MARITIME SCIENCE CENTRE

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Preface

The presented project is the master thesis developed by Marie Louise Thorning and Josefine Rita Vain at the department Architecture and Design at Aalborg University in compliance with the study guide of the 4th semester of Architecture MSc program. The paper is the final architectural project and will present the process of designing an integrated design solution of a Martime Science Centre in Randaburg near Stavanger. The project report will firstly introduce the underlying theory, then present the project and lastly document the designprocess followed by a outro putting the thesis in an objective of the architectual fiels of today.

All photographs from the site is ours. They are leaved untouched to communicate the atmosphere as close to the actual experience as possible.

Abstract

This master thesis propose a design of a Maritime Science Centre located in Tungenes near Stavanger, Norway. The framework is based on theory on finding the common denominator between a tectonic approach to architecture and social and technical sustainability. Dealing with an architectual world forced to fit into regulation ensuring a technical quality in a project, the perceptual experience of a building is highly downplayed in the design. The thesis aims to design a Science Centre where simulation tool such as BSim and LCAByg serves as guiding tool towards a sustainable building in addition to site specific analysis of environmental circumstances, to find the prospect for using different passive and active strategies. Involving a tectonics approach to architecture helps obtain a sensous spatial experience for the user through means of construction and a careful considerations concerning materials and tactiliy in relation to function. The architectual expression is influenced by the thought of breaking up the envelope into a transistion between the interior and exterior - revealing the elements to the visitor. This serves an educational purpose in general, and add depth to the articulation of architectual elements. The idea raise questions concerning the complexity of a building, being a visionary project, the thesis design can work its way around a range of parameters represented in actual designs of buildings.

Through an integrated design process it is possible to reach a design driven forward by aesthetic and technical parameters. The initiating methodology introduces a theory upon gesture in architectural processen, reinforcing a sense of the individual architects in the building. This way of thinking is elaborated through the report at evaluated in the outro.

01

ill. 1.1

INTRODUCTION

We believe that establishing an individual positioning on how to approach the task of uniting aesthetic and technique, will make one aware of forming architecture with meaning and perceptual quality.

Content

ill. 1.3 | The sheer field of Jæren with the characteristic stone fences creating edges in the landscape

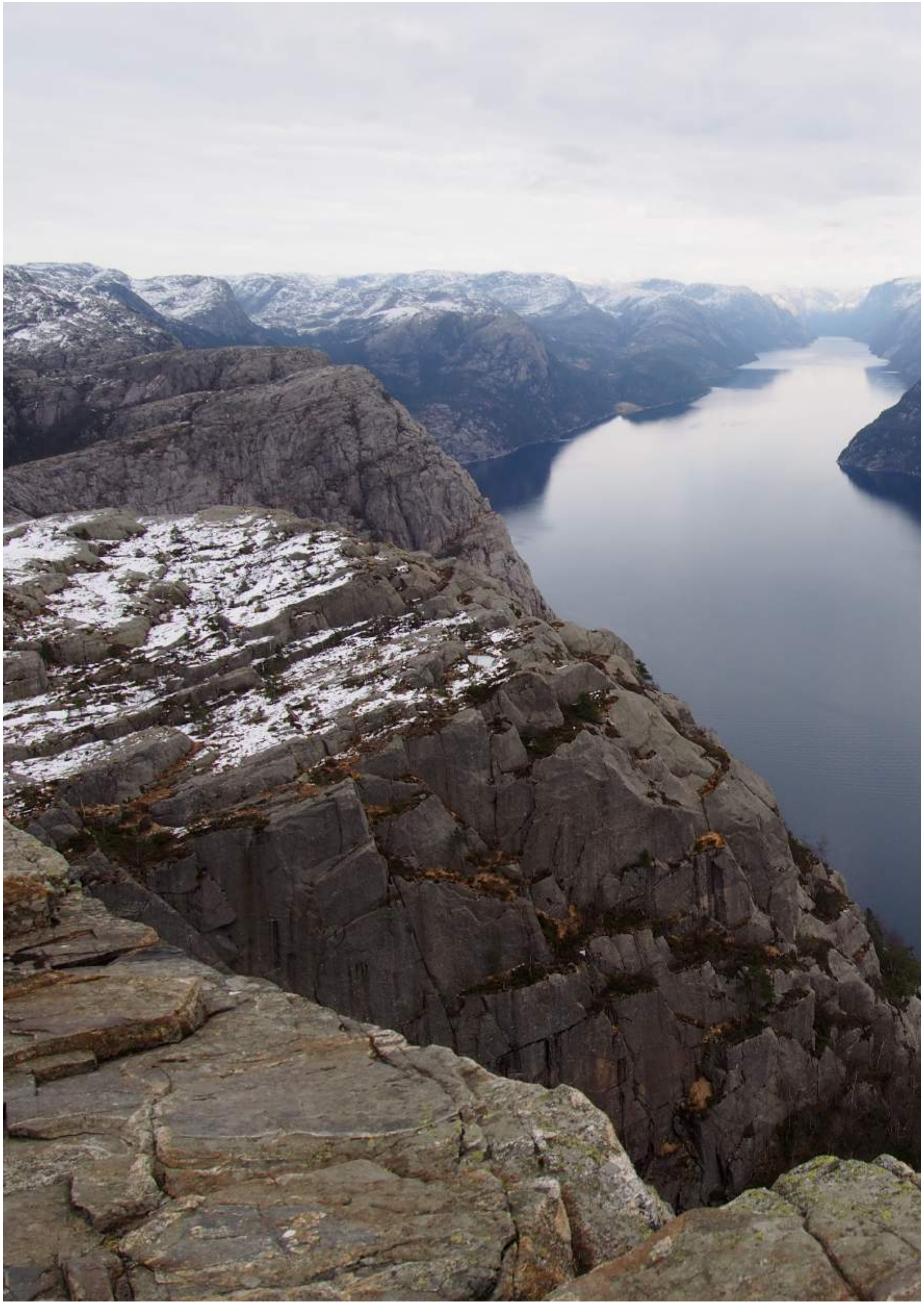
04 Presentation

05 Design Process

06 Outro

07 Drawing Folder

(seperate)



ill. 1.2 | Picturing the typical landscape of Norway from Preikestolen.

Motivation

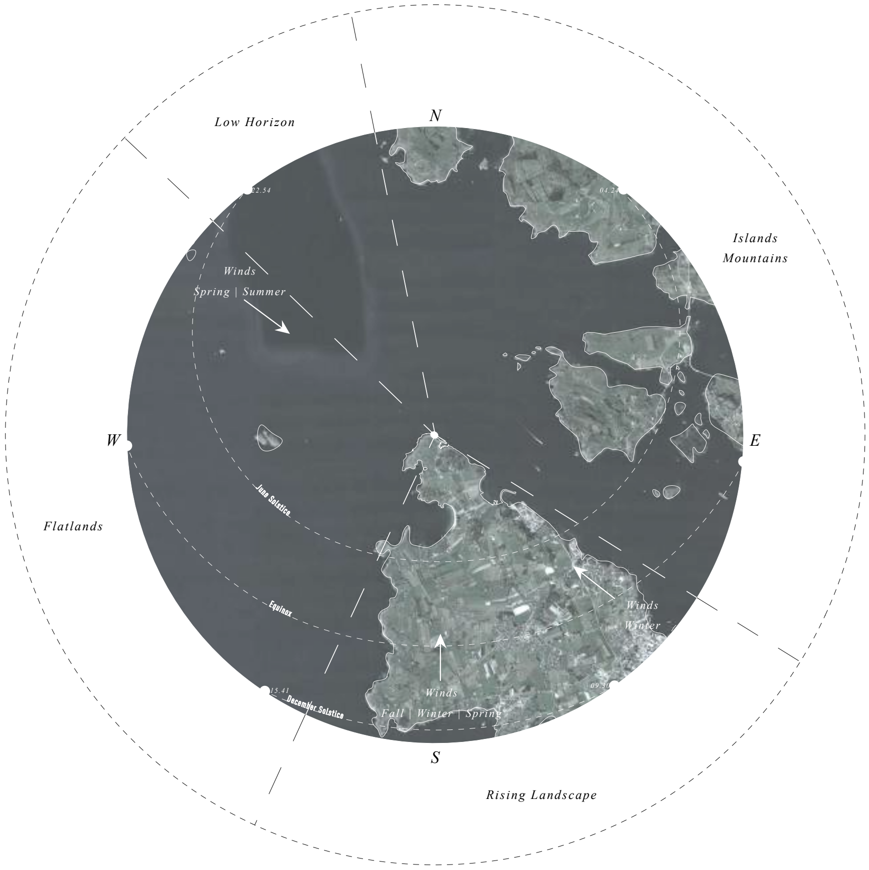
During the last century, architecture have seen a dramatic change in demand of environmental and social sustainability and increasingly implementing technological devices to meet the high standard of comfort. Building to ensure the technical requirement often challenges the structural and spatial quality of perceiving space. In response to this development, new problematics arises - how can sustainable architecture be developed to ensure architectural quality responding to the local context and human perception.

Our motivation when designing the Maritime Science Centre is the opportunity to investigate and explore an alternative to the contemporary understanding of a envelope, often defined as a solid element in architecture. The interplay between contextual conditions and architecture will serve as an aesthetic and exploratory platform of the thesis design. In continuation of this approach working with human perception and sensory experience will be the fulcrum of both the sustainable and structural aspects.

Our vision is to examine and challenge the general understanding of the idea of sustainability, that we believe creates a distance between human and the built. In order to underline the central subject, the aim is to develope an iconic building that expresses a statement of a direction in a sustainable future.

ill. 1.4

ill. 1.5



ill. 1.6

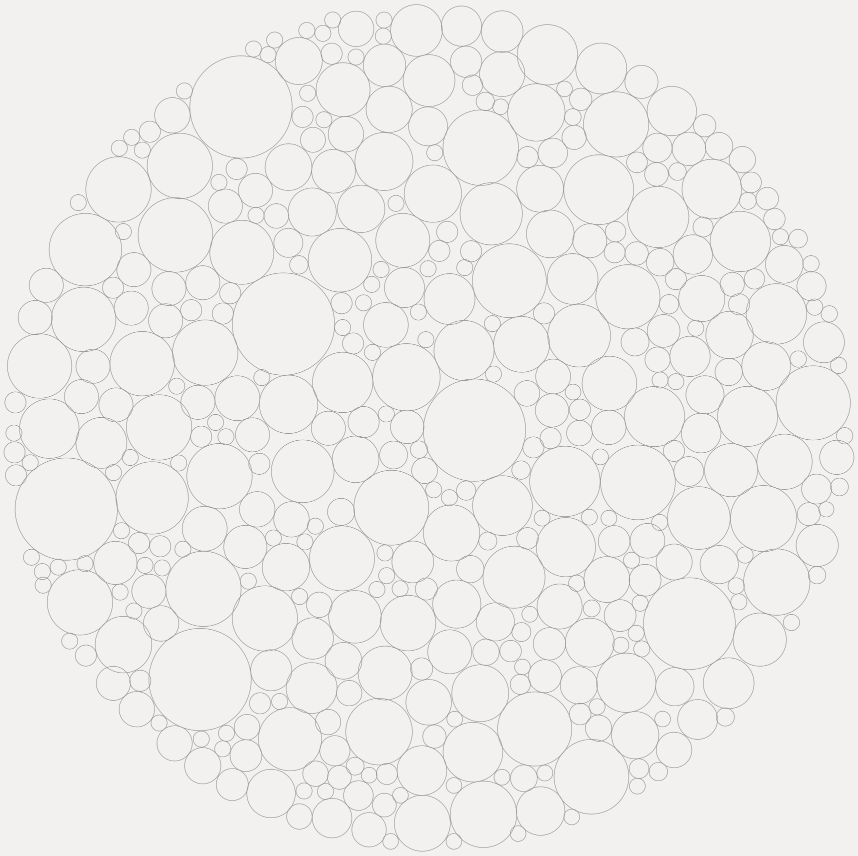
Introduction

The project focuses on creating a Maritime Science Centre located in Vitenvågen, Randaberg in the Stavanger-Region of Norway. The area is characterised by lower coastal areas south of Boknafjorden in Rogaland.The specific landscape, Jæren, stretches 10-15km along the coastline and is unique for this part of Norway. (Thornæs, 2014) The site is located in the outermost part of the region, having the North Sea on one side and the Boknafjord on the other.

The main part of the norwegian population lives by the sea. The coastline are of both recreational and industrial interest and the relation of life on land and water have been nutritious for the industry and the culture of the norwegian people throughout history, defining the Norwegian society today. Having the largest workplaces offshore e.g. oil production and aquaculture, the country is reliant on the development towards a more sustainable industry. This requires for a will to invest in a sustainable future leading to investing in sharing of knowledge and educating the next generation within the frames of environmental, social and economical sustainability. In continuation of this the Maritime Science Centre will offer a general intelligible and accessible experience - and learning platform around the past, present and future of Randaberg.

In order to create attractive and innovative experience- and learning environments, the thesis investigate the envelope as a functional elements as well as an active part of the sensory experience. To accommodate this challenge it is a necessity to rethink the traditional methods in architecture, introducing a range of approaches. In this case tectonic vision, contextual conditions and work with perception is included as focus parameters in the design, controlling and driving the process forward. Incorporating tectonics by theories on the ability to unite building components into a whole, embracing material application, composition and structural principles (Beim, 2004) and perception by looking into the crucial connection between designing and experiencing space.

The general purpose of the thesis is to reveal the common thread in the aspects of tectonics, experience and sustainability through an architectural design, thus providing the Stavanger Region with a centre of knowledge.



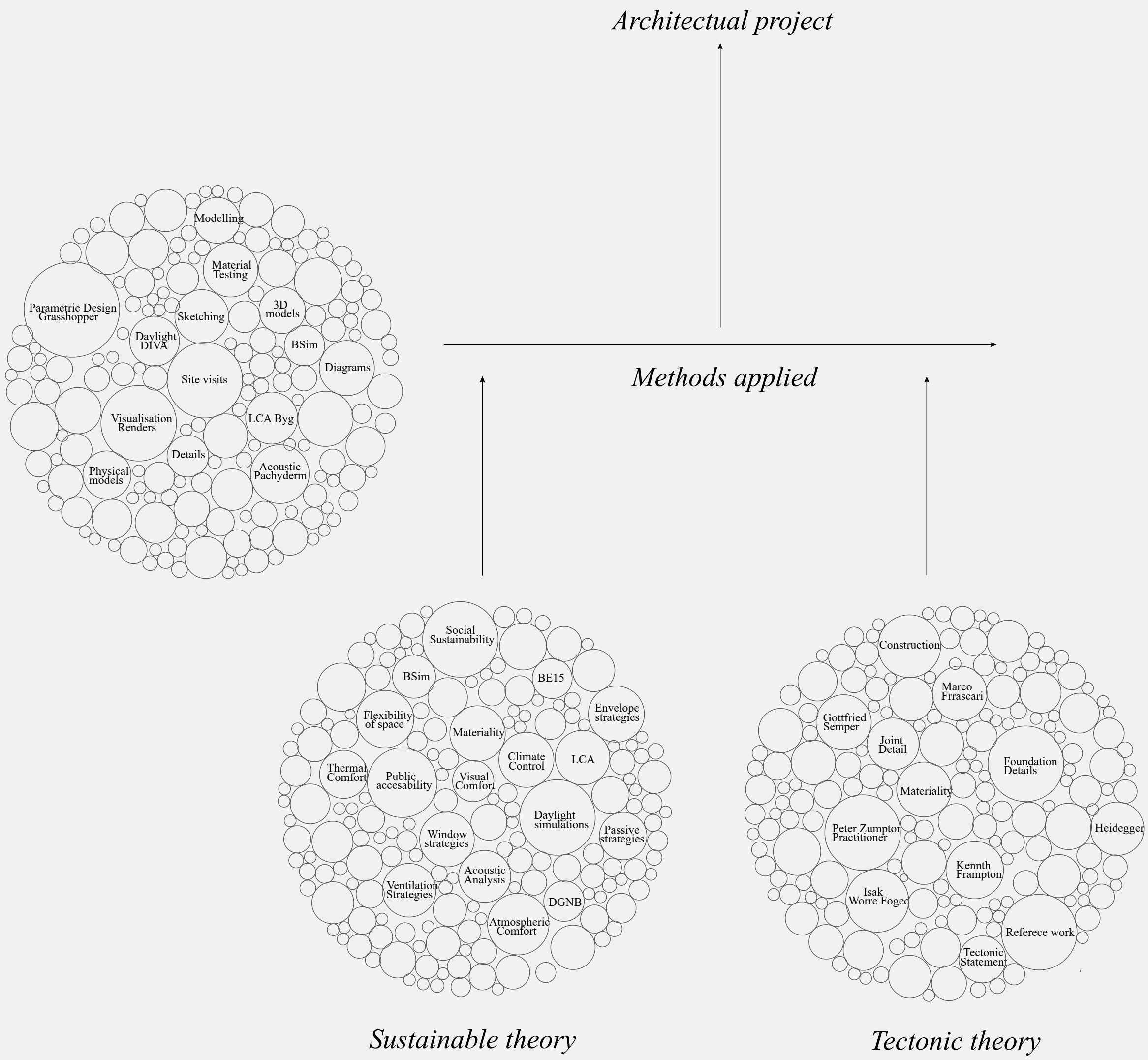
ill. 1.7 | Abstract Illustration - process complexicity

Methodology

Designing environmental sustainable architecture is a complex matter, and depending on the perspective and approach this subject can be understood differently; from the quantitative, measurable and empirical studies of natural and engineering science to the qualitative, emotive and phenomenological investigations that characterise humanistic perspective. Consequently, the design process needs a holistic approach merging and balancing the phenomenological and scientific research and methods. The multidisciplinary characteristic that defines architecture is what Vitruvius articulates in The Ten Books of Architecture stating that "…architect should be equipped with knowledge of many branches of study and varied kinds of learning, for it is by his judgment that all works done by other arts is put to the test" (Vitruvious, 1914). Hence, the complexity of architecture must deal with several branches in theory, research and methodology to investigate the potential of revealing these in architecture. This chapter will identify, explorer and discuss the methods and tools applied to this thesis.

Integrated Design Proces

To accommodate the complex nature of architecture several theorists have developed methodologies to provide strategies that can direct and structure the project. The overall approach designing this project is based on an integrated design process, that amongst others is described by Mary Ann Knudstrup in "The Integrated Design Process". The objective of this method is to integrate aesthetic, functional and technical aspects as equally relevant in the initiating design process to reach architectural quality. The conceptual map (ill. 1.7) depicts the different parameters that influence the architectural project causing a highly interdisciplinary concept of introducing analysis and knowledge from different focusses. It is important to note that Integrated Design Proces should be understood as a platform that makes it easier to control the many parameters of the project. The structure presented by Mary Ann Knudstrup introduces five separate phases; ´Problem and idea´,´Analysis and programme´, ´Sketching´ and `Presentation´.



ill. 1.8 | The informal and Seceltive Map

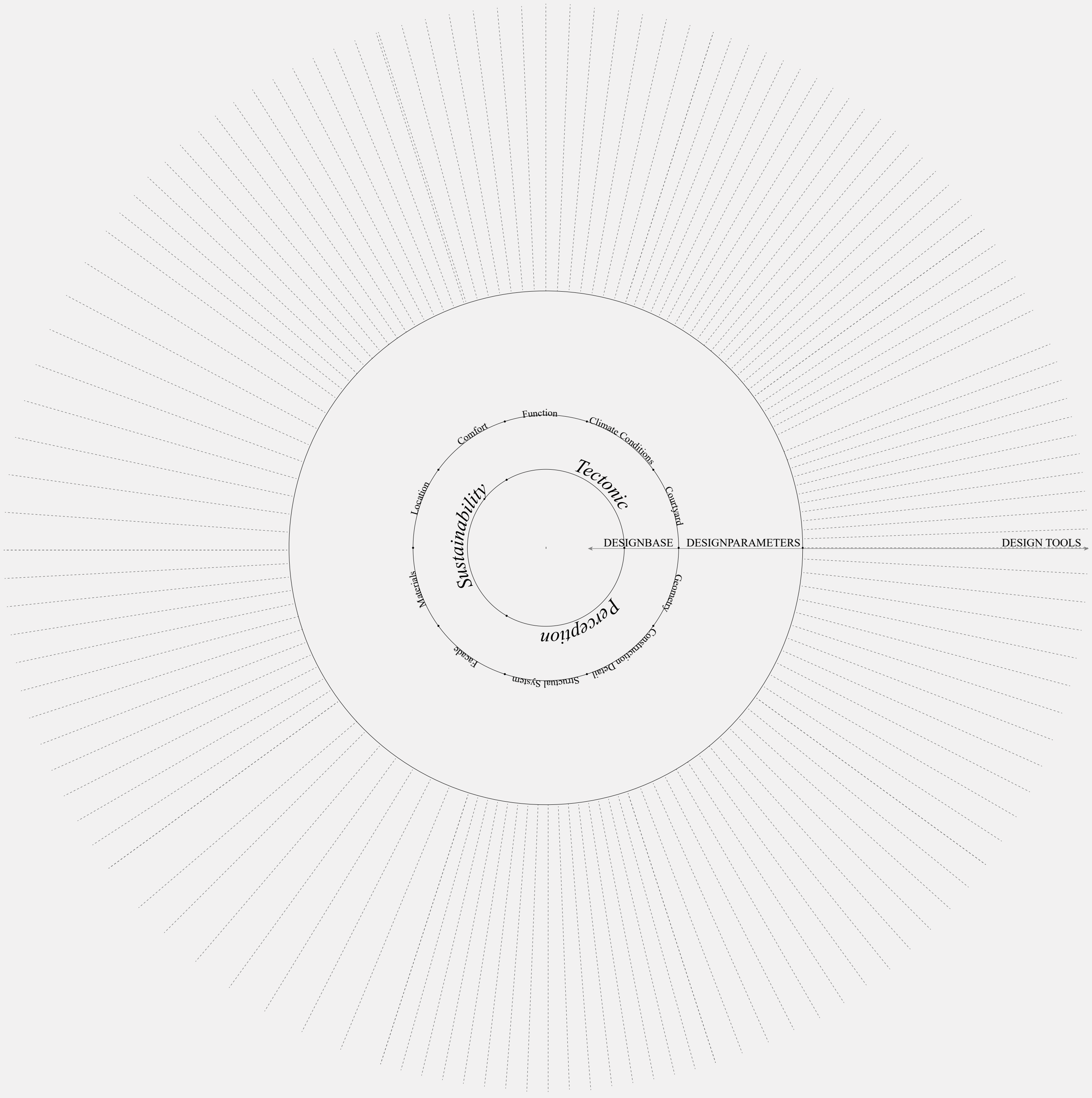
These phases illustrate a simplification of a complex process, thus the work flow should be considered of numerous loops between each phase, until the synthesis between aesthetic and scientific parameters is reached. (Knudstrup, 2004).

Gesture and Principle as Vocabolary for the Architectual Ideal

In addition to the Integrated Design Process as platform to direct the project, the theory of having an aesthetic ideal as the core will be introduced as a foundation.

Inspired by notes by Marie Frier Hvejsel on gesture and principle in the research journal “Everyday Tectonics” we will identify the gesture of the design initially. Marie Frier Hvejles base part of her research on the three tectonic theoreticians Gottfried Semper, Eduard Sekler and Marco Frascari. Semper positions tectonics in the creation of an inviting spatial experience, which is denoted as ‘gesture’. Sekler describe tectonic as critical shaping of spatial 'gesture' by means of structural 'principles', and Frascari is linking the spatial gesture and structural principles in building details.
Investigation the theory on tectonic will be elaborated in the Framework defining the potential of spatial details in relation to human scale allowing us to reflect upon the experienced quality.

The approach identifies gesture as the initial starting point reflecting the core value of architecture, thus expressing and investigating gesture spatially. The objective is to implement these aspects in the integrated design process ensuring a phenomenological statement as catalyst for the design to direct and inform the process. This creates an initial basis for describing and forming the design parameters affecting the project and reflecting the architectural ideal both in concept and detail. We believe that establishing an individual positioning on how to approach the task of uniting aesthetics and technique, thus establishing an architectural ideal, as reflected upon in the Motivation, will make one aware forming architecture with meaning and perceptual quality.



Ill. 1.9 | Instrumental Map
The diagram is inspired by a Research Mapping by Isak Worre Foged
in Environmental Tectonic (Foged, I. W. 2015)

Documenting the Design Proces
The conceptual map represented the many parameters affecting the process. This diagram is without order or hierarchy, thereby indicating an intangible and unmanageable approach to the project. By defining different attention to the subject, it is possible to identify the major influences we believe will direct the project. These fields of interest is depicted in the selective map (ill. 1.8). The selective map defines an order and provides an overview of the different methods, theorists and contextual conditions that have influenced the design. Yet, the diagram does not indicate the hierarchy and interplay between these fields, thus we suggest to introduce an instrumental map, which will be developed during the design process.

During the design process the instrumental map (ill. 1.9) will be implemented to clarify the process. This specific diagram represents the design base, design parameters and design process and how these relate to clarify and reveal the primary fields of interest and methods in this project. The design base; environment, tectonic and experiencing architecture is considered as the main input and challenges in the project and is organised in a circular form framing the thesis. Outside this base is the design parameters, which are essential to form the project. These are connected across the design base to categorise and map what is the major subjects and influences within these fields, which serves as the underlying structure of the thesis and essential for forming the project. Thus the circular diagram illustrated the web of relationships as a non-linear interplayed platform that align with the multidisciplinary and holistic design process that forms the project.

Reflecting upon Methods
In the analysis and program phase multiple methods are being used. The literary works by other professional individuals is based on their investigations, and then interpreted by us, consequently resulting in the use of double-hermeneutic (Bryman 2012). Using a phenomenological approach to acquire knowledge implements our own personal perception and experience as a subject into the project.

As means of communicating and exploring the design, the methods is mainly dominated by use of visually oriented methods e.g. sketching and modelling both physical and digital. These proposals are accompanied and evaluated by means of qualitative and quantitative studies. The advantage of using visual medias is the ability the communicate ideas and simple means to evaluate. However, using visual media may neglect the importance of exploring the experience using other senses. An objective through the process is to be aware of the perceptual means, using other sensual methods such as; physical modelling, activating textures and visiting the site, getting an phenomenological experience and general understanding of the context. The evaluations of every single phase along the way is crucial for the progress throughout the process. The way to evaluate is both using qualitative methods e.g. serial vision and genius loci and quantitative methods e.g. LCA and BSim calculations. Finally, the process should be open for iterations in a scale that allows going back to the analysis phase as the design progresses, to gather new knowledge and information for further improvement of the design.

02

Ill. 2.1 | The texture of moss and rocks , Tungenes.

PRELIMINARY STUDIES

The everchanging weather varying along with the seasons, in a generally cold climate, is a part of the nordic culture and identity.

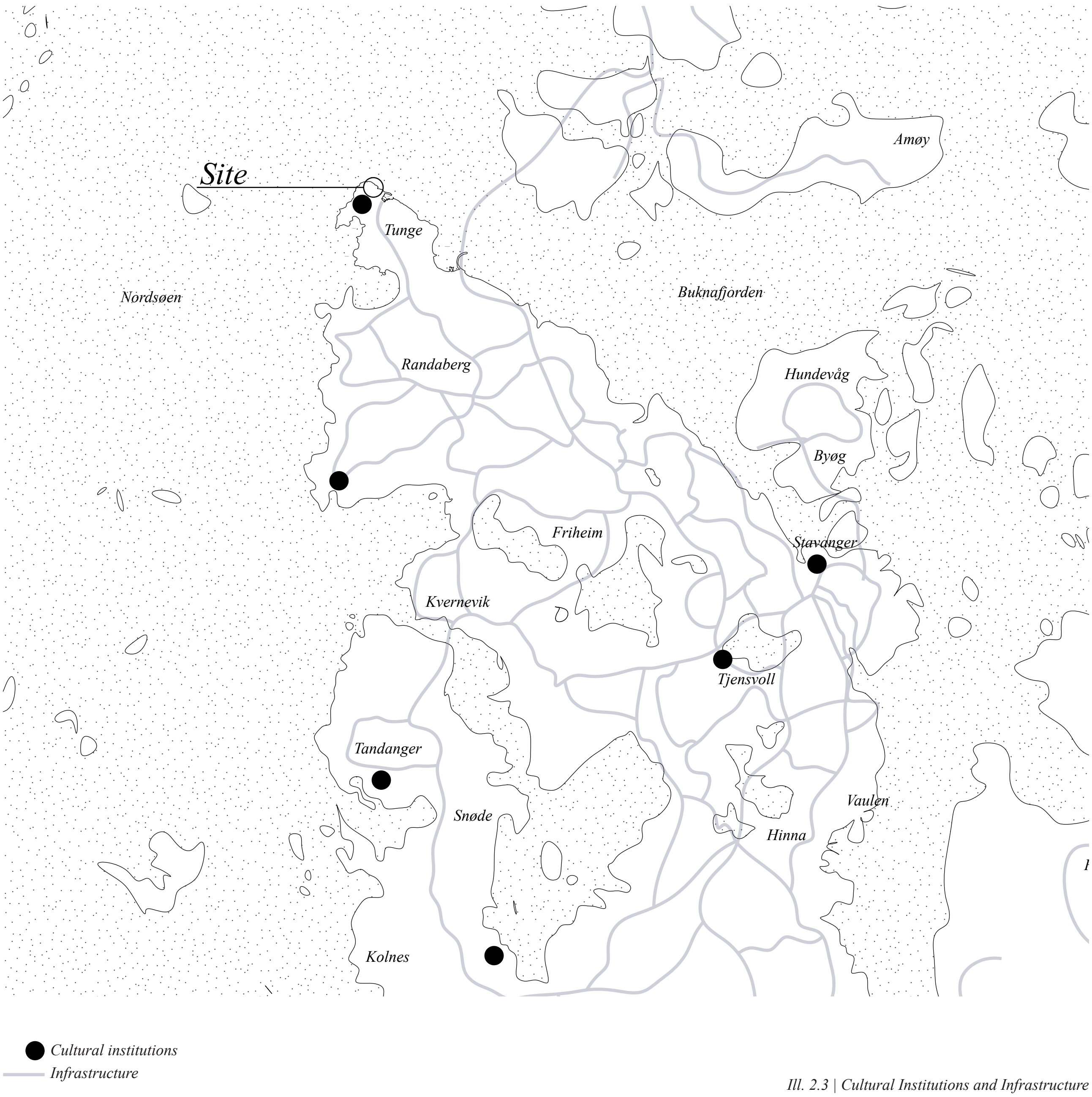
Stavanger Region

Historic Perspective
Stavanger Region is the third biggest city area in Norway. The wide half-island is located in southwestern part of Norway and the Northern part of the fertile and densely populated area Jæren. (Thornæs 2014) The flatlands of Jæren was one of the first settled areas in Norway due to the mild climate and farming potential. (Randaberg Kommune 2017) When the city of Stavanger was first established in 1125 it was founded on the agriculture and since also aquaculture. Today the region is still known as the Food Region due to the enormous food production from the sea. (Lomelde 2016)

In the 1960's the search of oil in the North Sea payed off, and Stavanger became the oil capital of Norway. This formed a new wealthy state economy having oil and natural gas extraction and export as the primary revenue (norden.org 2016) Over the years the state have controlled the oil industry through owning a majority of shares in private companies - presumably leading to the preservation of the social democracy and human rights in Norway, unsimilar to other oil-rich nations in the world. (The Economist 2013)
A Sustainable Future
Moving towards a post-oil era demands a change in society-philosophy. The Norwegians are aware of the future of the oil-industry and the government use the oil-industry to promote other industries, such as shipping and research on sustainable technologies. In the recent years the Norwegian state oil company, Statoil, operates the world's biggest floating wind farm and they examines technologies of how to store carbon dioxide under water, removing greenhouse gasses of the atmosphere. (The Economist 2016)

The Norwegian society today is developing into a self-sufficient operating system, however still relying on extraction of oil in the state economy. The country have been and continues to be highly established upon a national reliance on natural resources. Surrounded by mountains, forests and water the country have a variety of possibilities concerning food and energy production in the future. The country already have 98 percent of the energy production based on renewable resources and environmentally-friendly processes, with hydroelectric energy as the primary production. (Regjeringen 2014)

Ill. 2.2 | The egde of Jæren

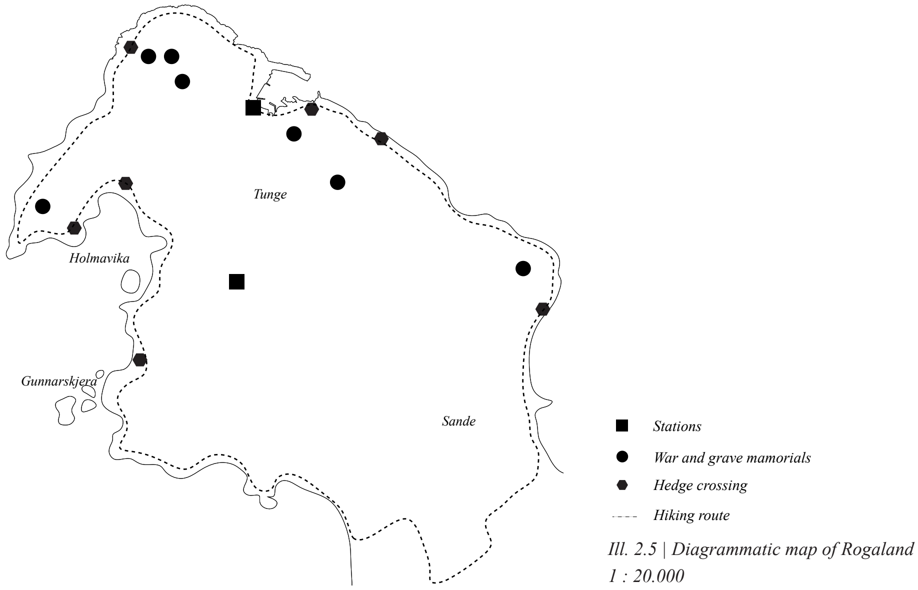


Ill. 2.3 | Cultural Institutions and Infrastructure
1 : 100.000

The Region have several museums and centres portraying the history of Jæren, the life of the vikings and the society connecting to the oil-industry (figure 4). The new Research Centre will be a complementary to the existing departments of the Region museum, Jærmuseum, documenting and communicating the recent history of Randaberg. Stavanger-Region have an international airport and a well-developed infrastructure of tunnels, ferries and bridges making it a popular visit for tourist. (Grøn, et al 2016). The site is easy accessible by car or bus. (figure 3)

Ill. 2.4 | Map of Tungenes
1 : 5000

Ill. 2.6 | Section AA
1 : 5000



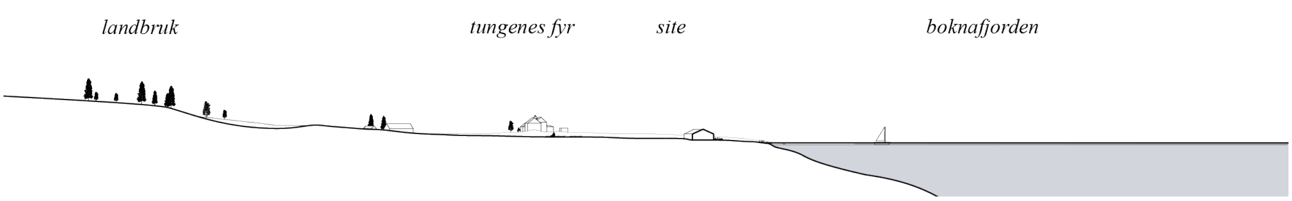
Ill. 2.5 | Diagrammatic map of Rogaland
1 : 20.000

Tungenes

The site is located at Tungenes, the outmost point of Randaberg. In the 16th century the area was marked by a lighthouse as a navigation tool helping the fishermen pass the entrance to Stavanger, marking the flat landscape surrounded by the sea. (Jensen 2012) Tungenes have a few private houses apart from the lighthouse. The existing two barns(ill. 2.4 - dotted line) house a small exhibition on the coast life history. The new Science Centre will replace these. At the moment Tungenes Lighthouse is the most prominent building in the area. In addition there is a parking, a small wharf and towards southeast the terrain is rising, creating an ideal spot to overview the area.

The site is characterized by a coastal atmosphere, formed by the lighthouse, the wharf and the passing boats as well as the condition of waves constantly striking the layered rock landscape at the coast. The senses are dominated by the sound and smell of the ocean and the stunning view towards the mountains on the northern islands and the plain horizon towards west. The sea occasionally turn heavy due to strong winds, attracting people seeking an experience of natural forces up close. Other times the site offers a silent escape from the city life, enjoying the sun, the mist or the rain in the quietness.

Points of Interest
Jæren is characterized by a flat landscape disrupt by stone fences made of moraine debris left on the ground, removed in order to farm the land (Sandalsand 2013) To pass the fences, there's is multural hedge crossing ladders adding an extra level of movement in the flat landscape (figure 1). During the WWII the region was occupied by the germans, using Tungenes Fyr for their primary base and installing gun positions, still occurring in the area today (figure 2). The relics of the past combined with the unique landscape cause for a popular hiking route around Randaberg.



Ill. 2.7 | Section BB
1 : 5000

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Ill. 2.8 | Serial picturing of the site

Genius Loci

This analysis is based upon a phenomenological study, investigating the atmosphere at the site. The photographs of the local area will support this study. Additionally, it should be mentioned that the studies have been done over two days in the beginning of February, where the weather conditions were markedly different.

Driving in the morning on the narrow road along the coastline passing the traditional wooden houses facing towards the ocean, one gets the impression of how the coastal landscape has shaped Randaberg and been livelihoods of people for hundreds of years. riving towards the tip of the mainland, where the road ends and the sea takes over - here unfolds the site. The empty marina, a couple of white wooden houses and the horizon of the sea set the scene of the arrival (1). Recognizing the smell of seaweed, the sounds of the ocean and the unobstructed breeze from the southeast, the weather with only few means set the atmosphere of being close to nature and entrust oneself to the forces hereof. The narrow gravel path leads one closer to the ocean, and after passing small crooked wooden houses on one site and the grey industrial concrete barn on the other, the green flat terrain dominate the view and in the background the lighthouse can be glimpsed. Now only few meters from the ocean, the terrain changes from the green soft earth into a dark hard rock terrain, which in a soft transition disappears into the ocean. (2, 4) The light splashing of the ocean that meets the mainland continues around the site marking an edge. The gravel path continues to the lighthouse, which stands out in the landscape as the white painted house and slate roof reflecting the sun. In the courtyard, a group of hikers are sitting in the sun leaning against the wall protected from the wind before continuing down the path. (4, 6)

The next day the clouds and fine rain hangs over Stavanger, which is often the weather in this region (3). Arriving at the site in the afternoon, the smell of the seaweed, the sound of the ocean and western wind remain. Behind the clouds the sun is faintly visible and gradually going down in west. Despite the cloudy weather the sunset is remarkable because of the low horizon and reflection of the ocean, creating a view only framed by the untouched environment.

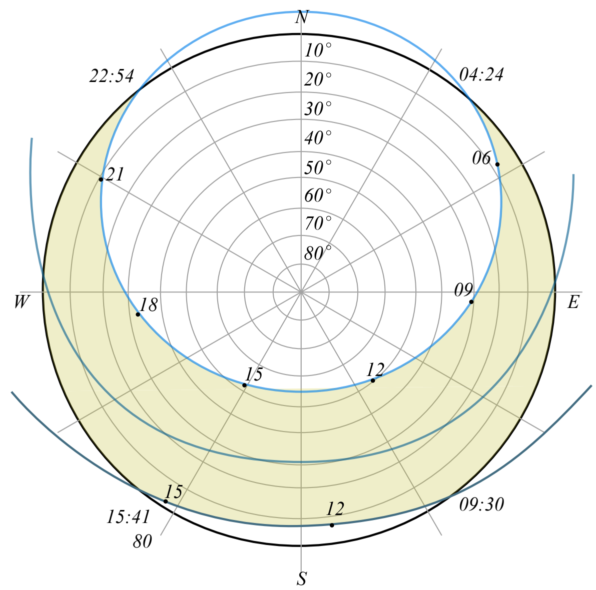
Ill. 2.9 | Mapping of route

Climate

The climate is an imperious aspect of human life - in symbiosis with nature and human created environments, it sets the scene of our lives. The weather affects us on a mental and physical level. Behind the obvious physical relation between the weather conditions and the human body arise a psychological effect - interfering with the senses, whether one is listening to the rain hitting the roof or feeling wind on the skin, the mind registers an atmosphere connected to associations of the specific person.

The climate is a part of our culture and by all means affect the way we built. A significant aspect differing the Nordic from other places are the climate conditions. The everchanging weather varying along with the seasons in a generally cold climate are a part of the nordic culture and identity. The climate of the Stavanger-Region is normally characterized as a mild and humid. It is dominated by cloudy skies and a steady rain, having no dry season at all. (WeatherSpark 2012) The rain and the sky can be forceful parameters working with atmospheres, interfering with our visibility reinforcing our other senses.

