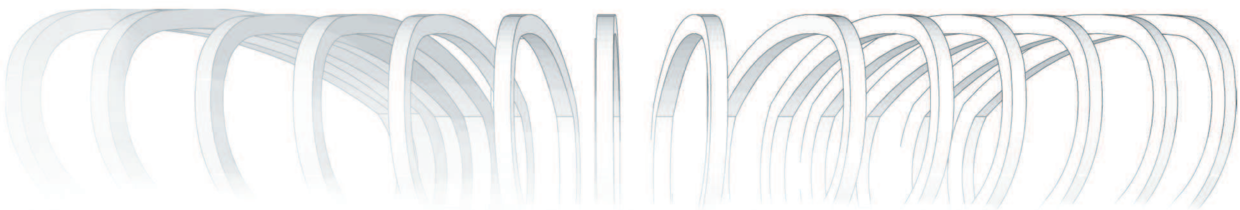


An information- and adventure centre in rough landscape

SYNOPSIS

An information- and adventure centre in the mountains of Norway is developed in this project. The site is chosen for its spectacular view and the building is designed with the intension to drag attention and interest to the municipality of Røyrvik. The design is developed on basis of Norwegian architecture and material usage. An inside out/ outside in design approach will be led, based on gathered preparation to create an architectural satisfying design. The goal is a building that incorporates design of a unifying structural, aesthetic and functional purpose.

PREFACE

This project is made by group 7, 4th semester master, Architectural Design at Aalborg University. The project is written from 1st of February 2012 to 23rd of May 2012. This is a master thesis with a tectonic approach. The goal is to design an information- and adventurecentre up in the mountains of Røyrvik, Norway.

AN INFORMATION- AND ADVENTURE CENTRE IN ROUGH LANDSCAPE

Date of submission	23rd of May 2012
Project period	1st of February to 23rd of May
Main Supervisor	Claus Bonderup
Technical supervisor	Andreas Falk
Number of pages	113

Aalborg University
Department of Architecture, Design & Media Technology
Architectural Design
4th Semester Master
Group 7

Camilla Grønbeck Heggli

TABLE OF CONTENTS

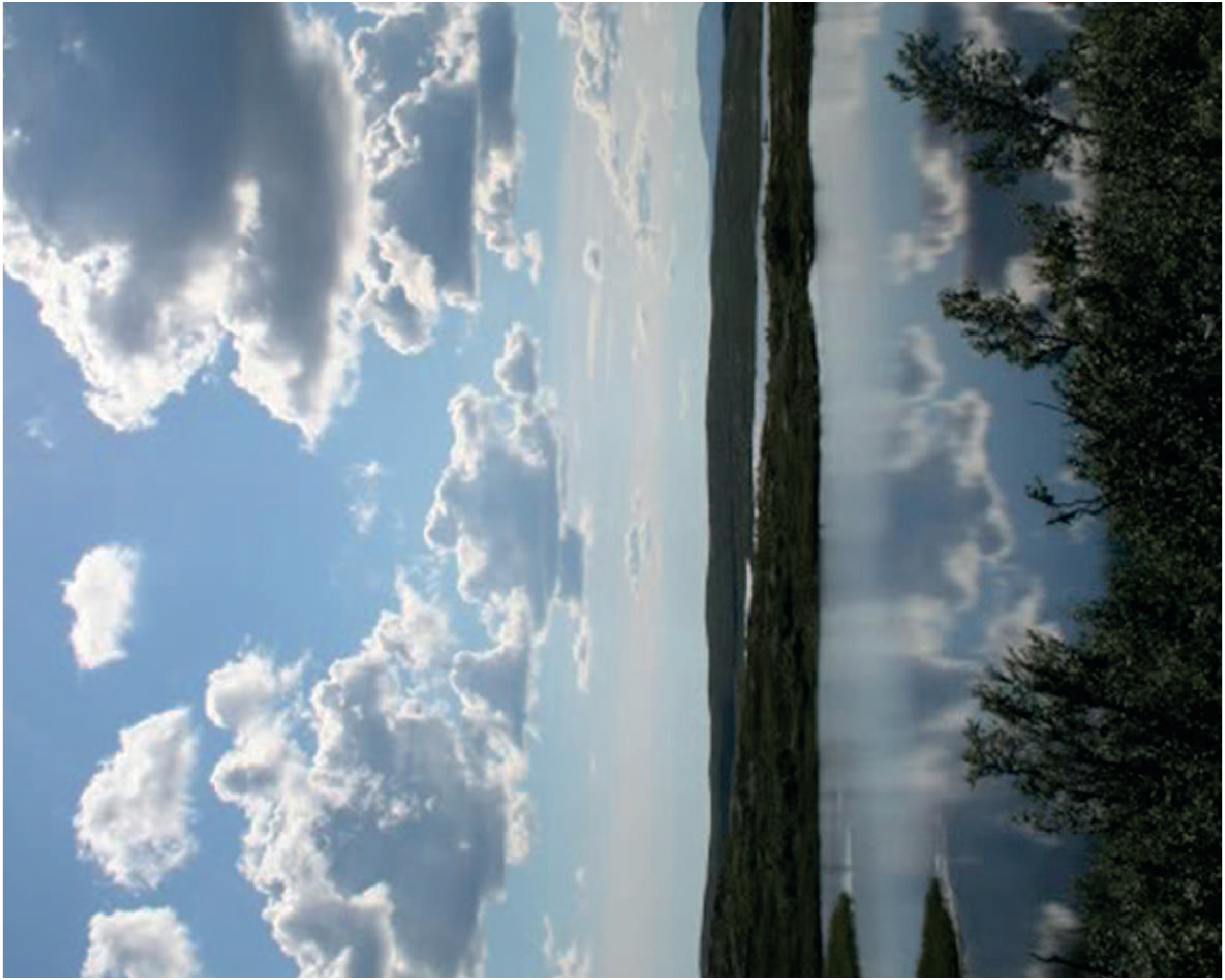
INTRODUCTION

The Municipality of Røyrvik is a place for outdoor activities and for active people. There are a lot of options for those who like to be outside enjoying the nature. The problem is that these people are hard to reach. There is a lot of competition from other places around, and the information about the place is lacking. How would you know what to do there, if you could not find any information about it? The municipality is suffering from depopulation and most of the tourists are just passing the exit to Røyrvik on their way to North Cape. There has to be created something interesting for them wanting to take a detour on their route.

The idea about this project is to create a place that will attract both tourists and local people. An information- and adventure centre where they can learn about the history of the municipality and where they will be tempted to try some of the outdoor activities the place has to offer. Here they will get a taste of what the nature has to offer and get a view of the beautiful landscape that they can be a part of.

The following programme is the outcome of the preliminary studies of the area, its users, Norwegian architecture and tectonic. The program is the starting process of the project and the intention is to understand and investigate the site and its surroundings, to be able to make a design proposal that suits the building site and its users.

Fig.1: Pictures from the municipality



THE SITE

The building site for this project is at Steinfjellet in Røyrvik municipality, Norway. Located approximately 510 meters above sea level. This is a mountain that divides two municipalities and by driving over this mountain the landscape of Røyrvik opens up. The mountain has always been rich on resources and for centuries people have been collecting food here.

Now, the area is mostly used for hunting on a hobby basis and for trekking.

One, of only two roads, that leads to Røyrvik goes over this mountain. During winter time the weather can be quite bad and the road is sometimes closed. This can result in total isolation for the people living here, as they also sometimes have to close the other road.

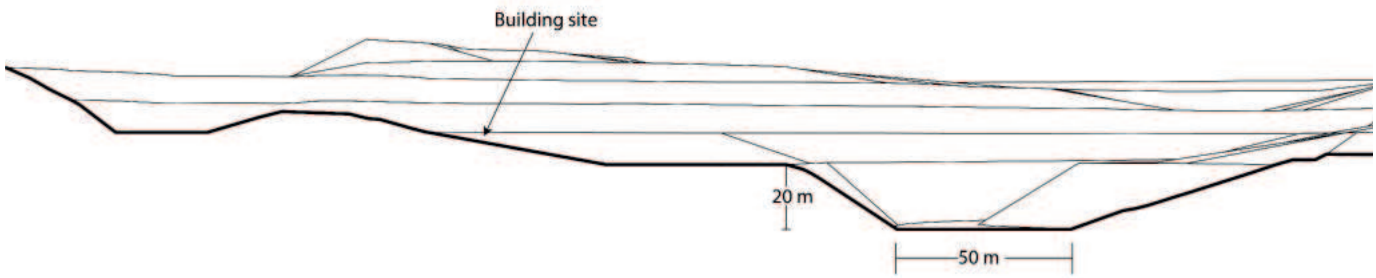
The site is at the end of the mountain, just before you start to drive down from it. Just next to the road there is a parking lot, and next to it there is a plateau where you have a clear view over the lake and the mountains in the horizon.

(To the left)Fig.2: Pictures from the municipality (to the right) Fig.3: Pictures from the site

CROSS-SECTION

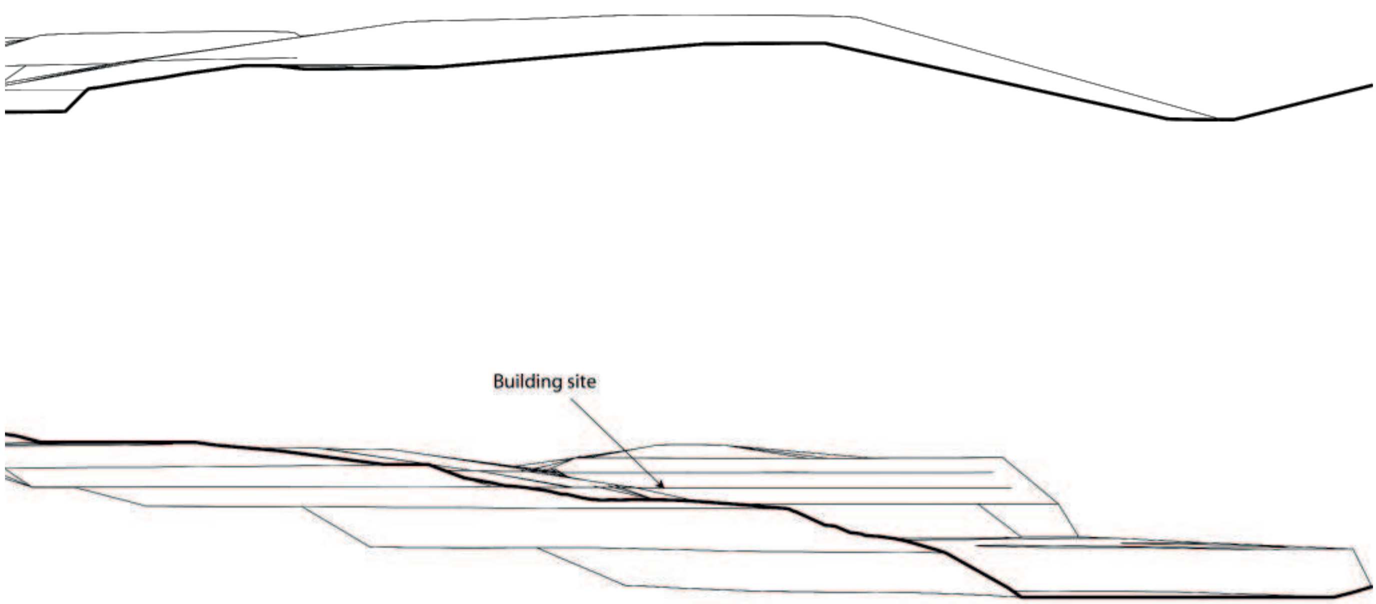
This shows two cross-sections of the site and how the landscape is changing in the area around. It also shows the dimensions of the landscape.

Cross-section from north to south



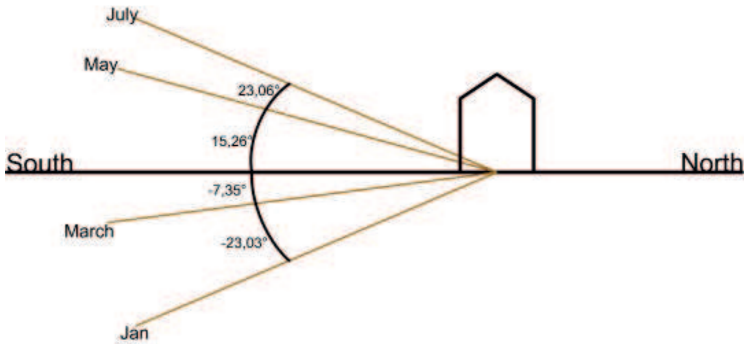
Cross-section from east to west

Fig.4: Cross-section from site


Building site

SUN

Month	Solar declination(in °)	Apparent sunrise	Apparent sunset
January	-23,03	10:11	14:09
February	-17,21	08:55	15:46
March	-7,35	07:15	17:24
April	4,78	05:22	19:00
May	15,26	03:32	20:37
June	22,13	01:47	22:25
July	23,06	01:27	22:53
August	17,86	03:07	21:16
September	8,05	04:47	19:24
October	-3,42	06:17	17:34
November	-14,62	07:55	15:44
December	-21,89	09:36	14:15



A simple sun study has been made to understand how the sun is affecting the place and how the shadows will move during the day. As the site is situated at the middle of Norway there will be periods with very little sunlight, so it will be necessary with some good artificial lighting during these periods. (www.srrb.noaa)

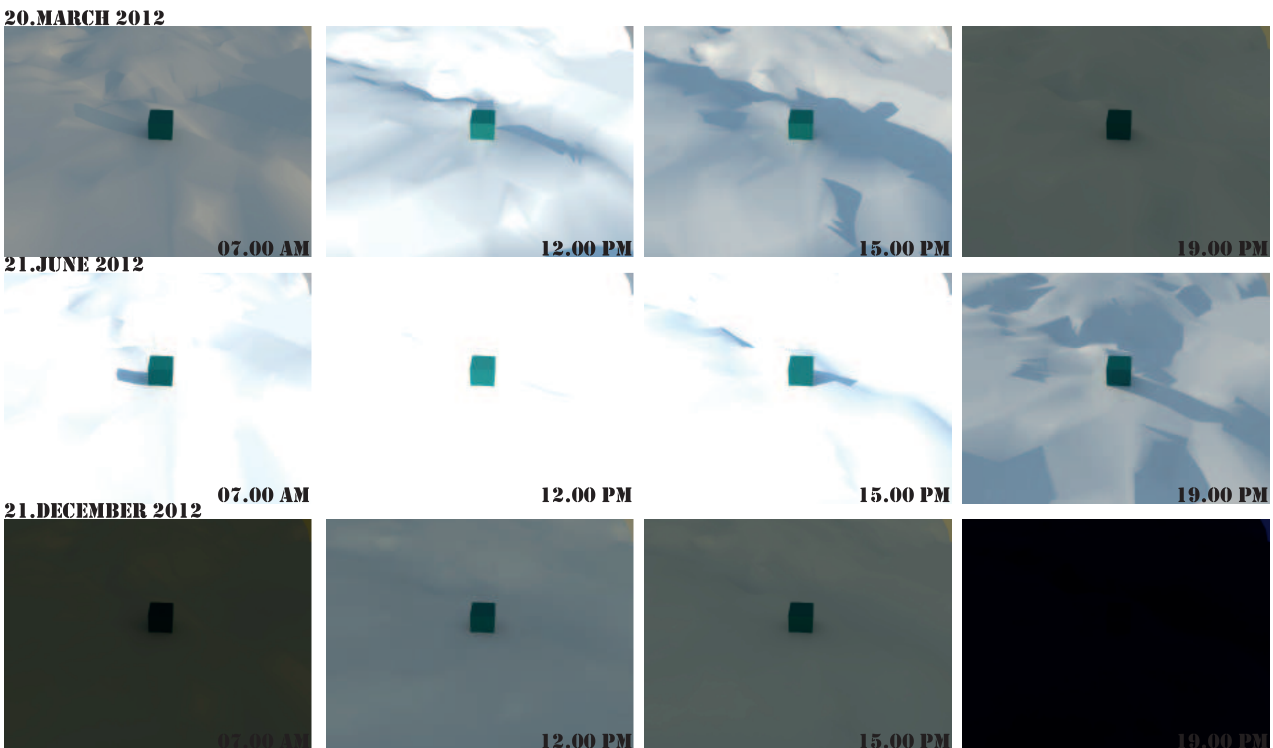


Fig.5: Sun studies

WIND

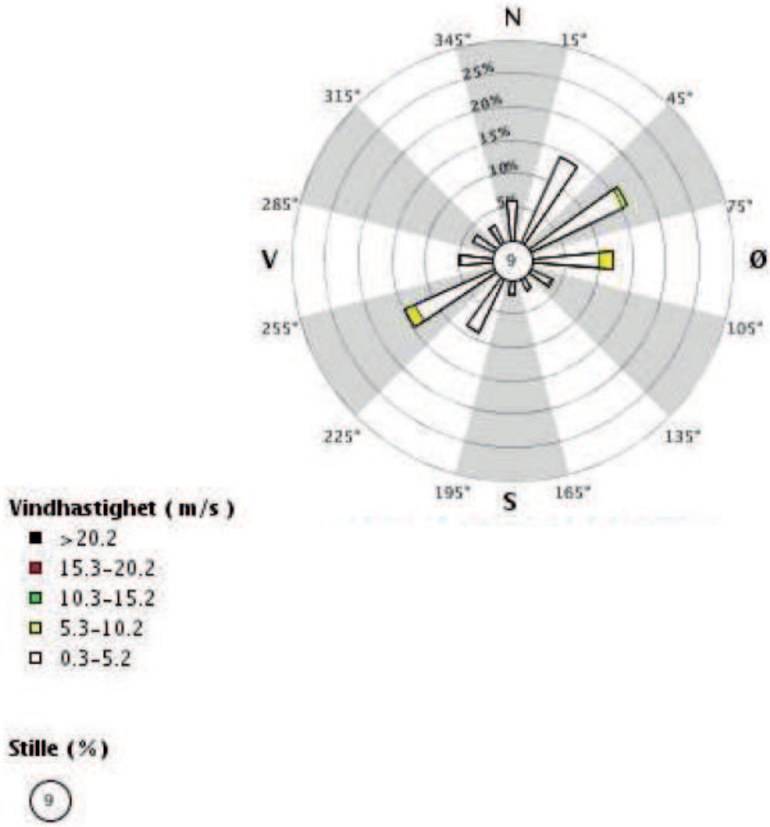


Fig.6: Wind diagram

At the average wind diagram it is seen that the wind is coming from all directions, but it is slightly stronger from the south-west and from north-east. The mesurements are not made at the top of the mountain where the site is, so the wind will automaticly be a lot stronger on the site. During winter the site suffers from a lot of storms and bad weather, so the calculations according to the wind will be a great part of the dimensioning part. There is a great risk of the roof flying of it is not attacehed properly, and there will be a lot of pressure and suction on the walls as well. (www.nb.windfinder.com)

SNOW

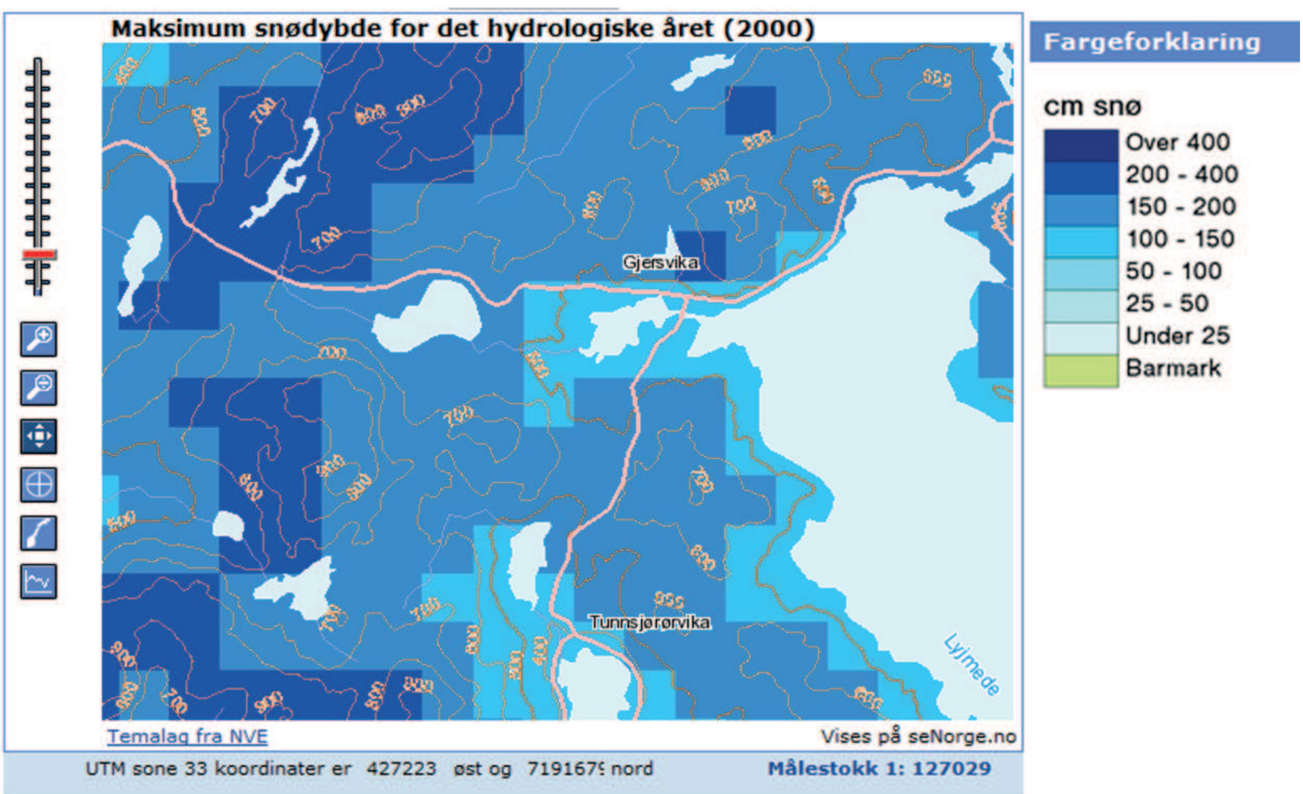


Fig.7: Snow diagram

The site has snow large amounts of the year. It can come as early as in October-November and it can stick to the ground until May-June. The conditions on the site can sometimes be quite rough. With snow and strong wind the sight will be bad and the road is sometimes closed.

The normal amount of snow through a winter is between 1 – 2 meters. Some places it will be more, because the snow is piling up from the wind. (www.senorge.no)

VEGETATION

Fig.8: Vegetation pictures

The different places in the municipality vary a lot when it comes to the vegetation. There are a lot of big coniferous forests at the lower levels, with some touch of birch as well. The tree line is between 5-600 m.a.s.l. The site is around 510 m.a.s.l and it is clear that the vegetation is having problems growing at this point. There is little conifer left and only small birches will grow.

The ground is covered with grass, moss and heath. There is some wetland a short distance from the site, where there can be found cloudberries. Some bare rocks can also be seen, especially where the mountain is drastically changing shape.

ROCK RESOURCES

Fig.9: Stone pictures

In the municipality of Røyrvik there are several occurrences of different kinds of rocks, like phyllite, slate and green slate.

Mining has been a large part of the history for this place.

In 1910 a large oar of pyrite was discovered. Large plans were made and they built roads to transport the goods. But when the 1st World War started all plans fell apart, since there was some French participating in the project. They did not restart the mining project before 1972, and this time they opened a mine at a different place, where they had found an even larger amount of pyrite. The pyrite was used in production of copper- and sink concentrate and it was shipped to Germany and other places in Norway. The mining period lasted until 1998 and the mines were shut down. The municipality suffered a big loss when 17 % of the citizens lost their job and moved away. The mine employed 140 people at the most.

(www.hit.hist.no)
(www.natursti.net)
(www.wikipedia.org)
(www.snl.no)

WATER RESOURCES

Fig.10: Water picture

With 1585 m2 land area in the municipality and over 1000 lakes with fishing opportunities, it is quite natural that the water resources are highly appreciated. Large parts of the tourism visiting the place are people hoping to catch the trout of their life or to live with the mosquitos on a hiking trip up in the mountains.

Norway's 7th and 8th largest lakes are also to be found here. In 1959 several lakes were dammed up, to make it suitable for power production. Some parts were dammed up as much as 14 meters, something that resulted in that some farms had to move and a lot of people lost big parts of their properties.

Today the municipality is gaining a lot from these resources, as it is supplying the Norwegian people with power for about 1 billion Norwegian kroner each year.

(www.royrvik.kommune.no)

NORWEGIAN ARCHITECTURE

The Norwegian architecture is very traditional when it comes to building materials and how the building relates to the nature. Especially with the use of wood you can see the closeness to the nature and how people relates to the old Norwegian building method. Based on centuries with handcrafts and experience with the material, the use of wood contributes to the distinctive characteristics of the Norwegian building traditions. Wood has always been an easy accessible material, and having a look at the Norwegian stave churches shows how advanced the building technic was already in the 1100s.

Stone was also a well-used material in earlier centuries. But because it was more expensive to build with (took more time) and it had a worse insulation capacity, it was mainly used for buildings were people wouldn't stay for a long period of time. Stone was often used for buildings like churches, stables and storage. A good example for this is the Nidaros Cathedral, the northernmost medieval cathedral in the world.

Even the modern architecture in Norway today shows the inheritance from earlier centuries. Concrete has become more common, but there is very often some touch of wood or stone in the design.

(www.norway.org)
(www.fuv.hivolda.no)
(www.snl.no)

Fig.11: Pictures of Norwegian Architecture

TECTONIC

Tectonics is inherent to the name of the profession architect, which is a contraction of the Greek word archi that means master and the Greek word tect that means builder and is related to the word tectonic(Framton)

Tectonics is understood as a specific quality of architecture that consciously uses the technical and pragmatic concerns in architecture to develop an architectural expression. The term tectonic refers to objects without distinguishing between the fields of art and technology, and the process of creating these objects.

