TUNGTVANN

TITLEPAGE

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SYNOPSIS

The thesis aims to design a museum for exhibiting the acts considered as the Heavy Water Actions, in Norway, during the Second World War.

The program for the museum is created loosely on the competition brief for the Danish "Frihedsmuseet" which has been a closed competition running in the spring of 2015 for a new museum for the Danish resistance movement.

From here, I have created a building programme, which better fits the needs and complications met when building in the situational context of the site in Telemark.

The location of the museum will be on the mountainous coast of the Tinnsjø, where it will utilize the advantages of the terrain as much as possible to create an intriguing experience for the users.

For the users to be able to get in depth with the story the exhibition will follow a chronological telling of the missions undertaken; the story will be broken up in descriptive parts, each representing a part of the exhibition. To further enhance the immersion into the telling, by the users, the exhibition of the different parts of the story will be accompanied by settings, creating an atmosphere close to the experience of the original participants.

The main focus of setting the atmosphere of the exhibition rooms will be working with the accessible daylight. Through experimentations, digital and in models, each part of the exhibition will be shaped to provide the conditions for the desired experience of the exhibitions as stated within the room programme designed and written for the museum on this site.

Besides having to control the alteration of the daylight, the structural part of the museum must also be proven to keep its structural integrity under the loads and forces affecting the constructions. These will be studied and determined to create the basis on which the design of the lighting is created.

By combining the understanding of structural integrity with knowledge of the light design, the goal is to improve not only the construction of the buildings but also the experience of the room aesthetics.

For this project, the main concerns within the integration of these parameters into the design process are to be found in the museum's location on a mountain. To solve the designs accordingly, they must conform to the site where direct sunlight must be prevented in the exhibitions while still using the natural light to create atmospheres that portray those experiences the guests are to receive within the exhibitions. Complicating this is the mountain's own shadowing of the site that prevents daylight.

The hillside of the mountain also prevents a flat layout, for ease of movement, of the museum without digging into the mountain. This will change the parameters of the loads acting upon the construction, which again may have an impact on the how the rooms are perceived.

CONTENTS

INTRODUCTION

This year, many northern European countries can celebrate their 70th jubilee for the freeing from the German occupying forces during World War 2. This also includes Norway and Denmark, which were liberated in the beginning of May. Both countries had effective underground sabotage units fighting to prevent the Germans from fulfilling their plans in the Nordic countries. In Denmark the "Frihedsmuseet", celebrating the men and women who fought for the country during these times, is to be rebuild after a devastating fire that ruined the building. This is done through an architectural competition, which is expecting the building to be completed by November 2018.

Within the last decade, more interest has been seen in the depiction of the national heroes of the time with big movies such as the Danish "Flammen og Citronen", "Hvidsten Gruppen" and the Norwegian "Max Manus". In Norway, a TV-series, depicting the actions of a group from the Norwegian resistance movement, sabotaging the German production of heavy water, has been aired with a popular following. These attacks have been named the "Heavy water actions".

For now, the commemoration of these events happens as part of the exhibition of the Norwegian Industrial Worker Museum, situated near Vemork, as this was the place for parts of the sabotage missions and a sign at the road close to where the sinking of the ferry DF Hydro happened.

As inspiration for the criteria to a museum that can exhibit and tell the story of these actions, the underlying basis has been the competition brief for the "Frihedsmuseet" but having changed it to fit with the requirements of the storytelling and environment of its Norwegian counterpart. Located within the area of the Heavy Water Actions, bordering Lake Tinnsjø, a proposition for a new Norwegian equivalent of the Danish Frihedsmuseet is designed. The intent of the museum is to allow visitors to be educated on the actions undertaken by the resistance movement and reflect over the decisions taken by the individuals in order to risk their lives for the greater good of the country.

The concept of the museum creates a good framework to work with a tectonic approach to the architecture, merging several technical aspects with the aesthetical properties to open up for a discussion on how to create rooms that can highlight the sensations brought forth during these missions.

By utilizing daylight as a main source of light for the mood, setting ambient light of the exhibition rooms, care must be taken to ensure the concepts and properties of the lights transcends through and are enhanced by the more structural elements of the construction. So that one neither overshadows the other, nor ignores its place within the importance of the synergy of the two main parts that make up the architecture.

MOTIVATION

The concept of designing a new museum to commemorate the Norwegian heavy water actions was partially decided by my interest in the possibility to convey a telling using the architecture. I have chosen to work within a Norwegian context as I find it interesting to see how the context of the building helps support the final form from the chosen location. This relies on an understanding of the placement in the terrain, and how this affects the possibilities of movement and connection within the building.

Light is an important factoring within any architecture in the way it affects the room helps define the space and the experience within. Therefore, it has been an important part of the design to incorporate an appropriate expression of the light to the design. By paying attention to how the light enters the room and reflects around the room towards the visitor, it is possible to mood the light according to preferences, hereby changing the overall atmosphere for a more enhanced experience.

I find the importance of a proper, well-lit room appealing as a central point of the project, for the many aspects of the quality of the experience of the room and the consequences needed to be encountered through the design solution to achieve the desired goal.

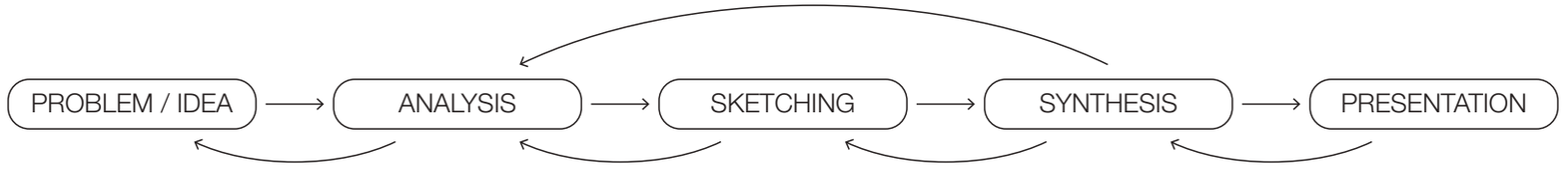
By applying different approaches to how the daylight enters and appears within the rooms of the museum, my goal for the experience of the architecture has been to set the atmosphere appropriately for the specific story told in each different exhibition of the museum.

METHODOLOGY

The project will be undertaken through the process of Problem Based Learning that is taught, in which basic problems for the project is defined and sought to be solved through the process to complete the project with the best possible result. When incorporating several highly regarded aspects into the design process, such as both the many vectors given by the location and specific settings for the desired effects of the daylight, a singular or linear process often cannot cope. Instead a non-linear process wherein shifting between different stages of the design process helps clarify or define the problems regarding the project, so these can be solved all together within the final design.

The method in which these problems are to be solved, invokes the Integrated Design Process as coined by Mary-Ann Knudstrup. The concept seeks to combine the different skill sets developed within both architecture and engineering to solve these complex problems. (Knudstrup, 2004)

For both the analysis and the sketching phase, many different tool sets will be used for the understanding and developing the project. This includes not only mappings and calculations, but also computational tool sets will be used for further and finer exploration from sun exposure to constructional principles.



Ill. 1 Integrated Design Process

BRIEF

To define the needs of the museum, the competition brief of the Danish "Frihedsmuseet" has been the inspiration to the equivalent requirements for a similar museum put into the Norwegian context. The close relationship between the two uses makes the program proposed ideal for defining the intentions of the museum and concepts of how this can be obtained. Both buildings will serve the purpose of engaging people in a chronological description of the history and foster understanding and reflection for the decisions of the involved parties, taking the visitors through the important aspects of the missions.

The line crossing choices of these people will be the main story for the museum which vision includes the possibility to exhibit authentic objects, allow for en emerging experience that encourages returns and letting the voices of the past be heard. To protect the possible delicate objects, the rooms of the exhibit must be shielded from direct sunlight as to prevent further decay of light sensible objects.

The museum will act as a depiction of the events and follow the group of Norwegians through their years of hiding and attacking the occupying forces in order to prevent the success of the production of heavy water from the plant of Vemork. To emerge the visitors as much as possible, the senses must also be evoked through the museum. Creating an atmosphere that caters the desired expression of each exhibition room will therefore be part of the task for the building.

Besides describing the goals for the museum, the Danish competition brief cannot be directly transferred to a related museum in Norway as the vicinity of the sites of the museums are nothing alike. Also the exhibitions differs widely where the Danish ventures through the full service during the war as to the proposed museum only depicting the heavy water missions, which took place over a period of about a year and a half. Therefore, will many of the requirements, although inspired by the given competition brief, be altered to fit the current placement and estimated use.

Just as the competition brief states, the museum is expected to be run by as little personnel as possible; this requires that the staffed stations within the museum should be set up so to minimize the workforce needed. This may require the position of different posts close by each other, so that they can be run by the same staff member.

HISTORY

To employ a narrating story through the museum, the exhibitions must build upon each other to describe the events. This is better done through a chronological walkthrough of the history, which invites the visitor to follow the men who risked their lives through the missions that make up the heavy water actions.

In order to divide the museum into smaller, fittingly exhibitions, we have to look at the different events that make up the heavy water actions. This gives an understanding of the different approaches to the mission and how these prompted other events to take place.

Grouse
After deciding to intervene with the German plans of producing heavy water at the Vemork plant, a small group of Norwegians, trained by the British army, was sent to the fells surrounding Rjukan in October 1942, to find a spot for the later landing of the soldiers to perform the attack.

Freshman
In November the same year, the mission as it was planned began. Several planes with British troops took off from Scotland and flew towards the landing spot as given by the Grouse group. Unfortunately, the area could not be found and all but one of the planes crashed. The soldiers that did not die in the crashes themselves, where caught and later executed by the Germans.

In all 41 people died during the Freshman operation.

Gunnerside
Because of the tragic events of Freshman, it was decided to send an extra group of battle trained Norwegians to aid the Grouse group. The Gunnerside group joined up with Grouse in February 1943.

Sabotage
Shortly after the two groups had met up and joined, they were able to sneak into the Vemork plant unnoticed and plant explosives that destroyed the heavy water production facilities.

After the successful mission, the group parted and some members fled to Sweden while a few stayed behind, living on the fell of what little food they could scavenge for an extra year.

Unfortunately the Germans were quick to have new equipment brought in and increased production.

Ill. 2 Images depict the Vemork Plant, the bombing of Vemork and Rjukan and the Sinking of DF Hydro

Bombing
After the British learned about the increased production of heavy water, it was decided to bomb the plant in November, the same year. Of the more than 700 bombs dropped on Vemork and Rjukan, only 18 hit the plant and one was unfortunate enough to hit a civilian bunker, killing 22 residents of Rjukan.

Halting the production
After the bombing, it was decided to move further production to Germany. Therefore, all produced heavy water from Vemork was to be transported to Germany as well.

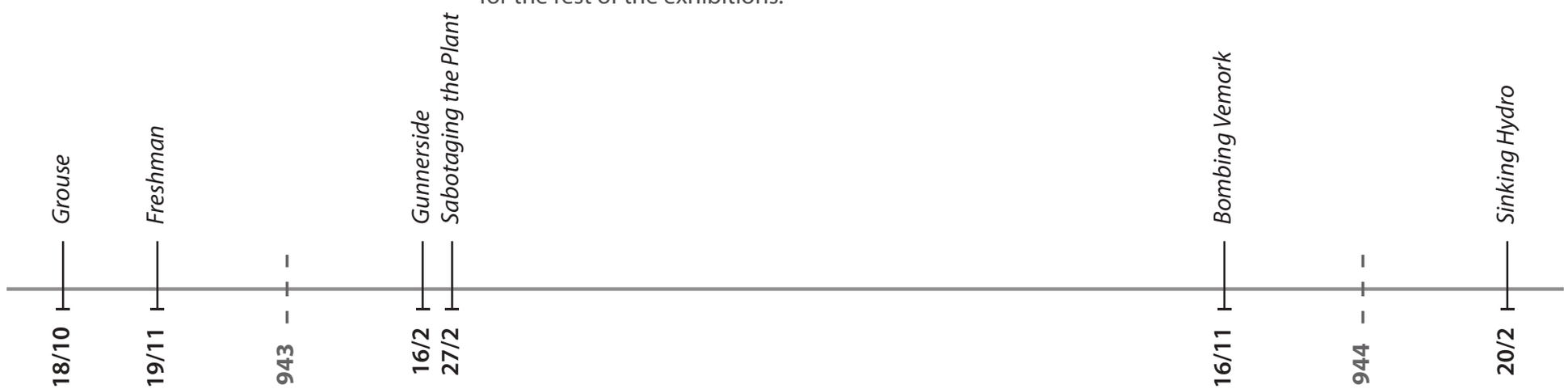
Sinking of the DF Hydro
In February 1944, the transportation of the heavy water began. However, before the trains containing the heavy water reached the ferry to bring it down over Tinnsjø, the remaining members of Grouse managed to sneak on board the ferry and place timed explosives that went off when the ferry reached the deepest part of its route. Unfortunately not all aboard the ferry where saved and in all 18 people drowned in the sinking of the ferry.(Visit Vemork, 2015)

The missions are to be divided into accounts that can be described and exhibited.

By accounting for all the attempts at landing in one exhibition, several dates can be combined although the period stretches over several months. The different escapes from the area are also compiled into one telling just as the survival of the fell presented over several periods can be told as one separate story.

Therefore, the museum is to consist of the following exhibitions as listed:

Introduction
An introduction to the heavy water missions and what their implications have been. This exhibition will include items and imagery to explain the situation leading up the heavy water actions and the consequences of what has been called “the most successful act of sabotage in all of World War II”. (Foot, 1985) After visiting the introduction, the guests of the museum should have gathered a basic understanding to be ready for the rest of the exhibitions.



Ill. 3 Timeline of the historical events. Background images depict the Vemork Plant, the bombing of Vemork and Rjukan and the Sinking of DF Hydro

As some objects in the exhibition may be light sensitive, as well as to keep the room of the exhibition available for video screening onto the walls, the room of the exhibition is to kept relatively dark and shaded from exposure to daylight. Artificial light can be used to accentuate certain objects of the collection.

Landing
The description of the landings of the three mission groups embeds the visitor into storyline. The inventory of the exhibition includes a full size parachute canopy deployed above the exhibition, breaking and spreading the light from a light high above, illuminating the room. By imposing parachuters onto the walls, a feeling of being amidst of the action is to be obtained.

Imagery and texts on the walls recollects the faith of the different missions' landings while other memorabilia regarding the landings may be included in the exhibition.

Sabotage
The depiction of the sabotage attack on the Vemork plant takes the guests into the attack on the heavy water plant at Vemork. The mission is undertaken in the cover of the night to prevent detection. The room must depict the tense suspension of climbing through the narrow valley, patrolled above by Nazi-soldiers.

The exhibition brings the men and the visitors close to the Germans and so these may be portrayed through uniforms and items alike. The machines of the plant and the target of the mission will be the centre point of the room.

As the room is to appear rather dark, artificial light may be used to highlight the different items of the exhibition.

Escape
As we follow the group after the successful sabotage and following escape from the Telemark towards Sweden, the visitors are presented with a relief from the dark. The room is to be light and welcoming, exposing the guests to the nature and giving them a view of the fjord.

The exhibition will include text and images of the individual members of the mission group and a map showing the routes used for escape.

As the room is intended to allow for a view of the surroundings, the layout should also include space for this as a break from the exhibition itself.

Life on the Fell
A representation of the life of the group, living in the fell. The visitor will be introduced to the conditions met by the members who stayed behind, living off moss and reindeers in small huts on the fells surrounding the Rjukan area.

The room is to be light without any direct sunlight. The appearance through the room is to be of the vast openness and bright light associated with the fells. To help ensure the experience, the room is not to have windows allowing for views of the surroundings.

Bombing of Vemork
The bombing of Vemork depicts the experience of the residents of Vemork, being at risk of being hit. The exhibition will include imagery of the extent of the damages done to the town.

The room is to be secluded from the outside, meaning no daylight but instead using artificial light to show the different objects in the exhibition. These objects will include bombs of the type used during the bombings. To illustrate the nighttime bombings, the room must come by as rather dark allowing for video use as well as not being darker than letting the visitors be able to move around. The exhibited objects are to be clearly highlighted by their spotlights.

The sinking
The sinking of the ferry concludes the tour of the museum. The exhibition will start out with showing the transportation of the heavy water to the ferry terminal by train. From here, the exhibition will continue on to the transport on the lake by the ferry before ending in the final sinking.

As the undertaking and the sabotage of the ferry was done under cover of the night, the room starts out dark and gradually lightens up towards the "relief" by the sinking of DF Hydro. Throughout the exhibition, directional ties to the surrounding area are to be obtained through well places views of the lake and ending in a direct view towards the actual spot of the sunken ferry. This view is to lead the visitor's eyes to the spot and should therefore not be too big.

The Exhibition is to include a train cart and smaller objects related to the ferry and the sinking. Video can be a possibility.

The historical aspect of the exhibition and the concept of defining the atmosphere of each room according to the circumstances of the specific events provide some limits regarding the individual rooms incorporated in the exhibition. These are to be worked into the Room Programme together with the gatherings from the coming analyses to define the final criteria for the exhibition rooms.

LOCATION

Lake Tinnsjø is located in the Norwegian county of Telemark, approximately 150 kilometres west of Oslo. It lies at an elevation of 190 meters above sea level and stretches about 32 kilometres from the southern end in Tinnoset towards North-North-West. The lake crosses two municipalities, Tinn and Notodden. From the west, the river of Måna feeds the lake from the Mösvatn, through the Vestfjord in which Vemork and Rjukan lies. The lake is surrounded by mountains, reaching heights of up to 1100 meters above the lake.

On the western side of the lake, at about water level, runs the route 37, which acts as the main traffic connection in the area, allowing Tinnsjø access to both Oslo towards the east and Stavanger on the west coast. The eastern side of the lake cuts steeper and is therefore not accessible in the same manner. Here the smaller road 364 runs within the countryside and encloses the lake with route 37 from the south and in the end of Vestfjorden.

The locations of the Heavy Water Actions which lies to ground for the museum, are spread out over the nearby area of the lake. In the backcountry to the Vestfjord are not only the sites of the landed paratroopers but also the many huts in which the participants hid in between the attacks. To the west of Rjukan lies Vemork where the power plant and production facilities where placed and which now houses the Norwegian Industrial Worker's Museum. On the southern bank of the Vestfjord lies the sister ship to the DF Hydro, the DF Ammonia, about 14 kilometres further towards the lake than Rjukan. Here is the old terminal from where the ferries sailed to and from, transporting goods and passengers to Tinnoset in the south. At approximately the halfway point of the length of the lake, at a small stop on Route 37, a memorial can be found for the sinking of DF Hydro. This is the site closest to where the ferry was sunk and still lies at the bottom of the 430-meter deep lake.

The distances between the fell, Vemork, the terminal and the final resting point of the ferry does not make it possible for the museum to directly connect to each of the places and thus a suitable site within the vicinity must be located for the site.

The fell, although large, open and empty, lies at the top of the mountains. This isolates it from the towns and roads leaving no proper means of access for visitors. By being in this open landscape, the building will be more exposed, allowing for less limitations regarding sunlight. This provides more possibilities for the creation of light experiences and with the more permanent snow layer reflects the daylight, providing an enhanced level of ambient light. The isolation also prevents the site of having any connection with the rest of the historical events. The lack of any specific areas within the surroundings fell helps disprove the area as the suitable location for the site of the museum.

