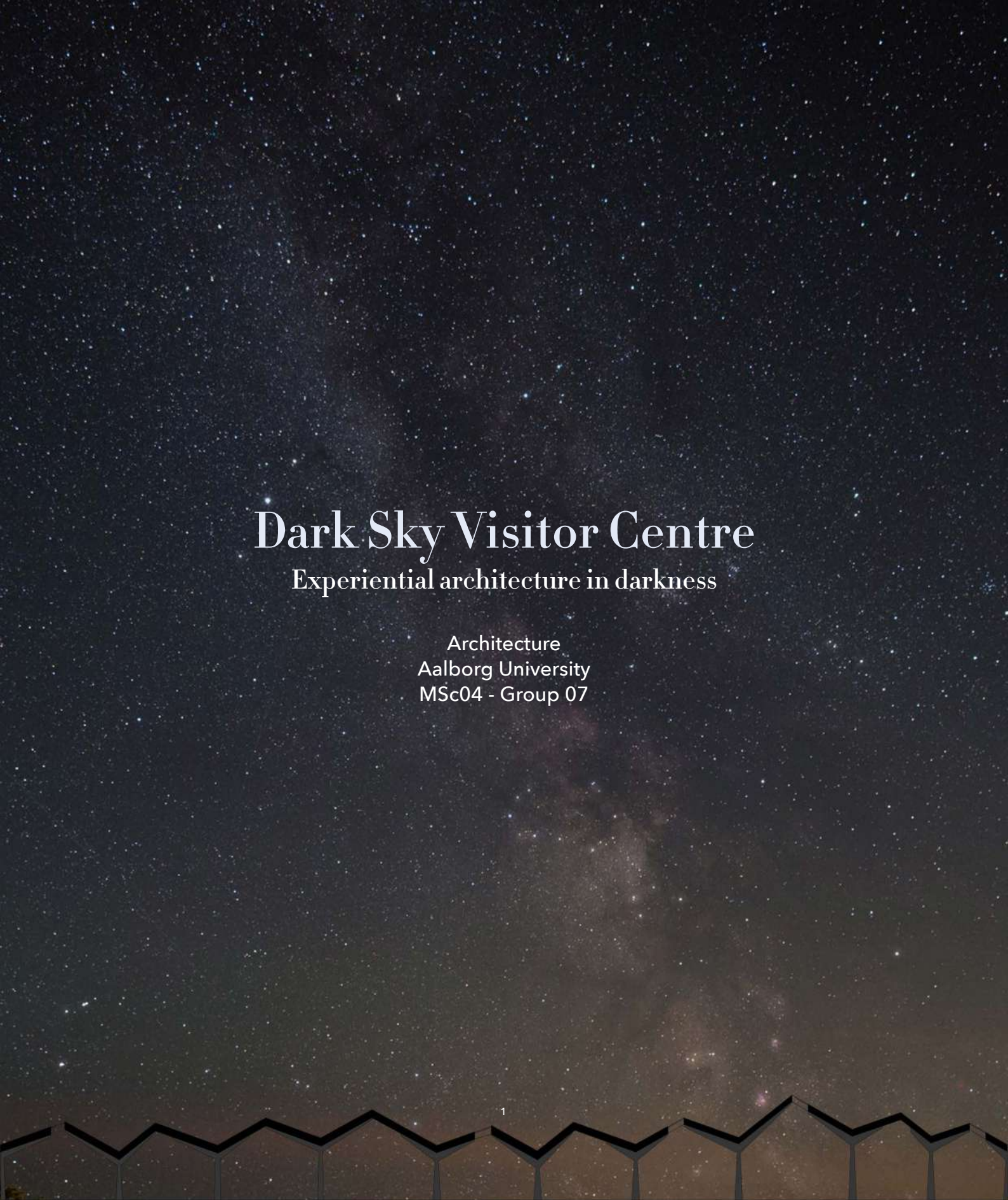

Dark Sky Visitor Centre

Experiential architecture in darkness

Architecture
Aalborg University
MSc04 - Group 07

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Ill.1 (Thilqvist, 2017)

PREFACE

As a part of the 4th semester on the education of Master of Science in Architectural Engineering, this project report has been conducted in spring 2020 from 1st of February to 28th of May. The theme for this project is "Architecture as an experiential and informative source" dealing with architecture being more than physical frames. The objective of this project is to design a visitor centre with a focus on the phenomenon Dark Sky at the island Nyord through the integration of both technical, functional and aesthetical aspects to demonstrate advanced use of the integrated design process. The master thesis gives the group the possibility to show and utilise the knowledge and skills gained throughout the master programs in architecture through the use of relevant theories and methods regarding the theme of this project.

The group wants to launch a special acknowledgement to the main supervisor Isak Worre Foged and the co-supervisor Dario Parigi for their interest in the project and for their contribution with knowledge, sparring and guidance that have taken the project to the final result. Even though it has been a difficult time for all of us due to the special situation with the coronavirus, they had found alternative ways to help and guide us when it was needed throughout the project. Further, a special acknowledgement wants to be given to Annette Tenberg, biosphere coordinator at Møn, and Simon Zachodnik, main director at House of Møn, for their collaboration about this project, and the project has gained from their insights and knowledge about Nyord and Dark Sky both through interviews and sent materials. Especially Annette has shown interest in this project and readiness to always lend a hand in before and during the site visits. Furthermore, a special thanks wants to be given to William Houman for the tour guide in Nyord with focus on the characteristic architecture concerning the historical aspects of the island. Thanks to, Ruslan Merzlyakov, a professional astronomic photographer, who has provided the project with knowledge about the stars and the universe and with some of the used pictures of Dark Sky at Nyord. Thanks to Susanne Nøhr, the owner of Tiendegaarden, who has provided a stay at her hotel during the site visit to Møn and shown interest in the project contributing with knowledge about the preserving of Dark Sky in Nyord and the local interest in the phenomenon. Finally, special thanks to Morten Pihl, the owner of the Pihl.net, and Palle Thilqvist, the owner of Palle Thilqvist photography, who have allowed the use of their photographs of Dark Sky in Møn.

Ill.2 (Thilqvist, 2017)

ABSTRACT

This project report constitutes the design of a Dark Sky Visitor Centre situated on the border between Nyord Salt Meadow and the moraine landscape at Nyord. This relation to the surrounding landscape is established through different views to the Nyord Salt Meadow and the moraine landscape from inside the building. This project takes its starting point in the themes: experiential architecture, tectonics, light pollution and Dark Sky, and through an integrated design process with a focus on the integration of aesthetical, functional and technical aspects the final design proposal is developed.

The vision of this project is to establish a spiritual connection between the human and the universe through the architecture, because it for decades has been affected by the increased light pollution in the metropolis. The final design proposal is based on a combination of visible y-shaped columns that due to their form direct the eyes towards the sky. Thus the construction will be the element of staging the phenomenon Dark Sky and establishing the connection between the human and the starry sky through the skylights defined between the construction elements. A variation of the columns and the distance between them provide different views of the starry sky and in interplay with the displacements in the building volume creates an interesting flow through the building with variating experience, allowing visitors to choose their own path of experience when moving around in the centre. Dark Sky is a phenomenon that must be experienced in darkness, which limits the sense of sight or directs it towards the sky, and therefore the other senses are addressed to help guide people through the centre and improve the experience of the stars through acoustics. Furthermore, this project aims to come up with the critical regionalism answer on the local architecture, so the new visitor centre still will be rooted in the site, while moving forward. This has been done through the innovation of the traditional gable roof found in the Nyord City and the purpose of different well-known materials, which together should create the wanted atmosphere and put a focus on Dark sky and the establishment of the connection between human and the universe through the architecture.

READING GUIDE

This project report consists of 6 chapters; Introduction, Program, Design Process, Detailing, Presentation and Epilogue. The first chapter introduces the reader for the underlying basis and the vision for designing a Dark Sky visitor centre at Møn. Further, the approaches and focus areas of the master thesis consisting of tectonics, experiential architecture, Dark Sky and light pollution will be explored. Additionally, the utilised methodologies used in this project will be covered to provide the reader with an in-depth knowledge of the iterative process of this project. The second chapter covers both quantitative and qualitative analyses of both the site, the context, materials, case studies and the target group. Based on these analyses, there will, in the end, be presented a set of design criteria, listed due to the order of the most essential criteria the design proposals should fulfil. The third and fourth chapter introduces the reader for the entire design process, which outline the technical, functional and aesthetical investigations from the initial sketching to the final design through the use of different methods. The fifth chapter will present the final project through plans, sections, elevations, technical drawings and visualisations. Furthermore, technical aspects like daylight, acoustics and the structure and construction will be presented in an interplay with aesthetical and functional aspects. The last chapter consists of a conclusion upon the whole project and a recapitalization of the entire project through a reflection upon the design process and the final design process.

At the end of the report, the literature and illustration lists are placed and made with the use of the referencing style: the Harvard method, which are shown as last name on author(s)/date.Besides the report, there will be attached a separated appendix consisting of the interviews conducted through the project, definitions of atmospheres used in the unit program, absorption coefficients related to the acoustic simulations, load calculations, dimensioning, joint calculations, u-value calculations and escape routes on escape routes. Due to the technical circumstances, the group recommend the supervisors and the external examiner to read the report on PDF Preview (mac) or Adobe Acrobat Reader at minimum a 27-inch screen, due to the size of the report. Furthermore, the report must be read as a double-page spread.

Ill.3 (Thilqvist, 2017)

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MOTIVATION

In the last 40 years, light pollution has increased significantly due to the remarkable amount of artificial lighting in the cities, which means that the natural darkness and the starry sky has become a rare sight. (Sustainable Environment, 2018) This entails in many people are not familiar with the phenomenon Dark Sky which is a natural dark sky with thousands of stars resulted by minimal or none light pollution.

Dark Sky is essential in the understanding of the universe and human existence and is crucial for the environment, human health and the ecosystems because of the negative effect of light pollution on the circadian rhythm of both humans, animals and plants. (International Dark-Sky Association, n.d.a) Møn and Nyord have been designated as Scandinavia's first International Dark Sky Park and Dark Sky community, where thousands of stars and astronomic phenomena can be experienced, and thus this project will be placed in one of these locations (VisitMøn, n.d.)

Creation of an architecture that focuses on the natural darkness and a starry sky requires that the architecture stages and promotes this experience through the different perceptual systems. The visual sense should primarily be directed towards the night sky and the landscape rather than towards the architecture itself and thereby a holistic experience will be created on the site. Further, this makes demands on the relation of the architecture to its specific location. To support the staging of the Dark Sky experience, it is crucial that the architecture adjusts the landscape without drawing attention from the rare sight, Dark Sky.

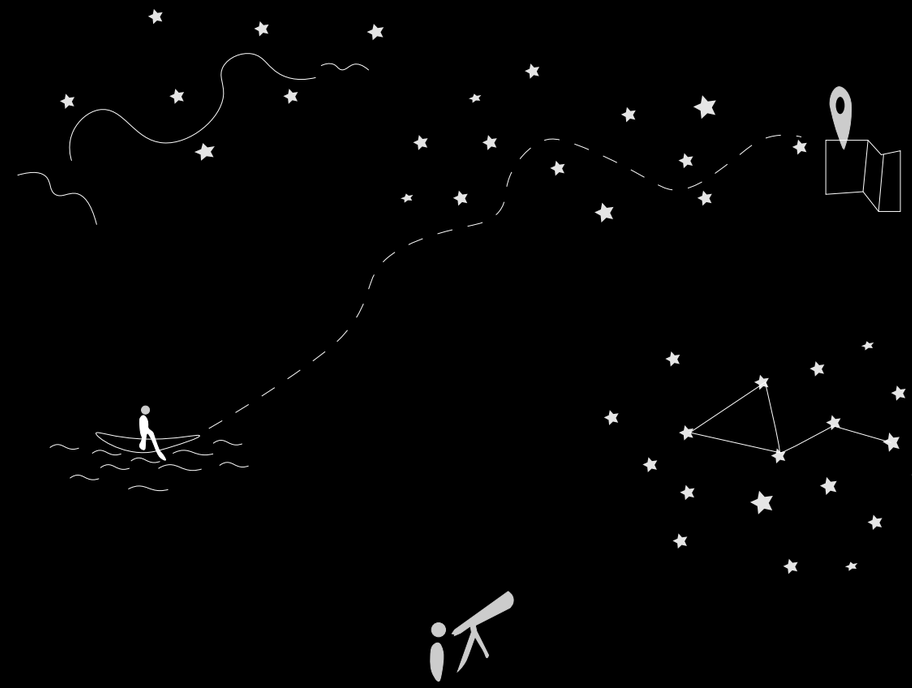
Ill.4 (Thilqvist, 2017)

VISION

In ancient times, the sky and the stars have played a major role as navigating points for humans, while the migratory birds still utilise the moon and starlight for navigation. Further, stars have contributed to the understanding of the universe and one's role within it. This questions, if the human in modern society has lost the connection to the stars due to the increasing amount of light pollution.This project deals with this problem area, and thus the vision of this project is to design a Dark Sky Visitor Centre that establishes the spiritual connection between the human and nature (the darkness and the starry sky) through the architecture.

The centre will become a communication and educating platform that creates curiosity, informs and raises existential and experiential reflections upon Dark Sky and one's role in the universe. Thus, it should reveal the importance of the stars and thereby promote guidance on how to preserve and protect this unique phenomenon. With a tectonic approach, the structure, construction and materials become essential elements in creating an architecture that navigates after the stars and through spatial sequences in darkness stage Dark Sky.

Simultaneously, the composition of the architecture should enhance the sense of sight directed towards the sky and minimise other external impacts like, for instance, reflected sound that can distract the captivation of these memorable views. Further, by placing the visitor centre on the boundary between the unique Nyord Salt Meadow and the moraine landscape with an intimate view to the starry sky highlights the essence of the location and the Dark Sky experience, gathering both professionals, locals and visitors - all sharing the same desire in exploring and maintaining Dark Sky.



Ill.5 The stars as essential elements for navigation and mapping used for different purposes

METHODOLOGY

The focus on tectonics and the interdisciplinary approach causes a series of different methods, which are brought into play at different times during the design process because of the need for extracting different knowledge regarding the position of the project and how to get closer to the target.

SITE ANALYSES

The beginning of the project encompasses primarily site analyses, which are both descriptive and prescriptive to achieve an understanding of the site while producing graphical presentations of it. One of the methods used is mapping by James Corner, which is a method used to visualise existing and visible elements in the chosen site or in its context and to actualise the potentials of these, presented graphically. (Corner, 1999) This concerns Dark Sky Parks, infrastructure, touristic attractions on Nyord and the microclimate.

CASE STUDIES

Additionally, case studies have been conducted in the preliminary stages of investigations to provide detailed knowledge regarding both architectural and technical qualities of existing projects that can be used as inspiration for the sketching process. Here, it is essential to strategically select cases in order to achieve the best possible amount of information on a given aspect. Thus, the chosen cases have been selected based on the expectations about their content, whether it is the relation to the context, to experiential architecture or to tectonics. (Flyvbjerg, 2006)

KNOWLEDGE-BASED RESEARCH

Though, to achieve a deeper understanding of the approaches and focuses of this project, state-of-the-art-knowledge has been brought into play, which is existing research of different themes. (Sand, 2009) Understanding Dark Sky and light pollution requires an evidence-based knowledge based on scientific research by the International Dark-Sky Association and other organisations with expertise within these fields. On the other hand, to understand the approach of tectonics and experiential architecture, practice-based knowledge based on the practical experiences of experienced architects and theorists within these fields is necessary. (Lipscomb, 2015)

METHODS RELATED TO SITE VISIT

To translate the gained knowledge into practice resulting in a final building, it is crucial relating this knowledge to the chosen site. Mappings have the potential to provide an overview of the site and the relevant elements focused on, but to achieve a broader understanding of the characteristics of the site and capturing the atmosphere, it is necessary with a site visit. A site visit is an evaluation technique describing the act of visiting a site for a limited period to gather information about it. This information can be captured either through the personal experience or experiences of other people. (Lawrenz, Keiser and Lavoie, 2003) Both approaches have taken place in this case.

Photography is a method used to understand the site, which is efficient in providing much data on a short time, but it makes it challenging to capture the whole experience in the picture. Thus, hand drawings have been used as a technique which bear the mark of the personal impressions of the identity and potentials of the site defined by the hand (Piper, 2015). One way to capture the atmosphere of the site is by using phenomenological methods and theories, in this case, the "Atmosphere as an Aesthetic Concept" by Gernot Böhme. Böhme describes the atmosphere as the relation between the subject (the site) and the object (the observers) and thus requires the physical presence to experience the space. This results in a subjective experience and perception of the sensorial qualities of the site. (Böhme, 1998)

Further, the personal experiences of other people, for instance, the locals are relevant too, because they have a long-term experience or knowledge about the certain site, the phenomenon Dark Sky or other relevant themes related to the focus of this project.

Thus, interviews have been carried out with both locals and experts to observe the themes from different perspectives and to understand the needs of the potential users of the Dark Sky Visitor Centre, whose needs it has to accommodate. Furthermore, it is crucial to experience Dark Sky ourselves since it is a phenomenon that is only visible at Nyord and Møn.

NEW DIRECTION ON THE PROJECT

The interview with the experts turned the project into a new direction with a new location for the visitor centre. This required new analyses of the new site, another site visit and new interviews. Furthermore, new analyses were made, for instance, microclimate simulations made in the Grasshopper plug-in Ladybug, because the microclimate affect one's experience, the quality of the outdoor spaces and can define the best conditions for experiencing Dark Sky. In interaction with the microclimate, analyses of the local architecture and its materials, construction systems, fabrication etc. have been carried out to understand the impact of the microclimate on the technical aspects. Timber has been chosen as the primary material in this project due to its aesthetical, functional, technical and sustainable qualities, and thus it is necessary with an in-depth analysis of it as construction material with a focus on these aspects.

SYNTHESIS OF DIFFERENT ASPECTS

All these described methods, theories and techniques are used do define the architectural, technical and functional aspects and criteria to the Dark Sky Visitor Centre conducted in a program. This is the basis for the further design process, which then seeks to convert these prerequisites to rational, interesting and efficient design solutions. This process is, especially in the beginning, characterized by the use of both hand drawings, digital models, physical models and simulations that each investigate a certain problem area or aspect of the building, but to strengthen the design and ensure integration of both functional, technical and architectural qualities within the project, it is necessary testing out each solution with the different techniques and perspectives. Thus, when designing, one aspect should always be examined in relation to the other aspect through different tools and techniques.

The hand drawing is a fast tool in generating numerous ideas at the beginning without using much time on precision. On the other hand, drawings can be misleading in relation to scale, whereas physical models increase the understanding of this together with spatiality. Though, the physical model can be time-consuming in the making and thus requires an idea of the model before it is carried out both in relation to its materials and construction to achieve the right purpose with the model. It is crucial to relate each study to the specific site, and thus a physical model of the site is necessary to create as soon as possible.

Although hand drawings and physical models have many advantages, it is also necessary to incorporate digital tools to specify and optimation the design and its presentation. The approaches can both be carried out in 2D or 3D. 2D drawings describe two dimensions on a flat plane, but are efficient to create an understanding of the spatial organisation of a building and makes detailing much easier. 3D models include the depth and thus are used to display a form which appears easy to understand with the eye and thus give a spatial understanding of the building.

Various models add something different to the development of the concept. For instance, volume studies test out the proportions, typology and scale of an idea in terms of the context, but the form can neither stand alone nor be defined by only aesthetical and functional aspects, because the construction, structure and material has a big influence on not only form but also the functionality, spatiality, durability and atmosphere of a space. Therefore, the technical issues should also be considered in relation to which structural systems and materials can provide this specific form or the other way around. Simultaneously, it has to be ensured that the defined program can be fit within that form.

The materials, joints and construction principles have been investigated in physical and digital models both concerning their technical, functional, aesthetic and sensuous potentials and how these contribute to the atmosphere of the centre. In interplay with physical and digital models, simulations have been implemented in the digital models to optimise and specify the design and its presentation.

Simulations are used to solve problems which cannot be carried out analytically or which are too complicated to try out in reality. Different simulations in both Grasshopper and Robot Structural Analysis are made to, for instance, test out and calculate on the stability and the structure and thus ensure the conceptual ideas are to a certain extent realistic.

The sensuous and atmospheric aspects of a project as sound, temperature and light can be explored through physical models, through case studies that reveal solutions similar to what is desired for this project, through own sensuous perceptions of different spaces, materials and atmospheres or through measurable simulations. These explorations will specify the selection of materials, surfaces and windows openings and take part in the form development of the

building along with the construction, plan and facade development. The atmospheric aspects have been made measurable by carrying out acoustic simulations in the Pachyderm plugin to Rhino, and light simulations in Velux Daylight Visualizer. Simulations are a fast way of testing out various parameters within the same model, but the simulations are not a full presentation of reality, whereas practice may differ from theory. Thus, it is crucial shifting between the tools to support and strengthen the design solutions investigated based on the same model, but defined differently depending on the focus area.

IN RELATION TO HUMAN, ARCHITECTURE AND THE SKY

The techniques and tools used should be defined by the vision of the project. A decisive foundation for the design process has been the relationship between human and the sky through the architecture, which this project aims to clarify. Thus, the section has been the major measure to, first of all, reveal this relationship through an adaptation of the structure to the human scale and the starry sky. Subsequently, more layers have been put on this basic principle tested out both in 2D, 3D, digitally, analogue and physically within the different focus areas of the project. One layer added is the definition of one module consisting of the characterised construction elements used for staging certain degrees of the starry sky. This requires the implementation of the star path projected in the program as a basis for the design of the construction elements according to the stars. Further, defining static schemes are necessary to find the best structural solutions for this case. This affects the distribution of the loads explored in Robot Structural Analysis which also influences the dimensions and material division of the structural systems which in the end have an impact on the aesthetic and spatial experience of these elements.

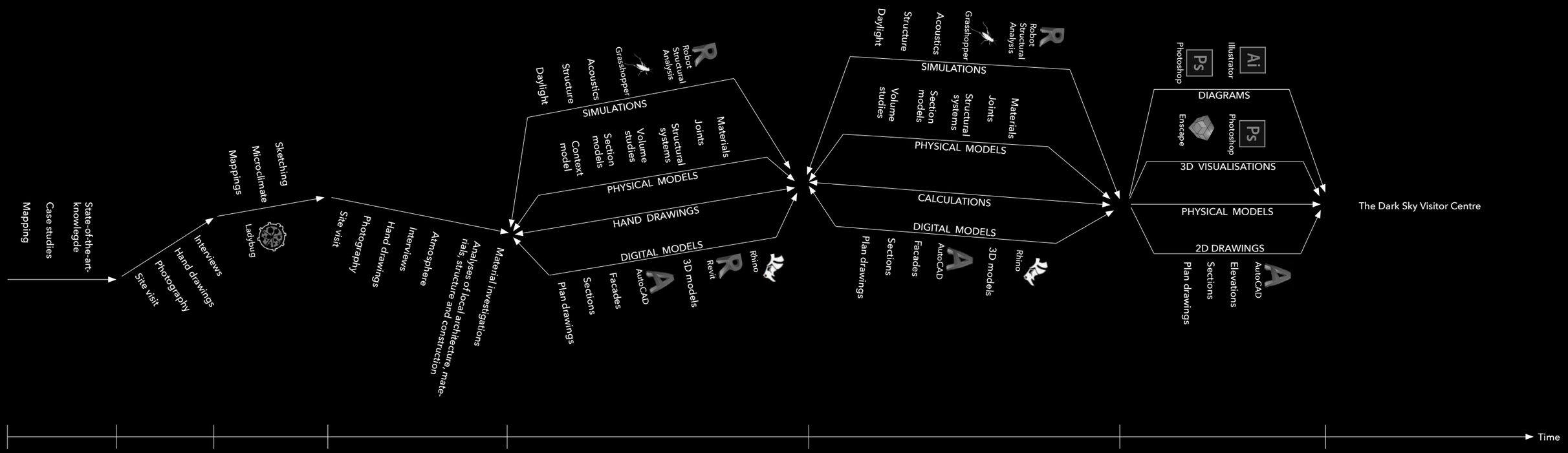
Another layer can be the composition and variation of the different modules that especially have an impact on the spatial organisation of the different functions, scale, logistics and spatial experiences. In this case, it is necessary to move beyond the traditional 2D section cut to incorporate more directions on the concept. 3D models and plan investigations can be utilised in this case in interplay with the structural and acoustic demands.

A third layer can be the materials within the different spaces that both have aesthetic and sensuous qualities and can be used to guide people around, which have been investigated through digital and physical models. They also affect the acoustics of the space simulated digitally, and thus the choice of the materials depends on several parameters. Thus, to ensure improvement, optimisation and integration, the studies should be repeated during the whole process until the most optimal solutions are found and thereby create coherence between the technical, functional and aesthetical aspects of the project. In collaboration, they should lead to a final design of a Dark Sky Visitor Centre that both works functionally, aesthetically and construction-wise and simultaneously create the sensuous experiences desired for the spaces within the centre and stage the phenomenon Dark Sky through the use of structure, form and material.

FINAL PRESENTATION

Presentation of the final design requires implementation of different tools as 2D drawings, 3D visualisations, physical models, diagrams, final calculations and simulations of acoustics, daylight and structure in order to create an in-depth understanding of the potentials of the project. The purpose of 3D visualisations is to create a spatial understanding of the project and specify a certain atmosphere. Though, these are often confused with reality, which results in focusing on details in the visualisation instead of the purpose with it. Diagrams are used to present the principals behind the design and clarify the different investigations. The final calculations and simulations should provide an overview of the efficiency of the structure which also impact the fabrication of the building and the perception of the building of the users.

The whole project, both from the initial ideas, the process and the final outcome, is collected in the report and presented though graphical materials, text and calculations.



III.6 Methodology diagram

APPROACH & FOCUS
TECTONICS

The word “tectonic” originates from the ancient Greek term “tekton” which refers to the craft of the carpenter or builder (Sekler, 1965, p. 73) The concept of “tectonics” has roots back to Vitruvius’s “De Architecture libri decem” (Ten Books of Architecture) in which Vitruvius defines the fundamental aesthetic principles of architecture. He states that architectural quality occurs when both firmitas (durability), utilitas (utility) and venustas (beauty) is included in the architecture. (Morgan, 2017).

REDEFINITIONS OF TECTONICS

The concept of “tectonics” has become an element for architectural discussion in the last centuries, especially from the 19th century with the publication of "Die Tektonik der Helleen" by Karl Bötticher in 1843-1852. The theory of Bötticher consists of a division of architecture into two forms; core-form and art-form, which was further developed by Gottfried Semper in his publication "Die Vier Elemente der Baukunst" and later on by Kenneth Frampton in "Studies in Tectonic Culture". (Foged, 2015) In Semper’s publication, he tries to move beyond Bötticher’s theoretical two-sided division of architecture (Ibid) and instead decompose the architecture into four elements: earthwork, hearth, roof and enclosure (Semper, 2004). These were categorised into the concepts of stereotomics and tectonics. For both Semper and Frampton the meeting between the stereotomics and tectonics define the quality of architecture, which has been elaborated by Kenneth Frampton in his work "Studies in Tectonic Culture" as “The quality of architecture lies in the interplay of the three converging vectors, the topos, the typos, and the tectonic” (Frampton, 1995, p. 2). (Foged, 2015)

In Semper’s seminal work "Style in the Technical and Tectonic Arts; Or Practical Aesthetics", this meeting between stereotomics and tectonics is a focal point, where he elaborated on how material assembly and joints between materials can be a way of expressing the properties of the material and revealing the architecture. Semper was interested in how things were created; how the knot becomes textile, the textile to the membrane and the membrane to facade which then in synthesis becomes architecture. The creation and craftmanship behind it is of importance in his understanding of tectonics. (Foged, 2015) The architectural theoretician Marco Frascari emphasises that the quality of architecture is

The earthwork (the foundation of a building that protects against external threads)

The hearth (the place within a building gathering people)

The enclosure (an enclosing membrane protecting from environmental impacts)

The roof (protecting the hearth from weather conditions)

III.7 The four elements of architecture according to Gottfried Semper

revealed through the joints in his book "The Tell-The-Tale-Detail": “The art of detailing is really the joining of materials, elements, components, and building parts in a functional and aesthetic manner. The complexity of this art of joining is such that a detail performing satisfactorily in one building may fail in another for very subtle reasons.” (Frascari, 1984). (Foged, 2015) In the detailing of the joint, Frampton argues that the structural integration is important to achieve a "structural ornament rather than "ornamented structure" (Frampton, 1983, 1995, 2011). (Foged, 2015) Tectonics oriented towards both structural and gravitational force is emphasised by both Carles Vallhorant and Eduard Sekler. Sekler argues that tectonics is an expressive form representative of structure and construction and thus a "relation of form to force" (Sekler, 1965:89). (Foged, 2015) The tectonic statement comes through as the play of forces which has the ability to provoke people’s empathetic participation in the architectural experience. (Sekler,

1965:76-77) Frampton instead work with a nuanced definition of tectonics as a method in establishing a specific atmosphere and in promoting the understanding of the construction for ordinary people (Foged, 2015):

"One has in mind a whole range of complementary sensory perceptions which are registered by the labile body; the intensity of light, darkness, heat and cold; the feeling of humidity; the aroma of material; the almost palpable presence of masonry as the body senses its own confinement; the momentum of an induced gait and the relative inertia of the body as it traverses the floor; the echoing resonance of our own footfall" (Frampton, 1983:28).

The German philosopher Martin Heidegger introduce people to the Greek term Aletheia, which means the act of revealing, which is carried out by the practice of the four causalities: "causa materialis (the matter out of which something is made), causa formalis (the shape into which the material enters), causa finalis (to which something is related to its requirements) and causa efficiens (the effect brought about by the finished something)" (Foged, 2015). On this basis Frampton describes tectonics as "the poetics of construction" (Frampton, 1995), which unifies the symbolic meaning in Semper's four elements and Heidegger's description of the act of revealing. (Foged, 2015)

TECTONICS IN THIS PROJECT

Based on the described definitions of tectonics in combination with the curriculum of this education that integrates architectural competencies with engineering knowledge, this project will consider both architectural, technical and functional aspects relevant to the design of a visitor centre with a focus on Dark Sky. The project aims to design an architecture that reveals the unique experience of the phenomenon "Dark Sky" referring both to its emotional and existential affection and local and global relevance for both humans, the ecosystems and the environment.

The architecture shall create a connection between what it reveals and what can be revealed. Thus, tectonics will be the bridge between architecture, the human and the phenomenon. The structure, construction and materials in the architecture (firmitas) are essential elements in the creation of durable physical frames for housing the specific functions taking place inside (utilitas). Due to the focus on tectonics, they should also communicate the architectural vision and create the visual expression of the building (venustas). This unity will promote a unique architectural piece with a clear communication of the architectural vision that simultaneously manages to move people and generate a sensuous participation in the experience of the centre.

Ill.8 Saint Benedict Chapel by Peter Zumthor (Merin, 2013)

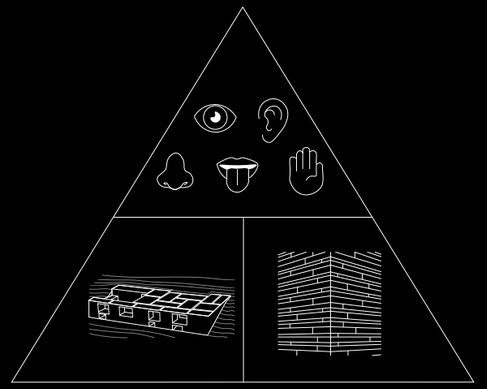
APPROACH & FOCUS
EXPERIENTIAL ARCHITECTURE

"How do people design things with such a beautiful, natural presence, things that move me every single time. One word for it is atmosphere. " (Zumthor, 2006, p. 10) The Swiss architect, Peter Zumthor, describes the atmosphere as the sensory qualities of a place – "a form of perception that works incredibly quickly" (Zumthor, 2006, p. 12). He features nine important elements in generating a certain atmosphere of a place:

1. The Body of Architecture
2. Material Compatibility
3. The Sound of a Space
4. The Temperature of a Space
5. Surrounding Objects
6. Between Composure and Seduction
7. The tension between Interior and Exterior
8. Levels of Intimacy
9. The Light on Things

Zumthor is acknowledged for the implementation of his theoretical knowledge about the multi-sensory experience in his design solutions. In the design of the Saint Benedict Chapel the terms "The Body of Architecture" and "Architecture as Surroundings" are emphasised through the relation of the architecture to its surrounding landscape. The chapel is built into the hill and thus arises from the landscape. Additionally, these are emphasised through the relation between the chosen material and the building volume revealed in the use of shingles that makes it possible to create the round shape. The material compatibility can be observed in Gugalun House, where the original building in wood has been preserved with an extension within the hill. The extension refers to the original building through the use of horizontal wood boards reinterpreted with the use of new technologies, which create a cohesive expression.

In the design of the Thermal Baths in Vals, the focus has been on creating a multi-sensory experience, where the shape and dimension of the room, the surface of the material and how the materials have been applied will affect the sound of space, the levels of intimacy and the light reflected on the walls. The light affects how the materials will be perceived psychologically making for instance concrete appear cold compared to wood. The temperature of the material can also be perceived



Ill.9 The relation between the senses, architecture, materials and structure

physically, both by touching the material and through the operative temperature in the room. In the project of the Thermal Bath Vals, the tension between interior and exterior is emphasized through the varying openings in the facade and the use of different materials, which provide the visitor with a view to the surrounding landscape, while still feeling protected by the building envelope. Juhani Pallasmaa, the Finnish architect, writer and professor, also describes the relation of architecture and the senses in his famous book "The Eyes of The Skin". According to him, architecture can both inspire, engage and enhance life through an architecture that addresses all the senses simultaneously. He defines the body as the "locus of perception, thoughts and consciousness" (Pallasmaa, 2014, p. 11), which means that the senses interact through the whole body. Through

a bodily interaction with the environment, the experience of one's existence in and understanding of the world is strengthened. Furthermore, this dialogue has a significant role in remembering a space or a place. (Ibid)

All senses are extensions of the sense of touch defining the interface between the skin and the environment. Instead of looking into the traditional five senses, Pallasmaa is referring to James J. Gibson's classification of the senses within five perceptual systems: the visual system, the auditory system, the taste-smell system, the basic-orienting system and the haptic system, when discussing the different dimensions of senses of archtiecture (Ibid).

These are only some of many theories dealing with the perception of architecture through all the senses and the whole body, but unfortunately, in practice, most architecture is made under consideration of only the sight (Vermeersch, 2013). Isolating the sight and suppressing the other sensory realms, places the vision in an objectifying position which causes a feeling of detachment, alienation and neglects the ability to perceive the surroundings of the person (Pallasmaa, 2014).

This problem is due to the widespread use of visualization techniques which turns the design process into a "passive visual manipulation" (Ibid, p. 14) that creates a distance between the designer and the object. Architecture is both a craft and art according to Pallasmaa, and thus architects should involve their bodies in their work. (Ibid) "As the work interacts with the body of the observer, the experience mirrors the bodily sensations of the maker." (Ibid, p. 71)

Ill.10 Bruder Klaus Field Chapel by Peter Zumthor (Aldo Amoretti, 2014)

EXPERIENTIAL APPROACH IN THE PROJECT

With reference to Zumthor's theoretical knowledge within the multi-sensory experience defined by architecture and James J. Gibson's classification of the senses within the five perceptual systems, the elements that define the atmosphere of the space will be investigated during the design process. By creating various design models, the different aspects of the atmosphere can be measured and optimised such as the acoustics, the light, the temperature etc. This can be done both through digital simulations, physical models and on our own body. The purpose of this project is to establish the connection between the human and the universe through the architecture. Because Dark Sky is a phenomenon that must be observed in darkness, the sight will be limited or at least directed towards the sky instead of the building itself or other objects. This will put a focus on the other senses which then will be activated to enhance the experience of the phenomenon Dark Sky in the centre.

In terms of the auditory system, design models that investigate the shape and dimensions of the building will be made because these factors impact the acoustics of a space. Further, a focus will be on materials both concerning the type of material, their form, their size and the composition of them on a wall. The purpose of the exhibition area is the experience of Dark Sky as its core, and here the acoustics of the space plays a major role. To create the best optimal physical frames to observe the phenomenon, other disturbing elements as the sound from the surrounding objects must be minimised, and thus the reverberation time must be decreased, which is defined as the time it takes the sound to decay 60 dB. Thus, much absorption is needed and therefore different materials and compositions with different absorption coefficients will be investigated through acoustic simulations in Rhino.

In terms of light, both physically and psychologically investigations should be implemented. The physical aspects can be investigated through daylight simulations for instance in Velux Visualizer to ensure that the requirement applicable for a workplace is achieved in the centre. Thus, the interior materials must be considered based on their reflection of light. This can minimise the need for windows on the facade and instead bring openings towards the starry sky into focus.

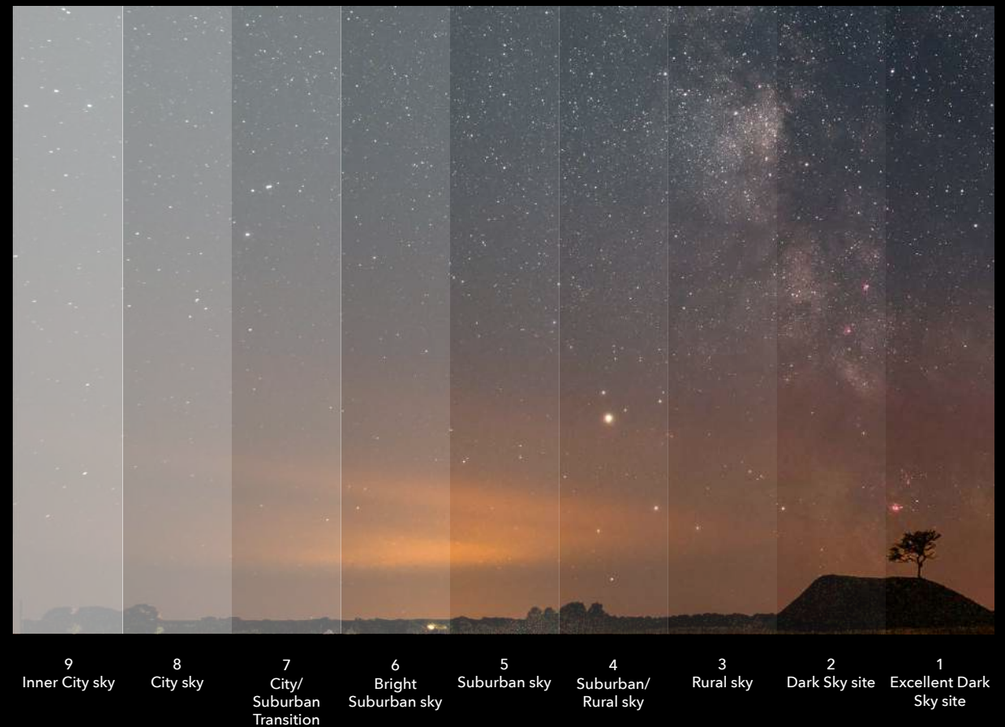
Additionally, light investigations in physical models can be conducted to investigate how the placement of the windows on the wall will affect the play between light and shadow and how the light will act on different surfaces of materials. The proportions between the human and the architecture will be tested through physical models to understand the scale and the connection between the human and the universe. These design models take part in defining the atmosphere of the centre and how the visitor will experience the phenomenon Dark Sky through the architecture.