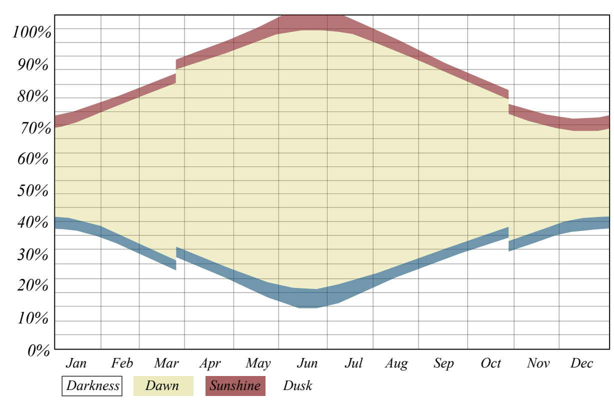
The following weather analysis are average numbers based upon measurements mainly from Stavanger Airport in Rogaland, which meteo station is the closest to Tungenes and the measurements are made in similar exposed settings as the site, close to the sea. Otherwise weather data from Bergen is used, due to the geographical similarities, however some variability may occur.



Ill. 2.10 | Sun path diagram, Norway

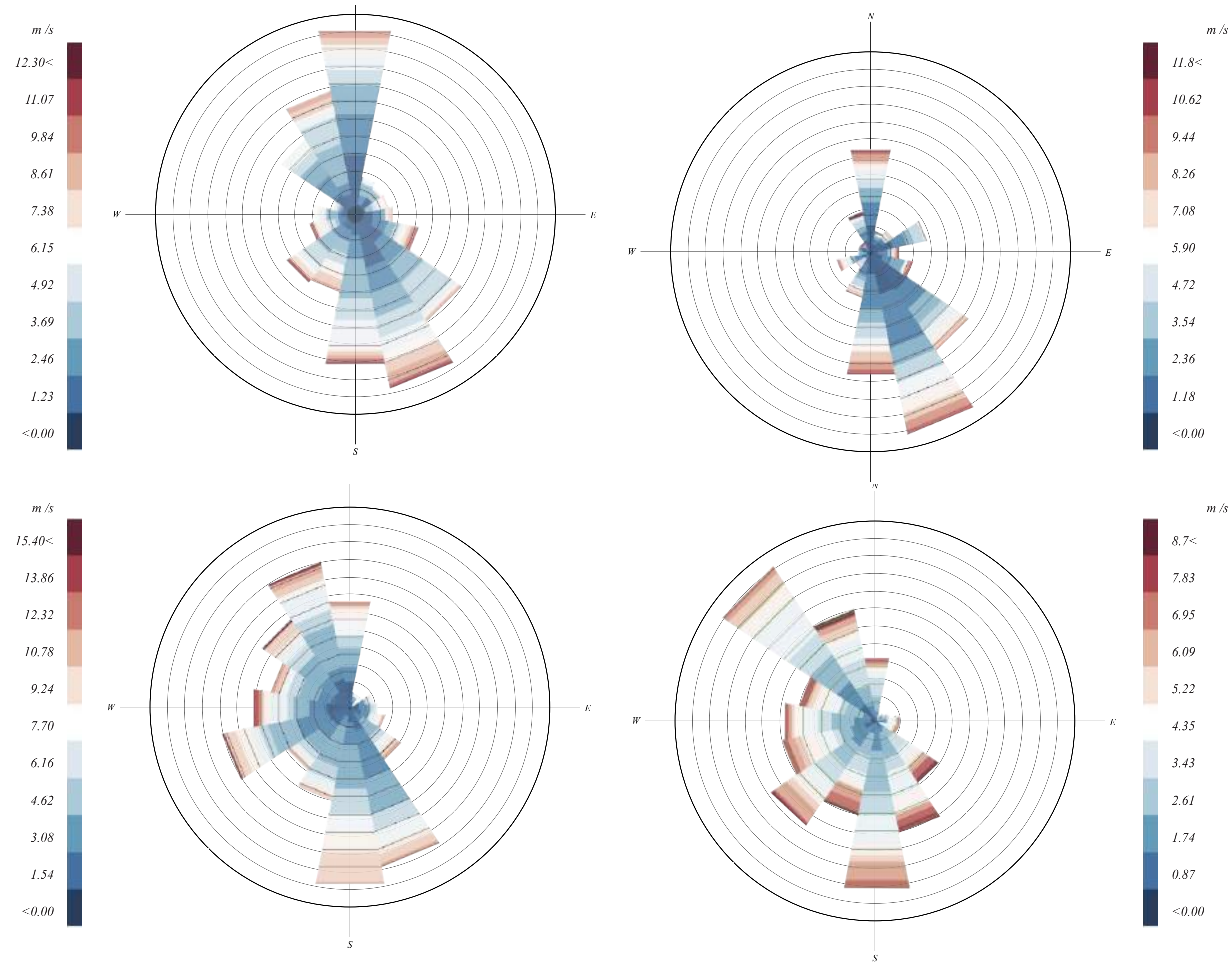
Illustration 2.16 portrays a significantly variation in length of the day over a year. As the shortest day, the 21th of December only have aprroximately 6 hours of daylight and the longest in June have 18,5 hours. Even though the sun is not the dominating element of the climate, it should be considered in relation to over heating challenges. (WeaterSpark 2012)

Due to the cloudy weather and early sunsets most of the year, the investigation indicates that the project should enhance other natural phenomenas in exterior space, such as view and materiality.



Ill. 2.11 | Sunset, sunrise, sun dawn and dusk times graph

Ill. 2.12 | The grasslands of Jæren



ill. 2.13 | Wind analysis in Grasshopper - Ladybyg
Data based on weather data from Bergen

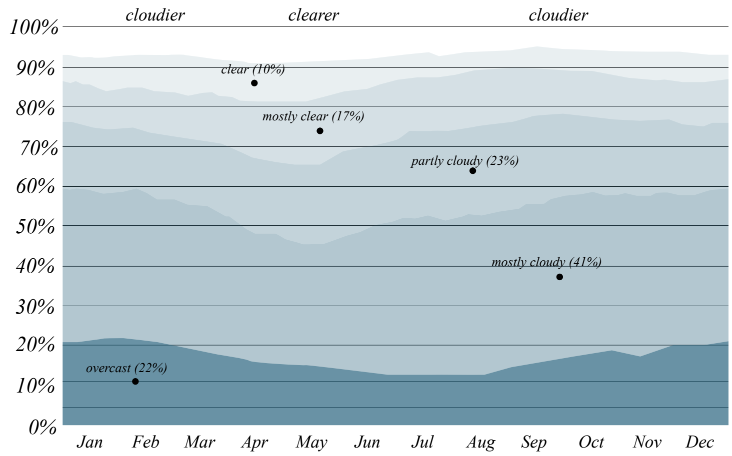
Wind

The primary wind direction varies over the seasons, mainly coming from southeast in winter, southeast and northwest in spring, northwest in summer and southeast in fall. 21% of the time the wind is coming from south, where 19% of the time it is coming from southeast. The wind speed rarely exceeds 14 m/s (high wind) and generally the wind speed is 0 m/s to 9 m/s with an average of 5 m/s. (gaisma 2012), similar to the wind strenght of Aalborg, Denmark.
These wind conditions are to be considered in the geometry and materiality of the building in order to make attractive outdoor spaces throughout the year.

Clouds

In contrary, clouds are a dominant natural feature of Tungenes. Cloudy days accounts for above 60% of all days, meaning the texture of it becomes extremely important to understand the atmosphere.

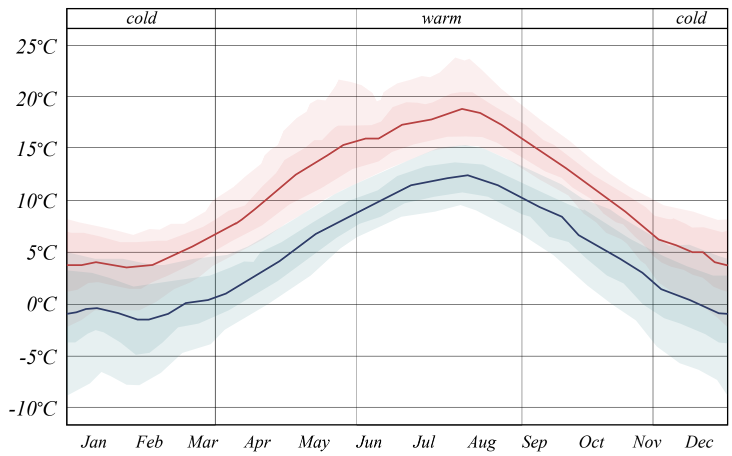
Mostly cloudy means that 6/8 to 7/8 of the sky is covered by opaque clouds. This accounts for 41% of the time, not varying significantly over the year.
(WeatherSpark 2012) This weather state provides a diffuse light.



ill. 2. 14 | Cloud cover types

Temperatures

The Stavanger-Region is known for its mild climate compared to the rest of Norway. The temperature in summer reaches around 18°C and drops to an average lower temperatures of -4°C in February. (WeaterSpark 2012)
The general low temperatures indicated a need for heating most of the year



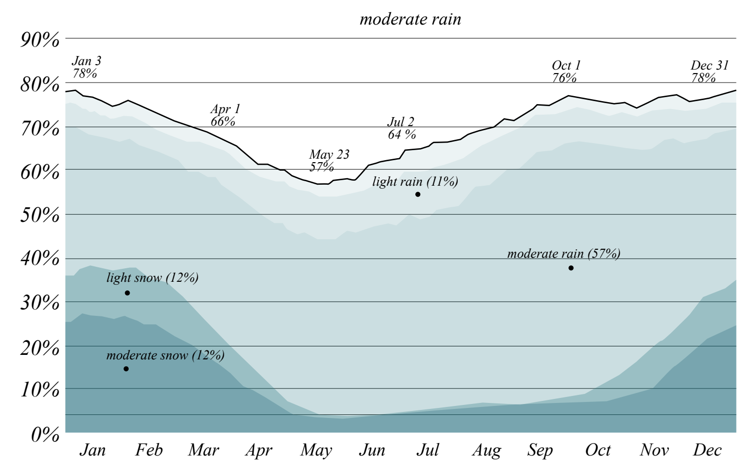
Ill. 2.15 | Daily high and low temperatures

Precipitation

As the cloudy weather is rather steady the precipitation varies significantly over the year, varying from 50 mm in April to 156mm in September, which averagely based is approximately three times asmuch as in Denmark. (ClimaTemps 2017) 59% of the rain is categorized as moderate rain, meaning that it is not excessive amount of rain in a short time but a little rain over a longer time. (WeaterSpark 2012)

The amount of rain should be considered in the shape of the building in relation to divert the rain and on terms of constructive treatment of building material.

The amount of snow falling in this part of Norway is not of significant value for the general notion on the climatic condition. As mentioned, in general the rain is more dominant in Randaberg. The maximum probability of snow is 19 % in January with a corresponding snow depth at 8,3cm(WeaterSpark 2012).

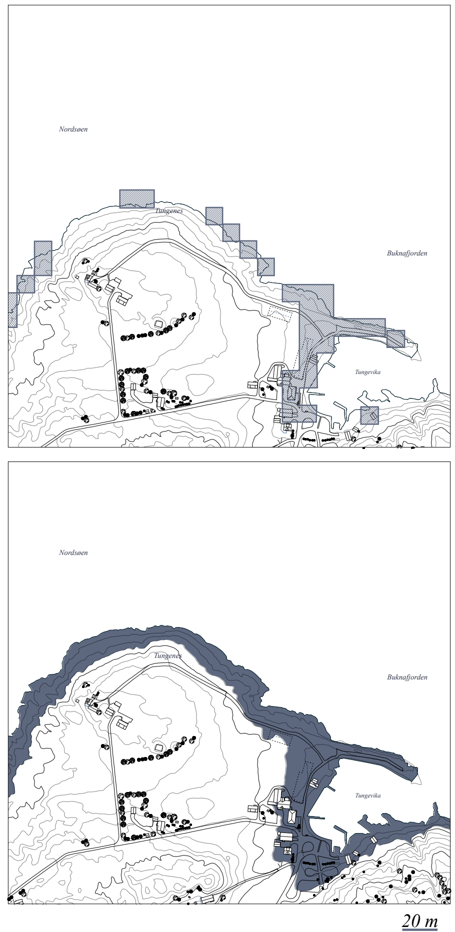


ill. 2. 16 | Distribution according to type of precipitation over a year

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avarage Percipetation (mm)	92	66	75	50	68	73	91	115	156	148	136	110	110

ill. 2. 17 | Precipitation average

"Again and again there is the sensuality of the material – how it feels, what it looks like: does it look dull, does it shimmer or sparkle? Its smell. Is it hard or soft, flexible, cold or warm, smooth or rough? What colour is it and which structures does it reveal on its surface?"
Manfred Sack (Deplazas 2005)



ill. 2. 18 | Potential risk of flooding (above) and level 3 flooding limit (below)

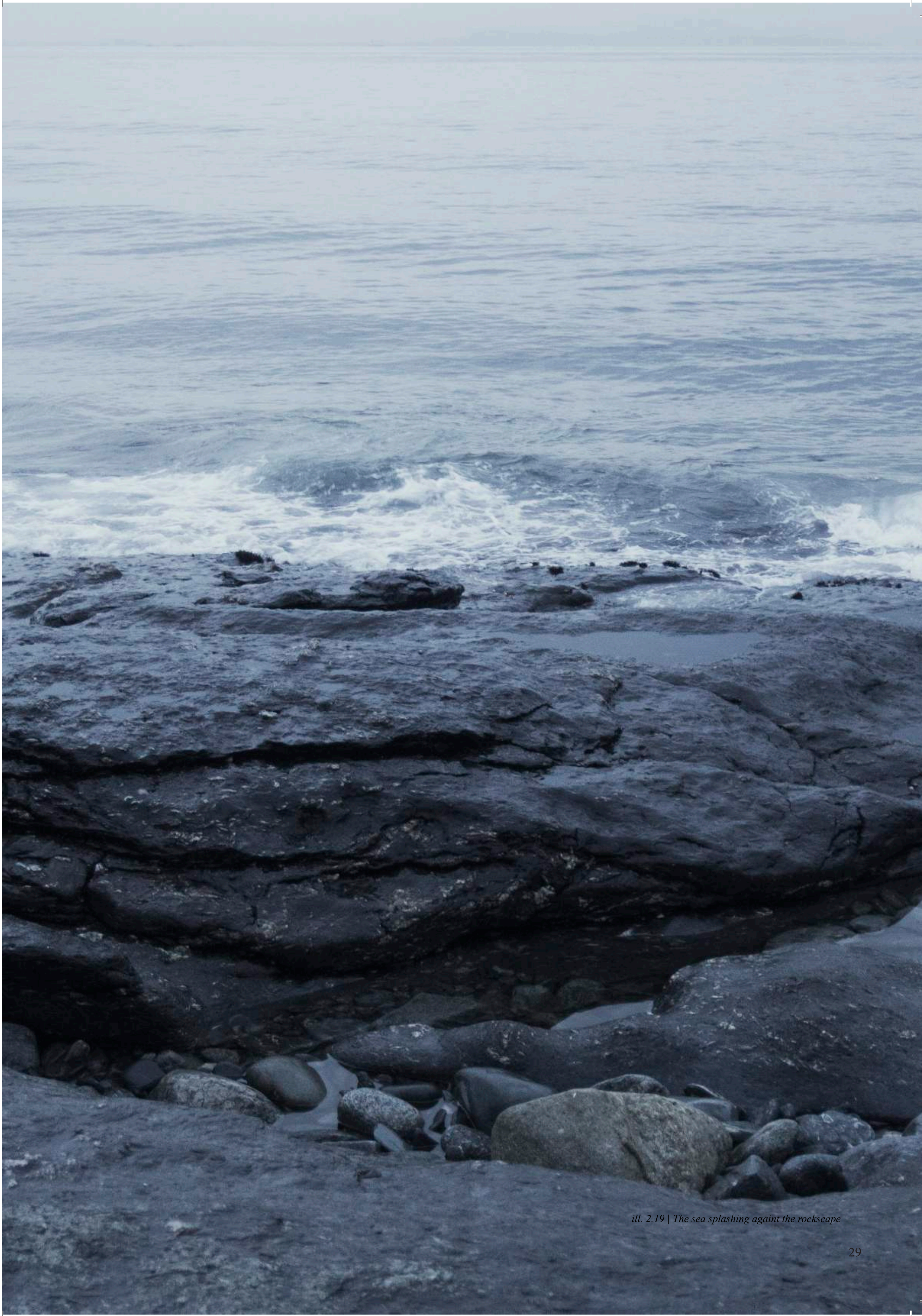
Geological Examinations

Soil Conditions
The Norwegian landscape is highly formed by the ice ages in general. Jæren stands out from the typical engravement of these times because the ice have moved slower, leaving sediments layered on the ground. (Norges Geologiske Undersøkelse 2009)
Common for Jæren is that it is built on a terminal moraine that continues into the sea, that partly rests on cliffs and partly on the bottom of the sea. (Sandalsand,2014)
The northern part of Jæren is characterized by the visible cliff formation arises by gletchers. The cliff landscape consisting of large rocks seem layered on top of each other. They are shaped flat by the ocean so one is able to walk and jump on them - experiencing the ocean up close. (Sandalsand 2014)

Flooding
Facing climate changes the Norwegian coastline risks a rise in sea level of 40-85cm over a 100 year period (Schlaupitz 2016) Illustration 2.18 shows areas of potential risk of flooding in Tungenes. The project prospect too outlines that building placed below level 3 have to be dimensioned to resist storm tide and erosion (ill. 2.18).

Topography
The area is overall continuing flatlands with only small irregularities of slanting edges in the landscape. The flat green landscape erratically blends with the rocks along the coastline at level 3. The difference in materiality is especially perceived here by the change in colors and shape. Southwest of the site the area rises more abrupt turning into a hill.

The aspects of soil condition, flooding risk and topographic difference only outlines the facts of the current and future condition of the site. In relation to the aim of the Science Centre portraying the development of Randaberg in a natural science perspective, this mights as well impact the design as the design dissociating with it. In that way immediate challenges might become potentials of designing architecture that sustains the natural environment rather than working to change it, e.g. thoughts on the articulation the building meeting the ground.



ill. 2.19 | The sea splashing againt the rockscape

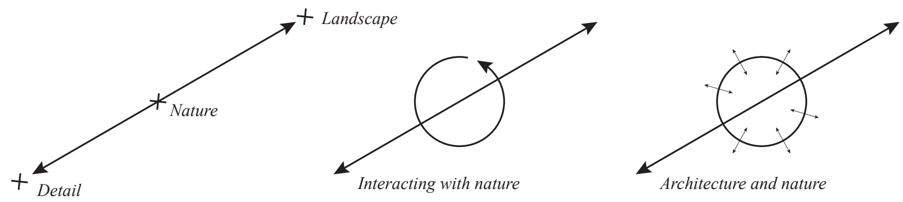
ill. 2.20 | The color scape of the rocks on a shiny day

Nordic Identity

The phenomenological exploration of the site, Genius Loci, has been conducted in a poetic attempt to describe the atmosphere of the site. The description provides an understanding of the essential qualities of the site, to form and relate the project to the contextual conditions. Part of understanding the contextual context is also the cultural and social environments in which the project will be manifested. The Nordic countries, Sweden, Denmark, The Faroe Islands, Iceland, Greenland, Finland and Norway posits many common ideological, cultural and political values. Due to the similarities in term of political system, shared history and heritage the architecture overall has evolved to a united understanding. In term of Nordic architectural ideals and approaches the common qualities emphasised is the implementation of light, craftsmanship in details and the relation and adaption of nature. (Haarder 2016)

"With its apparent shunning of artifice, Nordic Architecture has served as an alibi of authenticity in an increasingly simulacrumridden world, while Nordic architects, from Gunnar Asplund to Sverre Fehn, from Jørn Utzon to Sami Rintala, have been represented as design-savvy noble savages, unencumbered by convention or civilization." (Hvattum 2012, p.103)

Despite the common features the counties also inevitably differs, such as geographical and climatic conditions, thus reflecting in the national and regional architectural characteristic. A great characteristic in Norway is the "fjelllandskap" the mountain landscape, the coastline and the fjords. The varied and overwhelming nature, reflects in the architectural relation to nature adapting to the site. Traditional buildings in Norway are largely wooden constructions, thus based on local materials. Constructing and detailing in wooden work is a well-articulated mean and ornament in Norwegian architecture. Due to the often-clouded weather, the light appears cold and in winter, it is dark for a great part of the day, thus vice versa in summer. This characteristic of the light is articulated in the architecture in various means. (Hvattum 2012)



ill. 2. 21 | Conceptual relation

ill. 2.22 | The heavy rocky landscape constrasting the lightness of the built and the sky

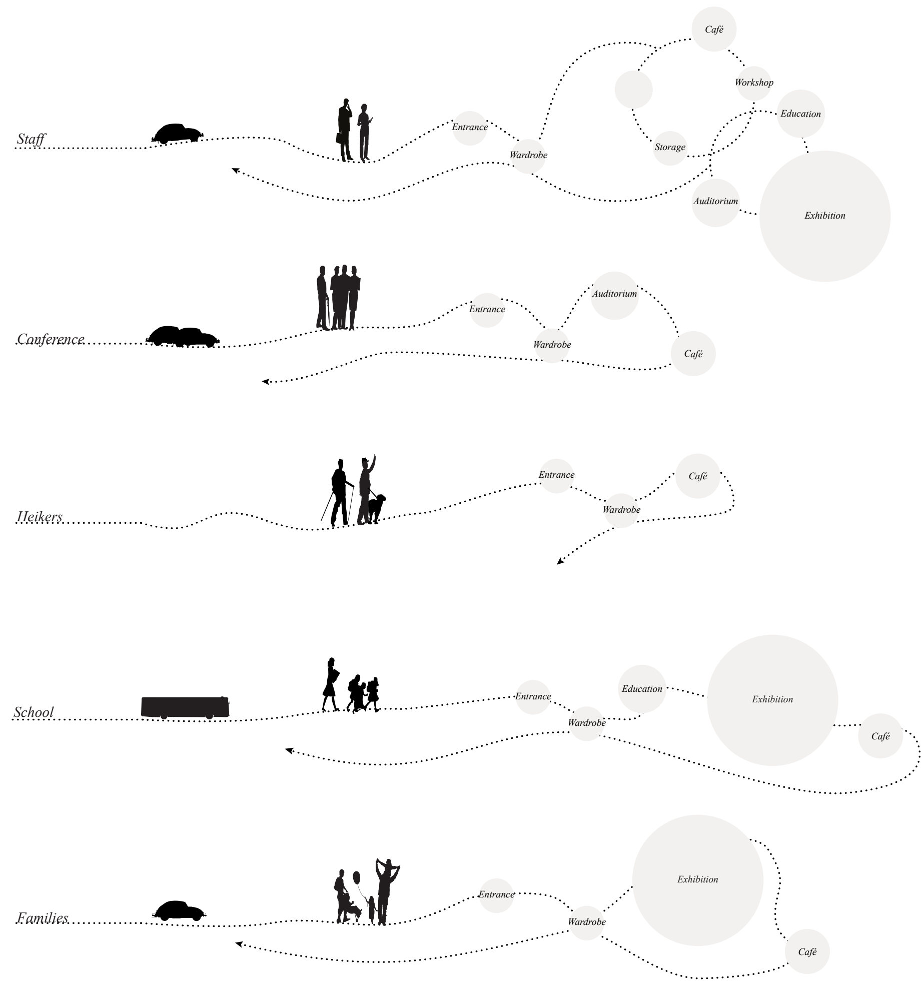
Nature | Architecture

The Natural Environment
The natural environment in Tungenes is dominated by the sea and the flatlands of low grass. Moving towards the water, the grass gradually meets the sea through a coastline of rocks, layered on top of each other. The wet and rough surface of the rocks and space between them catches seaweed from the tide and make a attractive biological environment for plants and insects, causing a enriched bird life. The plants and seaweed contributes to a colorful area of blue, green and yellowish colors.

The Build
The adjacent buildings are all wooden houses including the Lighthouse. Moving around the Stavanger-Region, the general building material is wood. Especially in Stavanger, where white houses of horizontal wooden cladding of different types are dominating the streets. At times the houses have a concrete construction and wooden cladding - having an immediate impression of a wooden house.

Norway have a great and growing ressource based in their forests. The forest are present almost everywhere in norway, providing a local material for all locations. Even with an environmentally responsible harvest they have a great potential of using wood as their primary building material. (Regjeringen 2013).

This cause for wood as the primary material in the Maritime Research Centre, both in constuction and cladding. In order to have a flexibility in the design, the wood might be combined with a material of better heat accumulation.



ill. 2.23 | Flow analysis

Function

The presented function will be elaborated in a room program in the next page.

Museum and Science Centre

The primary function of the Maritime Science Centre is to inform and educate in the given field of knowledge. The majority of the staff will be handling historic research and exihibition items. The exhibitions are mainly permanent (around 10 years) complemented by smaller temporary exhibitions of relevance at a time. In addition there will be janitors, cooks and service staff.

Common Facilities
The public functions descibe the functions operating within and at times outside of the opening hours of the exhibition and research areas.
Included herein is a café. The café functions together with the centre and seperately. Further more the public function covers the outdoor areas created to accomodate the hikers and tourist outside opening hours, as well as the vititors, giving something in return. In continuation of the Nordic Identity and sustainability the outdoor facilities should be available at all hours.

Educational and Conference Facilities
These areas should convey knowledge to larger groups, especially student ranging from kindergarten to high school. The teaching will take part in the educational facilities as well as in the exhibition rooms. The conference facilities will host events related to the community and Science Centre. This aquires a seperation from the exhibition area for security reasons.

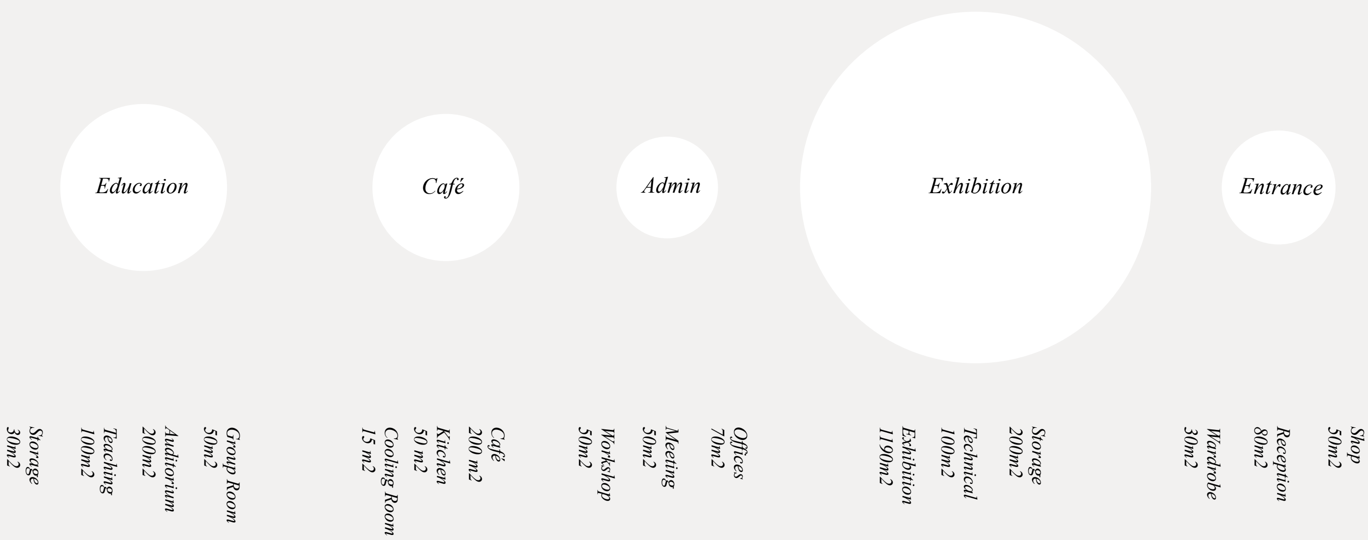
Flow
In order to accomodate the function different scenarios have been analysed to help design the Science Centre. The user groups are the staff, the hikers, the school classes, families and people who come for cultural events, dining or conferences. The diagram depicts the specific room in a expected flow for each user group.

Sceience Center

	Units	*Unit Area*	*Total Area*	*Daylight*	*View*	*Public Access*	*Height*	*Temp*	*People Load (maximum)*	*Equipment*
	[Nr]	[m2]	[m2]	[x]	[x]	[x]	[mm]	[oC]	[people pr unit]	[Text]
* Exihibition Rooms	1		1190	x	x	x	6000	21	250	Contain a large aquarium.
* Museum Shop/Reception	1		80	x		x	3000	21	50	Space for a desk and reception sale.
Wardrobe	1		30			x	2500	21		
Toilet	6	3	18			x	2500	21	1	
Offices	7	10	70	x			2500	21	10	7 workspaces
Meeting Room	3	16	48	x		x	2500		4	
Toilet (staff)	2	4	8				2500		1	
Workshop	1		50	x		x	3000	18	4	
Storage			200				3000			
Washing Room	1		30				2500	18		
Technical Room	1		100				3000			
Education Storage	1		30				2500	18		

Meeting Place

	Units	*Unit Area*	*Area*	*Daylight*	*Ocean View*	*Public Access*	*Height*	*Temperat ure*	*People Load (maximum)*	*Content*
			[m2]	[x]	[x]	[x]	[mm]	[oC]	[people pr unit]	[Description]
Café	1		220	x	x	x	3000	21	130	
Kitchen	1		30	x			2500	21	4	Industrial kitchen.
Cooling / Freezing Room	1		16				2500	5 / -18	-	
Auditorium	1		200	x		x	3000	21	200	
Education Room	1		100	x		x	3000	21	35	
Group Room	6	8	48	x		x	2500	21	5	~ 6 grouprooms
Total			2468							



ill. 2.24 | Room program

03

ill. 3. 1 | The texture of sea weed

FRAMEWORK

Environment emerges in a dynamic interplay between human actions and contextual circumstances.

Sustainability

ill. 3.2

ill. 3.3

Lyfe Cycle Assesment
Climatic environment
Cultural responsibility
Accessable / educational architecture
Perception
Readable gravitational forces
Material proporties vs. function

ill. 3.4

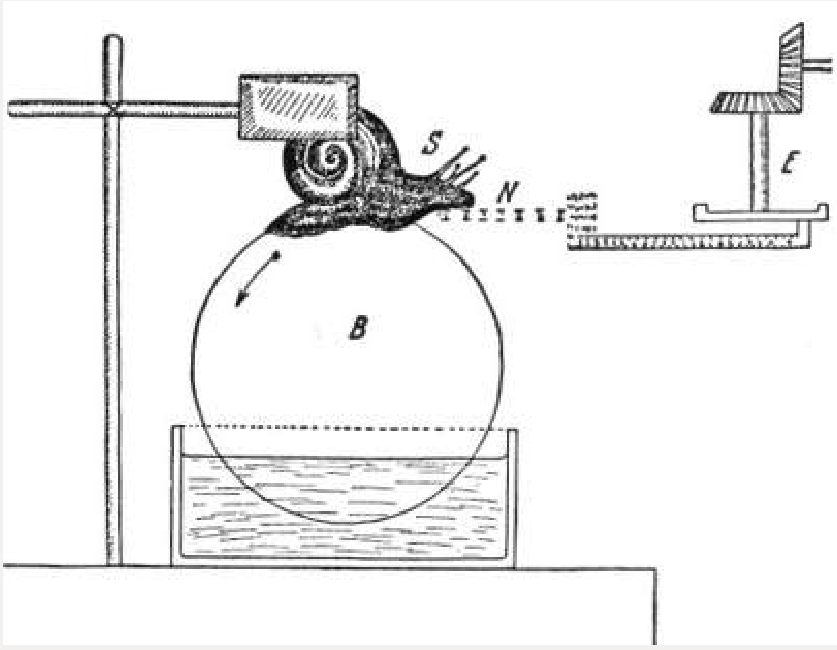
ill. 3.5

Tectonic Approach

Thesis Themes

The following section introduces the theory behind the main subjects. The aim is to establish an understanding of the interplay between the subjects. The idea is to use a tectonic approach creating a social and environmental sustainable design, thus ensuring the spatial quality and the relation to human perception, still optaining the quialities of sustainable architecture.

The investigations are based upon chosen theoreticans as well as practitioners. Such way the underlying process of the documentation consist of analysis, interpretation and inspiration from different reference works.



ill. 3.6 | Drawing by Jakob von Uexküll. A snail eperiment from his book ‘Streifzuge durch die Umwelten von Tieren und Menschen’ (1933). Quote translation by Joost Rekveld (Rekveld 2013)

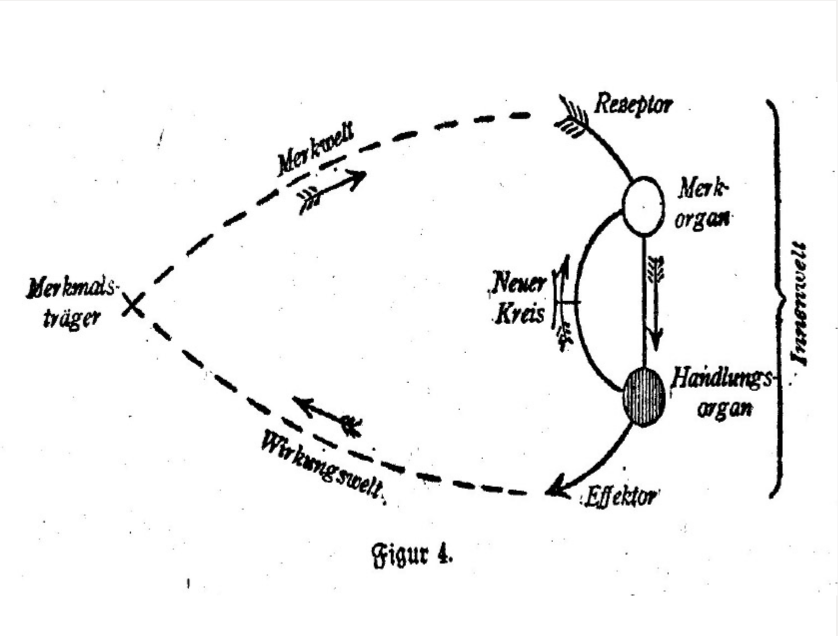
“A snail is put on a rubber ball that can move under it without friction, since it is floating on water. The snail’s shell is being held by a clamp. In this way the snail is free in its crawling motions, but will stay on the same spot. When we put a little stick in contact with its foot, the snail will crawl on it. When we hit the snail 1-3 times a second with the little stick, the snail will turn away. But if we repeat the contact four times or more per second, it will start to climb the little stick. In the ‘Umwelt’ of the snail, a stick that moves to and fro at a speed of four times per second has already become a stick at rest.”

Environmental Architecture

Preliminary
Over the last decades there have been major changes in the requirement of the built space, and thereby a development in how we perceive the environment.
Initially, in the modern movement the architectural philosophy aimed to investigate social sustainability. Le Corbusier was a remarkable pioneer in this era, stating architecture could solve the problems of society. By initially investigating spatiality and light by minimizing the details of materiality he established an early approach toward social sustainability, however later to become a regionalist implementing materiality as reinforcing the perceived space (Le Corbusier 1986).
In the modern era, the technological development of thermal modifying devices has resolved an evolution in how architecture relate the formal architectural style and local climatic context. The new technology made it possible to control the built environment, making modern architecture durable in every climate, thus neglecting the regional traditional methods. This allowed the development of the international style practicing the cleansed minimalism. Few architects of the international style such as, Frank Lloyd Wright practices regional considerations in architecture, which is visible in the composition of the prairie house. However, the arrogance towards the local environment that was also represented in the international style led to a failure.

The consequence of implementation of new technology and demand of thermal comfort in the built environment, have separated humans from the local climatic environment, causing an increasing demand for artificial lightning and air conditioning. If architecture does not create coherence between the built environment and local climatic and cultural environment, there is a greater demand to improve the thermal, acoustic and visual conditions, resulting in greater financial, atmospheric and energy costs. If the architecture on the other hand relate to the local surroundings, these costs can be minimized, and thus moving towards sustainable architecture. (Worre Foged 2015).
Consequently, this thesis is dealing with how environmental architecture creates an essential premise for sustainable architecture, thus it is necessary to establish a definition on the term environment.

Physical and Perceptual Environment
The term environment derives from environ and ment; Environ meaning to surround, encircle or encompass with something; lit. of a physical thing or fig. of a condition, emotion or circumstance ect. (Oxford Dictionary 2017). Thus, indicating the two meanings of the word depending on the context, one relates to the physical world and the other referring to the psychological or perceptual situation. In term of environmental sustainability both meanings of the word are relevant, as interplay between articulates the environments in architecture as an underlying reciprocal relationship. (Worre Foged 2015)
The Estonian-German biologist Jacob von Uexküll was perhaps one of the first to describe the interplay that forms an environment. Arguing that each organism creates its own environment based on its action



ill. 3.7 | Drawing by Jakob von Uexküll from his book Theoretische Biologie, 1920. Illustrating the notion on Funktionskreis

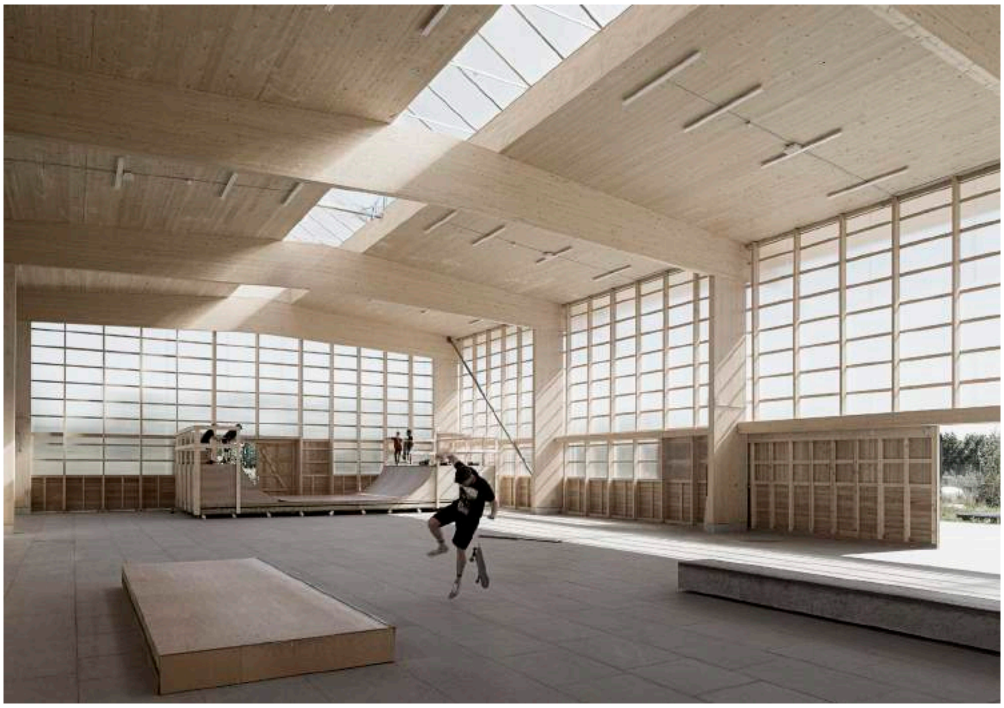
and ability to perceive the surroundings. From the literary work Umweltshistorie, Uxeküll describes the Merkwelt as the perceived world, the Wirkwelt as the affected world and the correlation of these connected by the funktionskreis, the functional cycle, hence creates the environment. Additional the Umgebung, the geographical environment and Welt, the scientific universe as simple contextual matter that also influence the environment. Though simple experiments, Uexküll established the relation between environment and perception. Based on individual sensory capacities the organism construct the environment through actions relating to the perceived surroundings. Thus the articulation of the environment is not only based on the making of external attributes of the human. Environment as an architectural matter is closely related to the perceptual understanding of atmosphere and it can be suggested that atmosphere could be a result of a constructed environment in architecture. (Worre Foged 2015)

Sustainable Environment

Designing sustainable architecture, several parameters is essential to consider; the construction, use of material and how architecture relates to its context and users and the global environmental impact. This thesis will articulate environmental sustainability using different means of measures. However, we believe that sustainability is not a checklist of different demands and requirement, but establishing a sustainable approach using different parameters to direct the project.

The technical principles of sustainability are addressed through measures and calculations, thus easier to acknowledge. The fact that 98 % of the energy production is from renewable sources, the operational energy consumption of the buildings in Norway can be defined as off-grid net zero energy buildings. Interesting is therefore to investigate passive strategy solutions utilizing the local climatic environment, aiming to create human oriented environment and atmosphere. In the approach toward sustainable architecture the tendency has been that buildings are perceived as in isolated initiative, such as operational sustainable buildings. However sustainable architecture involves a holistic approach of the process of planning, construction, operation, maintenance and demolishing the building.

Humanistic-perceived sustainability emphasizes the human scale as the essential focal point for creating architecture, in line with our vision of gesture as a catalyst of the design. Additionally, social sustainability is addressed focussing on the local community as an important aspect creating a sense of democracy and equality, important to Norwegian culture. Parameters such as access to the site, creating gathering space and architectural sensual quality to engage the visitor is crucial in this thesis.



