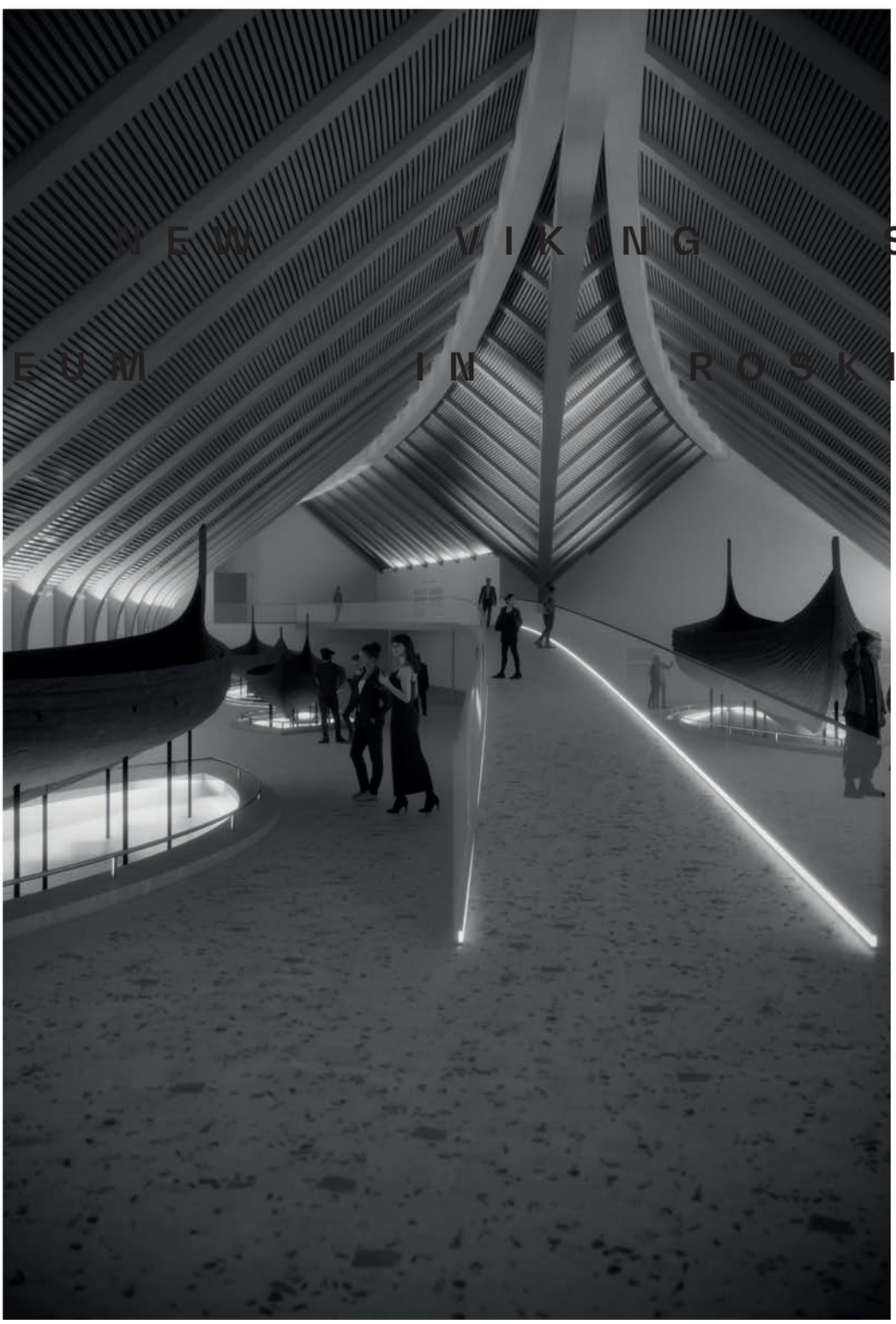
A master thesis

A NEW VIKING SHIP MUSEUM IN ROSKILDE



A NEW VIKING SHIP MUSEUM IN ROSKILDE

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READING GUIDE

The project is divided into three areas of design; a transformation of the existing museum, a transformation of the museum area, and lastly the creation of a new Viking Ship Museum. During the process a realisation of the workload results in a prioritised focus on the new museum and a more principal approach to the transformation of the existing.

Throughout the thesis, the existing museum will be referred to as 'The Viking Ship Hall' and the new museum as 'The Viking Ship Museum'.

ABSTRACT

This thesis is a response to the architectural competition for the new Viking Ship Museum. Issued due to threatening, rising water levels, the competition will ensure a climate-resilient design to maintain a part of the world's cultural heritage; the five Skuldelev ships.

The thesis focuses on both transformation of the existing and the creation of a new Viking Ship Museum, seen as an opportunity to retain the unique values of the place and allow for an expansion and renewal of the museum's narratives and dissemination activities. Altering the existing means that transformation is undeniably a part of this design, hence both new and old is co-dependent on the outcome and cannot be observed separately. Faithful to the *raison d'être* of the existing, the architecture's intention is to reflect the exhibited and contribute to a cohesive universe and dissemination concept, built on the three narratives of Vikings, ships and the museum's work with underwater cultural heritage.

01 program

Prologue

Theoretical and methodological approach

Site analysis

Design brief

02 design process

Part one

Part two

03 presentation

04 outro

INTRODUCTION TO THE SCOPE

The building industry is accountable for a large part of the climate impact, both directly from CO2 emission and indirectly from the impact of building processes, disposal of material, and energy consumption for operations. Studies show that the CO2 emission in a renovation scenario, where the supporting construction is reused, would be 56 times less than the amount of CO2 used in a traditional demolition- and new construction or building processes (Glavind et al., 2021).