LIGHT POLLUTION

In the last 40 years, light pollution has increased significantly over the whole world, especially in the metropolises due to the expanded use of artificial lighting at night to ensure security and safety both on private and public areas and for advertising. (Sustainable Environment, 2018) The International Dark-Sky Association (IDA) has specified light pollution as "inappropriate or excessive use of artificial light at night" (International Dark-Sky Association, n.d.a). Light pollution can occur in different forms like glare, skyglow, light trespass and clutter. (Ibid)

By reducing the amount of artificial lighting at night, it can reduce energy wastage, carbon footprint, save costs and provide the opportunity to experience Dark Sky. (NAS, 2019) The light pollution has a negative effect on the environment, human health, the wildlife and the ecosystem. (Globe at Night, n.d.) Especially exposure to blue light at night can disrupt the human's circadian rhythms and the production of the hormone melatonin and has a negative effect on the human health, increasing the risk of getting, for instance, depression, sleep disorder and breast cancer. The blue light is normally used in LED light bulbs applied in outdoor lightning or electronics displays. (International Dark-Sky Association, n.d.b) (Mattsson et al, 2012) Light pollution also disturbs the biological rhythm of plants and animals, which is encoded in their DNA. Thereby, it can have a negative effect on birds, insects and plants if the light pollution is too high. (International Dark-Sky Association, n.d.c) (Tallec, Perret & Théry, 2013) Artificial light at night also seems to disrupt the world's ecosystem. Especially the ability of orientation of migratory birds is interrupted by light pollution because they navigate after the starlight. This can cause the birds migrate towards the illuminated cities, which has deathly affects. (Chepesiuk, 2009)

Light pollution also affects the plants with a risk of frost damage due to the extension of the growth period. (Singhal, Kumar & Bose, 2017) Many insects are also affected by light pollution, especially bees, dung beetles and fireflies. Bees usually are diurnal, and therefore the artificial light at night is disrupting the circadian rhythms of the bees, which diminish their time for sleep and recovering, but also the pollination of the flowers that has a huge effect on the bees because they rely on the flowers as food. (International Dark-Sky Association, n.d.d) (Leibrock, 2018)



Ill.11 The bortle scale used to measure light pollution (Thilqvist, 2017) (International Dark-Sky Association, n.d.)

DARK SKY
DESCRIPTION AND DESIGN PRINCIPLES

Dark Sky describes a night sky affected by minimal or none light pollution. This results in a dark sky with thousands of stars, galaxies and other astronomic phenomena which can be experienced. (VisitMøn, n.d.)

INTERNATIONAL DARK SKY ASSOCIATION

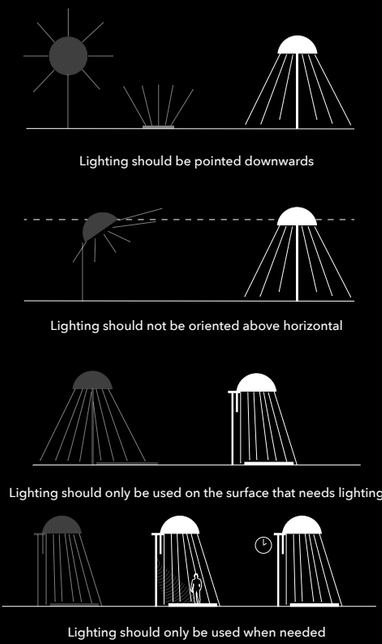
The International Dark-Sky Association is the leading organisation worldwide within combating light pollution and preserving and protecting the night skies. Additionally, their goal is to inform people about Dark Sky and in preventing light pollution through education, promotion of tools and resources. (The International Dark-Sky Association, n.d.e) Even though IDA has made significant progress towards clearer and darker skies with less light pollution in 51 countries, light pollution continues to increase worldwide due to the growth in the global population. (The International Dark-Sky Association, n.d.f) IDA's work is not to select the International Dark Sky Places (IDPS) instead they receive a nomination from a small group of individuals, who want formal protection of a specific night sky. After that, the application process can start to obtain the designations within one of the IDPS six types of designations which each has its own guidelines regarding managements, size and sky quality. The entire process from initial investigation to the formal designations takes typically around 1-3 years. (The International Dark-Sky Association, n.d.g)

DARK SKY PARK AND COMMUNITY

Møn and Nyord have achieved designations within both International Dark Sky Community and Park. An International Dark Sky Community is either a legally organised town, city, municipality or another form of community, which is dedicated to preserve and protect the clear sky and the natural darkness by implementing rules about quality outdoor lightning and make an effort in educating locals within Dark Sky and its importance for human health, the environment, the wildlife and the ecosystem. An International Dark Sky Park can be both a public and private area, which protects the clear night skies against local light pollution by implementing the right outdoor lighting. Additionally, the locals must provide visitors with Dark Sky programs. (The International Dark-Sky Association, n.d.h)

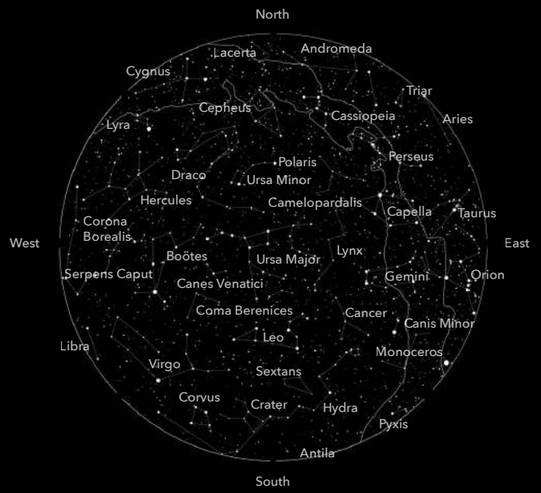
SIMPLE RULES TO OUTDOOR LIGHTING

Light pollution from outdoor lighting can be minimised by following simple rules described by IDA: to only use it when it is needed or where it is needed or intended, to decrease the brightness of the light and the blue light emissions and to shield the light and point it downward, so the light illuminates the object instead of affecting the night sky. (The International Dark-Sky Association, n.d.i)



Ill.12 Design principles for outdoor lighting (Dark Sky Møn, n.d.)

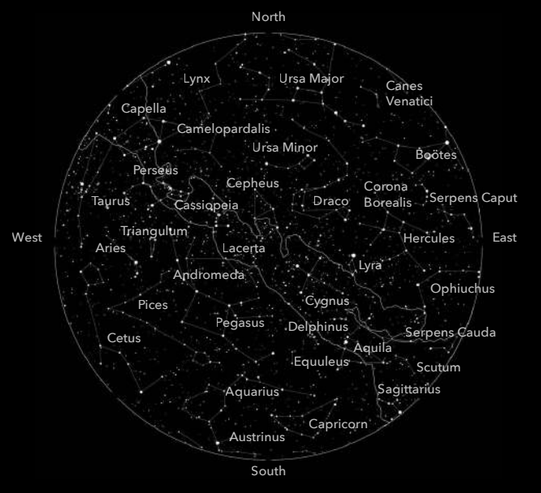
STAR PATH

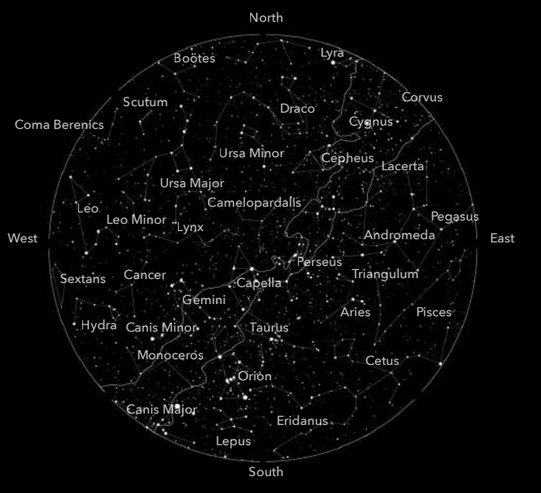


Ill.13 Spring (Mar 21st, 11pm) (Dark Sky - Tiendegaarden, n.d.)

Ill.14 Summer (Jun 21st, 11pm) (Dark Sky - Tiendegaarden, n.d.)

In the design of the Dark Sky Visitor Centre, it is crucial to look at the movement of the constellations across the sky during the different seasons to gain an understanding of how to establish the connection between the human and the night sky through the architecture. Due to the rotation of the earth, the appearance of the starry sky seems to change overnight, where the path of the stars across the night sky depends on the latitude of the observer. Additionally, it can be observed that the visible constellations on the sky changes during the different seasons. The annual change at the starry sky allows people to see the winter constellation Orion illuminated at the night sky at the beginning of the new year. In the spring Ursa Major is in zenith. During the bright nights in the summer period, only the brightest stars on the night sky can be seen as the star Vega in Lyra constellation, Deneb in Cygnus constellation and Altair in Aquila constellation, which together forms the Summer Triangle. In August, the darkness returns and the milky way can be observed between the Cygnus and Aquila constellation. In the fall Ursa major is illuminated on the northwestern part of the night sky, which illustrates the movement of the constellation across the sky. Besides Ursa Major, other constellations for instance Perseus, Andromeda and Pegasus are visible to observe during the fall. (Stjernehimlen.info, n.d.)





Ill.15 Autumn (Seb 21st, 11pm) (Dark Sky - Tiendegaarden, n.d.)

Ill.16 Winter (Dec 21st, 11pm) (Dark Sky - Tiendegaarden, n.d.)

Even though the location of the constellations at the night sky changes during the seasons, the appearance of each constellation does not change through millennia, because the movement of the stars in regards to the remaining stars is minimal and cannot be observed with the human eye. (Ibid) Due to the movement of the constellation across the sky during the different seasons, the experience of the night sky in the Dark Sky Visitor Centre will vary. Thus, it is essential that the arrangement of the exhibition area of the centre is flexible and can accommodate this variation.

In the design of a visitor centre, the focus should be on framing as many constellations as possible during the different seasons through the architecture, so the connection between the human and the universe can be established.

STARS AND ASTRONOMIC PHENOMENA

Due to the focus on Dark Sky and the staging of it, it is crucial to understand which astronomic phenomena besides thousands of stars that can be experienced in the Dark Sky Visitor Centre. This includes an understanding of the position and the calendar of these phenomena.

MORE THAN STARS

The night sky regularly changes because of the rotation of the earth and thus will have different appearance during the different seasons. Besides experiencing thousands of stars, that thereby change position, and the moon that changes within a month, other astronomic phenomena can be experienced in the natural darkness of Nyord. In Winter, the long period of darkness extends the opportunity to observe the thousands of stars and astronomic phenomena. Right before midnight, the brightest winter constellation, Orion the Hunter, reveals itself in the south-east and moves to the south-west during this period. In the mid-December, the brightest meteor shower Geminids can be experienced. Additionally, the meteor shower Quadrantids is visible from the end of December to the middle of January. (Timeanddate, n.d.) (Camp Møns Klint, n.d.a) During Spring, from March to April, the Milky Way can be experienced towards north-east. Further, Northern light reveals itself around equinox. In March and April, both the astronomic darkness and the Zodiacal light can be experienced after sunset. The Zodiacal light reveals itself towards west. From the beginning of May, the inclination of the sun in the Summer period will end darkness for the next three months. (Camp Møns Klint, n.d.a) In May, the Milky Way is only visible early in the morning. Despite the few hours, the period from May to July is the only period, the Noctilucent Clouds can be experienced two hours after sunset towards the west. In August, the darkness will return and create a new observation season, where the Milky Way and the biggest meteor shower Perseids can be experienced. (Ibid) Autumn is the best season to experience the starry sky and the Milky Way. The neighbouring galaxy Andromeda, which reveals itself in the zenith, can also be experienced in this period. (Ibid)

Adromeda galaxy

Autumn

Ill.17 (Pihl, n.d.)

Milky Way

Winter, Spring
Summer, Autumn

Ill.18 (Camp Møns Klint, n.d)

Zodiacal light

Spring

Ill.19 (Grønne, n.d.)

Meteor shower

Winter, Summer,
Autumn

Ill.20 (Merzlyakov, 2019)

Noctilucent Clouds

Summer

Ill.21 (Camp Møns Klint, n.d)

Northern light

Winter, Spring,
Autumn

Ill.22 (Camp Møns Klint, n.d)

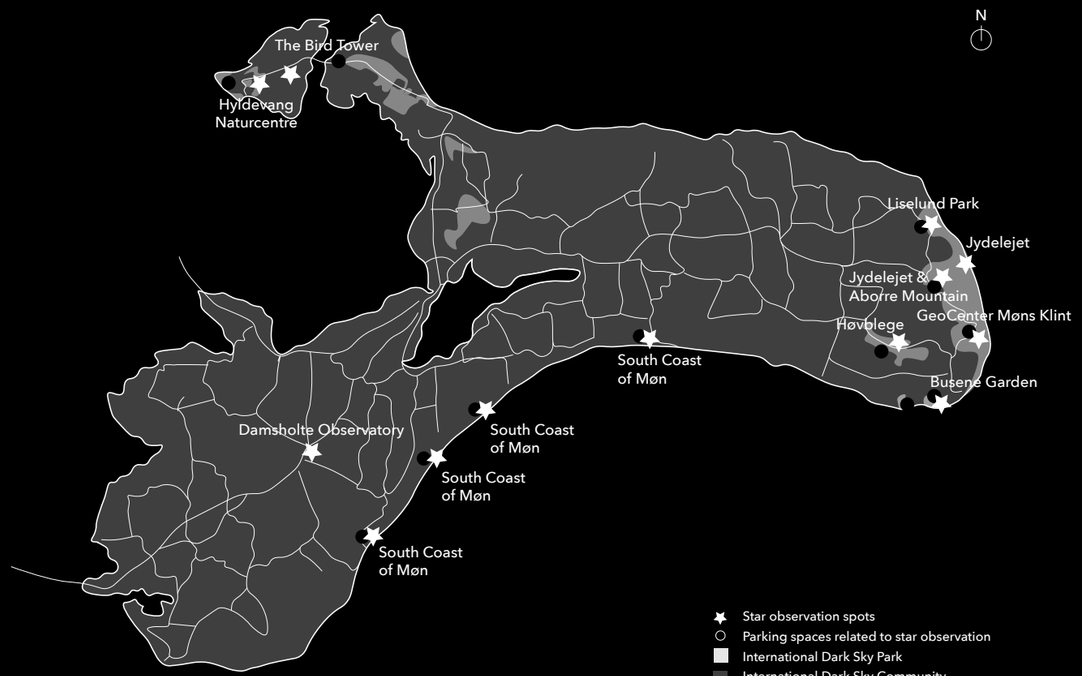
PROGRAM

The following chapter presents the program of the project which includes first analyses of Møn and Nyord's potentials concerning the project site location. Further, the potentials and weaknesses of the site and its context will be clarified through mappings, phenomenological analyses and microclimate investigations of the area which provide the project with both qualitative and quantitative knowledge. Furthermore, the local architectural style and different materials found at the site will be analysed in regards to both functional, aesthetical and technical aspects, which should be utilised to create a modern architecture that both relates to these circumstances and move forward. The second part of the program consists of case studies that should provide the project with different aspects and acquired knowledge within aesthetical, functional and technical aspects. The third part of the program consists of an investigation of the target group and the tourism at Nyord, which should help define the wishes and demands for the new visitor centre. The last part includes the unit program, the functional diagram and the design criteria which should define the foundation of the further design investigations to achieve the vision of the Dark Sky Visitor Center.

Ill.23 (Merzlyakov, n.d.)

ANALYSES
MAPPING OF DARK SKY PARK & COMMUNITY

Møn and Nyord are Danish islands in the Baltic Sea, southeast of Zealand. The International Dark-Sky Association has designated Møn and Nyord as not only Denmark's but Scandinavia's first International Dark Sky Park with Gold Tier status and International Dark Sky Community in march 2017. The islands are the first places in the world to simultaneously being assigned both certifications thanks to the close collaboration between local cities, local companies and the municipality for four years. (International Dark-Sky Association, 2017) The Dark Sky has become a local value for Møn and Nyord which the local community is interested about preserving through the installation of intelligent lighting, spreading the word about Dark Sky and its importance in a local and global perspective and by providing sensuous experiences of this extraordinary natural darkness and clear skies. (Ibid) The Dark Sky can be experienced in the certificated Dark Sky park areas (cf. ill. 24), which for Møn and Nyord includes parts of Høje Møn with Møns Klint and the island Nyord with the lowest light pollution. (Vordingborg Kommune, n.d.a) Thus, it is ideal this project is placed in one of these stargazing spots that provide the most optimal conditions to explore the natural night sky.



Ill.24 Mapping of International Dark Sky Park and Dark Sky Community at Møn and Nyord (Vordingborg Kommune, n.d.)

WHY NYORD?

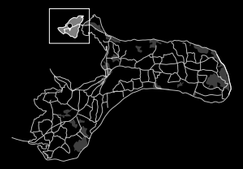
The Dark Sky Parks at Høje Møn and Nyord have different characteristics due to different landscapes. Thereby, different experiences of Dark Sky are provided. Høje Møn offers many activities in close connection to the stunning nature and Dark Sky. The astronomic phenomenon can be explored in the open sky at Camp Møns Klint or in exclusive tents provided by the nearby hotels. (Camp Møns Klint, n.d.b) The Dark Sky and the Danish nature, from its beginning to its present, can be explored in GeoCenter Møns Klint placed on the top of Møns Klint, 128 metres above the sea. The cliffs are vegetated by the preserved Cliff Forest. (GeoCenter Møns Klint, n.d.a) Thereby, memorable views to the starry sky are provided in the surroundings of the amazing nature enhanced by the functions and architecture nearby. On the other hand, Nyord provides a much different experience of Dark Sky. Most of Nyord is flat and covered by salt meadows. Only the western part is settled on a 13-meter high moraine hill. Thereby no vegetation or objects obstruct the views to the starry night sky, and hence a 360-degree view on the same level as the ocean is provided. Furthermore, the reflection of the stars on the lakes and the bird sounds from the bird sanctuary contribute to the extraordinary experience at Nyord. (Miljø- og Fødevareministeriet et al, n.d.) These different circumstances for the two Dark Sky Parks are crucial to consider in the placement of the Dark Sky Visitor Centre.

The attraction, GeoCenter Møns Klint, is an existing visitor centre which relates to the characteristic landscape and conditions of Høje Møn, whereas Nyord lacks an architectural unit that can gather both locals and tourists and reveal the beauty of Nyord. Thus, placing a centre on the flat landscape of Nyord is a way in counter-playing the GeoCenter on the hilly landscape of Høje Møn.

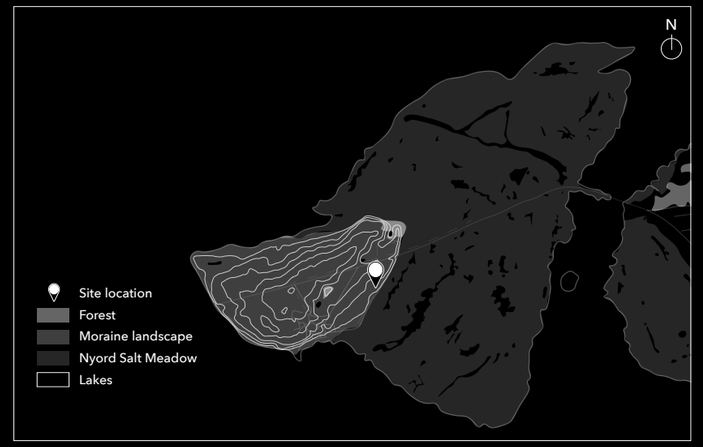
SITE ANALYSES
THE CHARACTERISTICS OF NYORD

NYORD ISLAND

Nyord is a small island situated north-west to the northern point of Møn, the peninsula Ulvshale, only separated by a narrow watercourse called Ulvshale Løb. Nyord is known for its diverse nature, bird sanctuary, Dark Sky and cultural heritage of the preserved village environment. The island is divided into two different types of landscapes. In the north-western part of the island, the landscape consists of 120-hectare moraine landscape including Nyord city and cultivated fields. The rest of the island consists of 400-hectare salt meadows called Nyord Meadow Bird Sanctuary, which is a habitat for wading birds and ducks. (Naturstyrelsen, n.d.a) The chosen site is situated on the border between Nyord Salt Meadow and the moraine landscape. Further, it is one of the tree ultimate Dark Sky starspots on Nyord (Miljø- og Fødevareministeriet et al, n.d.).



Ill.25 Location of Nyord



Ill.26 Mapping of Nyord 1:50.000

INFRASTRUCTURE AND FUNCTIONS IN NYORD

III.27 Mapping of infrastructure and attractions 1:75.000

In order for the project to have success and attract the relevant target group, the specific site location must fulfil other criteria, e.g. accessibility to the site. Nyord Bridge is the only connection between Nyord and the rest of Møn. Ulvshalevej is the main road from Møn to the edge of Nyord, but no public transport provides this cross-over. Thus, Nyord can be reached only by car, bike or walk. (Naturstyrelsen, n.d.b) Though driving opportunities are limited due to the driving prohibition in Nyord City, where only driving for residents is allowed. (Naturstyrelsen, n.d.c) From the main road Ulvshalevej, a side road leads to the site and ends in a parking space located north to the site, where bikes and cars can be parked. Nyord has to be experienced closely from the pathways, where the hiking trail starts from the site and provide sensuous experiences and unique views to the clear sky and ocean. (Naturstyrelsen, n.d.b) In the design of the visitor centre, it is also essential to gain an understanding of what functions would be attractive to incorporate in this centre, which are not provided in the existing attractions on the island. Thus, an analysis of the existing attractions is necessary (cf. next section).

III.28 1. Nyord Birdtower

III.29 2. The old pilot watch post

III.30 3. Nyord City

LOCAL ARCHITECTURAL STYLE

Nyord is characterised by its diverse nature, bird sanctuary, Dark Sky and well-preserved cultural heritage. Thus, in the design of a new building in this context, it is crucial to understand the local architectural style, structural systems and construction form of the existing buildings at Nyord and available local materials. Though, this should not necessarily result in a visitor centre that resembles the historic buildings and use the local materials in the same way that they have been used in the last 300 years. Instead, this project should come up with the critical regionalism answer on this local architecture with an architecture that moves forward, while still being rooted in the site. The project will question the use of the local materials, geometry and construction principles found at the island and how to use these in another context through the reflection upon modern techniques. Therefore, this analysis should contribute to the understanding of principles within the characteristic context, both concerning architecture, function, construction, structure and materials, which could inspire the design of the Dark Sky Visitor Centre.

1. NYORD BIRDTOWER

The first stop on the exploring route to Nyord, and simultaneously one of the best spots to explore the stars, is Nyord Bird tower which is situated on the middle of the salt meadows. (Miljø- og Fødevareministeriet et al n.d.) The tower is constructed as a light wood structure in two floors shaped like hexagons. The hexagon shape has benefits both regarding material use, construction and spatiality. The hexagon requires less material and takes less time to build compared to a square building. Further, the hexagon is preferable for compression forces due to the short distance to the edges of the shape that distributes the forces to the pillars and further down to the ground. The triangles have been used to create stability due to the rigid structure of the shape. (Ball, 2016) (Kemmis & Kosmola, n.d.) (Vyas, 2018)

The bottom floor of the tower provides views to the landscape in protection from the harsh climate in the winter period. The views are possible through three small square openings placed on each edge of the hexagon shape. The top floor has an open sky and thus contributes to the fascinating view of the starry sky. The division of the two floors is reflected on the exterior with the top floor lifted above the bottom. A small overhang placed around the bottom floor enhances this and simultaneously provides shadow from direct sunlight. The walls are covered with tongue and groove wood cladding that provides a more dynamic facade regarding light and shadow and decomposes the scale of the structure. (cf. site visit) The floors are carried by circular-shaped steel columns that due to the strength and efficiency of steel make it possible with a light structure enhancing the verticality of the bird tower. The columns are connected across with wood boards and stabilising crosses. Due to this verticality and the wooden material on the walls, the tower merges into the small grove of high trees in which it is placed near the main road. In daylight, the light brown wood material obtains an orange shade that relates it both to the surrounding trees and salt meadows. Though, the tower rises above the trees and provides an uninterrupted view to thousands of wading birds navigating after the moon and the stars. The characteristic outdoor wood staircase swings around the tower and stages the entrance and movement up to the tower, especially under the glow of thousands of stars. In the surroundings of flat salt meadows, the rising tower stands as a remarkable architectural construction. (cf. site visit)

Ill.31 Nyord Birdtower as great Dark Sky spot (Merzlyakov, n.d.)

2. PILOT WATCH POST

Møllestangen is Denmark's smallest historic museum revealing the history of Nyord as "the island of pilots" placed on the flat cultivated fields on the highest point on the island of Nyord. With this position, it becomes remarkable from a distance and provides an open view of the ocean in the background. Together with its position, Møllestangen succeeds in revealing a definite architectural style that reflects the function of the building as a pilot watch post. (Naturstyrelsen, n.d.a) The pilot watch post played a major role for Nyord because of its placement of the island on the sailing route from Copenhagen to the Danish southern islands and Schleswig. Due to the low water between Nyord and Ulvshale, the waters complicated the navigation. Thus, the local farmers became pilots and constructed pilot watch posts as Møllestangen from 1882. (Ibid)

The building is placed with a short distance to Nyord City, whereas the local farmers easily and quickly could access their second occupation as pilots. The only 4 m^2 small building was constructed to fit one local pilot, and due to the position of the building near the ocean, the building made it possible for the local pilots to orient the seafaring safely between the narrow channels around the island (Ibid). The building is constructed as a small house with gable roof in red tile, which gives it a rough expression relating it to the environment, and simultaneously due to the strength of tile as construction material, it protects the pilot from the harsh weather conditions on the exposed spot. Further, tile is resistant towards the salt from the ocean, and thereby the construction needs neither protection nor maintenance. The red tile does also make the building a conspicuous spot, whose presence is emphasised through its construction on a high concrete foundation that raises the building above the flat landscape to provide a better watch. (cf. site visit)

The watch post has a square shape referring to the local buildings and which simultaneously provide the possibility of openings on more sides of the building. Thus, views to its surroundings are provided through a small opening in three of the walls that frame specific views. The openings are not covered with glass in order for the pilots to extend their binoculars outside the openings, and thus wood shutters have been added to close the opening when the pilot left his work station. (cf. site visit) Other than reflecting the function of the building, its size also relates to human scale and to its flat surroundings which it respects harmoniously. Though its nearest context is the flagpole, and in interplay, they symbolise Danish culture and architecture. The unique characteristics of the building make it a popular icon for the island and also a great stargazing spot (VisitDenmark, 2020). Its isolated position on the flat surroundings provides a memorable view to not only the ocean but also the starry sky. At night, the total darkness covers most of the landscape with only the building visible, which strengthen its statement as a remarkable piece of architecture. (cf. site visit)

Ill.32 Pilot watch post as a remarkable icon on the flat landscape

Ill.33 Pilot watch post as great Dark Sky spot (Pihl, n.d.)

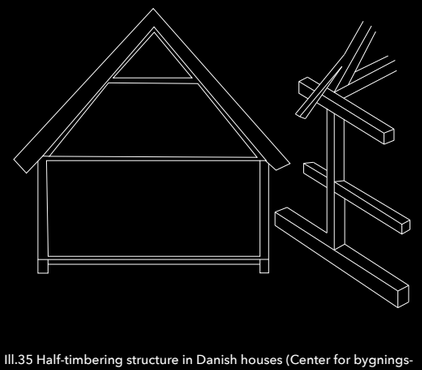
3. NYORD CITY

Nyord City is one of Denmark's best-preserved villages from the end of the 18th Century. The small city consists of former farmhouses that reveal the original position of the locals as both farmers and pilots and simultaneously demonstrate the historic development in the city reflected in the construction and materials. The local materials and local architectural style defined the former farmhouses which are characterised by precise proportions referring to traditional Danish architectural style from stone age; long and low buildings with the gable oriented towards east-west. Due to the strong winds on the island, the residence was placed towards west, while the barn and stable was placed towards east, which today consists of a garage and shed. The interior spaces were modest consisting of few small rooms, which made the heating of the spaces more efficient. (cf. appendix B) The glazing bar windows and the entrance were aligned with the walls and were placed on the front or back facades of the building directed towards north. The building is placed directly on the ground, which results in a fluent transition from outside to inside. (Forening Nyord, n.d.)

Ill.34 The local architecture reveals the use of local materials on different parts of the building, while the half-timbering structure is reflected on the exterior walls

CONSTRUCTION AND MATERIALS

The oldest farmhouses at Nyord are constructed as half-timbering, also called post and beam, which is a centuries-old construction method and describes a timber construction with the timber frame as the primary structural support for the building, while the holes between the elements are filled with non-structural materials as plaster, brick, stone, wattle, daub and laths. (Jeffers,



Ill.35 Half-timbering structure in Danish houses (Center for bygningsbevaring Raadvad, 2018)

Ill.36 Half-timbering structure visible on the whitewashed facade

2017) The timber frame consists of columns, beams and a truss system defining the gable roof of the farmerhouses. The trusses distribute the loads from the roof to the wall posts and further down to the foundation. The horizontal members called the tie-beam keep the walls from pushing apart by the roof load. Traditionally the structure was constructed of squared oak timbers connected with wooden pegs, mortises and tenons. Often the structural skeleton was stabilised at the corners with wood cross-braces. (Ibid) These joints can be done by hand-craft, whereby the structure is easy and fast to construct, which also makes it cost-effective. (Timber Structures, 2020) Further, the construction methods are easy to disassemble and thus can be used elsewhere. Though, the exposed wood construction and the plaster and masonry filled in between the structur-

al elements create thermal bridges. Thus, it is necessary to cover the exterior walls with wood boards or masonry due to the increased energy requirements. (Jeffers, 2017) The construction technique will be revealed in the assemblies that are given a unique character. Further, the structure will have a homogeneous expression, because the structure only relies on timber, which has many qualities as construction material (cf. pp. 72-75).

Nyord neither had or have forests today, because the earth was mainly used to agriculture, and thus timber was imported from neighbouring countries. Due to this limitation, the half-timbering was minimal, which is expressed in the dimensions and span of the structural elements. Further, no cross-braces were added between the columns. Though the structures were durable, even today. The half-timbering has either been painted black or can be decoded on the exterior walls that have been whitewashed, especially when touched or observed in daylight. The top part of the gable is covered with wood cladding which thereby separates the roof from the walls and reveals the construction of each part. (cf. site visit)

RED-TILED BUILDINGS

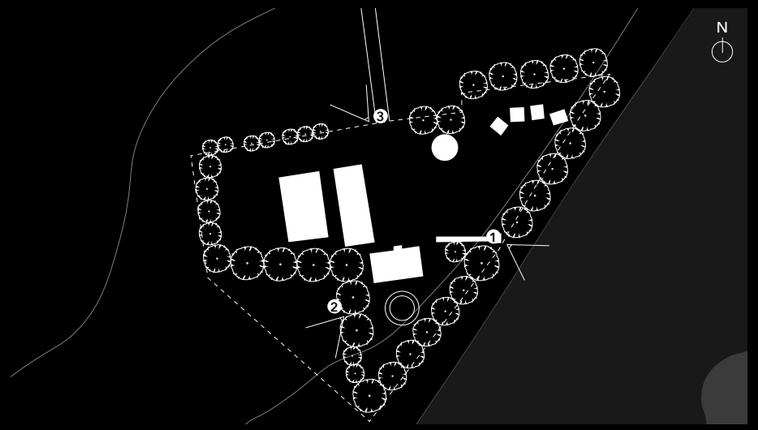
In 1880 a tileworks was established at Møn, from where the local farmers bought tile to the construction of their houses, and thereby red tile became the new dominating construction material. (cf. appendix B) Brick masonry is the oldest form of construction principle consisting of bricks laid in a systematic manner which are bound together with mortar. Thus, a solid mass is constructed to withstand external loads. These types of constructions are effective, both because of the brick as material and of the construction form (cf. pp. 66-67). (Muresan, 2020) The red-tiled builings were constructed wider than the former whitewashed houses and also had glazed bar windows with narrow bars placed aligned with the exterior walls. Some of the window frames were even coloured with, for instance, blue. The foundation is built by shaped boulders, while the walls are constructed in red tiles with a ribbon above windows and on the gable with oblique tiles. (cf. site visit) (Forening Nyord, n.d.) The local builders left their professional mark on the buildings through tile details on the houses that became a brand for the specific building. This could be a burned or arched

III.37 Detailing in the brickwork

III.38 The brick arch above the door

joint between the tiles or through the brick a rch defining the window openings. (cf. site visit) The form of the brick arch expresses unity, balance, proportion, scale and character which describes its aesthetical appeal. Further, it is structurally efficient due to its higher resistance towards compression forces than tension, whereas it can withstand the internal compressive stresses when loaded with a uniform load. This makes the masonry arch is an efficient structural element to span openings. (The Brick Industry Association, 1995) Traditionally the roofs were covered with reeds, but due to the need of exchanging the material frequently, the builder instead uses fibre-cement boards due to economic aspects (Forening Nyord, n.d.). Thus, Nyord city consists of a mixture of these two types of houses which reflect the architectural style of the city. Some of the red-tiled buildings are constructed as half-timbering but with red tiles facing towards the street (Ibid).

THE SITE IN RELATION TO ITS SURROUNDINGS



Ill.39 Mapping of the site and views provided 1:2.000

From the site, different views are provided in between the trees on the site. Towards the east, the bird sanctuary is located, which consists of 400-hectare salt meadows that is habitat for wading birds and ducks. The flat landscape is in a constant transformation which results in flooding of the salt meadows in winter, while in summer the area is used for grazing cows.

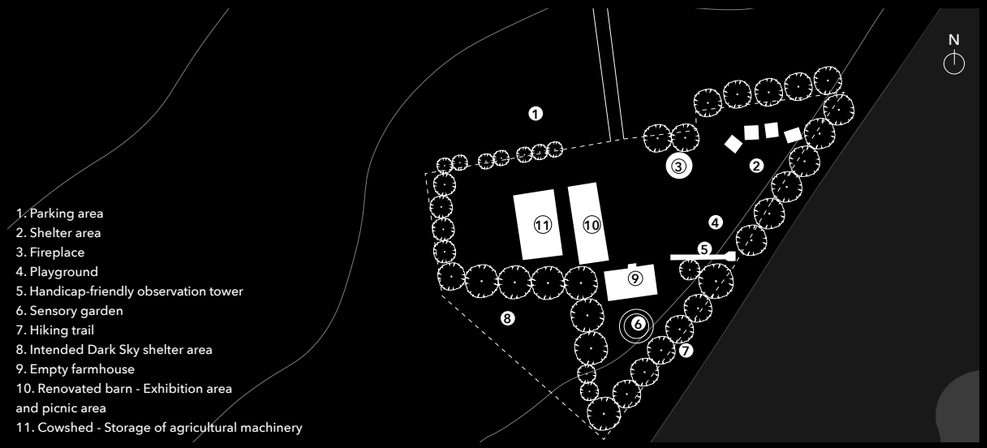
Towards the west, cultivated fields can be seen with Nyord City in the background. The Nyord City is placed on the moraine landscape sloping down towards the site. The hill provides shelter for the harbour placed on the west coast. (Naturstyrelsen, n.d.a). The whitewashed farmhouses and red-tiled buildings in the Nyord City contrast the surrounding green nature and thus are visible from a long distance. Due to the rise of the landscape towards the north, the view of the ocean is limited in this direction, but instead dominated by open fields with few trees and a glimpse of Børges Markhus situated on top of the landscape.

Ill.40 View 1: Salt meadows

Ill.41 View 2: Cultivated fields with Nyord City in the background

Ill.42 View 3: Fields with a glimpse of Børges Markhus

FUNCTIONS ON THE SITE



Ill.43 Mapping of the functions on the site 1:2.000

The project site currently consists of Hyldevang Naturcentre which is an abandoned farmhouse owned by Naturstyrelsen and is the only farmhouse placed outside Nyord City. (Vordingborg Kommune, n.d.b) (Naturstyrelsen, n.d.a) The border of the current cadastral is marked with trees the whole way around besides at the entrance to the site.

Since 2018, the site has been an attraction for tourists, locals and school classes due to the existing year-round open shelter area consisting of five shelters, fireplace and playground, which are frequently used by overnight school camps and tourists who want to experience Dark Sky under the open sky. Further, an exhibition about Dark Sky, a sensory garden consisting of plants from Nyord and a handicap-friendly observation tower with direct view to the starry night and the salt meadows are located on the site. In the south-western part of the site, an open area

Ill.44 Shelter area with fireplace

Ill.45 Handicap-friendly observation tower

Ill.46 Sensory garden

Ill.47 Hyldevang Naturcentre (Google Maps, 2019)

with a view to the bird sanctuary and Nyord City is situated, which provides good opportunities for a desired Dark Sky shelter area. (Miljø- og Fødevareministeriet et al, n.d.)