Bötticher describes tectonic as a relationship between the core-form and the art-form of a building, where the façade articulates the structure principles instead of being conceived as separate concerns. Architecture should be developed with an expression reflecting the given material and the technological context. After he had done some research on the Greek architecture he discovered that it was a close relationship between the art-form and the core-form. The ornaments where not there just for decoration, but they also had a purpose when it came to structural principles. When all structural and decorative parts are bound together like this, Bötticher calls it tectonic.

Gottfried Semper is often regarded as the father of the concept tectonic. He focused on the craft that was used to shape the materials, and introduced four elements of architecture; earthwork, hearth, roof and enclosure. The tectonic relation between material, function and technique influenced the expression.

"…*the beginning of building coincides with the beginning of textiles. The wall is that architectural element that formally represents and makes visible the enclosure space as such, absolutely, as it were, without reference to secondary concepts… The structure that served to support, to secure, to carry this spatial enclosure was a requirement that had nothing directly to do with space and the division of space. It was foreign to primitive architectural thinking and was in the beginning not a form-determining element.*" (Semper,1860)

What is specific to tectonic architecture is not only that the symbolic aspect of construction is understood as the most significant- it is also that the symbolic aspect represents the technical aspect of the architectural piece.

(The tectonic practice, Anne Marie Due Schmidt,2007)

Fig.12: Pictures of Tectonic Architecture

TECTONIC DESIGN APPROACH

To reach the desired design in this project, a tectonic approach will be used. This approach will be shown trough a clear and readable structure, where it is visible what is loadbearing and what the purpose of every element is. The design of the building will be shown through the structure, where the structure will design the building. The structure will be kept as simple as possible to make it easy to see and read the tectonic in the building.

There is a desire to make the qualities of the building material decide the spaces inside the building. Every material has its limitations and this should play a big role in the design. So heights and lengths should be decided from the material and then the spaces inside the building will come automatically.

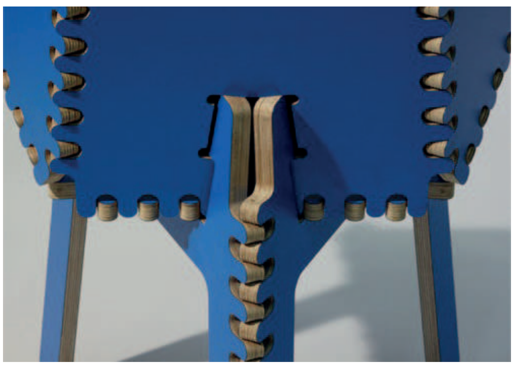


Fig.13: Pictures of Tectonic Design

INTRODUCTION

When designing a building that is suppose to work optimal for the users, it is important to study the user group. It is good to know how they live and what demands they have. In this section the user group is investigated, and a user profile will be set.

USER GROUP




Fig.14: Pictures of User group

The purpose with this building is to attract tourists and active people that like to be out in the nature. The user group will be those who are interested in learning more about what alternatives there is for activities and those who needs information about the municipality. The building will work as a tourist information and give information about the historical parts of the place.

School-classes and companies can be a user group that wants to have a day with teambuilding and recreation. Here they will be encouraged to do outdoor activities and they will learn how to work together as a group.

Families can come here and plan a daytrip or maybe a several days hiking trip. They will get different suggestions of activities and see their opportunities.

POSSIBLE ACTIVITIES IN THE AREA

Fig.15: Pictures of activities in the area

WILD REINDEER CENTRE PAVILION

Fig.16: Pictures of the wild reindeer centre pavilion

SNØHETTA architectural office, was asked by the Norwegian Wild Reindeer Foundation to design an observation and information pavilion at Hjerkinn in Dovre, Norway. The site is at 1250 meters above sea level and you have the view over Snøhetta Mountain.

This building is supposed to give shelter for groups and visitors when they are visiting the mountain for lectures about the wildlife and the history of the place.

Natural, cultural and mythical landscapes form the basis of the architectural idea. The building design is based on a contrast between a rigid outer shell and a soft organic-shaped inner core. A wooden core is placed within a rectangular frame of raw steel and glass. The core is shaped like rock or ice is eroded by natural forces like wind and running water. Its shape creates a protected and warm gathering place while still preserving visitor's access to spectacular views.

While they designed the pavilion they put a large focus on how the quality would be like and how the materials would last in this kind of climate. While they have used natural building materials, the Norwegian building tradition has been maintained, but they have also brought new technology to the project in the way the wooden core has been manufactured.

(www.snoarc.no)

SVALBARD RESEARCH CENTRE

Fig.17: Pictures of Svalbard research centre

Svalbard "the land of the cold coasts". Through a competition there was a wish to expand the university and research centre at Svalbard. Jarmund Vigsnæs Architects won the competition and the building extended four times from its original size. It contains the university, a research centre and Svalbard museum.

When you look at the landscape and the climate at Svalbard, it comes quite clear that this is a challenging place to create good and working architecture.

The wind and snow is one thing, but there is also consisting permafrost in the ground.

Jarmund Vigsnæs Architects expressed that *every commission should be unique with reference to its site and circumstances* when they were questioned about their design. This is showed through the design where the building is built on poles to prevent melting of the permafrost and how the copper-cladding is wrapped around the building to adjust to the wind and the snow. The main structure is in timber, to facilitate on-site adjustments and avoid cold bridges.

The interior was decided to provide warm and light public spaces and passages as a contrast for the dark and cold winter. It is made from wood and has complex geometry to reflect the outer façade.

(www.archrecord.construction.com)
(www.archdaily.com)

MUSEUM OF ALTAMIRA

Fig.18: Pictures of Altamira museum

In 1879 not far from the village of Antillana del Mar in Spain a cave called Altamira was discovered. It contained drawings and multi-coloured cave paintings of wild animals and human hands. Archaeological investigations have dated the oldest paintings from 15 000 BC.

The cave became a very popular tourist attraction and this had a bad effect on the paintings. The carbon dioxide breathed by the visitors and the dust from the clothes were covering the rocks and the paintings started to decay. The cave were closed in 1977 and then reopened in 1982 with limited visitors. The cave was closed again in 2002 and in 2010 it was decided that it would not open again, because of the human presence would destroy it.

To save the cave a museum, a research centre and a replica was built not far away from the actual cave site. It is on the other slope of the hill and they are separated by abundant vegetation. The slopes on the north side permits an access to the neocave that is similar to the original one. The site for the replica is located outside the natural runoff area of the original cave, so it is avoided that there will be any alteration from the new construction.

The museum, the replica, and the research centre are divided into two differentiated areas when it comes to construction: the diaphanous area of the neocave and research library suspended above it to the east. There are three lines going to the west from the main entrance, where there is exhibition halls, auditorium and a restaurant that extends to an open-air terrace.

(www.en.urbarama.com)
(www.showcaves.com)

ARCTIC CENTRE, ROVANIEMI

Fig.19: Pictures of Arctic centre, Rovaniemi

Arktikum is located on the banks of Ounasjoki River in Rovaniemi, Finland. The centre is meant to give information and tell the story about the people in the north. It is a museum, science centre and there is arranged cultural venues like meetings and conferences. The building is also a popular architectural sight in Rovaniemi.

The Arktikum was designed by the Danish architects Birch-Bonderup and Thorup-Waade. Local materials have been used in the building. The floors are made from the hardest type of granite you can get in Finland and from lime-washed pine. On the chairs there has been used birch and reindeer hide.

Most of the museum is under ground, but the visible part is a 172 metres long glass tube. The tube is splitted by the 30 metre wide highway to Kittilä. All in all the tube is covered with about one thousand panes of toughened glass. Every pane is two square metres in size. The tube is called the "Gateway to the North", as the entrance is at the south and the building leads you towards north. The exhibition space is under ground, symbolizing how the nature covers from the cold and rough winter. (www.arktikum.fi)

CONCLUSION

Each of these case studies were chosen because of the different qualities they have and how they relate to the nature and their surroundings. The climatic aspect has been a large part of the design and the building materials are local. The Reindeer Pavilion, The Svalbard Research Centre and the Arctic Centre are a clear reflection of the Nordic and the Norwegian architecture. They have a close connection to the nature and the building materials are typical Nordic.

There were some interesting aspects on the Svalbard and Rovaniemi projects. These two projects are located at sites where the weather and the climate can be quite harsh. There can be difficult snow conditions, just as the site for this project. In one way they are quite different, as one project is placed under ground and the other one is placed on poles. But the weather conditions have been carefully considered on both of them.

The Museum of Altamira was of interest since they recreated a cave and made a feeling that you are inside an old and historic place. The site for this project is located in a municipality where mining was very important and it could be an interesting idea to create the feeling of the mines.

TECHNICAL REQUIREMENTS

Snow loads

The table shows what loads that should be considered when it comes to calculating snow loads.
Sk is the characteristic snow load.
H is the hight above sealevel.
S_k is given in a table

Kommune	$s_{k,0}$ kN/m²	H_u m	H_g m	Δs_k kN/m²	$s_{k,maks}$ kN/m²
Røyrvik	8,0	425	550	1,0	9,0

Fig.20: Table showing snowload

Lighting requirements

For a room where people will spend a lot of time, the requirements say that the room must have a windowsize that is at least 10% of the floor area.

(www.bks.byggforsk.no)

ROOM PROGRAMME

ROOM DIAGRAM

The room programme below is made based on expected room area requirements for each room. Natural light inside the building is desireble in some rooms, therefore a priority from 1 to 3 is given to the different functions. Also the view is taken into account and evaluated from 1 to 3.

ROOM	SIZE (M^2)	QUANTITY	TOTAL SIZE (M^2)	LIGHT LEVEL (LUX)	VIEW
Tourist info	100	1	100	* * *	* *
Entrance hall	50	1	50	* * *	* *
Museum	250	1	250	* * *	* *
Offices	10	3	30	* * *	* *
Auditorium	75	1	75	*	-
Meeting room	25	1	25	* * *	*
Cafe	100	1	100	* *	* * *
Kitchen	30	1	30	-	-
Toilets guests	20	2	40	-	-
Toilets staff	10	1	10	-	-
Wardrobe	10	1	10	-	-
Storage	40	1	40	-	-
Staff lunch room	20	1	20	* *	* *
Cleaning room	10	1	10	-	-
Technical room	20	1	20	-	-
Total			810		

FUNCTION DIAGRAM

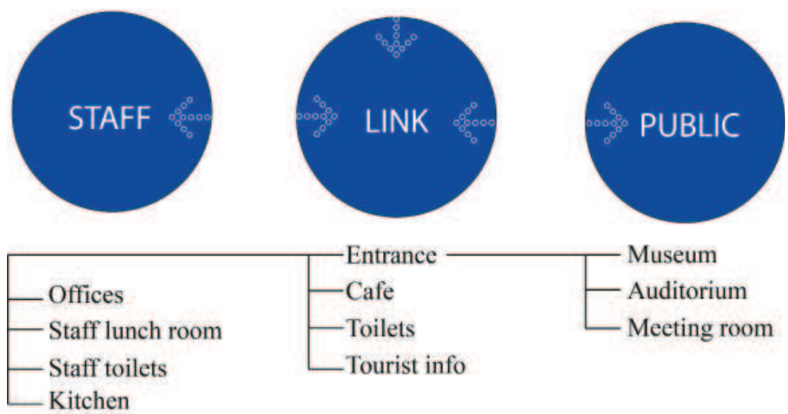


Fig.21: Room diagram

The organisation of the different functions in the building are made based on the room programme. The building is divided into 3 zones: staff area, public area and a link area. The entrance is placed in the link area, which will lead people to the different functions.

DESIGN PARAMETERS

- **The building should create clear view points over the lake and the landscape**
- **There should be an outdoor area in connection to the café**
- **The office area should have good light conditions and view towards the land scape**
- **The building should drag people closer to the nature**
- **The design should create curiosity and make people want to go there**

PROBLEM STATEMENT

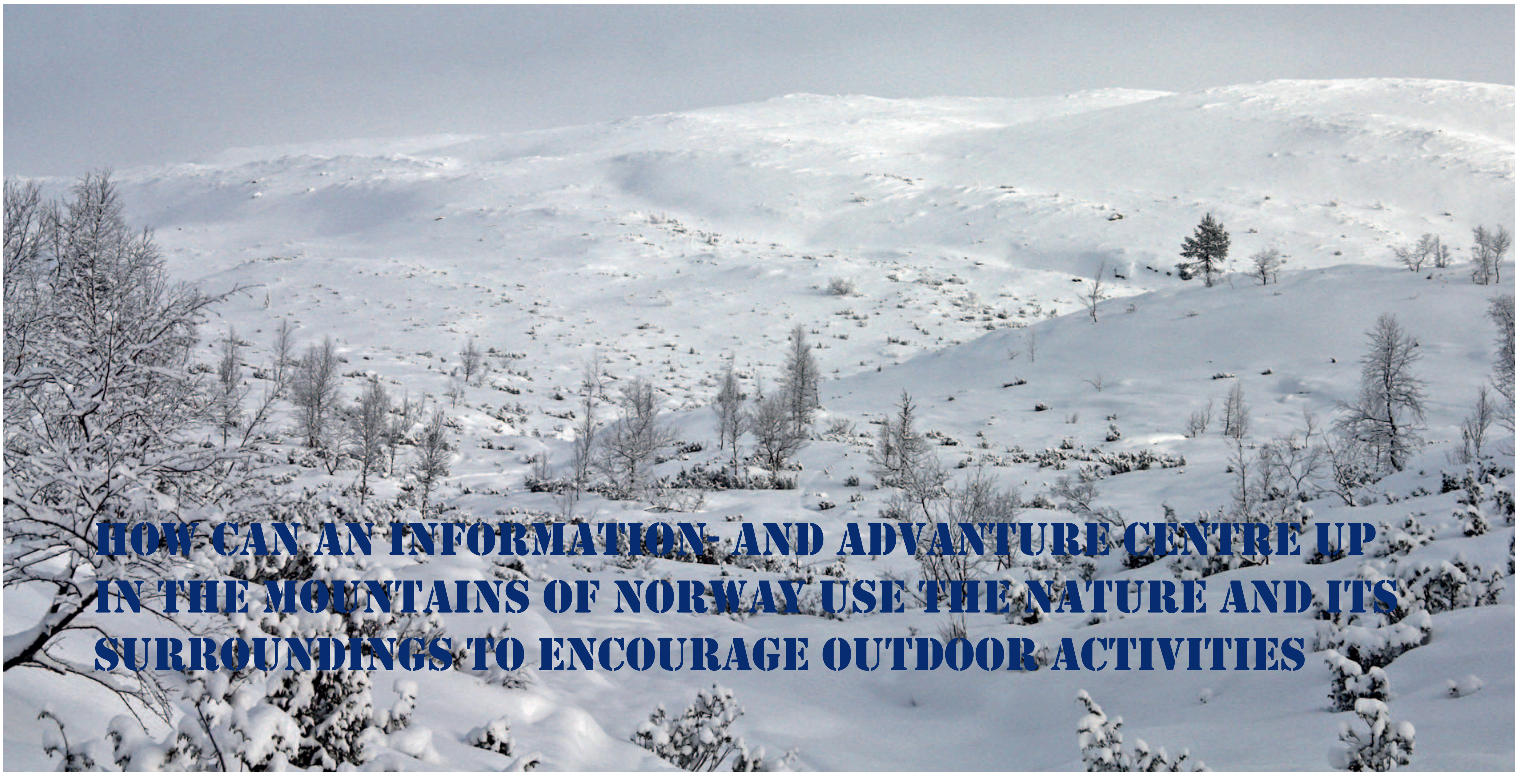


Fig.22: Picture of a mountain

VISION

Fig.23: Tourist information

The architectural vision for the building is to interpret the Norwegian traditions, focusing on the natural and honest when it comes to the materials and the construction. There should be references to the Norwegian architecture e.g. by the choice of materials and the closeness to the nature.

The vision is to design an information- and adventure centre that encourages people to be active out in the nature and that gives information about the municipality of Røyrvik. People should feel that this is a natural starting point for their trips and adventures, and it should be a meeting point for people that wants to be active.

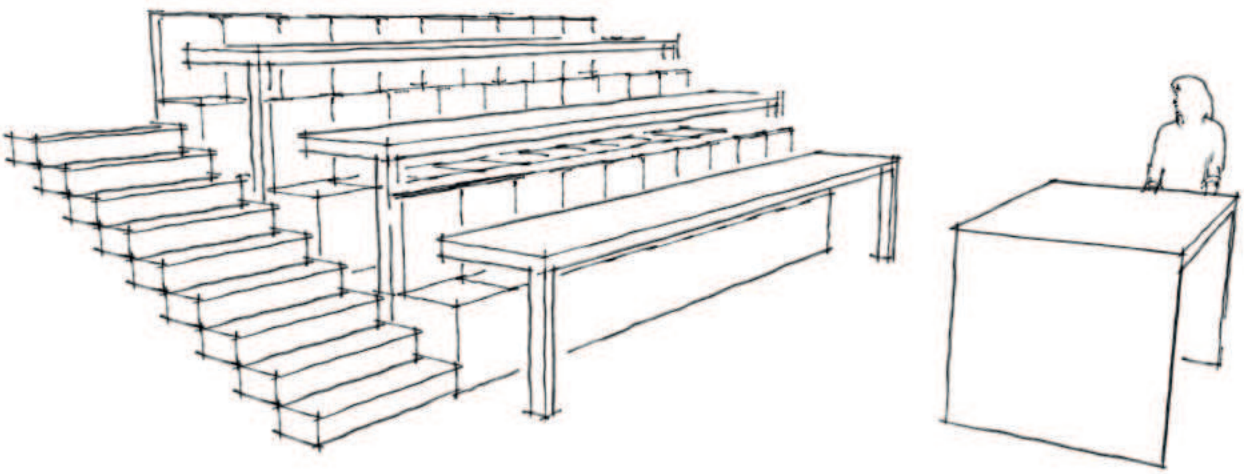


Fig.24: Auditorium

Fig.25: Bridge experiment

INTRODUCTION

Based on research of the site, the user group, tectonic approaches and building requirements the design process is started. The design process has been a parallel process where aesthetical and technological aspects have been considered at the same time. In this part of the report the concept is developed, and the overall idea of the design evolved. The concept reflects the ideas and design parameters found in the program, and where the final design will express it.

OVER OR UNDER GROUND

Pros under ground:
- There will be protection against the wind and the weather
- A large building will not be to characterized in the landscape
- The ground will insulate the building

Cons under ground:
- It is harder to get light into the building
- It can get expensive to remove a lot of rocks/soil
- It is harder to make a floor plan that works when it comes to light and views

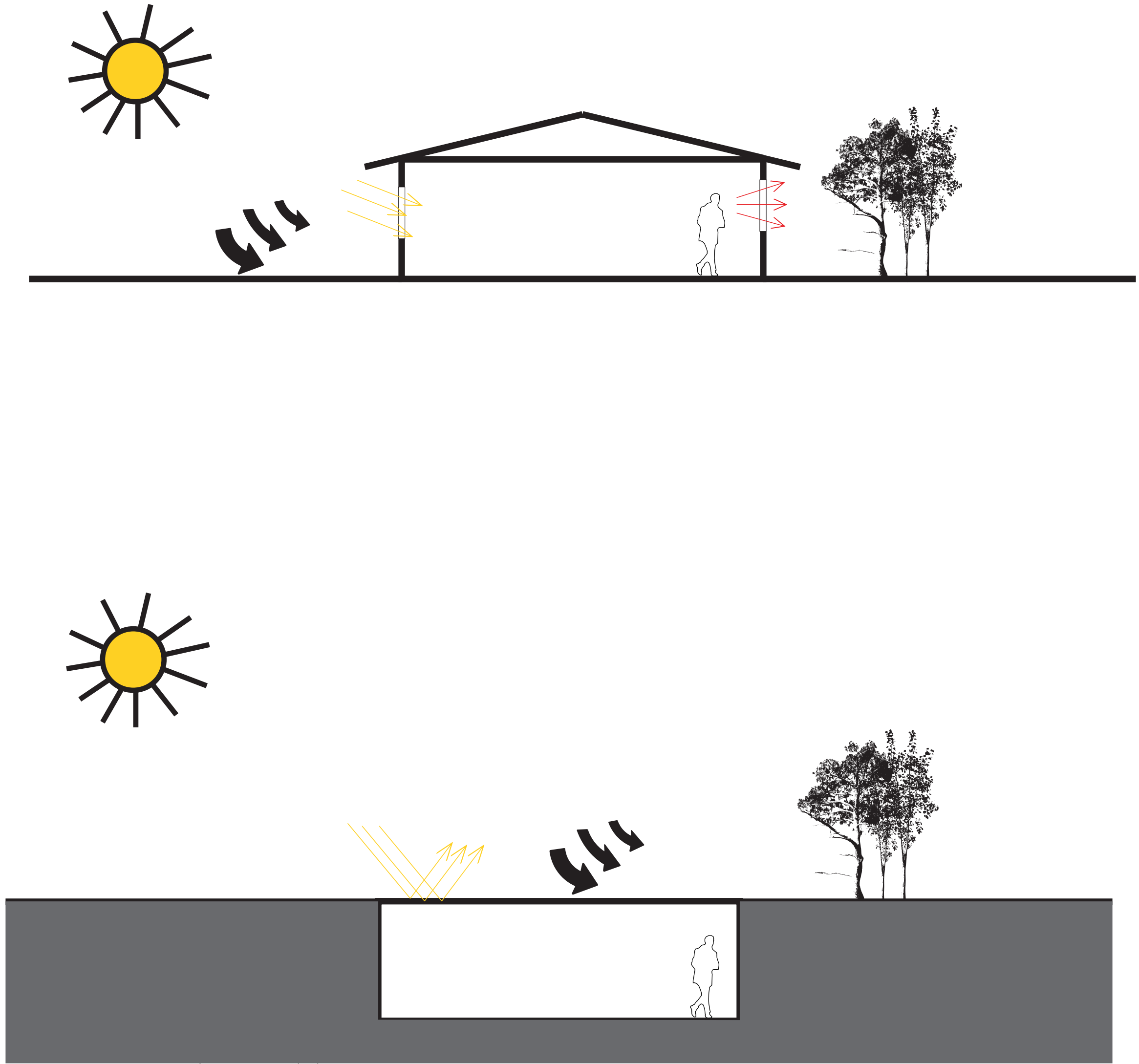


Fig.26: Over or under ground diagram

FUNCTIONAL PLACEMENT

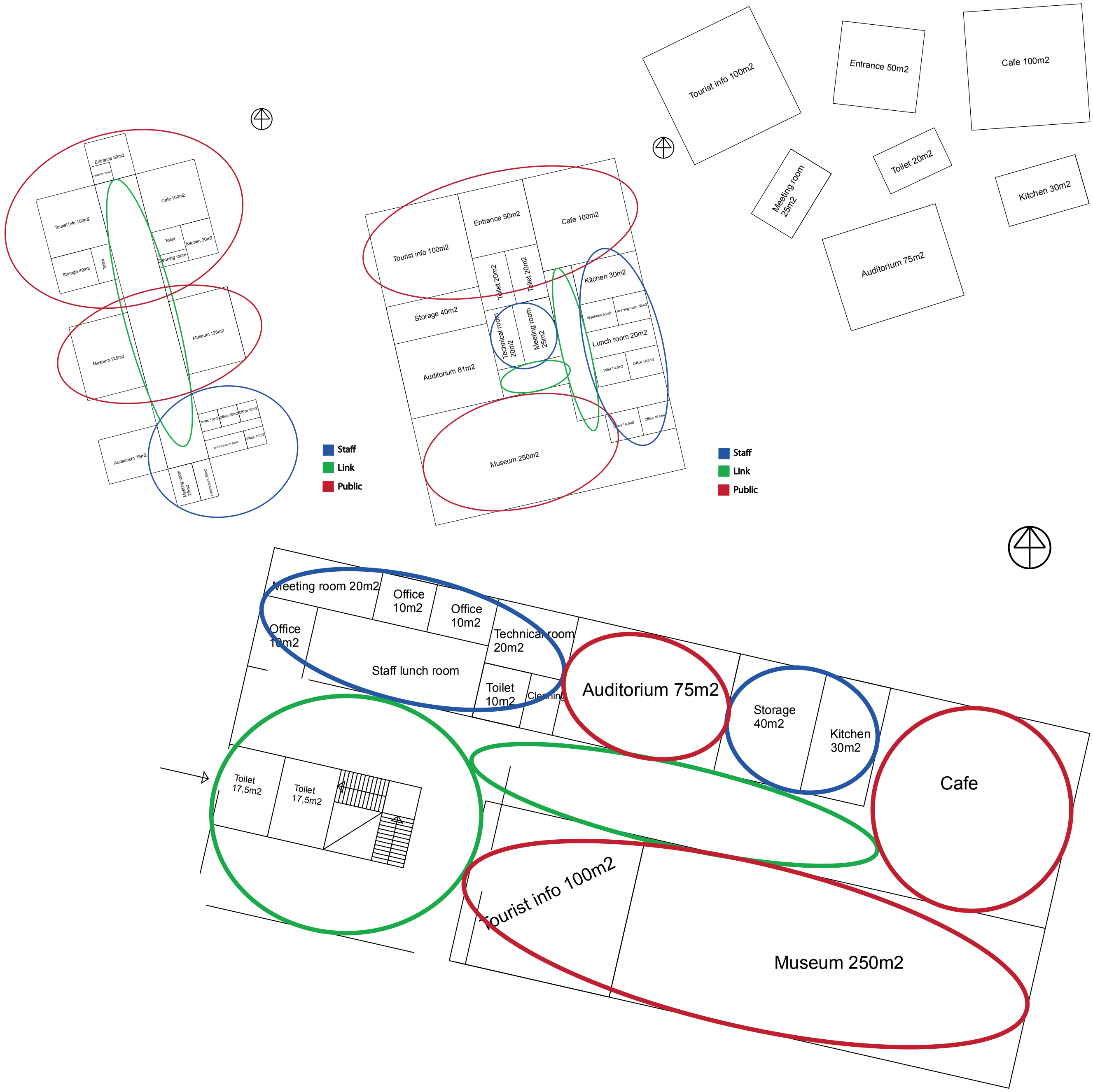


Fig.27: Functional placement

In order to achieve an idea of the possibilities of the room organisation, there's been conducted some experiments to see the different qualities that can occur. Qualities like the view, need of daylight and how to link the public and the staff area has been highly weighted. Since the weather is an important factor in this area, it has also been highly prioritised that the entrance at a certain level is sheltered from the wind and snow.