Every year more than seven million new square meters are built in Denmark. At the same time, 2-3 million square meters of existing buildings are torn down. This constitutes an unnecessary waste of materials, generates immense amounts of garbage, and creates a need for production of new materials, where even more CO2 is discharged (Abrahams et al., 2022).

It is more sustainable to renovate and transform than tear down and build new – both economically and environmentally, but also socially. We must transform our cultural environments to a sustainable future by preserving, transforming, renovating, and creating a good framework for a new life around our architectural cultural heritage. When demolishing preservable buildings, we also lose identity and places that contribute to social cohesiveness (Pedersen, 2023).

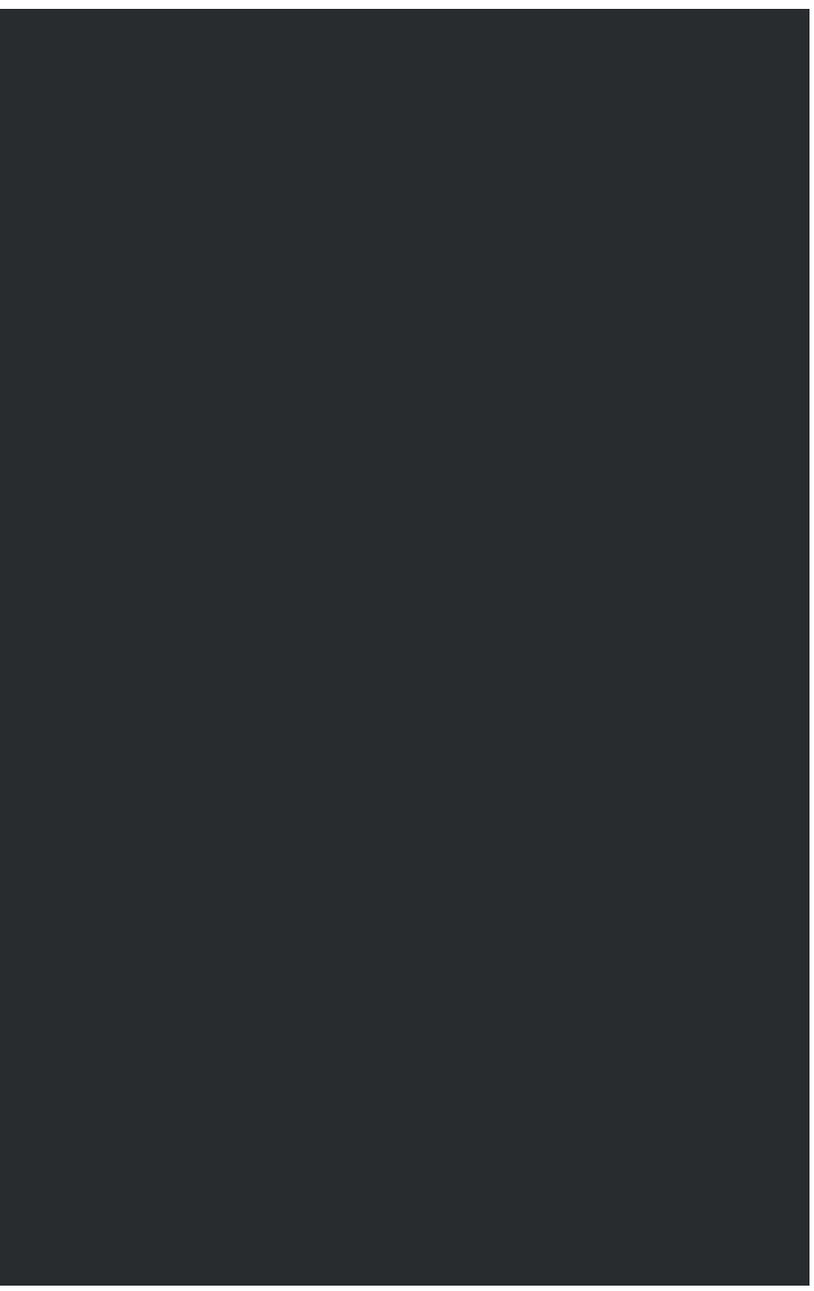
"*In sustainable building culture, three factors may constitute a theoretical framework: technical, functional and architectural parameters. In this perspective, to achieve longevity, a building must be technically robust, functionally adaptable and aesthetically durable. But what does it mean when we say that a building is 'classic'. Why is it that even though aesthetic ideals seem to change all the time, some buildings have the capacity to talk to us across temporal distance? It is argued that when a work of architecture become listed, it is because it is able to speak to us aesthetically through temporal distance. It is concluded that aesthetic sustainability is fundamentally a hermeneutic question. In this sense, the work of architecture is aesthetically sustainable when we understand something and ourselves. Some buildings talk to us because they say something true (alétheia) about being in the world*",
Nicolai Bo Andersen, (Harlang et al., 2020, p. 30) professor in building culture and sustainability.

The Danish Agency for Culture and Palaces describes listed buildings as an important and irreplaceable part of the Danish landscape both today as well as for the future generations. The values, knowledge and experiences the buildings contains are a point of assembly for communities and national identity. Each listed building contributed to a story, larger than the individual building. The buildings constitute characteristic symbols of another period; representing a multifarious history of the changes in architecture and society in Denmark throughout more than 500 years (Toftegaard et al., 2022).

In 1962, five Viking ships were excavated from Roskilde fjord, and was later exhibited in a museum built specifically for these historical pieces; the Viking Ship Hall.

The five Viking ships are part of Denmark's cultural heritage, and the Viking Ship Hall is internationally renowned for the interplay between the original Viking ships and the vibrant environment, where you can experience outstanding boatbuilding craftwork, participate in activities and sailing on the fjord in replicas of Viking ships (Vikingeskibsmuseet, 2019).