Lethallen for street sports designed by Vandkunsten is a simple construction of sustainable materials assembled in a simple structural envelope that is easy to disassemble, which potentially allows for replacing the elements in the envelope. Consequently creating a flexible and dynamic use of the building in the future. (Vandkunsten, 2015)

ill. 3.8 | Lethallen by Vandkunsten, 2015

The Envelope

In response to the sustainable environmental principles stated above a great focus in the thesis will be the investigations of the envelope. The purpose and understanding of the envelope have changed for eras. The origin building was intended to provide shelter in those conditions, human was not able to adapt, thus never not to provide comfort. In the writing "Contingent behaviours" the nature scientist Michelle Addington questions the correlation of the envelope and human, critical reflecting upon the modern envelope; "as a ´container´ of the environment of man and envelope and a "barrier" to the environment of nature". Based on the law of naturural science, Addington defines the envelope as the physical manifestation of the boundary, where the boundary is the zone in which the energy exchange takes place. Yet instead of perceiving this as a fixed barrier, Addington suggest that "the building envelope serves as a boundary that is simultaneously an extension of the body and an intention of the surrounding environment". (Addington 2009) This indicating the envelope as a more open system, where the boundary is not a fixed statement, but a fluent condition continuously being developed.

This way of perceiving the envelope serves as an initial approach for the design process, in order to decompose the transition between inside and outside.

Passive Strategies

The simulation tools will be implemented when geometry have been established. Persuing a environmental sustainable building, the passive strategies in the initial process will be of as much value to the design as the detailing. Providing a base for the process following passive startegies will be in mind when discovering the geomety and design.

- Natural ventilation
- Passsive solar heating
- Solar shading
- Materials (LCA)
- Envelope in relation to area

Materials

The analysis and framework leads to initial choises upon materials, meeting a desire to relate to local history and culture, the function of the building as well as taking a sustainable bencmark prior to the proces. The main material used will be wood, particulary glue laminated wood due to a very low energy consumption over its lifetime and the ability to reuse in energy production.

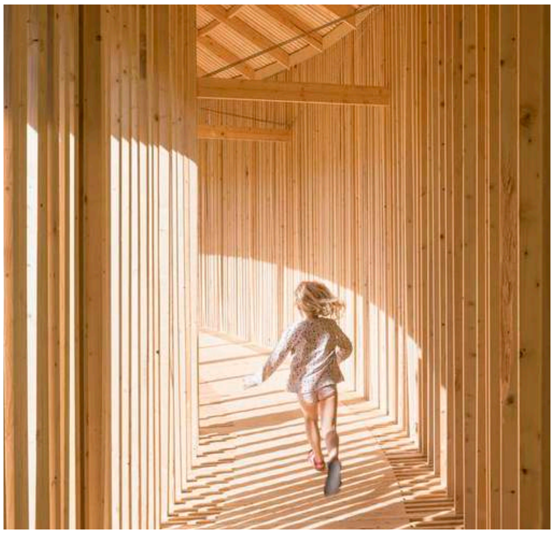
Dominating the performance of a building in a northern climate is the envelope, and its ability to store heating. To challenge the common view of an envelope an alternative insulation material is introduced. Sea weed is commonly known as insulation materials in the history of Læsø, and an rediscovered material among ingeneniørs as an alternative to mineral fibres due to its similar properties. (Bygtek 2017) With origin in the aestetic qualities discovered in Det Moderne Tanghus på Læsø by Realdania and Vandkunsten, the aim is to use the material of both technical and aesthetic character in the design. (Realdania 2013)

ill. 3.9 | Preikestolshytten by Helen and Hart

The cabin at Preikestolen in Norway works as a overnight accomodation as well as a service area in relation to the nearby hiking route to Preikestolen. The building construction is exposed and together with the patination of the material this compose the general expression of the building.

ill. 3.10 | Det Moderne Tanghus by Vandkunsten

Using seaweed as a dominting material arises the quistion of using insulation material in an aesthetic point of view. The materials, wood and sea weed, relates to the cultural environment (the history and the geographical context) as well as to technical perspectives of sustainability.



ill. 3.11 | Around Pavilion by Christiansen Andersen

Around Pavilion serves as an example on how to create a fluent transistion from inside to outside. The dimension and the material of the platform invites to both moving and stay. The three dimensional envelope challenges the idea of what is inside and outside by allowing air and thereby smell and sound directly through it.

Tectonics

This section aims to elaborate on the theme tectonics in relation to the design of a Maritime Science Centre in Tungenes. In order to establish an understanding of tectonics relevant to the thesis, a mapping of selected theoreticians of relevance will result in a description, having a benchmark for architectural quality in the design process.

In several contexts, tectonics have engaged concepts of structure, construction and poetic meaning. In that sense, tectonics have the potential to become an offset to certain aspects of sustainability, often having the challenges of bringing many technical requirements into the architecture, without a human-oriented point of view. Designing architecture anno 2017, one must have to fit in a certain framework of sustainability, often judged by a final calculation instead of a hybrid review accentuating eg. an involvement in matters of spatial connection and experience as well. This might be the build up of an envelope or dealing with flexible, reusable construction. By emphasizing the history of tectonics, one might notice an evolved attention to bringing the process of designing, the intention and the human-scale into the term. Portraying this development, the aim is to create a connection to linked sustainable initiatives, pointing out a need for bringing poetry into sustainable construction as well.

ill. 3.12 | Steilneset Memorial by Peter Zumthor and Louise Bourgeois

The Steilneset Memorial by Peter Zumthor and Louise Bourgeois serves as an example of tectonic approach in architecture. The iconic pavilion comprises a main scaffolding construction of pine wood, with exposed joints, that fluently moves along the landscape, emphasising the subtle movement. The scaffolding supports a suspended fabric cocoon containing an indoor exhibition.

The design portrays a logic construction of the materials corresponding to the structural forces, in a hiraki of silk fabric, wires and wooden beams and columns. This makes an intuitive trace of forces and a readable meeting with the surrounding terrain. This exploration of the structure results in an experience of being raised from the ground when entering the cocoon.

ill. 3.13 | Steilneset Memorial by Peter Zumthor and Louise Bourgeois

Theoretical Mapping of Tectonic Developement

1851

Die Vier Elemente der Baukunst
Gottfried Semper

Semper based his definition of tectonics on a exclusive model describing the origin of architecture by decomposing the Caribbean Hut from 1755 of Marc-Antoine Laugier. He presented a twofold notion concerning respectively the topography and mass opposite the spatial and light weighted, further divided into four categories of fundamental elements:

Stereotomic
- Earthwork
- Heart

Tectonic
- Framework/roof
- Enclosing membrane

In continuation of the quartering of building elements a focal point is the notion o n the framework and envelope are reserved a spatial intent. (Worre Foged 2015)

1852

Die Tektonik der Hellenen
Karl Bötticher

Bötticher divides the concept of tectonic in architecture based on the analysis of Hellenic Art, e.g. the ancient Greek temple. The core-form (Kernform) and the art-form (Kunstform), defining the function and symbolic meaning of an architectural object. (Worre Foged 2015)

1860

Der Stil in den Technishen und Tektonischen Künsten oder Praktische Ästhetics
Gottfried Semper

In this consequential dissertation Semper elaborate upon the importance of understanding the properties the transformation and joining of materials in order to perceive the intentional meaning of a building. His extraction of this point lies in his Stoffwechstheorie; that a material is undergoing a transformative process of specific treatment, technique and medication, becoming a composite in an certain architectural context.

The underlying idea becomes important by the necessity to make the transformation discernible - introducing the intention of a acting agent to the understanding of tectonics. (Worre Foged 2015)

1886

Prolegomena zu einer Psychologie der Arkitektur
Heinrich Wöllfin

Wöllfin established his notes on tectonic with origin in the knowledge on the German philosopher Theodore Lipp. Lipps made psychological investigations on the concept of empathy in architecture, as a continuation of the ancient belief; that there is a relation between the man and architectural formation.

In his treatise he formed the understanding of tectonics as a manifestation of empathy in the architectural field. Here he states that "We supposit our own image under all appearances", implying that the experience of a building is dependent on and inseparable from the experience of our body, that the concept of tectonics claims a layer of subjectivity. (Sekler 1964)

1965

Structure, Construction and Tectonics
Eduard Sekler

Seklers contribution to the concept of tectonics begins with unrevealing the meaning of structure, construction and tectonic. He states that the structure is the general and abstract concept of a system, whereas the construction is the realization engaging the ways of putting materials together.

Tectonic, then, is the play of forces corresponding to the arrangements of parts relating to the Greek origin of the word as the crafts of a carpenter.

"Obviously, what matters, [...] is the tectonic statement: The noble gesture which makes visible a play of forces, of load and support in column and entablature, calling forth our own participation in the experience."

In coherence with Heinrich Wölffins theory, the body's own experience can't be left out understanding tectonics. (Sekler,1964)

The Question Concerning Technology
Heidegger

1977

In his essay The Question Concerning Technology, the German philosopher Heidegger brings up Greek terminology and the etymology of early thinkers to understand the process of making in relation to culture and society. The objective is the understand how humankind will not be suppressed by technological processes.

Heidegger especially refers to the thoughts of Aristotle's and Plato's, enhancing the concept of technology and knowledge with a notion to its causes, introducing the four causes.

Causa formalis: the formation, the shape in which a material enters

Causa materials: the material, the way of which something is made

Causa efficiens: the effort brought about by the finished something.

Causa finalis: the end, to witch something is related to its requirements

Introducing the causes entitles a profound aspect to the act of creation. Looking into the Greek Aletheia, meaning revealing, Heidegger connects technology, ultimately derived from techné, to do with the activities of the craftsman in having the concept of art as a method and principle - introducing poisis to the concept of tectonics as well. (Worre Foged 2015)

The Tell-the-Tale Detail
Marco Frascari

1984

In his paper The Tell-the-Tale Detail Frascari aims to emphasize that both construction and the action of constructing is readable in the detail, and that the articulation of the detail is somewhat scale less, because a detail, equal a joint, can be anything from connection between two bearing element to the connection between the interior and exterior. (Frascari 1984)
Frascari states that details have the primal role of the experience, and that the precaution of succeeding is ultimately the responsibility of the architect (Hvejsel et.al. 2015)

Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Centure Architecture
Kenneth Frampton

1995

In continuation of Semper, Frampton agrees that it is in the meeting between the stereotomic and tectonic in which architectural quality lies. Frampton elaborates on the theory by introducing the three converging vectors, the typos, the topos and the tectonic in the discussion. He too emphasize with Heidegger, in matters of bringing the value of an act, intention and meaning, into the concept of tectonics, having not solely the observed articulation of a structure. In his book, Frampton sums up this merge of points of view into the poetics of construction. (Worre Foged 2015)

While the semperian description of tectonics points at a the spatial connection of the structure, Sekler's theory is based on a gesture made visible through constructing and Heidegger emphasizes the causes of creation based in ancient Greek philosophy. Wölffin outlines that every understanding of an object or a context of the physical world, is processed through the minds of human beings, hence the societal and cultural aspects can't be ignored and the structure and construction will always have aesthetic value.
Eventually, Frampton argues, in continuation of several of the abovementioned, an addendum of the intention of an act combined with the importance of the articulation of a joint in the definition of tectonics, emerging at the poetics of construction.

ill. 3.14 | Site plan drawing of Teshima Art Museum

The structural ability of concrete is exploided in the spatiality of Teshima Art Museum, where the rational structural principle in relation to natures becomes the explicit artistic expression. By using contrasting visual and sounds creating a changing environment, through human interaction creates a sensory experience. Entering the Art Museum the senses is intrigued through various, yet simplistic means. Using nature and weather as acoustical and visual sensory experience, the space create fluent transition between inside and outside.

ill. 3.15 | Picture of Teshima Art Museum by Iwan Baan

Reflection on Tectonic Approach

Despite an, at times, ambiguous definition of tectonics, the overview of theoreticians provides us with a range of well argued points of view of the matter. The term tectonics leads to several discussions upon the word up till today. However, the authors tend to address similar aspects concerning structure, construction and to some degree a relation to the human sensory experience obtained by constructing.

The perspectives from the timeline form an understanding of tectonics as a mean of architectural quality. The quite focus Marco Frascari puts in the articulation of a detail might be excessive, however the idea of details as scaleless lead to a broader understanding of his notions, as Frampton too saw, that the attention to these details of all scales are the crucial aspect of architectural quality - the meeting of elements. In continuation of Sempers notes on the act of value acquiring an acting agent, the architect, must possess the knowledge of constructing, meaning knowing the basics of joining materials according to its properties and the gravitational forces occurred in a structure.

This tectonic study lastly forms a benchmark for the design process. The following aspects are extracted from the selected theoreticians of significance to this thesis, offering a guidance within tectonic approach to architecture.

Attention to material properties and how this impact the structural principles.

Traceable gravitational force in any given structure.

Aesthetics are bound to the articulation of construction and joints.

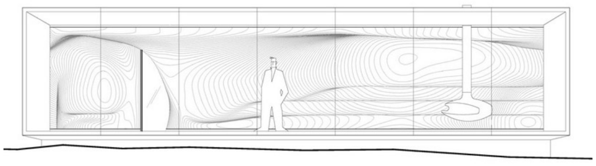
There is a state of rationality to the aspects, a logic bounded in the natural order and ancient understanding of man and architecture - which, perhaps, relates to the continuing discussion and relevance of the subject in a world constantly moving forward on the winds of technology.

These aspects implies a design that entrusts the potential of spatiality through construction. As sustainable matters of energy consumption and LCA, among others, are overlapping with matters of construction, the qualitative, subjective aspects of aesthetics here within inevitably concerns sustainable design.

Phenomenological Approach

In the experience of art, a peculiar exchange takes place; I lend my emotions and associations to the space and the space lends me its aura, which entices and emancipates my perceptions and thoughts. An architectural work is not experienced as a series of isolated retinal pictures, but in its fully integrated material, embodied and spiritual essence (Pallasmaa 2005:12)

On perception and atmosphere
The theoretical background of the thesis has particularly addressed and explored perception of architecture in correspondence to environment, tectonic, climate and contextual analysis. Thus, the core subject has been human perception and the importance of how certain initiatives and conditions can contribute to the sensory experience of space, thus creating atmosphere. The notation of atmosphere can have two meanings; one related to the globe or sphere surrounding the earth, the other describing a sense of mood or condition with in a situation. (Oxford dictionary 2017) In this thesis the word atmosphere will be referred to as the last notation, hence a singular interpretation of space perceived by human. (Worre Foged 2015) Reflecting upon environmental architecture suggest that the construction of environment perceived by humans is determined by the material and immaterial understanding, catalysed by the action of oneself, thus complex and dynamic in its spatial manifestation. The spatial construction can derive from tectonics, as an ideological basis for spatial experience and mean of perceptual architecture. Kenneth Frampton describes: "Thus we may claim that the built invariably comes into existence out of constantly evolving interplay of the three converging vectors, the topos, the typos and the tectonis" (Frampton 1995:2). Frampton, thereby, suggest the dynamic relation of tectonic and contextual conditions encircles the architectural form. The interplay between contextual, materiality and climatic conditions is therefor decisive perceiving architecture. Michelle Addington stresses from a physic-oriented approach that "we sense ourselves and only indirectly sense our environment" (Worre Foged 2015). Thus perceiving architecture it not a straightforward answer, but an interplay between physical conditions and circumstances deriving in the individual perception and actions, thus creating atmosphere. The perception of space is directly linked to previous analysis and is equally relevant aiming to create sensory architecture, ensuring architectural quality.



ill. 3.16 | Reindeer Pavilioin by Snøhetta by Kaas Van Ommeren

Another example of how architecture relates to nature, is the reindeer pavilion created by Snøhetta, yet other sensory means creates the experience and relation between architecture and nature. The reindeer pavilion is situated in the nature area as part of a hiking path, thus to reach the pavilion the human must walk through the nature of Norway. The pavilion itself creates shelter for the visitor, while viewing the overwhelming nature of Norway. The experience of the pavilion is a sensory journey hiking through landscape reaching the pavilion that though a tactile, thermal and visual experience frames the nature of Norway.

ill. 3.17 | Riverbed by Olafur Eliasson, 2014

Picture by Anders Sune Berg

An example of investigation nature through architectural studies is the installation of the Danish-Icelandic artist Olafur Eliasson, called Riverbed. The installation was situated in Louisiana in 2014 and unfolds a landscape of rocks within the museum, hence investigating the relation of outside and inside, nature and architecture. By fusing nature and space, Eliasson creates a sensory experience using the tactility and texture of the stone and sounds from the stream, and changing door heights, the human perceive the exhibition moving through the space.

"Our presence, where we are can also be topologically understood as a determination of place. Indeed, sensing physical presence clearly involves both physical distance from things, whether they are oppressively close or very remote, and also spatial geometry, in the sense of a suggestion of movement, reading upwards or bearing down. But a sense of ´whereness´ is actually much more integrating and specific, referring, as it does, to the character of the space in which we find ourselves. We sense what kind of space that surround us. We sense the atmosphere." (Böhme 2005:405)

Architecture and Site

Learning from the studies of Genius Loci, Nordic identity and analysis of the site, we wish to establish an architectural ideal towards how to approach the site as part the contextual understanding, thus aiming to achieve environmental sustainability. A spatial quality at the site is the surrounding water towards east, north and west. Due to the many mountains enclosing many cities in Norway the horizon line often appears very high, making the site stand out in a Norwegian context as the view of the ocean and fjord results in a low horizon line. The site is a flat area, and thereby no shelter from the wind and other climatic impacts. Consequently, to accommodate the building as a gathering point it is important to investigate how the building interacts with nature and climate. The interplay with the topographical conditions is essential as establishing a foundation of the project. Moreover the notation of daylight is an important aspect to address in correspondence to the spatial functionality as well as contributing to the sensory experience.

Thus picturesque, topological and climatic quality and challenges that the site possesses, is investigated in the design process through architectural studies. By working within different scales and distances as part of the perceptual experience, either it is focussing on specific material or construction detail or the panoramic view, the perceptual vision is to create a sensory journey accommodating the function and ultimately creating atmosphere. This objective follow the notation of atmosphere described by the german philosopher Gernot Böhme depicted above.

ill. 3.19 | The scale of the rockscape

Vision

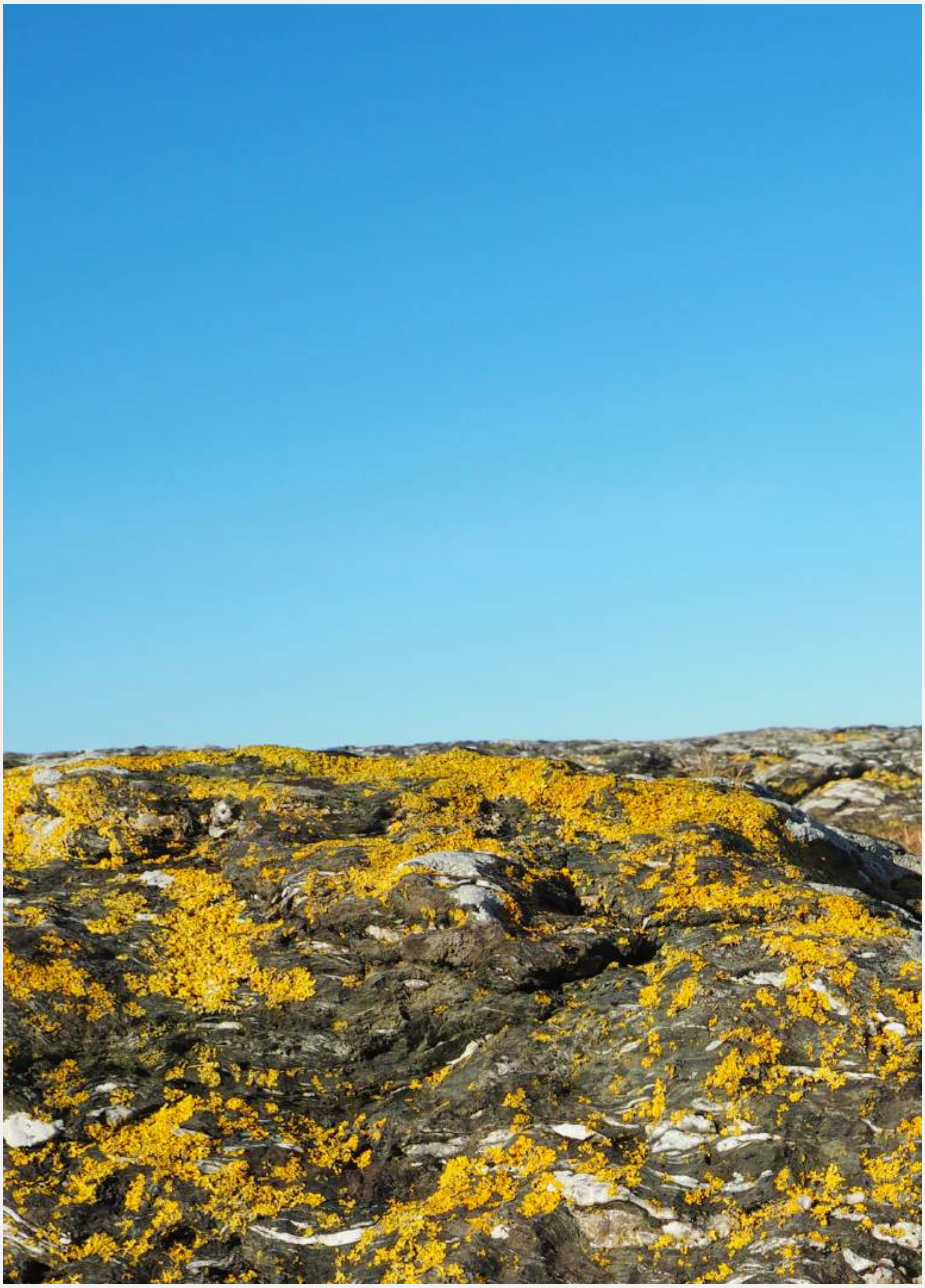
Based on the objective to create human-oriented environmentally sustainable architecture, the three previous chapters have studied different fields of theory as prerequisite for designing the Maritime Science Centre. The theoretical have been identified to examine to answer the question of how to achieve architectural quality in a sustainable context. Essentially the design pivot to exploit sensory experience using the existing contextual environment in relation to functions of the Science Center as mean.

The natural environment is a significant definition of the Norwegian identity, and the site for this thesis has a unique characteristic in Norwegian context, due to the flatlands of Jæren encircled by the ocean and with a rare view of the low horizons. The geographical and weather conditions create a diverse sensory experience and atmosphere at the site, which we aim to reflect in the built, to enhance the transition and relation between the built and nature, stressing the spatial quality of the water and landscape. To address this relation between the context and building, an important aspect is to address the foundation of how the building relate to the site. Additionally, the contextual qualities in relation to the building will be examined introducing acoustic, tactile, thermal and visual means to create a sensory experience.

The potential of tectonic is explored in relation to technical sustainability, as an aesthetic mean to investigate the structure and materiality. By revealing the gravitational force of structure and the meeting of elements, architecture has the potential to tell the story of logic forming a project of tectonic value. Thereby tectonic contributes to the perceptual experience as the construction reveals its spatial and aesthetic relevance. The initial choice of wood as the primary material relates to the tectonic approach in matters of detailing and tactile potential and to sustainability as a renewable material source and a beneficial material in flexible construction.

Environment emerges in a dynamic interplay between human actions and contextual circumstances. By investigating the envelope as an spatial and fluent transition between outside and inside, the boundary of space is challenged. Using means such as different thermal zones, spatial dynamics and visual directions, the project aim to manifest a sensory journey.

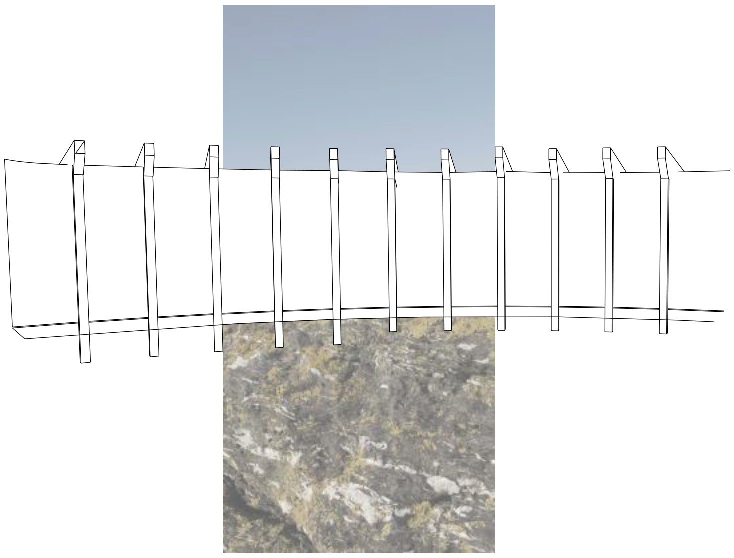
04

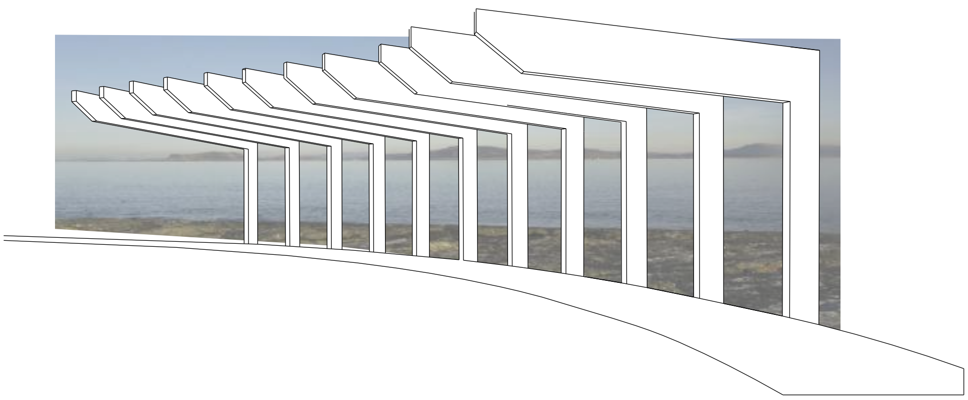


ill. 4.1 |

PRESENTATION

The experience lies within the acoustics of space, the materiality of the built and the sensation of light and shadow.





ill. 4.2

ill. 4.3

Architectural Concept

The circle unfolds grasping the existing pattern of the pathway and the curvature of the coastline. The exterior of the build¬ing seek to articulate transition in elements from grassland to stonescape, and stonescape to the sea while the courtyard encloses them, creating an intimate exterior experience that brings focus to the enriched and nuanced detail of the stonescape. Around the building a viewing platform establish function as a secondary flow to the existing,courtyard taking the visitor above the landscape, framing the view of the moun¬tains, the low horizon and the grassland. The spatial and repetitive construction frames the scatters the vies while moving around the building, thus creating s reciprocal and transiting interplay between nature and architecture.


Courtyard
Entrance
Lighthouse
Cluster of houses
4
8
12

ill. 4.4

Master Plan

The Science Centre is located the edge of Tungenes where roads ends and the low horizon appears stage by the rocky landscape and the sea. The parking is located by the cluster of houses near the dock, making the arrival to the Science Centre on foot, either along the existing path that moves between the rocky landscape and the grasslands or from the top of the hill at the location of the lighthouse. Platforms detach from the building and stretches out into the landscape directing the visitor in a smooth transition to enter the building.

2m

ill. 4.5 | East

2m

ill. 4.6 | South

The east facade shows the view from the sea-side, revealing the two-pitched roof and the roof balcony. The shadow under the building indicates the courtyard, and moving around the rocky landscape it is possible to enter the courtyard below the building.
The wood adds warmth to the atmosphere along with the colorful moss, contrasting the dark stonescape.

Towards south, the building foundation disappears behind the small slopes in the grassland. The roof has a significant sloping from east to west, revealing the movement from the lowest to the tallest part of the building. The balcony of the second floor is slightly visible from a distance, but will not be visible moving along the facade.

Facades

The facades show how the building relates to its contexts, in different way according to direction. Variations in roof shape and height, openings and balconies varies around the building along with the landscape and the view. The foundation changes according to the terrain, thus the building movement reflects its context.
The construction is made of glu-laminated larch elements and the facade is cladded with larch timber as well. The patina will be more eminent at the exposed construction and the roof cladding than at the walls, getting a grayish tone, creating further depth in the articulation of the facade.

2m

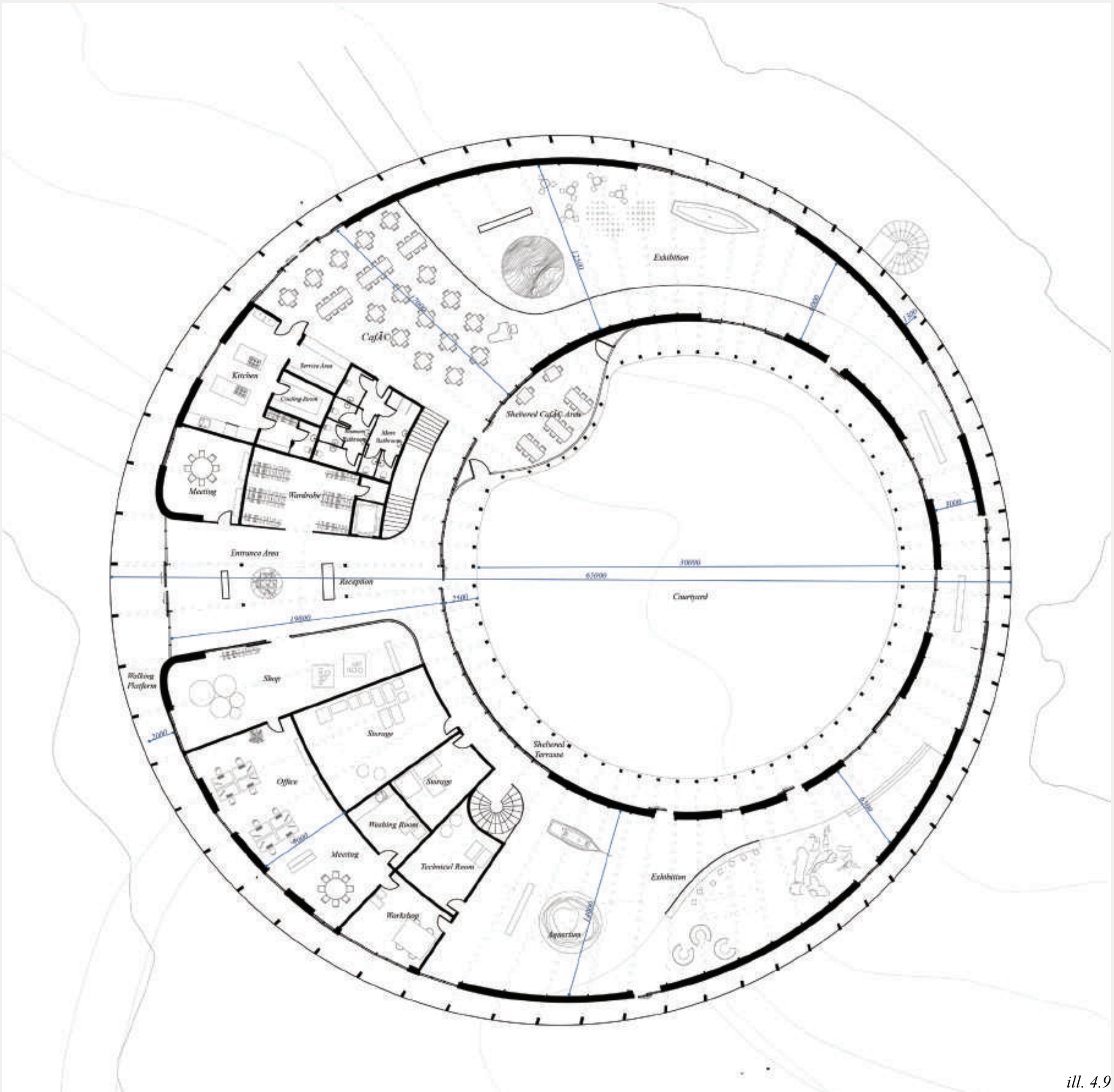
ill. 4.7 | West

2m

ill. 4.8 | North

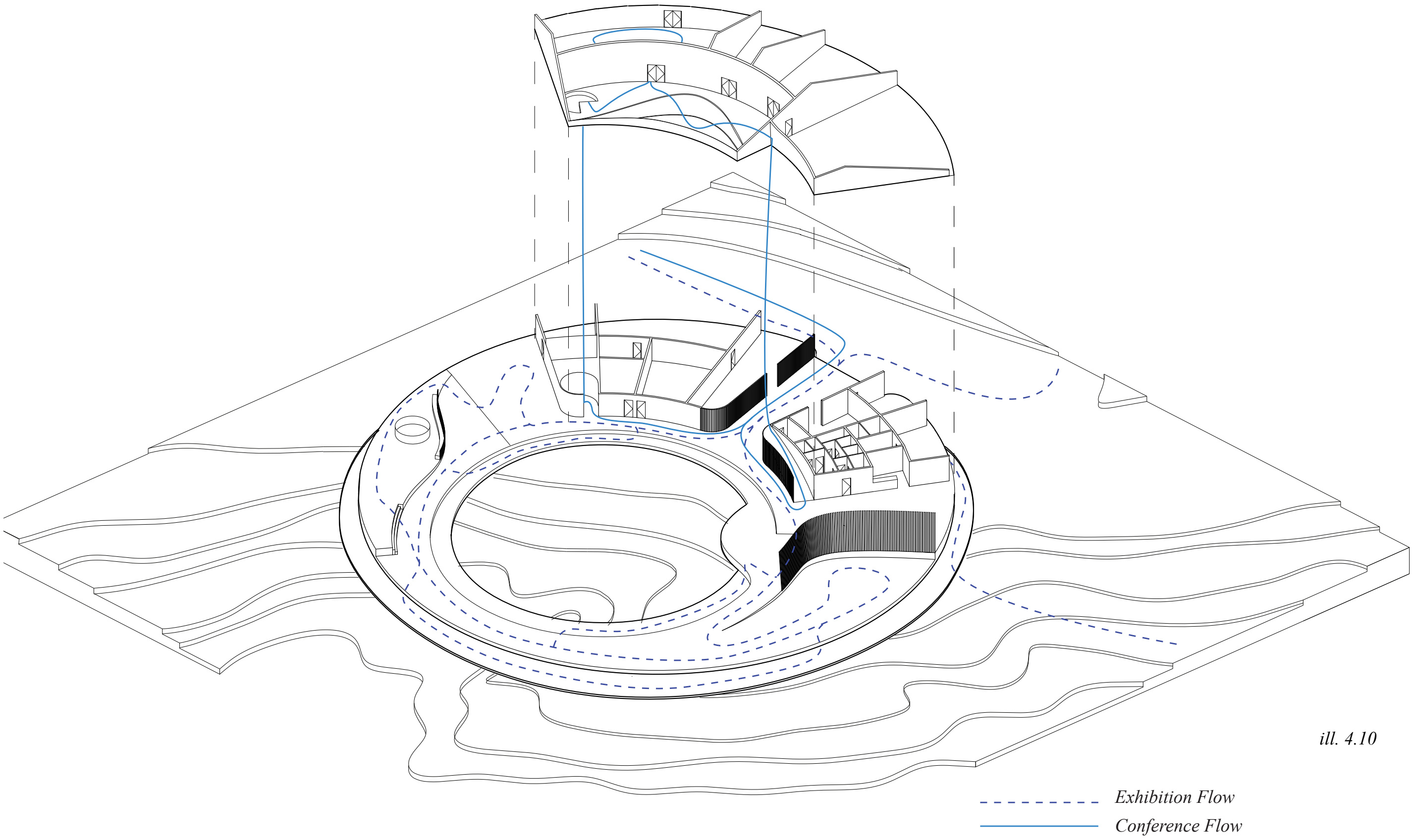
The western facade illustrates the roof disappearing from the view towards north. The entrance is pulled back in the first floor to make a natural flow in and out of the building from the platform. The landscape is slowly turning into stones again.

The two-pitched roof is visible from North. The concrete foundation at the grassland is peaking above the landscape underlining the difference of the terrain. The sloping ground towards east makes it possible to see the light from the courtyard below the building, guiding the visitor under the building.



ill. 4.9

The entrance area is placed at first floor, with nearby wardrobe and exhibition shop. The facade constrict at the entrance, where the facade is pulled back to direct the flow into the building. Here the area serves as a distribution space for all facilities, becoming a meeting point across functions and making it easy to navigate the building. The kitchen and servant area are placed near the café along with a staff area facing towards the entrance used for dining or meetings. The offices are placed southeast with views to the grassland and lighthouse. I continuation of this is a workshop, used for exhibition related assignments.

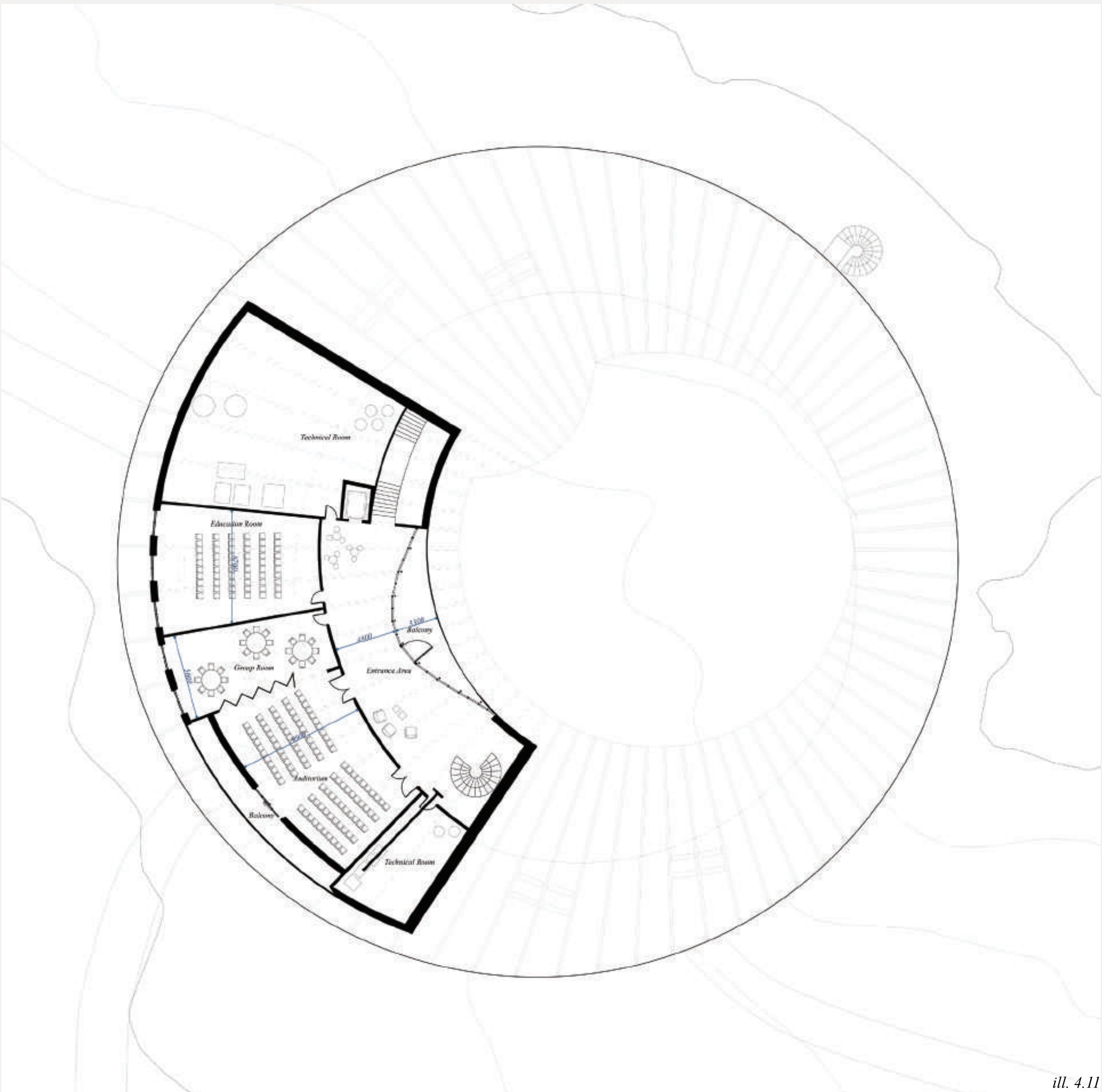


ill. 4.10

The exhibition space is an open plan with sloping towards east, creating a raised platform creating a distinction between exhibition and fluent flow. The slope continues to the eastern part of the building, where the surroundings and the courtyard are staged by framed views. When the temperature allows it, it is possible to move in and out of the exhibition, experiencing the circular platforms em¬bracing the building. A transparent wall is separating the exhibition and café area, filtering the sound and views, letting the atmosphere of the exhibition melt into the café area without noise.

