Trelleborg New Experience & Knowledge Center

September 2017

Pernille Gajhede
Architecture & Design
Aalborg University

Project title
Trelleborg New Experience- and
Knowledge Centre

Theme
Sustainability and Nordic Identity

About
Master Thesis, MSc04 ARCH
Department of Architecture & Design
Aalborg University

Project period
01.06.2017 - 04.09.2017

Copies
5

Pages
150

Author
Pernille Gajhede
Stud.Cand.Polyt.Arch
MSc04 Architecture
Department of Architecture, Design &
Media Technology, Aalborg University

____

Main Supervisor
Isak Worre Foged
Assistant Professor
Department of Architecture, Design &
Media Technology, Aalborg University

Tech. Supervisor
Claus Topp
External Lecturer
Department of Civil Engineering, AAU

Ill. 01: Front page design.

Ill. 02: Lone thistle on the remains of the inner ring wall of Trelleborg.

Dansk Abstrakt

Dette afgangsprojekt præsentere et design forslag til Trelleborg Ny Oplevelses og Videnscenter, som skal placeres nær Slagelse, Danmark.

Området er forbundet med en af de vigtigste vikingetidsmonumenter i Danmark, Trelleborg Monumentet, som hvert år udforskes af et stigende antal besøgende.

Det nuværende museum er imidlertid ikke egnet til at rumme denne mængde mennesker, og der er således udstedt en konkurrence om at designe et nyt center.

Hovedformålet med dette projekt har således været at designe et center, der understreger en naturlig bevægelse fra indgangen til sitet og ud mod monumentet, samtidig med at den omgivende kontekst respekteres.

Samtidig skal bygningen udformes med hensyn til bæredygtige løsninger for at skabe en energieffektiv bygning med et godt indeklima.

English Abstract

This master project presents a design proposal for Trelleborg New Experience and Knowledge Center, which is to be located near Slagelse, Denmark.

The area is associated with one of the most important Viking age monuments in Denmark, the Trelleborg Monument, which is explored by an increasing number of visitors each year.

However, the current museum is not fit to accommodate this amount of people and thus, a competition has been issued to design a new center.

The main objectives have as such been to design a center that emphasizes a natural movement through from the entrance to the site, through the center and out towards the monument, while simultaneously being respectful to the surrounding context.

At the same time, the building should be designed with regards to sustainable solutions in order to create an energy efficient building that provides a good indoor environment.

Guide of Reading

The master thesis is divided into different chapters that each seek to dissimilate a specific part of the project.

To facilitate the transparency of the project, each chapter is initiated with an overview and a brief description of the content, which also contributes to a clearer breakdown of the booklet. This introductory chapter includes basic information regarding point of departure for the project as well as the theoretical approach throughout the design process.

Having gained a basic understanding of these parameters, various types of analytical work concerning relevant subjects, cases, the site and the programme, are then set to follow before transitioning to the final presentation material.

The presentation is divided into two chapters, that display material of respectively visual and technical character, thus easing the dissemination.

Having presented the project and the thoughts behind it, the design process is displayed in terms of process-stages in which all considerations are discussed and finally, the booklet is rounded of with an epilogue, references and an appendix.

Table of Contents

Motivation

The choice of project theme has been motivated by personal interest as well as by socially relevant issues in relation to the conservation of cultural heritage in Denmark.

As society has become increasingly globalized and cultural diversity has slowly become equalized, a societal trend has emerged in which people display an increased awareness of own as well as foreign cultural heritage and identity. [New Nordic, 2012]

Thus, in recent years, there has been an increased interest in the scandinavian vikings both nationally and internationally, which is reflected not only by the growing number of visitors at Viking Age monuments and activities but also by international movie productions that have gained worldwide popularity.

This does as such create a situation where it may be advantageous to invest in and secure the future of Viking Age monuments, while also representing a unique opportunity to attract new audiences. [Future Navigator, 2016]

Competition Brief

The Viking Age monument, Trelleborg near Slagelse is one of only five uniquely designed military fortresses found in Denmark. Each represent a great understanding of design and construction and does as such bear witness to early logistics as well as organizational and aesthetic capacity

Thus, the military ring fortresses have contributed to an increased understanding of Viking culture and construction practice, but it has also contributed to a deeper historical understanding of Denmark's formation.

For these reasons, the municipality of Slagelse as well as the manager of the monument, the National Museum of Denmark, have sought admission on the UNESCO World Heritage list, which is expected to be granted within the next couple of years.

Additionally, in the event of a possible admission, the number of visitors at the monument is expected to increase significantly and new facilities are therefore needed to meet the new requirements.

As such, this master thesis is based upon a competition brief from 2015 regarding the design of a new experience and knowledge centre that is to be placed in connection with the Trelleborg Monument. [Competition Brief, 2015]

Objectives

As democratic cultural institutions in a knowledge-based society, museums are expected to rethink exhibition practice and continually develop their professional work to ensure access to current knowledge. [Lundgaard., Jensen 2013]

However, to ensure equality, it is important that musuem activities engages all- regardless of age, disability, etnicity, social status or political viewpoint.

This poses different requirements for both the design of the building and surrounding landscape as well as of the exhibition. However, simultaneously the building mus also remain considerate towards its purpose, location and connection to the monument.

The main objective of the project is as such to create a design that naturally enhances the movement between arrival, building and monument - thus making the new building a center of knowledge that supplies the visitor with a deeper understanding of the Viking Age.

Seeing as the dissemination of knowledge should be at the heart of the design the aim is furthermo-

Ill. 03: Replica of Viking Long House near the Trelleborg Monument.

re to encourage learning and improve dissimination by creating an environment that engages visitors through a wide selection of modern and classic learning tools both inside and outside the building - Thus, creating a more cohesive learning experience.

As advocates of preservation and sustainability, museums have a responsibility for promoting and communicating sustainable solutions through their conservaition of tangible and intangible heritage. [Lord, Barry et al. 2012]

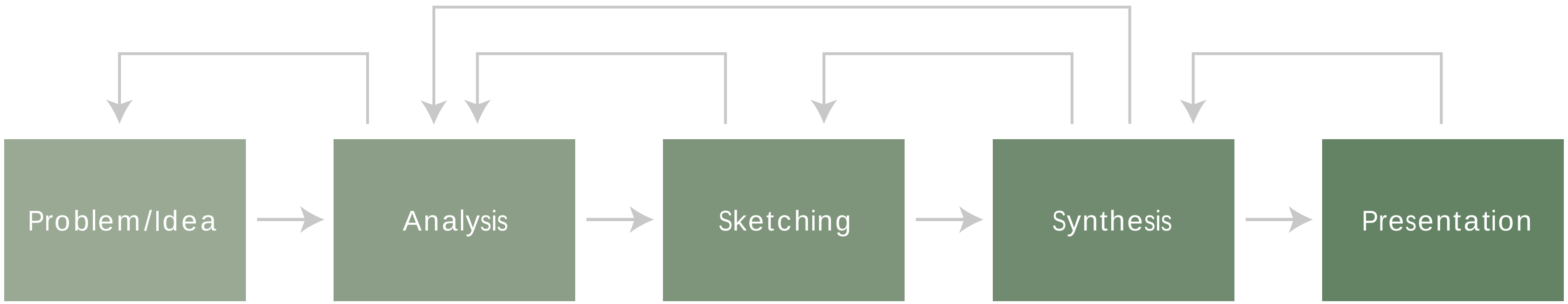
The new experience and knowledge centre should as such, as a minimum, meet the energy requirments defined in the Danish Building Regulation of 2020.

As the conservation tools are very energy-demanding and financially challenging, the primary focus of this master thesis is however put on the indoor environment in terms of defining the use and necessity for respectively passive and active energy strategies in the design.

These are the themes that define the initiating problem of modern museums and as such they form the basis for the master thesis.

As a result, the master thesis aims to present a sustainable design solution that embraces diversity and provides a wide range of learning tools in order to improve the learning experience for all visitors.

Analytical Approach



Ill. 04: Phases of The Integrated Design Process.

Designing an experience and knowledge centre is a complicated process in which many different parameters must be taken into consideration in order for the project to be successful.

For this reason, a holistic approach has been used. This approach focuses on solving problems but sees the project as an interconnected whole, thus merging intuitive considerations with scientific research.

Additionally, to ensure an academic approach, the project has been based on ”The Integrated Design Process” (IDP) as described by Mary-Ann Knudstrup. [Knudstrup, 2005]

The IDP is focused on integrating the fields of architecture and engineering to solve the complicated problems which are often associated with the design of e.g. sustainable buildings.

However, it should be mentioned that IDP does not ensure neither aesthetic nor sustainable solutions, but is simply a tool that helps to control the many aspects which should be considered and integrated in the project in order to achieve better solutions. For this reason it is also important to develop a strong concept in the initiating phases of the design process, as the concept - aesthetic or technical - should act as a beacon later in the project.

The design process consist of five phases as illustrated above (see ill. xx), which cover an iterative and very complicated process.

Problem / idea

In the first phase, the problem or project idea is identified and described, thus forming the basis of the project.

Analysis

In the analysis phase, all information regarding the project, both architectural and technical, is collected and analyzed, thus forming the framework of the project.

This include information about the site, local and municipality plans, vegetation, topography, climatic conditions, scale etc. However, it also includes information regarding site specific qualities and sense of place known as Genius Loci (see page 54) as well as more user oriented information.

The information can be obtained and disseminated in various ways. In general, the information- whether it is literature, statistics, video clips or other- should however come from reliable sources that are accepted within the profession

In this project, the site is located in a relatively open landscape meaning that there is not much city landscape to consider. Instead, information has therefore been obtained through either physical exploration on site (*Natural Qualities* and *Sense of Place*) or via analysis of statistics (*Climate Conditions*), literature (*Historic and Cultural Value* and *Formal Demands*) or other graphic material that has since been transformed into new texts, diagrams, 2D-illustrations, etc.

Especially diagrams are practical when displaying statistic values such as climatic data, as simple designs are easily read and can be used to highlight key values.

In this section, also the case study is used. This is a dominant methodology in architectural research, as the ability to work within a professional practice is often based on knowledge obtained through studies of preceeding cases. [Knudstrup, 2005]

Additionally, most architectural pieces or details are based on comparisons of known cases and the actual design situation, as it is these that often serve to spark innovation and creative thinking.

Thus, the case study is expected to capture the complexity of a particular case that is similar to the design being conducted, as this can further the understanding of varoius aspects and thus influence the new design. [Alizadeh, 2006]

As mentioned, also the user oriented information is processed. As the competion brief clearly defines the room program, but only grazes the connection between these as well as the users of the rooms, the case studies have given inspiration to the development of a functional diagram as well as the definition of potential user groups (supported by literary sources).

Additionally it is in the analysis phase that the principles for aesthetics and sustainability are decided, and based on the preceeding analysis, a set of design criteria are developed before stating the vision of the building.

Sketching

Based on the information and criteria defined in the analysis phase, different design tools are then used to create an integrated design proposal that meet the vision of the project.

These design tools include hand-drawn sketches, which is the fastests way of communicating ideas and making them tangible in terms of making plans, sections, elevations or perspectives; physical models that communicate visual and spatial relations within the structure or external relations to the context; and computational 3D models, which are used in the same way as physical models but have a larger potential in terms of transformation while also being more accurate in scale, as it is easier to use correct measures. Also the 3D model can be used to retrieve visualizations, facades, plans and sections in the final phases.

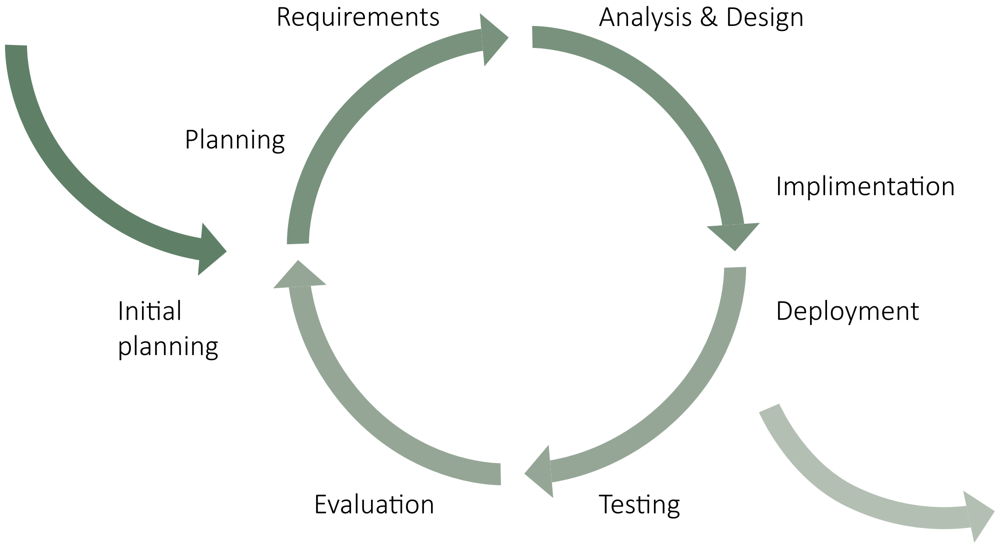
It must be emphasized that it is in the sketching phase that the fields of architecture and engineering are combined and integrated in a shared volume. Thus, choices regarding all aspects of the design must repeatedly be tested to estimate how each affect the building. This can for instance be done by using computer animated simulations that examine light and temperature conditions, energy requirements etc. but also by using the before mentioned models to evaluate spatial qualities.

Often the solutions features both strenghts and weaknesses and choices must therefore be carefully made with regard to the vision of the project.

Synthesis
In the synthesis phase, the new building proposal finds its final form in which all parameters flow together and interact.

To the extent possible, the design should then be optimized and the building performance should be documented in detailed calculation models, diagrams etc. to display potential qualities.

Presentation
Finally, in the presentation phase, all materials are gathered and presentation files are produced to display the project in such a way that all qualities are displayed while clearly illustrating how the vision and design criteria have been fulfilled.
[Knudstrup, 2005]



Ill. 05: The iterative process.

Iterative process
As mentioned, the analytical approach of the project is based on an iterative process, meaning that the desired result is reached through a cycle of operations that each seek to improve the project.
[Business Dictionary, ND]

The process is illustrated in illustration xx.

Approach

Museum Architecture

Sustainability

Nordic Identity

Tectonic Approach

Approach

The following chapter presents a series of texts which are used to define the approach of the project and clarify existing tendencies within the given field.

Thus, the chapter is initiated by a discussion of the challenges of temporary museum architecture, which is followed up by a text on sustainability in relation to museum architecture.

This is then put in relation to the nodes of Nordic Identity, which has served as the main inspriation for fusing the past and the present, before finally defining the tectonic approach to the project.

Museum Architecture

Purpose

Museums are complex social and educational institutions that seek to preserve, interpret and communicate their inherent knowledge to the visitors, and as social institutions, it is expected of them to continuously update their work to feature the latest trends in society.

To meet the required demands and standards - involving both continuously growing collections and ever-changing needs of the public- it is however critical that museums are carefully planned if they are to avoid quick and ineffective solutions.

Planning for people

Despite what many may think, museums are really about people. Planning for people is therefore essential if the museum is to realize its ultimate objective of preserving, interpreting and communicating its inherent knowledge. The role of the museum is however very extensive.

They act both as mediators of cultural, social and scientific change, accelerators of cultural change, unique leisure destinations, patrons of architecture, promoters of urban renewal and place-makers of cities and regions.

Thus, planning for people refers to the development of not only a design, but also a strategy which makes it possible for the museum to fulfill its many societal functions.

Planning for collections

Although the role of the museum is under constant development, the collections are still at the heart of the museum, and they do as such remain faithful to their mission as public educational institutions.

The term; collection, covers a wide range of materials including artifacts, specimens, works of art and archival documents that all have different preservation-requirements in terms of relative humidity, temperature, light exposure etc. To preserve these collections, it is therefore important that the exhibition climate is carefully controlled.

Also, to maintain the visitor's curiosity, it is important to plan an exhibition strategy.

Often, history or archaeology museums must choose between the alternative of either a thematic or a chronological approach to their subject, but depending on the design of the museum, this strategy may vary.

Planning for operations

When planning for operation, both the overall perception of the institute along with the staff and visitor experience, must be processed and it is therefore necessary to understand the details of how the museum should function in terms of e.g. staff requirement, full range of activities, involved risks and patterns of movement in the building.

Additionally, it must be taken into consideration that museums are highly variable environments and e.g. the indoor climate will therefore have to be regulated actively depending on visitor load, maintenance hours, shifting of exhibition collections etc.

Planning for building

Having analyzed, planned and defined strategies for respectively people, collections and operation, the facility strategy and functional program or brief may be defined. These are essential documents that are required in order to express museum requirements.

As the project is based on a finished competition brief, a space program however already has been stated and a functional program will therefore have to be developed based on staff and visitor needs, logic relations between spaces and aesthetic design.

Sustainability

Climate change has proven to be the biggest world-wide issue of our time and this has caused various sectors, including the building sector, to sharpen their regulations in order to stress the importance of reducing emissions of CO_2.

However, due to necessary regulation of indoor climate in exhibition areas, museums are often using an extensive amount of energy which must then be accounted for in terms of passive and active energy strategies if the building is to meet the requirements of the building regulation.

As museums in general are presented as the main tool for communicating sustainability due to their preservation of tangible and intangible heritage, it is however not enough to only be environmentally sustainable- they must also be sustainable in respectively social and economic aspects.

[Lord, Barry et al. 2012]

Ill. 06: British Museum, London.

Sustainability

In relation to Museum Architecture

Worldwide, climate changes constitute an increasing concern and the need for sustainable solutions is therefore more prominent than ever.

In relation to museums, this issue has however proven to be very complex as museums on one hand constitute the main tool for communicating sustainability through their conservation of tangible and intangible heritage, while on the other, the conservation tools in terms of climate controls, are very energy-intensive and financially challenging.

Thus, both in terms of ethical and legal aspects, museums must be sustainable, but it must be done in a highly innovative and holistic way that combines and reinforces the three pillars of sustainability: environmental, social and economical. (See ill. 07)
[Lord, Barry et al. 2012, Cambridge, 2013]

Ill. 07: Sustainability.

Social Sustainability

Social sustainability prioritizes the human factor and seeks to create a link between the physical and social environment. [DAC, 2017]

However, the link is especially important for museums, as they, as social benefit organizations, exist to serve the public and benefit from public investment. To be sustainable, it is therefore important that museums remain relevant and contribute to the community in terms of e.g. generating and dissiminating their inherent knowledge.

Economic Sustainability

Economic sustainability is generally considered to be the less important pillar of sustainability, which has much to do with the fact, that the outcome of using sustainable technologies may not be calculated according to traditional calclation methods.

Most museums have limited financial resources and are very expensive to operate. To maintain public, donor, and governmental trust, it is therefore important to plan and spend money wisely.

However, in terms of economic sustainability, economy must be seen in a broader perspective that takes into consideration the advantages of e.g. using materials of good quality that may last many years and have a low carbon footprint, and of installing active energy strategies that may be more expensive

at first but are cheaper and more climate friendly in the long run, etc.
[DAC, 2017]

Environmental Sustainability

Finally, Enivornmental sustainability is defined as *"a state in which the demands placed on the environment can be met without reducing its capacity to allow all people to live well, now and in the future".*
[Financial Times, ND]

This includes complying with the requirements of the current building regulation by integrating various passive and active energy strategies, possible certification according to DGNB, and assessment of the environmental impact of products or product systems throughout their life cycle (Life Cycle Asesssment) - methods which all aim to reduce the environmental impact of the building.

As mediators of sustainability, museums additionally have the opportunity to make a meaningful contribution to securing a sustainable future through encouragement of dialogue, education and visible display of good practice, within the unique programme of the museum.
[Lord, Barry et al. 2012]

Quadruple Bottom Line

By embracing the sustainable approach, a commitment is made to achieve what is called a triple (or quadruple) "bottom-line", meaning that all dimensions of sustainability should be optimized to create positive cultural capital.

For a long time, museums were expected to be made "for something" – often the primary collection – but lately the view of both the profession and its public have changed to be "for someone", as in being for the community. Thus, the natural link between museum practice and the environment has been highlighted and this can be used effectively to educate and bring awareness of environmental sustainability; thus demonstrating institutional commitment.

However as mentioned, the quadrable bottom line is based on both social, environmental and financial values; also known as "People, Planet, and Profit" and for museums, an additional "cultural" value, often interpreted as "Program", is added.

This refers to a fourth dimension of sustainability which indicate that the museum should be sustainable within its own community, thus making the "mission" of the museum, a driving force.

As such, the latter addresses the suitability of the space for activities that respect its actual purpose.

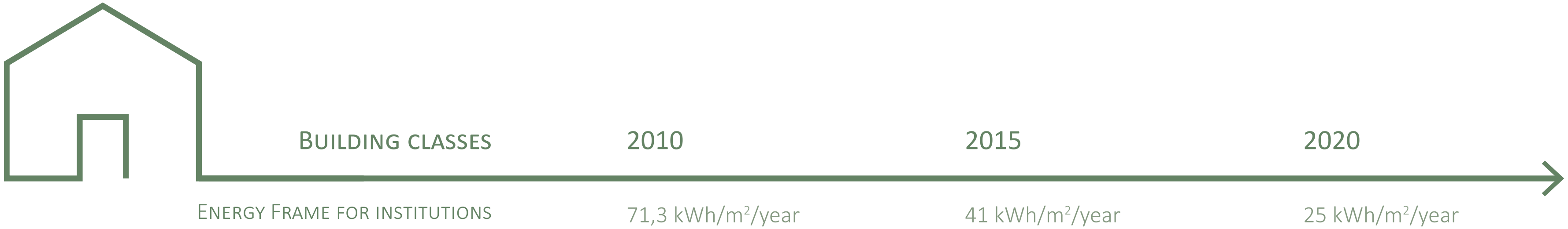
By actively integrating and optimizing all four sustainable dimensions, based on the quadruple bottom line, the museum is theoretically bound to succeed.

[Lord, Barry et al. 2012, Cambridge, 2013]

This master thesis seeks to address the issues related to all four dimensions of sustainability and process them in relation to one another in order to obtain an integrated and sustainable design proposal.

Technical approach

Energy Frame



Ill. 08: Dimensions of sustainability.

To be recognized as environmentally sustainable, any new building must be proven energy efficient to a degree that complies with the energy requirements of the applicable Building Regulation.

The Danish Building Regulation is a decree which, among other things, specifies the upper limit of the extent of a building's total energy requirement in relation to heating, ventilation, cooling, lighting and hot water, and to ensure modern standards, the regulation is continuously renewed. [VEB, ND]

As such, most new buildings in Denmark are presently designed to meet the standards of either low energy class 2015 or 2020 (*voluntary*), which both move towards a more sustainable building practice.

To meet the energy requirements of these classes it is however necessary to integrate both passive and active energy strategies in the building design as these may severely decrease the overall energy requirements of the building and thus the need for purchased energy.

However, this often result in an increased starting price for the building, as it demands a bigger investment. However, when considering the long-term efftects, the implimentation of passive and active energy strategies have been proven to be the better choice both environmentally and financially.

In the competition brief for Trelleborg New Experience & Knowledge Center, it is stated that the new construction as a minimum should comply with the low energy class 2020. [Competition brief, 2015]

Indoor Environment

To ensure that the new building complies with the Energy Frame of 2020 while still supporting a good indoor envirionment for both work, learning and conservation, it is important to test, optimize and document an indoor climate plan.

This includes carefully planning of the integration and use of passive and active energy strategies.

Passive design strategies utilize ambient energy sources such as daylight, natural ventilation, and solar energy, wheras active design strategies utilize purchased energy to run forced-air HVAC-systems (heating, ventilation and air conditioning), heat pumps, and electric light, in order to secure a comfortable indoor environement.

Finally, hybrid systems have been developed to use mechanical energy to enhance the use of ambient energy sources. This includes heat recovery ventilation, solar thermal systems, and ground source heat pumps.

To downsize the amount of active systems and thus the required amount of puchased, mechanical energy, the design first must first be optimized for passive energy strategies to the extent possible, before integrating potential active and hybrid strategies.

[Autodesk, ND]

Nordic Identity

Introduction

During the past 10-20 years, a revival of a common Nordic identity has happened within various fields, including architecture. Traditionally, Nordic architecture is considered to be closely linked with a distinguished sense of place and materials, proud building traditions and a continuous simplicity.

This revival has however more to do with cultural values and visions – a sense of pride that is deeply rooted in traditional culture and local raw materials – which are now being interpreted to fit into a hypermodern and globalized society.

Authencity

In a modern, globalized society, where communication and inspiration moves freely across national borders, slowly equalizing cultural diversity, it is only natural that people become more aware of their cultural heritage.

In the Nordic countries, there has always been a strong tradition of being connected to nature, but in a modern society this connection can easily get lost, and the Nordic revival therefore seeks to rehabilitate the human relation to nature while anchoring its cultural identity.

Within the architectural community, this relation is often expressed by emphasizing the building's relation to the site and using local resources.

However, the new Nordic architecture is also known for its simplicity and logic, its attention to detail and the artful integration of light. It is in other words the cultivation of the *Authentic* – a wish to emphasize that architecture should be conditioned by its context and thus the culture which it is placed in.

Genius Loci

The spirit of a place, as described by the Norwegian architecture historian, Christian Norberg-Schulz, was in 1979 assigned status as a starting point of architecture.

Norberg-Schulz believed that the architect's job was to read and transform the characteristic impressions of a given site in relation to its true identity, by which the architecture becomes an expression of the site's identity, and thus giving it a sense of authenticity.

When considering this in an environmental perspective, it however becomes evident that the building should also utilize its natural settings to reach environmental sustainability. (See ill. xx)

Sustainable Nordic Architecture

Nordic architecture is known for its simplicity and natural aesthetic, but due to the tight regulations of the building sector, many buildings bear witness to aesthetic compromises in terms of inappropriate integration of passive and active energy strategies.

If this is to be avoided, the natural settings of the building should therefore be used to naturally enhance passive energy strategies such as heating, cooling etc., before seamlessly integrating other strategies in the architectural design.

New Tendencies

Lately, new tendencies have pointed towards a more performative angle in regional architecture with people at the centre rather than the place itself. Here, the relationship between man and place is considered and the concepts of culture, identity and place are re-evaluated.

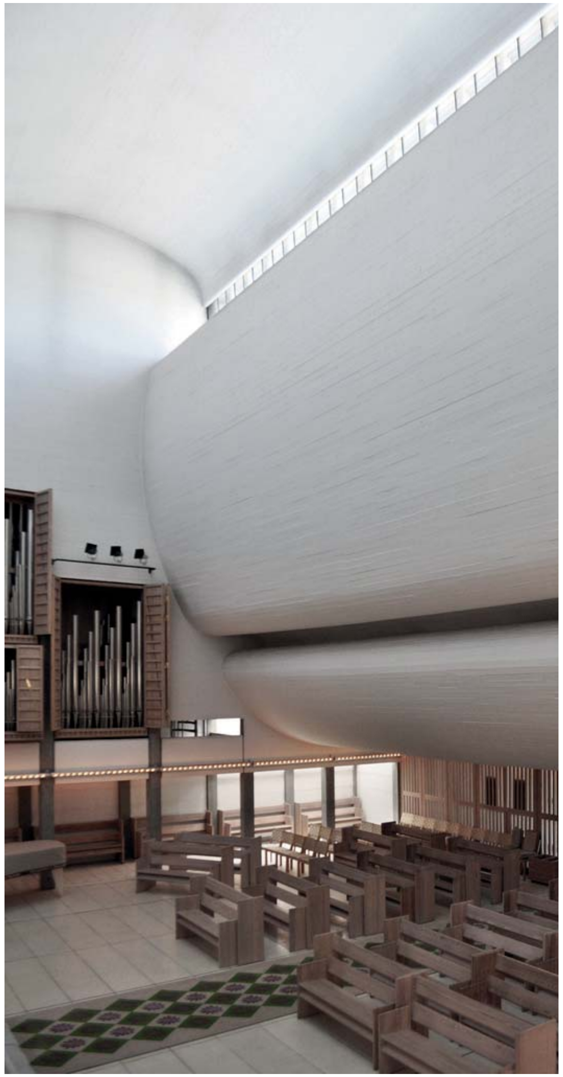
The place is no longer just a delimited geographical area. Instead, it supports a social construction that opens up to a broader view of the place that accommodates a living, flexible and dynamic culture that strives toward social sustainability. (See ill. 11)

Conclusion

In a globalized society, tendencies and inspiration moves freely and rapidly between countries, which gradually evens cultural diversity, but the fear of a universal homogenization also promotes a new interest in cultural characteristics such as local, place-rooted and close values, and as such we are contributing to and strengthening our perception of own identity.

To create successful architecture, it is no longer enough to only consider and interpret the spirit of the place, we must also consider the people who interact with daily. Thus, a place can no longer be perceived as a delimited, geographical area, but rather as a dynamic and constantly changing complex, consisting of many opposing forces. It has no true origin nor a definitive definition and the architecture that is built does as such represent not only the perception of the place but also of ourselves.

[New Nordic, 2012]



Ill. 09: Bagsværd Kirke by Jørn Utzon.

Ill. 10: Trollstiegen Visitor Centre by Reiulf Ramstad.

Ill. 11: Hereiane by 3RW Arkitekter.

Tectonic Approach

The term: *Tectonic* has been interpreted by several architects and theoreticians worldwide.

It originates from the greek word *tekton*, referring to a builder or carpenter. [Frampton, 1995], but has later come to be more commonly defined as *the art or science of construction*. [The free dictionary, ND]

Gottfried Semper

In 1851, the German architect Gottfried Semper contributed with one of the first notions of the modern understanding of tectonics.

In his book, *The Four Elements of Architecture*, Semper explores the origins of architecture in relation to anthropological relations between man and the natural environment.

This, with a theoretical departure in the primitive homes of normadic tribes that, according to Semper, may be reduced to consist of only four essential elements in conjunction with four material operations.

These elements consist of the hearth, the roof/framework, the textile wall and the earthwork, which are accomponied by four irreducable operations:

Ill. 12: Scarpian Ziggurat, Verona.

the moulding of the hearth, carpentry and joinery for the roof, weawing and plaiting for the walls and sterotomy for the foundations. [Kucker, 1996]

The building crafts can then be divided into two fundamental procedures that respectively access the *tectonics* of the frame, as represented by the assembly of lightweight, linear components into a spatial matrix; and the *stereotomics* of the earthwork, where mass and volume are formed by heavyweight elements - thus constituting the primal building when joined. [Semper, 1851]

In his book, Semper does as such attempt to formulate an universal theory of architecture in which he considers what assemblies and systems are applicable in all primitive structures.

Additionally he stresses functionalism as a prerequisite to intention and emphasizes the importance of the joint in the transition that occurs in architectural space and form.

Marco Frascari

In his essay *Tell the tail Detail* (1984), Frascari argues the role of details as generators for technology. According to Frascari both construction and construing should be embedded in the detail as it is the link between the creation of meaning (consturing) and of physical solutions (construction) that constitutes the core of tectonic thinking.

Thus, the potentials of materials and of construction methods must be understood in order to transform these into architectural solutions that represents a unifying whole.

> *"Whatever the air spaces, areas and dimensions involved, it is the precise study and good execution of details which confirm architectural greatness. The detail tells the tale."*
>
> *Jean Labatut, 1979*

To emphasize his point, Frascari accentuates the italian architect Carlo Scarpa, who uses artistic ideas as generators for creating a logic construction - something which is evident in his architectural work as it displays a constant search between the built and the perceived form.
[Frascari, 1984]

Sustainability in relation to tectonics

In a research project conducted by Claus Bech-Danielsen (2012), it is argued that due to modern challenges in terms of an increased energy consumption and global climate changes, a new approach to tectonics must be developed - one which recognizes and combines sustainable change with tectonic quality in architecture.