TRANSFORMATION AND CULTURE



Immense forces during storm surge; the facade is deteriorating, 2013. © Vikingeskibsmuseet i Roskilde

Ill. 1

The exhibition in the Viking Ship Museum in Roskilde is in danger. The listed modernistic museum building from 1969 is collapsing from the water pressure from Roskilde fjord. The building's iron skeleton is rusting and moisture spreads as water penetrates through cracks in the thin concrete shell. This has been the case for more than fifty years and during that time the museum's management and local politicians in Roskilde have tried in vain to call out the government (Pedersen, 2016).

Construction of new building mass is consequently not always avoidable. Flexibility in rooms and dynamics in spatiality, although quintessential for sustainable building practice in terms of longevity of built structures, is sometimes insufficient for an increasing need of square meters. In this controversial case of the new Viking Ship Museum, environmental sustainability comes in second to the importance of preserving the world heritage valuables the museum contains. The fragile finds in the museum requires careful protection through the materiality in exhibition spaces, taking extensive measures to mitigate deterioration.

After receiving the necessary funding, the fate of the Viking Ship Hall has been decided; the original Skuldelev ships must be moved into a new climate-resilient museum building. Throughout 2023 five chosen teams of architects, engineers and landscape architects will compete to create the new Viking Ship Museum in Roskilde, transforming the original Viking Ship Hall, and reinventing the museum district (Arkitektkonkurrencer, 2022).

The excavation of the finds, 1962
© Vikingeskibsmuseet i Roskilde

Ill. 2

THE VIKING AGE

Lasting from around 800-1050 AD the Viking Age was an eventful period in Danish history, characterised by many changes in society. Denmark became a monarchy with Harald Blåtand as the first king ruling the entire country, Christianity was officially implemented, and the first cities began to rise.

The Viking Age was a period defined by sailing and raids from the Scandinavian countries, Denmark, Norway and Sweden towards distant regions. As warriors and tradesmen, the Vikings sailed with ships and fleets to trade, rob, and conquer new land. At the end of the Viking Age, Denmark, Norway, England and parts of Sweden was ruled by the same Danish king (Nationalmuseet, nd.).

Today their memory is preserved by the many remanats grave monuments and Viking fortresses resting in the landscape, and the finds excavated by marine archaeologists in the sea, where the Vikings ruled for many centuries. Many of these magnificent findings can now be observed at museums around the world.

During the reign of Svend Eriksen, king of Denmark from 1047 to 1074, a system of barriers was established in the fjord at Skuldelev, to ensure control over traffic in the fjord and to protect the former capital Roskilde from attacks by sea (Vikingeskibsmuseet, n.d.). These were later to be found as some of the most well-preserved ships from the Viking Age.

The first ships that were excavated in Roskilde are the five Skuldelev ships, which have been the main exhibition in the Viking Ship Hall since its opening in 1969: Skuldelev 1 from 1030, Skuldelev 2 from 1042, Skuldelev 3 from 1040, Skuldelev 5 from 1030, and Skuldelev 6 from 1030. The ships are a unique collection of different ship types, used for fishing, trade, defence and war. They reflect a society which was oriented toward seafaring.

With Christian Erik Sørensen as the architect of the Viking Ship Hall, immortalising the ships and their history, where the five Skuldelev ships were assembled inside the Viking Ship Hall's large hall piece by piece from 1962-1993.

In 1997 during the expansion to the Museum Island, additional nine Viking ships were excavated; the Roskilde ships, whose origin spans over 300 years from 1025 to 1336 (Vikingeskibsmuseet, n.d.).

CULTURE POLITICS – THE STORY OF THE VIKING SHIP HALL

Already in the late 1970s, the Viking Ship Hall was showing indications of corrosion in the reinforcement behind the thin layer of concrete and was in general moderately degraded. The concrete is very exposed to weather, which led to an external renovation in 1989-90. The architect of the building, Erik Christian Sørensen, indicated several times that the building could not withstand with wear and tear from the weather.

The first renewal project was submitted by Erik Christian Sørensen. It was essentially a proposal for the expansion of the Viking Ship Hall in 1988. The project included an arrival building, medieval hall, find reception, shipyard, offices, harbour, and underwater galleries. The project had to be dropped due to a lack of funding.

The Viking Ship Hall was listed as a protected building facility in 1997. At the time the building was presented with this honour, it was already in disrepair (Vikingeskibsmuseet, 2019).

The case of the Viking Ship Hall is an example of how low priority culture is given in Danish politics. The process has lasted for years, the damage has been known for a long time, and it has only gotten worse, while the museum has tried to get the politicians to take an interest (Pedersen, 2016). The Viking Ship Hall cannot provide the necessary protection of the artefacts and the building has an estimated lifespan of 8-10 years without the necessary renovation (Teknisk Insititut, 2016).

The lack of restoration is caused by the limitations of being a listed building. Listed buildings can not undergo restorations unless it is approved by the Ministry of Culture. This sets a limit on the interference to be made on the building. Not only are restorations very expensive due to the time-demanding procedures, but the extent to which changes are allowed on the building is very limited and must be intact with its former style and condition. The museum is privately owned and the resources for the restoration within the guidelines of listed buildings could not be found. In collaboration with the mayor of Roskilde at the time, the museum applied for a de-listing in 2016, which after a long process was accepted by the Ministry of Culture in 2018 (Søndergaard & Heltoft, 2019).

In 2019, the building receives another honourable mention; being one of the 100 most important concrete buildings of the 20th century. However, this is paradoxical since the building is still decaying as years go by without restorations (Innova Concrete, 2019).

The area in general has also been criticized for not being able to create space for new exhibitions and activities and to achieve a clear whole around the museum facility. The renovation of the Viking Ship Hall alone would not solve any of the problems connecting the whole area. The Viking Ship Hall has applied for funds to finance the project, but none of the organizations willing to support the project financially believed in the existing building's faith. The funds would only be applied if the purpose was to transform the entire area with space for new exhibitions and build a new museum to protect the Skuldelev ships (Søndergaard & Heltoft, 2019).

