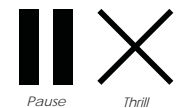
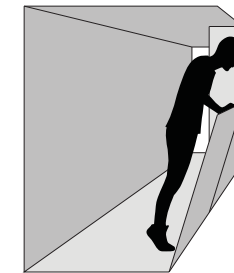


*Length increases sense of being directed.*

## The Spatial situation as part of a path



*Passing by an opening located high up is calm.*



*Stopping and leaning out is thrilling.*



*Sitting down and looking out is a calm experience.*

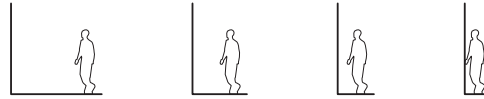
# Near



Being near means being close to and able to experience the details. You can see up close, but also touch. Being near is a way of engaging with the structure. What creates this engagement? Is it just distance that matters? Does it matter whether or not you can choose to be near?

If the natural choice is to keep your distance, then that's what you'll do. In order to really come near it has to be forced. However, the choice is important. When you voluntarily do something, you dare more. But if there is a gradient between safe and adventurous, you may stick with a slightly safer and more comfortable alternative. Therefore, creating a real difference between the two is important.

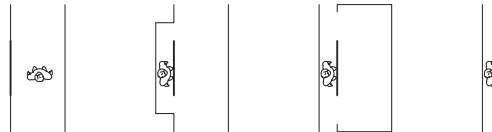
## Parameters that define the Spatial situation



*Smaller distance forces you to be near.*

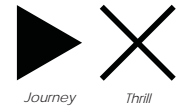


*Tilted walls enhance interaction.*

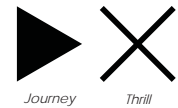
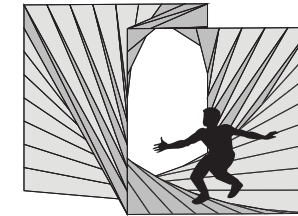


*Options can make you dare more.*

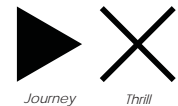
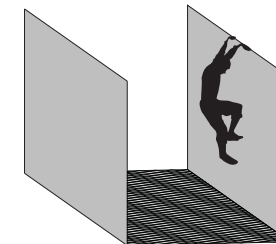
## The Spatial situation as part of a path



*Being forced to cling to the structure because the path is narrow is thrilling.*



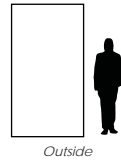
*To walk along a path where the floor becomes a wall and the other wall becomes the floor and so on is thrilling.*



*Climbing along the structure because the path below may not carry is thrilling.*



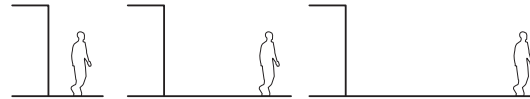
# Outside



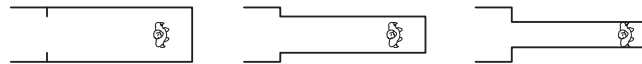
Being outside means being free and out in the open. The experience does not necessarily trigger a good and liberating feeling. Especially in a tower and at a certain height, the opposite can be expected. What counts as outside? Is it as soon as you step out of what is perceived as inside? Or does it require a certain distance? And how does the size of the space affect the experience?

The further away you get from perceived safety and the narrower the space is, the more pronounced the feelings get. It is a tingling sensation creeping through your body. It is at the same time exciting and very unpleasant. Perhaps if you dare to lean over the railing you can see something from a completely new perspective.

## Parameters that define the Spatial situation

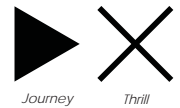
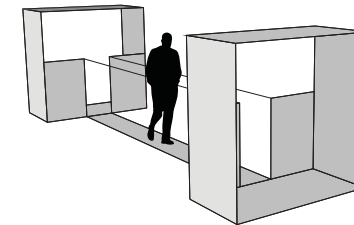


*Distance increases sense of non safety.*

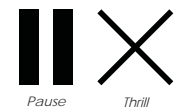
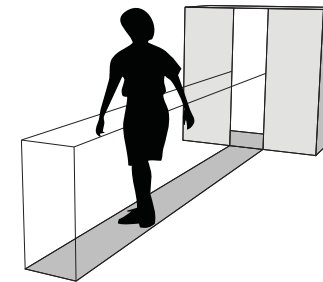


*Narrower space means less freedom to turn back.*

## The Spatial situation as part of a path

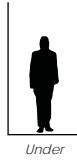


*Walking along a path that is perceived as unsafe between two safe and secure spots is thrilling.*



*To walk out on an similar stretch of path that is a dead end is also thrilling and you know you have as far to go to get back as you've been walking out.*

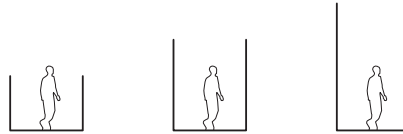
# Under



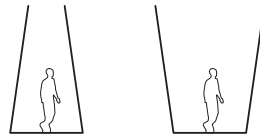
Being under doesn't require anything to be above, other than the sky. It is about being in a place that focuses your attention upwards and letting the sky become the view instead of just a complement to the landscape. How do you direct the attention upwards? What makes you comfortably rest and take in the view? What makes your attention stick to what you're actually under?

To focus your view upwards isn't the most natural thing. Ensuring that you know that there is a point to the space, that it's not just a dead end, is important. The entrance plays a big role here. Another important aspect is the direction of the space and the physical direction of yourself as you're in the space.

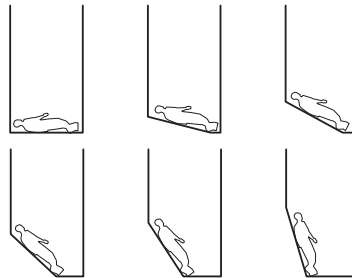
## Parameters that define the Spatial situation



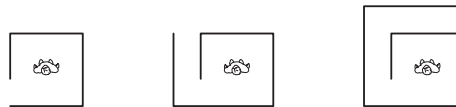
Height increases focus upwards.



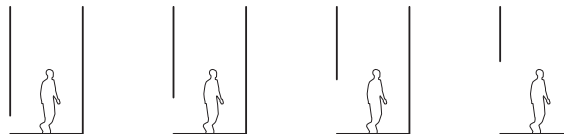
Tilt can focus or scatter the view.



Comfortably looking up requires tilt.

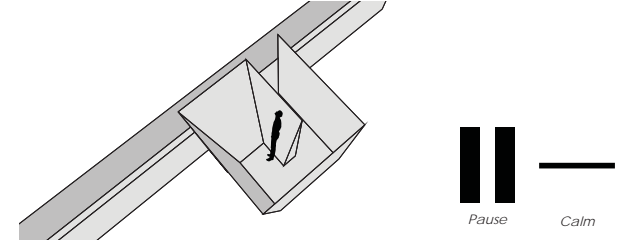


Maze-like walls make the space more defined.

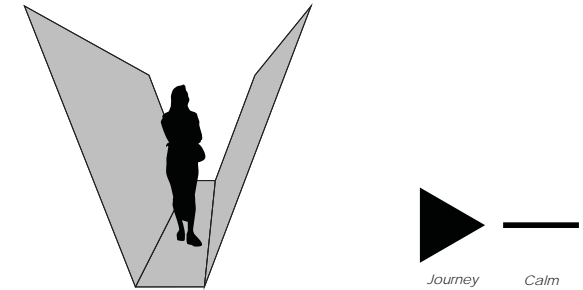


Larger opening means less defined space.

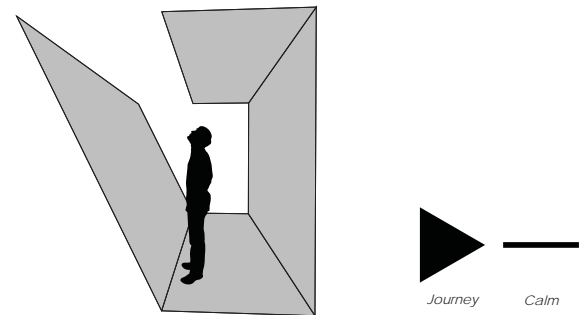
## The Spatial situation as part of a path



To stop in a space where you can lean against the tilted walls and the only opening is upwards is a calm experience.

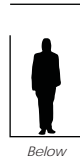


To walk along a path with walls tilting out and leading your attention upwards is a calm experience.



A path with a partial roof and a tilted wall has a similar effect, but the fact that the opening only allows certain views may trigger your curiosity.

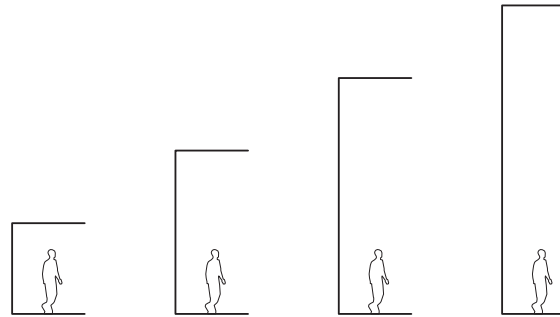
# Below



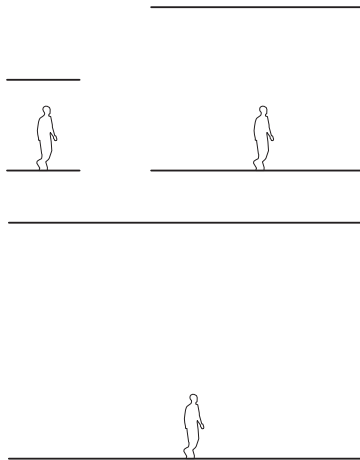
Being below means being in a place from where you can experience something above you. It could be something that's overhanging and threatening, but also something that draws your attention in a positive way. How close does the thing above you need to be to create this feeling? How big should it be?

What you're below could be a place above where you could also be, something that threatens you and presses you down, or something that just draws your attention upwards. The experience of being below can be uncomfortable and threatening, if what's above is too big and too close. It can also be interesting and create excitement and positive anticipation.

## Parameters that define the Spatial situation

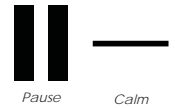
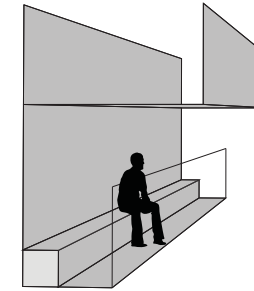


*Distance diminishes sense of being below.*

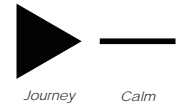
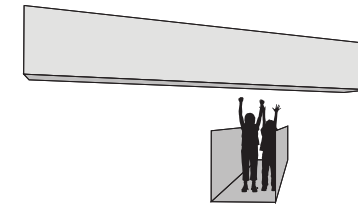


*Size counteracts distance and increases sense of being below.*

## The Spatial situation as part of a path

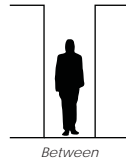


*To sit down and have another path above like a roof is a calm and potentially lonesome experience.*



*To walk along a path that crosses under another path is a calm experience that allows for social interaction with someone on the path above.*

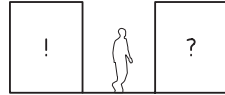
# Between



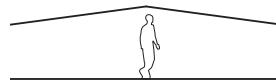
Being between is about having left something behind and being on your way to something new. It is a neutral experience in itself, but the experience before can give the experience of between any character. What influence does the space itself have on the experience of being between? What happens if walls or ceilings are tilted?

The experiences before and after between affect the experience while you're there and the memory of the experience. The space itself can be made more or less defined by tilting of for example the ceiling. That way it can be a space that is basically diminished, if the ceiling tilts up from the center of the space.

## Parameters that define the Spatial situation

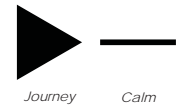
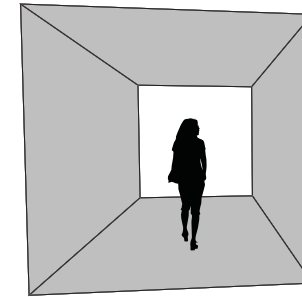


*Between implies relief and anticipation.*

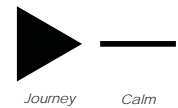
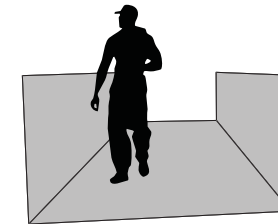


*Tilting creates a gradient from a point like space to an actual space.*

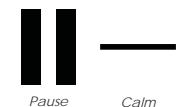
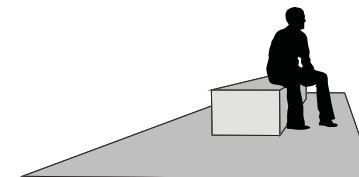
## The Spatial situation as part of a path



*The totally enclosed path is calm and secure and only allows focus to be put on what you just passed and what is ahead.*



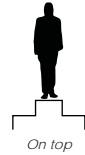
*The open path allows focus to be put elsewhere.*



*A place to sit down in between allows for reflection to take time.*



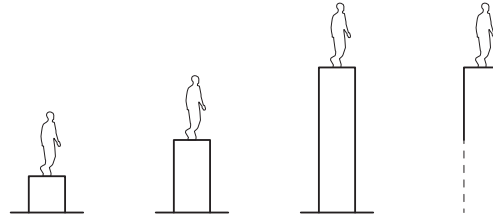
# On top



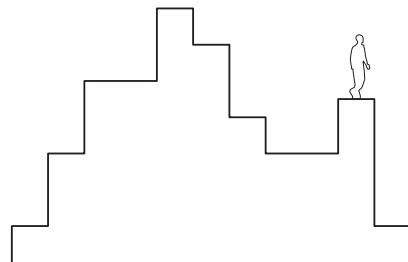
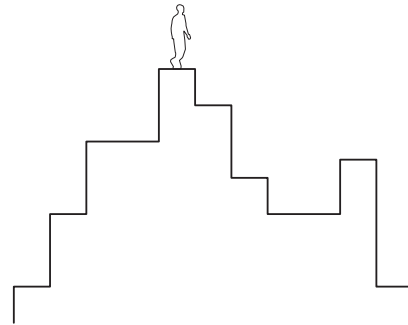
Being on top is about having achieved something. It requires reaching a certain height, but what height? Does where you come from matter? Is it the relation between this place and other places nearby that defines if it is experienced as on top?

It can be to reach the absolute top and be on a platform where you can see in any direction you like. It can also be a milestone along the way to the real goal, but it has got to be a top of some kind, not just a step along the way or a plateau. The experience of being on top may be most pronounced if the space is a place to stop and really take it in. It is not the height in itself that matters the most, but the achievement it is to get there.

## Parameters that define the Spatial situation

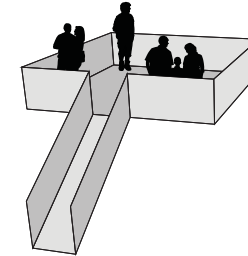


*All heights can be On top.*

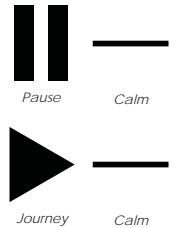
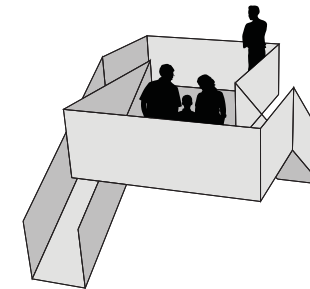


*A top is not necessarily the highest point.*

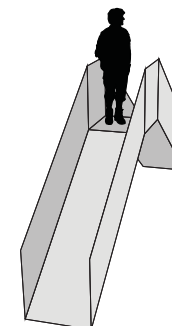
## The Spatial situation as part of a path



*With only one access point it becomes natural to stop for a pause and calmly enjoy the view.*

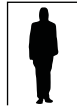


*With multiple access points, passing through becomes a natural option as well.*



*A smaller top can also be part of a path and a calm experience to pass over.*

# Above

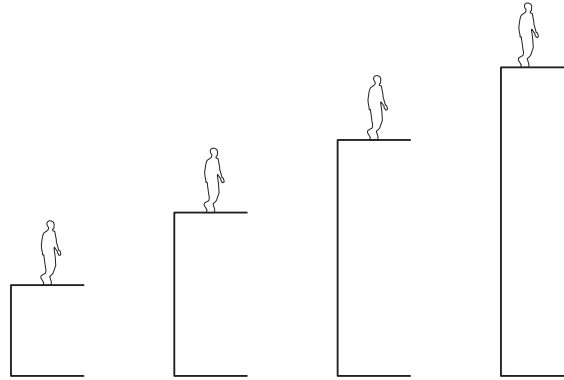


Above

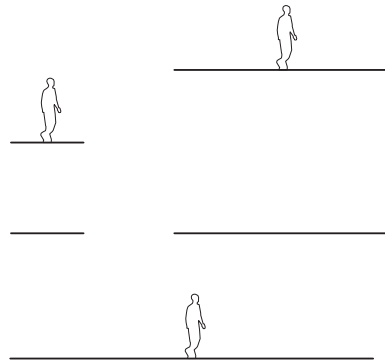
Being above is about being in a place where there is something below. The place below is preferably somewhere you have been before, or somewhere you could imagine being, so that the experience adds a new perspective to that other place and the experience of it. How connected does this place need to be to what's below? How far from what's below should the experience of being above be? How big should the space be?

The experience of being above is dependent on its relation to what's below. If the vertical distance is too big, the connection is lost, but it still has to be big enough to ensure the experience of above. The size of the space also affects the effect of height.

## Parameters that define the Spatial situation

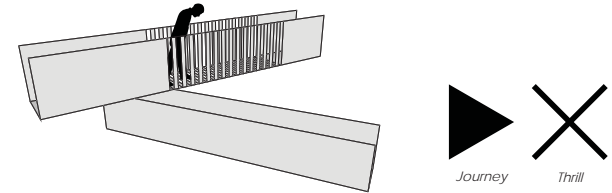


Height lowers contact with what's below.

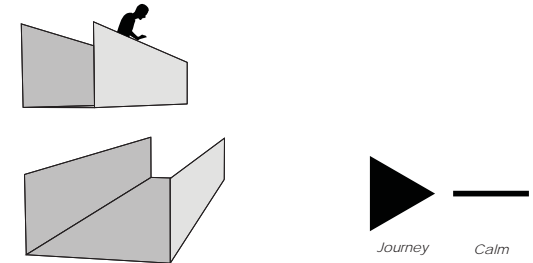


Size increases sense of safety and counteracts height.

## The Spatial situation as part of a path



A path that allows for views through it to what's below is thrilling as it means walking on a non-solid surface.



To walk along a more conventional path and have the option to just look over the railing is a much calmer experience.

# Different path types have different consequences

The paths up and down the tower can be either stairs or ramps. They can also be a combination thereof and combined with landings.

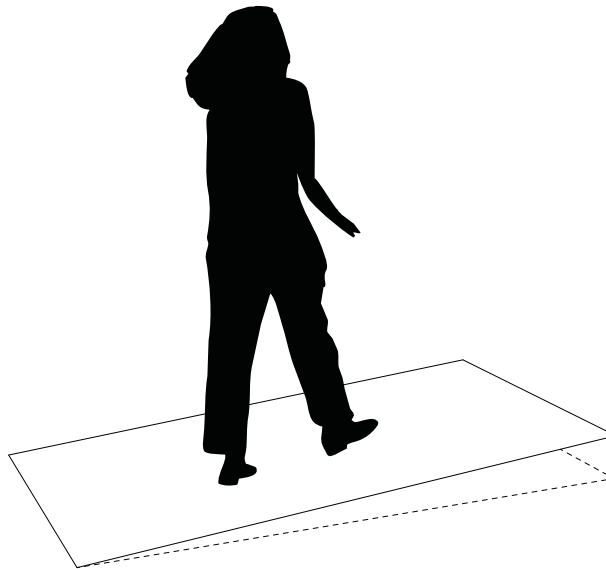
## Different types of path offer different physical and mental preparation

Stairs, ramps and landings differ in character and the way we move along them. The choice of path type affects the total length of the path as well as the movement along it. A switch between path types creates a switch in ways of moving.



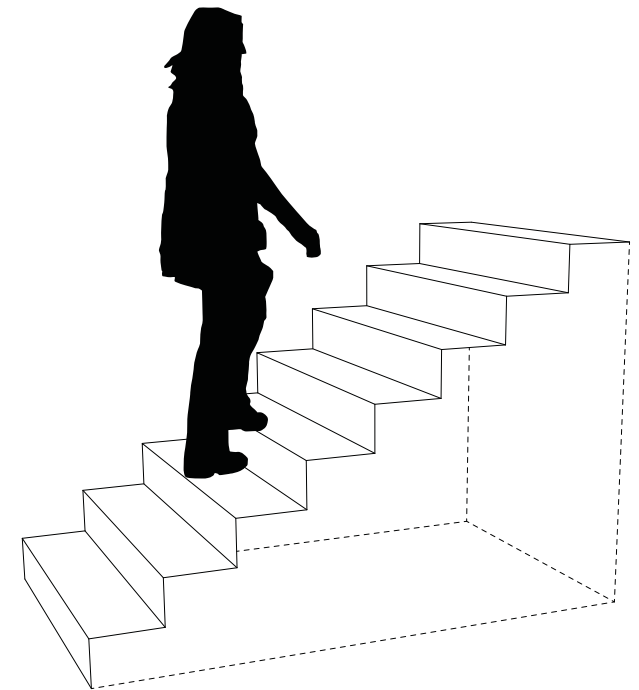
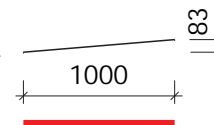
### **Landing**

*No physical resistance  
No vertical movement  
Infinite horizontal movement  
Promotes pause and smooth movement*



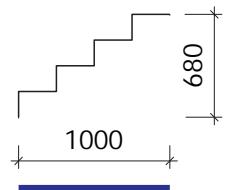
### **Ramp 1:12**

*Low physical resistance  
Ineffective vertical movement  
Long horizontal movement  
Promotes continuous, smooth movement  
Makes you prone to continue moving*



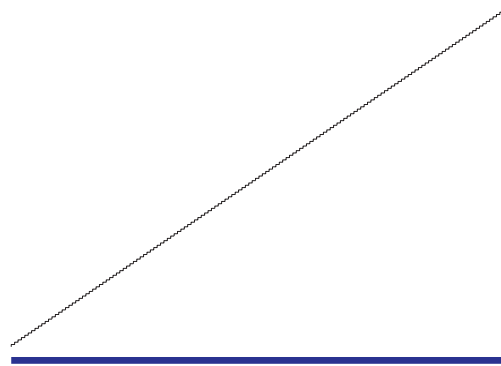
### **Stairs**

*High physical resistance  
Effective vertical movement  
Short horizontal movement  
Promotes discontinuous movement  
Makes you prone to pause*



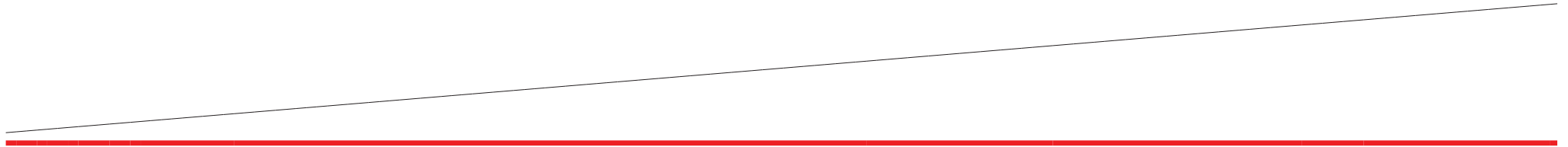
## Path type defines path length

The type of path chosen affects the total length of the path. As ramps are much less effective than stairs in terms of vertical movement, they require a much longer horizontal length. The two first examples show the path length required to achieve a vertical movement of 25 m without any landings with either only stairs or only ramp. The third example shows how adding landings increases the total length of the path. It also becomes clear that switching some stairs for ramps makes the path longer and vice versa.