The site of the Vemork plant has some potential. Here, the former plant has already been converted into a museum for the

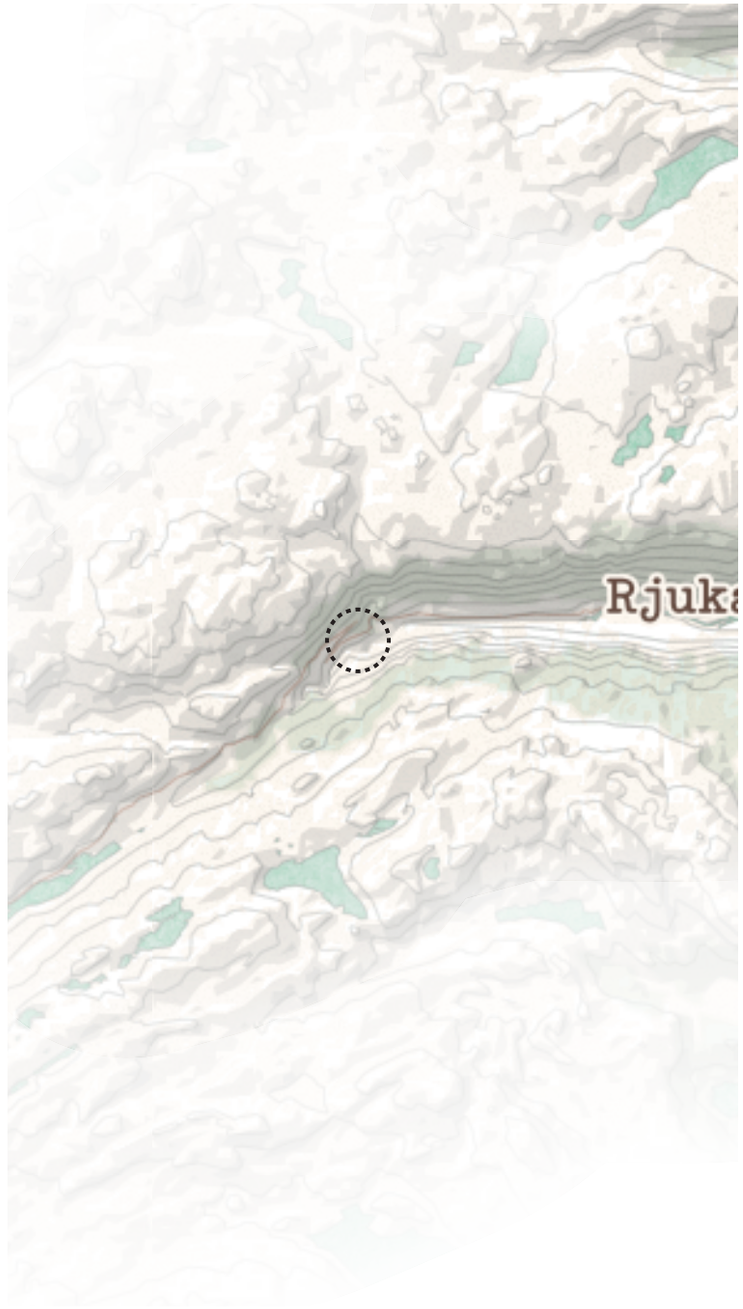
Ill. 4 *The placement of Tinnsjø*

Ill. 5 *Tinnsjø and the location of the three sites, from the right; the fell, Vemork and DF Hydro*

Norwegian industrial worker and takes up most of the southern wall of the very narrow valley, while the road winds up the other side. This leaves little space left for any other constructions and would hinder the views from the original plant. The sides of the valley are also at some of their steepest in the area, which is great for producing electricity but only provides limited space for any constructions. As the area is in the steepest part of the valley, the views from any site would be very limited, visibly isolating the site from the other areas concerned in the history. Not only are the views limited but daylight as well. This is seen no clearer than in the town of Rjukan where three large motorized mirrors have been installed on top of the northern valley side. These mirrors reflect a narrow cone of daylight towards the city square, so the residents of Rjukan are able to obtain a little daylight during the darkest winter months. This will not only impede but also probably prevent the museum from being able to use daylight to alter the experiences of the different room, as the daylight will not be available for most of the year, making any designs incorporating the use of daylight incapable for this period.

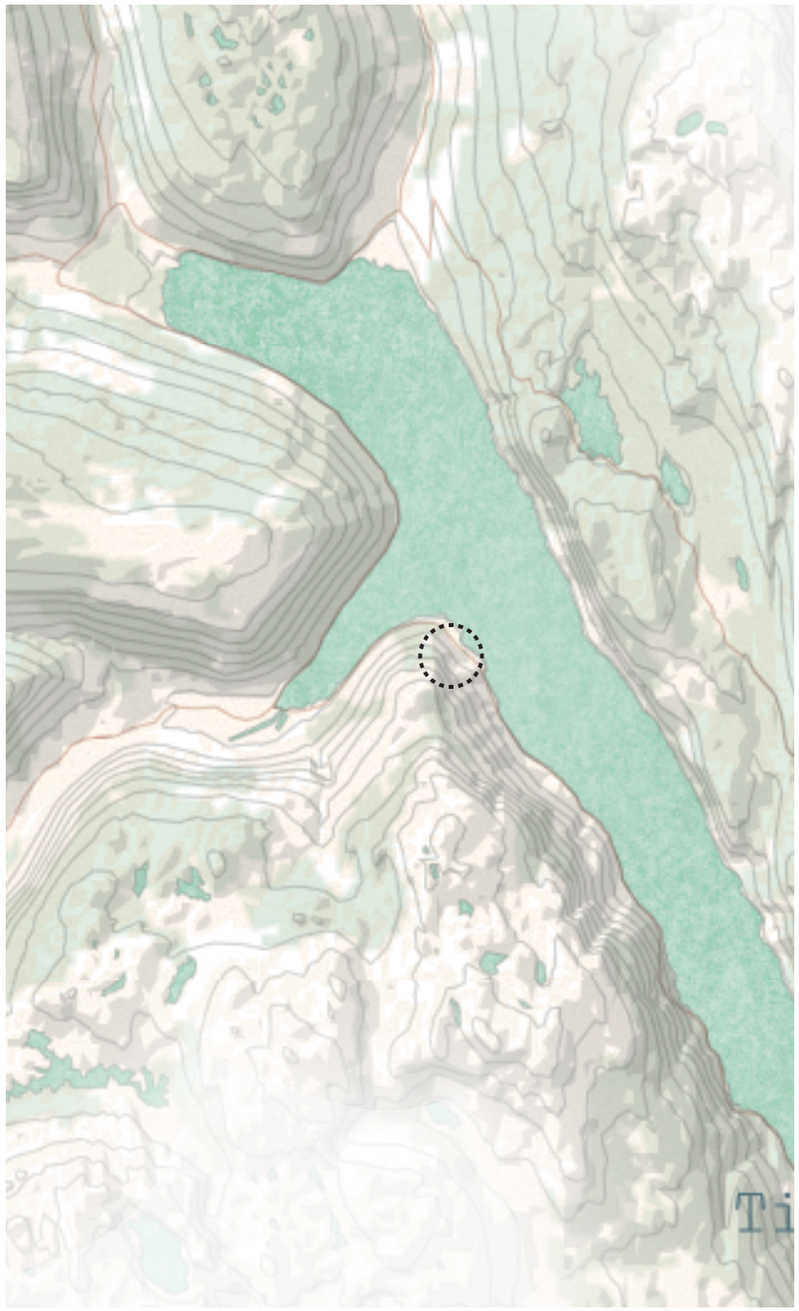
At the edge of the lake, closest to the point of the ferry sinking, a small lay-by lies at which a small memorial recognises it as the place of the sinking. The area is much flatter than at Vemork and includes a small lake. The area is more open due to the location next to the lake, which at this point is about a kilometre wide. This together with the eastern direction of the face of the mountain allows for plenty of sunlight throughout most of the year. This would be a positive point for the cafe and arrival area, but for the exhibition itself, will require more shielding to protect the delicate objects of the exhibition. The location of the area along the side of the lake disconnects it from the valley wherein the rest of the events happened.

The distances between the locations of the historical sites and the differences in the terrain make it difficult to create a complete story in any of the three places. Instead, an area almost right in between the two sites seems to offer the best qualities of both of the other prospected areas. The site for the museum is located on the south side of the opening of the Vestfjord. As the point protrudes into the lake, it offers sight lines towards the sunken ferry as well as inwards towards the fjord, giving an understanding of the direction and the topology at the site of Vemork. On the north-eastern part of the point a smaller, flat area extends out towards the water on the outer side of route 37, while the rest of the point rises to a peak 580 meters above Tinnsjø. Due to the openness to one side while being shielded by the mountains from the other, this area leaves many possibilities for using the light in the design of the experiences. By having altering terrain, the site also makes it possible to dig inwards to create pockets while leaving other parts of the museum exposed. This will be attempted in the later volume studies.

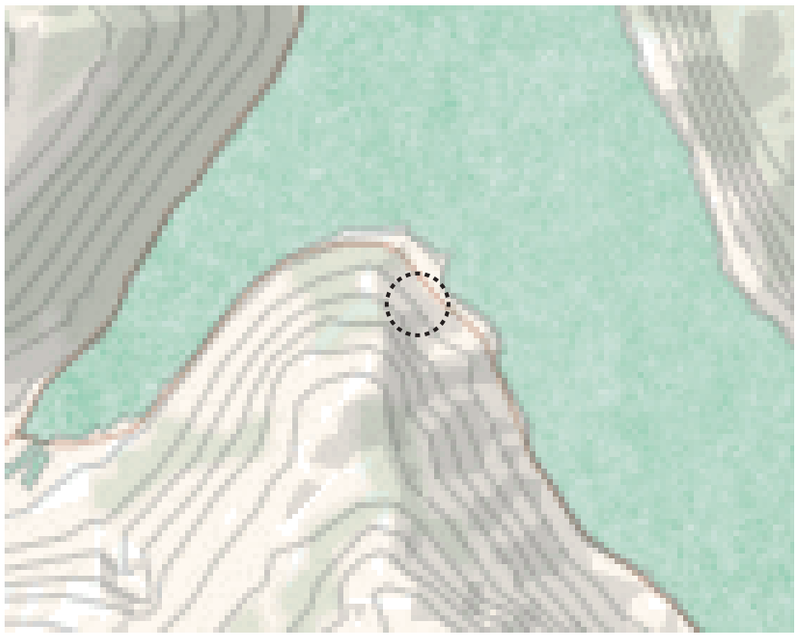


Ill. 6 Location of the Vemork Plant

Ill. 7 Loaction of the sunken ferry DF Hyrdo



Ill. 8 Chosen site between the two locations



Ill. 9 Defining the excact location

Ill. 10 Mirrors reflecting daylight onto Rjukan Town Square

CLIMATE

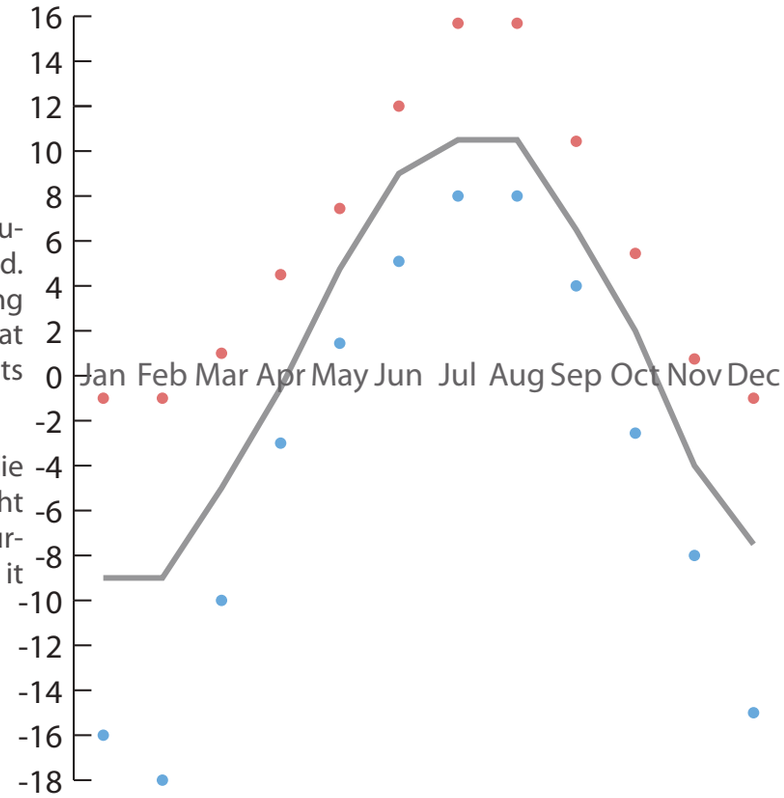
As part of the design process, it is impossible not to consider the surroundings. This also includes the forces that are affecting both the landscape but also a final design. In this case, the most important climatically affects are considered.

TEMPERATURE

The county of Telemark, although located in the southern part of Norway is still to be considered cold. By looking at the average temperature for each month, it can be seen that the overall average temperature will lie around 0˚C. Looking closer at the seasons, the temperature is expected to drop below 0˚C in November for not to rise above again before the end of April. During the summer season, the temperature is expected to reach around 11˚C, still colder than the allowed minimum temperature stated for the museum in the competition brief. (yr.no, 2015)

The museum can therefore not solely rely on passive energy sources, but a mechanical system must be expected if the museum is to maintain an acceptable temperature all year around. Investigations will also be required into whether the building overheats during periods of the summer months and in that case, the design must be iterated support the requirements needed for this to no longer happen.

As the temperature of the ground can be expected to lie around the average air temperature the whole year, it might be an advantage to dig parts of the museum into the surroundings for a higher exterior temperature while shielding it from the seasonal elements.



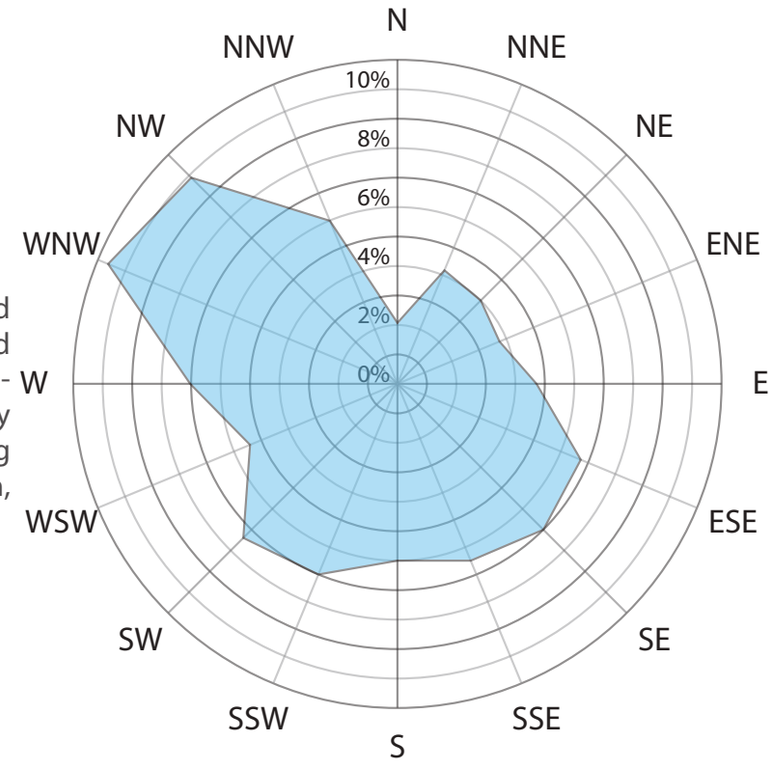
Ill. 11 *Average and peak temperatures for Rjukan*

WIND

Looking at the wind rose for the area, a predominantly western direction of the wind is clearly seen. Although the wind speeds barely rises over 6m/s, the fjord might act as a tract funnelling the wind faster through the valley and onto the lake. (Windfinder.com, 2015)

The wind speeds of the area are not to be defined as extreme, but for any outdoor areas where extended stays are expected, the chill factor could intervene with the comfort of the guests as the temperature as shown is already expected to be below the preferred temperatures of the competition brief.

With the point's extension towards the lake, it can be estimated that the wind will cause the eastern side to often be windward while leaving the western side of the point in the leeward position. By constructing on the eastern side of the point, not only are the sight lines towards the ferry secured, but the building will also be protected from the predominant wind direction, leaving the building less exposed.



Ill. 12 Wind rose diagramme for winds directions at Rjukan

DAYLIGHT

Due to the narrow valley surrounding Rjukan, not much light reaches the city during the winter months when the sun sets much lower in the northern hemisphere. This is seen as in the aforementioned solution for the town, where large mirrors have been installed to provide the citizens with a little daylight.

Although the site for construction is located on the point where it will be exposed the most towards the east and south to south-east, it is worth determining how the solar paths for the area are and what this means for the site itself as areas exposed to direct sunlight. Both for the benefits of an energy gain but also as protection for the more delicate exhibition objects that will require shielding from the direct sunlight.

In Nordic architecture, the sunlight is often an important design factor due to its ever-changing amount of light, defining the different seasons of the year. However, as many of the objects within the exhibition must sheltered from direct sunlight, parts of the parameters for the design must be how to utilize the daylight for setting the state of the atmosphere without directly using the sunlight within the exhibition areas.

By plotting in the solar paths of the unobstructed parts of the of the journey for the three most important equinoxes (March, June and December) over the model of the site, it is quickly visible that the point lies almost unobstructed for the summer season. Here the sun rises early in the morning and stays over the site until the evening hours, constantly providing sunlight to the museum.

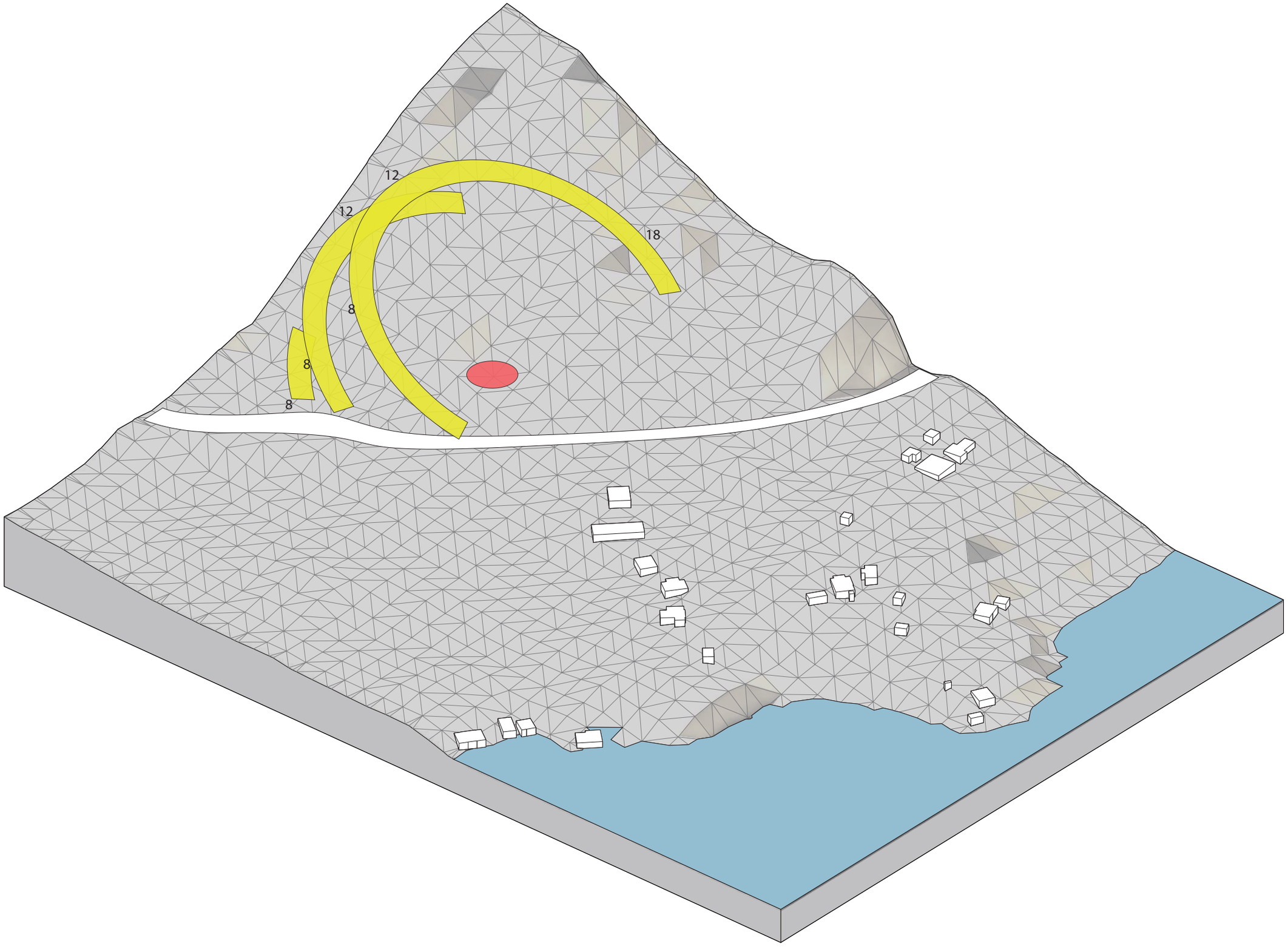
In the spring and hence also the fall, the sun also rises over the site from the morning but starts to hide behind the mountains in the early afternoon, ending the provided sun light to the site much earlier than the summer sun.

In the winter months, the sun barely rises above the surrounding mountains and therefore only a small bit of morning sun reaches the site of the museum.

To further extend the experience of the visitors, the atmosphere set by the lighting is to represent or enhance the feelings that the participants were to feel during the different epochs of the missions. By controlling the amount of daylight that enters the exhibitions, the ambient light level can tell a difference in not only the time of day but also the level of danger that our heroes would be in at the specific point. At the same time, altering the direction of the daylight can control whether or not direct sunlight reaches the exhibition and may be used to highlight certain objects or protect others from sunlight.

The placement of openings, either allowing for external views or not, may impose a feeling of certain levels of freedom and can be used to give the visitor a relief within the exhibition or point towards specific locations in the nearby surroundings.

These are all properties that are to be taken into consideration during the designing of the individual exhibitions.



Ill. 13 Solar paths diagramme for the site

SERIAL VISION

To better understand the area in which the museum is to be placed, the main road leading from Tinnoset to Rjukan is explored through a series of impressions of the differences in the landscape throughout the given route. The purpose of the investigation is to find the area's characteristics and purposely implement them into the design of the museum building. As the terrain surrounding the lake is often quite steep, a major part of the investigation will be to understand the different methods of constructing in the local terrain, in this case mostly portrayed by the road following the brink of the lake.