FORM EXPERIMENTS

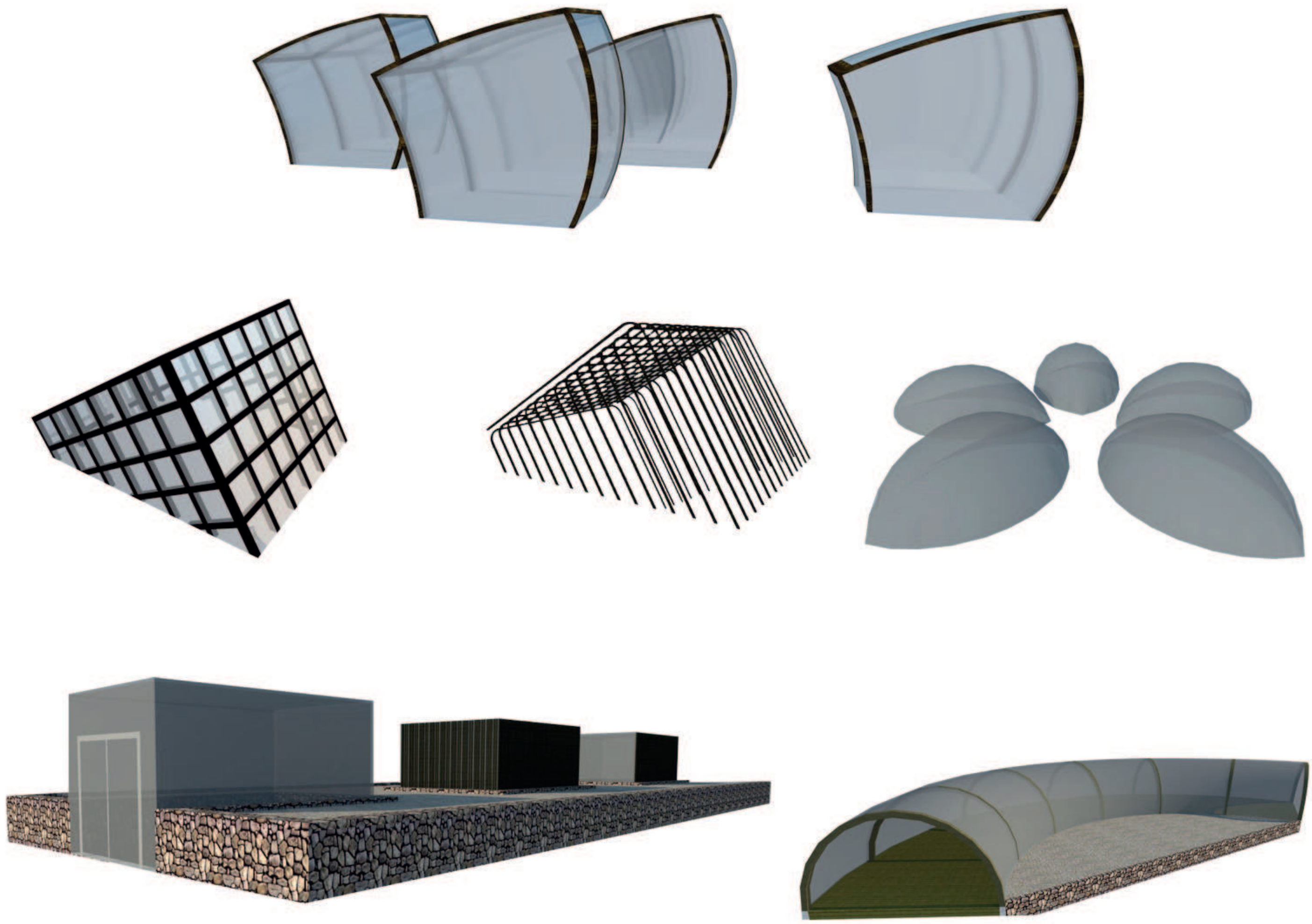
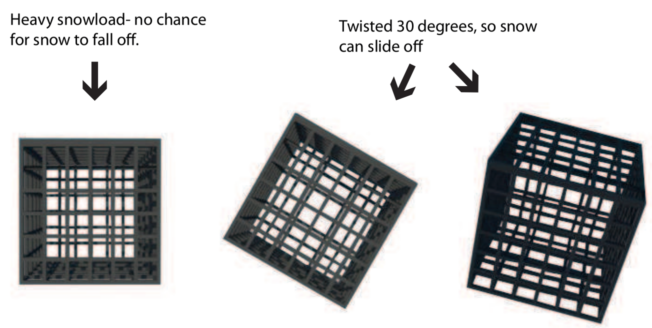
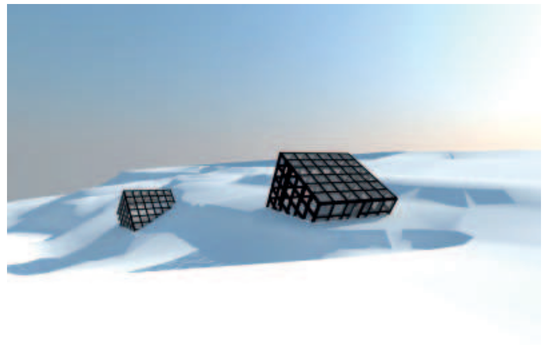


Fig.28: Shape experiments

Different form experiments were conducted in the search of a desirable shape of the building. From the early beginning of the project it was a wish to place some of the building underground, as a reference to the mines that played a large role for the municipality. The shape with the square boxes was the shape that was chosen for further development.

THE CUBES





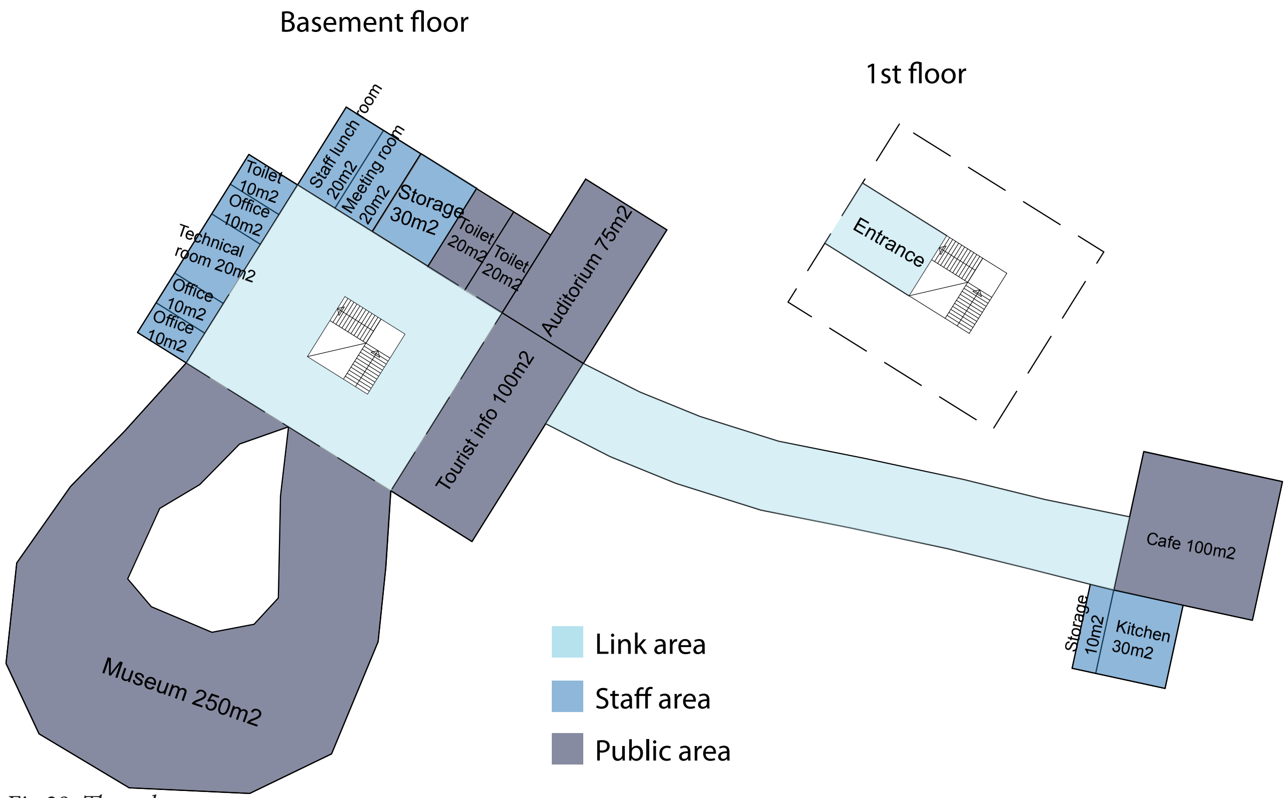


Fig.29: The cubes

Fig.30: Pictures of the cubes

The cube is meant to stand as a contrast to the landscape and the natural organic shapes in the surroundings. It is supposed to create curiosity of what's inside and underneath it. The thought behind it was to create a simple shape that would not steal too much attention from the surroundings, but still create interest.

Most of the rooms are put under ground to reflect back on the old mines in the municipality. The rooms will be blown out from the mountain and the walls will maintain the rock structure. The idea was to create the museum part as tunnels, since this part has no requirements for daylight.

The part of the building that is over ground will consist of two twisted boxes. One where you enter and the other will be the café area, which will pop out of the mountain. There were made some studies on how the boxes should be placed, according to snow load. With a straight box the roof would be flat, and the snow would not automatically fall of. So during some periods of the winter there would be heavy snow loads on the roof. Then the boxes were twisted so every surface had at least 30 degrees fall. In this way the snow could easily slide down and fall of.

Since the site suffers from heavy snow loads, the structure has to be quite massive. This weakened one of the important aspects of this project, the view. Some calculations were done on the structure and every glass area would only be around 1.5 x 1.5 meters. Something that was too little to get the clear view over the landscape.

Another problem area was the offices that require daylight and some view. The floor plan was worked a lot with to find a solution for these problems. At the end the offices were placed around the box where you enter, but still under ground. In this way they could get light from above, but they would still not have a view to the surroundings outside.

At the end the conclusion of this design was that it had too many weak points and that it did not fulfil any of the desired parameters. It could not reach the desired daylight and the view got interrupted by the structure.

STARTING OVER AGAIN

After a lot of work was made with the cubes and different floor plans were tested, there was still more problems than solutions. This design was at some points in conflict with the design parameters and did not really connect with the site. So rethinking the whole project had to be done. Brainstorming regarding the shapes and how to reach the requirements was started.

*Should large parts of the building be placed under ground?

*How can the rooms that require daylight get it?

*How should the public- and staff area be connected?

*How can the nature and the view be showed through the building?

*Should the building be a contrast to the landscape or should it blend more in?

After these points were put up for discussion, the shape experiments started over again. This time different organic shapes were tested and the thoughts of how to connect the building to the site started to roll. Since the structure has to be strong and massive because of the snow load, the shape is very important. Should the snow have a chance to fall of the roof or should it just fold around the building as it does on the rest of the landscape. In this way the building would have different expressions during winter and summer. Hidden during some periods in winter and eminent during summer.

The use of arches as the structural system started to become an idea and tests with different shapes of these arches was conducted. Since arches also are very good for compression they can easily take the snow load and at the same time show a clear structural system. What was one of the design parameters, according to the tectonic approach. The process from these points will be presented in the following pages.

FINDING INSPIRATION

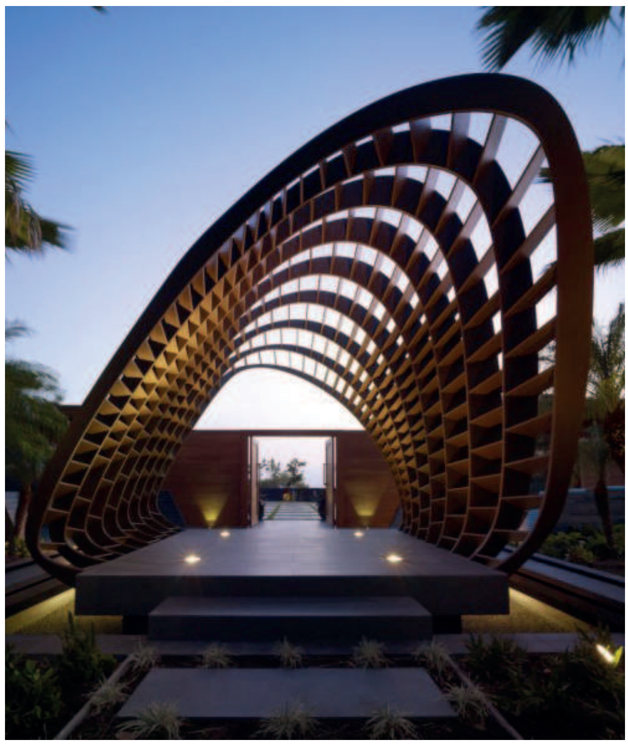


Fig.31: Inspiration pictures

PHENOMENOLOGICAL APPROACH

To understand and see the qualities of the area a phenomenological approach has been used. It is focusing on the way the weather and the climate is affecting the area and how the environment is being shaped after this. When the shape experiments started the idea was to design a building that was playing along with the landscape and that it could be traced back to the nature.

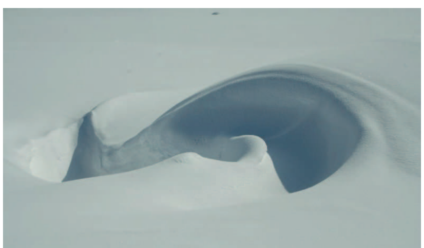
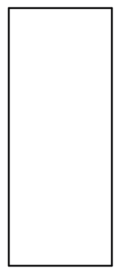
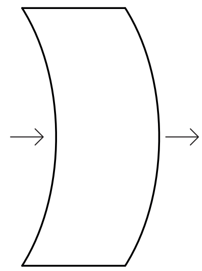



Fig.32: Phenomenological pictures

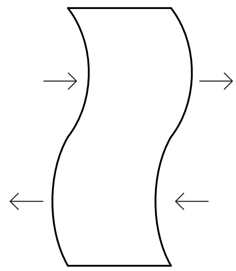
SHAPE EXPERIMENTS ON FLOORPLAN



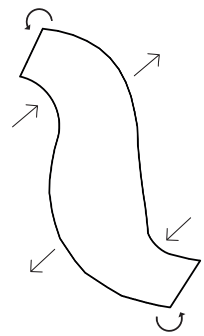
To stiff and did not work with the landscape



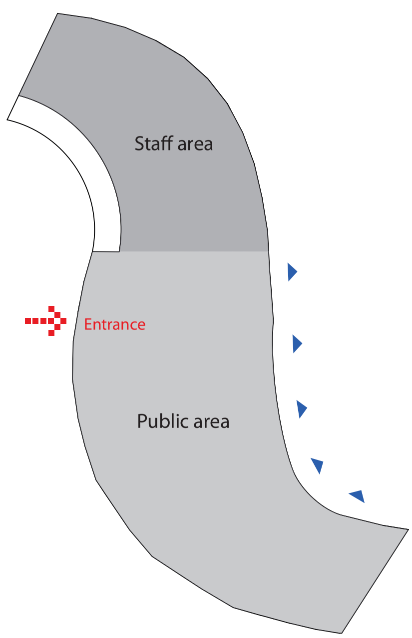
Trying a more organic shape, but there is problems with the outdoor areas



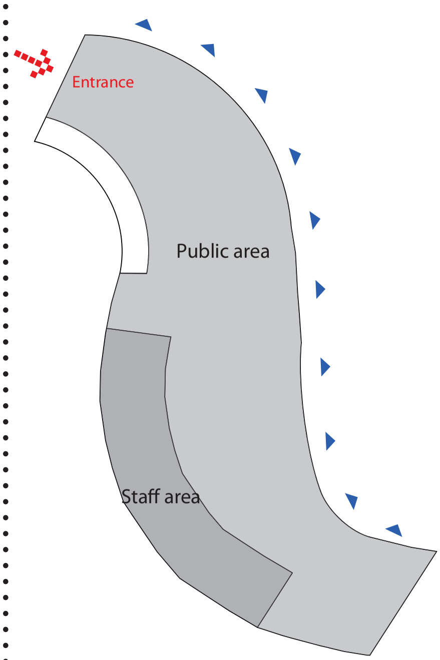
Pushing and pulling the shape to create outdoor areas, but it still does not fit in the landscape



Pushing, pulling and twisting the shape to create outdoor areas and to make it fit into the landscape



Floor plan with entrance at the middle of the building. The possibility to have a clear view over the landscape and the lake is reduced because of the staff area.



Floor plan with entrance at the end of the building. A clear line is kept through the whole building and the view possibility is in focus.

Fig.33: Floorplan experiments

CONNECTION TO SITE

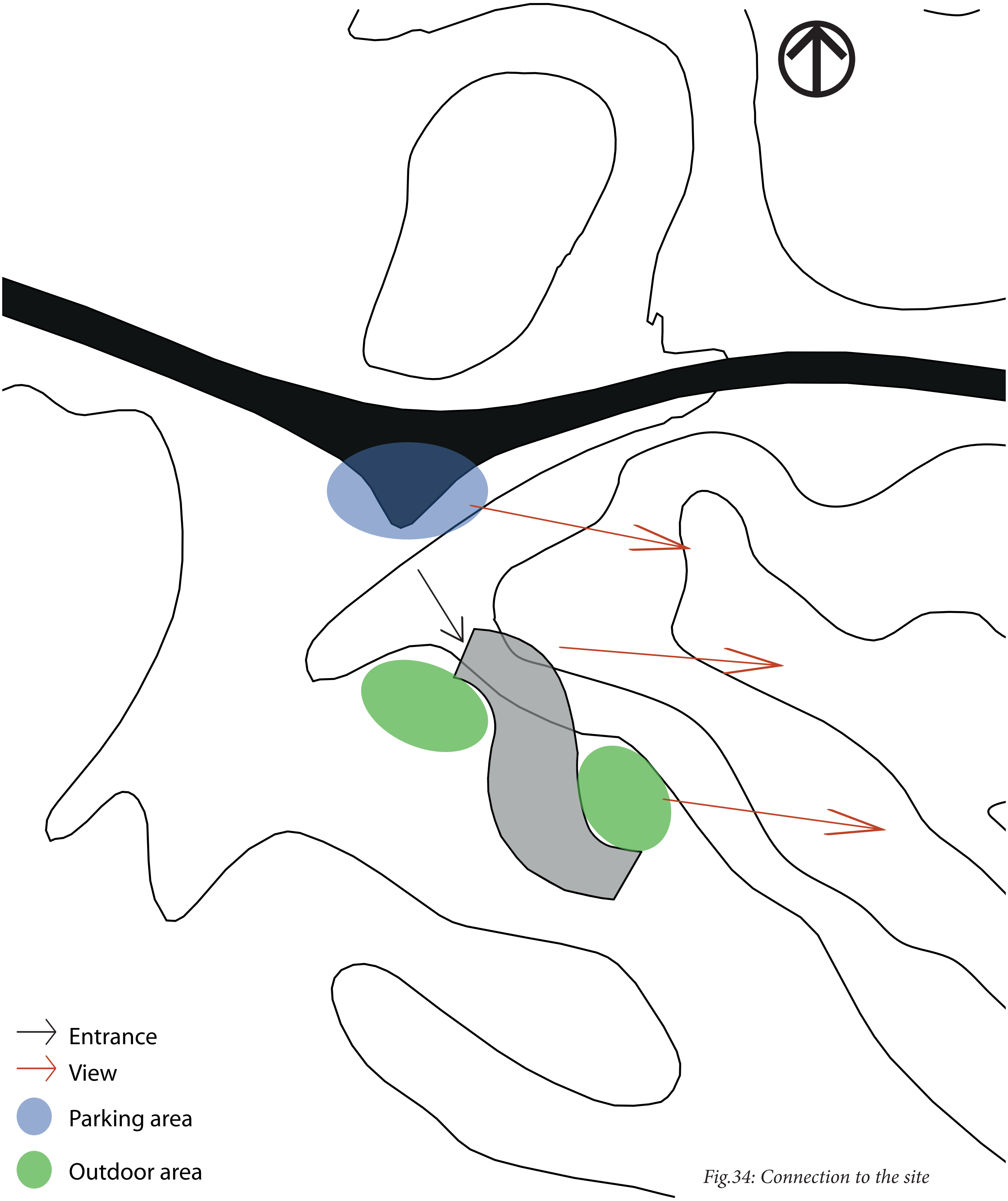


Fig.34: Connection to the site

SHAPE EXPERIMENTS ON STRUCTURE

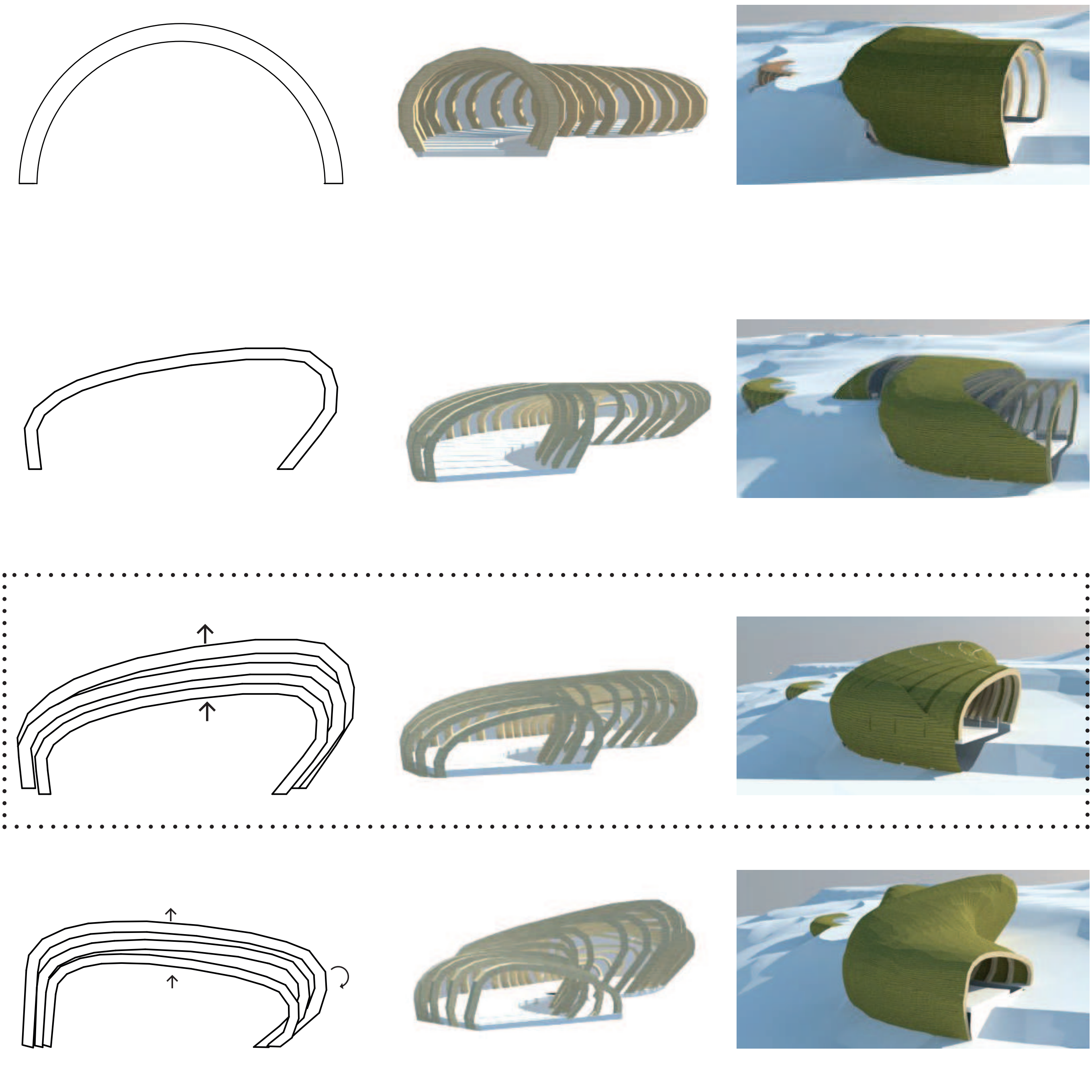
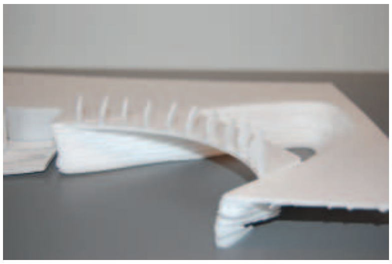
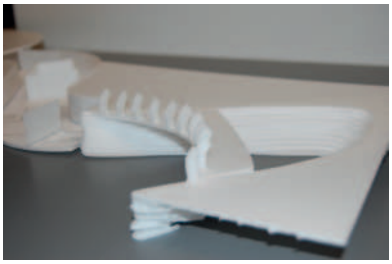


Fig.35: Structure experiments

SHAPE EXPERIMENTS ON BRIDGE

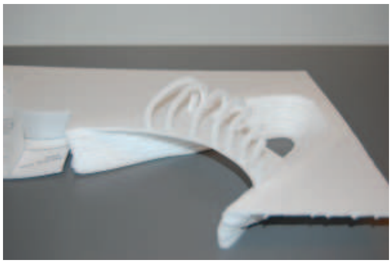
Experiment 1





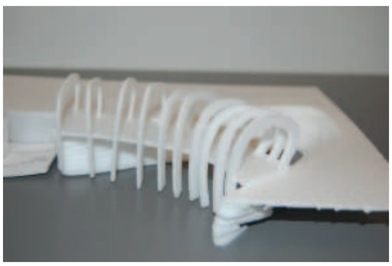
Shape experiment where the bridge consist of glulam columns that are cut in the same height. The idea is that they should have the same curve as the arches.