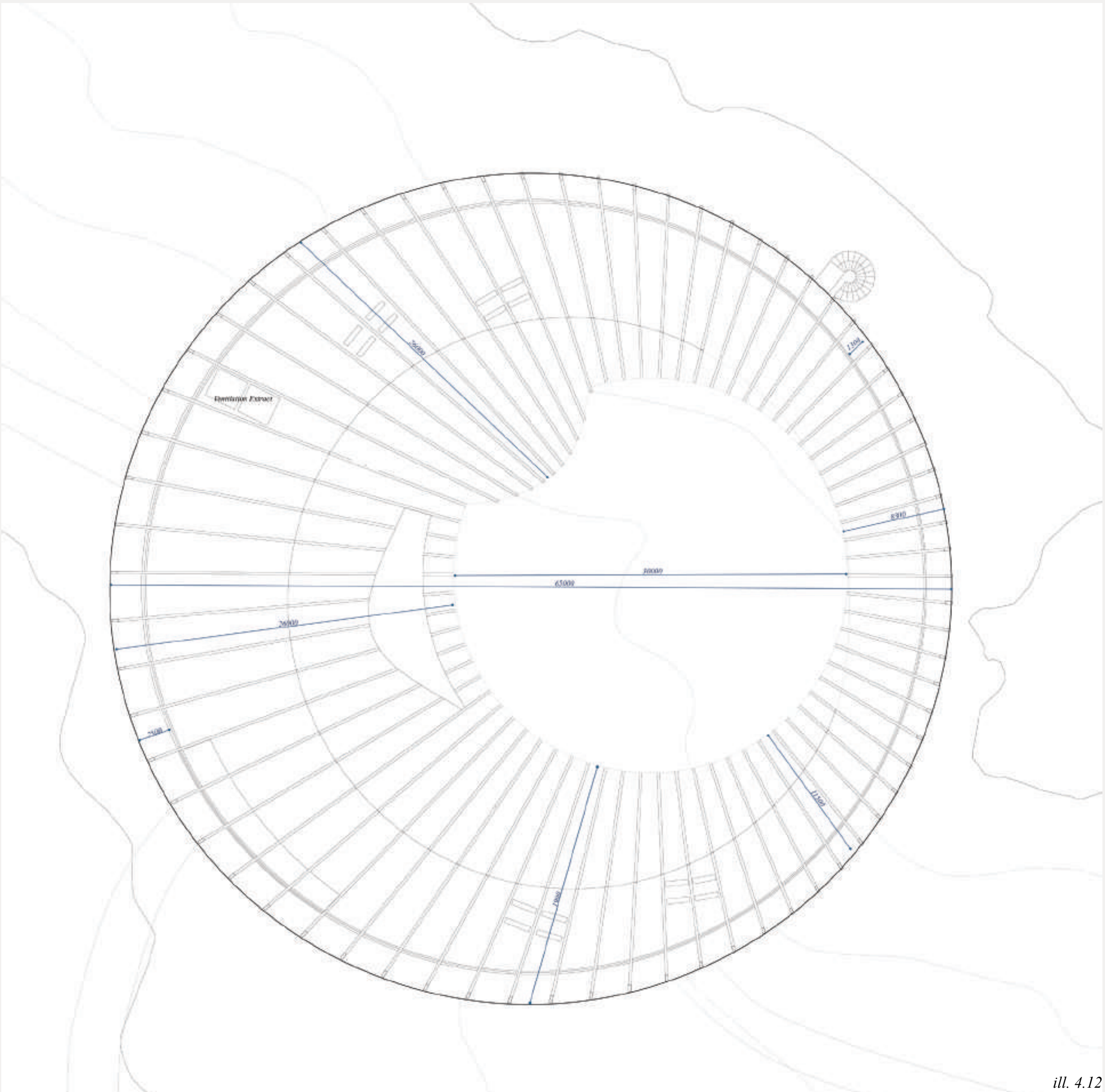
Plans

The Science Centre house exhibition, café, conference and education facilities. The presented scenarios in the Preliminary Studies in combination with a deep focus on the inside / outside connection have been the main design aspects of the plan. The layout will be depicted through plans (1 : 200 in drawing folder) and a flow diagram.



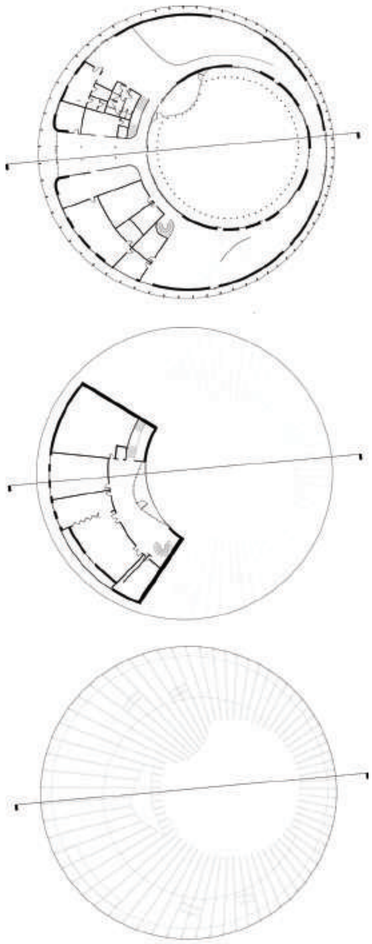
ill. 4.11

Between the entrance and café is a stair¬case leading to the upper floor, where the confer-ence and education facillities and technical room are placed. In front of the facilities is a lounge with a roof balcony having a view over mountain landscape and the sea. The lounge area mainly serves the facilities in the second floor, but can also be accessed by the visitors of the exhi¬bition area. A staircase in each end leads to the first floor, making an easy access both ends.
The group room and auditorium is separated by a flexible wall, so at larger events, the rooms can be put together..



ill. 4.12

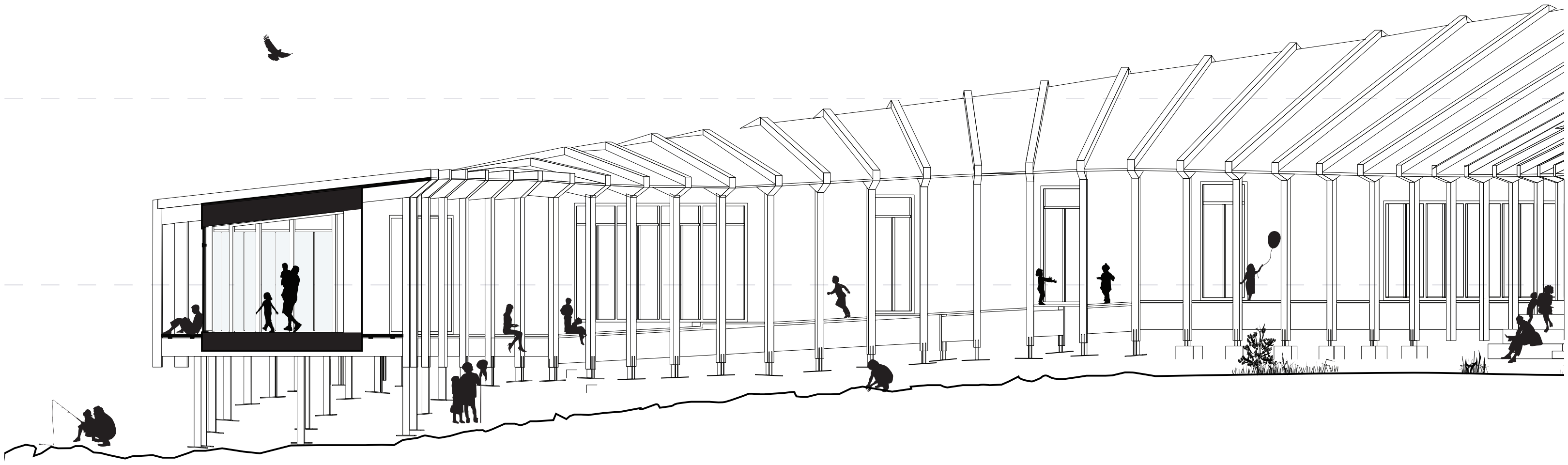
The technical room is placed on top of the kitchen area to accommodate the signifi¬cant ventilation requirement of this room. There is technical room in both ends of the second floor with room for ventilation system.



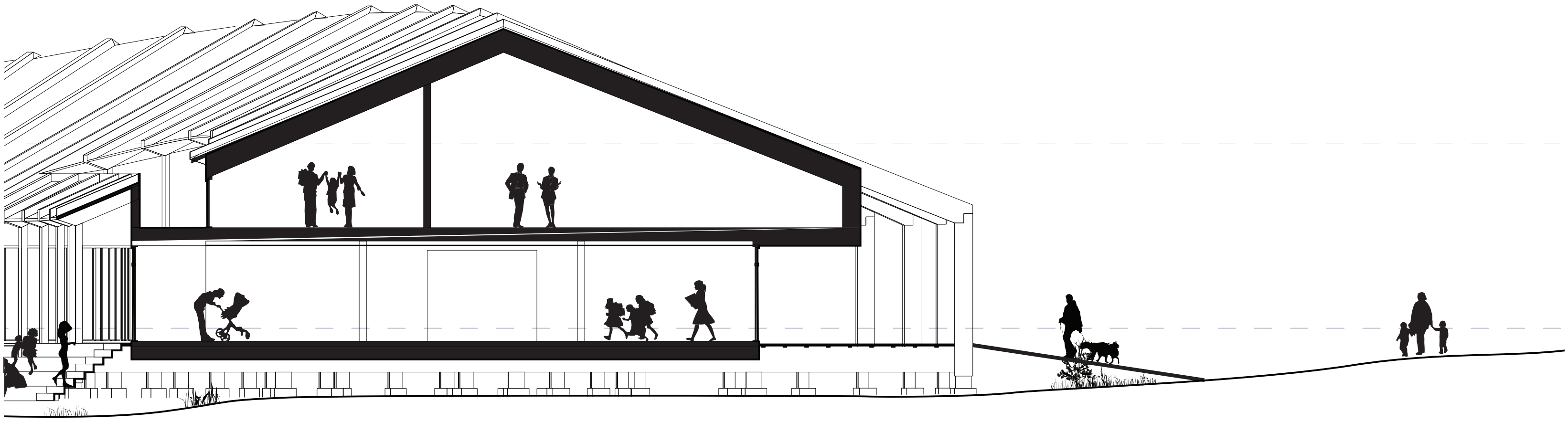
ill. 4.13

Section

The section shows the transition between nature and architecture - the outer plateau as viewing platform of the picturesque landscape and the inner courtyard emphasizing the detail in the landscape and the meeting between foundation and terrain. Lifting the building approximately 1000mm above ground at the lowest part and 2500mm at the highest, creates a remarkable and conscious change in the landscape. When entering the building, the environment changes from the raw natural materials to the processed wooden frame system that creates the building. The roof in the section depicts the spatial change, underlining the function of the space and contributing to the sensory experience of the atmosphere. The zoom in depicts the scenery at different part of the building - The outer plateau as viewing platform of the picturesque landscape and the inner courtyard emphasizing the detail in the landscape.



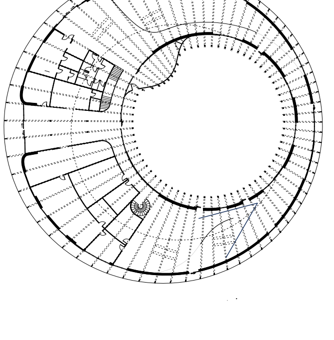
ill. 4.15



ill. 4.14

Exhibition

ill. 4.16



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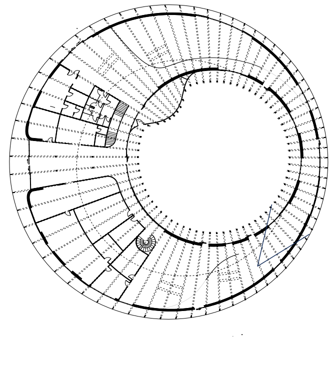
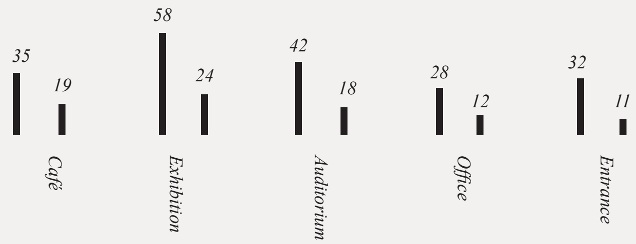


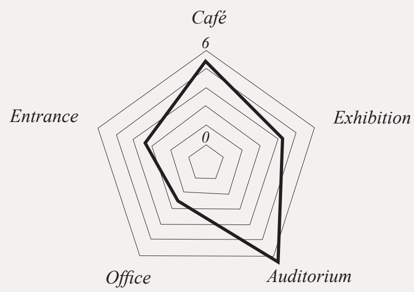
Courtyard

ill. 4.18

Exterior Platform

ill. 4.19





ill. 4.21 | Resulting Hours Above

ill. 4.22 | Daylight Factor in a point

ill. 4.20| Materiality and distribution of sound in the Auditorium reaching a reverberation time at 1,14s

An outline of the investigations reaching acoustic, thermal and visual comfort. The results will be further elaborated in the design proces

Thermal and Atmospheric Comfort

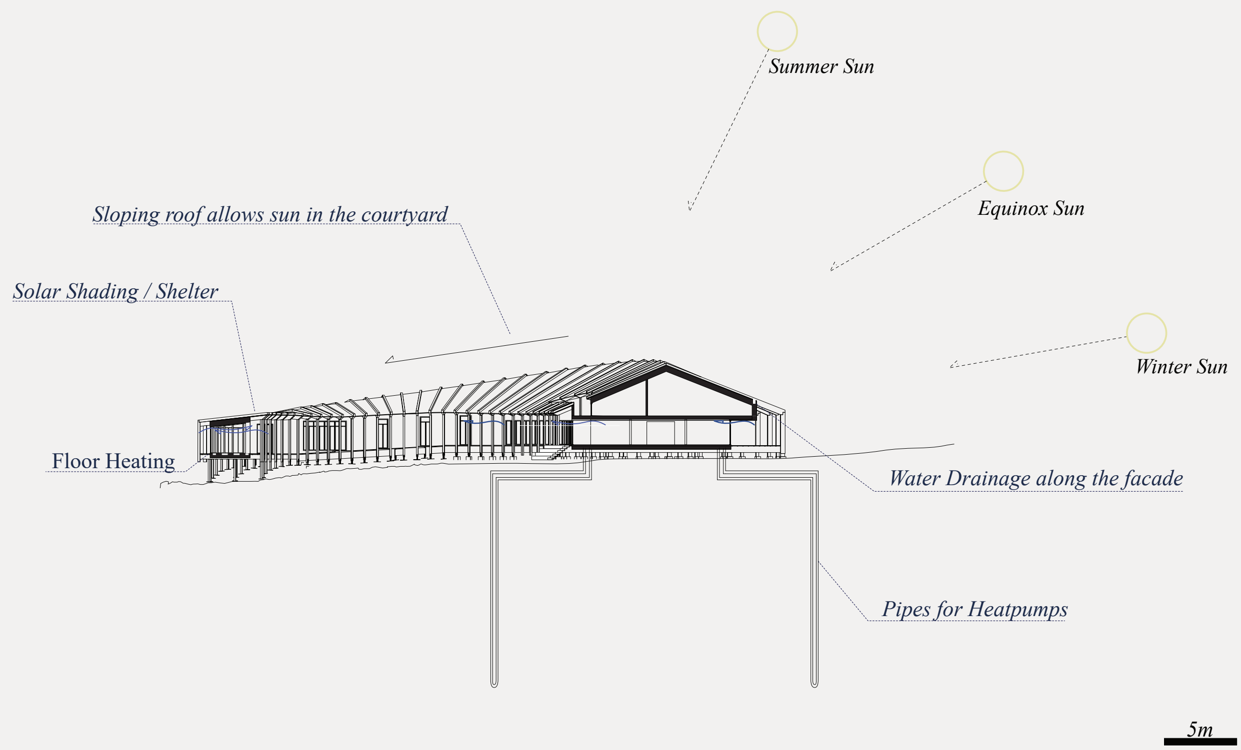
The perception of architecture is a complex composition of impressions experienced through our senses – The experience lies within the acoustics of a space, the materiality of the build and the sensation of light and shadow. The experience of a building is inevitably related to the atmosphere, the comfort or discomfort experienced, thus working with a sustainable initiative in a building is directly connected to the working with atmosphere.

The comfort has been evaluated upon thermal comfort in terms of overheating and comfort temperatures, visual comfort in relation to amount of daylight and acoustic comfort working with the reverberation time and distribution of sound. In the design process building simulations uncover challenges of excessive temperatures i the building. The resulting level of comfort is among other reach through passive strategies of natural ventilation and solar shading in the courtyard in addition to iterations dealing with window area and specification.

Ventilation Strategy

As the climatic analysis present, the Maritime Science Centre is located where the outdoor temperature most of the time is far from the comfort temperature presented in the DS/EN 15251. Thus, due to the location, a mechanical ventilation system is implemented to obtain an acceptable level of comfort in the building to avoid a excessive demand for heating and issues of discomfort due to draught. The mechanical system is necessary to reach a required level of comfort in terms of regulation, however the design accounts for natural ventilation as well, despite an undoubtedly smaller decrease in energy consumption. The natural ventilation is desired to accommodate a sense of place through acoustic, tactile and olfactive means when possible - letting in the natural environment. Working with building simulation, the results are based on one reference year, meaning that the actual situation could be different. Having both mechanical and natural ventilation provides a more flexible ventilation strategy, differing from year to year.

The mechanical ventilation runs with heat recovery, minimizing the need for room heating. For the heating in general, the idea is to use heat pumps for floor heating from ground vertical connecters in the ground due to the effectivity of this system. As mentioned, the ventilation system will be placed in the second floor, with short distance from the high polluting kitchen

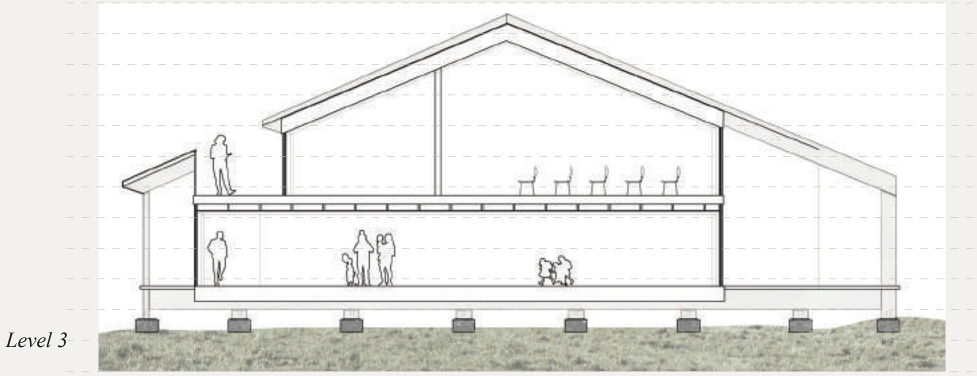


ill. 4.23 | Conceptual sketch showing the sustainable considerations of the geometry.

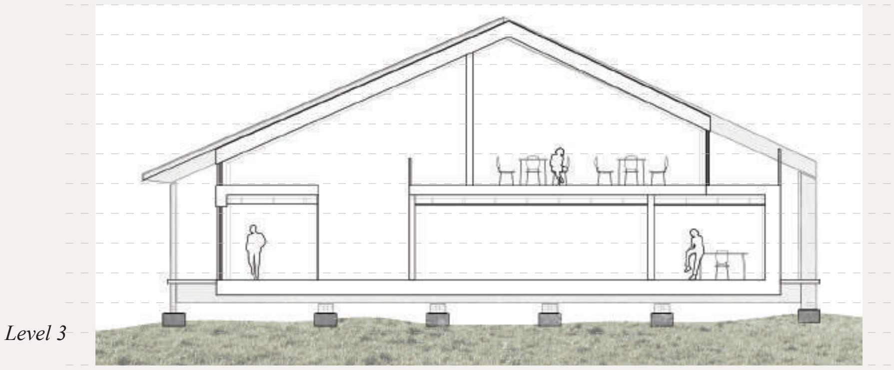
ventilation to the extract on the roof.

Visual Comfort
Visual comfort of the science Centre is evaluated in relation to a minimum requirement for workspaces of 2 %. The daylight factor at the workspace in the office is 3,6% in average. External blinds will be implemented to regulate the visual comfort when the slanting sun enters the room. The prospect of using daylight in the Science Centre serves as a spatial tool through framing of the openings. Having separated window, scattered over the facade creates contrast in the articulation of space walking around the exhibition area. Even though the sea in general don't increase the daylight factor, the intense rays of light will contribute to a sense of place in the interior. Walking through the eastern part of the exhibition the water and wet stone will reflect intense rays of light, creating a moving pattern.

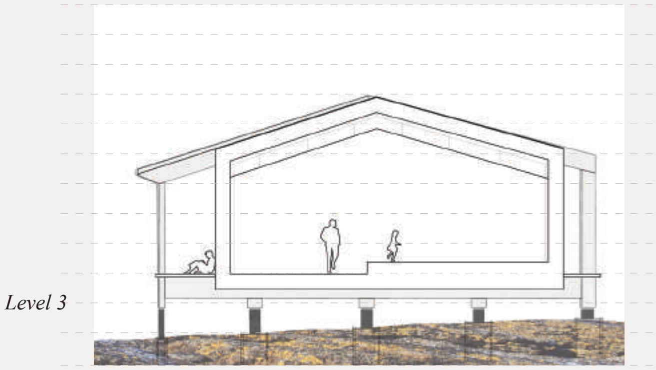
Acoustic Comfort
The acoustic comfort is regulated using wood in different ways and introducing lamella walls in the exhibition area, scattering the sound, preventing noise without separating the room. The acoustic regulation is highly dependent on the geometry, and the design process will present how an integrated process dealing with acoustic comfort, materiality and spatial geometry have led to the presented design. In the upper floor and the exhibition, the roof pitch is documented to spread the sound widely for the audience without echo.



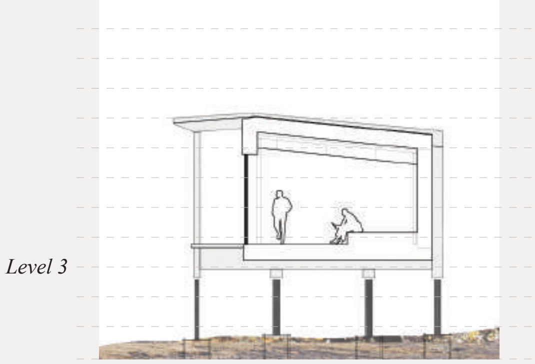
|AA|
The enterence is accessible from the south, and the open space creates a connection between the inner courtyard and sourroundings.



|BB|
The auditorium is placed on the second floor and seperated from the exhibition space, to become a secondary space for cultural event. The space utilizes the roof scape as an acoustic advantage of the building

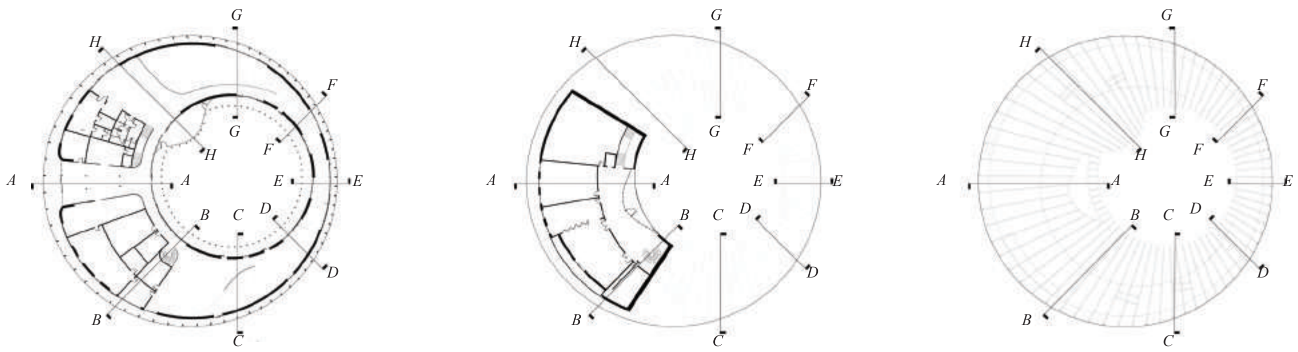


|CC|
Moving toward the first part og the exhibition, the spatial relation between ceiling and wall reveals. The open space to display larger artifacts and engage in the shared knowledge of martitime aquaculture



|DD|

ill. 4.25

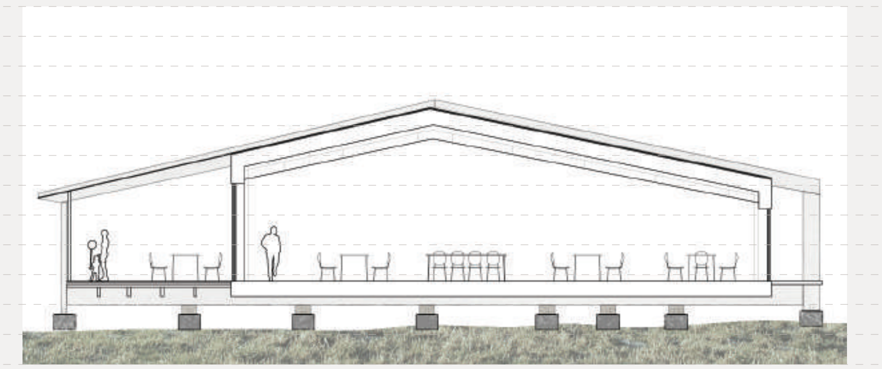


ill. 4.24

Spatial Relation

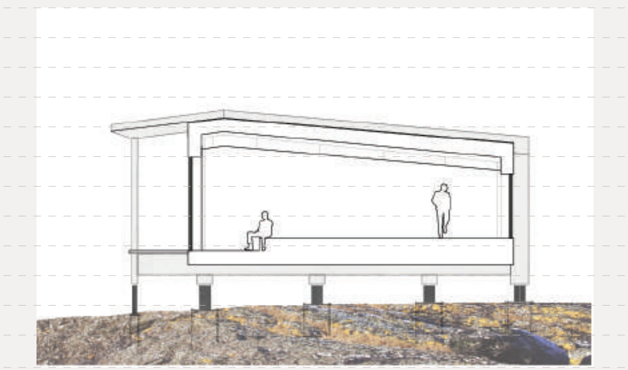
The set of section display the different spa¬tial relation moving around the building. The relation to the terrain is articulated using different types of foundation to accommodate the characteristic of the land- and stonescape. At the soft and moldable earthscape, concrete pillars is excavated into the earth and at the hard solid stone terrain, the pillars is placed on top fixed with screws. The changing level of height varies accordingly to the interior levels and building relation to the terrain. The different roof design causes different acoustic conditions. At the exhibition the roof is high and pitched creating open space, whereas the narrow part creates an intimate space and function as an acoustical division between the exhibition spaces. The auditorium utilizes roof shape obtain an acoustic environment that is suitable to the function.

Level 3



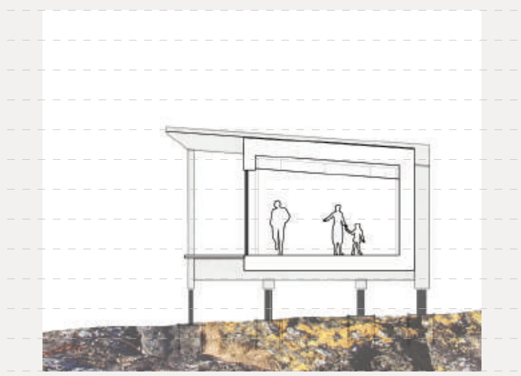
|HH|
The cafe area marked the end of the experience of the exhibition. Orientating the cafe towards the low horizon, the spatial experience stages unique view.

Level 3



|GG|
Entering the second part of exhibition the spatial experience again changes into an open space directed inwards to immerse oneself in the exhibition.

Level 3



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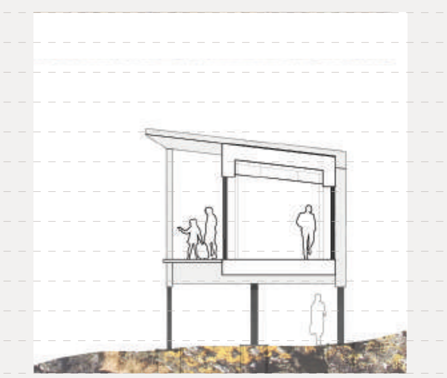
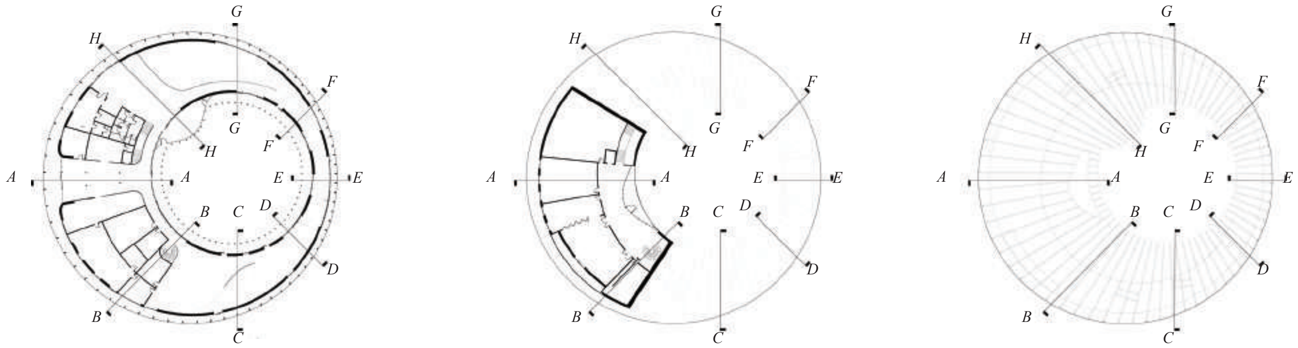


|EE|
The hallway create a narrow space with lower ceilings, aiming to frame the surrounding in different views. The space is linking the exterior grandeur exterior surroundings and the intimate courtyard toward the interior.

ill. 4.27



ill. 4.26

Draining system as a part of the facade expression.

Meeting between the Facade and the platform

Materiality

The primary material used in the building is wood. Glue laminated timber larch will be used for the primary constructional system, due to its high structural strength-en ability, and is available in large spans. Larch lamella is used for exterior cladding and plywood and wooden lamella for interior walls. Using seaweed as insulation as an alternative material the Maritime Science Center is based on materials with local availability. Additionally the seaweed holds the potential as an aesthetic mean in the façade underlining the building materials as narrative in the building identity, as seen in Tanghuset in Vandkunsten, which have been earlier referred to.

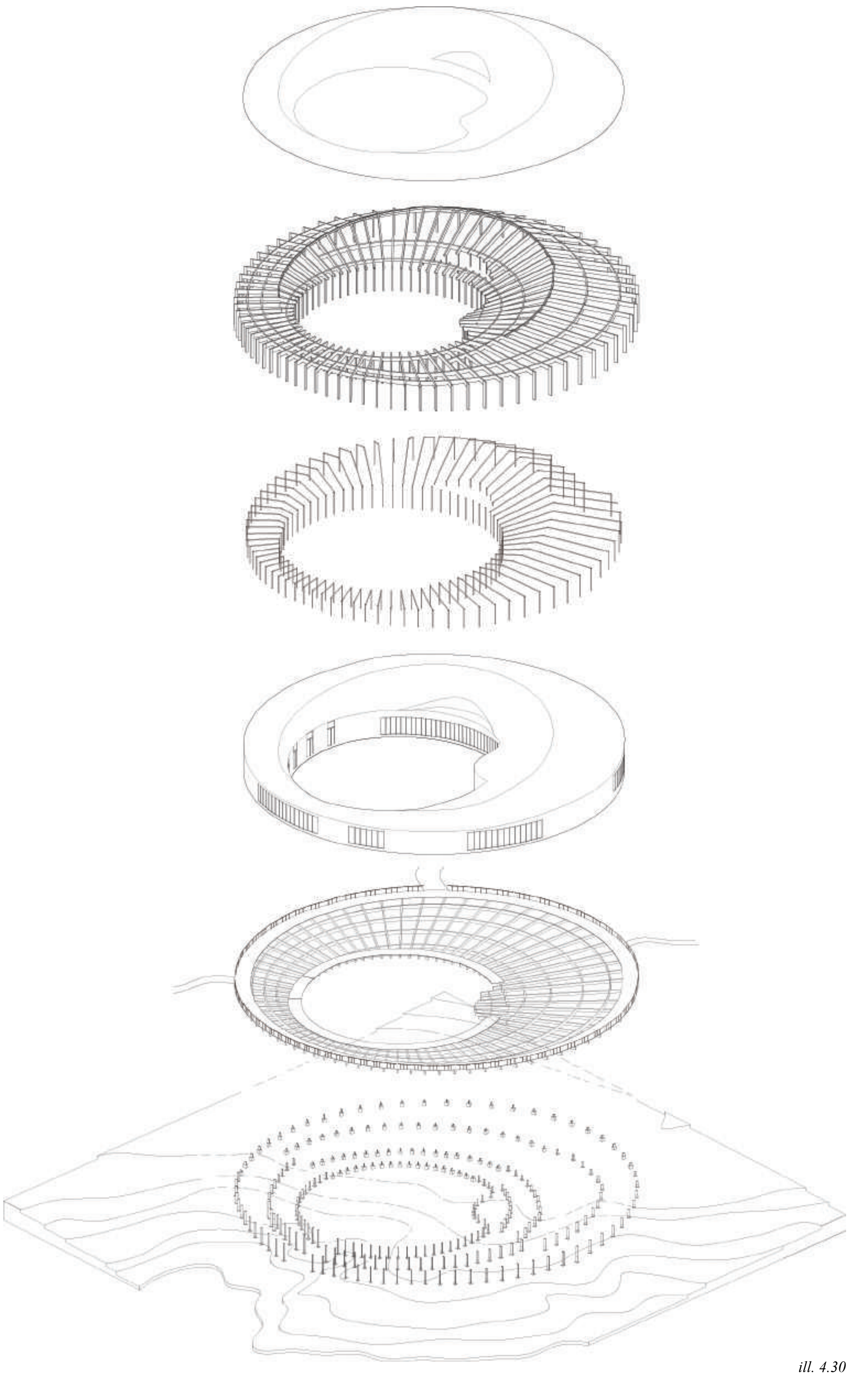
In time the texture and hue of the material will change due to the exposing of weather, and change into a gray tone endorsing the dark colors of the stonescape.
In the courtyard the warm tones of the wood will be preserved to some extent, as the overhang protects the wood. Thus the exterior will change in line with the impact of the nature, reflecting a dynamic perception of the building.

Roof beam meeting the columns of the courtyard

Steel foundation meeting the rockscape

Main fram towards the exterior

ill. 4.28



The roof cladding consists of lamellas inbetween the primary structual system, to enstrenghen the tectonic perception of the construction.

The primary construction serves as the structural core, depicting the gravitational forces in the building. The frames changes in wide, height and pitch to create a dynamic roofshape in the landscape

The interior columns and beams serves as a secondary structural system with the purpose of providing stabilization to the inner walls.

The interior wall, floors and ceiling form the interior spatiality and the changing shape defines internal function and flow.

The foundation platform that surrounds building and inner courtyard is placed on the floor beams. The floor beams is part of the primary structural system carrying loads and stabilizing the structure

The pillar foundation minimizes the footprint on the landscape and creating a statement in how the building meets the landscape. Two type of foundation is made to distinguish and articulate the different types of terrain the building the building crosses.

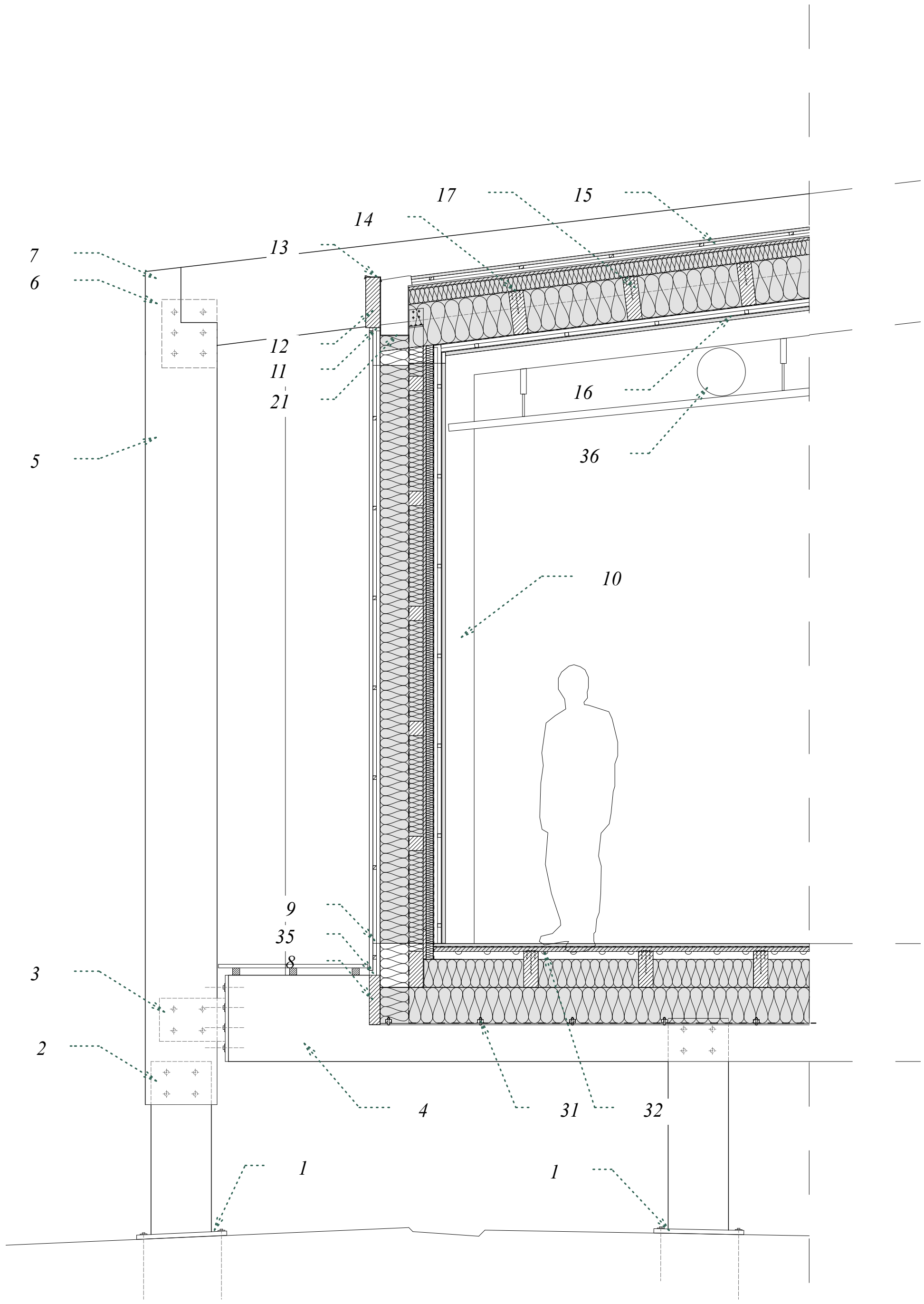
ill. 4.30

Details

The details correspond to the overall design of the building. Though the detail the building tell a story of how to relate in the landscape and the internal composition of the geometry.