Arrival to the site most likely will happen from south by route 37. Here the visitor will follow the road from Tinnoset, running along the brink of the lake, through tunnels before arriving at the site. The route is heavily uniform, having the flat, open lake on the right side while the mountains take up the vision in the left side. The low altitude of the lake means the foliage all the way along the route consists of a mixture of pine and birch trees while the ground cover is either bare rocks or moss covered with some sporadic long grasses. Along the road, cliff sides appear where the construction of the road has needed to cut their way through the mountains for the road. This leaves a vertical cliff wall towards the left side wherein artefacts from the formation of the mountains are visible, often as tilted lines running across the face of the open cliff. Breaking up this monotony of the beautiful landscape are the tunnels, dug through parts of the mountain. Opening up as an arch holding back the overlaying masses of rock and letting the drivers through. The tunnels are constructed as a thin concrete shell, which in colour matches well with the cliffs that it cuts into.

Deriving from the experienced stretch, these two approaches to working with the landscape prevails. Although scarring the surface the most, cutting away parts of the terrain allows for construction on the surface and thus creating the possibility for obtaining natural light and unobstructed views over the surroundings. Oppositely, the subterranean approach of digging into the landscape mostly prevents these parts, but allows for greater flexibility in the layout without disturbing the natural appearance of the terrain above. As some of the rooms of the museum's exhibit requires natural light and some do not, a combined approach which exposes the rooms needing the natural light or views and conceals the rooms that does not, further protecting the exhibited objects and the terrain above, is to be considered.

Approaching the site of the museum, the views from the site becomes visible and it is possible to determine the direction of the different views and sight lines from the site. These can possible help determine the placement of rooms with specific demands.

Ill. 16 Deep cuts in the landscape for levelling out the road

Ill. 15 The landscape along the route 37

Ill. 14 Tunnel digging through the landscape

The site is located on a point where the Vestfjord opens in to the west. This also opens the field of view compared to the route leading towards the site. The view changes as you move around the point. From looking towards the south on the eastern side, it is possible to follow the lake back towards Tinnoset, but it is cut short by the surrounding mountains shortly after the spot for the sinking of the DF Hydro. Following the view up the lake towards a northern view, at first the steep wall of the opposite side of the lake is seen, which transforms into framing the northern end of the lake between the mountain wall and the protruding north side of the Vestfjord. From here, the view is more straight and abrupt ended by the northern side of the fjord, rising up, taking the view before finishing with a small view towards the west, in through the fjord where the two sides of the valley surrounding it gives the experience of how the valley extends further and leads you towards Rjukan and Vemork.

Entrance to the museum would fit with the correspondingly larger amount of traffic following the route from the eastern side of the lake upwards from the south, also making the entrance the first visible spot from this direction. The exhibition of the sinking of the ferry should face towards the lake with views towards the spot of the sinking in the southern direction. Likewise should the escape-exhibition also have views over the surroundings. To create a counter balance to the southern views, this exhibition could easily be directed towards the northern views, tying the museum together with the Vestfjord and the actions that took place within the fjord. This will prevent direct sunlight but still allow for daylight to brighten up the exhibition as discussed in the prior chapter.

Ill. 19 View towards the south from the site

Ill. 18 View towards the north from the site

Ill. 17 View in throught the Vestfjord

SPATIAL PROGRAMMING

The basic premise of the museum stems from the competition brief of the Danish "Frihedsmuseet", which as earlier mentioned is converted and applied in such manner that it fits the Norwegian context rather than the placement in Copenhagen. The changes are therefore mostly connected with requirements for the exhibited objects for the exhibition, considerations to the placement and a slight cut in the expected occupancy of the museum to accommodate for the more rural location. Some of the requirements for the Danish equivalent are due to the placement in the small park "Churchillparken" but due to the wishes of retaining the natural landscape in this project as well, the requirements are kept near the same.

To limit the over terrain part of the construction, the museum is not to have as small a visible footprint as to not to take up the nature. This also limits the exposed constructions to stay within two storey's height. As the rest of the construction thus must be constructed underground, it is important that precautions are taken to prevent water from seeping into the construction. (National Museum of Denmark, 2014) As determined earlier in the program, many of these subterranean rooms will represent parts of the exhibition, why this is very important.

The museum is to be divided into two zones by default. One being the Service Zone wherein recreational facilities are to be placed. These facilities are not part of the exhibition and can therefore be opened to the public without the museum itself having open. (National Museum of Denmark, 2014) As the Service Zone is intended for longer stays, it is to be lit as much as possible with natural light.

The second zone contains the exhibition itself, the preparation rooms for the exhibition and an orientation room. The zone has to cover as large an area as possible. It needs to be cohesive and have a volume that allows for exhibition of larger objects. It is preferred that a major part of the exhibition area has a height of more than one storey. (National Museum of Denmark, 2014)

The Service Zone includes the arrival area, which is to help the museum be perceived as a vibrant place. To do so, the arrival area shall be the common grounds for all arrivals, this including guests and staff. The arrival area is to serve as an access point between the public areas and the exhibitions. Also included are the cafe and a multipurpose area. The cafe is to be able to serve small dishes such as sandwiches, prepared in the small kitchen connected to the cafe. A multipurpose area should be used for meetings, lunch packs and possibly films at different times. The area should be possible to use separately or combined with the cafe. (National Museum of Denmark, 2014) Lastly, a small shop is to be annexed into the public area. To minimize the workforce needed, the cafe and shop should be run from the same point in the Service Zone. Both cafe and shop will need their own respective storage areas, preferably within their confined spaces. For preparation of objects for the exhibits and for the exhibits themselves, a small room of 6-10 square meters and is to be used for storage of incoming objects and smaller repair jobs. (National Museum of Denmark, 2014)

For the exhibition area, there are also several requirements to make the museum able to fulfil its premise of not only showcasing the life and objects from the resistance movement but also be able to teach and explain why so many people decided to risk their lives. The area needs spaces large enough to gather school classes during tours while still allowing other guests to enjoy the museum uninterrupted. (National Museum of Denmark, 2014)

	Occupancy	Atmosphere	Light	Objects
Service Zone				
Cafe	min 30		Natural light	Seating and tables for dining
Shop				
Conference room	min 30		Able to be darkened for video projection	Installed seating for lectures
Toilets				Toilets
Exhibition Zone				
Introduction		Room is for video projection	Dim electrical light with video	Uniform and smaller objects in display cases
Landing		Visitors participate in landing with parachute	Natural light from above, no direct sunlight on objects	Parachute, uniform and smaller objects in display cases
Sabotage		Uninviting. The light from above represents danger	Daylight reflects off open cliff face. Electrical light on objects	Production plant, uniforms and smaller items
Escape		Open and inviting	Natural light from large windows, allowing for views	Map, smaller items in display cases and furniture for enjoying the view
Life on the Fell		Light and bright. No clear shadows	Daylight and sunlight reflected off the construction to avoid any real shadows	Skier, reindeer and moss
Bombing of Vemork		Dark and eery. A confined space	Electrical light from below the floor	Bombs
The Sinking		Going from darker to brighter, large panoramic views	Natural light from the large panoramic windows	Train cart and smaller items in display cases
Support rooms				
Kitchen			Natural light with assisted electrical lighting	Fully equiped kitchen
Preparation room			Electrical light	Worktable

Ill. 20 Room Program Schedule

The rooms needed for the exhibition are laid out in a chronological order, depicting the main events of the missions. The individual rooms demand their own light requirements according to the atmosphere and setting of the part of the story being told. In connection with the beginning of the exhibition, an orientation room is required. This serves the purpose of introducing the exhibition as well as allow for educational uses and an area for resting when it is not in use otherwise.

Due to the nature of the objects exhibited, use of natural light is possible but must respect that some objects may be sensitive to sun light. For these cases or in general the lighting can be artificial. The intake of natural light also has to take into consideration the needs for blinding for showing of media and for sunlight in rooms exposed towards the sun according findings within the design. (National Museum of Denmark, 2014)

All in all the museum will have a layout that follows a clear path, letting guests easily navigate through the exhibition while allowing for moments of reflection for the individual visitor. The museum is placed within the area of one of the most famous resistance actions in Norway, so not only the interior's exhibition but also the surroundings can be used for the explanation of the story and must be considered in the design. The service zone of the museum is to compliment the exhibition but also work and an individual service that can run without the museum for events.

To support the educational aspect of the museum, areas supporting school classes and lectures have to be incorporated to an extent where they also can be used accessed by guests when not in use.

As the main entrance is supposed to support all functions of the museum, the arrival area is to become a central hub from where it is possible to move towards the other facilities within the museum. (National Museum of Denmark, 2014)

INSPIRATION

With an understanding of the demands for the museum from both the requirements in the competition brief as well as from the understanding of the surroundings and their affect on the location of the site. To further be able to develop the concept for a museum living up to the brief and the concept of utilizing the natural light to set the atmospheres of the different exhibitions, different aspects architecture lies to ground for the future design approach to the museum.

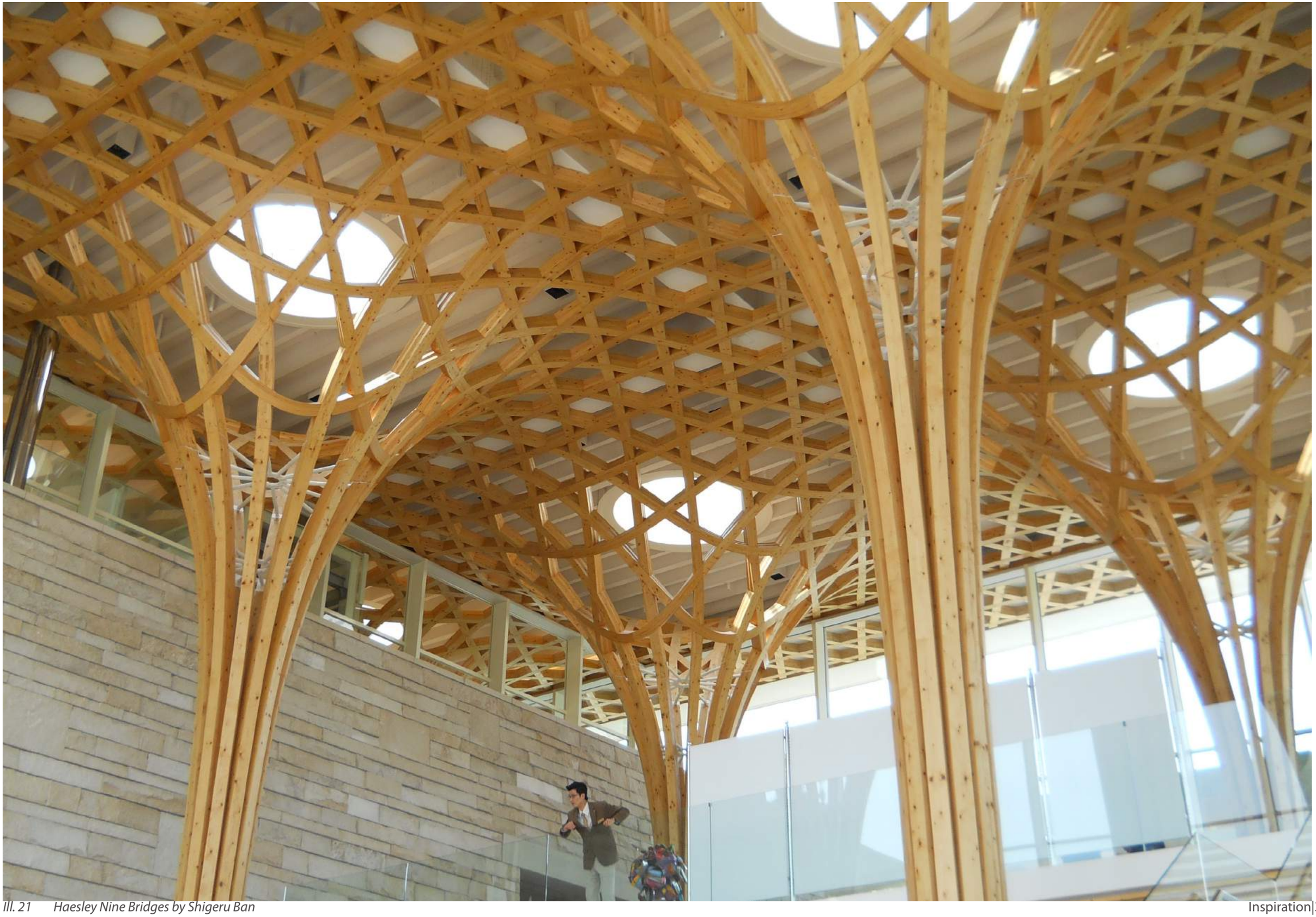
TECTONICS

The term tectonics is hard to define, as it incorporates many concepts. The word originates from the Greek word tekton or carpenter, from which the master builder or architekton is also derived, describing the profession of the person who knows the materials and how to fully use its properties for what they can. By doing so, honesty is given to the material within its context of the building by utilizing its strengths for defining the arrangement of the elements of which the construction consists of. (Frampton, 1995) Thus not only is the tectonics a physical concept that can be grasped, but also an expression within the architecture quality of the construction. (Sekler, 1964)

Tectonics is the discipline of understanding these properties of materials while combining the aesthetics and engineering skills learned to enhance the spatial qualities of the room through a structural order. By combining the knowledge of materials, structure and form, it is seen that the designer has an eye for the detail while remaining part of the larger entity as described by Juhani Pallasmaa. (Pallasmaa, 2012) It is this combination of not only a larger scale use of the materials but minimizing the use, forcing the materials to have to perform towards their best environments that are defining the word tectonics. (Frascari, 2008)

For the museum, the approach to the design should be focused on creating the desired experience, using light, as to improve the spatial awareness and understanding of the structural arrangement of the construction, to better accommodate the intended experiences through the way the light is led into the exhibitions. The construction of the different exhibition areas should thus consider the way the light has to arrive to the visitors, creating a relation where one helps the other where possible.

The concept of the tectonics is capable of being applied to the design process in many areas where the technical and the aesthetical concepts of the design merges. This means that all decisions taken to improve one part of the experience must be brought with into the considerations of the other aspects. When building in and into the mountains, as is the case of the museum, these includes much more than how the light enters the building. When placing the structures within the landscape, it is important to consider how the buildings interact with the natural forces. The rock type of the area is from the local tunnels considered mostly self-bearing and thus should not require the building's structure to carry much extra weight. On the other hand, the area is prone for large quantities of snow, which must be taken into consideration, as well as the drainage of the water from when the snow melts. This includes the melting water from the surrounding area, where the placement of the individual structures in the landscape must be taken into consideration.



Ill. 21 Haesley Nine Bridges by Shigeru Ban

SAINT BENEDICT CHAPEL

Peter Zumthor's chapel in the city Sumvitg is a simple representation of tectonic architecture. Here, the main object of the construction is the column that is accentuated to enhance the understanding of the structural principle used. The building creates a sanctuary where the use of light plays an important role in how the chapel is perceived. The use of the celestial light coming in through the high placed windows enhances the religious atmosphere and is comparable with the effect seen from cathedrals around Europe, which strengthens the understanding of the use of the space.

The timber columns of the chapel rise from the steep site on which the chapel is placed, and forms the general elliptical shape of the building. At the height of the top most point of the landscape, the interior floor joins the columns together to create a slab on which the services of the chapel can be held. The floor on this slab is slightly raised from the attachment to the columns, giving an understanding of how the columns proceed through the floor and leads the forces into the ground.

Protecting the chapel from the elements is a series of cladding attached to the outside of the timber columns. The cladding is connected to the columns through small pins, detailing the fact that the cladding is only for protection against the elements and do not participate in the transfer of the forces of the structure to the ground. The cladding stops shy of the ceiling and roof of the building where instead a row of windows disconnects the roof from the rest of the chapel except for the columns. The high placed windows create a sacral atmosphere within the chapel.

The roof of the chapel is a simple structure connecting a longitudinal beam to each of the columns by smaller wooden beams. Hereby are all the forces of the structure led towards the columns and easily into the ground.

The column in the chapel stands as the binding factor for the whole building, both physical and spiritual. By joining all the components of the chapel together and holding up the floor, the columns stand as the structural point of the construction.

By extending the cladding away from the column, creating a small void behind while the celestial light from the windows detaches the roof from the structure, enhances the spirituality of the chapel. All in all the atmosphere of the very simple space of the chapel is heavily enhanced through the considered use of the light. By creating an effect replicating the lighting of cathedrals and churches, the chapel, although small, retains the feeling of a sacred sanctuary in which the visitor is instantly clear of the intended use and atmosphere.

This can be projected to the design of the museum in the way the light is considered for the exhibition areas. Where direct light and open views subtly releases the experienced tension, indirect lights and obstructed views creates a feeling of suspense and importance.

Ill. 22 Saint Benedict Chapel by Peter Zumthor

NORDIC LIGHT

The long, dark winters of Scandinavia have resulted in a great focus on the workings with the light, which is enjoyed as a life-giving source sought after within the comfort of the Nordics homes. This tradition of designing for light has led to a strong understanding for the attention to contrasts and how this affects the qualities within the space of the building. This is also relevant for the museum where the concept of defining the specific atmosphere of each individual exhibition room through its light and setting requires the understanding of how the contrasts between light and darkness plays a role when designing a room for a specific frame of mind.

Nordic architecture is vastly seen as an integral process wherein a simple but functional use and detailing of material, the understanding of the qualities of daylight and a connection to the surrounding landscape is incorporated into the design of the building. In order to succeed with this combination of skills, good craftsmanship has also acted out an important role in defining Nordic design. (Sommer, 2009)

The identity of the building within Nordic Architecture is highly connected with the site of the building, creating a bond between it and its surroundings, which is an important factor for the interactions with the life of the area. (Kjeldsen, et al., 2012)

By bringing not only the knowledge of the material properties but also integrating ones understanding of combining the qualities of the area to better the possibilities for life around the building with proper use of light to increase the spatial qualities of the exhibition rooms, as well as for the lighter service zone, the museum will be able to reach much closer to its goal of creating defined atmospheres within an interesting space for learning and reflection.

Ill. 23 Reindeer Pavilion by Snøhetta

NORDIC PAVILION

The Nordic Pavilion by Sverre Fehn, built at the biennale grounds in Venice, attempts to recreate a Nordic atmosphere and lighting from the much sharper light found in southern parts of Europe. In this case, the light is altered by reflecting it through two series of diagonal crossbeams, each 1 meter high and 6 centimetres wide that span the full lengths of the pavilion to make up the roof structure. By using a light concrete colour, the light is reflected and diffused, so it spreads evenly within the pavilion and does not cast strong shadows as the Italian sun is used to do. The structure of the building, besides the roof, consists only of the four walls defining the inner space. The back walls are cast in concrete and stands as a defining edge of where the pavilion ends. On the other hand are the two front walls made from a sliding system of glass doors, diminishing the border between the interior and exterior if it was not for the large concrete beam overhanging the sliding doors and carrying the weight of the roof towards the solid walls and the columns between the two glass walls.

The whole interior is clad in the same lightly coloured concrete, except for a small garden in which three trees grow up through the ceiling and roof of the pavilion, once again defying the borders on interior and exterior.

With the pavilion Sverre Fehn shows how little is needed to create the impression of a complete different atmosphere with very simple architectonical gestures.

Ill. 24 *Nordic Pavillion by Sverre Fehn*

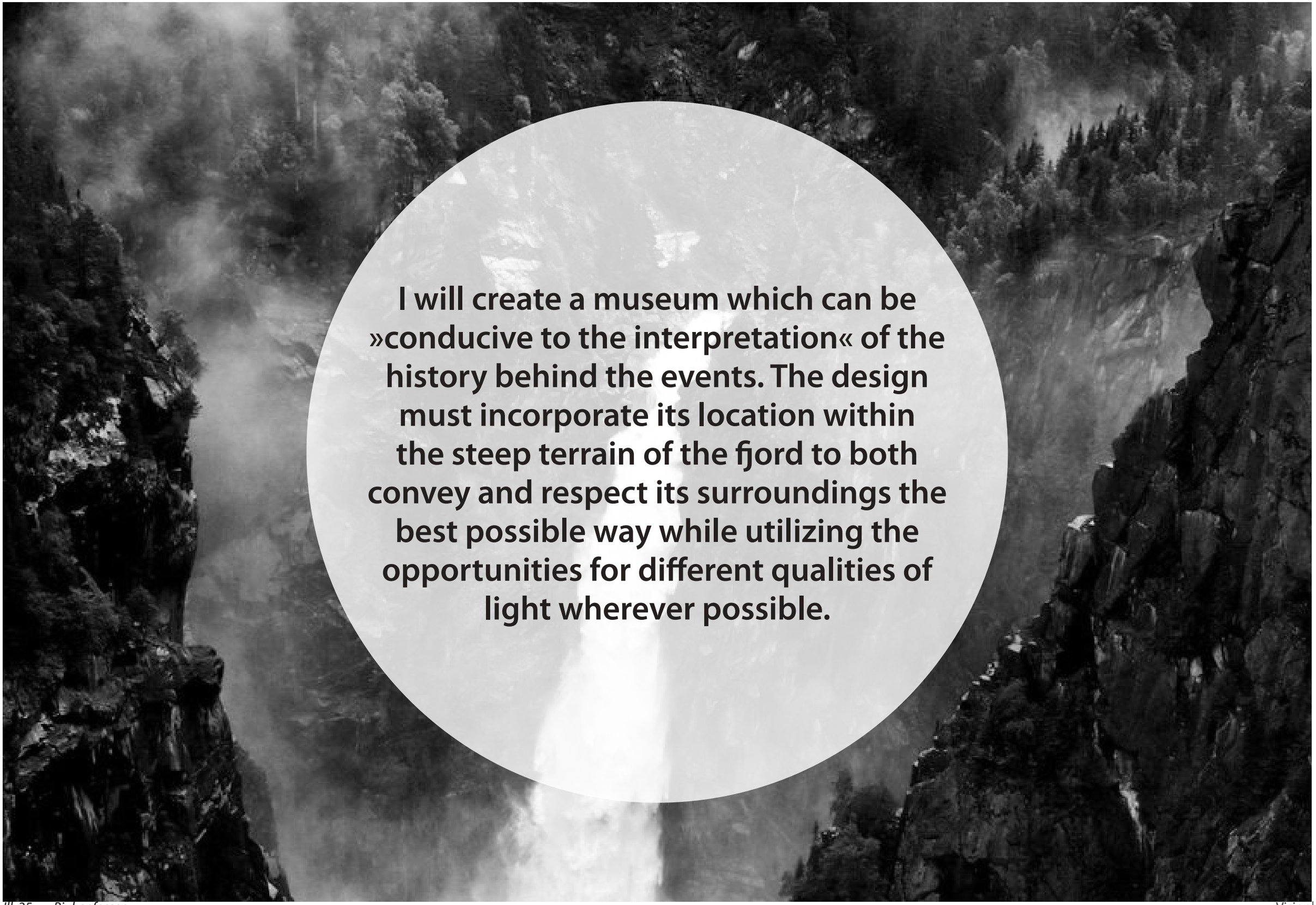
VISION

By combining the knowledge gained from the investigations with the considerations on how this is to be implemented into the requirements for the project, as defined through the competition brief, it is starting to be clear what the design of the museum should encompass.

