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I would first like to thank my supervisor, Isak Worre Foged,who supported me and adviced during my thesis. His help allowed me to reach better quality of my project.

I would also like to thank my secondary supervisor, Lars Damkilde, for technical feedback and giving me better understanding about structural issues of the design.

ABSTRACT

The following work is a Master Thesis Project done by Barbara Sopolinska at the 4th semester of MSc in Architecture at Aalborg University, Denmark. This paper includes the design proposal for the Illulisat Icefjord Center in Greenland, together with the entire design process and project framework, including analysis and case studies The main objective of the project is to, by taking inspiration from the tectonics and Nordic approach, create a building of a high-quality architecture that would be adapted to the extreme nature of the site.

READING GUIDE

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This report starts with a short introduction section where the main objectives and the approach are described. In the following chapter, there is included the project framework, such as the analysis of the local conditions. The last analysis part is a program framework, including case studies and user group. This part concludes with the program and design parameters used in the further design. The next chapter is a main presentation of the project including drawings and visualisations, together with brief descriptions. The final chapter consists of the design process throughout the project. The paper closes with honest reflections and limitations. In the end of the document, there is attached appendix.

LIST OF CONTENT

01

Ill.1.1 Illulisat Icejford

INTRODUCTION

This section describes the methodology, aproach and main focus of the project.

METHODOLOGY

A methodology is the essential tool to efficiently design any project. Different designs can be approached in a different ways, although it is important to find an adequate method. The following text describes what steps will be performed during the design process of the Icefjord Center, how to approach them, and, most importantly why they should be used.
The following steps are overlapping each other in order to find the best solution, and therefore the design process is not linear but rather iterative.

1. MAPPING & SITE ANALYSIS
The analysis of the site is collecting all the data and information for the project framework - such as local plan, climate conditions of the site and so on. Those define the criteria for the further designing. It is also important to keep in mind the sense of the place - or so-called genius loci. During the site analysis, there should be done mappings, which are necessary to find out important flows, existing facilities, communication etc.

2. CASE STUDIES
Case studies bring better understanding of selected issue or phenomenon by examining the real-life example. Case study analysis usually answers the question 'how' or 'why' something is done. It is necessary to carefully define those questions at the beginning of the research, to focus on the aspects relevant for our study.

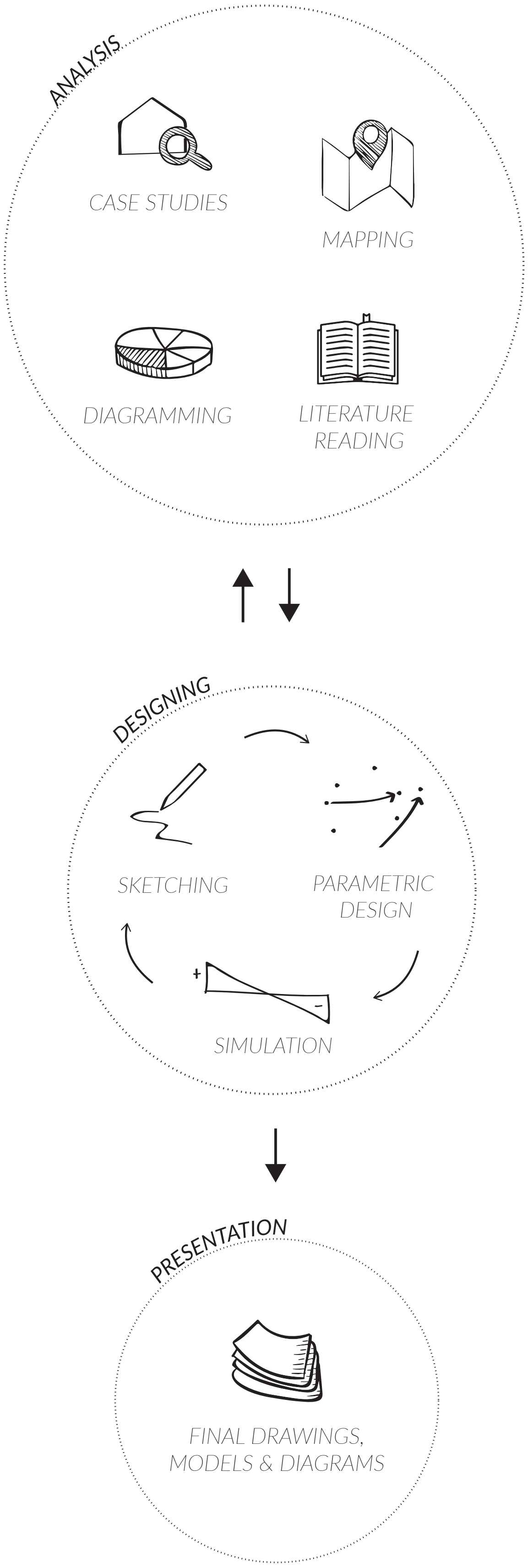
3. LITERATURE STUDIES
Literature studies bring theoretical knowledge to the project framework. The first step is to choose valuable and representative literature. Literature study basis on reading through, interpretation and making the conclusions. Conclusions of the theory will have input to the design process.

4. SKETCHING
Sketching is a tool to test different ideas. During the sketching, all the criteria and conclusions from the earlier analysis are applied, considering both architecture and engineering. It is important to visualise the ideas - therefore 'sketches' can be made using a variety of tools - from actual hand drawings to 3d modelling and physical models.

5. DIAGRAMMING
Diagramming is a creative graphic approach and useful method at almost every stage of the design process - from presenting collected data through communicating ideas to tracing the process, which otherwise would be difficult to explain. The context of a diagram must be clear and each diagram must easily readable. A diagram's content must be fully understood by it's simple description.

6. PARAMETRIC DESIGN & SIMULATION
To work with geometric and structural aspects of the project, there is going to be used software that allows testing iterative designs in a dynamic way. It means that every iteration of a changeable parameters will be tested simultaneously. The aim of Performance-Aided Design is the development of the tools and the understanding required to develop integrated design with respect to form, material, structure and fabrication (Pairigi, D., 2014) For structural design and analysis Grasshopper for Rhino is going to be used in combination with Autodesk Robot plugin.

7. PRESENTATION
The final phase of every project is presentation - where the ultimate documentation of the design is produced. This involves drawings, visualisations, results of the simulations and physical models. It is crucial to not underestimate this last stage and present the collected knowledge and qualities of the design in the best possible way.



Ill. 1.2 Methodology diagram

INTRODUCTION

PROLOGUE

Illulisat is a unique location - UNESCO protected area, 250 km above the North Circle, where one of the biggest calving icefjords runs into the ocean. This outstanding scenery is bringing more and more attention to the people from all over the world. This paper presents a proposal for the Icefjord Center that would provide visitors and locals with multifunctional space fulfilling their needs.

REASONS OF THE CHOICE

Extreme environments have always been my personal interests, particularly the harsh climate conditions of the north. In this paper, I would like to explore the challenges that they may bring during the design. Moreover, architecture facing climate change is an essential topic nowadays. The global changes can already be observed locally in the icefjord, and the Center would help to bring awareness to the visitors.

COMPETITION

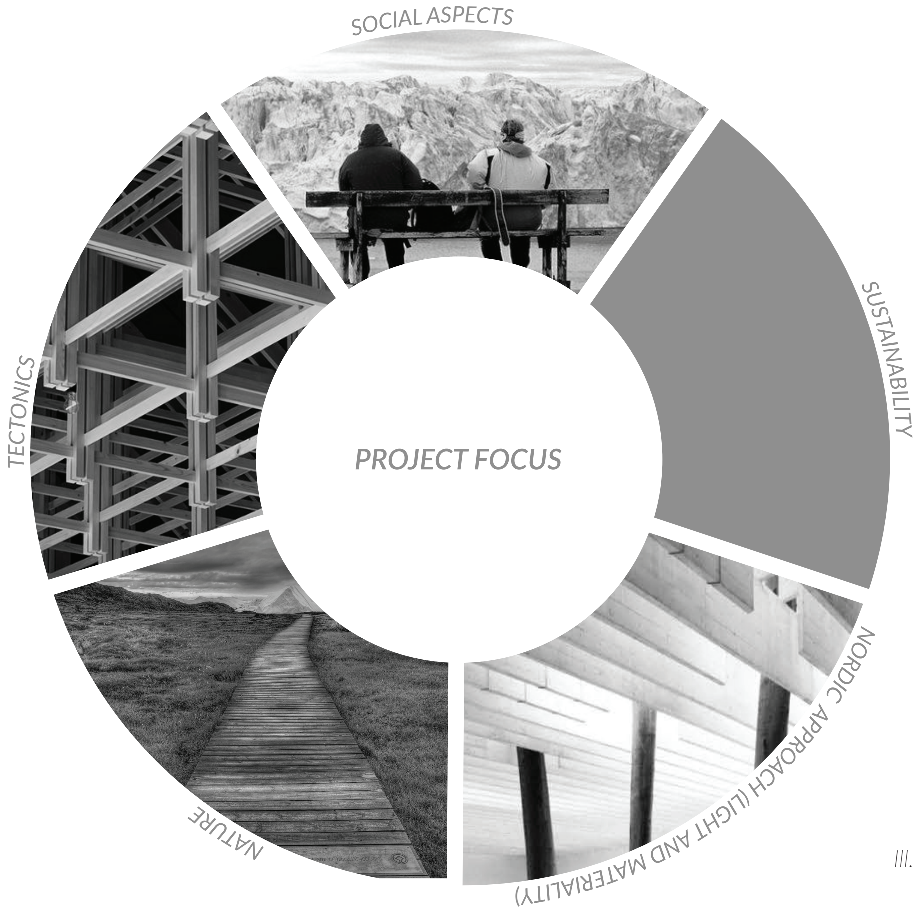
The thesis topic and objectives are freely based on the competition brief for the Illulisat Icefjord launched in 2015.

OBJECTIVES

The main goal of the project is to, by taking inspiration from the tectonics and Nordic approach, create a building of a high-quality architecture. The building should correspond with surrounding unique landscape, by both enhancing it and being adapted to the extreme nature of the site. It should be compact but flexible, dedicated to tourists, professional researchers and locals. Besides the exhibition and the educational function, the building shall work as a tourist attraction itself.

LIMITATIONS

Due to the limited time available to investigate the thesis project it is unattainable to fully solve both tectonics and sustainable aspects of the project. Therefore, the main technical focus is going to be tectonics and structure. The sustainability should be a crucial part of every project and the Icefjord Center should not contribute to the climate change, the basic sustainable principles and assumptions are going to be done.



Ill. 1.3 Project focus

FOCUS OF THE PROJECT

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TECTONICS
The main technical focus of the project is structure and its integration with the design. It is an intention to work with tectonics to achieve honest, yet beauty in its simplicity architecture as well as efficient structure. The authenticity of the relation between structure and architecture influences the whole design process.

SOCIAL ASPECTS
The key aspect of the Ilullisat Icefjord Center is brining global awareness about the climate change. Therefore it should serve as a meeting point for people of different background coming to Ilulissat local identity

NORDIC APPROACH - LIGHT AND MATERIALITY
As Greenland belongs traditionally to Nordics the goal is to attain Nordic qualities of architecture both in terms of materiality and light.

NATURE
The site provides unique, beautiful scenery and building should be adapted in a way that enhance this.
The aim is the concept for the building is to interact with the surrounding highly vulnerable landscape.

SUSTAINABILITY
Sustainability is not the main focus of this project, however the Icefjord Center is supposed to be a place of discussion about the climate change, thus it should not contribute to the change itself.
The environmental impact of the building in a life-cycle perspective should be limited through, for instance, use of the building materials.

TECTONICS

In theory of architecture, the term of tectonics was primarily developed by Gottfried Semper in XIX century. The origin of this word comes from the greek word tekton - carpenter - that is as well a source of the word arkitekton, the architect.
Tectonics is described as a filigree construction, 'roofwork' - in opposite to the term stereotomy, defined by Semper as an 'earthwork'. 'Roofwork' comprises all linear and rodlike elements of the structure, while 'earthwork' comprises of solid, heavy - such as walls, arches, domes.
The concept of tectonic structure is not new and has been reflected throughout centuries in traditional timber buildings, used wherever timber was an available material.
Semper considered the stereotomic mass as an extension of earth, to serve the tectonic part a base to arise from. The architecture exists within transition between the tectonic and stereotomic and that space is the physical essence of architecture. Thus, the joint as the symbol of the transition, is the most important, basic element. Semper describes the jont as 'the oldest tectonic, comogonic symbol' [Frampton, K. 2001, pp.86]

Kenneth Frampton is putting tectonic and stereotomic in relation to the sky and the earth. The tension created by the two opposing conditions become parameters to design within. The two merge through the detail, through the joining of tectonic and stereotomic in order to occupy a space.

"Thus the presencing of a work is inseperable from the manner of its foundation in the ground and the ascendancy of its structure through the interplay of support, span, seam and joint – the rhythm of its revetment and the modulation of its fenestration." (K. Frampton)

Moreover, another aspect of tectonics is the purposiveness of architecture elements. An example of this approach can be theoretical statement of Friedrich Schinkel in 'The Principle of Art in Architecture'. For Schinkel architecture should be derived from understanding of nature onto the material form of the building, in order to allow the building to transcend its material requirements [The Contradiction Between Form and Function in Architecture J.S Hendrix]

Ill. 1.4 Ryuji Fujimura Architects

CONCLUSION

To achieve the tectonics qualities all the elements of the building must have a structural or functional purposiveness and represent themselves the nature of the forces influencing the building.
The building should be designed in a way it unites aesthetics and structure as one. The properties of the material, which has been chosen timber, will influence the design from the very early stage of the process. .
Not only the general structure is part of an architectural expression, but also the joints and details.

Ill. 1.5 Nordic Pavillion

NORDIC APPROACH

'(...) Within each of the Nordic countries, the nuances in the architectural view are strongly felt. We are not as similar as is often said. [...] Seen from the outside, Nordic architecture has much in common. It is not pretentious and flashy as in southern Europe, monumentality is not a goal in itself; we strive for an architecture that serves life and people, that fits nature, that does not intrude, but instead wishes to be anonymous (Fisker, »Svensk Bygningskunst«, Arkitekten (Ugehæfte), Vol. , p. on la

The Nordic countries work within different context but share a common approach - approach known of honesty to the materiality and location. Respectfulness for the site is crucial aspect - the sense of a place known also as a genius loci, described by Norwegian architect, Christian Norberg - Schulz. Genius loci '(...) has been considered a reality one should understand and respect. Only by doing so one acquire identity and a foothold in life' [Kjeldsen et al., 2012 pp 36] It is fundamental for Nordic architecture to follow the true identity of the place.

It is also not only about respecting and enhancing nature on the site, but also about blending the architecture with nature. This can be done with materiality for instance by use of local materials, and therefore another important feature of the Nordic approach is materiality. Nordics cultivate a long tradition of craftsmanship, which means deep understanding about properties of different materials. It also often reflects in homogeneous structures made entirely from ex. wood or brick. Tradition is translated into contemporary in a way that results in high-quality architecture.

Due to varying light qualities in Nordic countries - bright summers and dark winters - light is a complex but crucial aspect in creating architecture. The light can be used as a powerful tool in creating distinct moods and feelings through the play of light and shadow.

CONCLUSION

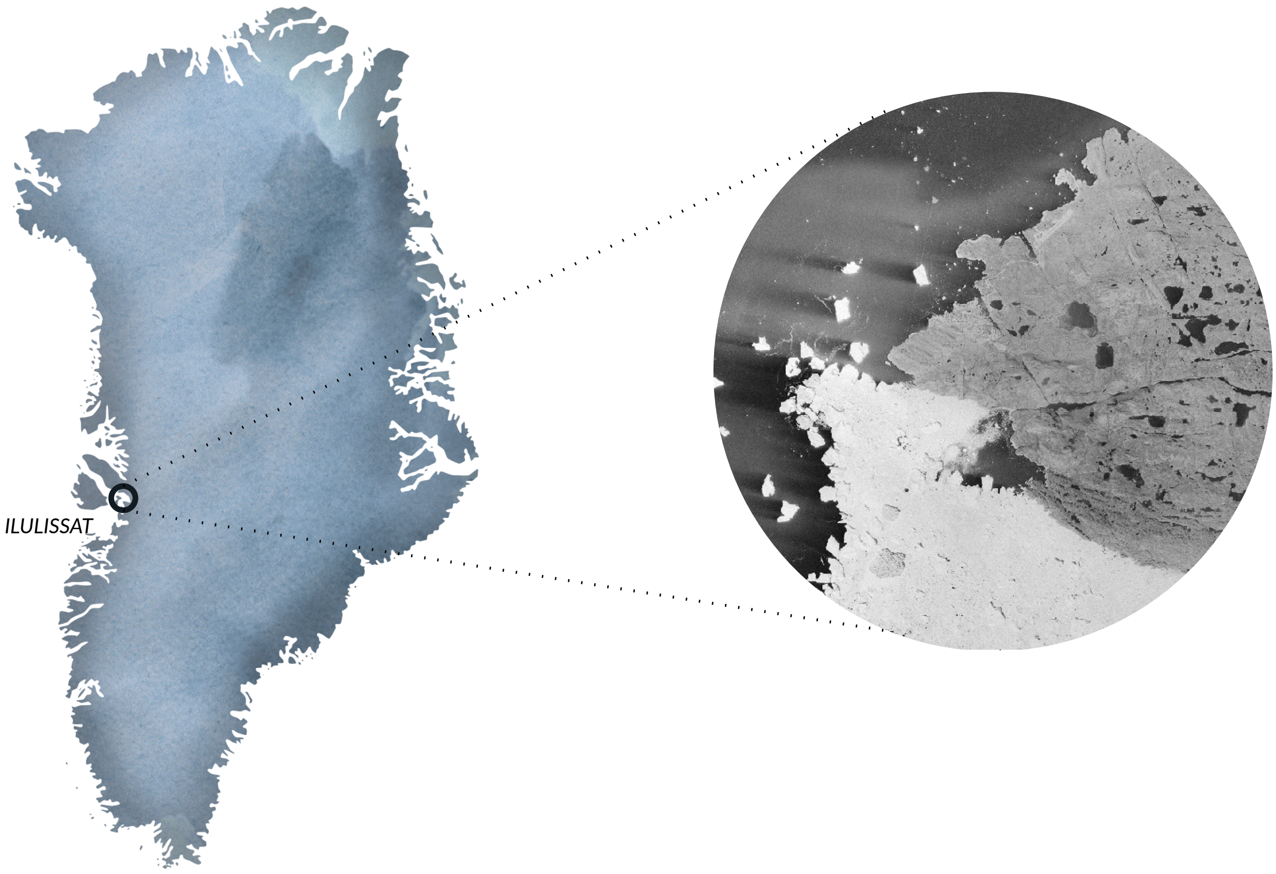
It is important to recognise the 'genius loci' of the very special site that Ilulissat Icefjord Center is about to be placed. The building should be developed with the respect to the surroundings as well as with the thoughtful use of materials.

The light is also an essential parameter and its changing qualities should be considered in the design.


02

PROJECT FRAMEWORK

In this part, there are presented framework conditions of the site (location, climate, and social aspects) for an information centre at the Icefjord in Illulisat. The analysis is summed up with a conclusion and design parameters for the further design.



Ill. 2.2 Greenland and Ilulissat location

GREENLAND

LOCATION

Greenland as a country is a complex cultural and historical phenomenon. It is the largest island in the world with an area of 2.175.600 km2 where around 85% is permanently covered by ice. It is located in the Arctic, between the Atlantic and Arctic ocean and the majority of the country is above 66° N, which defines Northern Circle. It is a land famous of its icebergs and the inland ice.

AUTONOMY AND POLITICS

Greenland was granted autonomy in 2009. Since then, there has been a trend towards increasing independence from Denmark. It is expected that, in time, Greenland will assume responsibility for more and more areas of society.

POPULATION

The majority of its residents are Inuit, whose ancestors began migrating from the Canadian mainland in the 13th century, gradually settling across the island. Nowadays, Greenland has 56,000 inhabitants and this number is expected to remain stable next 20 years.

CULTURE

Even though Greenland has been ruled from Denmark for a long time, the Greenland culture is in many ways very different from the Danish. The Greenlandic culture is centred around hunting and the traditional simple life.

ICEFJORD

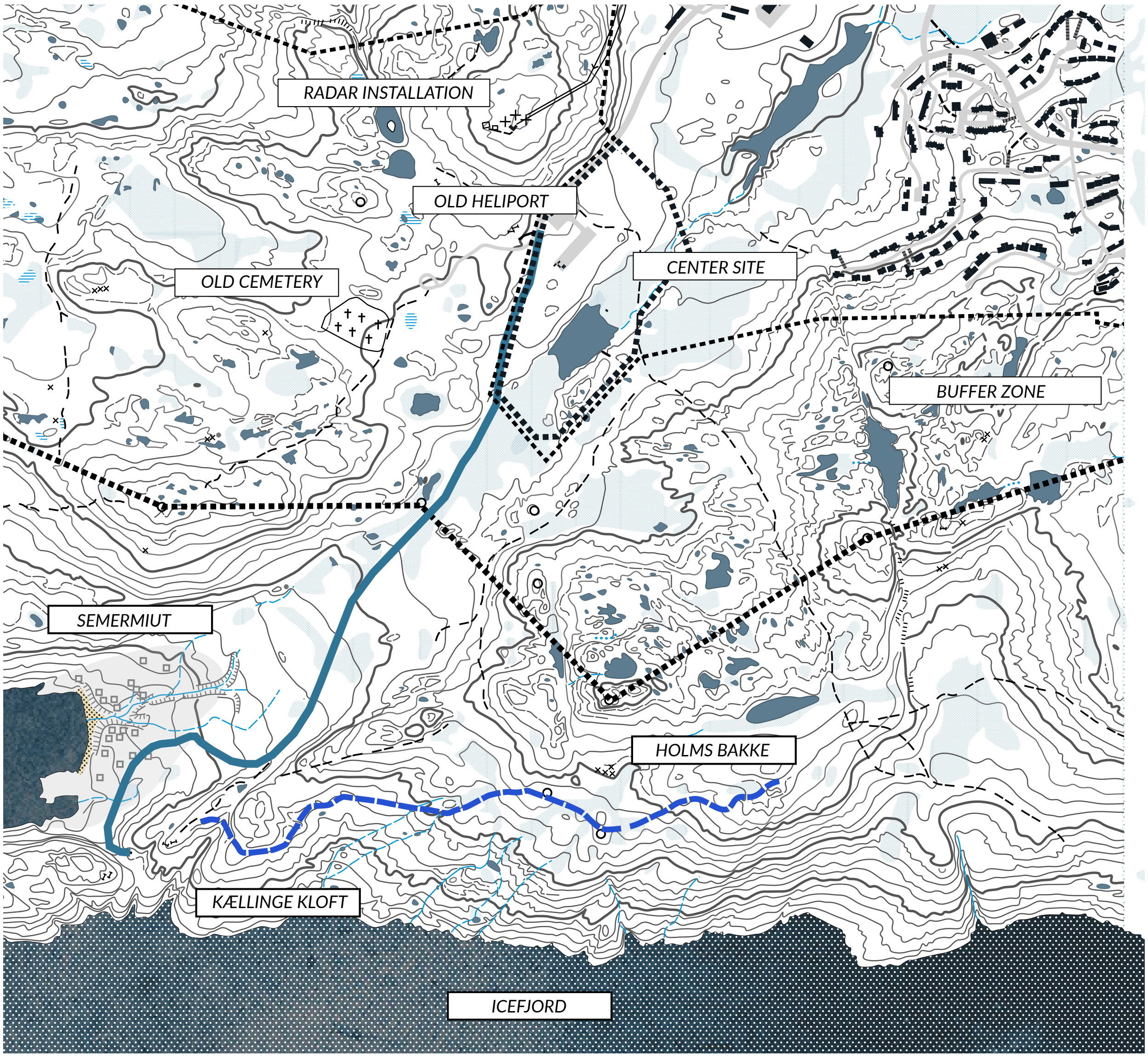
Illulisat Icefjord is located on the West coast of Greenland, at Disko Bay. This area in Greenland is called Kangia, and it is located 250 km north of the Arctic Circle. The Icefjord area is a UNESCO World Heritage site since 2004. Here it is possible to see one of the world's most active, calving glaciers. It's magnificent scenery and a great point for studying global climate change is attracting more and more visitors – tourists, scientists and politicians. The number of visitors is approximately 30 000 every year and rising.
Greenland's icecap co
In addition to the unique landscape, the area around Illulisat is exceptional for Greenland's culture and history due to over 4400 years of inhabitants in the land surrounding fjord. Nowadays it is protected the archeological and cultural monument.