Element tags

Steel plate joimt **1.**
Foundation Support **2.**
Steel joint (hinge) **3.**
Floor beam 200 x700mm **4.**
Main frame column 200x500mm **5.**
Steel plate joint **6.**
Marin frame roof beam 200x500mm **7.**
Crossing cover beam 75x350mm **8.**
Ventilation gap **9.**
Interior cover column **10.**
Ventilation gap **11.**
Crossing cover beam 75x350mm **12.**
Steel cover **13.**
Screw mountain particle board to batten **14.**
Ventilation gap **15.**
Sound absorbing material **16.**
Crossing roof beam 100x300mm **17.**
Interior cover beam **18.**
Ridge steel flashing **19.**
Ridge battens **20.**
Steel gutter **21.**
Drip cut **22.**
Crossing beam 100x240mm **23.**
Seismic seperation **24.**
Supporting column connecting to roof beam **25.**
Steel plate joint **26.**
Seperate window opening **27.**
Main window opening **28.**
Steel angle joint **29.**
Crossing floor beams **30.**
Mounting system wind insulation **31.**
Floor heating pipes **32.**
Main frame column **33.**
Steel cover **34.**
Foundation support **35.**
Ventilation ducts **36.**
Suspended ceiling system **37.**



Wall Layers

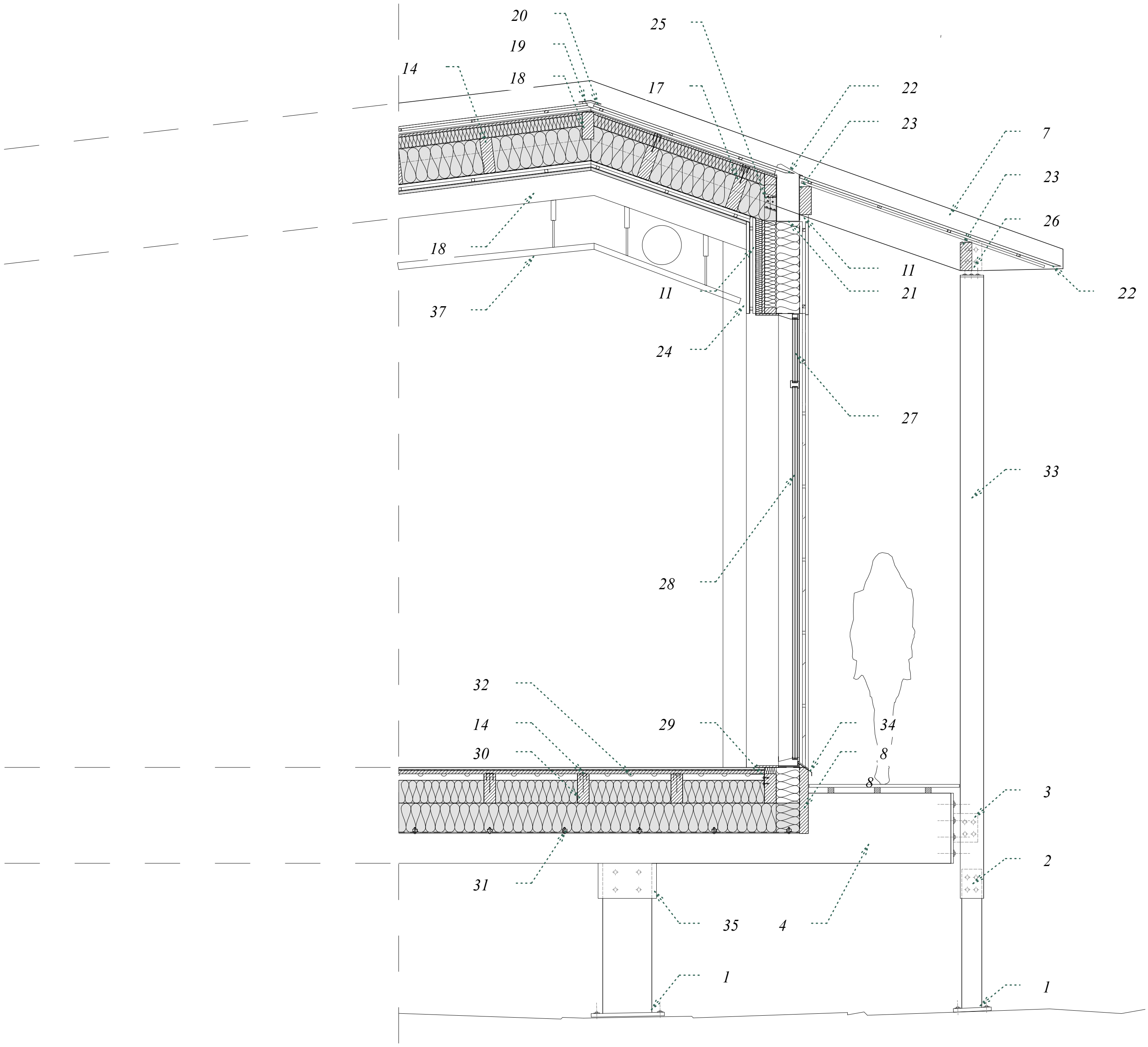
Larch wooden plank (60 x 20 mm) 20mm
Wooden batten (30 x 20 mm) 20mm
Wooden batten (30 x 20 mm) 20mm
Windproof insulation 10mm
Thermal insulation 200mm
Thermal insulation / crossing beams / supporting columns (100 x 100mm) 100mm
Particle board 20mm
Additional insulation 50mm
Vapor barrier 5mm
Wooden batten (25 x 25 mm) 25mm
Wooden batten (25 x 25 mm) 25mm
Sound absorbing material 5mm
Wooden planks 25mm

Floor Layers

Tile floor 20 mm
Floor foam 5mm
Particle board 20mm
Ventilation space / floor hrating pipes 55mm
Thermal insulation 195mm
Thermal insulation / wooden battens (20 x 20mm) 250mm
Wind insulation 10 mm

Roof Layers

Larch wooden plank (60 x 20 mm) 20mmFloor foam 5mm
Wooden batten (30 x 20 mm) 20mm
Wooden batten (30 x 20 mm) 20mm
Roof membrane 10mm
Particle board 20mm
Thermal insulation 100mm
Thermal insulation / crossing beams (100 x 300mm) 300mm
Vapour insulation 5m
Wooden batten (25 x 25 mm) 25mm
Wooden batten (25 x 25 mm) 25mm
Sound absorbing material 5mm
Wooden planks 25mm



ill. 4.31

Technical Section

The technical section show the build up of the envelope at an executive level. The insulation layer in roof is lowered from the beam to have a visible roof beam supporting the repetitive system of the frames. The insulation is hold in place by a inner columns and beams. The interior beam holds a lowered ceiling hiding the mechanical ventilation having a continuing ceilling. The inner layer of insulation is covered with a wind barrier, improving the ventilating ability.

All joints in structural elements are steel plate joints with visible bolt connecters, making a rigid frame. The steel plate at the top of the column on the exterior is made visible from inside of the constuction revealing the joining method. The floor beam is connected to the column in a hinge eliminating bending stresses transferring to the column. Dimensioning the structural elements is based on inspiraion works of similar constructio and character.

05

ill. 5.0 | The cleft of Preikestolen

DESIGN PROCESS

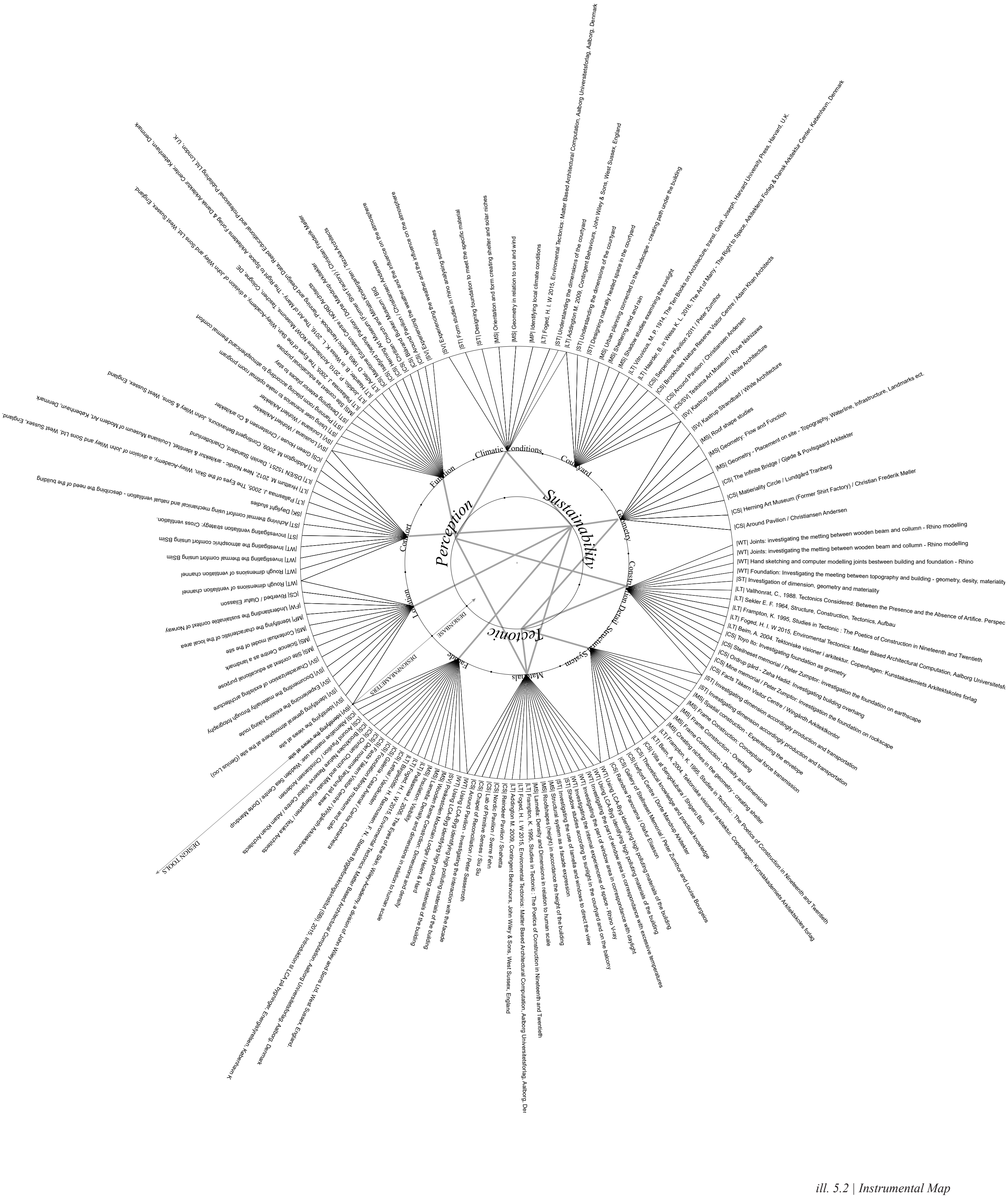
The element of framing nature to engender a focus on different natural elements - in this case of a Science Centre, perhaps as a mean to education on the exact environment the centre is about to find itself in.

Introducing the Design Process

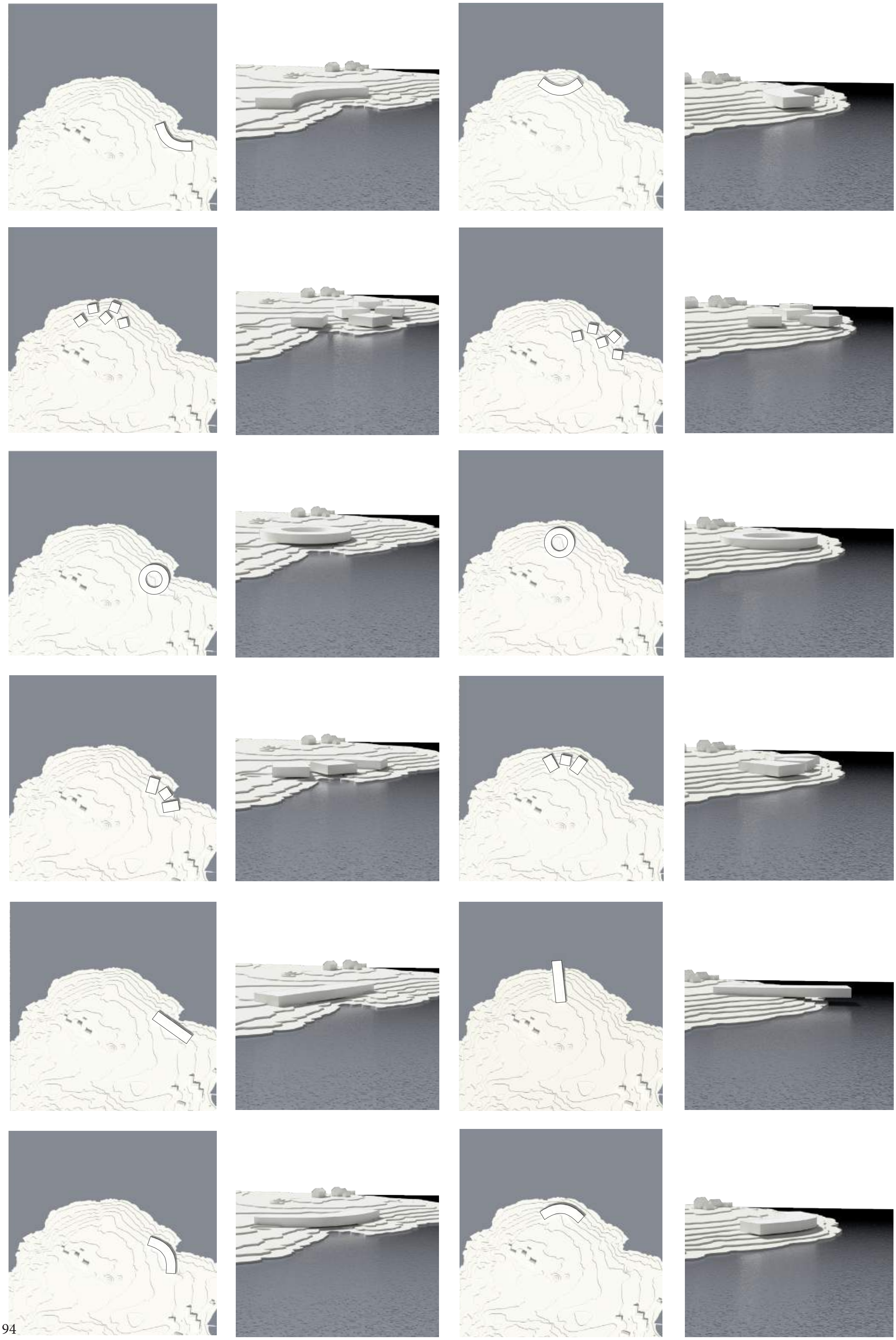
The integrated design process becomes complex when introducting more parameters. Changing one parameter may affect a branch of other parameters, making the process tangled and hard to reflect upon while practising. Thus the instrumental map introduced in the Methodology section is used to elaborated upon the process based on the knowlegde and the design studies.

The map is a simplification of a the actual design process, aiming to depict some of the complexicity by introducing specific work of references and work tools. It is not a complete depiction of the process, but the simplification makes it possible to give an overview of the most essential subjects and work tools, in order to reflect upon the project.

This identifies what aspects havde directed the process and influenced the design. From the initial studies towards the end of the process the wheel have been updated documenting the design proces.



ill. 5.2 | Instrumental Map
The diagram is inspired by a Research Mapping by Isak Worre Foged in Environmental Tectonic (Worre Foged 2015)



ill. 5.2

Floor Area | ~ 2000
Facade Lenght | 249m

Area | ~ 2000
Facade Lenght | 341m

Area | ~ 2000
Facade Lenght | 279m

Area | ~ 2000
Facade Lenght | 334m

Area | ~ 2000
Facade Lenght | 238m

Area | 2~ 2000
Facade Lenght | 249m

Initial form studies

The initial form studies introduce different volumes placed on a contextual model in 3D. Since the placement of the building on the site is not decided, the volumes are tested on two possible locations. They are evaluated in relation the visual expression from the seaside, from the Lighthouse and from the arrival path from the parking. The test of volumes is a basic way of examining the potential of each form in a specific location and of a specific area. This helps narrowing down the geometry of the project and at the same time it might show potential of geometries that was not the initial idea of the project. It should be noted that the massive volumes will be read differently than a structural or a materialized model, meaning that solely volume studies will not show the potential of a geometry alone.

A simple calculation of area compared to envelope have been made, to recognize the volumes potential of lowering the heat loss and be aware of the amount of material bound to a certain geometry. Thus, not dictated that the shortest facade length be the best solution - simple an awareness of the possibilities and challenges in relation to environmental sustainability early in the process.

Observations
The volumes range from regular, longitudinal volumes to scattered separated volumes. The longitudinal elements along with the circle imitates the movement of the coastline and have the can either stand out by mirroring the movement or continuously follow the coastline, melting into it. These are the two volumes of less facade to area. The wish for the design is for it to mingle with the natural environment, but still reference to the existing architecture of the area. The scattered volumes have a great potential to melt into the different levels of the topography, however there can be challenges solving the program. The challenges of the longitudinal volumes will be to soften up the volume by materials and construction not to stand out too much to the existing cultural environment.

ill. 5.3 | Nordic Pavilion by Sverre Fehn

ill. 5.4 | Chapen of Reconciliation by Peter Sassenroth

Nordic Pavilion by Sverre Fehn use a similar relation to the elements of nature. Letting the construction move around the trees, including the lowest part of the tree instead of the crown puts a delicate attention to the detail of the trunk and puts the proportion of the tree into a human scale.

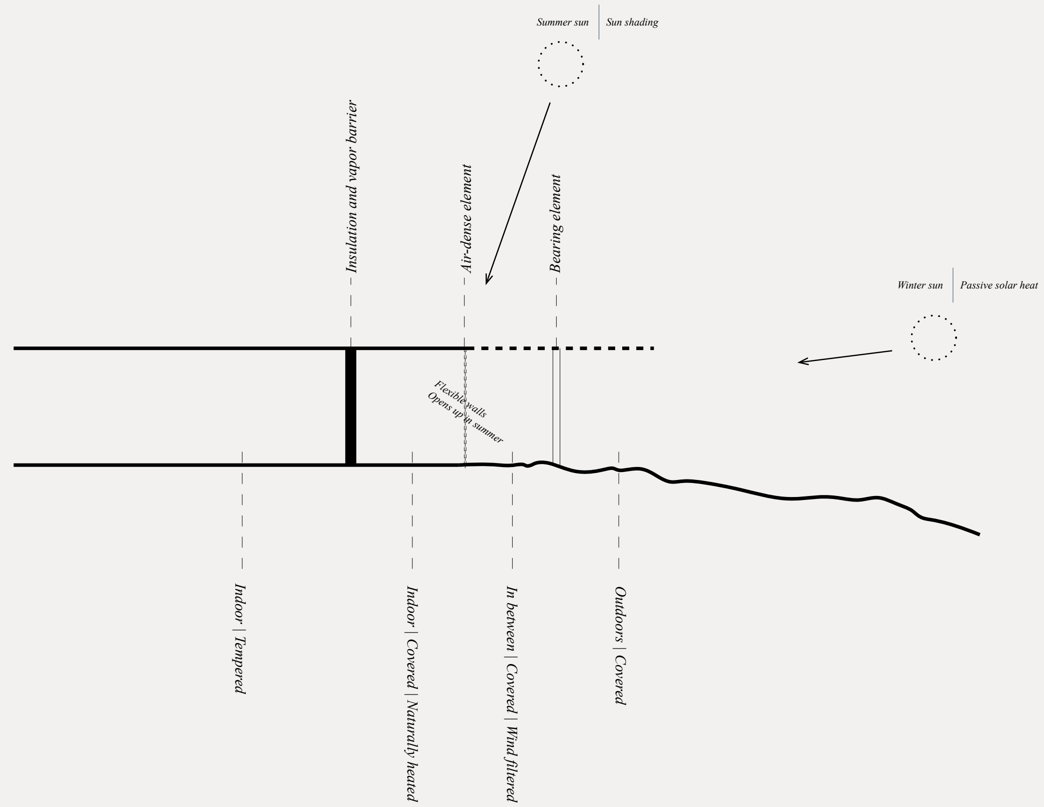
The Chapel of Reconciliation by Peter Sassenroth present a similar way to engage with the natural environment, by framing the view through lamellas and diffusing sound and wind yet letting a fraction in together with the thermal state of the outdoors.

ill. 5.5 | Reindeer Pavilion by Snøhetta

ill. 5.6 | Lab of Primitive Senses, Siu Siu

Reindeer Pavilion, as mentioned, uses the construction of the envelope as an interior and exterior furniture creating a similarity in the two scenarios, enhancing the experience of the thermal difference of being inside or outside on one or the other side of the furniture.

Siu Siu's Lab of Primitive Senses represents a variety of relations to the natural environment. Even though the architecture is built into the forest, the design almost makes it seem otherwise. The building respects the natural environment by letting it directly into the house at moments and at the same time it makes a barrier of fabric that creates a microclimate within the forest - a move which in the location creates a perfect environment for working as well as living. (Divooe Zein Architect 2014) The relation is inspiring, however the specific materials would not have the same effect in Norway.



ill. 5.7 | Conceptual sketch of the envelope

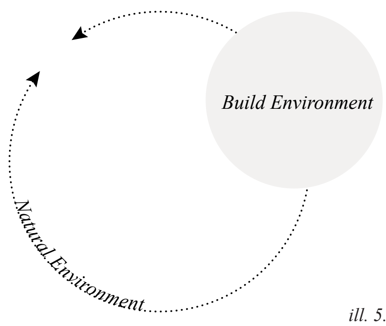
Interaction with the Surroundings

The preliminary studies and framework lead to a vision highly developed upon the interaction between the Science Centre and the existing environment. The idea was to make a state between indoor and outdoor, that could be used as a buffer zone for the function, where one can experience a fraction of the outdoor - the smell, sounds and temperature, and still be sheltered from the climatic conditions of the area. The idea is taking from different architectural pavilions, and inspired by simple memories of genuine conservatories and green houses in housing architecture.

In the transition between the outdoor and the indoor the envelope becomes extremely important. It becomes an experience of the envelope up close and in continuation of a tectonic mindset the construction of the envelope could be a part of the experience.

In relation to these thoughts architectural references have been used to understand and create a space creating a certain atmosphere.

The element of framing nature to engender a focus on different natural elements - in the case of a Science Center perhaps as a mean to education on the exact environment the Centre is about and find itself in. Since the climate is rather wet, there will be an element of sheltering from this, encouraging people to experience the outdoors in a great variety of weather.



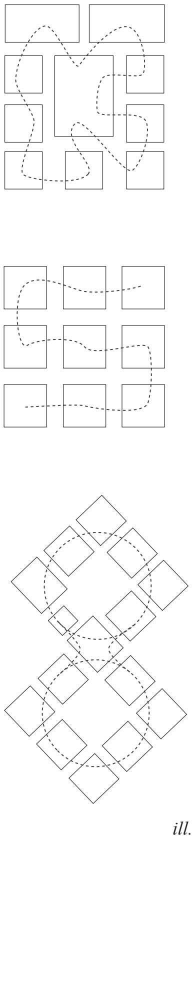
ill. 5.8

Function: Museum
Architect : BIG
Area: 2500 m2

Reference Works

The following studies illustrates the process of looking into architectural references regarding room program, dimensioning and flow. The projects are chosen due to their relation to the function as well as dimension of the buildings. The projects have been part of a sketching process and the visualizations with appertaining plans is used to describe a specific atmosphere in coherence with the architectural means determining the atmosphere.
Illustration 5.9 shows an abstract interpretation of how the flow through the exhibition can be controlled by the layout of the rooms. A balance between a fluent and directed movement is aimed to have a easy navigation through the building and still allowing an individual experience of the space.

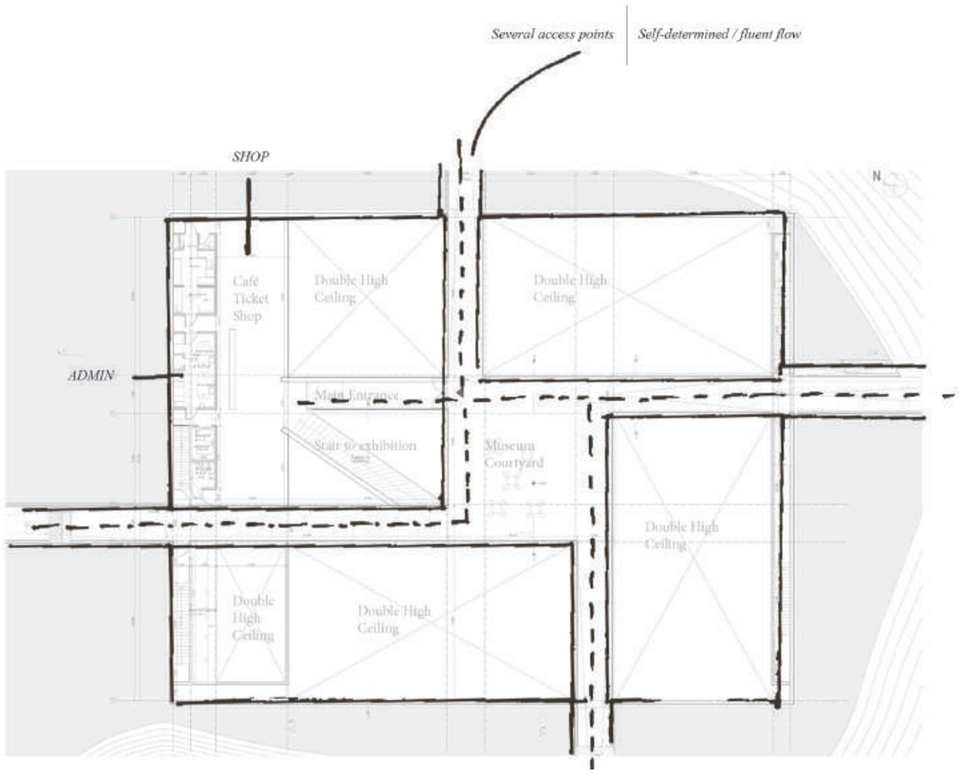
The selected works for this section are recent winning projects of similar character as the Science Centre. Therefor the possibility to visit the museum has not been realized. Secondary a number of realized projects have been used as inspiration, among these Louisiana Museum om Modern Art by J. Bo ans V. Wohlert, 21st Century Museum 8 by Sanaa and Teshima Art Museum by Ryue Nishizawa. These works have all been visited within recent time and too serves as reference for architectural means and atmosphere.

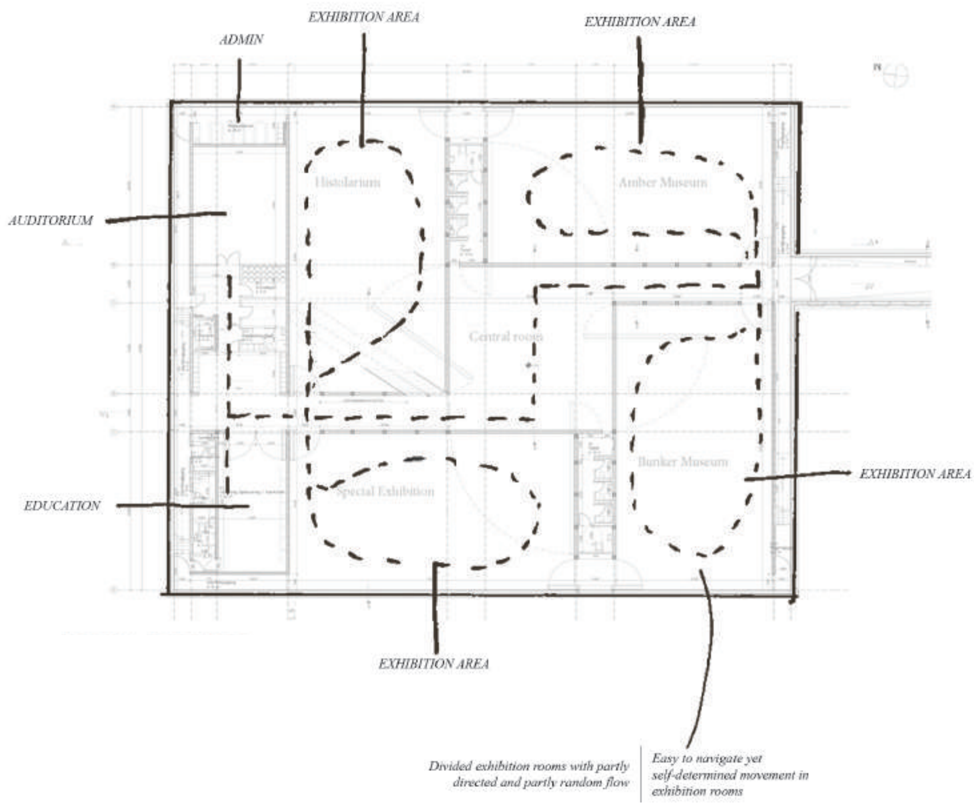


ill. 5.9

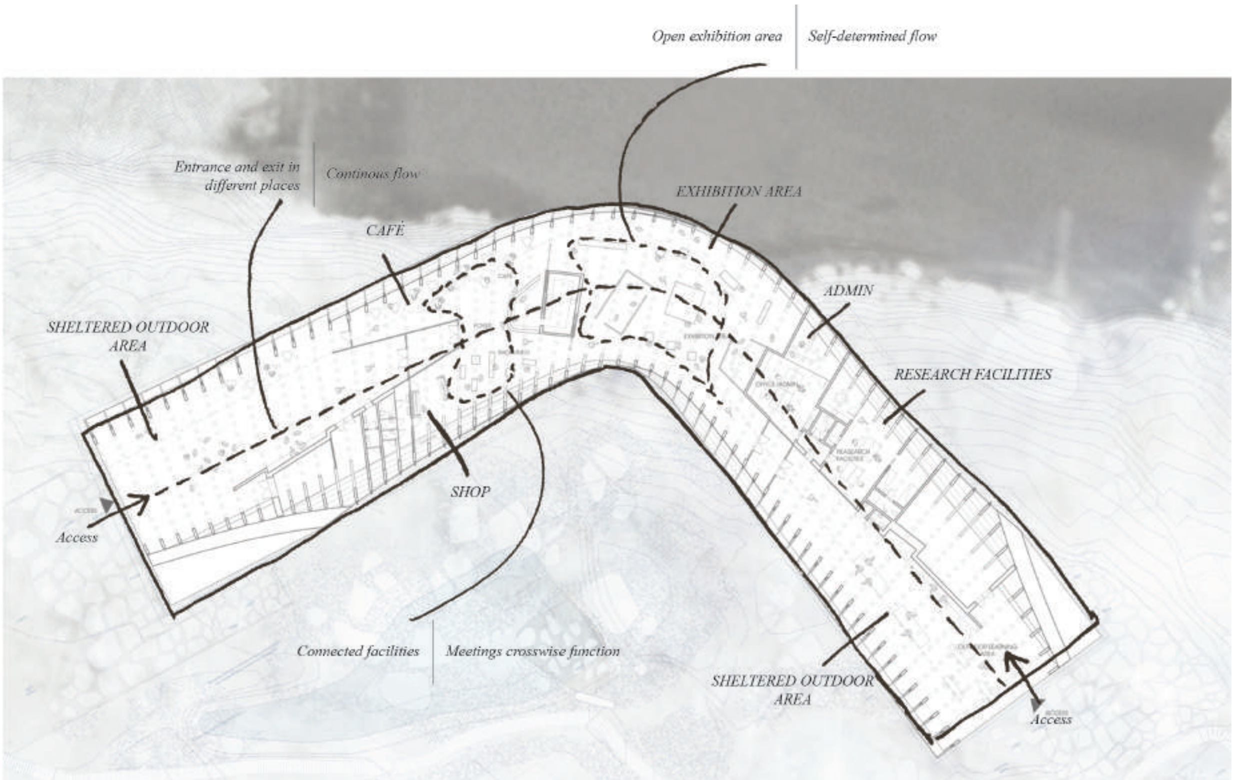
Observations

Blåvand Bunker Museum by BIG relates clearly to the landscape by having one floor underground and one floor on top of the ground with the characteristic danish coastal landscape moving on top of it. Four entrances to the top floor creates a prominent pattern in the landscape - guiding the visitor in the direction of the museum, yet accomodating the existing, fluent flow through the landscape by having several access points.
Entering the exhibition area, a reverse flow is presented. Here the visitor is clearly guided by narrow darker halls towards four large, flexible exhibition spaces. The building have a centeralized exterior metting point on top (courtyard) and a interior meeting point between the exhibition space making it easy to navigate in the narrow hallways. The staff program is distributed, having a parrallel flow to the visitors, and still close to the functions needed.

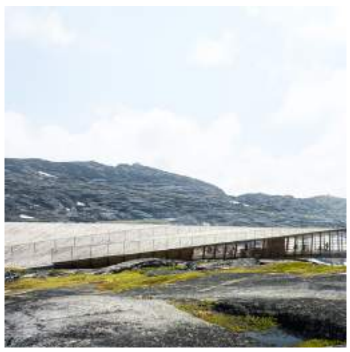




ill. 5.10 | Plan drawings and visualisations of Blåvand bunker Museum by BIG



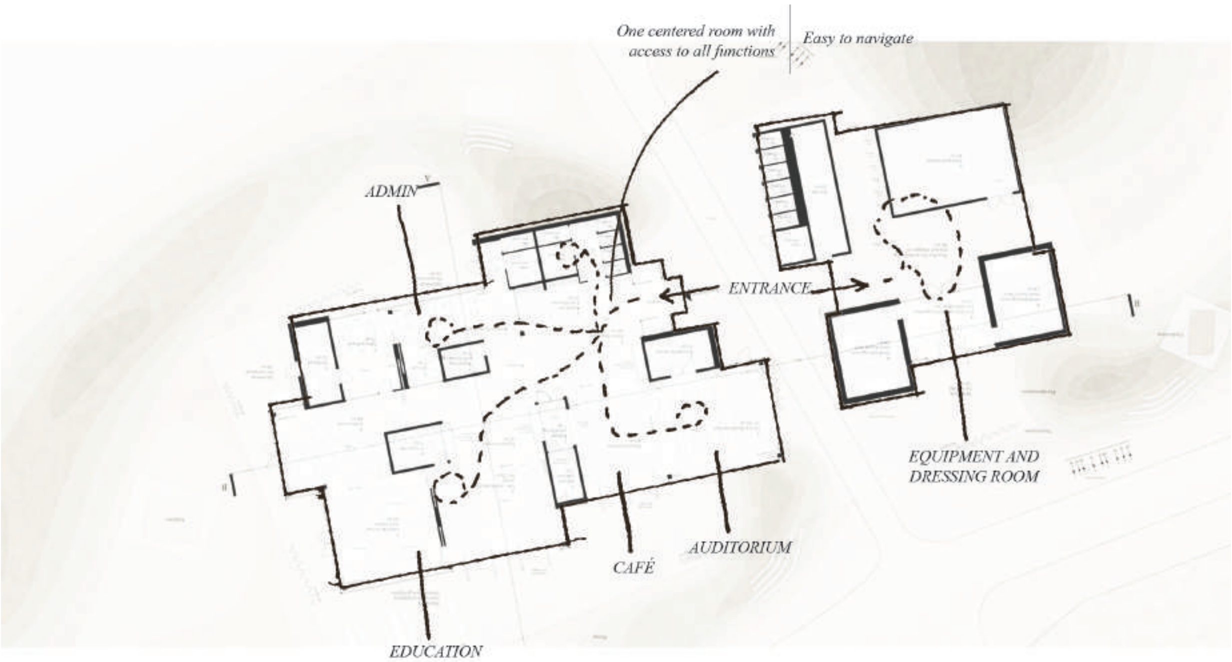
ill. 5.11 | Plan drawings and visualisations of Viewing Pavilion by Dorthe Mandrup Arkitekter



Function: Viewing Pavilion
Architect : Dorthe Mandrup Arkitekter

Observations

The visitors pavilion twist along the rocky landscape providing an interior view point for the surroundings. The program of the building is both interior and exterior, having the structure covering the ends of the arch, provinding flat terraces in the irregular landscape and sheltered space in the harsh climate. The pavilion contains a small open exhibition area and a connection of dining and shopping facilities. The building have two access points, as with the Bunker Museum, providing a self-determined arrival and encourage to experience the sheer landscape by walking through it to reach the pavilion..



ill. 5.12 | Maritime Education Centre by NORD Architects

Function: Maritime Education Centre
Architect : NORD Architects
Area: 700 m2

Observations

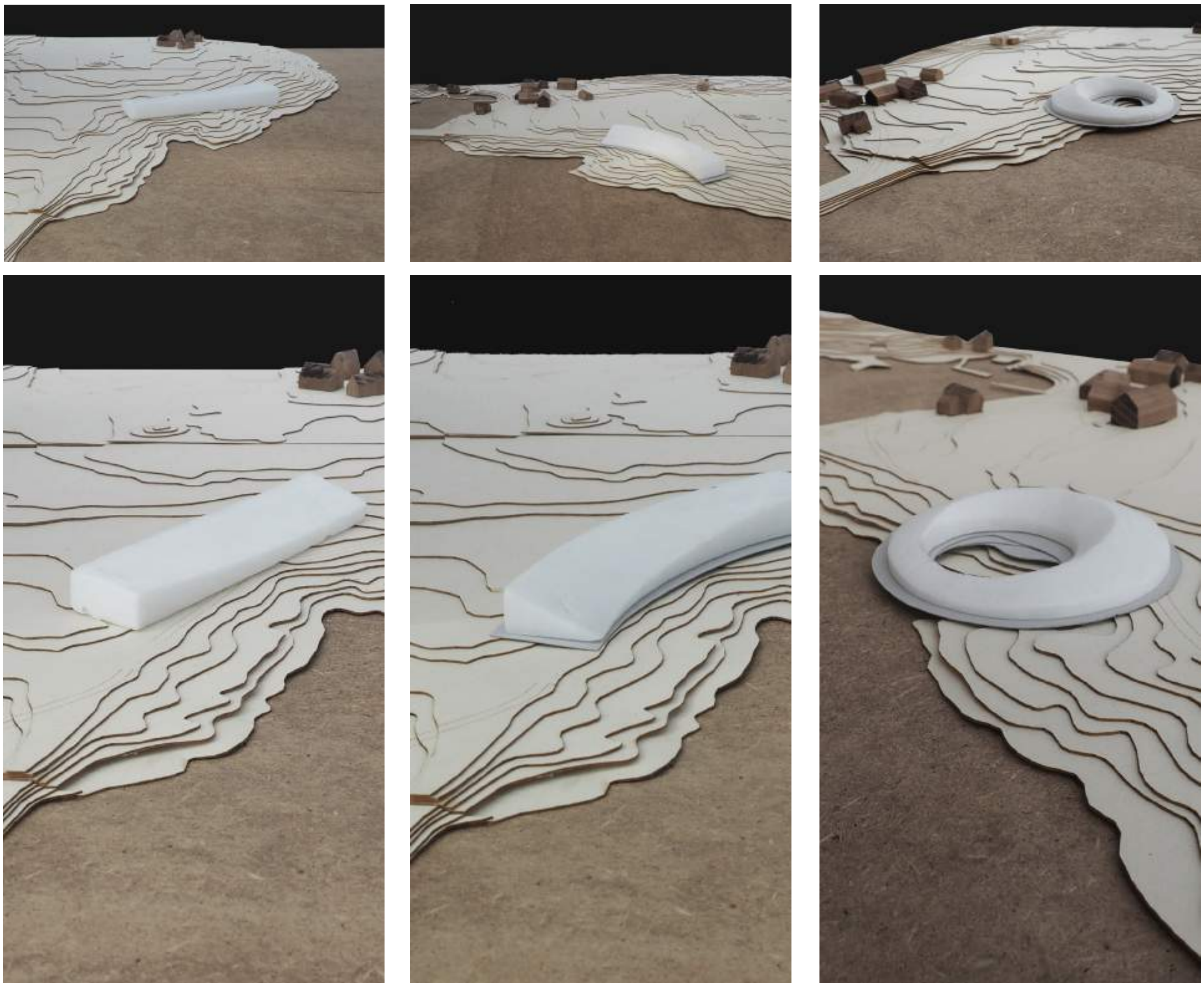
The winning proposal for the Maritime Education Centre in Malmø inspires the Science Centre in relation to target group and theme. The indoor rooms are flexible and provides a fluent flow across the functions. At the same time a centered entrance function as a distribution area for all functions, making it easy to navigate the building. The Education Centre consist of two buildings placed in the very same landscape as the educational aim is centered around - having a blurred transition using glass and urban landscape melting into the topography makes a intuitive relation between the exterior and inteior.

Sum up

The hightlighted works introduces several overlapping ideas using different means. The thesis project will conclude these ideas in a fourth way, focusing on

- the placing in the landscape by playing with the topography
- having a partly directed and partly self-determined flow
- making easy navigation and still having room for flexible exhibition areas an large groups of people.

The staff function will, as needed, be in close contact to the visitors function, since most assignments directly relates to the program of the visitor. This makes lay out of the staffs flow distributed and this should be considered in the programming. Most of the time this scattered flow will found an experience in the dayly workflow by moving through the building rather than staying in one area.



ill. 5.13

Observations

The regular longitudinal shape streches along a great part of the coastline. The shape is in contrast to the coastal landscape, which underlines the sloping of the landscape. According to the direction of the volume, it will create a sharp and rather long division of the grass landscape and the sea or the eastern and western part of the coast. This could be a challenge making the building compliment the landscape rather than differentiating from it in movement along the landscape.

Placing the volume makes it clear that an issue of the long walls could be the wind coming from more directions over the year. This cause for awareness when designing the exterior space.

Observations

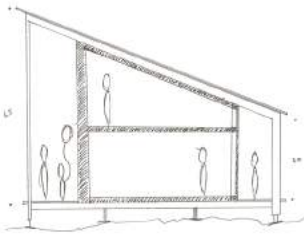
The arch has some of the same potential as the circle, moving along with the landscape making a clear attention to the direction of the coastline. The shape will still have the challenges as the longitudinal regular form, making an edge in the landscape, mainly due to the size of the volume. The shape handle the winds better than the regular shape, depending on the orientation of the building volume.

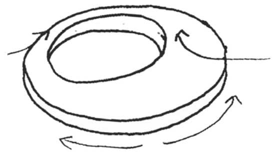
Observations

The circular shape with a courtyard encloses a part of the landscape creating a secondary environment. This provides a constant interplay between the enclosed landscape of the courtyard and the sheer landscape surrounding the building volume. Having the courtyard will make the colume seem bigger from the outside. With no edges in the landscape, the circular form sort of dissappears from different directions, making the colume seem less heavy than the regular form. The circle have a strenght in having no direction and no edges, leading on the wind and making it possible to have outdoor space all around the building.

Further Form Studies

The following section will present the further work of the volume studies. The longitudinal forms and the circle was brought further on to study in a physical context. After this the circle with a courtyard was chosen to examine as the primary shape of the building due to its characteristic play with the coastline, and the possibility to create a seperate environment within the courtyard in contrast to the ambient surroundings. As with the intial form studies, the articulation of a geometry will be constrained by solely volume studies. The shape will be considered in physical modelling, sketching and compututal models which will mainly be reported in relation to the construction in the next section.
The means of physical models have a great impact understanding the influence of the building in the landscape. The building will inevitely stand out in the sheer context, so the placing according to the parking and Lighthouse will be considered as well as the placing in the levels of the landscape to make the volume more fluently fit into the slanting typography.
The circle is a quite strong shape meaning it will fastly loose its geometrical expression by adding or removing pieces of it. Having these readable lines makes the architecture stand out from the rocky landscape as a human built environment. This contrast is desired to make, and makes the meeting with the landscape extremely important in order to make a fluent transistion between exterior and interior. The courtyard served another purpose having a different context than the face of the building outwards.