While creating spaces for learning and reflecting about the missions undertaken by these groups of men, in a chronological story through the exhibitions, the defining character of each room is to be defined through its lighting, and how this is used to set an atmosphere, fitting to the mood of the story depicted in the individual room.

The placement and construction in the terrain is to be done in a way that is respectful for the surrounding nature. This will mostly be done by digging in to the mountain thus preserving the landscape and shield the more delicate objects of the exhibition from sunlight. When placing the structures needed for the museum, their placement within the terrain should be considered according not only to their position in the order of the story told but also how they interact with the landscape. Hereby should their placement be optimised for the desired types of light and protection from the different natural elements present in the surroundings.

While the exhibition must be divided up to tell the individual parts of the story and render the atmospheres as intended, the so-called Service Zone in which the visitors arrive to the museum must be created as a more unison area, where lectures, lunches and other activities must be possible within the confined space with the use of as little staff as possible.



I will create a museum which can be »conducive to the interpretation« of the history behind the events. The design must incorporate its location within the steep terrain of the fjord to both convey and respect its surroundings the best possible way while utilizing the opportunities for different qualities of light wherever possible.

Ill. 25 Rjukanfossen

PROCESS

Working from the defined spatial programme together with the defined visi-on for the museum, the different aspects of the design comes together. In the following part of the report, the different processes undergone in the design phase will described and the final museum will slowly be revealed towards a presentation at the end.

PLACEMENT ON THE MOUNTAIN

When deciding to build on the edge of a mountain, many problems arise that are not always seen when accustomed to build in much flatter landscapes. Some have been acknowledged within the first part of the report, such as the limited access to sunlight while others have not been approached so far.

Sunlight and daylight, as mentioned, have been of great concern, as this is the basis of the overall design. The limitations created by these aspects lies mostly in the fact that the sun disappears behind the surrounding mountains. The daylight lingers a bit longer and is reflected around by the surroundings and the lake, which provides a natural light that, is more predictable. The properties of the diffuse daylight compared to the more direct sunlight also makes in more desirable as it is not as harsh on the objects of the exhibitions and keeps a spattered direction at all times where as the direction of the sunlight changes. To work with this, most of the exhibition areas must be protected from the sunlight while allowing the daylight either through placement and direction or through construction.

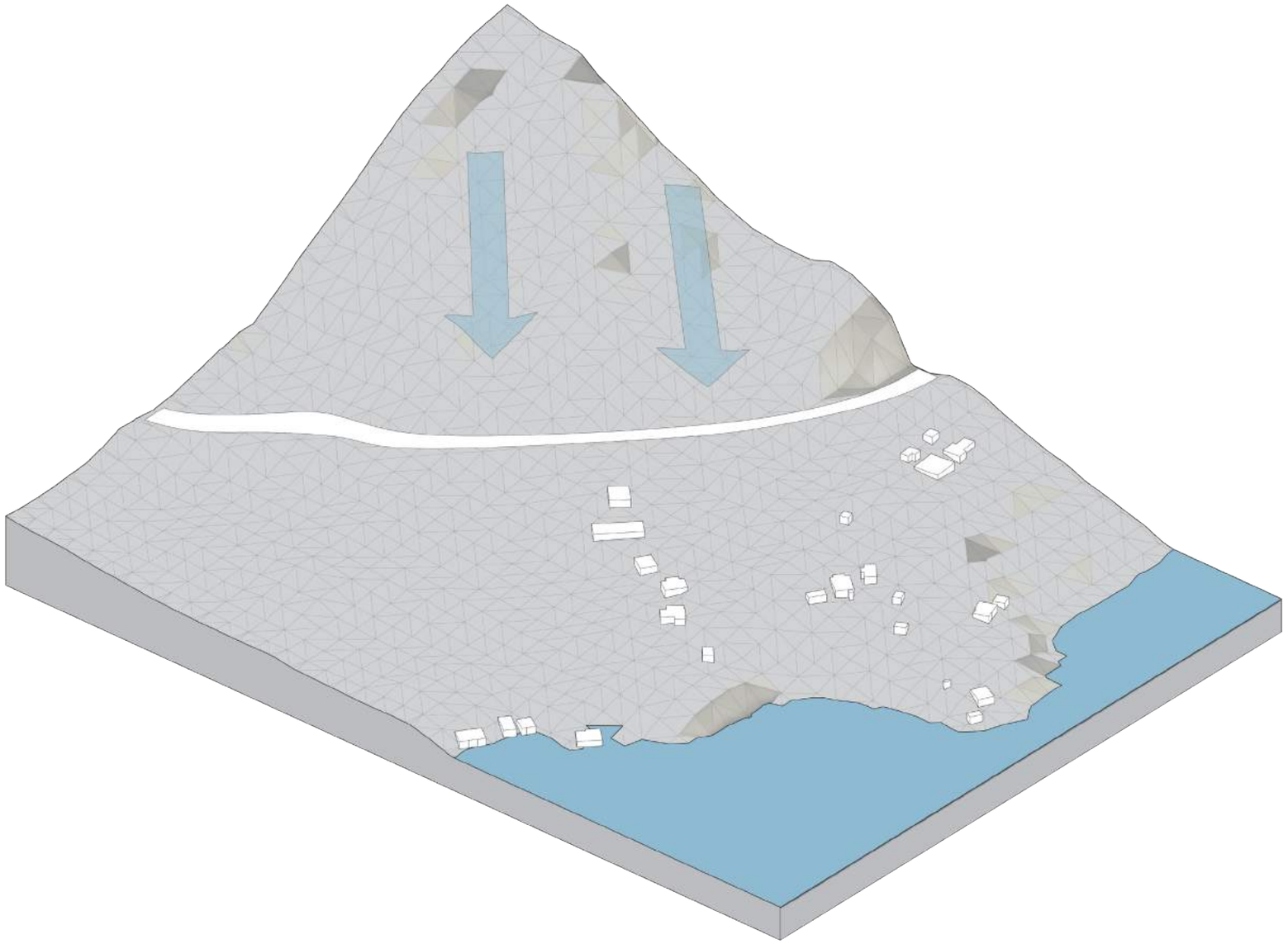
Trying to connect several rooms within the mountainous landscape has also proved difficult. When trying to open specific rooms up to the surroundings while covering others it is difficult to stay within the natural boundaries set by the formations of the terrain when the rooms are to be tied together in a strict order. This has proven to be one of the more difficult tasks when having to combine the desired atmospheres and views while maintaining the chronological order. To do so, many approaches have been tried as described in the upcoming volume studies and even further difficulties arose when connecting the rooms as described within the next chapter.

As the structures of the museum penetrate the surface of the mountain, they are left vulnerable to the natural forces of the area, one of which is the heavy snow that falls in Norway. Not only can we expect more snow per square meter at the site than anywhere in Denmark, applying extra loads to the constructions. However, the snow also has to disappear again, which introduces a lot of melt water. Not only does the design have to take into consideration how to lead the melt water of the constructions from the accumulated snow but also the melt water from the rest of the mountain above the museum poses a problem as it runs down the surface of the mountain towards the lake. The location of the museum lies upon to smaller indents in the mountain, which will naturally channel the water and lead if down through these. Thus it has been an important part of the planning of the layout of the museum to make sure that all structures leads the water towards these channels and do not obstruct the oncoming masses of water.

Another potential threat to the museum comes from the con-

cept of going underground. By digging in to the mountains, the roofs of the structures are no longer standing in the free but instead covered with potentially tonnes of rock that, depending on the type, might need to be carried by the structures of the buildings. To decide the level of this threat, visual inspections were done on the local structures that dug into the rocks after dialog with the technical supervisor. The inspections on the nearby tunnels showed the rock to be exposed nakedly in the ceiling of the tunnels, proving that the type of rock found in the area was structural fit to carry itself, and thus not needing supporting structures to be part of the design. This of course can only be taken as an estimate and much further projections would be needed for a final detailing of the project.

By choosing to build the museum within the mountains, many new aspects and concerns have sprung to life relatively to build in a Danish context, which I have been accustomed to. The process have brought forth new considerations that have been required to be taken care of to be able to finish the conceptual design of the museum in a way where these many concerns have been addressed properly in an integrated design combining technical and aesthetical aspects into a wholesome design.



Ill. 26 Natural water drainage on the maountain

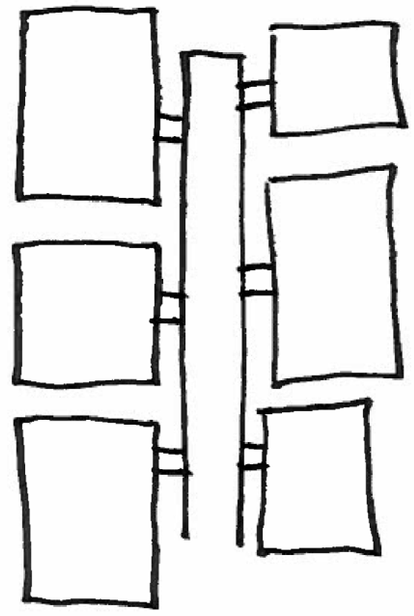
MOVING THROUGH THE MUSEUM

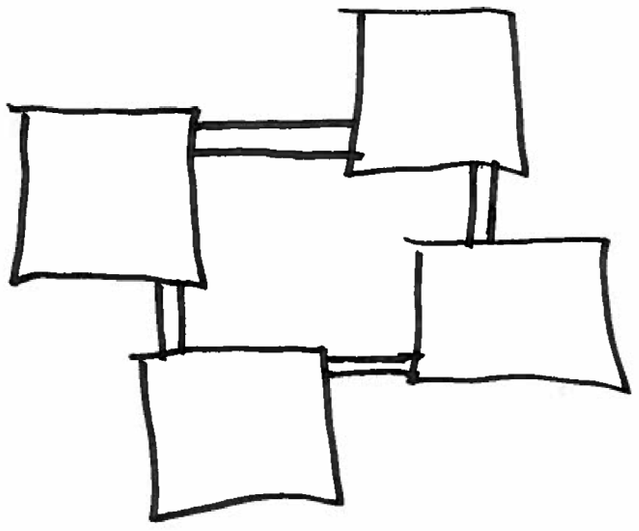
Due to the many requirements for each part of the exhibition and the expressed purpose of creating individual atmospheres for each part of the told story, the different parts of the exhibition is better off defined to each their own room rather than trying to solve all the desired experiences within one or more combined rooms for the exhibition. This introduces the decision on how to connect the different parts of the exhibition to each other.

The layout of the museum is partly limited by the requirement of keeping a chronological story throughout the exhibition. This requires but does not limit the layout to follow a strict order of the rooms of the exhibition. When considering the possibilities, the rooms of the exhibition could either be strung out as pearls on a necklace, creating a completely defined story where detours are not possible in any way. This ensures the storyline to be told correctly every time and leaves no room unvisited when venturing through the museum. This approach allows for many different layouts of the exhibitions rooms, whether they are closely connected or rather are placed apart, as long as a continuously line is possible between the desired rooms. The rooms can be connected between different heights as long as the paths in between can accommodate the incline. This prevents zigzagging though and the rooms must therefore be carefully considered within the terrain to succeed.

Another solution could mostly follow the same path as the necklace-concept, although allowing small detours to specific rooms from other rooms or passages as small cul-de-sacs. This potentially confuses the visitor when encountering a split road. This induces questions such as; does one go in one direction or the other? And what lies behind the room visible from the split, do they connect again or do you take a distinct decision in choosing which room to visit next? Of course, this could easily be remedied by applying numbers to the rooms and helping to guide the visitors through all the rooms. To keep up with the requirement of following a chronological story, this might be required if choosing this solution. By interconnecting rooms in several orders, the freedom of movement of the visitors is increased. Though this solution might also decrease the possibilities of the placement of the rooms, as several connections now have to fit together, preventing much of the three-dimensional freedom of the aforementioned solution.

Lastly, the rooms could all be placed adjacent to a central hallway from which all the rooms connect to. This way all visitors are led into the same space and from here they are able to move into the designated room in order of the exhibition or by their own desire. Some of the same concerns about the chronological movement as the former solution are brought up with this possibility. But by applying a logical order to the layout of the placement of the exhibition rooms this should easily be overcome. The solution locks the rooms' movement from each other somewhat more, as the connections from each room should always connect to the same hallway as the other rooms.



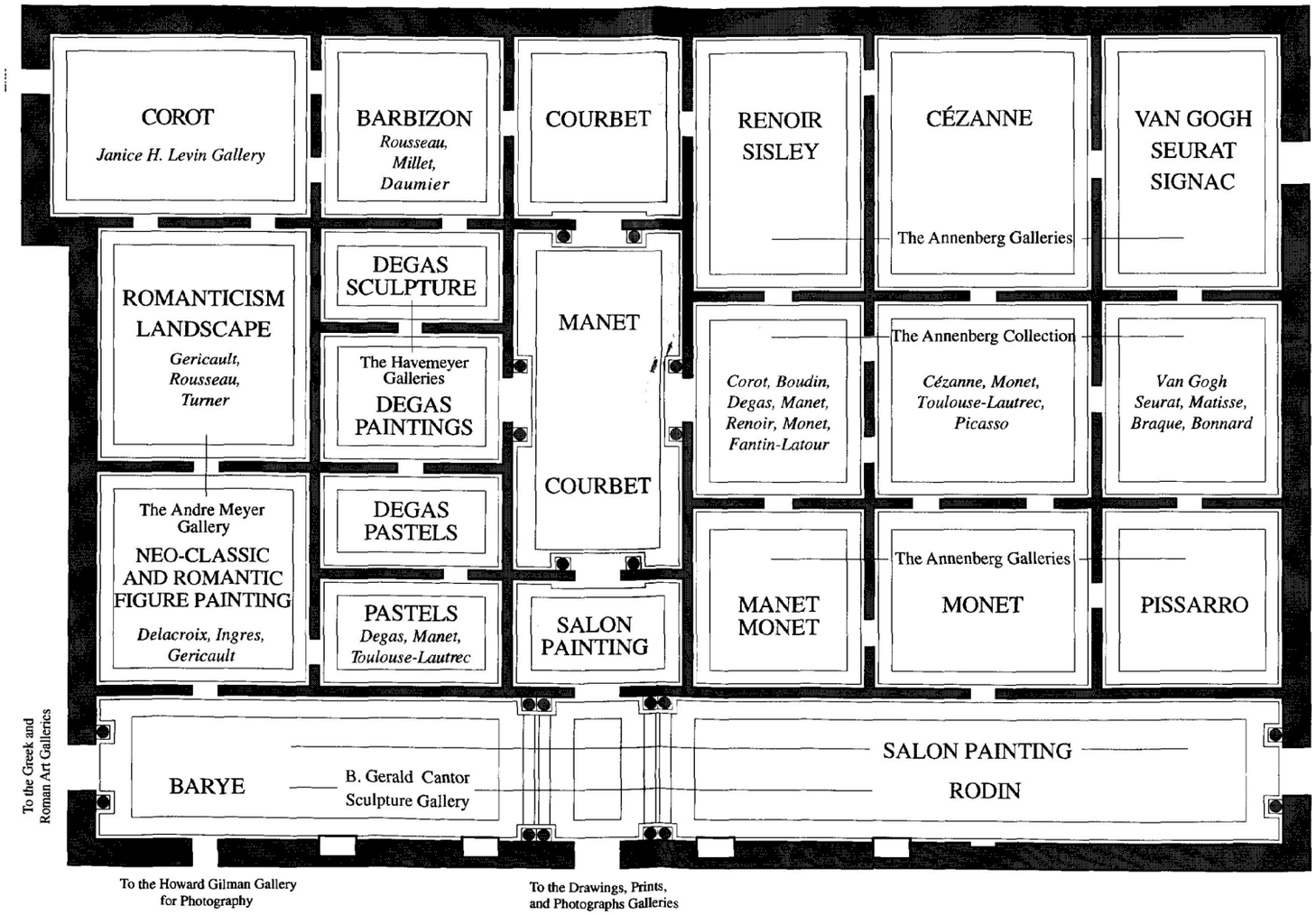


Ill. 27 Concepts for layout of exhibitions

EXAMPLES ON MUSEUM LAYOUT

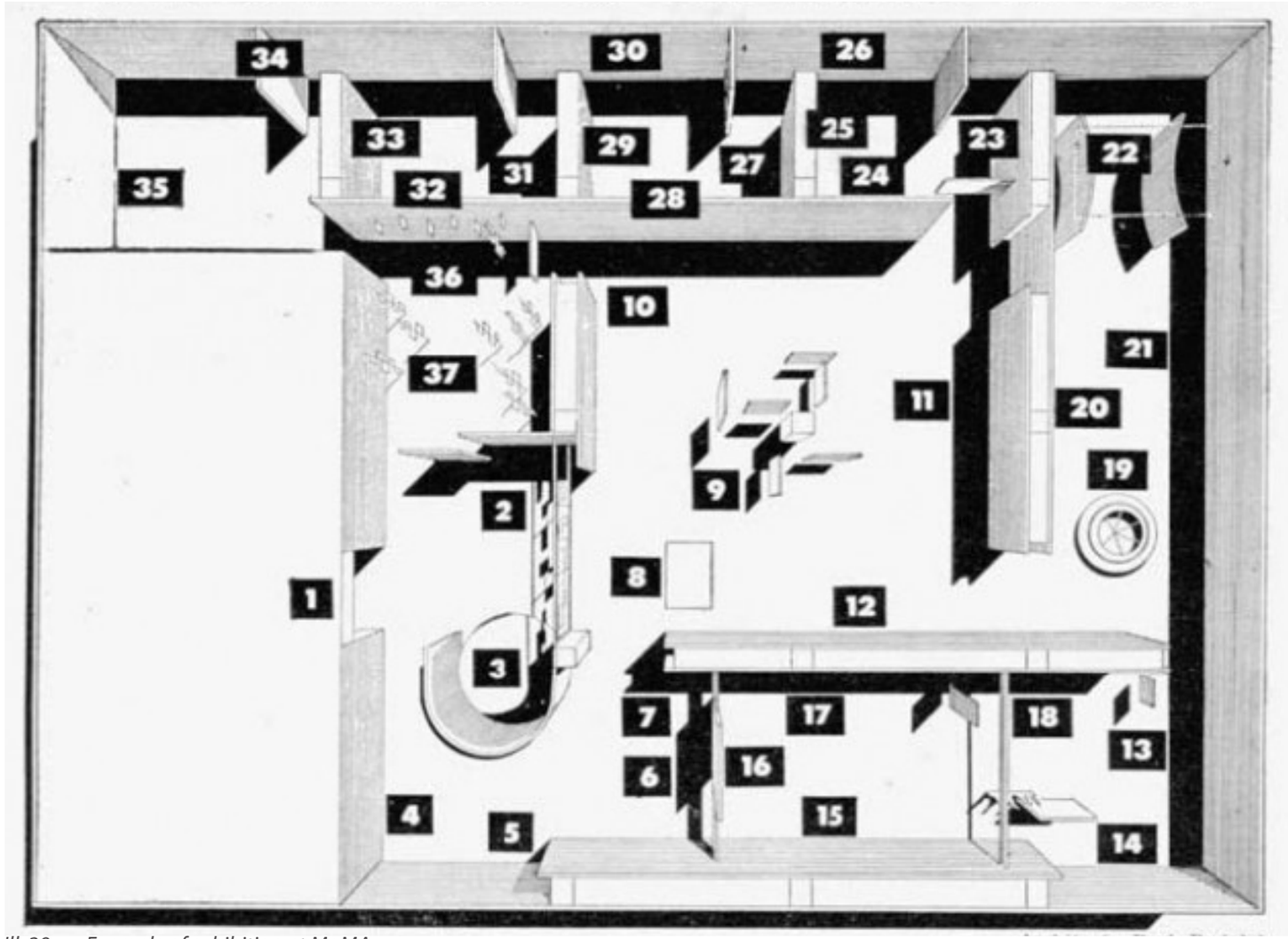
Looking at two different layouts of known museums, it should be possible to see how the more open plans of the museums allows for much more variety in the order of the exhibition and thus leaves the decision of what to be seen up to the individual visitor.