TOWN OF ILLULISAT

Illulisat (which in Greenlandic means 'icebergs') is the administrative centre of Qaasuitsup Municipality and one of Greenland's biggest towns. It is also the place for communication of knowledge about the icefjord. Illulisat has roughly 4600 inhabitants. First Inuits have settled in the fjord 4400 years ago. The fertile icefjord area is increasingly attracting tourists, and therefore Icefjord is Greenland's main tourist destination, with one-third of the total number of tourists. Illulisat has both industrial port and an airport and the transport to and from Illulisat fully depends on them.

Although Illulisat was lacking any kind of planning for many years, the town has grown in harmony with the landscape and nature. The protected UNESCO zone and the buffer zone south of Illulisat are determining town's development. The town is centred around the main street with the range of shops, few supermarkets and cafes. Illulisat has also Cultural and Community Centre, local history museum, two schools and a small local history museum. Brætter is Ilulissat's local market square for local hunters and fisherman, and it is attracting point to both locals and tourists.

Ill. 2.3 Map of Iulissat



Ill. 2.4 Local context

LOCAL CONTEXT

UNESCO PROTECTED AREA
Icefjord has been on UNESCO's World Heritage List since 2004. It has been ordered to protect natural and cultural heritage from any kind of destructive actions in this area.

BUFFER ZONE
The buffer zone is located between the protected area and urban zone of Illulisat. The purpose of buffer zone is to limit the activities in close proximity to conservation area. Icejford Center will be located outside of buffer zone.

OLD HELIPORT
The heliport is not used nowadays and the surrounded area is messy and chaotic -with old abandoned containers and buildings.

SEMERMIUT
Semermiut is the oldest settlement in the area and is 4,400 years old.

HOLMS BAKKE
Holms Bakke is a place where traditionally, on the 13 of January every year people gather to see the first sun rays after the dark winter time.

Ill. 2.5 Possible building area

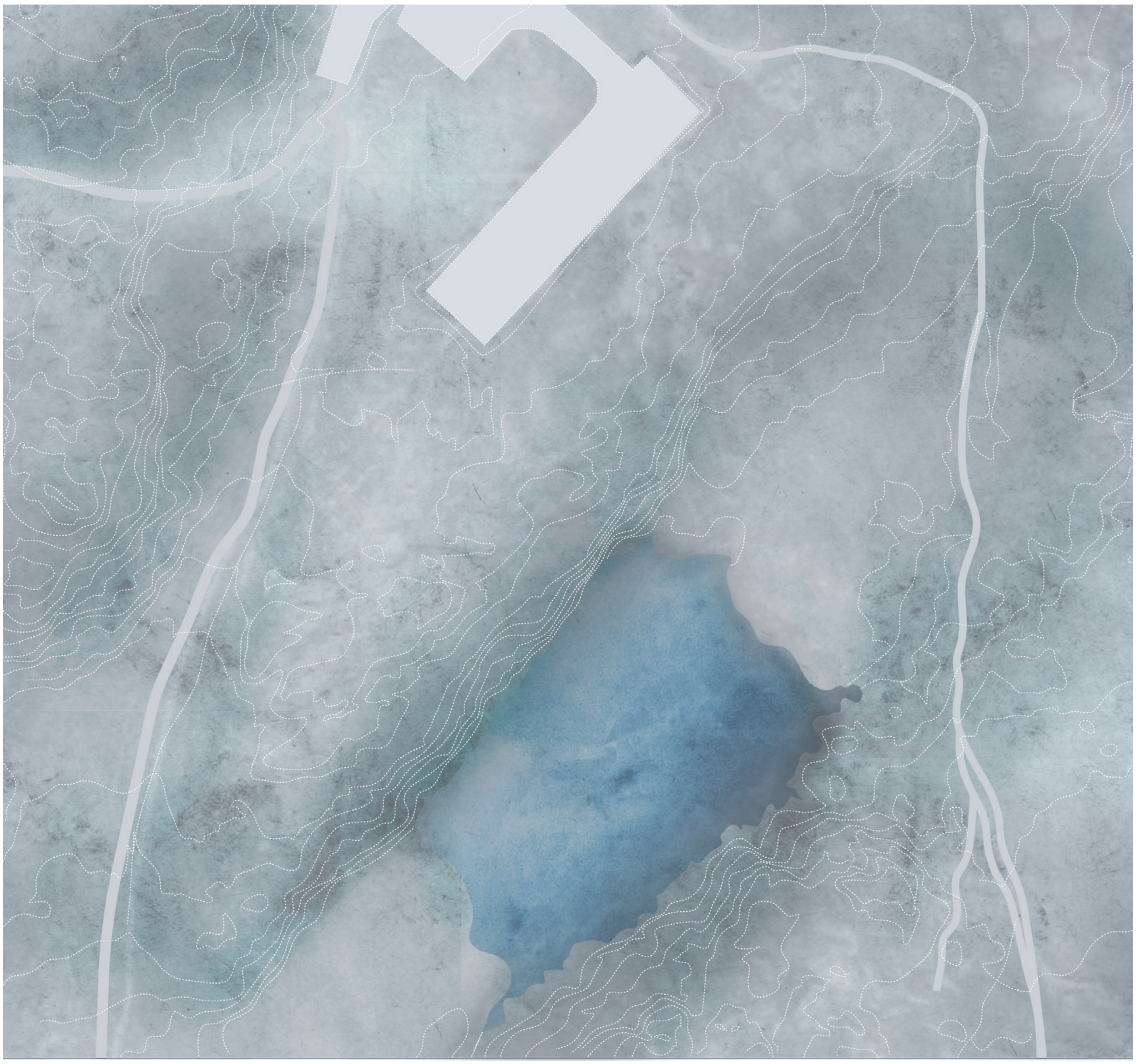
POSSIBLE BUILDING AREA

The area dedicated by Municipality for future Icefjord Center is set in between Illulisat build-up area and the buffer zone of UNESCO protected area. It is situated in the place of an old heliport and within the site exists a small lake. The total area is approximately of 7 hectares.

The site is located approximately 1 km from Illulisat center. Paved surface of an old heliport would be rearranged into parking space. Therefore would be possible to arrive to the Center both by foot or by car/bus.

The area is the starting point of 3 planned thiking trails - leading to Holms Bakke, along the fjord, and one leading longer way back to the town. It also connected to the main, existing wooden board-walk.

District plan for this area states that the Icefjord Centre can be maximum 3.5 storeys height and must be invisible from the protected area, except of Semermiut. The plan also impose that Center should contain research and exhibiton function, in connection with Greenlandic culture and history.



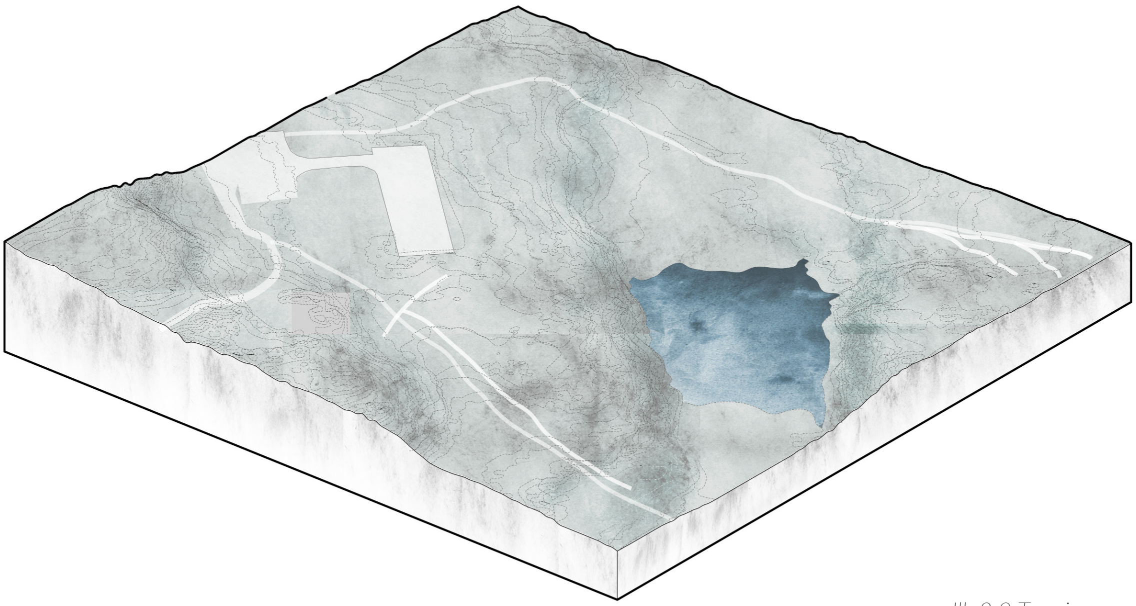
Ill. 2.6 Map of the site area

THE CHOSEN SITE

From the dedicated area for building the Centre, I have chosen the escarpment by the west side of the small lake. This has been done as it is elevated point, therefore the Centre will be visible from all the trails while having a great view to the Icefjord from the inside. Moreover, it gives the possibility to creating the entrance from the UNESCO boardwalk, as it is the most important trail. Placement by the lake gives an additional quality.

Ill. 2.7 Chosen site

Ill. 2.8 Chosen site



Ill. 2.9 Terrain axonometry

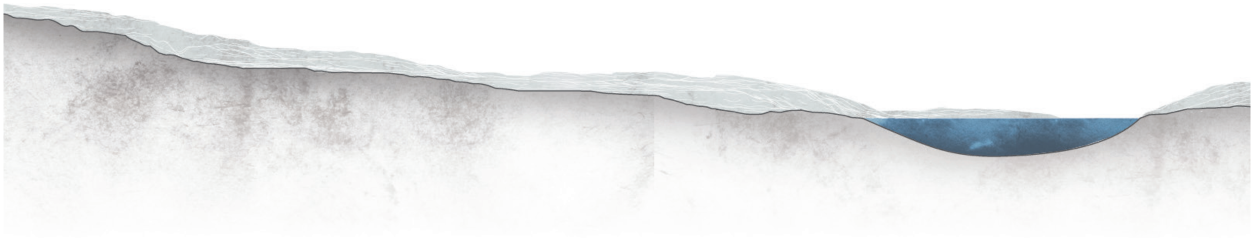
TOPOGRAPHY

The topography analysis is crucial it in order to place the building in the way that corresponds with surroundings.

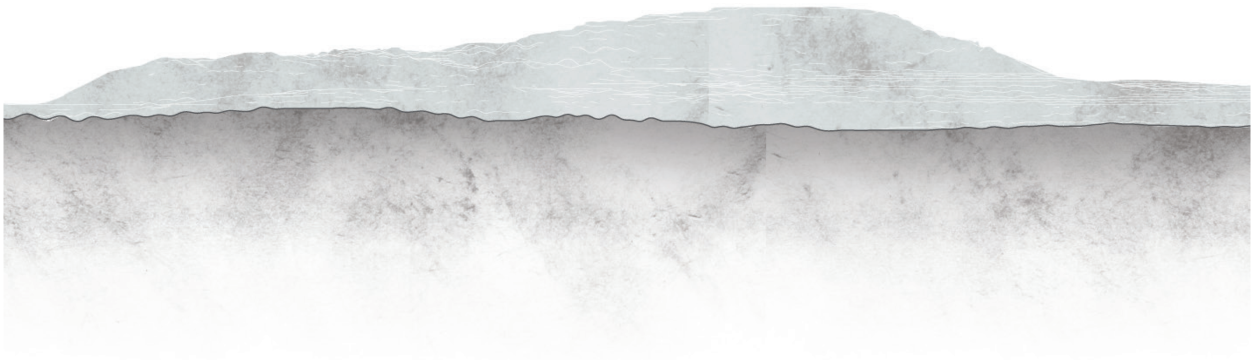
The site is located nearby the iceberg bank. Existing landscape is reminsescence of moving glacier, therefore the moraine terrain differentiates a lot. There are bigger rocky hills, surrounding the valley sloping towards the icefjord on the south. Moreover, many smaller boulders and pebbles are spread on the area, that have to be keep in mind during placing the building. In the recess of the valley there is located a small glacial lake. The flat area around the lake is mostly wetland.

Shaping of the site gives the opportunity to find a placement with breathtaking views to the icefjord. The lake also gives an additional value to the scenery.

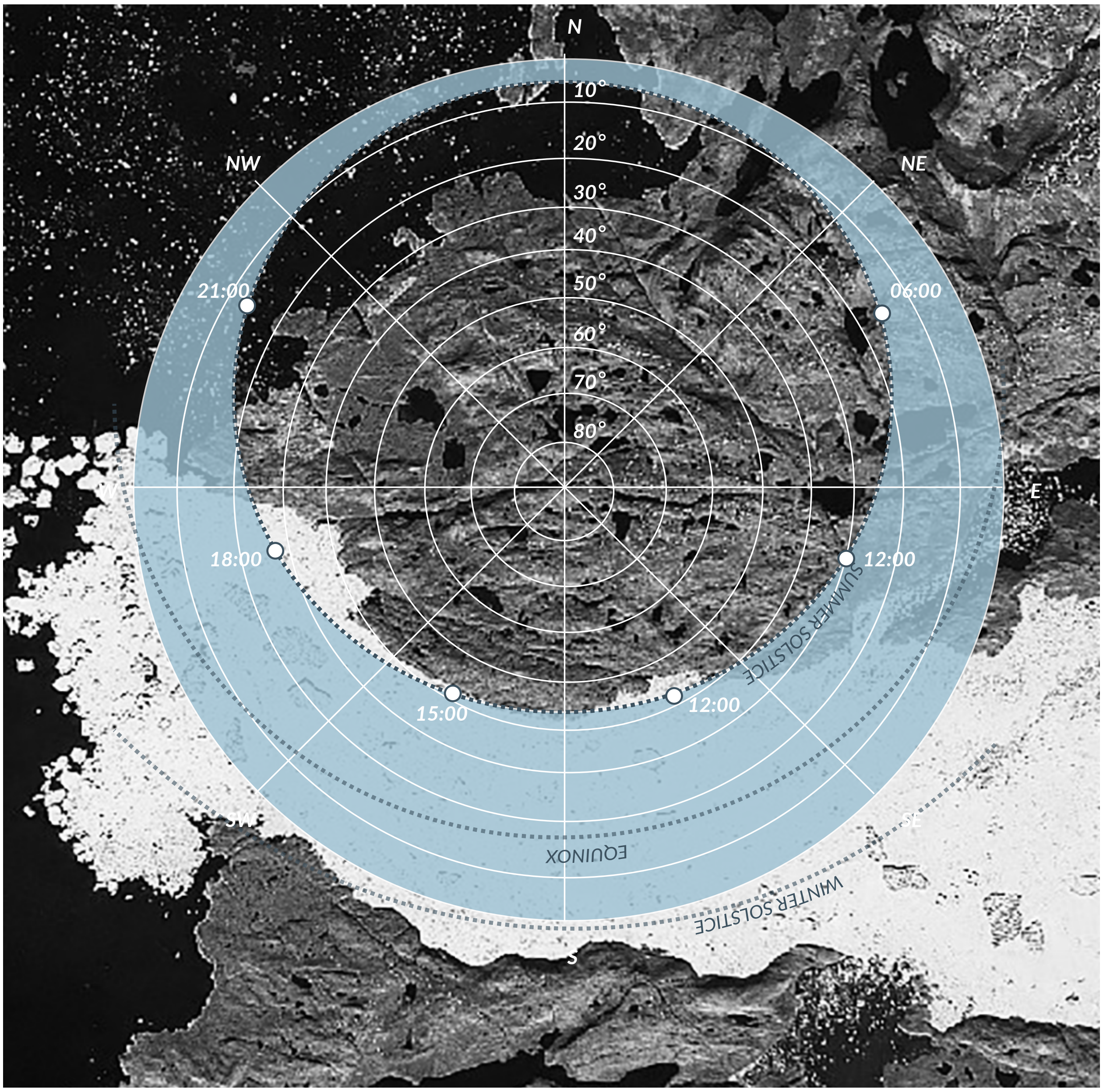
The following sections present sloping of the prefferd site chosen for the Center, which is going to be on the rock on the north-west side of the lake. The escarpment by the lake has a terrain difference of 10 meters. Section parallel to the lake shows in this direction there is not much sloping (up to) altough there are noticeable bumps and distortions of the terrain.



Ill. 2.10 Topography section



Ill. 2.11Topography section



Ill. 2.12 Sun diagram

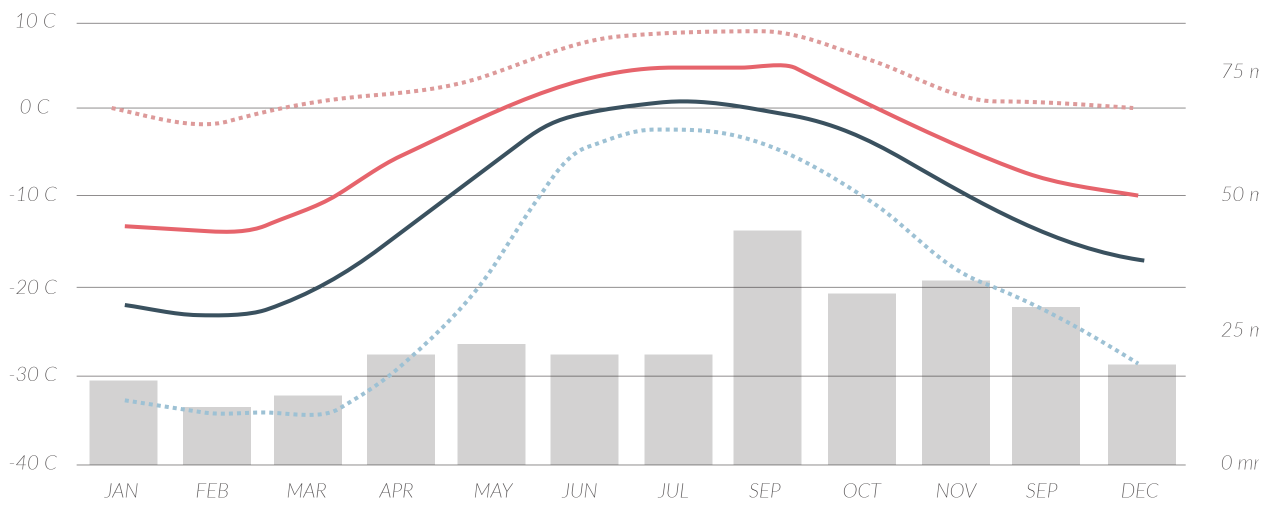
SUN ANALYSIS

The length of the day varies significantly over the year. The shortest days are during the winter, with 0 hours of sunlight and the longest during the summer, with 24 hours of sunlight.
Due to its extreme latitude, Ilulissat (Jakobshavn) experiences polar day (also known as the midnight Sun) during summer and polar night during winter. The precise start and end dates of polar day and night vary from year to year and depend on the precise location and elevation of the observer, and the local topography.
In summer, the Sun is continuously above the horizon for 63 days, from May 20 to July 22.

In winter, the Sun is continuously below the horizon for 44 days, from November 29 to January 12.

CONCLUSION

It has to be considered that during summer months sun never goes down and can reach the building from all directions - altough it has to be kept in mind it is rather low above the horizon. On the other hand during winter there is no sun at all therefore during winter months the only light will be artificial.



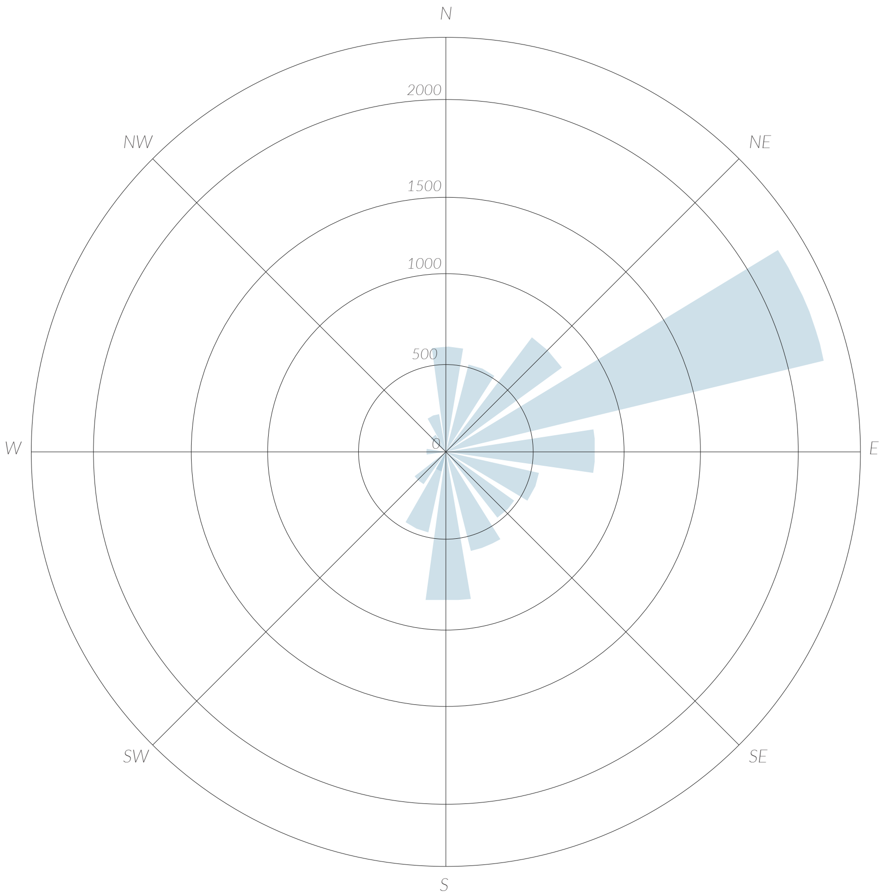
Ill. 2.13 Precipitation and temperature

CLIMATE - PRECIPITATION & TEMPERATURE

Greenland has an Arctic climate with average temperatures that do not exceed 10° C in the warmest summer months. However, due to low humidity in Greenland, summer temperatures feel warmer than it might be expected. The graphs above presents results particulary for Ilulissat. The mean temperature remains below +10° even in June, July and August and freezing from November through to April
The graph shows mean temperatures, therefore the average daytime temperature will be a little higher, whilst the average night time temperatures will be a little lower. At the same time, there can be large fluctuations from day to day, especially during the-summer.
Over the entire year, the most common forms of precipitation are light snow and moderate snow.
Greenland is not completely devoid of rain, but heavy rain is rare.

CONCLUSION

Due to low tempratures respectively thick insulation has to be implemented. Considering the snowload, the sloped roof should be considered as a solution to reduce the snow load.



Ill. 2.14 Wind diagram

CLIMATE - WIND

Generally-speaking it is not that windy in Greenland. Many days are completely calm with calm seas and glassy fjords and lakes. However, the wind can certainly pick up, and it there can be experienced wind with gusts of more than 50 m/s (111 mph), and are usually followed by precipitation. All in all, however, it is unusual for strong winds to be a problem for guests that are visiting Greenlduring the summer or for brief periods only. During the winter the wind can increase the effect of the cold.
Over the course of the year typical wind speeds vary from 0 m/s to 11 m/s (light air to strong breeze), rarely exceeding 15 m/s (high wind).
The diagram above presents wind conditions that have been analysed in the area of Ilulissat airport.

However, the precise results may differ from the conditions on the site, the main conclusion is that the strongest wind comes from the north-east. This can be additionaly enhanced on the site by the shape of Semermiut Valley.

CONCLUSION

Outdoor areas shall be sheltered, especially from the north - east. For further structure analysis a significant windload will be considered, that perhaps could be reduced by shape of the building.

Ill. 2.15 Calving icefjord

CLIMATE CHANGE

Global warming is more visible in the Arctic than anywhere else because the rise of temeperature can happen much faster. It can be easily observed in the Icefjord, that contains information of years of geological and climatic changes throughout thousands of years.
Recent studies shows that the warming in the Arctic has been twice as fast as in the rest of the world. Climate change has resulted in a significant melting of Greenland's ice cap - and that has resulted in a number of environmental problems in Greenland, as it's ecosystems are adapted to usual low temperatures. Ilulisat Icefjord has become a field for observation of global climate change due to it's largest and most active glacier in the north hemisphere, that is calving approximately 40 km3 of ice a year.
Greenland's ice loss causes rising sea levels and therefore influences the rest of the world.