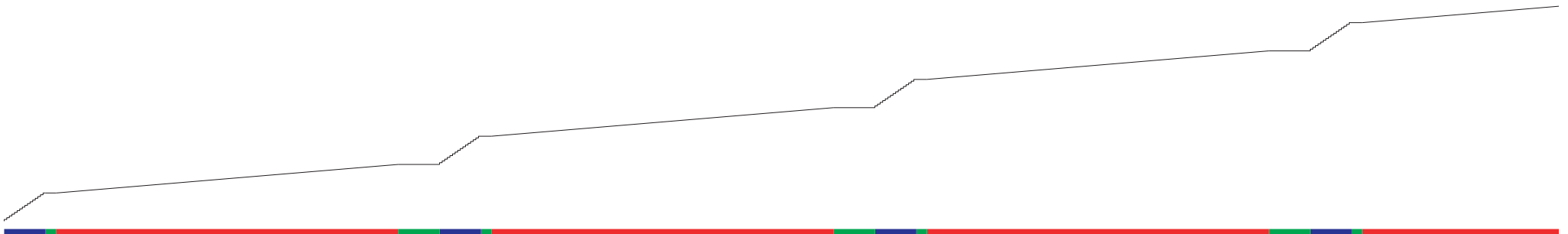
**Only stairs**

Horizontal length: 37 m



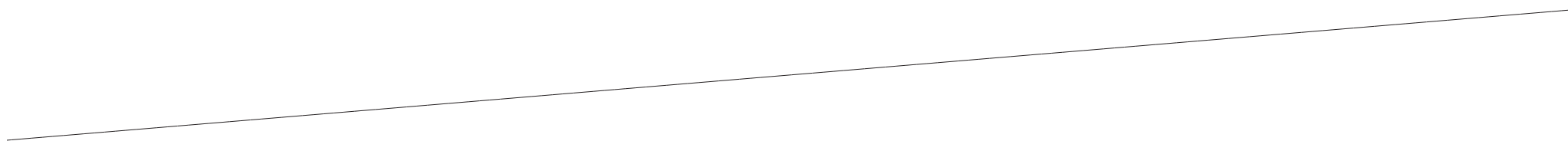
**Only ramp**

Horizontal length: 300 m



**Combining landings, ramps and stairs**

Adding landings increases the total length of the path.  
Combining path types makes the total length variable.











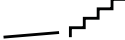





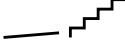


















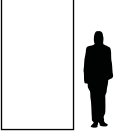




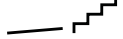










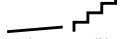










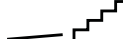





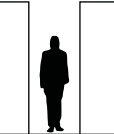









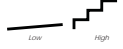





















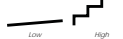
# Combining parameters into Events

The Spatial situations, if they are Thrill or Calm and if they should be experienced as Journey or Pause was summed up in a table. Scale was also introduced to indicate the actual space required for each experience; either Room or Bench. The combinations were called Events.

The different physical resistances of the path types, which makes you prone to continue moving or to stop, define what path type to use to achieve mental preparation for the Events.

Resistance during an event is rendered only by the resistance of the event itself. This could for example mean that an Event where you sit down prepares you for a following high resistance path, while an Event where you have to use both hands and feet to move forward is better followed by a low resistance path.

Event				Resistance before	Resistance after	Conclusion
Spatial situation	Thrill or Calm	Journey or Pause	Scale			
 Over	 Thrill	 Journey	 Room scale	 Low	 Low	<i>Over is about what's under. It can be very different depending on which alternative is chosen, Thrill and Journey is the combination that has the greatest effect.</i>
	 Calm	 Pause	 Bench scale	 High	 Low High	
 Inside	 Calm	 Journey	 Room scale	 Low	 Low High	<i>Inside is about feeling enclosed and secure. The Event should be Calm and contemplative.</i>
	 Calm	 Pause	 Bench scale Room scale	 High	 High	
 Near	 Thrill	 Journey	 Room scale	 Low	 Low	<i>Near is about engaging with a structure. There should be no alternative to this engagement, hence the Event has to be Thrilling.</i>
	 Thrill	 Journey	 Bench scale	 Low	 Low High	

Event				Resistance		Conclusion
Spatial situation	Thrill or Calm	Journey or Pause	Scale	before	after	
 Outside	 Thrill	 Journey	 Room scale	 Low	 Low High	<i>Outside is about feeling like you're outside of a safe structure. The Event is meant to be perceived as unsafe and Thrilling.</i>
	 Thrill	 Pause	 Room scale	 High	 High	
 Under	 Calm	 Journey	 Room scale	 Low	 Low High	<i>Under is about resting and enjoying the free space over. It is about calmly looking up into the crown of a tree or watching a portion of the sky as the clouds pass by.</i>
	 Calm	 Pause	 Room scale	 High	 High	
 Below	 Calm	 Journey	 Bunch scale Room scale	 Low	 Low High	<i>Below is about the relation to a space above, either where your path passes by or where another path passes by.</i>
	 Thrill	 Pause	 Bunch scale Room scale	 High	 High	
 Between	 Calm	 Journey	 Room scale	 Low	 Low High	<i>Between requires the path before and after to be long enough to really experience Between. The length is more important than the type of path.</i>
	 Calm	 Pause	 Bunch scale	 High	 Low High	
 On top	 Thrill	 Pause	 Room scale	 High	 Low High	<i>On top is an achievement and a goal, therefore it requires some resistance before so you really feel that you've achieved something.</i>
	 Calm	 Pause	 Room scale	 High	 Low High	
 Above	 Thrill	 Journey	 Bunch scale Room scale	 Low	 Low	<i>Above is meant to be experienced in motion. It is about the relation to a space below, either where your path passes by or where another path passes by.</i>
	 Calm	 Journey	 Bunch scale Room scale	 Low	 Low High	



# Combining path types is necessary for Events

There are 6 ways of combining a No resistance path, i.e. a landing, with a preceding and potentially a following path. By introducing Scale, the possible combinations doubles to 12.

The preceding path before a landing defines if the Event at the landing should be Journey or Pause. From the possible Events it then follows if the Event should be Thrill or Calm and what Spatial situations can be accommodated by that landing.

None of the combinations can accommodate more than 8 of the 9 Spatial situations. Therefore a combination of stairs and ramps is necessary to create a sequence where each Spatial situation is represented.

Varying the Scale is not necessary as all Spatial situations can be of Room scale, but it may be desired to achieve the sought after contrasts between Events.



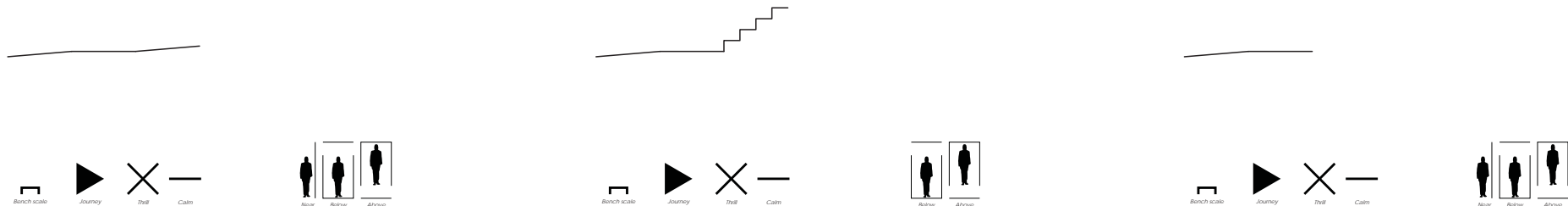
Preceding path,  
defines Journey  
or Pause for  
Event

Landing, length  
defined by  
Scale

Following path

*Combining preceding and following path with a landing*

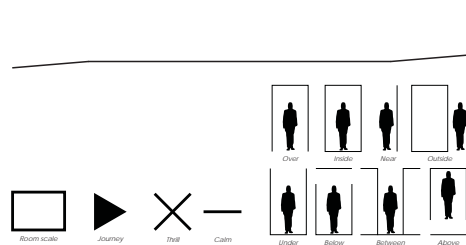
*Different combinations of path types allow for different Events, but no combination allows for all Spatial situations*



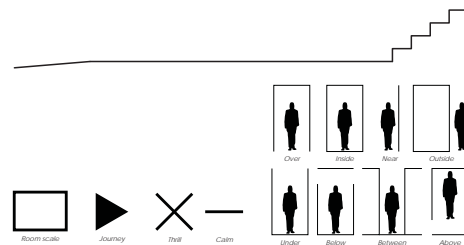
*Only Journey and 3 Spatial situations possible.*

*Only Journey and 2 Spatial situations possible.*

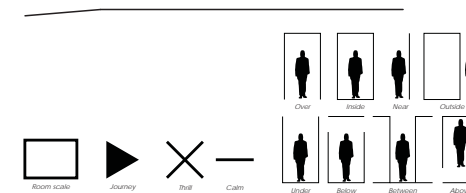
*Only Journey and 3 Spatial situations possible.*



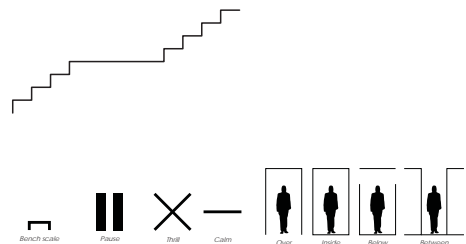
Only Journey and 8 Spatial situations possible.



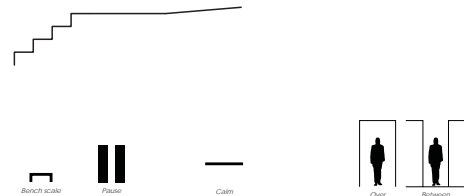
Only Journey and 8 Spatial situations possible.



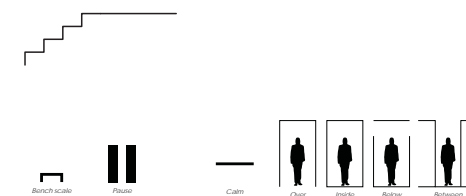
Only Journey and 8 Spatial situations possible.



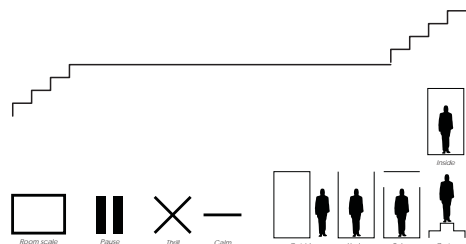
Only Pause and 4 Spatial situations possible.



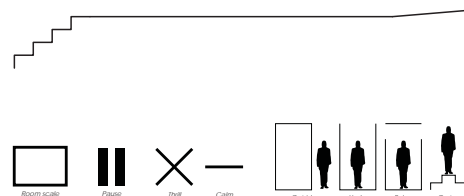
Only Pause, Calm and 2 Spatial situations possible.



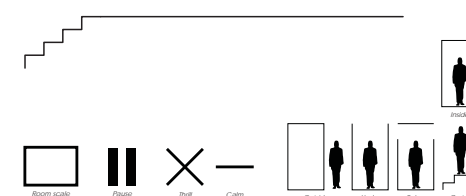
Only Pause, Calm and 4 Spatial situations possible.



Only Pause and 5 Spatial situations possible.



Only Pause and 4 Spatial situations possible.



Only Pause and 5 Spatial situations possible.

# STRUCTURAL INVESTIGATIONS

## Structure and movement

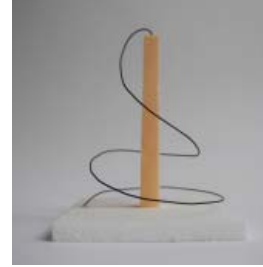
To brainstorm ideas on how a tower could be designed, a large number of quick sketch models were built to get as many ideas as possible. The models showed a multitude of ideas and many different interesting aspects. Some models turned out to be interesting as whole towers, while others seem more interesting when considered as details or zoom ins.

The models were considered based on similarities and differences in an aim at sorting them. In the end it all boiled down to a few interesting things, namely:

- Multiple paths
  - equal paths
  - slow/calm + fast/exciting paths
  - intersecting paths
- Horizontal movement
- Winding curves
- Shape shifting and changing silhouettes
- Beads on a string
- Balance

The Multiple paths idea was found interesting to work further with in developing a concept for the tower.

*All models that were built to generate ideas and eventually a concept for the tower structure*





# Intertwined is the best alternative for two paths

Through brainstorming in physical model the idea of multiple paths was discovered. Eventually 5 different options for how the paths can work, 4 of which contains an alternative path to some extent, were established.

The "Intertwined" paths option was the option that was found to be the best. It provides both alternatives and a clearly designed path from the ground to the top. It also provided a connection between the paths without the loss of the sequence that happens if you are continuously forced to choose which way to go.



## **Dead end**

*One way up and down. No options.*



## **Cul-de-sac**

*Part one way and part two options. Possible to have paths of different character.*



## **Loop**

*Two completely separate paths that never meet. No contact between the paths means you have to walk a path to know what goes on there. Possible to have paths of different character.*



## **Intertwined**

*Two separate paths that meet, but don't intersect. There is visual contact, but you can't switch path. Possible to have paths of different character.*



## **Intersecting**

*Two or more options. Paths that intersect and allow you to switch. No one clear path or sequence of experiences. Possibility to have paths of different character.*



## **Models to investigate multiple paths**

Model studies were done to come up with the possible alternatives. Some models describe more than one of the final alternatives for multiple paths. For example, Intertwined and Intersected take the same form in this type of model, though they are different in terms of how they would be in reality.

# Intertwined paths as a structural concept

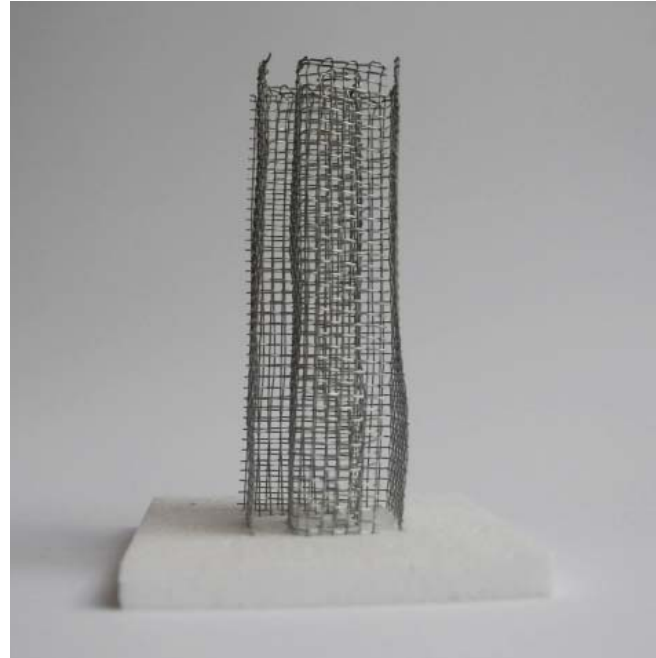
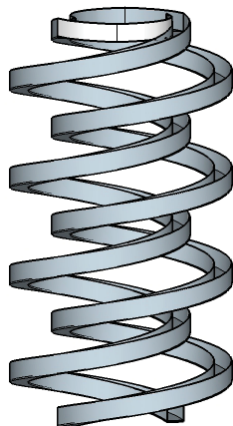
The idea of the intertwined paths was developed into a number of structural concepts. Eventually one of these concepts was found to be the best suited alternative for this project from both structural and architectural aspects.



## Swirl

*Two spirals swirling around each other with separate, but visually connected, paths that could have different shapes. The rotations that each spiral can have is limited by height to ensure walkability.*

*Structurally it is complicated as the spirals are like springs and require a significant stiffness to stay in place. Vertical members would reduce the stresses, but disturb the concept.*

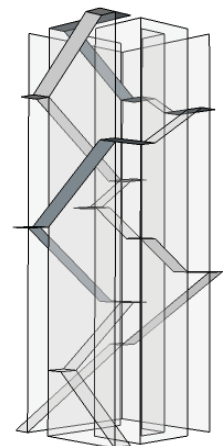


## Layers

*Transparency and different mesh densities. Two people can be in almost the same place, but separated by a wall.*

*Adding paths that climb on the sides of the walls feels forced. Architecture and structure is not one and the same.*

*The walls in themselves are sensitive to out of plane forces, but the folds provide stability.*



## Pine

*Two intertwined paths that are carried by a central column and stabilized by tensile chords. The silhouette could vary if the characters of the paths varies.*

*The central column is compressed and the chords tensioned. The paths only carry load from tensile chord to tensile chord creating point loads on the chords.*



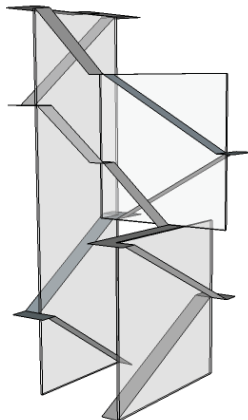




### Plates

The plates are diagrid walls of varying densities that gives varying transparency. Adding paths that climb on the sides of the walls feels forced. Architecture and structure is not one and the same.

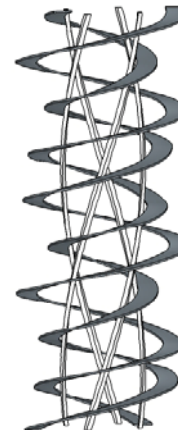
Where the walls are connected continuously the forces are spread out. That is better than when they meet in a point, which causes big stress concentrations.



### Rotational

Two paths that spiral around each other and that are connected by columns. The shape of the columns is twisting to follow the shape of the paths.

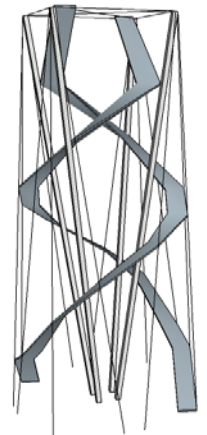
Vertical loads are carried within the paths to the columns. The paths touch all of the columns in each rotation and thereby functions as bracing members.



### Outside/Inside

Columns leaning outwards, tied down by tensile chords. This renders a spatial transition from outside the columns to inside. That way the paths would be wobbly at the bottom when attached to the chords and become more stable as they transition to inside the columns.

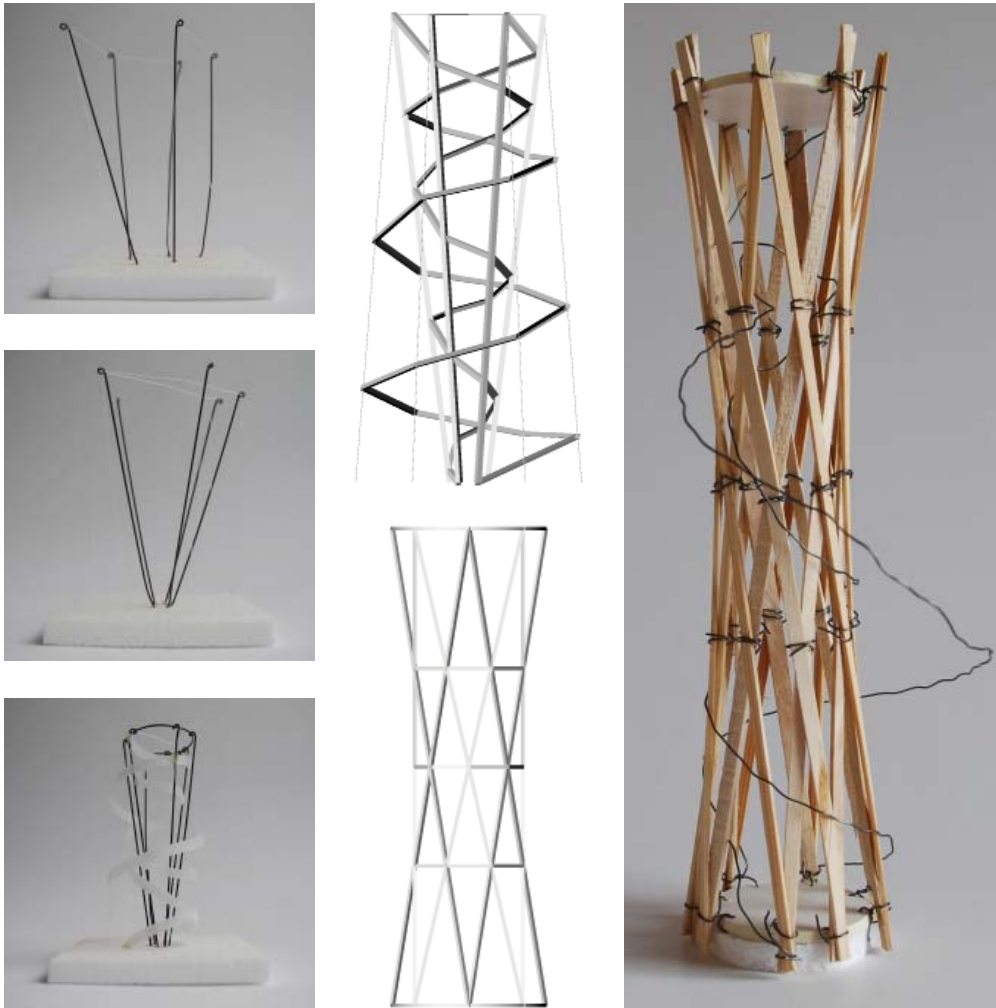
The structure's perimeter is defined by the chords that keep the columns in place and in compression.