Thus, it is suggested that a new model of analysis in relation to tectonic includes consideration to both product (elements or building components), system and building (organisation of concepts) level, whereby more attention is paid to all levels of construction and construing in relation to sustainability.
[Bech-Danielsen, Beim, Christiansen, 2012]

In relation to the project

This master project seeks to unify various aspects of design into a holistic architecture.

To achieve this, the integrated design process is therefore used, as it allows basic tectonic elements including functionality, construction and beauty to be merged through conscious decisions.

It is this merging of conceptual idea, construction, sustainability, and visual expression that acts as the generator of sensory experiences in the building, and the tectonic approach is as such used to reflect conceptual ideas and convey spatial understandings through details that emphasize and support both aesthetic and sustainable considerations.

Case studies

Trollstigen Visitor Centre

Moesgaard Museum

Case studies

The following case studies serve as inspiration in relation to both aesthetics, functionality and usability.

As such Trollstigen Visitor Centre is examined to expose and display how the architectural design has been integrated into the site, wheras the study of Moesgaard Museum is focused around the integration of sustainable strategies as well as around the exhibition area and the methods used to engage the audience.

Trollstigen Visitor Centre

Phenomenological Examination

Trollstiegen Visitor Center (2010) is located in Romsdalen, Rauma, Norway and is designed by Oslo-based Reiulf Ramstad Arkitekter.

The project includes a number of unobtrusive service facilities and scenic access routes which set out to enhance the experience of the landscape by emphasizing the location of the plateau and the nature in a thoughtful use of materials and design features. [Detail-online, 2011. Reiulf Ramstad Arkitekter, ND]

The architecture is set in a steep slope to protect the area from flooding from the river that flows next to it in a series of pools and regulated cascades. [Detail-online, 2011]

To create a sense of belonging, the design however uses the dynamic force of water as well as the static force of rock to create a gesture towards the nature. [Reiulf Ramstad Arkitekter, ND]

This gesture is sensed in the reflections created by glass, in the terrazed surfaces relating to the planned plateaus and in the building design mirroring the surronding mountains, which magnifies the spatialities of the site. It is a gesture that embraces the landscape and invites the visitors to explore it.

Ill. 13: Trollstigen main building with regulated cascades in the front.

This of course is only amplified by the subtle use of a few, selected materials such as Corten steel and concrete, which embrace the Scandinavian nature and enhances the effect of the gesture by reflecting the natural occuring colours. [Detail-online, 2011]

Thus, it is seen that though the project is characterized by a clear transition between planned zones and natural landscape , it still merges beautifully into the context, making it a seemingly natural part of it. [Reiulf Ramstad Arkitekter, ND]

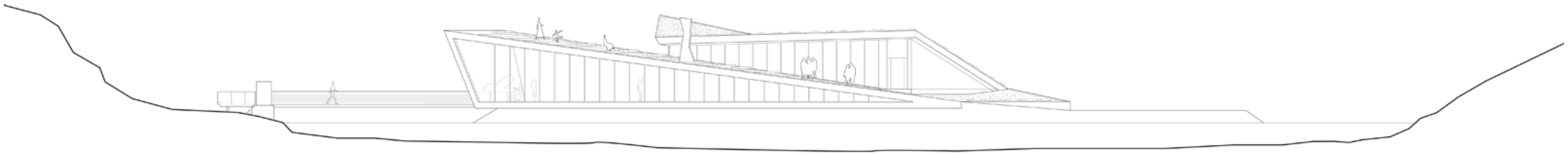
Relation to Trelleborg

Though the two centres are very different in terms of location and mission, inspiration can still be collected from the impeccable way in which the architects have integrated the building into the landscape.

Like Trollstigen, Trelleborg should subtly embrace the landscape and reinforce the coherence to other areas, and one way of doing this is by creating a design and using materials that reflect characteristic elements of the site, thus enhancing sense of place.

Ill. 14: Adjoining viewpoint from the plateau.

Ill. 15: View along the river.



Ill. 16: Section through the main building.

Moesgaard Museum

Architecture and Design (Excursion)

Ill. 17: Moesgaard Museum seen from the outside.

In the spring of 2014 the new Moesgaard Museum exhibition building, designed by Henning Larsen Architects, was inaugurated. The building has a total net area of 10.000 m^2 with public facilities constituting 2.070 m^2. [Moesgaard Museum, ND]

To obtain a better understanding of museum exhibitions in terms of relation to other facilities, interior setup and the combination of old and new technologies as means of dissemination, a field trip was conducted during the early phases of the project.

Moesgaard Museum is located next to the original Moesgaard Manor just outside Aarhus city center.

It is designed with great respect to the surrounding landscape as well as the cultural heritage of the region but has additionally been based on former exhibition spaces that include archaeological and etnographic collections.

However, the builing contains many different facilities that all have different requirements.

When arriving at the museum, the foyer functions as an arrival and distribution area in which the visitors can obtain information, buy tickets and in general gain access to different areas such as wardrobe, café, shop and exhibition areas.

Apart from the exhibition areas, which are constituted by black boxes, the museum is in general light and spaceous with a construction made of white concrete elements and detailed with wooden elements. For instance, the ceiling is made as an acoustic absorber, that uses wooden slats to shatter and diffues the sound while an underlying material absorbs the rays.

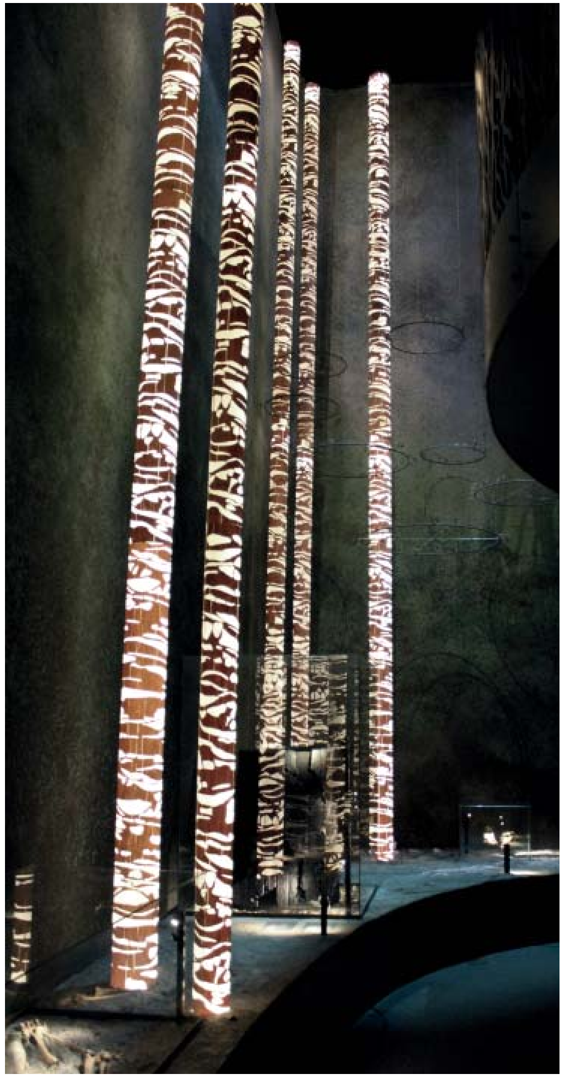
Additionally the facade is used actively to control ventilation, heating and day light depending on the weather outside as well as the individual needs of the rooms. Thus creating CO^2-neutral ventilation and cooling.

Furthermore the sloping roof design provides various passive energy strategies such as passive solar shading and cooling as the public green roof top helps absorp solar heat rays. Thus decreasing the need for active energy strategies and thereby making the building more sustainable. [MTHøjgaard, ND]

Ill. 18: Wax model of Stoneage woman.

Ill. 19: Panoramic cinema

Ill. 20: Wall paintings used to disseminate stories.



Ill. 21: Advanced settings

Exhibition Examination

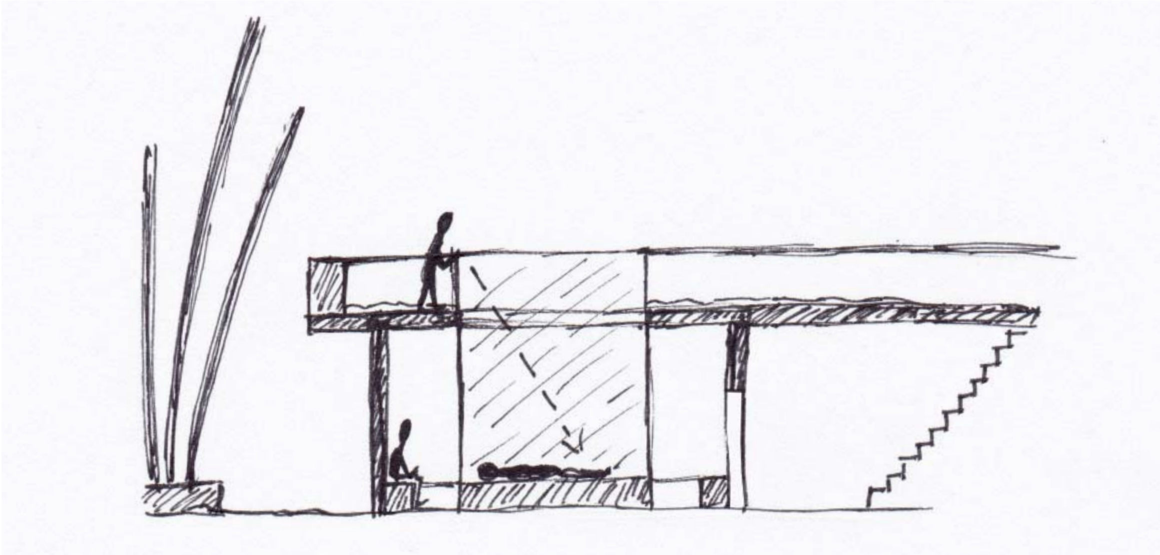
Due to the strict indoor climate requirements in exhibition areas, these have been located in the middle of the building volume to avoid direct heating during periods with warm temperatures outside.

The permanent exhibitions are accessed in the lower levels of the museum. Here, the mood is set already when entering the large distribution area which through efficient signage in both Danish and English as well as sound and light effects adjusted to the collections, captures the visitor's attention.

As the exhibitions rely solely on artificial lighting, this is used strategically throughout the exhibitions to create focus on selected items as well as to create different mood settings depending on the nature of the collections. Something, which is further enhanced by using dark colours to lower brightness.

Additionally, the architecture itself is used actively to enhance storytelling in terms of using multiple floor levels as well as different types of flooring to awaken the tactile senses (see ill. 22)

At Moesgaard Museum, the visitor is invited to explore the past through collections that recount stories from e.g. the Stone Age and Viking Age.

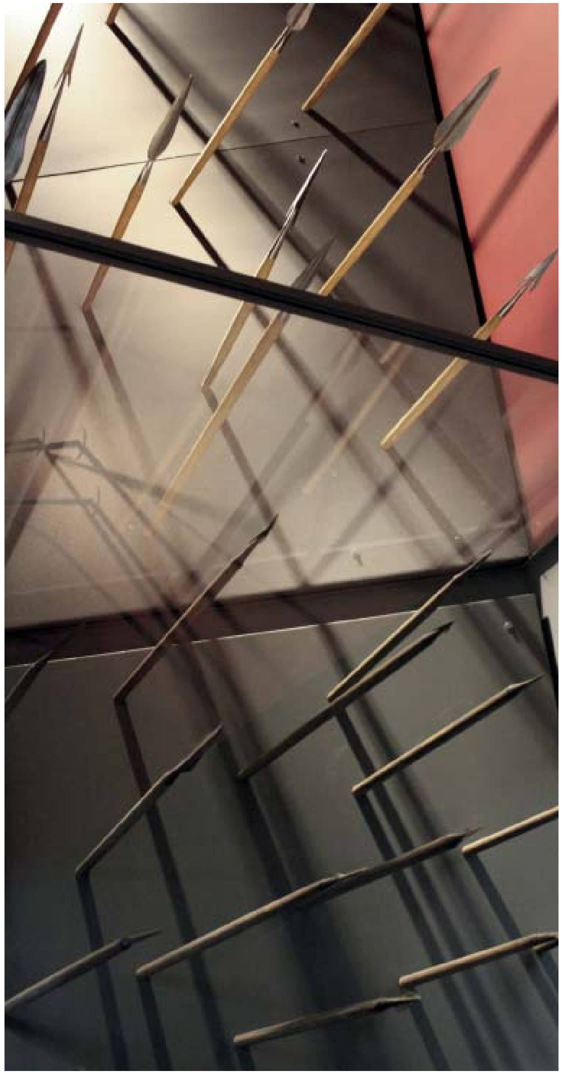


Ill. 22: Principle sketch. Use of different levels and interaction between them.

To be able to communicate the stories to a wide audience that includes visitors of all ages, Moesgaard Museum has focused on staging the different collections and using various techniques - both old and new - to disseminate the inherent knowledge and thus let the audience immerse themselves in the stories.

However, as the collections are very fragile by nature they need to be contained in a static environment that prevents all kinds of deterioration. For this reason, the museum has chosen to display all artefacts in showcases that maintain a constant temperature, relative humidity etc. which is suited for the individual artefacts, and thus allowing a more dynamic indoor climate outside the cases.

To improve the experience, the collections have however also been staged outside the showcases as some have been replicated and used in extension of the originals (see ill. 23)- sometimes along with illustrations that display context and purpose.



Ill. 23: Replicas are used in extension of originals.

Other techniques include the construction of life-size settings and use of wax models (see ill. xx), projections, TV-monitors, panorama cinemas etc. which are used actively to disseminate more aspects of one story.

To retain the attention of a younger audience, newer technologies, which require the audience to take active part of the story, have however also been integrated - including VR-glasses, interactive games, the option to follow a specific person throughout an exhibition, listening and feeling experiences and active selection of various movie clips.

As the exhibitions and technologies, which are used for the dissemination, may change over time, it is important that the settings can easily be changed and it is therefore seen that the otherwise squre exhibition spaces, are transformed into more intimate areas by using moveable walls, settings and textiles.

All this to create an authentic experience.

Program

Purpose and potential

Users

space programme

functional diagram

Exhibition

Program

The following chapter sets out to explore the conditions of which the space programme should be based upon. This includes user-needs and learning tools in relation to kognitive development but also more practical knowledge of room temperature and relative humidity.

Finally, a phenomenological introduction to the use of senses in the new experience and knowledge center is presented along with a conceptual display of the exhibition strategy.

It is noted that the project is based upon a competition brief from 2015 regarding the design of Trelleborg New Experience and Knowledge Center.

Purpose and Potential

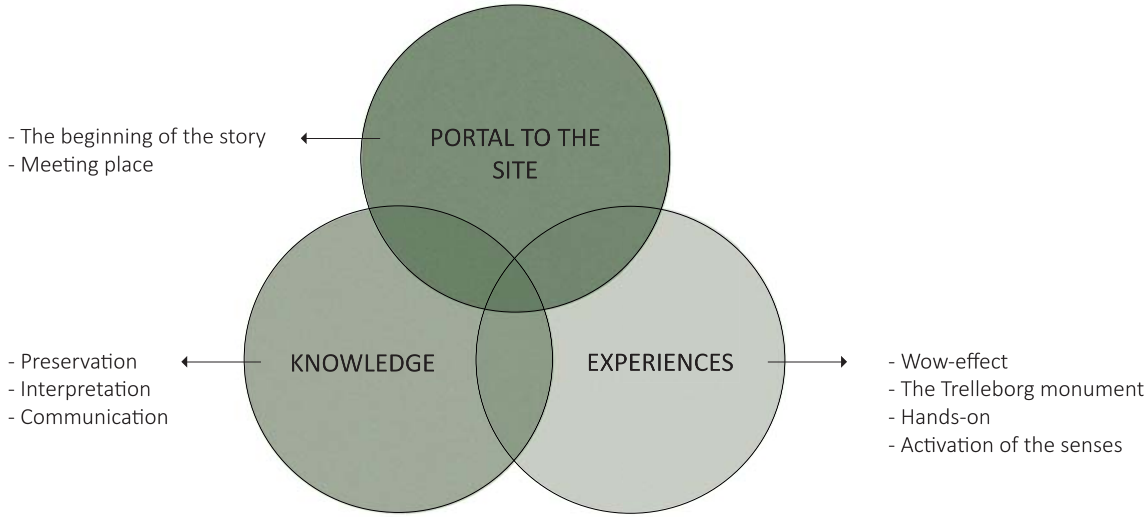
Trelleborg New Experience and Knowledge center is set out to be a unique landmark for the municipality of Slagelse and a beacon in the dissemination of the Viking Age.

The current museum is owned by the municipality of Slagelse and managed by The National Museum of Denmark, who have applied for admission of the monument onto the UNESCO World Heritage List. Should this be granted, a significant rise in the number of visitors is expected.

Thus, if future needs and demands are to be met - this both in terms of space, aesthetics, building and energy regulations as well as modern communication methods- a new experience and knowledge center is required.

As the main functions of the new center are essential in terms of both design and operation, these have been identified based on information given in the competition bried as: portal to the site, disseminator of knowledge and generator of experiences for all visitors. (see ill. 24)

Based on this information it has become possible to identify the required spaces for successful operation of the building (see ill. 24) along with the wide varity of user groups including permanent staff, volunteers and various types of visitors (see pp. 38-40). Groups that all contribute to making it a center of mixed activities and audience. [Competition Brief, 2015]

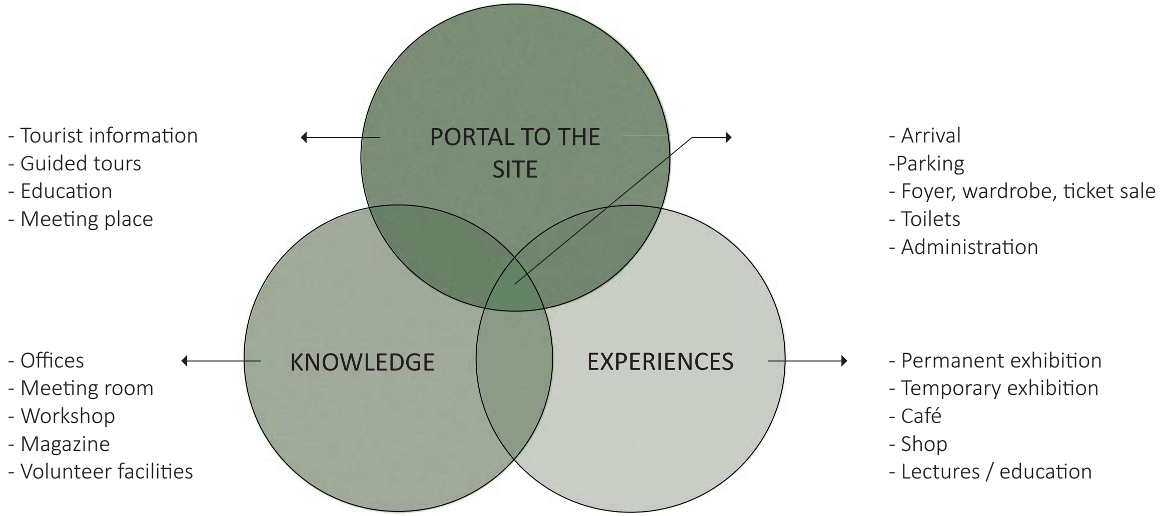


Ill. 24: Main purpose of the experience and knowledge centre.

Tourism

In recent years, there has been an increased interest in cultural identity both on a national and international level, and in relation to the nordic countries, especially the interest in the Vikings has flourished. This trend has caused the regions to invest heavily in the promotion of experiences related to both the Medieval and Viking Ages, and this has also been the case for the current museum at Trelleborg, which in 2014 meged with the National Museum of Denmark before granting visitors free access in 2015 while also becoming part of the project '*Danmark Bliver Til*'.

The project is based on a collaboration between Vest- and Midtsjælland, where recurrent events and



Ill. 25: Space program in relation to main purposes.

educational programs in schools as well as individual events in the community are used to increase the understanding of how events, people and cultural developments in the Medieval and Viking Ages have led to present day Denmark. [Kongens Togt, 2016]

It is these kind of initiatives that, among other things, have led to an increasement in number of visitors at the e.g. Trelleborg Museum - from 44.215 in 2014 [VD Online, 2014] to 55.220 in 2015 [TV ØST, 2015] and finally 65.699 in 2016. [National Museet, 2016]

The number of visitors is however still expected to rise with the construction of a new experience and knowledge center, and should the monument be admitted to the UNESCO World Heritage List, it is expected that an increasing number of foreign cultural tourists will become aware of the monument and thus generate a largere interest in visiting the associated center.

This expectaion is based on surveys conducted for VisitDenmark, which show that 43 pct. of all international tourists choose Denmark based on e.g. historic and cultural experiences.

Additionally 3,8 mio or 26 pct. of the total 14,5 mio yearly museum visits are conducted by foreign visitors, but this number could be increased significantly through better marketing. [VisitDenmark, 2014]

Users

Learning for different Audiences

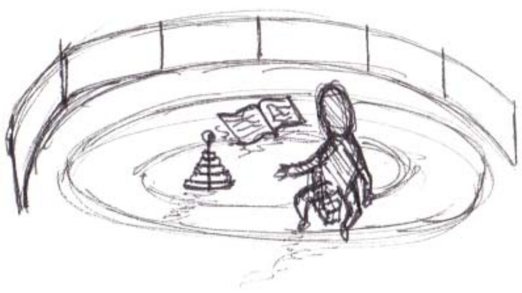
In order to plan facilities for learning and dissemination, it is important to understand the target audience, their age range, interests and learning style, as specific activities in most cases will appeal to specific ages or interest groups.

The New Trelleborg Experience and Knowledge Center is intended to address a wide variety of users ranging from local day-trippers of all ages to foreign cultural tourists.

These visitors all have very different needs and expectations depending on age, existing knowledge, interest, and time devoted to the visit, and it is therefore crucial that the center displays great flexibility in their communication.

To identify the learning style of the user, these may be divided into different categories, of which one is identity-related motivation and another is according to age.

In the following, the learning style is however commented according to age range, as this aspect takes into consideration the cognitive development and life-experiences of people, thereby giving a more general view of their ability to perceive and learn.



Ill. 26: Infant playing with toys in a delimited area.

Infants / Toddlers (0-3 years)

Infants or toddlers do not require large spaces but should rather be contained in a safe, enclosed environment with adult supervision.

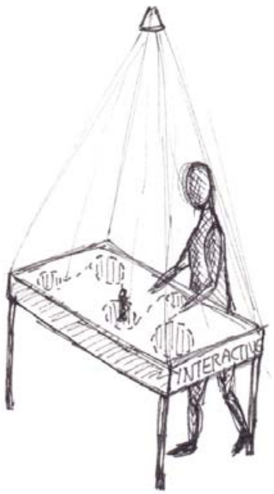
This area should contain various types of play-stations with hands-on experiences featuring puzzles and large toys or reading areas with organization-led programs of stories, music and games that are relevant to the experience and which make it possible for parents to participate.

Ill. 27: Children role-playing as vikings.

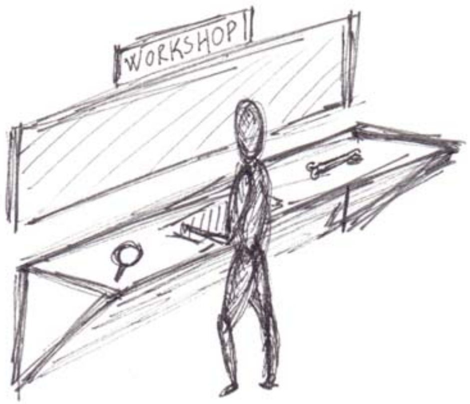
Children (4-7 years)

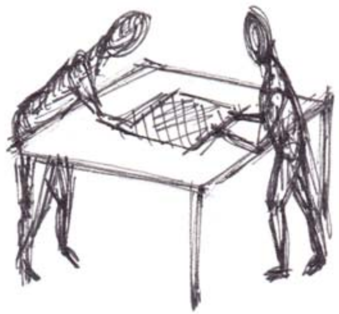
Children at this age often learn most efficiently through activity, participation and repetition.

Thus, the learning environment should include lots of space and opportunity to play with various materials and tools or participate in dress-up or role-playing activities.



Ill. 28: Interactive games.





Ill. 29: Workshop facilities for active involvement.

Children (8-12 years)

Learning spaces for this user group must address a need to figure things out and should as such provide activity driven learning. This often includes activities in which the child can make collections and create ways to display their discoveries.

However, technology can also be used to hold the attention of the children and to convey additional information through e.g. films and interactive games.

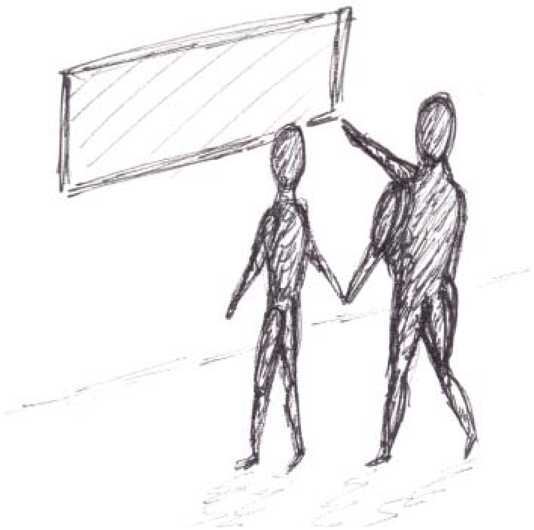
Adolescents (13-18 years)

People in this age range often seek more in-depth experiences and engagement in the activities or disciplines they are interested in.

The opportunity to engage in "behind the scenes" activities will therefore often be very attractive, as they get to learn alongside professionals and thus feel more important and involved.

Teens are however vey socially conscious and will thus seek activities in which they can socialize with people of their own age.

Thus, to attract teens, the experience and knowledge centre must continouesly seek to integrate the latest trends and technology, as this can allow them to feel comfortable and modern.



Ill. 30: Gaining new knowledge with like-minded.

Ill. 31: Seating arrangements for seniors.

Adults

Adults may choose freely to visit an experience and knowledge centre as a source of learning.

Here, they have the opportunity to meet and socialize with like-minded individuals but also to pursue professional or amateur research goals.

Adult learning spaces may therefore include galleries, a library, an arts and crafts studio, activity rooms, workshop areas or a lecture hall.

Seniors

The most significant difference between adults and seniors are their decreased mobility, sight, and hearing, which can cause difficulties in terms of access.

Thus, to enable seniors to acquire the same experiences as other users, the centre must be designed for accessibility.

Additionally, due to lower energy levels, it is important to incorporate seating areas in strategic places.

Staff

The experience and knowledge center employs a wide varity of people who are dependent on the creation of a safe and practical working environment that supports their work and ensures that it is efficiently executed.

These spaces must comply with the building regulations as well as the relevant Danish Standards (ds), which describes the rules and recommendations in terms of e.g. air quality, humidity, ventilation, light and sound.

However they must also take into consideration what kind of environment is relevant to the organization and its employees.

This is especially important as the facilities and the atmoshpere can help to attract and retain talent, thereby making the institution more competitive.

[Lord, Barry et al. 2012]

Program

Space Program

Welcome zone (zone 1)	Total Area (m^2)	Max. load (people)	Ventilation	Temperature (°C)	RH (%)	Natural Daylight
Foyer	100	-	Natural	20 - 25	> 70	●
Information / ticket office / shop	70	-	Natural	20 - 25	> 70	●
Café (including pantry kitchen)	235	-	Natural	20 - 25	> 70	●
Wardrobe	50	-	Natural	20 - 25	> 70	○
Toilets	50	-	Natural	-	> 70	○
Multifunctional lecture area / scene /teaching area	80	100	Natural	20 - 25	> 70	●
Subsum	**585**					

Behind the scenes (zone 1)						
Offices	110	10	Natural	20 - 25	> 70	●
Meeting room (including separate kitchenette)	40	14	Natural	20 - 25	> 70	●
Storage	100	-	Natural	-	> 70	○
Personelle toilet / Bath and changing room	40	-	Natural	-	> 70	○
Workshop	70	-	Mechanical	-	> 70	●
Room for volunteers / education	60	40	Natural	20 - 25	> 70	●
Waste room	20	-	Natural	-	-	○
Subsum	**440**					

Permanent Exhibition (zone 2)	Total Area (m^2)	Max. load (people)	Ventilation	Temperature (°C)	RH (%)	Natural Daylight
Exhibition area (incl. UV niches and break areas)	650	-	Mechanical	10 (Win.)- 25 (Sum.)	40 - 70	◕
Subsum	**585**					

Temporary Exhibition (zone 2)						
Temp. exhibition (incl. UV niches and break areas)	50		Mechanical	20 - 22	45 - 55	◕
Subsum	**50**					

Gross Area 1	
Addition	280
Total	**1.725**

Gross Area 1	
Total	**2.005**

* Areas such as equipment rooms, stairwells and hallways, which are not scheduled, must be included in the 2.005 m^2.

Diagram 01: Space program.

Functional Diagram

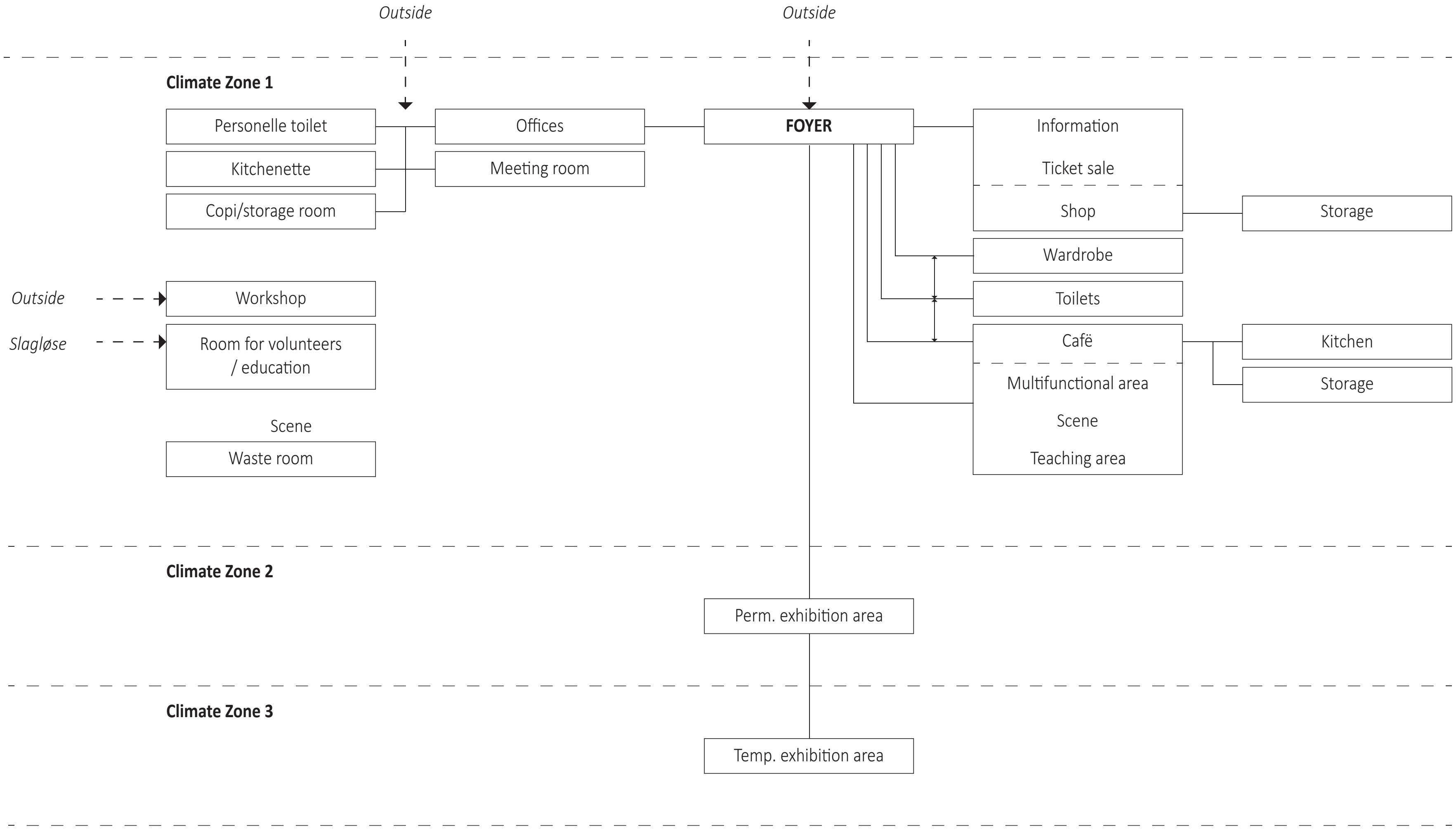


Diagram 02: Functional diagram.