CONCLUSION

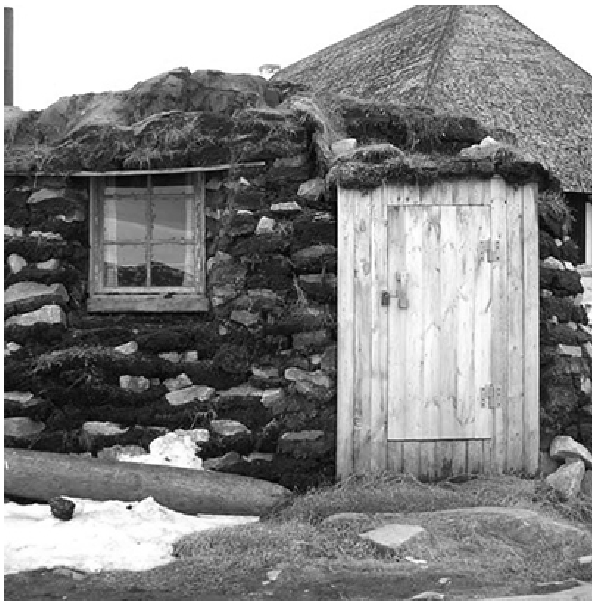
As Ilulissat Icefjord Centre is dedicated to be a place of discussion about the global climate change, it should not contribute to it through the environmental emission - this shall be considered in design especially in terms of choice of materials.

03

Ill. 3.1 Zion Church in Ilulissat

PROGRAM

This part consists of the program for the Icefjord Center. It is done based on the case studies of the chosen visitor centres and the user group analysis, also contained in this chapter.



Ill. 3.2 Turf hut

Ill. 3.3 Traditional summer tent

CASE STUDY:
GREENLANDIC ARCHITECTURE

Traditionally - for 4 thousand years Inuit people held semi-nomadic lifestyle and therefore their dwellings were supposed to be easy and fast to build. were using building materials they could find in Greenland - driftwood, bones, animal skins and even occasionally ice. Primitive wellings like this were used in some regions up to 1950's The type of houses could differ within seasons - from were all-year turf huts, bone and fur tents during the summer that gives more mobility during hunting and sometimes igloos during the winter.
The most rubust, hence most common type of housing were turf huts, that actually can be still seen in some places in Greenland. Insulation properties of turf.
This changed in XVIII century, with the Danish colonisation. Colonies were characterised with timber houses transported from Scandinavia as timber kits. The tradition of the characteristic, brightly coloured houses began here. The distinctive for Greenlandic landscape colourful house made from imported wood or plywood is rather compact, of an average of 70sqm. Back in the days colours used to be practical and indicated the function of the building It has typical high pitch roof, practical due to huge snow precipitation. Houses are usually raised around meter from the ground on a high base made of concrete or stone, contrasting with the colorful structure.
It is important to understand the cultural connection to the ocean. It is highly uncommon to have or build a house without ocean view or in some way relating to the ocean – a tradition having roots all the way back to the old Inuit turf huts and burial grounds

CONCLUSION

Outdoor areas shall be sheltered, especially from the north - east. For further structure analysis a significant windload will be considered, that perhaps could be reduced by shape of the building.


Ill. 3.4 Timber houses in Ilulissat

Ill. 3.5 Giant's Causeway Visitor Centre

CASE STUDY:
GIANT'S CAUSEWAY VISITORS CENTRE

Giant's Causeway located in Ireland is a visitor center designed by Heneghan Peng Architects. further in the design process during elevation studies. The architects intention was to create sculpture in the landscape that would be both visible and invisible. The recognizible mass reffering to the local basalt stone, fade into the landscape despite its massiveness. The lightness is achieved thanks to the shaping of window openings.
Inside the buidling the level of the floor varies to handle the sloping site, but are connected with ramps to provide accessibility.

CONCLUSION

This project is an inspiration how a building can merge into the landscape and be an outstanding landmark at the same time - and therefore achieve the qualities desired in the Icefjord Centre.
Ramps can be a good solution to provide accesibility in difficult topography and in the same time create distinct spaces

Ill. 3.6 Snæfellstofa visitor center

CASE STUDY:
SNÆFELLSSTOFA VISITOR CENTRE

Snæfellsstofa is a visitor centre located in the Vatnajökull national park in Iceland, desinged by Arkis Architects. The Center stands out thanks to its exceptional architecture, in the meantime it merges with surroundings. It's appearance attracts visitors and reminescence of a glacier - which is the topic of its exhibition
The center engage to both indoor and outdoor activities, and it's location on the site shelters from the wind and provides view on the mountains. Local materials are used for construction and envelope - larch, turf roof and landscaping walls are made of local rock. Building has the layout based on overlapping functions : the exhibitions- and education axis rises up to both sides and creates a framework for an exhibition space and a library.

CONCLUSION

Visitor center is distinguished due to its original shape, but fits to the surroundings thanks to materiality.
To engage activities and bring life into the buidling functions in the Centre shall be overlapping.

USER GROUP

TOURISTS

Icefjord is attracting more and more visitors every year. The annual number of tourists is approximately 30000, which is one-third of a total number of visitors in Greenland. They are coming to debate about the climate change, to study local geology or culture, but mainly simply to admire the beauty of the calving glacier. After UNESCO designation in 2004 a boardwalk was constructed from the old Illulisat's heliport to the Holms Bakke, making icefjord accessible for the wider range of visitors.

Visitors come to Illulisat in two ways - by the plane or by the sea. There is a type of cruise - ship tourists, which are generally rather an older age group - around 50 % of all tourists in Illulisat is above 55 years old. For them, Icefjord is usually not the main trip destination, but one of the stops on their way. Another type is people that are coming specifically to visit the Icefjord. This visitors are usually well prepared for the trip and are aiming to fully explore and experience the Icefjord nature.

RESEARCHERS AND OPINION FORMERS

Another type of people coming to Illulisat are professionals - scientists, journalists, politicians - that share common interest in climate change and global warming. For them, the crucial need that Center could fulfil is a space for debate events, conferences and all kind of meetings.

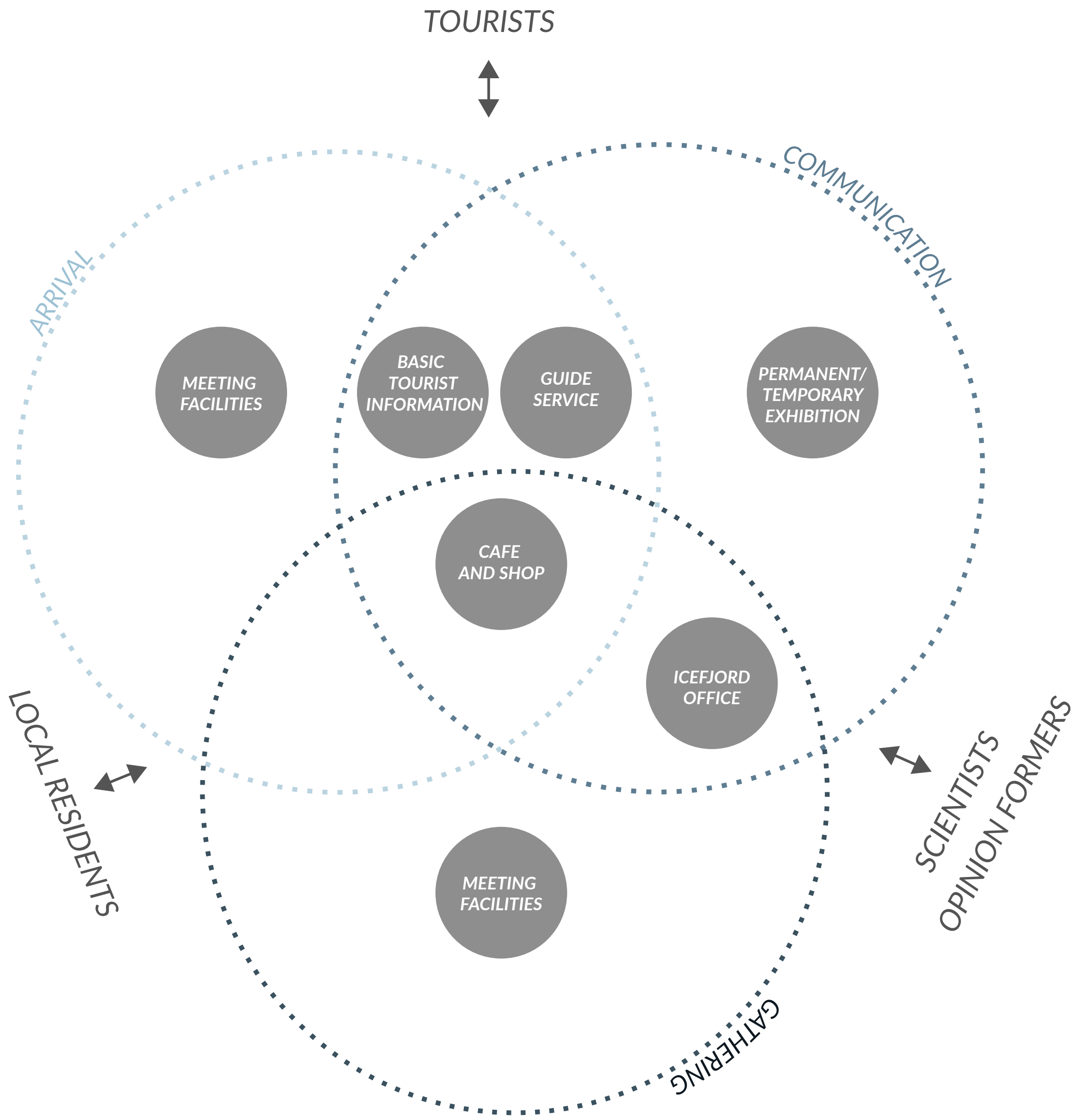
LOCAL SOCIETY

On the other hand, there are approximately 4,600 inhabitants of Illulisat, whose main activities throughout centuries were hunting and fishing. In the reality of limited infrastructure of Ilulissat, they could use the Centre as the meeting point, a cafe - especially for local young people. Locals could also sell their art in the museum shop. But besides this simple functions, the Centre would enhance local pride and identity as well as communicate information to the locals about their own heritage - both cultural and nature-wise.

CONCLUSION

The design of the Center Icefjord shall be addressed to both locals and visitors and enhance the communication of knowledge between them and each of. It is aiming to reach out a variety of target groups, such as tourists, climate specialists and politics. However specific function will be dedicated to a specific group, for instance, arrival point function will be dedicated mainly to tourists, it is the intention of the project to facilitate the meeting between different groups to exchange communication of knowledge.

Ill. 3.7 User group



Ill. 3.8 Functions diagram

FUNCTIONS AND ACTIVITIES

The Centre should be designed in a way that the flow through the center is clear and easily readible for visitors. Each function - dedicated for visitors, researches or administration - should be distinctly differentiated, however cohesive within the building and with the landscape. It is prefered to overlap some functions if possible.

SPATIAL PROGRAM

ENTRANCE AREA

The area would provide easy access to the other facilities, such as toilet, cafe and shop, and allow the flow between the rest of the Center area. The entrance should have the welcoming atmosphere and be the representative part of the Center.

EXHIBITION

There is a probability that most of the people stopping by in the Centre would also see the exhibition. Therefore there should be a visual connection and an easy access to the entrance and the exhibition. This space should create enough space for presenting information about the main theme which is ice - in relation to climate change, geology and nature and people.
In terms of ensuring cohesion between the exhibition concept and the building design, it is crucial to provide great flexibility in all exhibition facilities. Ideally, it should be possible to design exhibitions that flow from actual exhibition spaces into other spaces and into the surrounding landscape.

CAFE, KITCHEN, CONFERENCE AREA

Cafe should be a flexible space, located in close proximity to the exhibition space and the conference room - so in the case of events for big groups of people the meeting space could be extended.
Outdoor seating sheltered from the wind should be an addition to the cafe, to create the possibility of relaxing outside.

TOURIST INFO AND SHOP

In the shop, there should be provided with enough space for selling products and for a counter. The shop is supposed to be connected with a guide service, and therefore it will be a starting point for guide tours. Close to the shop there should be located tourist information point, providing basic information about the Icefjord and activities that one may do in the area.

RESEARCH FACILITIES

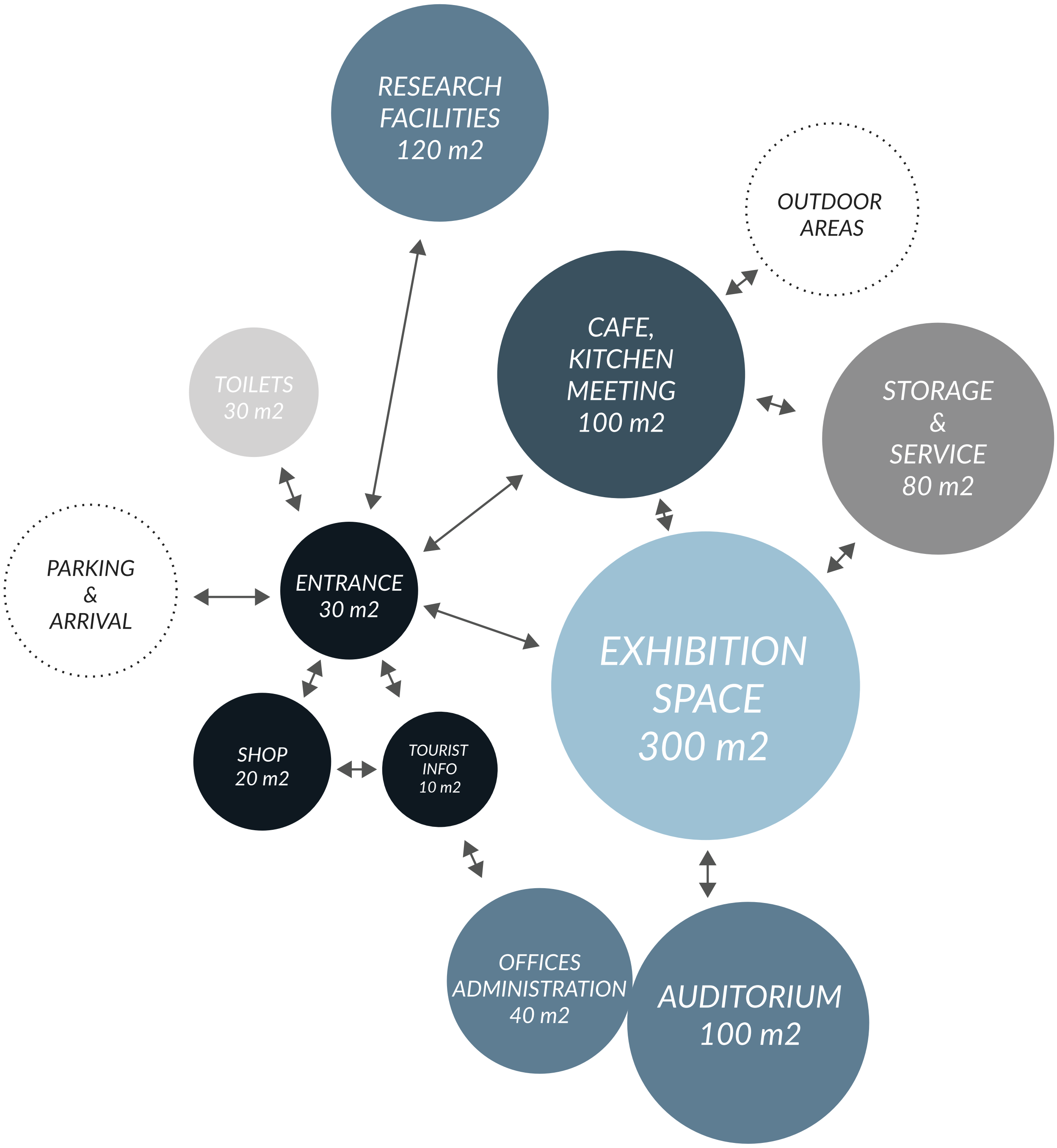
The Icefjord Centre should have facilities addressed for visiting researchers. As mentioned in previous user group study, researchers usually come to Ilulissat during the summer and use most of their time on the outdoor research To fulfil their needs, there shall be designed area with few flexible workstations, a sleeping zone with bunk beds for 3-4 people. Possibly there should be kitchenette and dining area together with toilet and bathroom.
As the scientists usually use a lot of work equipment there shall be provided space for their temporary laboratory/working space. Moreover, the equipment they bring needs to be stored - during they stay or for the long term in between researches stay in Greenland. Therefore a storeroom of approximately 10 m2 is needed, as the equipment is generally heavy and takes a lot of space.

OFFICE AND ADMINISTRATION

Existing today in Illulisat the Icejford Office is responsible for all tasks associated with the World Heritage Area. The Centre would give them an opportunity to move from town to the closer proximity of Icefjord itself, which would ease everyday management of the protected area - for instance ensuring activity at the centre all year round.
The office would need few workstations and facilities for a daily paperwork as well as hold meetings. The office also needs regular staff facilities - e.x. (break room) that could be shared with the rest of administration area.

TOILET, CLOAKROOM AND STORAGE

The toilets should be able to service big groups of people, including handicapped visitors. It can be considered to design additional toilet in the external area, accessible from the path.
In the entrance part, there should be included a cloakroom for up to 40 visitors. It has to be taken in mind, that due to the harsh climate conditions, clothes will take much more space, and therefore the cloakroom should be bigger than it normally would be.
A total area of 80 m2 should be arranged for storage and service functions. It would be addressed to storage the exhibition materials, but also all kind of other things necessary in the Center, for instance, conference room chairs etc.
The different storage functions should be separated.



Ill. 3.9 Spatial program

DESIGN PARAMETERS

/Cater the climatic and contextural challenges of the site actively in the design

/Use tectonic principles to create a building of an honest expression

/Create a building that stands out, while relating distinctively to the surrounding topography

/Respond to the needs of the variety of user groups

04

Ill. 4.1 UNESCO trail

PRESENTATION

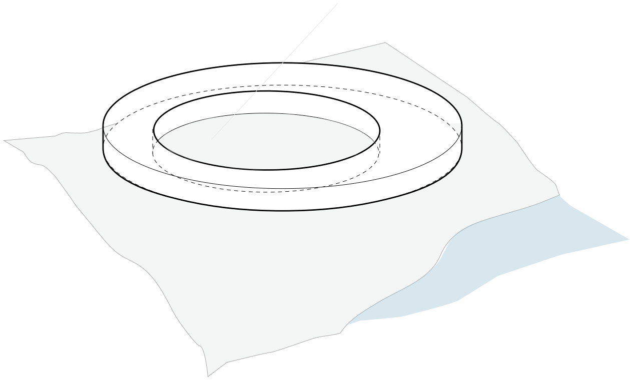
This part consists of final drawings and visualisations of the Icefjord Centre.

VISION

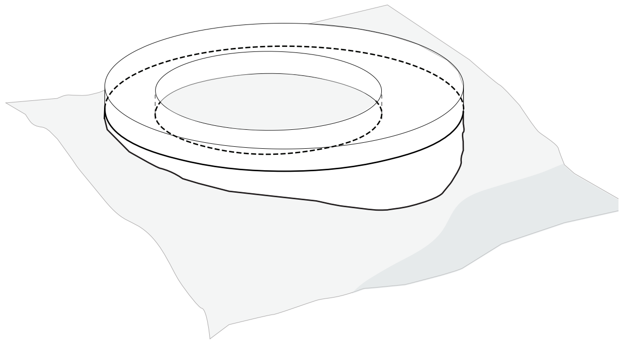
In Ilulissat there is a wish of a Centre that disseminate knowledge about the climate change, Icefjord and Greenlandic culture, that shall act both locally and globally. The variety of activities should provide a holistic Centre that will bring more visitors to Ilulissat.

The architectural objective is, by taking inspiration from the tectonics and Nordic approach, create a building that would be adapted to the extreme nature of the site.The concept relies on catching the essence of the site, through materiality and construction, with an that processes the placement in the landscape.

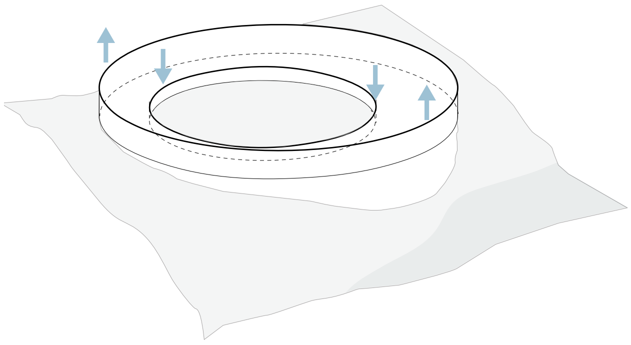
CONCEPT



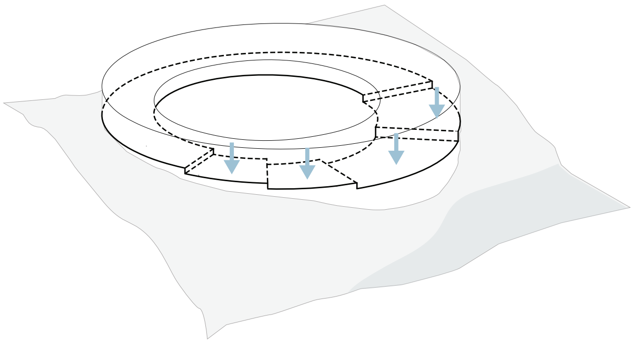
1. Circular volume is placed on the edge of the lake, with possibilities of views in every direction



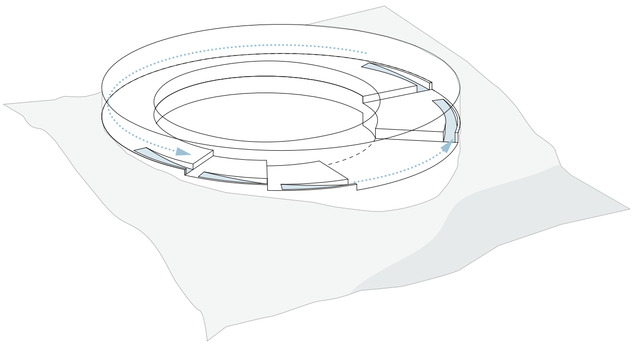
2. Distinction of stereotomic base and tectonic structure as a reference to local buildings



3. Monopitched roof is created to correspond with local climate conditions, but the horizontal line of facade is kept



4. Base is scattered into smaller plateaus and pulled down to follow the terrain



5. Ramps are created to provide uninterrupted flow of visitors

Ill. 4.2 Concept diagram

VIEW FROM THE RED ROUTE

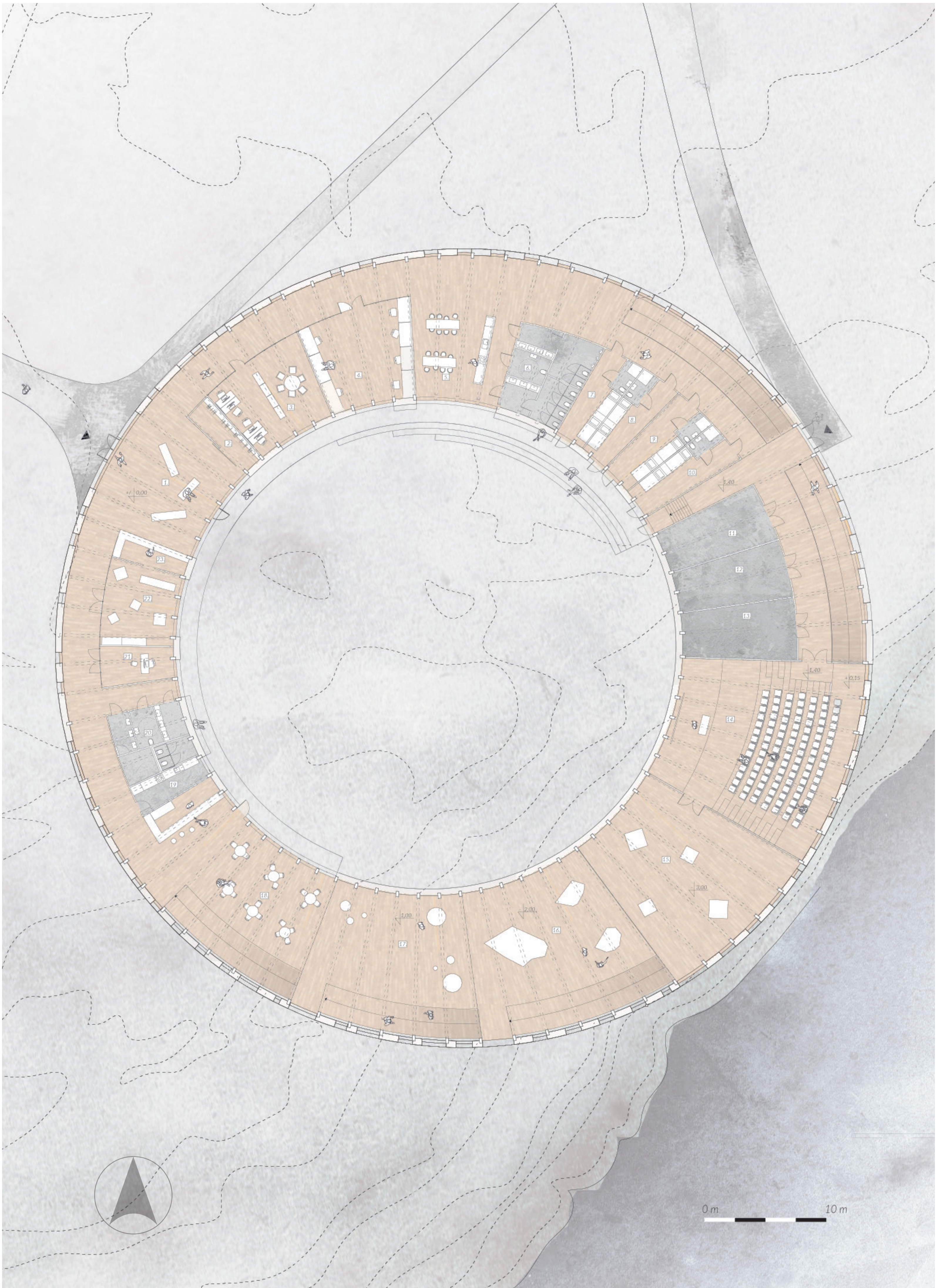
The Centre is going to be a visible landmark from the surrounding trails, but in the same time, thanks to it's materiality and a boulder-like massiveness will merge into the terrain.