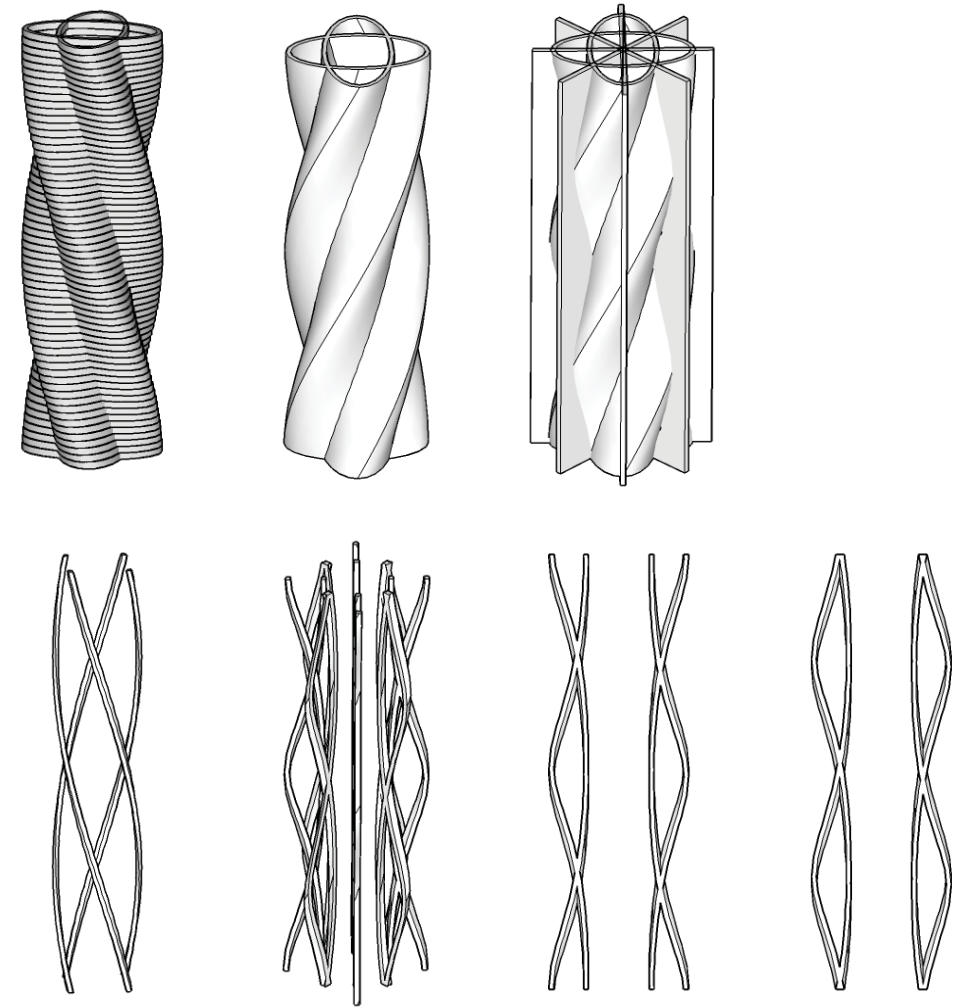
## Further concept sketches

Two pairs of concepts were combined in an attempt to find more suitable ideas. One concept was investigated further on its own and one concept was eliminated right away.



### **Pine + Outside/Inside**

*These two concepts were found to be very similar and were therefore combined. The hyperboloid is an alternative structure without cables, which has a similar silhouette as the Outside/Inside concept if only the upper half is used.*



### **Rotational**

*The columns are defined by the intersection of two rotational bodies. Another alternative could be to define columns by intersecting planes with the rotational bodies. In doing so different types of double columns are achieved.*



### ***Layers + Plates***

*Both these concepts felt forced, but still the transparency and the large surfaces was found interesting. The concepts were therefore combined and investigated further to see if boxes, frames, slabs or offset plates could be a solution.*

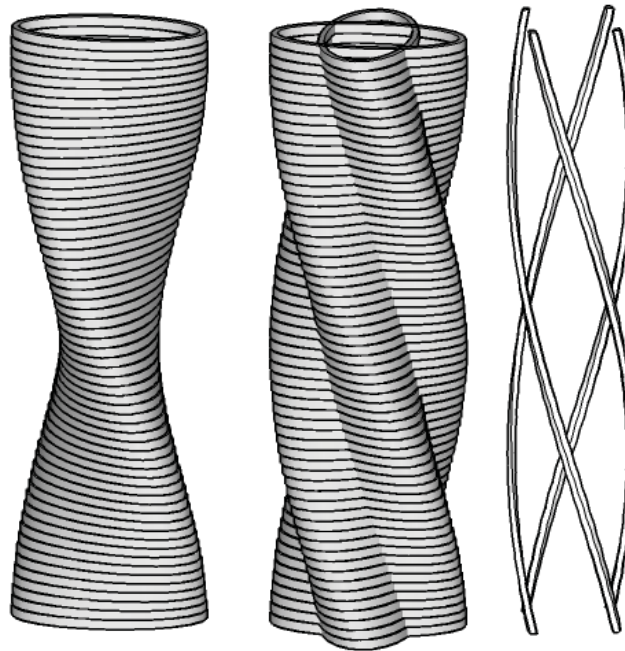
## The selected concept

After evaluating the initial concepts, further developing some of them and then evaluating again, one concept was chosen. It was considered the best for many reasons. One was because of its ability to accommodate different paths. Another the fact that the structure is rendered by the paths in a clear way.



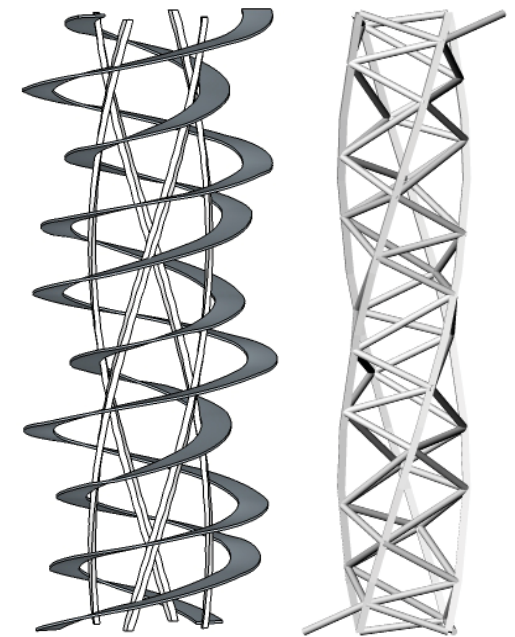
### ***Asymmetric and varying silhouette***

*The concept would allow the tower to look different from different sides. It could have a silhouette that varies as you move around it.*



### ***One volume per path***

*The idea is to have two rotational bodies, each rendered by the winding shape of a path. The intersection of the two bodies creates the vertical load bearing columns while the paths around give an idea of the volumes.*



### ***A truss system***

*Vertical loads are carried within the paths to the columns. The paths touch all columns in each rotation and functions as bracing members. With additional bracing in the other direction the structure becomes a truss. The elements become big, but not impossible, to handle by hand.*

# The paths define the structure

The original concept rendered 4 columns. However, the rendered structure bear little resemblance to the initial volumes and the structural elements are so large that it could be difficult to handle by inexperienced workers at the construction site. It also turns out that not all volumes defined by paths intersect nicely to create columns. Therefore a new idea formed. The idea is to find a way to create a structure consisting of more and thinner elements that would better represent the volumes and that would be easier to handle at the construction site.

## Rules

To try this out the following possibilities were considered:

Two curves, each describing a path, describes a volume each.

The curves could be

A. winding in the same direction.

B. winding in opposite directions.

The structure could be defined as

a. the outer surface, the union, of the two volumes.

b. the inner surface, the intersection, of the two volumes.

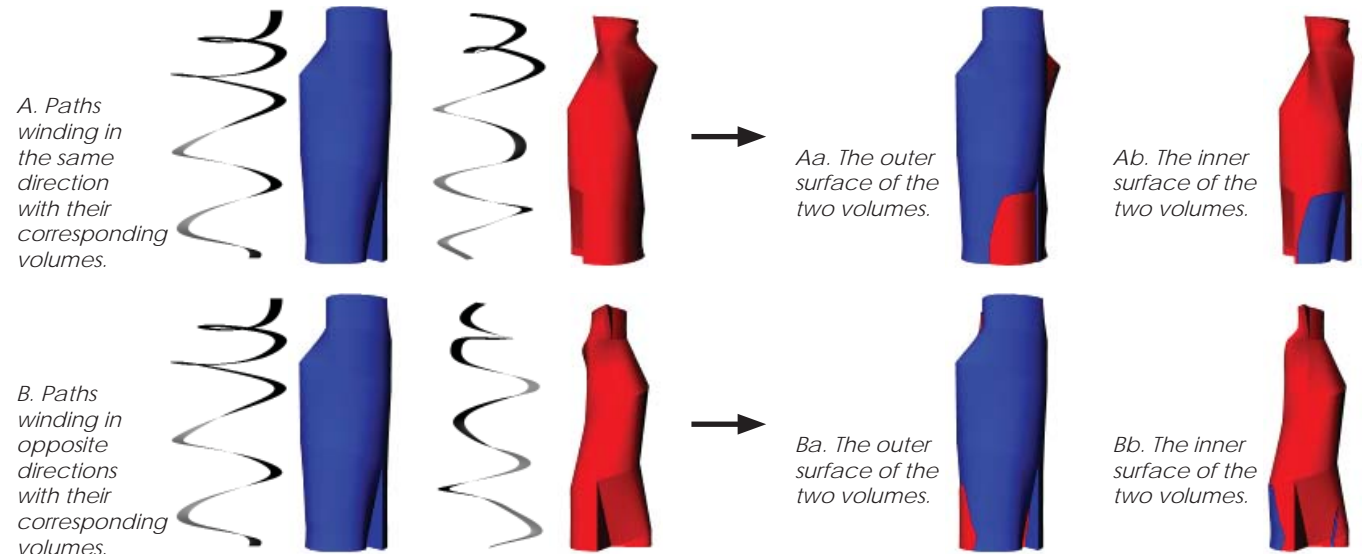
Each curve could be

1. representing the inner edge of the path.

2. representing the outer edge of the path.

3. located somewhere within the width of the path.

So, for each pair of curves (A and B) there are 6 alternatives to investigate.



1. The curve represents the inner edge of the path.

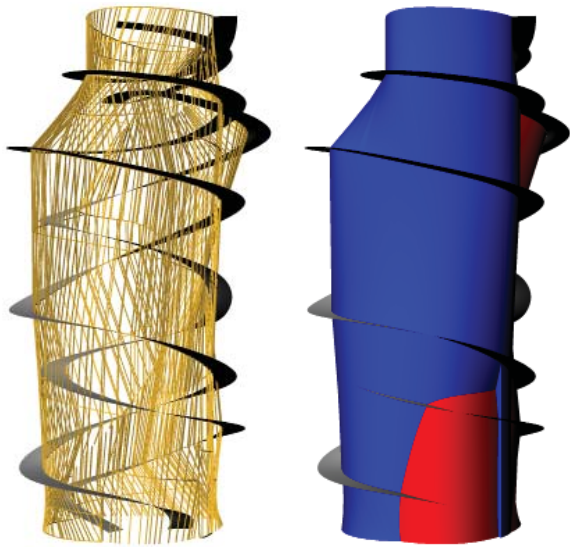
2. The curve represents the outer edge of the path.

3. The curve is located somewhere within the width of the path.

## Discovering possibilities and opportunities for structure and spatial experiences

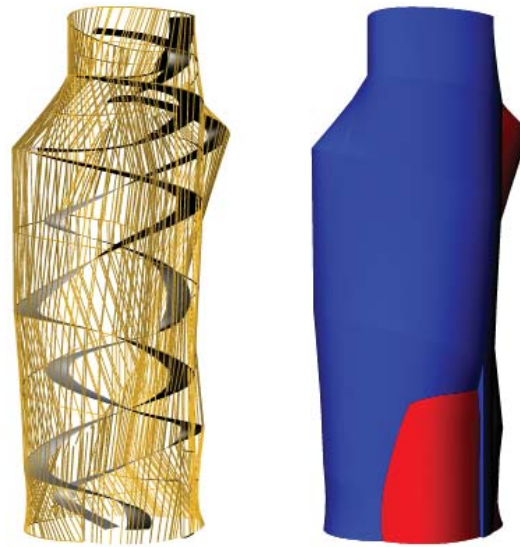
The same features appear in multiple variations, but not in the same combinations. This makes all alternatives different and hence their qualities differ. Structurally one could say that all alternatives based on the outer surface and the inner surface respectively are equal, but spatially and in terms of possible experiences they are different.





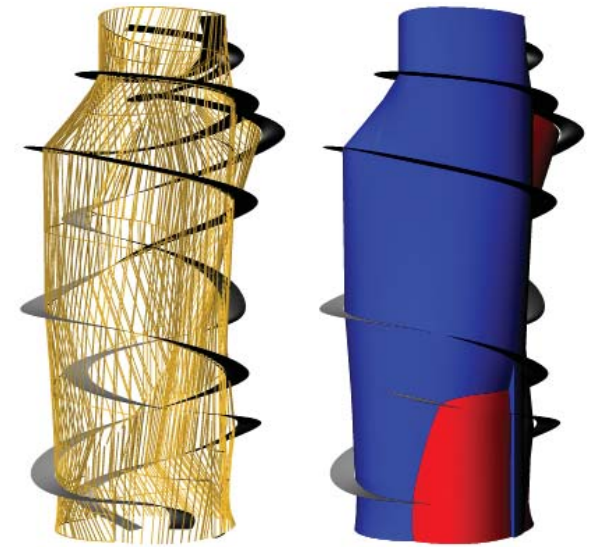
**Aa1 - Same direction, outer surface, inner edge**

The paths are either running along the outer surface of the structure or freely inside the structure. There is no part of the paths that cantilevers out from the structure.



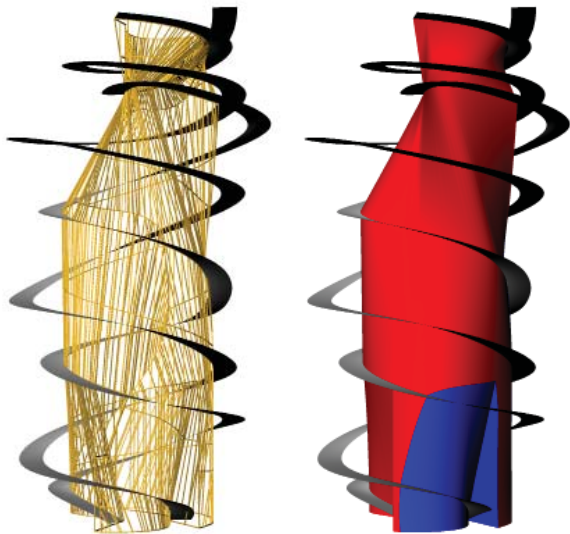
**Aa2 - Same direction, outer surface, outer edge**

The paths are either running along the inner surface of the structure or freely inside the structure. There is no part of the paths that runs outside the structure.



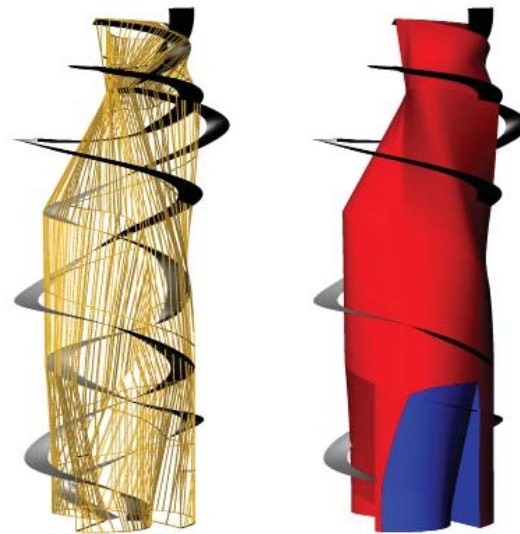
**Aa3 - Same direction, outer surface, within width**

The paths are either running along the structure or freely inside. There is no part of the paths that runs freely outside the structure. The paths along the surface may shift between inside and outside.



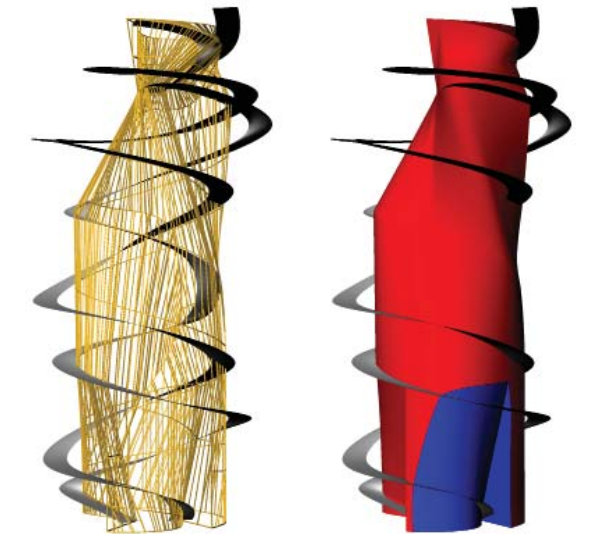
**Ab1 - Same direction, inner surface, inner edge**

The paths are either running along the outer surface of the structure or freely outside the structure. There is no part of the paths that runs inside the structure.



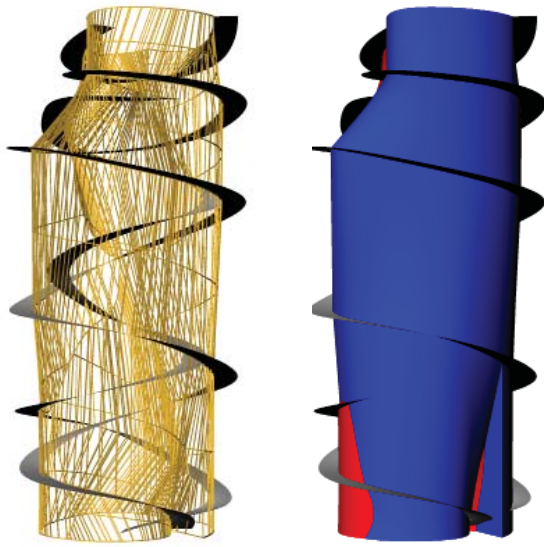
**Ab2 - Same direction, inner surface, outer edge**

The paths are either running along the inner surface of the structure or fully or partially outside the structure. There is no part of the paths that runs freely inside the structure.



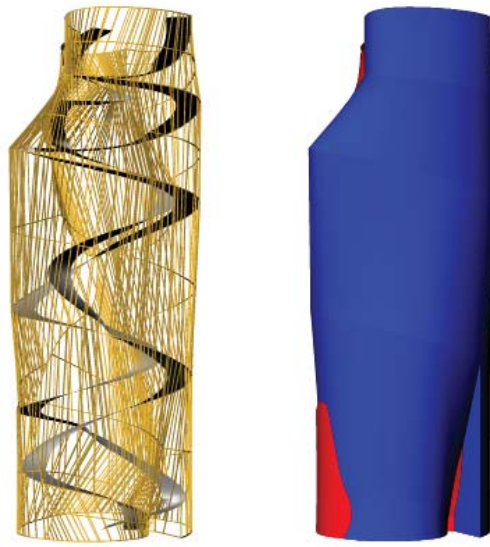
**Ab3 - Same direction, inner surface, within width**

The paths are either running along the structure or freely outside. There is no part of the paths that runs freely inside the structure. The paths along the surface may shift between inside and outside.



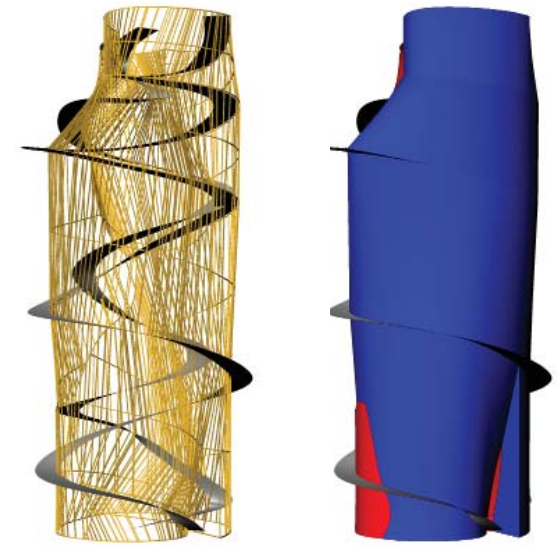
**Ba1 - Opposite direction, outer surface, inner edge**

The paths are either running along the outer surface of the structure or freely inside the structure. There is no part of the paths that cantilevers out from the structure.



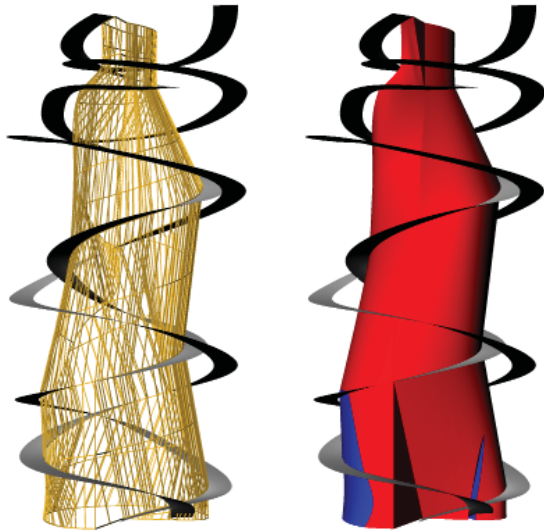
**Ba2 - Opposite direction, outer surface, outer edge**

The paths are either running along the inner surface of the structure or freely inside the structure. There is no part of the paths that runs outside the structure.



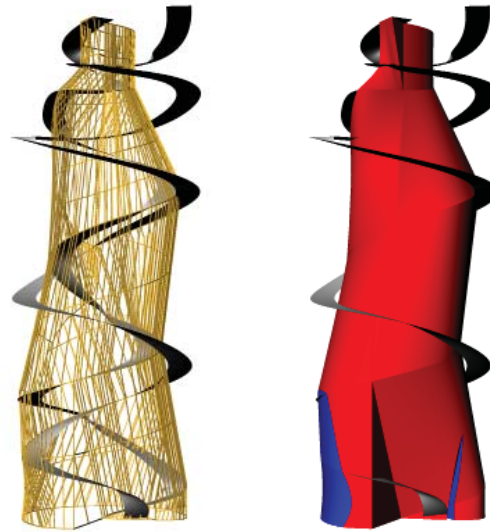
**Ba3 - Opposite direction, outer surface, within width**

The paths are either running along the structure or freely inside. There is no part of the paths that runs freely outside the structure. The paths along the surface may shift between inside and outside.