For the past years, since the de-listing of the museum building in 2017, it has been debated whether the esteemed brutalist piece of architecture, which is protected as a unique work and as a representative of an architectural style, should be renovated or simply demolished since the building cannot fulfil its purpose; to secure, preserve and disseminate the ships (Vikingeskibsmuseet, 2019).

The de-listing paves the way for an international architectural competition, which purpose is to develop, repurpose, and transform the current Viking Ship Hall and the Museum Island in interaction with a palette of new initiatives developed by the museum and municipality in Roskilde.

The Danish National Museum dictates that the Skuldelev ships can only be exposed to limited amounts of natural daylight due to deterioration. This diminishes the New Viking Museum's requirement for open views towards the fjord and leaves the monumental placement on the bank of the fjord to the existing hall (Kejser, 2023).

800-1050 AD
The Viking age

1962
The Skuldelev ships are excavated and raised from Roskilde fjord

1968
Assembling of the Skuldelev Ships started

1969
The Viking Ship Hall opened to the public

1993
Assembling of the Skuldelev ships completed

1997
The museum expanded to the Museum Harbour and Island

1998
The museum is listed for architectural heritage

2008-2012
Erik Christian Sørensen concludes that the Viking Ship Hall needs another structure to withstand weather after restoring problems for years

2010
First note on maintenance of the Viking Ship Hall

2013
The storm, Bodil, causes further damage on the Viking Ship Hall

2016
The Danish Institute of Technology gave the most exposed parts of the concrete construction an estimated remaining lifespan of 8-10 years

2016
Application to get the building delisted in order to create a less restrictive framework and new opportunities to develop a long-term solution for the preservation and dissemination of the Viking ships and for the realisation of the museum's vision and master plan

2017 December
Refusal to de-list the building from the Palace and Culture Board

2018 January
Appeal against refusal

2018
Approval of the de-listing by the Ministry of Culture. The Minister concluded that the preservation values of the Viking Ship Hall cannot be maintained through maintenance and restoration, but will be lost within the near future due to the rising water levels

2019
Recieving the price of one of the '100 from the 20th'

2022
Funding for the project

2022
Architectural competition teams are found

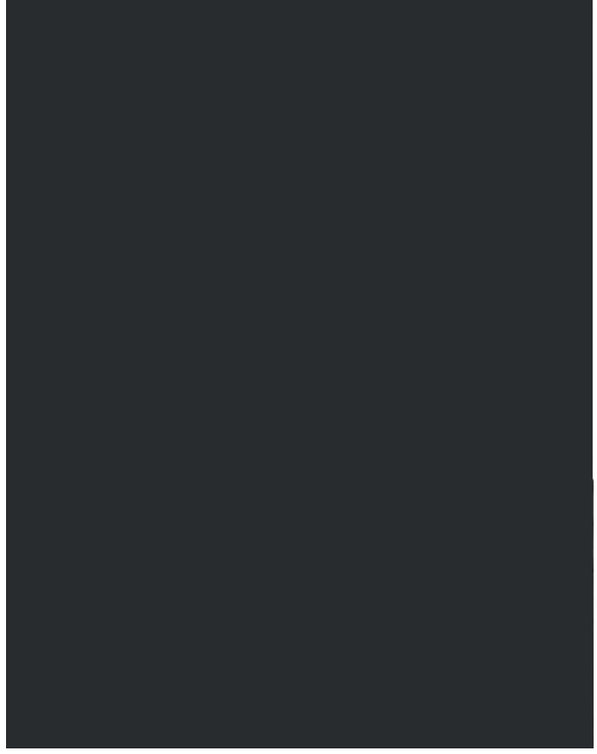
2023
Architectural competition completed

Museum timeline

Ill. 3

The Viking Ship Museum
Original facades, 1960s
© Unknown, Det Kongelige Bibliotek

Ill. 4



© Else Tholstrup
Erik Christian Sørensen,
1950s

Ill. 5

PORTRAIT OF ERIK CHRISTIAN SØRENSEN – THE DANISH MASTER OF BRUTALIST ARCHITECTURE

Brutalism is one of architecture's most controversial architectural movements with its emphasis on materials, textures, and construction, producing highly expressive forms. During the 1960s, the architecture of brutalism was dominated by the use of raw concrete; *beton brut*.

Scale became important and there was an emphasis on mass, characterised by large concrete shapes, textured surfaces created by wooden formwork, and explicit display of service ducts and ventilation towers (Brutalism, n.d.).