Ill. 4.3 View on the Centre from Red Route

Ill. 4.4 Site plan

SITE PLAN

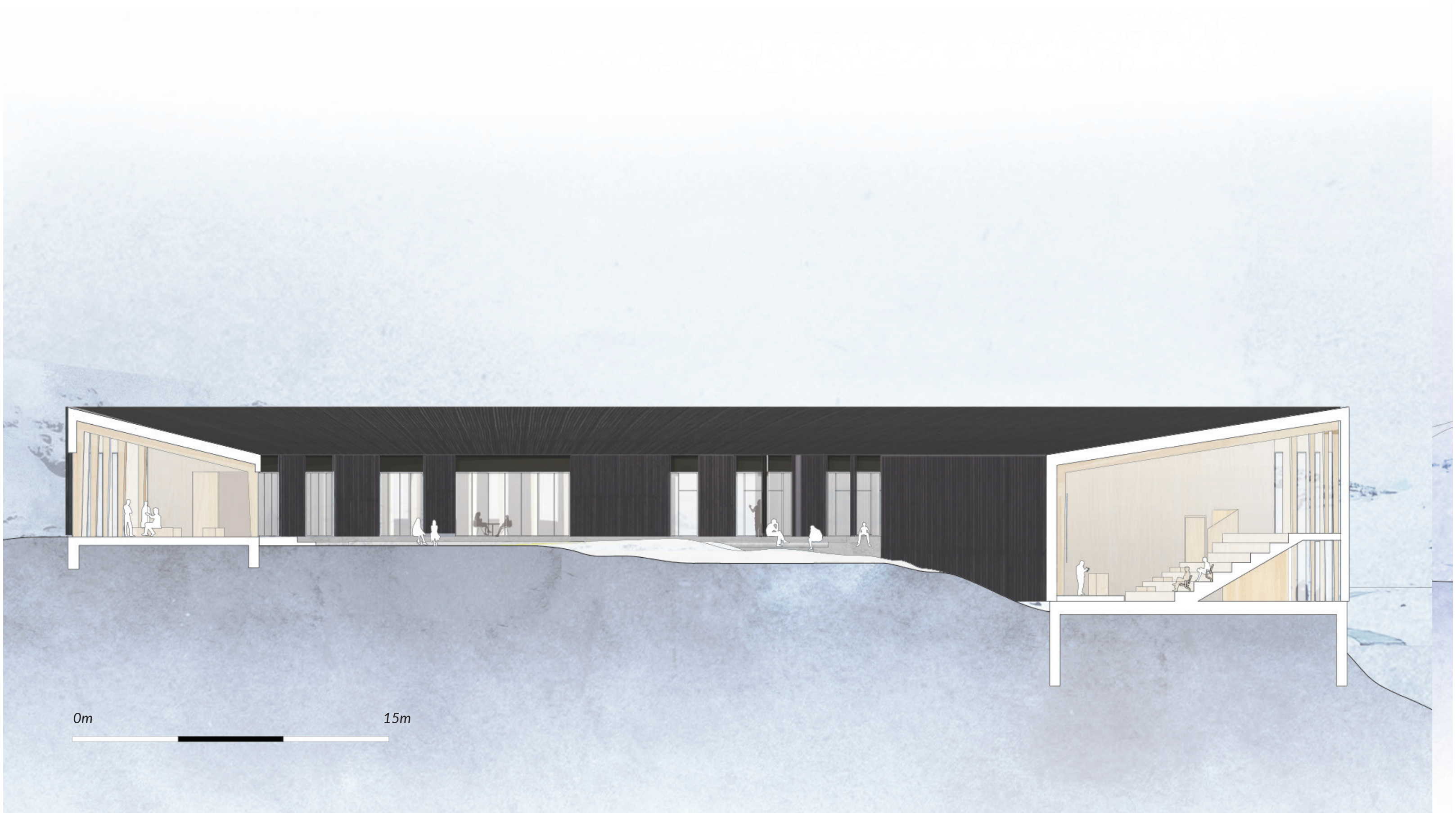
The site plan shows the Ilulissat Icefjord Centre in its context. The neglected area of an old heliport has been partly reduced to bring back natural landscape and partly rearranged into a parking area on the north.
The main entrance is accessible from UNESCO path, and to the secondary entrance has been led a new, wider path giving a possibility to access it with e.x. terrain car if there is such need. The introduced changes are minimal in order to keep the landscape as untouched as possible.



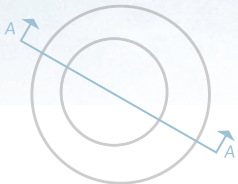
Ill. 4.5 Floorplan

FLOORPLAN

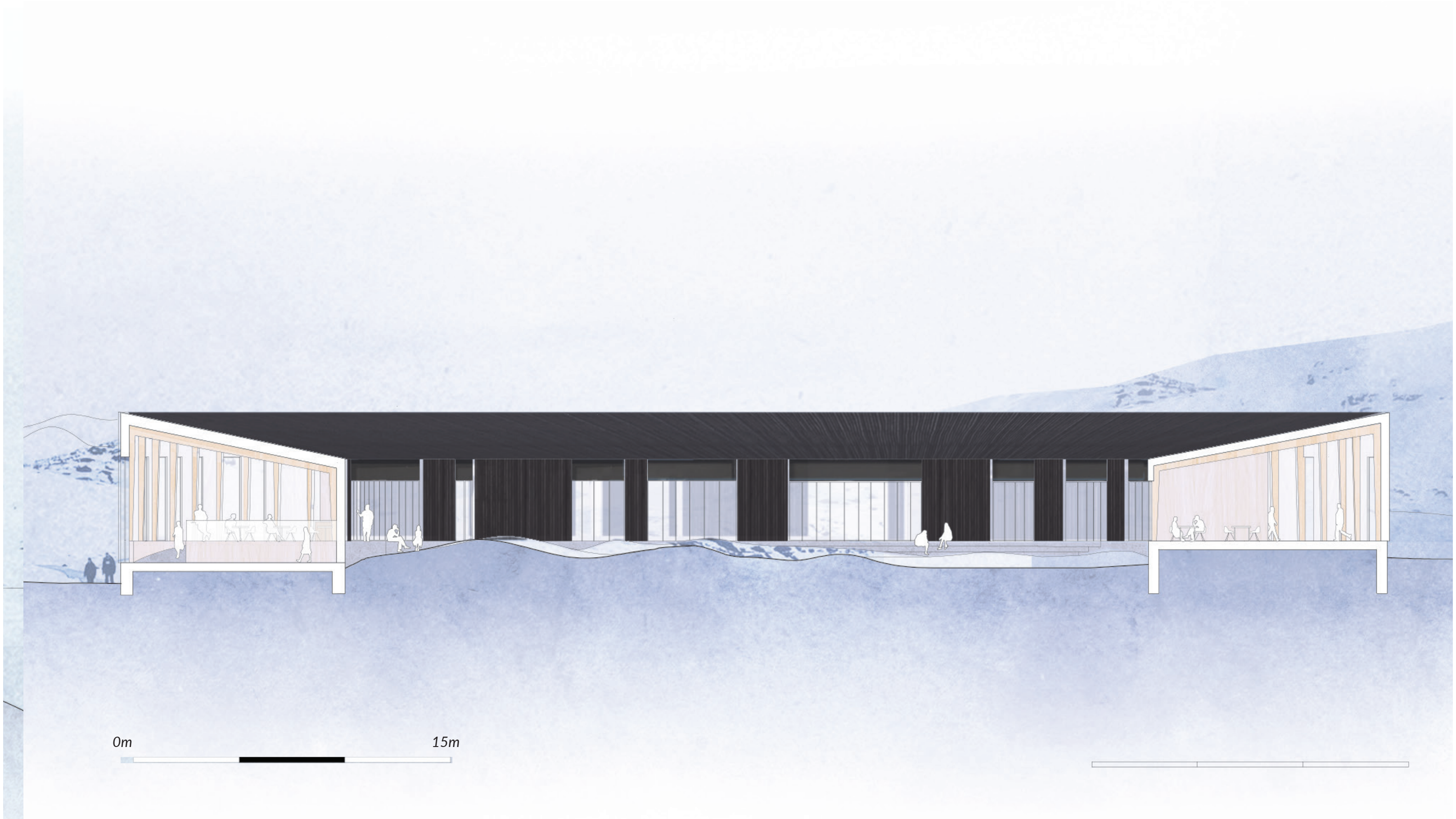
The different functions are shown on the furnished floorplan. Exact square meters of the rooms can be seen in an Appendix 2. Emergency exits and escape routes are applied according to Building Regulations (see Appendix 1)



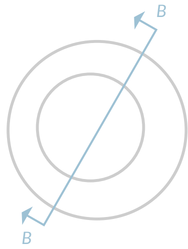
Ill. 4.5 Section AA

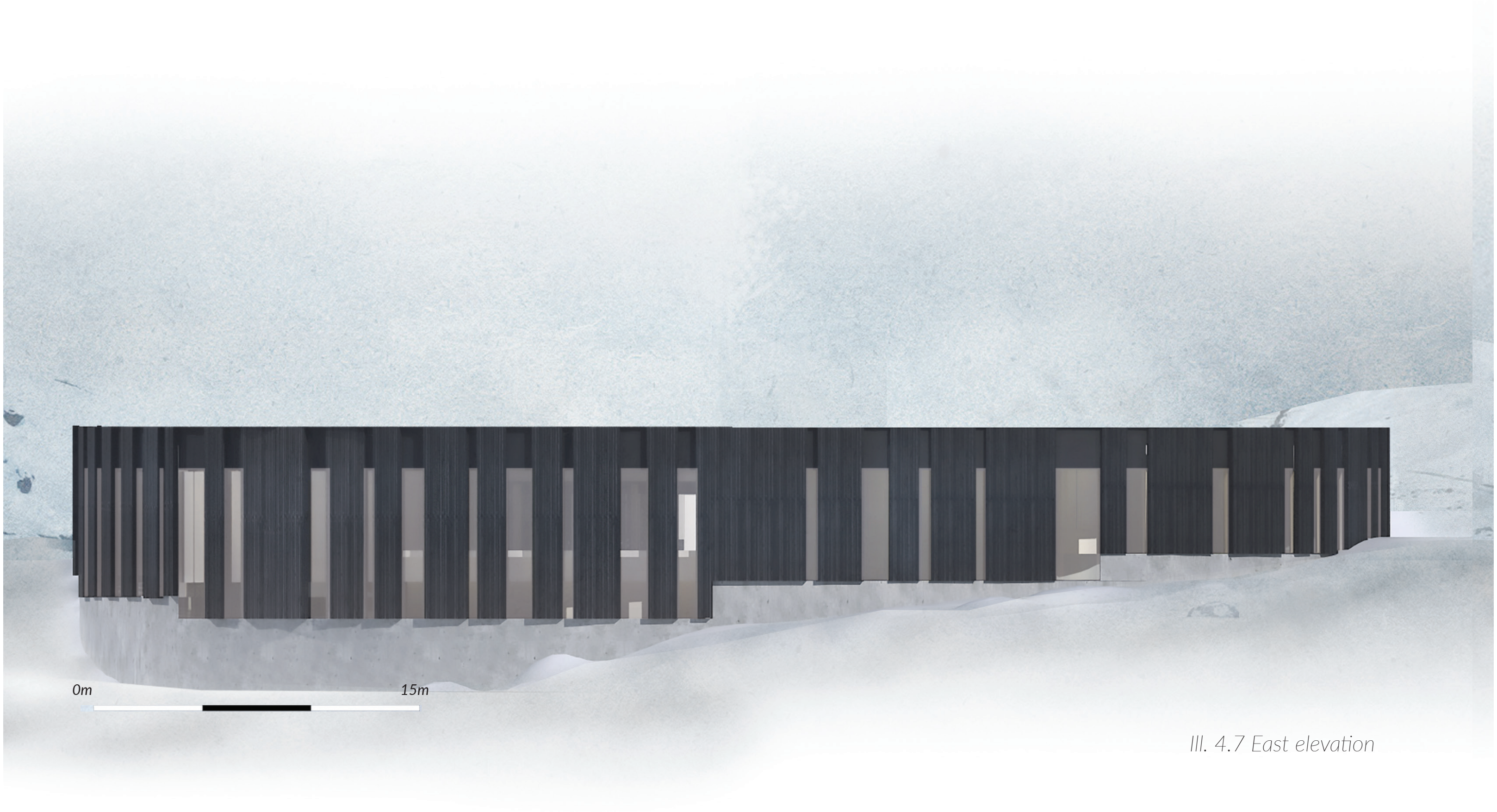


SECTIONS



Ill. 4.6 Section BB

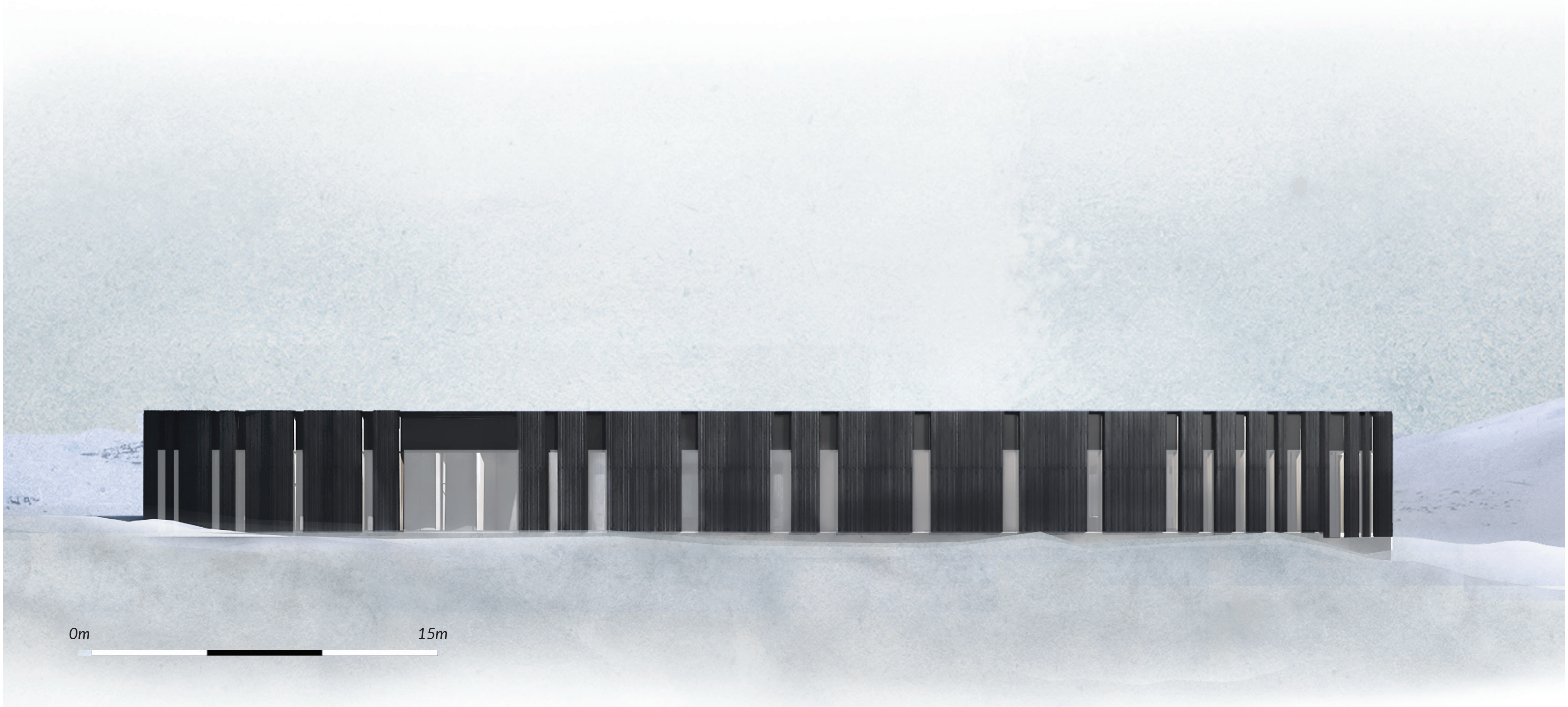




Ill. 4.7 East elevation

ELEVATIONS

Ill. 4.7 South elevation



Ill. 4.7 West elevation

Ill. 4.7 North elevation

Ill. 4.8 Reception

ENTRANCE

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Windows gradually opens up to create a wide entrance, and show off a warm, inviting interior. After entering the building visitors may use the wardrobe and ask for information in reception. There is a disposal of tourist functions to the right and administration to the left. There is also a possibility to access the outdoor deck.

Ill. 4.9 Entrance

Ill. 4.10 Cafe

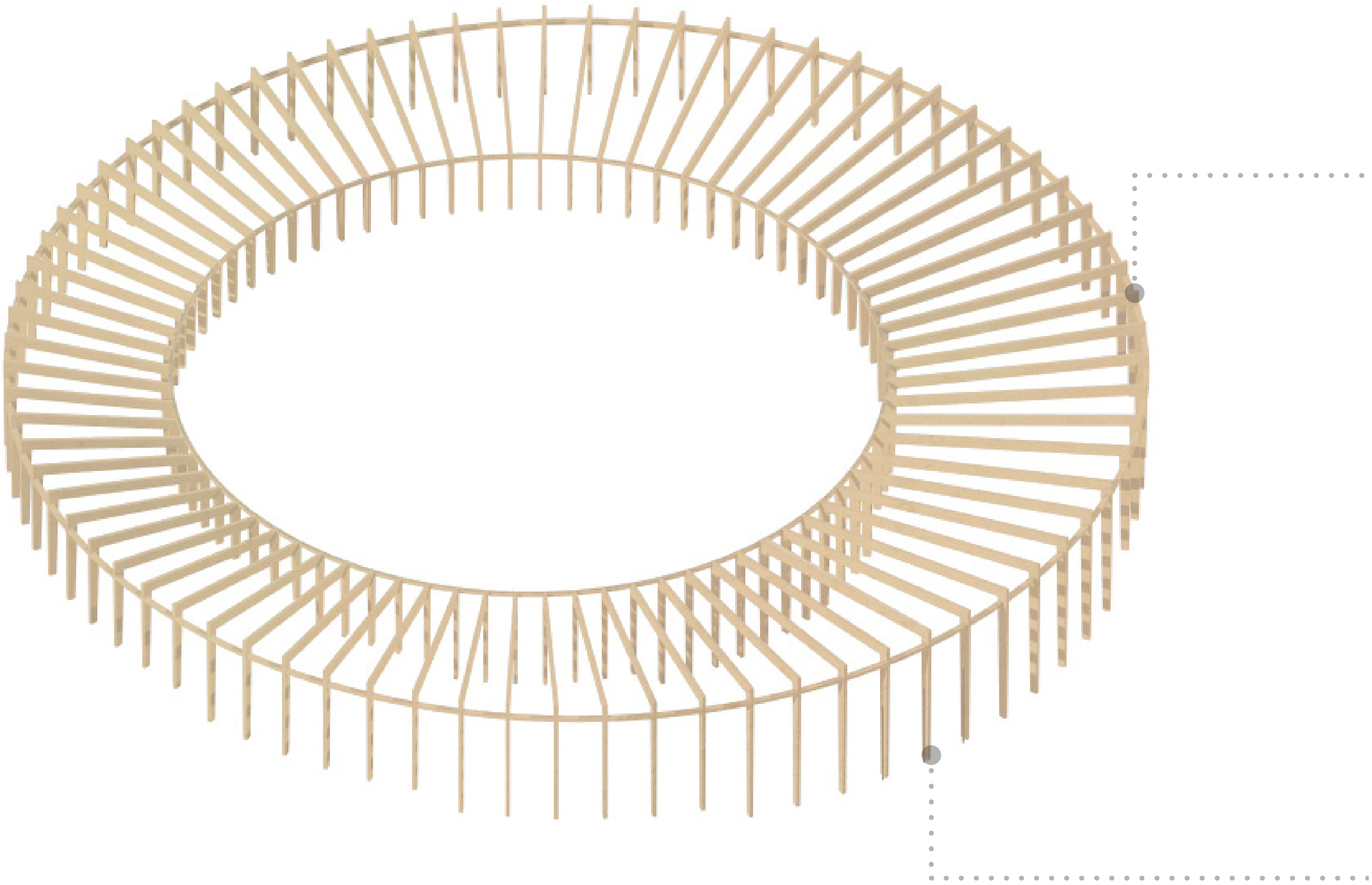
CAFE

Cafe opens up with a view towards the Icefjord, the view is additionaly enhanced thanks to the tall openings in the exhibition area . Cafe is visually connected with the exhibition and has also a possibility to access the outdoor space.

EXHIBITION

Exhibition area is divided into three plateaus, where each plataeu corresponds with different function. Gradually, going from the cafe first topic as a most 'public' is the climate change, further the Icefjord itself and the last and most intimate is the part presentic Greenlandic art and culture.

Ill. 4.11 Exhibition



Ill. 4.12 Structure axonometry

STRUCTURE AND DETAILS

The structural principle is based on a radially placed glulam frames, creating circular volume.
To achieve rigidity cross elements has been added to the top edged of the structure.
The supports are pinned (Ill. 4.14) and the joints are fixed (Ill. 4.13).

Ill. 4.13 Joint detail

Ill. 4.14 Support detail

Ill. 4.15 Exterior materials

MATERIALS // ENVELOPE

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On the envelope, in contrast with bright and warm expression of the interiors, will be used charred wood cladding. The biggest advantage of the charred wood is that the burning process extends it's durability and is naturally beautful in the same time. Concrete base in the harsh climate will be affected by weathering, and will mimick the surrounding rocks. To match the dark materials on the envelope, window frames are going to be powder coated black.

05

Ill. 5.1

DESIGN PROCESS

This chapter consists of design process, sketches, diagrams and studies that led to the project decisions.

SITE FACTORS - SUMMARY

The design process began with investigating of determinating aspects of the site - both natural and created by people - that could define orientation and shape of the building, Those aspects has been evaluated wider in the analysis part, although collecting them all together as a summary diagram was a starting point, to begin with sketching.u

Sun orientation is a key factor for every design, however, in Greenland sun orientation is unique - winters are dark while during the summer months the sun never goes down the horizon and we can observe it's travel around the horizon which could be interesting to use in the project.

The wind comes mostly from north-east, additionally enhanced by the valley shape so the outdoor spaces should be protected from this direction.