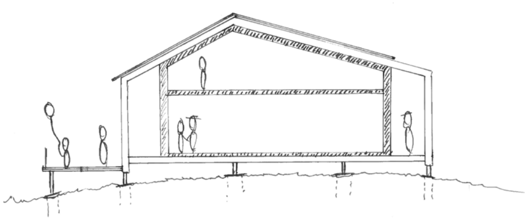


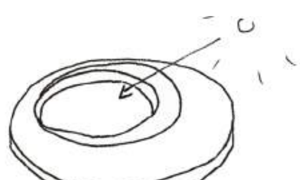


ill. 5.14

Observations

Moving towards a more clear understanding of how the circlular form can play with the landscape a model with a simple frame structure is introduced. The model is still abstract, however it shows the potential of a structure breaking up the heavyness of the volume, creating space in between the structure, framing the surroundings. The initial thoughts on the roof shape was to lead on the winds as the circular form in itself does. This makes a pitched roof, adding a vertical direction. In addition it makes room for a second floor in a part of the building.

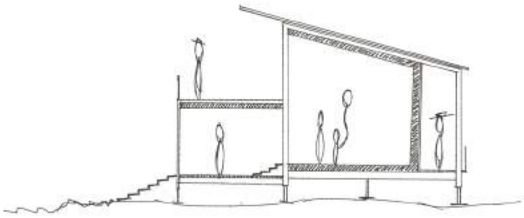




ill. 5.15

Observations

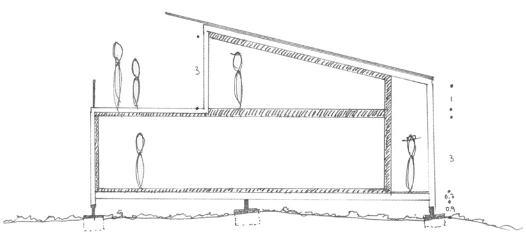
Another model shows a two-pitched roof in one part of the building allowing light to enter the courtyard. The courtyard consist of a number of platforms following the sloping of the ground, guiding the visitor closer to the elements of the rocky landscape.

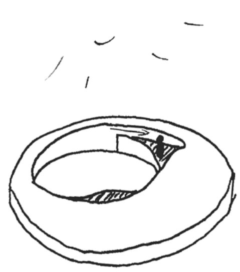


ill. 5.16

Observations

Another way to treat the courtyard is to add volumes to the circle, creating an irregular interior line, reffering to the irregularities in the ground. As the principle section shows, this creates an gradually movement towards the courtyard in the interior and room for a balony on top.

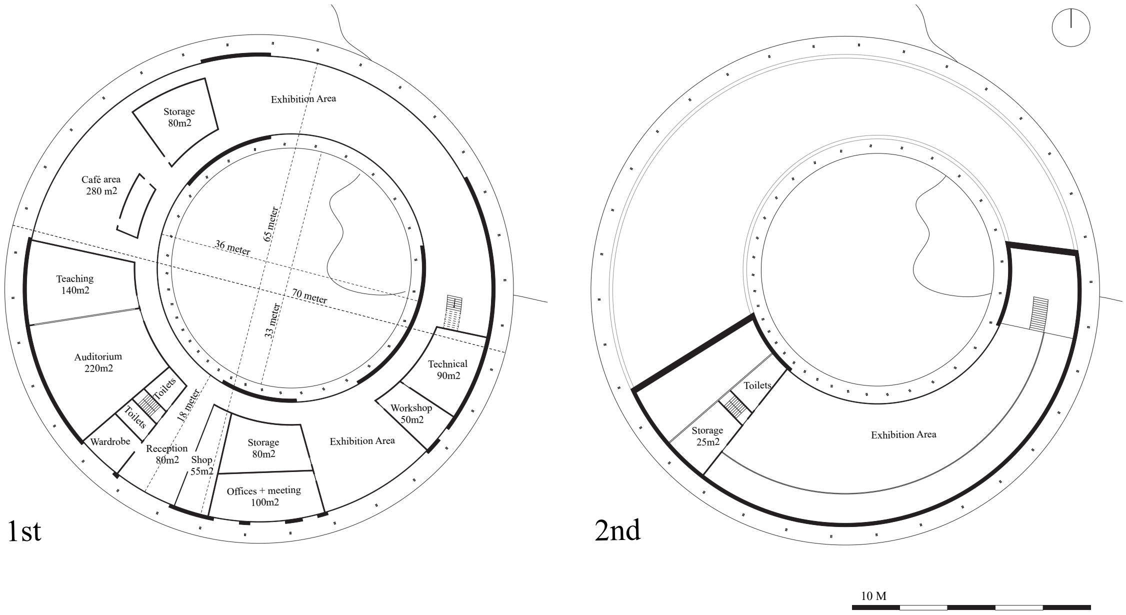




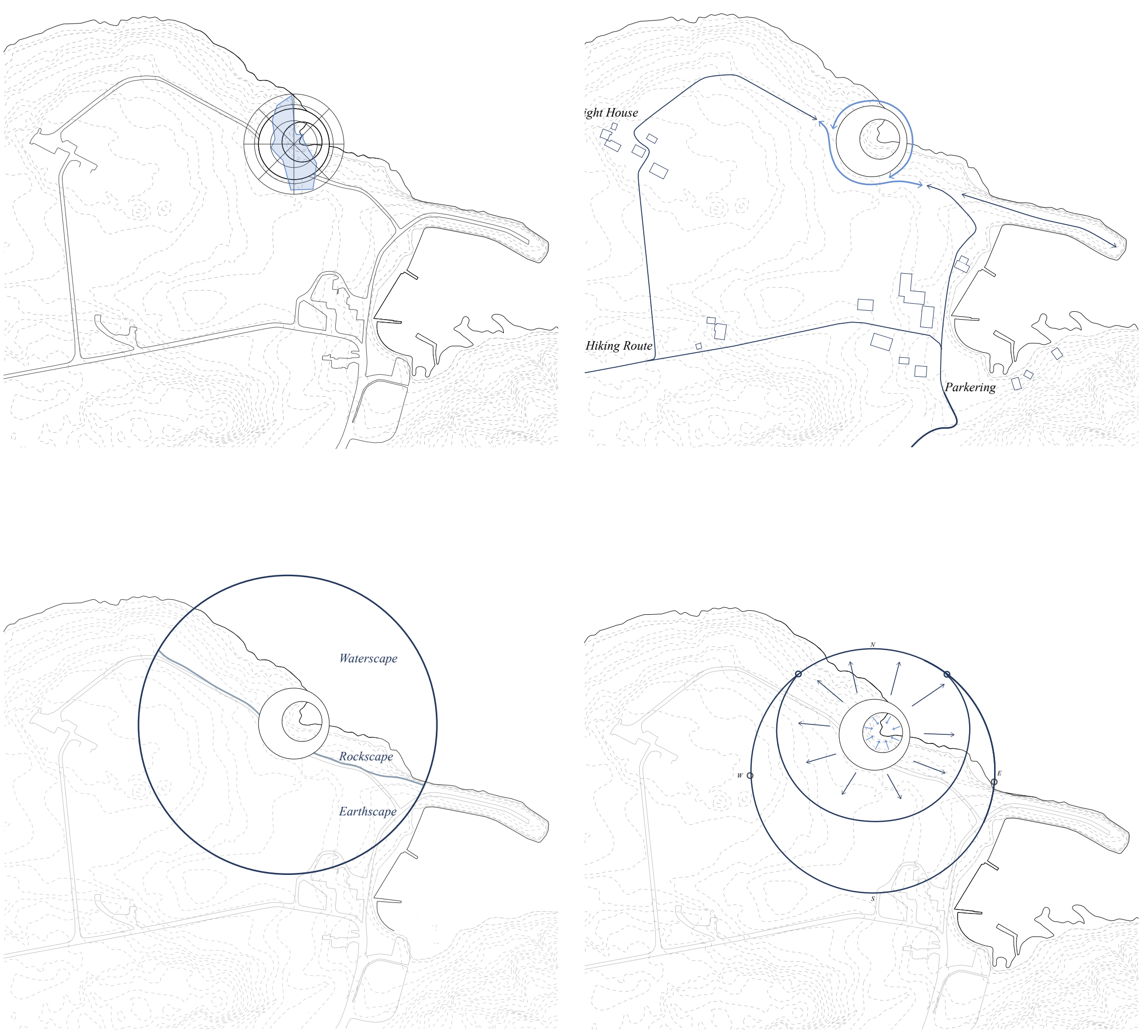
ill. 5.17

Observations

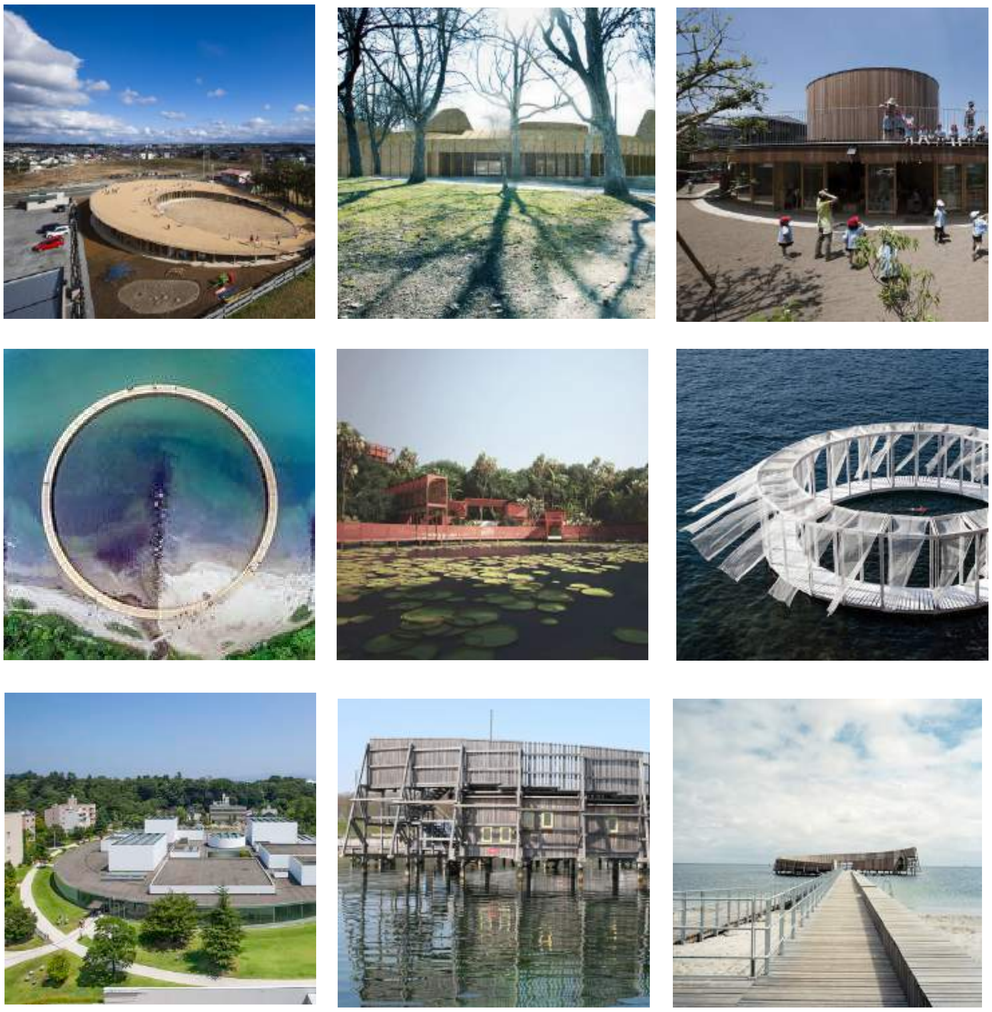
As opposed to adding volumes, this idea cuts shapes into the roof, providing a roof balcony where the sunlight can reach it. This conserves the strict circle in the courtyard.



ill. 5.18



ill. 5.19



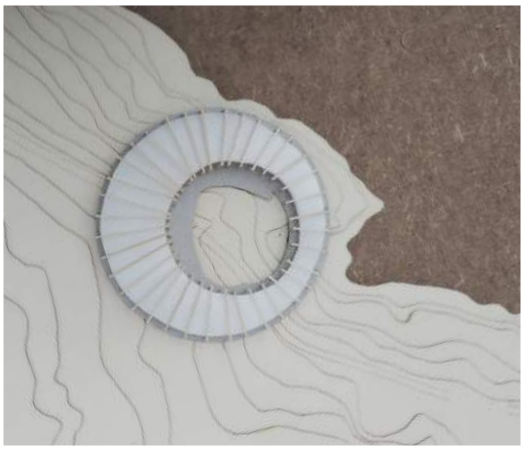
ill. 5.20

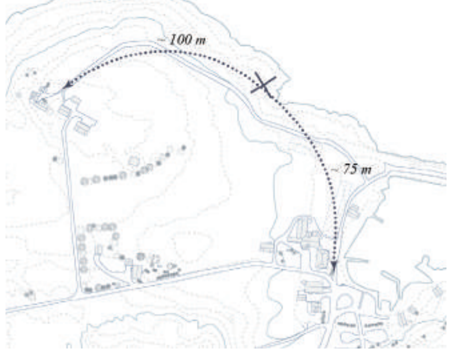
Programming

In order to verify the form on a detailed level, a process of programming was begun. The zoning of the rooms that was done in sketching, later turned into an initial plan drawing, making sure the areas of the rooms fit into the overall concept of the volume. Based on the program, the functions were placed according to thermal and atmospheric comfort.

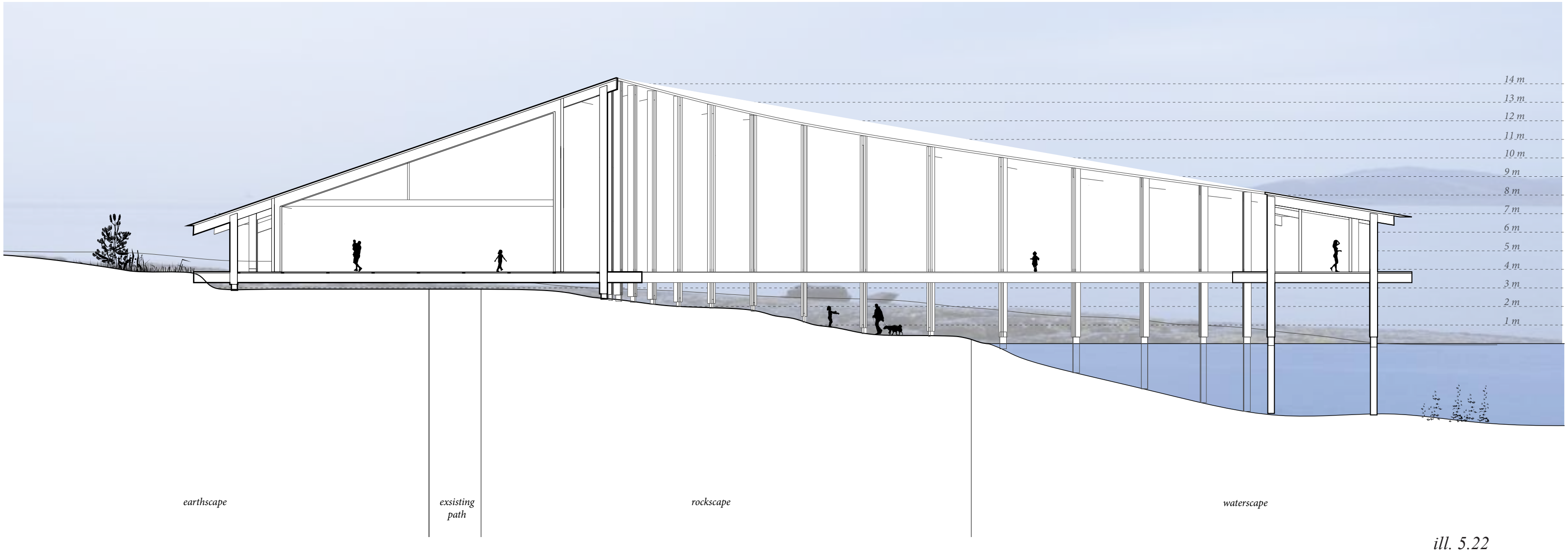
Observations
The plan in illustration 5.18 is based on a circular flow corresponding to the outdoor platform. This gives a repetition of the flow inside and outside. The circular flow can is directly interpreted, creating many similarities, making a predictable, unadventurous flow. This is furthermore established by placing the windows, with large window areas taking focus from the happenings in the interior. The aspect of window area is further analyzed in relation to the indoor comfort, documented later in the report. Placing volumes in the middle of the plan can be a challenge in terms of intake of daylight.

Following this state of the process will be a further development of the volume, especially the courtyard, creating a variety in the organic pattern, coursing a more varied flow on the inside of the building.





ill. 5.21



ill. 5.22

Location

Placing the Building

The vision for the project is to be a point of interest amongst the lighthouse and the dock - integrating within the existing cultural and geographical settings. The illustrations show three possible positions of the Science Centre. Two of them roughly in the middle of the parking and the lighthouse and the other on the tip of the coastal line.

Observations

The last mentioned have a more steep sloping than the first two, so the building seems at top of the landscape. The material here is mainly rocky landscape.

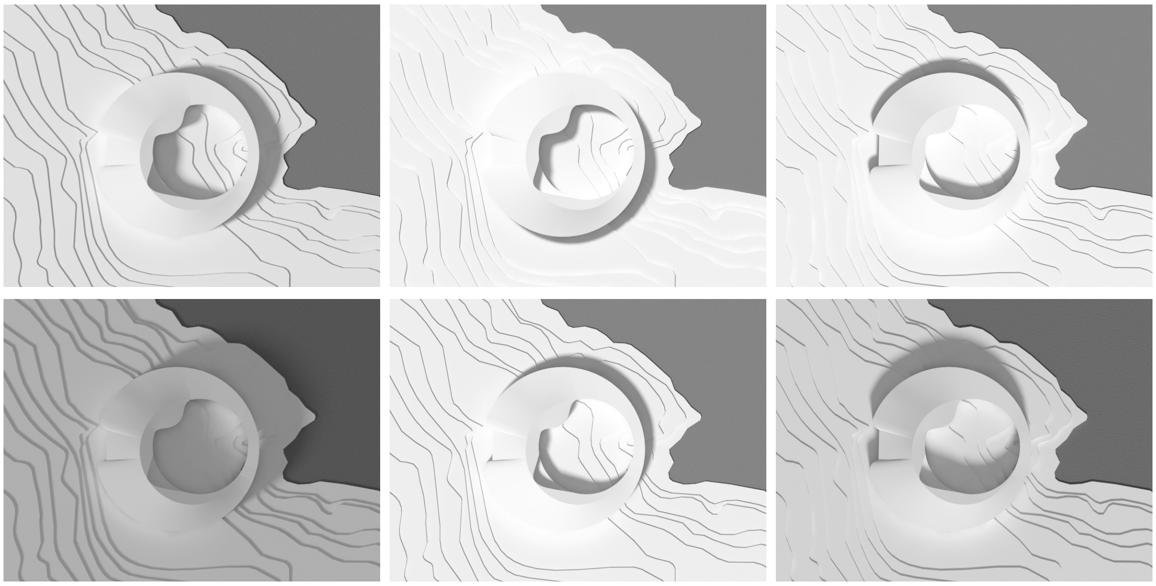
The second option utilizes the less steep sloping in the area. It divides the existing path in half, and the building will move upon both grass and stone, and at times in extreme weather, the water will rise up to the courtyard. The tide varies only 80cm in a normal day, still it will too bring the water closer during the day.
Placing the building here makes for a journey in the landscape before and after the experience of the Science Centre, since the Lighthouse will serves as a point of interest as well.
At this place the coastline moves in an irregular arch. The building can either grasp this arch, moving into the sea, or fit into the movement placed on land, letting the water move in and out of the courtyard.

The first placing of the building was as illustrated in picture 1, grasping the coastline and all three elements of the landscape. Later studies will show that due to the steepness at the drawn back part of the coastline, the building seem quiet heavy in the landscape from the arrival point of the parking. Therefor the placing is later changed to picture 2, still grasping two elements of the landscape and only letting the water in at times possible.

16:00 | *14:00* | *12:00*

21th of June

21th of March



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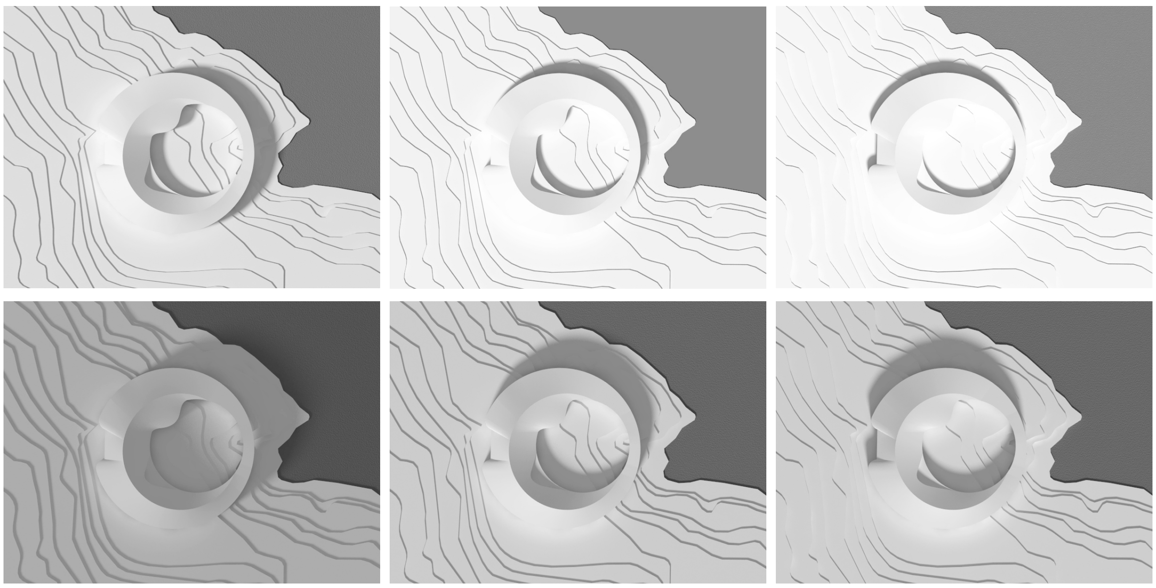

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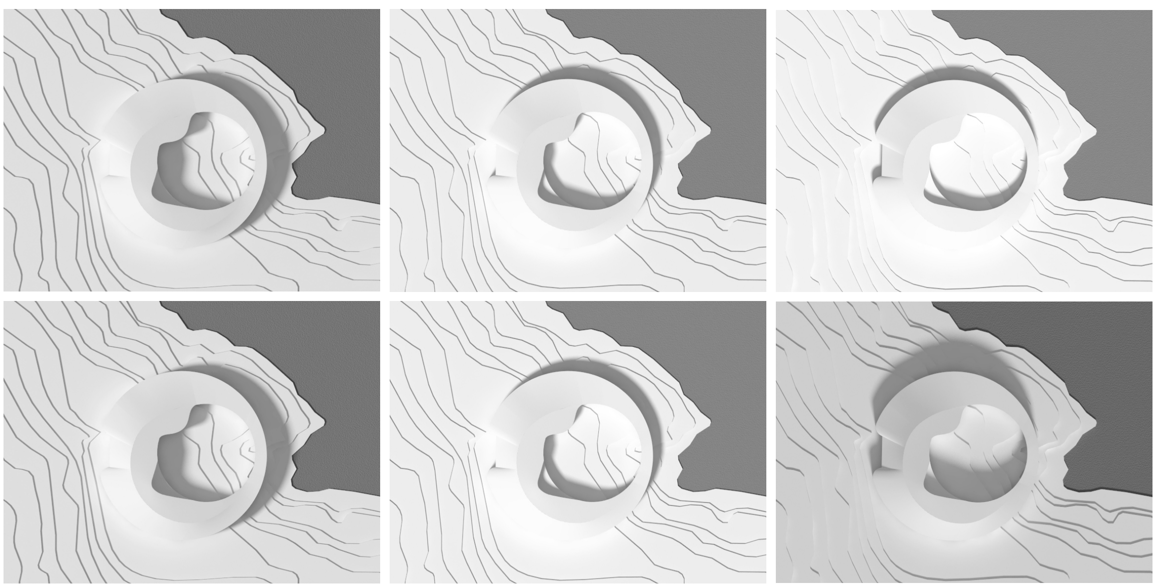
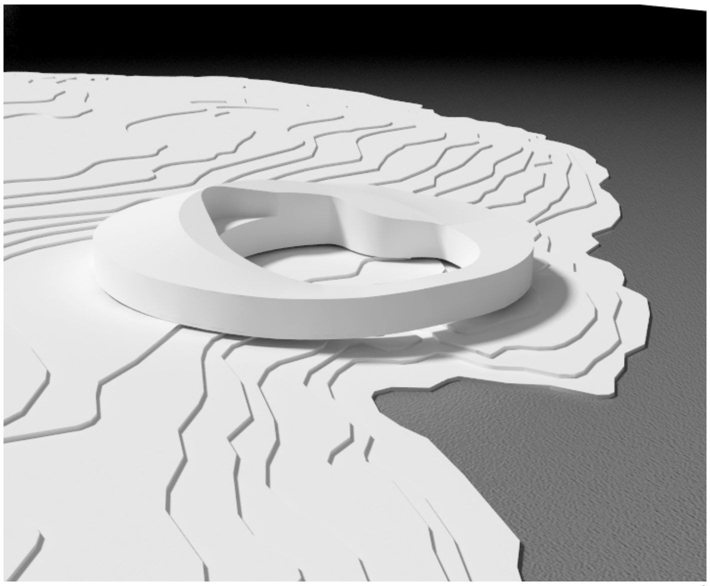
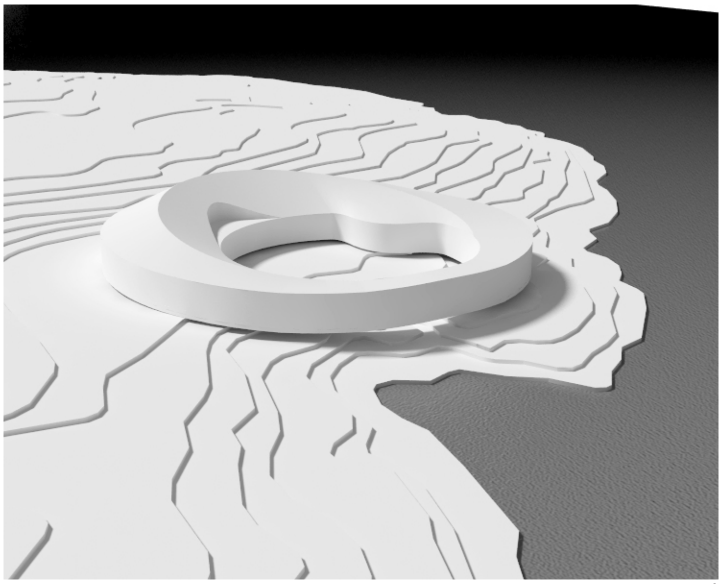
21th of March





1



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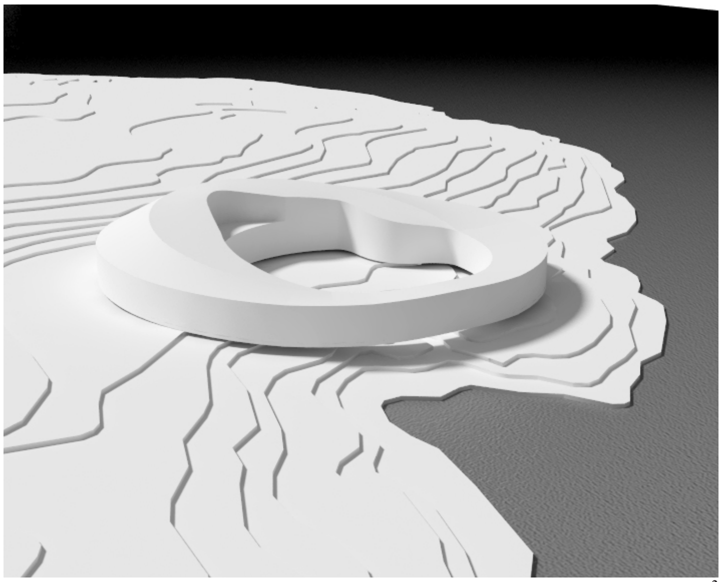


3

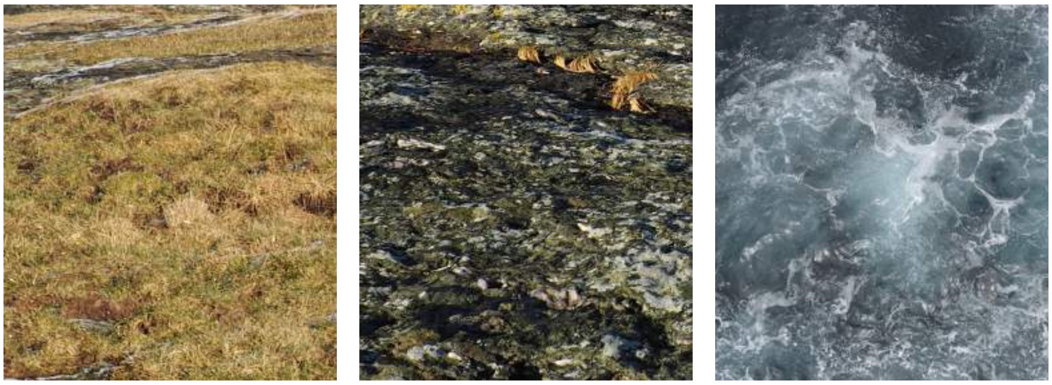
ill. 5.23

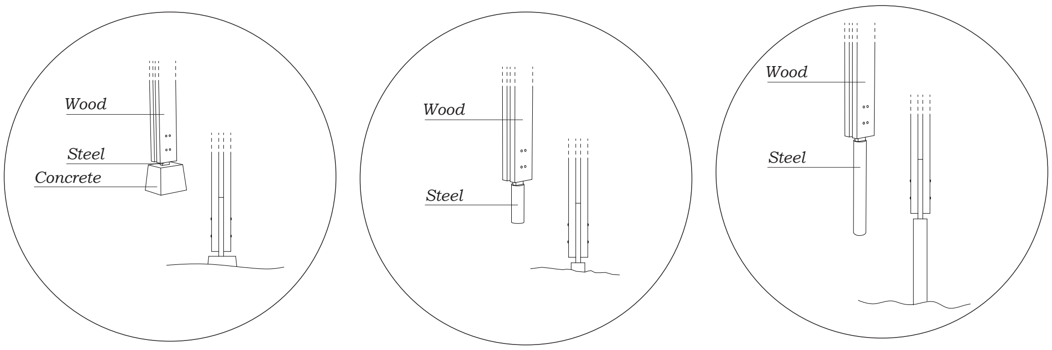
Shadow Studies

Designing the courtyard, shadow studies of the volume and roof shape have been investigated. The simulations are made for two times a year, spring equinox and summer solstice, and three times a day, since these are the times a year when the sun occur.

Observations

It has been decided to keep the roof pitch in the middle or towards the courtyard, to make the expression of the facade gradually moving towards the sky seen from the arrival. This highly dictates the shape of the inner rooms in the second floor, making the space dominated by the pitched ceiling. The qualities of the pitch roof can be utilized placing exhibition or auditorium and education rooms in the second floor to meet the acoustic demands at an early stage of the process. The second option with a roof pitch in the middle (2) and keeping the sloped roof towards the courtyard creates the best sun conditions for the balcony and the courtyard. However, this cause a narrow space on the upper floor in contrary to raising the roof in one direction (3). A solution is to make a higher roof, and this is tested in 3d modelling, concluding that the nessecary raising of the roof pitch, will not change significantly articulating the building in relation to the surroundings. The decision is finally made through plans and sections determining that the low-height areas can be used for storage and technical installations and in addition the balcony towards the courtyard takes up some of the low-height area.





ill. 5.24 | An early stage consideration of foundation types and materials in relation the to the ground.

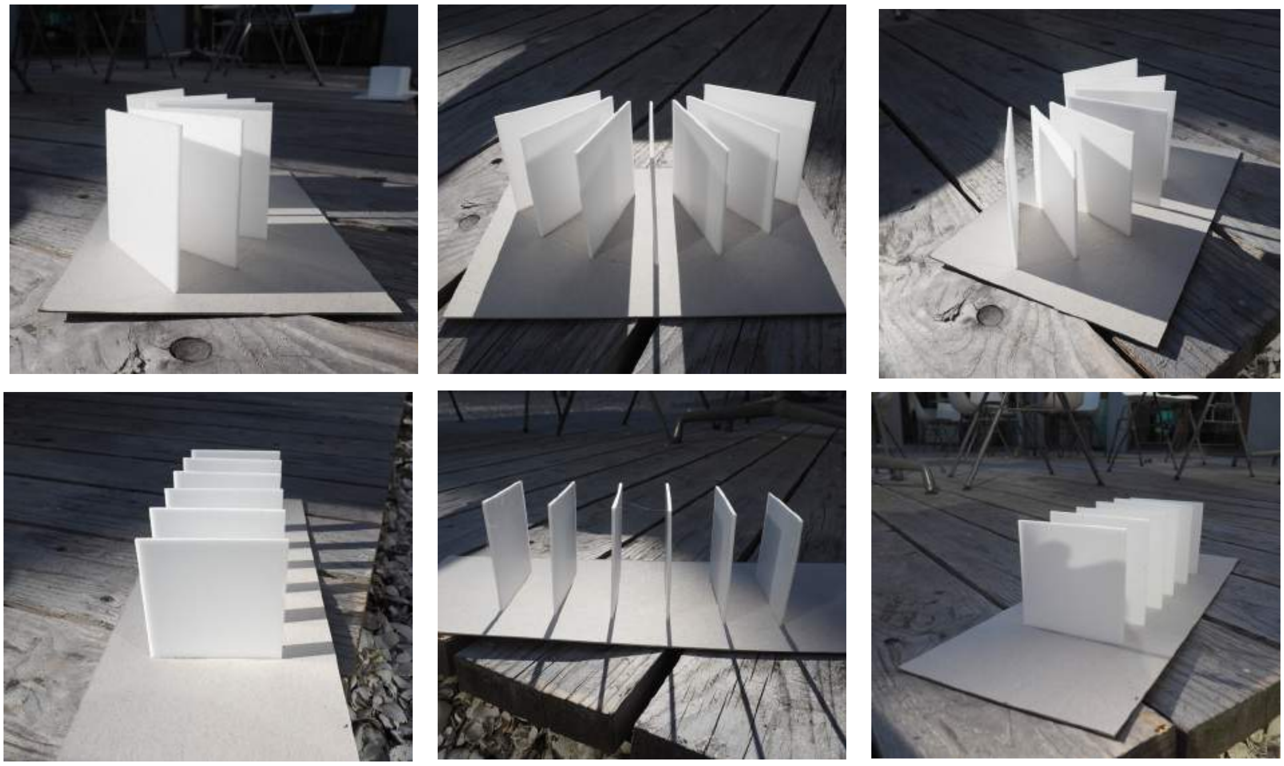
Structural Investigations

Developing a Structural Aesthetics
The objective of the constructional investigations is to enhance the architectural objective of the Maritime Science Centre, based on our tectonic vision as methods and mean. The potential of tectonics to express a structural logic and build as a narrative to tell the story of constructional principle and construction detail, we believe is essential to form an architectural aesthetics and tectonic value.

Aiming to fuse the understanding of sustainable architecture and tectonic vision to form the project have been an essential consideration which the interlaced design process reflects. The structural considerations of this project have been focused on how the building relate to the transition landscape and how to form the envelope in relation to sustainable initiatives. Investigation how the building meet the ground, different constructional principles have been investigated and further studies of how this relation between build and nature is articulated in the building detail. These investigations are evaluated in relation to the other design. The relation within the elements of the envelope was investigated through the aesthetic of frame construction and how to activate the different part of the envelope to create a spatial experience, and how this will be articulated in the design.

The investigations in this section overlap with iteration in previous, especially the further form studies. The illustrations focus on solving conceptual technical solutions, in a parallel workflow of investigating indoor environment and reveal the architectural intentions. The studies are based on initial and developed iterations which leads to the presented material, and form an foundation for the detailing of the construction and detailing.

ill. 5.25 | Structural process model of a frame structure



ill. 5.26

Observation

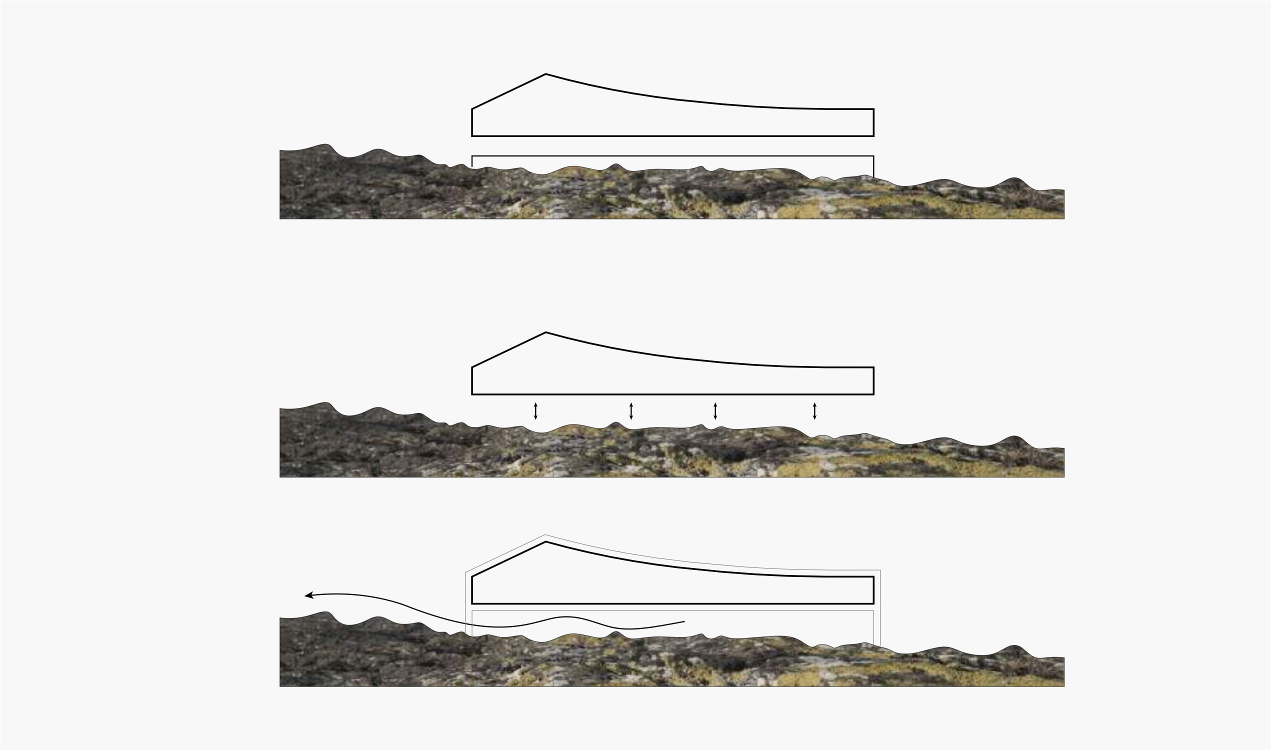
Conceptual observations on the potential of a repetitive system and framing surroundings. The linear creates a defined view consistent throughout the movement in contrary to the circular form creating a dense and an open framing of the surroundings.

Determining the Structural System

In line with the architectural intention of creating a transition between the build and nature, the circular geometry hold the potential of creating movement in the landscape. Though investigations of reference work we found the potential of the frame structure to investigate the transition of nature and the build environment. As the practitioner, Peter Zumthor, showcases in many of his works, the frame as structural system holds the potential of a contractual composition that articulate the meeting between the build and the nature, and in its repetitive and continuous form, creates a certain movement in the landscape. Thus, the build reflects the change in the landscape through smaller changes in the build.

Underlying the tectonic articulation the construction is exposed, making the tracing of forces easily readable, but also directly exposed to climatic conditions of the site. This cause for potential complication relating to the life time of the elements.