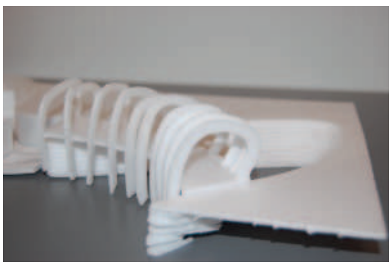
Experiment 2



Shape experiment where the bridge consist of glulam arches that are slowly being cut towards the end of the bridge.

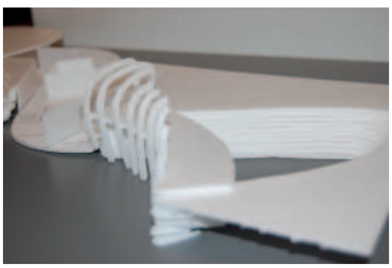
Experiment 3





Shape experiment where the bridge consist of glulam arches that have the same height through the whole bridge, and where the arches go down and meet the landscape.

Experiment 4



Shape experiment where the bridge consist of glulam arches that are being cut towards the end of the bridge, and where the arches go down and meet the landscape.

Fig.36: Bridge experiments

Conclusion on shape experiments

Floor plans:
The shape of the floor plans was created after several experiments on how the building would fit into the landscape. An organic shape was more desired then a orthogonal one, so the square shape was transformed from having sharp edges to be smoother.

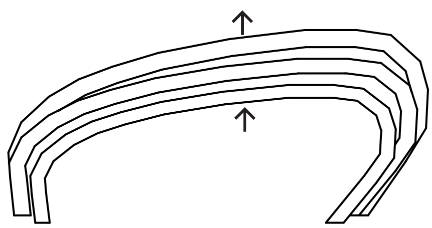
The view has been an important design parameter, so it was desired that the shape would emphasize it and bring a natural view point into the building. When the organic shape got more developed the ideas of creating outdoor areas became an important factor as well. By creating natural outdoor areas the nature and the landscape would automatically be dragged into the building and the visitors would get closer to the nature. So the shape got transformed into something that reminds of a snake shape. This way outdoor areas were naturally created between the building and the landscape.

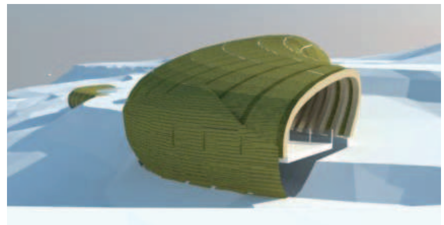
Some rooms in the building have daylight requirements. So the shape of the floor plan has been rotated in a way that some of the building pops out from the landscape. This way the required daylight can get into the rooms in the basement.

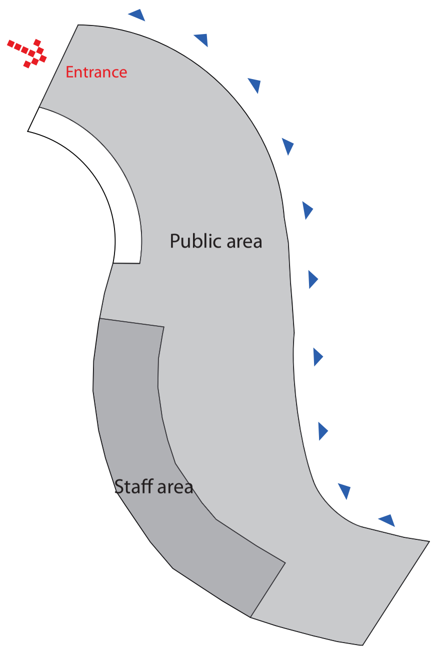
The structure:
The thoughts about using arches as a structural system came quite early in the process. First the shape was a symmetrical arch, but it got to stiff and did not play along with the landscape. After looking at some pictures of how the snow is moving in the landscape and how it folds around the nature, an unsymmetrical arch was created. The idea is that the arch should fold around the landscape at some points and be more open and playful at others.

When this unsymmetrical arch was created some experiments on how it should be placed was conducted. The first one was where the same arches were placed through the whole building. This shape did not create the desired movement in the building, and had to be developed more. The second experiment was to slowly raise the arches towards the middle of the building and then go down again towards the end. This created a nice movement in the building, where you get the feeling of going into something that opens up and then closing again at the end. The third experiment was to raise the arches as in the second experiment, but also twist them a little. This way it was possible to highlight the desired areas in the building. The conclusion of the third experiment was that the shape got messy and disturbing, and it did not have the clean lines anymore.

The structure was decided to have the shape as experiment number two. Where the arches are raised towards the middle. This is a shape that creates an interesting movement in the building, but still keeps the clean and simple lines.







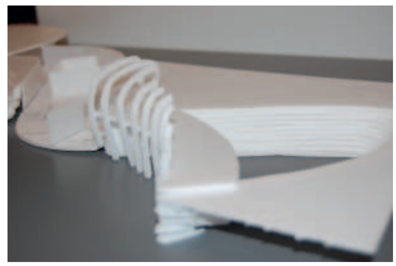


Fig.37: Chosen experiments

The bridge:
The idea about entering the building by walking over a bridge came after the experiments on the floor plans were conducted. It would be a great beginning in the experience of entering the building and it would create closeness to the nature from the very beginning. Between the parking lot and the building there is an intersection in the landscape where there is a small stream running. During some periods of the year it will be a lot of water in this stream and it could give some extra nature experiences by walking over a bridge at this point.

Different shape experiments have been conducted on the bridge. The one that works the best is experiment number four, where the arches are slowly being cut towards the end of the bridge and where they meet the landscape at the bottom. This was the shape that worked best with the building without stealing too much attention, but still managed to emphasize the lines and the shape of the building.

The idea with the arches going down under the bridge and meeting the landscape is that they should work as support for the bridge, but also be a beginning/end of the building. As the same shape of the arches will continue into the building and create the walls for the basement floor that is popping out of the landscape. This way there is a connection between the bridge and the building.

The bridge you see on the picture only has arches going down towards the landscape on one side, but it will be developed to have it on both sides so the structure will be stable.

AUDITORIUM EXPERIMENTS

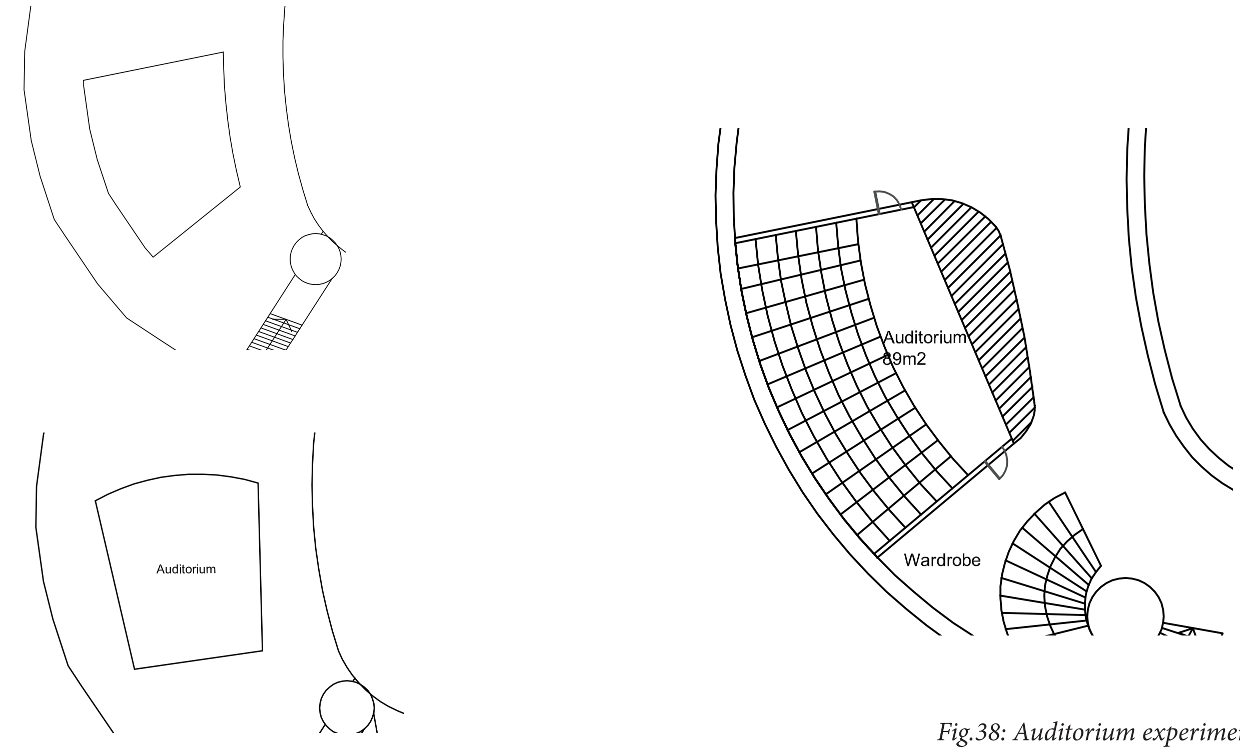


Fig.38: Auditorium experiments

Different experiments regarding the shape and the acoustic qualities of the auditorium has been conducted. The first idea was to create a room inside the room, where the walls would work as a structural support for the floor above. The shape should also be reflected from the shape of the rest of the building and create a connection between the tectonic and the stereotomic.

A lot of problems occurred with the room in the room shape, and the qualities of the area around the auditorium were weakened. The area around would be perceived as hallways and did not really get any good functional qualities. Also the acoustic qualities were bad when the room shape were totally reflected from the shape of the rest of the building.

Some rethinking regarding the shape and how the impression of the room should be received had to be done. In one way the shape of the auditorium should be reflected from the main shape of the building and in the other way it had to connect with the way you enter the room and what qualities it would give to its surroundings.

So the auditorium was placed next to the wall, where it will contain the lines from the main shape at the back of the auditorium. Because of some acoustic problems the front wall had to be straight. In this way some of the rock structure will be kept in the auditorium area, to create a natural and clean pathway towards the toilets, and still be in connection with the stairs and the museum. The idea with this rock structure is that it can be used as a small exhibition area with elements placed in the wall.

The walls of the auditorium will not work as a structural support, as there is a desire to have the same structural expression through the whole area. This means that the glulam beams from the floor above will be expressed inside the auditorium ceiling.

THE MUSEUM

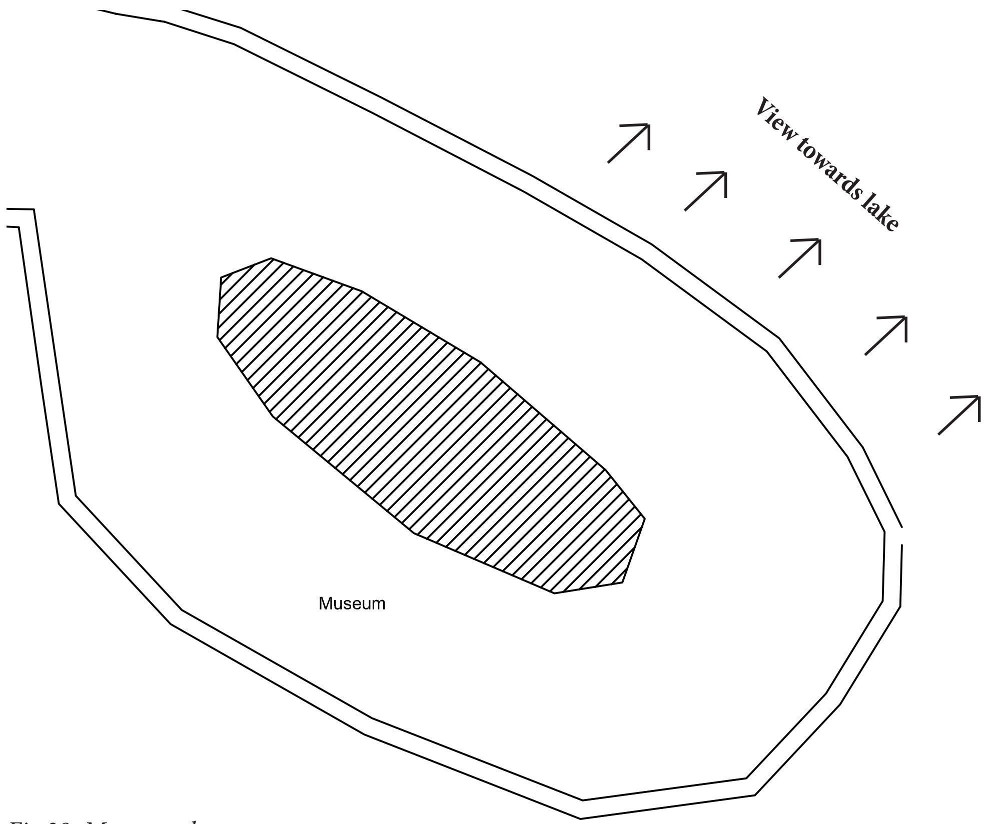


Fig.39: Museum shape

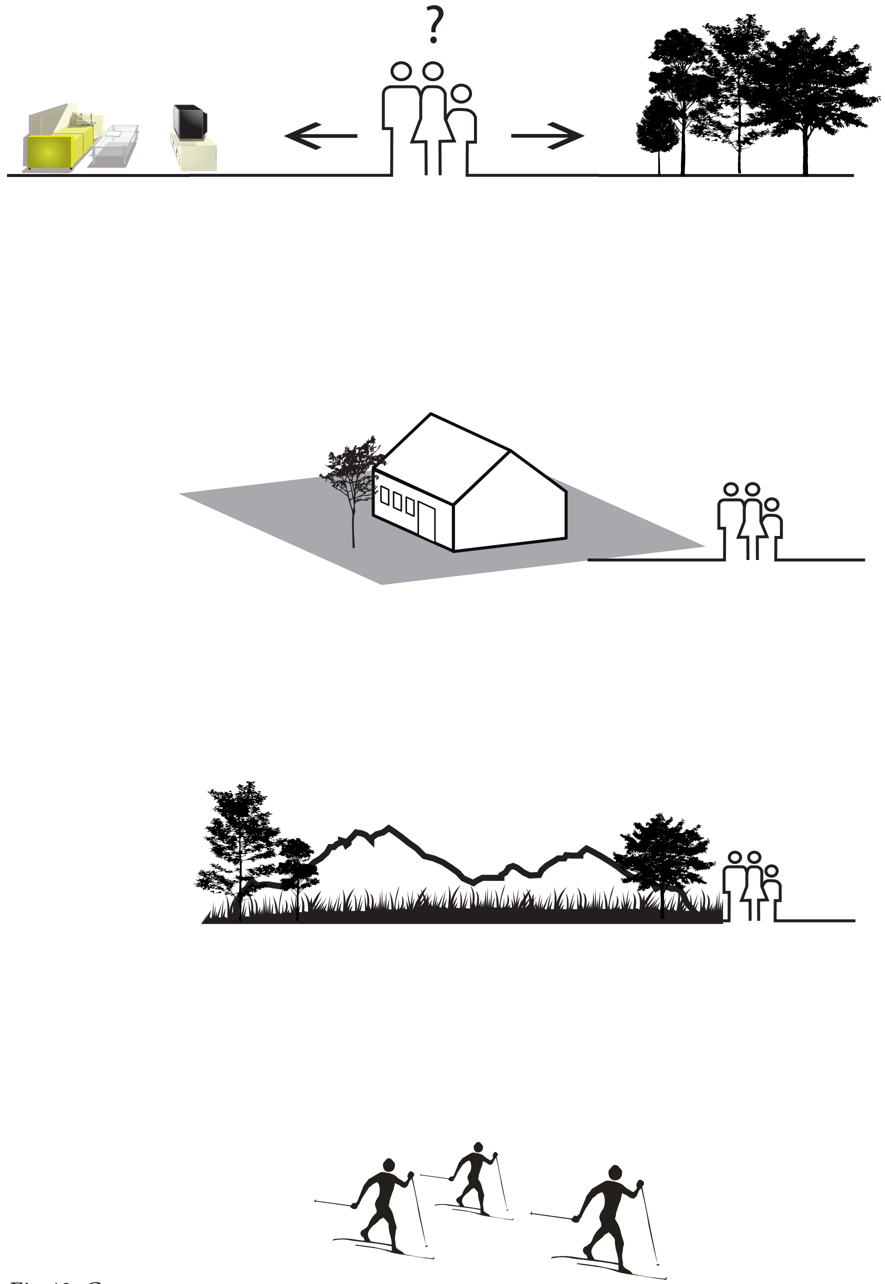
One part of the building that is underground will consist of a museum showing the history of the municipality. It will contain of the mining history, how the lakes in the area were dammed to create power plants and how the Sami people have been living here for centuries.

The museum will be designed as tunnels inside the mountain. This is to create a reflection back to the mines and make a closer relation to the museum and the exhibition. At one point the tunnels will lead the building out from the landscape and make a view point over the landscape and a lake. At this point you will actually look at one of the lakes that were dammed and the idea is that this will enhance that part of the exhibition.

CONCEPT

When a building is placed in wild and deserted nature, it has to be considered how it will be conceived and understood. Will people understand it as a part of the site or will it be seen as a foreign element that was just placed there. The building should create curiosity and make people want to go inside to see what's happening. They should feel closeness to the nature and be tempted to be active outdoors. The nature should be dragged into the building and this way show the beauty that can be experienced when living an active outdoor life.

The diagram on the next page shows the concept for the design. People have the choice to be active and do outdoor activities or they can stay at home. For some people the problem is that they don't know what activities they can do and the imagination sets a limit for you. And of course lack of information is an important factor as well. The concept is to create a building that will give you a kick-start to the outdoor experience. Entering this building will give you a feeling of being close to the nature, and you will get information and ideas of activities you can do. With the view of mountains and lakes, the information- and adventure centre will be the starting point for great adventures and experiences.



A family is wondering if they should stay home or go out in the nature

They go to the information- and adventure centre

Here they get a touch of nature and ideas of what activities they can do

They will have information about the municipality and activities they can do here

Fig.40: Concept

TECTONIC MEETS STEREOTOMIC

In the museum and the rest of the floor that is put underground the rock structure will be kept as a visible wall material. This way of using a stereotomic design is to reflect on the old mines and the meaning they had for the municipality.

The idea is that the tectonic and the stereotomic will be combined in a way where the tectonic design is transforming into a stereotomic design. This is shown in the way where the glulam arches are folding around the landscape and going from being a clear and visible structure, into being a hidden building underground. The experience when going through the building will transform from a pure tectonic vision when entering the building, and slowly transforming into stereotomic the further and deeper into the building you go. At one point in the museum, where some of the building is coming out from the landscape, the tectonic design will again be visible with the arch construction and glass façade creating a view point over the landscape and the lake.

Fig.41: Stereotomic building

THE VISITOR EXPERIENCE

1. Visitors parking the car
2. Walking over the bridge
3. Entering the building
4. Visiting the cafe
5. Visiting the museum

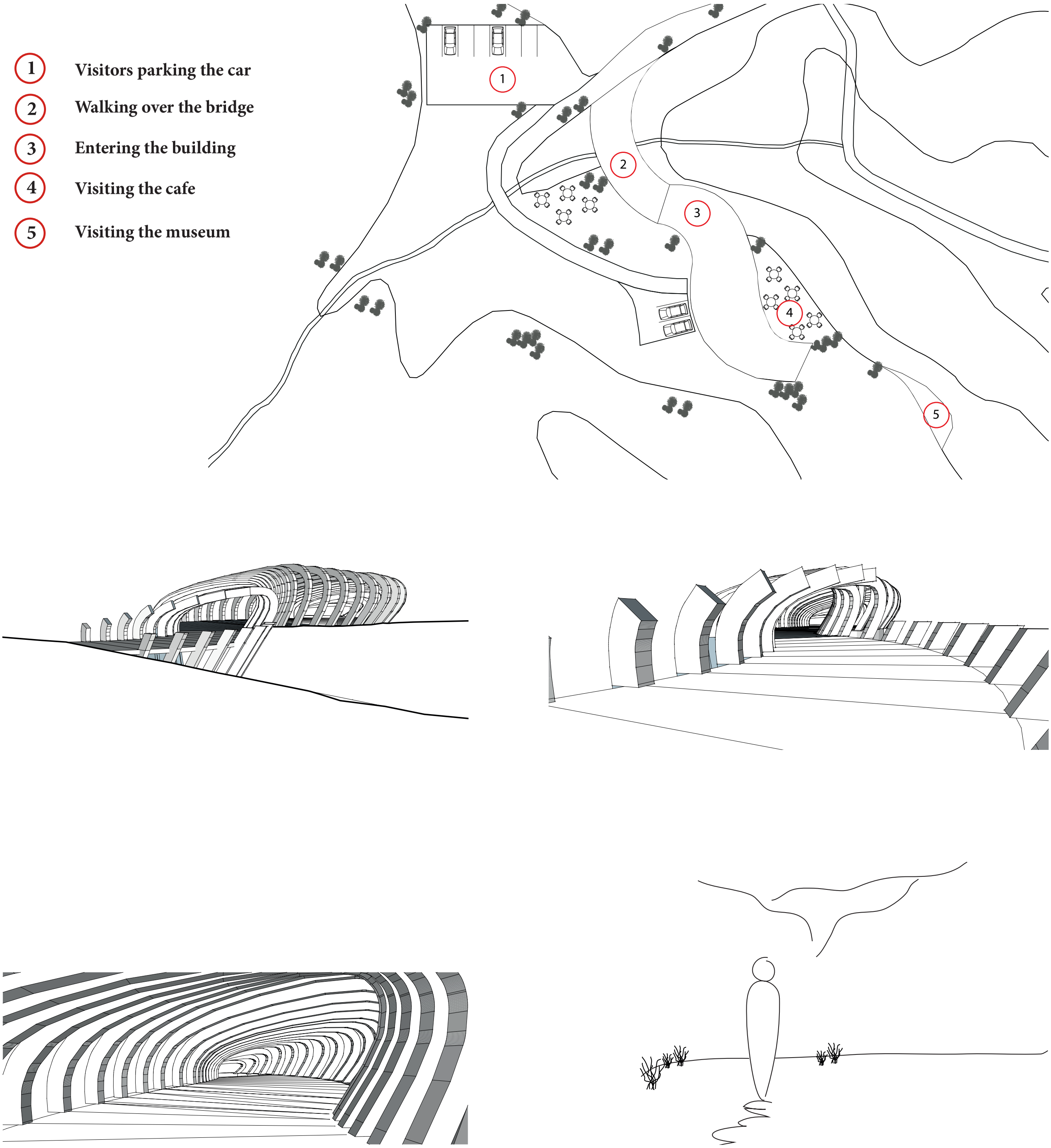


Fig.42: Visitor experience

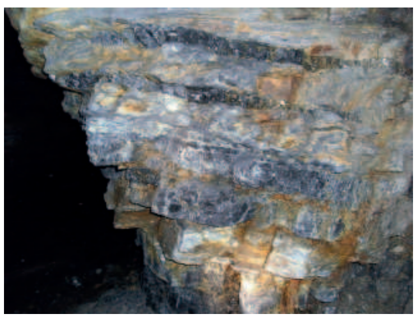
FACADE AND MATERIAL CONSIDERATIONS

Through different references and case studies it is quite clear that the choice of materials will have a big influence on the expression of the area and the building. One of the desired design approaches was to take inspiration in the Norwegian architecture and the typical material usage from Norway. With the use of natural materials and an aim for constructional transparency some considerations has been made.

The main construction will be glulam arches, where there will be smaller glulam beams connecting these arches together and carrying the façade. The façade itself will be of glass. This way the structure of the building will be emphasized, and the building will open up towards the landscape and also bring the nature into the building.

Inside the building the floors will be made of wood and on the storey that is under ground the walls will be kept in the rough rock structure that will appear after the mass has been blown out. This way the mining history of the municipality will be dragged into the building.

Glulam beams is used as the main structure and to carry the floors. The facade will consist of glass.



The walls in the basement will have a rough rock structure.

The floors will be made of wood.

Fig.43: Material consideration

ACOUSTICS

There will be a need for an auditorium for educational and informational purpose, where groups and visitors can go for lectures and courses. In "Architectural Acoustics", Marshal Long gives some guidelines of how to design an auditorium. Based on these, initial plans and sections are made. The design evolves from some of the parameters that Marshal Long gives. [Long 2005]

•A stepped or sloped floor, along with a raised platform for the talker, aids in the useful reflections and reduces grazing attenuation.

•The ceiling above the podium and the side walls surrounding the podium should be slanted to avoid flutter echo.

•The ceiling is a series of flat-stepped elements, which provide beneficial early reflection. Flat ceiling elements are both more practical to build and better for intraclass discussions than more complicated ceiling shapes.

•A fan shaped configuration brings the audience close to the platform of the speaker.

•The first-reflected sound path should be kept short. To that end the ceiling should be hard and relatively low.

•"Good sight lines give good listening conditions".

HOW TO CHANGE ACOUSTICS IN A ROOM:
•Change dimensions (longer time delay of echo)
•Change form/shape/geometry (alters the direction/angle of the reflections)
•Change materials (flat surfaces bounces most of the sound in the same direction, bumped surfaces spread the sound waves in multiple directions, hard materials absorbs little sound while soft materials absorbs more sound).
•Concave shapes focuses the sound while convex shapes spread the sound
[PHK 2010]

AUDITORIUM

DETERMINATION OF VOLUME:
When designing an auditorium the area and volume should be kept to a minimum. This is to shorten the sound paths, so the audience will get a better sound experience.

The ceiling height in feet can be calculated as 20 times the desirable reverberation time (Egan, 2007). As the auditorium is meant for educational and teaching purpose, the reverberation time is around 0.6 seconds. With this information the optimal ceiling height can be calculated.