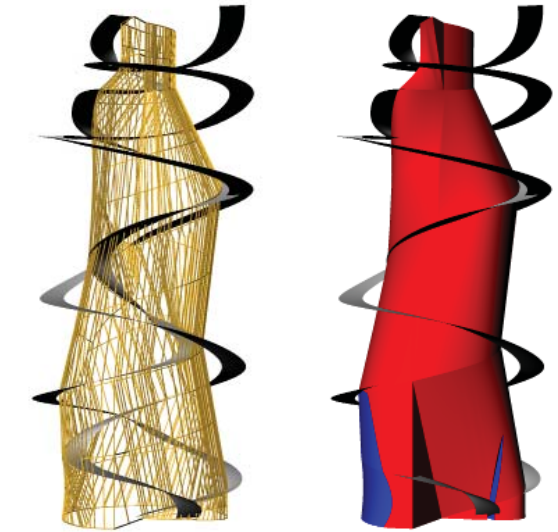
**Bb1 - Opposite direction, inner surface, inner edge**

The paths are either running along the outer surface of the structure or freely outside the structure. There is no part of the paths that runs inside the structure.



**Bb2 - Opposite direction, inner surface, outer edge**

The paths are either running along the inner surface of the structure or fully or partially outside the structure. There is no part of the paths that runs freely inside the structure.



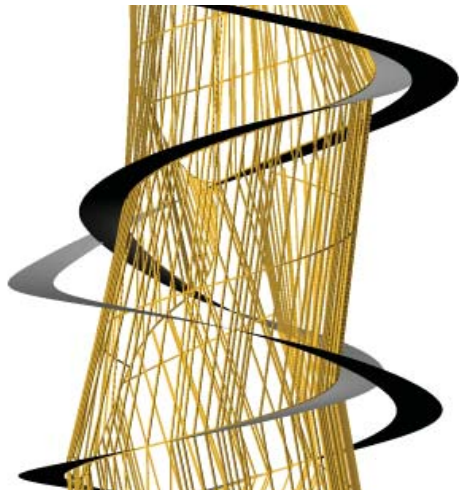
**Bb3 - Opposite direction, inner surface, within width**

The paths are either running along the structure or freely outside. There is no part of the paths that runs freely inside the structure. The paths along the surface may shift between inside and outside.



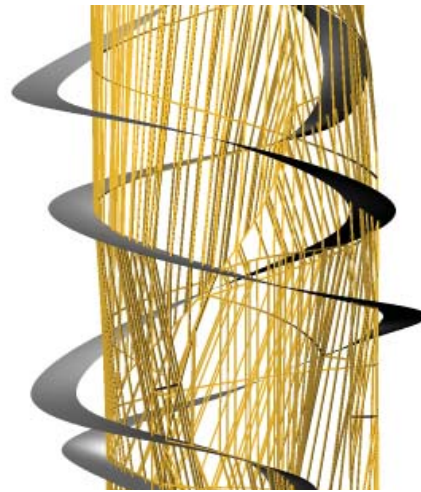
## Different options have different interesting aspects

The above alternatives give light to many interesting things. However, each combination of path directions, inner or outer surface and way to define the path in relation to the curve renders a given combination of features. None of these combinations exhibit all interesting aspects. Hence none of the above alternatives is the ultimate solution. Instead of using one of these, all different interesting aspects should be considered for the design. To achieve this, a new way of defining the path and its relation to the structure was defined.



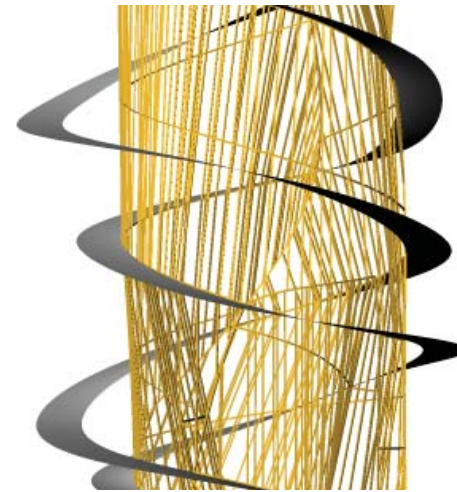
### ***Opposite directions create meetings***

*When the two paths are winding in opposite directions they naturally meet twice per rotation. This creates natural meetings between the paths and allows for visual connections between visitors on the different paths.*



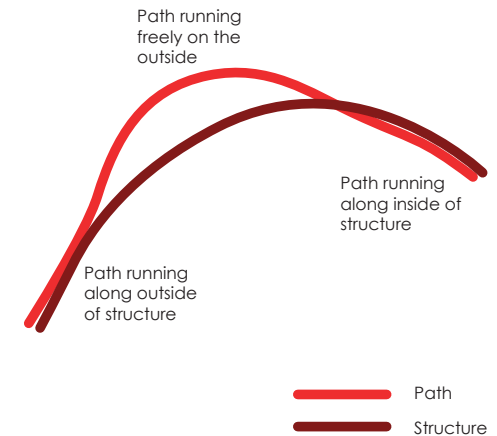
### ***Alternations between outside and inside are interesting***

*When the structure is defined by a curve within the width of the path, the path can weave in and out of the structure, which creates an interesting movement as the path alternates between following the outer and the inner surface of the structure.*



### ***Paths running freely creates thrill***

*Using the inner surface to define the structure creates paths running freely outside the structure, which creates an unsafe feeling and a thrilling experience. Paths running freely on the inside can create a similar, but not as extreme, experience.*



### ***Two curves per path***

*To be able to achieve all of these interesting aspects there should be two curves per path. One curve should describe the path itself and the other the horizontal relation between the path and the structure.*

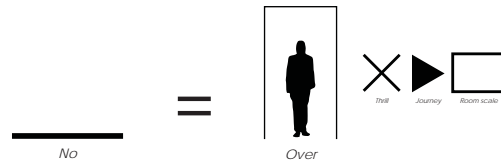
# SEQUENCE INVESTIGATIONS

## Sequencing Events

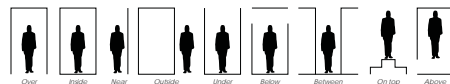
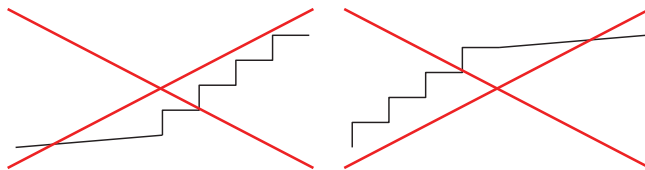
To create two sequences of Events, one for each of the two intertwined paths, some conditions and rules were set up. The two paths should have different characters. There should be one Adventurous path with all Spatial situations and other components represented and one shorter Inspiring path that is more conventional and that can be conquered by everyone.

### Rules

*Landing = Event. Every no resistance path, i.e. landing, should be an Event.*



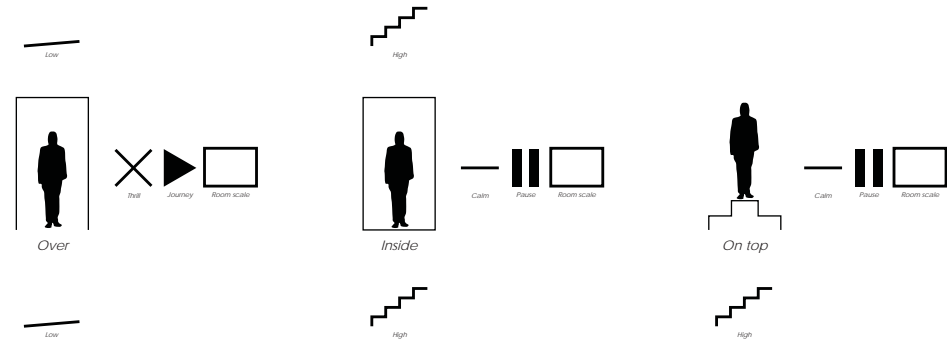
*Switching path type. Switches between path type is not allowed without an Event.*



*Parameters. Along the Adventurous path all parameters should be represented.*

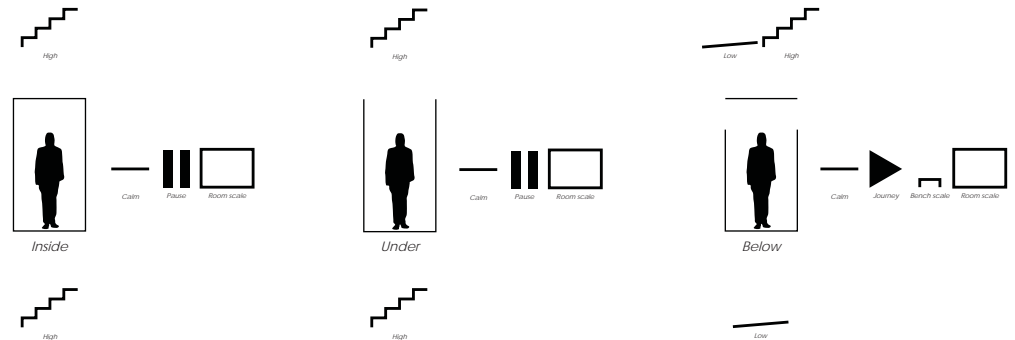
## Important Events

For the two paths some Events seemed more important than others. These were listed and when combining Events into sequences the configuration of these Events was nonnegotiable.



### Adventurous path

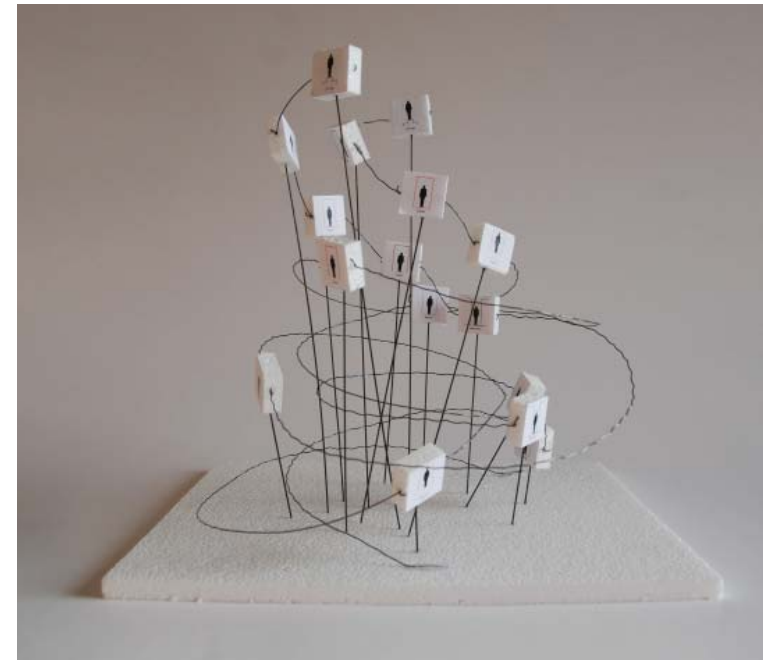
*There are 3 Events with corresponding resistances before and after that are particularly important for the Adventurous path. For the Spatial situation On top, resistance after isn't important, which is convenient as that Event is meant to be placed on top of the tower, at the end of the path.*



### Inspiring path

*There are 3 Events with corresponding resistances before and after that are particularly important for the Inspiring path. Below offers some different opportunities in the design. On top is important as well, but the Event will be shared with the Adventurous path and hence only the preceding path type may differ.*



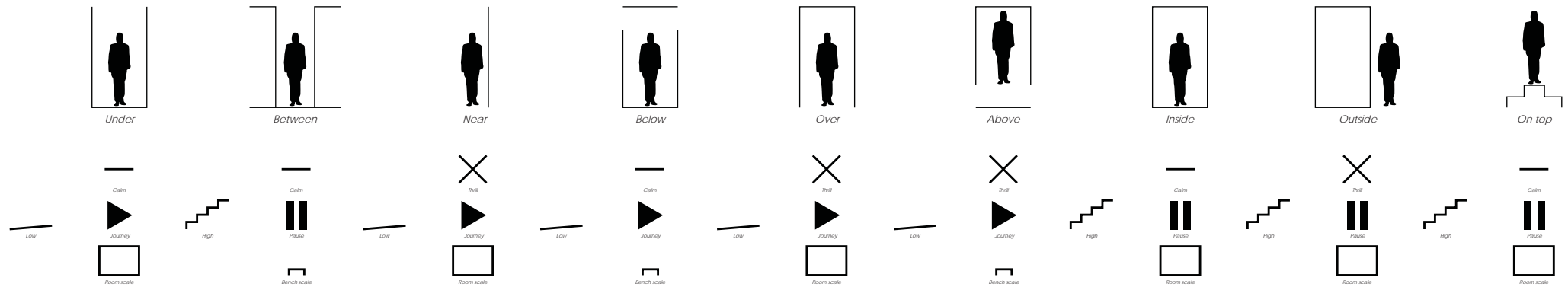


***Models to investigate the relation between Events in space***

*The relation between the Events in a sequence is controlled by the rules, but the Events also relate to all other Events that can be seen from it. Visualizing the sequences in models was an effective way to get an idea of how these relations work.*

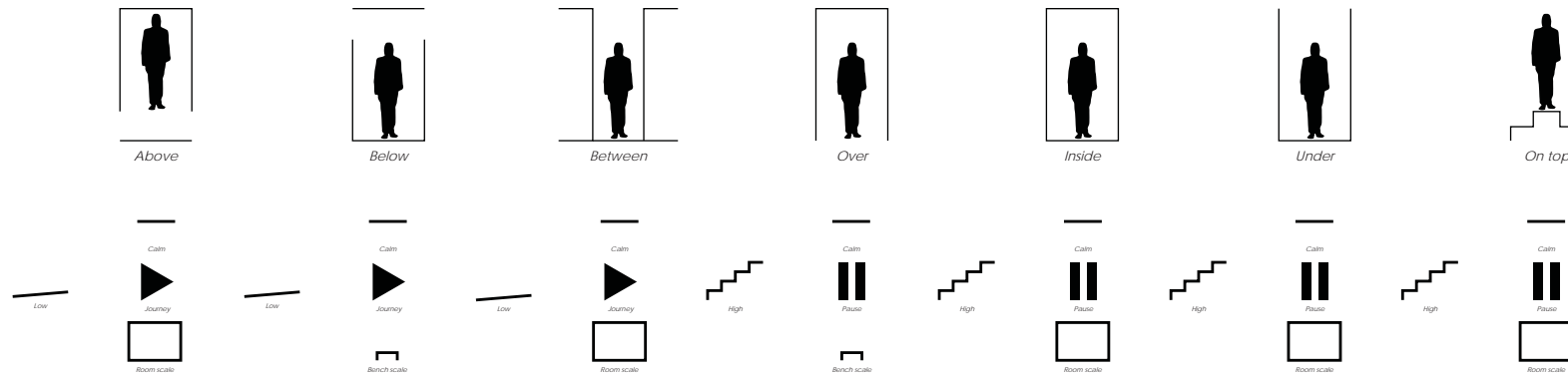
## Established sequences

The sequences of Events were created by combining the Events in various ways until an order that worked with the rules was established. The 3 important Events per path were not changed. In addition, the height of some Spatial situations was considered so that for example Above wouldn't be at ground level and On top would be at the top.



## Adventurous sequence

In the Adventurous sequence all Spatial situations are represented. The Events alternate between Thrill and Calm, Journey and Pause as well as in Scale. The path types between the Events varies between ramps and stairs. All possible parameters are represented.



## Inspiring sequence

Only 7 of the 9 Spatial situations are represented, since both Near and Outside can only be Thrill and all Events along the Inspiring path should be Calm. Aside from these two Spatial situations and Thrill, all possible parameters are represented to ensure a varied sequence of experiences.

# CONTEXT

## A small town with an industrial heritage

Bengtsfors is a small town in a municipality with the same name. It is located in the region of Dalsland, on the west side of lake Vänern. The region is filled with lakes and forest, both of which has been great assets to the town through history (Bengtsfors Kommun, 2016). The water connects the area, via the Dalsland's canal, to Vänern (Dalslands kanal, 2016). From there, other canals connect down to the coast and the harbor of Gothenburg. This way timber used to be transported to be exported. Later on the railway was built and the timber was transported that way instead (Bengtsfors Kommun, 2016). The water was also an asset because of its ability to generate electricity, something that attracted the chemical industry to the town (Bengtsfors Kommun, 2014).

Today, both the canal and the railway are used for tourism. There are tour boats on the canal as well as canoeing and private boating. The railway is used for a railbus as well as trolleys that you pedal yourself. The chemical industry also left its mark on the tourism in town. Its former site has recently been decontaminated and transformed into an educational environmental park ([www.vastsverige.com/bengtsfors](http://www.vastsverige.com/bengtsfors)).

Just east of the town center the local history museum, Gammelgården, is located. This is where the tower will be located.

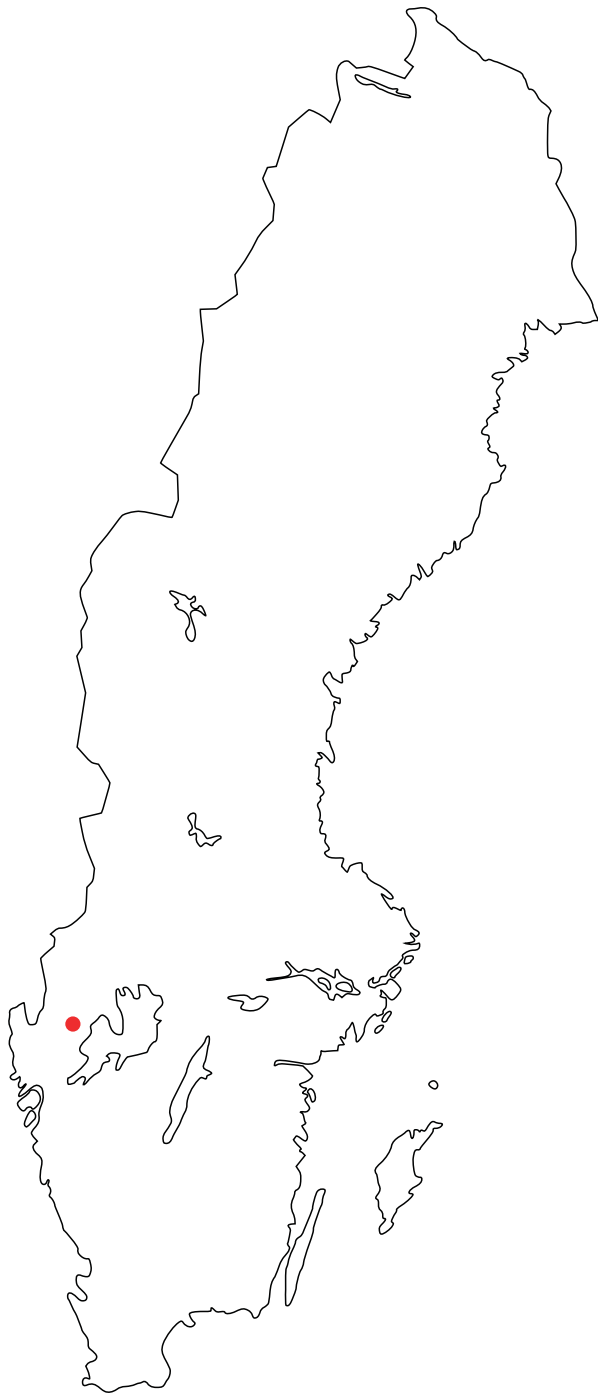


***The water offered transportation for the forestry***  
*The water and the canal made it possible to transport timber down to the coast before the railway was built. Today the canal is used for boat tourism and canoeing.*

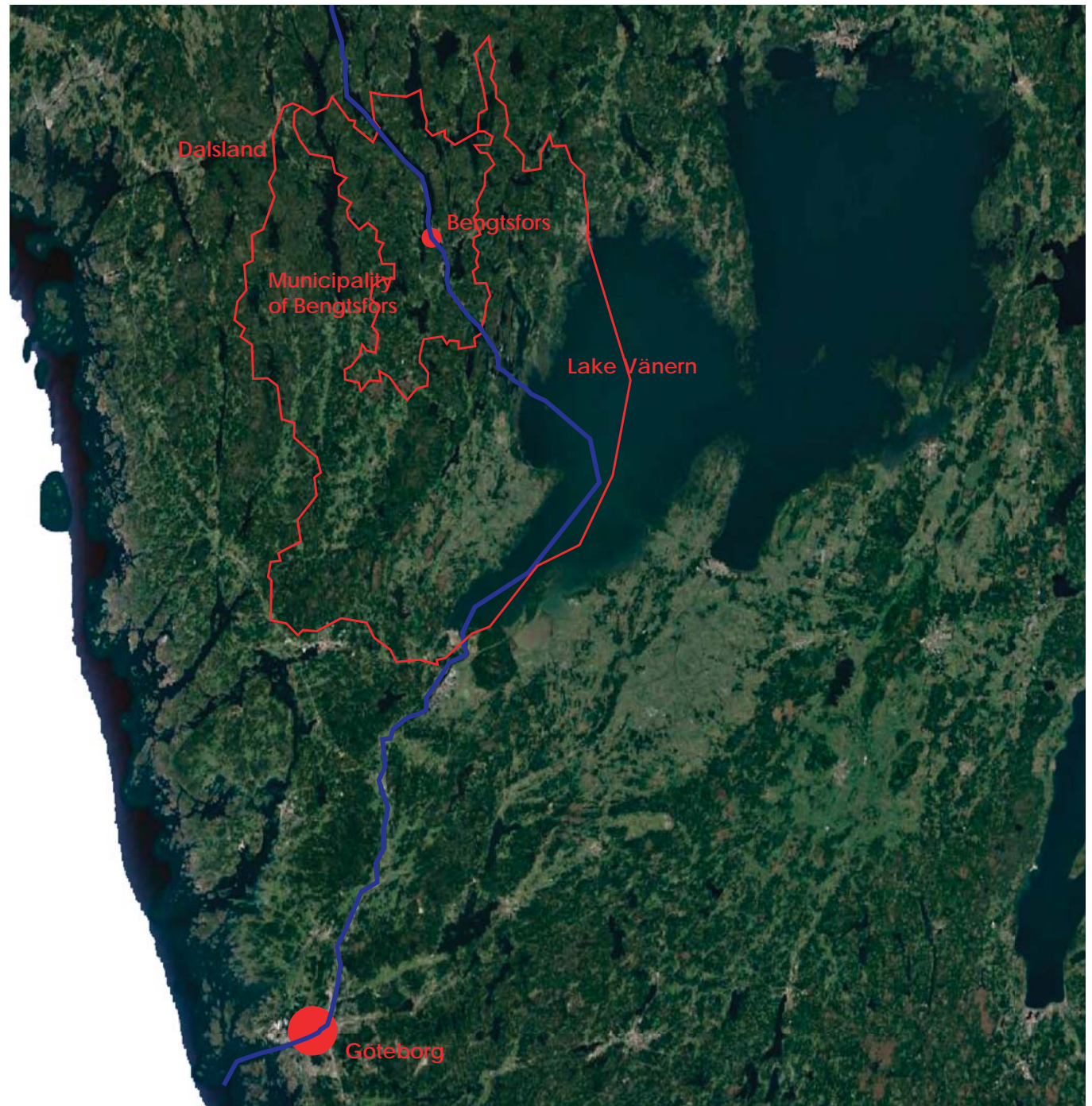


***Today the railway is used for tourism***  
*The railway was initially used for transportation of the timber down to the coast. Today it is used for tourist trains and railbuses.*