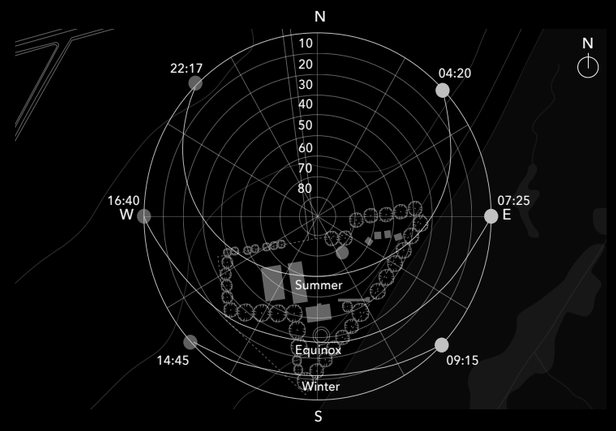
The former farm on the site consists of three farmhouses; cowshed, renovated barn and an empty farmhouse, all revealing the history of the place. Today, the cowshed is used for storage of agricultural machinery, and the barn is used as both picnic area for school classes and tourists, exhibition area about Dark Sky and workshop facilities. (Vordingborg Kommune, n.d.b) Vordingborg Municipality has planned to demolish the farmhouses because they are very decrepit and thus not worth maintaining. This provides an opportunity to create a new function appealing to locals and tourists, which enhances the potential of the site and stages Dark Sky concerning the existing facilities related to nature, camping and stargazing. (cf. appendix A)

MICROCLIMATE

SUN PATII

In the design of a visitor centre with a focus on Dark Sky, it is crucial to look at the sun path for the location to understand the amount of night hours compared with sun hours in the different seasons. Dark Sky is a phenomenon occurring in the night sky, and thus the best conditions to experience not only thousands of stars, but also the different astronomic phenomena are at night on a clear sky. In summer, the sun rises around 4 am and sets around 10 pm, which results in many sun hours and thus less night hours. On the other hand, in winter the sun rises at 9 am and sets around 3 pm and thereby create the best circumstances for experiencing Dark Sky in a longer period compared to summer.

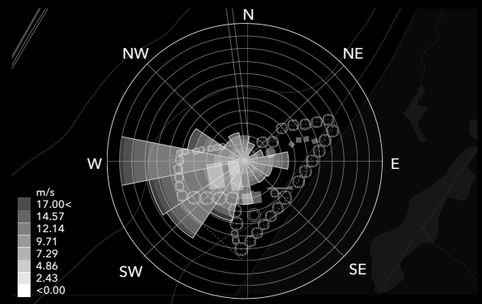
Thus, it is essential that the Dark Sky Visitor Centre also can be used outside the summer period, which currently is the main period for tourist attractions at Møn. This will extend the Dark Sky season and provide the opportunity to experience the starry sky and the astronomic phenomena during the whole year in the Dark Sky Visitor Centre at Nyord. Additionally, the seasonal variation of the sun position influences how the visitor will perceive the interior space both at night and during the day in terms of how much light that will penetrate the room and affect the atmosphere. Further, the variation of the sun position will influence the interplay between light and shadows on the interior materials.



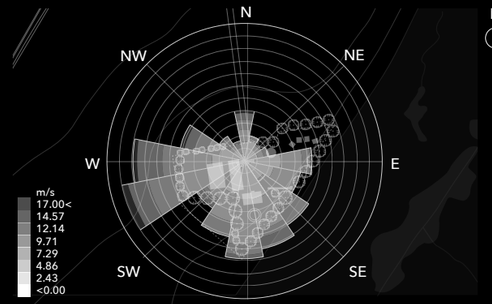
Ill.48 Sunpath for winter, equinox and summer (EnergyPlus, n.d.)

WIND

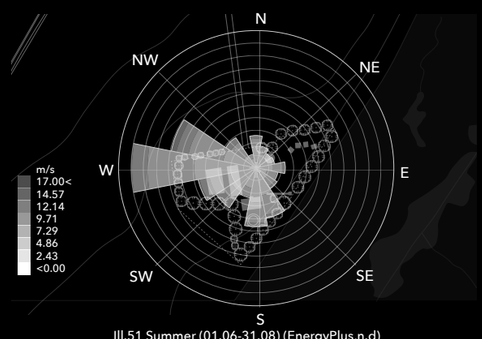
Due to the flat and open landscape of Nyord the island is exposed to a lot of wind. The site is surrounded by trees which provide sheltering from the wind in all directions besides at the entrance to the site, at the observation tower and at the south-western part of the site. The wind roses indicate that the strongest wind comes from the west, where Nyord City is placed and thus will break up most of the wind before it reaches the site. The remaining wind has to be considered in the desired shelter area. In Spring, the observation tower is exposed to wind from the east, while the desired shelter area will be exposed to wind from the west.



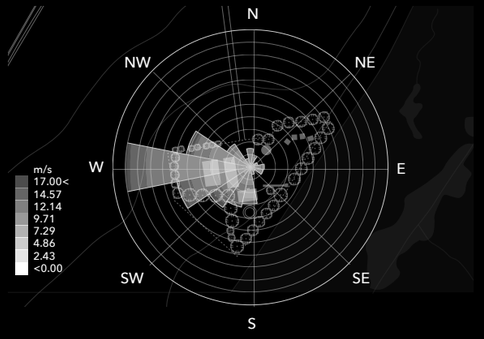
Ill.49 Winter (01.12-28.02) (EnergyPlus,n.d)



Ill.50 Spring (01.03-31.05) (EnergyPlus,n.d)



Ill.51 Summer (01.06-31.08) (EnergyPlus,n.d)



Ill.52 Autumn (01.09-30.11) (EnergyPlus,n.d)

PHENOMENOLOGICAL ANALYSIS

THE ATMOSPHERE - AT DAY

A narrow road from the straight main road, Ulvshalevej, leads to the site situated on the cultivated and occupied moraine landscape directly on the other side of the flat and wet landscape of the salt meadows. Within a short distance, it reveals the characteristics of Nyord in one glance. Everything seems so close and visible, and even the historic Nyord City is apparent in the background. With a linear direction, the road ends in a gravelled and muddy area that is intended as parking area As soon as one gets out of the car, the spirit of the place can be sensed. The demarcation of the area is clearly defined by a dense row of naked oak trees and provide an overview of the site which seems easy to explore.

The smell of the grass growing on the flat ground, characteristic sounds from the wading birds drowning out the one from the wind, which the trees protect against, and the glimpse of the characteristic surroundings between the trees which activate one's senses. The marks on the ground clearly indicate the former use of the site to agriculture.

Further, a narrow pathway has been engraved on the ground which orient one towards the small fireplace huts, shelter area and the playground made in same wood materials contributing to the sense of being in direct touch with nature. The slight slope on the handicap-friendly watch post provides a comfortable walking on it and leads to the edge of the moraine landscape with an incredible 180-degrees view to the large salt meadows; the blue lakes contrasting to the yellow salt meadows, the wading birds flying above the meadows seeking for food and the clear sky. One feel overwhelmed by the flatness and the uniqueness of this landscape and the open horizon which enables skimming Ulvshale Forest in the background. Walking beyond the middle-high trees towards the southern edge towards the cultivated fields, a similar view can be experienced, but here, the experience feels more intense, because one stands on the ground, which due to the horizon on eye-level seems to continue into the salt meadows, the ocean and in the end unites with the sky.

Ill.53 The atmosphere of the site at day

PHENOMENOLOGICAL ANALYSIS

THE ATMOSPHERE - AT NIGHT

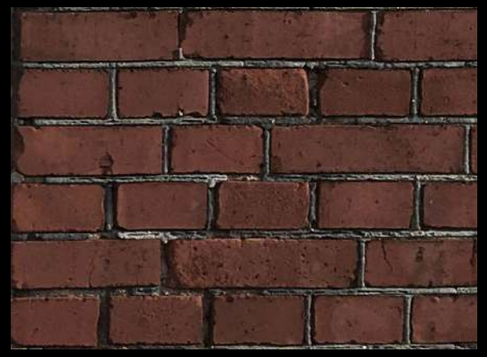
At night, the sensuous experience is different and more unique. Due to no artificial lighting neither on the site nor in the surroundings, the site is covered by total darkness. When arriving at the site, one is insecure about the delimitation of the site and the border between the firm ground and the salt meadows, because the trees blend in with the darkness. Limiting the sight seems to also limit one's capability of orientation, and thus the other senses must be strengthened. One move slowly and carefully around the site, but with time the sight seems to adapt to darkness, and one becomes capable of distinguish what one can sense on the site.

One thing is for sure clear to observe; the thousands of stars in the clear dark sky surrounding one and revealing the phenomenon Dark Sky. The amazement of this incredible view is breathtaking and contributes to oppressing one's orienting sense in a second due to the attempt in getting an overview of the stars. From the watch post or from the desired shelter area, this admirable experience is enhanced due to the open horizon. The stillness of one's body increases the touch of the wind passing by without anything to obstruct it, but with the sky provided, these issues seem of less matter. The stars shine so clear that they can be count, and on this night they form a wide band of stars stretching from one end of the sky to the other, designated the Milky Way. The lakes on the salt meadows mirror the stars, and thus the clear dark sky seems to unite with the salt meadows and the ocean in the background. Suddenly, the sky feels so close, and one feels so small.

Ill.54 The atmosphere of the site at night

MATERIALS
LOCAL AND SUSTAINABLE

The characteristic architecture of Nyord is mainly constructed in local materials available on the island or imported nearby. Thus, this project should take the starting point in the local materials available, not to claim these should define the project, but to have an understanding of the possibilities of the existing materials and due to sustainable concerns. Thereby, these materials are investigated further both regarding aesthetic, functional and technical aspects.

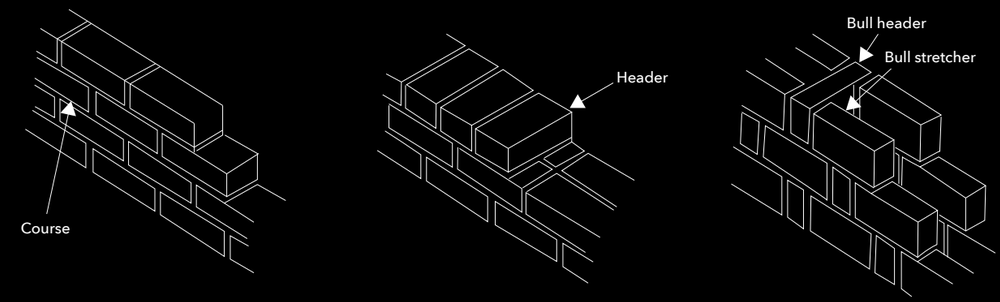


III.55 Red bricks

BRICKS

Some of the buildings in Nyord have been constructed in bricks (cf. pp. 54-55) produced at the tileworks nearby, which today is closed. Though, brick is still a popular building material, especially in Denmark and has in thousands of years been used as a structural material in different structures due to its many qualities.

Brick masonry is often considered as an unsustainable method due to the high CO_2-emissions related to the energy-intensive firing process. Though sustainability covers other elements such as the life cycle of the material, maintenance, durability and recyclability. (Chua, n.d.) Bricks have a long lifespan and are robust, hard and durable which make them efficient in construction and make them capable of withstanding a large number of compressive weight loads due to the high compressive strength. Brick masonry is easy to construct because of the uniform shape and size of the bricks, which also are easy to handle and transport. (Jamal, 2017) (Muresan, 2020) The raw material of bricks are easily available, which also make them economic and cheaper than, for instance, concrete blocks. Bricks are reusable and recyclable, fire-protective and highly resistant towards weather and rotting. Brick masonries do also increase the thermal mass of a building, whereby the brick gradually absorbs heat during the day, when the temperatures are higher, and releases the heat at night. On the other hand, brick masonries are time-consuming to construct and have a low tensile and torsion strength. (Jamal, 2017) (Muresan, 2020) Concerning aesthetic qualities, the brick gives a rustic and natural appearance, which fits well in the Danish landscape. Further, the bricks have a variety of colours and textures, which give different opportunities in defining the aesthetics of a building. In terms of acoustics, bricks have sound-reducing properties due to the high density and thus prevent soundwaves from passing through the brick construction into space. If having a brick wall, the two layers of bricks will trap additional noise and thereby acting as added sound-proof insulation. (Austrial Bricks, n.d.)



III.56 Brick masonry construction forms (Heiserman, 2015)

EELGRASS

Eelgrass is another characteristic material on the island, growing along the Danish coasts for instance in the 200-year-old sea wall on the north-western side of Ulvshale. (Naturstyrelsen, n.d.a.) Eelgrass is a plant living underwater consisting of 50-100 cm long fibres that grows on coasts with low-water and good light conditions with muddy or sandy bottom soil. (Miljø- og Fødevarestyrelsen, 2018) The local farmers on Nyord use the material as insulation in the walls and roof construction due to its excellent thermal, fire and acoustic properties.

Eelgrass is a sustainable material, because it is a natural raw material, and thus there is an interest in producing insulation batts of eelgrass to replace traditional insulation solutions as mineral wool. Companies as Advance Nonwoven (ANW) have developed insulations batts of eelgrass that fully consist of natural material, are reusable, do not cause waste-water under production and simultaneously are fire-resistant, which is caused by the high level of salt. Eelgrass has similar insulation properties as mineral wool with a thermal conductivity, λ of 0.037 W/mK. Further, eelgrass insulation batts also have good acoustic and sound-reducing properties because it is a porous material and thus has good absorption qualities. At the highest frequencies, an 80 mm eelgrass insulation batt competes better than a mineral wool batt of the same thickness. Concerning the LCA environmental analysis, eelgrass performs better regarding the greenhouse effect (CO_2) which for eelgrass is 464 g CO_2 equivalents per kg end product, while it for mineral wool is 1329 g CO_2 equivalents per kg end product. (Ibid) The converting of eelgrass to insulation batts starts on the coasts when eelgrass is washed ashore on land. It is important collecting as clean raw material as possible to maintain the quality of the material, and thus eelgrass must be collected as quickly as possible from the coasts. Afterwards, the eelgrass will be distributed on a nearby field and washed to clean the grass from salt and sand. In a few weeks without rain, it will dry up, and with a water percentage below 15 to 20 % in the eelgrass, it should then be torn together and pressed into round bales. These can then take part in a further process to convert them to insulation batts or other forms. This process requires the right knowledge and techniques and is therefore expensive, which also results in high prices of eelgrass (around 7000 DKK per ton). By making this process more efficient and in an interplay with a higher demand on the material, the end price on eelgrass can then be reduced. (Ibid)

Ill.57 Eelgrass texture (Zostera, n.d.)

Ill.58 Eelgrass insulation batts

CLAY

Clay is a finely-grained natural rock or soil material composed of one or more clay minerals, and it has been used for construction for thousands of years (Designing Buildings, 2020). Until 1850, clay was used to fill in the holes between the timber columns in the half-timbered construction in Danish farmerhouses. (Vadstrup, 2012a) Clay has high plasticity due to the particle size and the water content, though only until it is dried or fired, where it then becomes hard and brittle. Further, clay is a robust material and has good stability and durability, which makes it suitable as construction material, where it mostly is baked into brick or roof tiles. Clay is also fire-resistant and has the ability in withstanding seismic activity which gives it a lifespan of at least 100 years. (Vinding et al, n.d.)

Clay is considered a sustainable material because it is an unrestricted raw material that can be extracted from the moraine earth (Ibid.) and afterwards proceeded by adding water to change its shape. (Designing Buildings, 2020) A part of the landscape on Nyord consists of moraine earth, and thus clay is an available local material. The strength of clay can be increased by adding straw or sand (Designing Buildings, 2020). Clay has good moisture regulating properties, which makes it useful in absorbing and releasing moisture and thus contributes to maintaining a good indoor climate. Clay does also absorb the moisture from the wood in the half-timbering and thus avoids rot of the timber. Clay also has good insulating properties because it stores the heat longer than other materials and thereby increases the thermal mass. Furthermore, it has good acoustic properties by reducing the sound that transmits from one space to another through the construction. (Vadstrup, 2012a)

Ill.59 Clay (Deposit photos, n.d.)

CONCLUSION

The analysis of the described materials should clarify the advantages and possibilities in working with these materials which refer to the local architectural style of Nyord. Common to the materials, except for bricks, is that they are natural materials that can be extracted from the moraine earth or the surrounding coast, which both has sustainable and economic benefits. Further, the materials have various amount of qualities suitable for the construction of the Dark Sky Visitor Centre.

Bricks have a high compression strength, are durable, have a long life-span and are highly resisting towards the harsh weather, and thus it can be used in a masonry construction of the external walls. Bricks also have sensuous qualities that will contribute to the creation of an architecture that itself is an experience due to the natural and rough appearance and characteristic tactility and sound of bricks. Though a brick facade appears heavy due to the high density of the material, and thereby a building of the size of the centre fully constructed in bricks will seem massive and remote. Due to the vision of creating a structure that establishes the connection between the human and the sky, the exterior walls should not be loadbearing. Thus, bricks should only be used due to its other qualities, while its high density could be used to enhance the structure as bearing the roof. Hence, it should be combined with other materials, for instance, a lightweight material.

The insulation both in the wall and the roof can consist of eelgrass compressed to insulation batts because eelgrass is a sustainable material but with equal efficiency to the well-known mineral wool. Besides the good insulation properties of eelgrass, its good acoustic and soundproofing qualities are beneficial in minimising exterior noise that could disturb the experience of the Dark Sky within the centre.

Clay is considered in this project due to sustainable reasons, its good insulating properties increasing the thermal mass of the building and its acoustic properties that could be used to absorb the sound within the centre, for instance, to enhance the sight towards the sky instead. Thereby, clay could be used as interior walls or in the floor construction.

STRUCTURAL MATERIAL
WOOD

Even though that wood is not a local material on Nyord which neither can be taken from the protected forests at Møn, the material is considered being used in this project imported elsewhere. It is considered in this project due to its sustainable qualities and structural, thermal and acoustic properties. Further, wood is an important characteristic of Nordic architecture, even used in the local buildings on Nyord.

Wood is, first of all, a natural resource and thus easily available, but which means a little processing of the material itself is needed before it can be used in structures. (Cruvellier, Eggen & Sandaker, 2011, p. 98) Further, it is a sustainable material because it is biodegradable, renewable, and no fossil fuels are needed to produce wood. (Understand Building Construction, n.d.) Though, wood is a complex material, because it is anisotropic which means it has different properties in the different directions due to its cellular tube structure. Thus, it has different strength and stiffness properties along the grain than perpendicular to the grain. In general, wood is stronger and stiffer in the longitudinal direction, which means in the direction parallel to the grain. (Cruvellier, Eggen and Sandaker, 2011, p. 98) Wood is strongest in tensile parallel to the grain than in compression which makes it capable of resisting bending under pressure without breaking and makes it a good structural material, for instance, as beams. Further, it is very strong concerning its weight which makes it a very efficient structural material and results in a light expression of the building. (Cruvellier, Eggen and Sandaker, 2011, p. 98) (Understand Building construction, n.d.)

Wood insulates well and has good thermal properties with high resistance to high temperatures which dries wood out and makes it stronger as the heat increases. Further, wood has a low heat conductivity compared to other materials, which makes it suitable, for instance, as wall coverings and ceilings. Wood also has good acoustic properties related to its absorption of sound and thus it is used in concert halls and theatres where a proper acoustic is necessary. (Understand Building Construction, n.d.) Aesthetically, wood has a warm, welcoming and natural appearance that makes it an attractive material that relates well to the Danish landscape.

Strength Class	Density, ρ12,k (kg/m3)	Tensile strength along the fibres (MPa)	Compression strength along the fibres (MPa)	Bending strength along the fibres, (MPa)	Stiffness – Elasticity modulus along the fibres (MPa)
C24	350	14	21	24	7.400
GL24h	380	16.5	24	24	9.400
GL32h	430	22.5	29	32	11.100
GL32c	410	19.5	26.5	32	11.100

Ill.60 Characteristics of different strength classes (Martin & Munch-Andersen, 2013)

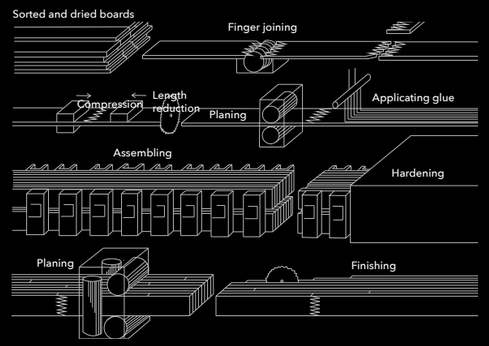
MANUFACTURING OF WOOD

Wood can be manufactured as different products to use in construction. Wood sawn longitudinally is termed lumber and is classified depending on its strength and density affected by knots, splits and warps. If the wood members are larger than 125 by 125 mm, they are termed as timber. Engineered wood or laminated wood (glulam) is another type of wood used in construction with other benefits than the construction timber. (Cruvellier, Eggen and Sandaker, 2011, p. 98)

Glue-laminated timber consists of layers of wood that are glued together to form cross-sections of specific dimensions. The glue has the advantage of providing a static interaction between the layers resulting in strength of the cross-section as if it was made from one, homogeneous piece of material. The different layers of wood of 30 to 40 mm thicknesses have been selected properly to avoid knots and split in the wood material that can decrease the strength and the stiffness. Thus, the quality and strength of glue-laminated timber are higher than

construction timber of the same dimensions. Further, glue-laminated timber provides elements with higher length and larger structural dimensions. (Ibid, pp. 98-99) Glulam is constructed of thin bendable pieces, which makes it a ductile form that can be shaped and curved easily and can be adjusted to various dimensions. It can easily and quickly be adjusted on the construction site, which also has economic benefits. Glue-laminated timber is a light material that makes it suitable for a larger span. Further, it has high fire resistance. (Træinformation, 2002) In relation to LCA (Life Cycle assessment), the glue-laminated timber has a high GWP (global warming potential) due to the glue production. GWP is measured in CO_2 per equivalents and describes how much energy the emissions of 1 ton of a gas will absorb over a given period, relative to the emissions of 1 ton of carbon dioxide (CO_2) (EPA, n.d.) Further, it has a high primary energy total use (PEtot).

Ill.61 Glue-laminated timber (Instabuilt, n.d.)



Ill.62 Glue-laminated timber manufacturing (Træinformation, 2002)

TYPES OF SOFTWOOD

Wood can be classified into two primary categories: hardwood and softwood. Hardwoods are leaf-bearing trees that are considered to be heavier and denser than softwoods which are any cone-bearing trees such as spruce, pine and fir. (Understand Building Construction, n.d.) Softwoods are light and strong materials making them suitable for structures. (Cruvellier, Eggen and Sandaker, 2011, p. 98) Glue-laminated timber is mostly produced by softwood. (Træ.dk, n.d.a) The most common types of softwood used for construction in Denmark have been analysed and compared to choose the most optimal for this project.

Ill.63 Spruce (Træ.dk, n.d.a)

Ill.64 Pine (Træ.dk, n.d.b)

Ill.65 Beech (Træ.dk, n.d.c)

Ill.66 Ash (Træ.dk, n.d.d)

Wood type	Density (Weight – air dry) (Kg/m3)	Tensile strength along the fibres (MPa)	Compression strength along the fibres (MPa)	Bending strength along the fibres, (MPa)	Elasticity modulus along the fibres (MPa)	GWP (Kg CO2 equiv./ m2)	Primary energy total (PEtot) (kWh/m2)
Pine (scots pine)	500-540	104	45-47	83-89	10.000-12.000	9.09	76.12
Beech	690-750	135	52-56	105-118	10.000-16.000	8.94	96.41
Ash	550-800	165	38-58	80-120	8.300-13.400	-	-
Norway Spruce (Whitewood)	440-470	88	35-44	66-84	8.300-13.000	8.20	67.09
Glulam	-	-	-	-	-	15.67	170.33

Ill.67 The different wood types and their characteristics (Træ.dk.b-e)

PINE

Pinewood is widespread throughout Denmark, especially around Silkeborg, Northern Zealand and Læsø. It is the second-most produced wood type in the Nordic countries and the second-most used wood type for timber construction in Denmark. Additionally, it is used as exterior cladding, windows, doors, floors and steps. Thus, it is highly imported to Denmark, especially from northern Sweden. (Træ.dk, n.d.b) (Vadstrup, 2012b) Pinewood is a fast-growing material, which makes it soft and thus suitable as floor material due to the limited hardness of the material. Additionally, pinewood is a cheap material compared to other wood types. (Odinsgulve, n.d.) The wood type is highly resistant towards drought, frost and strong winds. It has a high stiffness compared to some of the other softwood types, a low GWP and primary energy total. Pinewood has a light red-brown core in contrast to the white-yellow sapwood and visible growth rings with a width of typically 1.5 to 2 mm. (Træ.dk, n.d.b) (Vadstrup, 2012b)

BEECH

Beechwood grows in most areas throughout Denmark, especially in eastern Denmark. The core and the sapwood have both a light yellow tone, which become red-brown when dried. The growth rings are hard to recognise, whereas the structure of it seems uniform. Though, vertical stripes characterise the wood. (Træ.dk, n.d.c) The wood is characterised by the hardness of the material and few knots, which provide high compression and bending strength and stiffness along the grain compared to some of the other types and a low GWP. (Ibid) Beechwood is mainly used for parquet floors as small composed staves placed in different patterns (Vadstrup, 2012b).

ASH

Ash grows like beech in most of Denmark. Both its core and the wide sapwood have a yellow-white colour tone and it has clear growth rings that give it a dynamic appearance. Ash is a heavy wood type with good mechanical properties and a good tensile strength along the grain compared with some of the other types. It is mostly used for tools, flows, furniture and veneer due to its high durability compared to pine and spruce and because the material is easy to process. Additionally, ash wood is not resistant to fungus and rot. The wood has large knots which gives a possibility of cracks in the material when it is exposed to frost. (Træ.dk, n.d.d)

SPRUCE

Spruce is one of Denmark's main wood types growing at same places as pine and is used to same purposes. There are different types of spruce, but Norway spruce is the most used wood material in Denmark. The tree has a straight and regular form that makes it suitable for construction purposes, and thus spruce is used for glue-laminated timber and roof trusses, though mostly imported from Sweden. Besides having a high stiffness, spruce has a low GWP and primary energy total compared with the other wood types which make it more sustainable.

Spruce has knots that appear as dark and hard cylindric when the branches fall. Further, it has small knots between the whirl of branches whereas it differs from pinewood. (Træ.dk, n.d.e) (Vadstrup, 2012b)

In contrast to pinewood, there is no colour difference between the core and sapwood of spruce, and it does not become darker in the light as pinewood. Further, it has wider growth rings than pinewood. Spruce is less resistant towards fungus and insects. Further, the wood is hard to impregnate due to the closed-cell structure. Though, this improves the water-resistance of spruce which makes it suitable for exterior cladding, while the uniform and light appearance makes it suitable as floor material. (Træ.dk, n.d.e) (Vadstrup, 2012b).

CONCLUSION

Due to the tectonic approach in this project and thus on the structure and construction that both have aesthetic, atmospheric and functional qualities and create the relation to the phenomenon Dark Sky, this results in a visible structure. Thus, a structural material that both can provide flexibility in shape and dimensions, provide large spans to maintain space for exploring and experiencing and with high aesthetic quality is preferred. Thereby, glue-laminated timber will be used as structural material due to its qualities that accommodate the described criteria to the structure. Though, it environmentally has some disadvantages due to the use and production of the glue between the timber elements in glulam. Glue-laminated timber is much stronger than normal construction timber and thus less material will be needed to carry the same loads, which is both beneficially concerning economics and sustainability. This also results in more slender structural elements and thus can be more elegant, which is important in this project because the elements are kept visible in the design. The material to the glue-laminated timber will be spruce because it is easily available and thus more economical than some of the other materials. Further, it is the most used wood type to construction and glue-laminated timber, and it has a uniform light colour. Besides, it has good environmental properties.

SUBCONCLUSION
SITE ANALYSES

The described and visualised analyses should form the basis for the choice of the specific site for a Dark Sky Visitor Centre and its functions. Further, these should provide an understanding of the site, its potentials concerning creating and enhancing the Dark Sky experience and its surroundings both in relation to infrastructure, existing attractions, architectural style and local materials.

FUNCTIONAL POTENTIALS

When focusing on Dark Sky, it is crucial placing the new building on one of the best stargazing spots, which mainly are placed in the Dark Sky Parks at Møn and Nyord. Due to the preserved park on Høje Møn and the existing visitor centre GeoCenter Møns Klint relating to the characteristic landscape and Dark Sky, Nyord has been chosen, which is an island with many qualities and a unique landscape which make the Dark Sky experience more magical (cf. pp. 42-45). Nyord already has local attractions, where the visitor can experience Dark Sky outside, but to extend the Dark Sky season, a visitor centre with a focus on Dark Sky at the island will be preferable. Thus, besides having potential in attracting many visitors to the island, these analyses lead to the choice of the specific site that should not be placed next to an already existing attraction, but on a site with accessibility from the main road and parking opportunities. The building is placed on the border between the moraine landscape and the salt meadows and bird sanctuary, which the architecture of the centre should enhance through different views that can contribute to the full experience gained in the centre (cf. pp. 46, 56-57).

Besides, the site already consists of a shelter area, a watch post to the sky and the salt meadows and an exhibition area, which according to the site interviews (cf. appendix A) are very attractive, and thereby the site already has potentials in being a great spot for the visitor centre (cf. pp. 58-59). To optimise this and utilise the site in the best way, the existing decrepit farmhouses will be demolished according to Vordingborg Municipality (cf. appendix A).

EXPERIENTIAL POTENTIALS

The star path and the astronomic phenomena are relevant investigating when designing a centre with a focus on Dark Sky (cf. pp. 36-39). According to the analyses, the night sky changes during the whole year, which means the constellations of the stars change position, and different phenomena take place during the year. Thus, the architecture of the visitor centre should focus on framing as many constellations as possible during the different seasons, while the program of the exhibition area can vary depending on the specific phenomena which require flexible facilities. Thereby, the centre has potentials in being open the whole year. The microclimate analyses support this by stating the darkest skies can be explored in the winter and thus create the best opportunities to stargazing (cf. p. 60). Thus, this project should focus on enhancing the experience of Dark Sky from inside the centre to create reflections upon the connection between the human and the night sky through the architecture.

The wind does not seem like a problem on the site because of the surrounding trees which provide shelter from the wind (cf. p. 61). These circumstances are also bodily experienced during the site visit where it felt like a calm area, and this silence strengthened the hearing sense, especially of the sound of the several wading birds from the neighbouring bird sanctuary. At night, the total darkness only improved this sense even more but complicated movement due to the lack of exterior lighting. During the night, the only elements visible are the thousands of bright stars above one that touches one emotionally and makes one wonder. Seeing this concerning the flat landscape of the salt meadows and the reflection of the stars in the water makes one feels surrounded by

stars (cf. pp. 62-65). Thus, the architecture should enhance the sight towards the stars by reducing the sense of sight towards other elements through the darkness and the sound from disturbing elements within the centre. Simultaneously, it should provide easy wayfinding around the centre for instance through the use of the other senses like the sense of touch and movement.

ARCHITECTURAL AND TECHNICAL POTENTIALS

The visitor centre must support and enhance the memorable experience through the architecture and its structure that simultaneously touch one sensuously, but it must also respect the characteristic and local architecture of Nyord. An understanding of this in relation to both the architecture, structure, materials and construction principles in the context is relevant because the local architecture is a part of the preserved cultural heritage of the island. The verticality of the bird tower that leads towards the sky and merges within its surroundings due to the light timber structure and wood cladding which are essential elements in creating a close relation to its specific site while providing a 360 degrees view to the Dark Sky in the context of salt meadows (cf. pp. 48-49). On the other hand, the robustness of the pilot watch post provided by the brick masonry construction and the humble size of the building that frames the landscape through small openings on the wall reveals its location in another context. At night, the position of the iconic building as great Dark Sky spot is enhanced under the thousands of stars (cf. pp. 51-52). Both cases are crucial examples that can be used as inspiration for the design of the visitor centre.

The half-timbering construction used in the traditional farmhouses at the island have many qualities both structurally, economically and construction-wise resulting in a light but a strong structure with unique assemblies that can be done by hand-craft. On the other hand, the red-tiled buildings are constructed with brick masonry which is a strong, robust and durable construction form that is easy to construct, to handle and transport, and simultaneously the bricks give flexibility in creating patterns on the exterior walls. (cf. pp. 53-56) Though the centre should not resemble the idiom of these buildings, but it should come up with a critical regionalism answer on the local architectural style through an architecture that both moves forward while still being rooted in its site.

In this project, local materials are considered to be used as facade, roof and floor cladding due to the relation to the local architecture and the qualities of these materials. Further, these materials are considered of sustainable and economic reasons due to the easy accessibility of the raw materials at the island. Glue-laminated timber has been chosen as structural material because of the strength and quality of the material, its flexibility in shape and dimensions, its small density that makes it suitable for larger spans and its fire-resistance. Softwood is most suitable for glue-laminated timber, where spruce is chosen as material due to its availability, its uniform light texture and its sustainable benefits regarding minimal global warming potential and primary energy total compared to the other investigated wood types. (cf. pp. 72-77) Bricks or wood, either alone or in combination, is chosen to be used as facade cladding due to their different functional, technical properties and aesthetic qualities. Eelgrass will be used as insulation material due to its excellent insulation, acoustic and fire properties. Clay is another sustainable and easily-available material that can be used either as bricks, floor material or as thermal mass incorporated in the building. The project should questions the use of the local materials, geometry, structures and construction principles of the local architecture and suggest how to use these in new ways to achieve the desired purpose with the centre.

HAMMERSHUS VISITOR CENTRE
CASE STUDY

ARCHITECT: ARKITEMA ARCHITECTS AND CHRISTOFFER HARLANG
ENGINEER: BURO HAPPOLD
YEAR: 2018
LOCATION: ALLINGE, BORNHOLM
GROSS AREA: 1470 M^2

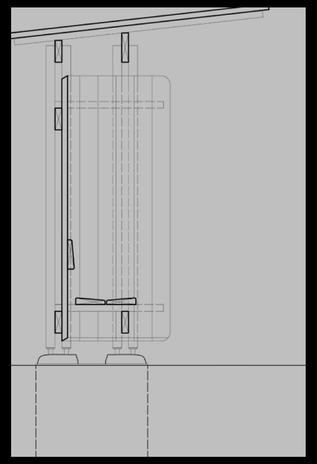
RELATION TO THE LANDSCAPE

In the hilly landscape, the tourist attraction Hammershus can be experienced from Hammershus Visitor Centre which is shaped by the contours of the terrain and built discretely into the west-facing cliff that makes the building appear of secondary importance compared to the landscape. Additionally, building into the cliff has some benefits constructively, where the surrounding cliff material can be used as thermal mass to heat and cool the building in respectively periods. (EUmiesaward, 2019 (Miljøministeret & Naturstyrrelsen, 2013)

The foundation and the walls towards the cliff are constructed in cast-in-situ concrete with an aggregate of granite to make the building blend into the rocky landscape. In contrast to the underlying concrete walls, the facade towards Hammershus consists of floor to ceiling ribbon windows with thin black steel frames that frame the view of the castle, the surrounding landscape and the sea and blur the line between the architecture and landscape. (Arkitema Architects & COWI, 2014) (Pind, 2018) (Langer, n.d.)

As an integrated part of the landscape, the roof of the centre appears as a natural extension of the hilly landscape; the visitors can not see the architecture when they approach Hammershus which thereby avoid distracting the view of the main attraction. Further, the visitor is provided with a view of the ruin castle, Hammershus, from the platform. (Langer, n.d.) The roof surface of the centre is shaped like an extension of the surrounding footpath system, where it is stretched between the two arrival areas and provides the visitors with sensuous experiences on the path to the ruin with the visitor centre hidden in the landscape. A light footbridge built on pillars runs from the terrace in the front of the centre

Ill.68 Visitor Centre Hammershus (González, 2018)



Ill.69 Window detail of the visitor centre (Christoffer Harlang Architects, n.d.)

connecting it to the castle ruin. (Pind, 2018) (Langer, n.d.) (Arkitema Architects, 2018) The floating roof of the centre is constructed of oak boards placed on visible transverse glue-laminated beams, which span from the underlying concrete structure to the light concrete columns. These are placed along the building facade and thus ensure a flexible plan solution. (Arkitema Architects & COWI, 2014) (Pind, 2018) (Miljøministeret & Naturstyrelsen, 2013) The relation between the visitor centre and the landscape is emphasised in its use of local materials from Bornholm such as stone, concrete and oak wood. Additionally, these materials also contribute to a pleasant indoor climate and have sustainable qualities, require minimal maintenance due to the durability of the materials, and their patina provides a high aesthetic value. (Lillelund, n.d.) (Miljøministeret and Naturstyrrelsen, 2013)

ILULISSAT ICEFJORD CENTRE
CASE STUDY

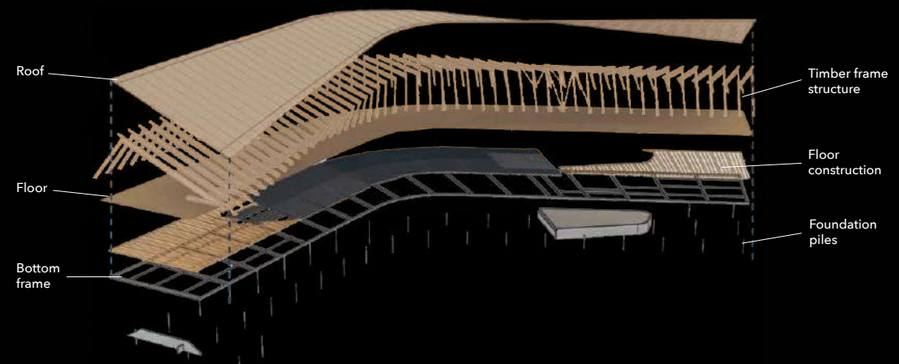
ARCHITECT: DORTE MANDRUP ARKITEKTER, ARKITEKT KIRSTINE JENSEN TEGNESTUE AND NØHR & SIGSGAARD ARKITEKTER
ENGINEER: SØREN JENSEN RÅDGIVENDE INGENIØRFIRMA AND MASANTI DANMARK RÅDGIVENDE INGENIØRFIRMA
YEAR: 2021
LOCATION: ILULISSAT, GREENLAND
GROSS AREA: 900 M^2

STRUCTURE, FORM AND SUSTAINABILITY

The visitor and research centre, Ilulissat Icefjord Centre, located in one of UNESCO's World Heritage areas, should act as a gathering point for both locals, climate researchers and tourists who can meet and learn about the Icefjord and the climate changes. (Raaberg Funder, 2019) The primary purpose of the building is to create an architectural piece with satisfying indoor climate and minimal energy consumption, and thus a close relationship between the construction, the form of the building and sustainability is emphasised in this project. (Søren Jensen, n.d.) The visitor centre should impact the hilly landscape and the UNESCO heritage area as minimal as possible, which has resulted in the use of foundation piles and rock anchors as the foundation. Due to the arctic climate, it has been necessary to cast the foundation into the cliff. (Realdania, n.d.)