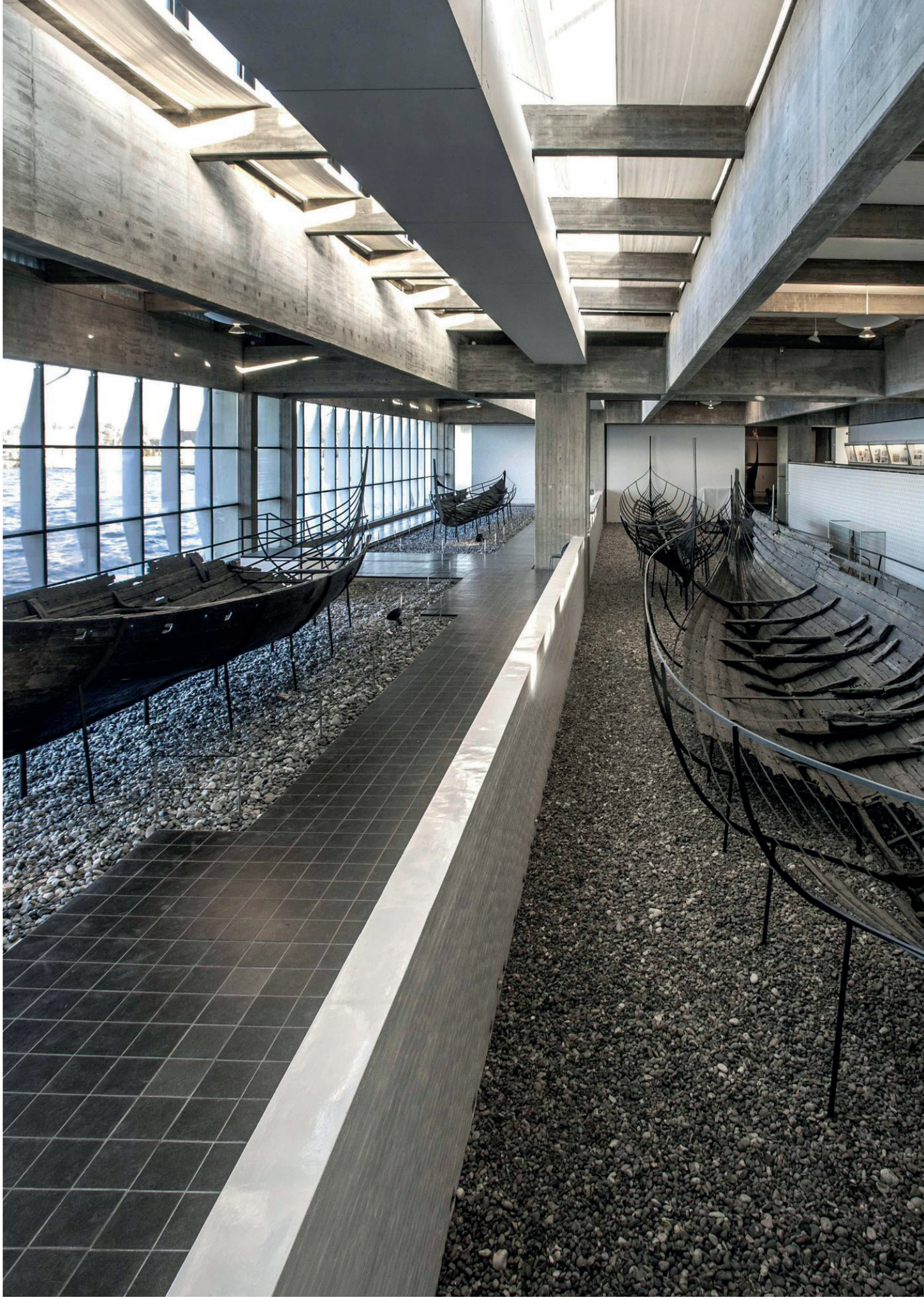
Erik Christian Sørensen has made a clear mark on Danish architectural history; as a professor at the Royal Danish Academy for more than thirty years, and with distinctive buildings such as the Viking Ship Hall in Roskilde and his own house in Charlottenlund (Harlang, 2021). About his work, he says "*After all, I would like to discover architecture's fundamental means: proportion, rhythm, light, texture*" (Realdania, n.d.).

Throughout the Viking Ship Hall, reinforced concrete with wooden marks, iron, and glass are used to enhance and elevate the sharp lines of an architectural work that represents Sørensen's research into brutalism. His work is a sublime encounter between Danish building culture and international impulses; "*it is a child of its time, but is very much based on timeless insights and effects*" (Harlang, 2021, p. 8).

In Erik Christian Sørensen's idea of showcasing the finds in the building, he describes, "*The museum guest should enter a largely dimensioned room and see the entire find as a triumph. The ships should be a theatrical silhouette towards the water, and later to be discovered in a walkabout to see them properly*" (Sørensen, 2003, pp. 39-40).

"*The roof should be in one, and its bearing structure be a longitudinal purlin towards the pillars of the gable. And so, the five bays of the building were clearly shown, whereas an interplay between [Skuldelev ship] three and five occurred*" (Sørensen, 2003, p. 40).

A building truly made for the exhibition of the Skuldelev ships.



Ill. 6

The Viking Ship Hall
before the storm surge
© Vikingeskibsmuseet i Roskilde

THEORETICAL AND METHODOLOGICAL APPROACH

Many opinions on the faith of the museum

Ill. 7

TRANSFORMATION OF URBAN SPACES

Architecture can be viewed as a static structure. It physically assembles diverse programs and serves as a framework for the use. Physically, architecture can help to change the space, scale and access to a given site. Architecture is part of the built environment's continuous transformation; affecting both the physical dynamics and the experience of structure. Through its programs, it helps to adjust everyday practices on the ground. In this way, it can shift the perceptions of the neighbourhood.

The book 'Catalyst Architecture' deals with architecture's ability to be a catalyst for physical, social, and cultural change of place, described through two analytical concepts. The term covers architecture's ability to connect with a place, setting the framework for the site's use and transformation of place as both a physical and social construction.

The concepts suggest there is an internalised performance and an external performance in architecture. The internalised architectural performance includes the project's programmatic structure and organisation, its formal language, associated semiotic meanings and aesthetic effects, related to the different users and their active use and experience of architecture.

The internalised performance includes the user's interaction with the architectural work; whether it is flexible enough to meet many different needs and to change its aesthetic appeal accordingly.
The structural architectural perception must be supplemented by a concept of relational architecture.

This approach emphasizes the users' occupation and use of architecture. In the relational architectural understanding, a building becomes architecture in its interaction with human beings.

The external architectural performance includes the experience of the place and the users' perception of a place. It suggests, the contribution of the given project to the physical transformation of the built environment, the everyday life in the project's immediate environment and site usage, encouraging an interest in meeting and learning from other people (Kiib & Marling, 2015).

In the book 'In Search of New Public Domain' the role of urban life and everyday practices; and how everyday practices create democratic cities and places. This might be constructed as a temporary public domain in connection to summer events or they may be permanent locations.