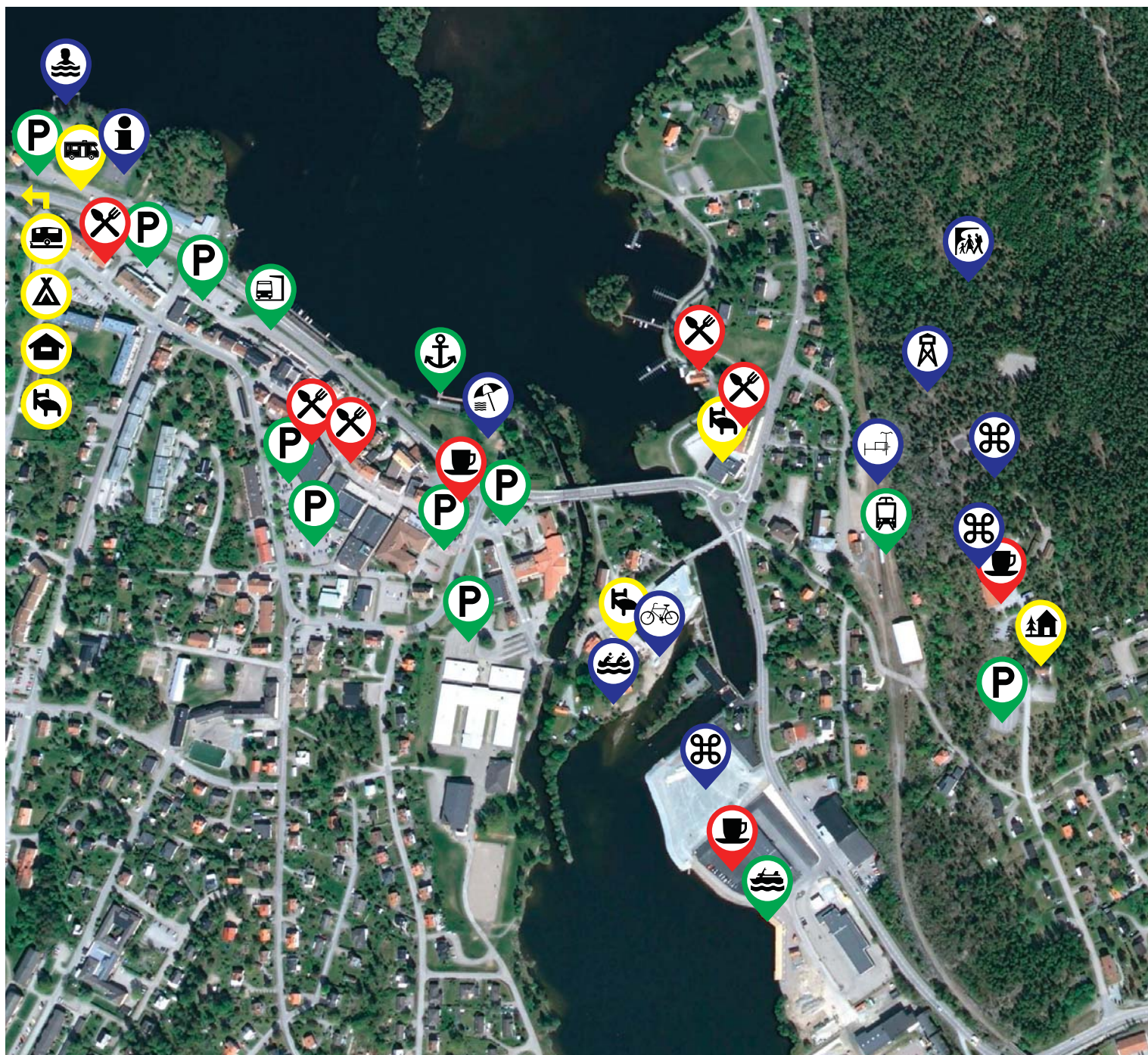







*Bengtsfors's location in Sweden*



*The system of lakes and canals connecting the Bengtsfors area with the coast*





-  Transportation
-  Accommodation
-  Restaurants & cafés
-  Activities & culture
-  The View of Wood observation tower

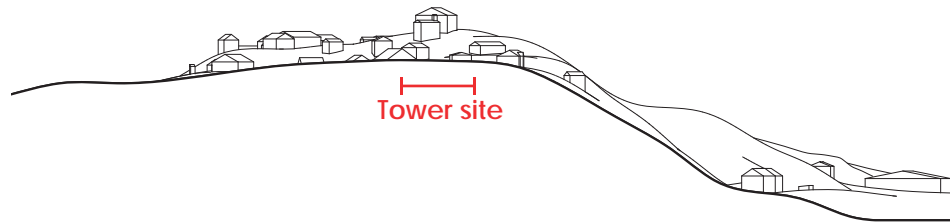
*Tourism related functions in the town of Bengtsfors*



# The museum area and the site

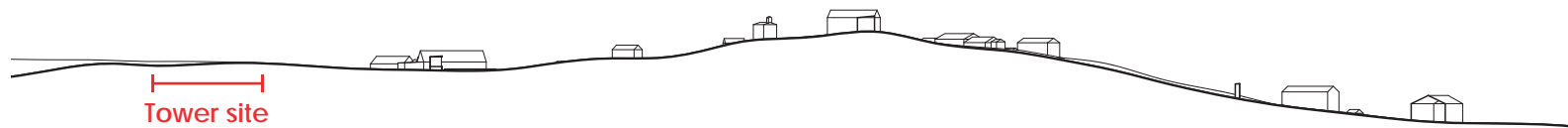
Gammelgården, the local history museum (Swedish: Hembygdsgård), consists of a collection of buildings from around Dalsland. The entrance to the area is from the south. The site for the tower is in the north of the museum area. It will be placed as a continuation of the museum. If you are visiting the museum you will walk around and enjoy the traditional buildings first and then continue north to the tower.

There are two clear ways from the museum area to the tower site. One way is from the dance floor, the other is from the chapel. One can also arrive at the tower site via a trail up the steep slope from the train tracks to the west or via the hiking trails to the north.



## Section A-A 1:2000

*Just west of the tower site the slope is quite steep. There is a height difference of over 30 m from where the tower is placed to where the ground evens out down by the railway station.*



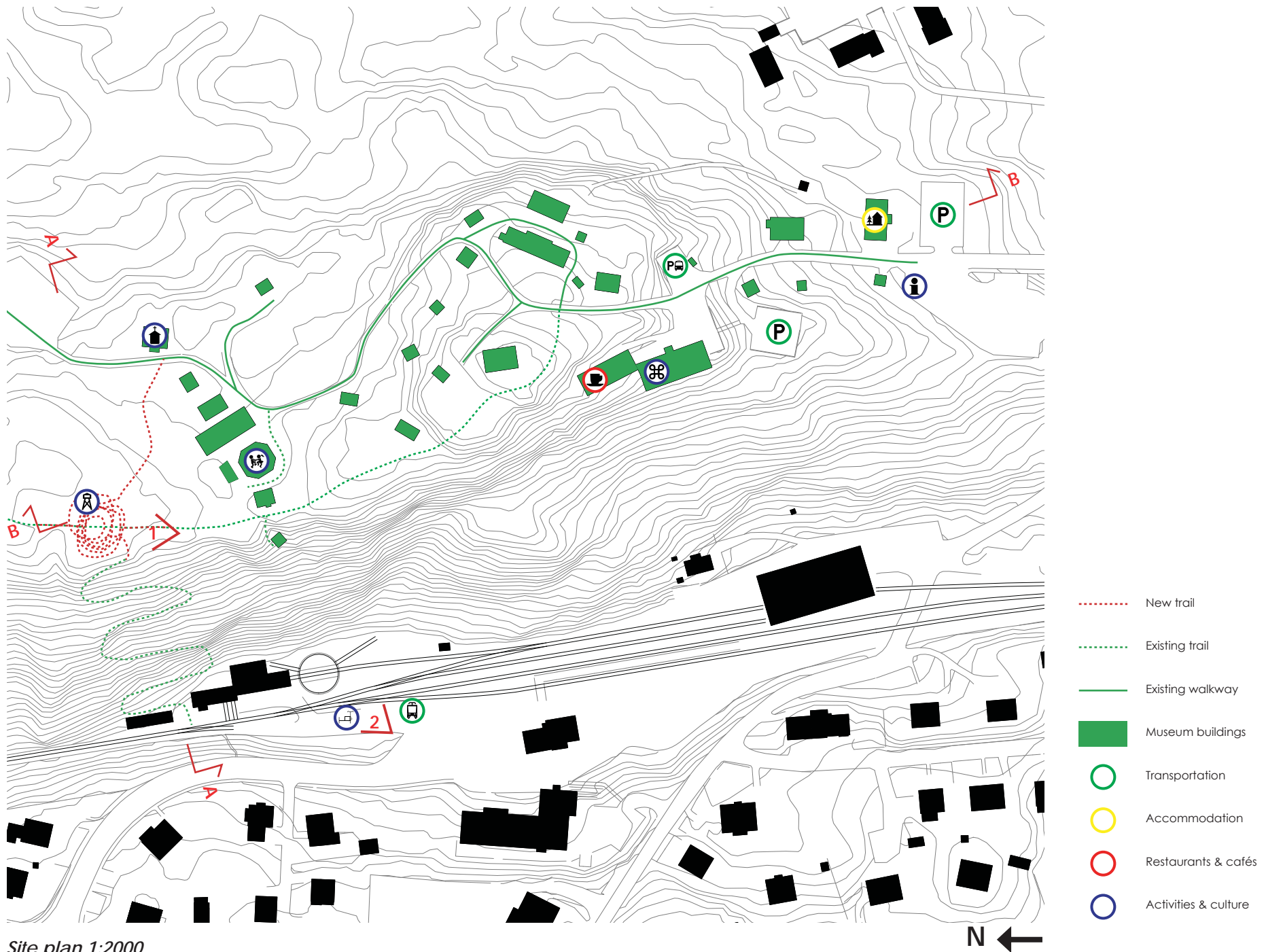
## Section B-B 1:2000

*In the north-south direction the ground level is quite even, especially near the site of the tower.*



## The tree height

*The tallest trees in the forest surrounding the site become 25 m tall. Therefore, the top platform of the tower will be placed 25 m above ground, so that when you're at the top you'll be just above the treetops.*



### Site plan 1:2000

The entrance to the area is in the south, by the parking lot. The site for the tower is in the north, where the new trails become walk path winding up the tower.



*The adventurous family coming from the train tracks and up the trail arrives to the tower site from the west.*



*The friends coming from the hiking trails arrive from the north.*



*The retired couple coming from a meeting in the chapel walks through the forest and arrive from the south east.*



*The tourist group walking around the museum find the trail beside the dance floor. They arrive from the south.*

**The visitors**



### **1. The site for the tower**

*There is a clearing in the forest which is the site for the tower. The tower is meant to be built on the rock, which provides a stable foundation.*



### **2. View from the train tracks**

*From the train tracks west of the site the slope up towards the tower can be seen. The slope is mostly rock and the vegetation consists of shrubs and lower trees.*





### ***The character of the area***

*Around the area are a group of traditional buildings. Most of them have been moved here from around Dalsland, while some have been built for the site using traditional techniques and historical models. The different buildings are furnished in the way they were from the beginning and for their respective purpose. There are homes, storage, a forge and a chapel among other functions.*

# The view from the tower

The view from the site today is best in the south and the north west directions. However, it is partially blocked by smaller trees and shrubbery. From the top of the tower the views will be unhindered and it will be possible to see in more directions and further.



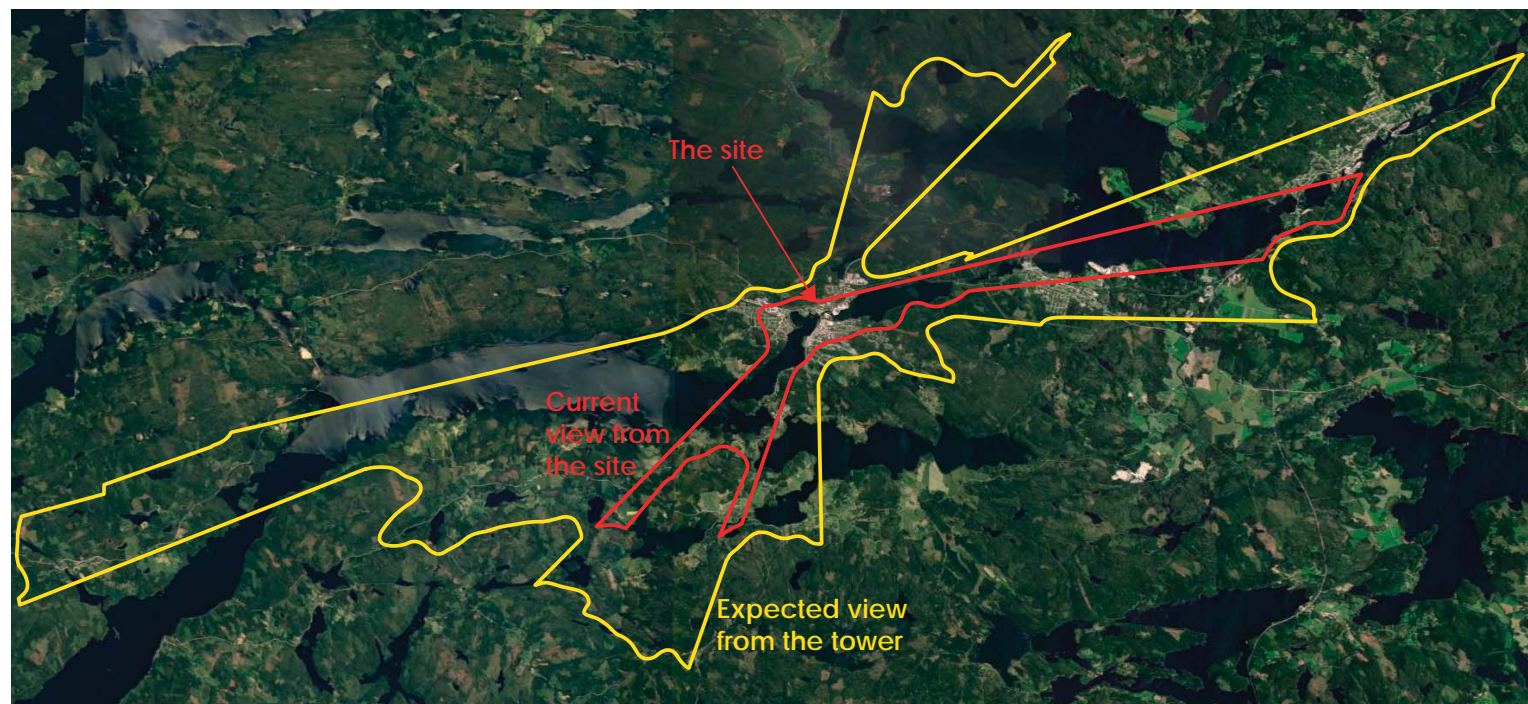
*Panoramic view from the top of the tower* View to the south in the direction of Billingsfors.

View to the west over the town of Bengtsfors.



### ***Views from the site today and the expected views from the top of the tower***

*The view from the site today is blocked by the forest to the north and east and partly hindered by shrubs and smaller trees to the west and south. The unhindered view will be much greater from the top of the tower than from the ground. The image indicates the first obstacles for the view, but it will of course be possible to see higher hills further away too.*



*View to the north along the lake Lelång.*

*View to the east over the forest landscape.*



# FORMATION

The results of all of the investigations come together in a design proposal. The Events and their preceding and following paths and the theoretically established sequences were placed on site. With respect to the four ways of approaching the site and the different categories of visitors that would come from each direction, the start of the Adventurous and the Inspiring paths were placed. The sequences were adjusted and some Events changed in order to better work with the site and the opportunities it offers in terms of views and experiences. The structure was then established using the double curve system that was the conclusion from the structural investigations.



## ***Coming from the train tracks***

*The adventurous family coming from the train tracks arrive right at the beginning of the Adventurous path.*



## ***Coming from the hiking trails***

*The friends coming from the hiking trails north of the site arrive at an additional path leading into the base of the tower. Once inside the structure they can go right to get to the Adventurous path or left to get to the Inspiring path.*



## ***Coming from the chapel***

*The retired couple arriving from the chapel walks right onto the Inspiring path.*



## ***Coming from the dance floor***

*The tourist group coming from the museum area arrive at another additional path. Once inside they can choose to go left to get to the Adventurous path or go right to get to the Inspiring path.*



## ***Axonometric view of the tower from the south 1:200***

*The visitors arrive from different directions and either directly to one of the paths or into the base of the tower where they can choose which path to take.*



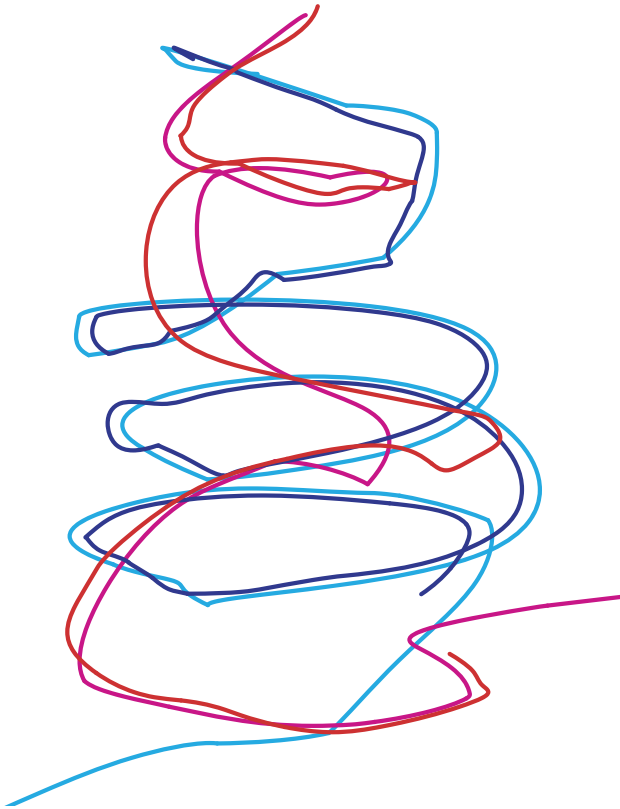
### ***On top***

*Regardless if you walked along the Adventurous or the Inspiring path you will end up at the same top platform. Here the families, tourists, retired and hikers all meet and enjoy the view.*



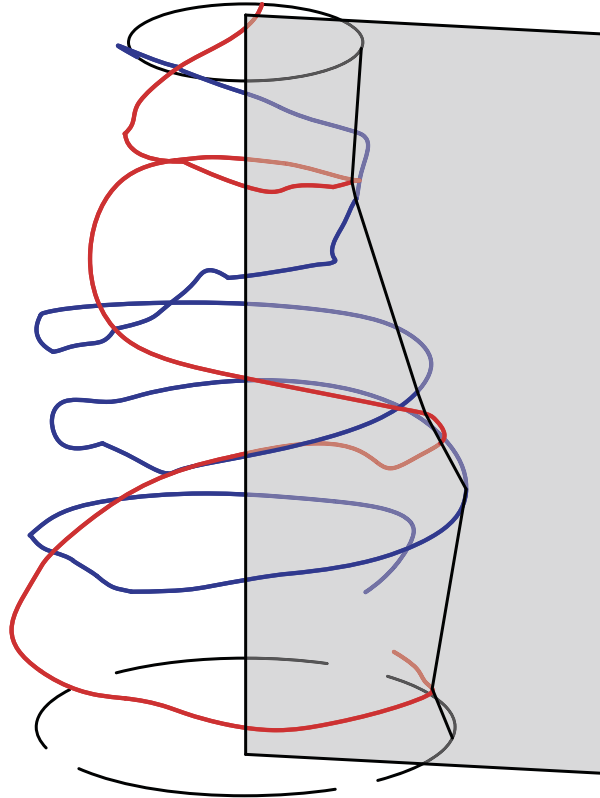
# The structure defined by the paths

The idea of each path being described by two curves; one for the actual path and one for its relation to the structure, was used to develop the load bearing structure. First curves describing the paths were defined. Then the relation between the path and the structure was considered at every point along the curves and the structure curves were established.



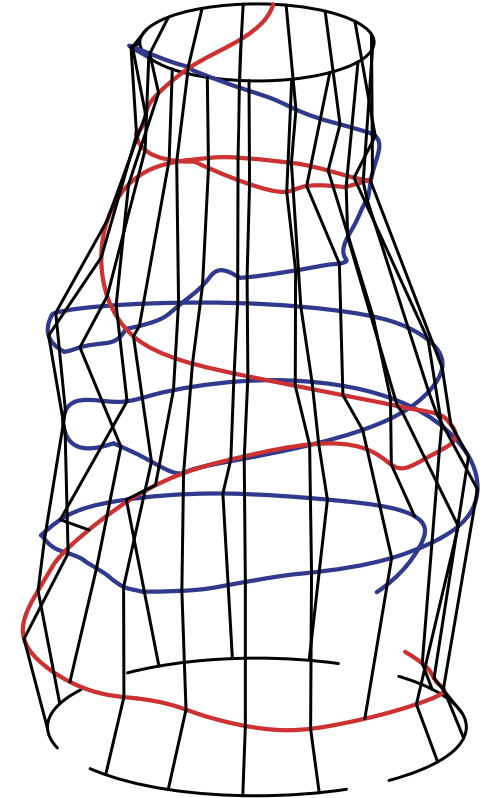
## ***Path curves and structure curves***

The light blue and pink curves define the center of the Adventurous and Inspiring paths respectively. The dark blue and red curves are the structure curves. They can run along the inner or the outer edge of the path. It can also cross the path, indicating the path passing through the structure, or run at a larger horizontal distance from the path, indicating the path running freely.



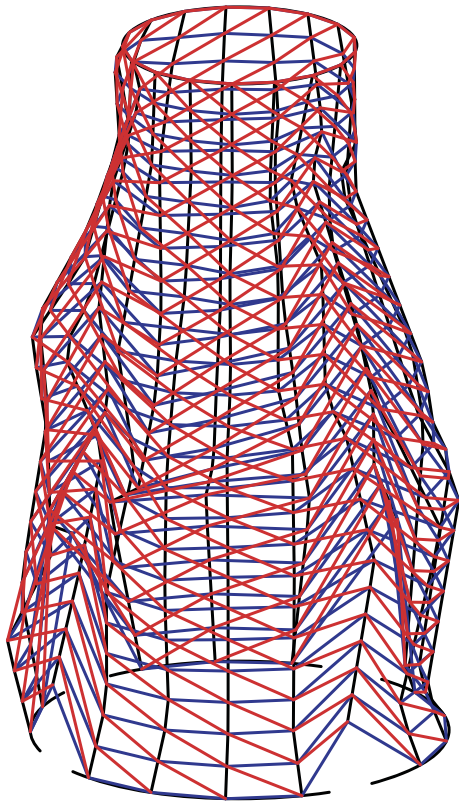
## ***Silhouette rib defined by structure curves***

Circles define the top and bottom of the tower. Openings at the bottom are achieved by gaps in that circle. A vertical plane with one side along the central axis of the tower defines points where it intersects with structure curves and the top and bottom circles. By connecting all intersection points along the plane a rib that define the silhouette of the structure is created.