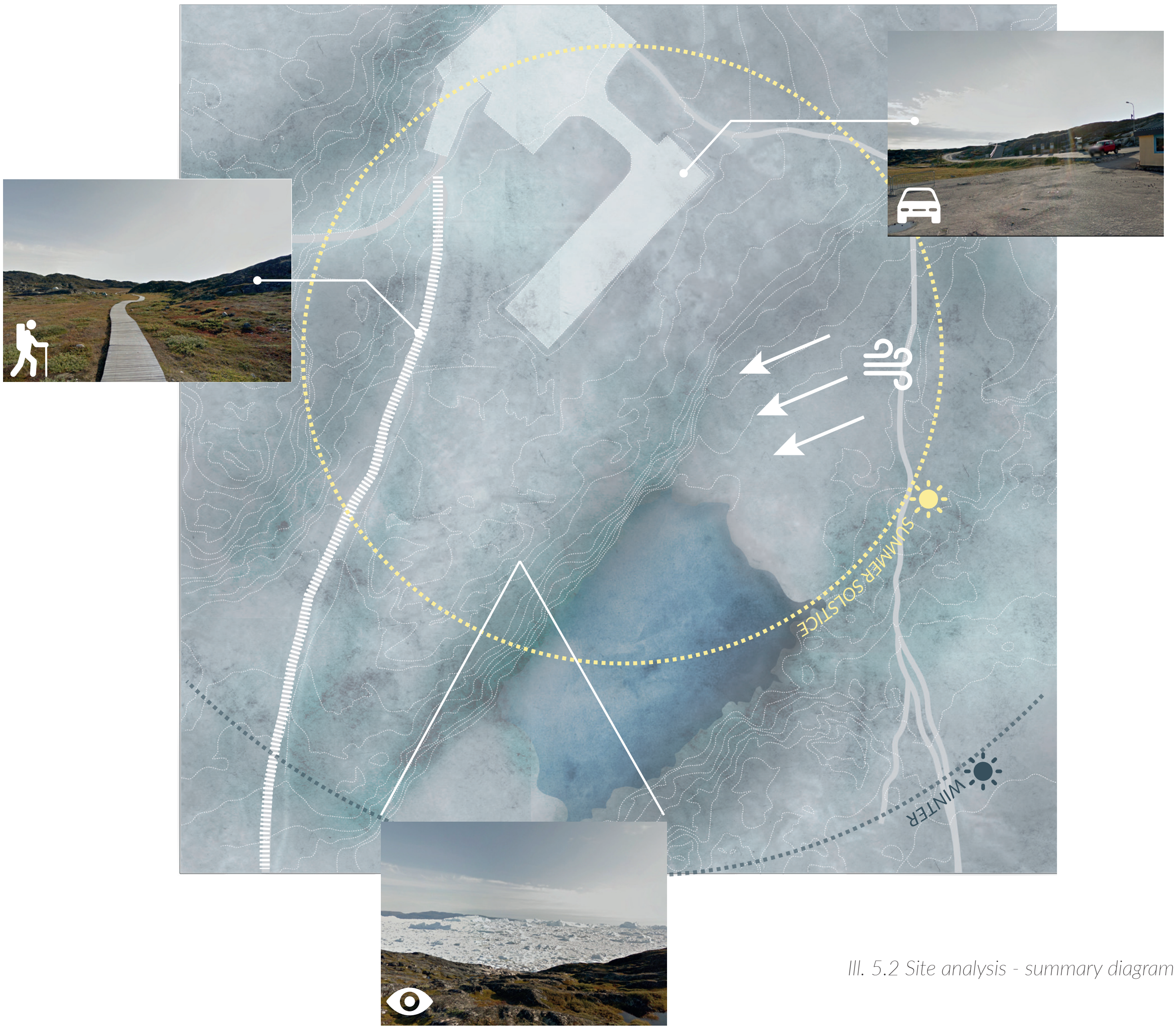
Existing on the site little lake is very typical for this area, although brings an extra value in terms of views. However, together with snow, it can be causing a glare that has to be examined during designing window openings.

Another essential element to be kept in mind in the design process is the view to the Icefjord, located on the south from the site - and this will be kept in mind in connection with exhibition functions as well as other tourists facilities.

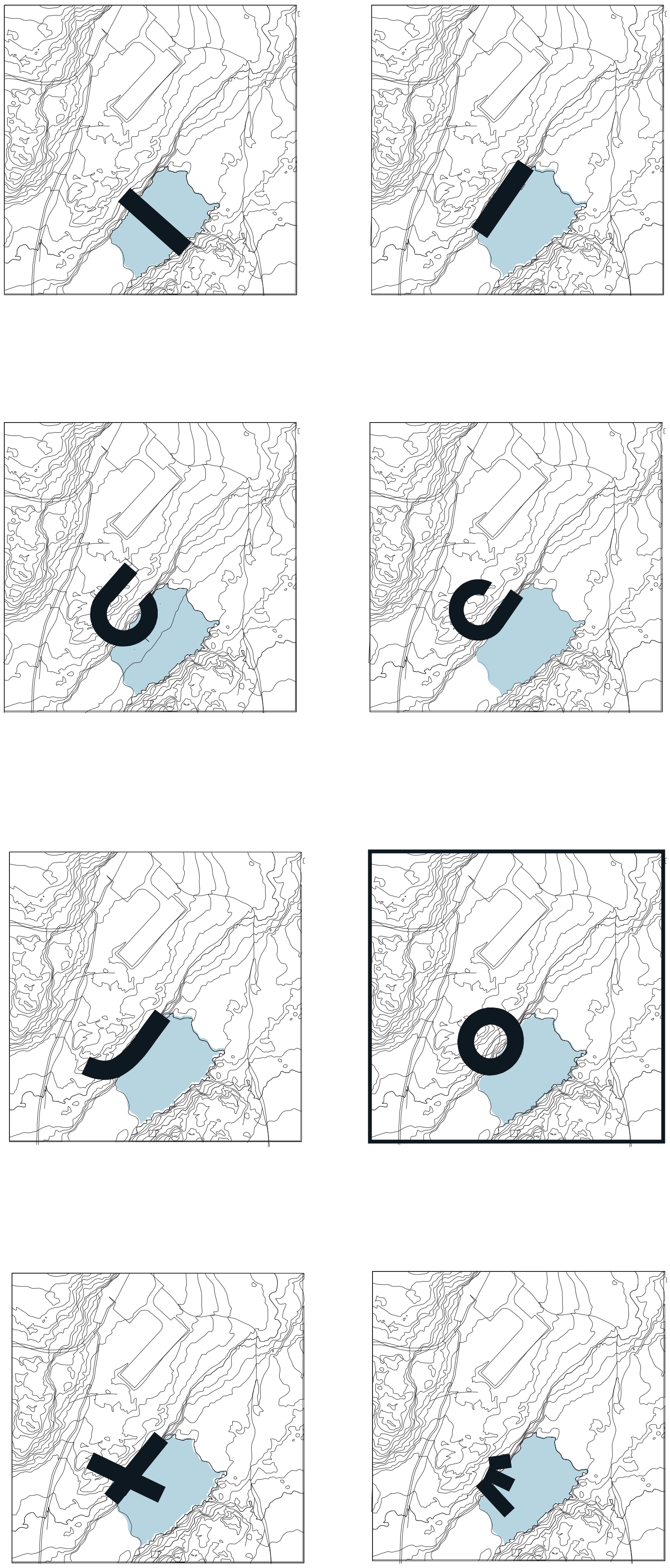
In matters of landscape, the terrain is generally rocky with a slight slope towards the Icefjord. As the Center will be placed by the lake overlooking the icefjord, the steep slope towards the lake will be the main challenge.

On the north, there is located paved surface of an old heliport, which will be rearranged as a parking and should have a direct connection with the Center.

On close proximity to the site, we have two walking paths: main boardwalk that guides visitors out to the icefjord, and the path called 'Red Route' leading to Holms Bakke.



Ill. 5.2 Site analysis - summary diagram



Ill. 5.3 Initial volume studies

INITIAL VOLUME STUDIES

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The considarations of the shape and volume were consequence of the site analysis. The main goal of this investigation was to find a solution that would be reflecting the site qualities, while having predispsition to have a functional layout. This phase was crucial for the further development of the project. Early decision has been made to work with the circular floorplan. Decision has been made due to the variety of inside / out experiences it can give, and possible sheltered outdoor space inside the ring

Ill. 5.4 Disposal diagram

USER GROUP : VIEWS AND INITIAL DISPOSAL

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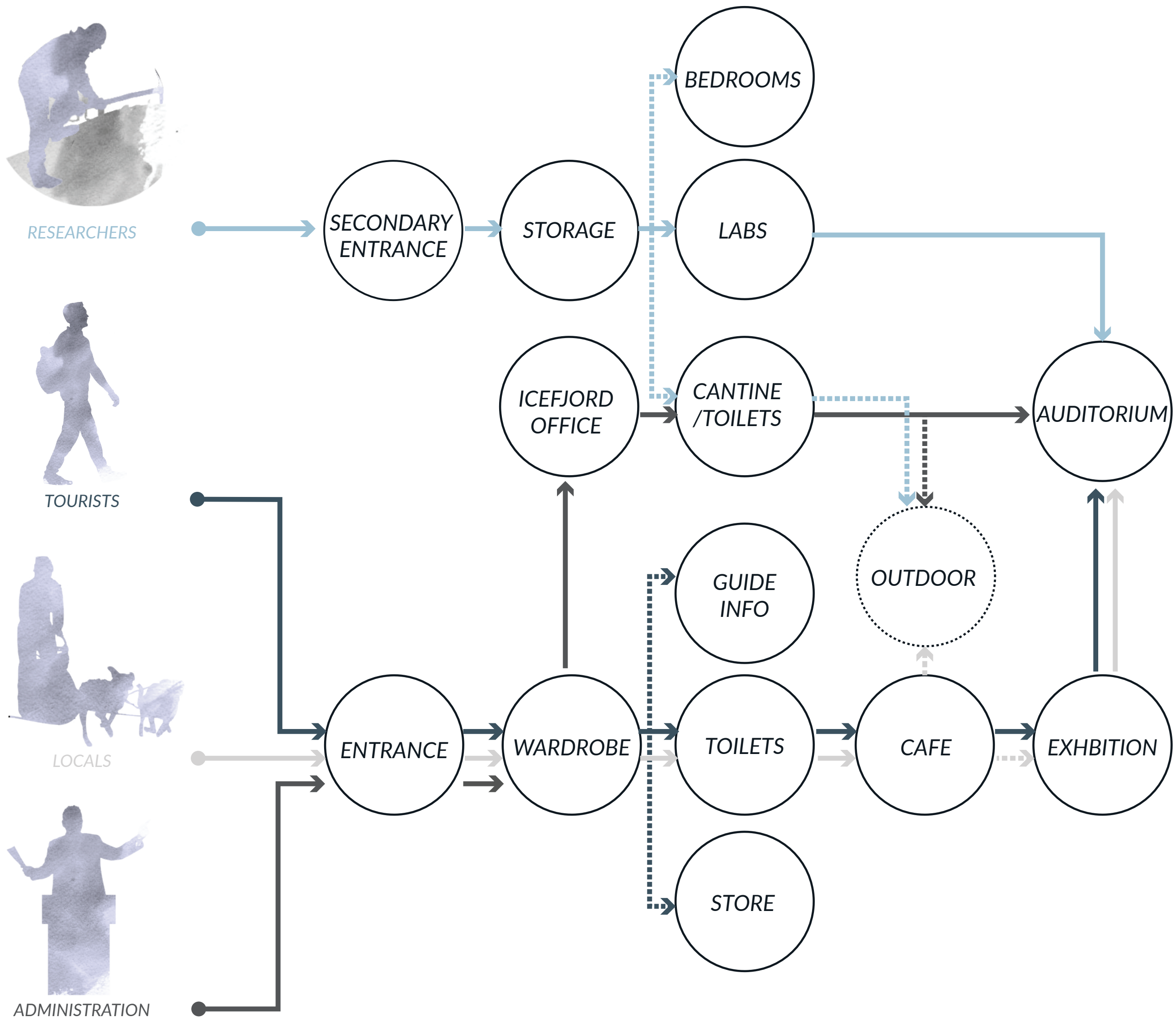
Having in mind aiming for a circular plan and better understanding of the likely behaviour of users, the next move was to dispose of the different functions in the building. The main idea was that each sector of the ring would be dedicated to different function, while also giving everybody the ability to move around the functions.
Disposal of the functions depended on few factors. One of them were directions of arrival. The main entrance would be facing the UNESCO boardwalk, as it is the most popular path, so the Center would be a stop on a way to the Icefjord. Then the secondary entrance for researchers would be in close proximity to the parking / old heliport, as those users might need to transport heavy equipment to their labs.
From the main entrance, there would be a clear disposal of tourist functions on one side and office functions on the other.
Another aspect was opening to the surroundings from inside out and giving views to the landscape. It is desired that exhibition and other tourist function have the visual connection towards the Icefjord, as that is the main reason they came to Ilullisat - to appreciate breathtaking vistas. On the other hand for the administration and researchers this visual connection is minor, as their are working in this environment every day - therefore they may have openings towards the town and mountains.



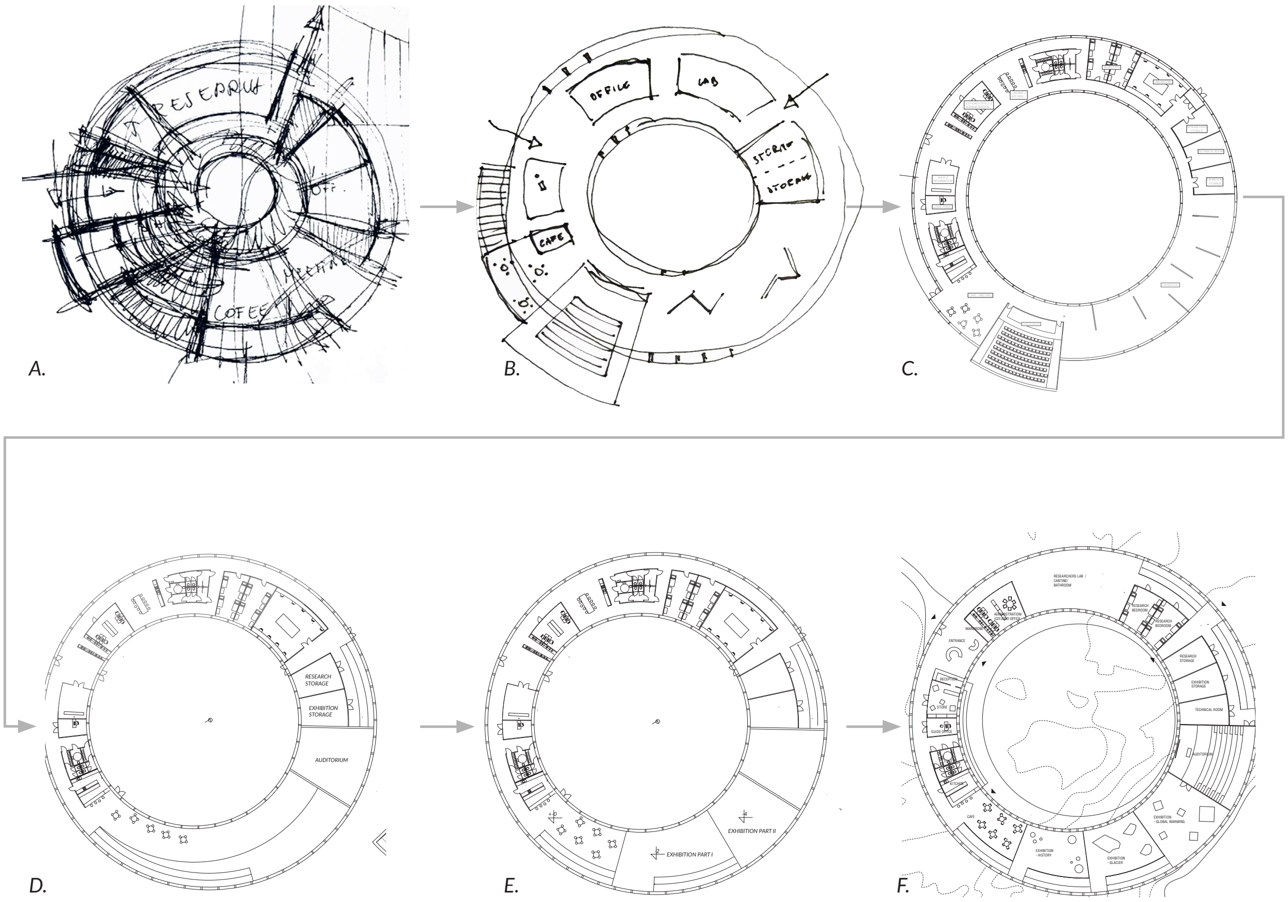
Ill. 5.5 Scenarios diagram

PROGRAM - SCENARIOS

After analysis of user groups and setting building program the next step was to imagine visitors behaviour in the Center. As the user groups are quite different in terms of their activities and needs, it is fundamental to understand their flows to give them a possibility to meet - without interrupting when it is not desirable.

As it was said before, there are three main types of people that will be using Icefjord Center - tourists, professionals (such as researchers and journalists but also Icefjord Office workers)and local inhabitants. The biggest focus is put on tourists, hence the biggest part of the design will be the exhibition. For the professionals, it is essential to give them privacy to work and rest, although it is not intention to isolate them completely from the other users. Local people mainly will use the Center as a cafe and a meeting point, although it might profit from it for instance by selling their works in the visitor's store, as guides in the guide point and so on. Interesting conclusion is that local people will use similar functions as tourist, which is a great value as a building should serve to share experiences between people of different background

Auditorium as a point of exchange of knowledge is dedicated for every user group and therefore should have the capacity to host a big amount of people and be accessible to everybody.

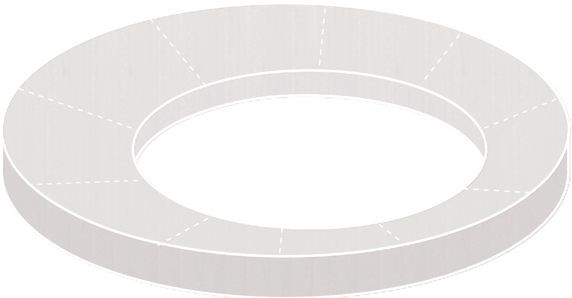


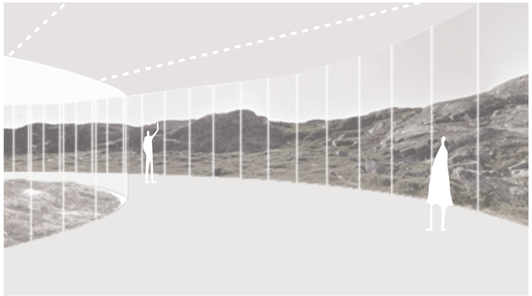
Ill. 5.6 Ciruclar plan development

CIRCULAR PLAN DEVELOPMENT

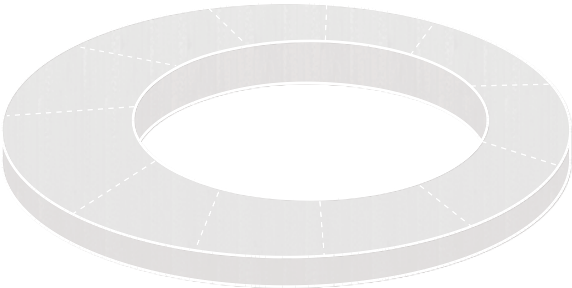
Having a vision of general disposal and idea about the flow between particular activities, the development of the floorplan could begin. First sketches A-C were discussing functions located on one level floorplan, where the functions are placed in the middle of and flow happens on both 'sides'. This, however, did not work too well with a steep terrain. Another issue is keeping the same width of the building does not differentiate the expression of functions such as exhibition, or is simply not enough for the capacity of the auditorium. Next steps D-F differentiate width within the ring but are also strictly connected with the investigation of relation with terrain (page 84). First consideration (D) was a version of creating a double-height exhibition, with a gallery that could serve as for instance cafe. Thus, this solution would separate exhibition, divide the flow and perhaps was not the best in terms of the following terrain. Sketches E. and F. are iterations where the base is scattered into smaller plateaus to follow the landscape and distinct different exhibition topics. Version F. is the one that was detailed and developed into the very final floorplan.

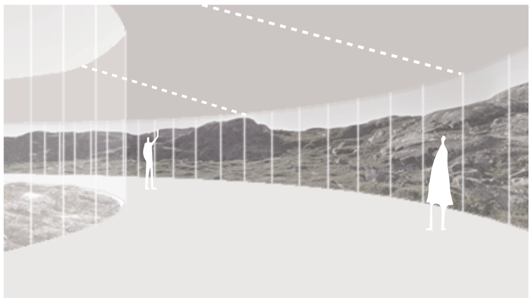
1. MONOTPITCHED ROOF SLOPE INWARDS



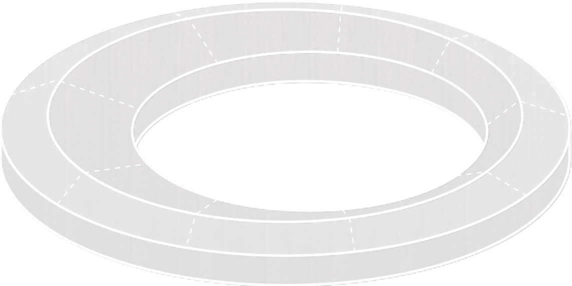


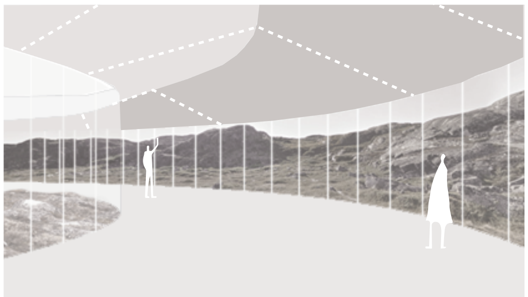
2. MONOTPITCHED ROOF SLOPE OUTWARDS





3. PITCHED ROOF





Ill. 5.7 Roof design process

ROOF

During developing the general vision for the project it was kept in mind that the project will be executed in a timber structure. The most obvious, but efficient and honest at the same time was a simple frame typology.
To define the initial shape of the frame further studies had been made (Ill.) Due to local climate conditions (snowfall) I started with a sloped roof. Then I have tried variations of different slope directions of a monopitched roof as well as the pitched roof, and later on compared them with the future experience of the visitors from inside.

Iteration 1, has been chosen due to the biggest openings towards surroundings as well as overall expression of keeping a straight line from the outside.

STRUCTURE - INITAL DIMENSIONING

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As the structure has a crucial influence on the interior, it was important to explore the possibilities of dimensioning it to achieve the best spatial qualities. The goal was possible lightest expression of the structure while keeping transparency to later on create openings to the lanscape. Following iterations of the span has been analyzed : 1.5m, 2.5m and 4 m,The final choice of 2.5 m span was a compromise between efficient structure and aesthetics.

The initial study was made with dimensioning with diagrams and the final choice was later on analysed in Robot after implementing load combinations.

STRUCTURE: TECTONICS / STEREOTOMICS RELATION WITH TERRAIN

As the landscape was one of the biggest challenges of the project, it is vital to mention

The initial vision of design was to create a tectonic structure, that horizontal line would create a contrast with the sloping terrain and therefore enhance its beauty. (Fig 1)

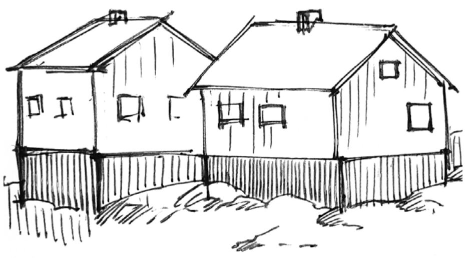
At this point, any relation with terrain could have been considered, for instance, a structure as a cantilever, structure floating above the terrain and supported on the columns etc.

However, a decision has been made to refer to traditional solid base foundation, typical for Greenlandic timber houses. (Fig 2) This solution also ensures durability and stable support, for, while the top tectonic structure is easy to transport and- sustainable mount by local labour.