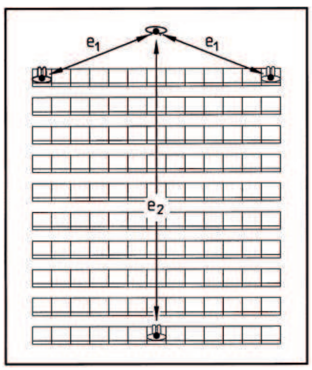
H= 20 x 0.6 = 12 feet = 3.7 m

With an auditorium meant for speech and a room height of 3.7 meters, these requirements are recommended to be followed:

	Minimum	Maximum
Volume per seat	$2.3m^3$	$4.3m^3$
Volume for 72 people	$165.6m^3$	$309.6m^3$
Floor area for 72 people	$44.8m^2$	$83.7m^2$

(Egan 2007,www.kemt.fei.tuke.sk, www.rockfon.co.uk)

SOUND DISTRIBUTION:
For an auditorium the fan-shape is the most suitable, as it gives the most even sound distribution. For an auditorium with room for 72 people the dimensions should be around 7 meters wide and 10 meters long. (http://bks.byggforsk.no)



In an auditorium e1/e2 ≤ 2/3 considered the directional audio transmission from a speaking person.

ASSUMPTIONS:
To conduct the experiments some assumptions has been made:

Speaker sound level: 60dB
Place of speaker: 1.6m above floor

ANALYSIS RESULTS
One of the criterias during the investigations was that the room should have a shape so it played along with the organic shape of the rest of the building. This way the shape of the roof has been kept fairly simple with the beams supporting the floor above visible in the room. The requirements have been reached without the need to add an internal roof for the acoustics.

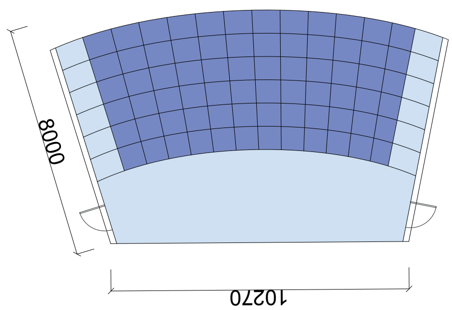
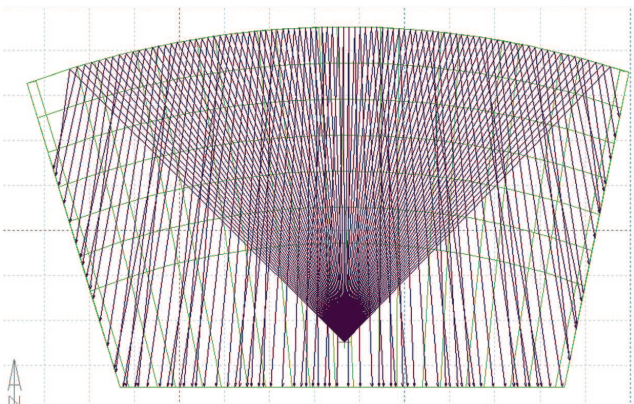


Fig.44: Acoustic experiments



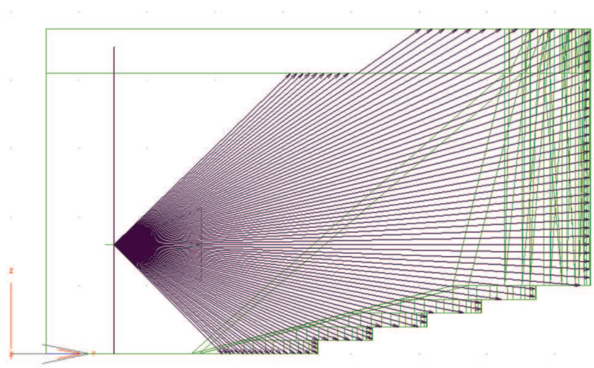


Figure..: These figures display how the sound is distributed in the room

SECTION EXPERIMENTS:
Sectional experiments lead to different qualities and acoustical properties in the room. The auditorium section is made as simple as possible, both to make it follow the structural support of the floor above and because of the scale of the room. A more complex shape would not fit that well in this scale.

As both an aesthetic and an acoustic element, the backwall is designed as a concave surface. This way the sound is spread out in the room, echo is prevented and the reverberation time is at an acceptable level according to auditoriums for speeches.

MATERIALS:
As discussed in the material chapter, the preferred materials is wood and concrete. By analyzing the auditorium in Ecotect, with the preferred materials, the best solution would be with the following materials:

Front-, ceiling and side walls:	Wood
Back wall:	Woodysorber
Floor:	Painted concrete
Seating:	Upholstered

Fig.45: Woodysorber

FIRE

According to TEK10 there is a general requirement that a building should be shaped and conducted to secure fast and safe escape during a fire. People in the building need access to escape routes or openings directly to the outside, in case of fire. Escape routes has to lead to the outside, or to a safe place in the building.

The building will be equipped with an automatic sprinkler system and automatic fire alarm. The internal ceiling and walls are made so they do not contribute to the fire- and smoke development while people will escape the building. In the basement there will be placed emergency lights because there is no access to daylight.

(www.bks.byggforsk.no)

Conditions that affect the escape
There are different conditions that affect the escape of a building during a fire:

•The spread of fire and gasses. There has been experienced that people will turn around in the escape route if they can't see further then 10 meters.

•How big the building is (how large area and the number of storeys).

•How the plan of the building looks like and how clear it is.

•If there is fire signals and good information. A speaker that says where it is burning and where you should escape has been proved effective.

•The number of people that is in the building. It makes a big difference if they know the building good or bad and if they are sleeping.

•The physical and psychological condition of the people in the building.

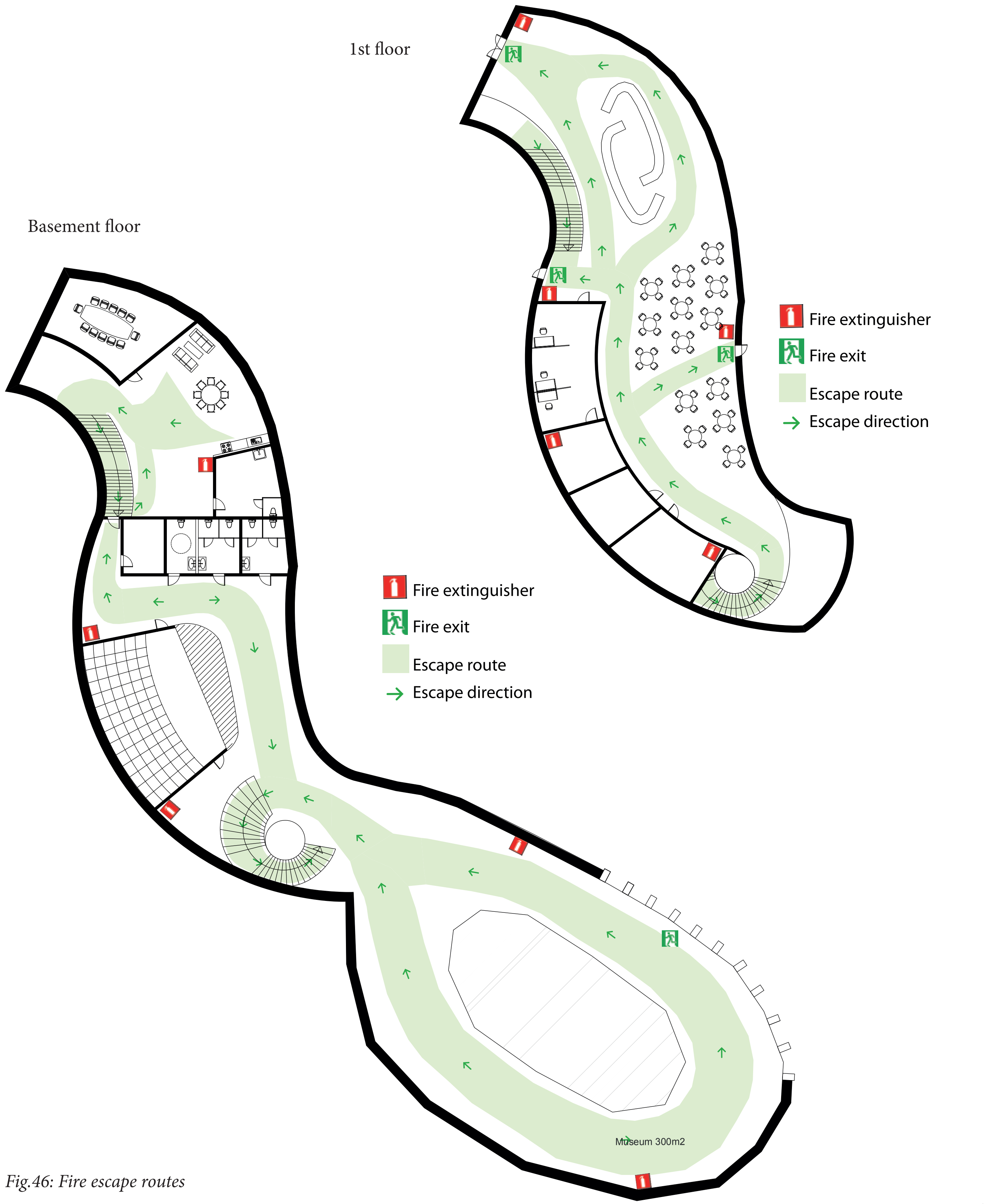


Fig.46: Fire escape routes

VENTILATION

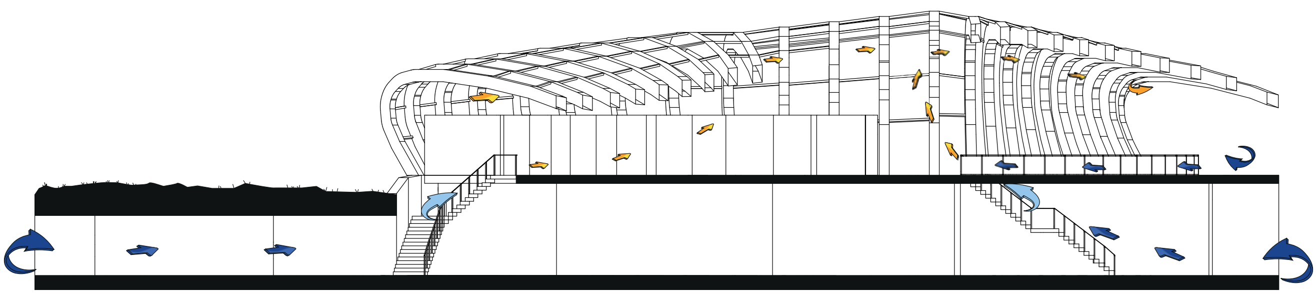


Fig.47: Ventilation strategy

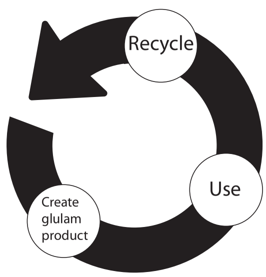
The ventilation strategy is to use natural ventilation where buoyancy ventilation is the most suitable. This means that cold air will come in at a low level in the building and the warm air will naturally go up towards the roof and the highest point in the building, because cold air is heavier then warm air.

There will be intake of fresh air in the basement floor in the areas that are coming out from the landscape, and the open staircases will make it work as a stack ventilation. The warm air will then automatically float up towards the roof where it should be possible to open the windows with electrical steering.

Some mechanical ventilation might be needed in the museum part that is under ground.

GLULAM AS A STRUCTURAL MATERIAL

ADVANTAGES:
-Strength
-Density
-Fire resistance
-Sustainable
-Easy to shape



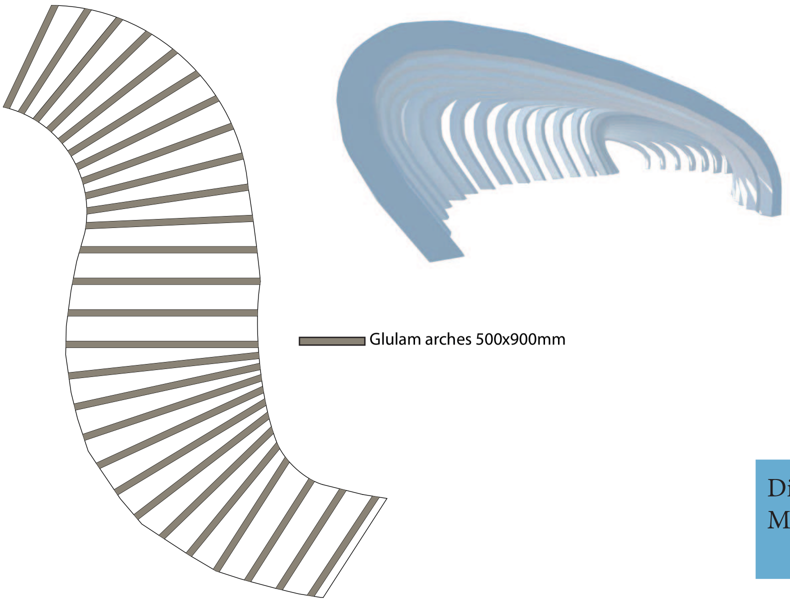
"Glulam is strong, rigid and form stable"

Building a structural system with glulam is a good alternative to concrete and steel, and it gives a warmer expression to the building. It is a renewable material and because of its qualities it can take big loads and carry big spans. It can also tolerate aggressive environments very well, without a lot of maintenance. When it comes to glulam structures there are almost no limits, except how to transport the large elements. It can have every desired shape, something that gives the material good architectural qualities.

During a fire a glulam construction will normally resist the heat and the flames better than a steel or concrete structure, if it has a sufficient dimension. The surface will ignite quite fast and the incineration will continue in a constant speed. But it will go slow, because of the coal layer that occurs is heat-insulating and it prevents air to reach the material. Even after a long time in fire, the temperature will stay under 100 °C in the parts that are not burned. Compared with a steel structure where the temperature would just be raising during the fire, which will make it start deform after a while.

(www.svensklimtra.se)

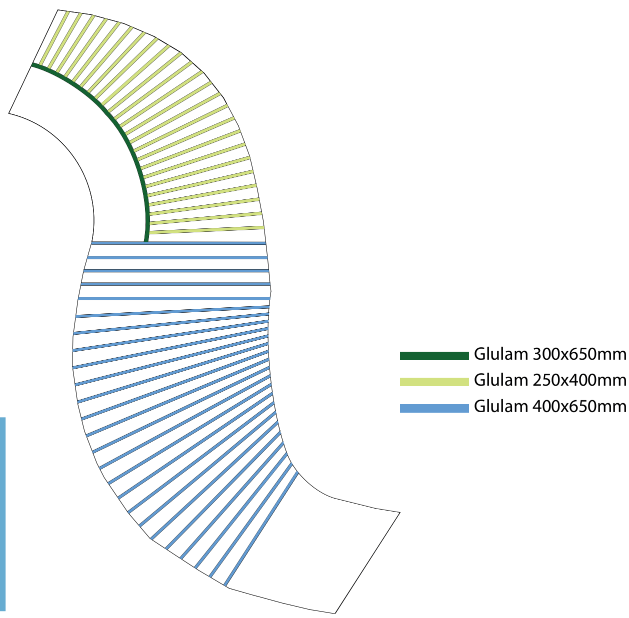
CONSTRUCTION



THE ARCHES:
The main construction will consist of glulam arches in different heights. The arches will slowly be raised towards the middle of the building and then lowered again towards the end to create a movement in the building The height will be 4.6 m at the entrance and 7.2 m at the highest point in the middle. They will have a maximum distance of 2 meters, as the dimensions will get very big with a larger distance.

Dimension of arches:	500x900 mm
Max span of arch:	15300 mm

Floor 1st floor:
There will be a wooden floor that will be supported by glulam beams. These beams are necessary because of the large span in the building. The floor is divided into two areas, where the beams will have different dimensions. The reason for this is the desire for different room qualities, which made it impossible to have the same structure all over.



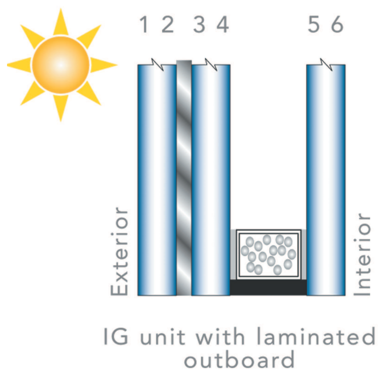
Floor thickness:	247 mm
Floor beams in staff area:	250x400mm
Beam supporting floor beams in staff area:	300x650 mm
Floor beams in public area:	400x650 mm

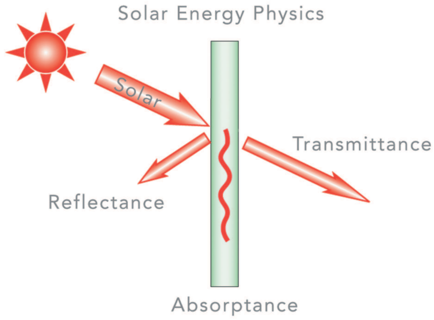
Column:
In the staff area it will be necessary to have a column to support the curved glulam beam. This is to reduce the dimensions of the glulam beam.

Dimension of column:	200x200 mm
Height of column:	4103 mm

Fig.48: Construction illustrations

GLASS FACADE





When considering what glass to use in the façade, there are several aspects that should be considered. The price, energy efficiency and the environmental impact can vary tremendously. The glass should work as a good insulator, and still give good visual qualities.

Since the whole façade is going to be covered with glass it is important that the performance of the glass gives acceptable thermal comfort and that it gives a good visual opportunity through it. The comfortable temperature range is between 18 and 26 °C and the main function for these windows will be to reduce the heat flow between indoor and outdoor spaces, providing good insulation. The windows should have a low U-value and still remain the aesthetic appearance of clear glazing. The ideal would be that they transmit the light and reflect or block the ultraviolet and infrared energy, and still appear pleasant for the exterior and the interior of the building.

The desired appearance of the façade is clear glass, where it is possible to see the glulam structure from the outside and to have a clear view over the landscape from the inside. This is possible by using a 3 layered insulating glass with a coating that almost does not affect the view, but still reflects some of the energy from the sun. The U-value can this way go down to 0.5 W/m2K, and still have a light transmittance of over 90%. The glass surfaces will be connected together with a silicone edge to create a continuous surface without being disturbing.

The glass façade will be attached and connected to steel pins that will be attached to the glulam arches. This way the attachment of the glass won't be disturbing and it is not necessary with some extra structure to carry the glass. The glass will also get some distance from the glulam arches, and this way the arches will be in a protected environment.

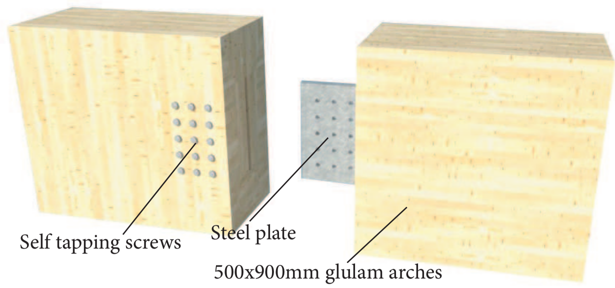
Some calculations on the dimensions of the glass has been made, regarding the heavy snow load that appears. The largest dimensions that can be made are a surface of 1x2 meters, with a glass thickness of 19mm. See appendix.

(www.sunguardglass.co.uk)

Fig.49: Glass facades

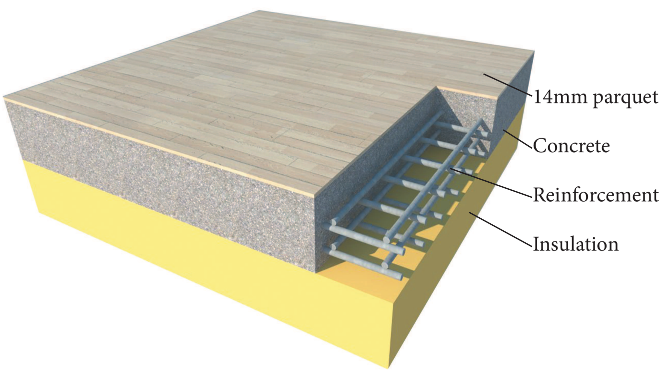
DETAILS

Beam connections



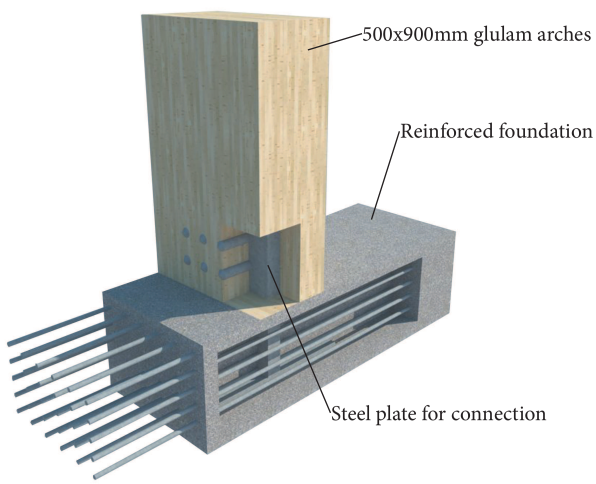
Because of transportation problems the arches must be divided into several pieces. They will be connected together in a way where a steel plate is placed between the laminates and then attached together with self tapping screws.

Basement floor



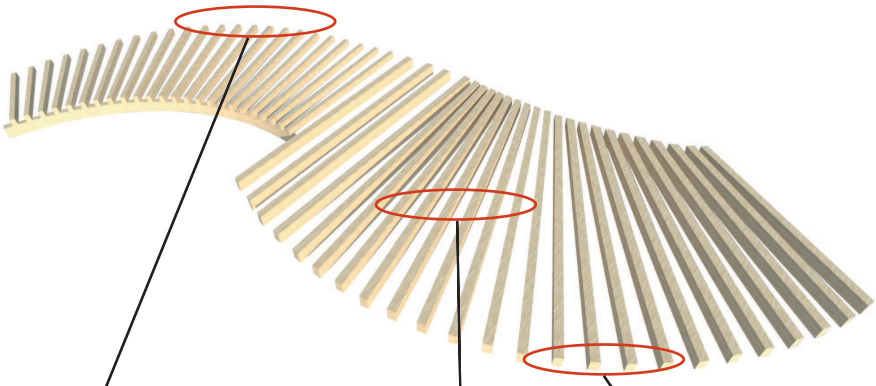
The basement floor will be made from concrete, with a parquet layer on top. There will be a layer of insulation underneath and floor heating will be put around 7cm down into the concrete.

Arch to foundation

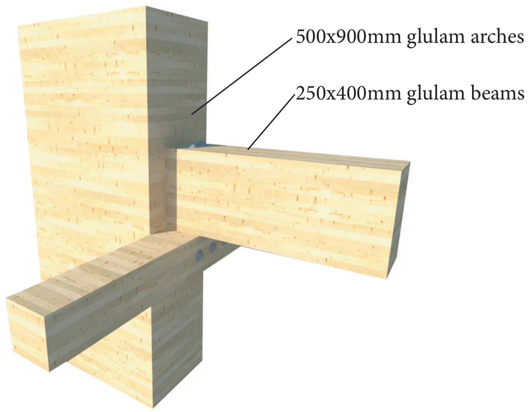


The arches will be attached to a reinforced concrete foundation. A steel plate will be casted into the concrete and a recess will be made in the glulam arch. This way the glulam arch will be placed around this steel plate and bolted to it.

Fig.50: Details

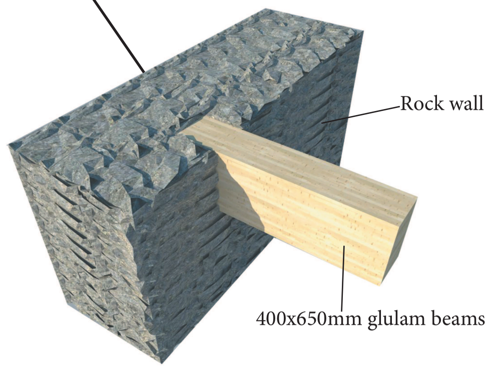


Floor attached to arch



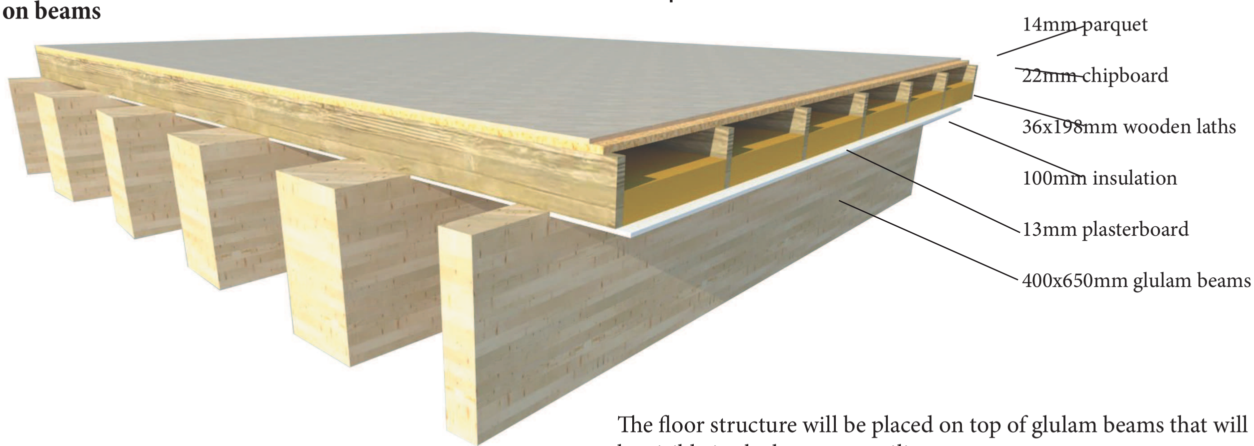
In the area where the building is coming out from the landscape, the floor has to be attaced to the arches. A beam will be attached to the arches and the floor structure will be submitted on top of this beam.

Floorbeams into wall



In the areas where the building is under ground, the floor structure will be placed in recesses in the rock wall. This recess will have moisture protected edges, which will be a rubber sheet covering the edge and the support area.