The Metropolitan Museum of Art, also known as "The Met", in New York City, exhibits collections many different forms of art from all over the world. Although the collections are divided into categories, the individual areas, as many other international art museums, consist of many individual rooms interconnected with each other in several ways. As seen here in the Nineteenth-century European Arts Gallery of the museum, nearly every room is connected to its neighbours on all sides. This breaks up the paths of the visitors who are freer to roam around and discover the artworks on their own. On the other hand it may also leave several rooms unvisited as no clear distinction of which rooms have been visited is available nor is it clear from which rooms it is required to moved into the other rooms in order to reach all the art works.



Ill. 28 19th Century artist wing at the Met

Museum of Modern Art or "MoMA" also in New York City, shows a bit more structured, although still rather open layout. The room of the exhibition is rather open with dividing walls creating smaller sections wherein the art pieces are placed. The layout of the exhibition creates a distinctive order in which the pieces are meant to be seen although any other order can also be taken by the wish of the visitor. As the inserted obstructions that creates the different sections are mostly detached from the surrounding walls they appear as the inserted objects they are and make it easier to distinguish them from the borders of the exhibition, letting the visitor know that there is more to investigate.



Ill. 29 Example of exhibition at MoMA

Although art museums may be better off allowing the visitors to move around freely, and explore the different corners of the museum and their own pace and interest to the different artists or styles, the core concept of the proposed museum in this case is to tell the chronological story of the actions undertook in the heavy water missions. As the story is only parted into seven parts, the storytelling heavily relies on the visitors explores every following exhibition for the whole story to come through. To do so and to allow for the most freedom in placing the rooms throughout the site, the approached plan of the museum's exhibits are laid out as pearls on a string, with each room in succession of each other, ensuring the chronological order.

VOLUME STUDIES

To explore the many solutions into creating the concept of the museum, a multitude of different approaches were tried in models and digitally to investigate the different properties of the proposed designs.

To do so, the overall area required, was estimated from the spatial programming and through the exercises of experimenting with the geometries, the total area was attempted to be kept as closely to the required as possible.

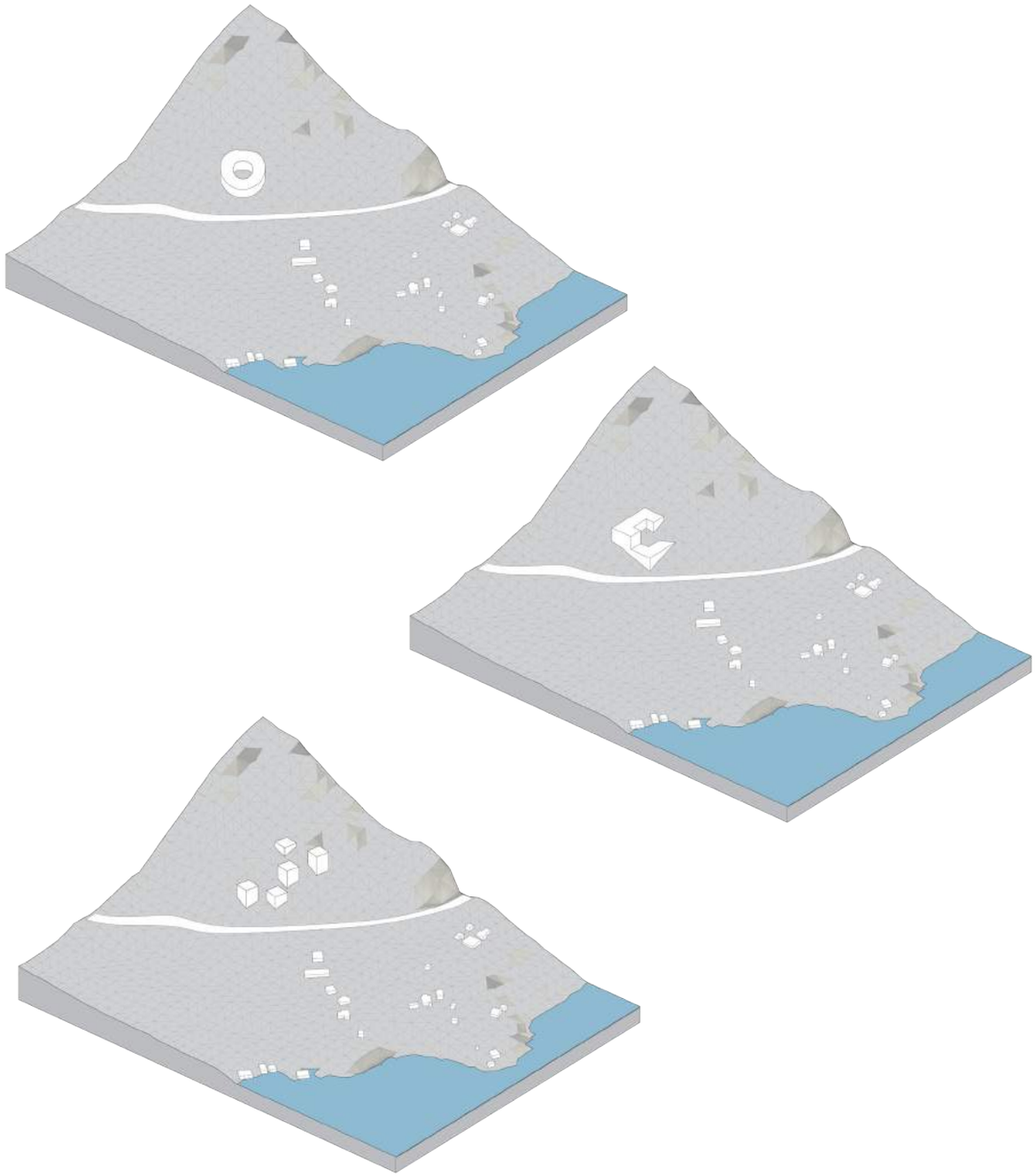
By looking at the pros and cons of the different designs it is possible to deduct the potential of each design and its effect on the surrounding landscape. These can be compared and from here the general layout of the museum can be deducted before the actual layout and design is begun.

The different volume studies are all placed into same context and from here considered against each other and the requirements for the museum defined by the competition brief and the vision among other requirements given to the museum.

Circle
The first proposal is a close approximation towards a tube protruding from the ground. The circular form of the geometry creates a closed loop, which can take the visitors all the way around the exhibition and back to the entrance in one movement. This clearly defines the designated path around the exhibition but the rooms are also strictly locked into the geometric shape and exposure to the surroundings is controlled by the openness of the structure in the specific room together with its placement into the ground, only controlled by the natural shape of the terrain. The roof is angled downwards to allow views to the surroundings from the higher parts of the circle over the lower parts.

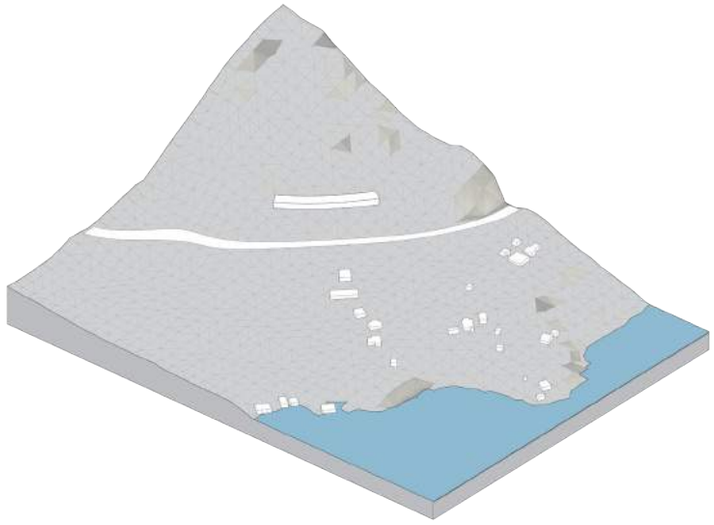
Square
Much like the circle, the square in question creates a closed loop due to its hollowed out centre. The shape is cut into two storeys, allowing for use of the roof of part of the structure from the other and at the same time, it digs into the mountain, completely covering parts of the building. This naturally allows for completely darkened rooms and cuts down on the visible amount of the structure. The stricter shape breaks from the surrounding nature and creates a more distinct structure in the landscape.

Columns
The smaller individual structures are spread out through the landscape and create an appearance related to the houses lying below the site. By dividing the structure into several smaller buildings, the layout of the museum is opened for much more diversity where each structure can be rotated and manipulated to fit the requirements of each individual exhibition room as needed. The structures need a way of being connected to be able to create a complete museum but this opens up for many possibilities of ways to bring the visitors from one structure to another.

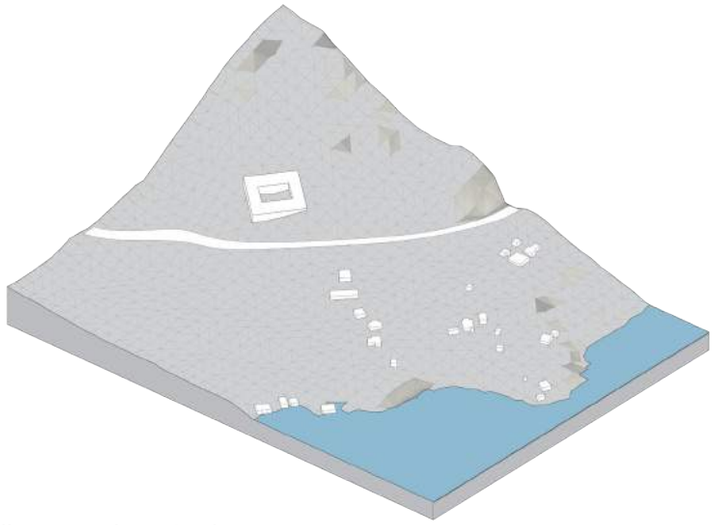


Ill. 30 Volume Studies

Bar
A long single structure, stretching across the site allows for all the exhibition rooms to be easily connected. The structure curves with the terrain, around the mountain while slowly descending, somewhat symbolising the sinking of the ferry. As the visitors reach the end of the structure, there is no clear way back and either the structure must be divided in half, creating one side of rooms with a possible view and another shielded between the outside and mountains. Otherwise, the structure could be split and a new, descending bar could return the visitors even lower at the point of beginning. This would require a multi-storey entrance building and care must be taken as to not make the inclines to big.



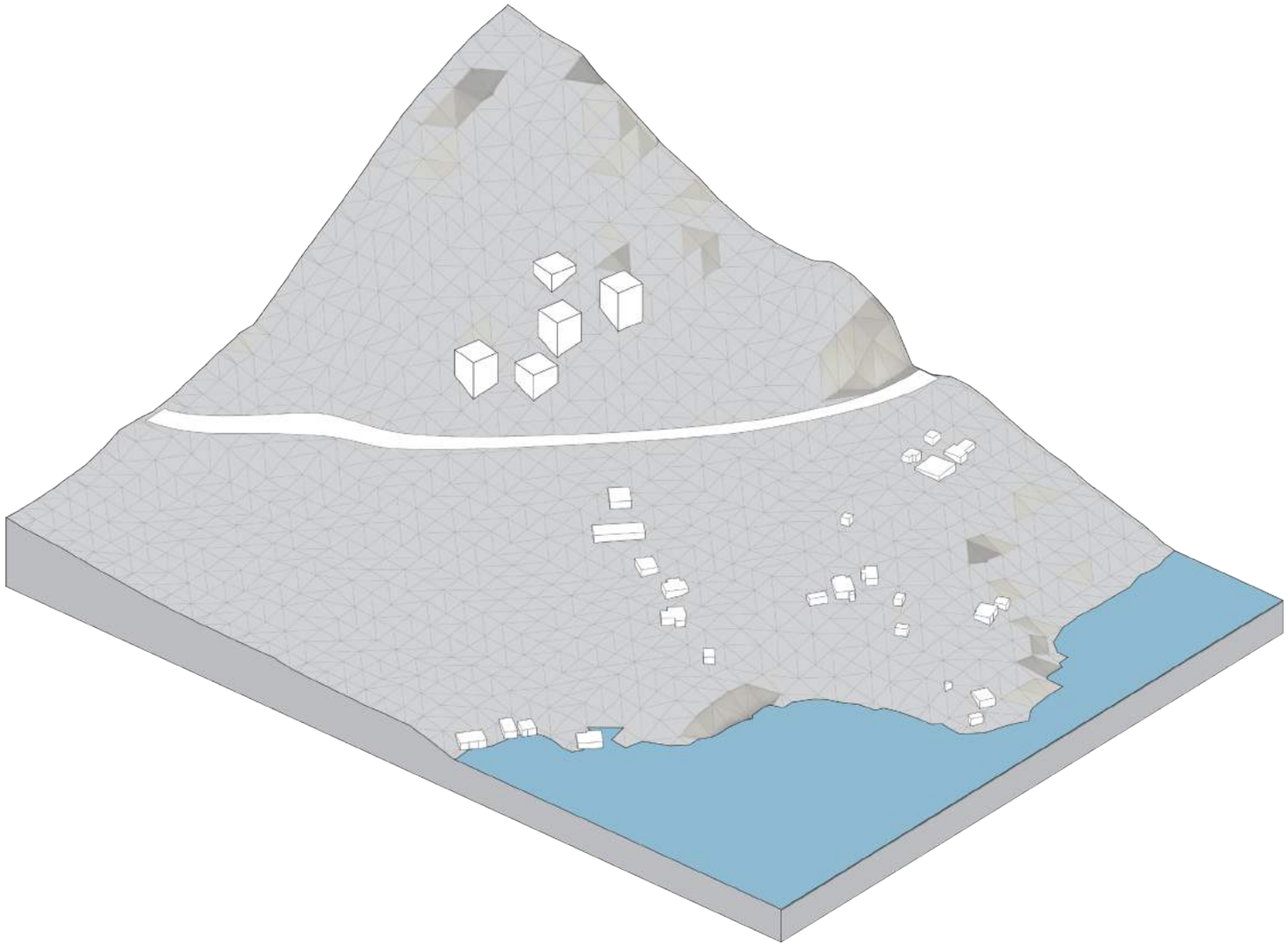
Tilted square
Much like the circular structure, the tilted square brings the visitors around the exhibit and back towards the entrance in one storey. Due to the rectangular shape, the rooms of the exhibition will have distinct properties regarding to their individual orientation, which cannot easily be corrected in accordance with the room requirements. Compared to the other square, the one storey creates a more unified appearance, which lies better with the nature surrounding the museum.



Ill. 31 Volume Studies

As most of the proposed volumes tie everything into a strict order, they appear to prevent the individual rooms of the exhibit to fully develop their potential regarding the required atmospheres. The "columns" is the only of the highlighted proposals that allow for this to happen. By examining the "bar" and the troubles regarding bringing the visitors back towards the entrance, it can be deduced that the exhibition should form a sort of closed loop wherein the visitors are brought around to the exhibits, but also back towards the entrance. This will also be preferred for the requirements of the views from within the last room of the exhibition, looking towards the sinking of the ferry.

Working off a concept of a visual impression for the museum of individual pavilions placed onto and into the mountain within the site, from where each of these pavilions will provide the design basis for creating the optimal conditions for the desired experiences to be met. To encompass the need for a continuous movement between the exhibition rooms, underground tunnels are to be dug between the rooms according to the layout of the rooms in chronological order. This also allows for the rooms to be moved into different heights to better merge in with the surrounding terrain.



Ill. 32 Principle of the Museum Design

ARTICULATING THE EXHIBITS

With the general concept for the museum in place, each room of the exhibit along with the general entrance building containing the cafe and shop among the more educational rooms. The following section will describe the closer detailing of the proposed design for the individual buildings and their collective creation of the museum.

OBJECTS

Each individual room of the exhibition is related to a specific part of the story of the heavy water actions and thus most of the exhibited objects in the museum will be closely confined within a specific exhibition within the museum. Besides the many historical objects included in the exhibition, the rooms will also contain imagery in the form of either video or posters, telling and enhancing the current exhibition's story to inform the visitors and define the red line going through the chronological storytelling of the museum.

As no definitive program has existed for the proposed museum, all objects to be included in the exhibition has been required to be defined from the ground up. Inspiration has been taken in how the Danish Resistance Museum has been described in its competition brief, although all decisions and selections of objects have been made solely on the quality of their presence within a museum related to the local, Norwegian resistance missions.

Introduction
In the first chamber of the exhibition, the visitors are introduced to the state of Norway during The Second World War. The country being occupied and more specifically the British intelligence have discovered the production of heavy water in the Vemork Plant. This part of the exhibition is meant to teach the visitors about the condition of living in Norway and why the production of heavy water was needed to stop the Germans from being able to join the research into nuclear weapons.

The exhibition is to include German uniforms and other smaller objects the average Norwegian would be able to run into in his daily life as the first part of this room's exhibition. Projections are to be able to be shown on the walls and can change from Norwegian daily life over information on the nuclear researches under The Second World War to introducing the visitors to the Norwegian resistance movements.

Within the exhibition objects related to the production and use of the heavy water will also be present. As many of the objects from both parts of this exhibition will be actual memorabilia from WWII, their requirements towards protection from deterioration will be rather high. Many objects are to be kept out of direct sunlight and smaller, fragile items are also to be kept away from the visitors. Therefore, most of the exhibited items will be kept in display cases in which the light can be sharply controlled. To be able to keep both the objects protected and the possibility to projects video in the exhibition, the room is to be sheltered from the outside and instead be lowly lit through controlled, electrical light.

Landing
As the exhibition in this room depicts the different attempts at landing soldiers and agents onto the fells surrounding the Rjukan-area, focus will be on the equipment used as well as on the faiths of the several unsuccessful attempts. The main objects of the room will be a fully deployed parachute hanging from the ceiling of the exhibition room. To introduce the feeling of being part of the air deployment, video from parachute drops will be projected onto the walls.

Around the exhibition room, other artefacts related to the paratroopers are to be exhibited. These include a full armour stand showcasing the equipment carried by the troops when being dropped, smaller objects in display cases of the same kits as wells as explaining the faiths of the many troops either caught by the German forces or killed upon impact of their crash landings.

Similarly, posters will, also in this exhibit, tell the story and further pass on the part of the heavy water actions showcased within the room.

To be able to deploy the full parachute, and have it hanging over the rest of the exhibition, the ceiling height of the room must be able to accommodate the height of the parachute. To protect many of the objects and allow for the projection of film within the room, direct sunlight, as a minimum, must be avoided.

Sabotage
The attack on the Vemork Plant by the mission group is depicted in the third room of the exhibit. Here the visitors are introduced to the production of the heavy water through full size equipment similar to the ones used in the plant to produce the heavy water. As these are made of stainless steel, they will be robust enough to withstand both the audience and any types of light.

The exhibition also includes the approach to the plant in which the crew were to sneak past the German guards of the plant and infiltrate the production facility. To visualize this part of the mission, the different equipment parts used by the group will be exhibited along with depictions of the guards of the plant. These items include different weapons along with the explosives used to destroy the facility and should hence be protected from the audience using display cases. Most items will not be severely affected by daylight, although direct sunlight should be avoided.

Escape
After the successful sabotage mission, the group had fulfilled its mission and thus split up to avoid capture of the Nazi forces. As this was completed mostly by travel across long distances, not many objects are to be shown. Instead, the focus of the exhibit will be to relay the history of the individuals partaking in the missions and their story. (VG.no, 2015)

The exhibit thus contains mostly posters describing the individuals and their further journey along with few smaller objects that fits with the telling. The main piece of the exhibit will be an overview map of the groups travel routes towards Sweden and freedom. As neither of the main objects of the exhibit are affected by the light, no strict requirements lies upon the exhibit.

As the room is also meant for a smaller break within the tour of the museum with views towards the surroundings, a small instalment of furniture is to be placed so that the views can be enjoyed from these.

Living on the fell
Although most of the members of the group fled towards Sweden, a few stayed, operating the radio contact with London. After the sabotage missions, they could no longer possibly interact with the citizens of the Rjukan area and instead had to keep to themselves, living off of what was to be found upon the fell. (VG.no, 2015) The exhibition room is to exhibit these living conditions.

The story of brought forth to the visitors within the exhibit will rely on descriptive posters, while the central pieces of the exhibit will consist of three larger objects. A skier in full outfit similar to what was used will represent their means of transportation between the different hunting lodges used during their yearlong occupation of the fell. Similarly a stuffed reindeer, one the few sources of food for the men will be part of the exhibition next to a small rocky piece of nature, showing yet another of their most important food resources, growing moss.

Due to the nature of the subjects of the exhibit, no direct requirements of the light is needed, although direct sunlight might quicker tarnish both the stuffed reindeer and probably the skier, why they should be kept to a minimum.

Bombing of Vemork
The bombing of Vemork is one the darker highlights of the campaign, in which the Allied tried to bomb the restored plant, to prevent further production. Sadly, the bombings took their toll on the city of Vemork and killed several civilians.