Phenomenological Space Program

> *"Architecture has the capacity to be inspiring, engaging and life-enhancing. But why is it that architectural schemes which look good on the drawing or the computer screen can be so disappointing 'in the flesh'"*
>
> Juhani Pallasmaa, 2005

Architecture is not simply about creating a design that looks nice. To be truly successful architecture must also involve the sense of touch, hearing and maybe even our sense of smell, as activation of the senses has been proven to strengthen the ability to store and process knowledge. [Pallasmaa, 2005]

Thus, it is important to consider what impressions visitors will meet upon arrival, when walking through the museum, staying in the café and finally upon leaving the museum.

Some of the most prominent impressions are attempted explained in the following.

Arrival

Upon arriving at the museum, visitors are met by a spacious, bright and welcoming foyer that forms the heart of the center and provides them with an intuitive sense of where to turn. From here, visitors are distributed to, respectively, the information area, shop, wardrobe, toilets, café, multifunctional area and exhibitions- both permanent and temporary.

Additionally, materials and interior design are used to create an atmosphere that awakes the tactile sense and prepares the guests for a viking age experience.

Café

In the café, drinks and light meals can be bought and consumed. Visitors are therefore met with a comfortable and intimate atmosphere in a spacious environment that provides direct views to the Trelleborg Monument.

During the summer, the facades can furthermore be opened and the dining area expanded to include an outdoor area which hereby creates a more seamless transition between the indoor and outdoor environment.

Exhibition Areas

In the exhibition areas, the atmosphere is adjusted according to theme and exhibited artefacts. This involves activating the senses by exposing them to evocative lighting and sounds, but also to use physical activity and modern technology to involve the visitor and thus strengthen the communication of knowledge.

As the exhibitions, must be able to accommodate a large number of visitors simultaneously, spacious solutions are furthermore integrated in the designs to ensure easy passage and the possibility to stay in relation to guided tours and education.

Due to the fragile nature of the collections, the microclimate is furthermore carefully controlled both in the individual zone but also between zones, meaning that buffer zones are integrated to avoid degradation of artefacts.

Break Areas

Throughout the exhibitions, break areas are integrated to provide visitors with room for relaxation and peace to absorb the impressions which they have been exposed to.

These areas are therefore provided with views to the outdoors and are using natural daylight and materials to provide an intimate and soothing environment.

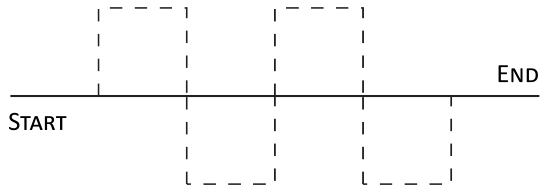
Exhibition Design

An exhibition is defined as a public display of works of art or items of interest. it is a way of providing visual as well as intellectual access to the museum collections and is the main source of interaction with museums for the general public

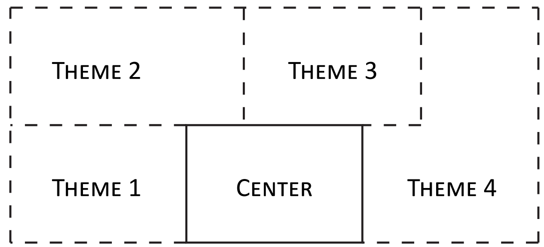
To create a successful exhibition that engages and challenges its audience, it is thus important to generate an exhibition strategy that takes into consideration both the nature of the collection as well as its audience.

In general, history and archaeology museums may choose between a chronological or thematic exhibition layout. While chronology may seem the obvious choice in a presentation of historic events, carefully selected themes may however prove to be more effective as it allows the event to be communicated in a wider perspective, thus giving the visitor an opportunity to comprehend the given theme in depth.

Often, this choice of exhibition strategy may also be reflected in the location of the galleries, as a linear sequence of galleries may suggest a chronological approach whereas a concentric layout may be more suitable for a thematic approach. (See ill. 33)
[Lord, Barry et al. 2012, Cambridge, 2013]



Ill. 32: Linear layuot - Chronological approach.



Ill. 33: Concentric layuot - Thematic approach.

In the new Trelleborg Experience and Knowledge Center, the Viking Warrior is set to be the focal point for dissemination, and thus the exhibitions must communicate Trelleborg's stories and riddles based on his life.

To ensure that the most important stories are being communicated to the visitors, the competition developers have selected five different themes:

Military
Warriors / weapon / strategy / garrison

Cult Space and Sacrifice Rituals
Child sacrifices / cult place / cemetery

Policy and Communication
Kingship / Christianity / statehood

Architecture
Construction methods / mysterious circular shape / defence

Archaeology
Practical archaeology / findings / how do we know?

[Competition Brief, 2015]

Taking into consideration the formal demands regarding the exhibition, it has been decided that the layout should be of a concentric character to emphasize a thematic approach.

Delimitation

As the project is developed with architecture and engineering as focal points, the exhibitions are to be considered only on a conceptual level, thus including spatial division, conceptual placement of montres and choice of atmosphere in relation to spatiality, materials, flexibility and collections care.

Spatiality and Flexibility

The exhibition areas are to be built with the aim of creating a flexible environment in which walls, installations and suspensions may switch location when exhibitions change or develop.

This, to be able to process the spaciousness using different means and thus strengthen the dissemination without compromising the experience.

Collections Care

When considering collections care, the building fabric is key to prevent damage to the collections and the following is therefore considered in the design:

- Adaption to local outdoor climate conditions.
- Quality of materials and construction techniques.
- Protective structure:
    - Air and weather-tightness
    - Moisture resistance (flooding protection)
    - Thermal performance
    - Resistance to undesired access
- Ceiling heights and headroom.
- Avoidance of unnecessary level changes.
- Expandability to accommodate future growth.
- Fire protection.

As such, the collections are dependent on a carefully executed building structure that takes into consideration the conditions on site and integrates various methods to take advantage of them rather than working against them.

However, the maintenance of a good indoor environment is equally important.

As the collections at Trelleborg primarily consist of organic material, they are very fragile and more prone to decomposing. This is related to the moisture content, which changes based on surrounding temperature and relative humidity conditions. One of the most common temperature-induced causes of damage is however not caused by ambient temperature conditions but rather by infrared radiation from direct sunlight through an unfiltered window or from exposure from an incandescent or tungsten halogen lamp.

To avoid such damage, the light exposure from natural daylight is therefore limited in the exhibition areas and in areas with very light-sensitive materials, light emitting diodes (LED) are used as these have a low damage potential and a wide range of beam patterns while also being energy efficient.

Additionally, mechanical ventilation is used in the exhibition areas to maintain a comfortable temperature for the guests, secure good air quality and prevent accumulation of CO_2 and humidity due to fluctuations in the number of guests.

To further protect the collections from changes in the indoor climate, theft and vandalism, all fragile pieces of the collection are furthermore being placed in display cases and are being supported by replicas, graphic illustrations and other means of communication outside the display cases to give a coherent and intimate experience despite the shielding of original objects.

Framework

Historic and Cultural Value

natural qualities

climatic conditions

Formal Demands

Framework

In the following chapter, the site is presented through a series of analysis which seek to communicate the current conditions on site.

As such, the chapter is introduced with a historical and cultural overview before the natural conditions are discussed both in terms of fauna and flora as well as climatic conditions that may affect the structure.

Finally, the key points of the new local plan 1137 are highlighted to ensure that the legal demands are accounted for in the project.

Trelleborg Monument

historic and Cultural value

Ill. 34: Denmark

History

Trelleborg is a military ring fortress, which is located near Slagelse on Vestsjælland, Denmark.

The fortress has been dated to the year 980 through dendrochronology, and based on this information it has been possible to link the purpose of the ring fortresses to the political situation of that era, where Harald Blåtand attempted to strengthen the monarchy by subjugating petty kings and local chieftains

This is consistent with the findings of additional four ring fortresses of similar designs; Aggersborg north of the Limfjord, Fyrkat near Hobro, Nonnebakken in Odense and Borgring near Køge. Though it is not known with absolute certainty, Harald Blåtand is believed to be the mastermind behind the ring fortresses, as this comprehensive system of power testifies to a strong central monarchy, which undoubtedly has been the only power factor of the time with sufficient funds to implement such effort.

This interpretation of origin can also explain the short operation time as the fortresses presumably have been very expensive to man, but also due to the end of the civil war, which occurred shortly after. [Nationalmuseet, ND]

Ill. 35: Slagelse, Denmark

Culture

The ring fortresses are seemingly unique in terms of design and construction and have as such not been found anywhere but Denmark, and of the five known fortresses, Trelleborg is by far the best preserved and most technically advanced. It was excavated in 1934 and here the nature of the fortress was first established.

The fortress represents an important part of Viking Age culture and bear witness of early logistic, organizational and aesthetic capacity. Thus, in 1955 the independent institution, The Museum at Trelleborg, opened to the public, displaying the majority of the material which was found during the excavations of Trelleborg.

Since then, more artefacts have been reconstructed both physically and computational and hands-on experiences are being offered to provide visitors with more tools to better understand the Viking Age, and this is well-received in a time where people tend to seek out their cultural heritage.
[Competition Brief, 2015]


Trelleborg Monument
Vårby Å

Ill. 36: Site plan with context.

Genisis Loci

The following analysis is based on physical and psychological observations that have been conducted at the building site a sunny summer day (02.08.2017).

The area surrounding the Trelleborg Monument is characterized by the architectural accomplishments of the Viking Age and the historic events connected to it. Due to the historic importance of the area, continuous conservation is thus conducted to ensure that the physical remains of the monument are kept visible. Thus, resulting in a very scarce vegetation near the monument.

As the surrounding land, primarily is used for cultivation of crops the site however fits seamlessly into the landscape of fields, thus making the monument a seemingly hidden gem.

The same applies for the building site, which in style with nearby settlements, is bounded only by living windbreaks towards North, South and East respectively. However, presumably to emphasize the connection to the monument, viewpoints to this have been created towards West.

As such, the atmosphere on site is affected by both the natural and historical environment but also by-

Ill. 37: View to the site seen from the moument.

the museum activities which aim to recreate a sanctuary in which visitors may engage in the challenges and daily chores that were part of everyday life during the Viking Age.

The activities are primarily located on the activity site, Slagløse, which is set to be preserved when the new experience and knowledge center is built, but due to the size of the site, new experiences may be scattered more widely in order to adjust for a growing number of visitors.

Combined the parameters create a relaxed atmosphere in which guests are allowed to reflect upon Danish cultural heritage, thus also becoming more aware of own identity.

Seeing as it is the natural environment that forms the primary framework for this atmosphere, the new building should thus be designed with consideration to existing qualities.

Ill. 38: Long house replica.

Ill. 39: Entrance to the inner ring fortress.

Ill. 40: Concrete pillars marking past settlements.

Ill. 41: Outside cover of the long house.

Ill. 42: Scaled model of the Trelleborg Monument.

Ill. 43: Fire at the activity site Slagløse.

Ill. 44: Selection of Viking Age kitchen utensils.

Natural Qualities

Flora and Fauna

The site is located in a relatively open landscape consisting of fields used for agricultural purposes and marshland that lies in relation to the streams, Tude Å and Vårby Å.

In these areas, it is possible to find sporadic vegetation consisting of deciduous trees and bushes, which are furthermore used to create hedgerows in connection with settlements and delimitation of plots.

It is however Tude Å that provides the main attraction for wildlife enthusiasts, and a new project, prompted by the municipality, therefore seeks to improve the accessibility to nature as well as to cultural values such as the Trelleborg Monument through preservation and improvement of said values.

Additionally, the project is predicted to have a large

Ill. 45: Gul Iris.

Ill. 46: Lapwing Eggs.

impact on local wildlife as it involves the establishment of new wetlands that hold potential for both flora and fauna.

As the water in the wetland areas is very rich on nutrients it is expected that a reed bed will develop in the area and by using cattle as a means of grazing, the best conditions are being created for new plant and animal species.

This includes various types of waders and ducks such as the marsh harrier, bittern, mallard, teal and gray gees while the project simultaneously seeks to secure the presence of e.g. godwits, lapwings and dwarf terns.

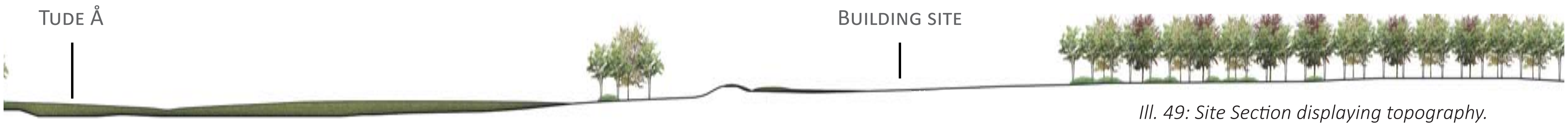
Overall, the municipality seeks to create a more diverse plant and animal life in the area, and while this

mean that landowners must cede parts of their land, it may turn out to their advantage, as the wetlands during periods of flooding may store the water and thus prevent flooding of the agricultural land – something which has been a recurring problem during the summer period. [Tude Ådal, 2014]

As the new centre is to be located in a natural area, it is important that respect is paid to scale and context, and since the municipality has an explicit wish to enhance the natural experience, the design should strongly relate to the sense of place both in terms of scale, materials and shape.

Ill. 47: Dunet Vejbed.

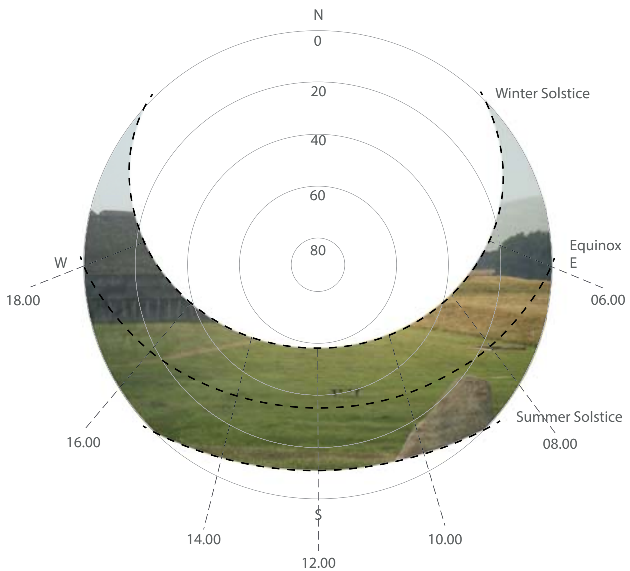
Ill.48: Lapwing.



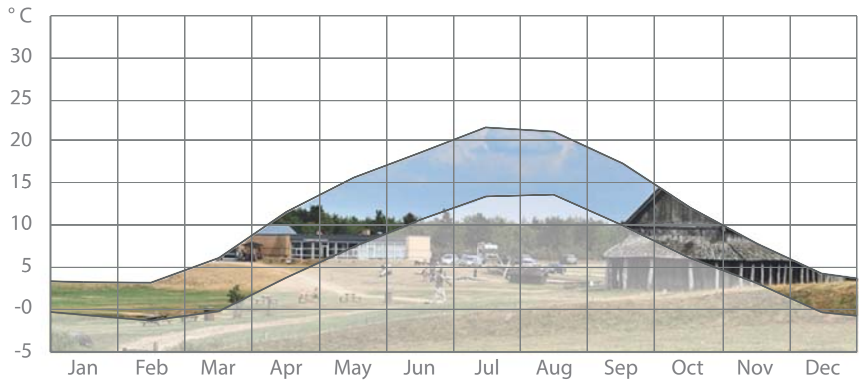
Ill. 49: Site Section displaying topography.

Climatic Conditions

Temperature, Precipitation Wind & Sun



Ill. 50: Solar diagram (Period: xx-xx). [SunEarthTools, 2017]



Ill. 51: Decadal mean temperature - hottest and coldest (Period: 2001-2010).

The climatic conditions have been analysed, based on data from previous years, in order to predict potential risks and possibilities in relation to natural phenomena, as these in many cases can have significant impact on the design of the building.

Sun and Temperature

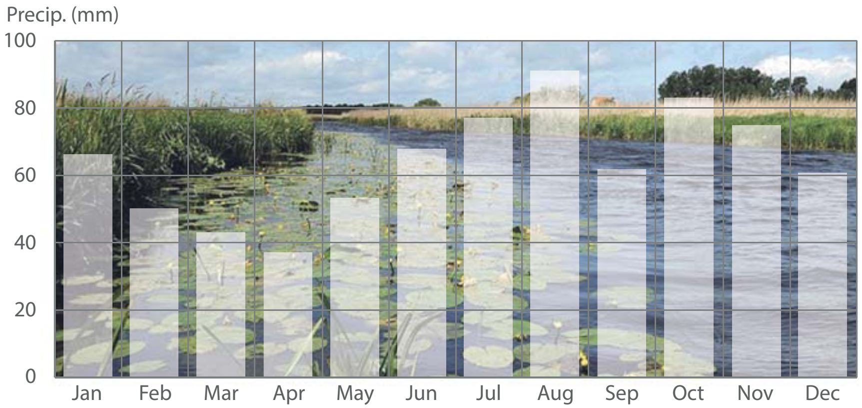
Due to the location on the northern hemisphere, it is seen that the solar path and thus daily number of hours with natural daylight, varies greatly throughout the year (see ill. 50). [SunEarthTools, 2017]

This of course affects the temperature and it is seen how the decadal mean temperature varies from approx. -2 to 25 °C, however with greater fluctuations within this period. [DMI, 2015]

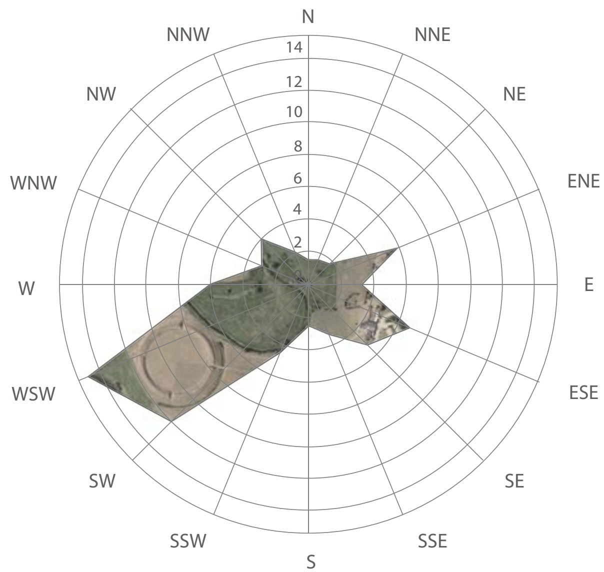
As museums, must be kept relatively cool at all times due to preservation of collections, while simultaneously using only a limited amount of energy to remain sustainable, it is necessary to design and place e.g. exhibition facilities strategically in order to avoid direct heating.

This can for instance be done by placing the exhibitions underground, in parts of the building that are less affected by the sun or by making buffer zones between the outside and exhibition areas.

The same is however relevant for offices and meeting areas which optimally should face north, as they thereby avoid direct sunlight and heating while still being illuminated by diffuse light which provides a better working environment.



Ill. 52: Decadal mean precipitation (Period: 2001-2010). [DMI, 2015]



Ill. 53: Wind diagram (Period: 2001-2010)

Precipitation

In relation to the close distance to Tude Å, the precipitation and water levels have been analysed, and it has been found that in cases of heavy rain or regular cloudbursts there is risk of flooding.

This is due to the fact that surface water has great difficulty seeping into the ground as the degree of consolidation is medium high while the hydraulic conductivity is of average to poor quality, which thus reinforces the negative effect.

Additionally, groundwater may pose a problem. The average depth of the ground water in the area is estimated to be 0,3 m, but during periods with heavy rain the groundwater may reach the surface and as it is predicted to rise additional 0,1 - 0,2 m during the period 2021 - 2050, measures must be taken to avoid flooding in the new center. [DinGeo, ND]

Wind

Trelleborg is located in a relatively open landscape and the wind is therefore expected to behave as displayed in the wind diagram (see ill. xx). However, hedgerows located north and east of the site, will provide some shelter from these directions.

Wind from west is however the most prominent, but as the Trelleborg monument is located in this direction, alternate sheltering methods must be considered as a direct view to this must be preserved. The wind does however also provide options for using natural ventilation in areas that do not require a static indoor environment. [Windfinder, 2017]

Formal Demands

Local Plan nr. 1137

In relation to the construction of the new Trelleborg Experience and Knowledge Center, a new local plan has been developed.

The local plan includes all of cadastre 17c and is used to determine the disposal of the area, including access roads, parking, location of building site and the use of open spaces.

As such, it has been decided that the existing museum building, must be demolished and replaced with a new construction located in the northeastern corner of the building site.

Excerts from the local plan

- The museum should conform to the landscape and should not influence either the monument protection line nor protected natural areas.

- The museum is expected to generate more visitors, which increases the demand for more parking spaces and traffic management in connection with this.

- There should be a minimum of 1 parking space pr. 10 m^2 floor area.

- The design must ensure accessibility for visitors both with and without disabilities to move around freely in the area.

- Along both Tude Å and the Trelleborg monument, various protection lines are made to ensure that no changes are made unless permission is given from Slagelse Municipality and the Danish Nature Agency.

- The new museum should communicate the special character and qualities of the area and should therefore be adapted to the existing landcape and local crafts tradition.

- Window frames should be made in wood, alumnium, composite or a combination of these.

- It is allowed to integrate solar cells on a smaller part of the roof surface - up to 20 %. These must however be integrated into the roof surface and appear to be conherent with the rest of the surface.

- The roof must be established as either a green roof or a roof with black roofing felt. Additionally, the roof should be either flat or a shed roof with an inclination of max. 30 degrees.

- Ventilation must not be visible from puplic roads and paths and must futhermore not be placed on roof surfaces or facades.

- Facades must be carried out in glass, concrete, bricks and textile in such a way that a coherent expression is obtained between the used materials.

- Wood cladding should appear in black, earth tones or the natural colour of the wood.

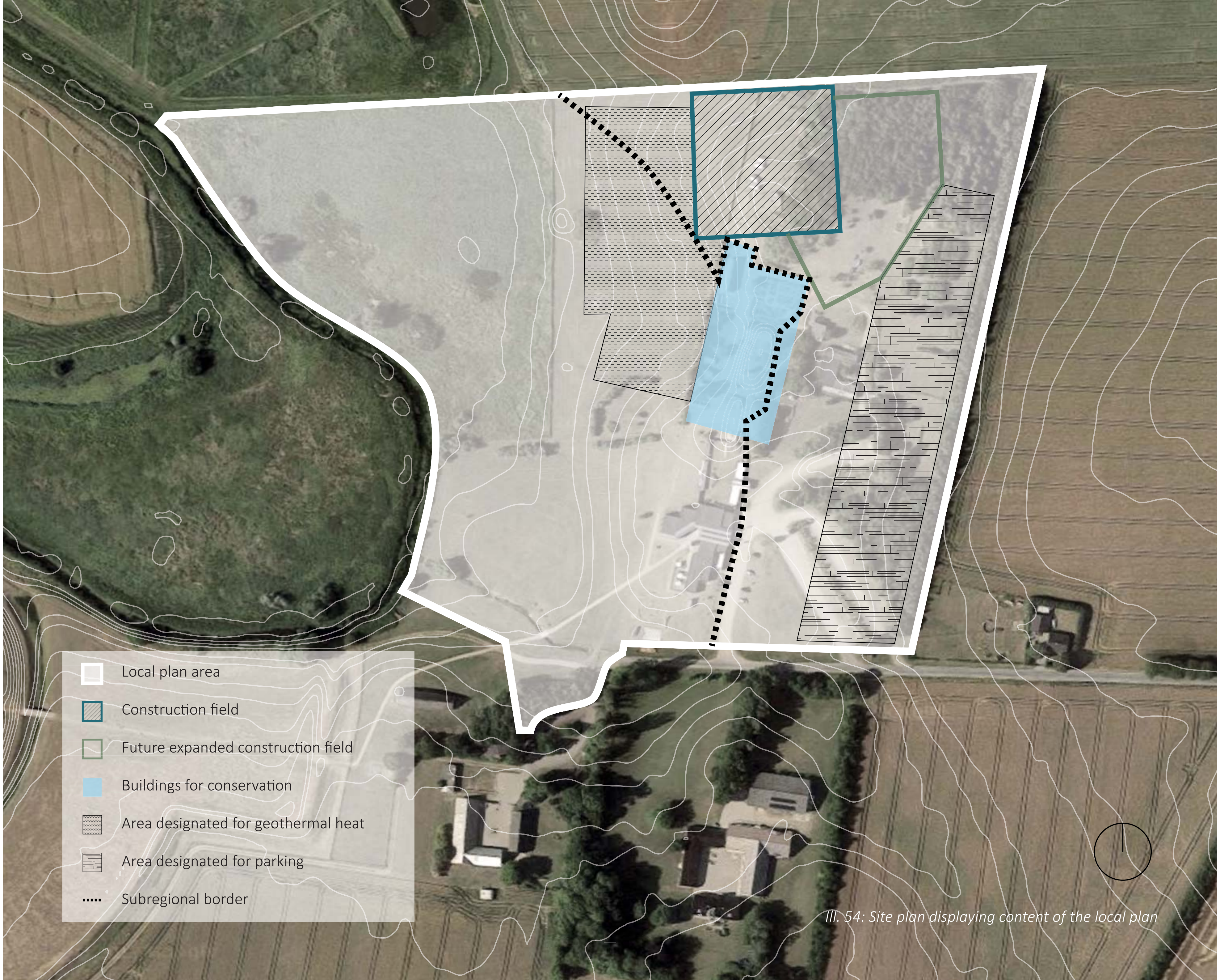
- The building must not be taller than 10 m measured from the ground level.

- The building must not be built with more than two floors. [Slagelse Kommune, 2016]

Summary

The excerts mentioned only represent part of the local plan, which includes far more directives that should all be considered in the design of the new experience and knowledge center.

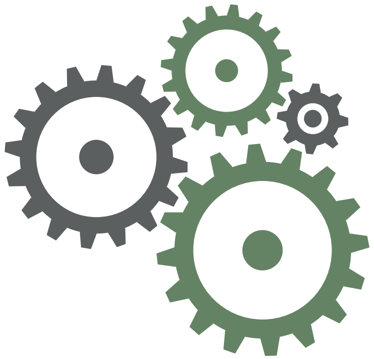
However, it must be taken into account that the local plan has been based partly on the winning project, why some directives are more relevant to this project than others, including directives regarding relation to the landscape and sustainability.



Ill. 54: Site plan displaying content of the local plan

Design Criteria

Functional



Ill. 56: Functional design criteria.

Natural movement towards the monument.

Division of functions in relation to climatic conditions, workflow and accessibility.

Separation of private and public spaces.

Utilize roof space.

Accomodations for varied number of visitors.

Technical

Ill. 57: Technical design criteria.

Meet the requirement of BR20. (*See "Energy Frame" page 20*)

Comfortable indoor environment (*See "Space Programme" page 42 and Appendix pp. 142-145*)

Integration of passive and active energy strategies. (*See "Indoor Environment" page 21*)

Aesthetic

Ill. 58: Aesthetic design criteria.

Visual connection to nature.

Visual connection to the monument.

Integration of nordic materials and building practice.

Vision

The vision for the New Trelleborg Experience and Knowledge Center is to create a building that relates to the natural conditions and history of the site while simultaneously creating its own identity.

As such, the vision is to create a design with regards to the primary objectives of the building, which are to act as a gateway to the Trelleborg Monument, to disseminate knowledge of Viking Age history, and to offer experiences that challenges the senses and promote learning.

To obtain a coherenent expression and promote sustainability, the building is additionally developed with consideration to the indoor climate conditions as well as overall energy requirement.

Thus, through careful integration of passive and active energy strategies with functional and aesthetic design principles, the building is set to form the framework of prehistoric reflection and experiences as well as everyday work.

Conceptual Studies

Design

The Circle

Gesture

Final Concepts

Conceptual Studies

The following section present the thoughts that have been made regarding the final concepts of the building.

This includes spirit of the place, placement of functi-ons, shape and integration on the site.

Design

In relation to site and program

The shape of a building contributes to the way in which it is experienced both internally and externally, and the basic geometry should as such not only support the function of the building but also relate to its surrounding context. [DAC, No date]

Ill. 59:The landscape near Trelleborg.

Genesis Loci

Genesis Loci, or the spirit of the place is in the case of Trelleborg, deeply rooted in the historic significance of the site and since the Trelleborg Monument is considered to be one of the most important Viking Age monuments in Denmark and thus part of Danish cultural history, it is imperative that the new experience and knowledge centre relates to it and supports the intrinsic atmosphere.

The site is located in a relatively groomed yet natural setting with few, low buildings, large open plains, naturally occurring streams, living windbreaks and otherwise sporadic vegetation.

Combined, this creates the setting for a solemn, yet relaxed and recreational atmosphere.

Additionally, since the open plains provide only little shelter from the wind as well as good natural lighting conditions, the natural conditions of the site can be utilized as passive energy sources in terms of natural ventilation, heat pumps and solar energy.

Conceptual deliberations

When considering conceptual ideas for the new building, it is important to bear in mind the qualities of the site, the wishes of the competition developers and the actual function of the building.

The experience and knowledge centre at Trelleborg should not only provide visitors with a basic knowledge og the Viking age and more specifically of the life a Trelleborg, but also act as a gateway to the monument, providing visitors with a better understanding of its history and importance.

As such, the building becomes a portal to the past, a symbol of enlightenment, and a mediator of culture and nature.

A design proposal should therefore be a representation of these qualities to make itself valid.

PRIVATE FUNCTIONS

- Offices → *Foyer / Outside*
- Meeting room
- Kitchenette
- Personelle toilet/bath → *Public functions*
- Storage rooms

PUBLIC FUNCTIONS

- Foyer → *Outside*
- Information / Ticket sale
- Shop
- Wardrobe
- Toilets
- Café → *Monument*
- Multifunctional area
- Permanent / Temporary exhibition area

SEMI-PRIVATE FUNCTIONS

- Workshop / garage → *Outside*
- Room for volunteers / education → *Slagløse*
- Toilet → *Outside*
- Waste room → *Outside*

Physical division

- Prevent the spread of fire
- Sound barrier
- Functions placed according to relevans on site
- Access outside opening hours

Diagram 03: Division of program in relation to access.