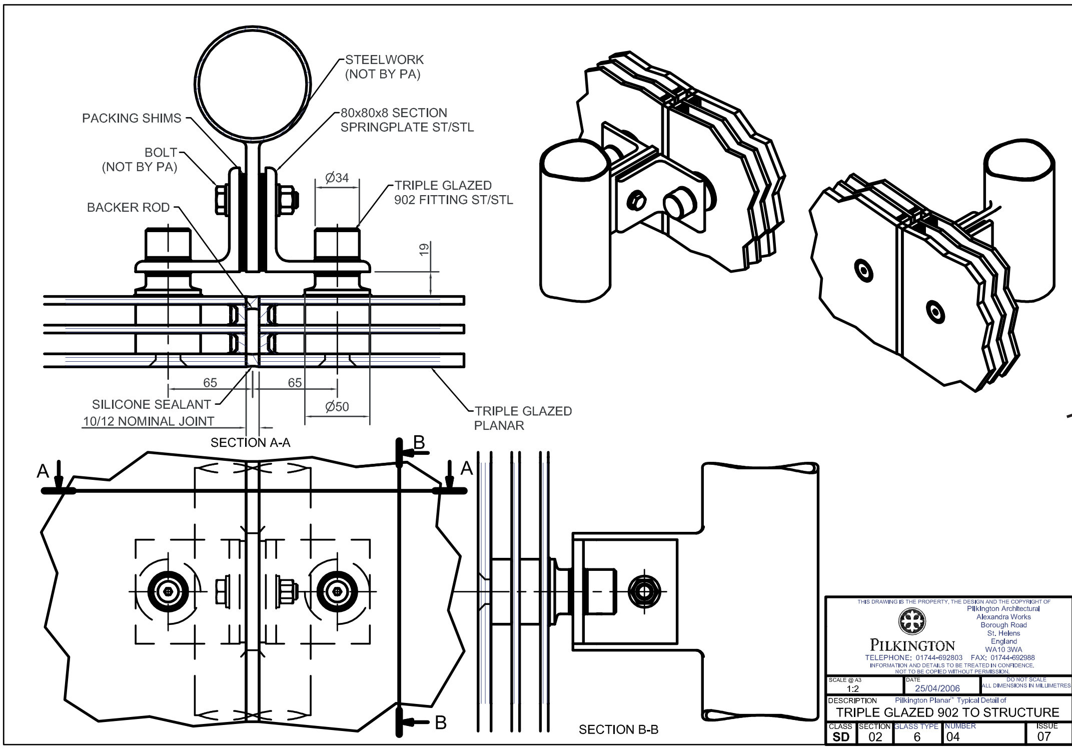
Floor on beams



The floor structure will be placed on top of glulam beams that will be visible in the basement ceiling.

TECHNICAL DRAWINGS

Detail on how the glass is attached to the glulam beams



Detail on glulam arch

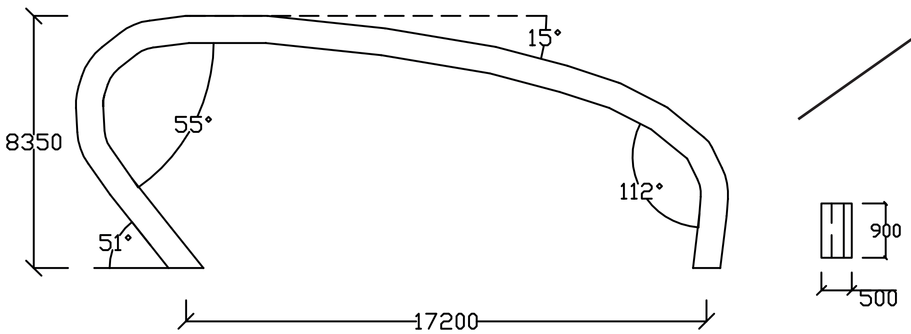
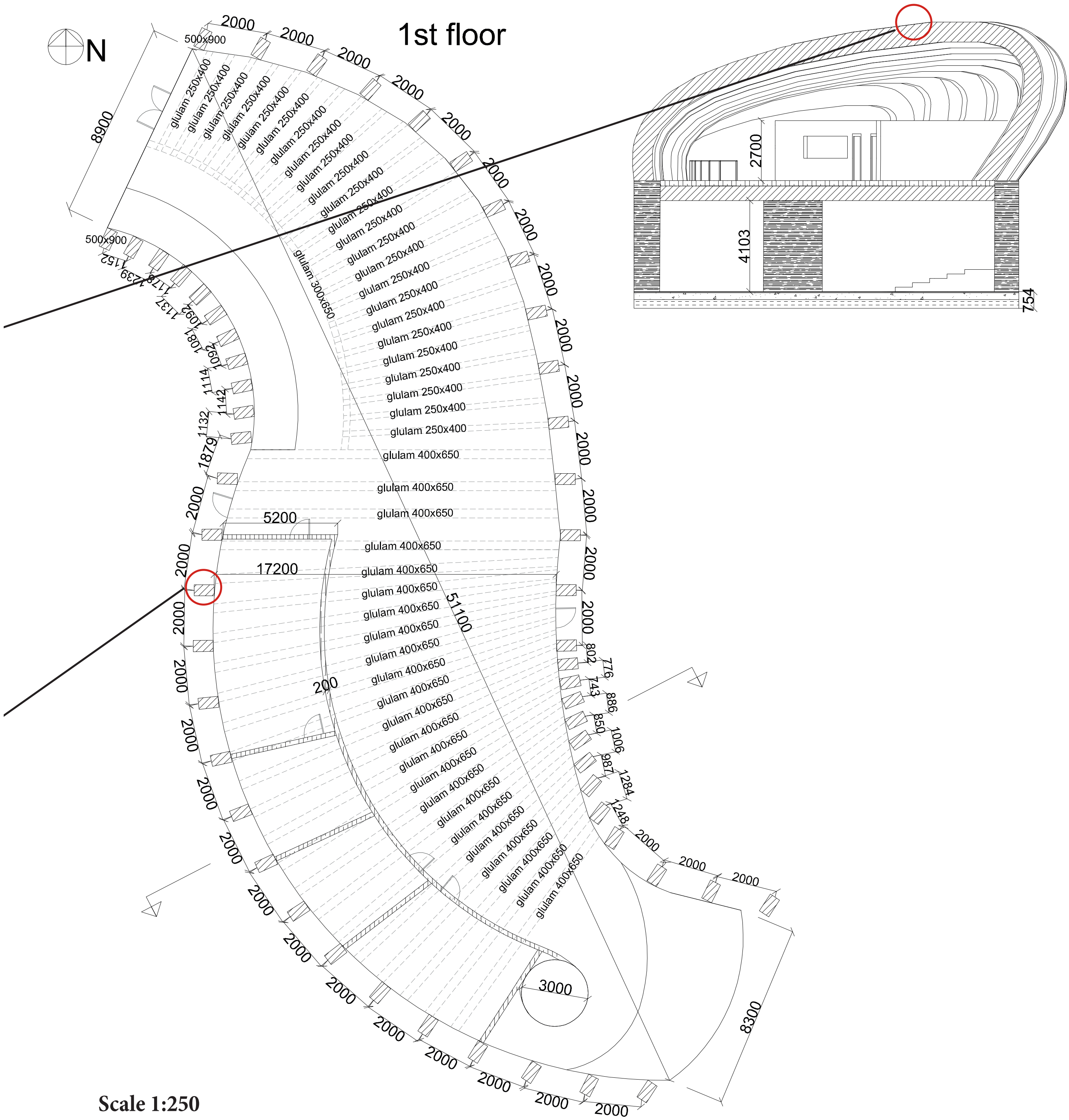


Fig.50: Technical drawings

1st floor



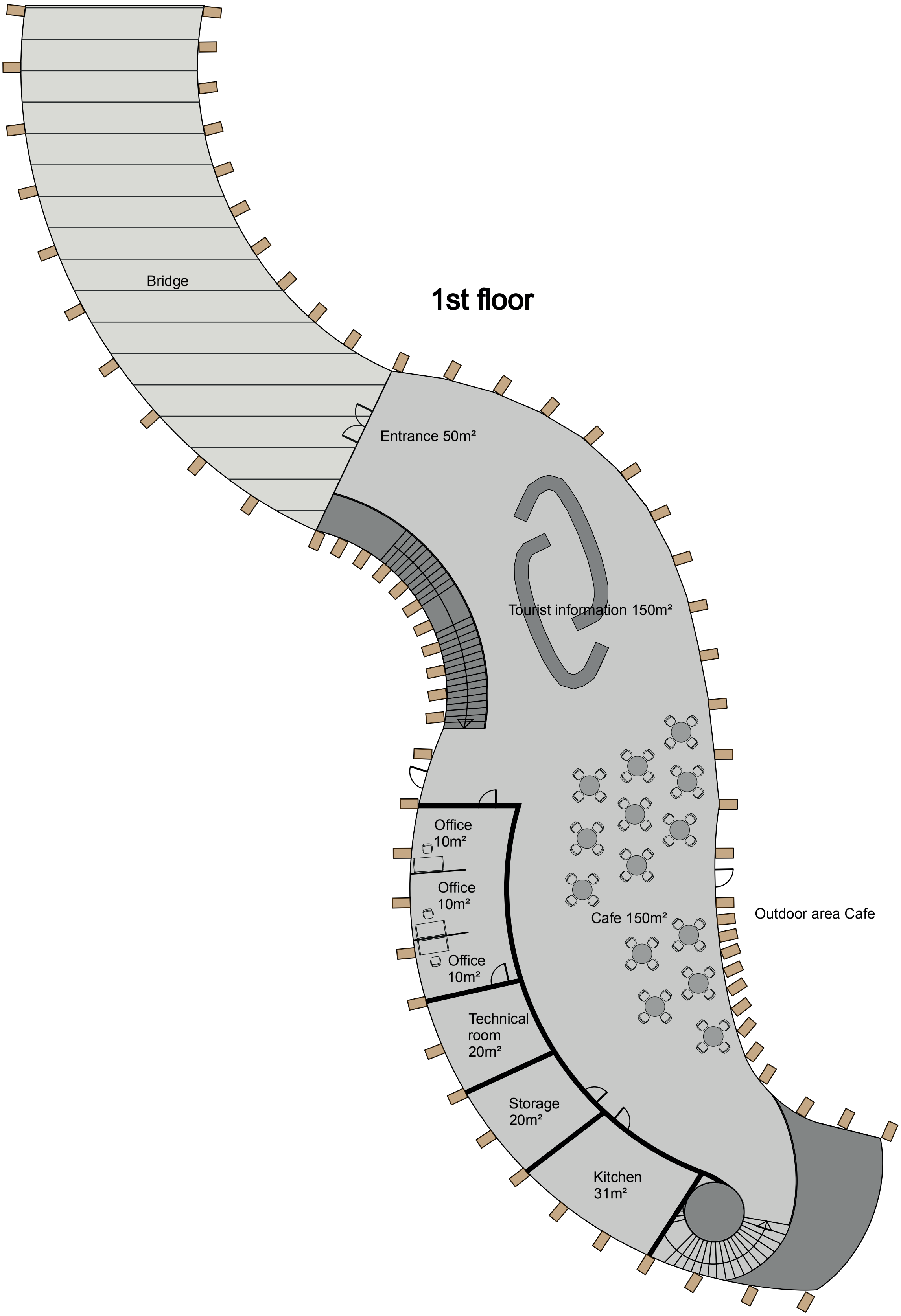
Scale 1:250

Fig.51: Building on site

INTRODUCTION

Based on the program and the design process, the information- and adventure centre has been developed. The following section is a presentation of the final result.

FLOOR PLANS


1st floor
Bridge
Entrance 50m²
Tourist information 150m²
Cafe 150m²
Outdoor area Cafe
Office 10m²
Office 10m²
Office 10m²
Technical room 20m²
Storage 20m²
Kitchen 31m²

Basement floor

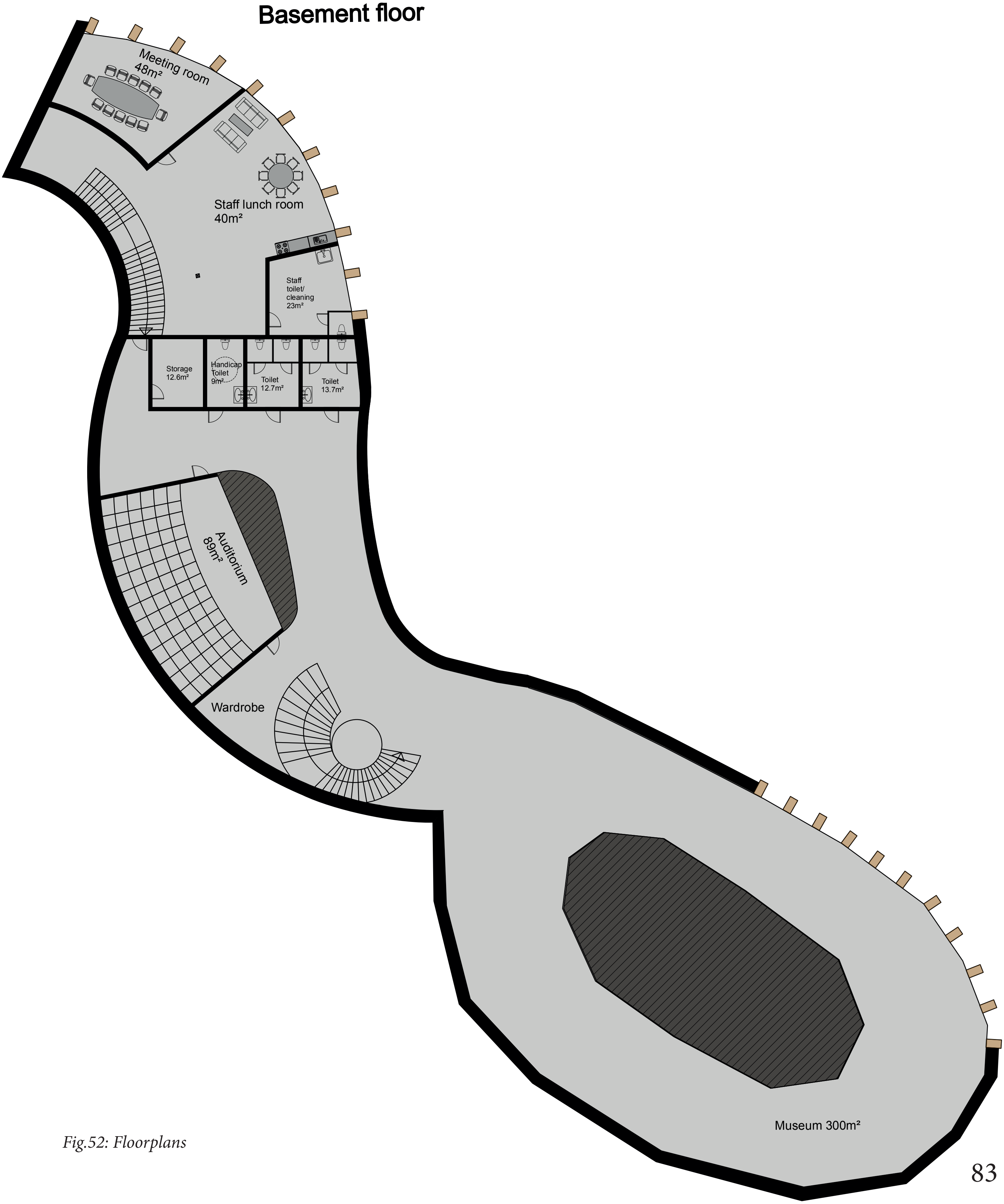


Fig.52: Floorplans

ELEVATIONS

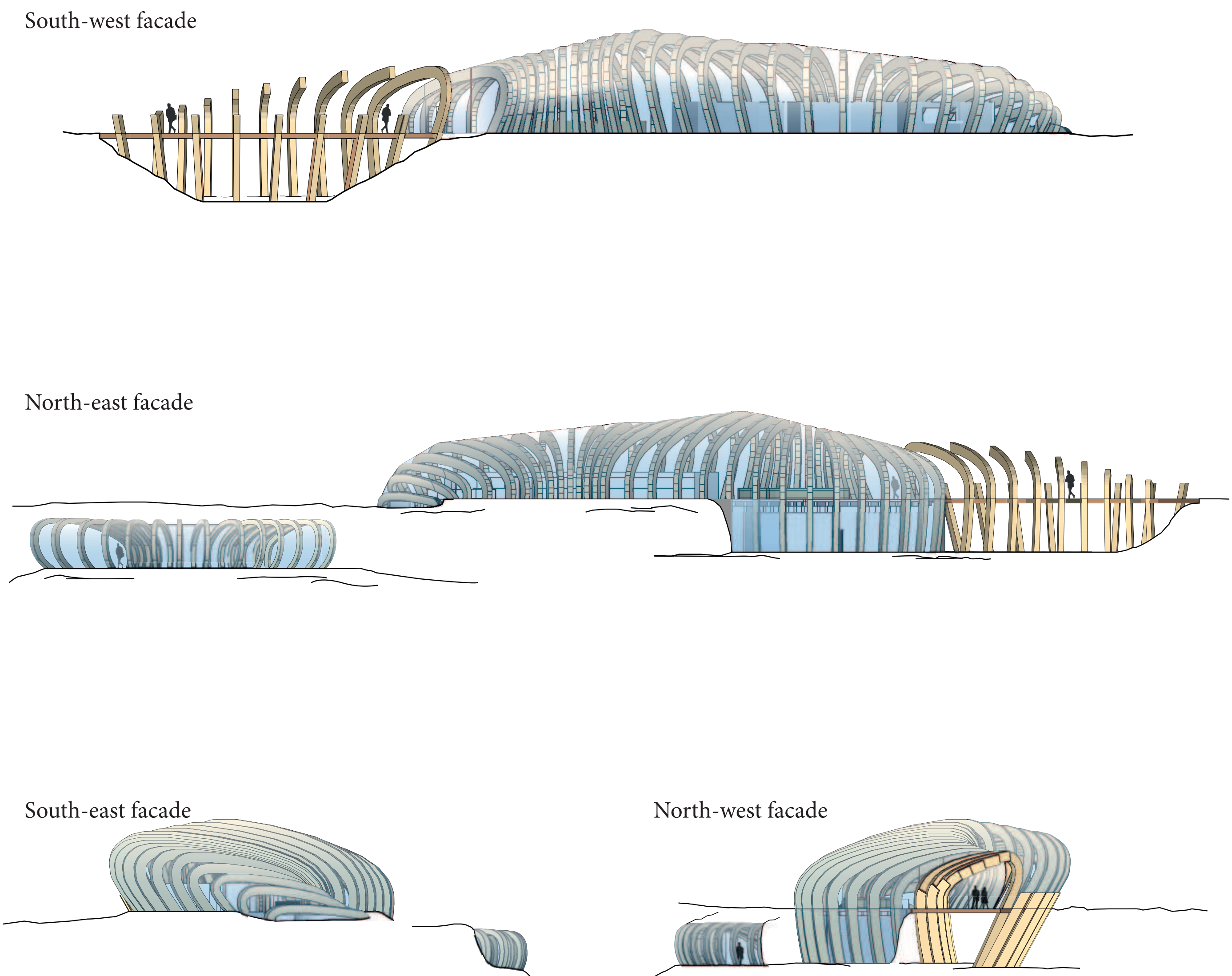
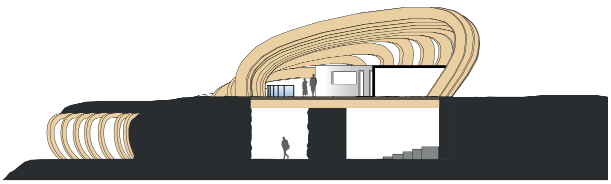
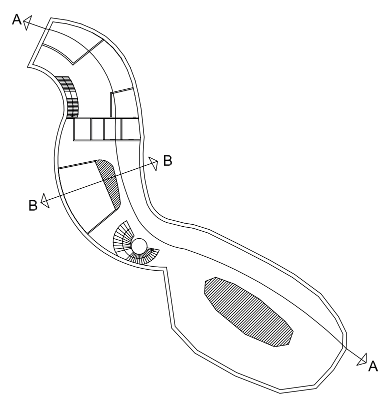