To let the visitors really understand the effect of the bombings and how heavily the town was hit, the exhibit will consists of approximately 730 500lbs pounds, similar to the ones dropped on Vemork. To accommodate this amount of bombs, they will be interred under the glass floor, allowing the visitors to move freely above them inspecting the rest of the exhibit. This will mostly rely on pictures of the aftermath of the destruction along with a single bomb for inspection up close by the visitors.

Sinking of the DF Hydro
As the exhibition draws towards its closure, the final part of the story is told. Here we follow the transport of the produced heavy water from the plant in Vemork towards Germany.

The main object of the exhibition will be a train cart similar to the ones used for the actual transportation. This will be accompanied by yet more posters depicting the transport and the later destruction of the ferry. Neither objects requiring special focus regarding exposure to natural light.

A small display case will showcase some of the equipment used to construct the timed bombs while the rest of the exhibition mostly relies on the views of the lake, showing the route of the ferry.

The final point of the exhibition will be a direct sightline towards the ferry's final resting point within the lake.

The many objects decided to be exhibited at the museum helps define some of the final requirements for the light. Although the main object of the use of natural light will be to create atmospheres within the exhibitions to enhance the experiences of the visitors and further emerge them into the story, the protection of the more delicate objects cannot be disregarded and must therefore be an important factor when designing the exhibitions through their individual atmospheres.

LIGHT AND EXPERIENCE

As all individual rooms of the exhibition are to represent an atmosphere related to their part of the story of the heavy water actions, each room must be designed with regard on how the light affects the appearance of the room to the visitors.

The investigations into the experiences of the exhibition rooms have been done through the use of the integrated design process in which several disciplines have been combined to define and further refine the final design of the rooms of the exhibition through several iterations. In the following parts, some of the processes partaken in determining and executing the desired atmosphere experienced by the visitors, of the exhibition rooms will be described for two of the rooms where the techniques used differ most from each other.

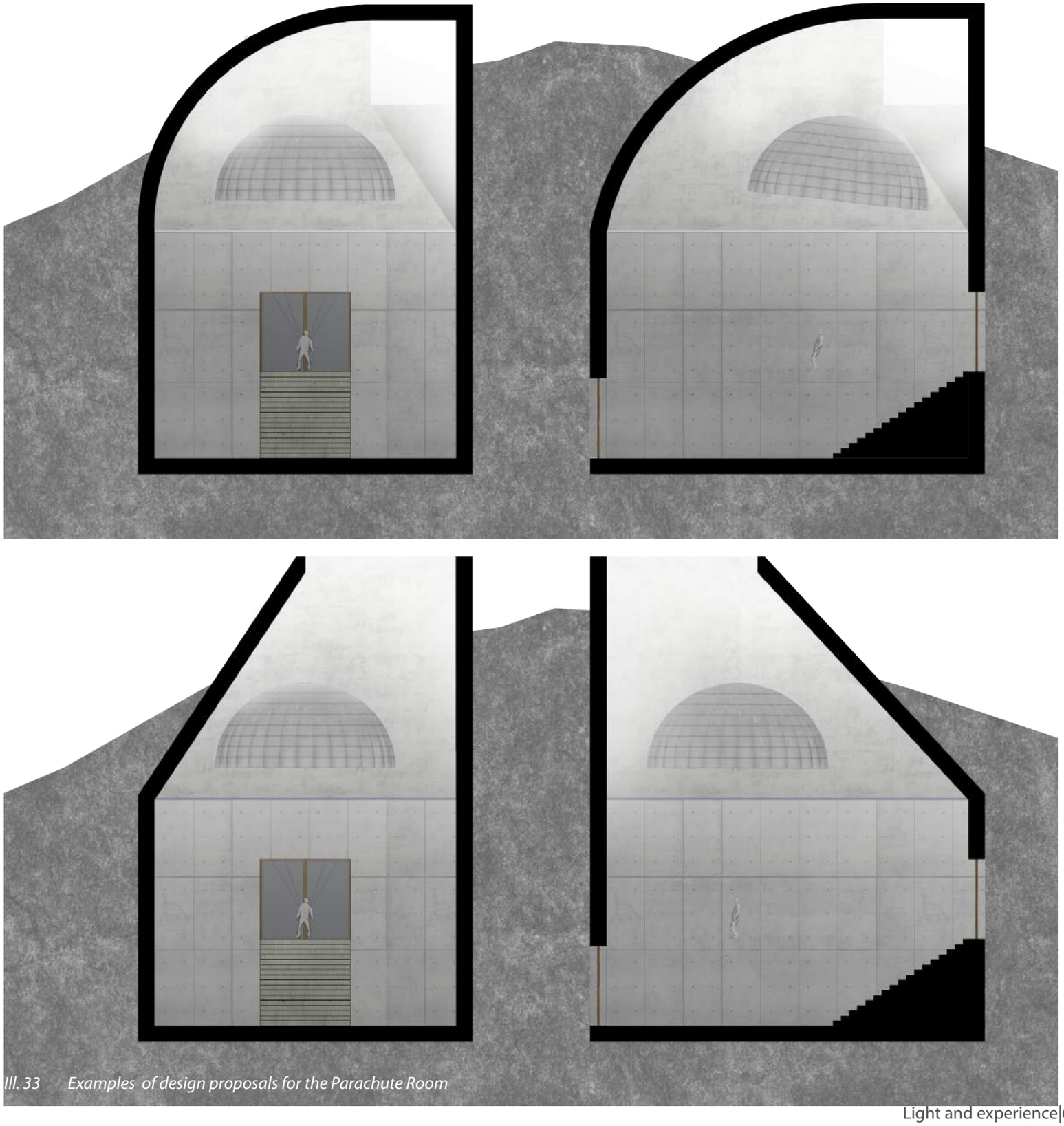
LANDING

The goal of the exhibition for the landings of the members of the group upon the fell is to create the experience for the visitors of partaking in the landings themselves. The room is to have the daylight coming in from above, creating a diffuse setting in which a deployed parachute can scatter the light through the room while the intensity of the light slowly fades off as the light is brought closer to the ground of the exhibition.

To achieve the desired effect, several concepts were thought up using different ideas of how to bring the light into the building and from there disperse out through the whole volume of the exhibition. From the sketches, the most promising results were further investigated in digital 3D-models before being turned into physical models to compare the results of the digital simulations with testings in real life.

The two concepts illustrated here represents two different approaches. The first uses a vaulted ceiling that reflects the incoming light in downwards in many angles. The opening is facing towards south-east to obtain as much light from both the direct sunlight as well as daylight.

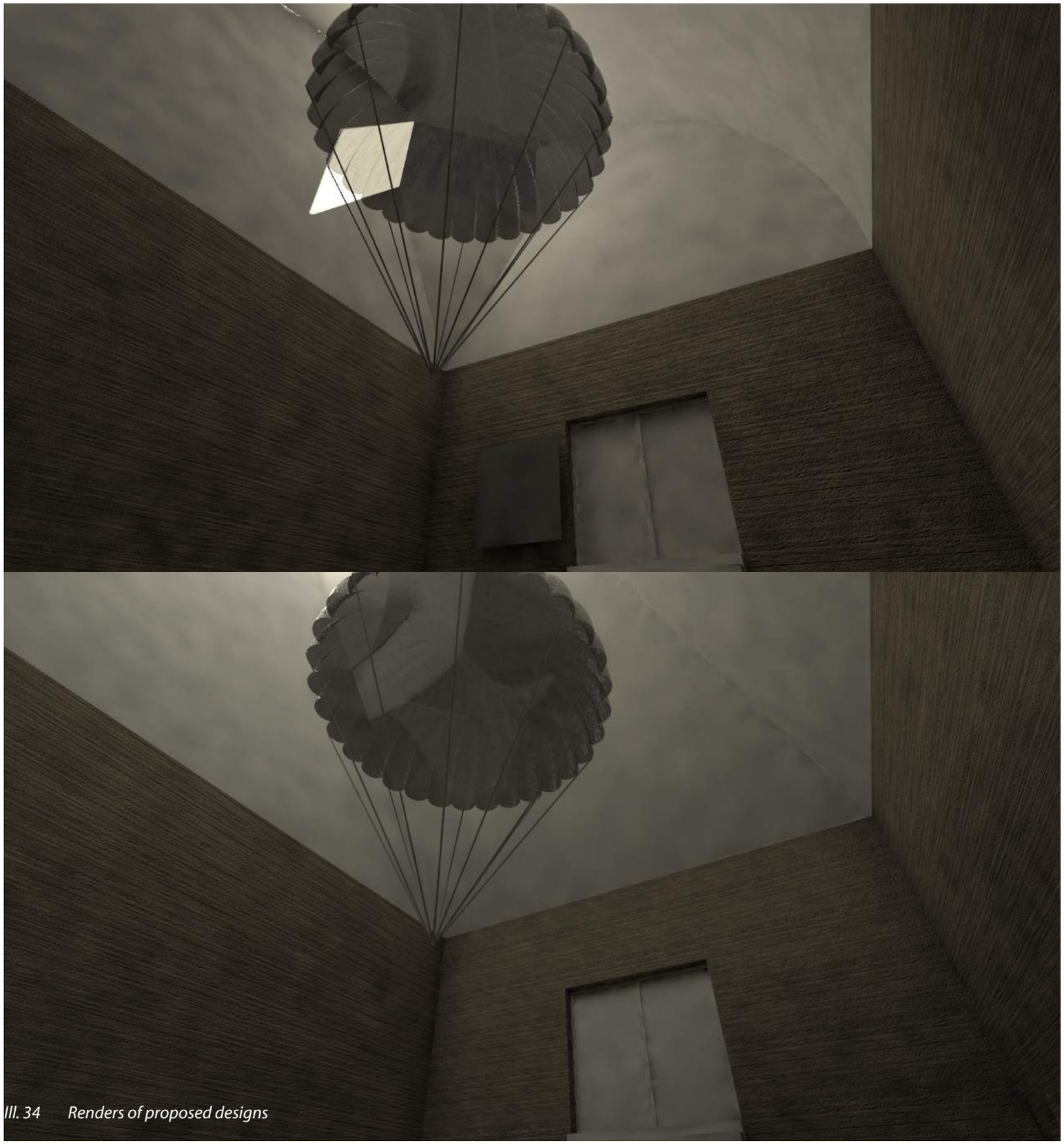
The second focuses more on the daylight. The ceiling is tilted, leaning towards the noth-eastern corner of the room where a square opening lets in the light through the roof. Any direct sunlight will in this case be reflected straight of the walls, diffusing it severely from the beginning.



Ill. 33 Examples of design proposals for the Parachute Room

As both concepts seem to have their advantages, simulations are brought further in rendering the experienced light from the 3D-models. From the vaulted roof, the direct light can be seen hitting the side wall of the ceiling construction. From the opening the light appears bright and slowly dissipates as it moves away from the opening and down into the room, with most light still around the walls leading to the opening.

Not much changes when comparing the second proposal. The light have now shifted to the north-eastern corner instead, which may ahve a stronger affect on moving the visitor's eyes towards the deployed parachute, as they will now be staring through the room through the parachute towards the opening from the entrance instead of having the opening above them.



Ill. 34 Renders of proposed designs

For further investigations, small physical models have been built to test the practical effects happening from the placement of the ceiling light. When try to re-enact the desired lighting effect in the vaulted ceiling, strange artefacts appear on the walls from reflected light, breaking the harmony of the conceptualised, uniform fading of the light. With little control as to where these artefacts will appear within the room, the design seem to be losing some of its initial value as a concept for the shape of the room.

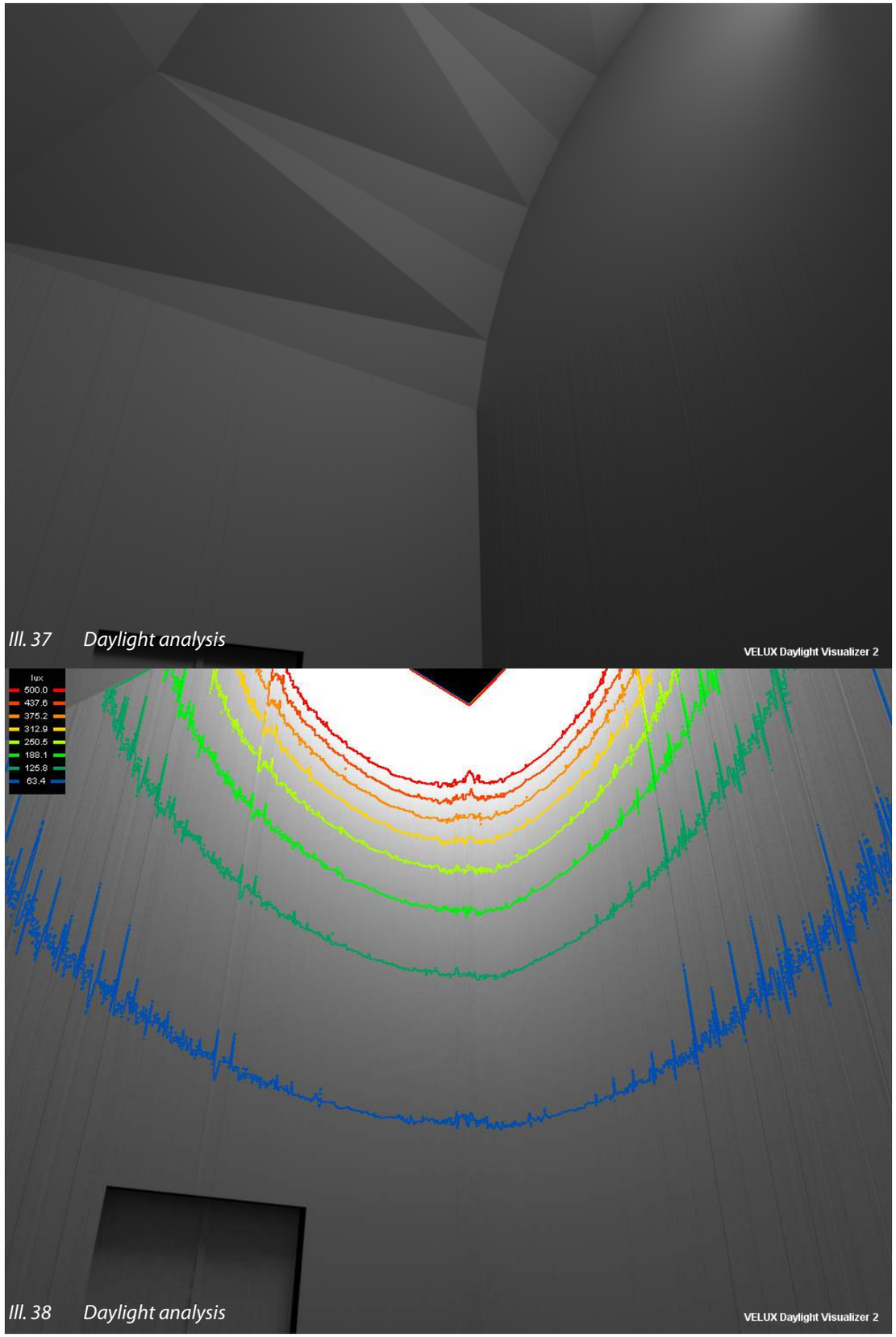
On the other hand, the raised corner of the other prospected concept shows the light reflecting off the corner and into the room. As the opening is places the longest away from the path of the sun, the direct sunlight must be bounced off the wall directly as it enters the room, which leaves it much more controllable.

Ill. 35 Physical model of vaulted ceiling

Ill. 36 Physical model of raised corner

To further proove the concept, the two alternations of the design are simulated with Velux Daylight visualizer to compare the results metrically. When looking at the results of the vaulted ceiling, the same artefacts as the physical model revealed seem to show up again. The light does not spread through the room evenly, but instead seem to "collect" in areas. Part of the result may be from the rough draft of the 3D-model used, but when the results seems to be possible to replicate through physical trials, it cannot be exclusively blamed on the modelling tools used.

The raised corner's simulation shows what appear to be rings of the fading amount of light within the room. With a close to uniform distance between the rings, the amount of light fading off must be close to uniform, creating the gradual darker concept desired within the room.



Ill. 37 *Daylight analysis*

Ill. 38 *Daylight analysis*

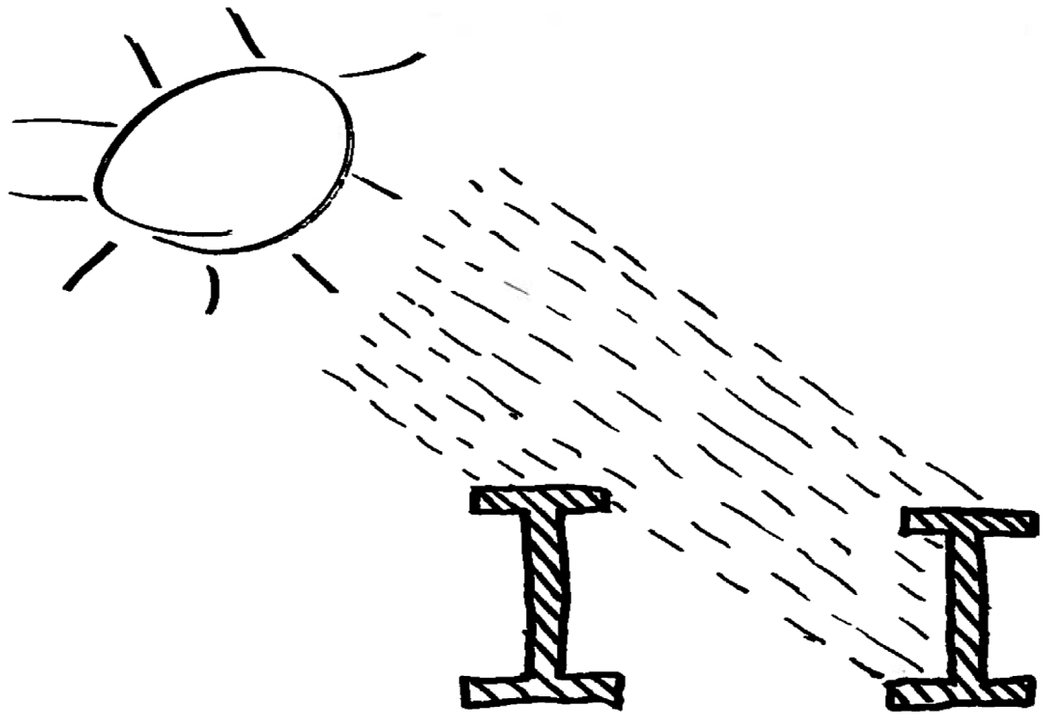
After doing many trial with several conceptual designs, the raised corner stood out the most as being the design closest to the desired experience within the room. The placement of the opening in the most northern corner clearly helped to prevent direct sunlight reaching anywhere within the room, but was rather diffused as quickly as possible by being bounced off the walls.

LIVING ON THE FELL

For the fell room, the conceptualised experience for the visitors is meant to give them the feeling of actually visiting the barren fell with its high, diffused sunlight, leaving no clear shadows on the surroundings. To achieve this effect, the idea is to create a roof consisting of roof lights, being reflected off their structural members and thus being diffused throughout the room.

By constructing the structural part of the roof of the exhibition of transversal steel beams which will carry the roof structure and acts as the reflectors for the sunlight. To be able to control the amounts of snow and rain that the roof will have to endure, the roof will consist of a pitch roof consisting of glass surfaces towards the south and roof towards the north.

As the beams are to reflect the sunlight, they must be placed evenly across the length of the building in such way that the highest elevation of the sun will not be able to allow rays of sun reaching in between the placed beams. To do so either the height of the beam or the distance between the beams and thus the number of beams can be altered to reach the desired coverage.



Ill. 39 Concept of how the beams of the Fell Room protects from sunlight

Through the development of a spreadsheet calculating the forces of the beams and determining their structural integrity, as described in appendix 1, the solutions can be visually and aesthetically investigated through 3D-visualizations.

Besides the requirements of structural integrity in the beams, the aesthetical requirements to the chosen solution would be to allow for enough headroom above the visitors as to not feel confined while still be able to ahve large section of glass to transmit enough light into the exhibition. These requirements are rather soft and can thus only be determined through visual confirmations within the design process. Through several iterations forth and back between the calculations and visual investigations, a solution that resolves both structural and aesthetical requirements to the full extend was reached.