Program-specific architecture

In general Nordic architecture is characterized as being site-specific. A structure that utilize natural materials to obtain an authentic expression, and which implement the changes of daylight and the seasons in general to highlight aesthetic qualities.

These are all genuine characteristics, but Nordic architeture is not only about the sense of place. It is also about people and how they interact with architecture.

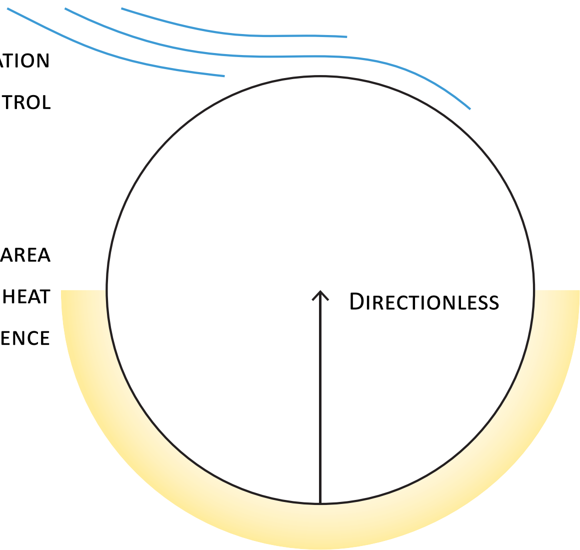
Thus, the design should primarily be based on the spatial dimensions of its program as well as normative behvavior of its guest in order to stay true to its function.

The building program may be divided into three categories: public functions, private functions and semi-private functions, but although none of the functions are dispensable in the operation of the building, it may in some cases be optimal to physically divide them.

As such, diagram 03 is used to display the division of the room program based on public relevance as well as how the functions may relate to the outdoors or to each other in between zones.

Finally, a physical split between functions are argumented in terms of practicality.

The Circle



Ill. 60: The circle.

A circle has no orientation, no beginning and no end. As such, by nature it has a very strict, symmetrical geometry that is oriented towards its own centre and in time it has become a symbol of unity, perfection, infinity and the ideal order.

So, what happens when the circle is *broken*?
By cutting into the circle, it is possible to emphasize depth and add a sense of direction. Something which is only emphasized by the otherwise soft, introvert and directionless curves.

However, despite not being complete, the circle is still seen as a singular unit, and this is one of the qualities which should be reflected in the new experience and knowledge centre.

Additionally, the shape creates a symbolic reference to the strict circular geometry of the Trelleborg Monument, and by rotating it to point directly towards the monument, the relation between the two is emphasized and the function as a gateway is constituted.

The circle in relation to engineering

In architecture, aesthetic conceptions are combined with practical and technical considerations but to create a truly integrated design that represent the fields of both architecture and engineering, the design must remain considerate to both fields throughout the design process.

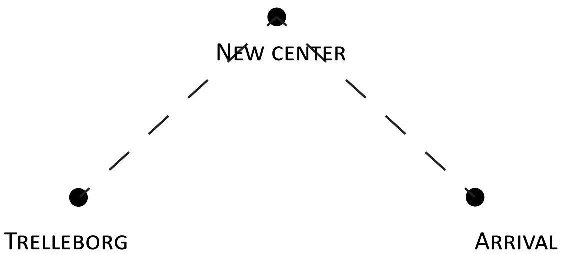
As such, the circle must also be considered in relation to an engineering point of view.

These days, the circle is often a subject for extensive criticism as it is more complicated to successfully execute in plans with perpendicular partitions compared to square or rectangular shaped buildings.

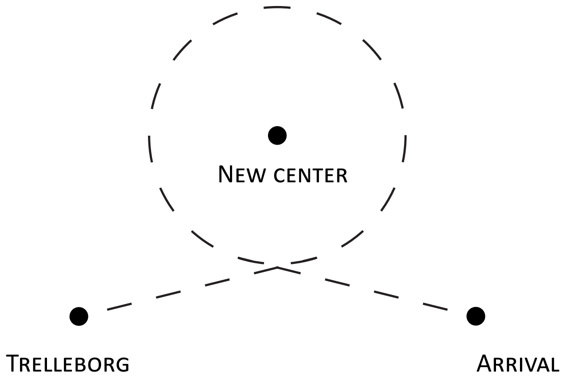
However, in terms of energetic efficiency, the circle is often more effective due to a minor surface area and thus heat transference.

Additionally, in architecture with curved facades, the orientation width is automatically greater and the use of solar radiation and/or natural ventilation is as such easier to control through strategically placed openings in the façade. [Garcia, 2014]

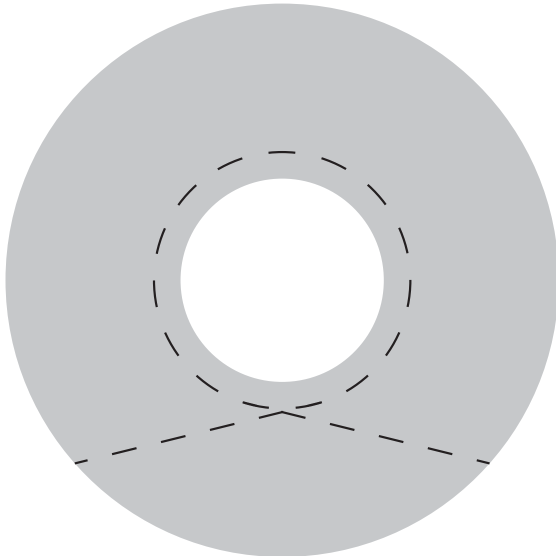
Concept of Connection



Ill. 61: Connecting places.



Ill. 62: The connection becomes a journey.



Ill. 63: The building emphasizes the connection.

Connecting spaces

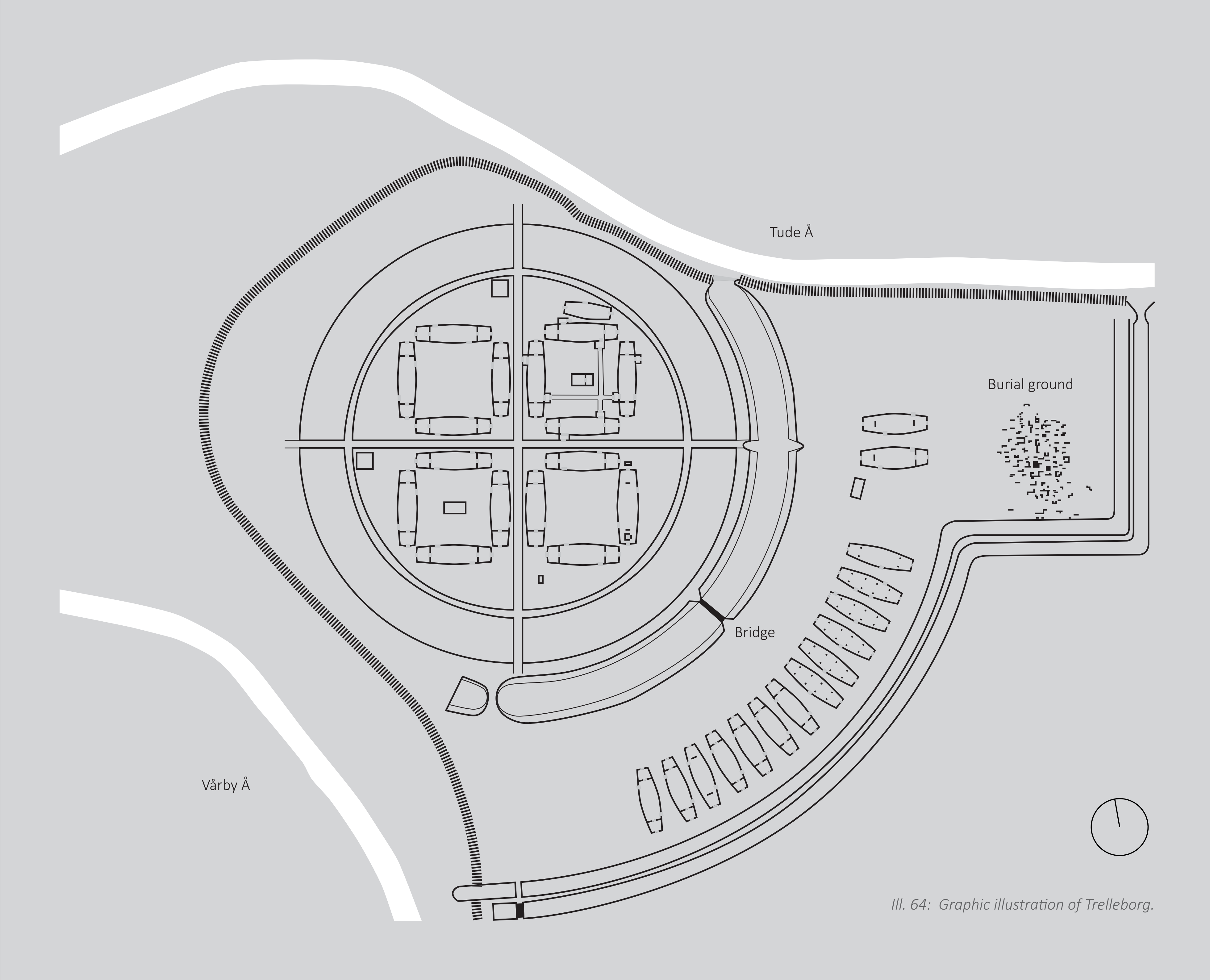
The new experience and knowledge center is set to constitute a portal to the site that connects spaces and emphasizes the trip to the Trelleborg monument.

The connection becomes a journey

To create a natural transition between the arrival and the Monument, a loop is formed, thus creating a seamless journey that may also be interpreted as a journey of knowledge.

Circular connection

A circle is created around the loop to emphasize its organic shape and allow a display of unity and depth in the building volume.



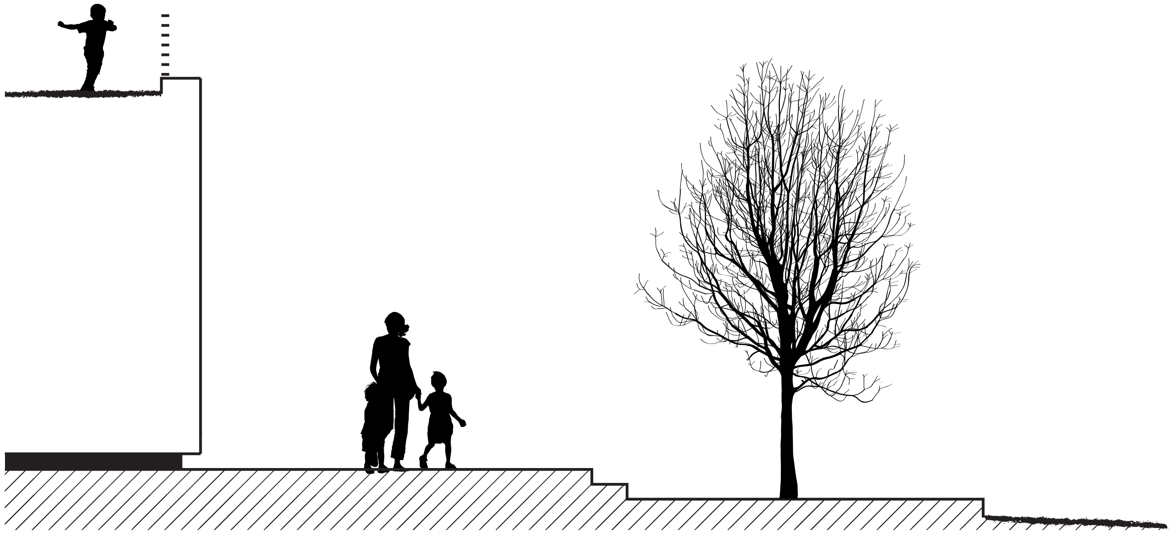
Ill. 64: Graphic illustration of Trelleborg.

Gesture

In the northwest corner of the building site there is a slight, natural slope in the terrain that leads down to the field on which the annual Viking Age Festival is being held.

From this point, direct views are created to various outdoor museum activities and a close connection is maintained to the activity site, Slagløse. This leaves space to design a large area for arrival, while maintaining a natural transition to the experience and knowledge centre.

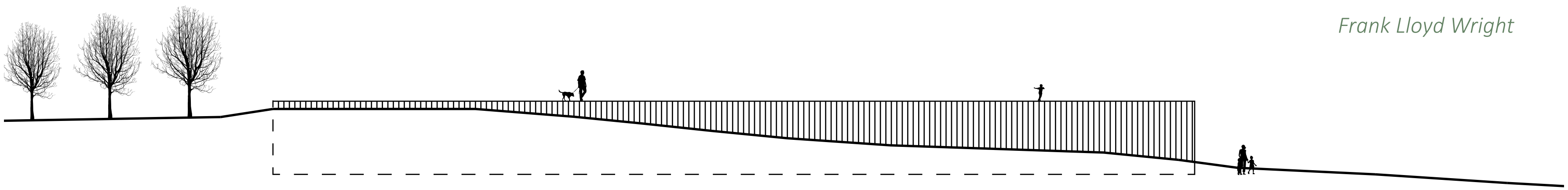
Based upon these arguments, the new building structure has been given a location (see ill. xx), but rather than placing the building on top of the slope, it has instead been integrated into it, thus embracing the natural settings and utilizing the given possibilities.



Ill. 65: In connection with the building, a terraced outdoor area, which follow the downward slope, is installed.

"No house should ever be on a hill or on anything. It should be of the hill. Belonging to it. Hill and house should live together each the happier of the other."

Frank Lloyd Wright

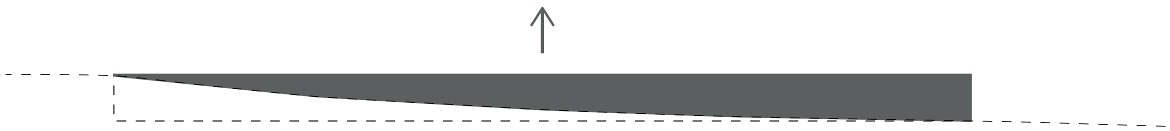


Ill. 66: The building volume is integrated into the sloping hill, thus casusing the building to gradually open up towards the monument.

Final Concepts

Emerging from the landscape

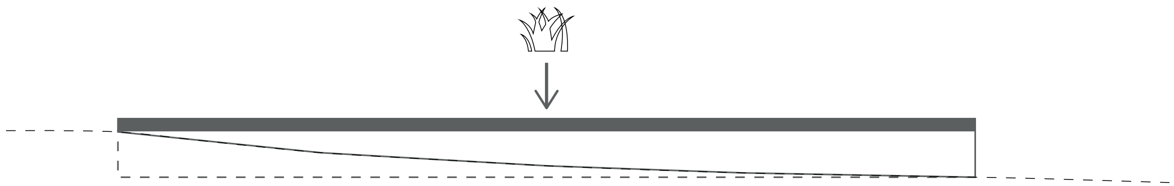
The new experience and knowledge center is integrated into the sloping landscape, which creates the illusion that the building emerges from the landscape. Simultaneously this also creates a natural opening towards the monument.



Ill. 67: Emerging from the landscape.

Creating a green roof

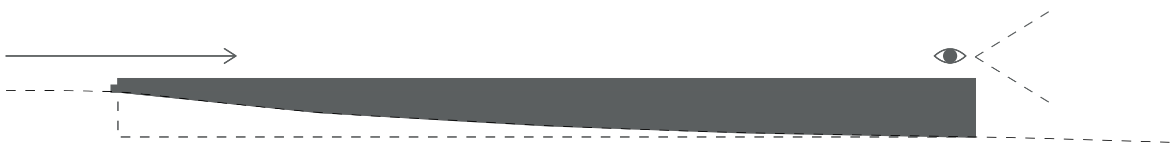
A green roof with wild grass and herbs is installed to emphasize the buildings affiliation with the site. Additionally, this is utilized as a passive energy strategy that is to contribute to the reduction of the energy requirement.



Ill. 68: Creating a green roof.

Creating a view towards Trelleborg

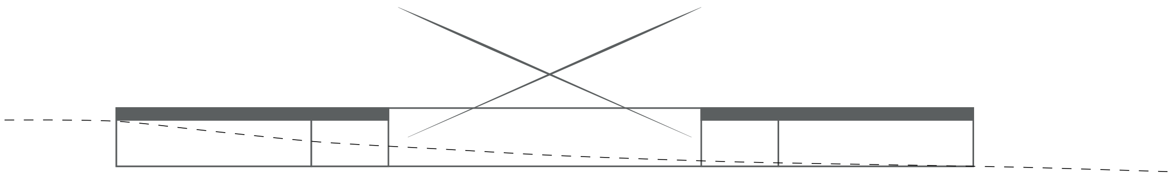
The slope of the site is used to create a natural transition to the roof of the building from which visitors are given a scenic view to the monument and its surroundings.



Ill. 69: Shape and location.

Letting in the light

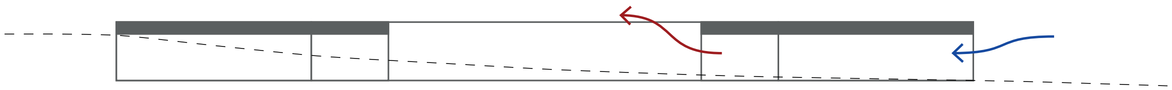
In the middle of the building, an open atrium is created to allow natural daylight into the otherwise deep building volume.



Ill. 70: Letting in natural daylight.

Conditions for natural ventilation

The atrium creates good conditions for the integration of double-sided natural ventilation.



Ill. 71: Creating the conditions for natural ventilation.

Presentation

Master plan

Plan

Area statement

Elevations

Spatial relations

Materials

Details

Sustainability

Indoor climate considerations

Daylight considerations

Groundwater and LAR-solutions

Presentation

The following passage is constituted by a presentation of aesthetic and technical aspects respectively, but also a presentation of how the two are considered and integrated into the new experience and knowledge center.


The Trelleborg Monument

The experience and knowledge centre rises from the landscape North of the activity site, Slagløse, thus providing access and great views to both the monument as well as the scenic landscape.

Also, the location provides a natural space for arrival Southeast of the building, which is bounded by wild vegetation that creates a natural transisition to the building and surrounding context.

Ill. 72: Masterplan

Trelleborg New Experience and Knowledge Center, is integrated into the scenic environent near the Trelleborg Monument, using a soft, circular shape and natural, Nordic materials that create a modern, yet respectful expression.


Ill. 73: Trelleborg New Experience and Knowledge Center seen from the monument.

Plan

The building's plan design is based upon a wide range of design criteria presented by the competition developers and redefined in order to fit with the master project's focus areas and issues in relation to both architecture and engineering.

As such, the functions of the building are oriented around a loop that emphasizes the movement leading visitors from the arrival area to the monument.

Foyer / Hall

The foyer constitutes the heart of the building which all visitors must pass through upon arrival and when exiting the building.

Upon entering the building, the visitor is naturally drawn towards the foyer, which faces a large open atrium, thus ensuring that the natural daylight reaches the center of the building.

From here, each user may find passage to the functions which they seek whether they are visitors or permanent staff.

Café / Multifuntional area

The café is located towards Southwest with a direct view to the monument from the outdoor terrace.
It lies as a natural extension of the foyer by which it is ensured that the visitor is made aware of its location both upon arrival and when leaving to explore the monument.

In the same space, a multifunctional area meant for lectures and other gatherings is placed, thus making it possible to use the areas either independently of each other or combined as one big space.

Offices

The offices are located towards northwest in order to avoid direct glare and excessive overheating from solar rays during workhours.

This area, which includes workspaces for ten people, a meeting room that may contain up to 14 people, toilet and bathing facilities, and a kitchenette with adjoining dining area is accessed either from the staff entrance or from the foyer, thus making it possible for the permanent staff to mingle with visitors and make the building audience more diverse.

Exhibition

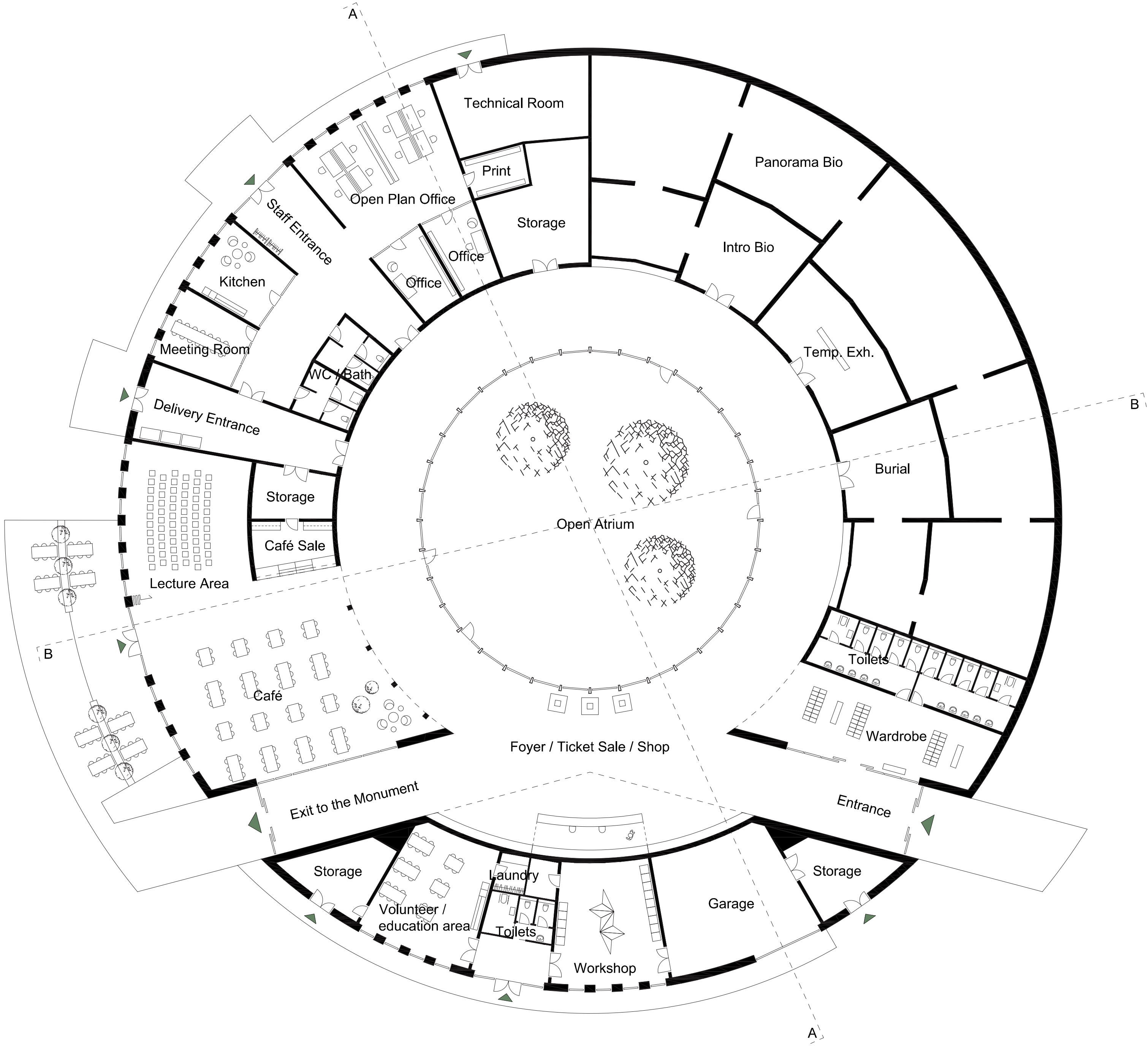
The exhibition is the only large space which do not require daylight, and this has thus been placed up against the hillside to exploit its cooling properties. Simultaneously the hall, from which the entry point is, functions as a buffer and resting zone, that prevents the exhibitions from being directly exposed to the outdoor climate conditions.

Since mechanical ventilation is required when dealing with exhibition artefacts, natural ventilation is not needed and window openings are therefore not necessary

Volunteer / workshop area

Areas for volunteers and educational purposes are located towards south to ensure quick access to the activity site, Slagløse.

In relation to these quarters, a workshop, storage facilities and a garage for larger agricultural machinery has furthermore been integrated without direct access to the remaining part of the building as it is hereby made possible to install a wall functioning as a sound barrier between the two parts - thus avoiding noise from the workshop and garage to reach the public spaces.



Ill. 74: Furnitured Plan Drawing. NIS.

Area Statement

The area statement indicates the given gross area, as have been estimated necessary to fulfill the requirements of each room. This was provided by the competition developers.

Next to it, is the actual gross area of the proposed design.

As seen, the actual gross area surpasses the desired area with a total of 1.070 m2, which in competitions may be reason for disqualification.

However, the additional space is primarily caused by the loop-shaped hall, which is deemed fundamental for the concept of the design.

Another reason for the added space is the integration of an independent garage, which is meant as an extension of the workshop where project requiring much ventilation may be processed.

Finally to fully embrace the circular geometry, it is sometimes necessary to embrace rounded areas despite them not being necessary to fulfill the spatial requirements.

Welcome zone (zone 1)	**Desired Gross Area (m^2)**	**Actual Gross Area (m^2)**
Foyer	100	160
Information / ticket office / shop	70	85
Café (including pantry kitchen)	235	240
Wardrobe	50	85
Toilets	50	60
Multifunctional lecture area / scene /teaching area	80	90
Subsum	**585**	**720**

Behind the scenes (zone 1)		
Offices	110	90
Meeting room (including separate kitchenette)	40	30
Storage	100	150
Personelle toilet / Bath and changing room	40	40
Workshop	70	65
Room for volunteers / education	60	65
Waste room	20	25
Subsum	**440**	**465**

Permanent Exhibition (zone 2)	Desired Gross Area (m^2)	Actual Gross Area (m^2)
Exhibition area (incl. UV niches and break areas)	650	680
Subsum	**650**	**680**

Temporary Exhibition (zone 2)		
Temp. exhibition (incl. UV niches and break areas)	50	65
Subsum	**50**	**65**

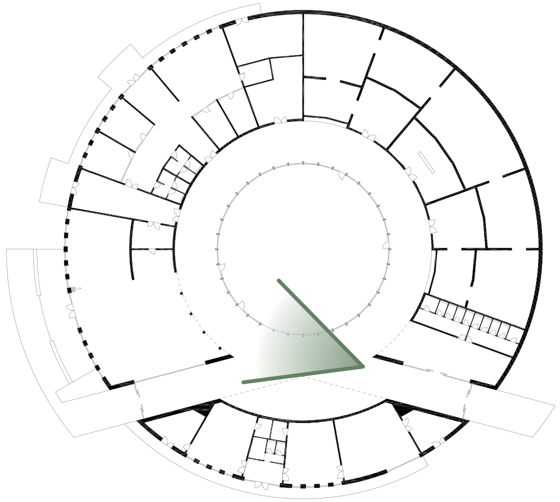
Gross Area 1		
Total	**1.725**	**1.930**

Gross Area 2		
Addition	280	1070
Total	**2.005**	**3.000**

* Areas such as equipment rooms, stairwells and hallways, which are not scheduled, have been included in the total gross area m^2.

Diagram 04: Area statement.

The Foyer / Hall



Ill. 76: Placement of visualization view.

Upon entering the foyer, the visitor is naturally lead towards the information desk due to the large open atrium that lights up the area.

From here merchandise or tickets to the temporary exhibition may be purchased, and access is obtained to the adjoining functions.

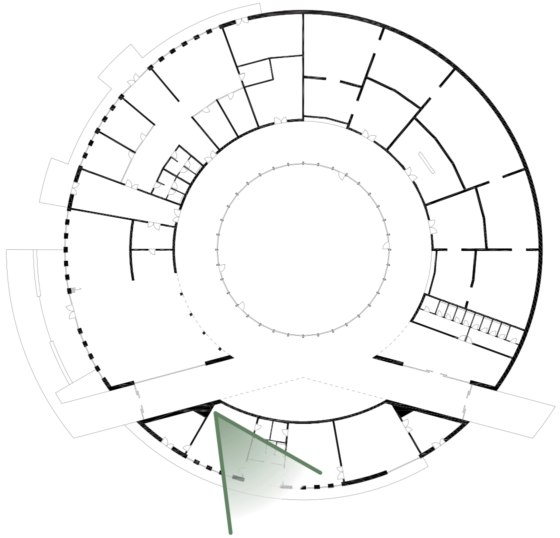
Elevations

Ill. 77: Elevation South.

Ill. 78: Elevation West.

Ill. 79: Visualization of the Volounteer area.

Volunteer / education area



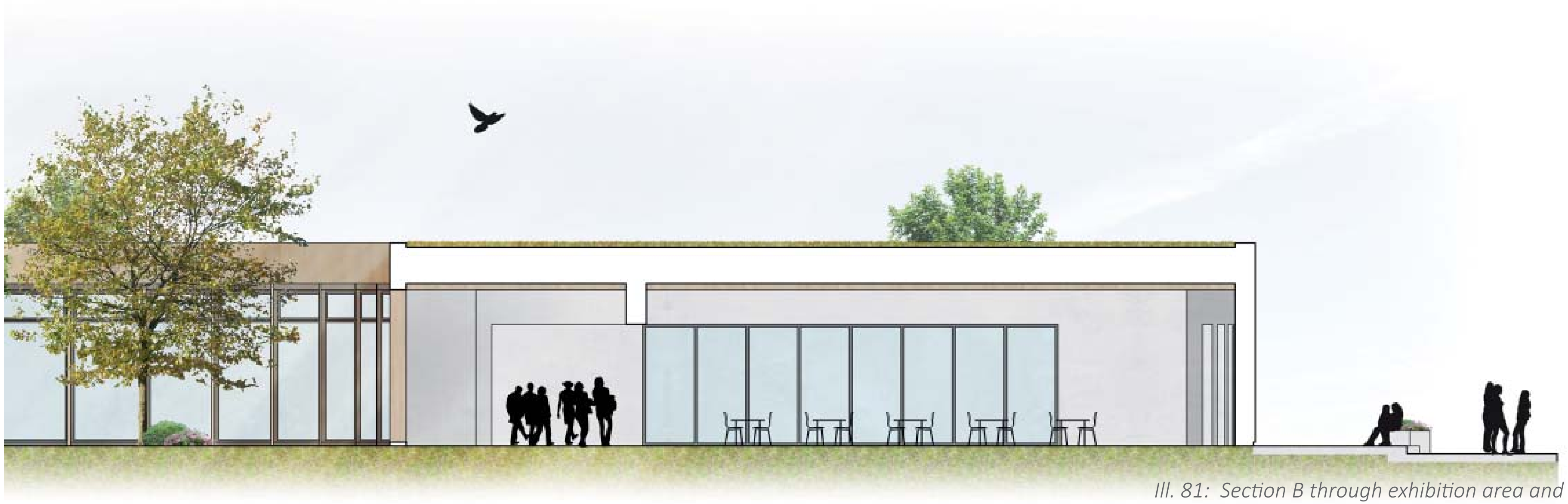
Ill. 80: Placement of visualization view.

The volunteer / education area is located with direct connection to the activity site, Slagløse.

Thus, it is possible for volunteers to quickly gain access and pupils on school trips have good views to the activity site which they are to engage in.

The seemingly secluded location furthermore contribute to create a more relaxed atmosphere, which is what Slagløse is known by.

Spatial Relations



Ill. 81: Section B through exhibition area and café.

Ill. 82: Section A through workshop, foyer and office area.

Materials

In accordance with the demands of the competition developers, the new experience and knowledge center is executed in materials that emphasize the buildings connection to the natural surroundings.