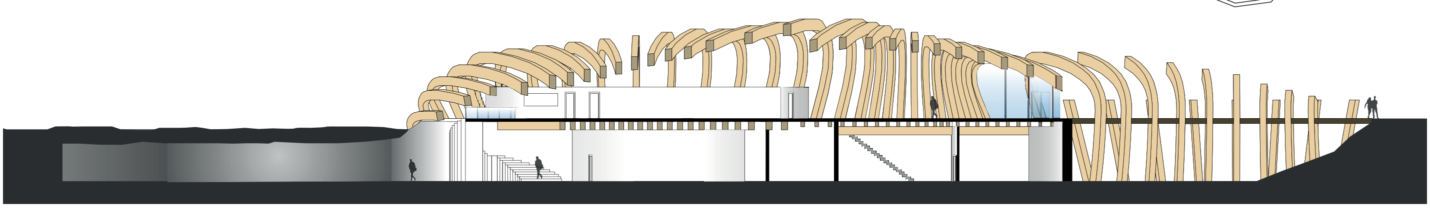
Fig.53: Elevations

SECTIONS



Section B-B from north-west, scale 1:600





Section A-A from north-east, scale 1:600

Fig.54: Sections

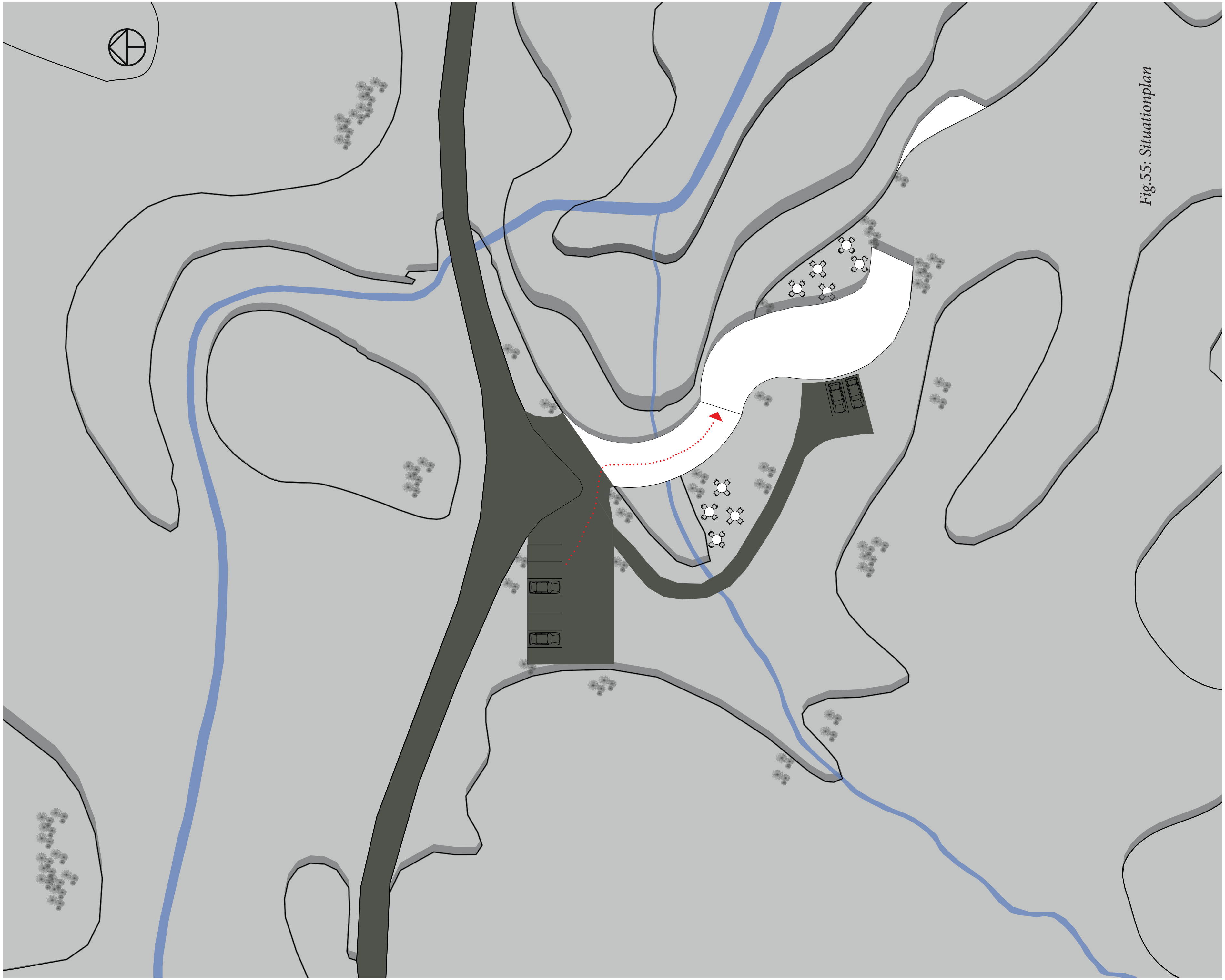


Fig.55: Situationplan

Fig.56: Building in site

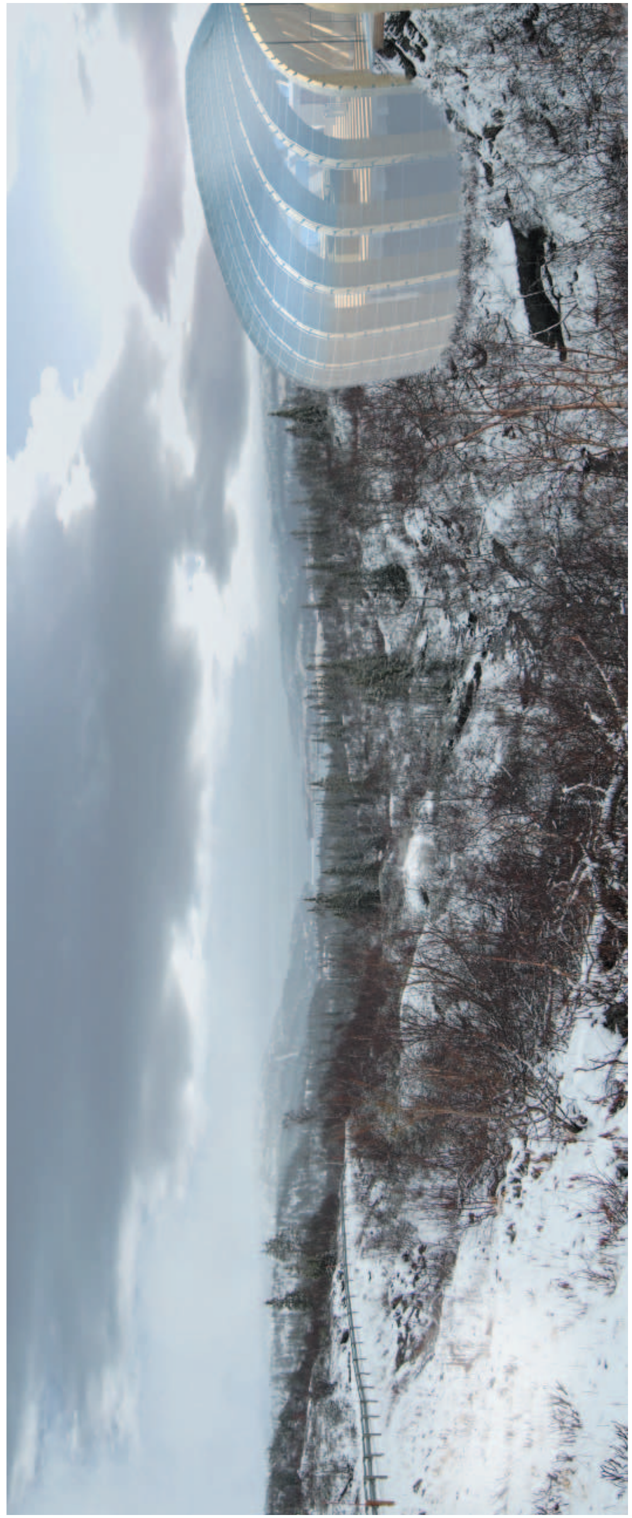
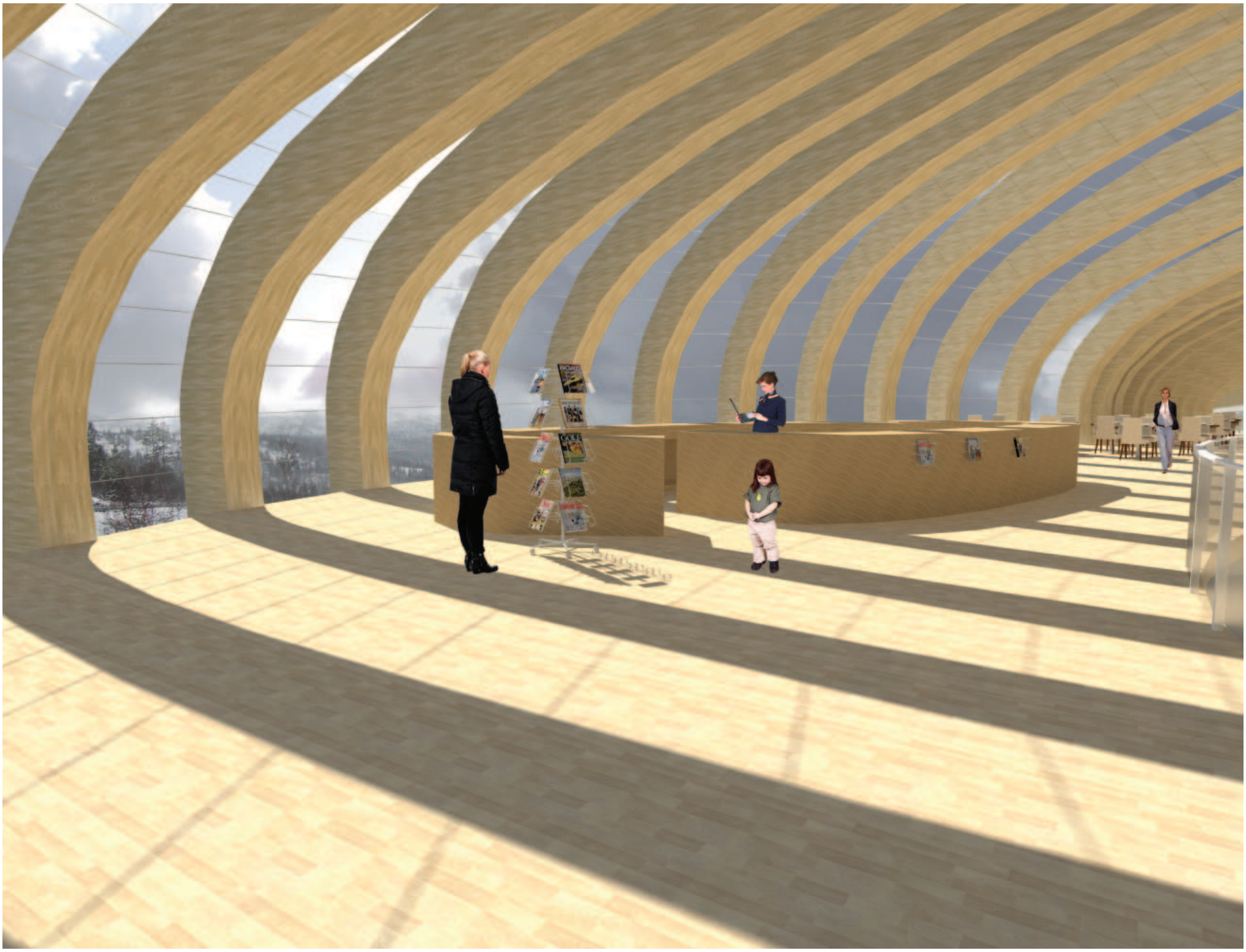


Fig.57: View from parking lot

Fig.58: View from bridge

Fig.59: View towards touristinformation



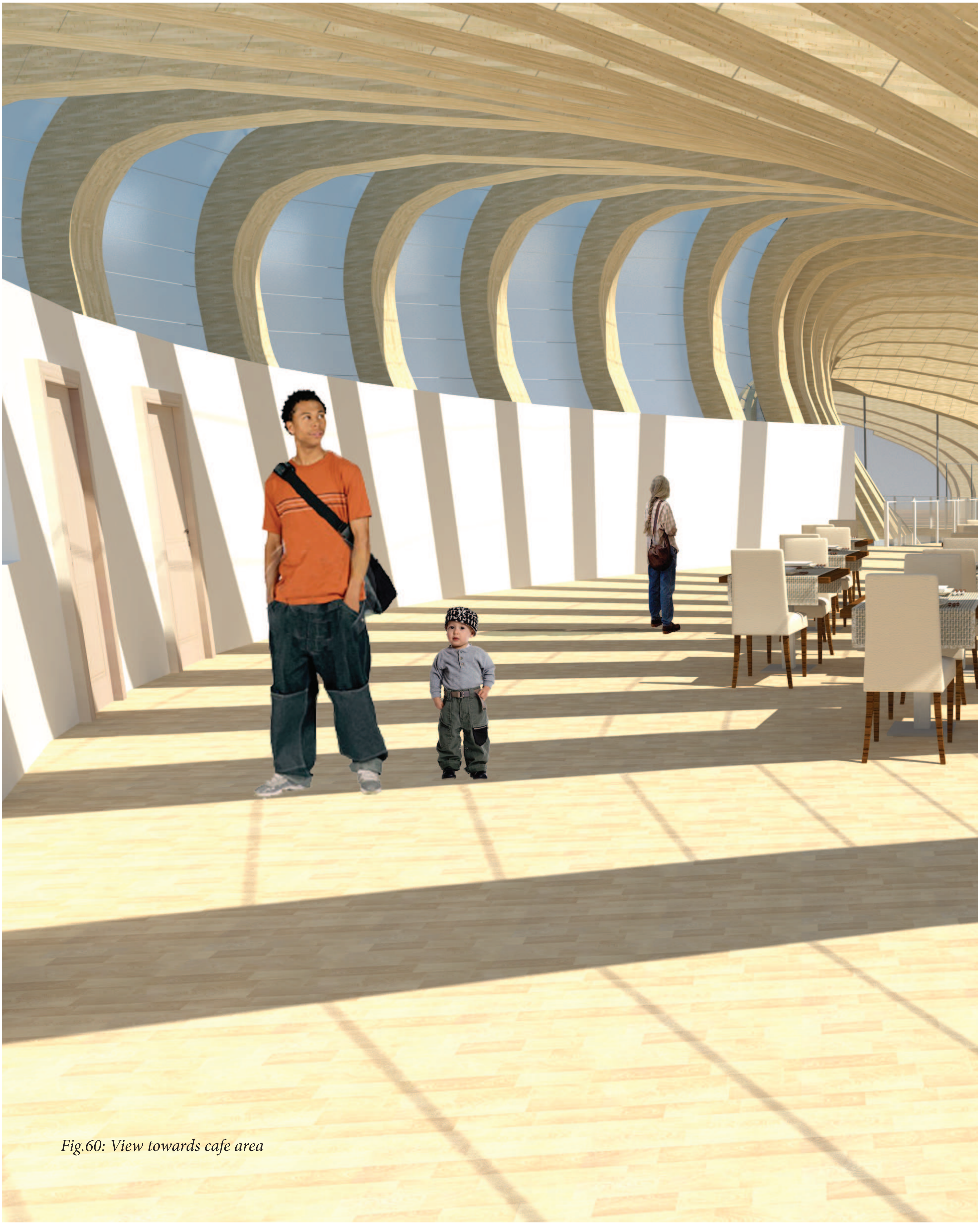


Fig.60: View towards cafe area

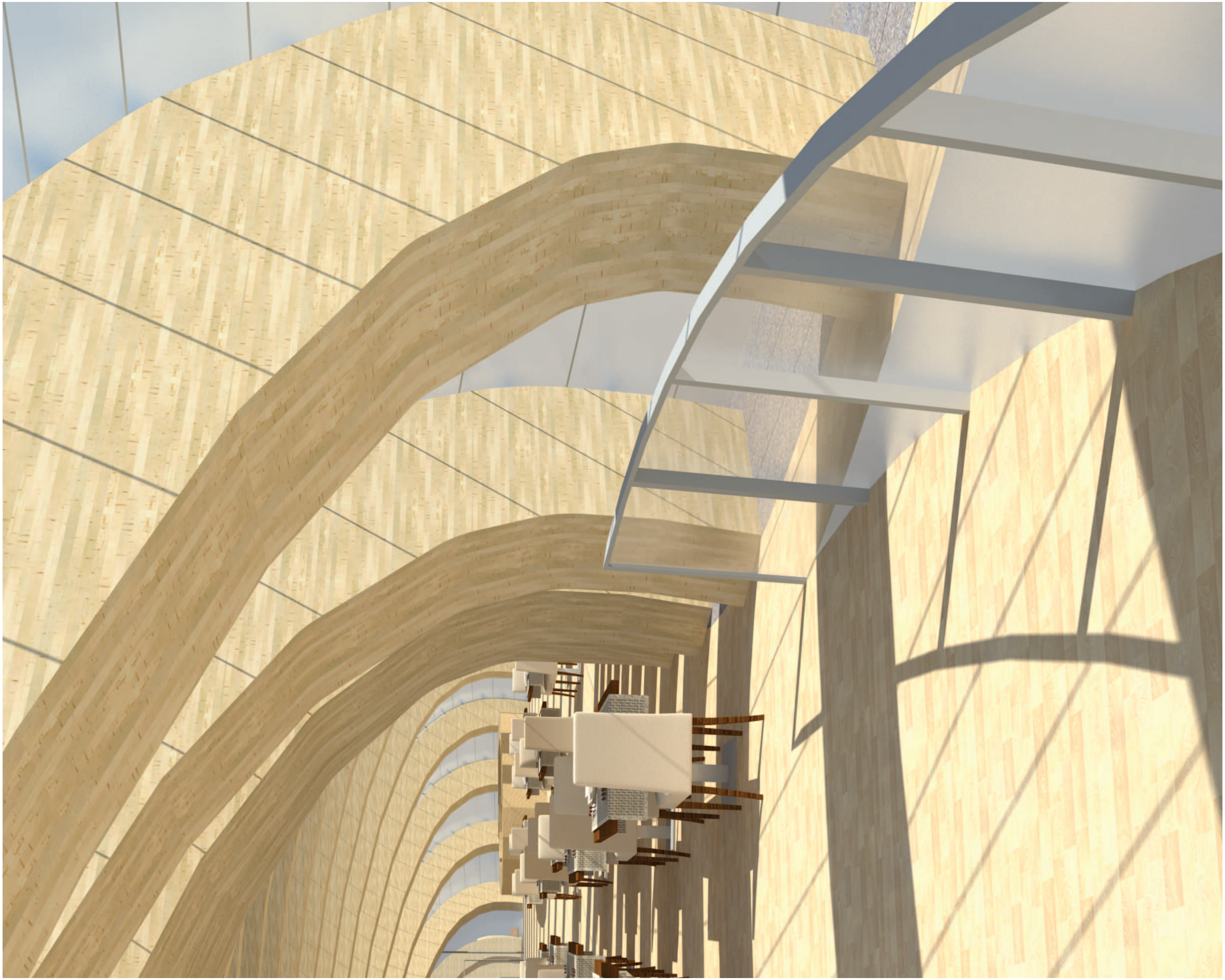


Fig.61: The museum

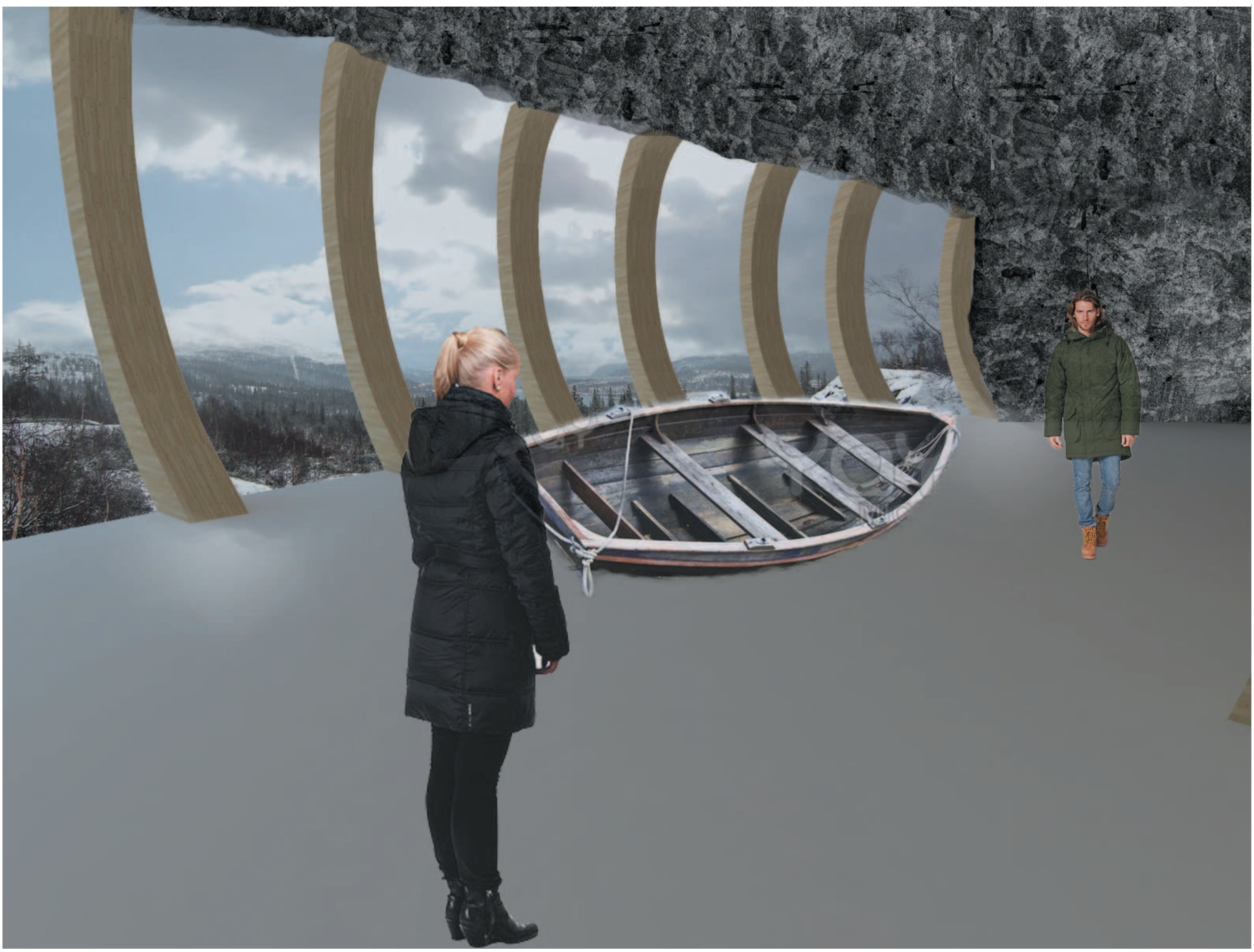
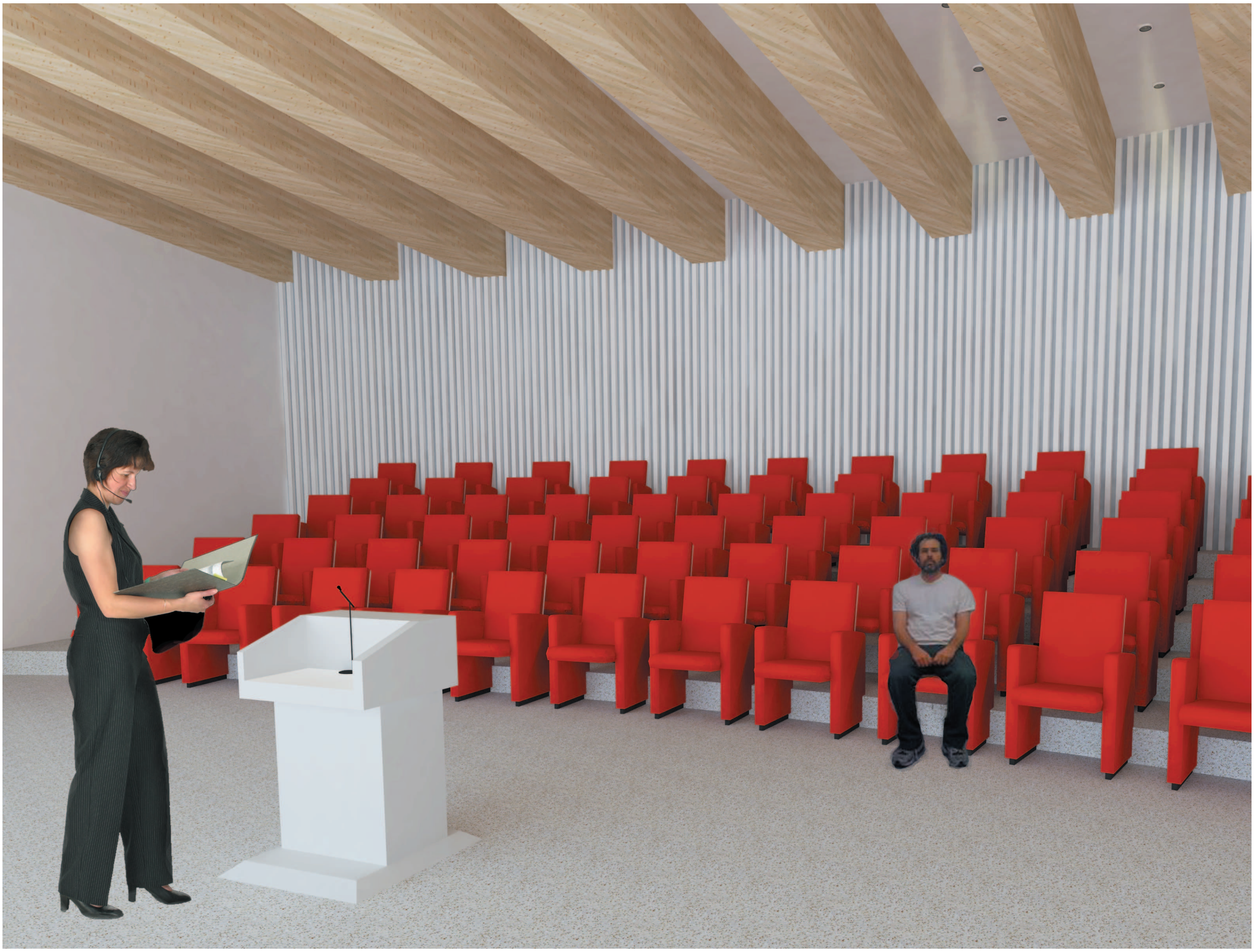


Fig.62: Auditorium



CONCLUSION

The vision for this project has been to design an information- and adventure centre up in the mountains of Norway. The building shall create interest in outdoor activities, give a feeling of nature and people should get curious of what kind of place this is when seeing the building.

Through tectonic design the information- and adventure centre has been designed with a clear and readable structure that gives the expression to the building. With only glass as facade covering, there is a transparency both visually and structurally. The readable structure continues in the floor plan that is under ground, as the support system for the floor above creates the ceiling. This support system will follow the footprint of the building, and therefor create a special pattern.

When approaching the building the visitors will be led up towards a bridge that will be the starting point for an indoor/outdoor experience. While being inside the building a relation to the nature will occur, as the transparency in the façade will give you a feeling of closeness to the nature. By this transparency all kinds of weather and seasons can be closely observed and experienced in a protected and safe environment. The information- and adventure centre should be perceived as a warm and welcoming place, when the forces of nature are taking control.

The building is in close relation to its surroundings and the nature around, as it follows the landscape and the contours. Outdoor spaces are automatically created in the way the building curves and this will create an even stronger relation to the nature.

REFLECTION

The main focus of the project has been how to create a building that will attract people into being active and how to give them a kick start in nature experiences. This is a building where you can get inspiration and information about outdoor activities, but it is not enough with only the building itself. It is a known fact that people are spending more time home in their sofa in front of the TV, then spending it outside. A change in people's mindset has to be done for a place like this to work and for people to get the best experiences while out in nature.

The idea about having the museum part as tunnels in the mountain creates several issues that has not been specified in this project. The plan was that the tunnels would be blown out from the mountain without disturbing the surface of the landscape. But by doing this, a test of the rock quality has to be done to figure out how deep the tunnels have to be, before the roof collapses. There are no such tests, so the depth was just assumed to be around 2.5 meters. Another issue is also that this would probably be a lot more expensive than just blowing out the mountain and refill the hole again afterwards.

Another issue regarding the museum part is how building under ground would affect the indoor climate and the moisture that would occur. There is a risk of water dripping from the rock structure, so a good draining system has to be considered as well.

At this point the glulam arches has been decided to have the same dimensions. It would be desirable to do calculations on every arch to see how the structural appearance would change and it could also be possible to do tests on changing the dimensions through the arch, depending on how the forces are reacting in different places.

Since the main theme for this project is tectonic, there has not been conducted any analysis of the indoor climate. Since the whole façade is glass, it has to be considered that the building could get overheated during summer and that it could have a large heat loss during winter.

SOURCES

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(www.nb.windfinder.com) http://nb.windfinder.com/windstats/windstatistic_namsskogan.htm
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(www.bks.byggforsk.no) http://bks.byggforsk.no/DocumentView.aspx?sectionId=2&documentId=2613
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Illustrations:

Fig.1-3: Own pictures
Fig.4: Cross-section from site
Fig.5: Sun studies (www.srrb.noaa)
Fig.6: Wind diagram (www.nb.windfinder.com)
Fig.7: Snow diagram (www.senorge.no)
Fig.8: Own pictures
Fig.9: Stone pictures http://www.stonetohome.com/gbu0-prodshow/green-ridge-slate-rockery-rustic.html
Fig.10: Water picture
Fig.11: Pictures of Norwegian Architecture
http://www.visittrondheim.no/turist/personer/markus-sletten/nidarosdomen/
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http://en.wikipedia.org/wiki/File:Borgund_stavkirke.JPG
Fig.12: Pictures of Tectonic Architecture
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Fig.13: Pictures of Tectonic Design
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Fig.14: Pictures of User group
http://www.visualphotos.com/image/2x4743579/young_woman_with_camera_in_poppy_field
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Fig.15: Pictures of activities in the area
Fig.16: Pictures of the wild reindeer centre pavilion
(www.snoarc.no)
Fig.17: Pictures of Svalbard research centre
(www.archdaily.com)
Fig.18: Pictures of Altamira museum
(www.en.urbarama.com)
Fig.19: Pictures of Arctic centre, Rovaniemi
(www.arktikum.fi)
Fig.20: Table showing snowload
(www.bks.byggforsk.no)
Fig.21-29: Own diagrams, illustrations and pictures
Fig.30: Pictures of the cubes
Fig.31: Inspiration pictures
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Fig.32: Phenomenological pictures
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http://29.media.tumblr.com/tumblr_lz8ql2eYSg1qdb2suo1_1280.png
Fig.33-40: Own diagrams, pictures and illustrations
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http://en.wikipedia.org/wiki/File:Macleay_stone_building.jpg
Fig.42: Own illustration

Fig.43: Material consideration
http://commons.wikimedia.org/wiki/File:Glass_and_wood.jpg
http://www.lughertexture.com/index.php?option=com_rsgallery2&page=inline&id=408&Itemid=2
Fig.44: Own illustrations
Fig.45: Woodysorber
http://www.acousticpanels.co.za/acoustic_absorbers.htm
Fig.46-48: Own illustrations
Fig.49: Glass facades
www.sunguardglass.co.uk
Fig.50: Own illustrations
Fig.50: Technical drawings
http://www.pilkington.com/europe/uk+and+ireland/english/products/bp/bybenefit/glasssystems/planar/downloads.htm
Fig.51-62: Own pictures and illustrations

CALCULATING THE ARCHES

When calculating the glulam arches the program called Autodesk Robot Structural Analysis has been used. Only the arch that is highest and has the largest span has been calculated on, and the rest of the arches have been decided to be the same.

In this calculation two things has been analysed. How the stresses are working on the structure and how much it deflects. Different centre distances between the arches were tried out and at the end it was decided that maximum 2 meters would be a proper distance.