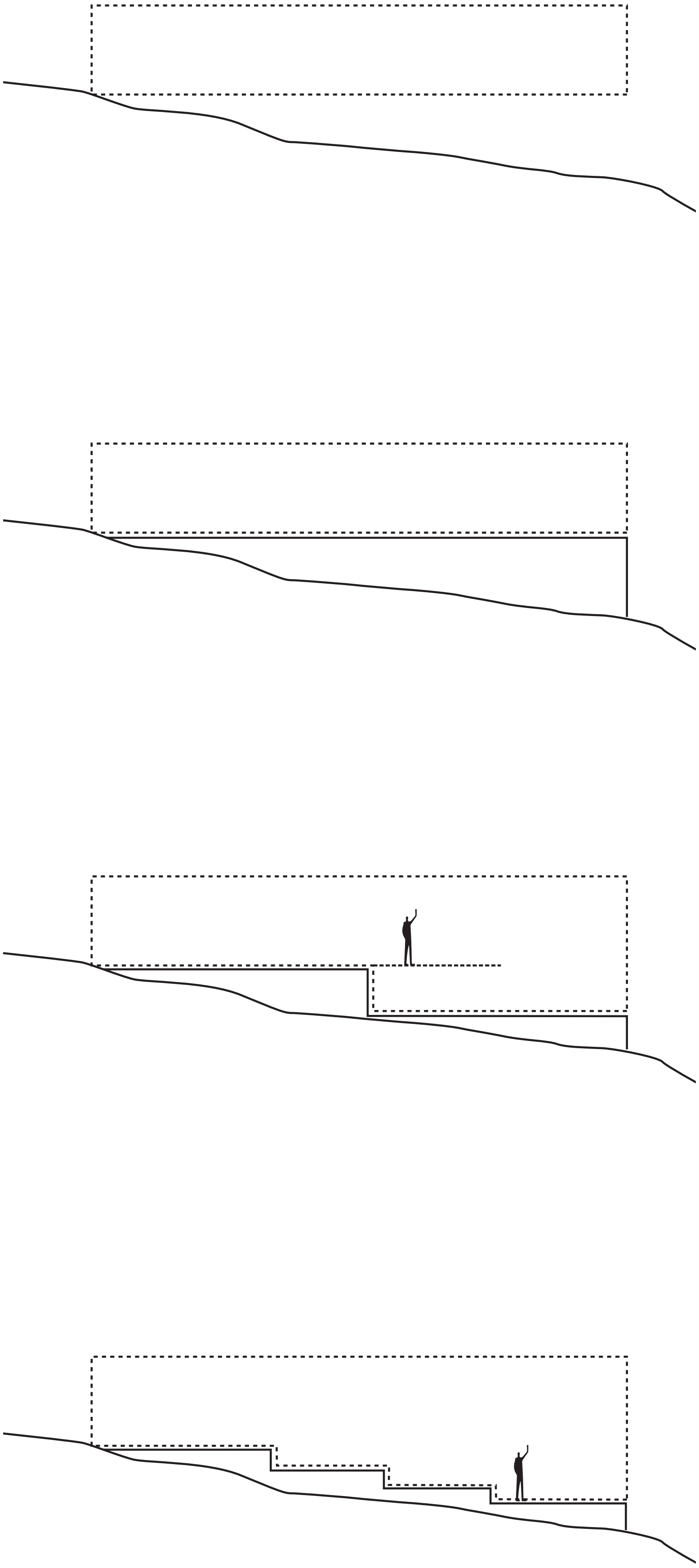
Nonetheless, this solution is not very efficient - in terms of use of space and materials. Therefore there has been an idea to 'push' the base in order to follow terrain more and in this way create two levels and/or gallery. Hence the '-1' level could be used as an exhibition space that can be observed also from the cafe (page 86 fic C). High ceiling will be also practical for future auditorium development.

This design, however, was against the idea of continuity of the space. Moreover, the 'step' in the base was again quite high. For this reason, decision has been made to make more smaller plateaus, where each could be dedicated to different function or different exhibition topic (fig d)

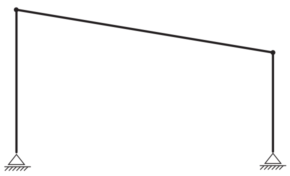
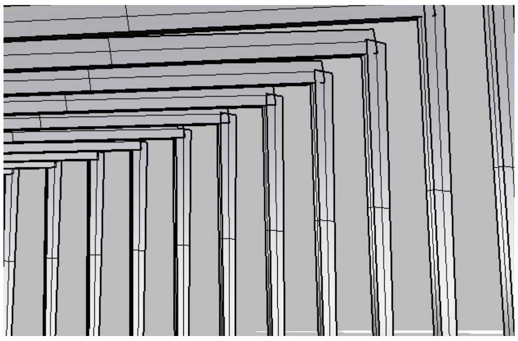
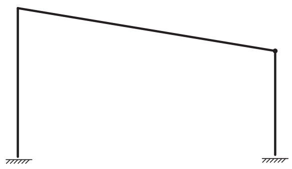
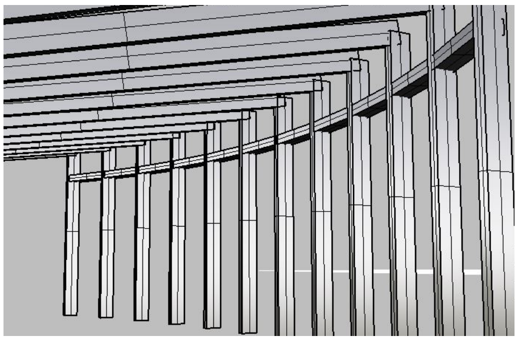
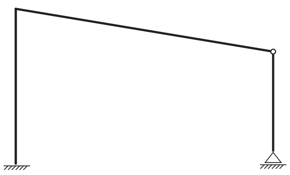
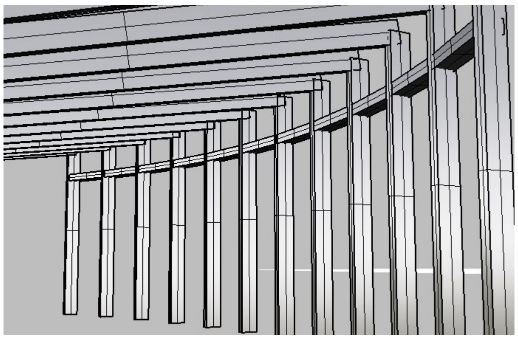
Each stereotomic plateau will be connected with ramps, to ensure accessibility for everybody.



Ill. 5.9 Greenlandic timber houses



Ill. 5.10 Relation with terrain proces diagram

STATIC SCHEME	*COLUMN DIMENSIONS*	*PERSPECTIVE VIEW*
	*COLUMN : 20x400/600 mm*	
	*COLUMN : 20x400/600 mm* *BEAM : 20x600 mm*	
	*COLUMN : 20x400/600 mm* *BEAM : 20x600 mm*	

Ill. 5.11 Static scheme test

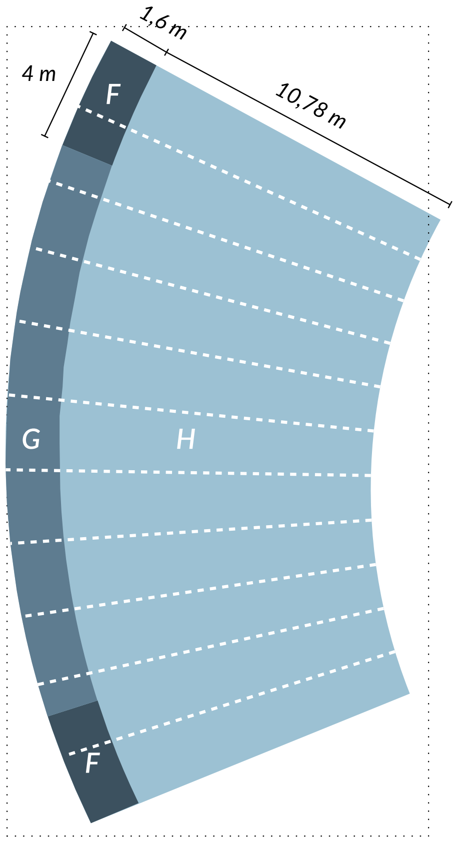
STATIC SCHEMES AND DIMENSIONING

…………………………………………………………………….

The next aspect that has been analysed was the static scheme. Three different solutions have been tested: A. Frame with fixed supports and fixed joints B. pinned supports and fixed supports and C. Mixed supports and mixed fixed and hinged joints.
As mentioned before, to evaluate which scheme will be the most efficient, single frame of the biggest span and height has been analysed in Robot.
To start with, as small sections are possible are checked in Robot. Then the results are compared by modelling the frames to see which scheme gives expression of the lightest structure and takes the least space from the floor.
The Robot results can be sen in the Appendix 3
The final choice was frame with pinned supports and fixed joints, as it gives the smallest dimensions most florplan space, therefore is the most efficient one.

LOADS

In order to find out the final dimensions of the structure the loads are calculated according to Eurocodes. The loads affecting structure are:
-self load,
-wind load
-snowload
Hand calculation of windload and snowload are attached in Appendix X, self load was calculated in Grasshopper to Robot plugin by adding the gravity load and the other roof components has been hand calculated (Appendix)
As the layout of the building is complex ánd does not simply fit into Eurocode handbook, herefore, a simplification had to be done.
Therefore, I decided to examine in Robot a section of the circle with the biggest span and height of the frames (auditorium and exhibition area). In the calculation of loads and load distribution the section was assumed a rectangular. The idea behind analysing just this section was that the strucutre will have same dimensions in the whole building, therefore if it will work for the biggest heigh and span, it will for for everywhere.
According to the Eurocodes structure has been divided into zones in order to apply correctly loads to the different parts of the structure.
The structure has been analysed for different load combination, in Appendix XX there can be seen results for SLS with dominating wind load.



Ill. 5.12 Load zones

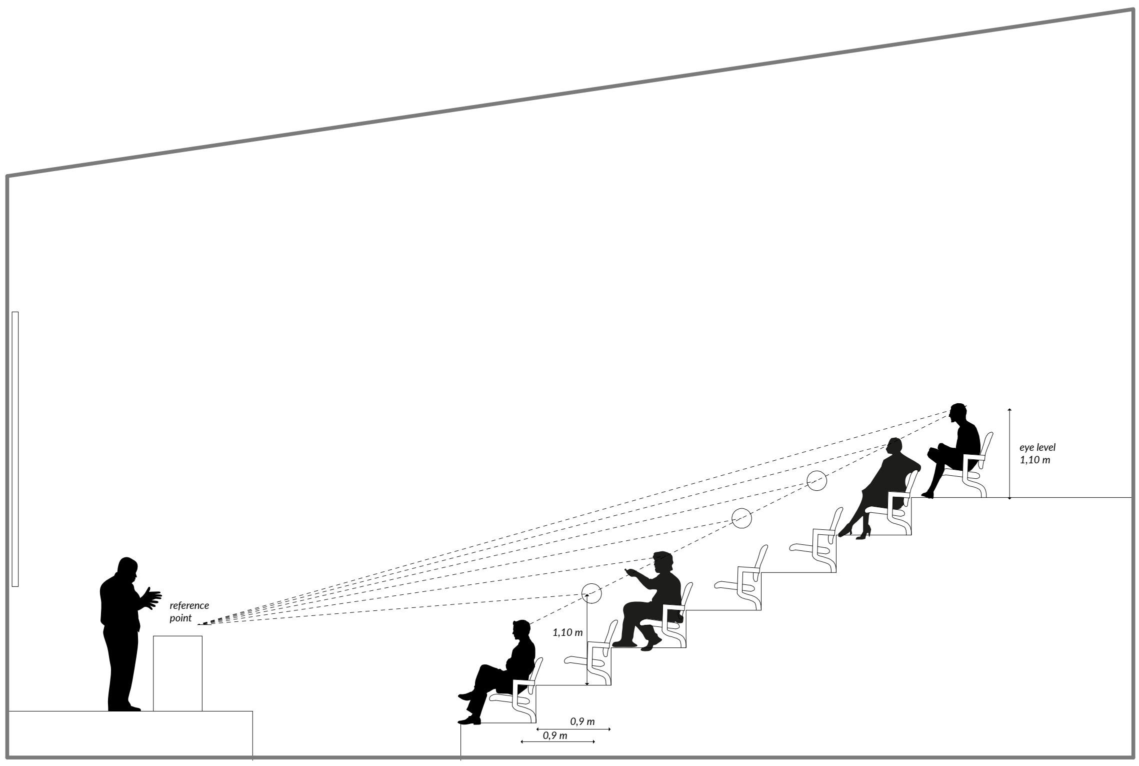
ULS - DOMINATING SNOW LOAD

ULS - DOMINATING WIND LOAD

SLS - DOMINATING SNOW LOAD

SLS - DOMINATING WIND LOAD

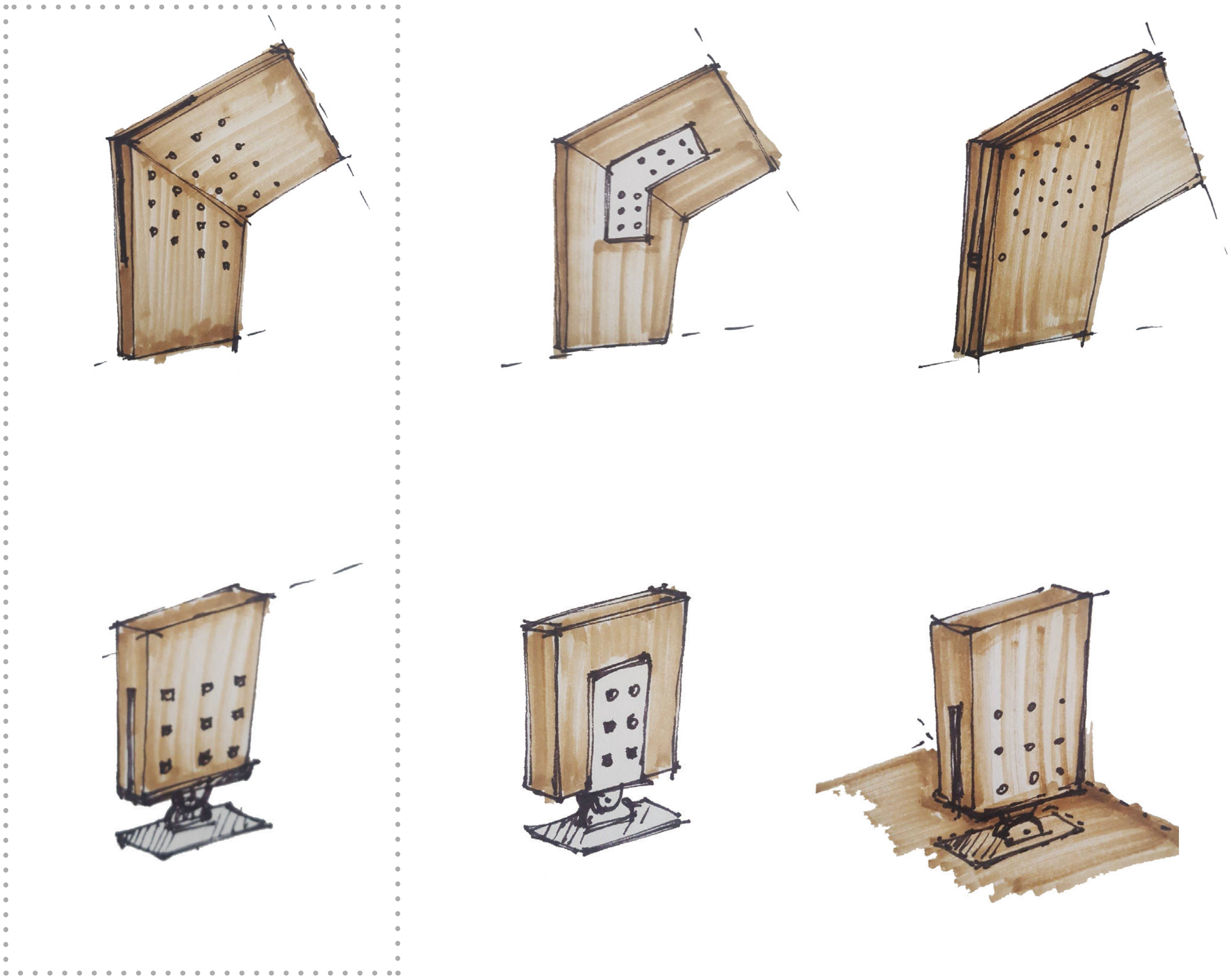
Ill. 5.13 Load combinations



Ill. 5.14 Visibility diagram

AUDITORIUM

Before I started with acoustics studies of the auditorium. I wanted to assure its functionality and visibility. The auditorium is dedicated to approximately 120 listeners. Fan shape of the room determined by the circular plan of the Center is an often used layout for lecture halls and small auditoria, therefore, there was not any bigger challenges. I decided to create steps that will raise up the audience so all the listeners can see both speaker and the screen. Wooden steps are further considered in the Pachyderm model. Different dimensions of the auditorium has been considered and Pachyderm results together with ray trace analysis can be seen in Appendix 3



Ill. 5.16 Timber joints

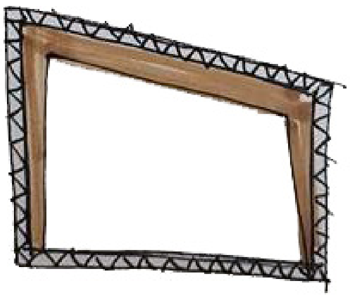
DETAILING THE CONSTRUCTION

…………………………………………………………………..

As the type of joint and supports were chosen, the next step was to investigate them in detail.
Considered joints were
A. hidden connection as a metal plate in between post and beam, with visible bolts
B. joint with a metal plate visible
C. joint of a beam in between two post elements
However solution C. has an advantage of possibility of mounting on the site (and therefore is easier to transport) solution A, has been chosen to not introduce additional elements and keep simple expression.
The pinned supports could be designed in either visible or partly visible joint that lifts the columns up from the floor and makes them appear lighter. Decision has been made that the metal connection with the base will be exposed , keeping in mind desired, honest tectonic experience.
Therefore, combination A.1. is the one used in the project.

Sustainability should be one of the crucial aspects of Illulisat Visitor Center, which in this project will reflect mainly in detailing envelope. However, all the following solutions and considerations are done on the conceptual level, therefore no simulations or calculations will be done.

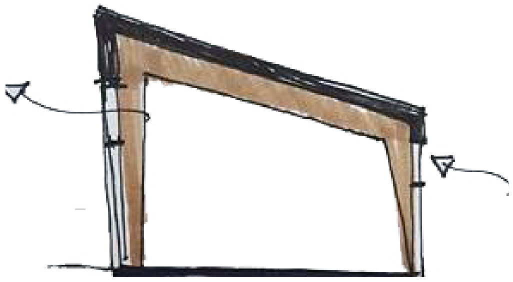
U-VALUE AND AIRTIGHTNESS
The primary solution is ensuring that building is properly insulated and air tight, especially due to harsh local climate conditions. Heating and cooling are the most energy-consuming aspects, thus this can be lowered by thick insulation.
Another aspect can be reducing thermal bridges, therefore the decision has been made to not expose loadbearing structure outside, but keep it insulated on the inner side of the envelope. There might be considered tectonic consideration of exposing the structure also from outside, although in the chosen solution the structure will still be exposed from the inside in an honest way while being functional in this climate.
Currently, Greenland is just introducing... and temporary follows Danish BR10, but plans are to improve it to therefore the project will aim for BR15 (U-value of)



Ill. 5.17 Envelope principle

GLAZING AND SHADING
As one of the design goals is a visual connection with the landscape, thus it will be desired to create a lot of glazed surfaces.
One issue high percentage of glazed areas is bigger transmission loss through those. Therefore to improve the indoor climate the used windows should be of a low g-value,
Moreover, Greenland during summer months day lasts 24 hours, moreover during the bright days sun is quite low above the horizon - those factors combining with light reflected from the snow or lake may cause glare. This effect is undesirable - especially in the exhibition area. Columns of the timber structure will diffuse the light in the glazed areas, although for the specific times during the year/day it might be needed to incorporate an active internal shading, that would also prevent overheating.

NATURAL VENTILATION
As the building layout is ring-shaped, the 'width' of the ring is approximately 10 m (and at the widest point it is 14 m). Moreover, there are window openings on both internal and outer ring, thus natural ventilation will occur.
However, as the building is circular openings are not always perpendicular to the wind. Due to the shape of the roof, it is possible to create openings on different heights, and thus enhance the ventilation with thermal buoyancy effect.



Ill. 5.1 Envelope principle

CLADDING
Qualities of sustainable cladding should be durability and low- maintenance, especially to withstand hard climate of Greenland. However, cladding impregnates and paints are most of the time not environmentally friendly therefore it will be desired to find a solution that is both efficient and natural.

VS.

Ill. 5.19 Charred wood

Ill. 5.20 Weathered wood

MATERIALS - EXTERIOR

As the tectonics principals have been used from the beginning of design process, it was known that light materials will be used - such as timber cladding for external envelope. , consequently, the only choice had to be done between the type of timber. The objective was to use in design a durable, but the environmentally friendly cladding - thus conventionally impregnated wood was not a choice. Naturally weathered wood, however beautiful, would not be durable enough in harsh Greenlandic climate. Therefore the solution of charred wood has been chosen to give the cladding life longevity.u

As the wood used in Greenland is typically imported from Scandinavia (mostly Norway) therefore the type of timber has been chosen spruce

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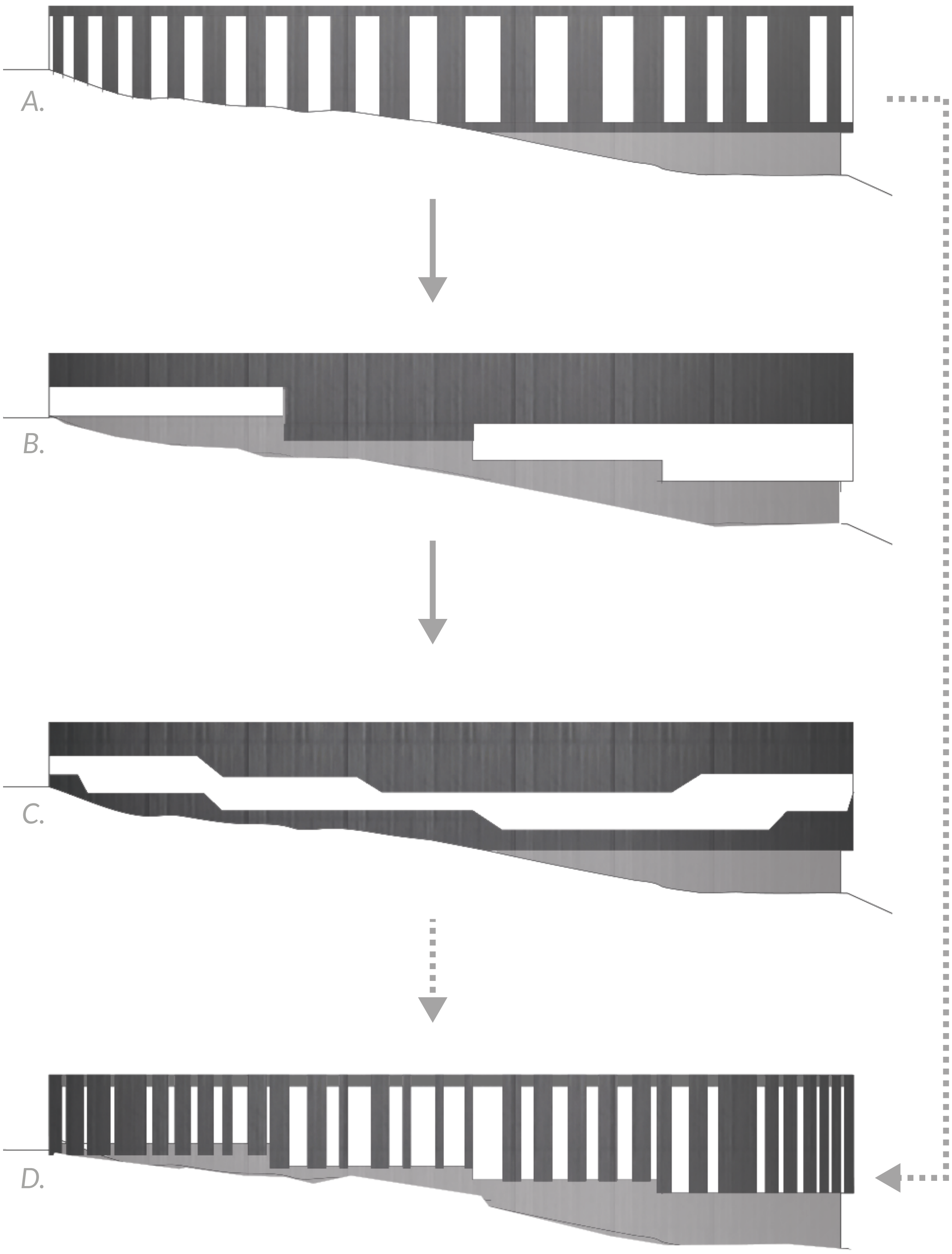
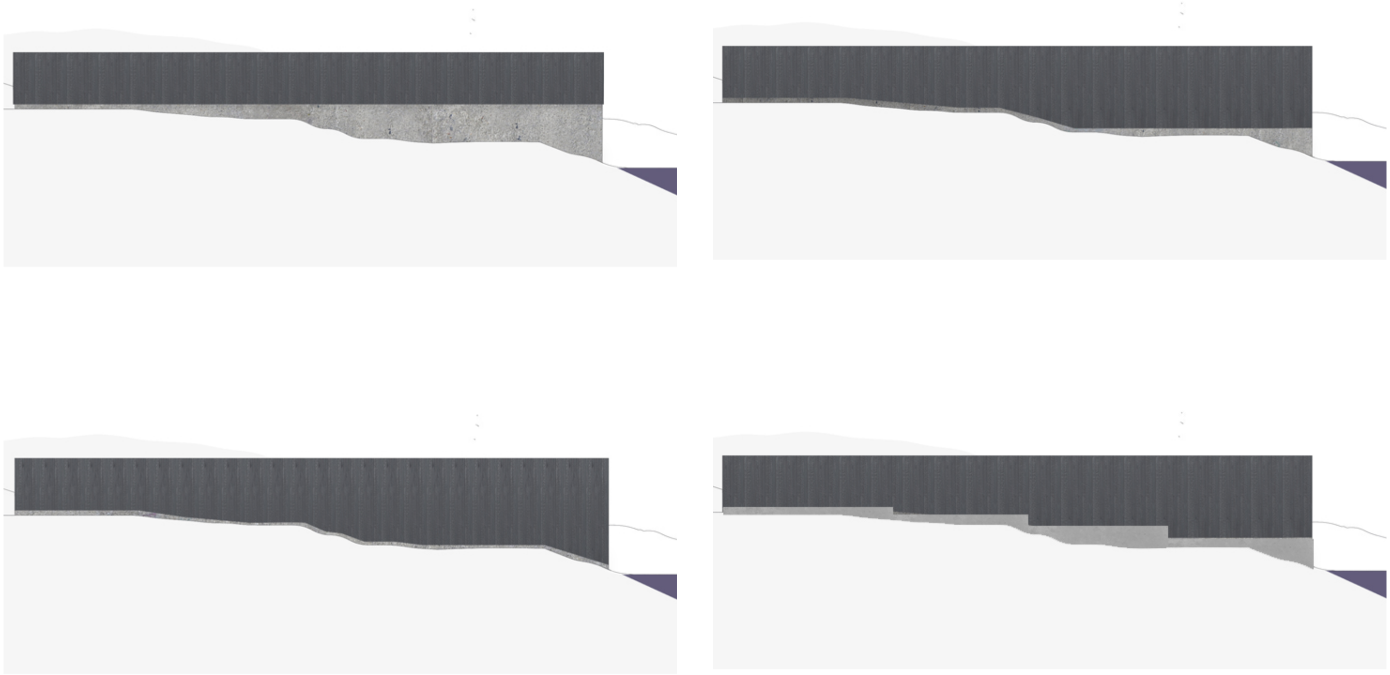