Based on the principles of Nordic architecture, the building is thus executed in a light-colored concrete which has a smooth, grey finish that resembles the aesthetics of natural stone, and in European oak which compliments the cool grey surface by providing it with a warm glow that in time will become less distinguished as the patina becomes paler.

In terms of durability, the materials are both known for having a long lifespan as e.g. European Oak is a type of hardwood that may last between 15 to 25 years depending on the climatic conditions on site and degree of maintenance, whereas concrete may last for several generations, has great structural and thermal mass properties and is highly recyclable.

However, while concrete has many advantages that also include acoustic performance in terms of reducing airborne noise transmission, providing separation of sound between rooms, and reducing noise from exterior sources, exposed concrete may heighten impact sound, and thus create a bad acoustics.

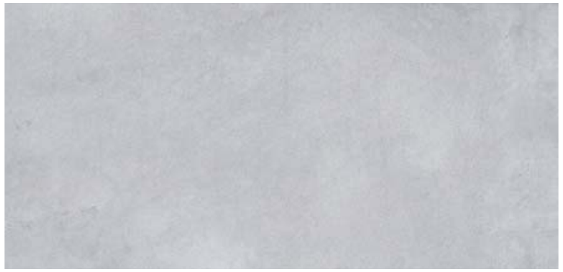
Ill. 83: Inspiration for use of natural materials.

To prevent this, sound barriers have been added to some of the internal walls in rooms that are frequently in use, oak is implemented as lamellas in the ceiling to shatter sound and the ceiling is furthermore covered by acoustic Troldtekt plates that are used to absorb incoming sound waves. This in order, to create a good acoustic indoor environment.

As such, each material is chosen based on its inherent properties and aesthetic expression when combined.

Ill. 84: Troldtekt.

Ill. 85: Oak - New and with patina.



Ill. 86: Light Concrete.

Details

The following details including roof, wall, window and foundation have been drafted in accordance with Danish standards in order to create a building that is able to meet the requirements of the Building Regulation of 2020.

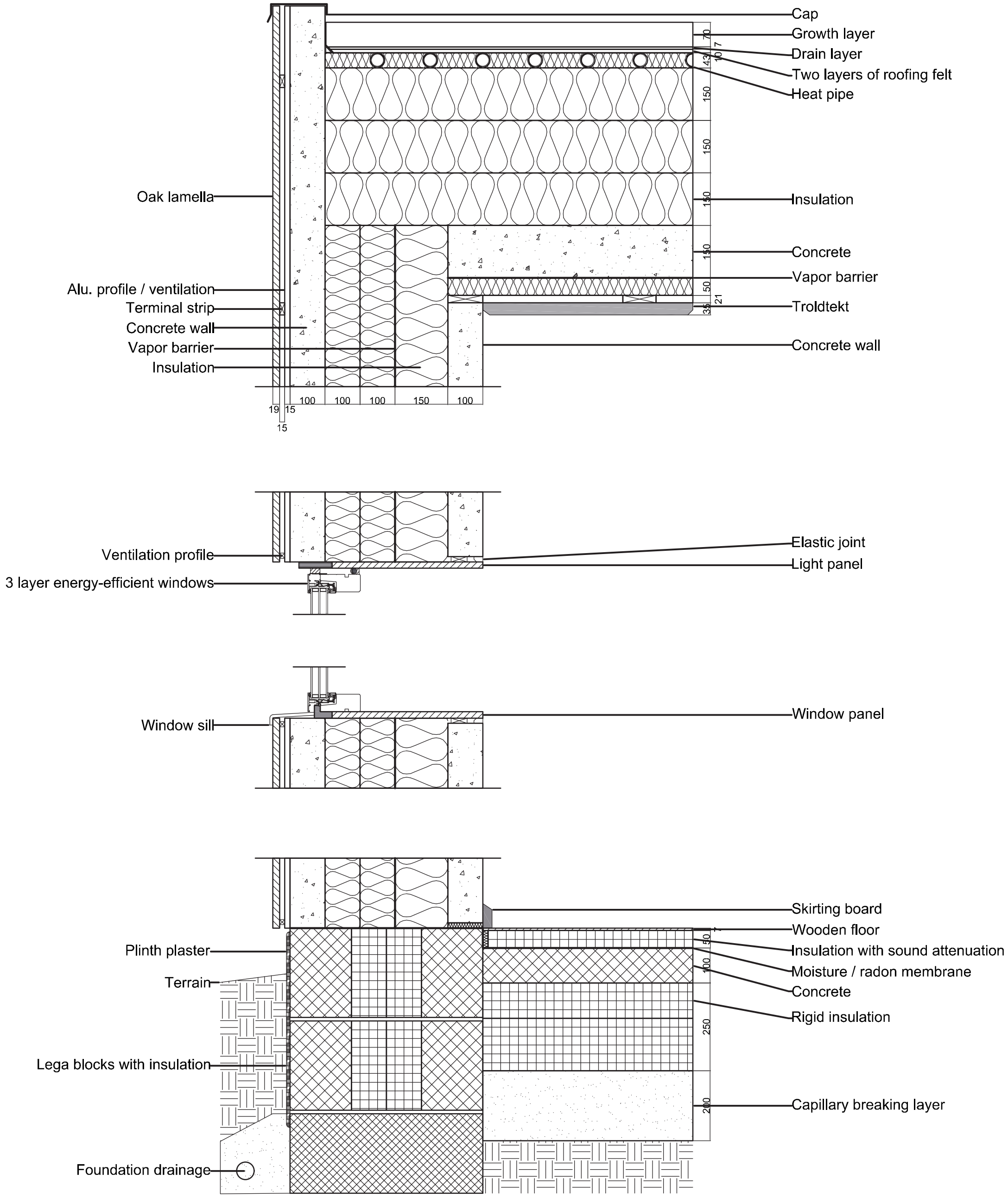
This includes integrating various passive design strategies of which one is to create a well insulated building envelope.

To ensure this is the case, ROCKWOOL Energy Design has been used to develop various designs and ensure that these achieve a sufficient R-value.

The final R-values are as follows:

- Roof: **0,06 W/(m²k)**
- Wall: **0,09 W/(m²k)**
- Foundation: **0,08 W/(m²k)**

(See appendix xx)



Ill. 87: Construction details.

BE15

In the design criteria, it is stated that the experience and knowledge center should meet the energy requirements of the building regulation 2020.

To document the energy production and consumption in the new building, the calculation program, Be15 has been used, thus also allowing the design to develop with regards to fulfilling the energy frame.

As the indoor climate in exhibition areas in terms of air quality, light etc. varies greatly depending on the displayed items, specialists are often assigned to design the exhibition as this requires specified knowledge regarding light intensity, ventilation requirements, atmosphere, strategic placement etc.

Key numbers, kWh/m year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
136,1	0,0	136,1
Total energy requirement		37,8

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
71,8	0,0	71,8
Total energy requirement		37,8

Energy frame BR 2015

Without supplement	Supplement for special conditions	Total energy frame
41,3	0,0	41,3
Total energy requirement		37,6

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
25,0	0,0	25,0
Total energy requirement		24,3

Ill. 88: Key numbers from the Be15 calculation.

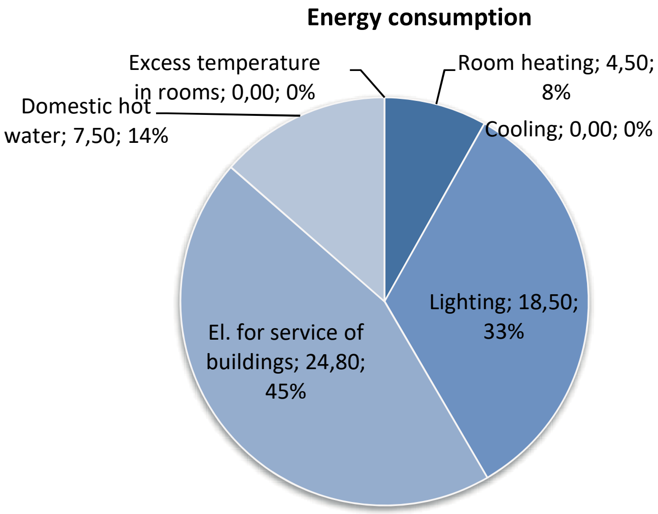
For this reason, the calculations regarding the exhibition areas should only be considered as being an estimate and thus a certain margin of error must also be recognized.

Building structures containing functions such as offices, schools and cultural institutions are considered to be a 2020 building if the energy requirement does not exceed 25 kWh/m^2 in supplied energy for heating, ventilation, domestic hot water, cooling and lighting.

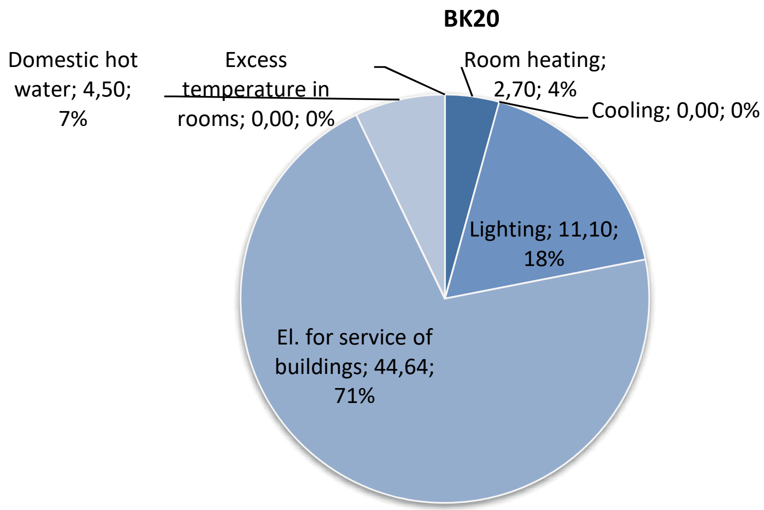
To achieve these goals, it is important to consider building orientation, size and orientation of openings in the facade, and density of the climate screen, roof and floors, as these severely impact the heat loss and gain.

Due to the shifting climate conditions in Denmark, it is important to design a building, which accommodates the energy and heating demands both during the summer and winter period. Illustration 93 displays the el consumption vs. production throughout the year and it is obvious that while the integrated solar cells, are most efficient during the summer, the energy consumption is larger during the winter due to the increased need for artificial lighting as well as the need for mechanical ventilation to obtain a satisfactory indoor climate.

Be15 uses primary energy factors when calculating the energy requirement and, these factors are each multiplied with their respective consumption form.



Ill. 89: Energy consumption in percentage.



Ill. 90: Energy consumption in percentage for BK20.

District heating has a factor of 0,6, whereas electricity has a factor of 1,8, thus making this the most expensive form of energy.

This is not very advantageous when making calculations for non-residential buildings, as lighting must be included in the energy frame, and since exhibitions are often filled with atmospheric lighting fixtures the required energy for this feature alone has a large impact on the total energy requirement. (see ill. 89)

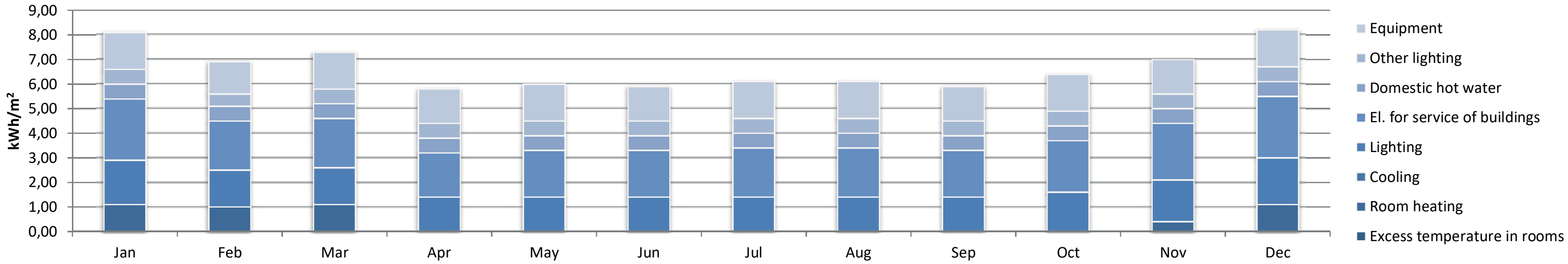
The same applies to the form of ventilation, which in exhibitions rely solely on mechanical ventilation in order to avoid fluctuations in temperature, relative humidity etc.

To lower the need for purchased energy, solar cells have been installed on the roof in accordance with the local plan for the area, and with further integration of geothermal heat West of the building, the building has been included in the building class of 2020.

As mentioned, the calculation is however only an estimate, and it must thus be expected that the building might have a higher energy requirement.

For this reason it has also been tested whether it is possible to lower the total energy requirement further with the integration of more solar cells, while still keeping the amount of solar cells below the allowed 20 % of the roof area- This it is.

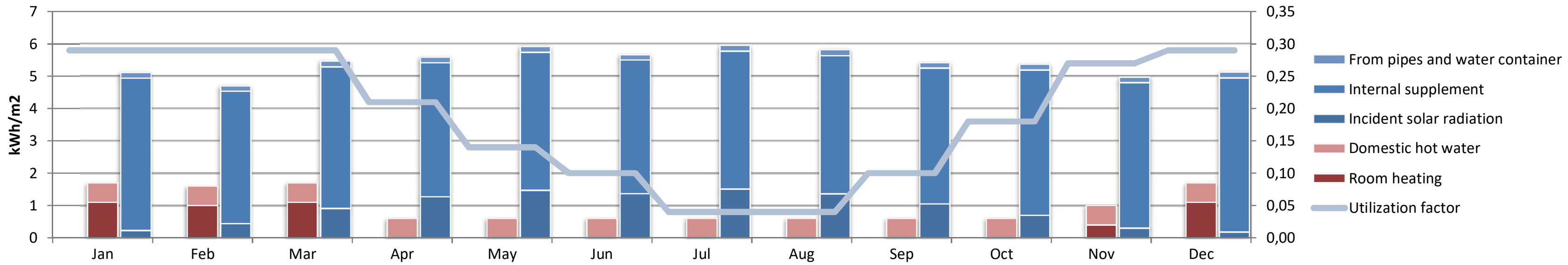
Energy consumption



kWh/m^2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Excess temperature in rooms	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Room heating	1,10	1,00	1,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,40	1,10	4,50
Cooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lighting	1,80	1,50	1,50	1,40	1,40	1,40	1,40	1,40	1,40	1,60	1,70	1,90	18,50
El. for service of buildings	2,50	2,00	2,00	1,80	1,90	1,90	2,00	2,00	1,90	2,10	2,30	2,50	24,80
Domestic hot water	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	7,50
Other lighting	0,60	0,50	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	6,90
Equipment	1,50	1,30	1,50	1,40	1,50	1,40	1,50	1,50	1,40	1,50	1,40	1,50	17,10

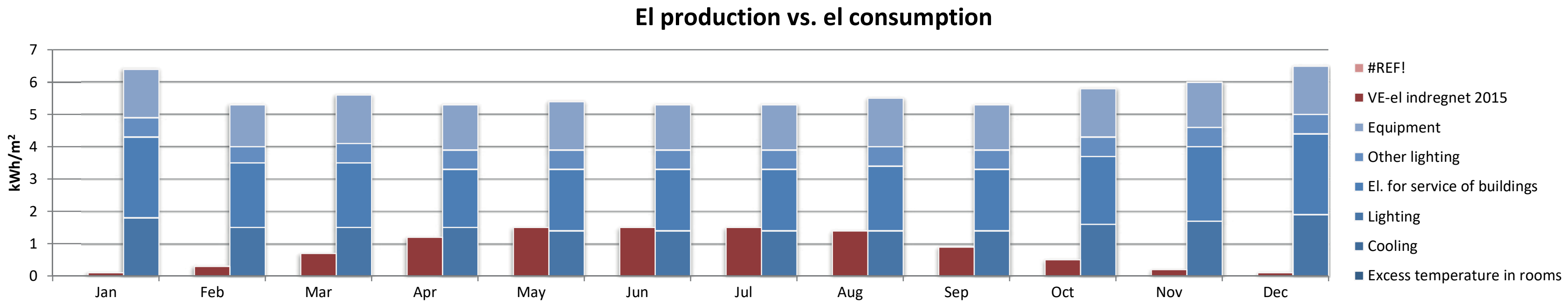
Ill. 91: Energy consumption.

Heating demand vs. Heat supply



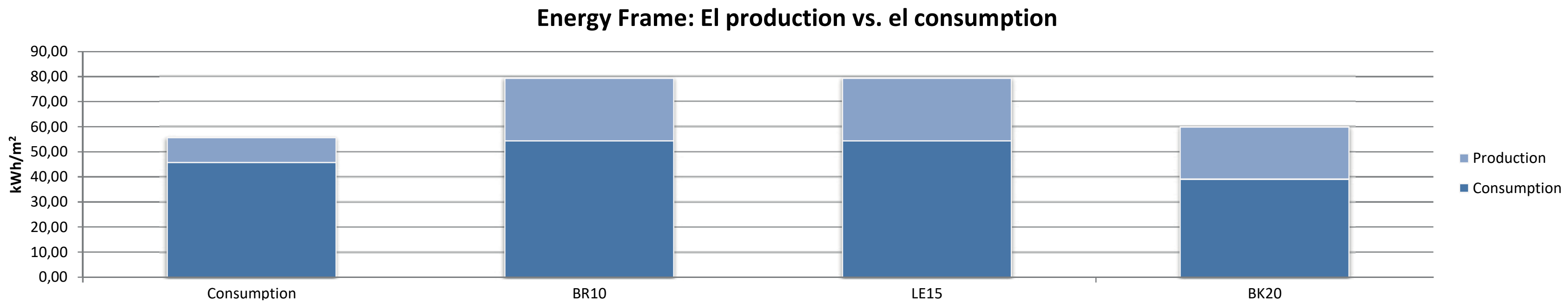
kWh/m^2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Room heating	1,10	1,00	1,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,40	1,10	4,50
Domestic hot water	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	7,50
Incident solar radiation	0,23	0,44	0,91	1,27	1,47	1,37	1,51	1,36	1,05	0,70	0,30	0,18	10,78
Internal supplement	4,71	4,10	4,38	4,15	4,27	4,13	4,27	4,28	4,20	4,49	4,50	4,77	52,25
From pipes and water container	0,18	0,16	0,18	0,17	0,18	0,17	0,18	0,18	0,17	0,18	0,17	0,18	2,13
Utilization factor	0.29	0.29	0.29	0.21	0.14	0.10	0.04	0.04	0.10	0.18	0.27	0.29	0.19

Ill. 92: Heating demand vs. Heating supply.



kWh/m^2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Excess temperature in rooms	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lighting	1,80	1,50	1,50	1,50	1,40	1,40	1,40	1,40	1,40	1,60	1,70	1,90	18,50
El. for service of buildings	2,50	2,00	2,00	1,80	1,90	1,90	1,90	2,00	1,90	2,10	2,30	2,50	24,80
Other lighting	0,60	0,50	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	6,90
Equipment	1,50	1,30	1,50	1,40	1,50	1,40	1,40	1,50	1,40	1,50	1,40	1,50	17,10
VE-el indregnet 2015	0,10	0,30	0,70	1,20	1,50	1,50	1,50	1,40	0,90	0,50	0,20	0,10	10,00

Ill. 93: El. production vs. El. consumption.



Energy consumption & production

kWh/m2 year	Consumption	BR10	LE15	BK20
Excess temperature in rooms	0,00	0,00	0,00	0,00
Cooling	0,00	0,00	0,00	0,00
Lighting	18,50	46,25	46,25	33,30
El. for service of buildings	24,80	62,00	62,00	44,64
Other lighting	6,90	17,25	17,25	12,42
Equipment	17,10	42,75	42,75	30,78
VE-el indregnet 2015	10,00	25,00	25,00	18,00
VE-el indregnet 2020	11,57	28,93	28,93	20,83

Energy factors

	BR10	LE15	BK20
El	2,5	2,5	1,8

	Consumption	BR10	LE15	BK20
Consumption	45,73	54,33	54,33	39,11
Production	10,00	25,00	25,00	20,83

Ill. 94: Energy Frame: El production vs. El. consumption.

Indoor Climate Conditions

Office space

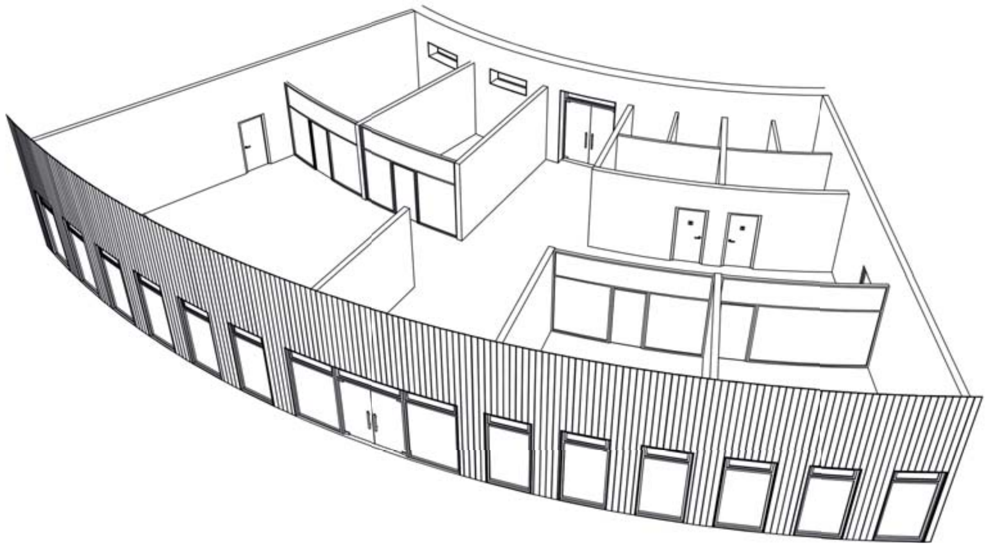
To achieve a good indoor environment, it is important to consider the air quality as this describes the degree of pollution in a room.

Bsim is a simulation program developed by the state building research institute, which in this case has been used to evaluate the quality of the indoor climate in the office space.

In relation to this, the ventilation strategy has furthermore been considered.

Ideally, the indoor climate requirements could be covered by natural ventilation, but since natural ventilation during the heating season, often causes large fluctations in temperature that thus creates discomfort among users, hybrid ventilation has been implemented instead.

This involves using mechanical ventilation during the heating season, by which fluctations are avoided, and instead relying on natural ventilation during the summer to the extent possible. Should the temperatures or level of pollution in terms of CO_2 however surpass the specified limits, the mechanical ventilation will turn on until a satisfactory climate has once again been obtained.



Ill. 95: Office space.

The limits have been defined by the building regulation which furthermore divide buildings into classes in relation to the indoor climate requirements.

The Experience and Knowledge center aims towards building class II which prescribes that the level of CO_2 must not surpass the outdoor climate with above 500 ppm, thus reaching a total of 850 ppm.

Additionally, the temperature is not to reach 26 degrees celcius for more than 100 hours and 27 degrees celcius for more than 25.

As seen by the result (see ill. xx-xx) these requirements are nicely met with no problem in terms of both overheating and pollution.
This is expected to be due to the ventilation strategy, that automatically is regulated, if the natural ventilation does not provide enough air, and simultaneously this solution is more energy effecient compared to a case in which only the mechanical ventilation is active.

Ill. 96: Temperature

Ill. 97: Pollution in PPM

Ill. 98:Building Category (PPM).

Ill. 99: Building Category (Degrees Celcius).

Daylight Conditions

Daylight Factor

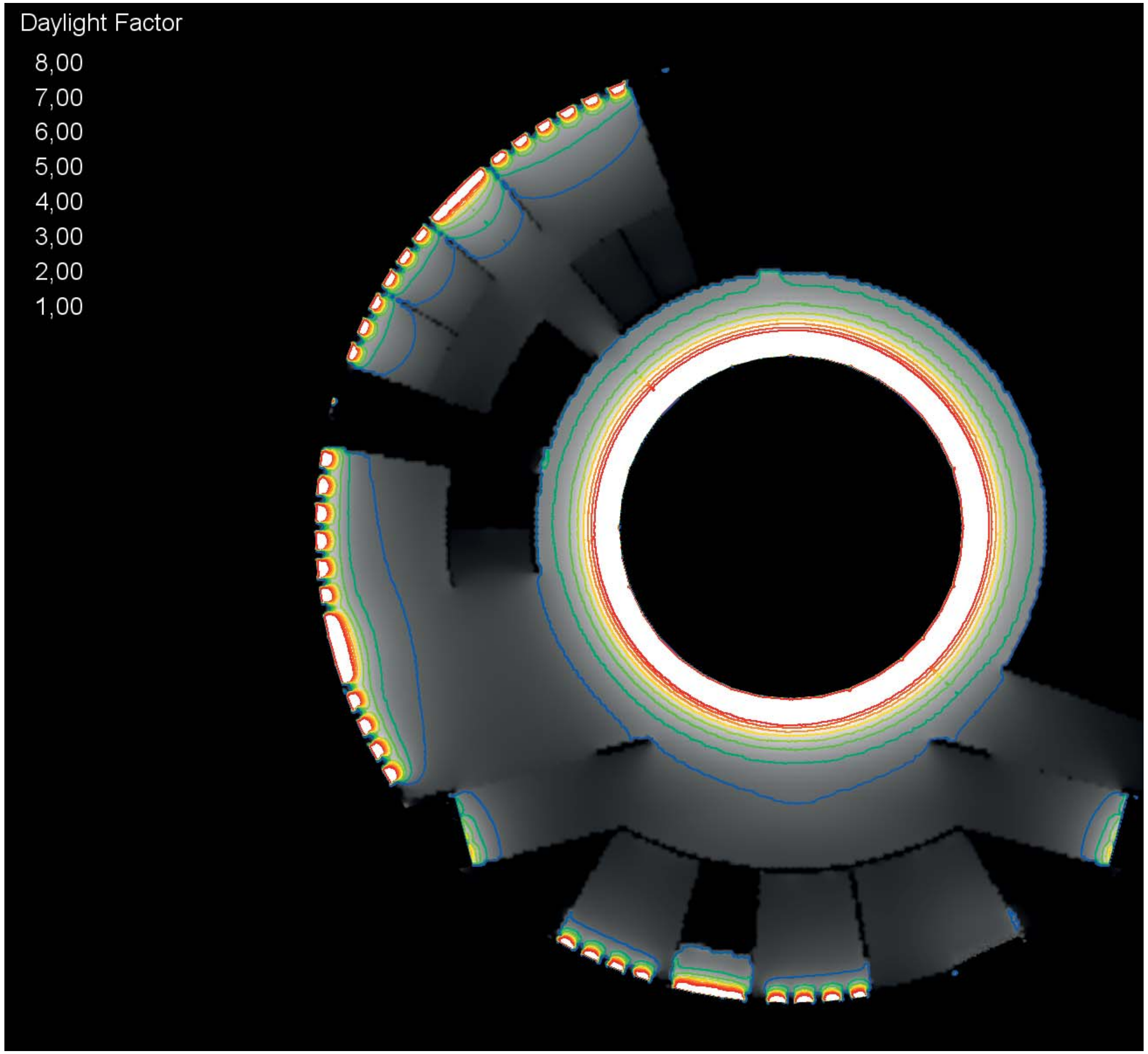
The quality of the indoor climate is greatly affected by both the macro and micro-climate on site, and the building has thus been designed with consideration to the current conditions as well as the wishes of the competition developer.

However, while striving for a high daylight factor in most rooms, some degree of compromise has been made, to keep the indoor temperature at a durable level, that does not require a high energy consumption to mechanically lower the temperature.

As such, tall, singular window openings have been integrated to allow daylight into the building as well as to create a visible connection to the surrounding context throughout the building - this, with the exceptance of both exhibition spaces which are designed as black-boxes due to conservation purposes.

As such, in terms of daylight factor, it is seen that the daylight factor is kept relatively high in the Western / Norhtwestern part of the building, which is where the offices and café are located, while the daylight factor is lower in the workshop / voluntary spaces.

This is considered to be acceptable, as the latter are only in use for shorter periods of time.

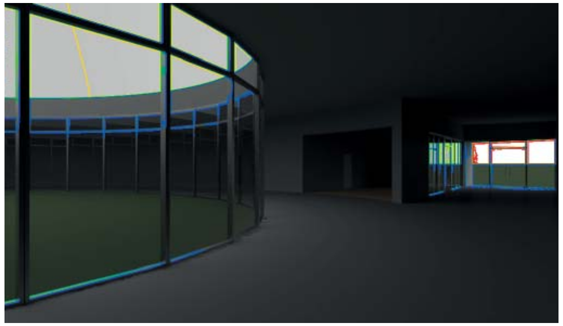


Ill. 101: Daylight Factor - June 21.

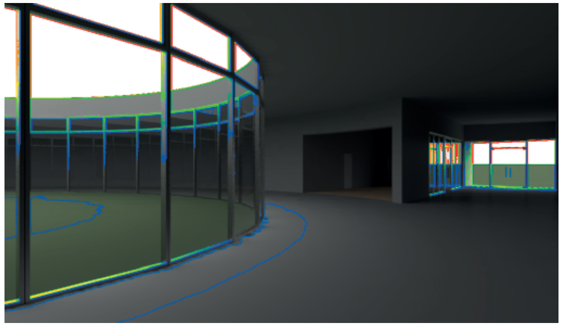
Ill. 102: Office space. December 21st at 12:00.

Ill. 103: Office space. March 21st at 12:00.

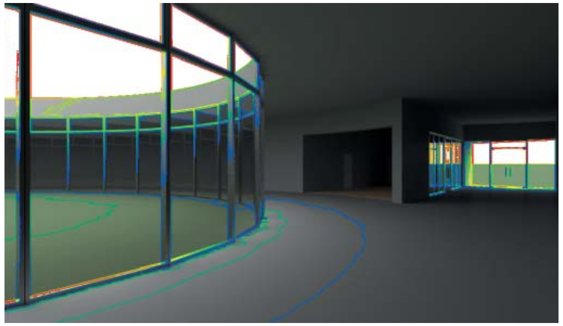
Ill. 104: Office space. June 21st at 12:00.



Ill. 105: Café area. December 21st at 12:00.



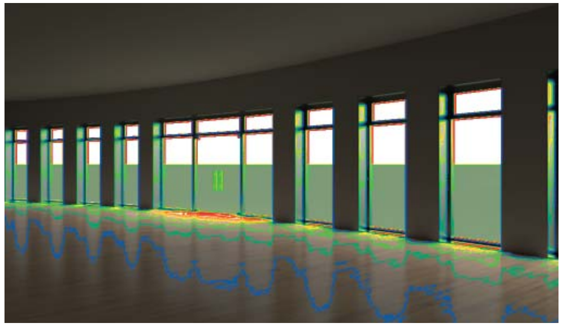
Ill. 106: Café area. March 21st at 12:00.



Ill. 107: Café area. June 21st at 12:00.

Ill. 108: Foyer. December 21st at 12:00.

Ill. 109: Foyer. March 21st at 12:00.



Ill. 110: Foyer. June 21st at 12:00.

Design Process

Initiating the design process
Initial form studies
Relation to the context
Plan design
Facade design
Facade cladding
Window considerations
Solar studies
Sustainable solutions
Structural investigations

Design Process

The following chapter is set to display the complex nature of the integrated design process by introducing the processed parameters and illustrate their impact on the design from beginning to end.

Initiating the Design Process

The following section sets out to display an overview of the thoughts and iterations that have contributed to the emergence of the final design.

As the project is partially based on an existing competition program, it has been important to, to the extent possible, meet the official demands that have been made in terms of size, atmosphere and location of each room but also the relations to internal and external functions.