The form of the building has been conducted through parametric modelling with the integration of energy and structural analyses early in the design process to optimise the construction and form of the building in regards to sustainable aspects. (Søren Jensen, n.d.) The centre is shaped like a twisted structure, as a wing placed in the landscape with the association to "a snow owl's flight through the landscape" (Realdania, n.d.). The twisted structure is generated by 50 individual and unique wooden frames (Ibid), which are placed both inside and outside the building. The construction will be fabricated in glue-laminated timber due to the architectural expression of the building, the durability of the material in the arctic climate and the strength and ductility of the material, which are necessary for a climate with a huge difference between indoor and outdoor temperature. Along with the building, the wooden frames are stabilised by steel cross bracings, and plywood boards are utilised across the building. (Knudsen, n.d.)

Further, the building is positioned as a curving cantilever beyond the valley, which creates a spectacular view to the Icefjord and the valley. (Realdania, n.d.) (Søren Jensen, n.d.) The framework is covered with a hyperbolic wooden boardwalk which at the same time acts as a watch post platform. The geometry of this characteristic structure is based on



Ill.70 Construction principle (Søren Jensen, n.d.)

a triangle frame which changes during the movement within the building resulting in a rectangular shape in the middle of the building to again a triangle shape in the end. Thus, movement across the roof is created, from the intimated landscape protected by the building and the cliffs to the expansive open landscape, which makes the building act as a gateway between civilisation and nature. On top of the roof, the visitors will achieve a view of the Icefjord and perceive an overview of the UNESCO World Heritage trail.

The movement of the structure and form creates inside a continually changing view of the landscape from the inclining window panes, which enhances the experience of nature and the change of the colour of the sky depending on the direction of the view. (Realdania, n.d.)

The open facade strengthen the relationship between human and nature by creating transparency between the exhibition and the surrounding nature. The huge glass facade both has a positive and negative effect on the indoor climate and the energy consumption. In the winter the inclining window panes will take part in heating the visitor centre, while in the summer it can be necessary to use the integrated louvre in the ceiling, which is mounted on the inside of the facade to regulate daylight and glare. (Ibid)

THERMAL BATHS
CASE STUDY

ARCHITECT: PETER ZUMTHOR
ENGINEER: VIABIZZUNO (ELECTRICAL ENGINEER)
YEAR: 1996
LOCATION: VALS, SWITZERLAND
GROSS AREA: 1395 M²

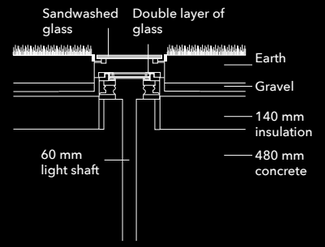
ARHCITECTURE, CONSTRUCTION AND ATMOSPHERE

Architecture has a significant influence on, how humans perceive their surroundings which they interact with through their senses. Not only through the sight, but also when they touch the wall or the door through the temperature, surface, structure and tactility of the used materials. These also impact the smell of the building, and simultaneously, the building elements work as an instrument of collecting the sound which the human will hear as reflected sound. (Meier, 2014) An excellent example of a sensuous architecture is the Thermal Baths, Vals by Peter Zumthor. This architecture is not only physical frames but a sensous experience created through the combination of light and shadows on the material surfaces, open and enclosed spaces and the activation of the human senses. (Archdaily, 2009) (Copans, 2014) The access to the building is through a dark tunnel from the associated hotel, which serves as a transition from the outdoor world and prepares the visitor for a memorable experience. (Archdaily, 2009)

Zumthor had in the design of the thermal baths the intention to create a silent space that enables the body and mind to relax without being disturbed by loud attractions. When entering the building, the visitors first hear the sound of water, which creates a relaxing atmosphere. Though, the parallel walls in the building have the opposite effect acoustically, because they reflect more sound in the building than intended. Therefore the visitors may prefer the small intimated room. (Meier, 2014)

The construction of the building consists of concrete walls and thin layers of local gneiss rock inside in varying thickness which are assembled in a way that makes it appear coincidental. Though, it follows a regular order consisting of rocks with three different heights that are placed on top of each other. The order will visually create a varying expression without complicating the construction, and additionally, the use of raw and untreated materials will create a rough tactility in the Thermal Baths. Zumthor intended to achieve the same tactility as his intended giant blocks of stone, which could not be fabricated as high as needed to achieve the desired space

III.71 Light and shadows on the construction material (Openhouse, 2011)



III.72 Detail of the light opening in roof

III.73 Wall pattern of rough stones with varied heights (Chang, n.d.)

and definition of the building. The building consists of 15 separated volumes with a cantilevered concrete roof enabled by beams. The arrangement of the volumes creates a flexible flow through the building, which makes it possible for people to create their path of experience. (Wikiarquitectura, n.d.)

The roof between the units is separated by eight centimetres glass gap, which allows natural daylight to infiltrate the dark rooms. The light will hit the horizontal stone wall and create an interesting play of light and shadows. Further, this creates depth in the wall and variety in the interior space. The light also enhances the character of the materials and creates a therapeutic atmosphere together with the water in the rooms. At night, this experience varies because the light instead appears in the water itself. (Souza, 2016) (Copans, 2014)

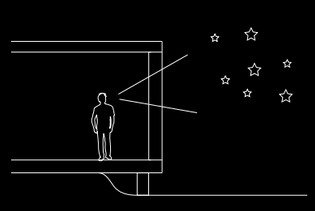
The architecture creates a singular atmosphere in each room depending on the utilised colours of the rooms that reflect the temperature of the water. Additionally, elements contributing to the specific atmospheres are the scale of the volume, and taste, tactility and temperature of the materials. The light and colour of the material will affect the tactility of the surfaces. (Souza, 2016) (Copans, 2014)

SUBCONCLUSION
CASE STUDY

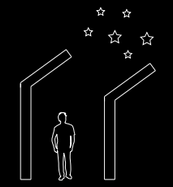
The presented case studies have been chosen in regards to the theme of the project and have provided different aspects and acquired knowledge, which should form the basis of the following design process.

In the design of Hammershus Visitor Centre, the relationship between the architecture and the surrounding landscape has been emphasised through the use of local materials and through the design of the building as an extension of the landscape, where it is built into the cliff and shaped by the contours of the terrain. The case study will lead to design investigations of how to emphasise the relation between the architecture, construction and the surrounding landscape. The site in this project is located on the border between the salt meadows and moraine landscape, which provides the visitor with different views between the trees. Thus, it is essential investigating how architecture can enhance the relationship between the two different landscapes and emphasise the different views (ill. 74). In the design of Ilulissat Icefjord Centre, the construction principles support the view of the characteristic landscape both from inside and outside the building through the use of a twisted structure which due to its parametric change in the form creates a continually changing view of the landscape. How construction can contribute to the framing of a view is an important aspect that will be investigated in this project too. Here, the structure must frame the starry sky to establish the vertical relation between the human and the universe through the architecture (ill. 75)

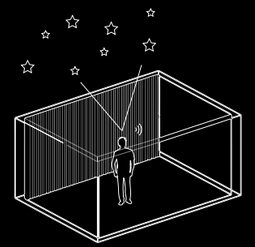
In the project of Thermal Baths, Peter Zumthor has investigated how to create a multi-sensory experience through the combination of light and shadows on the material surfaces and open and enclosed spaces. Thus, materials and constructions principles have been investigated and chosen concerning their scale, light reflection and absorption, taste, tactility and absorption of sound. This case study is an example of the creation of an atmosphere through architectural elements which will be investigated in this project. Here, the focus will be on light, acoustics, thermal comfort and the tactility of materials. The light will be investigated both concerning physical and psychological aspects.



Ill.74 The architecture should enhance the relation of the building between the salt meadows and the moraine landscape and thus the memorable view to the Dark Sky



Ill.75 The structure should create the basis for a connection between the human and the stars



Ill.76 Materials will contribute to creating the atmosphere within the exhibition area and enhance the view to the Dark Sky

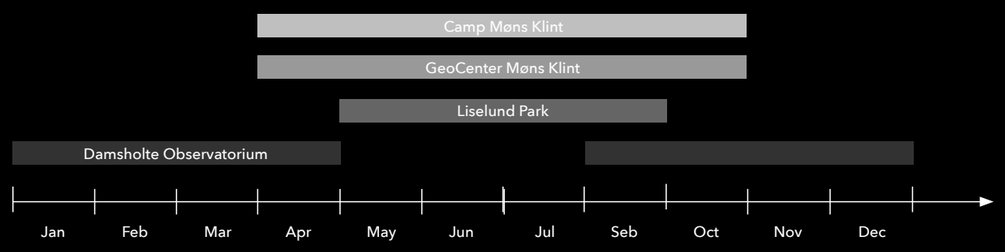
The physical aspects will be investigated through daylight simulations in Velux Daylight Visualizer, and the psychological aspects will be investigated through physical models with a focus on the placement of the windows and how the light will act on different surfaces of materials. The acoustics will be investigated through simulations of the reverberation time because the purpose of the exhibition area is to minimise the reverberation time and thus disturbing elements such as noise to enhance the sense of sight directed towards the sky. In interplay with these investigations, it is crucial to test different design solutions of how to navigate in the darkness, where the visual system is minimised through the integration of the other senses (ill. 76)

TOURISM

Nyord is an island that invites many tourists every year, which has to be considered in the design of the visitor centre. Approximately 180.000 guests crossed the Nyord bridge in 2018 besides the local traffic, which is increased since the crisis years in 2008 and 2009, where tourism fell significantly. In relation to the increase in tourism, the distribution of the tourists according to their nationalities has also changed. In 2016, more than 60% of the visitors at Møn were foreign, primarily Germans. The rise is caused by several reasons including the Dark Sky Gold-certification of Nyord and Møn which generated both national and international attention. (Møn Sydsjælland Turistforening, 2017)

Thus, Dark Sky is also crucial in relation to commercial aspects, and hence both Møn and Nyord offer many activities in close connection to Dark Sky placed near the best stargazing spots (cf. p. 43). The opening hours of these attractions define the tourist season, and it is specified that most of these are only open from April to November and thus closed in the winter period most likely due to the bad weather conditions in this period.

On the other hand, Damsholt Observatorium, which focuses only on the observation of the night sky, from indoors, namely has open in the autumn and the winter period which relates to the best conditions for stargazing. (Camp Møns Klint, n.d.c.) (GeoCenter Møns Klint, 2020) (Nationalmuseet, n.d.) (Damsholte Observatorium, n.d.) Thereby, a Dark Sky Visitor Centre, which is open the whole year and provides more than just star exploring would be for the benefit of the local revenue and contribute to the tourist development at Nyord.

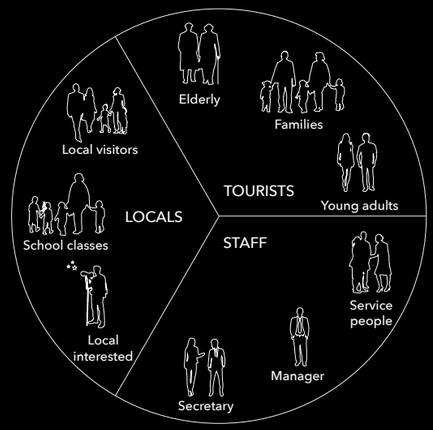


Ill.77 Opening season for Dark Sky related attractions

TARGET GROUP

THREE TARGET CATEGORIES

When designing the visitor centre, it is important to understand who the target groups are, their needs and desires and thereby the functionalities related to these. The visitor centre should address a wide target group due to the aim of a centre that is opened the whole year to provide the possibility to experience Dark Sky and astronomic phenomena. Thus, tourists will be attracted outside the current tourist season while other activities and attractions at Møn and Nyord are closed. Dark Sky is a night phenomenon, and thus the primary functions of the visitor centre that are related to the experience of Dark Sky should be available during the afternoon and the night. By day the centre should function as a gathering point, where both tourists, local interested parties, local visitors and school classes can learn about Dark Sky and light pollution through the use of the educational and exploring facilities as the auditorium, workshop areas and the exhibition area. Additionally, there will be designed a Dark Sky shelter area, where visitors and school classes have the opportunity to stay over-



Ill.78 Categories of the target group

night and experience the phenomenon after they have used a day at the centre learning about for instance the Dark Sky and its impact on the human health, the ecosystem and the environment. Thus, the centre must be flexible in both its opening hours by day and in the program of the centre. The target group can be divided into three categories: The tourists, the locals and the staff (ill. 78).

TOURISTS

The tourist is curious and thus strives for exploring and experiencing the phenomenon that is characteristic for the specific centre: Dark Sky, whether it is the view to Dark Sky or learning about this phenomenon, darkness in general or light pollution. The tourists can both be foreigners or Danes, since Dark Sky is only situated at Møn and Nyord in Denmark. The length of the stay often limits the possibility to experience the same attraction twice, and thus they often spend longer time at the visitor centre than locals. Hence, they will carefully investigate all the opportunities, the centre offers to not miss anything. This category consists of families, elderly people and young adults. Families visiting the visitor centre are often people who are on vacation at Nyord in a weekend or a holiday. For them, it is essential that the visitor centre can be an experience itself providing opportunities to investigate, play and be activated through the whole body, which the architecture can play a role within.

Elderly people are often visiting Møn outside season in a longer period because their holidays are not depended on their workplaces. They have a lot of time and enjoy being away from home. They will normally use a longer time at the centre compared to the families because they experience in a slower tempo and are curious too. Thus, they spend time carefully analysing each detail both within and outside the centre. Elderly people normal travel in groups with a guide, who can inform them about the phenomenon and the different exhibition areas in the centre. Young adults are normally only visiting Møn in a short time period due to their limited time and thus desire in experiencing as much as possible. Thus, the centre must provide various experiences dealing with different themes that can capture the attention of the young adults and inspire them.

This information about the tourists and locals are based on an interview with local Dark Sky interested parties (cf. appendix A)

LOCALS

The locals consist of both children from school classes or kindergarten, local interested parties and local visitors. The local visitors are not affected by a limited vacation, since they can visit the centre when it fits them, often outside the tourist season, because they normally are elsewhere in the summer period. Most locals have heard about Dark Sky, and maybe where and how it can be experienced, but they do not all understand the importance of it in relation to human's health, the environment and the ecosystem. Thus, they will definitely use the exhibition area.

On the other hand, local interested understand this and thus are interested in achieving the right knowledge about Dark Sky to preserve it, communicate it and use it for developing a private business both in the benefits of themselves and the community of Nyord and Møn. They will use the centre to obtain the right education or to create a contact with experts, customers or tourists. The school classes or students will also use the centre with an educational focus through different workshops, lectures and experiments made in the centre. The local visitors are using the centre to experience Dark Sky and learn about it in the exhibition area.

STAFF

The staff consists of both managers, secretary and service people. The managers have the overall responsibility of the centre by ensuring it runs as supposed by contacting, inviting and manage the activities in the centre. They work by day, while the service people both will be working at day and at night to promote service for visitors, whether it is in the reception or in the café.

UNIT PROGRAM

Service and dining

Function	Amount	Net area (m^2)	Functional Demands	View to Dark Sky through the structure	Daylight	Atmosphere*
Reception	1	70	Open office for 2 people Information provided Placed near the entrance		X	Informative Welcoming
Local shop	1	35	Local products related to the exhibitions and Dark Sky Placed near the entrance			Welcoming Inspiring Informative
Wardrobe	1		Integrated wardrobe in the wall towards the entrance			
Cafe and terrace	1	450	Serve drinks and precooked food brought from local providers Sitting area to enjoy food Seats for 90 guests indoor and can be extended on the terrace	X		Welcoming Social Authentic
Outdoor picninc area	1	250	Outdoor sitting area to enjoy own brought food Seats for 100 guests	X		Authentic
Small kitchen and food storage	1	55	Preparation of the food orders from the cafe Include ovens, fridges and freezes to warm up and store the precooked food and drinks			
Public toilets		90	11 toilets including two designed according to rules for disabled			

Administration

Open office	1	60	For max 8 persons in an open office plan		X	Functional
Meeting room	1	30	For 8-10 persons indcluding screen		X	Functional
Lunch area	1	40	Sitting area for 10-12 persons to enjoy own brought food Kitchenette included		X	Functional
Archive	1	6	Printer and copier			
Toilet	1	6	Toilet designed according to the rules for disabled			

*The used terms to describe the atmosphere of the functions are specified in the appendix C.

Dark Sky education, exploring and knowledge-sharing

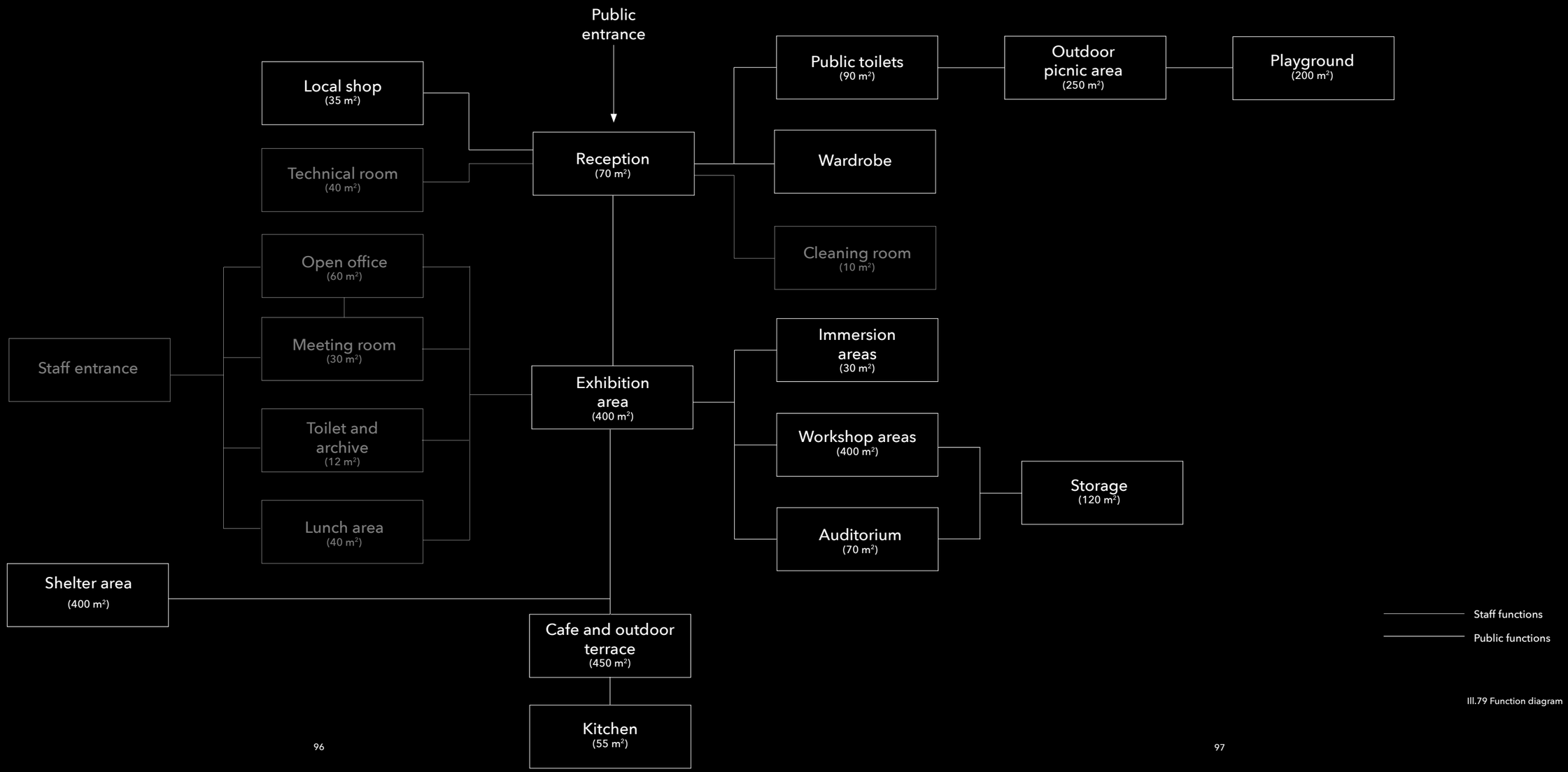
Function	Amount	Net area (m^2)	Functional Demands	View to Dark Sky through the structure	Daylight	Atmosphere*
Auditorium	1	180	For lectures and conferences Seats for 100 people Flexible arrangement of seating	X	X	Functional Inspiring
Workshop area	2	200	For exploring and developing Dark Sky related tasks Flexible and can be rented out	X	X	Interactive Progressive
Exhibition area	1	400	Exhibition of themes concerning Dark Sky and light pollution Should stage Dark Sky Temporary exhibitions that change with time	X	X	Informative Inspiring Captivating
Storage	2	60	For the exhibition, workshop areas and the auditorium, for instance, chairs and exhibition material			
Immersion area	2	15	Small outdoor area for stargazing Should differ in both materials and atmosphere from the rest of the exhibition area to provide a different unique experience of Dark Sky	X		Informative Inspiring Captivating Unique
Dark Sky Shelter Area	1	500	Outdoor shelter area for stargazing with shelters for both singles/pairs and small groups Include access to toilets and bath	X		Captivating Unique

Diverse

Playground	1	200	Outdoor activity facilities for children	X	X	
Technical room	1	40	Free access from reception			
Cleaning room	1	10	Include cleaning facilities			
Storage	1	15	Storage of diverse things related to the shop			

Total gross area (excl. shelter, outdoor picnic areas and playground)		2500			

FUNCTION DIAGRAM



Ill.79 Function diagram

DESIGN CRITERIA

DRIVER

The structural element should define the openings in the roof from where the visitor can experience the phenomenon Dark sky and be oriented towards the night sky, so the vertical connection between the human and the universe will be established through the architecture.

CRITERIA*

1. The structure of the building should be visible and be used as an element to frame different views of the starry sky that covers the sky sphere as much as possible.

2. The materials used in the centre should reduce the reflected sound, which could disturb the captivation of the memorable views.

3. Since the experience occurs in darkness, the materials on the interior walls and floor should enhance the sense of movement and touch through their tactility and compositions and through the idiom of the spaces to help navigate the visitor through the building.

4. The building should relate to the surrounding landscape by framing the existing views to the different types of landscapes, especially at night in relation to the starry sky.

5. The centre should provide different ways in experiencing Dark Sky to raise existential and experiential reflections through different spaces and functions – both inside and outside the centre.

6. The primary experience of Dark Sky should occur inside due to the harsh climate at the site, especially in winter where the best conditions for experiencing Dark Sky take place.

7. Nowadays the human has a significant impact on the earth. However, the salt meadow and the phenomenon Dark Sky is living its own biological time independently of humans, and thus this minimised influence of the human on the context should be enhanced in the building through the use of natural and sustainable materials with minimal maintenance.

8. The building should relate to its surrounding landscape and nearby architecture by rethinking the use of local materials, structures, construction principles and idioms found at Nyord and come up with the critical regionalism answer on this with an architecture that moves forward, while still being rooted in the site.

9. The logistics of the building should be functional to provide easy wayfinding for both staff and visitors.

10. During the day optimal daylight should be provided in the working areas with darker spaces in the exhibition areas with minimal use of artificial light.

11. The parking area should be placed away from the visitor centre to transfer the mindset of people from modern society to a new time horizon with a focus on the relation between the universe and the human, before they enter the building.

*The list above are arranged according to the most essential criteria the design proposals should fulfil.

DESIGN PROCESS

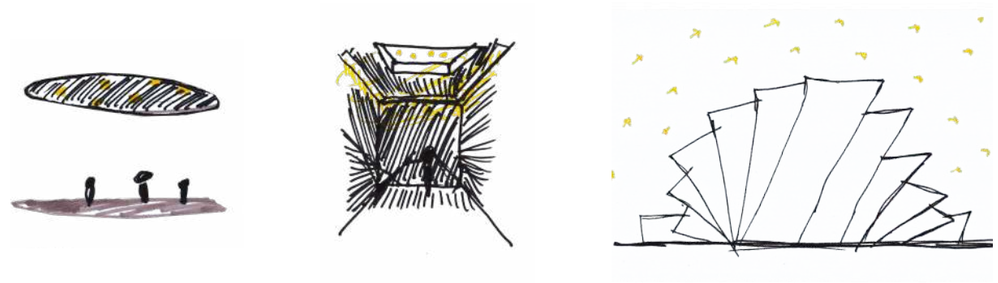
The following chapter will take the reader through the design process from the initial sketches to the final design proposals and tell the story of how the new Dark Sky Visitor Centre is developed through a combination of both functional, aesthetic and technical investigations. The design process is categorised into different topics to make it easy to follow for the reader, even though each part of the design process has had an influence on each other. In the design process different tools have been used, starting with sketching and physical modelling, in the beginning, followed by the addition of extra layers to the design by integrating other methods like 3D modelling, materials and joints investigations, structural analyses and simulations. Thus, to ensure improvement, optimisation and integration, the studies are repeated during the whole process until the most optimal solutions are found and thereby created coherence between the technical, functional and aesthetical aspects of the project. In the design process, the concept model, developed early in the design process, has been the driving force in moving forward in the design of the visitor centre due to the wish of establishing a vertical connection between the human and the universe through the architecture.

Ill.80 (Pihl, n.d.)

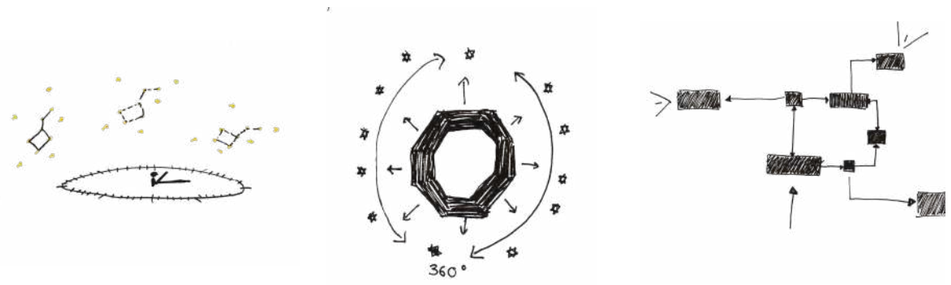
INITIAL SKETCHING
RELATION TO DARK SKY THROUGH ARCHITECTURE

In the early design process, it is essential to investigate how to establish the spiritual connection between human and nature (the darkness and starry sky) through the architecture. Dark Sky is a phenomenon that must be observed in darkness, and thus the sight will be limited or directed towards the sky. Hence, it is crucial to investigate how to navigate people through the building in darkness by activating the other senses through acoustics, minimal artifical lighting, variating materials and visible construction. The relation to Dark Sky through the architecture has been further investigated by framing the stars and enhance the movement of the star constellation through different openings in the roof and through the organisation of the functions. Relating the building volume to its function as Dark Sky Visitor Centre is processed by either shaping the building like an observatory with openings in the roof or like a glass dome with a 360-degrees view of the starry sky.

Ill.81 Initial sketching of architecture in darkness in relation to the senses and the structure



Ill.82 The architecture framing the starry sky through openings in the roof

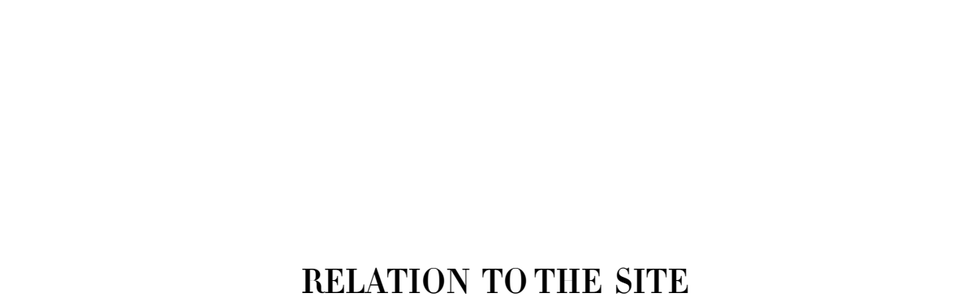


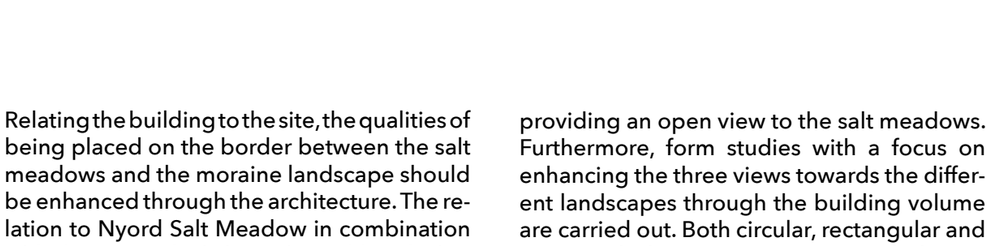
Ill.83 The organisation of the functions in relation to the movement of the stars or made as a star constellation

Ill.84 The shape of the building related to its function as Dark Sky Visitor Centre

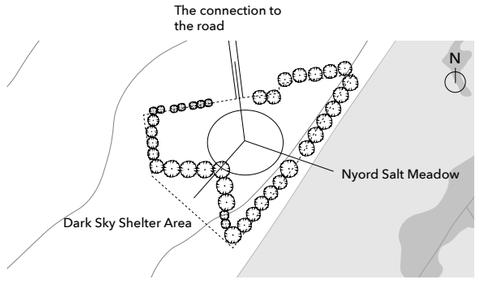
RELATION TO THE SITE

Relating the building to the site, the qualities of being placed on the border between the salt meadows and the moraine landscape should be enhanced through the architecture. The relation to Nyord Salt Meadow in combination with the starry sky is investigated by placing the building on the edge of or by extending the building over the salt meadows and thus providing an open view to the salt meadows. Furthermore, form studies with a focus on enhancing the three views towards the different landscapes through the building volume are carried out. Both circular, rectangular and separated shapes are investigated due to their relation to the Dark Sky, the local architecture and the shape of the site (ill. 86-91).

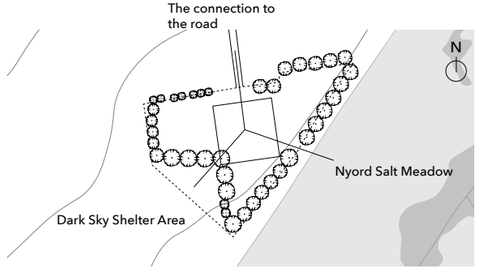




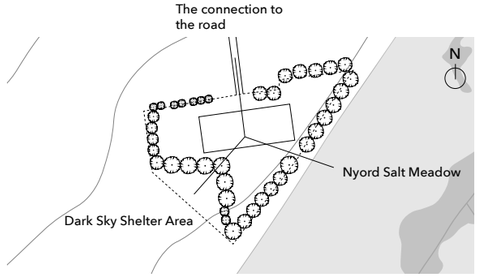
Ill.85 Initial sketching of the relation of the architecture to the specific site and the Nyord Salt Meadow



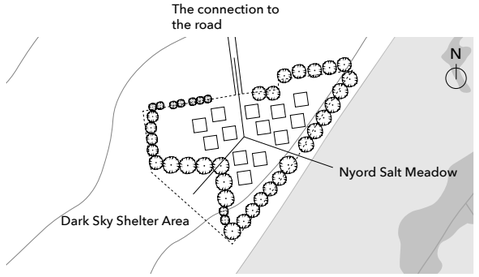
Ill.86 Form investigation 1: Round building (1250 m²) 1:4.000



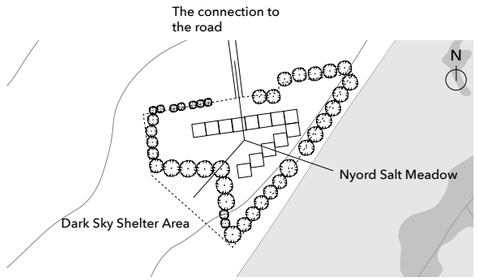
Ill.87 Form investigation 2: Square building (1600 m²) 1:4.000



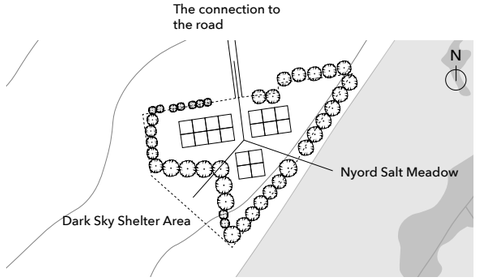
Ill.88 Form investigation 3: Rectangle building (1450 m²) 1:4.000



Ill.89 Form investigation 4: Functions placed as a small village arrangement (1300 m²) 1:4.000



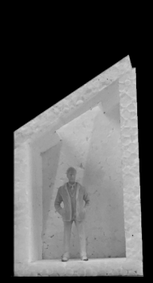
Ill.90 Form investigation 5: Functions placed as modules following the shape of the site (1300 m²) 1:4.000



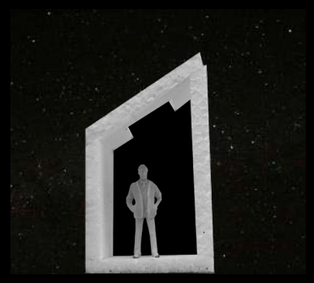
Ill.91 Form investigation 6: The centre is divided into three major buildings (1800 m²) 1:4.000

CONNECTION TO THE STARS THROUGH THE STRUCTURE

The initial sketching entailed a potential of a visible structure that frames the starry sky through the roof. Thus, this has been processed further. The initial prestudies of the construction investigate how to direct the sight towards the sky through the shape of the construction, the spatiality of the room and through the openings both concerning their size, shape and the slope of the roof. The open frame is discovered as a potential structural system to work with, both regarding the framing of the stars and to create movement through the building when these are combined.



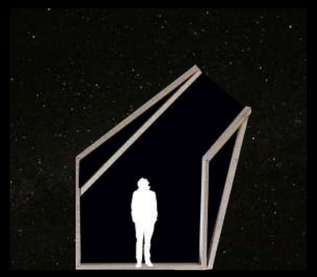
Ill.92 Skylight with a sloped roof at day



Ill.93 Skylight with a sloped roof at night

Ill.94 Skylight investigation 1

Ill.95 Skylight investigation 2

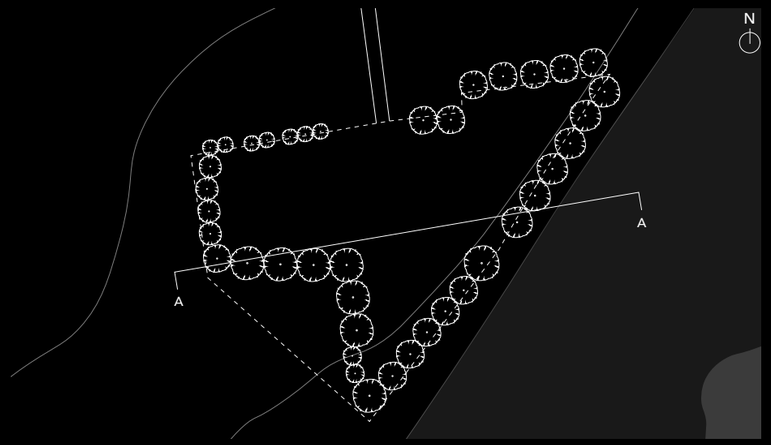


Ill.96 Skylight investigation 3

Working further with the establishment of the connection between the human and the starry sky through the visible construction, a concept for the construction is established. The concept is based on a combination of y-shaped columns that due to their form point towards the sky. Placing these next to each other creates an opening in the roof that frames a certain part of the night sky. Variating the columns and the distance between them provide different views and an interesting flow through the building with variating experience. Thus, this concept clearly indicates the relation between human and the night sky through the structyre as the element of staging the phenomenon Dark Sky.

Ill.97 Section model of concept principle: The construction frames the stars and creates the connection between the human and the sky

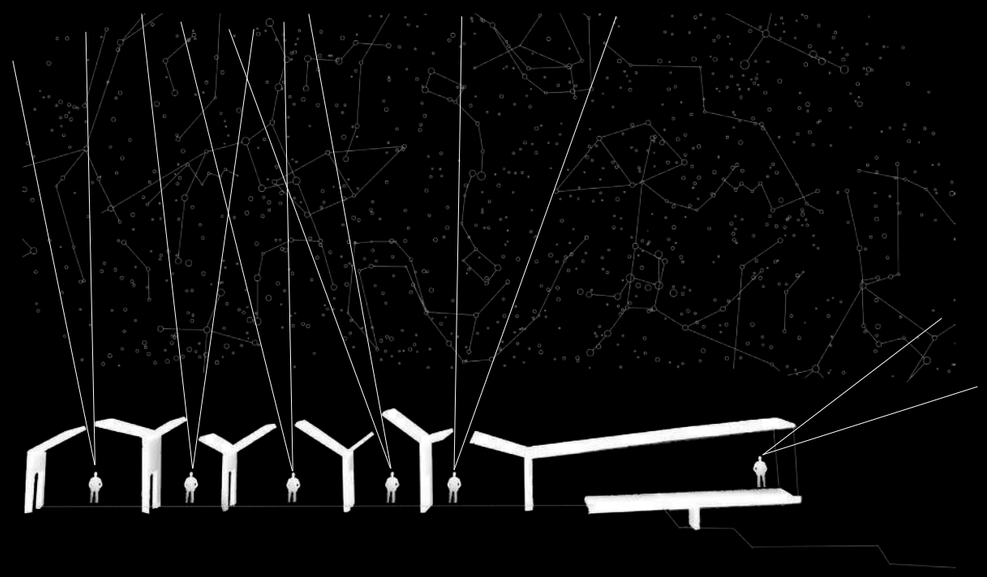
FRAMING THE STARS



Ill.98 Mapping of the site indicating section AA 1:2.000

Relating the concept to the earlier site investigations is processed through different section iterations, where the section across the site (section AA) is chosen to further development due to the aim of creating a connection between the two different landscapes throughout the building and provide a 180-degrees view to the Dark Sky in the context of the salt meadows. Furthermore, the shape and the combination of the y-shaped columns have been investigated in order to frame as much of the night sky sphere as possible and create an interesting and variating spatial experience within each space between two columns. This is made possible through different heights of the columns, different slopes on the beams and different distances between the columns, all defining the skylights. Each space between two columns, which can be observed as a module, is designed to frame different parts of the starry sky and establish the connection between the individual human and the sky and across people in the horizontal axis. The openings have also been observed in relation to daylight due to opening hours both during day and night. Thus, the inflow of light has a vital role in creating the atmosphere during the day through a play of natural light and shadows reflected in the different spaces.