Hajer and Reijndorp investigate the interaction zones and places where there are social and cultural learning and interaction among people with completely different lifestyles, and cultural, ethnic, and economic backgrounds. The public domains should be a perspective from which you analyse existing public, semi-public or private space in the urban landscape (Hajer & Reijndorp, 2001).

"We define 'public domain' as those places where an exchange between different social groups is possible and also actually occurs. […] We are interested in the question of which spaces are positively valued as places of shared experience by people from different backgrounds or with dissimilar interest. In principle, such places can also be found beyond the traditional urban space of streets, parks and squares. They can even be spaces that are not public in the strict sense, for example privately managed collective spaces that still function as public domain. What in fact gives such places their public quality? […] Why does this place have a central function in the city, both for residents and for its visitors?" (Hajer & Reijndorp, 2001, p. 11).

Architect | Cubo and Nord Architects
City | Aalborg
Built | 1947
Renovated | 2011

Nordkraft

Nordkraft is the reminiscence of the industrial history of Aalborg. With the transformation from a power station to a cultural rendezvous, the area was given life through an urban planning strategy that proposes a psychical connection between the building and the rest of the city.

Different intersecting zones manifest transition from a cultural sphere with events, a theatre, and galleries to athletic and educational functions; attracting a diverse group of users throughout the shared spaces and meeting points that enable interaction between the many users of the house (Waco, n.d.).

The building's programmatic structure allows the different users and their active use and experience of the architecture on their own premises; *an internal and external performance* unfolding in the interaction with human beings. The public 'street' in the building unites the different functions, without compromising the more private events unfolding around it. The building allows different events to unfold with its open plans; continuously adapting to the needs of the citizens.

Nordkraft during market weekend

Ill. 8

ETHICS IN TRANSFORMATION

In the mid-19th century, the theoretical interest in how to adress old buildings began. The French architect and theorist Eugène Viollet-le-Duc and the English art historian John Ruskin represents the two most significant positions in terms of restoration and transformation. Viollet-le-Duc and Ruskin represents opposites in classic restoration theory; maximum and minimal impact respectively. Whereas Viollet-le-Duc believed that the purpose of restoration was to reinstate the building in a condition of completeness which may never have existed at any given time, Ruskin argued for preservation and advocated restoration as destruction under false description. Although these opposites dissent on almost every aspect of transformation, their principles and values of restoration philosophy were both measured and defined by their faithfulness to the authentic.

Especially the Venice Charter from 1964, a manifest of conservation and restoration, was epochal in terms of the beginning of modern restoration practice. The principle that perhaps had the most influence on the way the architect should relate to the existing is described as:

"*Replacements of missing parts must integrate harmoniously with the whole, but at the same time must be distinguishable from the original so that restoration does not falsify the artistic or historic evidence*" (ICOMOS, 1964, p. 112).

The interesting question regarding transformation in architecture is, according to Nicolai Bo Andersen, not to be found in the contrast between new and old, but rather between good and bad. If the purpose is not to appear as faithful to the original piece as possible and is not a question to be historically correct, the transformation architect becomes a co-creator of a new entity (Harlang & Andersen, 2015).

"*All buildings, once handed over by the builders to the client, have three possible fates, namely to remain unchanged, to be altered or to be demolished. The price for remaining unchanged is eventual loss of occupation, the threat of alteration is the entropic skid, the promise of demolition is of a new building*" (Scott, 2008).

The architect and artist Fred Scott highlights the lack of focus on the social dimensions in the general restoration debate. Through alteration, he argues, buildings can be extended beyond their time through a shift in use and occupation, providing an alternative to preservation or demolition. Transformation has in that sense distinguished itself from considering architecture as something that should not be altered. Because of the subjective perspective on different buildings, it is essential to acknowledge historic, social as well as cultural qualities and values to clinch the transition from past to present. The scientist and architect Christopher Wren claimed that buildings should aim for eternity, and aspects of buildings living different lives through different purposes may suggest that buildings could become an element of continuity.

The work of alteration should aim for an incomplete perfection, or a perfect incompleteness (Scott, 2008 p. 212).

In contrast to views from classic restoration theory, buildings are dynamic objects and exist through periods in time. Alterations should not tarry and become relics of the past. Transformation should be reinterpretations that are "*designed to change into a building that 'learns' from the existing building and that acknowledges, but does not faithfully preserve, its intentions*" (Peters, 2014 p. 3).

The architect Terri Peters, argues that even though sustainable transformation of existing buildings is an urgent global concern, the precise meaning or measure of sustainability in this context is poorly understood across disciplines. Therefore, it is of great significance to define this thesis' sustainable notion and use of the term.

"*Sustainable renovations are often confused with energy-efficient renovations. But this distinction matters and the choice of language and priorities is key. Learning from past mistakes, future renovations must not only be "energy efficient" focusing on quantitative parameters such as energy or cost, but also "sustainable renovations" incorporating a balanced and multi-faceted building-specific approach to social-architectural, environmental-energy and economic-appropriate contexts*" (Peters, 2014 p. 3).

According to Terri Peters, transformation of old buildings is not only a concern of quantitative parameters such as environmental concerns but goes beyond what is built and unbuilt. Truly sustainable transformations need to be designed with social and cultural viewpoints in mind and resist these qualitative assessment elements. These topics seem to be considered key aspects of general renovation. Architecture is unavoidably a part of societies where cultures exist, and these elements must be acknowledged.

© Mir
Trilateral Wadden Sea
World Heritage Partner Center

Ill. 9

Architect | Dorte Mandrup
City | Wilhelmshaven
Built | WW2
Transformation | 2024/25

Wilhelmshaven was Germany's most important naval base during World War 2. Because of the bunker's robustness, a few of them still appears as remnants of the war. As part of the 'Trilateral Wadden Sea World Heritage Partnership Center Wilhelmshaven', this bunker is being transformed into the administration of the three-country corporation between Denmark, Germany and the Netherlands working to protect the Wadden Sea area.