To ensure that the new experience and knowledge center is an example of integrated design solutions, each design iteration has additionally been evaluated in relation to the analysis of the site regarding topography, geology (see appendix xx) and climatic conditions, as these have great impact on the energy requirements and indoor climate.

As such, the design process was initiated with a wide study of shapes, in terms of aesthetic and technical possibilities, as well as their relation to the terrain

Since the museum is of a smaller scale and the available space is rather large, it makes sense to exploit the space and create a building that gathers all activities on one floor. Thus, easing transportation, while also avoiding extraordinary safety precautions which must be made whenever the collections are not located in the ground floor. [Lord, Barry et al. 2012]

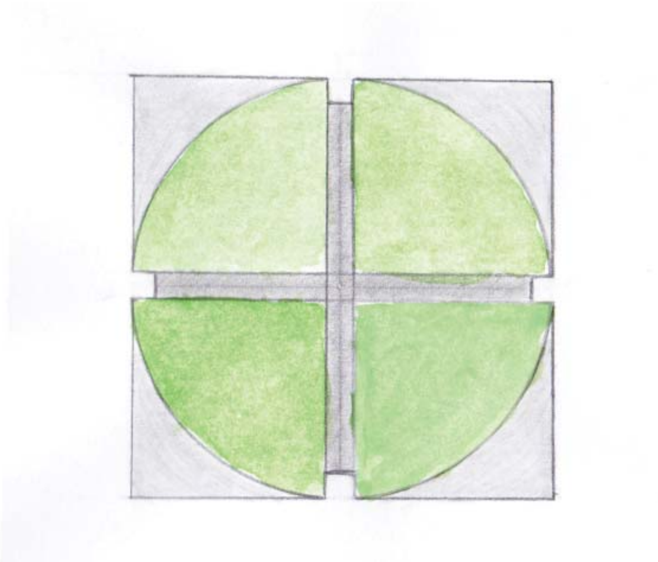
Also, the large exhibition spaces often require the building to constitute a rather compact volume that makes it possible to obtain a specific temperature and relative humidity without requiring too much energy due to external climate factors such as solar rays.

It is due to these factors that the building shapes have been kept rather simple and compact in the initiating designs, but also due to the wanted relation that should be created to the surrounding nature and monument.

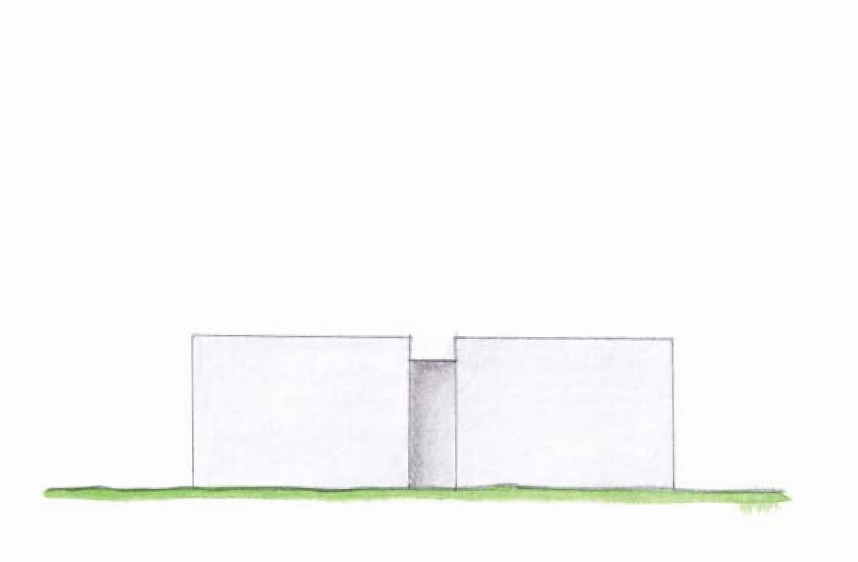
The building site is located in a natural setting, and being an experience and knowledge center for Viking age collections and activities, the building should seek to compliment the monument rather than surpassing it by being too noticeable in the landscape

Initial form studies

The Sun Wheel



Ill. 111 : Top view.



Ill. 112: Front view.

To investigate the potential of integrating Viking Age symbols into the building design, various shapes have been tested to see whether they might hold potential in terms of shape.

The sun wheel, which is a classic Viking age symbol is known by the circular shape which is divided into four equal pieces symbolizing the four seasons by two spokes.

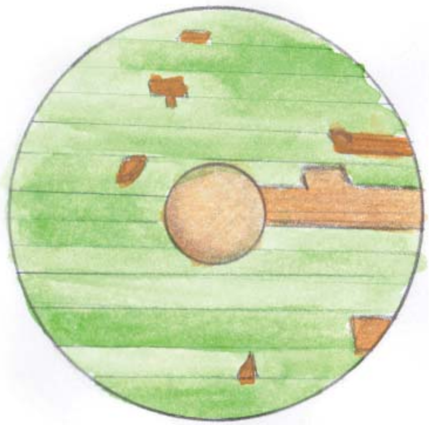
In the above drawings, this has been reinterpreted into a square building which is still clearly defined by the spokes on the side of the building.

Due to the square shape, the building holds great potential in terms of room layout, and it will furthermore be easy to create a climate screen that ensures only little transmission loss.

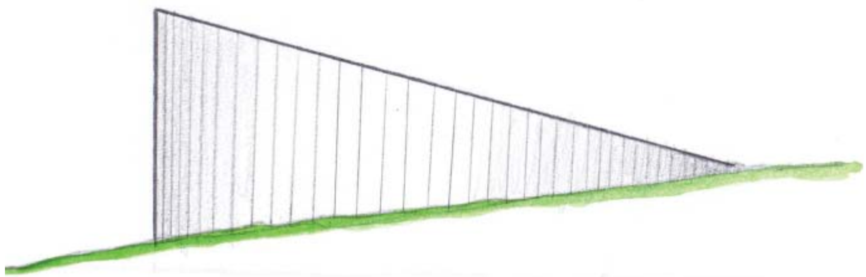
However, to create enough space for the building to accommodate all functions, the building will have to be at least 45m x 45m, thus creating a very deep and compact building volume, in which skylights will have to be integrated, if the sun is to reach the middle of it.

Another possibility is to place the exhibition area in this part of the building, as these spaces are to be designed as black boxes that do not require daylight.

The Viking Shield



Ill. 113: Top View



Ill. 114: Side view - Emerging from the landscape.

One of the most treasured artefacts of the present Trelleborg Museum is a Viking shield which is estimated to be from the same period as the Trelleborg monument itself.

The shield has slowly been degraded over the years and is as such characterized by this aesthetically, which is also reflected in the illustration above.

The drawing (see ill. xx) displays a circular building shape which appears from beneath the" shield". Additionally, the building has been integrated into a slightly rising hill, to make the building seemingly emerge from the hill, rather than to be on top of it.

To enhance the feeling of direction, the shield has furthermore been tilted up towards the monument, thus creating an inside space that gradually opens up towards the landscape.

This notion furthermore has the potential of increasing the amount of sunlight that enters the building, given that the windows follow the height of the building.

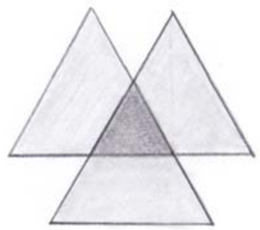
However, in terms of the thermal indoor climate, the rise may not be optimal as more energy is required to circulate the air.

Other Shapes

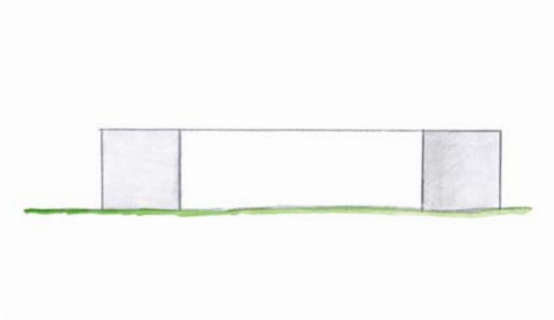
The Viking symbol, Valknut, which is characterized by its three joined triangles, thus constituting a prismatic shape, has also been evaluated. (See ill. xx-xx) However, the many triangles provide a rather large surface area compared to the actual size of the building, and it is thus assumed that the heat transmission loss will be significant.

An iteration of the circular building was the implementation of an exterior passage that goes right through the building, thus creating a straight passage to the monument.
This division additionally makes it possible to allow sunlight further into the building while also creating a noise and fire barrier through separation.

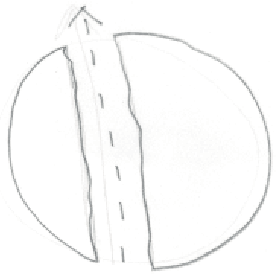
In terms of layout, the rectangular shape inhabits many of the same possibilities as the square, and while it is possible to orient the building in such a way that many of the functions directly face the monument (see ill. xx), the energy requirement might rise, as the exhibition cannot avoid facing at least one of the climate screens.



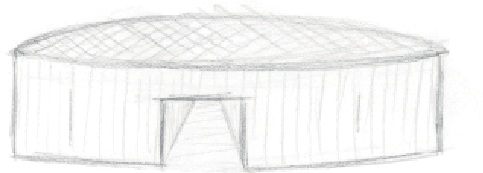
Ill. 115: Rectangular building shape (top view).



Ill. 116: Rectangular building shape (Perspective).

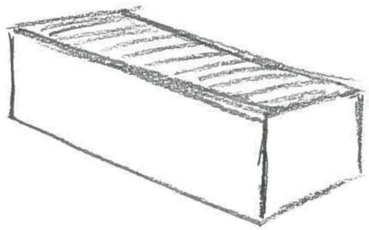


Ill. 117: Rectangular building shape (top view).



Ill. 118: Rectangular building shape (Perspective).

Ill. 119 Rectangular building shape (top view).



Ill. 120: Rectangular building shape (Perspective).

Relation to the Context

As it is required that the new building creates strong relations to the surrounding context including the monument, the activity village, Slagløse, the replica long house, and the entrance road to the site, the location of the building is very important.

Examining the site and topography, it is discovered that in the northern part, the site is characterized by a slope that descends towards west, whereas the part in which the current museum lies is flatter.

This creates different possibilities of integrating the building with the context.

The illustrations xx and xx are examples of this and it is seen, that the building which seemingly emerges from the landscape, has a much subtler character.

In terms of energy requirement, this solution additionally often proves to be more sustainable, as the building is kept cool during the summer, thus avoiding less use of mechanical energy.

However, this is only possible, as the exhibition does not require natural daylight to enter and therefore may be placed here.

Ill. 121: Building located on top of the landscape.

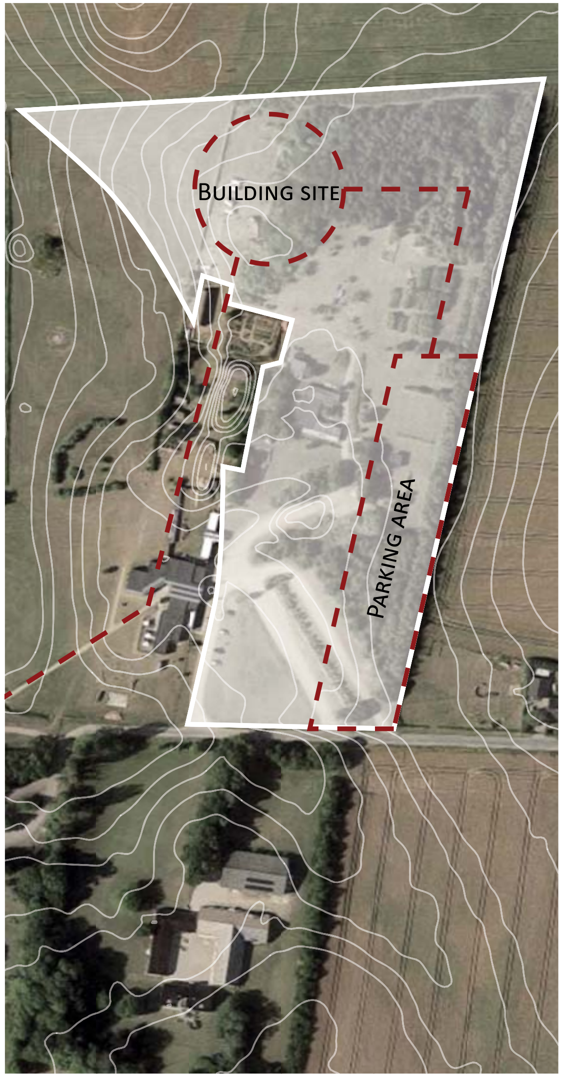
Ill. 122: Building emerging from the landscape.

By leveling the building with the ground, it is furthermore possible for visitors to gain access to the roof, by which this may be turned into active square meters that can be used as viewpoints to the monument and the surrounding context.

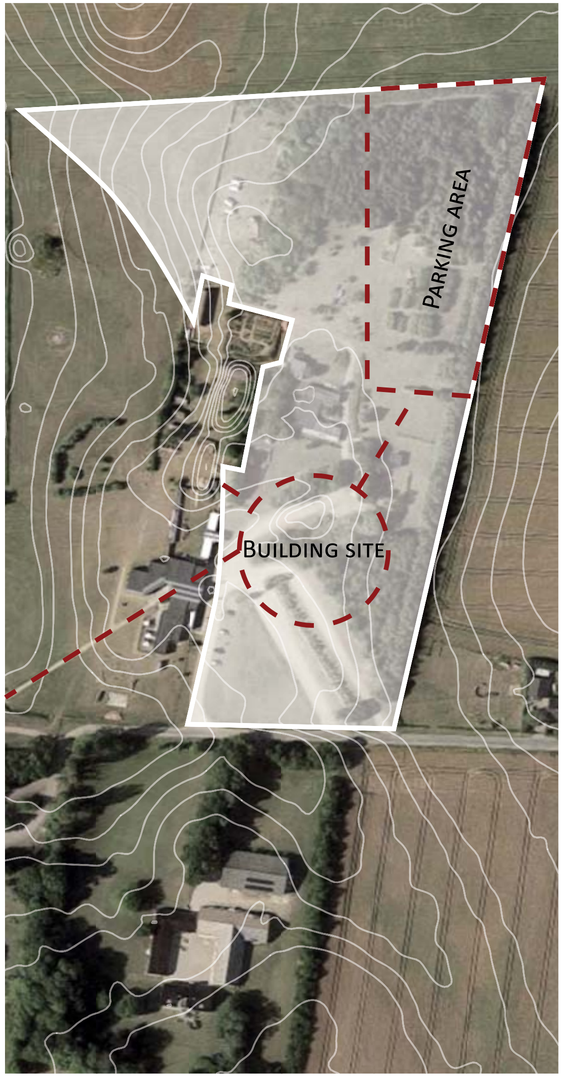
The illustrations xx and xx displays the two locations that have been taken into consideration. In either case it is important that the building volume is oriented towards the monument to emphasize the relation between the two, but simultaneously the building must also take into consideration the arrival to the building as well as the relation to the activity site, which should be a natural extension of the experience and knowledge center.

As such, the illustrations display different relations to the surrounding activities, that both hold potential in terms of connection.

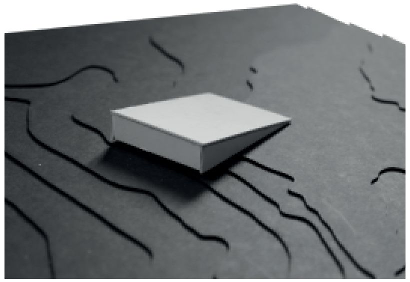
Placing the building in the northern part of the site it is possible to stage the environment in such a way that the view from the building is not marred by cars passing by, which would be the case if the building is placed towards south.



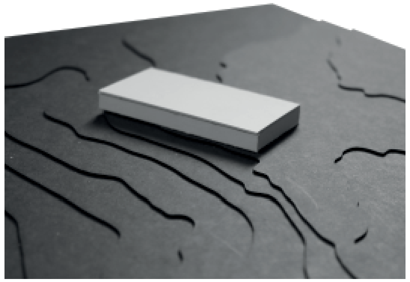
Ill. 123: Located in the northern part of the site.



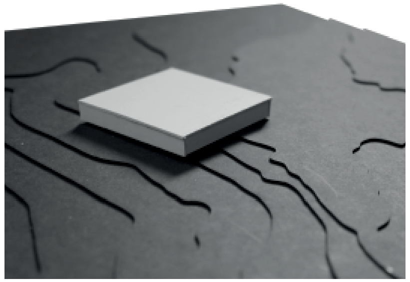
Ill. 124: Located towards southern part of the site.



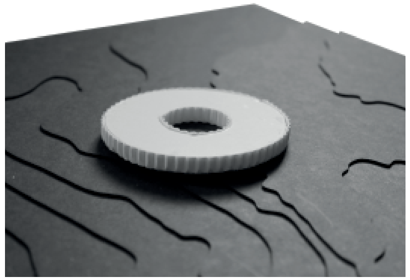
Ill. 125: Rect. building with slope.



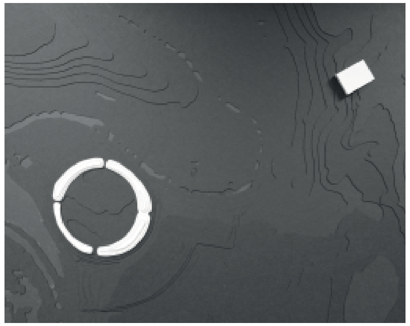
Ill. 126: Rectangular. building.



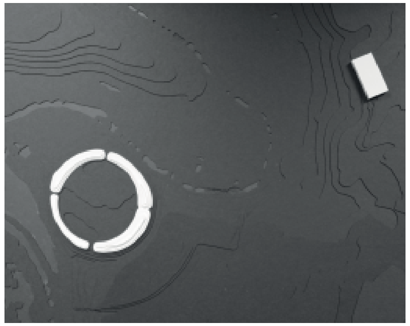
Ill. 127: Square building.



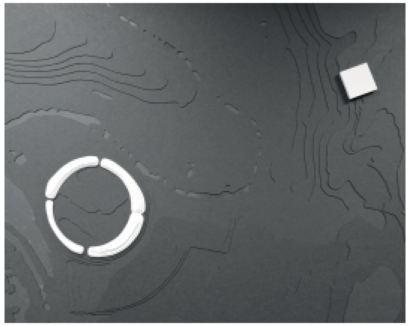
Ill. 128: Circular building.



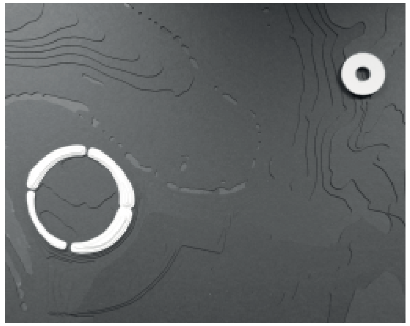
Ill. 129: Located towards north.



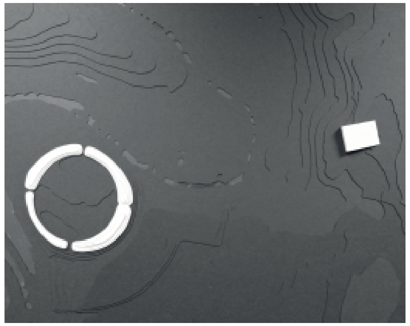
Ill. 130: Located towards north.



Ill. 131: Located towards north.



Ill. 132: Located towards north.



Ill. 133: Located towards south.

Ill. 134: Located towards south.

Ill. 135: Located towards south.

Ill. 136: Located towards south.

In the illustrations xx-xx, different shapes are matched with the masterplan to get an idea of how they fit together, and the shapes are additionally placed in respectively the northern and southern part of the site, to give an overview of, which migth be the better solution.

By orienting the building volumes relative to the monument, it is possible to create a more obvious connection, which is especially important when considering the square and rectangular building shapes, and it is seen that especially the rectangular shapes provide aesthetically pleasing connections, whereas the circular shape seems more independent due to its directionless appearance.

Simultaneously, the circular building does however seem to assimilate the shape of the monument, by which the two become unconsciously linked - something which cannot be ignored.

To further explore the possibilities and weaknesses of the designs, iterations have therefore been made and the shapes have been tested in terms of plan design.

Plan Design

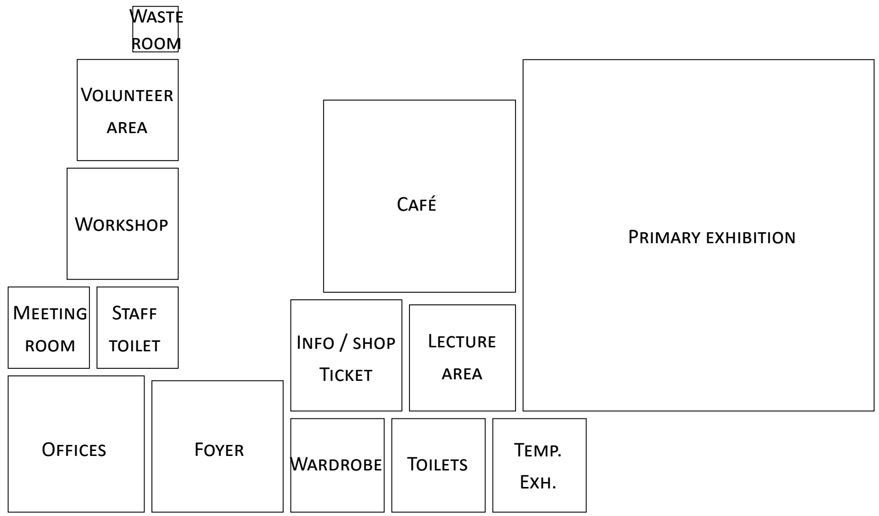
In general, most museum structures are made using straight lines, as these are often easier to work with in terms of exhibition layout, storage facilities and other functions.

As such, when planning the floor layout, many considerations have to be made as each function has various requirements in terms of practical as well as logical connections between rooms and outside activities, environmental requirements in terms of daylight and temperature, and finally the division between public, semi-public and private spaces.

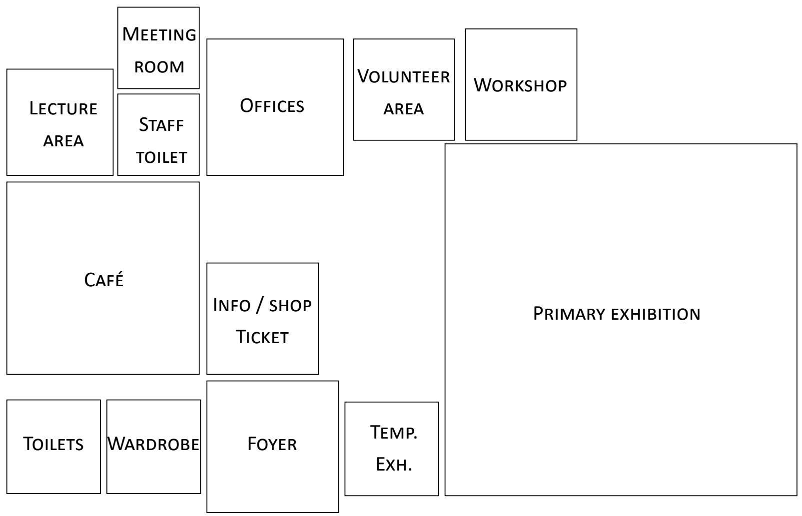
Many of these requirements have been listed in the competition program, but placing the functions accordingly has proven to be very tricky.

In the initiating phase of the plan design, pieces of paper that have the measures to obtain the exact area of the functions in scale 1:200, have been cut out and placed in lightly considered patterns in order to catalyze the creative process.

These designs have then been analyzed to find the ones that were most valid in terms of fulfilling the before-mentioned requirements (see ill. xx and xx), and some have been further processed to see if they



Ill. 137: Plan design 1 redrawn in Illustrator.



Ill. 138: Plan design 2 redrawn in Illustrator.

could fit with the exterior designs from the preceding design phase.

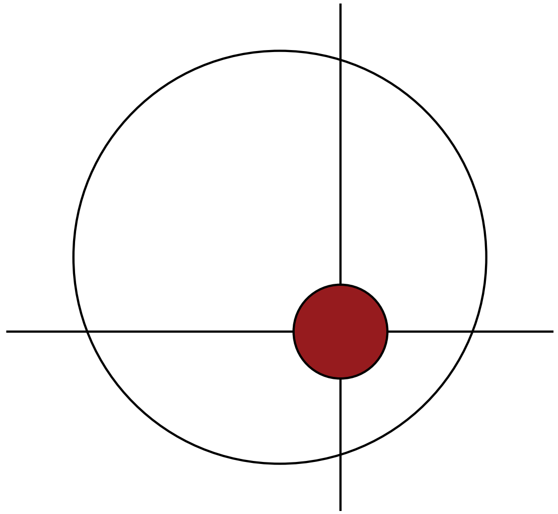
When designing the plan layout, various techniques have been used and combined in order to get an idea of not only the functional room division in 2D but also the spatial opportunities in 3D.

For this reason, the plans have first been drawn in 2D (Hand drawn sketches, AutoCAD), before quickly transferring them to 3D modelling software, (SketchUp), in order to understand the spatial opportunities and/or weaknesses.

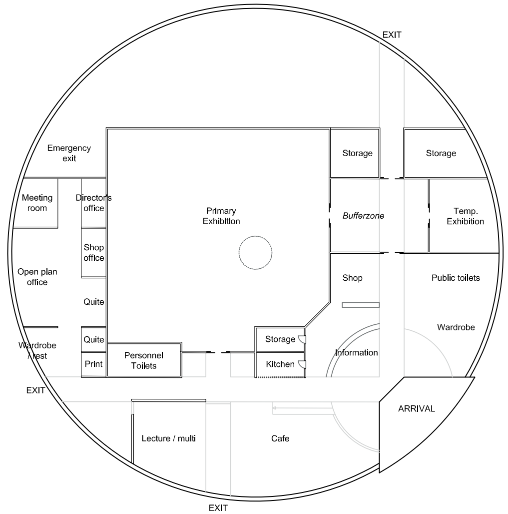
Examples of this practice is seen in ill. xx- xx, in which placement of the functions have been thoroughly processed.

The two illustrations xx and xx illustrate the entrance point of the building, around which the other functions have been placed accordingly with consideration to both climate, connections etc.

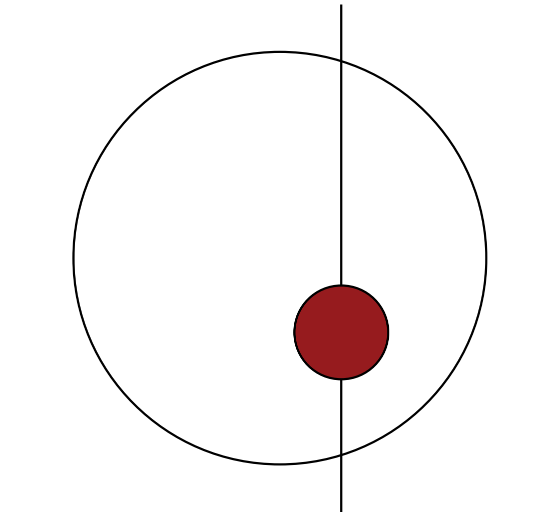
However, in both layouts, the placement of functions seems somewhat forced due to the orthogonal divisions in a circular shape, thus raising the question whether the shape should be circular at all.



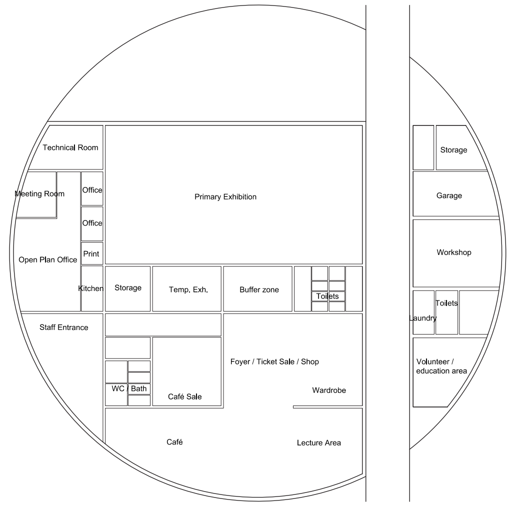
Ill. 139: Placing the Foyer / heart of the building.



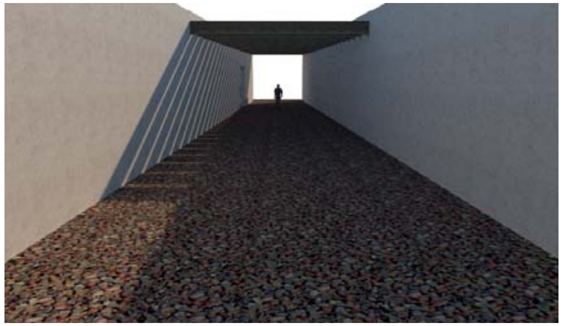
Ill. 140: Plan layout.



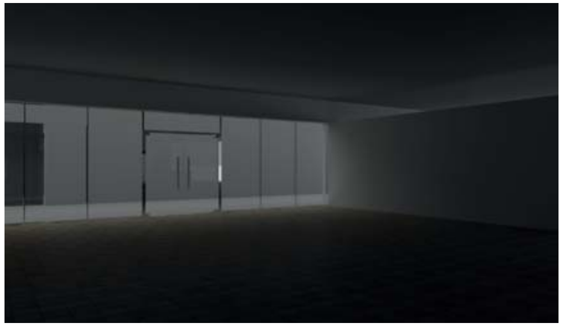
Ill. 141: Placing the Foyer / heart of the building.



Ill. 142: Plan layout.

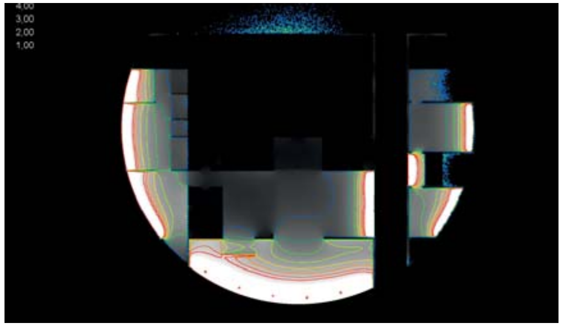


Ill. 143: The passage - Visualization.

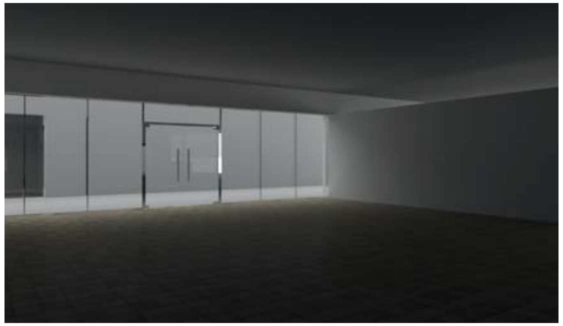


Ill. 144: Daylight - Flat roof - Dec. 21.

Ill. 145: Daylight - Sloped roof - Dec. 21.

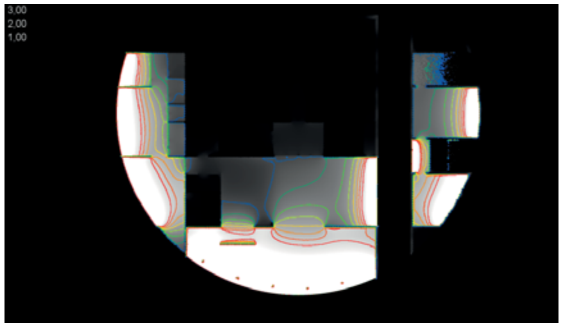


Ill. 146: The passage - daylight factor with flat roof.