Ill. 5.23 Development of window openings

Ill. 5.24 Directioning the view

DETAILING WINDOW OPENINGS

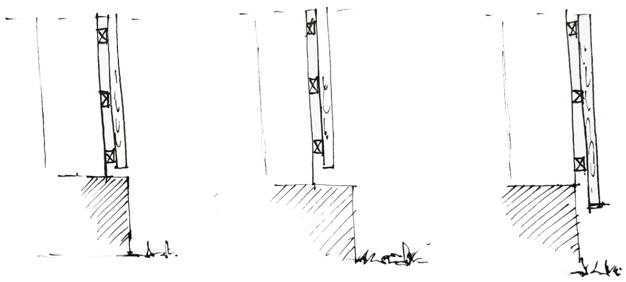
For the elevation of the Centre different types of window openings were investigated.
The very first idea (A.) was the simple vertical typology of a static expression, where glazing is put in between the frames. This, however, were resulting in too big openings, and difficult to differentiate. Therefore some windows of more horizontal typology were tested (B.) as well as more dynamic, that follow the sight line of visitor and opens up more towards the interesting views (C.). This iterations again were hard to differentiate the atmosphere from the inside, while looking unorganized on the outside. Therefore the step back has been made to the vertical openings, this time gradually opening up or closing off depending on the need. The 'gradient' opens up in functions such as cafe and entrance and closes on the north facade or in the passages, just to inlet enough light.
As the windows are placed always one edge to the frame, this is used to controlling the view, as dependin on the direction we can have different spectrum of view (Ill. 5.24)



Ill. 5.21 Meeting with the base proces diagram

MEETING WITH THE BASE

The solid base foundation on which the building is standing has a big influence on overall expression of the building, therefore it was an object of investigation.
The illustration above presents different possible solutions. Illustration nr .. presentsa version where the base does not change its level. Illustration is an iteration where the both light structure and foundation are covered with cladding, and it is not possible to recognize them from the outside. A-ws the intention was the most possible honest language betwen the foundation and light structure therefore the option on the Ill. XX has been chosen.



Ill. 5.22 Detailing the meeting of cladding and foundation

Next step was to decide how the two materials meet in detail. Illulstration XX shows different possibilities of detailing, The option on Ill. X.X has been chosen .

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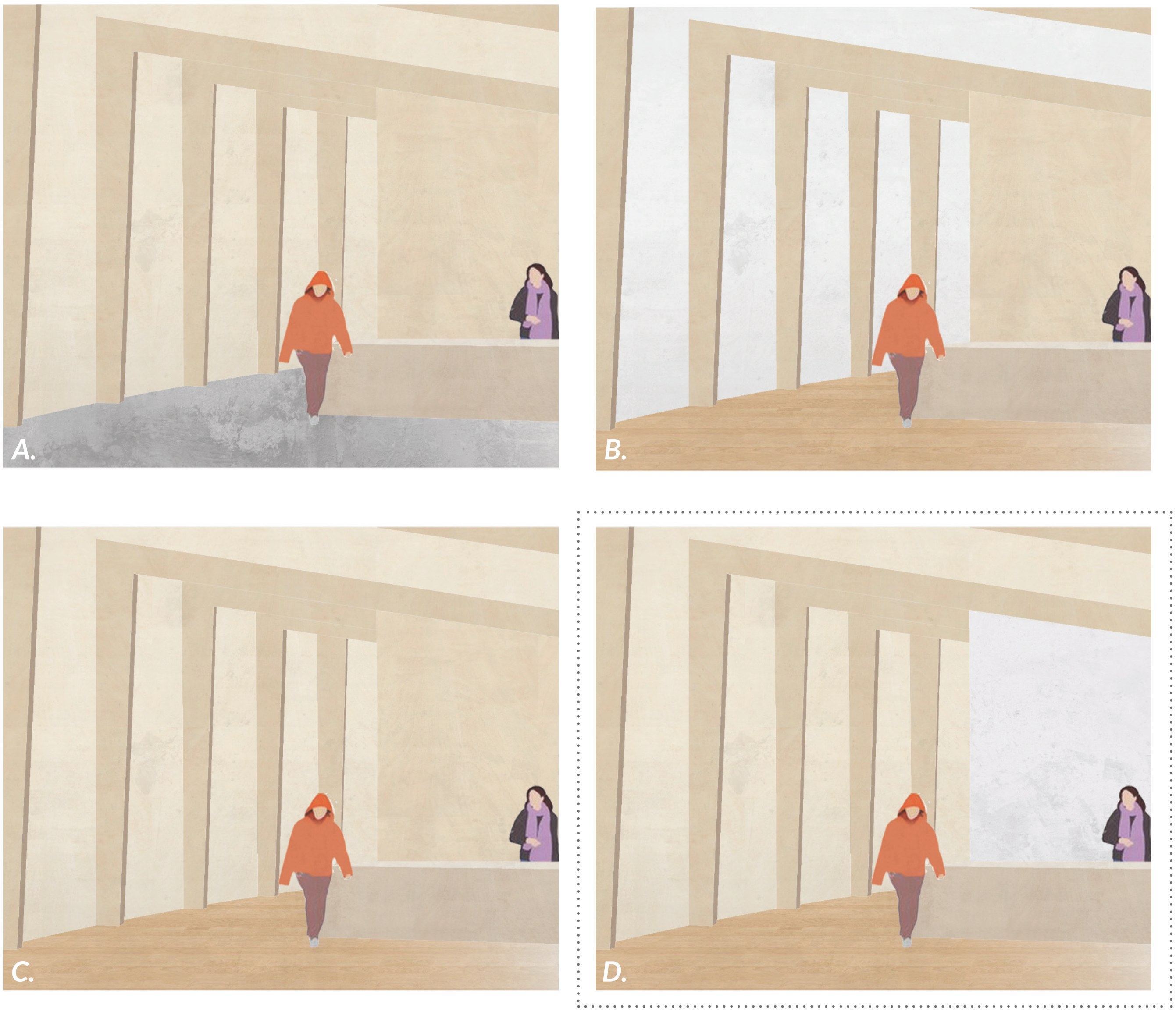

Ill. 5.25 Interior materials studies

MATERIALS INSIDE

When detailing materials inside the goal was to create warm, bright interiors where visitors can relax after hiking in the outdoors. The defined element are glulam frames. Illustratior 5.25 shows different consideration of the materials, combining wooden or concrete floor and plywood or white plaster walls. However wood is desired material, to break the monotony iteration D. has been chosen, where the white rooms are standing out while the main walls are warm plywood.

06

EPILOGUE

This part consist of brief conclusion and honest reflection on the project.

CONCLUSION

……………………………………………………………….

Ilulissat is already a destination for visitors to both admire the unspoilt beauty of Arctic landscape and be where climate change unfolds. The visitor centre should enhance the experience by communicating knowledge as well as giving a possibility to stop, relax and simply admire the surroundings.
As the site provides beautiful natural scenery, the main concept of design was the juxtaposition of landscape and information centre. This has been tried to achieve through clear design identity that is visible but not intruding element in the landscape The idea was to create aesthetically simple and attractive proposal. The result is an architectural concept of the circular plan, strengthen during a design process. A building, that distribution of functions relies on the flow around spaces. There is no main room in the Center but rather the design is conceived as a loop where different activities permeate.
One of the fundamental ideas behind the design is the stereotomic base follows the terrain and refers to the Danish colonial housing, typical for Greenlandic landscape. Heavy placement in the landscape ensures stability and durability. On the other hand, the building primary structure is a light wooden structure which top line remains straight and contrasting with the terrain slope. The changing 'gap' between heavy base and the light roof creates spaces of different qualities.
Honest expression of the building is complemented via the visible structure, light transparency and contact with a ubiquitous beauty of nature.
I believe that Ilulissat Icejfjord Center due to its qualities and accessibility is the building that could bring a wider range of people and therefore contribute to Ilulissat locally and globally to the climate change discussion.

REFLECTION

………………………………………………………………..

Working on Illulisat Icejfjord Center was an uneasy task. The site provides naturally beautiful scenery, which the objective was to enhance it without taking main attention from the landscape. Thus, there was a need to balance many aspects of the project. The architectural approach was held through Integrated Design Process, which, working on my own was a great challenge, but allowed me a full understanding of every part of design, both conceptual and technical ones.
However, there were no radical changes in the project through the design process, but a rather constant improvement detailing of the starting idea.
Main design parameters and main concept were used as a design tool, that allowed me to accomplish the project with a strong vision.
Nonetheless, I am aware that there are aspects of the project that could be developed more in details and some could have been studied deeper in order to achieve better qualities. If the time frame would be longer, I would like to focus more on detailing of the project envelope, in terms of the design of openings or perhaps introducing a shading system. However, the precise light analysis came a little bit late in the studies, and therefore some design aspects have already been unchangeable Also acoustic aspects could have been studied more in detail, not only in the auditorium but in overall building.
Moreover, in some cases, design principals have been set very early in the process, such as for example structural concept, which if done otherwise could bring new design possibilities.
Another aspect was lacking discussion, that would occur naturally during teamwork. Therefore, it necessary to force myself into honest reflecting of my own concepts and ideas and taking 'step back' every now and then.
Despite this, reviewing the overall process, I believe that main objective has been achieved and coherent design has been made. In my opinion the idea behind the project is clear and tectonic and nordic qualities visible. I have no doubt that the building would fulfill the needs of visitors.
Last but not least, the project has testified my skills and accomplishing this design I consider my personal achievement. In conclusion, I hope that my design proposal for Ilulissat Icefjord Center attained well the design parameters stated before

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Dansk Standard, Eurocode 0

Dansk Standard, Eurocode 1-1-3

Dansk Standard, Eurocode 1-1-4

Dansk Standard, Eurocode 5

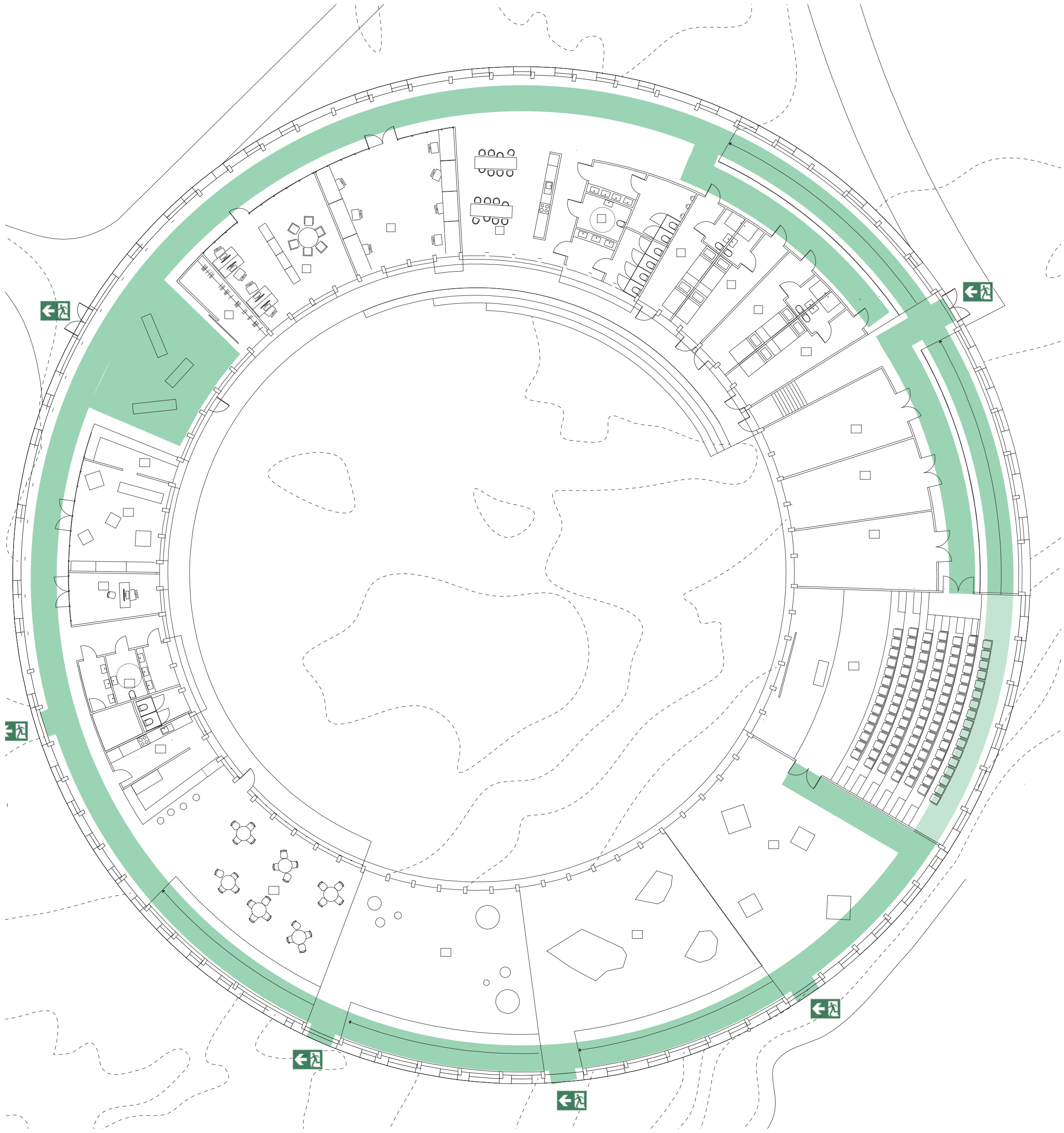
ILLUSTRATION LIST

……………………………………………………………….

Ill. 1.1 Illulisat Icejford
Ill. 1.2 Own drawing
Ill. 1.3 Own drawing
Ill. 1.4 http://www.designboom.com/architecture/ryuji-fujimura-architects-facility-for-ecology-education-tokyo-japan-07-20-2014/
Ill. 1.5 http://www.archdaily.com/784536/ad-classics-nordic-pavilion-in-venice-sverre-fehn
Ill. 2.1 https://visitgreenland.photoshelter.com/galleries/C0000J85Qo_d.wCE/G0000wJ0YaL.BKVY/Ilulissat Copyrights: Mads Pihl
Ill. 2.2 Own drawing
Ill. 2.3 Own drawing
Ill. 2.4 Own drawing
Ill. 2.5 Ilulissat Icefjord Centre competition brief by Realdania and Quasuitsuup Municipality
Ill. 2.6 Own drawing
Ill. 2.7 - 2.11 Own drawing
Ill. 2.12 http://www.gaisma.com/en/location/ilulissat.html
Ill. 2.13 https://weatherspark.com/y/29789/Average-Weather-in-Ilulissat-Greenland
Ill. 2.14 https://www.google.dk/search?q=windfinder+ilulissat&oq=windfinder+ilulissat&aqs=chrome..69i57.4619j0j4&sourceid=chrome&ie=UTF-8
Ill. 2.15 http://www.greenland.com/en/about-greenland/nature-climate/climate-changes/
Ill. 3.1 https://visitgreenland.photoshelter.com/galleries/C0000J85Qo_d.wCE/G0000wJ0YaL.BKVY/Ilulissat
Ill. 3.2 http://tinyhouseblog.com/tinyhousehistory/igloos-ice-tiny-houses-inuit-culture/
Ill. 3.3 http://www.glenbow.org/thule/?lang=en&p=outside&t=enhanced&s=3-2&q=4&mi=4
Ill. 3.4 http://www.istockphoto.com/dk/photo/greenland-homes-gm184285576-17194329
Ill 3.5
Ill. 3.6
Ill. 3.7- 3.8 Own drawing
Ill. 4.1 https://visitgreenland.photoshelter.com/galleries/C0000J85Qo_d.wCE/G0000wJ0YaL.BKVY/Ilulissat
Ill 4.2 - 4.16 Own drawings
Ill. 5.1 Own photo
Ill. 5.2 - 5.18 Own drawings
Ill. 5.19 http://inhabitat.com/the-observatory-is-a-duo-of-charred-timber-off-grid-artists-studios-traveling-around-the-uk/feilden-clegg-bradley-studios-charred-wood-mobile-artists-studios-3/
Ill. 5.20 http://download.highgraphic.com/aquafina/textures/80517558_highgraphic.com.jpg
Ill. 5.21 - 5.26 Own drawings

APPENDIX

In this part there is described methodology, approach and main focus of the project.



The layout of the building should be done in a way that there is an access outside in case of an emergency. In any case there can not be more than 25 meters to the exit or an emergenxy opening.
Sections of the building are under different categories, depending of their function. Auditorium of a capacity of 120 people is under category 3, while the other rooms are under category 1. However, it is sufficient for the jount escape routes to all fullfill the application of category 3, and therefore escape routes should have a width of minimum 130 cm [Bygningsreglementet, 2012]
The access to these exits should have an even distribution of the users and there always should be multiple excape options - all windows big enough for a person to pass through is considered an escape opening [Bygningsreglementet, 2021]

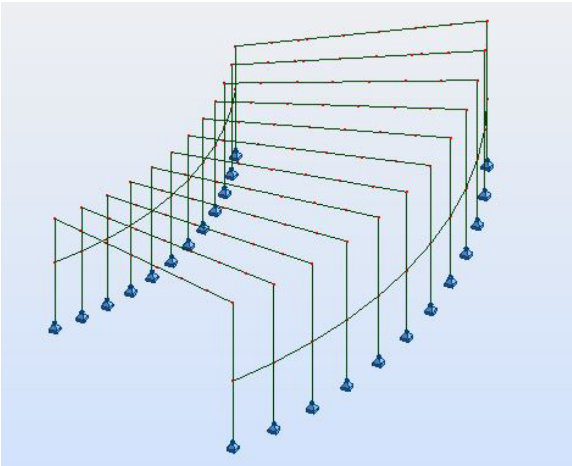
ROOM PROGRAM

ROOM :	m2
1. ENTRANCE & RECEPTION	80,6
2. WARDROBE	11,5
3. ICEFJORD OFFICE /ADMINISTRATION	42
4. RESEARCH LAB	47,7
5. CANTINE & KITCHEN	43
6. TOILETS	31,7
7. BEDROOM	19,7
8. BEDROOM	19,7
9. BEDROOM	19,7
10. STORAGE	38,9
11. STORAGE	38,4
12. TECHNICAL ROOM	28,2
13. AUDITORIUM	154,5
14. EXHIBITION- GREENLANDIC CULTURE	132,2
15. EXHIBITION - ICEFJORD	137
16. EXHIBITION - CLIMATE CHANGE	119
17. CAFE	106
18. CAFE KITCHEN	23
19. TOILETS	24,6
20. GUIDE OFFICE	15,6
21. STORE	30
TOTAL :	1650 m2

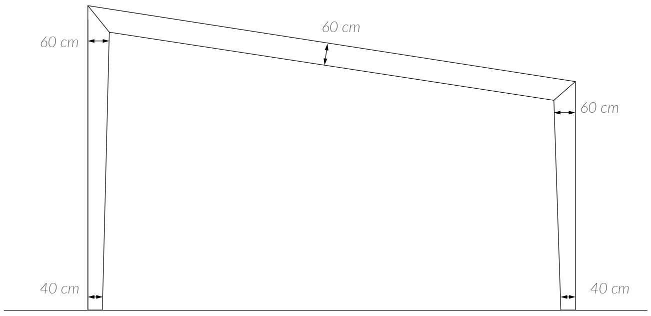
APPENDIX 2 // FINAL ROBOT ANALYSIS

………………………………………………………………..