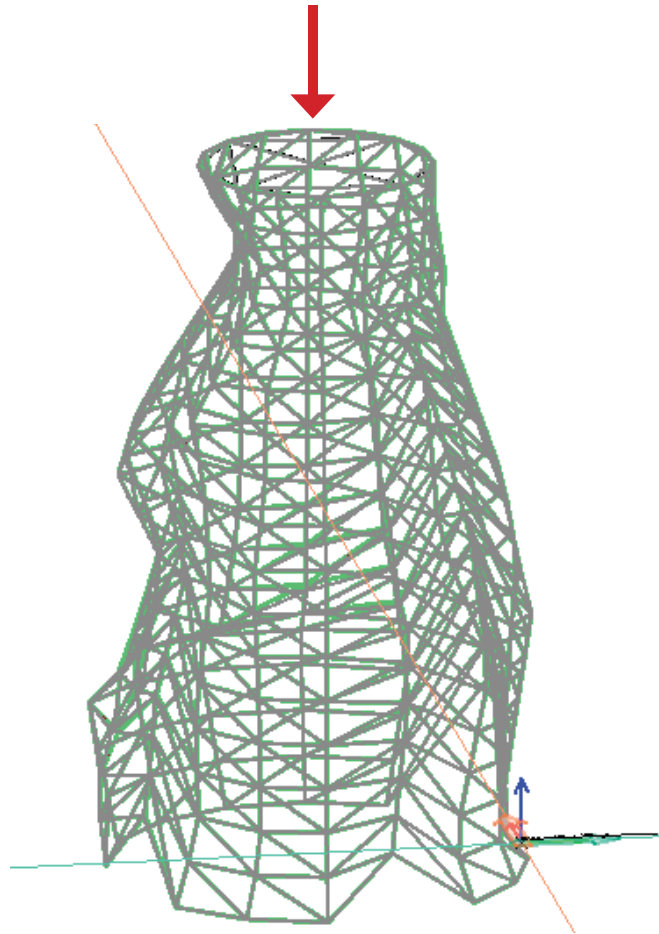
## ***Multiple silhouette ribs define the structure***

By rotating copies of the plane around the central axis of the tower multiple ribs are defined.



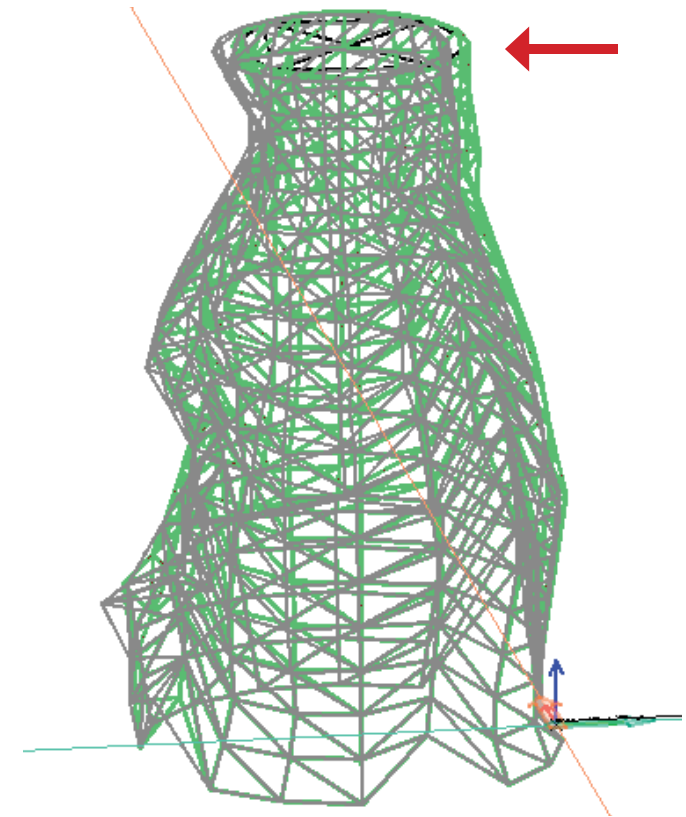
### ***A triangulated bar structure***

*Horizontal division of the silhouette ribs defines the nodes of the structure. By connecting the ribs to each other horizontally and diagonally a truss like structure that consists entirely of bars and that is completely triangulated is obtained.*



### ***Behavior under vertical loading***

*The structure handles vertical loading well and exhibits small deformations. It is assumed that with the right dimensions of the structural members the structure will be stable.*

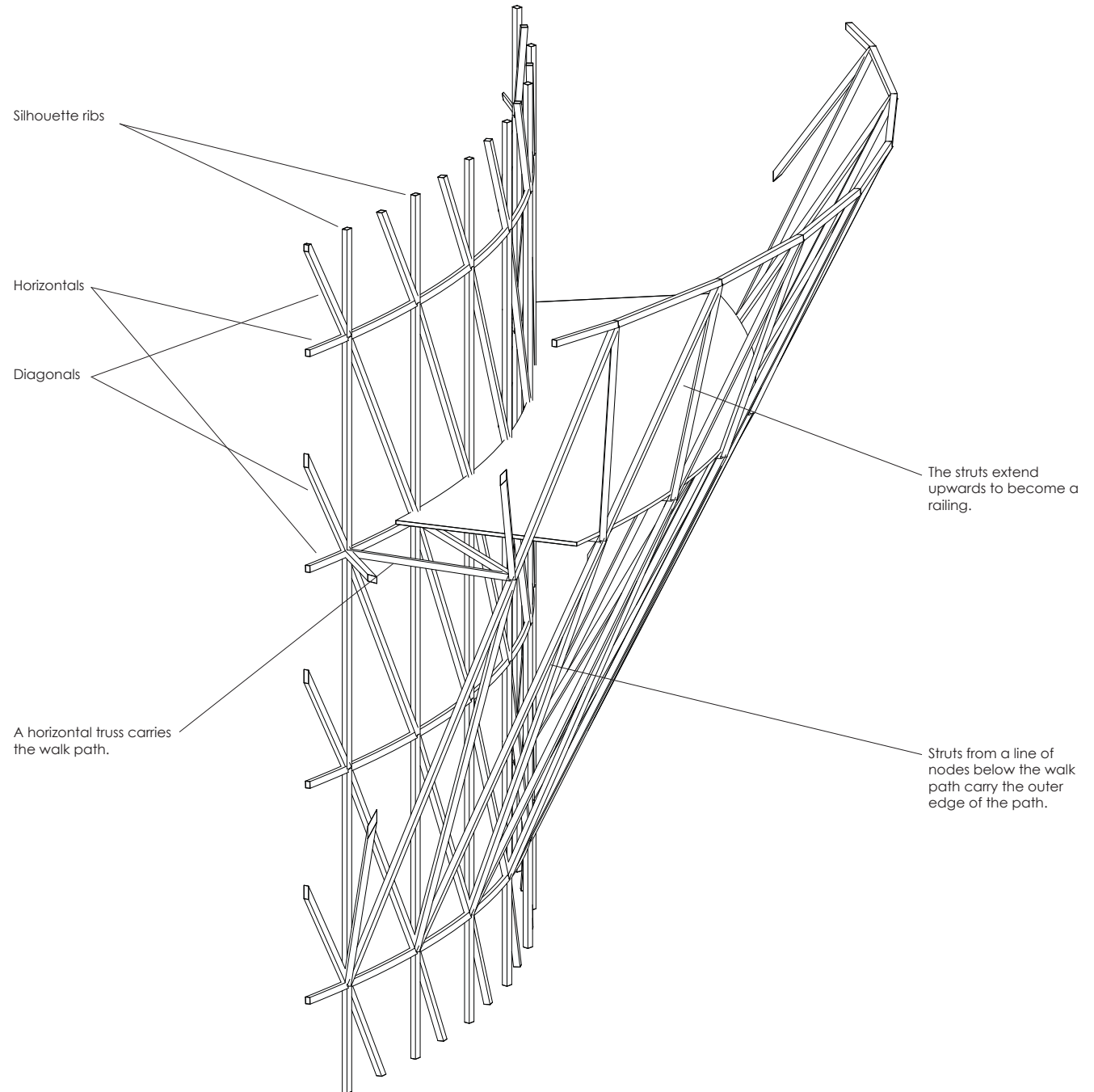


### ***Behavior under horizontal loading***

*When subjected to horizontal loading the structure deforms more. However, the deformed shape is reasonable and it is assumed that with the right dimensions of the structural members the structure will be stable.*

# The structure that carries the paths

The walk paths are integrated into the structure. When the paths are added, the silhouette of the structure becomes much more interesting and complex than the primary load bearing structure defined by the structure curves is by itself.



## Axonometric drawing of the structure carrying the walk paths

The walk paths are carried along one side by the structure itself and along the other side by struts from the structure below. These struts extend upwards to form a railing along the path. The walk path itself consists of a horizontal truss structure between the structure and the struts. Onto this truss the actual walk path is attached.





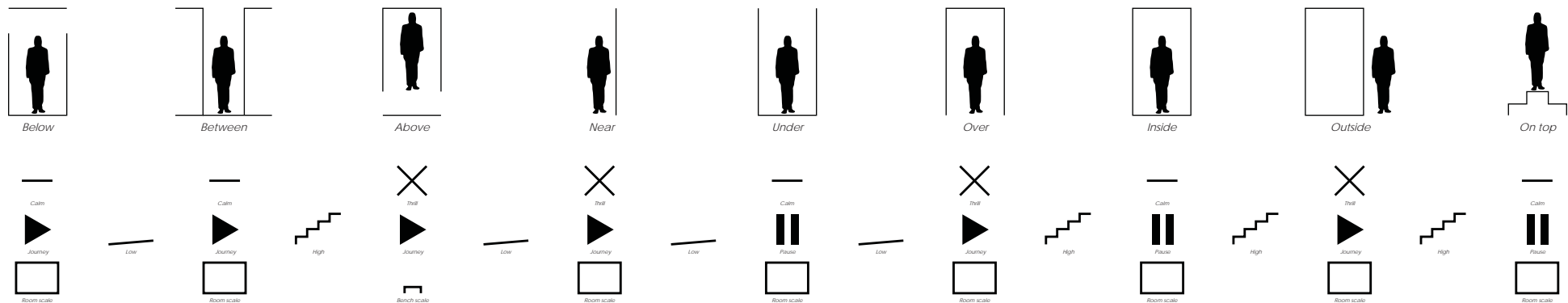
***Inside along the Inspiring path***

*When you get up to Inside you have just climbed a long flight of stairs. It is nice to sit down and rest for a while and just enjoy the view straight into the forest.*

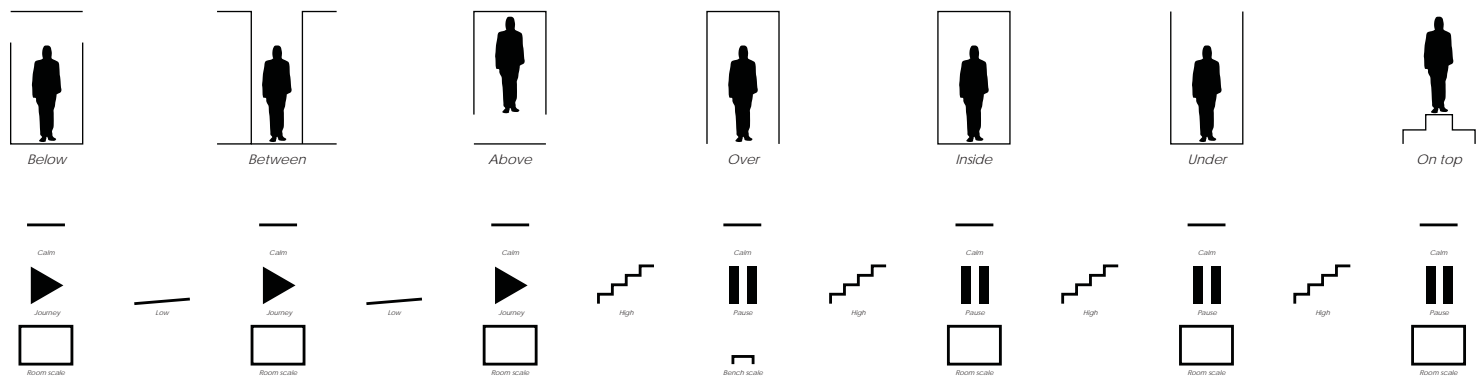


# Sequences in space on site

The final sequences were adjusted, compared to the previously established sequences, in order to ensure the best experiences of the site. With all their Events and the path types that link them together these sequences form the two paths up the tower. The Adventurous path is long, over 180 m, and winds around and around the structure. The Inspiring path is much shorter and a significant part of the height up the tower is covered by a flight of stairs inside the structure. The Inspiring path is both a non-thrilling way to take and a fast track. Perhaps you take the Adventurous path up and the shorter Inspiring path down while reflecting over the experiences you had going up as you go down and meet the next group of visitors conquering the Adventurous Events.



*The final Adventurous sequence*



*The final Inspiring sequence*

**Adventurous path**  
Total length: 183 m



**Inspiring path**  
Total length: 107 m

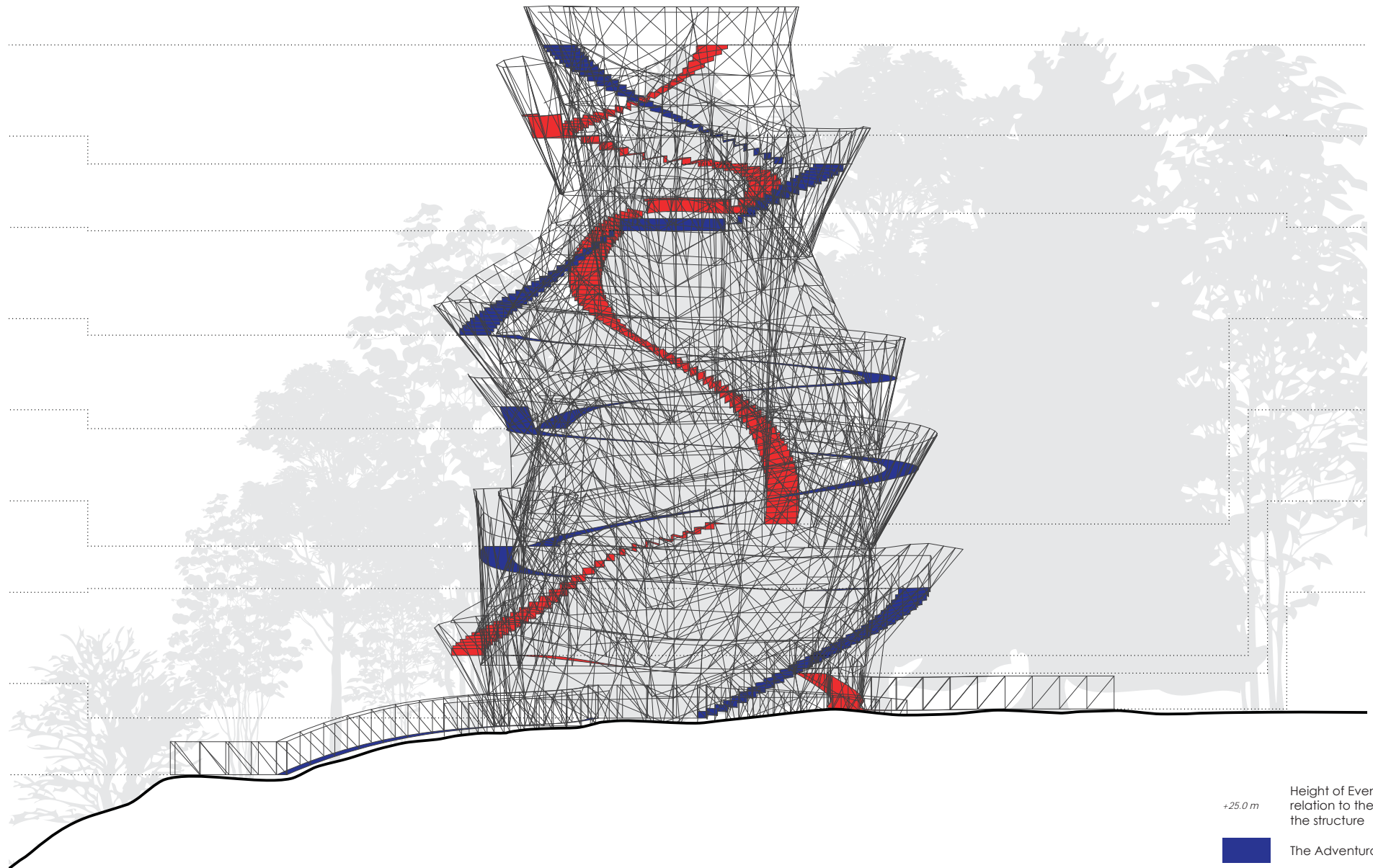
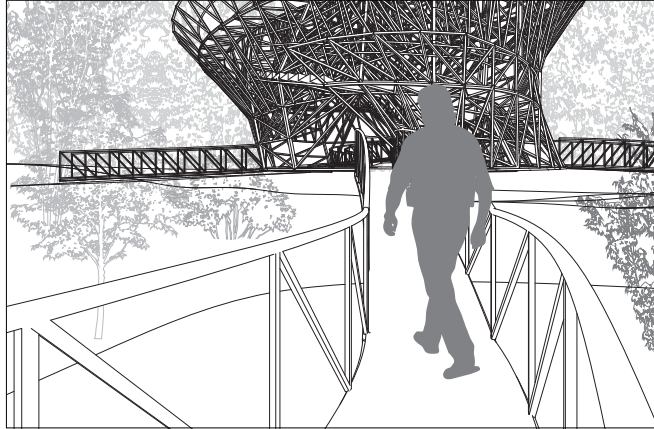


Diagram of the paths, view from the south 1:200

## The Adventurous path

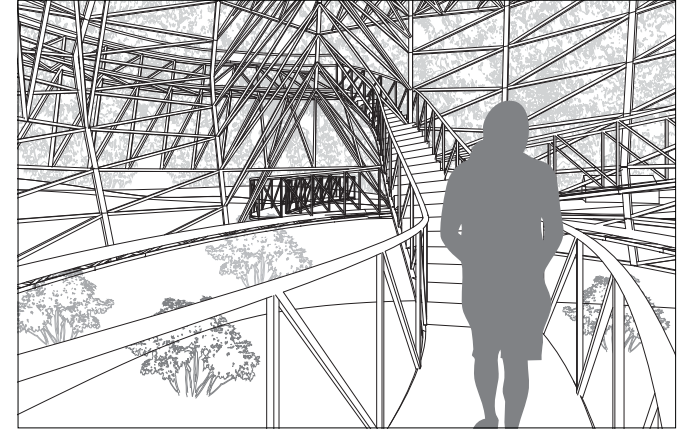
The Adventurous path is the path you arrive at when coming from the train tracks. It is a longer journey to the top of the tower. Along the path you'll experience different things. Some experiences will be calm and allow you to relax, while others will be thrilling.

Along this path the contrasts are the most prominent. When moving from Calm to Thrill and from Journey to Pause, the Events enhance each other.