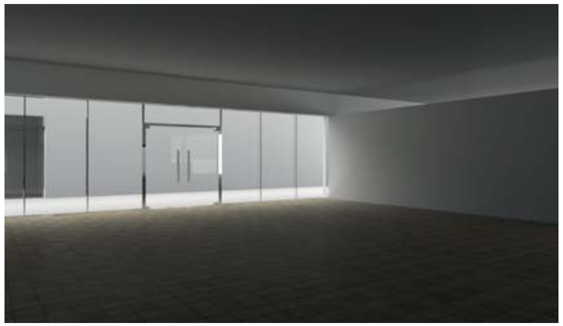


Ill. 147: Daylight - Flat roof - Mar. 21.

Ill. 148: Daylight - Sloped roof - Mar. 21.



Ill. 149: The passage - daylight factor for sloped roof



Ill. 150: Daylight - Flat roof - Jun. 21.

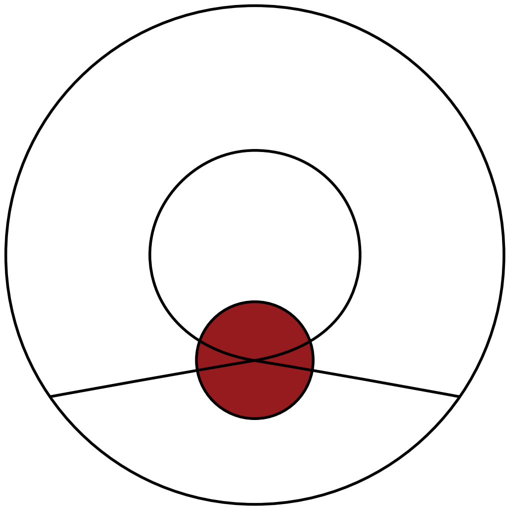
Ill. 151: Daylight - Sloped roof - Jun. 21.

Illustration xx and xx does process the orthogonal lines better, as the passage straight through the building volume contributes to making these a part of the design, but still it is found that if the building volume is to be big enough for the exhibition to be placed in the middle and have other functions located around it, a significant part of the building will become excess space that has no use. Once again questioning the validity of the circle.

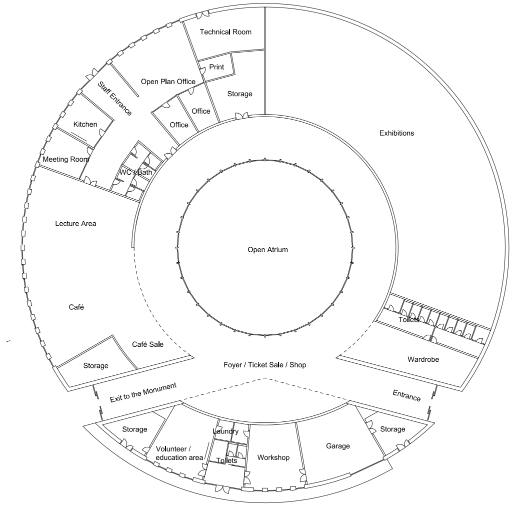
However, the division of the functions with the volunteer space and workshop area separated into their own space, might prove to be a good idea as a sound and fire barrier may then be constructed. Thus providing additional protection of the artefacts in the exhibition.

With the creation of several design that all seemed to lack something, considerations were made in terms of the actual functions of the building and what would create a nice experience for the users-something which might be an experience.

With this, a loop shape was created, which meant to guide the visitors from one point to another, providing them with knowledge and experiences as they went.



Ill. 152: Placing the Foyer / heart of the building.



Ill. 153: Plan Drawing of the loop.

Ill. 154: The plan in 3D.

Ill. 155: The building with roof.

Facade studies

Ill. 163: Treated oak to darken the color.

Ill. 164: Natural oak and black bricks.

Ill. 165: Natural oak and concrete.

Ill. 166: Treated oak to darken the color.

Ill. 167: Natural oak and black bricks.

Ill. 168: Natural oak and concrete.

When considering the aesthetics of the new building, it has been important to use materials that are known for their durability in order to create a building that may last for a long time without being in need of too much maintenance.

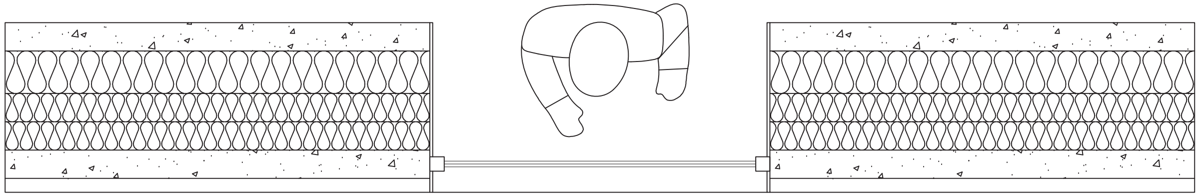
As the materials are furthermore required to reflect the nature in which they are to be located, materials that are considered to reflect the Nordic tradition have been chosen. This includes oak, concrete and glass.

These materials have therefore been tested in combination with one another and in different colors in order to see the effect of this.

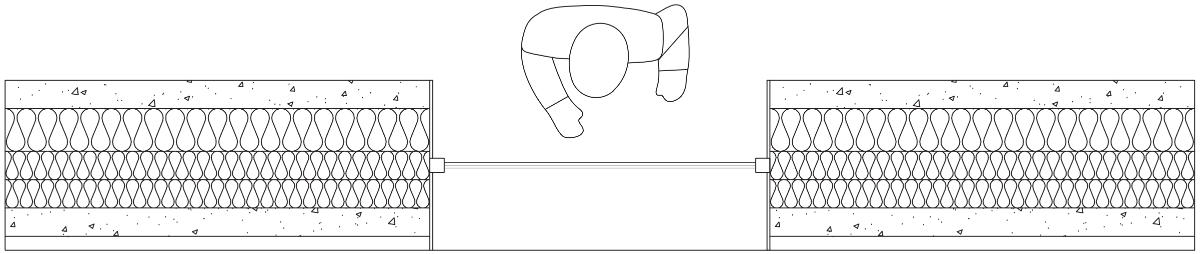
Basically, the facades are kept relatively simple with windows that do not provide much life, however by mixing the materials, an extra dimension is added which makes the facades more intriguing.

An example of this is the example xx, which divides the facades horizontally, thus completely preventing the wood from coming into contact with the damp ground while simultaneously making the building seem lighter in the top part, due to the darker color in the lower part of the building.

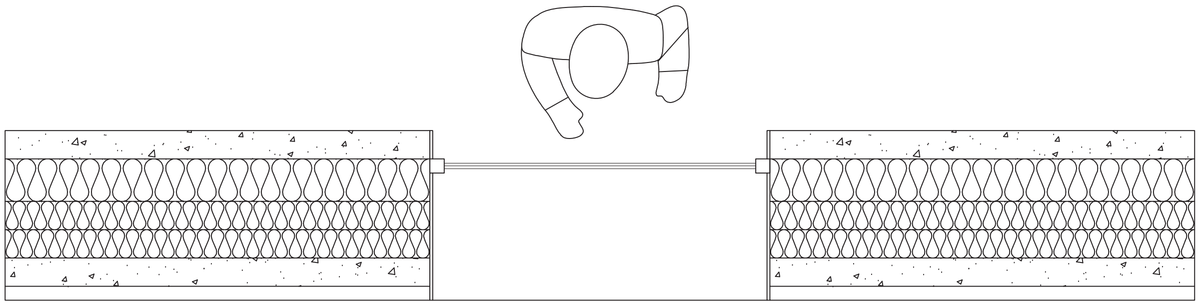
Window Considerations



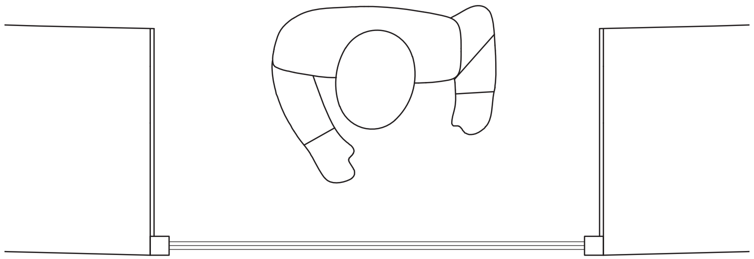
Ill. 169: Window placement - Outermost in the window section.



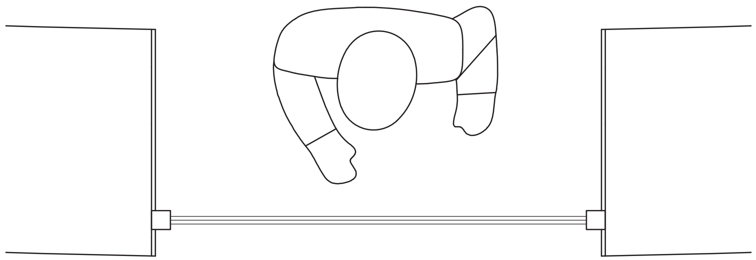
Ill. 170: Window placement - Middle of the window section.



Ill. 171: Window placement - Innermost in the window section.



Ill. 172: Window placed in the outermost part of the window - not desirable.



Ill. 173: Window slightly withdrawn from the outermost part - desirable.

As the building envelope, in time has had to achieve better insulating properties to prevent heat transmission, the walls have gotten proportionally thicker.

While this is an advantage in terms of energy efficiency and indoor climate, if ventilated correctly, the thick walls do however make it more difficult to create light designs in which the sun can gain easy access.

In the illustrations xx-xx the windows have been placed in respectively the outer, middle and inner part of the window.

These placements do each affect the line loss differently as well as the indoor climate, as the window placed in the outermost part of the window has greater potential of utilizing the solar rays for passive solar heating.

Additionally, the internal space will be affected by the location of the window, as the window either include or exclude the available space.

In the final design it has thus been decided to make the windows slightly withdrawn from the outermost part of the window, thus limiting the line loss while also including the area in front in the building volume.

Sustainable Solutions

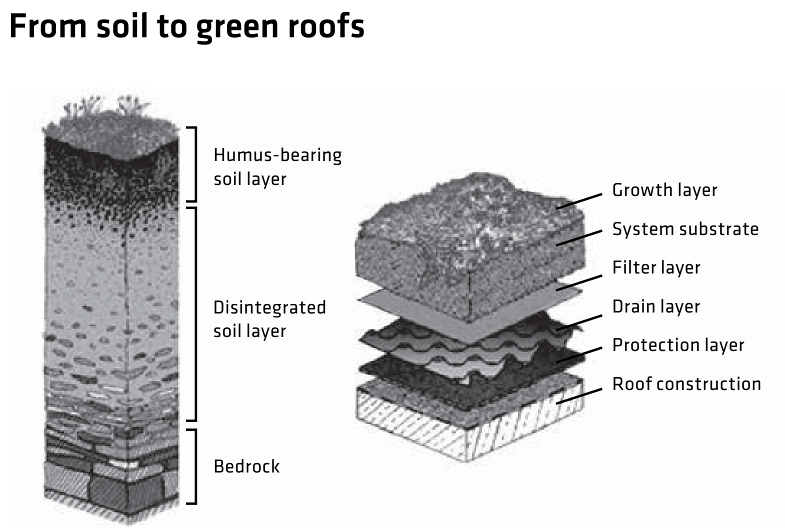
As mentioned and demonstrated, energy efficient design solutions have been considered throughout the design process, and the division into phases is as such only a way to simplify an otherwise complicated and intertwined design process.

In the design process, multiple tools have thus been involved to secure the status as an integrated design project that combines the fields of both architecture and engineering.

When planning the layout for the building, each decision has as such been based on design criteria from the developers as well as knowledge obtained regarding indoor climate conditions

By integrating various passive design strategies from an early point in the design process and analyses changes in respectively, Velux Daylight Visualizer, Be15 and Bsim, it has been possible to create a design that meets the energy requirements of the building regulation 2020- however with the integration of active energy strategies too.

One of the passive energy strategies include integrating a green roof which simultaneously has come to act as active square meters.



Ill. 174: Detail of green roof components.

Green Roof

As is apparent from the exterior shape design phase, working with a green roof has been considered already in the early stages of the design process.

Depending on whether the roof should be walked upon, the nature of the vegetation changes and so does the architectural possibilities.

By creating a slightly sloped or flat roof as displayed in in the shape studies, the roof becomes an asset to the experience and knowledge center, as it can be used to create viewpoint from which the Trelleborg Monument and the historic surroundings can be observed.

In general, the implementation of a green roof, regardless of shape, has many advantages, as it aids in lowering the temperature of the roof surface during the summer period while retaining heat during the winter period.

Also, a green room is estimated to be able to absorb approx. 50-80 % of the annual rainfall, thus reducing pressure on the sewer system. As the building site is known to have problems with drainage during periods with heavy precipitation (see appendix: Geological Information) the green roof may therefore prove to be a good investment. [Klimatilpasning.dk, ND]

Natural ventilation

When considering the indoor climate, it is important to find a solution that ensures that the building meets the requirements of the building regulation, while simultaneously being energy efficient

As an elongated building was not desirable, the building volume quickly became very compact, causing the building to become very dark, as the sun could not gain access.

Simultaneously, this also prevented natural ventilation to reach far into the building, as it had to solely rely on single-sided ventilation.

With the implementation of an open atrium in the middle of the building volume, this has been changed, and it is now possible to create cross-ventilation from one side of the café to the other, thus increasing the air change rate.

While the atrium might have contributed to a brighter and more comfortable atmosphere, it does however also have disadvantages, as the addition to the facade area contributes to an increased heat loss, and as such, the advantages and disadvantages must continuously be weighed against one another.

Epilogue

Epilogue

As an epilogue, an overall conclusion is made of the project and a reflection on the choices made during the design process and the possible improvement and further development, is presented.

Finally, a list of references and a list of illustrations is presented.

Conclusion

The aim of the master thesis has been to design a project proposal for Trelleborg New Experience and Knowledge Center, which aesthetically has been designed with the aim of creating strong relations to the natural context, while simultaneously contributing to the experience of the site.

With the design of the loop, the building is not only a pitstop on the path towards the monument, but an experience in itself, as it leads the visitors through the indoor public functions, providing them with knowledge, as they go, before finally reaching the monument with a deeper understanding of its history.

To obtain a design that is functional for all - staff, volunteers and visitors alike - thorough consideration has been made in terms of what each user group requires and based on the user group analysis, various elements have been integrated to accommodate these needs, involving strategic placement of functions, intuitive design solutions etc.

To create an atmosphere that is pleasing not only in terms of aesthetics, another aim has been to create a sustainable building design, that accommodates the individual requirements of each room, while simultaneously meeting the energy frame of the building class 2020.

While facing the complex task of preserving tangible and intangible heritage, museums must themselves also be sustainable in all aspects in order to remain valid.

In terms of energy frame and indoor climate, this has been solved by creating a design that from the very first step of the design process, has been merged with sustainable solutions that are set out to ensure the future of the building, while in terms of social sustainability, the unique experiences of the building and site combined, have been developed to intrigue visitors into visiting,

Overall the project has as such developed into a harmonic and sustainable building design that includes the existing nature and creates a visual connection to the adjacent Trelleborg Monument.

Reflection

When designing an experience and knowledge center using the integrated design process, it is important to maintain an overview of the many processes that constantly intertwine.

Ideally, this process must cover all subjects within the fields of architecture and engineering, however due to the limited timespan and labor shortages, some subjects have only been briefly considered, while others have been thoroughly processed.

In retrospect, there is still so many subjects which could have been beneficial for the legitimacy of the project. This includes being more aware of sustainability in terms of the building's lifespan, which could have been uncovered, had an Life Cycle Assesment (LCA-analysis) been conducted.

In this analysis, the life cycle of various materials is examined from early origin to the final days of use, and the choice of material could as succh have been affected.

In the same category is the DGNB Certification, which, among other things, uses the Life Cycle Assesment and Life Cycle Cost assement to evaluate to which degree a building is sustainable.

It is about integrating sustainable solutions from an early stage in the design phase, and though this has indeed been the case in this master thesis, the DGNB criteria might be helpful in terms of being more concious in terms of sustainability.

In terms of interior design, what should have been evaluated is the acoustic environment, as this has a great impact on the experience of the room.

While it is possible to apply sound absorbing panels in strategic places post construction, the best acoustic environment is obtained, if the building is shaped according to its use.

While the design process has been characterized by various iterations of plan layouts that each have strived to achieve a logic composition, the exhibition layout has been given less attention, despite this being the main sensation of the new building.

The primary reason for this is that it has not been possible to gain access to the competion material regarding the exhibition, and as such it is notknown, how much space should be dedicated to each exhibition theme and neither has it been possible to obtain information regarding the exhibited artefacts.

While it is always possible to look back and think about what could have been improved, it is however also important to consider the journey.

Designing an experience and knowledge center all by oneself, when one is used to groups of 4-5 people, is a challenge. Not only because the responsibility lies entierly upon oneself but also because potential problems in the design are not always easily fixed and this can sometimes provide heavy setbacks in the timeschedule.

On a positive note, it has however been a valuable lesson in valuing the opinion of others distribution of time, and responsibility, and since every aspect of the project has had to be treated single-handedly, much knowledge has been rediscovered during the inherent time-period.

References

The following list is based upon the Harvard Reference style, but is here divided according to the section in which it first appears and then in alphabetical order.

Motivation

[Competition Brief, 2015]
Ny Trelleborg, (2015). *Ny Trelleborg Oplevelses- & videnscenter*. 1st ed. [PDF] Slagelse: Dystan & Rosenberg, 60. Available at: https://nytrelleborg.slagelse.dk/media/7216797/Trelleborg_KP_samlet_final_1-kopi.pdf [Accessed 03-02-2017]

[Future Navigator, 2016]
Torup, L. (2016). *Find din indre viking frem.* [Online] Available at: http://futurenavigator.dk/find-din-indre-viking-frem/ [Accessed 28-06-2017]

[Lord, Barry et al. 2012]
Lord, B., Lord. G. D., Martin, L. (2012). *Manual of Museum Planning – Sustainable space, facilities, and operations.* 3rd ed. Plymouth: AltaMira Press.

[Lundgaard., Jensen 2013]
Lundgaard, I. D., Jensen, J. T. (2013). *Museums - Social learning spaces and knowledge producing processes.* 1st ed. [PDF] København: Kulturstyrelsen. Available at: https://slks.dk/fileadmin/user_upload/dokumenter/KS/institutioner/museer/Museumsdrift/museums.pdf [Accessed 28-06-2017]

[New Nordic, 2012]
Louisiana Museum of Modern Art, (2012). *New Nordic Architecture & Identity*. 1st ed. Louisiana Museum of Modern Art, Humlebæk, Denmark.

Analytical Approach

[Alizadeh, 2006]
Alizadeh, P. (2006). *Case Study as a Methodology in Architectural Research*. [Online] Available at: http://www.daneshir.ir/fileEssay/tahghighat-87-1-16-b-sy.pdf [Accessed 27-02-2017]

[Business Dictionary, ND]
Business Dictionary, (No date). *Iterative process.* [Online] Available at: http://www.businessdictionary.com/definition/iterative-process.html [Accessed 28-02-2017]

[Knudstrup, 2005]
Hansen, H. and Knudstrup, M. (2005) *The Integrated Design Process (IDP) – a more holistic approach to sustainable architecture.* [Online] Available at:
http://vbn.aau.dk/files/1624830/The_Integrated_Design_Process__IDP____A_more_holistic_approach_to_sustainable_architecture [Accessed 27-02-2017]

Sustainability

[DAC, 2017]
DAC, (2017). *Hvad er bæredygtighed?* [Online] Available at:
http://www.dac.dk/da/dac-cities/baeredygtige-byer/om-baeredygtige-byer/hvad-er-baeredygtighed/ [Accessed 25-06-2017]

[Financial Times, ND]
Financial Times, (No Date). *Definition of environmental sustainability.* [Online] Available at:
http://lexicon.ft.com/Term?term=environmental-sustainability&mhq5j=e3 [Accessed 25-06-2017]

Technical Approach

[Autodesk, ND]
Autodesk, (No date). *Passive Design Strategies.* [Online] Available at:
https://sustainabilityworkshop.autodesk.com/buildings/passive-design-strategies [Accessed 10-03-2017]

[VEB, ND]
Videnscenter for energibesparelser I bygninger, (ND). *Energikravene i BR15.* 1st ed. [PDF] Available at:
http://bygningsreglementet.dk/file/586802/BR15_kvikguide.pdf [Accessed 10-03-2017]

Tectonic Approach

[Bech-Danielsen, Beim, Christiansen, 2012]
Bech-Danielsen, Beim, Christiansen, (2012). *Tectonic Thinking in Architecture*. The Royal Danish Academy of Fine Arts, Copenhagen.

[Frampton, 1995]
Frampton, K. (1995). *Studies in Tectonic Culture: The Poetics of Construction in the Nineteenth and Twentieth Century Architecture*. MIT Press, Cambridge Massachusetts.

[Frascari, 1984]
Frascari, M. (1984). The Tell-the-Tale Detail. VIA, No. 7.

[Kucker, 1996]
Kucker, P. (1996), *The Semperian Paradigm: Developing Issues of Tectonics in Foundation Design*. [PDF] University of Virginia.

[Semper, 1851]
Semper, G. (1851). *Die vier Elemente der Baukunst*. Germany.

[The free dictionary, ND]
The free dictionary, (No date). *Tectonic*. [Online] Available at:
http://www.thefreedictionary.com/tectonic [Accessed 15-04-2017]

Trollstigen Visitor Centre

[Detail-online, 2011]
Detail-online, (2011), *Visitors' Centre on the Trollstigen Plateau*. [Online] Available at:
http://www.detail-online.com/inspiration/visitors-centre-on-the-trollstigen-plateau-107060.html [Accessed 22-02-2017]

[Reiulf Ramstad Arkitekter, ND]
Reiulf Ramstad Arkitekter, (No date). *Trollstigen Visitor Centre.* [Online] Available at:
http://www.reiulframstadarchitects.com/trollstigen-visitor-centre/t25f4r7os45ekqotsfvb4voix68caf [Accessed 22-02-2017]

Moesgaard Museum

[Moesgaard Museum, ND]
Moesgaard Museum, (No date). *Fakta om Bygningen*. [Online] Available at:
http://www.moesgaardmuseum.dk/besoeg-os/arkitektur-og-natur/udstillingsbygningen/fakta-om-bygningen/ [Accessed 23-02-2017]

[MTHøjgaard, ND]
MTHøjgaard, (No date). *Moesgaard Museum – kulturhistorie i nye rammer.* [Online] Available at:
http://mth.dk/Projekter/Offentligt-byggeri/Kultur-Idraet/Moesgaard [Accessed 24-02-2017]

Purpose and Potential

[Kongens Togt, N.D.]
Kongens Togt, (No date). *Om Danmark Bliver Til.* [Online] Available at:
http://www.kongenstogt.dk/kontakt/om-danmark-bliver-til/ [Accessed 17-02-2017]

[National Museet, 2016]
MyNewsDesk (2016), *Trelleborg sætter igen besøgsrekord.* [Online] Available at:
http://www.mynewsdesk.com/dk/nationalmuseet/pressreleases/trelleborg-saetter-igen-besoegsrekord-1664415 [Accessed 17-02-2017]

[TV ØST, 2015]
Kyed, S. (2015). ***Trelleborg slutter sæsonen med rekord.*** [Online] TV ØST. Available at:
http://www.tveast.dk/artikler/trelleborg-slutter-saesonen-med-rekord [Accessed 17-02-2017]

[VD Online, 2014]
VD online (2014), Rekord: *Trelleborgs besøgstal går bersærk!* [Online] Available at:
http://www.vdonline.dk/Slagelse/Rekord-Trelleborgs-besoegstal-gaar-bersaerk-/artikel/3577 [Accessed 17-02-2017]

[VisitDenmark, 2014]
Nielsen. T., Kirstine (2014), *Kulturturisme i Danmark – Kyst- og naturturister & Storbyturister.* 1st ed. [pdf] København: VisitDenmark, 38. Available at:
http://www.visitdenmark.dk/sites/default/files/vdk_images/PDF-and-other-files/Analyser/2016/kulturturisme-i-danmark.pdf [Accessed 17-02-2017]

Phenomenological Space Program

[Pallasmaa, 2005]
Pallasmaa, J. (2015). *The Eyes of the Skin – Architecture and the Senses.* John Wiley & Sons Ltd, West Sussex, England.

Historic and Cultural Value

[Nationalmuseet, ND]

Nationalmuseet, (No Date). *Trelleborgs Historie – Den historiske baggrund.* [Online] Available at:
http://natmus.dk/museerne/trelleborg/om-trelleborg/trelleborgs-historie/ [Accessed 03-02-2017]

Natural Qualities

[Tude Ådal, 2014]

Slagelse Kommune, (2014). *Tude Ådal*. 1st ed. [PDF] Slagelse: Jannerup A/S, 60. Available at:
http://www.hejninge.dk/wp-content/uploads/2015/10/Tude-%C3%85dal-Projektkbeskrivelse-2014.pdf [Accessed 26-02-2017]

Climatic Conditions

[DinGeo, ND]

DinGeo, (No date). *Trelleborg Alle 4, Hejninge 4200 Slagelse.* [Online] Available at:
http://dingeo.dk/adresse/4200-slagelse/trelleborg-alle-4/#oversvoem [Accessed 16-02-2017]

[DMI, 2015]

DMI, (2015). *Decadal mean weather.* [Online] Available at:
http://www.dmi.dk/en/vejr/arkiver/decadal-mean-weather/ [Accessed 10-02-2017]

[SunEarthTools, 2017]

SunEarthTools, (2017). *Hejninge, Denmark*. [Online] Available at:
http://www.sunearthtools.com/dp/tools/pos_sun.php#top [Accessed 10-02-2017]

[Windfinder, 2017]

Windfinder, (2017). *Wind & weather statistics – Korsør/Slagelse.* [Online] Available at:
https://www.windfinder.com/windstatistics/korsor_slagelse [Accessed 10-02-2017]

Formal Demands

[Slagelse Kommune, 2016]

Slagelse Kommune, (2016). *Lokalplan Nr. 1137 – Oplevelses- & Videnscenter Trelleborg.* [Online] Available at:
http://www.hejninge.dk/wp-content/uploads/2016/09/Forslag-lokalplan-1137-Trelleborg.pdf [Accessed 08-02-2017]

Design Process

[Klimatilpasning, ND]

Klimatilpasning.dk, (No date). *Green Roof Copenhagen.* [Online] Available at:
http://www.klimatilpasning.dk/media/631048/green_roofs_copenhagen.pdf [Accessed 15-03-2017]

Illustration List

Unless otherwise stated, the illustrations or pictures are created by myself, Pernille Gajhede.

Approach:

06: British Museum:
https://www.pinterest.dk/pin/444308319472597577/

09: Bagsværd Kirke
https://www.flickr.com/photos/seier/5933306410

10: Trollstigen
http://www.reiulframstadarchitects.com/trollstigen-visitor-centre/

11: Hereiane
https://3rw.no/work/rest-stop-hereiane/

12: Scarpian Ziggurat
https://www.flickr.com/photos/the-third/sets/72157621296652711/

Case Studies:

13: Trollstigen
http://www.admexico.mx/arquitectura/galerias/trollstigen-por-reidulf-ramstad-architects/318/image/5411

14: Trollstigen
http://www.reiulframstadarchitects.com/trollstigen-visitor-centre/

15: Trollstigen
http://www.reiulframstadarchitects.com/trollstigen-visitor-centre/

16: Trollstigen
http://www.reiulframstadarchitects.com/trollstigen-visitor-centre/

Framework:

45: Gul Iris
http://www.hejninge.dk/vegetation-i-hejninge-mose/

46: Lapwing Eggs
http://www.hejninge.dk/vegetation-i-hejninge-mose/

47: Dunet Vejbed
http://www.hejninge.dk/vegetation-i-hejninge-mose/

48: Lapwing
http://www.shropscwgs.org.uk/sample-page/clee-hill-community-wildlife-group/clee-hill-bird-group/

Presentation

83: Atmosphere
https://www.dezeen.com/2015/07/05/con-tekst-combines-oak-stone-concrete-inside-minimal-belgian-house-pulle-belgium-staircases/

84: Troldtekt
http://www.bygmax.dk/byggematerialer/loft-og-vaeg/traebeton/troldtekt-traebeton.html

85: Oak Texture
https://www.pinterest.dk/pin/550846598160278368/

86: Concrete
http://leopardo.com/

Design Process

174: Detail of Green Roof Components
http://www.klimatilpasning.dk/media/631048/green_roofs_copenhagen.pdf

Appendix

Indoor Climate

Museum Visitors

Geological inforamtion

Rockwool Energy Design

Fire Strategy

Public / Private spaces

Air Change Rate Calculations

Appendix

The appendix includes a collection of documents that have not been necessary for the formulation of the different sections of the report but are still relevant for the choices made during the design process.

Appendix 01- Indoor Climate

Passive and Active Design Strategies

The new Trelleborg Experience and Knowledge Centre is set to meet the energy requirements defined in the Danish Building Regulation of 2012, meaning that the requirement for the energy framework, must constitute an energy consumption of max. 25 kWh/m^2/year. This includes heating, hot water, ventilation and cooling. [Energitjenesten, ND]

As such, the energy frame indirectly defines the requirements for the indoor climate conditions, and since the indoor environment in the exhibition areas is especially important in relation to conservation, the indoor climate conditions have been chosen as the technical focal point of the project.

To meet the requirments it is however neccessary to integrate passive and active energy strategies in the construction as these can help reduce the energy requirement while maintaning a comfortable indoor environemt.

Passive design strategies utilize ambient energy sources such as daylight, natural ventilation, and solar energy, wheras passive design strategies utilize purchased energy to maintain a comfortable indoor environment, including strategies such as forced-air HVAC systems, heat pumps, and electric light.

Another strategy includes hybrid systems, that make use of mechanical energy to enhance the use of ambient energy sources, thus including heat recovery ventilation, solar thermal systems, and ground source heat pumps.

To downsize the amount of active systems and thus the required amount of mechanical energy, the design is first optimized for passive energy strategies before active and hybrid strategies are implemented. [Autodesk, ND]

Ventilation

To obtain an indoor environment which is comfortable for the users of the building, ventilation is neccessary. In relation to this, a distinction is made between natural, mechanical and hybrid ventilation.

Natural Ventilation

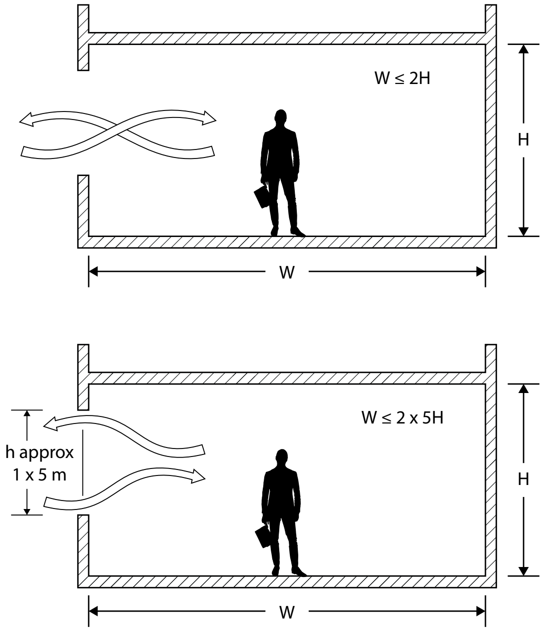
Natural ventilation is divided into four categories: single-sided ventilation, cross ventilation, stack ventilation, and combined cross and stack ventilation, which make use of natural driving forces such as buoyancy force (stack effect) and wind pressure.