The frame structural system is introduced early in the process as we found an aesthetic potential in the repetitive system and as a mean to create space using the depth of column and beams. The space between the frames frame the view in segments. Each frame will contribute to the whole experience, and in between the frames, the articulation of space will appear defined, yet open to the surroundings, thus creating a direct relation between the building and the natural environment.



ill. 5.27

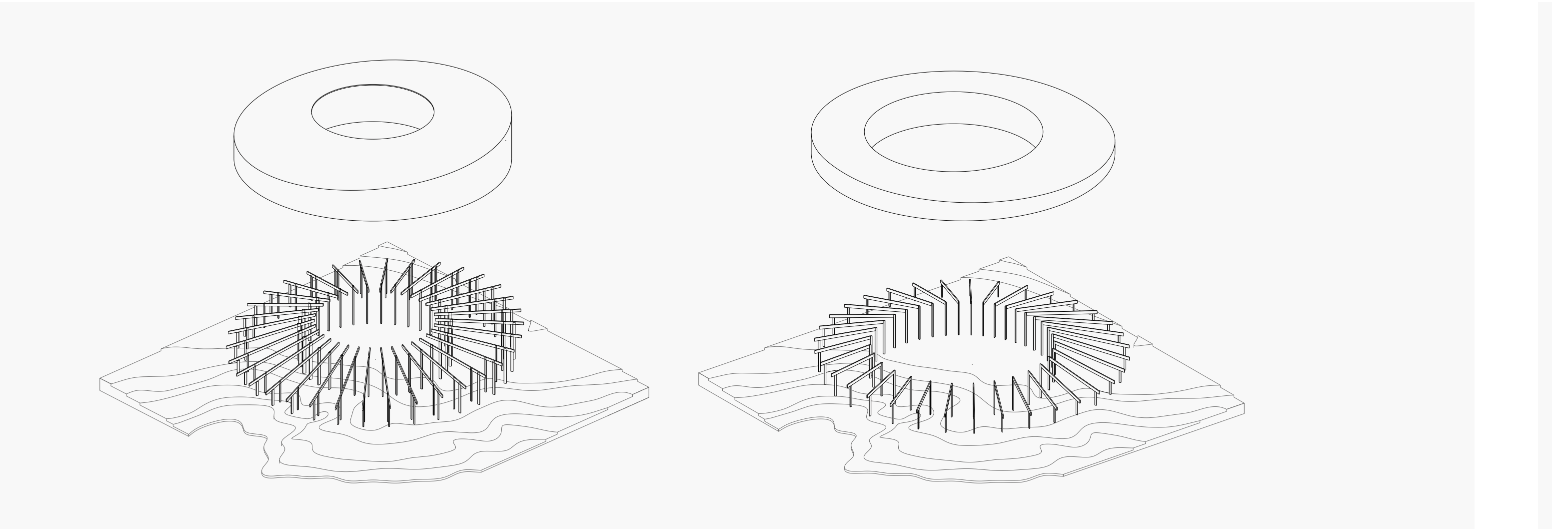
Observation

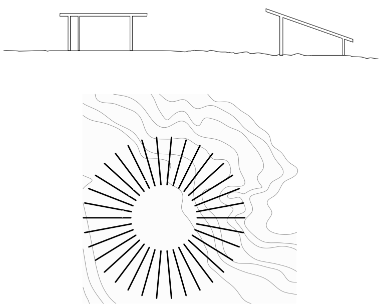
Conceptual explorations of the meeting between the stereotomic and the tectonic. The different ways of treating the meeting between the ground and the building will affect the general articulation of the building. By having a linear foundation the building intervene a major part of the natural environment comparable to the other solutions that preserve the environment as a statement to the destinguish between the natural and the built environment.

Iterations of Circular Frame Structure

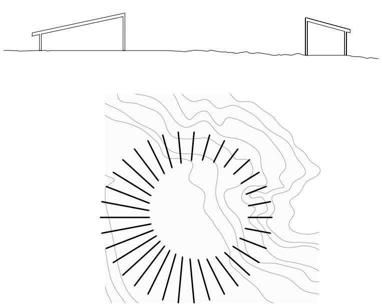
Developing the Frame Composition
Based on the repetitive elements that create the structure of the building, the focus was to explorer the singular frame in composition with the overall geometry and evaluate these based on different parameters such as shape, spans, distances, the courtyard and three dimensional envelope.

Evaluating how to construct the singular element to in a giving geometry, we have used parametric modelling in Grasshopper plugin for Rhino. As the structure significantly influences the spatial experience moving around in the circular shape, it was important to investigate the shape of the frame.

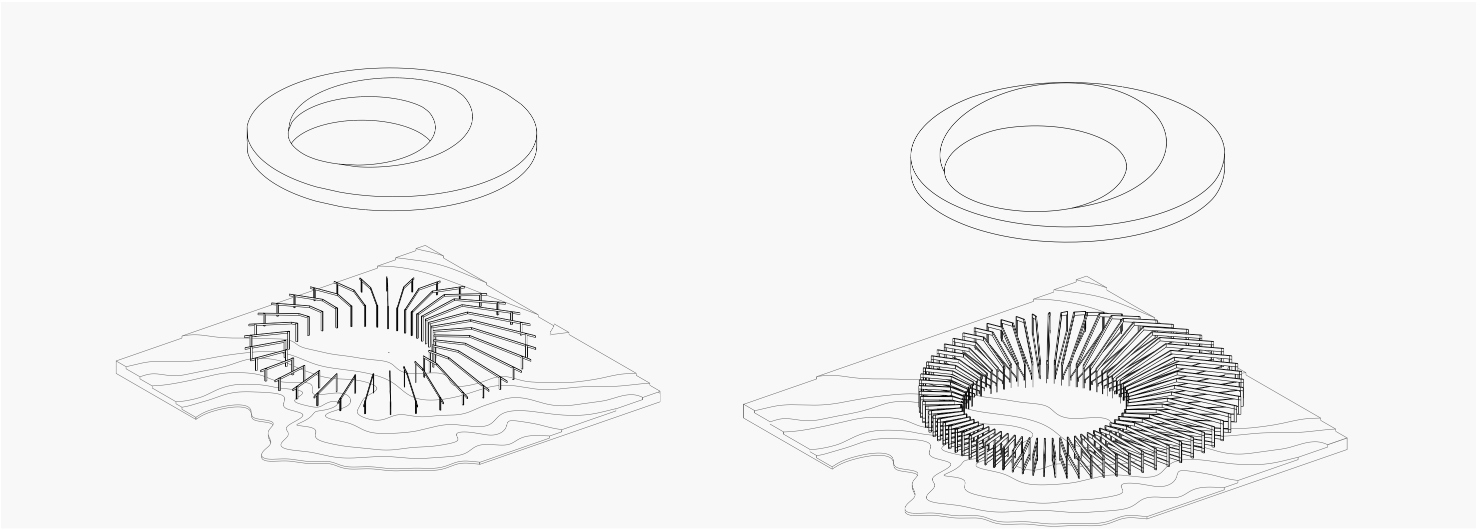


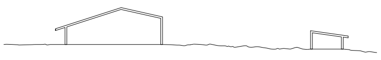


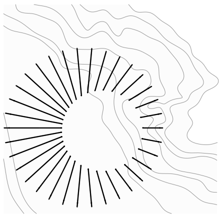
Observation
An initial frame structure that transits from a flat roof shape into a sloped roof shape. Placing the courtyard in the middle create an continuous interior dimension resulting in a monotonous experience of the structure.

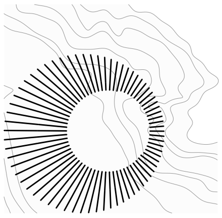


Observation
The roof shape slope toward the exterior, creating a high facade towards the courtyard and low toward the surroundings. Displacing the courtyard from the center makes a variation in frame dimension, thus creating a transitioning hierarchy in the spatiality of the interior. The single frame is constructed to create an overhang outside, as part of the experiencing the frame structure









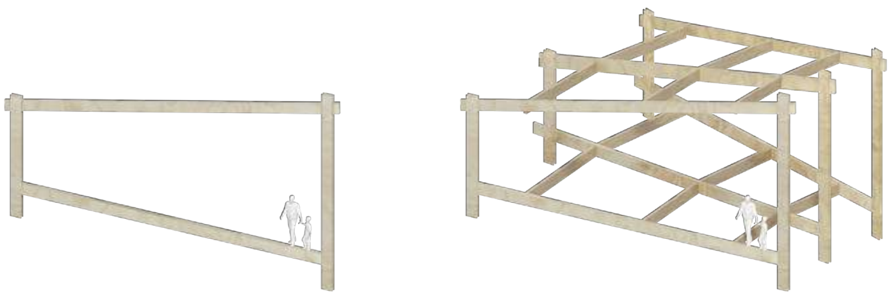
ill. 5.28

Observation

Sloping the roof shape towards the courtyard as well as the exterior surroundings, accommodate the shadow studies and emphasize the intimacy we aim to obtain in the courtyard. In human scale the building will appear lower in the landscape, thus creating a balance between the build and the surroundings.

Observation

The density of the frame structure is increased to strengthen the understanding of the movement and the articulation of the relation between build and nature. The composition of frames is oriented towards the middle of the courtyard, creating a repeating distance of 1,5m between the frames, thus dictating the placement of the frames.



ill. 5.29

Detailing the Frame

Developing the Singular Frame
Using a rather simple frame that in composition creates a complex structure. The individual frame is developed with a focus on how the detail in combination with the overall construction creates a comprehensive understanding of the building.

Illustration 5.27 depicts how the singular frame is stabile in one direction. By placing the frames in a circular shape and using transverse beams, the circular frame structure stabilizes the itself.

Exposing the structural system reveals the tectonic quality of the project. Placing the core in the middle of the building and providing a ramp along the building, allows the visitor to experience the building at different scenarios. Walking within the frame provides a spatial experience of the frames.

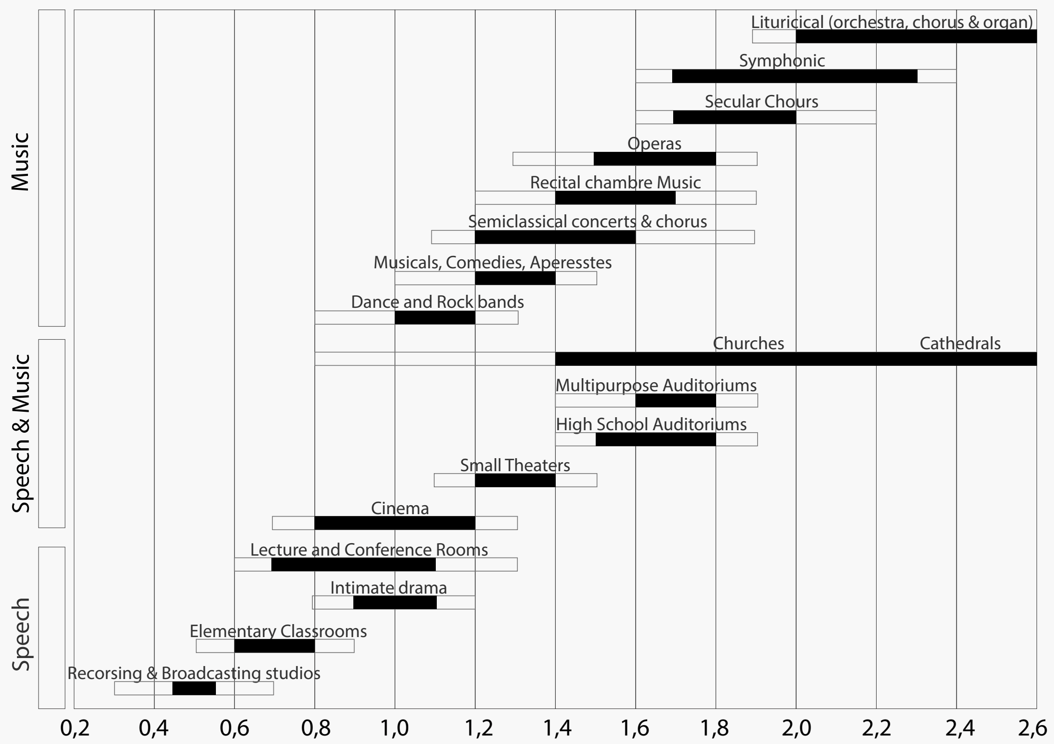
ill. 5.30

ill. 5.31

Observation
The initial frame structure consisting of two columns and the beams in between. The joint allows the minimalized transformation in the wooden elements, thus creating a system easy to assemble. The depicted assembling makes the forces tranfer throught the joint rather that directly from the roof beam to the column. The foundation consists of a simple steel column.

Observation
Each frame is consisting of solid wooden beams and columns. Each element is a customized frame. Sloping the frames, the columns towards the courtyard will be rather tall compared to human scale, thus the column will be more exposed to bending. The forces will directly tranfer form the beam to the column, putting less pressure on the joint.

Observation
The upper beam of the frame slopes in two directions, creating shorter columns towards the courtyard. The frame structure relates to human scale, creating a more intimate perceptual experience in the platform along the building. The roof joint utilizes the advantage of transfering forces directly from element to element.



ill. 5.32

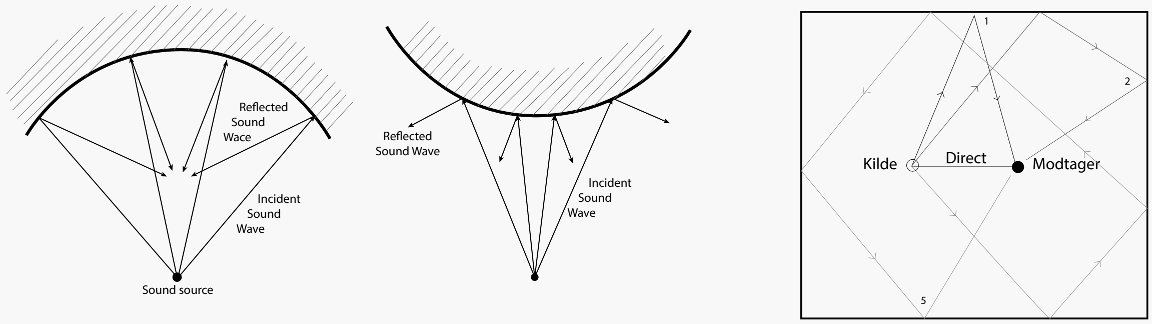
Architectual Acoustics as a Design Intrument

Acoustic as Architectural Experience
The acoustics of space have a great in¬flu¬ence on how space is perceived, weather it is the grandeur of a cathedral or an en¬closed recording studio, it is reflecting the use of the space. Designing the Maritime Science Center the acoustic experience have been investigated to exploit the potentials of the building in relation to the function.

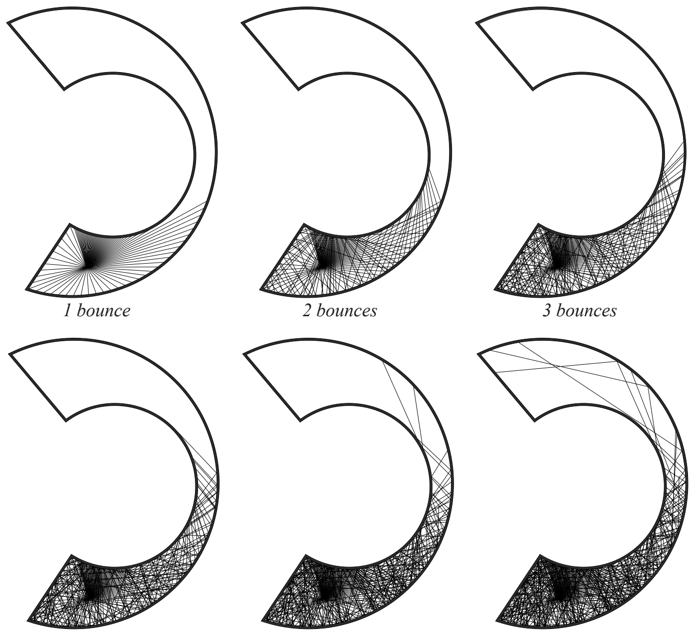
Objective
Focusing the project on two different ar¬chitectural situations, we define the acous¬tic objective of the building.
Due to the circular open floor plan of the exhibition space, the sound can potentially be reflect¬ed in circular movement, creating a rotunda effect. To avoid this condition the building will be formed in acoustic zones, investigated through mate¬rials and geometry. As the Science Center is primarily intended children and young people to explorer and experience the space, the acoustics needs to accommodate potentially high noise levels.
The auditorium is indented for confer¬ences, school classes and cultural events and the objective for the acoustics, is to provide the optimal conditions for speech.

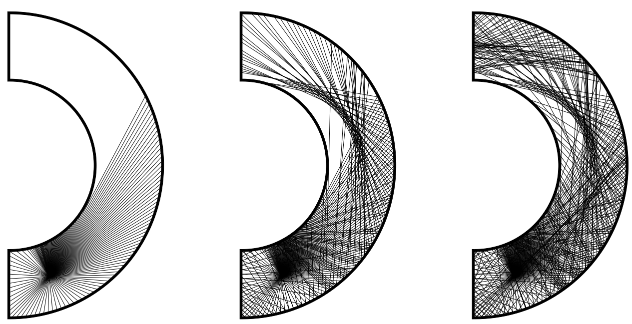
Parameters
The overall studies are based on the theory of reverberation time and the sound distri¬bution in space. The basic theory of acous¬tic is how the sound wave corresponds to the geometry and use of material. Initially each sound ray holds a giving amount of energy. The energy of the ray reduces when traveling through air and reflecting onto the geometry. Thus the reverberation time is an expression on how long time it takes for the a direct sound to reduce to 60 dB. By forming the geometry and testing different materials, the reverberation time is calculated to give an estimate on how the acoustic of the space behave. Illus¬tration 5.3 depicts the preferred reverberation depending on the function and use of space.
The acoustical sound distribution in the exhibition is investigated using ray trac¬ing to simulate the movement of sound. The basic theory is that the entrance angle is equal to the exit angle when the sound is reflects of the geometry. This assumption is a sim-plification and depended on the materials ability to absorb, reflect and scatter sound. Introducing soft, medium and hard mate¬rials the depicted in illustration 5.35, investi¬gation takes its departure in choosing the different materials

ill. 5.33 | Tezuka Architects
Zion Christian Church + Mihato kindergarten
Inspiration work for materiality and geometry of the auditorium.



ill. 5.34





ill. 5.37

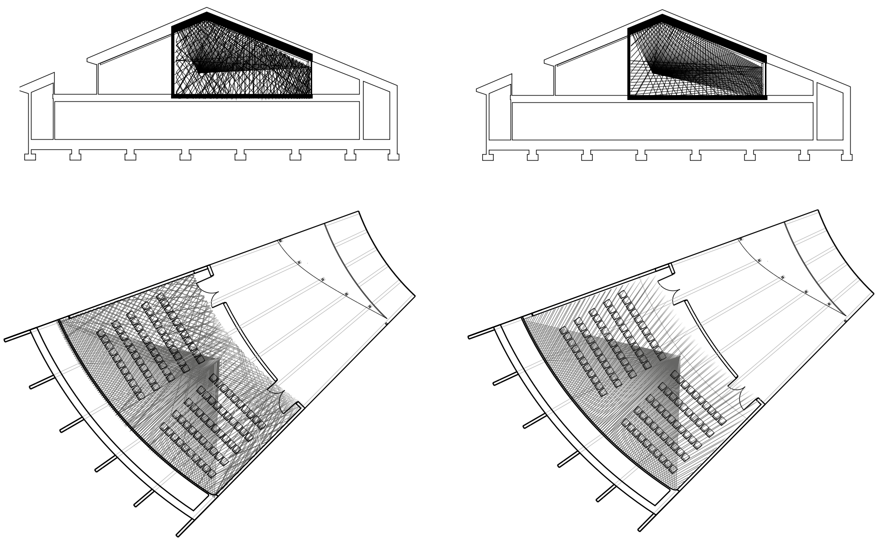
Observations

Illustration 5.34 shows the distribution of sound simplified in a ray tracing for the exhibition area. The initial form of the exhibition is a half circle equally wide along the geometry. The sound is reflected in two bounds from one end of the building to the other, potentially causing a rotunda effect and the prob¬lematic of controlling the sound. By displacing the inner circle, narrowing the exhibition space the hall way will function as an acoustical division. The sound will bounce five times before ap¬pearing in the other part of the building, and depending on the absorption value of the material, the sound energy will be reduced.

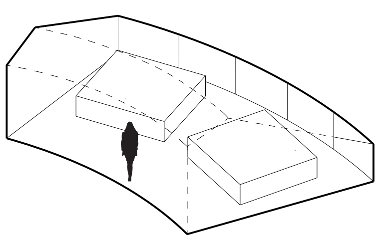
Absorption of architectual materials

	MATERIAL	Absorption (%) 125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Hard	22 mm chipboard w. 50 mm mw	0,12	0,04	0,06	0,05	0,05	0,05
	Floors wooden	0,15	0,11	0,1	0,07	0,06	0,07
	Double Glazing, 2-3 mm glass, 10 mm air	0,15	0,05	0,03	0,03	0,02	0,02
Medium	Timber boards, 100mm wide, 10mm gap, 500mm mw	0,05	0,25	0,6	0,15	0,05	0,1
	12 mm plywood over 150 mm airgap	0,28	0,08	0,07	0,07	0,09	0,09
	12 mm wood panelling on 25 mm battens	0,31	0,33	0,14	0,1	0,1	0,12
Soft	Cedar, slotted and profiled on battens mineral	0,2	0,62	0,98	0,62	0,21	0,15
	Wood panels, 15mm slot and 35 mm wooden slat	0,1	0,36	0,74	0,91	0,62	0,5

ill. 5.35



ill. 5.36



Observations

Further investigations of the auditorium is examined in term of how the geom¬etry layout corresponds to the sound distribution and how choice of materi¬al influence the reverberation time. The geometry creates a parabolic end wall in the auditorium, which project and focuses the sound toward the audience. The acoustic potential of using a parabolic shape can be traced back to the ancient, where the theaters were shaped as a parabolic form. The roof shape additionally contribute to the distribution directing the sound to¬ward the audience.

Acoustic Material Studies

Using wood as the primary material, the investigations take its origin in the different properties of wood as acoustical mate¬rial and how to treat the material to obtain different acoustical properties. Following the acoustic investigation of how the sound distribute in the auditorium, studies on choice of material in relation to reverberation time and spatial understanding of the room is made. Illustration 5.37 shows a visual representation of different choice of materials. The visualization is made for one half of the room, and the other half is symmetrical to this. As the space primarily function as auditorium, the desired reverberation time is approximately 0,8 - 1,2 ms cf. illustration 5.31.

Hard Materials
Reveverant time: 3,18 s

Observations
The material of the space is chipboards on walls and ceiling, which is a hard wood with low absorption values. The material is a composite material and the surface can be treated differently to obtain dif¬ferent textures and appearance. The reverberation is remarkably higher than the desired acoustics.

Medium Materials
Reveverant time: 1,88 s

Observations
The materials on walls and ceiling consist of plywood, which we defines as material with medium absorption val¬ues. Plywood is a composite material of planar wooden surfaces, thus to some extent preserving the wooden texture of the material. The reverberation time is markedly lowered, yet unfit to the desired.

Soft-Medium Materials
Reveverant time: 1,14 s

Observations
Replacing the plywood in the ceiling with lamellas, improves the reverberation time. The change in material creates contrasting textual surfaces, enriching the spatial experience.

Soft-Medium-Glas Materials
Reveverant time: 1,4 s

ill. 5.38

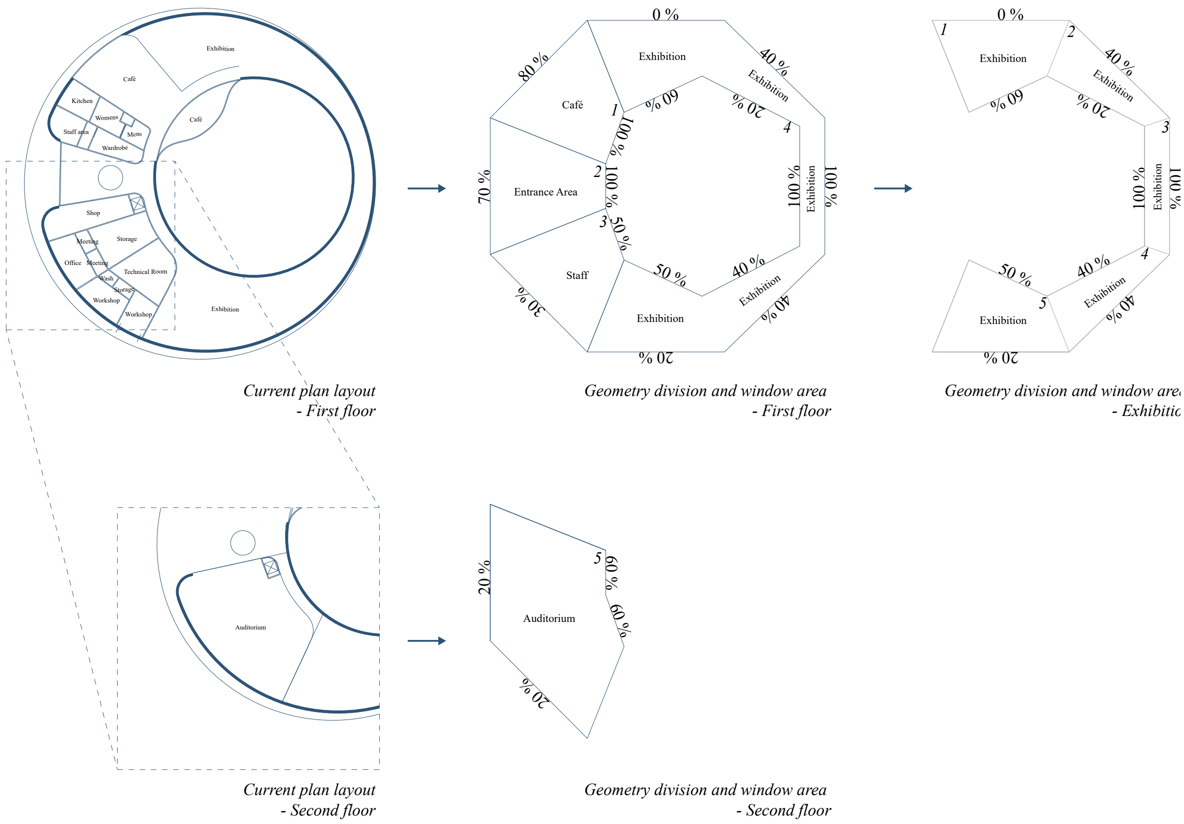
Observations
Corresponding to the daylight analysis the window area is changes, contribut¬ing to the daylight factor, yet increasing the reverberation time, due to the lower absorption values.

ill. 5.39

Designing the Facade

The constant interplay between environmental sustainability and human perception especially appears in the design of the facade. In this phase of the design, the range of sustainability is dependent on the climate screen in terms of indoor comfort and energy use and materials in terms of production, recyclability, abolition, etc. Both topics not only respond to sustainable aspects but to the human perception in terms of materiality and the indoor / outdoor connection. Moving around the building the facade is close to the user, available to all senses, making the sensuous affection vital to general atmosphere of the space.

Designing the facade is a balance of calculations and experience-based examinations. Initially, the main material, wood, was chosen due to the sensuous attributions and sustainable properties. In addition, the calculation tools BSim and LCA Byg is used to examine which areas of the design will have a crucial impact to the indoor comfort and life cycle of the building. Light analysis in DIVA plugin for Rhino is made continuously to ensure enough daylight in certain areas while changing the facade.
To support the calculations the changes of the design according to the results are examined in either a 3d model, physical model or plans and sections to ensure or review the desired atmosphere of a room.



ill. 5.40

BSim as a Design Tool
The idea of using BSim as a tool in the process was to identify the critical areas according to comfort temperatures. The calculation was initiated at a point where the overall geometry and appearance was designed in accordance to the previous examinations, thus the simulations serves as an argument of orientation, solar shading and amount and direction of openings.

The first calculation reveals that a exposed area of the simulation model is the exhibition space. At this point the exhibition is made as one room, meaning it faces almost all directions. The exhibition is divided in order to discover which area is contributing the most to the outcome of the comfort temperatures. As seen in illustration 5.39 area 3 of the exhibition have a high contribution to the hours above in relation to the other areas. Even though the facade of area 3 is facing east and west, the geometry and the sloping of the roof allows the sun to enter the courtyard most of the day, exposing both facades of exhibition 3. At this phase, these facades are a 100% glass, corresponding to an idea of having three connected scenes: a path connecting the sea, the interior and the courtyard.

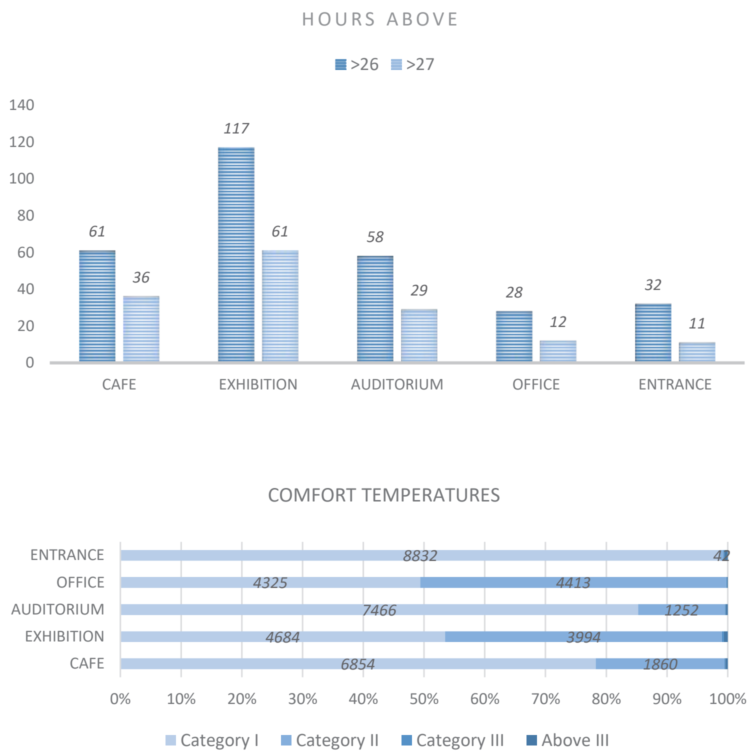
The results were supported by simple 3d visualizations coursing a review of the solution - having a clearer connection between the three scenes enhancing the interior with a closed facade, framing the view of the courtyard and the sea.

The general overheating challenge of the building is accommodated by creating an overhang in the courtyard along the facade. The excessive temperatures of the entrance is helped by pulling back the entrance area, creating an overhang and an attention to the entrance area when walking around the building. Finally, the g-value (solar transmittance) is improved and external shading added on windows to reach the comfort requirement of excessive temperatures - a yearly maximum of 25 hours above 27 degrees and 100 hours above 26 degrees.

Observations

The graphs show the output of excessive temperatures and comfort temperatures of the initial analysis. As seen the Café, Exhibition and auditorium does not fulfill the requirements. In addition, the entrance is later lowered of reasons of atmosphere, in this context there is created an overhang on the outer face of the building to accommodate potential overheating issues.

Even though the hours-above analysis shows excessive temperatures, the general comfort temperatures are almost within building category 2 meeting a medium level of expectations.



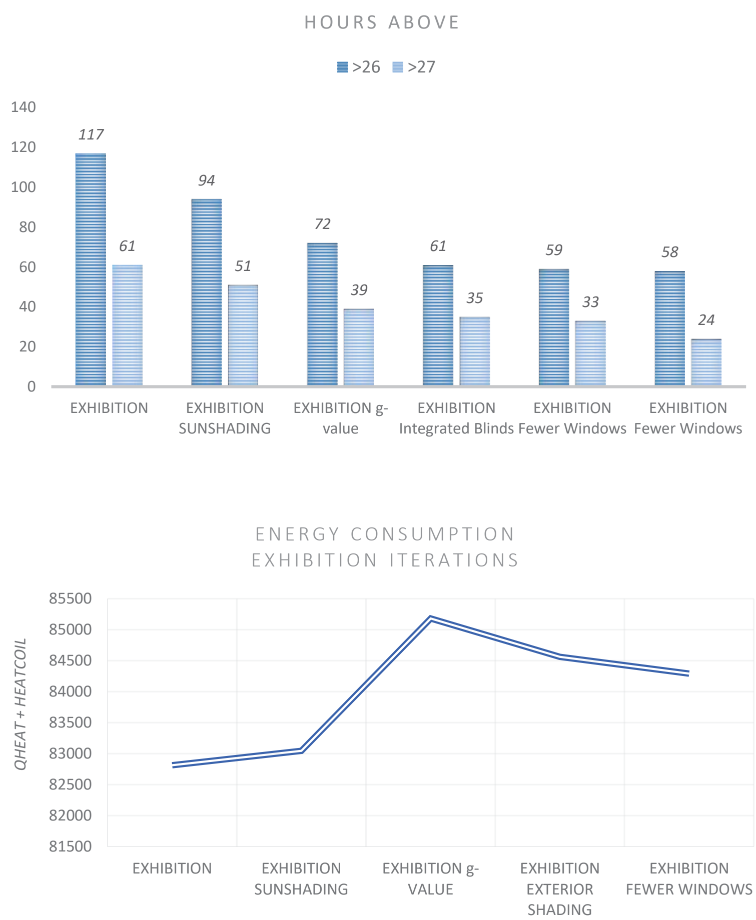
ill. 5.41 | Initial building simulation

Observations

Decreasing the excessive temperatures, the critical area of the exhibition is further analyzed with respectively sun shading in the courtyard, better insulted windows (g-value), integrated blinds, and two rounds of fewer windows.

This shows that the hours above are getting decreasing for each step. The room is seen as a separate room, and the numbers is therefore not precise, but guiding.

The following analysis of the energy consumption shows that the energy consumption in general increases due to the changes of the design. Especially seen when the substitution of windows are made, since better insulated windows cause less passive solar heating, eventually causing a higher heating demand.

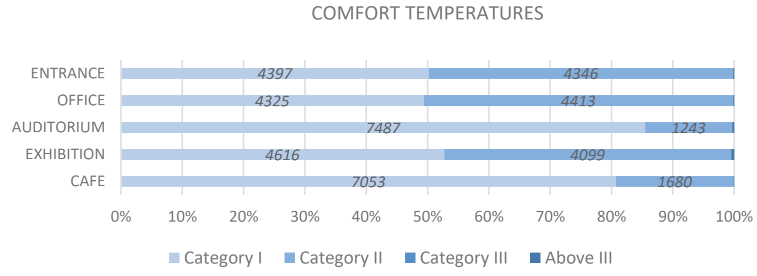


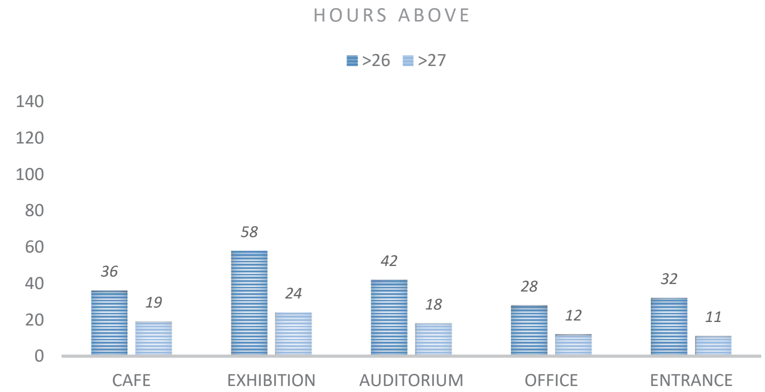
ill. 5.42 | Second iteration

ill. 5.43 | Visalization with large window area

Observations

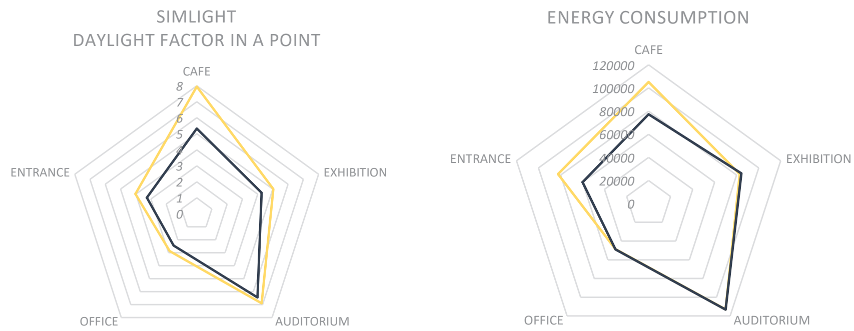
Illustration 5.43 and 5.44 shows the examintion of perceptual influence of the changes in the building corresponding to the results from the calculations.
In the eastern part of the exhibition, going from a open, undefined framing of the surroundings to framing nature, also creating usable space for the exhibition.
The physical construction model (ill. 5.39) supports the atmosphere occurring when having an overhang in the courtyard, providing shelter and making a significant outline of the sky. This design enhances the atmosphere of the courtyard, in contrast to the platform facing outwards, as a intimate space, framing the enclosed natural environment.





ill. 5.45 | Resulting Hours Above and Comfort Temperatures

ill. 5.44 | Visualization with fewer windows



ill. 5.46 | Resulting daylight and energy consumption

Observations

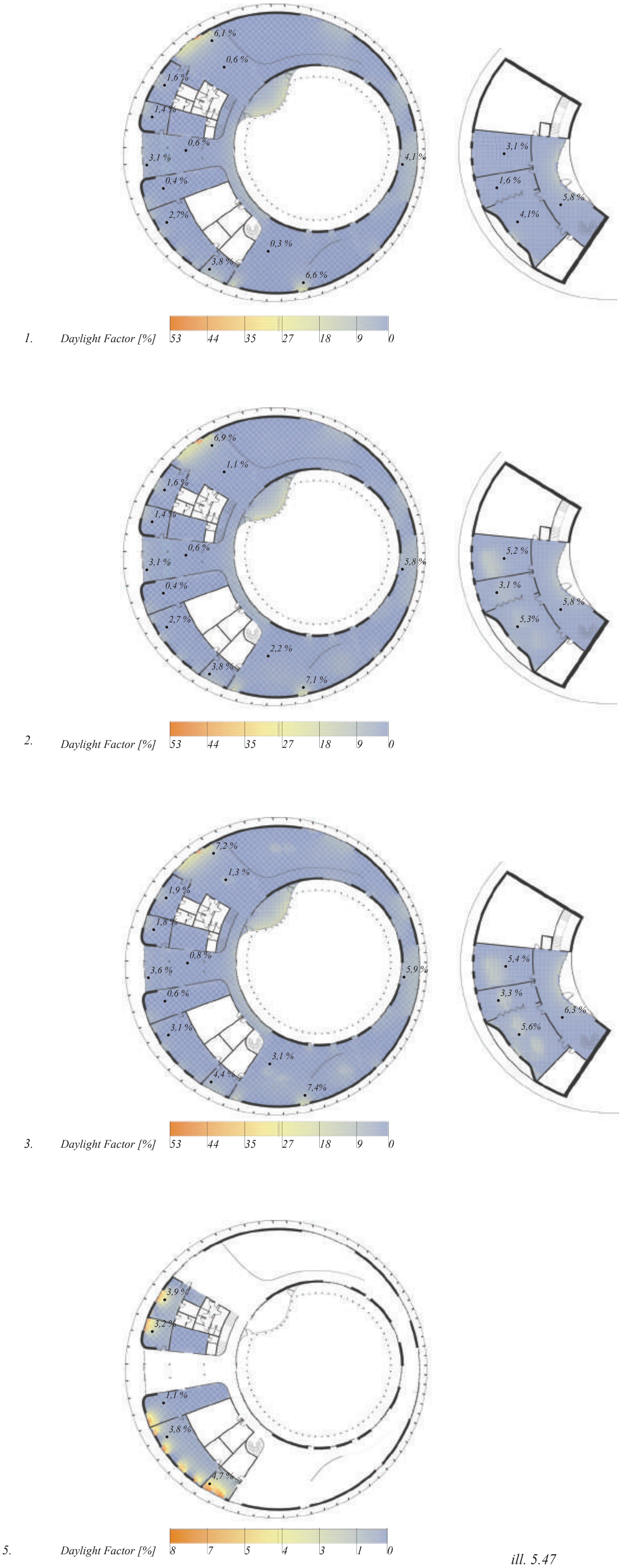
The graphs of hours above and comfort temperatures (ill. 5.45) shows the result where similar changes, as applied to the exhibition room, are made in the other areas with excessive temperatures. It can be discussed whether higher insulated windows or external shading should be applied to the whole all areas in terms of simplification, however consequence will be that the energy consumption will increase even more.

Another consequence of the better insulating windows is that the comfort temperatures in general increases. Almost all temperatures are still within category 2, preserving an acceptable level of comfort.

When changing the windows a parallel analysis of the daylight factor in a single room is made. It shows a significant decrease in the intake of daylight with lowering the g-value.

In further studies, the balance between energy consumption, daylight and comfort temperatures could have been examining further changing the window placement to find an acceptable change in daylight, energy consumption and still fulfill the requirements of comfort.

ill. 5.48



ill. 5.47

Observations

Additional studies of daylight have been made with DIVA for Rhino for the building, showing the daylight distribution and relation between the rooms. The values and description of the analysis can be found in Appendix xx.
The daylight factor expresses the intake of daylight as a percentage of the outdoor light, with overcast sky. The factor counts both the specular and diffuse reflection of a material. The importance of daylight in the Science Centre exist in terms of enough daylight in workplaces as well as an architectural mean to create atmosphere and thereby support the specific function of the specific room.

The iterations shown build upon a base model with no skylights in the roof. The iterations show how the implementation of skylights and lighter materials - first of the whole building and since in the low-height areas which are mainly staff functions.
The amount of daylight follow the guideline of the Danish Building regulations in terms of having at least 2pct. daylight at a workspace - however when looking at the whole office or kitchen area, it becomes clear that it is only in the region close to the windows where the daylight factor is 2 pct. or above (Bygningsreglementet 2017) The final daylight analysis for the exhibition shows a balanced contrast between light and darkness, providing necessary wall space for exhibition materials and spot light from the skylights in the middle of the room.
Originally, the thoughts on placing the exhibition area near the water would influence the light and thereby the atmosphere. The characteristic glare of light reflected in water surface would influence the light condition in the exhibition. Water itself does not reflect much light, but when the sun is shining the water will reflect the light directly rather than diffuse, making it seem more intense due to its smooth surface. The effect will appear from the rocky landscape as well when the sun appears after a rainy day. Since the water and stone in general does not reflect much light and the sun in a annual base does not appear often, the effect on the average daylight simulation does not show. Instead, it is visible that the openings near the grass reflects more due to its higher reflectance value.