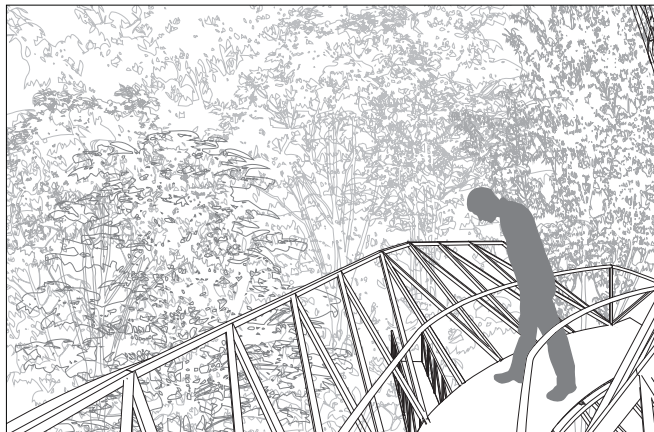
### 1. Below

*When approaching from the train tracks expectations start to build. You can see stretches of paths that you will soon be experiencing.*



### 2. Between

*As you enter into the structure the actual experience starts. You are between the expectation and the experience, in the tower, but on the ground.*



### 3. Above

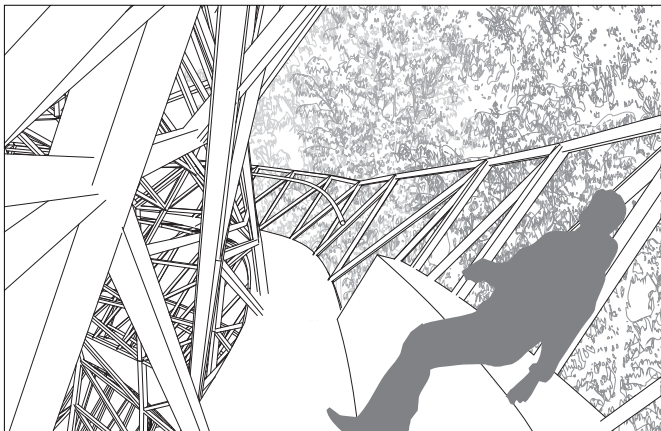
*The ascend has begun. The first relation to what's below is experienced when you get out of the structure again and look down onto the beginning of the Inspiring path.*



### 4. Near

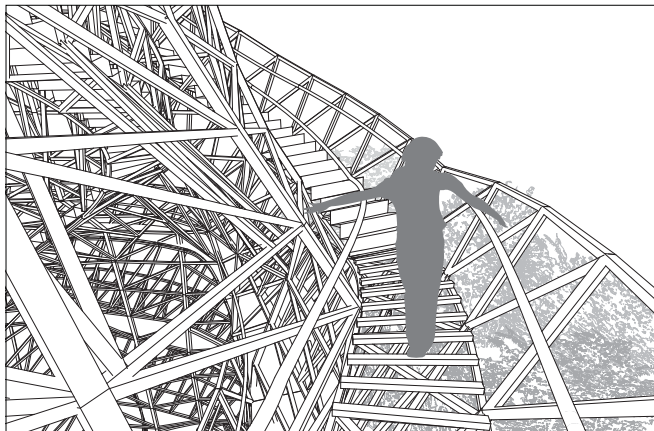
*There are no railings to hold on to, only the path to walk on and the structure to get through and experience.*





### **5. Under**

*Dare to lean against the struts carrying the path. Relax and be under the clouds for a moment.*



### **6. Over**

*The path you are walking on dissolves. You have to watch where you put your feet. You'll see the ground below and the rocky slope down to the train tracks.*



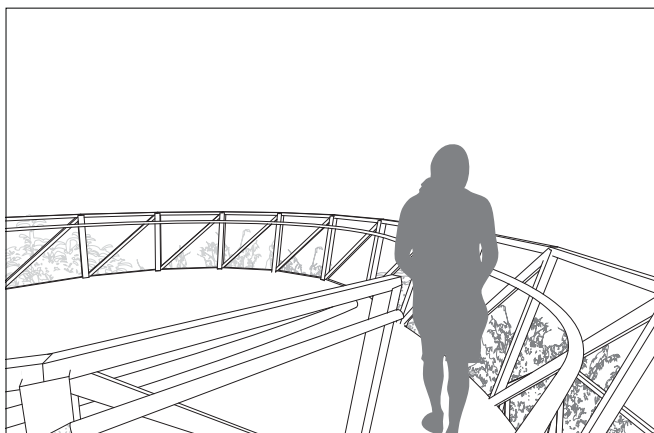
### **7. Inside**

*Protected inside the structure. Sit down for a while and look into the trees outside.*



### **8. Outside**

*The path lets go of the structure for a bit.*



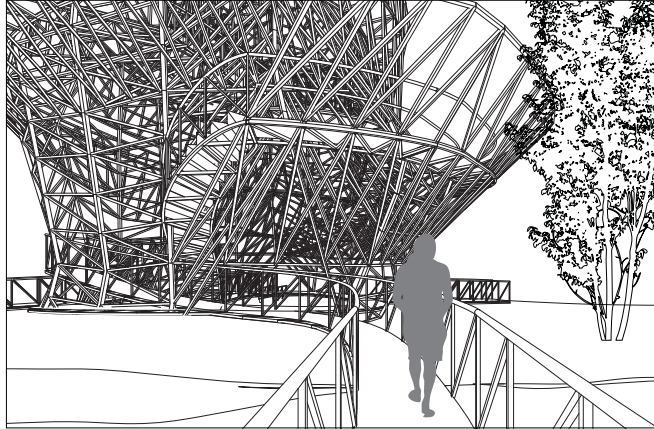
### **9. On top**

*At the top the paths meet. You can walk around the platform and enjoy a 360° view of the landscape.*

# The Inspiring path

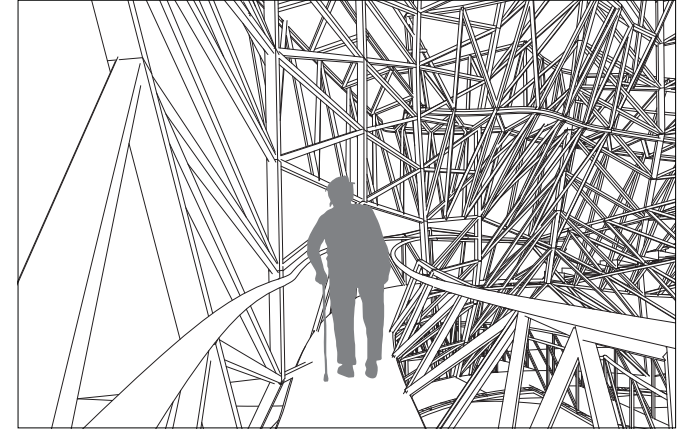
The Inspiring path is the path you arrive at when coming from the chapel. The trail that leads here is a clear way from the museum area to the tower. The Inspiring path is a shorter path to the top of the tower.

All Events along the path are Calm, but it still offers a variety of experiences. This path shall be possible to conquer for everyone. Maybe you feel that the experience of simply going up to the top of a tower is thrilling enough for you, then this path is the one you take.



## 1. Below

*When approaching from the chapel expectations start to build. You can see stretches of paths that you will soon be experiencing.*



## 2. Between

*As you enter into the structure the actual experience starts. You are between the expectation and the experience, in the tower, but on the ground.*



## 3. Above

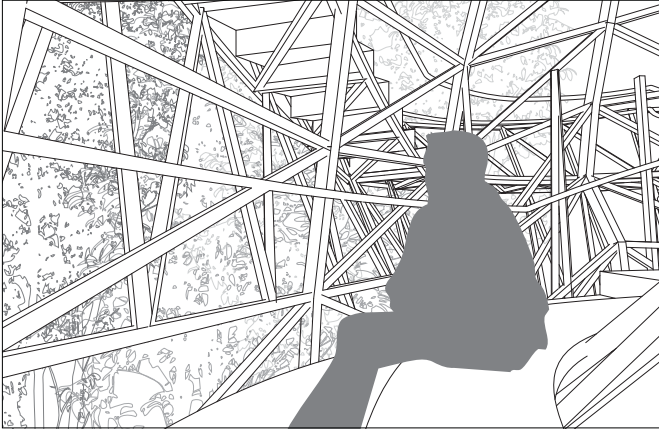
*The ascend has begun. The first relation to what's below is experienced when you get out of the structure again and look down onto the beginning of the Adventurous path.*



## 4. Over

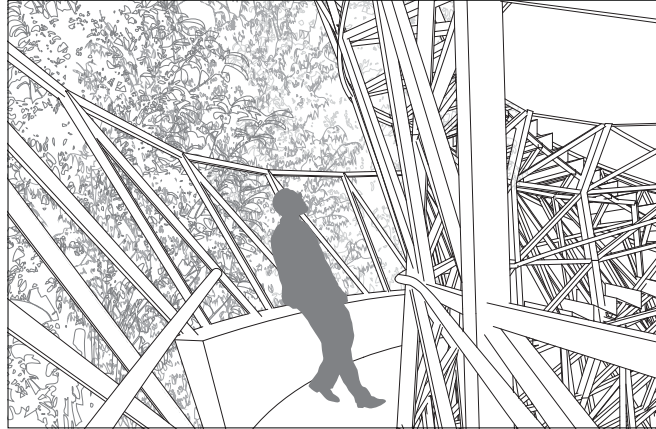
*The path is not connected to the structure. It is a little place to stop and acknowledge that there is nothing below, only empty space down to the ground, but you are inside the structure and only a step away from the "safe" path.*





### **5. Inside**

*Protected inside the structure. Sit down for a while and look into the trees outside.*



### **6. Under**

*Lean against the struts carrying the path. Relax and be under the clouds for a moment.*



### **7. On top**

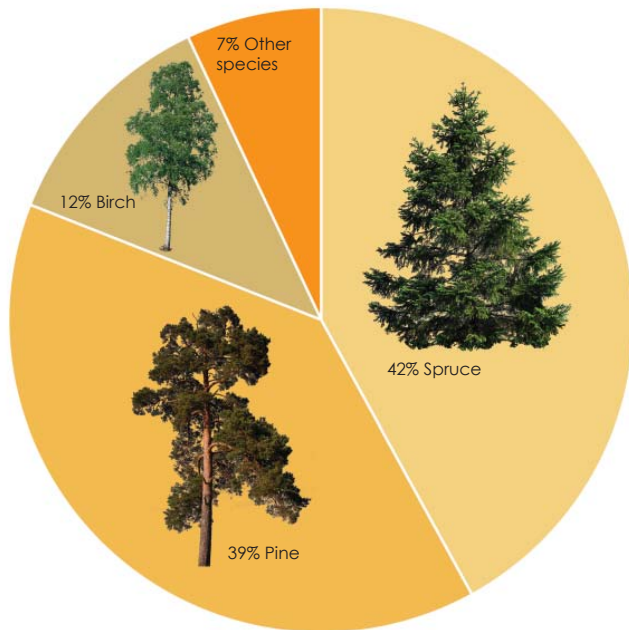
*At the top the paths meet. You can walk around the platform and enjoy a 360° view of the landscape.*

# Material

Before going into dimensioning of members, joinery and how to actually build the tower, it is necessary to consider what materials to use.

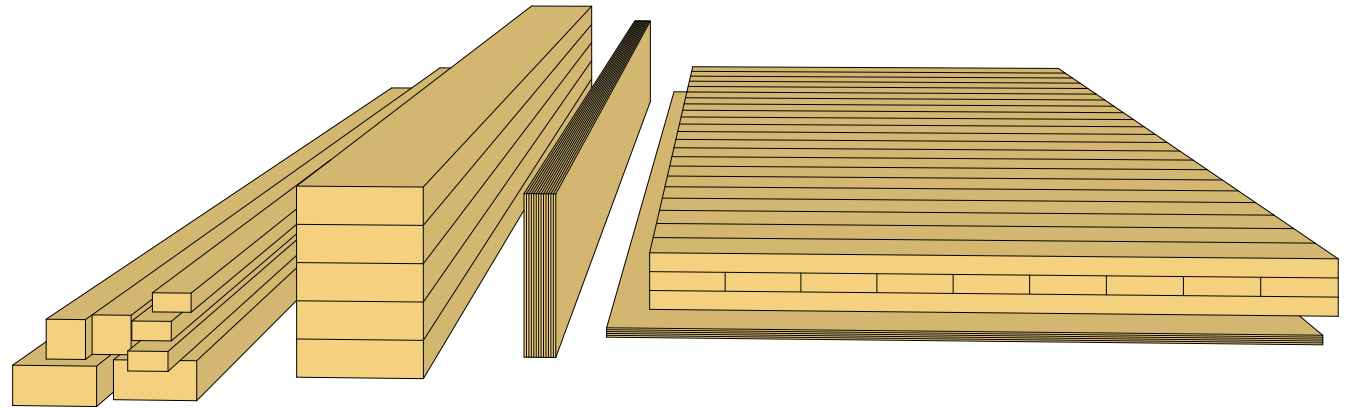
## Timber

To be able to utilize timber it is necessary to be aware of its properties. Wood, the perfect little piece of the material that can be investigated in a lab, has its properties, but timber, the large pieces that can be used for construction, have imperfections to take into account. It is a natural material and hence its properties can only be controlled to a certain extent. It is necessary to be aware of the basic strengths and weaknesses of the material.



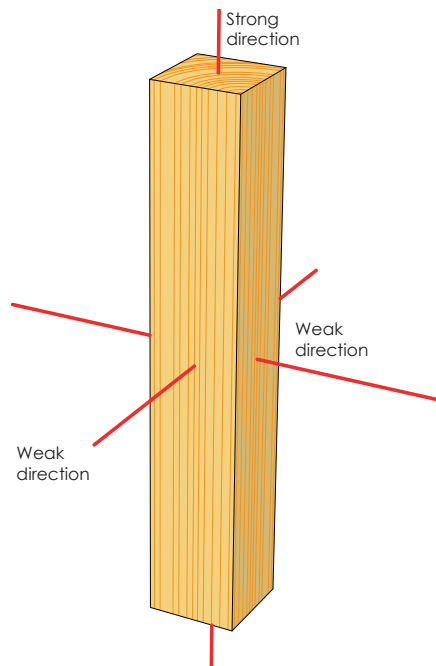
### Swedish forest

The Swedish forest consists of spruce, pine and birch and some other deciduous species (Skogsstyrelsen, 2016). It is primarily spruce and pine that are used for structural purposes.



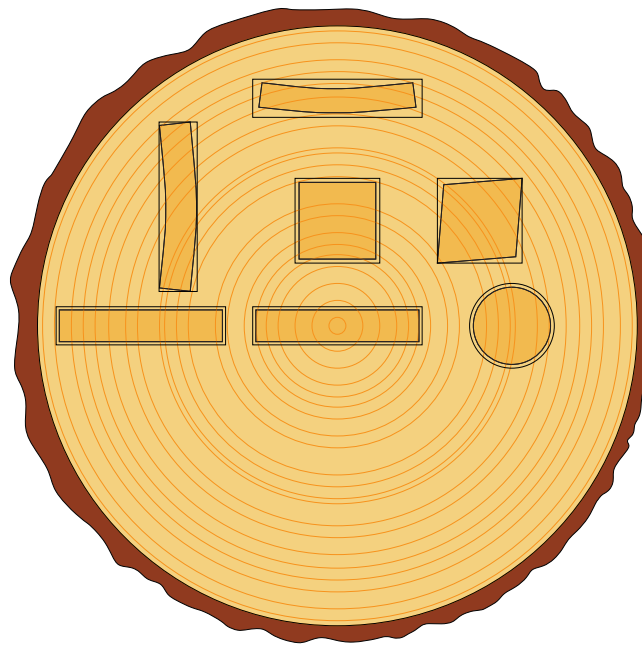
### Timber products

The market offers a variety of structural timber and engineered timber products. For the tower it is primarily structural sawn and planed timber and glulam that is most likely to be used. Plywood, laminated veneer lumber (LVL) and cross-laminated timber (CLT) may also be considered for platforms, stairs, ramps and landings.



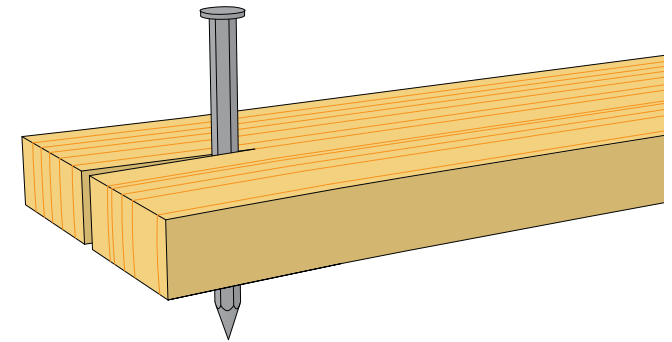
### **Wood is anisotropic**

The properties of wood differ in different directions. It is strongest in tension and compression parallel to the grain, i.e. along the length of the tree, and weak in loading perpendicular to the grain.



### **Effect of shrinkage**

The growing tree contains more moisture than the timber products used in construction. After the tree is cut it starts to dry, which causes shrinkage. The material shrinks differently in different directions, which is important to consider when sawing the trunk into planks in order to avoid deformations.



### **Splitting makes joints weak links**

The weak link in timber structures are often the nodes. In order to transfer the forces, the dimensions of the members may need to be increased. This is because timber has a tendency towards splitting. Due to this there are limits regarding how close to the edge a fastener can be applied and how small the spacing between the fasteners may be.

# Steel

It's been determined that steel is a good complement to timber. Steel should be used for joinery. It could also be used as structural members to ensure stability. The structure will always be subjected to weather. Therefore, all steel, whether it is structural members or connectors, shall be treated as to withstand corrosion. A way of obtaining this is hot-dip galvanization.



## ***Structural members***

*Steel rods and cables may be used. For example, steel can be an alternative for diagonal members as it is an effective way of accomplishing bracing against lateral loading such as wind.*

## ***Fasteners***

*Screws, nails and bolts with washer and nut are possible fasteners. Depending on the size of the members to be connected and the forces to be transferred the appropriate type of connector should be chosen.*

## ***Brackets and plates***

*Standard brackets, nail plates and bulldog plates can be used to increase the strength of a joint. The bulldog plates and customized slotted plates can be used for elegant joinery where the steel is barely visible or can't be seen at all.*





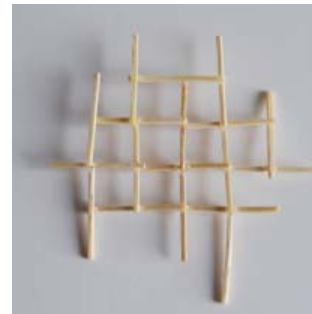
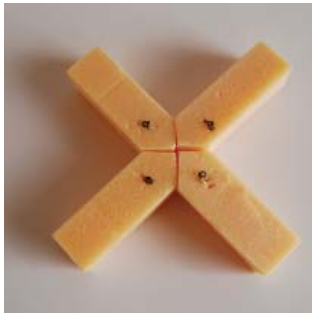
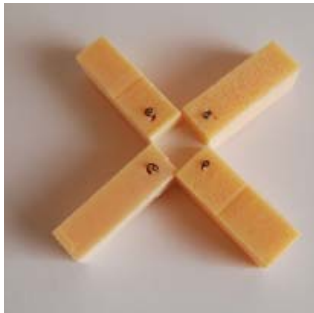
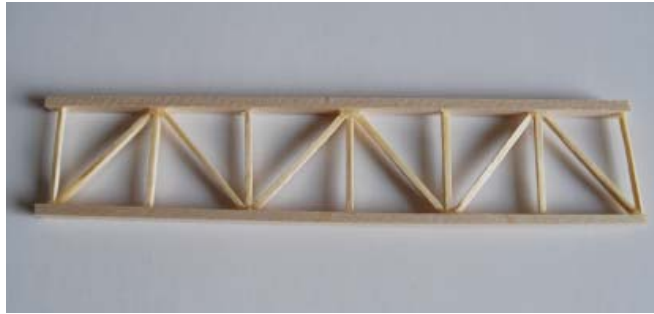
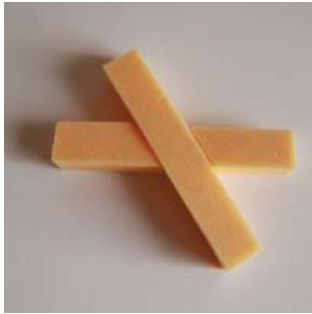
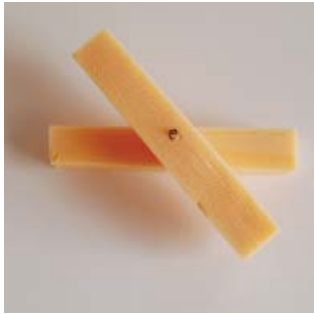
***Over along the Adventurous path***

*The path you walk on is just ribs. Maybe you need to look straight ahead to be able to pass by. You could also look down and experience being Over the steep rocky slope down towards the train tracks.*



# Joinery

The starting point for the joinery was the previously developed truss structure. Through sketching in models two more redundant alternatives developed.

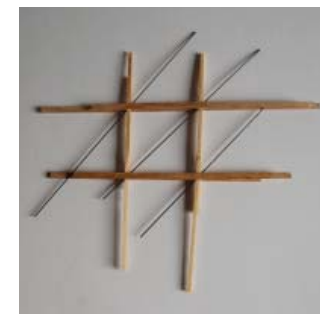
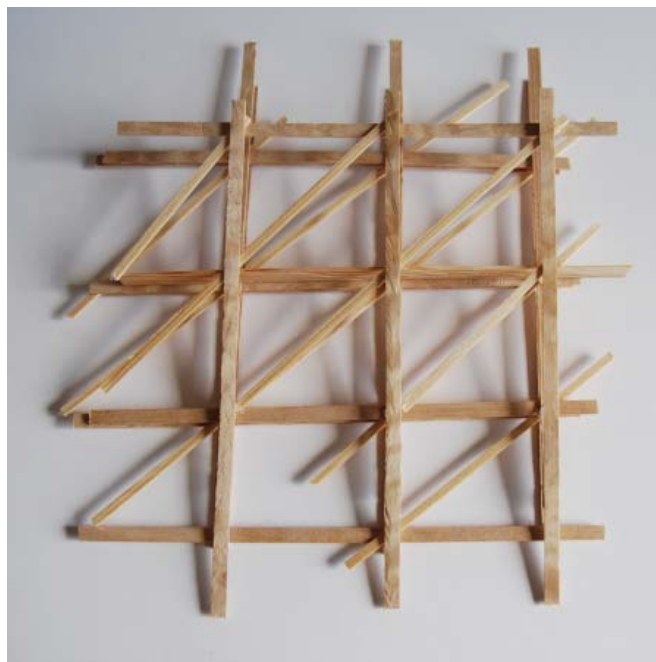


## ***First ideas of nodes and configurations of slotted steel plates***

*The truss structure has nodes where 6-8 elements join at arbitrary angles. An idea to solve this eventually developed in the form of slotted plates connected by a hinge system. However, it turned out that the actual nodes were very difficult to figure out even in a digital model and hence would not be a good alternative for a real construction project, especially not with unskilled labor.*

## ***Ideas for the structure***

*A truss structure could have a varied spacing of its elements depending on force concentrations. The truss structure does not necessarily have to be orthogonal and straight. An idea related to the initial structural concept is the twisting truss structure where nodes are placed at different heights. The joints of the truss structure could also be inspired by Zollinger's lamella roofs and its short elements could overlap in the nodes.*



### ***Ideas based on wooden roller coasters***

*With the most vertical elements, the silhouette ribs, considered as the main elements and placed centrally in the nodes, all other elements could span node to node and be cut to fit perfectly together in the right angles. The silhouette ribs could consist of shorter elements that are joined together using slotted steel plates and bolts. These joints could be in the node, like in the model above, but they could also be mid-span to leave a continuous element through the node.*

### ***Ideas with continuous elements***

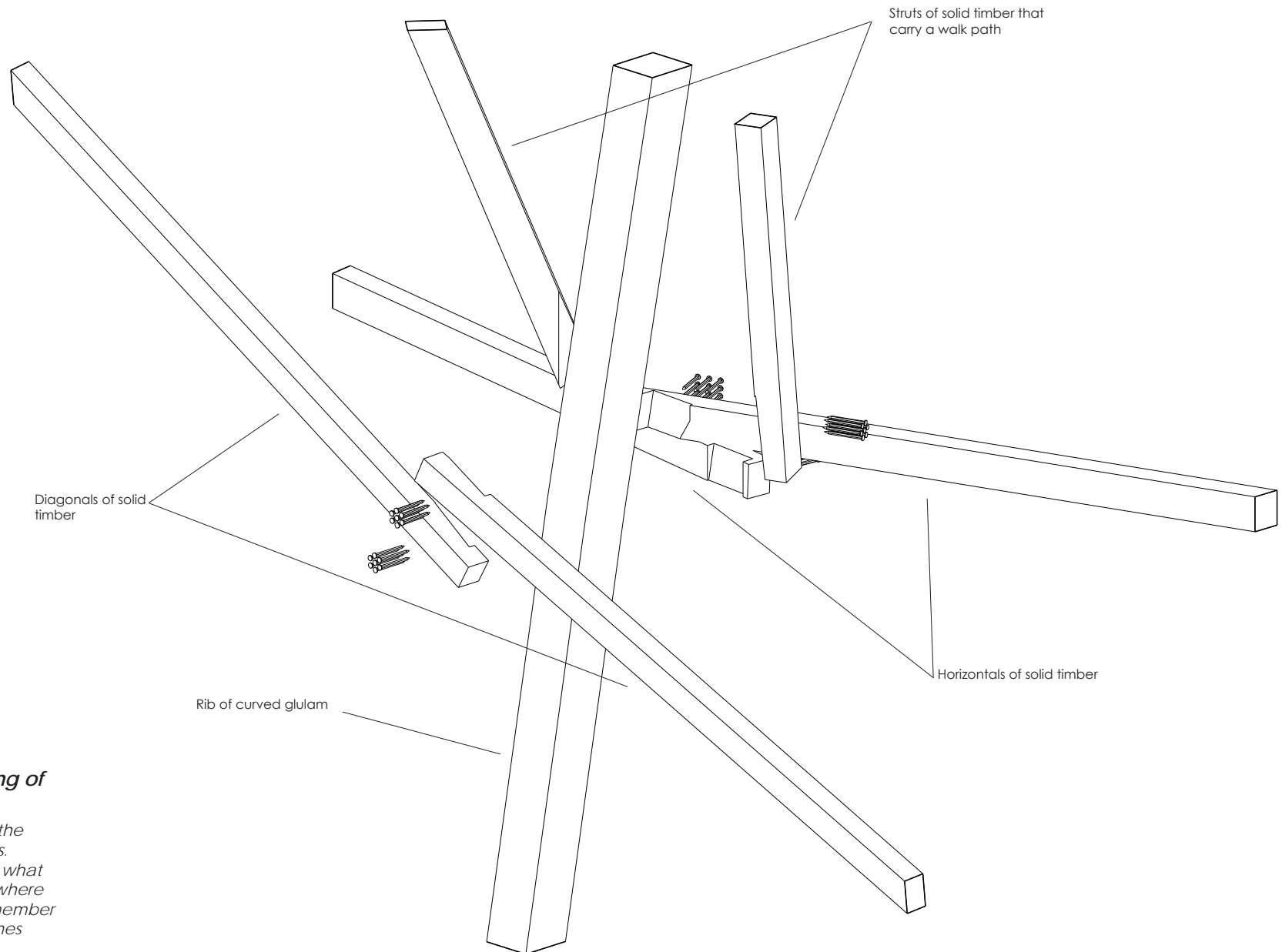
*With vertical members, i.e. the silhouette ribs, horizontal members and diagonal members there could be one, two or three types of members that are continuous. The Zollinger inspired structure could be stabilized by continuous diagonals or a system of continuous verticals and horizontals could be complemented by node to node diagonals. With all members continuous an idea is to work with double members to create a symmetric cross section of the structure.*

## Alternative 1

Inspired by wooden roller-coasters this idea is that the tower would be built up by continuous columns, corresponding to the silhouette ribs, connected by horizontals and diagonals that span from one rib to the next.