STRUCTURE



DIMENSIONS



MEMBER VERIFICATION

73	OK	Middle_Beam	GL32h	53.89	215.58	0.49	11 ULS - Dom. wind
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76	OK	Middle_Beam	GL32h	55.60	222.41	0.17	11 ULS - Dom. wind
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88	OK	Columns_3_1	GL32h	17.77	103.92	0.06	10 ULS - Dom. sno
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99	OK	Columns_3_1	GL32h	23.69	138.56	0.13	11 ULS - Dom. wind
100	OK	Columns_3_1	GL32h	23.69	138.56	0.18	11 ULS - Dom. wind
101	OK	Columns_3_1	GL32h	23.69	138.56	0.13	11 ULS - Dom. wind
102	OK	Columns_3_1	GL32h	23.69	138.56	0.12	11 ULS - Dom. wind
103	OK	Columns_3_1	GL32h	23.69	138.56	0.08	11 ULS - Dom. wind
104	OK	Columns_3_1	GL32h	23.69	138.56	0.06	11 ULS - Dom. wind
105	OK	Columns_3_1	GL32h	23.69	138.56	0.06	11 ULS - Dom. wind
106	OK	Columns_3_1	GL32h	23.69	138.56	0.09	11 ULS - Dom. wind
107	OK	Columns_3_1	GL32h	23.69	138.56	0.12	11 ULS - Dom. wind
108	OK	Columns_3_1	GL32h	23.69	138.56	0.14	11 ULS - Dom. wind
109	OK	Columns_3_1	GL32h	23.69	138.56	0.15	11 ULS - Dom. wind
110	OK	Columns_3_1	GL32h	23.69	138.56	0.16	11 ULS - Dom. wind
111	OK	Cross Segme	GL32h	28.89	17.33	0.02	11 ULS - Dom. wind
112	OK	Cross Segme	GL32h	18.26	10.96	0.07	11 ULS - Dom. wind
113	OK	Cross Segme	GL32h	28.89	17.33	0.03	11 ULS - Dom. wind
114	OK	Cross Segme	GL32h	28.89	17.33	0.01	11 ULS - Dom. wind
115	OK	Cross Segme	GL32h	28.89	17.33	0.02	11 ULS - Dom. wind
116	OK	Cross Segme	GL32h	28.89	17.33	0.01	11 ULS - Dom. wind
117	OK	Cross Segme	GL32h	28.89	17.33	0.01	8 Wind Load_Zone I
118	OK	Cross Segme	GL32h	28.89	17.33	0.03	8 Wind Load_Zone I
119	OK	Cross Segme	GL32h	28.89	17.33	0.03	11 ULS - Dom. wind
120	OK	Cross Segme	GL32h	28.89	17.33	0.03	11 ULS - Dom. wind
121	OK	Cross Segme	GL32h	28.89	17.33	0.03	11 ULS - Dom. wind
122	OK	Cross Segme	GL32h	28.89	17.33	0.03	11 ULS - Dom. wind
127	OK	Cross Segme	GL32h	18.26	10.96	0.04	11 ULS - Dom. wind
128	OK	Cross Segme	GL32h	18.26	10.96	0.03	11 ULS - Dom. wind
129	OK	Cross Segme	GL32h	18.26	10.96	0.03	11 ULS - Dom. wind
130	OK	Cross Segme	GL32h	18.26	10.96	0.02	8 Wind Load_Zone I
131	OK	Cross Segme	GL32h	18.26	10.96	0.02	8 Wind Load_Zone I
132	OK	Cross Segme	GL32h	18.26	10.96	0.04	8 Wind Load_Zone I
133	OK	Cross Segme	GL32h	18.26	10.96	0.04	11 ULS - Dom. wind
134	OK	Cross Segme	GL32h	18.26	10.96	0.05	11 ULS - Dom. wind
135	OK	Cross Segme	GL32h	18.26	10.96	0.06	11 ULS - Dom. wind
136	OK	Cross Segme	GL32h	18.26	10.96	0.07	11 ULS - Dom. wind

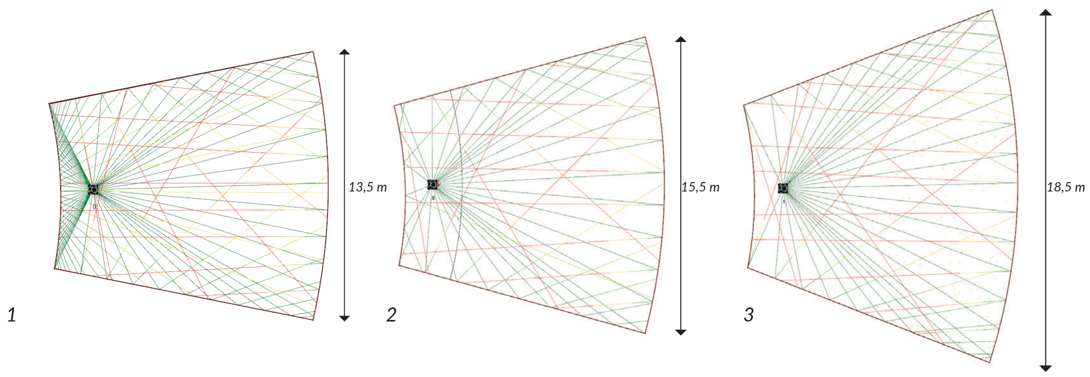
APPENDIX 3 // PACHYDERM RESULSTS

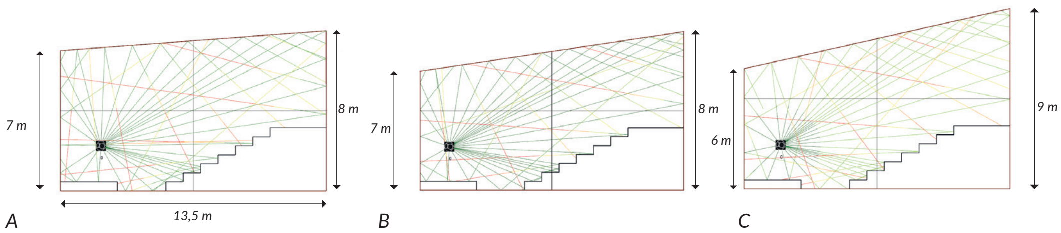
....

PACHYDERM RESULTS RT60

		1	2	3
A	rec0	T-30 ISO Compliant: Yes 62.5 hz. : 2.84 s. 1000 hz. : 8.22 s. 125 hz. : 1.53 s. 2000 hz. : 46.4 s. 250 hz. : 0.58 s. 4000 hz. : 0.06 s. 500 hz. : 0.54 s. 8000 hz. : 0.06 s.	Parametric Analysis T-30 ISO Compliant: Yes 62.5 hz. : 2.02 s. 1000 hz. : 14.65 s. 125 hz. : 0.22 s. 2000 hz. : 0.22 s. 250 hz. : 1.61 s. 4000 hz. : 0.4 s. 500 hz. : 1.24 s. 8000 hz. : NaN s.	T-30 ISO Compliant: Yes 62.5 hz. : 0.29 s. 1000 hz. : 0.21 s. 125 hz. : 119.11 s. 2000 hz. : 0.21 s. 250 hz. : 1.95 s. 4000 hz. : 9.15 s. 500 hz. : 0.07 s. 8000 hz. : NaN s.
	rec1	62.5 hz. : 1.5 s. 1000 hz. : 1.48 s. 125 hz. : 1.6 s. 2000 hz. : 2.32 s. 250 hz. : 0.38 s. 4000 hz. : 0.6 s. 500 hz. : 0.39 s. 8000 hz. : 48.27 s.	T-30 ISO Compliant: Yes 62.5 hz. : 1.47 s. 1000 hz. : 0.54 s. 125 hz. : 1.2 s. 2000 hz. : 6.14 s. 250 hz. : 0.59 s. 4000 hz. : 1.4 s. 500 hz. : 0.55 s. 8000 hz. : 15.88 s.	T-30 ISO Compliant: Yes 62.5 hz. : 1.16 s. 1000 hz. : 0.79 s. 125 hz. : 0.08 s. 2000 hz. : 0.5 s. 250 hz. : 1.22 s. 4000 hz. : 7.22 s. 500 hz. : 1.19 s. 8000 hz. : 11.58 s.
B	rec0	-30 ISO Compliant: Yes 2.5 hz. : 1.64 s. 1000 hz. : 35.45 s. 25 hz. : 0.47 s. 2000 hz. : 6.66 s. 50 hz. : 0.6 s. 4000 hz. : 4.76 s. 00 hz. : 1.16 s. 8000 hz. : 4.05 s.	T-30 ISO Compliant: Yes 62.5 hz. : 1.18 s. 1000 hz. : 0.41 s. 125 hz. : 0.54 s. 2000 hz. : 2.42 s. 250 hz. : 0.48 s. 4000 hz. : 8.03 s. 500 hz. : 0.54 s. 8000 hz. : 2.03 s.	T-30 ISO Compliant: Yes 62.5 hz. : 0.29 s. 1000 hz. : 0.21 s. 125 hz. : 119.11 s. 2000 hz. : 0.21 s. 250 hz. : 1.95 s. 4000 hz. : 9.15 s. 500 hz. : 0.07 s. 8000 hz. : NaN s.
	rec1	62.5 hz. : 1.58 s. 1000 hz. : 3 s. 125 hz. : 2.19 s. 2000 hz. : 347.84 s. 250 hz. : 0.97 s. 4000 hz. : 0.38 s. 500 hz. : 2.99 s. 8000 hz. : 33.45 s.	T-30 ISO Compliant: Yes 62.5 hz. : 1.47 s. 1000 hz. : 0.54 s. 125 hz. : 1.2 s. 2000 hz. : 6.14 s. 250 hz. : 0.59 s. 4000 hz. : 1.4 s. 500 hz. : 0.55 s. 8000 hz. : 15.88 s.	T-30 ISO Compliant: Yes 62.5 hz. : 1.16 s. 1000 hz. : 0.79 s. 125 hz. : 0.08 s. 2000 hz. : 0.5 s. 250 hz. : 1.22 s. 4000 hz. : 7.22 s. 500 hz. : 1.19 s. 8000 hz. : 11.58 s.
C	rec0		T-30 ISO Compliant: Yes 62.5 hz. : 1.19 s. 1000 hz. : 9.84 s. 125 hz. : 0.17 s. 2000 hz. : 5 s. 250 hz. : 0.84 s. 4000 hz. : 0.15 s. 500 hz. : 2.29 s. 8000 hz. : 0.65 s.	T-30 ISO Compliant: Yes 62.5 hz. : 2.79 s. 1000 hz. : 0.34 s. 125 hz. : 0.9 s. 2000 hz. : 4.85 s. 250 hz. : 0.34 s. 4000 hz. : 0.34 s. 500 hz. : 7.09 s. 8000 hz. : 0.34 s.
	rec1		T-30 ISO Compliant: Yes 62.5 hz. : 6.87 s. 1000 hz. : 0.09 s. 125 hz. : 0.13 s. 2000 hz. : 17.84 s. 250 hz. : 0.06 s. 4000 hz. : 0.07 s. 500 hz. : 1.66 s. 8000 hz. : 0.07 s.	T-30 ISO Compliant: Yes 62.5 hz. : 2.79 s. 1000 hz. : 0.34 s. 125 hz. : 0.9 s. 2000 hz. : 4.85 s. 250 hz. : 0.34 s. 4000 hz. : 0.34 s. 500 hz. : 7.09 s. 8000 hz. : 0.34 s.

RAYTRACE ANALYSIS





SNOW LOAD CALCULATION

$S = \mu_i * c_e * c_t * s_k$ *(5.1, Eurocode 1-1-3, pp. 18)*

c_e - exposure coefficient
ct - thermal coefficient
c_t- characteristic value of snow load on the ground at the relevant site [kN/m2]
μ_i- snow load shape coefficient

Exposure coefficient:

Table 5.1 Recommended values of C_e for different topographies

Topography	C_e
Windswept [a]	0,8
Normal [b]	1,0
Sheltered [c]	1,2

[a] *Windswept topography*: flat unobstructed areas exposed on all sides without, or little shelter afforded by terrain, higher construction works or trees.
[b] *Normal topography*: areas where there is no significant removal of snow by wind on construction work, because of terrain, other construction works or trees.
[c] *Sheltered topography*: areas in which the construction work being considered is considerably lower than the surrounding terrain or surrounded by high trees and/or surrounded by higher construction works.

ce=0,8 (windswept)

Thermal coefficient:
$c_t = 1$ (Not high thermal transmittance) *(Eurocode 1-1.3, pp. 20)*

Characteristic value of snow load on the ground for Greenland:

$s_k = 1{,}2\ kN/m^2$ (*EN 1991-1-3 GL NA:2010)*

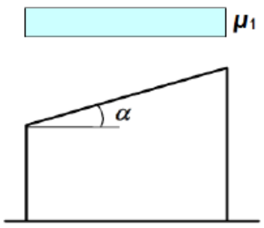


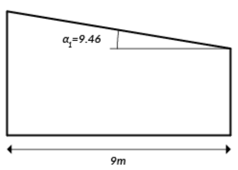
Table 5.2: Snow load shape coefficients

Angle of pitch of roof α	$0° \leq \alpha \leq 30°$	$30° < \alpha < 60°$	$\alpha \geq 60°$
μ_1	0,8	0,8(60 - α)/30	0,0
μ_2	0,8 + 0,8 α/30	1,6	--

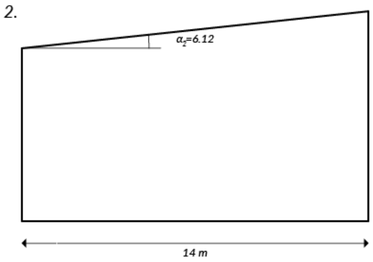
(Figure 5.2, Eurocode 1-1.3, pp. 21)

(Eurocode 1-1.3, pp. 22)

1.



2.



(Characteristic sections, own drawing)

Therefore for both sections. :

$\mu = 0{,}8 \quad S = 0{,}8 * 0{,}8 * 1 * 0{,}9 = 0{,}57 kN/m^2$

Distribution of snow load to beams:

ZONE A

Roof Area:

Beam Load Area

$$\frac{Area}{Number\ of\ beams} = \frac{}{} = m^2$$

Point Load:

$$Beam\ load\ area * Area\ Load = m2 * 0{,}57 \frac{kN}{m^2} =$$

$$\frac{Point\ load}{Length\ of\ beams\ (average)} = \frac{kN}{m} = kN/m$$

APPENDIX 4 // WIND LOAD

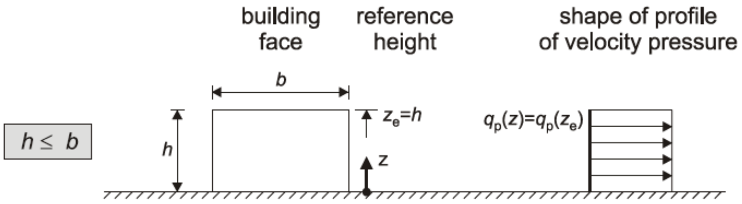
……………………………………………………………….

WIND PRESSURE ON EXTERNAL SURFACES

$w_e = q_p(Z) * c_{pe}$ *(Table 5.1, Eurocode 1-1-4, pp. 24)*

w_e= Wind pressure on external surfaces
$q_p(Z)$= Peak velocity pressure
c_{pe}= Pressure coefficient for external pressure

h=8 m (the biggest height)
b = 14 m (the biggest width in the biggest height)
$h \leq b$



(Figure 7.4, Eurocode 1-1-4, pp. 35)

PEAK VELOCITY PRESSURE

$v_b = c_{dir} * c_{season}$

v_b = Basic wind velocity
c_{dir} = Directional factor
c_{season} = Season factor
$v_{b,0}$ = Fundamental value of basic wind velocity

Recommended values *(Note 2 and 3, Eurocode 1-1-4, pp. 18)*:
$c_{dir} = 1$
$c_{season} = 1$

$v_{b,0}$=35 m/s (*EN 1991-1-4 GL NA:2010, pp. 6)*

$v_{b=\frac{m}{s}*1*1=35m/s}$

$q_p(Z) = \left(1 + 7 * l_v(z)\right) * 0{,}5 * \rho * {v_m}^2(z)$ *(4.8, Eurocode 1-1-4, pp. 22)*:

$l_v(z)$ = Turbulence intensity
ρ = Air density = 1,25 kg/m3
${v_m}^2(z)$ = Mean wind velocity
z = building height = 8 m

Turbulence intensity:

$l_v(z)=\frac{\sigma_v}{v_m(z)} = \frac{k_I}{c_0(z)*\ln(z/z_0)}$ for $z_{min} \leq z \leq z_{max}$ *(4.7, Eurocode 1-1-4, pp. 22)*:

k_I = Turbulence factor = 1 (recommended value)
$c_0(z)$= Orography factor

Table 4.1 — Terrain categories and terrain parameters

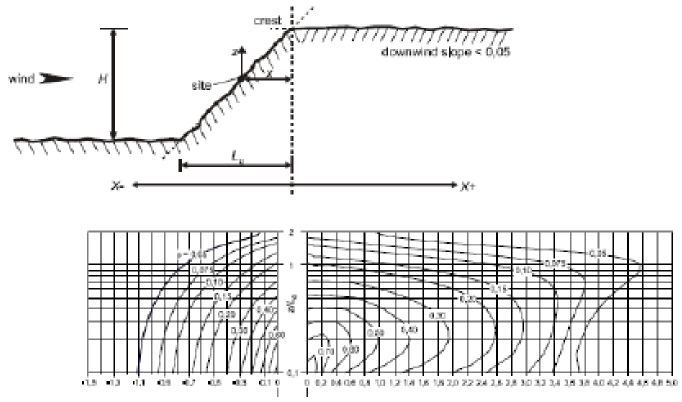
Terrain category		z_0 m	z_{min} m
0	Sea or coastal area exposed to the open sea	0,003	1
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	0,01	1
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0,05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0,3	5
IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1,0	10

NOTE: The terrain categories are illustrated in A.1.

Terrain category 0 →
$z_0 = 0{,}003$ m
$z_{min} = 1$ m
$z_{max} = 200$ m

Orography factor:
$\phi = \frac{H}{L_u} = 0{,}105$

$0{,}05 < \phi \leq 0{,}3$ *(A.2, Eurocode 1-1-4, pp.96)*
→ $c_0(z) = 1 + 2 * s * \phi$
where **s** = Orographic location factor to be obtained from figure A.2



$l_v(z) = \frac{1}{1{,}031 * \ln\left(\frac{8m}{0{,}3m}\right)} = 0{,}3$

Mean wind velocity:
$v_m(z) = c_r(z) * c_0(z) * v_b$ *(4.3, Eurocode 1-1-4, pp. 19)*

$c_r(z) = k_r * \ln\left(\frac{z}{z_0}\right)$ *(4.4, Eurocode 1-1-4, pp. 19)*

$c_r(z)$ = Roughness factor
k_r = Terrain factor depending on roughness length

$k_r = 0{,}19\left(\frac{z_0}{z_{0,II}}\right)^{0{,}07} = 0{,}19\left(\frac{0{,}003}{0{,}05}\right)^{0{,}07} = 0{,}156$ *(4.5, Eurocode 1-1-4, pp. 20)*

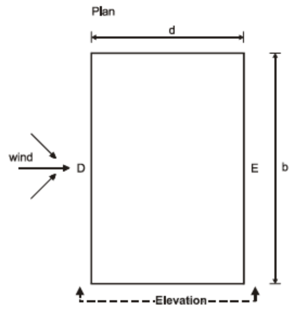
$c_r(z) = 0{,}156 * \ln\left(\frac{8m}{0{,}003m}\right) = 0{,}152$

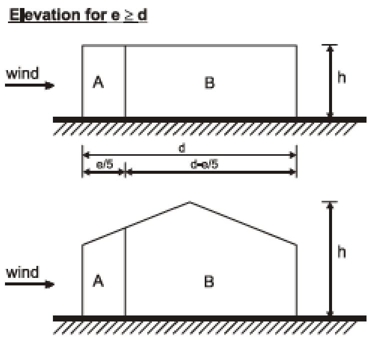
$v_m(z) = 0{,}152 * 1{,}031 * 35\frac{m}{s} = 5{,}484\, m/s$

PEAK VELOCITY PRESSURE

$q_p(Z) = (1 + 7 * 0{,}3) * 0{,}5 * \frac{1{,}25kg}{m^3} * \left(\frac{5{,}484}{s}\right)^2 = 1609{,}72\frac{N}{m^2} =$
$\underline{\boldsymbol{= 1{,}61\, kN/m^2}}$

EXTERNAL WIND PRESSURE ON THE WALLS





$A = 3{,}2m$

$B = 12{,}38\ m$

$C = 15{,}58\ m$

$D = 15{,}58\ m$

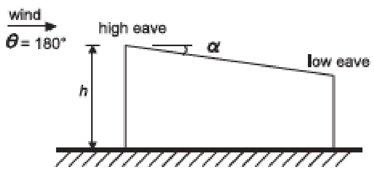
Only the pressure force and will be applied to the structure, as a line load on columns, because the analysed structure is part of building, not a separate one. The rest of the building will obtain suction on the sides.

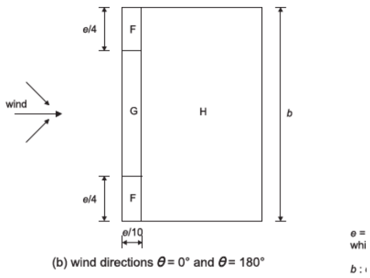
$w_{e,C} = 1{,}61\frac{kN}{m^2} * 0{,}7 = 1{,}127\,kN/m^2$

$w_{e,D} = 1{,}61\frac{kN}{m^2} * (-0{,}3) = -0{,}483\ kN/m^2$

EXTERNAL WIND PRESSURE ON THE ROOF

$w_e = q_p(z) * c_{pe}$





(b) wind directions θ= 0° and θ= 180°

$G_{depth} = F_{depth} = \frac{16}{4} = 4m$

$F_{width} = \frac{16}{10} = 1{,}6\ m$

$G_{width} = \frac{16}{10} = 1{,}6\ m$

$H_{depth} = 15{,}58 - 1{,}6 = 14\ m$

$w_{e,F} = 1{,}61\frac{kN}{m^2} * (-1{,}7) = -2{,}73\,kN/m^2$

$w_{e,G} = 1{,}61\frac{kN}{m^2} * (-1{,}2) = -1{,}93\ kN/m^2$

$w_{e,H} = 1{,}61\frac{kN}{m^2} * (-0{,}6) = 0{,}966\ kN/m^2$

Pitch Angle α	Zone for wind direction $\theta = 0°$						Zone for wind direction $\theta = 180°$					
	F		G		H		F		G		H	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5°	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-2,3	-2,5	-1,3	-2,0	-0,8	-1,2
	+0,0		+0,0		+0,0							
15°	-0,9	-2,0	-0,8	-1,5	-0,3		-2,5	-2,8	-1,3	-2,0	-0,9	-1,2
	+0,2		+0,2		+ 0,2							
30°	-0,5	-1,5	-0,5	-1,5	-0,2		-1,1	-2,3	-0,8	-1,5	-0,8	
	+0,7		+0,7		+0,4							
45°	-0,0		-0,0		-0,0		-0,6	-1,3	-0,5		-0,7	
	+0,7		+0,7		+0,6							
60°	+0,7		+0,7		+0,7		-0,5	-1,0	-0,5		-0,5	
75°	+0,8		+0,8		+0,8		-0,5	-1,0	-0,5		-0,5	

………………………………………………………………..

Persistent and transient design situations	Permanent actions		Leading variable action (*)	Accompanying variable actions	
	Unfavourable	Favourable		Main (if any)	Others
(Eq. 6.10)	$\gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$

(*) Variable actions are those considered in Table A1.1

NOTE 1 The γ values may be set by the National annex. The recommended set of values for γ are :
$\gamma_{Gj,sup} = 1,10$
$\gamma_{Gj,inf} = 0,90$
$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)
$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

NOTE 2 In cases where the verification of static equilibrium also involves the resistance of structural members, as an alternative to two separate verifications based on Tables A1.2(A) and A1.2(B), a combined verification, based on Table A1.2(A), may be adopted, if allowed by the National annex, with the following set of recommended values. The recommended values may be altered by the National annex.
$\gamma_{Gj,sup} = 1,35$
$\gamma_{Gj,inf} = 1,15$
$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)
$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)
provided that applying $\gamma_{Gj,inf} = 1,00$ both to the favourable part and to the unfavourable part of permanent actions does not give a more unfavourable effect.

(Table A1.2(A), Eurocode 0, pp. 51)

LOAD	φ_0	φ_1	φ_2
Snow Loads on buildings:			
In combination with dominating imposed load (E)	0.6	0.2	0
In combination with dominating wind load	0	0	0
Other	0.3	0.2	0
Wind Loads on buildings:			
In combination with dominating imposed load (E)	0.6	0.2	0
Other	0.3	0.2	0

(Table A.1.1 (section), Eurocode 0, pp. 38)

ULS – Ultimate Limit State:

$$\underbrace{\sum \gamma_{G,j} G_{k,j}}_{Permanent\ loads} + \underbrace{\gamma_{Q,1} Q_{k,1}}_{Dominating\ variable\ load} + \underbrace{\sum \gamma_{Q,i} \varphi_{0,i} Q_{k,i}}_{Other\ variable\ loads}$$

With dominating snow load:
$\gamma_{G,j} = 1.1$ (Unfavourable)
$\gamma_{Q,1} = 1.5$ (Unfavourable)
$\gamma_{Q,i} = 1.5$ (Unfavourable)
$\varphi_{0,i} = 0.3$ (Other)

$$1.1 * self\ weight + 1.5 * snow\ load + 1.5 * 0.3 * wind\ load$$

With dominating wind load:
$\gamma_{G,j} = 1.1$ (Unfavourable)
$\gamma_{Q,1} = 1.5$ (Unfavourable)
$\gamma_{Q,i} = 1.5$ (Unfavourable)
$\varphi_{0,i} = 0$ (In combination with dominating wind load)

$$1.1 * self\ weight + 1.5 * wind\ load + 1.5 * 0 * snow\ load$$

SLS – Serviceability Limit State:

$$\underbrace{\sum G_{k,j}}_{Permanent\ loads} + \underbrace{Q_{k,1}}_{Dominating\ variable\ load} + \underbrace{\sum \varphi_{0,i} Q_{k,i}}_{Other\ variable\ loads}$$

(6.14b, Eurocode 0, pp. 47)

With dominating snow load:
$\varphi_{0,i} = 0.3$ (Other)

$$self\ weight + snow\ load + 0.3 * wind\ load$$

With dominating wind load:
$\varphi_{0,i} = 0$ (In combination with dominating wind load)

$$self\ weight + wind\ load + 0 * snow\ load$$