Single-sided ventilation occurs when ventilation openings are placed in only one wall and the ventilation will thus rely om thermal buoyancy in the winter and wind pressure in the summer. Though the size, type, location and orientation of the opening does have some influence on the ventilation rate it is in general lower than the one generated using other principles, and the generated air does as such not penetrate far into the room.

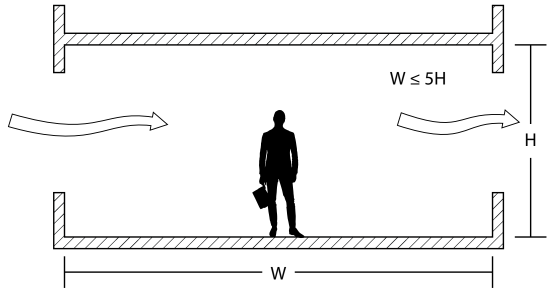
Cross ventilation occurs when ventilation openings are placed in two sides of the room, which can then generate high ventilation flow rates driven by wind-induced pressure differentials. Due to variations in the natural wind flow it is however difficult to control this type of ventilation.

Finally, stack-ventilation makes use of the buoyancy force, which is the movement of air into and out of buildings due to differences in indoor and outdoor temperature and relative humidity. An effect which is amplified by great thermal differences as well as the height of a structure.

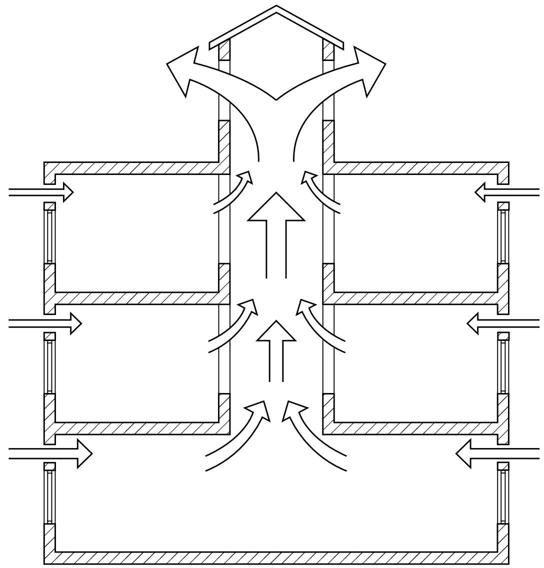
The integration of these principles in a building have many advantages as they decrease the energy consumption for heating, can be used for both ventilation and passive cooling, improve the air quality during the summer season and have a low noise level.



Ill. 175: Single sided ventilation.



Ill. 176: Cross-ventilation.



Ill. 177: Stack Ventilation.

However, the principles also have disadvantages as it may be difficult to fulfill the requirements for thermal comfort during the winter season, the indoor temperature will vary greatly, and the air flow rate is dependent of natural driving forces, which may result in poor indoor air quality and high interior temperatures.
[Heiselberg, 2006]

Mechanical Ventilation

Mechanical ventilation systems are used to circulate fresh air using ducts and fans, thus ensuring a better and more controlled air quality throughout the year as increase in relative humidity, odors and other pollutants are avoided.

Due to the extensive amount of HVAC (Heating, Ventilation and Air Conditioning) equipment, only the most valid systems in relation to the project are discussed. This include exhaust ventilation systems, which are typically installed in bathroom, kitchen and workshop spaces as they are used to exhaust concentrated moisture and odors, which often occur in these areas, to the outdoors using fans.

Another system includes balanced ventilation systems in which equal amounts of air are brought into and out of the building using two fans - one to bring in fresh air and another to send indoor air out. The most common systems include heat recovery ventilation (HRV) and energy recovery ventilation (ERV).
HRVs utilize heat from exhaust air to heat up in-

coming air during cold periods, while transferring heat from the incoming air to the exhaust air during warmer periods to reduce heating and cooling load as well as to improve indoor comfort.

ERVs are used to transfer heat and moisture between incoming air and exhaust air, thus reducing the moisture content of the incoming air which would otherwise have to be dehumidified during warm periods, while conversely adding additional moisture to the incoming air from the outgoing air, thus avoiding excessively dry air in the indoor environment during cold periods.
[Energystar, ND]

Hybrid Ventilation

In terms of hybrid ventilation, various concepts have been developed which vary greatly depending on the level of integration and industrialization.

For this project, the most valid type of hybrid ventilation is based on the integration of both natural and mechanical ventilation, thus constituting two fully autonomous systems that either switches between systems or uses one system for one task and the other for another task.
This is higly valid in connection to exhibition areas, as these spaces require static indoor conditions that can only be achieved using mechanical ventilation, whereas other areas can more easily rely on natural ventilation during periods with mild weather, thus reducing the mechanical energy requirement.
[Heiselberg, 2006]

Pollutants

To protect collections against chemical attacks from air pollutants, a relatively low range of relative humidity should be maintained- preferably a standard of 45 or 50 percent RH with diurnal fluctuation limited to +/- 5 percent.

Pollutants can be divided into two different categories, particulate and gas. Particulate pollutants include all types of solid material such as dust, clothing fibers, hair and bacteria; whereas gaseous pollutants include e.g. sulfur dioxide, hydrogen sulfide, and ozone that are typically found in the outdoor environment as well as pollutants generated within the building due to the release of volatile components.

To avoid dust particles, particle filters can be included in the air-handling unit of the climate control system. As the filter is located in the path of the air, a static pressure is however created within the system, thus requiring the fan to work harder and the capacity of the system to match the static load of the filter.

For museums it is important to maintain a clean environment, and for this reason the particulate filter should remove as much dust as possible. The filter should therefore preferably be a high efficiency filter with a dust-spot efficiency rating of 90-95 percent, capable of stopping particles as fine as tobacco smoke, and no less than a minimum of 80-90 percent.

As gas phase filtration is expensive, takes up a lot of space, imposes high static pressure loads on the system, and has to be costum made, it is not common to use these types of filters within museums unless the quality of outside air is very poor and highly polluted. [Lord, Barry et al. 2012, Cambridge, 2013]

Active use of envelope

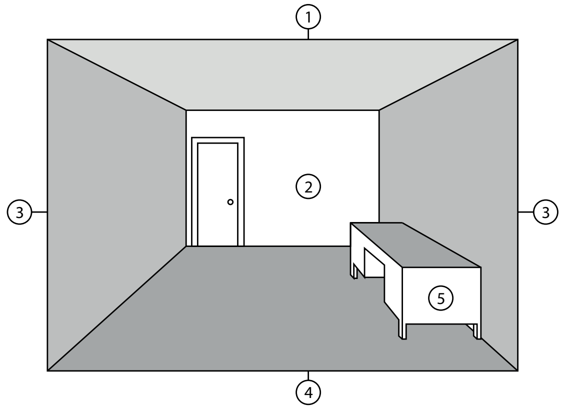
To support the use of natural ventilation and ensure a controlled indoor environment, mechanic controls can be installed to intercept and regulate thermal conditions, moisture in the air and general air quality in terms of using automatic opening of windows in the envelope.
Also in terms of regulating daylight conditions in

the building, the envelope can be used actively to ensure that sufficient quality light is provided, while direct glare, veiling reflections and excessive brightness ratios are minimized.

To satisfy these goals, various strategies can be implemented, including orientation and shape of the building both internally and externally, light finishes on surfaces to increase distribution and penetration of daylight, and high reflectance factors on ceilings (see ill. xx).

In terms of orientation, a southern orientation is generally the best for daylighting, as this side is the most consistent in terms of receiving daylight throughout the day, wheras the north orientation has a rather low quantity of light but is often used due to the high quality of light and few problems in terms of direct glare. [Heiselberg, 2008]

The exposure to direct sunlight does however generate additional heating inside the building volume, which can be exploited during the winter period. However, during the summer, active solar shading strategies may be necessary to ensure a comfortable indoor climate without increasing the cooling load. Shading strategies may be implemented in various



Ill. 178: Order of reflecting importance.

vays both in terms of exterior and interior shading, as well as integrated shading in the building volume.

Due to aesthetic reasons, the use of the building form for exterior shading is however the most desireable solution, which can be carried out in terms of setting the windows back into depper wall sections or by extending the elements of the skin to blend with the envelope.
[Windows, ND]

Appendix 02- Museum Visitors

User profiles

The table seen on page xx. display the learning styles and museum activities and programs which are best suited according to age range of the audience.

Thus it has been used to gather knowledge and define the different user profiles which are expected to visit the experience and knowledge centre.

The table is copied from the book "Manual of Museum Planning" which is also refered to in the illustration list.

Ill. 179: Learning styles and programs for different age groups.

Age Group	Learning Style	Museum Activities and Programs
Infants and Toddlers (0- 3 years)	Learn by play in a safe and familiar environment. Hands-on large toys and puzzles Act out songs and stories, move and clap to music	1. Interaction with Mom and Dad in a special tots enclosed play-learn area. 2. Museum-led programs of stories, music, and games, some of which promote parenting skills.
Children (4- 7 years)	Learning about self and the world by exploring and doing. Using materials and tools, active physical movement, make believe and role playing, songs and playing musical instruments.	1. Tackle a wider range of "I can do it" activities. 2. Check out discovery boxes. 3. Join in guided art, music and movement programs led by organization staff, related to collections themes.
Children (8- 12 years)	Learning with others (teams and clubs) and learning facts and information, discovering things for themselves, make collections and create things that show their discoveries	1. School Group Programs work in teams to solve challenges in exhibits, labs and research room. 2. Attend Summer History Camp. 3. Visit with Families for fun interactive exhibits. 4. Create a personal collection – flowers, photos.
Adolescents (13- 18 years)	Learning and socializing with peers, with some adult guidance, need more in-depth "cool" experiences to tweak their developing instincts. Need opportunities to create own projects, to assist and volunteer especially "behind the scenes," building confidence and responsibility.	1. Use online and hard-copy resources independently for school projects, contract scientists with own questions. 2. Take workshops and studio courses, join peer interest groups. 3. Have fun taking interactives to advanced levels, creating new content. 4. Become a junior volunteer or intern.
Adults	Adult learning cycle moving from concrete experience through reflection to abstract conceptualization to active experimentation and back to concrete experience. Lifelong learning. Self-driven and self-selected, requiring more in-depth experiences, access to information and to experts.	1. Pursue professional or amateur research goals. 2. Take basic to advanced workshops. 3. Visit alone or with friends and family. 4. Join a special-interest group. 5. Become a volunteer, teacher or mentor.
Seniors	Potentially incorporate all ages and learning styles, require design attention to accessibility issues. Exhibitions and activities must be designed to be "multi-level" to respond to different interests and abilities, attention span, mobility, etc., alternate activities for teens, allow adults and seniors to assist toddlers and younger children.	1. Pursue professional or amateur research goals. 2. Take basic to advanced workshops. 3. Visit alone or with friends and family. 4. Join a special-interest group. 5. Become a volunteer, teacher or mentor.

Appendix 03- Basic Site Information

Trelleborg Allé 4, 4200 Slagelse

Using the site www.dingeo.dk, basic geological information has been found regarding the site.

This involves information regarding e.g. contamination, noise, risks of flooding and presence of radon.

As such the following information was retrieved:

Radon

Based on geographical conditions and building data, the risk of radon on site is rated to be very high, thus placing the location in radon class 3.

This implies that the radon level may reach 200 Bq/m^3. For comparison, WHO recommend an upper limit of 100 Bq/m^3 and it is thus important to secure the building against radon.

These measures may include sealing of the foundation construction, regular ventilation of the building and if necessary implementation of a passive or active radon suction going from the terrain to the roof.

Noise

Since the site is located in a very shielded area and in addition is placed far away from the neares highway, no noise has been detected on the site.

Flooding and Groundwater

Despite the close proximity of Tude Å and Vårby Å respectively, there is no risk of flooding from this due to the placement in the leveled terrain.

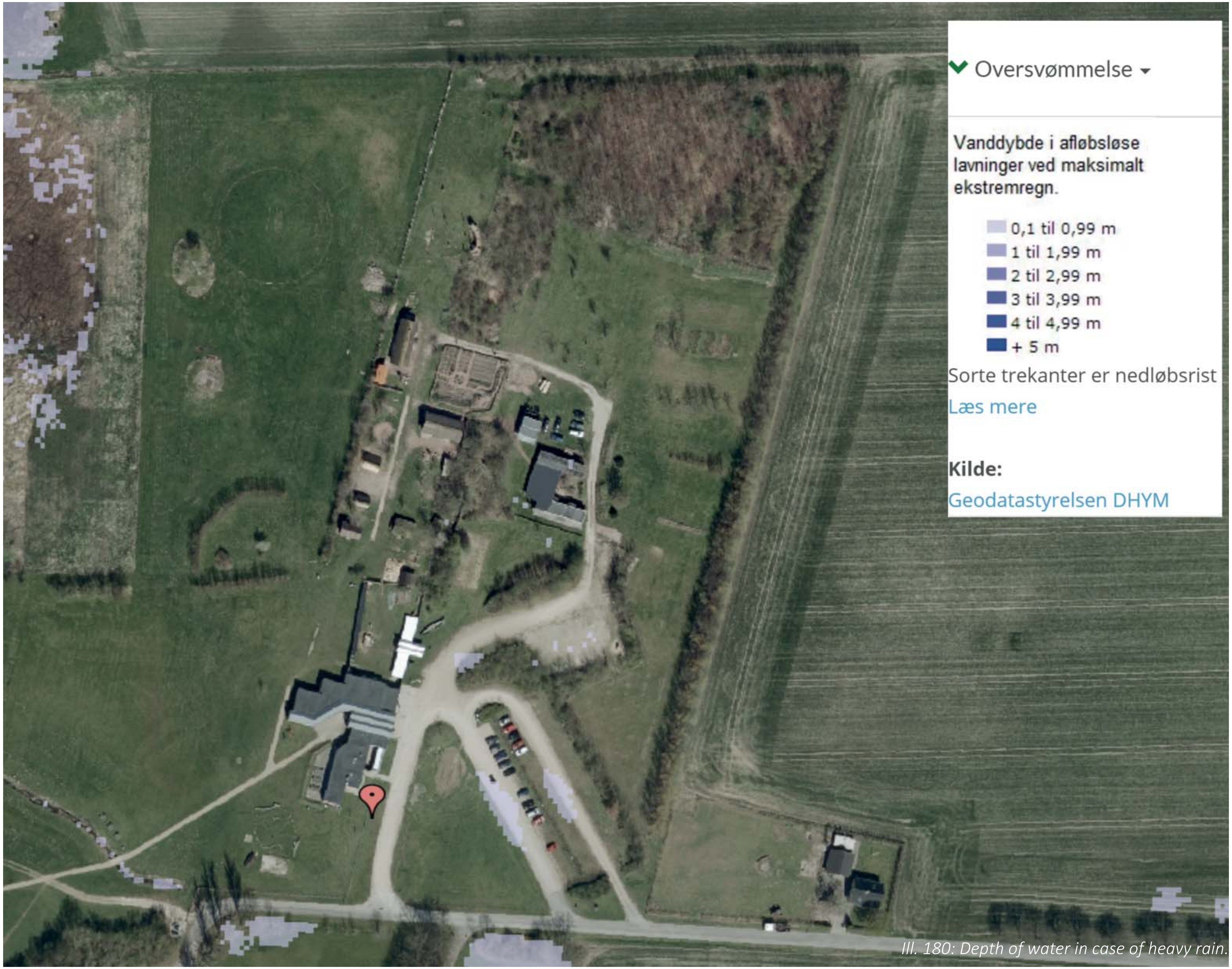
In case of heavy rain or cloudbursts there is a chance of flooding on the site, depending on the location of the new building.

The problem is however not caused by immersions in the terrain but rather that surface water may have difficulty seeping into the ground due to its high density.

In terms of groundwater, this may also prove to be a problem, as the average groundwater depth has been estimated to lie just 0,3 m below the surface and with a predicted rise of 0,1 m in the period 2021-2050, this might cause the groundwater to reach the surface during periods of heavy rain.

Based on this information it might be necessary to install drainage solutions near the building which may also lead the water away from the building.

Additonally, excessive use of dense surfaces should be avoided to prevent accumulation of water.



Ill. 180: Depth of water in case of heavy rain.

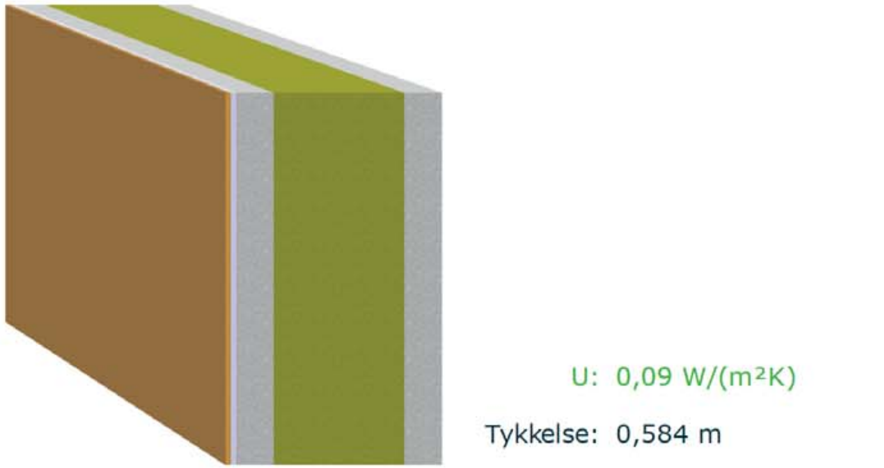
Appendix 04- Rockwool Energy Design

Wooden Floor Construction

Rockwool Energy Design is a online energy frame calculation program which resembles Be15.

However in Rockwool Energy Design it is possible to assemble custom made building elements based on an online catelog with already stated R-values, thus providing engineers, architects, constructors etc. with a design tool that may quickly calculate and change the resistance of an element.

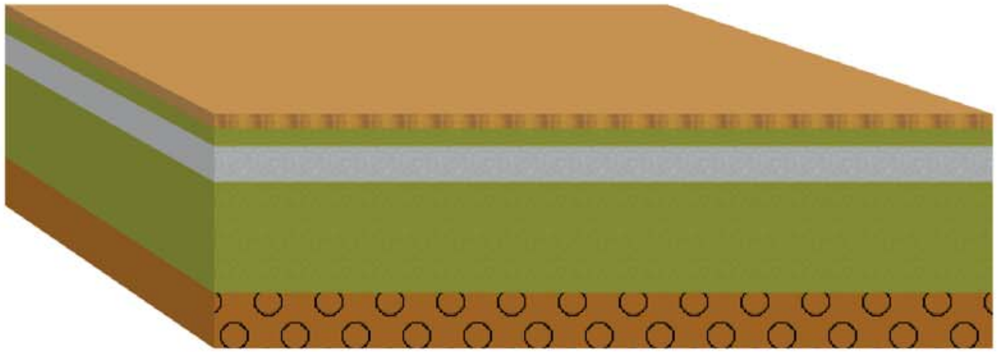
This has also been the case in these calculations in which it has furthermore been possible to find the optimal type of insulation based on knowledge given in the program.



	i	Fabrikat	Materiale	d[m]	lambda [W/(mK)]	Q	R [m²K/W]
		Rse (ude)					0,13
	☑	Generisk materiale	Træ 450kg/m3	0,019	0,120	B	~~0,16~~
	☑	Generisk materiale	Ventileret lag	0,015	-	B	-
	☑	Generisk materiale	Beton, høj densitet 2400 kg/m3	0,100	2,100	B	0,05
▶	☑	ROCKWOOL A/S	BETONELEMENTBATTS 34	0,200	0,034	A	5,88
	☑	Generisk materiale	Aluminiumsfolie 0,05 mm	0,000	200,000	B	0,00
▶	☑	ROCKWOOL A/S	BETONELEMENTBATTS 34	0,150	0,034	A	4,41
	☑	Generisk materiale	Beton, høj densitet 2400 kg/m3	0,100	2,100	B	0,05
		Rsi (inde)					0,13

Ill. 181: Wooden Floor Construction

Outer Wall Construction



	Fabrikat	Materiale	d[m]	lambda [W/(mK)]	Q	R [m²K/W]
	Rsi (inde)					0,17
	Generisk materiale	Parket 20 mm	0,020	0,182	B	0,11
	Generisk materiale	Spånplade 22 mm	0,022	0,140	B	0,16
▶	ROCKWOOL A/S	GULVRENOVERINGSPLADE	0,050	0,037	A	1,35
	Generisk materiale	Polyethylen film 0,15 mm	0,000	0,170	B	0,00
	Generisk materiale	Beton, høj densitet 2400 kg/m3	0,100	2,100	B	0,05
▶	ROCKWOOL A/S	TERRÆNBATTS ERHVERV	0,150	0,037	A	4,05
▶	ROCKWOOL A/S	TERRÆNBATTS ERHVERV	0,150	0,037	A	4,05
▶	Kapillarbrydende lag	indeholder:	-	-		1,53
	Rj (jord)					1,50

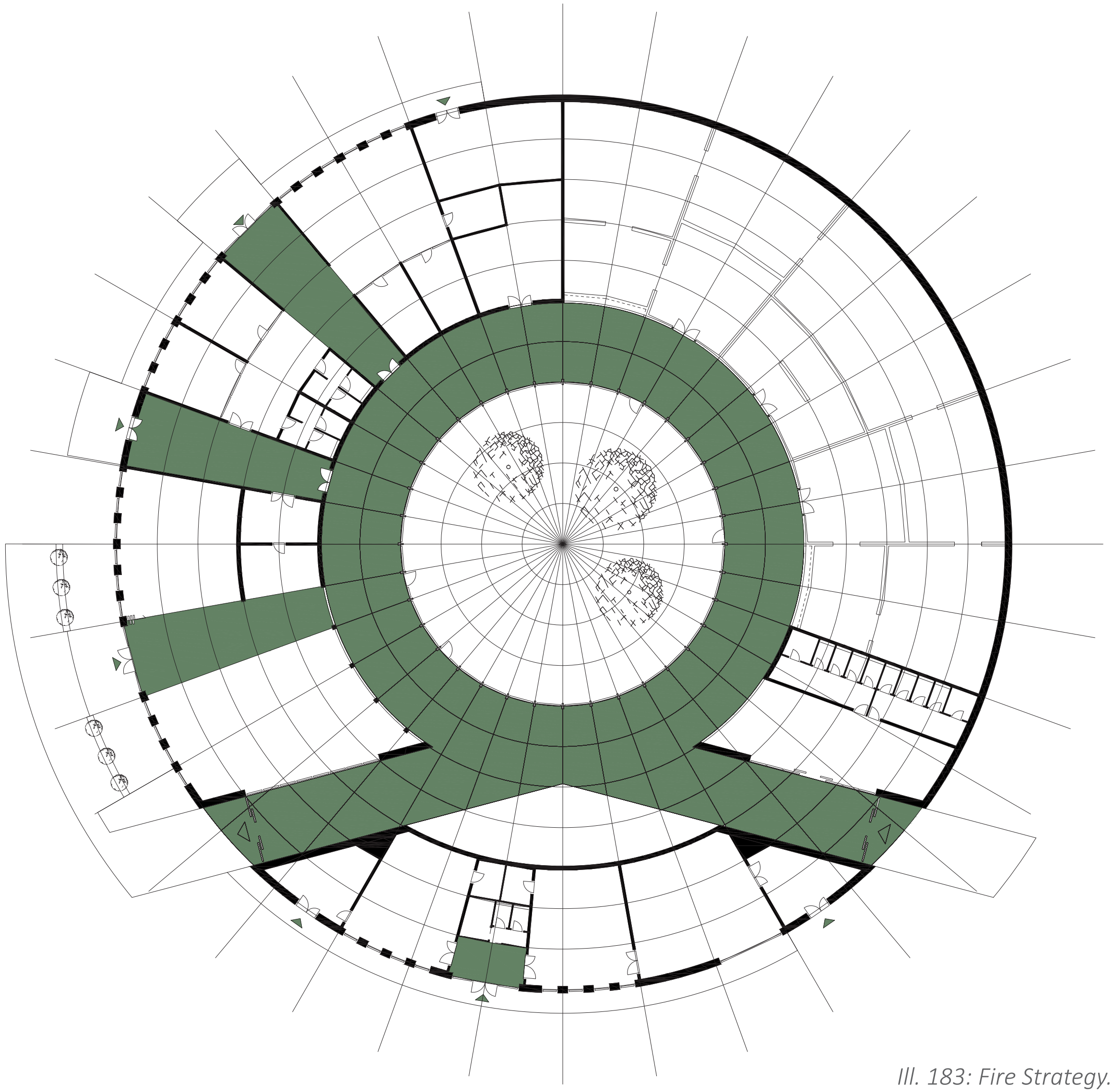
Ill. 182: Outer Wall Construction

Appendix 05- Fire Strategy

The fire strategy for the building has been planned in accordance with the Building Regulation rules which specify that by establishing at least two emergency exits independently of each other in one room, fire cell or fire section.

In traditional buildings, the emergency exits should furthermore be placed in such a way that from any point in the building, the distance to the nearest exit or door to an emergency exit should as a maximum be 25 m.

Additionally, the wall both interior and exterior have been designed to withstand the flames, gasses and heat from a potential fire for at approx. 60 minutes, thus classifying the internal walls as EI 60 and exterior walls as REI 60.



Ill. 183: Fire Strategy.

Appendix 07- Air Change Rate

The following pages include manual calculations, which are used to evaluate the necessary air change rate in the primary and temporary exhibition respectively.

Based on these calculations it is then possible to decide, which ventilation system might be necessary to meet the requirements.

Due to the very complicated nature of exhibitions which vary greatly depending on which artefacts are displayed. For instance, the light fixtures may produce a large amount of heat, which is taken into consideration in the calculations.

The caluculations should thus only be accepted as estimates.

Air Change Rate on Basis of CO_2 Level

The air exchange rate is determined according to the CO_2 concentration for building class 2 in DS/EN 15251. The CO_2 load must as a maximum be 500 ppm higher than the outdoor CO_2 concentration, which in general is 350 ppm in Denmark. It is assumed that a person exhales 10 l/min with a CO_2 concentration of 4%.

	Primary Exhibition
Net Area (A)	650 m^2
Room height (h)	4 m
Volume (V)	2600 m^3
People load (P)	100 persons
Activity level (M)	1,4 met

$$q_1 = \frac{4}{100} * 100\ persons * \frac{10\frac{L}{min} * 60\frac{min}{h}}{1000\frac{L}{m^3}}$$

$$= 2{,}4\frac{m^3}{h}$$

$$\frac{2{,}4\ \frac{m^3}{hr}}{3600} = 0{,}667\ \frac{m^3}{s}$$

The air change rate is calculated:

$$850\ ppm = 10^6 * \frac{2{,}4\ \frac{m^3}{h}}{n * 650\ m^2} + 350\ ppm$$
$$\rightarrow\ solve, n = 7{,}38\ h^{-1}$$

Air Change Rate on Basis of Olf Calculation

To find the necessary air change rate in the room, the pollution concentration must first be found. In the calculation, it is assumed that one person has a pollutant load of one OLF and that building materials have a total load of 0,2 OLF per m^2. Additionally, the outdoor air quality is assumed to be 0,1 decipol corresponding to a good air quality.

The total pollutant concentration is calculated:

$$q = 100\ persons * 1\ olf + 0{,}2\frac{olf}{m^2} * 650\ m^2 = 230\ olf$$

The necessary airflow supply is determined:

$$c = c_i + 10 * q/V_L$$

$$1{,}4\ decipol = 0{,}1\ decipol + 10 * \frac{230\ olf}{V_L}$$
$$\rightarrow\ solve, V_L = 1.769{,}23\frac{L}{s}$$

$$\frac{1.769{,}23\frac{L}{s}}{4} = 442{,}31\frac{l}{s} * m^2$$

The air change rate may now be determined:

$$\frac{1.769{,}23\frac{L}{s} * 3600\frac{s}{h}}{1000\frac{l}{m^3} * 2.600\ m^3} = 2{,}45\ h^{-1}$$

When comparing the necessary air change rate in relation to the CO_2 Level and experienced air quality respectively, it becomes obvious that the air change rate should be dimensioned according to the CO_2 Level.

$$CO_2\ Level > Experienced\ air\ quality$$

$$\mathbf{7{,}38\ h^{-1}} > 2{,}45\ h^{-1}$$

Thus, it is concluded that the required air change rate should be 7,38 h^{-1} if the dissatisfaction is to be kept below 20%. This corresponds to an air supply of 19.188 m^3/h.

$$V_L = n * VR$$

$$7{,}38\ h^{-1} * 2.600\ m^3 = 19.188\frac{m^3}{h}$$

Air Change Rate on Basis of CO_2 Level

The air change rate is determined according to the CO_2 concentration for building class 2 in DS/EN 15251. The CO_2 load must as a maximum be 500 ppm higher than the outdoor CO_2 concentration, which in general is 350 ppm in Denmark. It is assumed that a person exhales 10 l/min with a CO_2 concentration of 4%.

	Primary Exhibition
Net Area (A)	64 m^2
Room height (h)	4 m
Volume (V)	256 m^3
People load (P)	10 persons
Activity level (M)	1,4 met

$$q_1 = \frac{4}{100} * 15\,persons * \frac{10\frac{L}{min} * 60\frac{min}{h}}{1000\frac{L}{m^3}}$$

$$= 0{,}24\frac{m^3}{h}$$

$$\frac{0{,}24\ \frac{m^3}{hr}}{3600} = 0{,}0007\ \frac{m^3}{s}$$

The air change rate is calculated:

$$850\ ppm = 10^6 * \frac{0{,}24\ \frac{m^3}{h}}{n * 64\ m^2} + 350\ ppm$$
$$\rightarrow\ solve, n = 7{,}5\ h^{-1}$$

Air Change Rate on Basis of Olf Calculation

To find the necessary air change rate in the room, the pollution concentration must first be found. In the calculation, it is assumed that one person has a pollutant load of one OLF and that building materials have a total load of 0,2 OLF per m^2. Additionally, the outdoor air quality is assumed to be 0,1 decipol corresponding to a good air quality.

The total pollutant concentration is calculated:

$$q = 10\ persons * 1\ olf + 0{,}2\frac{olf}{m^2} * 64\ m^2$$
$$= 22{,}8\ olf$$

The necessary airflow supply is determined:

$$c = c_i + 10 * q/V_L$$

$$1{,}4\ decipol = 0{,}1\ decipol + 10 * \frac{22{,}8\ olf}{V_L}$$
$$\rightarrow\ solve, V_L = 175{,}38\frac{L}{s}$$

$$\frac{175{,}38\ \frac{L}{s}}{4} = 43{,}85\ \frac{l}{s} * m^2$$

The air change rate may now be determined:

$$\frac{175{,}38\ \frac{L}{s} * 3600\frac{s}{h}}{1000\frac{l}{m^3} * 256\ m^3} = 2{,}47\ h^{-1}$$

When comparing the necessary air change rate in relation to the CO_2 Level and experienced air quality respectively, it becomes obvious that the air change rate should be dimensioned according to the CO_2 Level.

$$CO_2\ Level > Experienced\ air\ quality$$

$$\mathbf{7,5\ h^{-1}} > 2{,}47\ h^{-1}$$

Thus, it is concluded that the required air change rate should be 7,5 h^{-1} if the dissatisfaction is to be kept below 20%. This corresponds to an air supply of 1.920 m^3/h

$$V_L = n * VR$$

$$7{,}5\ h^{-1} * 256\ m^3 = 1.920\frac{m^3}{h}$$