Ill.99 Section AA: Daylight entering the skylights at day



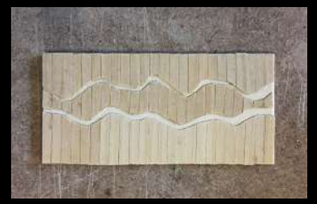
Ill.100 Section AA: Sightlines framing the stars at night

ATMOSPHERE AND ACOUSTICS

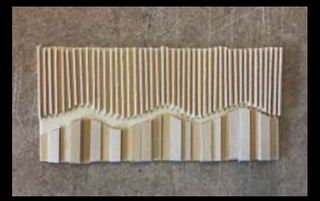
MATERIALS AND GUIDING METHODS IN DARKNESS

Dark Sky is a phenomenon that must be observed in darkness, which limits the sight or directs it towards the sky, and therefore the other senses become crucial in the movement of the body through the centre and in the perception of a specific atmosphere. The materials play a major role concerning the atmoshphere of the space and activating the senses to guide people through the darkness. Wood has been investigated as interior wall material due to its aesthetic and sensual qualities. Integrating a railing on the walls is one way of guiding people through the centre in darkness. This can, for instance, be done by cutting into the wood panels in different heights to both consider children, adults and disabled people (ill. 101 and 102).

Bricks have also been investigated as material which allows flexibility in the brick pattern, whereby displacements of the bricks can be used to direct people (ill. 105). Thereby, the tactility of the material becomes important. Guiding people through the building can also be done by working with different tactilities on the wall through a change of direction on the panels (ill. 104). Working with wall panels as modules with a certain width can also help people obtain an understanding of distance emphasised by the shift between the modules (107). The tactility on the floor is also essential, whereby a shift in the floor material placed in a pattern that orient people forward has been investigated (ill. 103). The hearing sense does also become important when working with architecture in darkness, whereas the materials can be used to increase a specific sound, for instance, the step sound through unequally displaced wood panels or convex forms that scatters the sound or by absorbing the undesired sound (ill. 102 and ill. 105).



Ill.101 Materials used for guiding people by integrating railing in the walls to lead people forward



Ill.102 Materials used for guiding people through the integrated railing, while the diversity in the cladding is used to spread the step sound (bottom) and absorb other sounds (top)

Ill.103 Materials on the floor used for guiding people forward in the right directions

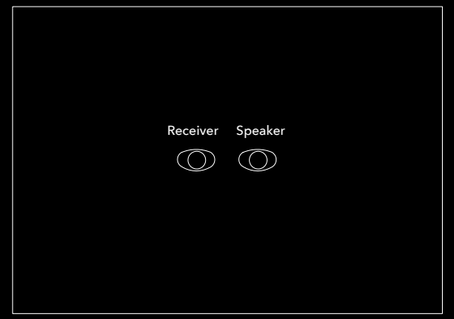
Ill.104 Materials used for guiding people by changing the cladding direction (left) or by integrated railing in the material (right)

Ill.105 Materials used for spreading the sound (left) and guiding people forward through displaced bricks (right)

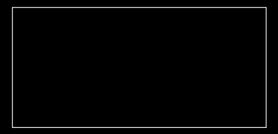
Ill.106 Materials used to indicate a distance within the room through the panels with the same width (left) or through regular placed columns (right)

ACOUSTIC WOOD PANELS

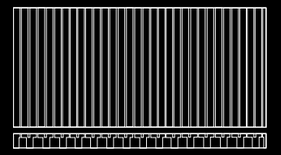
In the establishment of the relation between human and the night sky through the architecture, the sense of sight should be directed towards the sky while the other senses should support this. The acoustics plays a major role within this because the sound can interrupt the experience of Dark Sky within the centre. Hence, the aim is to minimise the sound through absorption of it. The acoustics within a simple room has been simulated to obtain a preferable reverberation time a maximum of 0.5 seconds. The absorption properties of the material are thus relevant because it is inversely proportional with the reverberation time. In the investigations, different acoustic wood panels with high absorption coefficients have been chosen. The results show that even that wood is a porous material, the wood itself is not enough to absorb the sound. Thus, the wood panels with holes, grooves or other cuts into the wood perform better because the wood thereby becomes a perforated resonator that reduces the sound. This is caused by the holes that prevent sound waves from passing through the wood. The absorption is highest on the lower frequencies, while the sound is reflected more on the higher frequencies. (Eugene, n.d.) Thus, wood panels with holes in some manner will be used in the further investigations.



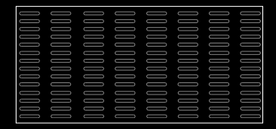
Ill.107 Plan of investigated room W:5m, L:7m, H:2.5m 1:100



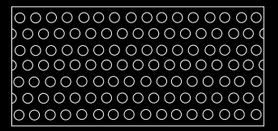
Ill.108 Case 1: Wood boards



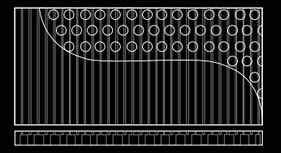
Ill.109 Case 2: Vertical wood lamellas (oak)



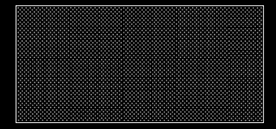
Ill.110 Case 3: Perforated acoustic wood panels with wide holes



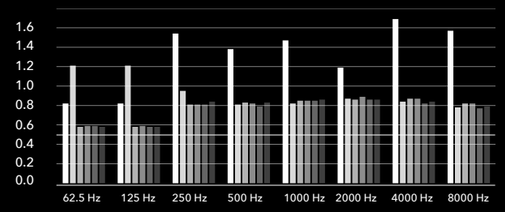
Ill.111 Case 4: Perforated acoustic wood panels with circular holes



Ill.112 Case 5: Wood lamellas with the back layer of perforated acoustic panels with circular holes



Ill.113 Case 6: Microperforated acoustic wood panels with circular holes



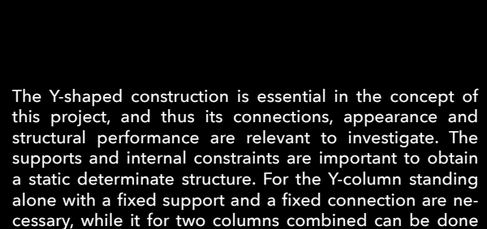
Ill.114 Reverberation time, T-30 [s]

For all cases, wood floor on joists, wood ceiling and wood boards on front and back walls have been applied.
Only acoustic panels on sidewalls vary in the different cases

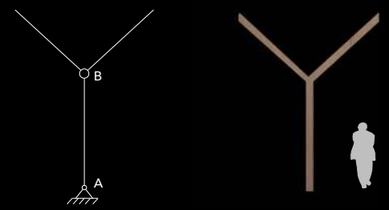
- Case 1: Wood boards
- Case 2: Vertical wood lamellas (oak)
- Case 3: Perforated acoustic wood panels with wide holes
- Case 4: Perforated acoustic wood panels with circular holes
- Case 5: Wood lamellas with the back layer of perforated acoustic panels with circular holes
- Case 6: Microperforated acoustic wood panels with circular holes

INITIAL CONSTRUCTION
STATIC SCHEMES

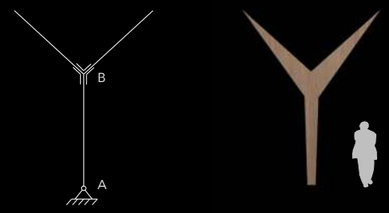
The Y-shaped construction is essential in the concept of this project, and thus its connections, appearance and structural performance are relevant to investigate. The supports and internal constraints are important to obtain a static determinate structure. For the Y-column standing alone with a fixed support and a fixed connection are necessary, while it for two columns combined can be done with a hinge support and a fixed connection. The supports and connections impact the force distribution and internal stresses within the elements. The fixed support and the fixed connection result in large moments in these connections, while in the case with the hinge support and the fixed connection, the moment will be biggest in the middle of the column. A clear relation between form and forces is desired in this project, and thus the material will be distributed according to the internal moments in the elements. In both cases, this results in an elegant structure that points upwards, but in the case with separated columns (ill. 115 left) the beams point towards the opening in which the stars are framed and thus clearly create a relation to the sky. On the other hand, the other case with the combined y-columns (ill. 115 right) the columns orient towards the meeting between the elements and thus pay no attention to the sky, whereby the opening is placed in the roof construction independently from the columns. Further, the fixed support in the first case indicates a solid statement on the ground while the elements become lighter closer to the roof and thus enhance the lightness of the roof structure. Hence, case 1 with the separated columns has been chosen to continue within this project.



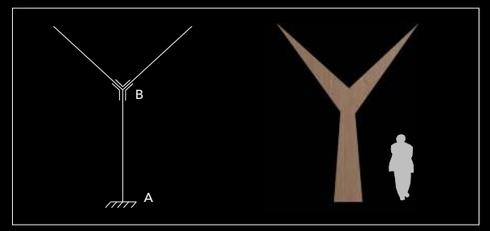
Ill.115 Separated structural elements and combined structural elements that both are static determinate



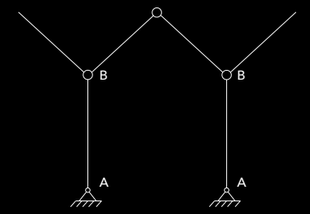
Ill.116 A: Hinge B: Internal hinge (kinematically indeterminate - mechanism)



Ill.117 A: Hinge B: Fixed connection (kinematically indeterminate - mechanism)



Ill.118 A: Fixed support B: Fixed connection (static determinate)

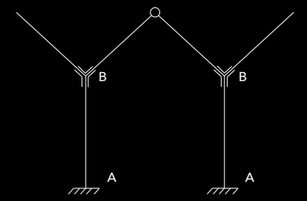


Ill.119 A: Hinge B: Internal hinge (kinematically indeterminate - mechanism)

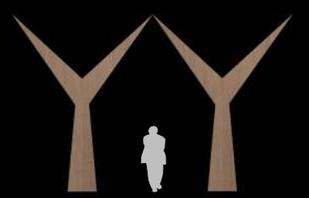
Ill.120 The material is distributed equally

Ill.121 A: Hinge B: Fixed connection (static determinate)

Ill.122 The material is distributed in relation to the internal moment which is biggest at the fixed connection



Ill.123 A: Fixed support B: Fixed connection (statically indeterminate - mechanism)



Ill.124 A: The material is distributed in relation to the internal moment which is biggest at the fixed support and the fixed connection

JOINT INVESTIGATIONS - FIXED CONNECTION

The fixed connections between the structural elements, which has been investigated in this analysis, can be designed in different ways. The fixed connection puts demands on the material of the connectors due to the large moments in the wood elements in the connection.

Thus all these investigations are based on steel-to-timber connections because steel has high strength and can thus resist the large internal moments. Further, less steel material can be used than if working with wood connectors, for instance. Though, the steel members should only be expressed as secondary elements, because the focus should be on the overall shape of the structural elements and their function as bearing elements of the light roof. Hence, a humble solution only using metal bolts is desired, and thus the metal fitting should not be placed on the front of the columns, because it would take a focus from the wood structure and the shape of the y-column. Furthermore, the solution should be simple and thus easy to fabricate and assembly. Simultaneously, it has to be ensured each element (the two beams and the column) are expressed as equal elements that, in collaboration, create the unique structure. Thus, the solution shown on ill. 133 is chosen.

Ill.125 The structural element divided into two pieces bolted together with sharp division of the different elements

Ill.126 The structural element divided into two pieces bolted together

Ill.127 The column is divided into two pieces placed on each side of the beams

Ill.128 The metal fitting is bolted on the front of the structural element and thus put in focus

Ill.129 The elements are assemblied with a metal shield

Ill.130 Equal division of each element which is connected with metal fitting on the depth of the elements

Ill.131 No division of the elements which are connected on the depth with metal plates

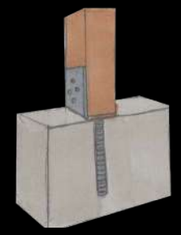
Ill.132 Division of each element connected with bolts and metal fitting cut in the wood

Ill.133 Equal division of each element connected with bolts and metal fitting cut in the wood

JOINT INVESTIGATIONS - FIXED SUPPORT

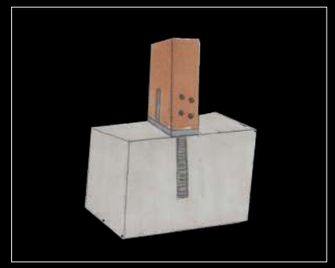
Similar to the fixed connections, the fixed support does also put demands on the type of connectors used in this connection due to the large moments in the connection, and thus steel is required because of its high strength. Different investigations on how to connect the structural elements to a firm floor (concrete foundation in the floor construction) have been made.

The column can both be directly bolted to the floor (ill.134-136, 139) with steel as the element connecting the column to the floor. Thereby, the importance of the different materials and their role within this connection is stated. Furthermore, the case with the column connected to a plateau is investigated (ill. 137). Here, the bottom is given more mass whereby the lightness of the overall shape of the column that narrows closer to the roof and the sky is enhanced. Though, in this solution, the connection between the floor and the column is not directly. Further, the plateau can complicate the movement of people in the area in darkness and create a distance between people and the structure. The structure can also be raised above the ground through metal timber connectors (ill. 140-142). Though, these solutions create a separation between the wood and the floor and simultaneously do not support the vision of creating a structure that creates the connection from the earth to the sky. Thereby, the first investigations are more suitable for this project, and to create a relation to the fixed connection between the structural elements and to not take a focus from the overall structure, the simple and humble solution shown on ill. 136 is chosen.

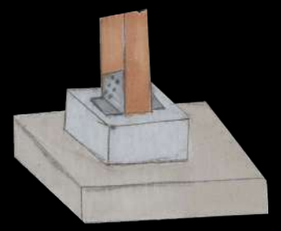


Ill.134 Column connected with metal fitting on the depth and drilled to firm ground with pole shoe

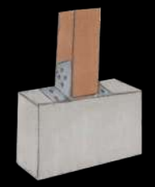
Ill.135 Column inserted in metal shell bolted to firm ground



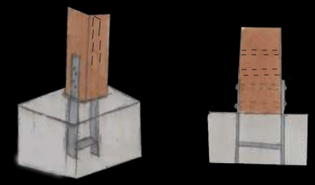
Ill.136 Column bolted to metal fitting and drilled to firm ground with a metal shoe in the bottom of the column



Ill.137 Column bolted to plateau with metal fitting



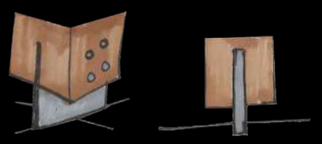
Ill.138 Column bolted to firm ground with metal fitting



Ill.139 Column bolted to firm ground with a wood screw

Ill.140 Column bolted to metal timber connector type 1

Ill.141 Column bolted to metal timber connector type 2



Ill.142 Column bolted to a metal plate and fit into slit in ground

STRUCTURAL MODULES

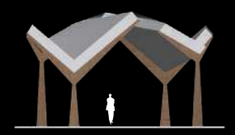
Based on previous investigations of the structure, the y-shaped columns should be placed in two pairs to define a space and thus can be considered as a module. In the simple case, the pairs of columns face each other creating a strict rectangular space, but in this analysis, different investigations of combining these modules have been conducted with a focus on both technical and architectural aspects. The purpose of this investigation is to use the variation between the two pairs of columns to define the flow through the centre, to create dynamics in the roof and to vary the skylight to provide different views of the starry sky.

The first case consists of a pair of columns facing the other pair that has been mirrored, which twists the roof and thus creating a double curved roof. This appears dynamic but will create difficulties with the construction of it. In the second case, the one pair of columns is increased in height, which provides an opportunity to vary the heights in the centre to adapt to the functions. Further, the shape of the opening leads to a specific direction. Additionally, the placement of the columns will not define a flow through the building due to their position facing each other.

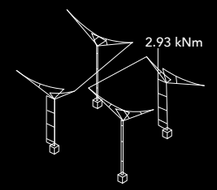
In the third case, the one pair of columns has a wider span than the other, whereby the opening has a variating width that provides the visitor with different views depending on their location under the window opening. Though, this will cause custom-made windows and minimal influence on the flow through the building. The fourth investigation consists of one pair of the columns displaced in relation to the other. This creates a dynamic flow through the building forcing the people to move in a non-linear direction. Further, the opening will cover more of the sky sphere and provide different views depending on their location under the window opening.

In interplay with the investigation of the architectural aspect, the technical aspects have been investigated through structural simulations in Robot Structural Analysis. The results show that the construction with the increasing height has the biggest internal bending moment contrary to the columns that are mirrored which have the lowest internal bending moment. Based on both architectural and technical aspects, the module consisting of displaced columns have been chosen to further development.

Ill.143 Mirrored front columns

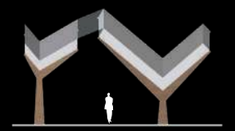


Ill.144 Mirrored front columns - section

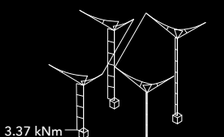


Ill.145 Moment curve with maximum internal bending moment indicated

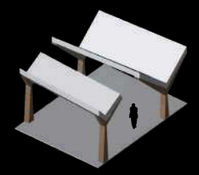
Ill.146 Front columns increased in height



Ill.147 Front columns increased in height - section

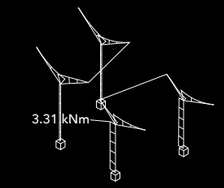


Ill.148 Moment curve with maximum internal moment indicated



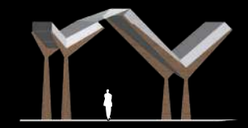
Ill.149 Front columns with a wider span

Ill.150 Front columns have a wider span - section

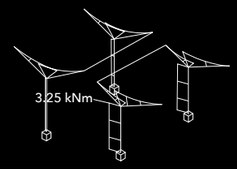


Ill.151 Moment curve with maximum internal bending moment indicated

Ill.152 Displaced row of columns



Ill.153 Displaced row of columns

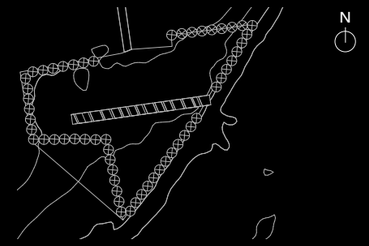


Ill.154 Moment curve with maximum internal bending indicated

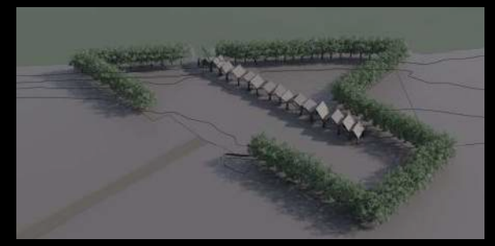
COMBINING MODULES

Ill.155 The modules of displaced columns are combined to create a path with diverse roof openings framing different stars

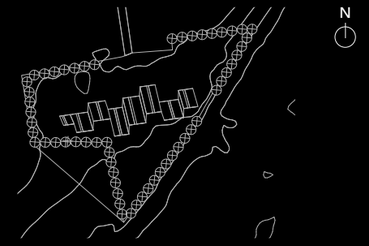
To create a building that contains the necessary functions of the Dark Sky Visitor Centre and simultaneously provide different views to the stars, different modules must be combined. The modules are based on the same structural principle, but the columns differ in height, while the beams differ in length and angle. Thus a varying experience is given when moving through the building. The different combinations of the modules are essential to investigate in consideration of the placement of the building on the site. They can either be placed in a row as a straight path that ends with a view to the Nyord Salt Meadow (ill. 156-157), which neither considers the size of the site or its surroundings. Based on this investigation, the modules have been displaced to create a dynamic flow both inside and around the building and thereby can be utilised to guide people through specific paths. The displacements of the modules can be made vertically (ill. 158-159) or horizontally (ill. 160-161). The last solution reflects the modular system on which the form is based on expressed as horizontal displacements, while the displacements of the columns within the modules create vertical lines in the roof structure.



Ill.156 The construction modules are placed on a straight path directed towards the Nyord Salt Meadow - plan

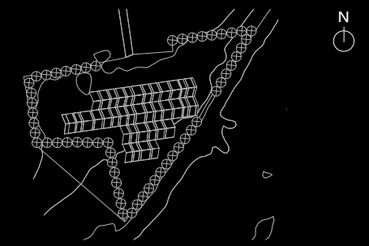


Ill.157 The construction modules are placed on a straight path directed towards the Nyord Salt Meadow - perspective



Ill.158 The column modules are displaced vertically to create a more interesting pathway - plan

Ill.159 The column modules are displaced vertically to create a more interesting pathway - perspective

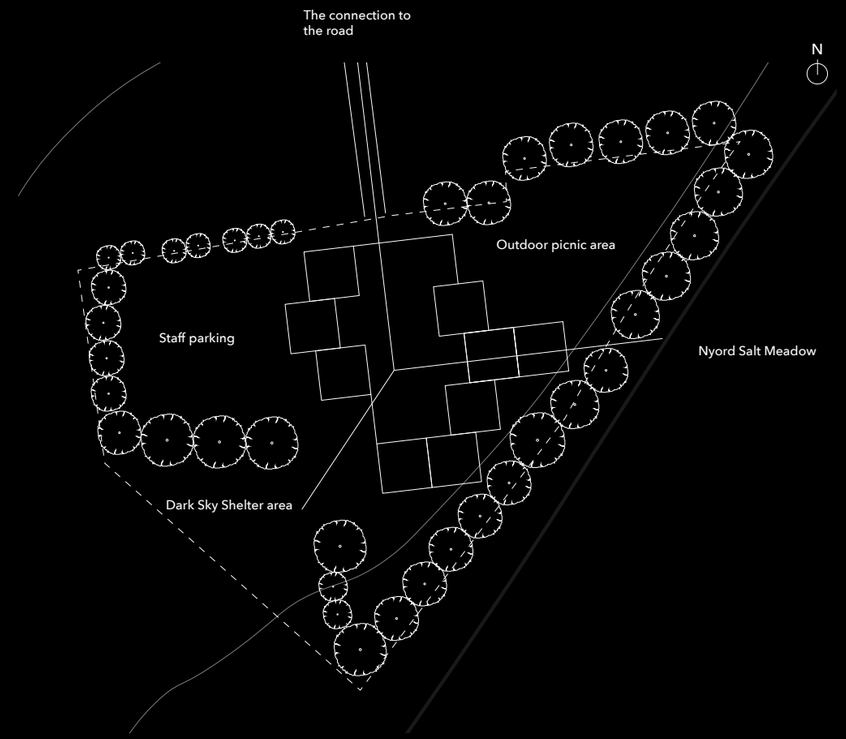


Ill.160 The column modules are displaced horizontally to provide more area and create dynamic in the shape of the building - plan

Ill.161 The column modules are displaced horizontally to provide more area and create dynamic in the shape of the building - perspective

CREATING A FORM

Based on previous iterations of the combination of the modules and early form studies in relation to the context, the concept for the form of the building has been conducted. The concept is based on the exhibition area as the heart of the building with the other functions situated around it. This creates easy accessibility between the different functions and enables satisfying daylight conditions in the working areas placed around the exhibition area. Furthermore, the concept is based on displacements, bot internal and external, to emphasise the three characteristic views: the view to the salt meadows, the fields with a glimpse of Børges Fieldhouse and the view to the cultivated fields with Nyord City in the background. The external displacements decompose the building volume and enhance the human scale. Additionally, the displacements will create dynamics in the facade and help guide people around the building. The internal displacements take part in creating a dynamic and non-linear flow and guide people from the entrance of the building to the shelter area located at the south-western corner of the site.

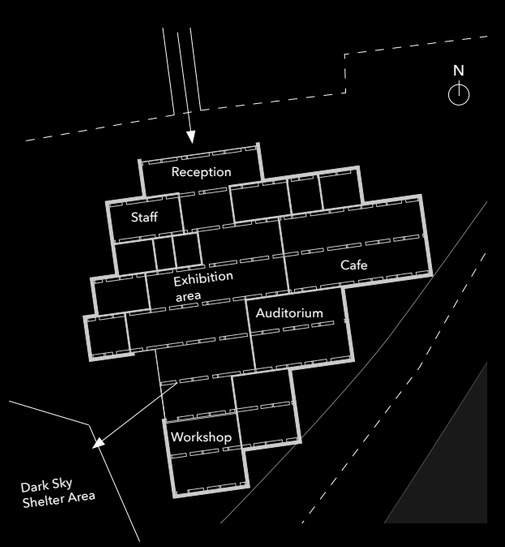


Ill.162 The concept of the shape of the Dark Sky Visitor Centre 1:2.000

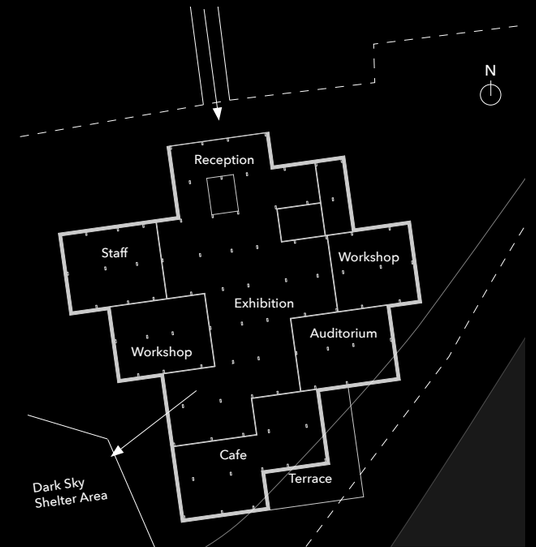
SPATIAL ORGANISATION

In interplay with the processing of the external shape of the building, the spatial organisation is investigated to figure out the possible challenges and advantages of the displacements regarding the program of the visitor centre. Relating the function of the visitor to the possibility of the site is processed through different plan solutions. The position of the staff is early decided to be in the northwestern corner of the building due to the need for diffuse light for working and the easy accessibility to the reception and the parking area that will be placed in the western part of the site. The reception is decided early to be placed near the main road and the public parking place to make it visible and create easy accessibility for visitors. The exhibition area has been located as the heart of the building which geometry is defined by the internal displacements that define the flow from the entrance to the shelter area in the southwestern corner of the site.

Different positions of the cafe have been investigated. It has both been placed towards the east with direct view to the salt meadow and close to the reception (ill. 163) or at the end of the exhibition area (ill. 164) to avoid noise in the area which could disturb the experience of Dark Sky. It has been chosen to locate the cafe in the end as a completion of the exhibition with an cantilevered terrace over the salt meadows to create the connection between the two landscapes through the building. The workshop and auditorium have been located on either the same side of the exhibition area (ill. 163) or on both sides (ill. 164) which provide a different flow through the exhibition area in the two cases. The auditorium has been decided early to be placed near the cafe so that the area can be used during bigger events in the breaks, serving food and drinks for the visitors. Thereby, the exhibition area becomes the connection between the different functions.

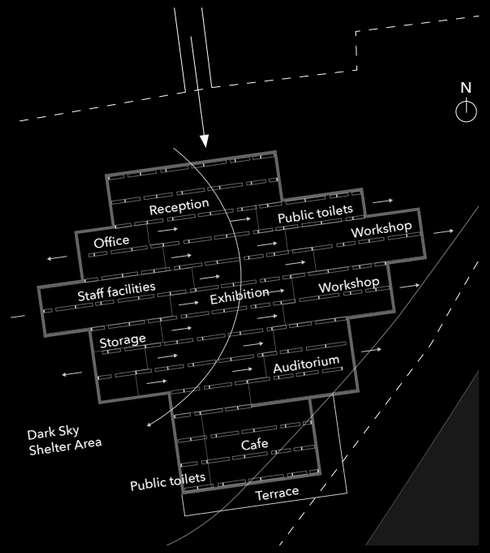


Ill.163 Plan investigation 1, 1:1.000

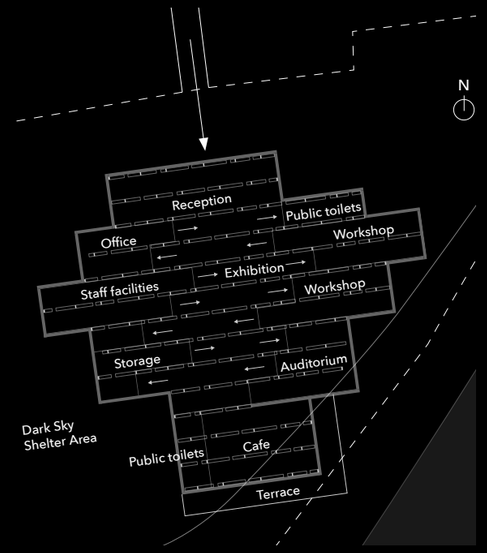


Ill.164 Plan investigation 2, 1:1.000

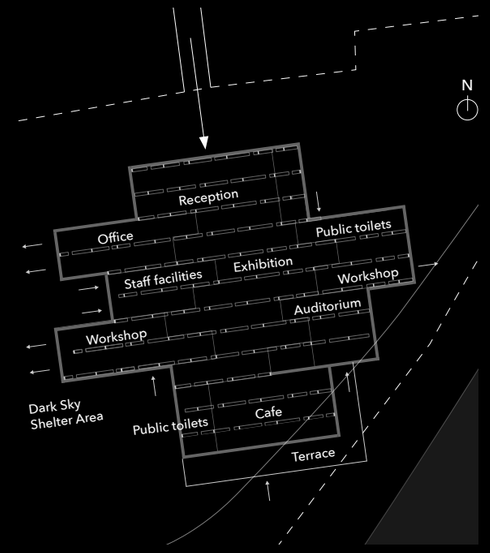
PLAN DEVELOPMENT



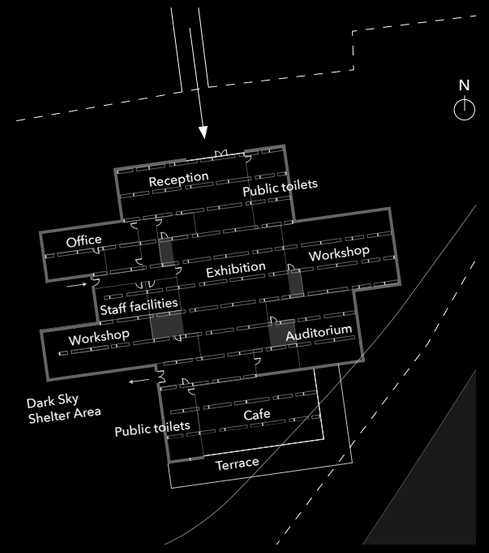
Ill.165 Plan development step 1, 1:1.000



Ill.166 Plan development step 2, 1:1.000



Ill.167 Plan development step 3, 1:1.000



Ill.168 Plan development step 4, 1:1.000

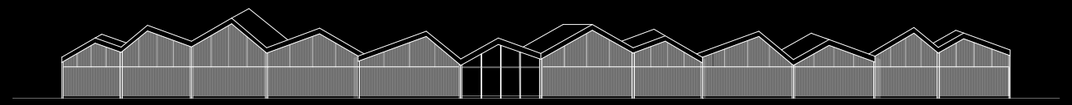
Based on the preferable spatial organisation of the different functions of the visitor centre and the desire of creating a connection between the entrance to the building, the salt meadows and shelter area (ill. 165), the form and plan of the building have been developed further. To create a more dynamic, but still systematic flow within the centre and simultaneously increase the surface area of the walls to absorb more of the sound and thereby minimise the reverberation time, each module row is displaced, shifting direction throughout the centre (ill. 166).

The external displacements are important to consider too because these create a flow around the building and decrease the scale of the building when observed nearby, but these should not distract from the true experience inside. Furthermore of functional and technical reasons, the displacements outside will be minimised. Though it should be ensured the external displacements on each side of the reception are different both concerning the area of the single function, but also to continue on the pattern from inside. (ill. 167) To avoid a direct transition from the exhibition area to the other functions and thus provide transition and rest zones, the internal displacements will be adjusted to create these. Thereby, the entrance to the different rooms will be placed on the side of the displaced walls. Further, a natural and wind-protected entrance to the staff area is created by one of the external displacements. Thereby, the plan can be detailed further (ill. 168).

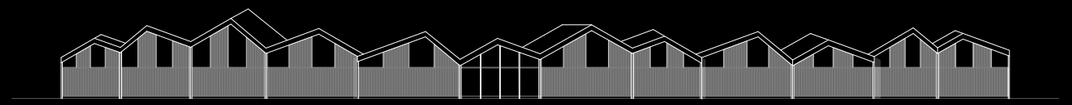
FACADE PROCESS

The interior layout affects the exterior expression of the building, as well as the desired facade, has an impact on the internal spaces concerning light and transparency. Thus, it is crucial to observe both aspects as early as possible. The facade should reveal the structural system that differs along the axes reflected in the dynamic roof structure. It is essential that the facades enhance the role of the structure and its connection to the sky.

Different facade investigations have been made, which show that a plain facade consisting of the same material (ill. 137) does not support the desired story, because the cladding appears heavy and as part of the bearing system of the roof even though it should be carried by the columns. Furthermore, the facade appears long and monotone. Adding window openings help decrease the scale of the facade, but it still does not relate to the structural principle of this building. Breaking up the cladding with a transparent and light glass section clearly distinguishes the facades in three layers; a closed and heavy base, a light roof structure carried by the characteristic y-shaped columns and a light section in between to enhance this separation (ill. 172). Furthermore, the vertical glazing bars counterbalance the vertical orientation of the building form. This direction can be enhanced through horizontal bars which placed in a dynamic pattern dissolve the uniformity of the facade (ill. 173). The separation of the three layers can also be made by allowing the glass section following the shape of the roof (ill. 174) or by creating a sharp edge between the three layers in the facade, which enhances the difference between the heavy base and the light roof connected with the glazed section and the role of the columns as the only bearing structure. These investigations will be the basis for further facade investigations. Though, the glass section will mainly be placed on the north and south facade where the reception and the cafe are located. Thus, the other facades will mainly be constructed with a minimal opening in the top of the facades to maintain the separation of the heavy base and the light roof structure.



Ill.169 Investigation 1: North facade with cladding 1:500

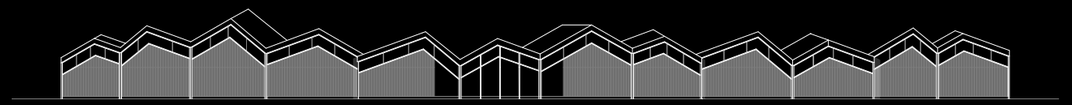


Ill.170 Investigation 2: North facade with a shift between cladding and the glass 1:500

Ill.171 Investigation 3: North facade with a shift between cladding and the glass 1:500

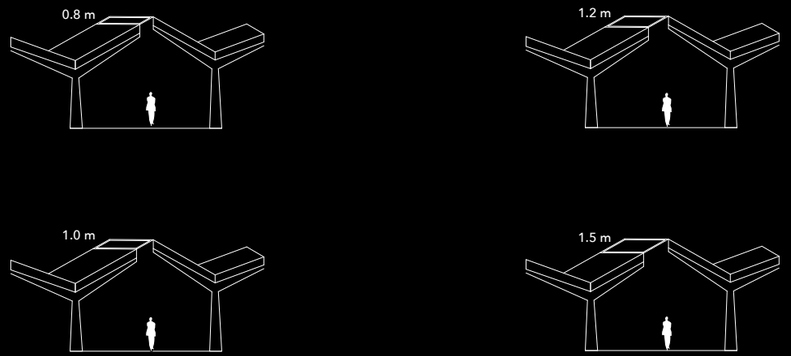
Ill.172 Investigation 4: North facade with a clear division between the base and the roof with the glass section in between 1:500

Ill.173 Investigation 5: North facade with a clear division between the base and the roof with the glass section in between with both horizontal and vertical glazing bars 1:500



Ill.174 Investigation 6: North facade with a clear division between the base and the roof with the glass in between following the shape of the roof 1:500

DAYLIGHT INVESTIGATIONS



Ill.175 Skylight investigations

The relation to the Dark Sky through the architecture will be established through the construction defining skylights, from which the main part of daylight will enter. Thus, only a few windows at eye level will be placed on the facades; in the workspaces due to the requirement of providing a view to the surrounding landscape and in the cafe due to the wish of having a view of the salt meadow in connection with the starry sky. During the design process, different sizes of skylights have been simulated in VELUX Daylight Visualizer to achieve the minimum daylight requirements regarding the functions of the rooms, which is a daylight factor on 2%. The final size of skylights will vary in the different functions due to the difference in size and geometry of the rooms and the amounts and placements of openings (ill. 179). Thus, larger skylights (1.2 m x 4.0 m) will be provided in the exhibition area to frame as much of the starry sky as possible. The same size will characterise the openings in the workshop areas and the lunch area due to the large depth of the rooms. In the transition zones, only 0.8 m x 4.0 m skylight is needed, and thereby another atmosphere is created in these niches than in the rest of the exhibition area. In the auditorium, an alternation of 1.0 x 4.0 meter and 1.2 x 4.0 m skylights are necessary to also minimise the risk of glare on the screens and still provide a view to the starry sky.

Ill.176 Daylight simulation with 1.0 m x 4.0 m skylights

Ill.177 Daylight simulation with 1.2 m x 4.0 m skylights

Ill.178 Daylight simulation with 1.5 m x 4.0 m skylights

Ill.179 Daylight simulation with combined skylights (0.8 m x 4.0 m in the staff area and the transition zones, 1.0 m x 4.0 m in the meeting room and 1.2 x 4.0 m in the workshop areas, the exhibition area, the lunch area and the auditorium)

EXTERIOR MATERIALS

With the accomplishment of the required daylight factors in the different functions, the facades can be developed further. Based on the north facade in which the entrance to the centre is placed, the other facades will be designed based on the previous facade investigations (pp. 130 and 131) containing a clear separation of a heavy base, a light roof structure and a transparent light glass section in between them to enhance the role of the structure. The base is raised around 2.5 m to avoid disturbing eyes into the functions.

Vertical wood lamellas are considered as exterior cladding because of its relation to the Nyord Bird Tower which with its characteristic visible structure is placed in a similar context as this project. Thus, wood with a greyish tone stands well in the context consisting of the oak trees (ill. 180). Wood does also have a warm expression which makes it appear welcoming. Further, the vertical lamellas support the vertical direction towards the sky and counterbalance the horizontal direction of the building. Though, wood has a low lifespan and is not recyclable, which can increase its environmental impact, because it as cladding has to be replaced more often than bricks, for instance.

The harsh climate at Nyord require the use of durable materials which thereby can be obtained by bricks. The heavy base will also be hard to obtain with wood due to its lower density and light expression supported by the raised cladding from the ground due to protection of the wood cladding. Thus, brick masonry is an option to obtain the desired expression and heaviness due to the high density of the bricks. Further bricks have other qualities that make them a preferable material in a Danish context, for instance, due to its weather resistance and low maintenance. The bricks can be horizontal which enhances the horizontal axis of the building that makes it appear very long (ill. 181). Placing the bricks vertically breaks this direction and instead enhance the vertical direction similar to the wood lamellas and simultaneously direct one's view towards the roof. Thus this solution combines the verticality of the wood lamellas and the heaviness and durability to the harsh climate of the bricks (ill. 182).