Integrating and using the heavy bunker as an anchoring point for the new building gives way for the bunker to act as the building foundation while altering into a shimmering, yet open lighthouse for the area. This solution is characteristically taking advantage of the existing by using an unmovable building and integrating its nature into the new project.

While the entire project is encased in a transparent glass layer, the distribution of functions also enhances the appearance of the bunker as a gigantic rock on the seabed. The bunker will be used for exhibition space and its roof reinvented as an internal courtyard. The public will also have access to meeting- and conference facilities on the first floor, whereas multifunctional spaces and a library, are located on the second floor. The third and fourth floor consists of office and meeting spaces along with a wind-protected terrace and viewing platform with public access, boasting scenic views of the Wadden Sea and surrounding landscape.

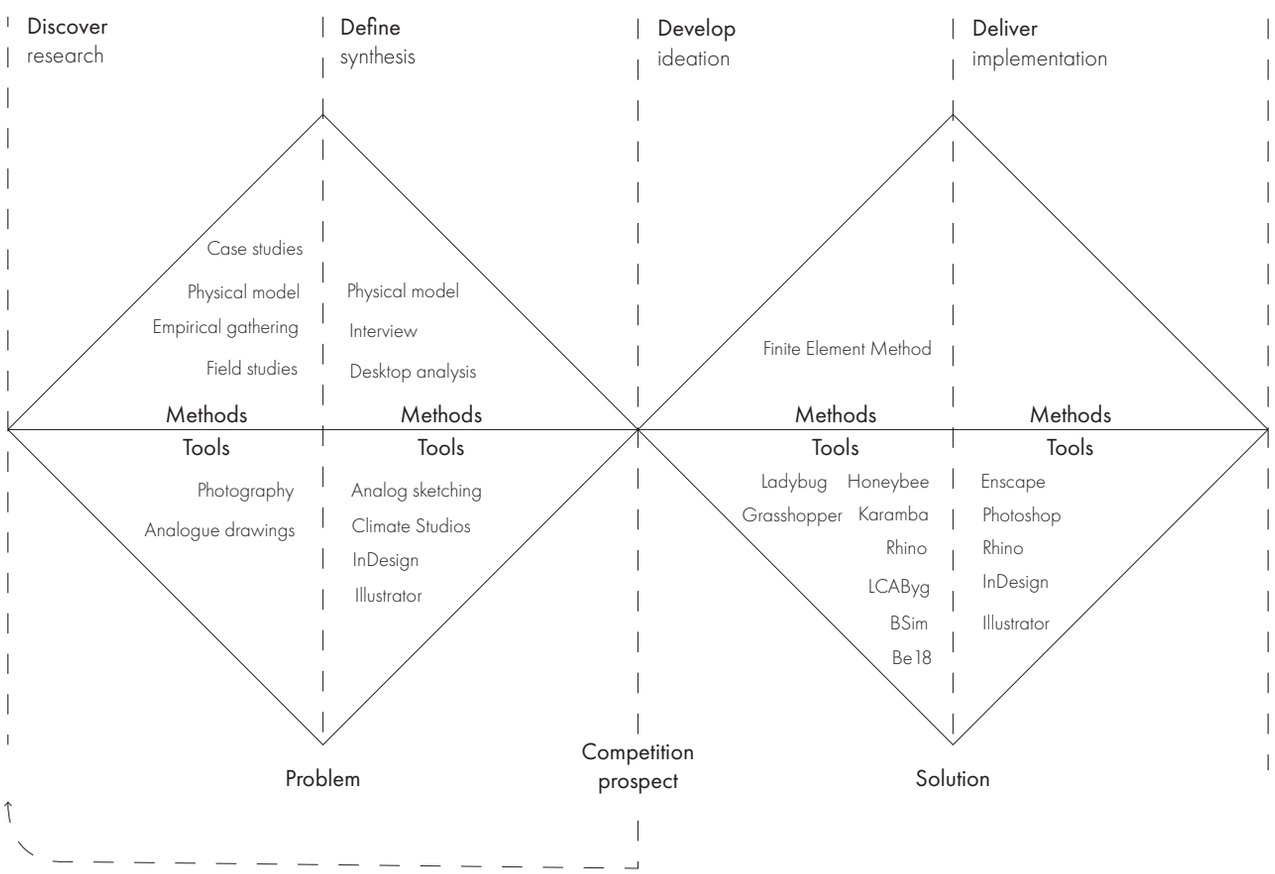
DESIGN METHOD – INTEGRATED DESIGN

The architectural competition for the New Viking Ship Museum has paved the way for the project – numerous pre-examinations on the state of the existing building, reports on environmental impacts due to extreme weather events, accounts on public involvement by the municipality, and a 44-page prospectus on the visions for the New Viking Ship Museum. In that sense, this project enters the Double Diamond design process at the middle by having a series of specific problems to solve.

The Double Diamond design thinking diagram is a universal tool for analysing, planning, and structuring the intricate phases of designing. Originally thought out by the Design Council mapping the work process of designers to "*demystify design process and make it accessible to a non-design audience*" (Ball, 2019).

The design process respectively undergoes a series of divergent and convergent stages of scoping first the problem and then the solution. The respective stages *discover, define, develop, and deliver*, each contributing to reaching an understanding and a solution to design problems as they occur.

These will be utilised throughout the project to keep a structured approach within the scope of architecture and engineering to the three design foci; transformation of the existing museum, transformation of the urban surroundings, and a new Viking Ship Museum.



Ill. 10

Integrated design through
the Double Diamond method

Discover

Theoretical basis framing the themes moving forward with the project – gathering the needed empirical knowledge and synthesising it through a case study revealing a subjective position on the presented theory.