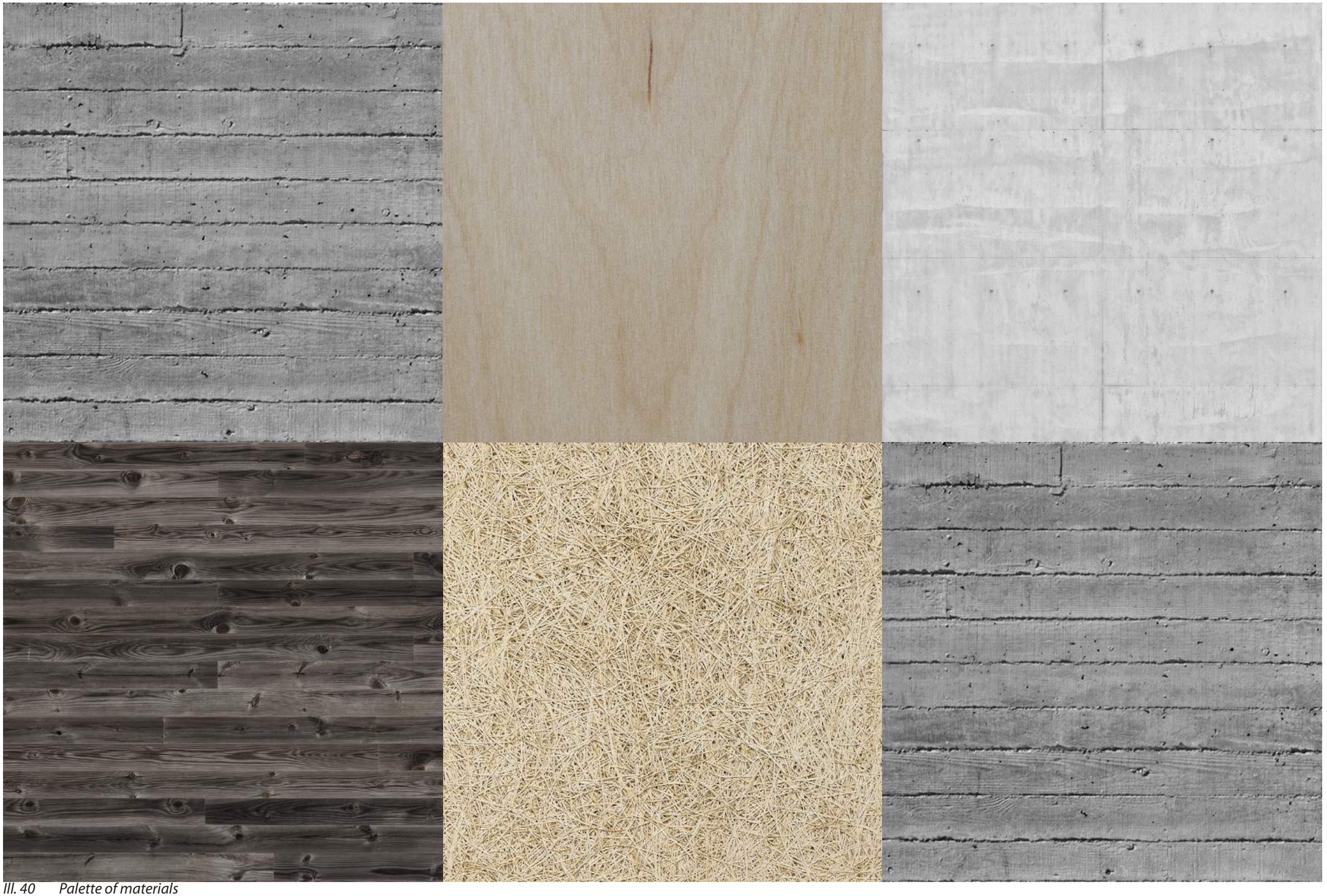
MATERIALS

While the walls of the museum are cast in-situ in concrete to match the excavated holes best possibly, the interior walls are finished with a thin shuttering technique, which leaves a slightly rough surface in long fine bands across the interiors, simulating a crafted finish on the rock itself. The colour of the interior concrete is kept in a medium grey tone, comparable to the local rock, while still maintaining some warmth to the construction.

To liven up the harsh concrete surfaces of the museum's rooms, wood materials are brought into the palette as flooring boards and furniture. The flooring is kept in a darker hardwood, while fine, bright birch plywood is used for display cases, the cladding of the hanging exhibition room within the main building as well as being the material used for the surfaces of the doors in between the different rooms of the complex. While the hardwood flooring brings life to the buildings, the darker colour helps to not bring attention towards the flooring but rather towards the exhibited objects, which are displayed on top of cases constructed from the lighter birch wood.

As many of the materials used in the construction leans to the harder side, the quality of the sound within the rooms would quickly deteriorate as the reverberation times would go up. To prevent this from happening, the ceilings of the museum are clad in sound absorbing fiber panels. The use of fiber panels was chosen to comply with the natural feeling which the random placement and sway of the strands in the panels accomplish. While choosing a light, natural tone for the colour of the panels, the ceiling is also given an extra dimension of life, helping to keep the ward off the darkness which could arise from building underground complexes in concrete.

The exterior of the museum is kept in white concrete to enhance the simplistic expression of the architecture.



Ill. 40 Palette of materials

CONNECTING BETWEEN THE EXHIBITIONS

Interconnecting the many exhibition rooms, a system of underground hallways is dug between the individual buildings in their chronological order. The importance of these hallways is to bring the museum together into one continuously experience for the visitors in which they are not forced outside the building, which could hinder the practicality of the museum through the very cold winter-season.

The passages are to allow free movement for all visitors, which determine their maximum incline to no more than 5%. (Trafik & Byggestyrelsen, 2014) This limits the height difference between the different buildings of the museum without extending the passages to extreme lengths. The target of the placement of the passages have been to find a solution to building in a terrain that, together with the demand for a closed loop of the buildings, dictates the need for placement of the structures at different heights.

To reach an acceptable solution, a small tool was developed through the use of Grasshopper for Rhino. The premise of the tool has been to connect the exit and entrance between two consecutive exhibition rooms of the museum and calculate and display the incline for the section of passageway. To utilize the tool within the designing of the museum, the instant display of the incline was used to determine the accepted height differences between each room of the exhibition while still securing their required placement in the landscape. In some cases, this means the incline will be too steep and thus other remedies must be taken to support the limit of the incline. By adding smaller bends to some passageways, the overall distance between the rooms was extended thus decreasing the incline. By adding the overall lengths to the instant display, all passageways were simultaneously determined to maintain manageable distances in between the exhibition rooms.

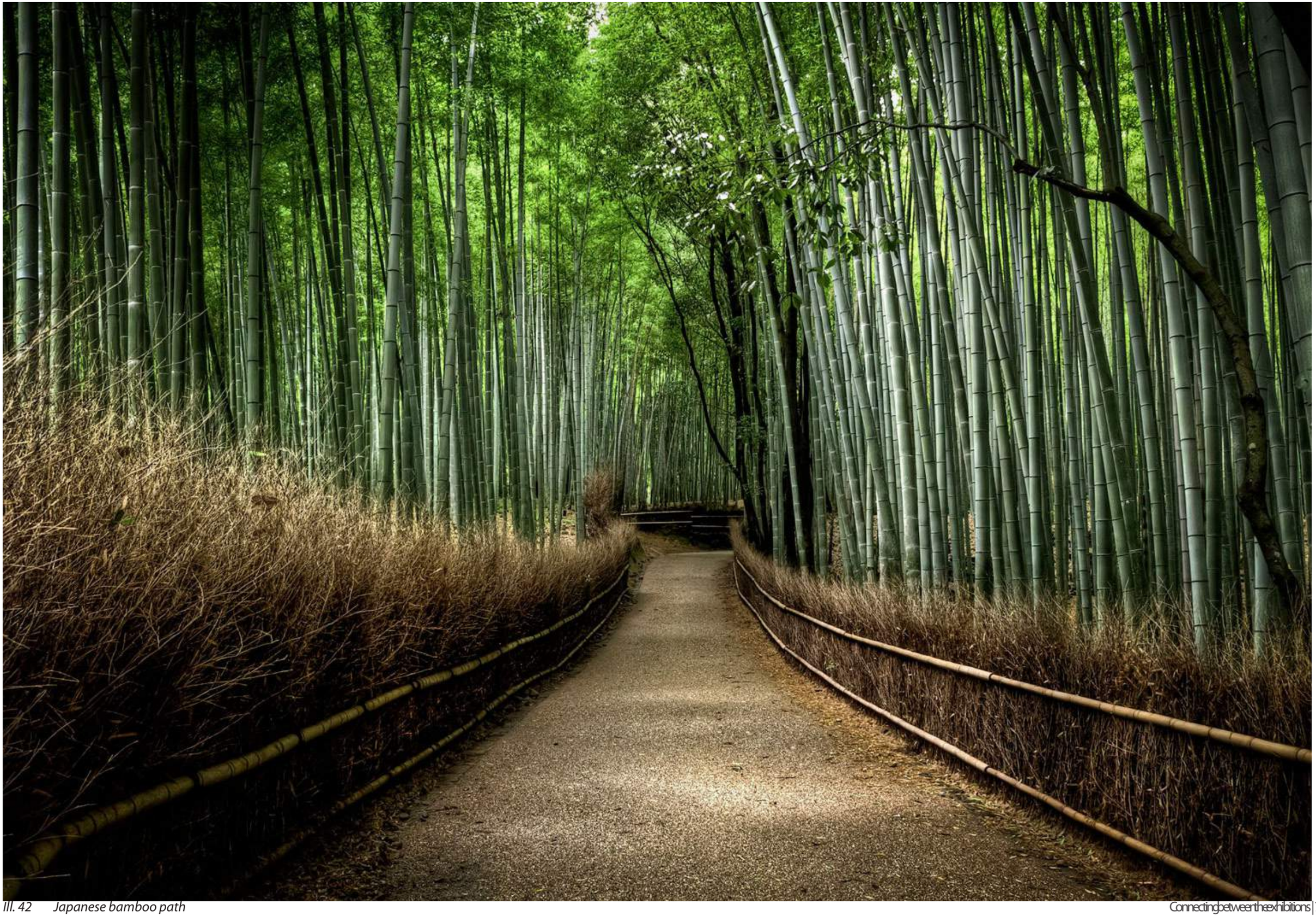
Ill. 41 Example of dug out tunnel through mountains

THE JAPANESE ENTRANCE

For inspiration to the appearance of the passageways, the concept of creating a break from the constant change of experiences in the exhibition rooms was determined. Instead, the passageways are to acts as a metaphorical palate cleanser, preparing the visitors to enter the coming part of the exhibition and being ready for a new experience.

The same concept can be seen in Japanese temples, where the entrance leads through a small path encased by bamboo growing to above head-height on both sides, creating a small, uniform section of path that requires the visitor to only pass through and not focus on anything in particular. Hereby the bamboo garden instils a mental serenity, preparing the visitor for the temple grounds lying past the end of the bamboo path.

To create a similar effect in the museum, the passageways are kept simple, with only bare rock on all sides and a solid floor leading towards the coming experience in the next exhibition room.

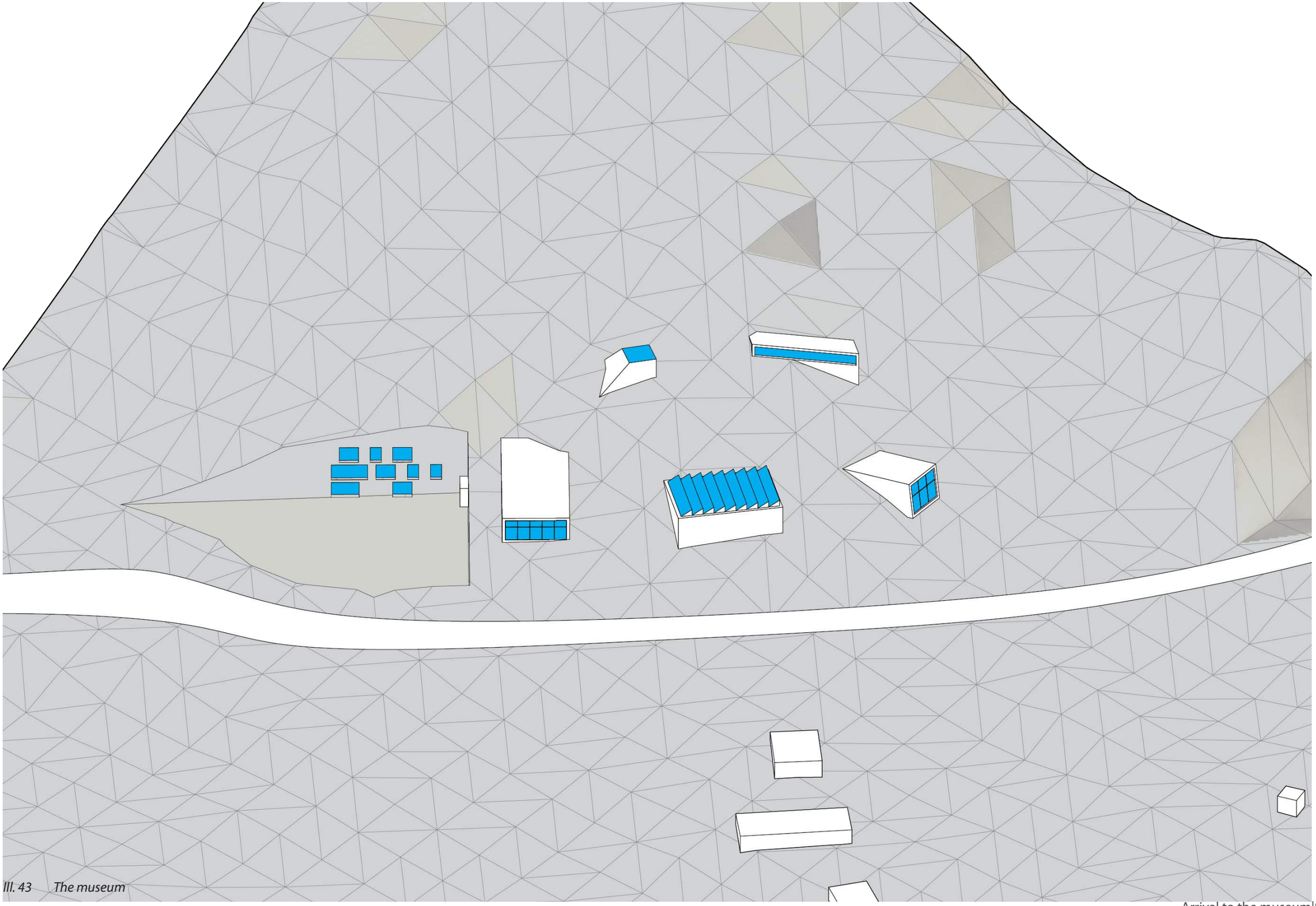


Ill. 42 Japanese bamboo path

ARRIVAL TO THE MUSEUM

When arriving to and departuring from the museum, its placement in and on the mountainside will be revealed to a much larger extent than what can be seen from within the museum and its exhibition rooms.

The vision for the museum's appearance is to be a visible marker of the events and the history it contains while still maintaining a relation to its surroundings.



Ill. 43 The museum

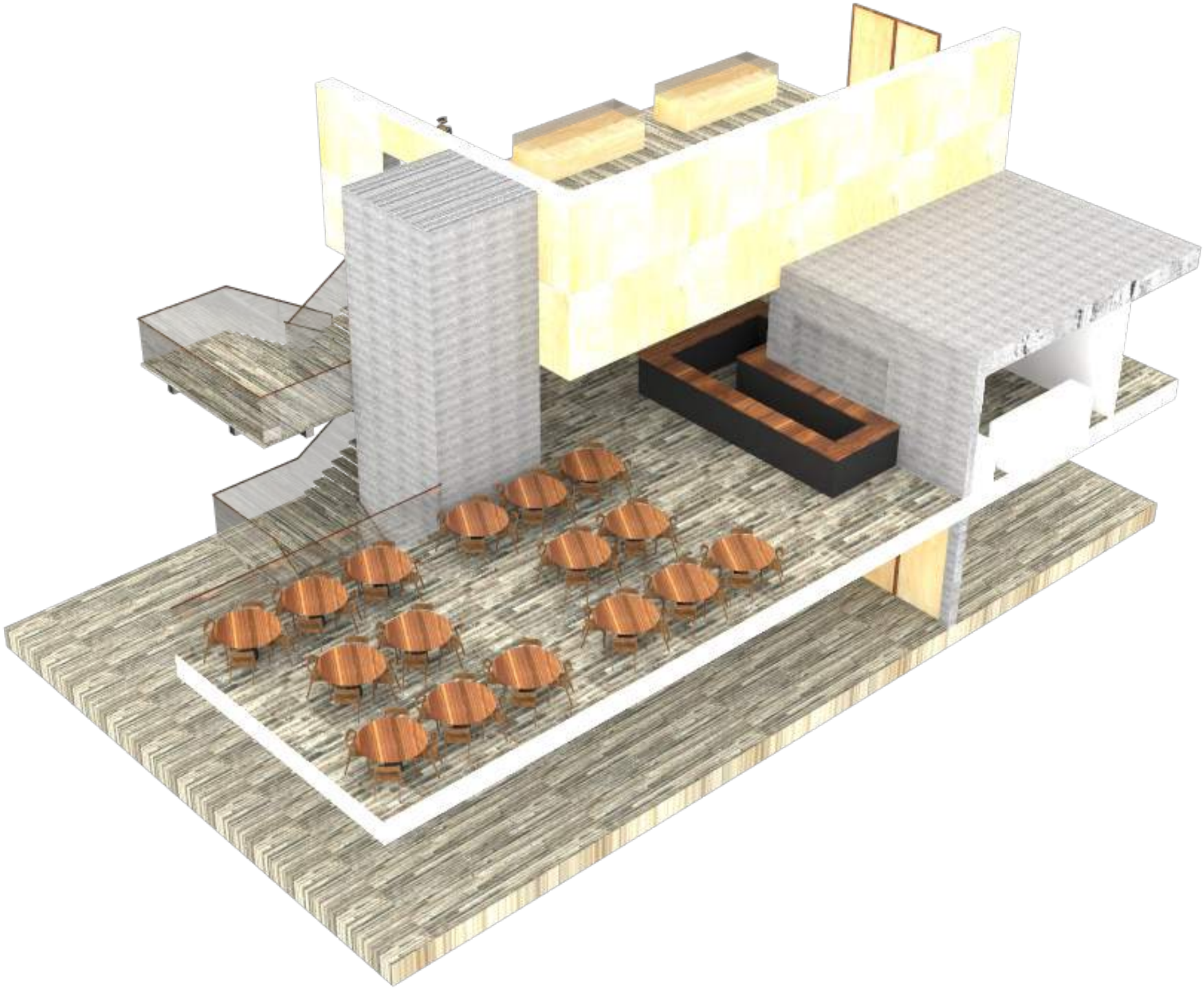
MAIN BUILDING

The main building with entrance dissociates itself visible from the rest of the museum by being built straight into the mountain. From the parking lot of the museum, the only visible expression of the entrance is the holes cut into the mountain-side, which represents the windows and door of the main building. Inside, the first floor opens up to a wide space in which different operations are able to take place. In the back, an auditorium allows for lectures and presentations while preparation rooms allows for preparing objects for the exhibitions.

On the second floor, the cafe and shop are run from the central placed desk with direct access to the kitchen to allow for the required minimal staffing of the museum. The first and second floor can due to their openness be used as a conjoined area for hosting larger events.

Within a wooden box, hanging over the shop, the first room of the exhibition, the introduction, is connected to the rest of the main building by the means of both the main staircase and the elevator serving all three floors. Due to its location within the main building it is either possible to include it in events held at the building, giving a small taste of the exhibitions or it can be locked off, keeping the guests within the two first floors.

From the introduction, the route through the exhibition leads the visitors on to the next story from the heavy water actions. At the same time, the final view of the sinking ferry from the exhibition, leads the visitors back on the second floor and straight into the shop area, ending the tour of the museum.