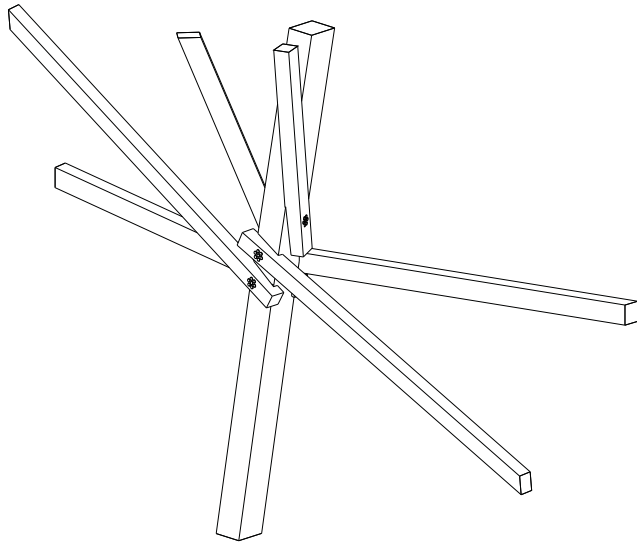
The shorter members are individually cut using a CNC machine to fit together with the rib. Each member is marked during the prefabrication so that it is clear how they are to be assembled on site.

The struts that carry the walk paths are attached to the ribs in the same way as the horizontals and diagonals.



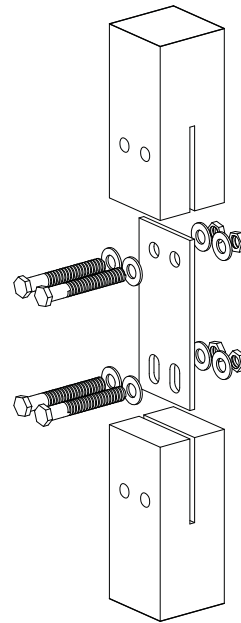
### ***Exploded axonometric drawing of the joint***

*Each shorter member is attached to the continuous rib using a number of nails. Markings show at what height and in what direction to place the member and where to place the nails. The cuts in each member ensure that its angle to the rib becomes correct.*



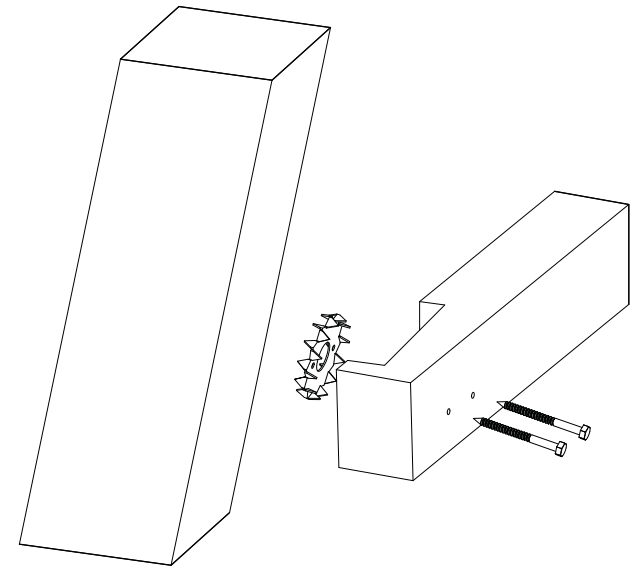
### ***No moisture traps***

*Each member that connects to the rib is placed in such a way that rain and condensation always can run off. This hinders water from being trapped and prevents moisture damage, which help to ensure the service life of the structure.*



### ***Connecting elements of the ribs***

*The ribs are prefabricated as shorter units and assembled on site with slotted steel plates and bolts.*



### ***Possibility of stronger connections***

*An alternative to the nailed connections could be to use bulldog plates and screws.*



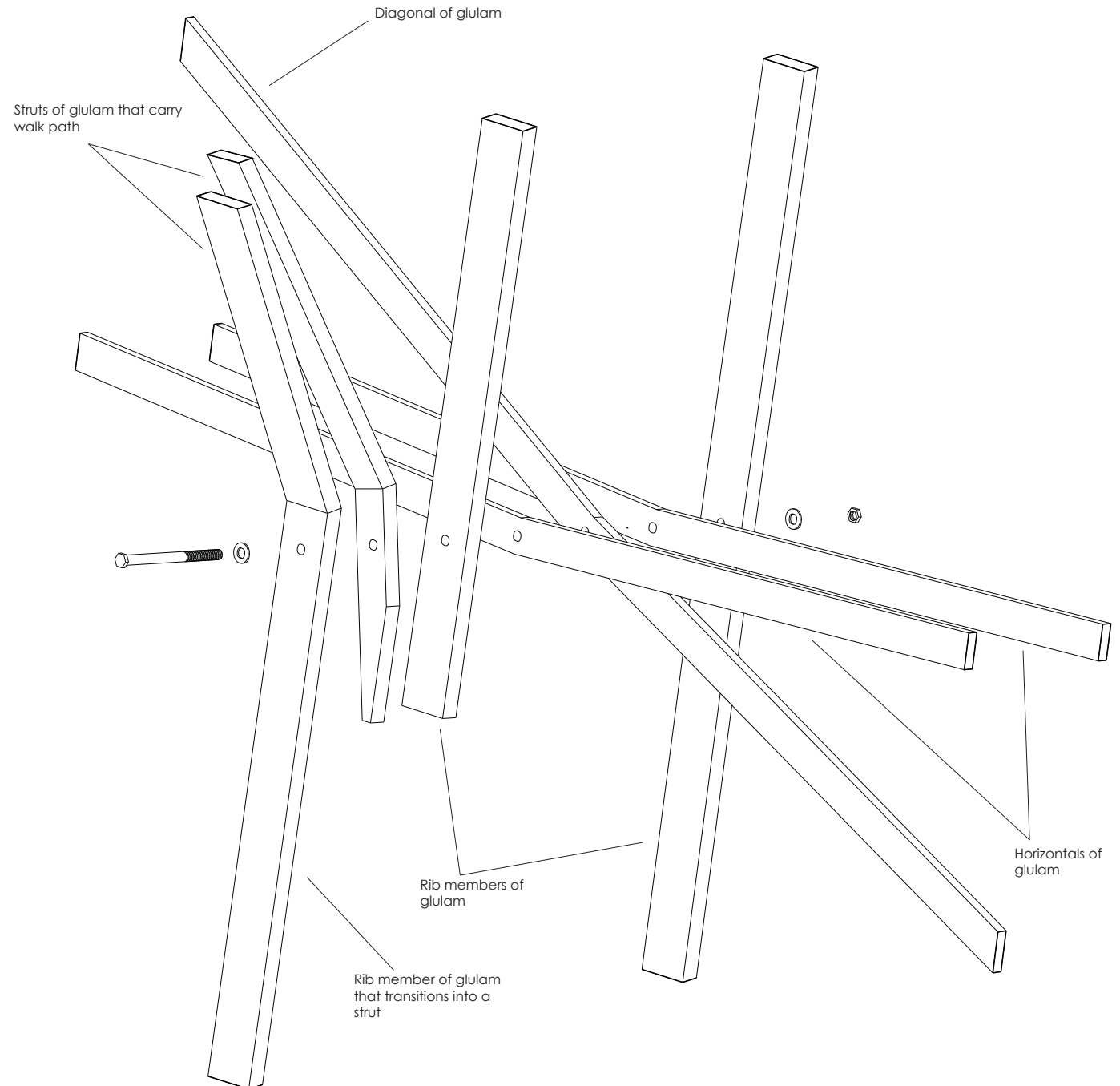
## Alternative 2

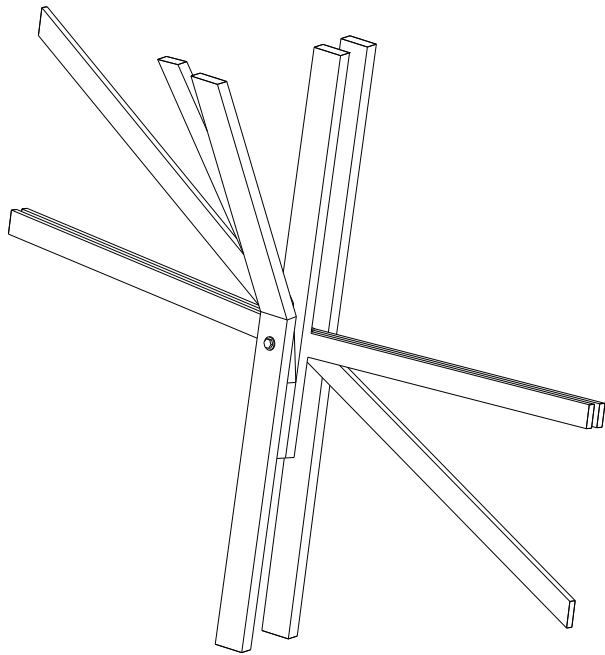
Another idea is to build the tower by layers of only continuous members. The silhouette ribs and the horizontals are double. A single diagonal member is placed centrally. Outside the diagonal are a horizontal on each side and outside the horizontals are one rib member on each side. The struts that carry the walk paths are introduced on one side, depending on what side the path is on, in the appropriate joints.

All members are steam bent as part of a prefabrication process in order to be easy to fit together into the shape of the tower.

### *Exploded axonometric drawing of the joint*

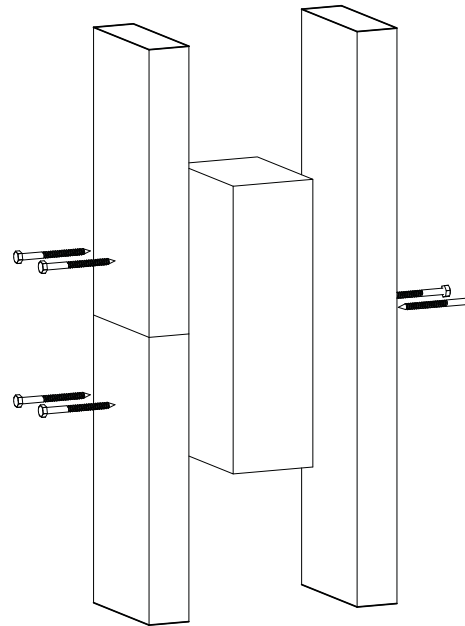
*All members are continuous. The ribs and the horizontals are double and the diagonal is single and placed in the middle. One of the struts that carry the walk path is a rib member that bends out and becomes a strut. A new rib member is introduced to continue upwards.*





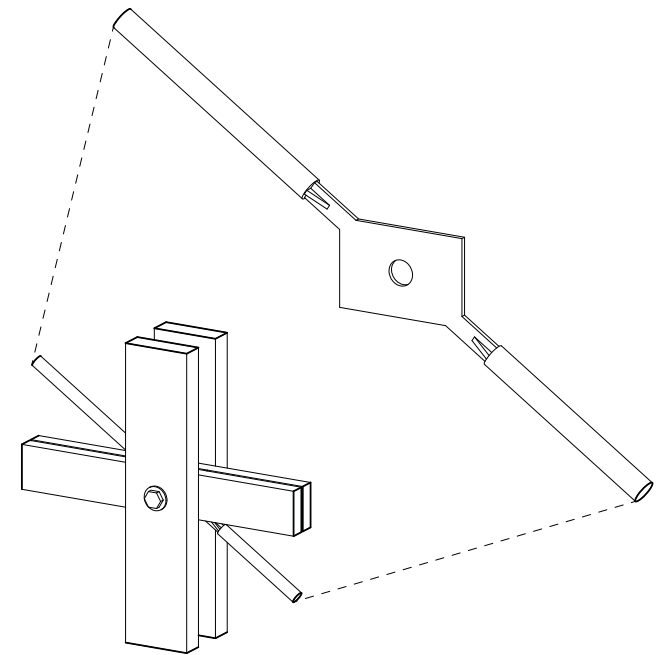
### ***Double members contribute to a safe structure***

*The continuous and double members imply that if something breaks the load can be carried by another member and the forces can find a way around the broken part.*



### ***Connecting elements of the continuous members***

*The joints along the members are offset so that one of the two elements in a pair always is continuous at the point where two parts are joined along the other member. The joint consists of a block placed between the elements and into which all three parts are fastened with screws.*



### ***Possibility of steel diagonals***

*The diagonals could be made of steel bars. A customized steel plate is placed between the horizontals and the bars are welded onto the plate during mounting. That could decrease the dimensions of the diagonals and thereby render a more open expression of the structure.*

# CONCLUSION

Finally, what became of the questions raised in the beginning? How was the process to get there? And how did it go with the parallel work in structural engineering?

Looking back at the questions to be answered within this thesis, the design proposal is new and has developed through a number of investigations. That way it can be something for the municipality to be proud of and something that attracts both visitors and attention to a modern timber structure, which by extension draws attention to the material and its possibilities. It is not just a way to get to the top and see far, but instead the tower is a way to experience the site and the surroundings in new ways. The ideas for the joinery show both how the tower could be built from smaller elements and how the actual assembly can be designed to be easy to understand and assemble. That way it will be possible to build the tower as a conclusion of the courses at the adult education.

## Reflections

This thesis ends with a first iteration of the design of an observation tower in Bengtsfors. It is a series of investigations, not a ready to be built design project. The first investigations, into spatial experiences, are only concerning spatiality and experiences, not the wooden material. The second group, those concerning the structure and the overall concept of the structure, always have the material in mind and each concept idea is considered both in terms of spatiality and actual construction methods. Eventually, as the thesis moves into the formation of the tower, the design as well is a series of investigations. It starts with an overall view of the tower and then goes into explaining how the structure is obtained and what the sequences of experiences along the paths to the top are. It ends in an investigation of the materials and the joinery and how to actually build it.

The material investigation goes into the basics of timber building and the material properties. One may ask why so relatively simple and basic aspects are emphasized. Looking back to the beginning of the thesis, with the discourse and the local conditions, this becomes clear. The aim of the tower project is not just to build a tower, but to introduce a new group of people into the trade of carpentry, which requires starting from the beginning. It is also about showing what the local high quality material can be used for and the great potential that is there in the forests of Dalsland and a complex structure built from relatively simple means is a great way of doing just that.

To sum it all up, it started with the local conditions; the material, the education and the will to draw attention to the project, both as a project and as a built object. By investigating how to create certain experiences and how to turn that into an actual tower the thesis eventually ended up in a design proposal. The proposal is a close integration of architecture and structural engineering, where the two disciplines have guided each other throughout the process.

## To consider in future work

The next step would be to implement the proposed alternatives for the joinery and see what they would imply for the tower, both architecturally and structurally. It would also be necessary to adapt the design of the structure to follow the paths in a better way so that there always are well placed nodes into which the paths can be attached and to ensure a good way of creating openings in the structure where the paths goes through it. That would also increase the visual integration of load bearing structure and walk paths. Finally, all elements have to be dimensioned and number of members versus the dimensions of them considered.



## Exhibition

The thesis was exhibited at the Chalmers School of Architecture's master's thesis exhibition in January 2017.



# REFERENCES

## Written references

Bengtsfors Kommun (2014). *EKA miljörum* [Information Brochure]. Bengtsfors, Sweden: Bengtsfors Kommun.

Bengtsfors Kommun (2016). *Historia*. Retrieved from <http://www.bengtsfors.se/lankarinvanareforetagare/kommunochpolitik/kommunfakta/historia.4.6554dd511370c19f16342bd.html>

Dalslands Kanal (2016). *Detta är Dalslands kanal*. Retrieved from <http://www.dalslandskanal.se/om/dalslands-kanal/>

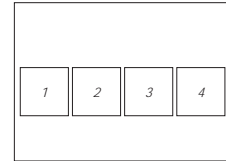
Skogsstyrelsen (2016). *Sverige är ett skogsland*. Retrieved from <http://www.skogsstyrelsen.se/Upptack-skogen/Skog-i-Sverige/Fakta-om-skogen/>

## Other references

Schlyter, C (2016). Seminar at the "Trä & Teknik" fair; *Industrialiserat hantverk, träfasadsystem för stora byggnadsprojekt*. 8 September, 2016, Göteborg, Sweden.

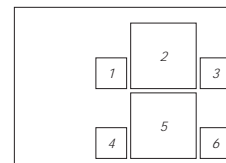
## Figures

All photographs and images not listed below are the authors own.



P. 10

1. Unknown photographer. *Cross laminated timber - Interior*. Retrieved from <http://www.eugen-decker.de/en/products/cross-laminated-timber.html>
2. Slotover-Smutny, S. *Building Thistleton Waugh CLT tower in London*. Printed with permission. Retrieved from <http://www.treehugger.com/sustainable-product-design/no-timber-towers-happening-america-concrete-industry-blocks-tall-wood-international-building-code.html>
3. Pages, L. *Wood house 1 by Schlyter Gezelius*. Printed with permission. Retrieved from <http://www.archdaily.com/431485/wood-house-schlyter-gezelius-arkitektkontor/524250eae8e44ecb17000065-wood-house-schlyter-gezelius-arkitektkontor-photo>
4. Pages, L. *Wood house 1 by Schlyter Gezelius*. Printed with permission. Retrieved from <http://www.archdaily.com/431485/wood-house-schlyter-gezelius-arkitektkontor/52425170e8e44e67bf000063-wood-house-schlyter-gezelius-arkitektkontor-photo>

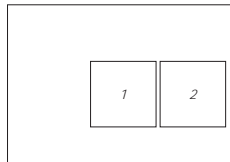


P. 11

1. Authors own photography
2. *Im Baumturm des Baumwipfelpfades Neuschönau* by High Contrast - Licensed under Creative Commons Attribution-Share alike 3.0. Retrieved from [https://commons.wikimedia.org/wiki/File:Weg\\_im\\_Baumturm.JPG](https://commons.wikimedia.org/wiki/File:Weg_im_Baumturm.JPG)
3. Jenssen, Dag. *Interior view from the Seljord Watch Tower*. Printed with permission. Retrieved from <http://www.archdaily.com/212966/seljord-watch-tower-rintala-eggertsson-architects/5017849628ba0d225a000dc1-seljord-watch-tower-rintala-eggertsson-architects-photo>
4. Boake, T. *Roof construction joinery at the Jackson Triggs Estate Winery*. Printed with permission. Retrieved from <http://www.tboake.com/SSEF1/timber.shtml>

5. Ano, D. *Joinery in the Sunny Hills Dessert Shop by Kengo Kuma*. Retrieved from <http://www.designboom.com/architecture/kengo-kuma-weaves-wooden-lattice-into-sunny-hills-dessert-shop-in-japan-02-27-2014/gallery/image/kengo-kuma-completes-sunny-hills-japan-shop-in-wood-designboom-31/>

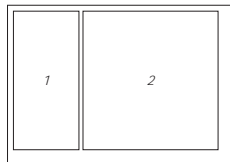
6. Cajmatz, S. *Beam to column connection detail at Tamedia, Zürich*. Printed with permission.



P. 45

1. Unknown photographer. *Timmerflottning*. Retrieved from <http://w1.302.telia.com/~u30207616/timmerfl.htm>

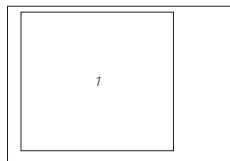
2. *Bengtsfors järnvägsstation och ett tåg från DVVJ* by Riggwelter - Licensed under Creative Commons Attribution-Share alike 3.0. Retrieved from [https://sv.wikipedia.org/wiki/Bengtsfors#/media/File:Bengtsfors\\_railway\\_station\\_Sweden\\_001.JPG](https://sv.wikipedia.org/wiki/Bengtsfors#/media/File:Bengtsfors_railway_station_Sweden_001.JPG)



P. 46

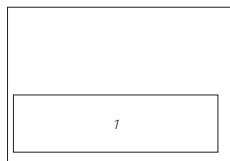
1. Background image *Map of Sweden* by Jarno. Retrieved from <https://openclipart.org/detail/182961/map-of-sweden>

2. Map data © 2016 Google, Landsat



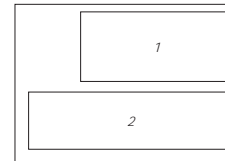
P. 47

1. Map data © 2016 Google, DigitalGlobe, Lantmäteriet/Metria



P. 52

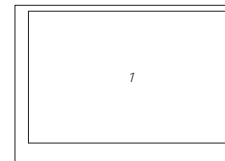
1. Bengtsfors Kommun (2016). *Panorama of the view from the top of the tower, from video from the site*. Printed with permission.



P. 53

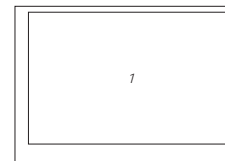
1. Map data © 2016 Google, DigitalGlobe, Lantmäteriet/Metria, CNES/Astrium, Landsat

2. Continuation of *Panorama of the view from the top of the tower, from video from the site*.



P. 55

1. Background image by Bengtsfors Kommun (2016). *Still image from video from the site*. Printed with permission.



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