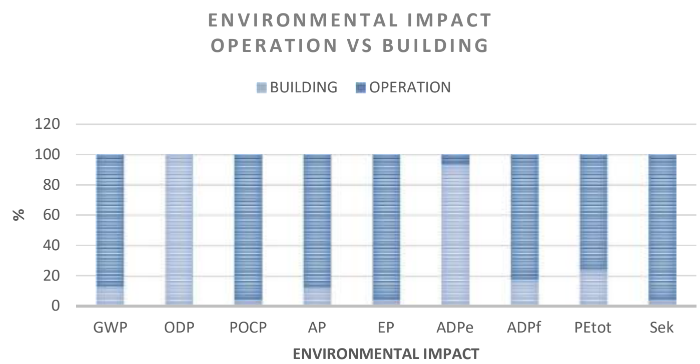
ill. 5.49

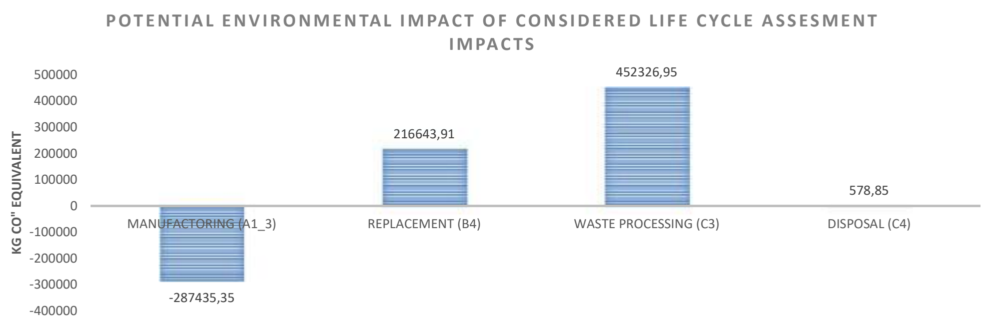
LCA

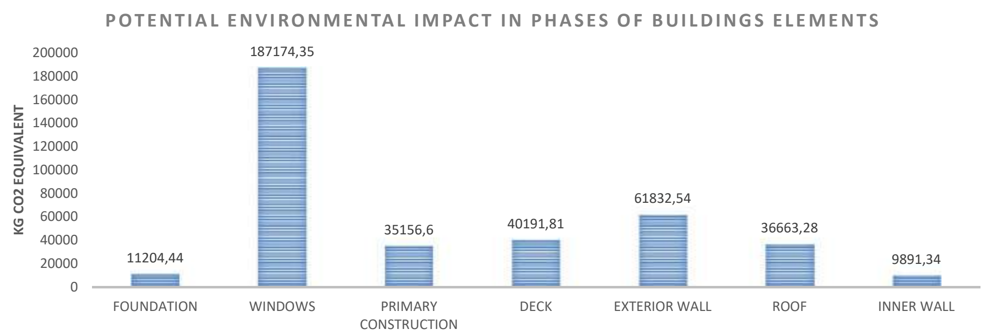
In continuation of the BSim analysis, LCA Byg contributes with a complementary view on energy usage in the building industry, considering the embodied energy of the materials for the building. Considering wood as a benchmark for the project, the life cycle have been reasoned early in the design phase. The purpose of the LCA analysis at this point is, as well as the BSim examination, to identify critical aspects of the building performance that can be prevented before the whole design is in place. In that way the LCAByg tool act as a verifying to understand the consequence of the chosen materials.

Observations

The analysis provides an overview of the contribution of the different elements to the environmental profile. This entails knowledge on which elements to be aware of in the design process. Illustration 5.49 shows the result of the LCA analysis was introduced at the same stage as the BSim analysis. The maximum energy use for a Danish Building Class 2020 is used to have a comparable factor, as seen in ill. xx the operational energy surpasses the building embodied energy for a great part of the environmental impacts. The primary global warming potential (GWP, CO2 equivalency) is caused by the waste process of the materials used. The illustration shows that the primary element contributing to this is the windows. This amplify the importance of considering the window area in the design, as well as the BSim calculation did. However, this should be in coherence with the function and the experience of the place both inside and outside of the building.


ENVIRONMENTAL IMPACT
OPERATION VS BUILDING
BUILDING
OPERATION
120
100
80
60
40
20
0
%
GWP
ODP
POCP
AP
EP
ADPe
ADPf
PEtot
Sek
ENVIRONMENTAL IMPACT


POTENTIAL ENVIRONMENTAL IMPACT OF CONSIDERED LIFE CYCLE ASSESMENT IMPACTS
500000
400000
300000
200000
100000
0
-100000
-200000
-300000
-400000
KG CO" EQUIVALENT
-287435,35
216643,91
452326,95
578,85
MANUFACTORING (A1_3)
REPLACEMENT (B4)
WASTE PROCESSING (C3)
DISPOSAL (C4)


POTENTIAL ENVIRONMENTAL IMPACT IN PHASES OF BUILDINGS ELEMENTS
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
KG CO2 EQUIVALENT
11204,44
187174,35
35156,6
40191,81
61832,54
36663,28
9891,34
FOUNDATION
WINDOWS
PRIMARY CONSTRUCTION
DECK
EXTERIOR WALL
ROOF
INNER WALL

ill. 5.50

06

ill. 6.1 | The sky at a overcast day in Tungenes

OUTRO

The ancient believes of an architect being the carpenter is still relevant today int erms of reaching high-quality architecture and streamline the process from concept to construction.

Conlusion

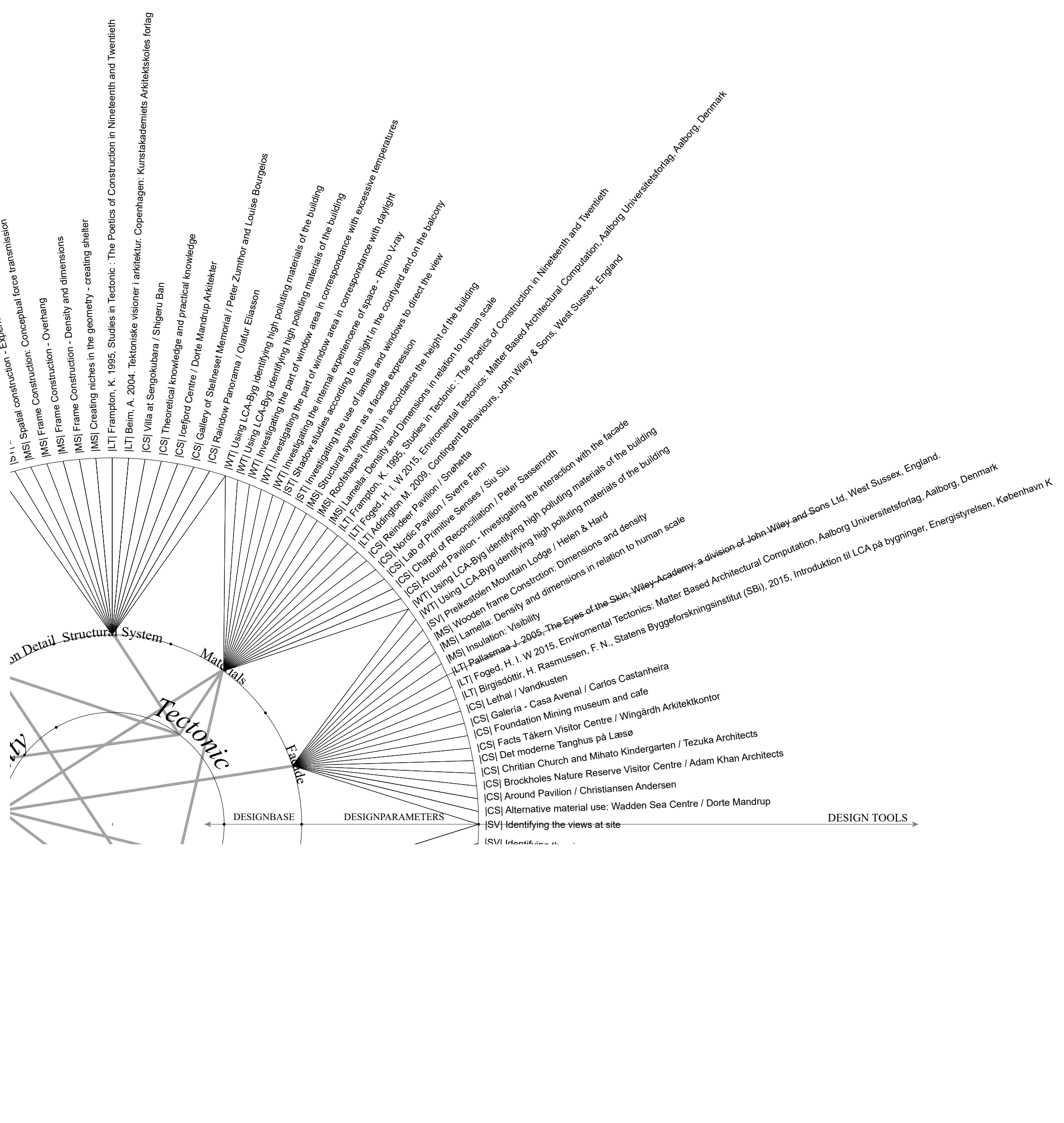
The Master Thesis originate from a competition program, establishing the need of a Maritime Science Centre i Tungenes, Norway. The program adresses the background of the projects, in terms of function and the thesis transfer these aspects into a general context of a architectural landscape dealing with spatial quality and social and technical sustainable solutions in architecture.
The project suggests a new geometry in Tungenes, meeting the scale and function of the Science Centre in combination with a cultural relevans of materiality and understanding the prospect of contributing to the existing natural and social environment of Stavanger Region. The design is a proposal for a new experiencing platform, that attracts people for the exhibition as well as the experience of the building.

To us, the Master Thesis is a the opportunity to challenge an established understandings in the field of architecture, to state our vision designing architecture, and question the tendencies in the education, believed to reflect tendencies in the actual architectural world. This is based upon a reflection on an integrated design proces in relation to parameters introduced in Architecture and Design at Aalborg University, and a wish to introduce a more individual approach to architecture, further elaborated on in the reflection. The means of doing this have been found in the tools given at the study - a theoretical background supported by inspiration from practicicans and an attempt to use simulation tools of quite complex identity in an early stage of designing.

The thematics of tectonic and sustainability have been chosen due to the overlapping aspects of structure, envelope and materiality eventually leading to a relation between the human created and the naturalenvironment. A common thread of the themes is the phenomenological approach to architecture. In terms of tectonic seen as the relation between the senses and the construction of a building, and in terms of sustainability a focus on indoor comfort, which inevitably relates to senses as well. It is our believe that the regulations found in relation to environmental sustainability, with its aim of helping the world from downfall dealing with global changes, should be seen as guideline, and that the evaluation of a building should be made upon its ability to create adventous spatiality as well as a comfortable indoor environment according to function.

The Maritime Science Centre uses a repetional system of timber frames to break up the boundaries between nature and architecture - creating a greater understanding of the role of the envelope by inviting the visitor in between the insulating core and the construction carrying the forces to the ground. The building uses its primary material, wood, in different ways accoding to function. The material is chosen due to its visual, acoustic, thermal and tactile proporties. In addition it related to the building tradition in norway and from a sustainable point of view function because of the low pollution over a life time.
The platform surrounding the exterior of the building provides a framing of the natural environment, and the placement of the building takes the visitor close to the sea above the rock scape and the coastline. The inner courtyard serves as a secondary exterior space, enclosing a part of the natural environment, to create an intimate atmosphere, where the long-distant view is eliminated and focus turns to the depth of the closer elements of nature, understanding the biological life existing between the rocks and in the grassland.
The exhibition is established as a flexible exhibition room, organized around a circular flow, taking the visitor through the whole building. The exhibition is connected to the courtyard through several openings, to include the coutyard in the exhibition when the weather allows it. The ceilling in the exhibition area serves as an acoustic and visual element, making the visitor focus on the exhibition, using framed views for intake of daylight and picturing the environment of which the exhibition theme relate to.

The Maritime Science Centre become a cultural platform in line with the nordic attention to acceasble architecture, making the most for every user scenario. The theoretical background of sustainability, tectonic and perceiving architecture have been brought to a design through an integrated design process, dealing with a range of parameters in order to create an experience of how the building can serve both as a science museum for children and a place for immersion with all levels of the remarkable landscape.



ill. 6.2 | Instrumental Map
The diagram is inspired by a Research Mapping by Isak Worre Foged in Environmental Tectonic (Worre Foged 2015)

Perspective

Establishing Our Approach to Architecture

The foundation of the Maritime Science Centre is established noticing a societal tendency to follow general codex's, rules and certain methods to label a level of sustainability in an architectural project. However small in its context, this thesis aims to challenge this way of thinking, to raise the gesture designing sustainable architecture. The gesture as 'an action performed to convey a feeling or intention' (Oxford Dictionary) introduces a subjective benchmark as foundation for the project, dealing with individual intentions and feelings, making it hard to evaluate or judge an architectural project. One articulate and process space differently according to cultural and societal impacts and understandings. There are tendencies of specific point of views or architectural identities within ranges of geography, culture, gender, etc., thus the gesture methodology may cause challenges in the encounter crosswise these identities. However, it is our believe that a varied architectural landscape of materiality and spatial means is beneficial for the well-being of human-being. The worldwide agenda of global changes is evident, and allowing an individual statement and human scale back into the field of sustainable architecture should not be an excuse to find ways around high standards of comfort or energy consumption. It should rather pave the way for a specific environmental analysis of both social and technical character, finding a balance to face the existing site specific potential - e.g. use geographical or climatic condition to benefit in the operation of a building.

The Role of the Architect

The integrated design process and designing and building architecture in general, requires knowledge in a branch of fields of natural and social science. The ancient believes of an architect being the carpenter is still relevant today in terms of reaching high-quality architecture and streamline the process from concept to construction. In line with Marco Frascari, our believe is that the basis of the experience and the quality of space lies with the architect. To conserve the spatial quality presented in a concept, the architect must use knowledge of construction and comfort to make sure this idea is expressed in the constructed building.

Introducing the intention in the thesis allows the project an experimental character, in this case, relying on spatial quality by means of structure and materiality. The exposed structure becomes the essential expression of the building, making an easy trace of forces from roof top to ground. We believe that this concept increases the quality of the building, working with a visible trace of forces and materials related to sustainable aspects of a building as well as function in relation to human scale and tactility.

Holistic Design - A Reflection upon the Process

Throughout the process the balance of influence parameters has been sought leading to the presented design of the Science Centre. Reviewing the process, it becomes clear that two aspects of the design becomes a challenge in the detailing. The exposed structure in relation to constructive treatment of the wood and the circular geometry in terms of irregularities in elements and variability in the construction joints and meetings between elements. Despite the believe in the spatial quality of these decisions, one may argue that the realization of such project is rather complex compared to a regular form. In this case, simplification and investigations on how to simplify the construction of elements could have been accomplished, without losing the aesthetic value established in the visible construction and the circular geometry. In this context, a discussion of how to make the structural elements visible without exposing bearing elements to the wet climatic conditions may have improved the design in matters of life cycle of the building.

Instrumental Map

The instrumental map is a diagrammatic representation tool, which we have developed during this thesis, in order establish an overview of a complex and iterative design process. Dividing the wheel into three parts establish different levels of detailing in the process and establishing the focal points of the building. The web of connecting lines in the inner circle represents the iterative nature of working integrated. The other circle depicts what we found to be the most important influential work tools, case studies and theories of the design process, and depending on the level of detail this could have been even more adequate. Inspecting the outer circle of the wheel, reveal that two of the most important aspects in during the process have been investigating case studies and making model studies. We believe that this reflect the challenge of working with the circular building in term of construction and how to unite tectonic and sustainability as an architectural aesthetic vision. Using case studies to identify the solution of other projects provided a more tangible knowledge in how to approach these aspects. While the design process wheel at its current stage is represented as a two-dimensional, it could have been interesting to add time as a third dimension creating a spiral repersentation, to identify in which stage the different design tool have been applied.

References

Litterature

Addington M. (2009). Contingent Behaviours, John Wiley & Sons, West Sussex, England

Adler, D (1969). Metric Handbook - Planning and Design Data, Reed Educational and Professional Publishing Ltd, London, U.K.

Beim, A. (2004). Tektoniske visioner i arkitektur. Copenhagen: Kunstakademiets Arkitektskoles forlag

Birgisdóttir, H. Rasmussen, F. N., Statens Byggeforskningsinstitut (SBi) (2015). Introduktion til LCA på bygninger, Energistyrelsen, København K

Böhme, G. (2005:405). Atmosphere as the subject matter of architecture. In P. Ursprung (Ed.),

Natural History - Herzon de Meuron Series. Lars Müller Publishers. Bryman A. (2012). Social Research methods, Oxford University Press Inc, Oxford, U.K.

Deplazes A. (2005). Constructing Architecture - Materials, Processes, Structures A Handbook, Birkhäuser - Publisher for Architecture, Basel, Switzerland.

DS/EN 15251, 'Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoorair quality, thermal environment, lighting and acoustics', Danish Standard, Charlottenlund

Frampton, K. (1995:2). Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture, MIT Press.

Foged, I. W. (2015). Environmental Tectonics: Matter Based Architectural Computation. Aalborg Universitetsforlag. (Ph.d.-serien for Det Teknisk-Naturvidenskabelige Fakultet, Aalborg Universitet). DOI:10.5278/vbn.phd.engsci.00010

Haarder, B. in Weiss K. L. (2016). The Art of Many - The Right to Space, Arkitektens Forlag & Dansk Arkitektur Center, København, Denmark

Hvattum M. (2012). New Nordic - arkitektur & identitet, Louisiana Museum of Modern Art, København, D

Hvejsel, M. F. (2015). Everyday tectonics, SINTEF Academic Press, Oslo, Norway.

Hvejsel, M. F., Klok, J. S., & Bøhnke, M. M. (2014). 'A Place to Sit': Tectonics as Method in Architectural Education. (1. ed.) Aalborg University, Architecture & Design files: Institut for Arkitektur og Medieteknologi. (Department of Architecture and Designs skriftserie, Vol. 80).

Hyldgård, C., Funch, E. and Steen-Thøde, M. (1997). Grundlæggende Klimateknik og Bygningsfysik. Aalborg: Instituttet for Bygningsteknik, Aalborg Universitet.

Knudstrup M. A. (2004). Integrated Design Process in Problem-Based Laerning, Aalborg Universitet forlag, Aalborg, Denmark

Le Corbusier (1986). Towards a New Architecture, transl. F. Etchells, Dover Publications, Dover.

Pallasmaa J. (2012:12). The Eyes of the Skin - Architecture of The Senses, Wiley-Academy, a division of John Wiley and Sons Ltd, West Sussex, England.

Sekler E. F. (1964). Structure, Construction, Tectonics, Aufbau

Vitruvious, M. P. (1914). The Ten Books on Architecture, transl. Gwilt, Joseph, Harvard University Press, Harvard, U.K.

Web

Bygtek (2017). Visited 8. of March 2017
http://bygtek.dk/artikel/isolering/arkitekter-er-klar-til-at-bruge-tangisolering

ClimaTemp (2017). Visited 5. of February 2017
http://www.norway.climatemps.com/

The Economist (2013). Visited 17. of February 2017
http://www.economist.com/news/special-report/21570842-oil-makes-norway-different-rest-region-only-up-point-rich

The Economist (2016). Visited 17. of February 2017
http://www.economist.com/news/special-report/21710634-glimpse-post-oil-era-when-oil-no-longer-demand

The Engineering Toolbox (2016). Visited 14 of April 2017 (Carbon Dioxid Concentration: Comfort Levels)
http://www.engineeringtoolbox.com/co2-comfort-level-d_1024.html

Gaisma (2012). Visited 5. of February 2017
http://www.gaisma.com/en/location/moss.html

Grøn, A., Garff, J. og Jørgen, N. I Den Store Danske, Gyldendal (2009). Visited 26. of February 2017
http://denstoredanske.dk/index.php?sideId=106029

Informative Estonian Museums (1992). Visited 24. of February 2017
http:www.muuseum.ee/et/erialane_areng/museoloogiaalane_ki/ingliskeelne_kirjand/p_van_mensch_towar/mensch24

Jensen, E. (2012). Visited 15. of February 2017
http://erlingjensen.net/Maritim/Tungenesfyr.htm

lca-center (2017). Visited 18. of February 2017
https://lca-center.dk/hvad-er-lca/generelt-om-lca/

Lomelde, I. WWF (2016). Visited 19. of February 2017
http://www.wwf.no/dette_jobber_med/norsk_natur/

norden.org (2016). Visited 4. of February 2017
http://www.norden.org/en/fakta-om-norden-1/the-nordic-countries-the-faroe-islands-greenland-and-aaland/facts-about-norway

Norges Geologiske Undersøkelse (2009). Visited 20. of February 2017
https://www.ngu.no/nyheter/istidsgeologi-flasker-seg-p%C3%A5-j%C3%A6ren

OED Oxford English Dictionary - The definition record og the English langue (2017). Visited 23. of February 2017
http://www.oed.com/

Randaberg Kommune (2017). Visited 3. of March 2017
http://www.randaberg.kommune.no/no/Om-Randaberg/

Realdania (2013). Visited 2. of april 2017
https://realdania.dk/samlet-projektliste/tanghuse-paa-laesoe---det-moderne-tanghus

Regjeringen.no (2013). Visited 15. of February 2017
https://www.regjeringen.no/no/aktuelt/tre-er-fremtidens-bygningsmateriale/id712128/

Regjeringen Norge (2014). Visited 15. of February 2017
https://www.regjeringen.no/no/tema/energi/fornybar-energi/fornybar-energiproduksjon-i-norge/id2343462/

Rekveld, J. (2013). Visited 13. of April 2017
http://www.joostrekveld.net/?p=1126

Sandalstrand (2013). Visited 19. of February 2017
http://www.sandalsand.net/norway-jaeren-the-coastline-explained/

Schlaupitz, H. (2016). Visited 19. of February 2017
https://www.visitnorway.dk/rejsemal/fjord-norge/stavanger/

Thornæs, G. I Store Norske Leksikon (2014). Visited 23. of February 2017
https://snl.no/%C3%A6ren

Weatherspark (2012). Visited 15. of February 2017
https://weatherspark.com/averages/28898/Stavanger-Rogaland-Norway

Illustrations

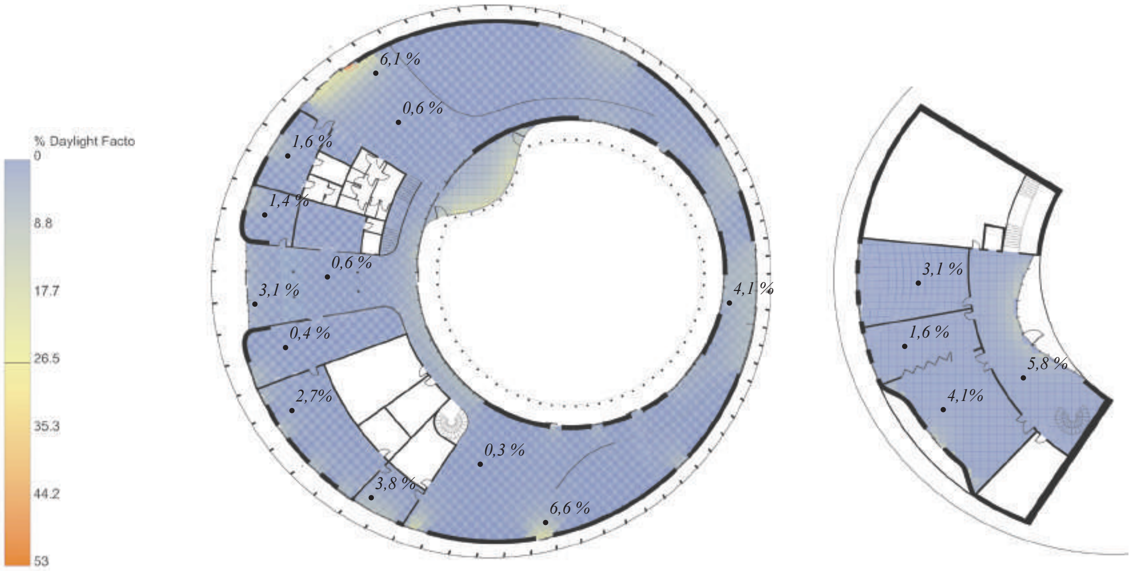
APPENDIX

1 Daylight Factor

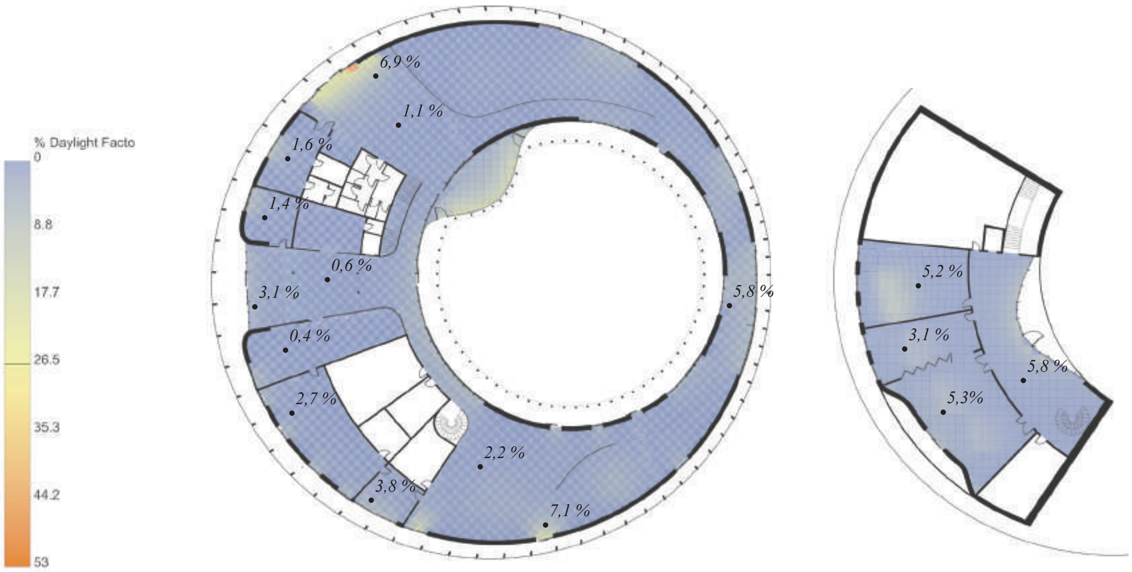
2 Air Change - Hand Calculations

3 Dimension Ventilation Duct Exhibition

Daylight Factor



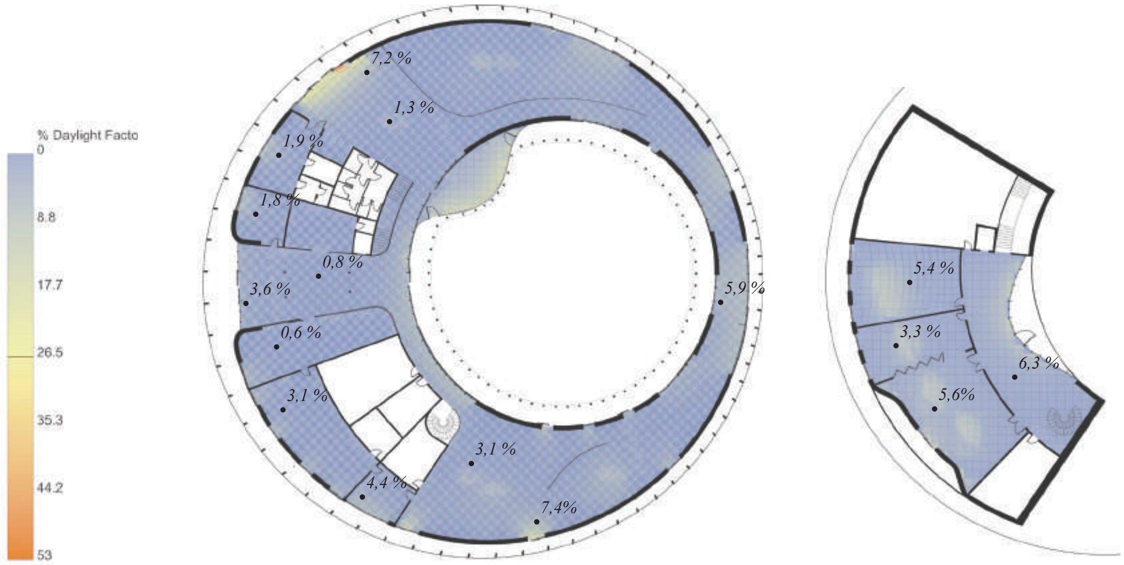
1.



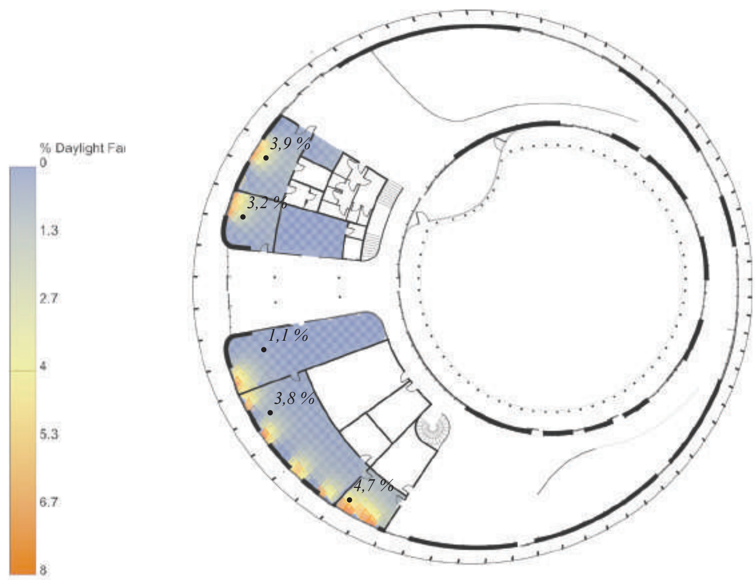
2.

DIVA Daylight Analysis

	1.	*2.*	*3.*	*4.*	*5.*	*Final Daylight Factor*	
Exhibition low	1,24	1,22	1,51	1,76		1,51	
Exhibition + Entrance	1,63	1,97	2,16	2,46		2,16	
Wardrobe	0	0	0,02	0,03	0,05	0,05	
Meeting	1,28	1,11	1,41	1,61	1,86	1,86	
Kitchen	1,07	0,96	1,26	1,33	1,68	1,68	
Service	0,2	0,17	0,21	0,26	0,36	0,36	
Education	0,21	1,87	2,02	2,35		2,02	
Office	0,97	0,86	1,14	1,28	1,59	1,59	** DF 3,8 in work area*
Workshop	2,34	2,08	2,44	2,96	3,01	3,01	
Outdoors Café	7,73	7,66	7,76	9,78		7,76	
Shop	0,38	0,35	0,46	0,49	0,69	0,69	
Entrance Education	1,33	1,17	1,52	1,69		1,52	
Auditorium	0,6	1,29	1,75	1,86		1,75	
Group Rooms	0,06	0,84	1,16	1,24		1,16	
	** Original Materials*	** Skylights in exhibition, café, auditorium, education roon and group rooms*	** Skylights in exhibition, café, auditorium, education roon and group rooms*	** Skylights in exhibition, café, auditorium, education roon and group rooms*	** White ceiling in low-height rooms*		
	** Original Windows*	** Original Materials*	** Lighter Materials*	** Lighter Materials*	** White walls in low-heigh rooms*		
				** High Reflectance Windows*			



3.



5.

	Original Materials	Lighter Materials	High Reflectance Windows	White Walls and Ceilling in low-height areas
Frame construction	OutsideFacade_30	OutsideFacade_35		
Exterior walls	OutsideFacade_30	OutsideFacade_35		
Outdoor plateau	OutsideFacade_30	OutsideFacade_35		
Roof	OutsideFacade_30	OutsideFacade_35		
Windows	Glazing_DoublePane_LowE_65	-	Glazing_DoublePane_80	
Internal walls	OutsideFacade_30	OutsideFacade_35		WhiteInteriorWall_70
Floors	OutsideFacade_30	OutsideFacade_35		OutsideFacade_35
Ceiling	OutsideFacade_30	OutsideFacade_35		HeighReflectanceCeiling_90
Stone	OutsideGround_10	-		
Water	Water_surface	-		
Grass	OutsideGround_30	-		

**DIVA standard materials - chosen with origin in the following webpages*
http://lighting-materials.com/ material library

http://www.intelligence.tuc.gr/renes/fixed/info/reflectanceinfo.html

https://corona-renderer.com/forum/index.php?topic=2359.0

Daylight Factor Analysis made in DIVA for Rhino with basic material from DIVa Material Library.

The studies shows the developement of the daylight factor as an average (table) and at certain points of the building according to changes in openings and material proporties.

2 Air Change - Hand Calculations

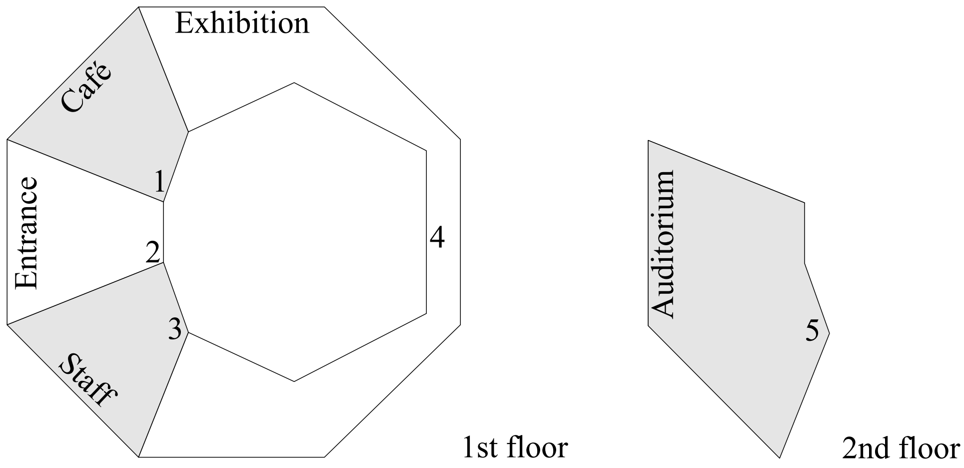
In the process of using BSim results to identify the critical areas of the building, calculations of the maximum air change according to volume and people load have been made. The calculations are done with both CO2 and olf pollution to determine the critical pollution rate and thereby the maximum required air change rate. The building volume is divided in 5 sections according to appendix xx (illustration xx).
Initially, the requirements to minimum air change rate of the Danish Building Regulation are calculate:

MINIMUM AIR CHANGE RATE						
According to Danish Building Regulations						
Accordint to the Danish Building Regularion the air flow must not be lower than 5 l/s/person plus 0,3 l/s/m2 [Søren Aggerholm, 20						
	People	Area	Air Flow Pers	Air Flow	Total Air Flow	Air Change
		A				
	[number]	[m2]	[l/s]	[l/s]	[l/s]	[m3/s]
Section 1	120	310	600	93	693	0,693
Section 2	150	336	750	100,8	850,8	0,8508
Section 3	30	310	150	93	243	0,243
Section 4	150	940	750	282	1032	1,032
Section 5	240	646	1200	193,8	1393,8	1,3938

The results are used in comparison to the following results - making sure they exceed the minimum requirements.

All formulas for the calculations are according to (Hyldgård 1997). Design values for indoor climate is set to meet the requirements of Danish Standard category II - applying to a normal level expectations, used for new buildings (DS/EN15251 2007)

AIR CHANGE RATE								
Based on [olf]								
Key Numbers								
c		1,4	*[decipol]*	*Pollution equals 20% dissatisfaction*				
ci		0,03	*[decipol]*	*City pollution - Low pollution*				
Building pollution rate		0,2	*[olf/m2]*					
One person pollution rate		1	*[olf/person]*					
Air Flow								
VL = q * 10 / (c-ci)								
VL is the required air flow rate			*[l/s]*					
q is the pollution load (olf)			*[olf]*					
c is the experiences air quality			*[decipol]*					
ci is the experienced outdoor air quality			*[decipol]*					
Calculation Air Change								
	People	Area	Height	Volume	Pollution Load	Air Flow		
		A	h	V	q	VL	VL	Air Change
	[number]	[m2]	[m]	[m3]	[olf]	[l/s]	[m3/s]	[h-1]
Section 1	120	310	4	1240	182	1328,47	1,33	3,856840122
Section 2	150	336	4	1344	217,2	1585,40	1,59	4,246611053
Section 3	30	310	4	1240	92	671,53	0,67	1,94961149
Section 4	150	940	4	3760	338	2467,15	2,47	2,362168039
Section 5	240	646	5	3230	369,2	2694,89	2,69	3,003593139



AIR CHANGE RATE

Based on CO2

Key Numbers

1 person exhales	10	*[l/min]*	
CO2 exhale concentration	4	*[%]*	
CO2 pollute | one person	0,024	*[m3/h]*	
c	900	*[ppm]*	*- According to the Danish BR, the CO2 level should not exceed 900ppm for longer periods*
ci	350	*[ppm]*	*- Corresponding to a normal outdoor level (The Engineering Toolbox, 2016)*

CO2 production rate

The amount of CO2 pollute for one person sitting down:

q =((0,04*1pers)*(10l/m*60m/h)) / (1000 l/m3)

-> q =0,024 m3/h

Air Flow

C = q / (nV) + ci

*-> n = q / ((C - ci) * V)*

n is airchange	*[h-1]*
q is the production rate of pollution in the room	*[m3/h]*
c is the allowable pollution rate	*[ppm]*
ci is the pollution rate in the intlet air	*[ppm]*
V is the volume of the room	*[m3]*

Calculation Air Change

	People	Area	Height	Volume	Pollution Rate	Air Change
		A	h	V	q	
	[number]	[m2]	[m]	[m3]	[m3/h]	[h-1]
Section 1	120	310	4	1240	2,88	4,2228739
Section 2	150	336	4	1344	3,6	4,87012987
Section 3	30	310	4	1240	0,72	1,055718475
Section 4	150	940	4	3760	3,6	1,740812379
Section 5	240	646	5	3230	5,76	3,242330425

CONCLUSION
CONCLUSION
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CONCLUSION

3 Dimension Ventilation Duct Exhibition

Dimensioning the ventilation duct for the exhibition origins in table values of DS447 (Danish Standard) for typical pressure loss in ventilation systems and the required air flow rate for the exhibition which are put in the SBi nomogram showed. From this the diameter of the ventilation duct is identified. Different iteration have been made of respectively one and two ventilation ducts in the exhibition.

Key numbers				
VL Exhibition:				
[m3/s]	*[m3/h]*			
2,47	8881,751825	*1 duct*		
	4440,875912	*2 ducts*		
Exhibition Duct Length:				
[m]	*[m]*			
105	*53*			
1 kp/m2 =9,81 Pa				
Calculation		Low	Typical	High
Typical Pressure Loss DS447	*[Pa]*	100	200	300
	[kp/m2]	10,19367992	20,38735984	30,58103976
	[(kp/m2) / m]	0,09708266589	0,1941653318	0,2912479977
Ventilation duct diameter 105 m	*[mm]*	662	564	525
Pressure loss	*[Pa]*	100	200	300
	[kp/m2]	10,19367992	20,38735984	30,58103976
	[(kp/m2) / m]	0,09708266589	0,1941653318	0,2912479977
Ventilation duct diameter 105 m 2 ducts	*[mm]*	490	423	390

Udsendt af Statens Byggeforskningsinstitut 1967. Bestilles hos Teknisk Forlag, Skelbækgade 4, 1717 København V. Tlf. (01) 21 68 01. Giro 204 90

SBI-nomogram 10	Tryktab for kanaler af galvaniseret jernplade	Luft 25°C

Anvendelse: Ventilationsanlæg.

Temperaturområde: Nomogrammet gælder ved 25°C. I intervallet 0-50°C er fejlen på de aflæste tryktab mindre end ± 10%.

1 kp/m² = 1 mm H_2O = 9,81 N/m²

Anvendelse af aksen for luftmængde V

V-aksen under den lodrette pil er suppleret med 5 lodrette hjælpelinjer (betegnet a:b = 1,0 — 2,0 — 3,0 — 4,0 — 5,0), som kun anvendes ved rektangulære kanaler.

Cirkulære kanaler: Markér luftmængden på V-aksen som det fremgår af skitsen til venstre. Brug ikke hjælpelinjerne.

Rektangulære kanaler: Markér luftmængden på V-aksen og gå vandret mod højre til skæring med den lodrette linje, som angiver det aktuelle a:b-forhold. Herfra går man skråt nedad langs de skrå retningslinjer til skæring med V-aksen. Herved er fundet det punkt igennem hvilket en linje kan trækkes til skæring med de andre nomogramakser (se skitsen til højre)