Ill. 44 Overview of the Entrance Building

LANDSCAPING

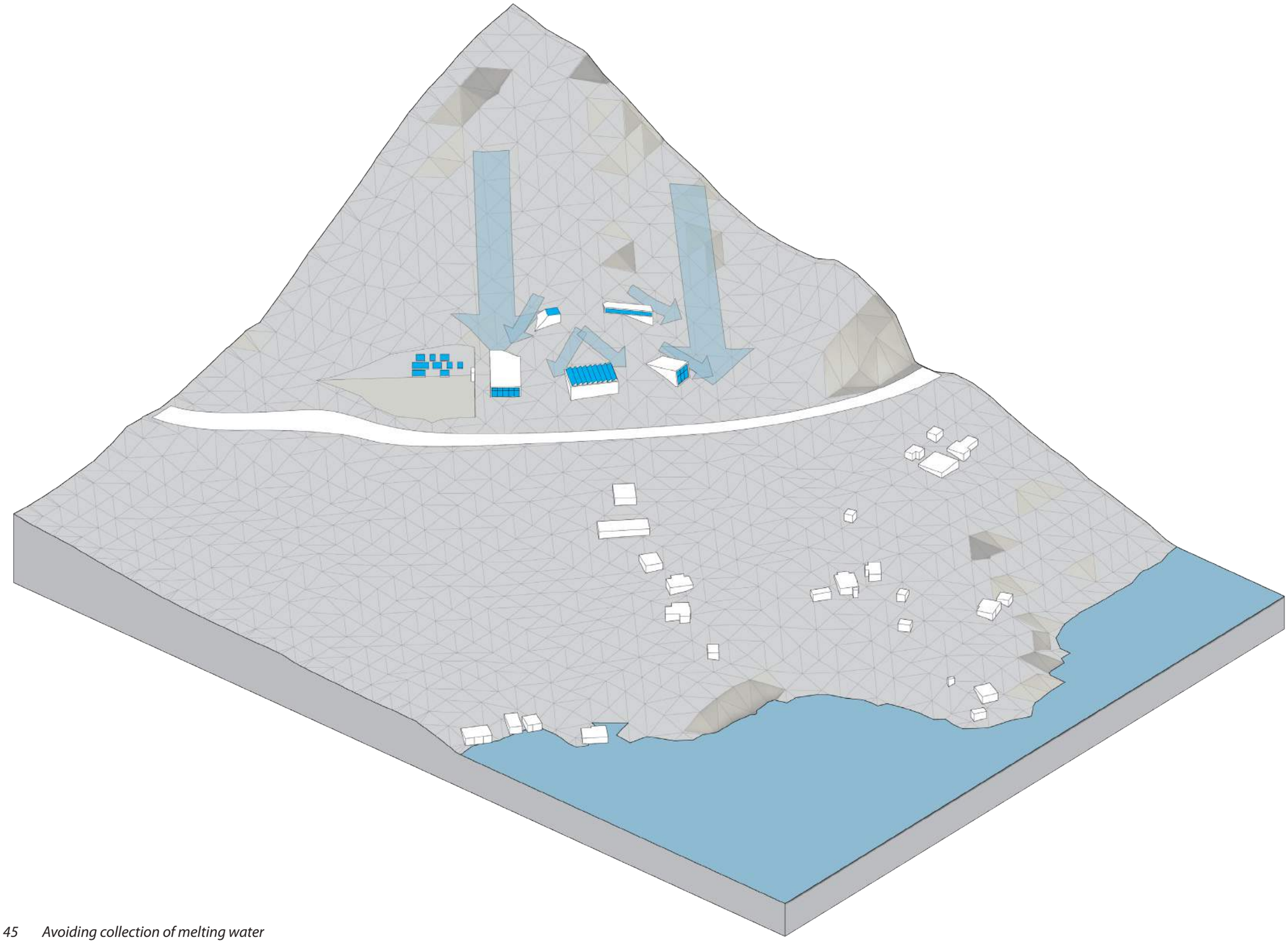
To keep the vision of respecting the surroundings of the museum, the mountain's surface is mostly kept intact. The only area, which is visible altered, is related to the parking lot in front on the entrance. To accommodate the visitors of the museum a cut is created into the mountainside, similar to discovered during the investigations of the serial vision of the nearby areas.

This leaves two sharply drawn faces of the mountain's interior visible, which are soften slightly by the openings of the main building and the protruding view from the ending of the exhibition. The horizontal face of the cut is kept with a small incline out towards the lake and down towards the southern direction of the highway, allowing for access to the parking lot.

The tilted surface of the parking lot also helps to drain off the accumulating amounts of rain- and melt water running down the surface of the mountain.

The issue of the large amounts of water collected by the surface of the mountain, needed to be drained into the lake has also has hat its influence on the placement of the protruding buildings of the exhibition. The two natural occurring channels within the mountain, running through the site of the museum, is kept clear of obstructing structures while the remaining buildings are placed on the higher parts next to these channels and rotated such, that any water ending at the surfaces facing the direction of the mountain is naturally led towards either of these natural channels.

The only occurrence where the structure is not kept out of the channels is the exhibition room depicting the sinking of the ferry. Instead, the roof has been tilted to allow the water flowing without obstructions over the roof and run down on the front of the building. Here a small overhang secures that the water leaves the building while providing a cascade of water running in from of the large panorama window, creating an effect of being about to be submerged into the water.

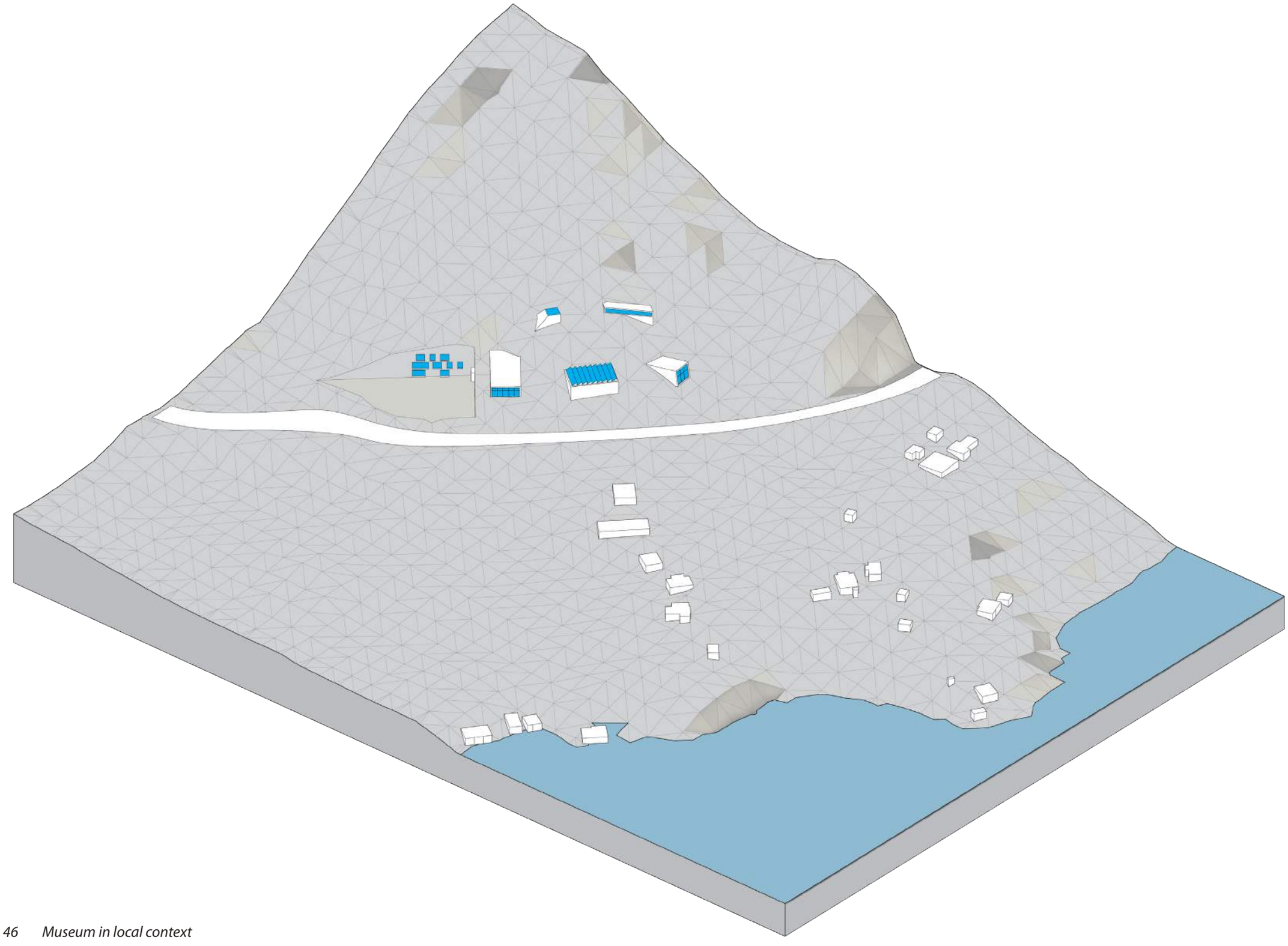


Ill. 45 Avoiding collection of melting water

EXTERIOR APPEARANCE

As the museum is divided up into individual structures from the outside with no visible connection, a similarity between the otherwise changing shapes of the exhibition is accomplished by maintaining the same use of materials on all visible exterior surfaces together with a simple expression to the design of the buildings.

The use of in-situ cast, white concrete creates a light and welcoming group of structures protruding from the mountain above the highway at the tip of the point where the Vestfjord reaches the lake. The divided look of the five visible exhibition rooms diminishes the conception of a large structure as a single building would, while somewhat imitating the huts and houses laying on the lower part of the point.



Ill. 46 Museum in local context

EPILOGUE

CONCLUSION

Through the working of integrated design processes and many iterations of the different rooms of the exhibition in the proposal for the new heavy water missions' museum, the final design touches many aspects of architecture and techniques of the skill.

The overall task has been to create a museum that could exhibit and emerge the visitors into the story of how a small group of men thought arms in arms against a much more powerful enemy and even so prevailed. To do so, the museum centres on expressing the story through atmospheres related to how the exhibition is divided up, leaving the guests with more than just a told story as they are almost re-enacting parts of the events while venturing through the museum. To express these atmospheres through architecture, the museum uses and controls the natural light as to alter it towards each individual experience, creating a pseudo reality within its exhibition rooms.

From the exterior, the vision for the museum has been to keep it underplayed and not stand out too much in the surrounding terrain, which is done through very simple geometric shapes protruding through the ground.

The scope of the project has been focused on expressing experiences through the altering of the natural light in the architectonical spaces, which has proven rather successful. By focusing the project and its tectonical approach on this one element, many other subjects that would be required for a complete and finished ready-to-build museum has not been investigated. For further development of the museum in the future, areas such as indoor climate and energy consumption would be just an interesting approach to do on the museum.

Shifting from the flat Danish construction sites and building on the side of the museum has proven to be difficult in many ways. The sudden change into being able to build and move each and every individual room within its own 3-dimensional space creates unlimited possibilities when trying to determine the best solution overall which has proven even more difficult when the project suddenly is done as an individual and no longer as a group.

Overall, the project has introduced me to many firsts, which by the result of the project, the museum, seems to have ended out quite well anyways.

PRESENTATION

Through a quick tour of the museum and its exhibits, the different rooms will be shown in their final form while the experience and function of the rooms are discussed.

CAFE

Standing in the seating area of the cafe, most of the entrance building is visible. The desk and kitchen can be seen straight ahead, while the shop lies under the wooden box that makes up the first room of the museum's exhibition.

The walls are kept in the same shuttered concrete as the rest of the museum rooms while the introduced wooden furniture and cladding of the exhibition box helps bring some warmth to the experience of the room. To the left, the open space tying all the floors of the entrance building together with the staircase and elevator can be seen.

INTRODUCTION

The introduction to the exhibition consists of the smallest of the exhibition rooms. The floor space is kept open to be able to gather group together while the lefts side is used for the exhibited objects and the right wall is intended for projection of video material.


THE HEROES
OF TELEMARK

LANDING

Entering the room, one's eyes are firstly directed towards the height of the room and the hanging parachute, scattering the incoming lights around the walls of the exhibition. While other paratroopers are being dropped to one's right, a full uniform and equipment is placed across the room, while posters are decorating the walls. The middle of the room is occupied by display cases, although enough room is still kept around these for even groups to be able to move around.

SABOTAGE

While sneaking through the narrow valley leading to the Vemork plant, the group of men where always in high danger of being discovered by the German guards, patrolling above. The same feeling should be brought to the visitors as the open surface of the cliff reflects the incoming daylight in to the slightly lit exhibition room.

Larger displays through the room are highlighted by electrical light for better viewing purposes.

ESCAPE

After venturing through the long hallways between the first couple of exhibition rooms and experiencing the dimly lit Sabotage, the visitors are greeted by a much lighter and welcoming room, opening up towards the surroundings. From here, the visitors can look inwards of the Vestfjord or towards the northern part of Lake Tinnsjø.

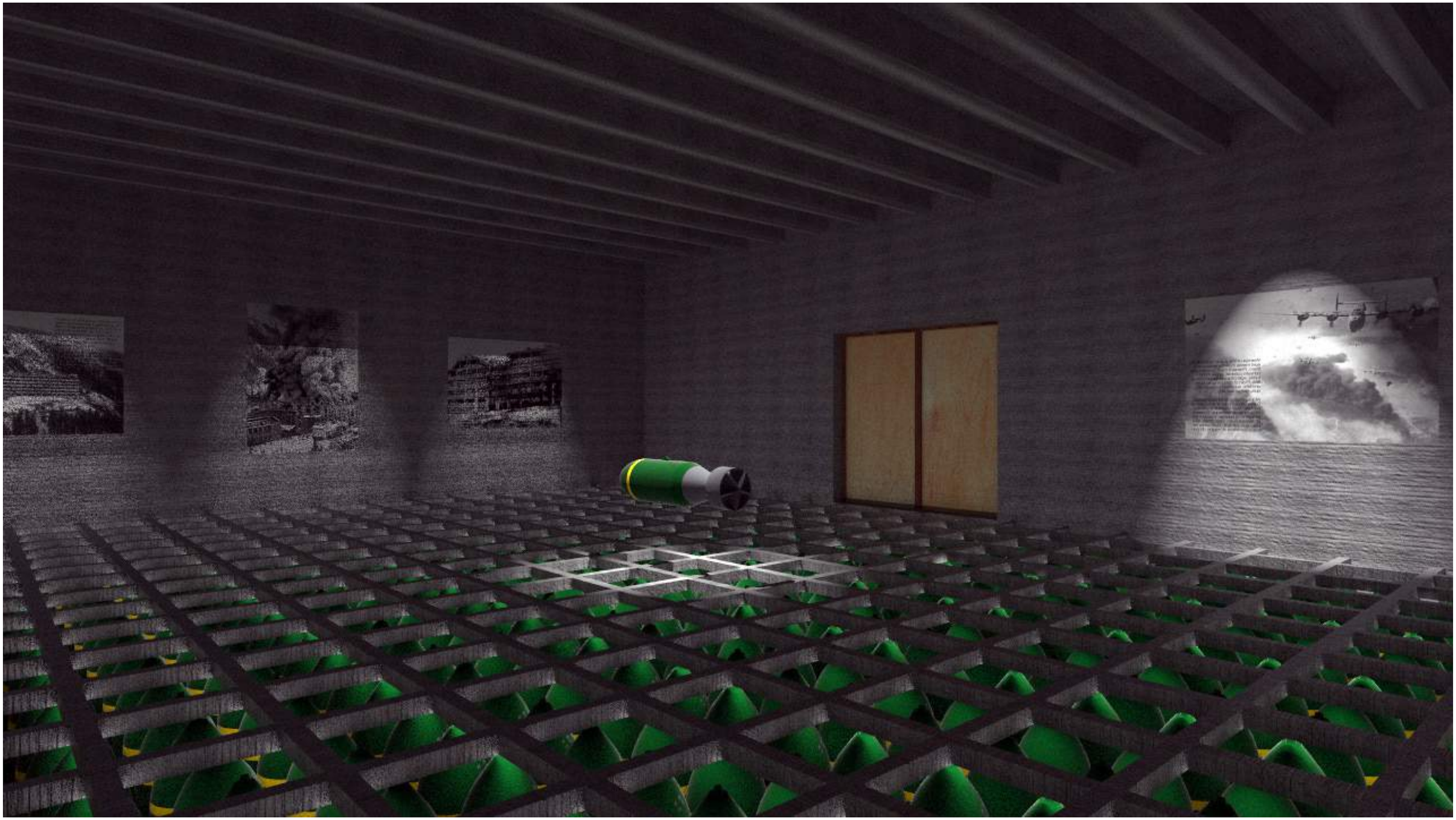

Anthony Mann's
THE HEROES
OF TELEMARK
"EROII DE LA TELEMARK"

FELL

The bright, diffuse light of the ceiling lights in the fell room casts no direct or strong shadows, but instead softens up the light by reflecting around the whole room. The rooms vastness enhances the feeling of openness similarly to the fell itself, while the reindeer and skier helps provide some familiar objects tying the life of the remaining members of the group to the story and room.

BOMBING OF VEMORK

Dissappearing into the mountain once again, the visitors are brought to a very dark room, lit up dramatically from beneath the glass floor, where also a multitude of large bombs are revealed to take their place. In the middle of the room, a single similar bomb is hanging freely, highlighted by a singled spotlight while the walls of the room are decorated with imagery of the destruction that took place during the bombings.



SINKING OF DF HYDRO

From the dark back of the exhibit, the visitors are brought past a parked train cart as the heavy water is being moved towards the ferry. As the visitors are nearing the front of the exhibit, the room starts to be lit up brighter by the long panoramic windows. From here a great view is available of most of the lake on which the DF Hydro traversed towards its final resting point.

After returning back on the other side of the parked train cart, the visitors are taken into a small hallway, ending in a narrow window, overlooking the furthest visible part of the lake. Here a small indicator marks the point where the bombs aboard the DF Hydro were detonated and the ferry along with all the heavy water was sunk.

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APPENDIX

TECHNICAL CALCULATIONS

For at sikre en strukturel integritet af de bærende elementer i tagkonstruktionen til fjeldrummet, bestemmes dimensionerne af de tværgående bjælker som en del af den integrerede designproces af rummet.

Da udregningerne er tiltænkt at fungere i samarbejde med de visuelle observationer gennem arbejdet med at opnå den ønskede atmosfære i lokalet, er et regneark udviklet til at tillade ændringer af de mange variabler involveret i udregningerne. Dette åbner for muligheden for hurtige ændringer i dimensionerne på bjælkerne og derved en lettere forbindelse til resten af designopgaven forbundet med rummet.

Regnearket er vedlagt på rapportens CD mens denne beskrivelse vil beskæftige sig med de relevante operationer til at udregne og bestemme de krævede dimensioner af bjælkerne. For resultaterne til beregningerne henvises derfor til udregninger i regnearket.

Tagkonstruktionen til fjeldrummet består af et pulttag, gående parallelt med bjergets retning på den pågældende placering. Taget spænder 12 meter i bredden og dækker hele rummets 18 meter i længden.

For at bestemme den nødvendige styrke af taget, må vi først kigge på tagets laster:

Mens de permanente laster af taget defineres af dimensionerne af taget selv, udregnes de variable laster i forhold til miljøet som konstruktionen findes i. Da taget bestemmes til at kunne bære i de mest ekstreme tilfælde af sne og vind, kan de mindre nyttelaster til et overslag, ignoreres.

Snelasten bestemmes ifølge Eurocode ud fra formlen

Formfaktoren for saddel- og pulttage defineres ud fra taghældningen i forhold til tilhørende tabelværdier. Ligeledes defineres igennem Eurocode til en konstant. udregnes ud fra faktorer for topografien af området, der i dette tilfælde sættes til normal vind mens bestemmes til at gælde tage med lav vandret udstrækning. beskriver den lokale terrænværdi for snemængder, der gennem opslag bestemmes til for Telemarksområdet.

Med værdierne på plads, kan en samlet snelast udregnes til over taget.

Vindlasten for taget bestemmes i tre tilfælde gældende for tryk og sug fra forsiden af taget samt sug i tilfælde af vind fra bagsiden. Hertil bestemmes terrænkategorien fra de to retninger til henholdsvis kategori I for et fladt, åbent område over søen, samt kategori IV grundet den tættere beplantning og bjergsidernes nærhed for bagsiden af konstruktionen. peakhastigheden af vindene udregnes herefter ved brug af formlen

For pulttage opdeles taget ifølge Eurocode i tre forskellige zoner, for hvilke en formfaktor bestemmes i forhold til hvert tilfælde af vindens retning. Disse påregnes peakhastighederne for de enkelte tilfælde hvorved de forskellige belastninger af taget begynder at tage form.

Da pulttage gentager formen af tagkonstruktionen gentagne gange, ændres vindens opførsel og styrke over de individuelle tagformer. For at konstruere den mest optimerede tagkonstruktion, ville det være muligt at bestemme den konkrete

belastning på hver enkelt bjælke. I stedet kigges der her på den hårdest belastede bjælke, hvorefter dimensioneringen af denne bruges gennem hele konstruktionen. Dette hjælper også til at skabe den ønskede samlede identitet gennem hele loftet af fjeldrummet.

Da de beregnede kræfter herfra påvirker taget i konstruktionens retning, forventes det at alle horisontale kræfter kan optage af tagets fæste til væggene og i stedet fokuseres der på de lodrette kræfter. Derfor opdeles kræfterne i henholdsvis horisontale og vertikale kræfter og de vertikale bruges således til de videre udregninger. Her fokuseres på den absolutte største kraft og kræfterne for hver zone sammenlignes derfor og den højeste absolutte værdi benyttes til de senere beregninger.

Den endelige kraft der påvirker bjælken beregnes ved at påføre de variable laster deres i forhold til konsekvensklasse 3.

Til at bestemme dimensionerne af selve bjælken, arbejdes med en opsvejst I-profil med materialeegenskaber lig S275J2. Bjælken eftervises i forhold til bæreevne og eventuelt kipning. Dimensioneringen af bjælken foregår i samarbejde med opdagelserne der gøres gennem undersøgelser af de æstetiske indtryk og opnåede parametre i forhold til den ønskede atmosfære i lokalet.

Efter at bestemme tværsnitsklasserne for både flanger og krop af bjælken, kan det effektive tværsnit udregnes. Her findes forskydningen bjælkens tyngdepunkt i forhold til det statiske moment om underflangen. Med det effektive tværsnit summet op fra alle inkluderede elementer kan det effektive modstandsmoment af bjælken fastslås og derfra kan brudgrænsetilstanden udregnes og sammenlignes med den reelle belastning af bjælken.

Ligeledes kan anvendelstilstanden undersøges ved at kigge på den maksimale nedbøjning tilladt af bjælkens længde og sammenligne denne med den udregnede nedbøjning af bjælken belastet med de tidligere udregnede laster.

For kipningen udregnes den maksimalt tilladte moment for brudgrænsetilstanden, hvor under kipningen af bjælken kan blive optaget i sig selv. Ved at sammenligne med resultatet fra brudgrænsetilstanden, kan det bekræftes om belastningen af bjælken risikerer at få bjælken til at kippe.