The glazing bars are both placed horizontally and vertically to break up the scale of the window section giving a dynamic expression and to enhance both the horizontal direction of the building and the vertical direction of the structural elements. The glazing bars will be made in black aluminium which enhances the direction of the lines even from a distance and the aluminium makes it possible having narrow and elegant bars not to draw attention from the main elements in the facade. The roof will be constructed in spruce boards because it is a natural material and due to the water-resistance of spruce and its uniform appearance (p. 77). The boards will be given a dark greyish tone to direct one's view to the roof when observing it and make it remarkable from a distance.

Ill.180 North facade with wood cladding (vertical wood lamellas)

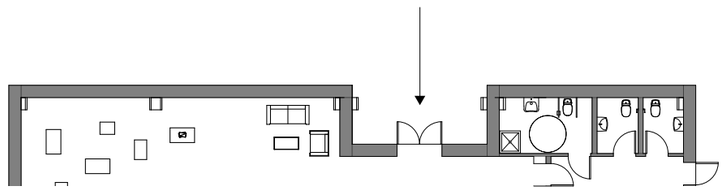
Ill.181 North facade with horizontal bricks

Ill.182 North facade with vertical bricks

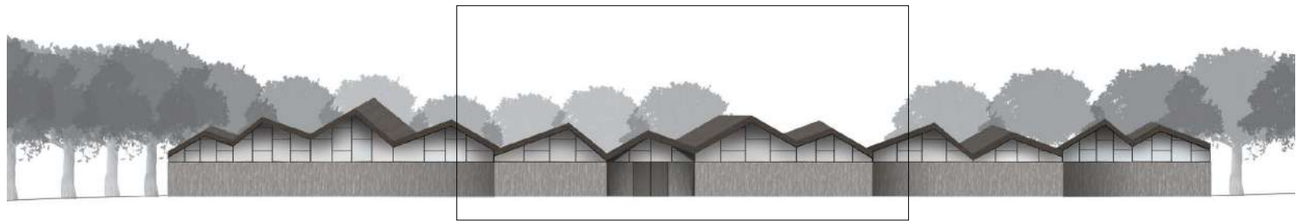
ENTRANCE

The entrance to the centre is of great importance because it creates the transition from the external and internal areas and thus it creates the frames for the first interaction with the building. Hence, it should be marked on the facade for easy recognition, which is made possible by displacing the entrance inwards. This allows the bricks on the rest of the facade to wrap around the corners. The door becomes the lock of the brick bond that continues around the building. Increasing the height of the door to meet the edge of the brick masonry prevents breaking the heavy base and thus maintains the principle of the facade. The door is made in bright greyish wood to create another expression from the brick facade, and thereby mark the entrance for the visitors.

The transparency of the building is only promoted on the upper part of the facade through the glass section that reveals the structure which bear the characteristic roof and thus emphasise the principle of the facade and the relation between the human and the sky through the architecture. To enhance this, even more, the glass section is given a slope inwards, whereby it does not become or appear loadbearing, but instead support the loadbearing structure consisting of the characteristic y-columns. Further, this results in a small overhang of the roof that thereby floats above the walls.



Ill.183 Plan section of the north facade with entrance marked



Ill.184 North facade with a vertical brick base that continues around the corners of the displaced entrance

Ill.185 Detailed view of the displaced entrance and the exterior materials

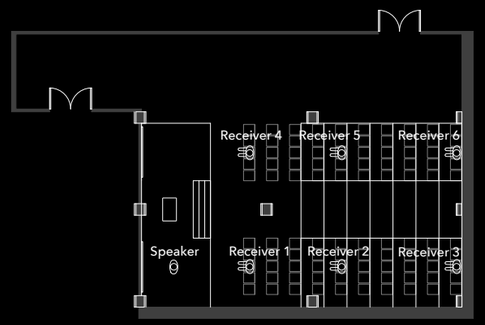
DETAILING PROCESS

In the following chapter, the detail of the visitor centre has been conducted through different investigations concerning both aesthetical, functional and technical aspects, which should clarify the decisions within for instance materials, detailed analyses of certain areas in relation to acoustics and outdoor areas, navigation in the darkness, lighting and structural dimensioning, which all underly the final design. This part of the project has taken place simultaneously with the design process, but these two chapters have been divided to provide the reader with an in-depth understanding of chosen aesthetical, functional and technical aspects. This should illustrate the process and the many aspects which have affected the design development of the visitor centre, even though the design development has been an iterative process with loops back and forth.

Ill.186 (Merzlyakov, n.d.)

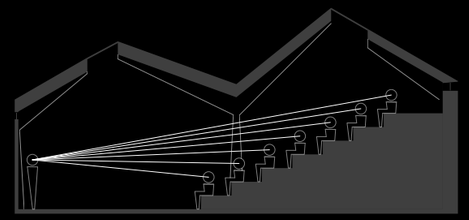
AUDITORIUM
SIGIITLINES AND ACOUSTICS

The auditorium is at day a place for talks for instance by experts related to Dark Sky and light pollution and space for inspiration for both locals, school classes and other visitors. At night, it will as the rest of the building mainly remain in darkness and thus can be utilised to documentaries or other events in darkness. The acoustics in the auditorium is crucial, because it is important that the audience, even in the rearmost sitting can both see and hear the speaker. Thus, the sitting opportunities and acoustics of the space have been investigated. To ensure efficient utilisation of the area and provide much possible sitting, the audience can be positioned on a tribune with a height increase of 150 mm (ill. 190), while the speaker is raised. This gives each person the possibility of view to the stage. The tribune is flexible so it can be folded when not used. Further, the raytracing of this solution indicates a spread of the sound (the direct sound, 1st and 2nd reflections) to the whole audience because the sound waves from the speaker become reflected by the ceiling above him that due to the angle on the roof reflect the sound backwards (ill. 191).

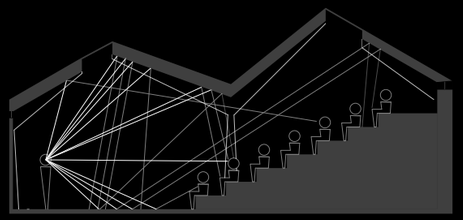


Ill.187 Plan of the auditorium with speaker and receivers

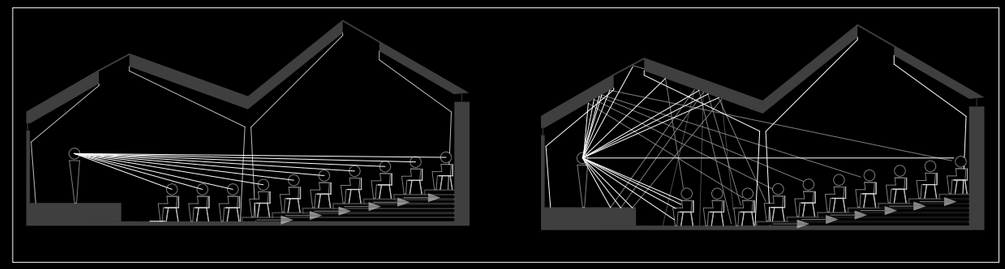
Furthermore, a clear articulation of speech must be ensured. Thereby, the auditorium has been simulated with focus on both reverberation time, definition and sound pressure level aiming for a balance between these. A reverberation time of around 1 second is preferable for speaking in the auditorium with a definition of at least 50%. Thus a balance between reflection and absorption of the sound



Ill.188 Investigation 1: Stepped seating (450 mm rise)

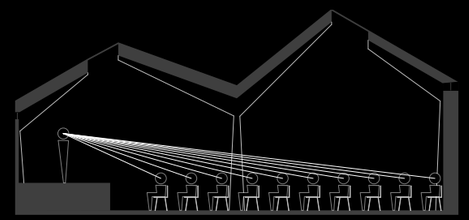


Ill.189 Investigation 1: Raytracing (direct sound, 1st and 2nd reflections)

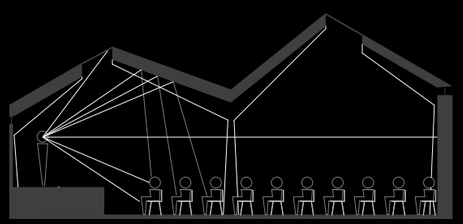


Ill.190 Investigation 2: Stepped seating (150 mm rise) and speaker raised (600 mm)

Ill.191 Investigation 2: Raytracing (direct sound, 1st and 2nd reflections)



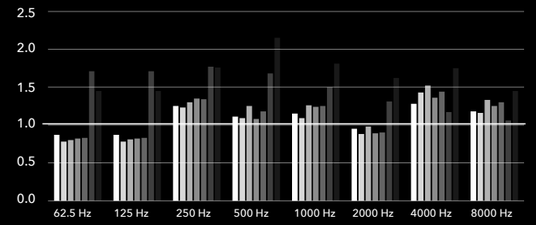
Ill.192 Investigation 3: Speaker raised (900 mm)



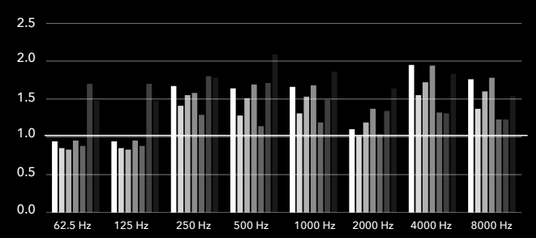
Ill.193 Investigation 3: Raytracing (direct sound, 1st and 2nd reflections)

is necessary, and cases with different materials have been investigated. The results indicate that the requirement to the definition is fulfilled in all cases, while the reverberation time with the case of concrete and bricks walls is too high due to the high reflective properties of these materials. On the other hand, the sound pressure level of the sound is highest in these cases. To ensure a balance, the case with rammed earth floor and reflective wood panels on the walls and ceiling is chosen. Though the SPL is below the recommendation on the lower frequencies, but in cases with speaking, the frequencies from 250 Hz to 2000 Hz are of importance, and in these frequencies, the recommendation is fulfilled.

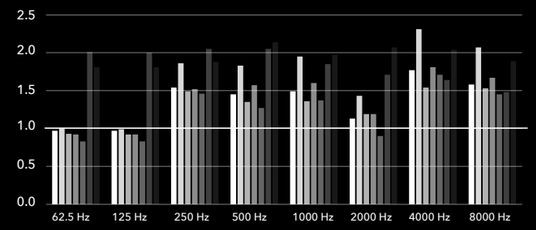
- Case 1: Rammed earth floor, reflective wood panels (ceiling and walls)
- Case 2: Rammed earth floor, microperforated panels (front and back wall), reflective wood panels (sidewalls and ceiling)
- Case 3: Rammed earth floor, microperforated panels (front and back wall and ceiling above receivers), reflective wood panels (rest of ceiling and walls)
- Case 4: Rammed earth floor, plasterboard (ceiling), microperforated panels (front and back wall), reflective wood panels (sidewalls)
- Case 5: Concrete floor, microperforated panels (front and back wall), reflective wood panels (sidewalls and ceiling)
- Case 6: Rammed earth floor, reflective wood panels (ceiling and front and back wall), concrete (sidewalls)
- Case 7: Rammed earth floor, reflective wood panels (ceiling and front and back wall), bricks (sidewalls)



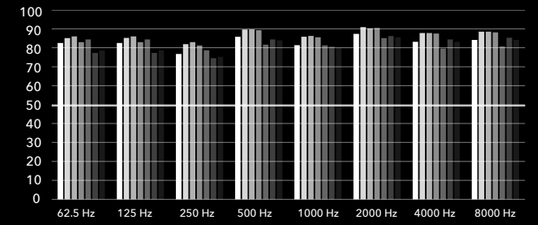
Ill.194 Reverberation time, T-30 [s] - Receiver 1



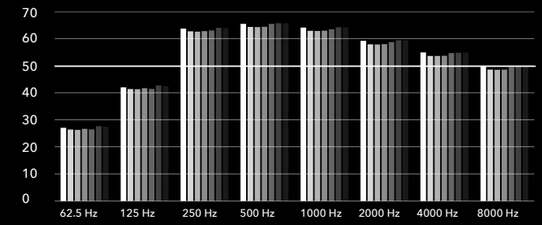
Ill.195 Reverberation time, T-30 [s] - Receiver 2



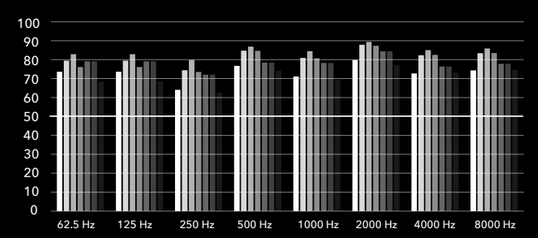
Ill.196 Reverberation time, T-30 [s] - Receiver 3



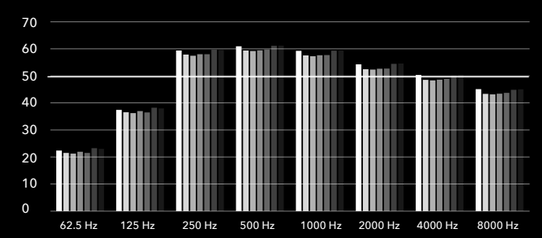
Ill.197 Definition, D-50 [%] - Receiver 1



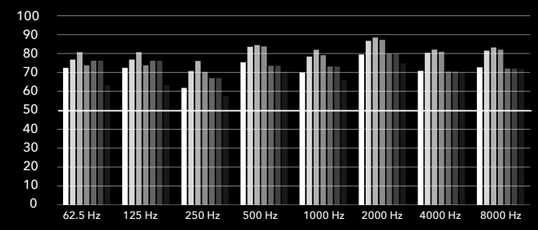
Ill.200 Sound Pressure Level, SPL [dB] - Receiver 1



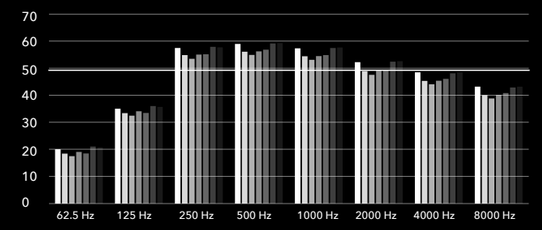
Ill.198 Definition, D-50 [%] - Receiver 2



Ill.201 Sound Pressure Level, SPL [dB] - Receiver 2



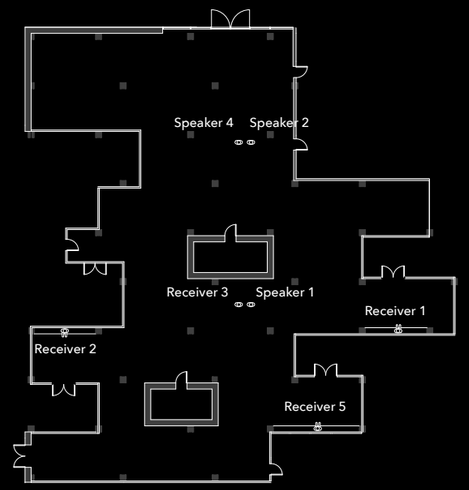
Ill.199 Definition, D-50 [%] - Receiver 3



Ill.202 Sound Pressure Level, SPL [dB] - Receiver 3

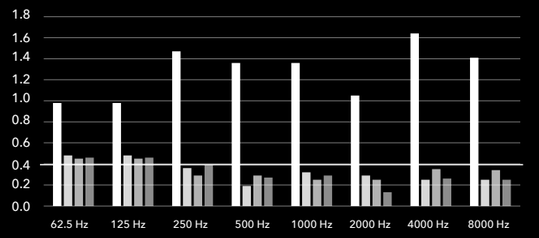
EXHIBITION AREA
ACOUSTICS

The exhibition area is a flexible room that at day exhibit different objects and provide activities related to Dark Sky and light pollution, while at night the stars can be experienced through the skylights in the area. The Dark Sky experience will occur in darkness. Thus it is important to investigate the acoustics to minimise disturbing sound coming from the talk from other visitors. Hence, the reverberation time becomes essential to consider, whereby the acoustics in the area has been simulated. The geometry of the room plays an important role within this because the size of the surface area defines the absorption of the sound. Thereby the displacements on the geometry of the exhibition area will increase the absorption area. Further, the used materials are also important to consider. Different acoustic wood panels with high absorption coefficients have been analysed (cf. pp. 112-113).

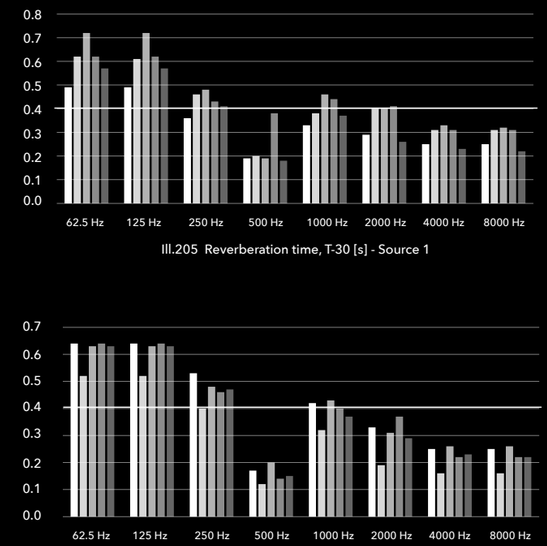


Ill.203 Plan with speakers and receivers in the exhibition area

The aim of these investigations is to achieve a low reverberation time and thereby much sound absorption, but still on a level that makes the area comfortable to stay in. The area will also be used at the day where speaking and discussing will occur, and thus some reverberation is necessary. Case 2 with perforated wood lamellas appear to have the lowest reverberation time that simultaneously can be comfortable in the exhibition area, even for the person standing next to the speaker (ill. 204).



Ill.204 Reverberation time, T-30 [s] - Receiver 3 with case 2



Ill.205 Reverberation time, T-30 [s] - Source 1

Ill.206 Reverberation time, T-30 [s] - Source 2

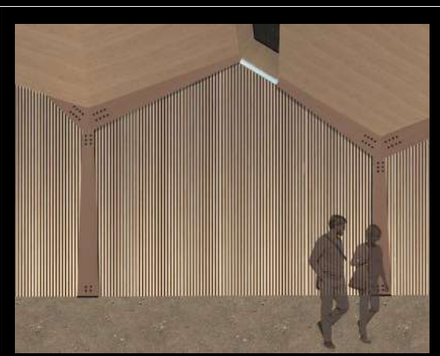
Case 1: Rammed earth floor, wood boards (ceiling), reflective wood panels (walls)
Case 2: Rammed earth floor, wood boards (ceiling), wood lamellas (walls)
Case 3: Rammed earth floor, wood boards (ceiling), perforated acoustic panels (walls)
Case 4: Rammed earth floor, wood boards (ceiling), microperforated panels (walls)

Receiver 1
Receiver 2
Receiver 3
Receiver 4
Receiver 5

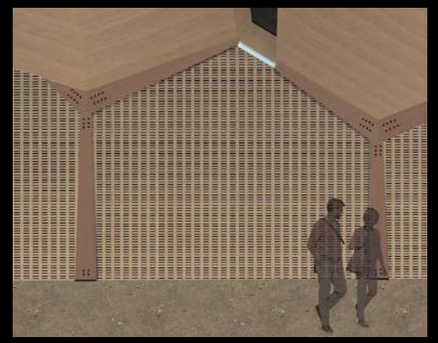
MATERIALS

The choice of interior materials within the exhibition area should not only be based on the simulation results of the acoustics, but also aesthetic aspects. For these investigations rammed earth has been chosen as floor material in the building due to its sustainable properties, its warm expression, sound absorption properties and high thermal mass (cf. pp. 70-71). As ceiling material plain wood boards have been chosen to not draw attention from the complex roof construction and the characteristic structural elements. In relation to the acoustic simulations, the investigated wall panels have been evaluated in this analysis. This shows that the plain wood panels create a uniform and monotonous expression together with the plain wood boards on the ceiling (ill. 207). The microperforated panels have been investigated due to their good absorption coefficient, but aesthetically the holes are too small to be noticeable and will create a similar expression as the plain wood panels (ill. 210). With a focus on sensual architecture and architecture in darkness, the tactility of the material becomes of great importance. Thus the cases with both perforated wood panels and wood lamellas (ill. 208 and 209) appeal to the sense of touch, especially in the darkness where the sight is minimised. The lamellas do also give a dynamic expression at day and give the opportunity in integrating wall elements for instance posters or paintings in the walls by cutting off the lamellas without these elements disturbing the space. Furthermore, the lamellas have a vertical direction that supports the direction of the columns and orient upwards to the sky. Both due to these qualities of the wood lamellas and its acoustic properties, these are chosen as interior wall material.

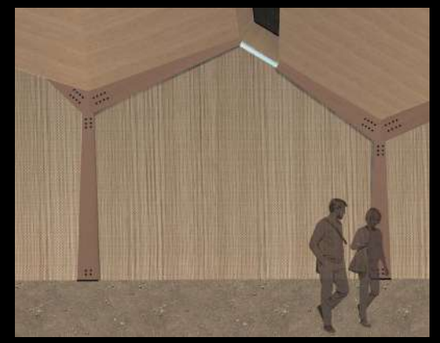
Ill.207 Case 1: Wood panels (oak) on walls, wood boards on ceiling, rammed earth floor



Ill.208 Case 2: Wood perforated lamellas (oak) on walls, wood boards on ceiling, rammed earth floor



Ill.209 Case 3: Perforated acoustic panels on walls, wood boards on ceiling, rammed earth floor

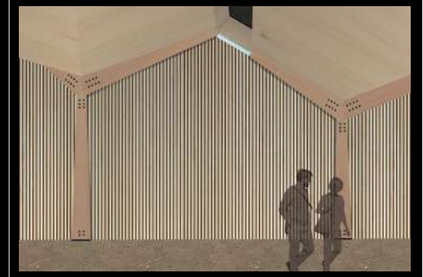


Ill.210 Case 4: Microperforated panels on walls, wood boards on ceiling, rammed earth floor

INTERIOR MATERIALS

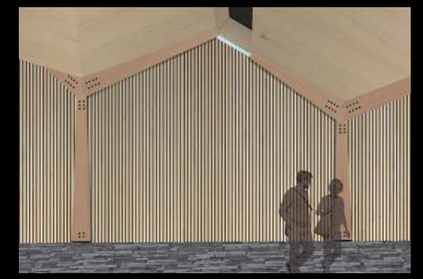
Due to the tectonic approach in this project and thus focus on the materials, it was essential in the program to investigate different materials both regarding their construction, aesthetics, acoustic properties and their effect on light. In this section, different interior material investigations are presented which are based on these previous analyses (cf. pp. 66-77). Here, spruce was chosen as a structural material due to its low environmental impact, easy accessibility and its uniform light colour. Spruce has similar to pine a light uniform colour, but different tones of it have been investigated. The analysis shows that the light colour of spruce enhance the lightness of the columns, whereby this has been chosen. Wood cladding will be used on the ceiling due to its warm expression, tactility, good acoustic properties and its low environmental impact. Both oak and pinewood have been investigated due to their different architectural expressions in colour and texture. As interior cladding, it has been chosen to have pinewood boards on the ceiling and pinewood lamellas on the walls based on the previous investigations of the acoustics in the exhibition area. Pinewood has been chosen due to its easy accessibility, low environmental impact and light expression that together with the spruce columns will create a unity in the centre. On the floor different materials have been investigated, where it has been chosen to use rammed earth because of its good fire, moisture and acoustic properties, low environmental impact, its high thermal mass and its interplay with the other materials.

Ill.211 Wood lamellas (pinewood) on walls, wood boards on ceiling (pinewood), rammed earth floor and dark columns

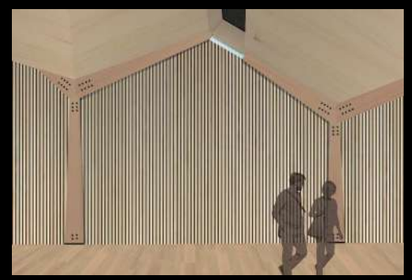


Ill.212 Wood lamellas (pinewood) on walls, wood boards on ceiling (pinewood), rammed earth floor and light columns

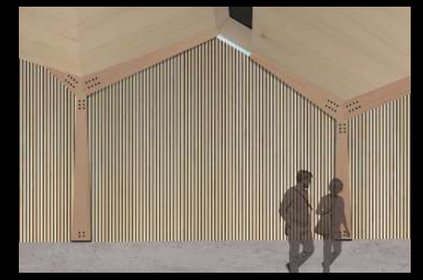
Ill.213 Wood lamellas (pinewood) on walls, wood boards on ceiling (pinewood), stone floor and dark columns



Ill.214 Wood lamellas (pinewood) on walls, wood boards on ceiling (pinewood), stone floor and light columns



Ill.215 Wood lamellas (pinewood) on walls, wood boards on ceiling (pinewood), parquet floor and light columns

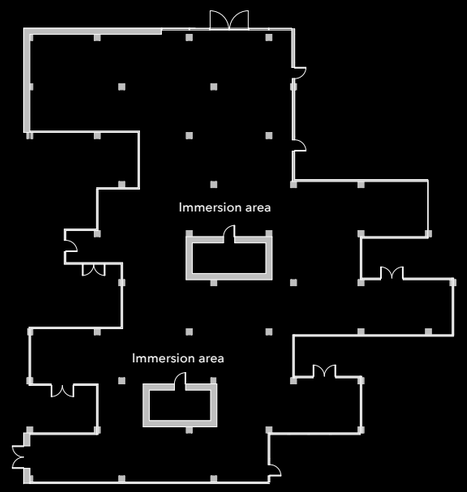


Ill.216 Wood lamellas (pinewood) on walls, wood boards on ceiling (pinewood), concrete floor and light columns

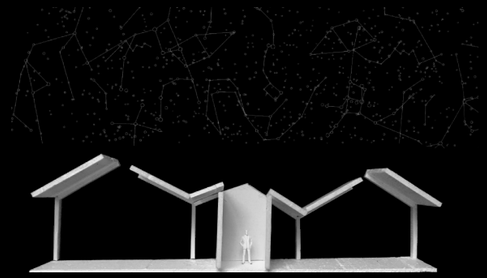
IMMERSION AREAS
DIMENSIONING

The exhibition area provides the connection to the stars through the roof construction, but to give another experience of the stars and create reflections upon the human existence and size compared to the universe, small outdoor areas (immersion areas) will be placed within the exhibition area. Here, the human is only surrounded by the walls of the building without any other disturbing elements or a great number of visitors. Thereby, it creates the frames for only focusing on the night sky. Additionally, together with the internal displacements in the exhibition area, the immersion areas break the large exhibition area and create a change between open and enclosed spaces giving the visitor opportunity to define their path of experience when moving around in the centre.

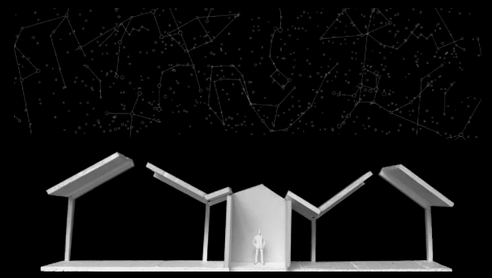
The dimensions of an immersion area have been investigated in section models (ill. 218-221) concerning the wanted atmosphere of being enclosed in another dimension. The area with the dimensions of 3.0 m x 3.5 m and 3.0 m x 4.0 m have been chosen, because these dimensions appeal to the human scale without it being too narrow when more people enter the area. Thereby, different sizes on the areas have been chosen to create a variating experience in the two areas and to frame different amounts of the stars.



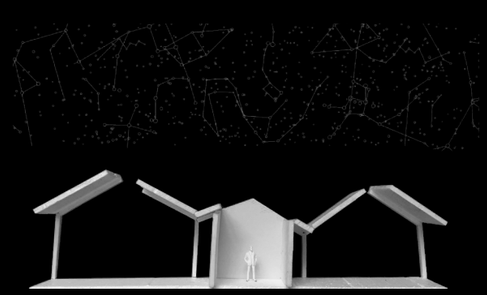
Ill.217 Plan with the position of the immersion areas in the exhibition area



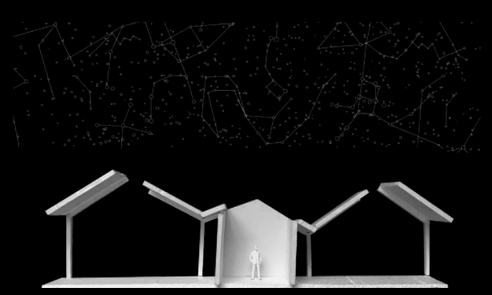
Ill.218 Immersion area with dimensions W: 2.0 m, D: 3.5 m



Ill.219 Immersion area with dimensions W: 2.5 m, D: 3.5 m



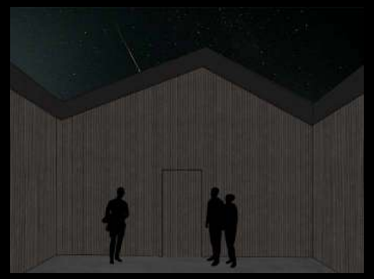
Ill.220 Immersion area with dimensions W: 3.0 m, D: 3.5 m



Ill.221 Immersion area with dimensions W: 3.0 m, D: 4.0 m

MATERIALS

When walking from inside the exhibition area and out to the immersion area, these should give the experience of entering another dimension far away from the everyday stress and rush. Here, the human is outside surrounded only by four walls and the stars above him. This should provide the opportunity to put things into perspective and reflect upon one's existence in the universe and to establish the spiritual connection between the human and the starry sky. This wanted atmosphere is investigated through the use of different material combinations (ill. 222-227). To emphasize the shift between the two worlds of experiencing the Dark Sky, brick walls and pebbles have been chosen which will be experienced differently from the wood cladding and the rammed earth floor applied inside due to the different tactility and acoustic properties of these materials. The pebbles and the rough brick walls have been chosen, so the visitor will feel the rugged terrain when entering the room and the rough tactility on the walls. Further, the sound of the wind and the reverberant sound of the birds navigating in the darkness will be heard. The experience is entirely different from the interior spaces, where disturbing elements like the reflected sound is minimised not to distract the captivation of the memorable views of the starry sky. In the immersion areas, the sound and the rough tactility is a part of the experience and the captivation of the soul of the area. Additionally, brick and pebbles have been chosen due to the minimal maintenance which will evoke an area like the salt meadow which lives in its own biological time independently from the human.

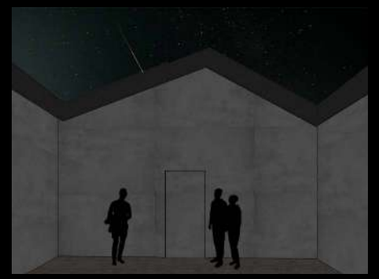


Ill.222 Wood lamellas on walls and concrete covering

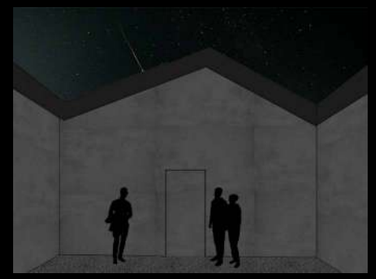
Ill.223 Wood lamellas on walls and pebbles covering

Ill.224 Brick walls and concrete covering

Ill.225 Brick walls and pebbles covering



Ill.226 Concrete walls and wood parquet covering

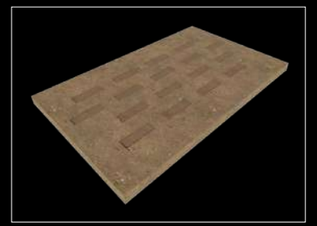


Ill.227 Concrete walls and pebbles covering

NAVIGATING IN THE DARKNESS

III.228 Rammed earth floor with raised tactile guidance path

III.229 Rammed earth floor with engraved tactile guidance path

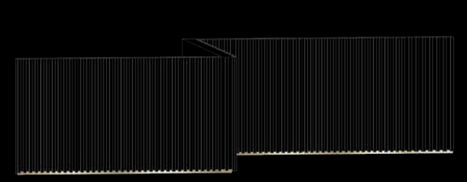


III.230 Rammed earth floor with a shift in the material on same level defining the tactile guidance path

GUIDING LINES ON EXHIBITION FLOOR

Dark Sky is a phenomenon that must be observed in darkness, and the sight will thus be limited. Navigating in the darkness will thus require that the other senses will be activated like, for instance, the sense of touch through the feet of the visitors. Based on how blind people navigate in urban areas, different iterations have been made on how the tactile guidance path can be integrated into the floor. The first iteration is similar to the existing tactile guidance path seen in the townscape, whereas in the second iteration, the guideline is engraved. These two examples can cause unstableness for the walking people but clearly indicate the path the visitors can follow.

In this project, iteration three has been chosen because it presents a shift in the material on the floor compared to the one in the guidance path. The different tactility and sound of the two materials will take part in guiding the visitor through the centre both during day and night.



III.231 Bond of lighting along with the edge of the wall

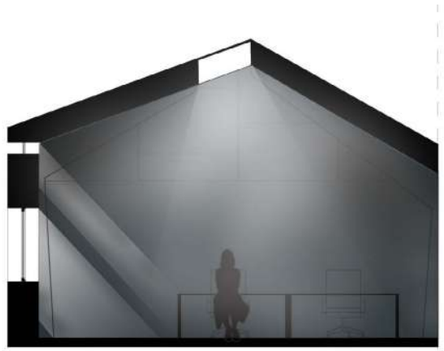
III.232 Bond of lighting along with the edge of the tables in the cafe

INTEGRATED LIGHTING

In the centre, only minimal lighting during the night is incorporated to avoid that the light will disturb or at worst case prevent people from seeing the Dark Sky from the centre. The lighting will be designed due to previously stated design principles for outdoor lighting (cf. p. 35), where the lighting should be pointed downwards, only used where and when it is needed, and the light should have a warm colour. It has been chosen to place a bond of lighting along the edge of the wall and the edge of the tables in the cafe to help navigate people through the centre and make it comfortable to eat in the darkness without distracting the visitor from the memorable view of the starry sky.

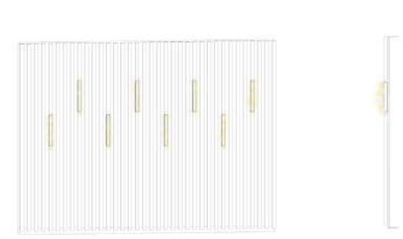
LIGHT AND SHADOW
NATURAL AND ARTIFICIAL LIGHTING

The Dark Sky Visitor Centre function both day and night the whole year, and thus the daylight conditions are crucial to consider. The window openings have been placed and designed according to the requirements for daylight in the different functions (cf. pp. 132-133). Due to the focus on the sky through the skylights, the windows on the facades are minimised, and thus an interplay of light and shadow is created in the centre. The light from the skylights and high openings in the facades highlight the structural elements due to the slope on the roof that orient the light towards the structure (ill. 233). This distribution of light creates dark niches throughout the centre, where light only enter where it is necessary, which creates a natural atmosphere based on natural light (ill. 234)



Ill.233 Natural light and shadows in office area 1:100

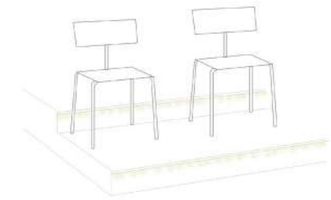
Ill.234 Natural light and shadows in the different areas within the Dark Sy Visitor Centre 1:400



Ill.235 Lighting integrated into the interior walls in the working areas

Ill.236 Lighting integrated into the interior walls in the exhibition area to light up the posters

Ill.237 Lighting and placement of computer integrated into the reception desk

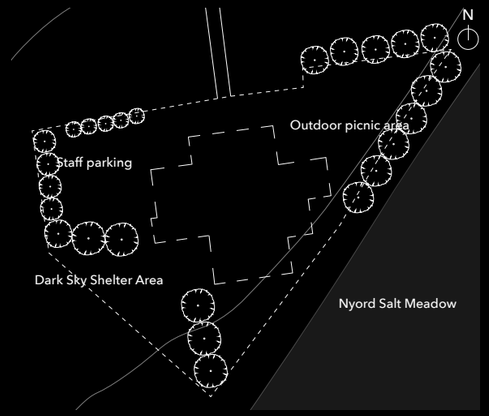


Ill.238 Lighting integrated in the tribune into the auditorium to indicate the seating and steps

INTEGRATED ARTIFICIAL LIGHTING

The building cannot only be based on natural light because this is limited in winter. Thus, narrow wall lamps will be cut into the wood lamellas on the walls in the different areas within a dynamic pattern to enlight different zones in different heights. At night, the experience occurs in darkness, but it is important highlighting the different functions, objects and sitting opportunities. Thus, artificial lighting is necessary, but this will be based on the simple rules of lighting announced by the International Dark-Sky Association (cf. pp. 34-35). Thereby, the artificial light will be minimised to only be placed where it is necessary, will point below horizontal and will be integrated into the wall panels and the interior. The humble use of artificial lighting should be sufficient for the eye to adapt to the current light and darkness.

OUTDOOR AREAS



Ill.239 Outdoor areas 1:2.000

Ill.240 Outdoor picnic area in front of the visitor centre protected from the wind by the existing trees

Ill.241 Cantilevered terrace with a view to Nyord Salt Meadow and Dark Sky

Ill.242 Dark Sky shelters with a view of the characteristic nature of Nyord and Nyord City

The shape of the visitor centre defines different outdoor spaces (ill. 239) that relate to the experience of Dark Sky but also parking areas for both visitors and the employees of the centre. The parking area for the staff will be placed near their entrance on the west side of the site. The parking area for the visitors will be placed on the road to the visitor centre, and thus the visitors will have to walk a distance before reaching the centre from the parking space. Thereby, they are given time to adapt their sight to the darkness and the different atmosphere from their everyday life.

OUTDOOR PICNIC AREA

The existing outdoor facilities have inspired the choice and placement of the outdoor areas in this project such as the existing playground and shelter area because these are today used by many people. Therefore, an outdoor picnic area is intended to be placed in the northeastern corner of the site and thus near the hiking route and close to the parking space. Thereby, this area is free to be used by other people than the visitors. From the picnic area, there will be access to the public toilets in the centre.

CANTILEVERED TERRACE

From the glazed walls in the cafe placed in the southern part of the site, the view to the Nyord Salt Meadow and the Dark Sky is established. From the cafe, the visitors have the opportunity to step outside on the cantilevered terrace over the salt meadows, which is born by a timber column. Standing here provides them with a feeling of being reconciled with nature in the sound of singing birds while they experience Dark Sky. The furnishing on the terrace works as an extension of the cafe to create a gradual transition from inside to outside.