When analysing stresses and deflection, the load cases have to be looked at in two different ways. The serviceability limit when we are talking about deflection and the ultimate limit state when we are talking about stresses. In this case the stress calculation has been simplified, as only the normal stress has been looked at. For a proper and thoroughly analysis the shear stresses should also be considered.

In this case only two load cases have been placed in the model, the load from the glass cover and the snow load. The wind load has been neglected, as the snow load would be the dimensional one for this building.

Load cases for deflection, with 2 meter centre distance:
Dead load from glass cover: 1 kN/m
Snow load: 8 kN/m² x 2m = 16 kN/m

Load cases for stresses, with 2 meter centre distance:
Dead load from glass cover: 1 kN/m
Snow load: 8 kN/m² x 2m x 1.5 = 24 kN/m

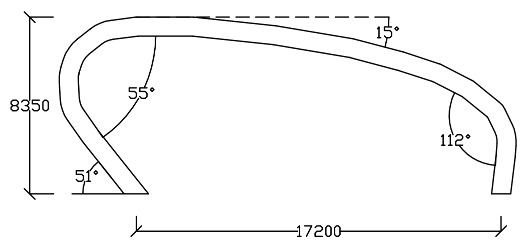
Final dimensions for the glulam arches is 500x900 mm

Tabel 7.2b Regningsmæssige styrketal i MPa for limtræ. Anvendelsesklasse 1 og 2. Normal kontrolklasse.

	GL32h					GL32c					GL28h				
	P	L	M	K	Ø	P	L	M	K	Ø	P	L	M	K	Ø
$f_{m,d}$	14,8	17,2	19,7	22,2	27,1	14,8	17,2	19,7	22,2	27,1	12,9	15,1	17,2	19,4	23,7
$f_{t,0,d}$	10,4	12,1	13,8	15,6	19,0	9,0	10,5	12,0	13,5	16,5	9,0	10,5	12,0	13,5	16,5
$f_{t,90,d}$	0,23	0,27	0,31	0,35	0,42	0,21	0,24	0,28	0,31	0,38	0,21	0,24	0,28	0,31	0,38
$f_{c,0,d}$	13,4	15,6	17,8	20,1	24,5	12,2	14,3	16,3	18,3	22,4	12,2	14,3	16,3	18,3	22,4
$f_{c,90,d}$	1,52	1,78	2,03	2,28	2,79	1,38	1,62	1,85	2,08	2,54	1,38	1,62	1,85	2,08	2,54
$f_{v,d}$	1,75	2,05	2,34	2,63	3,22	1,48	1,72	1,97	2,22	2,71	1,48	1,72	1,97	2,22	2,71

	GL28c					GL24h					GL24c				
	P	L	M	K	Ø	P	L	M	K	Ø	P	L	M	K	Ø
$f_{m,d}$	12,9	15,1	17,2	19,4	23,7	11,1	12,9	14,8	16,6	20,3	11,1	12,9	14,8	16,6	20,3
$f_{t,0,d}$	7,6	8,9	10,2	11,4	14,0	7,6	8,9	10,2	11,4	14,0	6,5	7,5	8,6	9,7	11,8
$f_{t,90,d}$	0,18	0,22	0,25	0,28	0,34	0,18	0,22	0,25	0,28	0,34	0,16	0,19	0,22	0,24	0,30
$f_{c,0,d}$	11,1	12,9	14,8	16,6	20,3	11,1	12,9	14,8	16,6	20,3	9,7	11,3	12,9	14,5	17,8
$f_{c,90,d}$	1,25	1,45	1,66	1,87	2,28	1,25	1,45	1,66	1,87	2,28	1,11	1,29	1,48	1,66	2,03
$f_{v,d}$	1,25	1,45	1,66	1,87	2,28	1,25	1,45	1,66	1,87	2,28	1,02	1,18	1,35	1,52	1,86

Strength of glulam. Table is taken from Teknisk Ståbi.



When analyzing the stresses, the strength number should not exceed this number

Displacements SLS: global extremes

	UX (mm)	UY (mm)	UZ (mm)	RX (Rad)	RY (Rad)	RZ (Rad)
MAX	0,0	0,0	0	0,0	0,003	0,0
Node	3	3	5	3	20	3
Case	1	1	1	1	1	1
MIN	-15	0,0	-28	0,0	-0,004	0,0
Node	22	3	16	3	12	3
Case	1	1	1	1	1	1

The deflection is maximum 28 mm. The accepted deflection would be up to l/200 => 86 mm

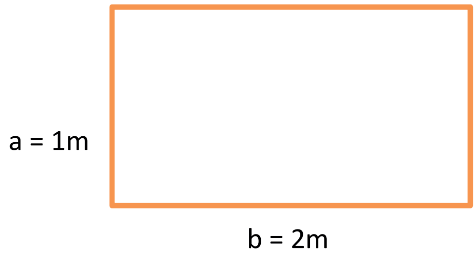
Stresses - Global extremes

	S max (MPa)	S min (MPa)	S max(My) (MPa)
MAX	20,17	0,23	19,51
Bar	21	8	21
Node	26	12	26
Case	1	1	1
MIN	0,02	-18,85	0,01
Bar	9	21	9
Node	12	26	12
Case	2	1	2

	S max(Mz) (MPa)	S min(My) (MPa)	S min(Mz) (MPa)	Fx/Ax (MPa)
MAX	0,0	-0,01	0,0	0,86
Bar	3	9	3	3
Node	3	12	3	3
Case	1	2	1	1
MIN	0,0	-19,51	0,0	0,01
Bar	3	21	3	12
Node	3	26	3	17
Case	1	1	1	2

The maximum stress is 20.17 MPa, which is under the limit of 22.2 MPa

GLASS CALCULATIONS



Max bending stress: $\sigma_e = \beta \frac{wa^2}{t^2}$

Max deflection: $\delta_e = \alpha \frac{wa^4}{Et^3}$

$\frac{b}{a} = \frac{2}{1}$ => From table => β = 0,791

α = 0,165

w = 0.08 kg/cm^2 (from the snow load)

a = free edge

t = glass thickness

E = 730 000 kg/cm^2

Load for deflection: 0.08 kg/cm^2

Load for stress: 0.08 x 1,5 = 0,12 kg/cm^2

$\sigma_e = 0.791 \text{x} \frac{0.12x100^2}{1.9^2}$ = 262.9 kg/cm^2 (Ok! Allowed with maximum 350 kg/cm^2)

$\delta_e = 0.165 \text{ x} \frac{0.08x100^4}{730\ 000x1.9^3}$ = 0.26 cm => $\frac{l}{200} = \frac{100}{200}$ = 0.5 cm is the allowed deflection, so 1.9 cm glass thickness is ok!!

(http://www.ksg.com.my/download/physical_bend.pdf)

FLOOR CALCULATIONS

How the floor is built up:

14mm parquet

22 mm chipboard

Wooden beams 36x198mm

50 mm Insulation

13 mm plasterboard

Height of floor: 14mm + 22mm + 198mm + 13mm = **247 mm**

Loads

Live load on floor: 3.0 kN/m^2

(http://www.ansatt.hig.no/leifs/Statikk/Eksamensoppgaver/2009-Mai/Vedlegg.pdf)

Out from the table in (http://bokasnettressurs.no/asset/1016/1/1016 1.pdf) you can see that the beams that carry the floor can be **36x198mm**.

Deadload parquet: 8.5Kg/m^2 = 83.39 N/m^2 = 0.08339 kN/m^2

Deadload chipboard: 300kg/m^3= 300*0.022= 6.6kg/m^3= 64.8 N/m^2 = 0.06 kN/m^2

Deadload wooden beams: 320kg/m^3= 320*0.198= 63.36kg/m^3= 621.56N/m^2= 0.62 kN/m^2

Deadload insulation: 100kg/m^3= 100*0.05= 5kg/m^3= 49.05N/m^2= 0.05 kN/m^2

Deadload plasterboard: 725kg/m^3= 725*0.013= 9.425kg/m^3= 92.46N/m^2= 0.093 kN/m^2

Sum deadload on structural floor: 0.08339 kN/m^2 + 0.06 kN/m^2 + 0.05 kN/m^2 + 0.093 kN/m^2 = 0.283 kN/m^2

(http://www.glava.no/sitefiles/1/dokumenter/ProdDok 567 1.pdf)

(http://www.smith.no/fileshare/filArkivRoot/Smith/Portalside/Lafarge/Godkjenning%20brann%20og%20lyd%20Lafarge%20GKB%20Scan41.pdf)

(http://www.betongelement.no/betongbok/BindE/Del 1/E6/E6 Varmekonduktivitet og motstand.pdf)

(http://www.proffparkett.no/3%20stav%20parkett%20eik%20natural%20mattlakk?keyword=eikeparkett&description=1)

NS 3470-1 5th edition 1999

Loads from floor:

Deadload from floor on to glulam beams: 0.08339 kN/m^2 + 0.06 kN/m^2 + 0.62 kN/m^2 + 0.05 kN/m^2 + 0.15 kN/m^2 + 0.093 kN/m^2 = **1.053 kN/m^2**

Live load on floor: **3.0 kN/m^2**

Glulam beam next to auditorium:

Length of glulam beam: 15.51 m

Length of load area: 1.1m

Deadload on glulam beam: 1.1m * 1.053kN/m^2 = 1.16 kN/m

Live load on glulam beam: 1.1 * 3.0kN/m^2 = 3.3 kN/m

After the loads are placed in Tre-Dim the dimensions will be: **400x650mm** with GL36c quality

Glulam beams in staff area:

Length of glulam beam: 8.7 m

Length of load area: 1.1m

Deadload on glulam beam: 1.1m* 1.053kN/m^2 = 1.16 kN/m

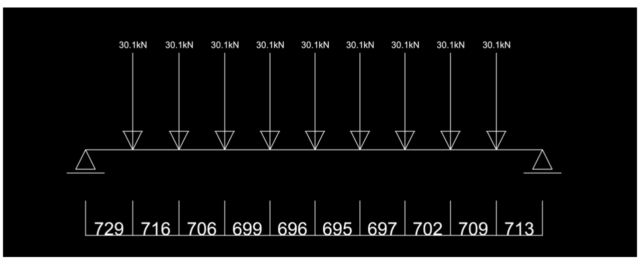
Live load on glulam beam: 1.1m * 3.0kN/m^2 = 3.3 kN/m

After the loads are placed in Tre-Dim the dimensions will be: **250x400mm** with GL36c quality

Curved Glulam beam supporting the floor in staff area:

Length of glulam beam: 7.06 m

Loads on beam:



After the loads are placed in Tre-Dim the dimensions will be: **300x650mm** with GL36c quality

Column supporting curved glulam beam in staff area:

Length of column: 4.103 m

Load on column: 140.2 kN (Maximum load from curved beam)

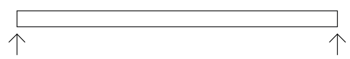
After the loads are placed in Tre-Dim the dimensions will be: **200x200mm** with GL36c quality

Floor 1st floor:

There will be a wooden floor that will be supported by glulam beams. These beams are necessary because of the large span in the building. The floor is divided into two areas, where the beams will have different dimensions. The reason for this is the desire for different room qualities, which made it impossible to have the same structure all over.

Glulam beam in floor next to auditorium

400 x 650 GL32c
L = 15,51 meter



Bjelkens : 0,0°

Nedb. 47 mm
L/329
15510

Oppleggskraft:
61,4 kN — 61,4 kN
Nødvendig oppleggs-lengde:
68 mm — 68 mm

SNITTKREFTER:	KAPASITET.	OPPTREDENDE.	UTNYTTELSE.
Moment :	470,3 kNm	238,0 kNm	50,6 %
Skjærkraft :	193,9 kN	61,4 kN	31,7 %

BEREGNINGSREGLER:
NS-EN 1995 - NS-EN 1993 - NS-EN 1990 - NS-EN 1194 - NS-EN 338

TRE-DIM Versjon 10.0 BJELKE
TRE-KONSTRUKSJONS DIMENSJONERING

- er programmert av ingeniør Ingvar Skarvang

Materialfaktor: 1,15
Pålitlighetsklasse: 2
Lastvarighetsklasse: Korttidslast
Klimaklasse: 1
Kategori: B

JEVNT FORDELT LAST PÅ DRAGER:
NYTTELAST : 3,300 kN/m
EGENLAST : 2,470 kN/m
BRUDDLAST : 7,914 kN/m

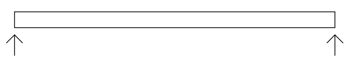
TRE-DIM BJELKEBEREGNING
Dato : 08.05.2012 Tid: 22:28:06

glulam beam in floor next to auditorium without support

Registrert bruker :

Glulam beam in floor in staff area

250 x 400 GL36c
L = 8,70 meter



Bjelkens : 0,0°

Nedb. 25 mm
L/350
8700

Oppleggskraft:
30,1 kN — 30,1 kN
Nødvendig oppleggs-lengde:
40 mm — 40 mm

SNITTKREFTER:	KAPASITET.	OPPTREDENDE.	UTNYTTELSE.
Moment :	130,4 kNm	65,6 kNm	50,3 %
Skjærkraft :	88,6 kN	30,1 kN	34,0 %

BEREGNINGSREGLER:
NS-EN 1995 - NS-EN 1993 - NS-EN 1990 - NS-EN 1194 - NS-EN 338

TRE-DIM Versjon 10.0 BJELKE
TRE-KONSTRUKSJONS DIMENSJONERING

- er programmert av ingeniør Ingvar Skarvang

Materialfaktor: 1,15
Pålitlighetsklasse: 2
Lastvarighetsklasse: Permanent last
Klimaklasse: 1
Kategori: B

JEVNT FORDELT LAST PÅ DRAGER:
NYTTELAST : 3,300 kN/m
EGENLAST : 1,650 kN/m
BRUDDLAST : 6,930 kN/m

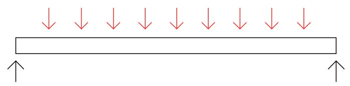
TRE-DIM BJELKEBEREGNING
Dato : 09.05.2012 Tid: 19:36:03

Glulam beam in floor in staff area

Registrert bruker :

Curved glulam beam supporting floor in staff area

300 x 650 GL32c
L = 7,06 meter



Bjelkens : 0,0°

Nedb. 9 mm
L/769

7060

Oppleggskraft:
139,1 kN 140,2 kN
Nødvendig oppleggs-lengde:
266 mm 268 mm

SNITTKREFTER:	KAPASITET.	OPPTREDENDE.	UTNYTTELSE.
Moment :	352,7 kNm	274,7 kNm	77,9 %
Skjærkraft :	145,4 kN	140,2 kN	96,4 %

BEREGNINGSREGLER:
NS-EN 1995 - NS-EN 1993 - NS-EN 1990 - NS-EN 1194 - NS-EN 338

TRE-DIM Versjon 10.0 BJELKE
TRE-KONSTRUKSJONS DIMENSJONERING

- er programmert av ingeniør Ingvar Skarvang

Materialfaktor: 1,15
Pålitlighetsklasse: 2
Lastvarighetsklasse: Permanent last
Klimaklasse: 1
Kategori: B

JEVNT FORDELT LAST PÅ DRAGER:

NYTTELAST : 0,000 kN/m
EGENLAST : 0,990 kN/m
BRUDDLAST : 1,188 kN/m

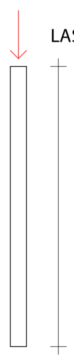
PKT.LASTER:

30,100 kN 0,729 meter fra A
30,100 kN 1,445 meter fra A
30,100 kN 2,151 meter fra A
30,100 kN 2,850 meter fra A
30,100 kN 3,546 meter fra A
30,100 kN 4,241 meter fra A
30,100 kN 4,938 meter fra A
30,100 kN 5,640 meter fra A
30,100 kN 6,349 meter fra A

TRE-DIM BJELKEBEREGNING Dato : 09.05.2012 Tid: 20:05:13
Curved glulam beam in staffarea
Registrert bruker :

Column supporting curved beam in staff area

LAST: 140,20 kN (Bruddlast)



TYPE SØYLE: GL36c 200 x 200

KNEKKLENGDE = 4,103 m om Y-akse: 200 mm
KNEKKLENGDE = 4,103 m om Z-akse: 200 mm

Utnyttet kapasitet : 34,61 % OK

Søyletrykk mot tre, utnyttet: 100,0 %
OK med søylens endeflate.

BEREGNINGSREGLER:
NS-EN 1995 - NS-EN 1993 - NS-EN 1990 - NS-EN 1194 - NS-EN 338

TRE-DIM Versjon 10.0 SØYLE
TRE-KONSTRUKSJONS DIMENSJONERING

- er programmert av ingeniør Ingvar Skarvang

Materialfaktor: 1,15
Pålitlighetsklasse: 2
Lastvarighetsklasse: Permanent last
Klimaklasse: 1
Kategori: B

TRE-DIM SØYLEBEREGNING Dato : 09.05.2012 Tid: 20:37:23
column supporting curved glulam beam in staff area
Registrert bruker :

ACOUSTIC ANALYSIS

Materials	125 Hz	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Wood	0.15	0.11	0.10	0.07	0.06	0.07
Painted concrete	0.10	0.05	0.06	0.07	0.09	0.08
Woody sober	0.62	0.82	0.78	0.81	0.54	0.49

Table .. :The material properties used for the ecotect analysis

The woodysorber is a wooden panel used to apply for ceilings and walls for a full acoustic coverage. It absorbs unidirectional and is very good in the medium range of sound spectrum. The panels can be mounted as joint-free continuous surfaces and can be manufactured in any size. (http://www.acousticpanels.co.za/acoustic_absorbers.htm)

Front-, ceiling and side walls:	Wood
Back wall:	Woodysorber
Floor:	Painted concrete
Seating:	Upholstered

The design of the woodysorber

These results show that the room should have good reverberation time both when it is occupied and when it is empty. The important frequency area to look at is between 300 and 3000 Hz, as these are the most significant frequencies for voice.

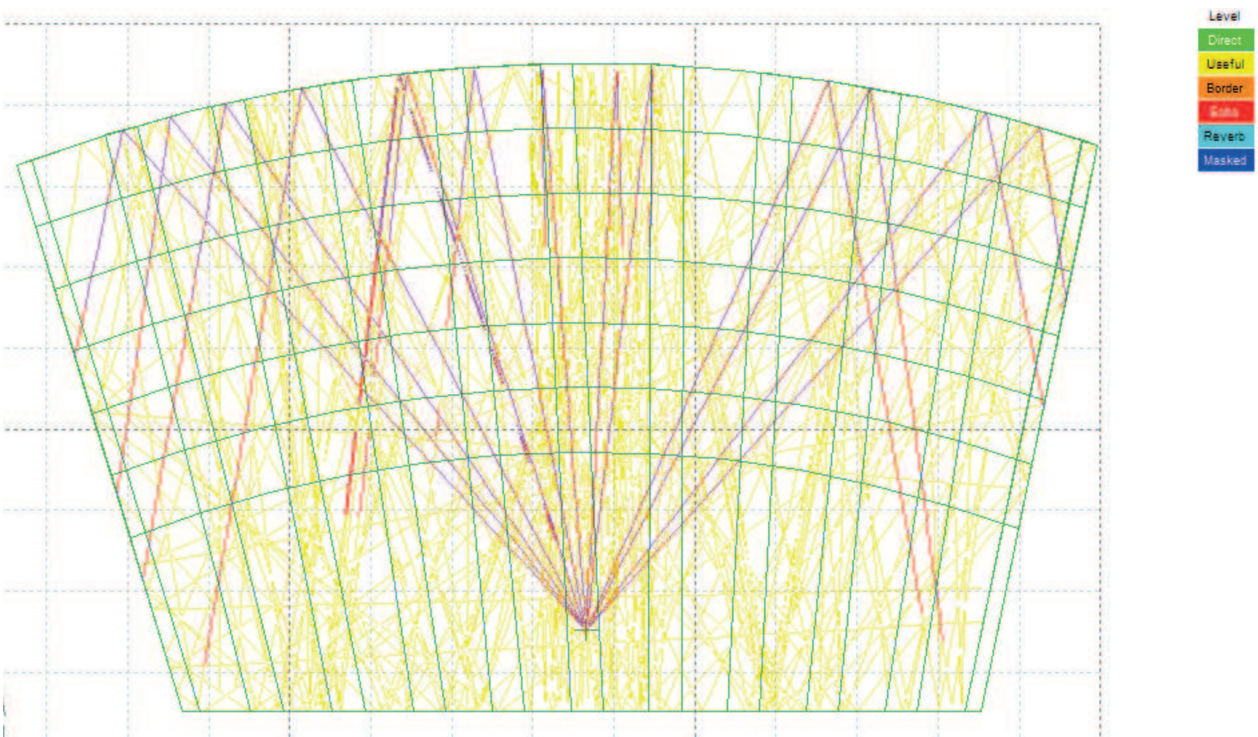


Table .. :Acoustic rays spreading in the room

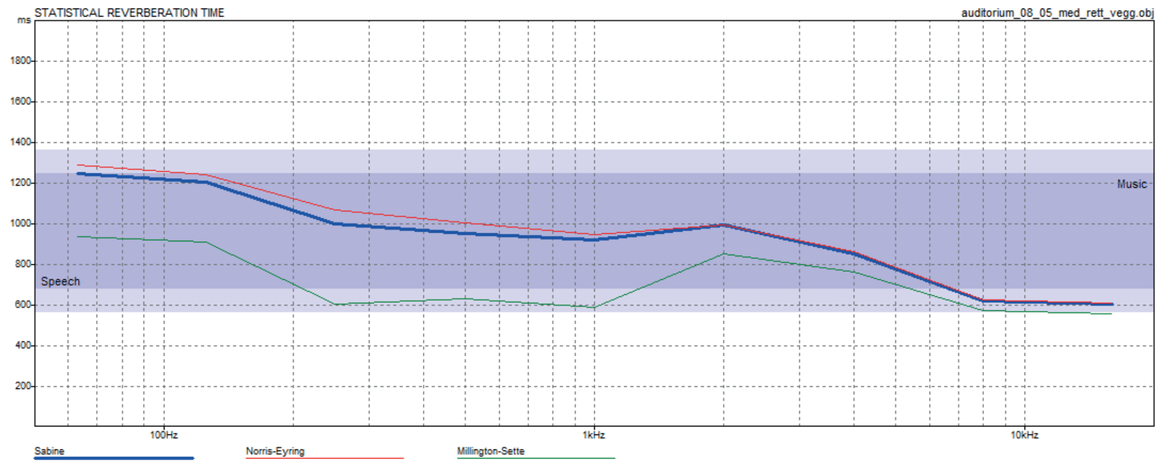


Table .. :Statistical reverberation time of final room, 0 % occupied

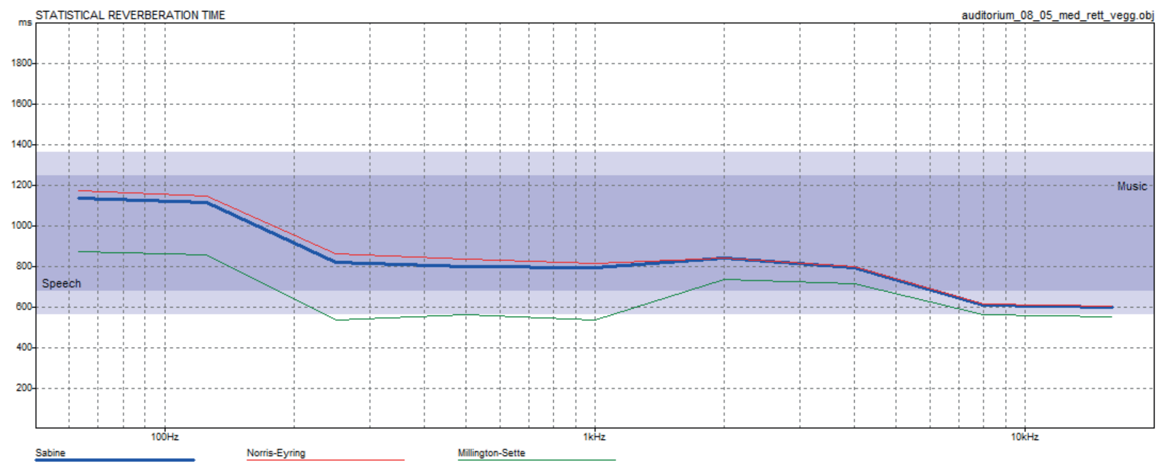


Table .. :Statistical reverberation time of final room, 100 % occupied

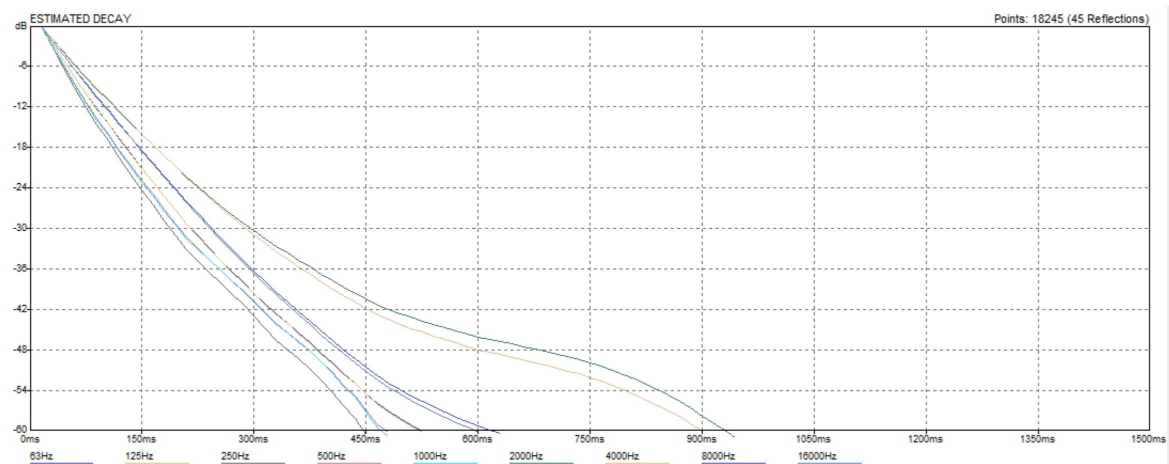


Table .. :Estimated decay of the auditorium. Around 600ms is optimum for speech(500 Hz)