SHELTER AREA

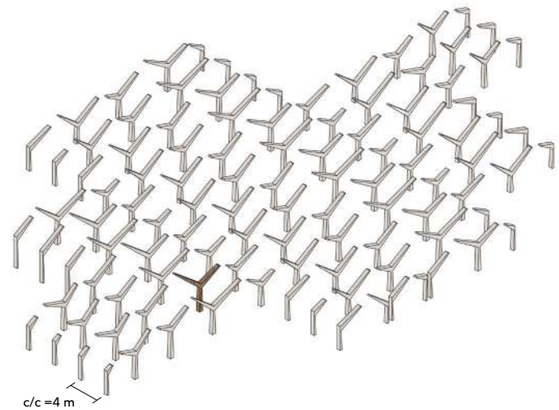
In the southwestern corner of the site, the Dark Sky shelter area is located with a direct view of the characteristic nature and the starry sky. The shelter area is towards northwest and northeast sheltered by the existing trees on the site, which together with the closed facade of the centre create privacy for the visitor spending a night in the shelters. An opening through the trees towards the centre provides the visitors with easy accessibility to the centre and the bath and toilets facilities placed in the centre.

STRUCTURAL DIMENSIONING
DIMENSIONING OF CRITICAL COLUMN AND BEAM

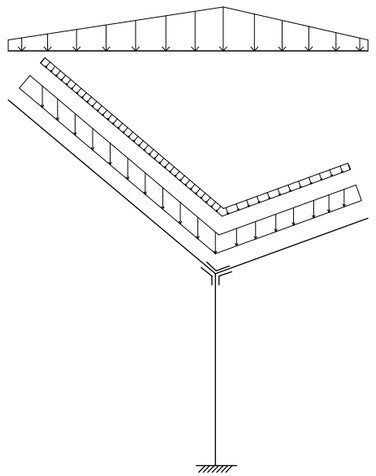
This project focuses on a tectonic approach and thus on the structure and construction that both have aesthetic, atmospheric and functional qualities and is essential for the concept of this project consisting of the characteristic visible structure that frames the starry sky and establishes the connection between the human and the universe. Thus a structural material, that both can provide flexibility in shape and dimensions, provide large spans and with high aesthetic qualities is preferred. Based on previous analyses in the program (cf. pp. 72-73), glue-laminated timber has been chosen due to its strength compared to construction timber, which can result in more slender structural elements and thus be more elegant which is preferred due to the visible structure. Furthermore, the structural performance of the characteristic columns, their shape and the joints have a huge influence on the final result of the visitor centre.

The columns have been analysed in Robot Structural Analysis to identify the most critical y-column based on the load calculations (cf. appendix E). The structure is dimensioned due to the greatest load combination in the ultimate and serviceability limit states, which is for dominating snow load. The most critical y-column is highlighted in illustration 244 which has the highest internal forces caused by the longest beam in the overall structure. Different iterations have been conducted (ill. 246-250) to optimise the construction, so the y-column is dimensioned to what is necessary to carry the loads. The elements have varying cross-sections along the length of them due to the desire of placing the material according to the distribution of the internal bending moment in the material. Thus, the elements have the biggest dimensions in the connections, which are the most critical ones and thus these are verified both in Robot and manually.

The dimension of 400 mm x 400 mm for both the column and beams on their largest cross-sections have been chosen. Though the internal forces are lower in the column, but a uniform expression on the elements is desired, so the material is equally divided between the elements. This will also ensure elegant elements with a light expression oriented towards the sky. Further, the dimensions are depended on the dimensioning of the bolts that also put demands on the height of the cross-section of the elements, which cannot be lower with the chosen amount and size of bolts (cf. pp. 164-165).



Ill.244 Structural principle

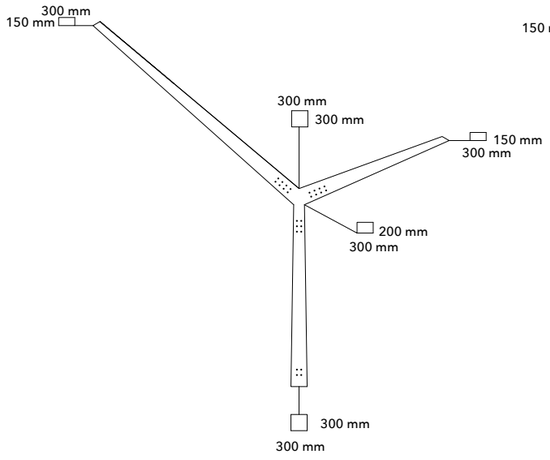


	Ultimate limit states	Serviceability limit states
	Q_{snow}=13.2 kN/m	Q_{snow}=8 kN/m
	Q_{Wind}=0.37 kN/m	Q_{Wind}=0.23 kN/m
	G=3.47 kN/m	G=3.156 kN/m

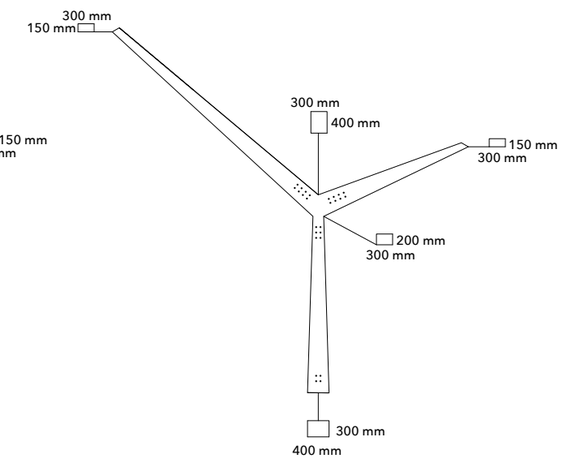
Material data

GL32 h
k_{mod}: 0.8
$f_{m,y,k}$: 32 MPa
$f_{c,0,k}$: 29 MPa
$f_{V,0,k}$: 3.8 MPa
$E_{0,K}$: 11100 MPa

Ill.245 Static scheme for the critical structural element with dominating snow load



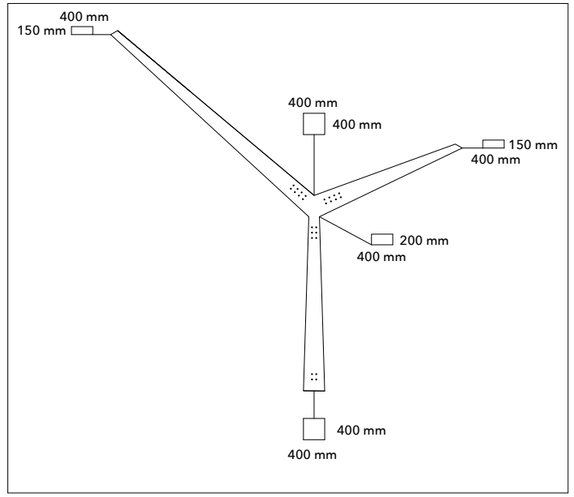
III.246 Iteration 1: Structural elements of 300 x 300 mm



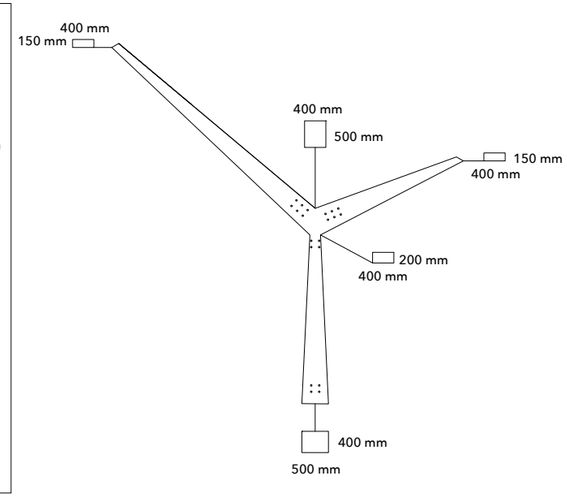
III.247 Iteration 2: Structural elements of 300 x 400 mm

Beam						
Iteration	N(kN)	M(kN*m)	$\sigma_{m,y,d}$(MPa)	$\frac{\sigma_{m,y,d}}{f_{m,y,d}} \leq 1$	u_{fin}(mm	u_{max}(mm)
1	44.24	-111.37	24.48	1.26	14.72	19.28
2	45.68	-112.24	14.03	0.71	6.21	19.28
3	46.38	-112.57	10.55	0.54	7.46	19.28
4	47.27	-113.05	6.78	0.34	3.81	19.28

III.248 Dimensioning of most critical beam



III.249 Iteration 3: Structural elements of 400 mm x 400 mm



III.250 Iteration 4: Structural elements of 400 mm x 500 mm

Column							
Iteration	N(kN)	M(kN*m)	$\sigma_{c,0,d}$(MPa)	$\sigma_{m,y,d}$(MPa)	$\frac{\sigma_{c,0,d}}{k_{c,y} \cdot f_{c,0,d}} \leq 1$	$k_{c,y}$	$\frac{\sigma_{c,0,d}}{k_{c,y} \cdot f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} \leq 1$
1	137.93	13.34	2.3	6.67	0.132	0.98	0.47
2	136.39	11.91	2.27	5.96	0.131	0.98	0.43
3	135.83	13.77	1.7	5.16	0.098	0.98	0.36
4	134.86	17.13	1.69	6.42	0.097	0.98	0.43

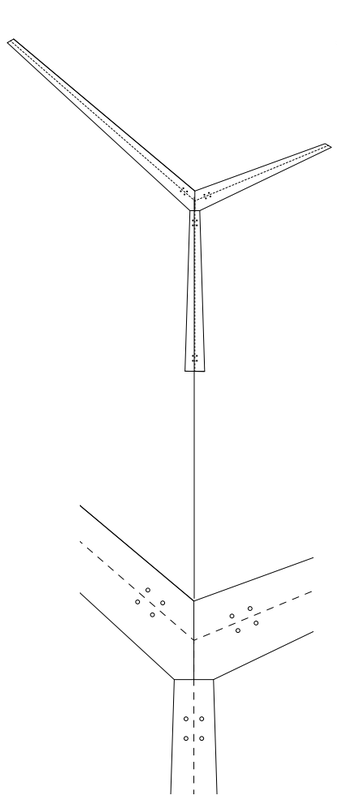
III.251 Dimensioning of column

STEEL - TO - TIMBER CONNECTIONS WITII METAL BOLTS

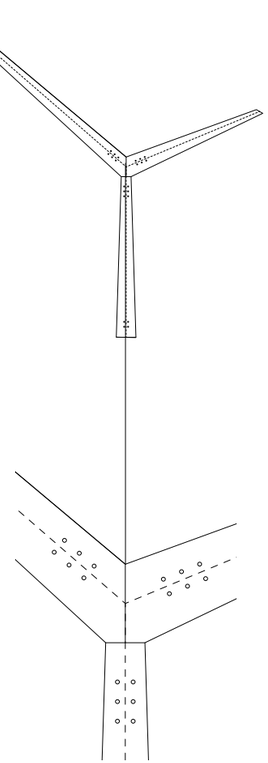
The fixed supports and connections have crucial impact on the dimensioning of the structural elements, and thus these should also be verified. The connection with the most critical internal bending moments have been investigated which is the one between the column and the beams. The biggest internal moment occurs in the longest beam, and thus this will be the dimensioning parameter for the other elements. The connection consists of bolt connections due to the strength of steel and the less material use. The number of bolts and the spacing between them have crucial importance on the design strength of the fasteners. Different cases have been analysed, and the results indicate that an amount of 8 bolts on the critical beam makes it possible for the beam to resist the internal bending moment. The lowest distance between the bolts is chosen to concentrate the bolt within a smaller area which limits the bolts impact on the visual expression of the column (ill. 255).

Bolt diameter d_{bolt} [mm]	Amount of bolts n	x-distance between bolts [mm]	y-distance between bolts [mm]	Critical force F_{crit} [kN]	Load carrying capacity F_{cRk} [kN]	Design strength of fastener F_{vefRd} [kN]	Ratio F_{crit}/F_{cvefRd} [-]
20	4	100	80	107.93	10.33	17.48	6.18
20	4	100	120	105.15	8.07	13.66	7.70
20	4	150	120	98.38	7.66	12.96	7.59
20	4	200	120	91.37	10.06	17.02	5.37
20	6	100	80	30.63	8.30	14.04	2.18
20	6	100	120	29.77	7.79	13.18	2.26
20	6	150	120	25.00	9.23	15.63	1.60
20	6	200	120	21.20	7.55	12.78	1.66
20	**8**	**100**	**80**	**10.23**	**7.39**	**12.51**	**0.82**
20	8	100	120	9.80	10.27	17.38	0.56
20	8	150	120	8.27	10.26	17.36	0.48
20	8	200	120	7.54	8.41	14.24	0.53

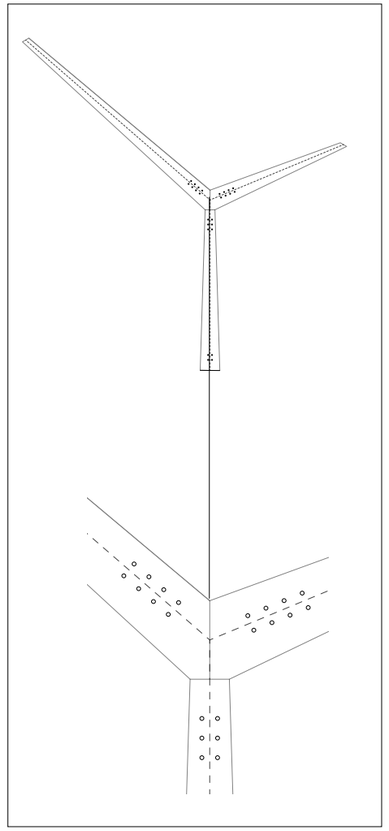
Ill.252 Cases of dimensioning bolts in the most critical beam



Ill.253 Critical beam with 4 bolts



Ill.254 Critical beam with 6 bolts



Ill.255 Critical beam with 8 bolts

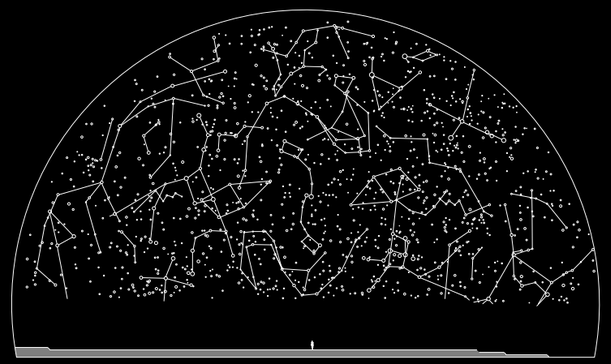
PRESENTATION

The following chapter presents the final proposal for the Dark Sky Visitor Centre. This includes presentation material of the centre consisting of a masterplan, plans of the centre for both at day and at night, sections, elevations and both internal and external 3D visualisations. The technical aspects of the project are revealed in a presentation of the characteristic structural system, detail drawings and daylight and acoustic simulations. In collaboration, a tectonic example of an architecture in darkness with focus on Dark Sky should be provided.

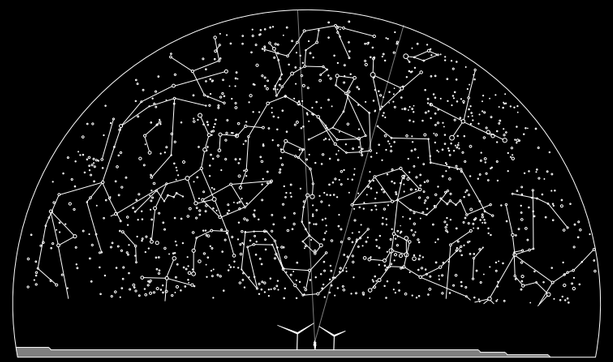
Ill.256 (Merzlyakov, n.d.)

CONCEPT

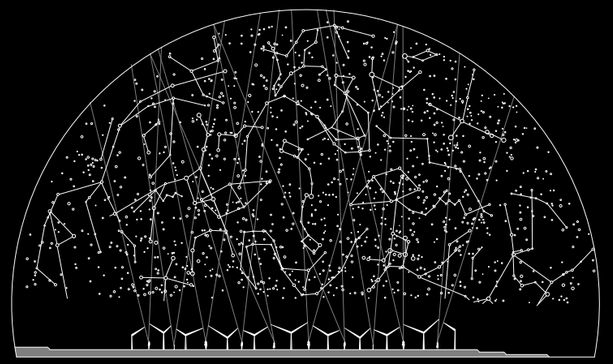
The stars exist on the night sky before the human.



The human existence is present on the site, but the stars appear distant due to a lack of connection between human and the night sky.



The human build the architecture to create a vertical connection between the ground, the human and the night sky by framing a certain part of the sky through the architecture. This should raise reflections upon human existence and its relation to the universe.



Humans interact with other humans, and thus the single architectural unit is assembled as a combination of varying modules to create a spatial path with different experiences of the sky and establish the horizontal connection between the humans.

III.257 Concept diagram

Away from the everyday stress and rush, on the border between Nyord Salt Meadow and the moraine landscape in between the oak trees, the new Dark Sky Visitor Centre has arisen, carried out in materials that blend with the surrounding landscape and create a harmonious experience of the area. While walking towards the centre from the parking area placed along the road, the Dark Sky Visitor Centre is revealed gradually when moving forward. The expression of the building puts one's attention towards the roof and reveal its functions as a Dark Sky Visitor Centre and at the same time invite people into the centre through the displacement in the facade.

Ill.258 External visualisation of the Dark Sky Visitor Centre at day

MASTERPLAN

From the main road Ulvshalevej that cuts through the large area of the characteristic Nyord Salt Meadow, a side road leads to the project site. On the end of this road, the Dark Sky Visitor Centre is placed in the border between the two landscapes of Nyord; the moraine landscape and the salt meadows. This is strengthened by the cantilevered terrace above the salt meadows. Before the visitors reach the site, they park their car on the established parking area in a distance from the centre. The centre is covered by the strictly placed existing oak trees that protect it from wind and harsh weather. From the parking area, the visitors walk the rest of the way to the centre to capture the unique atmosphere of the site in natural surroundings, in the sound of wading birds and under thousands of stars at night. The centre gradually reveals itself during this walk. The main entrance to the centre is directed towards the road and takes one into a whole different dimension that brings the human in focus in connection to the stars.

The cyclists have an opportunity in parking their bikes close to the centre with both direct access to the outdoor facilities and the hiking trail to Nyord City. The employees have their private parking area close to their entrance to the centre hidden on the western facade. On the south-western edge of the site, a Dark Sky Shelter Area is promoted with the building sheltered by the trees behind it towards the centre creating a remote area and providing a view to both the Nyord Salt Meadow and Nyord City that at night disappears in the starry sky.

Ill.259 Masterplan 1:1.000

Ill.260 North elevation 1:200

Ill.261 East elevation 1:200

Ill.262 South elevation 1:200

Ill.263 West elevation 1:200

When entering the visitor centre, the visitors are given a glimpse of the exhibition area in the background, which will establish curiosity among the visitors about what they can experience in the centre. Before entering the exhibition area, the visitors have the opportunity to store their personal belongings while using the centre in the incorporated wardrobe to the left from the entrance. In the reception to the right, the visitors are offered personal service and an overview of the different star constellations, which can be experienced at the centre at night, situated at the wall next to the reception desk. Moving further into the exhibition area on the integrated tactile guidance path, the exhibition area will gradually open up and provide the user with limitless opportunities to create their own path of experience when moving around in the centre.

Ill.264 Internal visualisation of the reception at day

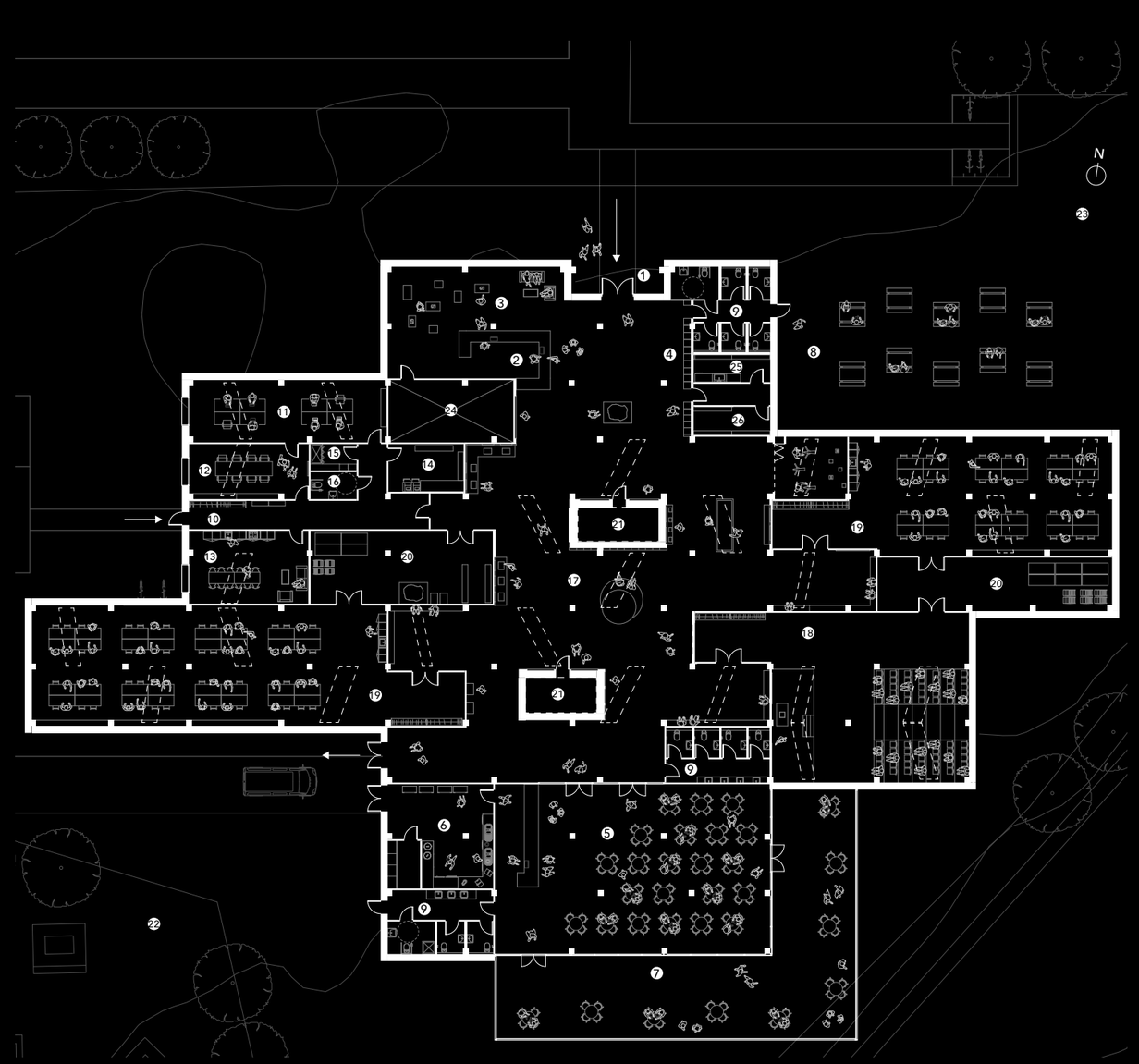
PLAN - DAY

During the day focus is on learning, exploration and experimentation concerning Dark Sky and light pollution. When entering the building through the displacement in the facade, the visitors will get an overview of the reception and a glimpse of the exhibition area in the background. To the left from the entrance, the visitors will have the opportunity to store personal belongings in the incorporated wardrobe while being in the centre. To the right, the reception desk is placed, which provide visitors with personal service and tickets before entering the exhibition area. In front of the reception desk, the local shop is situated which provides books and accessories about Dark Sky and light pollution designed by locals.

Moving further into the exhibition area, following the tactile guidance path at the floor, the visitors will to their right get an overview of the different stars constellations on the star map, which they can experience at night. From there the visitors have different opportunities to create their own path of experience due to the displacements in the exhibition area and the incorporation of the immersion areas, which define different paths and a shift between enclosed and open space. While moving around in the exhibition area the visitors have the opportunity to experience and learn about different topics concerning light pollution and Dark Sky through the use of different materials. The immersion areas, on the other hand, brings one from inside out into another dimension, where the existence of human is enhanced in another way than the rest of the exhibition through the geometry of the space and rough materials.

The displacements in the plan layout of the centre create transition areas from the exhibition to the other functions giving the visitors space for rest. The exhibition ends in front of the café with access to the Dark Sky Shelter Area to the west of the centre. From the café, the visitor can enjoy a meal with a 180-degrees view to the characteristic Nyord Salt Meadow through the glazed facade. School classes and other interested people will have the opportunity to use the workshop areas to learn about Dark Sky and the effect of light pollution on human and nature. In the auditorium, lectures can be hold concerning Dark Sky, while the flexible tribune gives opportunity to use the space for different events.

The staff will enter the centre from the west facade close to their private parking area. Their working stations are concentrated in an open office area with optimal daylight conditions. From this area, they can enter the exhibition area at the end of the hallway. They can enjoy their lunch in the cosy lunch area or use the meeting room situated near the entrance, which is suitable for guests. From the workshop areas, exhibition area and auditorium there will be direct access to the storages, where extra furniture and exhibition material can be stored when it is not used.



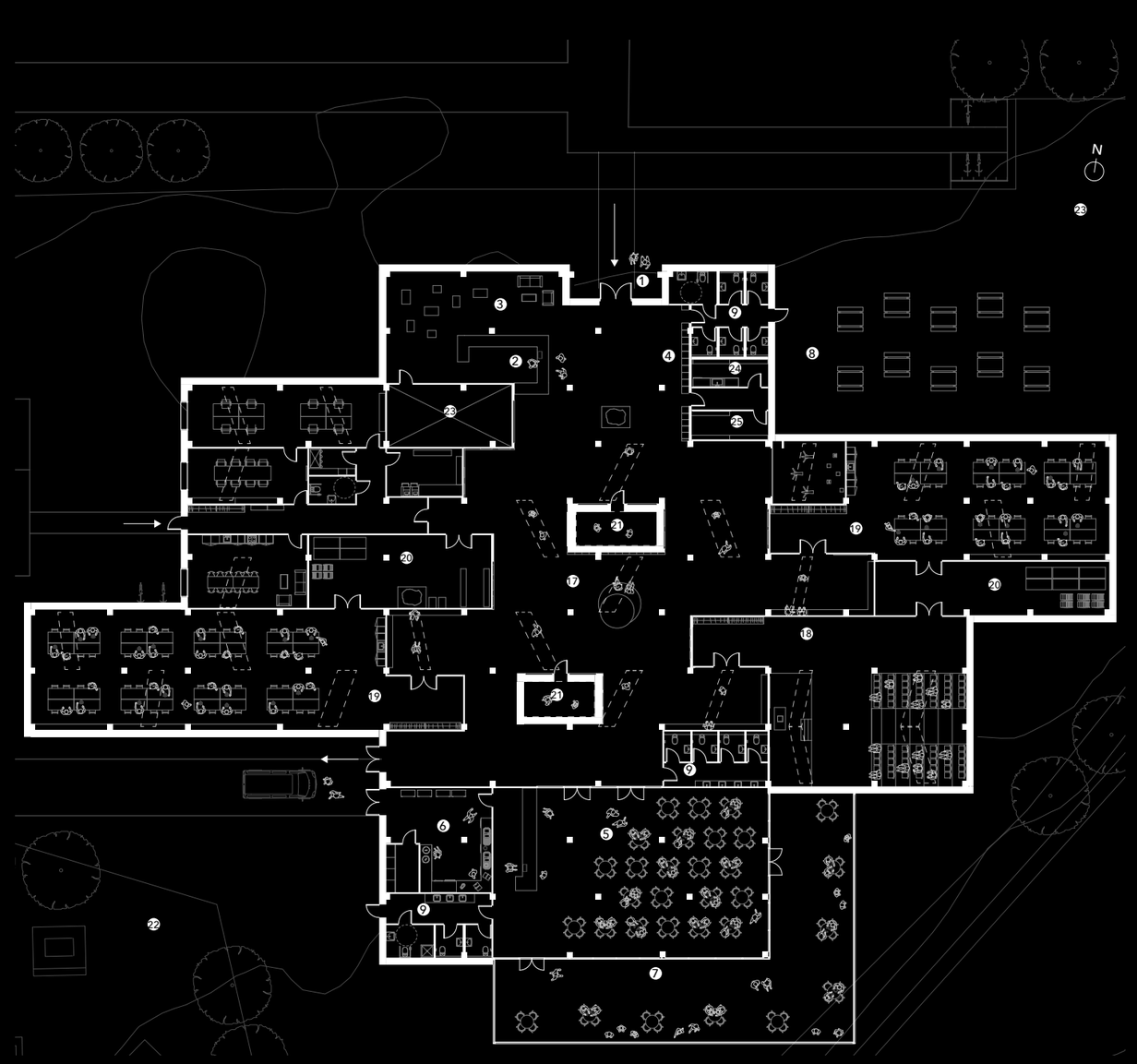
III.265 Plan at day 1:400

PLAN - NIGHT

During the night the focus is on experiencing the phenomenon Dark Sky through the skylights in the roof construction which are defined by the y-columns oriented towards the sky that thereby should establish the spiritual connection between the human and the universe. When entering the building, the whole centre is covered in darkness, which limits the overview of the centre and the sense of sight even though the distance between the parking area and the building has adapted the eye to the darkness. Inside, only minimal lighting is present like, for instance, a thin shaft of light along with the reception desk and along the bottom of the walls to define the borders of the space and guide people through the building together with the shift in the material at the floor.

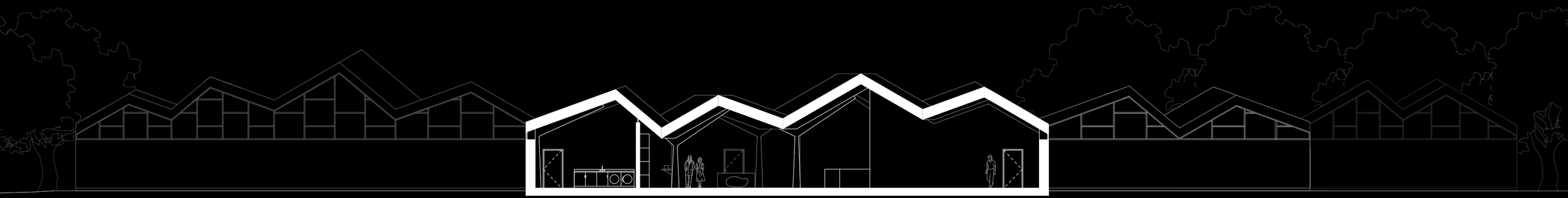
Walking in darkness will occur in a slow tempo, and because the focus is above one, the exhibition material and tables are stored or hidden away in the lamellas on the walls. Following the tactile guiding path on the floor, the visitors are guided through the centre provided with different openings in the roof with a view to different parts of the starry sky in non-disturbing circumstances due to the minimal reflected sound from other people. In the middle of the exhibition area, the sitting area is oriented towards the skylight, which allows the visitors to sit down, lean back and give an excellent view of the starry sky. The change of the position of the star constellations during the year will affect what can be experienced through the different openings in the centre. This creates a flexible exhibition with different experiences at each visit. From the exhibition area, the visitor can enter the immersion areas, which should provide the experience of entering a new dimension with the feeling of being surrounded by the stars and taken away from the everyday stress and rush. The shift in material from inside to outside emphasises the shift from one atmosphere to another; here, the visitor will feel the rugged terrain and rough tactility on the walls and hear the sound of the wind and the reverberant sound of birds navigating in the darkness.

The workshop areas will be used for different light experiments like, for instance, how different lighting will affect the experience of Dark Sky. The auditorium will remain in darkness and thus can be utilised to documentaries or other events in the darkness. Both in the auditorium and workshop areas, a thin shaft of light will be used to highlight the sitting opportunities and objects. In the cafe, only limited artificial light along the table edges will be visible providing the user with a direct view to the Nyord Salt Meadow in connection with the starry sky while enjoying a meal together. From the exit to the Dark Sky Shelter Area, the user will move through the openings in the trees and end on the flat ground with a view to Nyord Salt Meadow and Nyord City seen in connection with the stars.

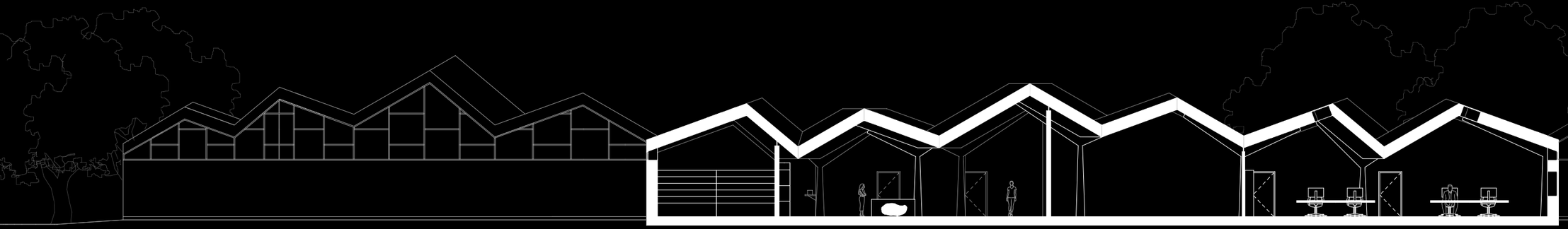


Ill.266 Plan at night 1:400

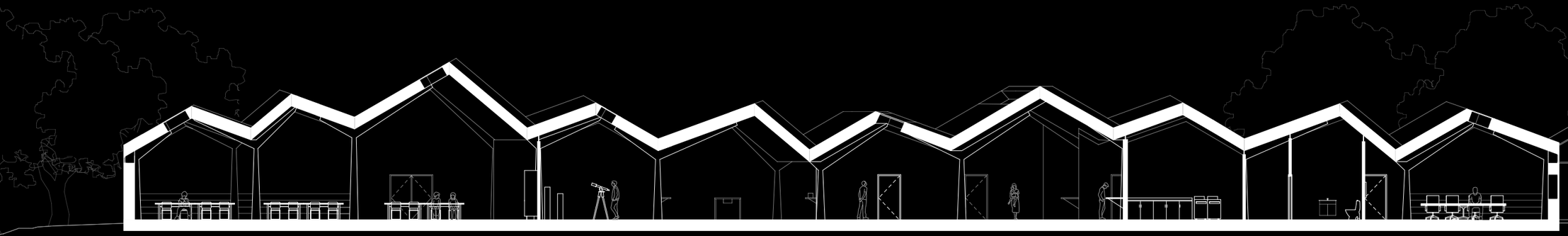
Ill.267 Section AA 1:200



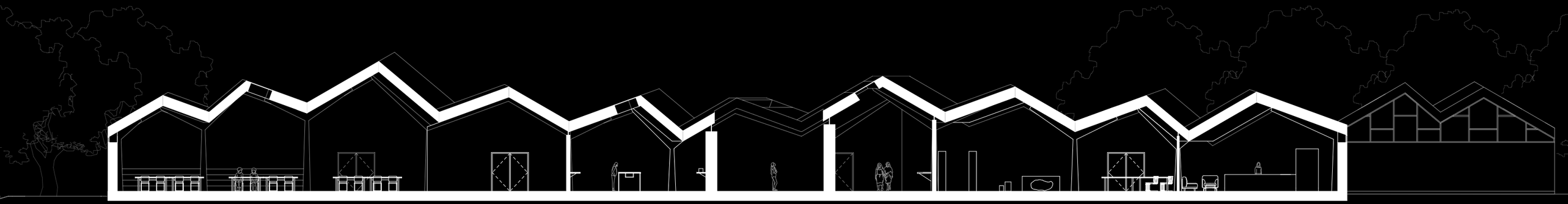
Ill.268 Section BB 1:200

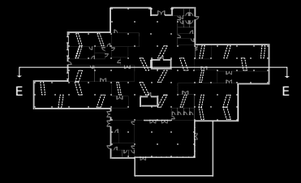


Ill.269 Section CC 1:200

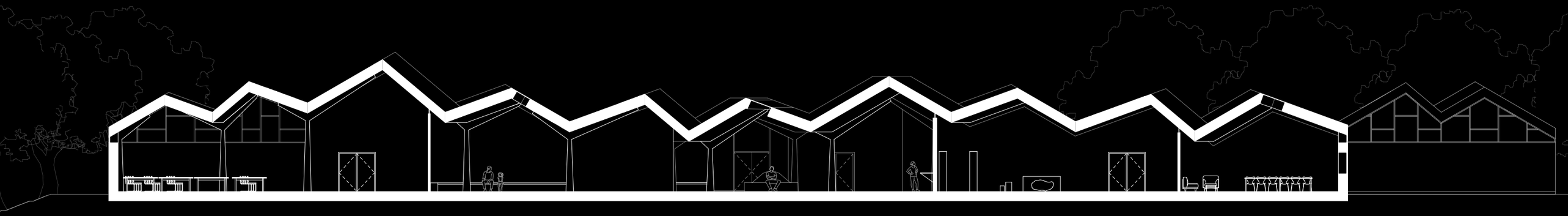


Ill.270 Section DD 1:200

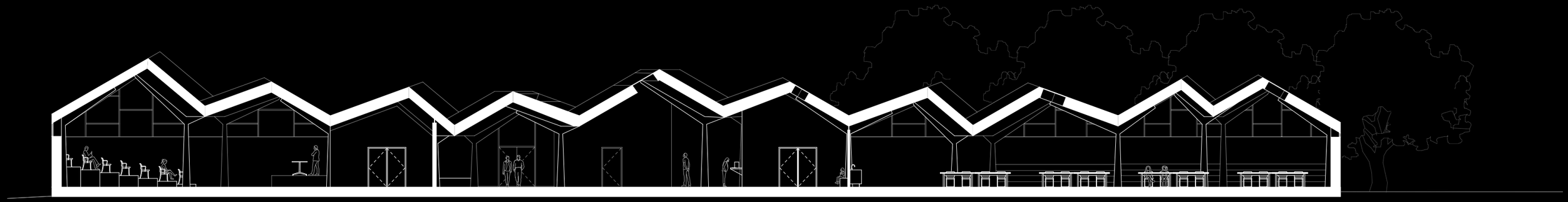




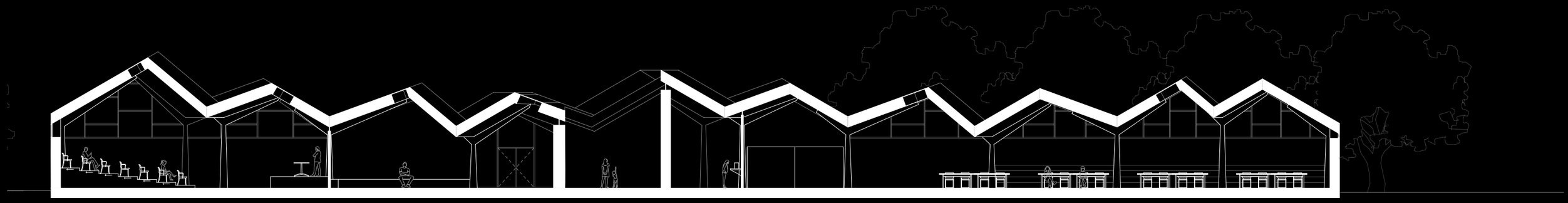
III.271 Section EE 1:200



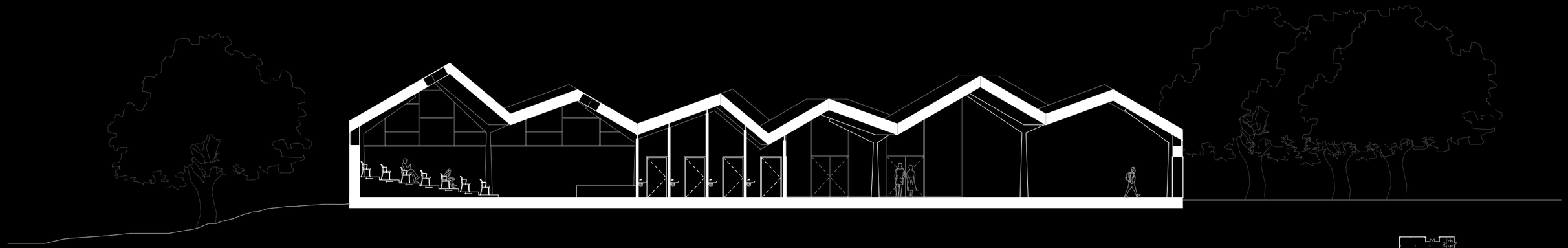
III.272 Section FF 1:200



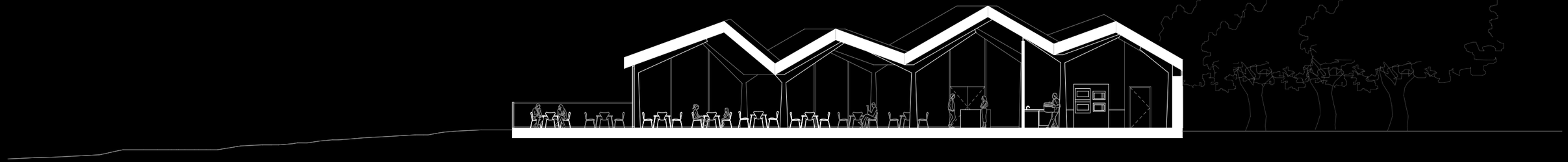
Ill.273 Section GG 1:200

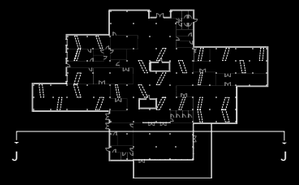


Ill.274 Section HH 1:200

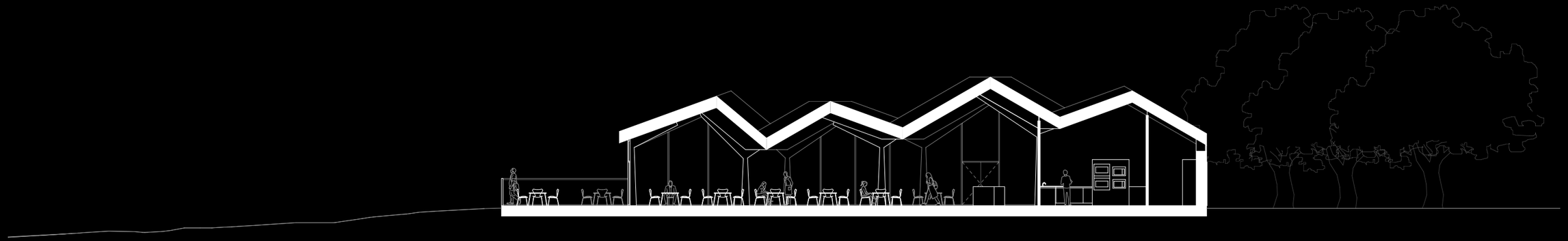


Ill.275 Section II 1:200

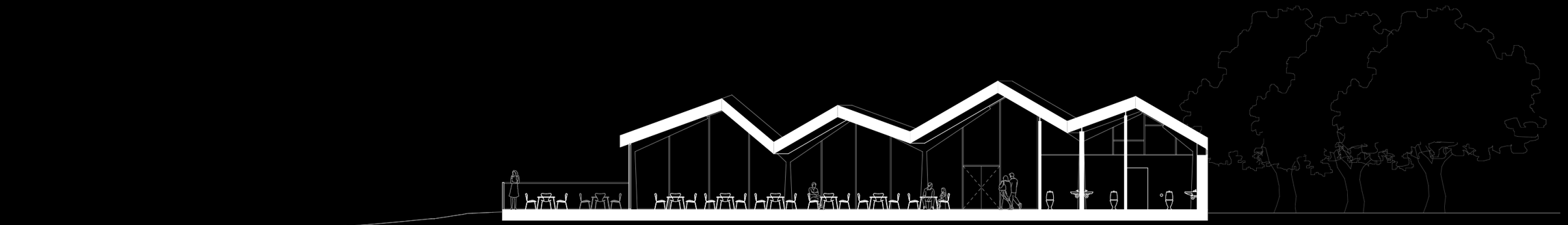


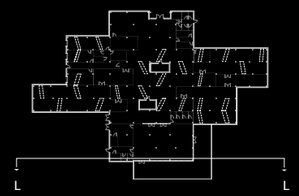


Ill.276 Section JJ 1:200



Ill.277 Section KK 1:200





Ill.278 Section LL 1:200

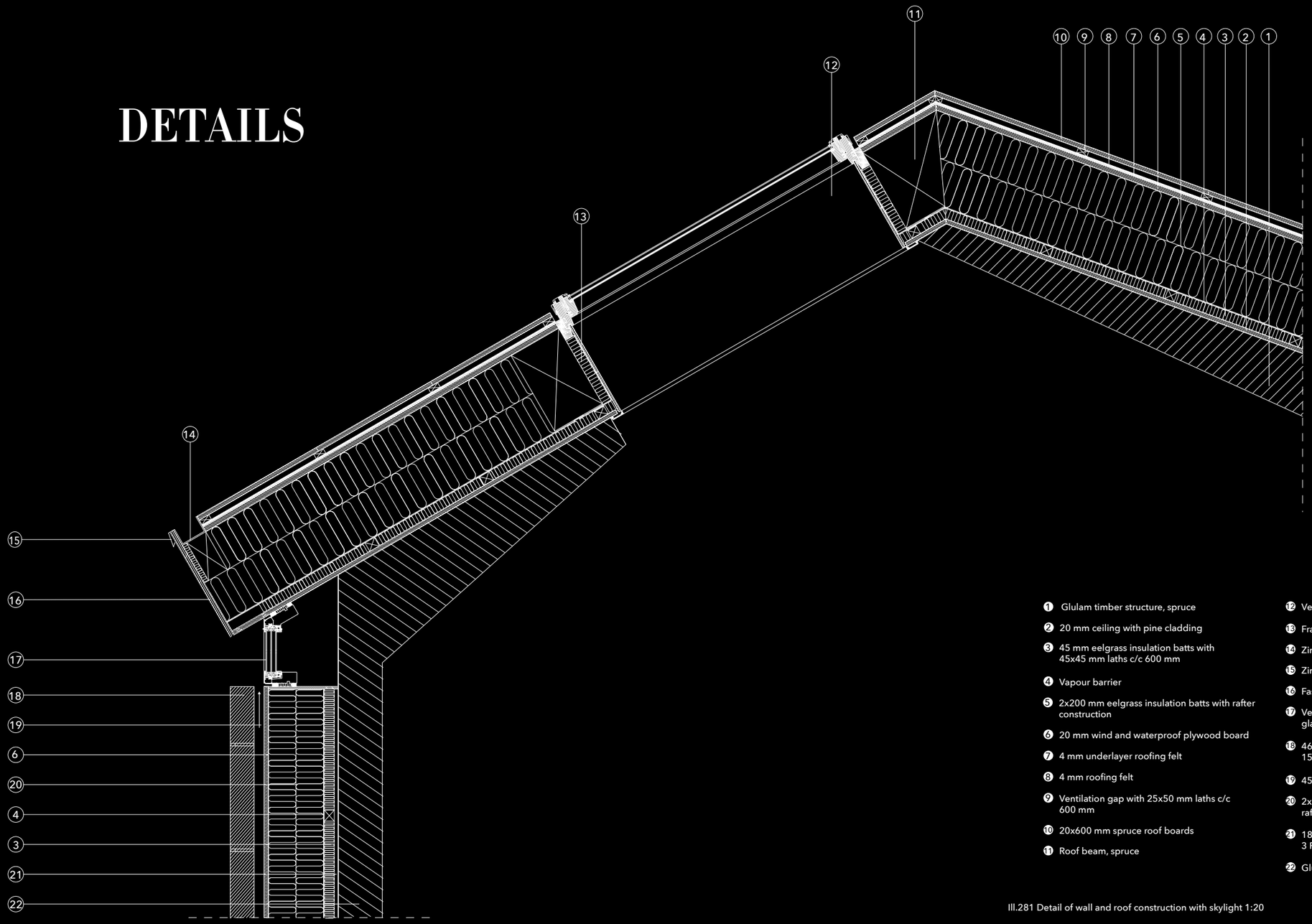
The exhibition area provides a place for exploration, information and inspiration that at day exhibits themes and objects related to the phenomenon Dark Sky. The visible and characteristic structure does not only create different spaces and define the path through the exhibition area, but it does also contribute to the aesthetics and the atmosphere of the area. The illumination of the columns enhances its crucial presence through the entering of the daylight from the skylights defined by the columns.

Ill.279 Internal visualisation of the exhibition area at day

At night, another atmosphere characterises the exhibition area. The darkness takes over the space resulting in the necessity of other means to ensure the right movement and experience in the area; the bottom edges of the surfaces are illuminated to indicate the borders of the space, while the difference in tactility in the floor material support the movement in the area. The sense of sight is oriented towards the sky from where the only glow of light enters coming from the thousands of stars exposed in the skylights defined by the characteristic y-columns. The interior supports this experience that establish a spirituel connection between the visitors and the stars.

Ill.280 Internal visualisation of the exhibition area at night

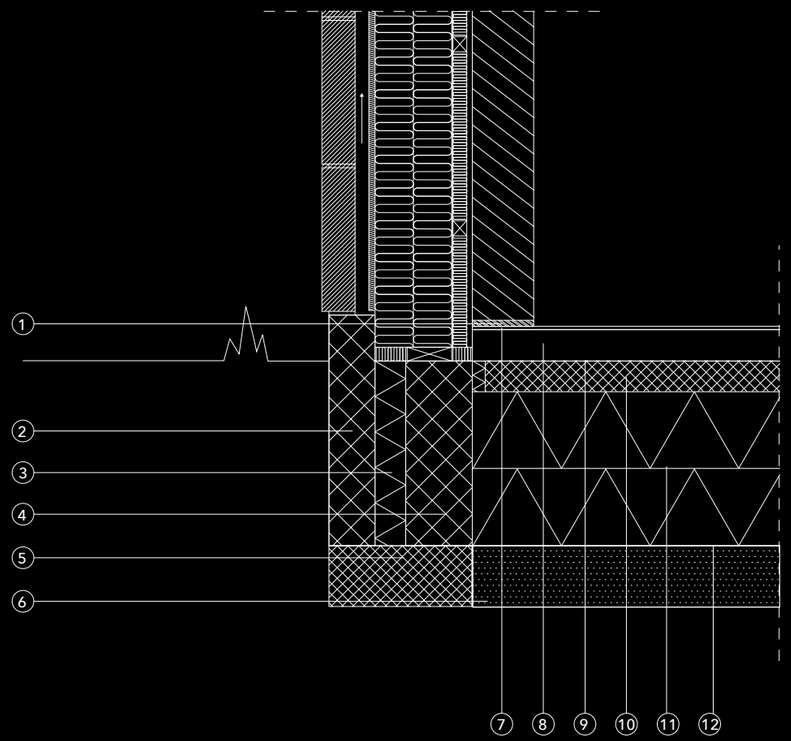
DETAILS



1. Glulam timber structure, spruce
2. 20 mm ceiling with pine cladding
3. 45 mm eelgrass insulation batts with 45x45 mm laths c/c 600 mm
4. Vapour barrier
5. 2x200 mm eelgrass insulation batts with rafter construction
6. 20 mm wind and waterproof plywood board
7. 4 mm underlayer roofing felt
8. 4 mm roofing felt
9. Ventilation gap with 25x50 mm laths c/c 600 mm
10. 20x600 mm spruce roof boards
11. Roof beam, spruce
12. Velfac Skylight with 2 layers of glazing
13. Frame insulation
14. Zinc gutter
15. Zinc edge
16. Fascia board
17. Velfac 200 Energy window with 3 layers of glazing
18. 468x108x38 mm Randers Tegl, Ultima RT, 153 bricks,
19. 45 mm ventilation gap
20. 2x125 mm eelgrass insulation batts with rafter construction
21. 18 mm Perfopan acoustic panel CODE NO. 3 F 13A-PR 13%, DS 4000, pine
22. Glulam timber structure, spruce

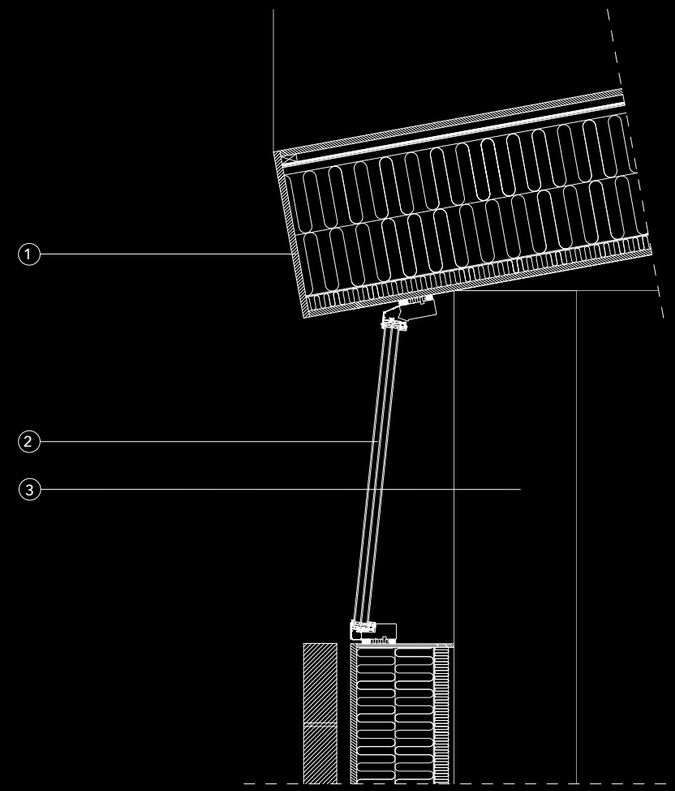
Ill.281 Detail of wall and roof construction with skylight 1:20

1. Steel plate
2. 150 mm reinforced concrete
3. 100 mm polystyrene
4. 220 mm reinforced concrete
5. Concrete foundation
6. Sand pillow
7. 10 mm floor surface treatment
8. 100 mm rammed earth
9. Moisture barrier
10. 100 mm reinforced concrete
11. 2x250 mm polystyrene
12. Radon and moisture barrier



Ill.282 Detail of floor construction 1:20

1. Bargeboard
2. Customized angled window (6 degrees) with 3 layers of glazing
3. Glulam timber structure, spruce



Ill.283 Detail of angled glazing in wall construction in the North and South facade 1:20

The different impressions given in the exhibition area give rise to reflection, which can be made under a cup of coffee in the cafe placed in the southern part of the building. The uplifted visible structure in combination with the light and dynamic roof construction frame the characteristic surroundings and thus provide a 180-degrees view of the salt meadows. The full transparency in the exterior wall erases the border between inside and outside, which is enhanced by the extension of the cafe on a cantilevered terrace above the salt meadows.

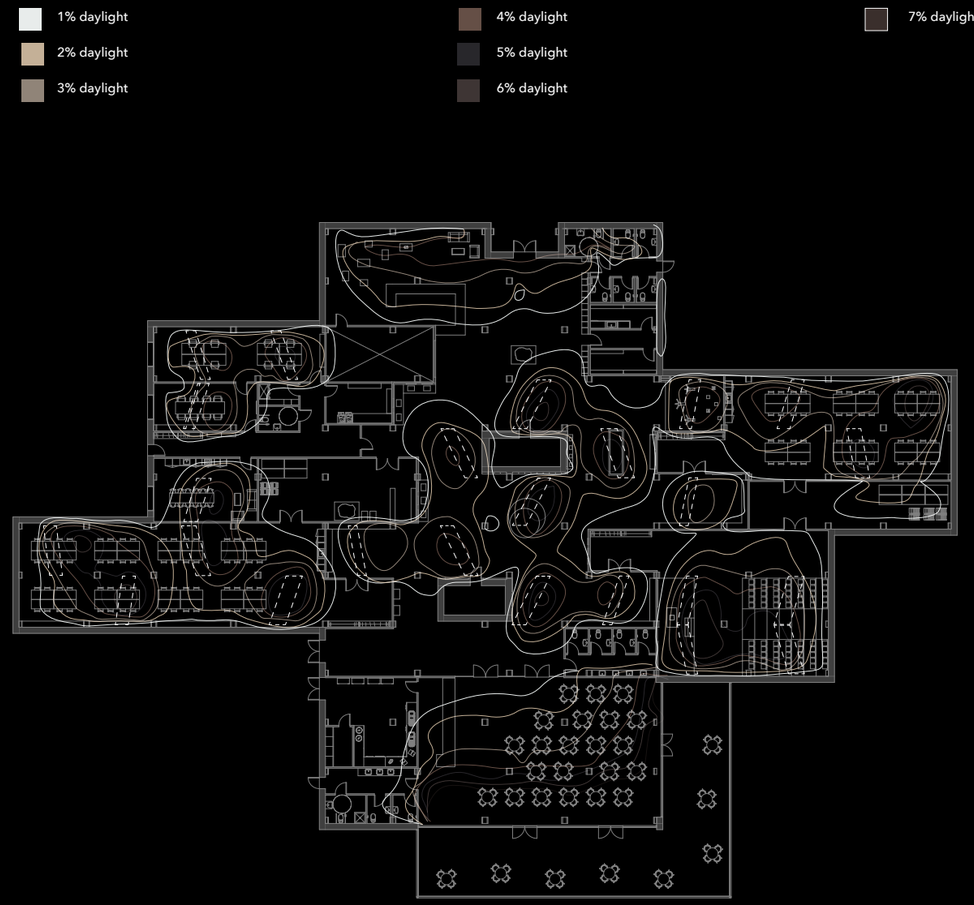
Ill.284 Internal visualisation of the cafe with a view to Nyord Salt Meadow at day

DAYLIGHT

The spiritual relation between human and the universe is established through skylights in the roof defined by the expression of the y-columns, oriented towards the sky, from where the main part of the daylight will enter. To direct the view of the visitors towards the sky, only few windows at eye level at the facade will be integrated due to the requirements of having a view of the surrounding landscape from the working areas and due to the wish of framing the Nyord Salt Meadow in connection with the starry sky in the café. In the visitor centre, varying sizes of skylights have been integrated to achieve the minimum daylight requirements regarding the functions of the rooms because of the difference in size and geometry of the rooms and the number of possible skylights provided in the room.

In the exhibition area, larger skylights with the dimensions 1.2x4 m will be provided to frame as much of the starry sky as possible. In the lunch area and workshop area, the same size will be used due to the large depth of the room. In the transition zones, only 0.8x4 m openings are necessary which create another atmosphere than in the rest of the visitor centre resulting in darker areas that are secluded from the rest of the exhibition area.

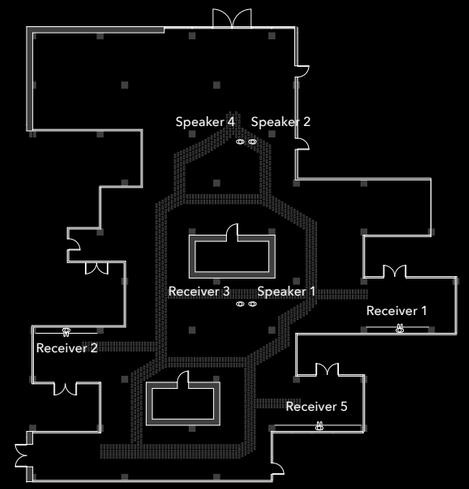
In the open office and meeting room, skylights with the same size as in the transition zones are necessary due to the entrance of light from the windows in the facade. In the auditorium, an alternation of 1x4 m and 1.2x4 skylights are needed to achieve the required daylight conditions and to minimise the risk of glare on the screen, while still providing a view to the starry sky from the people sitting on the flexible tribune. The facade is separated into three layers; the heavy base, the light roof, and the glass section in between, which together with the skylight provides a satisfying daylight condition in the visitor centre and creates a play of light and shadows on the walls and in the corners of the ceiling.



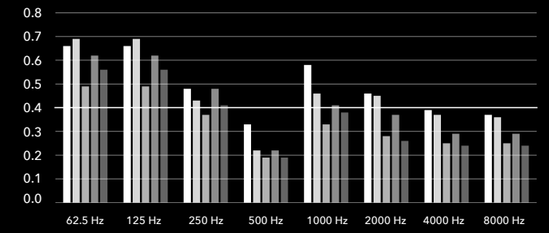
Ill.285 Daylight simulation

ACOUSTICS
EXHIBITION AREA

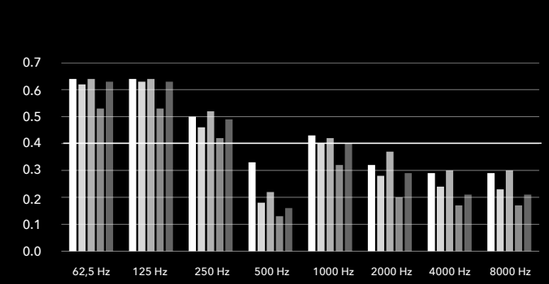
With basepoint in the acoustic simulations in the design process (cf. pp. 144-145), the final acoustics in the exhibition area has been simulated to ensure the fulfilment of low reverberation time on maximum 0.4 s. Because the reverberation of sound is inversely proportional with the sound absorption of space, the low reverberation time will indicate a high absorption of the area. The presented results support this which is caused by the geometry of the room that influences the absorption of the sound due to the large surface area in the exhibition area promoted by the internal displacements. Furthermore, the use of acoustic panels consisting of vertical wood lamellas with perforated panels behind has a huge impact on the acoustic performance of the room. The holes generate the porous nature of the wood and thus makes it a good resonator that reduces the sound. This is caused by the holes which prevent sound waves from passing through the wood. This results in a low reverberation time independently from the placement of the speaker or receiver. It is ensured that even when two people are close to each other, the sound coming from one of the persons will not be reflected in the space and thus interrupt one's true experience of Dark Sky through the skylights in the centre.



III.286 Plan with speakers and receivers in the exhibition area



III.287 Reverberation time, T-30 [s] - Source 1



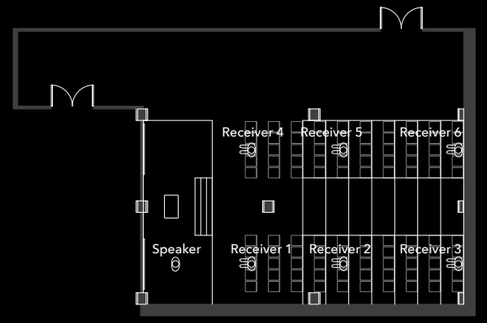
III.288 Reverberation time, T-30 [s] - Source 2

Receiver 1
Receiver 2
Receiver 3
Receiver 4
Receiver 5

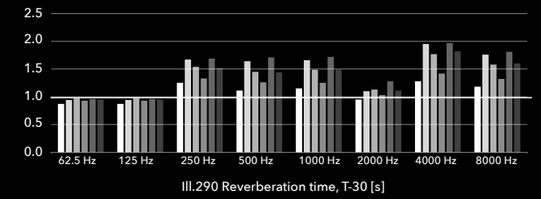
AUDITORIUM

With basepoint in the acoustic simulations in the design process (cf. pp. 140-143), the final acoustics in the auditorium has been simulated. The aim is to achieve a balance between the reverberation time, the definition and sound pressure level to obtain good acoustics within the space. It is crucial that each receiver can hear the speaker with a clear articulation of the speech. The chosen seating from the design process supports this by ensuring each person on the flexible tribune both can see and hear the speaker. Furthermore, materials play a major role. Both absorbing and reflective materials are used to obtain the desired balance. Rammed earth floor has a sound absorptive property while the wood panels on the ceiling and the walls reflect the sound to a certain extend.

The results show that a reverberation time below 1 second is achieved in the lower frequencies compared to the higher frequencies, but still on an acceptable level because this gives flexibility in using the space for other events too. The requirement to the definition is fulfilled in all cases, while sound pressure level is around the recommended level in the frequencies from 250 Hz to 2000 Hz which are of importance in speaking situations.

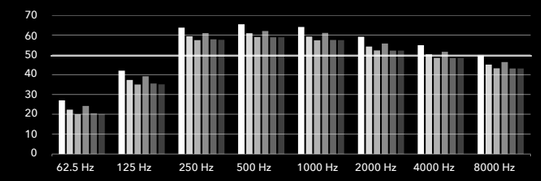


III.289 Plan of the auditorium with speaker and receivers

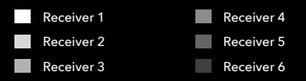


III.290 Reverberation time, T-30 [s]

III.291 Definition, D-50 [%]



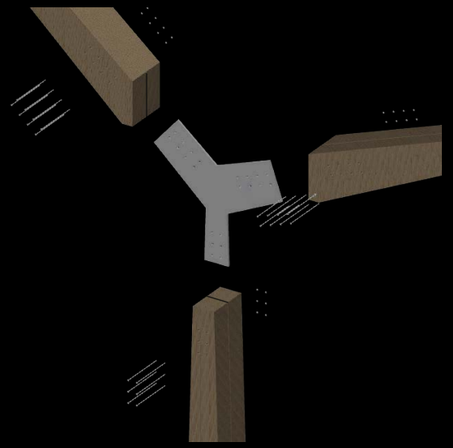
III.292 Sound Pressure Level, SPL [dB]



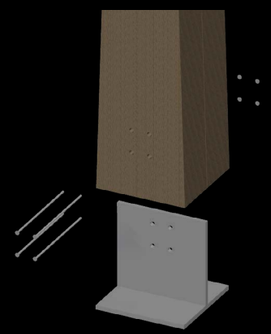
STRUCTURE

The essence of this project and thus in the establishment of a connection between the human and the night sky through the architecture is the characteristic structure of the centre which consists of freestanding y-shaped columns that orient towards the sky and in combination define openings in the roof from where thousands of stars can be observed.

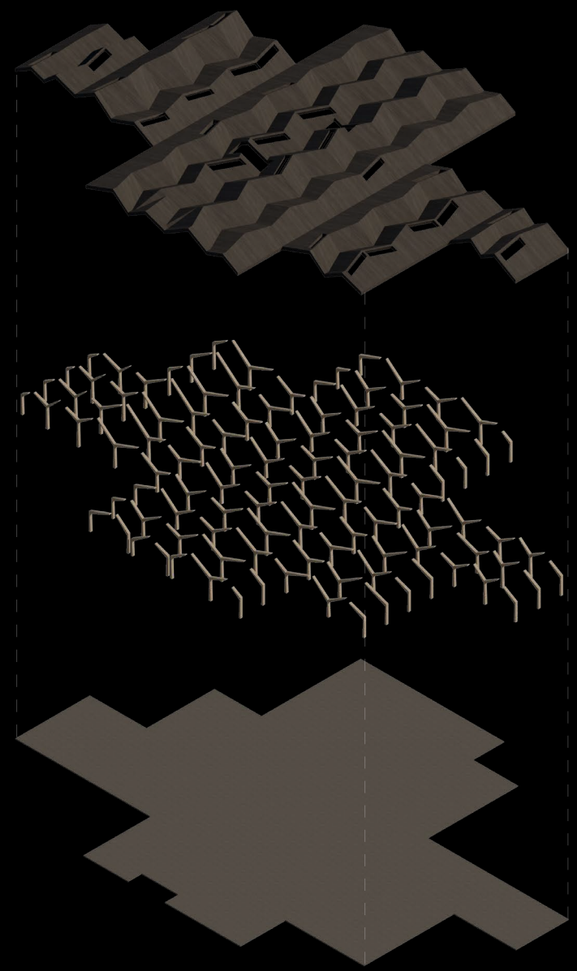
To relate to the diverse and changeable night sky, the columns within a row differ in both height and angle to frame different pieces of the sky sphere and are subsequently repeated and displaced to create a flow both inside and outside the centre. The construction and the assembling of the elements are crucial in the definition of the form, dimensions and structural performance of the columns. The fixed connection and fixed support ensure a static determinate structure. These are constructed with metal bolts dimensioned to resist the large internal moments but without taking focus from the main element in this project; the y-columns orienting towards the sky.



Ill.293 Assembling the fixed connection with metal bolts



Ill.294 Assembling the fixed support with metal bolts



Ill.295 Exploded view of the structure in relation to the floor and the roof

At night, the site is covered by total darkness only illuminated from the thousands of stars above one's head which provide a different and unique sensuous experience. When moving towards the visitor centre, the visitor will be moving slowly due to the limited sense of sight which will limit their capability of orientation, and thus the other senses will be strengthened like the hearing sense of the birds over the salt meadow and the wind touching their body. With time the sight of the visitors will adapt to the darkness, and they will be capable of seeing the architecture and its relation to the starry sky.

III.296 External visualisation of the Dark Sky Visitor Centre at night

EPILOGUE

This final chapter gathers all material presented in this project within a common conclusion that responds to the vision of this project and the focus areas; tectonics, experiential architecture and Dark Sky all in relation to the project. Furthermore, a reflection upon both the design process and the final proposal for the Dark Sky Visitor Centre is presented revealing both its strengths and suggestions for improvements.

Ill.297 (Merzlyakov, n.d.)

CONCLUSION

The design proposal for the Dark Sky Visitor Centre revolves around establishing the spiritual connection between the human and the starry sky through the architecture. With a tectonic approach, the structure has become an essential element in creating an architecture that navigates after the stars through openings in the roof defined by the characteristic y-columns that due to their proportions lead the eye towards the sky and stage the phenomenon Dark Sky. The structure is consistent in the whole centre providing these memorable views to the night sky with a base point in the exhibition area that is placed in the heart of the centre connecting all the other functions and with direct access from the entrance.

Furthermore, in the day the openings bring in natural light to the different areas and create a play of light and shadows which impact the atmosphere of the spaces. The visible structure does also define the form of the centre, its spatial organisation and the flow both within and outside the centre due to the displacements of the columns but also the dynamic displacements in the building form.

The whole design of the centre is based on the aim of supporting the essential role of the structure in creating the unique experience of the sky. Thus the facade is divided into three parts; the heavy base consisting of vertical bricks which emphasise the vertical direction towards the sky, the light roof carried by the freestanding columns and an angled glass section in between which strengthen the seperation of the heavy base and the light roof.

The implemented functions are of necessity to both maintain the centre and to provide communication, inspiration and education related to the themes of this project. Visitors are encouraged to interact with both aspects related to the themes of Dark Sky in the exhibition area, auditorium and workshop areas but also with the building itself. Because Dark Sky is a phenomenon that has to be experienced in darkness, and therefore the only light in the centre comes from the minimal use of lighting along the edges and objects to create recognition and define the borders of the space, but also from the glowing from the stars shining above one when looking up towards the skylight.

To promote movement in the centre and increase the spiritual experience within the centre, the architecture activates the other senses through the tactility of different materials, both on the floor and on the walls, but also by minimising distracting sound from the surroundings within the centre. Thereby, the focus is only on the relation between the human and the stars. Thus, the centre provides a remarkable experience brought to another dimension that raises existential and experiential reflections upon one's existence and connection to the universe.

This unique experience is enabled by the placement of the building in a unique Dark Sky spot with minimal light pollution that makes it possible to observe thousands of stars and astronomic events on the night sky reflected in the surrounding salt meadows which can be experienced from the cantilevered terrace towards the south or from the shelters in the southeastern corner of the side. Furthermore, by placing the centre on the border between the moraine landscape and the salt meadows highlights the essence of the location that becomes a gathering point for people with the same desire in exploring and maintaining Dark Sky.

REFLECTION

The vision of this project was to create an architecture that establishes the connection between the human and the night sky, and through an iterative non-linear design process, explorations, experimentations and intuitive thinking concerning this were made. The concept of the y-shaped columns defining openings in the roof structure was found early in the process and became the driver for the rest of the project. This defined the focus of the project and enabled the precise development of the concept, and thus decisions were based on the vision and the design criteria for the project. This can question if the connection between the human and the stars could be made differently through the structure, and different investigations regarding this have been made before choosing the concept principle. Because the connection is vertical, the roof construction is essential when aiming for an architecture that creates this connection. If only concentrating around the roof construction, skylights could be placed and designed in various ways, but due to the focus on tectonics, a structural principle that not only define the openings but also unite the other aspects of architecture as functionality, aesthetics, construction, technology and atmosphere was desired. The y-shaped columns have potentials that integrate all these aspects in one design, which the final proposal demonstrate.

The Dark Sky phenomenon could also be experienced from outside which would put other demands to the architecture than nowadays, or the architecture could be designed to frame the whole sky at once. The architecture should play an essential role in creating a memorable experience of the phenomenon Dark Sky that only can be experienced in this unique building that relates to the unique Dark Sky spot, and thus the architecture becomes more than just physical frames.

WORKING WITH ARCHITECTURE IN DARKNESS

Working with architecture in darkness with focus on the stars puts not only demands on the architecture itself, but also the design process. Usually, architecture as a profession depends on the visual expression, but when the sense of sight is minimised due to darkness, the architecture has to be designed to address the other senses. Thus, other aspects of the architecture have to be considered such as movement in darkness and using acoustics to absorb the sound to enhance the spiritual experience of Dark Sky instead of spreading the sound which is the issue in other design cases, such as in the auditorium. Thus, material investigations and simulations have become important elements for this project and are thereby implemented frequently in the process. Though, the acoustic aspects of the auditorium could have been more integrated earlier in the process to optimise the acoustics of the space. The structural elements and thus the shape of the ceiling in this room is defined from the focus of the project but instead of being designed concerning the acoustics in the auditorium. Another compromise is made with the indoor thermal climate in the café. This is not a focus in this project, but the orientation of the large glass area in the café to the south will result in high indoor temperatures. An overhang could be an opportunity to minimise the direct sunlight entering the space, which also has been investigated, but this caused less daylight in the café. In this project, the daylight has been valued highest, but alternative ways of sun shading could be integrated without decreasing the quality of light.

According to Pallasmaa, if architects are directly engaged in their work with their bodies, an architecture giving a sensuous experi-

ence to inspire and captivate can be created. Thus, another level could be put on the understanding of the theme of the project, if the bodily interaction with darkness through architecture was investigated in the design process, for instance, through navigation in a dark room or by measuring the time it takes the eye to adjust to the darkness. Though, the phenomenon of Dark Sky was to a certain degree experienced early on a visit to Møn which created inspiration for the focus of the project and the challenges the darkness creates which the architecture should deal with.

The relation to the nature in which the building is placed is crucial in Nordic architecture, but in this project due to the site location, nature is the night sky, whereas the vertical orientation becomes essential in this process. Thus, the section becomes an essential method in investigating, creating and presenting this direction which the concept principle illustrates. The section has been used frequently in the design process to ensure the connection of the architecture to the stars, but have also created challenges. The section established a path consisting of the characteristic columns, but this cannot directly be translated to a form, which was otherwise attempted in this project. This resulted in complicated forms that neither considered the site or maintained the essence of the structural principle. Thereby, a reinterpretation of the use of the section was necessary which enabled working with the structure as modules than in combination created the form of the centre.

This has resulted in an untraditional form of the building that makes it a remarkable icon at the island but still relating to its surrounding landscape and nearby architecture by rethinking the use of the bricks, the timber structure and the gable roof. In this project, the bricks on the exterior facade are not used as a structural material, but as a protective shield for the harsh climate at Nyord. Due to the high density of bricks, it creates an optical perception of a heavy base on the facades that enhances the lightness of the roof. Orienting the bricks vertical does also support the vertical relation to the sky. The timber structure utilises the qualities of glue-laminated timber that enables that the columns become the only loadbearing elements in the project and thus strengthen their role in creating the connection to the sky through the skylights.

The traditional gable roof that can be identified in the local architecture of Nyord has been developed to create a path both internally and externally through the displacements of the columns which results in a dynamic and twisted shape on the roof. This puts demands on the material used for the roof and its construction that thereby require new techniques. Thereby, the centre comes up with the critical regionalism answer on the local architecture with an architecture that reveals modern materials, construction principles and techniques, while still being rooted in the site.

CHALLENGES IN THE PROJECT WORK DUE TO EXTERNAL CONDITIONS

The duration of the master thesis the whole semester has given possibilities in an in-depth understanding of the chosen theme and space for further development. Though, a group only consisting of two members instead of five as in other projects put demands on the working process, which can necessity faster decisions and in the selection of the focus. The current situation concerning the coronavirus has also challenged the project work because of the shutdown of the university, the closed stores and digital communication with supervisors. Architecture is a profession that requires experimenting and investigating to obtain a design proposal that fulfils the requirements. Thus, physical material is crucial, but with the lack of this or of tools from the workshop area that can process the material, other means had to be used to make the necessary investigations. The digital tools are crucial concerning this, but these would define the investigations differently than when working with the material through handcraft.

Furthermore, these digital working models had to be translated to understandable material for others that precisely reveal the right focus of the investigation when communicated to the supervisors through a digital platform, which has developed new ways of thinking the presentation of the project.

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