Analysis based on qualitative and quantitative principles, such as:

Cartographic mapping of existing structures and environmental impacts.

On-site examination and photographing of the museum and its surroundings, as subject to the phenomenological experience of the museum, categorising materials, paths etc.

Field studies at museums in Aalborg, Helsingør and Humlebæk of quantitative measures of dimensions and of qualitative atmospheric affection towards lighting, rhythm, scale, and forms of exhibition.

Modelling of context (buildings, landscape) in physical and digital form to achieve insight into the existing structure and as a tool for designing on the specific site in relation to the exciting structures.

Define

After gathering the needed empirical foundation, this stage elaborates the insights and refines the initial assumption based on the learnings from the previous phase.

Interview with the project manager of the new Viking Ship Museum clarifying key information regarding design requirements and visions.

The software ClimateStudio has been used for site analysis regarding the climatic aspects: wind conditions through a wind rose diagram, solar studies through a sun path diagram and shadow analysis.

Diagrammatising of functions according to experiential connection in the narrative of the museum to organize the layout of the building programme through a narrative.

Utilising relevant theory as design drivers. E.g., museum planning, museum narratives, and transformation methods.

Develop

In this phase, different solutions are developed to answer the challenge identified during the defining stage.

Quantitative calculations on daylight amounts along with atmospheric studies on the perception of lighting – through daylight analysis tool LadyBug and HoneyBee in Rhino and Grasshopper, and 3D-rendering in Enscape to visualise the light ambience.

Utilising a Finite Element Method tool for the design process through iterations of the structural system in Karamba3D for Rhino and Grasshopper, giving instant and intuitive feedback on the statics in the construction by altering materials, cross sections, supports, and joints.

Concept ideation through analogue sketching as a quick and effective means of communicating syntheses from conducted analyses into design concepts.

Life Cycle Assessment in LCAByg will be used as a tool to evaluate structural, material, and performance aspects of the design process.

Indoor climate simulations through BSim as a mean to achieve a suitable indoor climate in the most critical rooms according to temperature and indoor air quality.

Deliver

The final phase examines the final result - meaning that the concept devised addresses the challenge identified during the discovering stage.

3D-rendering of the concluded design proposal to express the intended atmospheres and visualise key design interventions.

Two dimensional drawings of plans, sections, and elevations illustrate scale and cohesion in programming of the design, narratives, and technical aspects of the structure, using tools as Rhino, Illustrator, and Photoshop.

Synthesis of design proposal in a report complemented with presentation models and architectural posters presenting the project.

TRANSFORMATION METHOD; FIVE STRATEGIES

These methods each represent a way to work with heritage, transformation and restoration. The starting point is by studying the properties of materials, the history of architecture, and existing structures in construction, several significant architectural characteristics can be uncovered and thus ensure that the conservation qualities of the cities and buildings are not destroyed (Harlang & Andersen, 2015).

Technical, historical, phenomenological

A method that is about understanding architecture both as material and tectonics, as part of a larger historical context, and the building as it is experienced and understood through our senses. The purpose is to enable the technical, historical and phenomenalogical approach to be synthesized into a new, architectural whole as a method of simultaneously experiencing and analyzing, feeling and thinking about architecture (Harlang & Andersen, 2015 p. 75).

Landscape, still life, portrait

The method extends a field of scale that can help identify and develop the complex span of nuanced architectural features, spatial contexts and experiential qualities in architecture (Harlang & Andersen, 2015 p. 78).

Skin, meat, bone

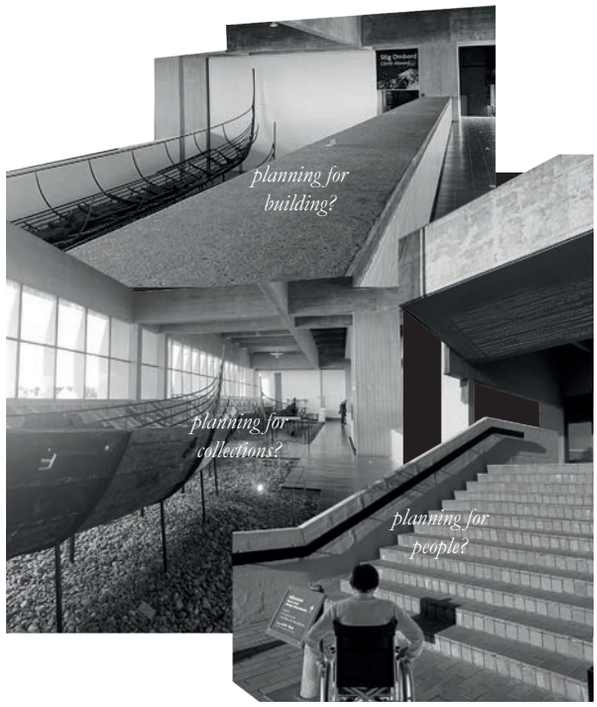
A method that can be used as a tool for analyzing the tectonic and constructive links of an existing structure, the concepts can denote a way of presenting a project that deals with the three drawing formats of the double right-angled projection, elevation, plan and section. Skin - meat - bone describes a working method that can be used to develop the temporal and significant links of architecture and optimize the use of resources in a sustainable holistic perspective (Harlang & Andersen, 2015 p. 81).

Look, throw, project

A method that can be used regardless of whether it is a listed building, a house worthy of preservation, or an existing context. The method can help identify and further develop existing architectural qualities and help maintain the building's conservation values throughout the process (Harlang & Andersen, 2015 p. 82).

Subtraction, reconstruction, reperation, reformation, addition

A method of architectural intervention that applies both to classical restoration practice and to the design of a completely new house in an urban or landscape context. The intention is that cultural heritage, transformation, and restoration should not be understood as a limited, independent field, but as a naturally integrated part of a building artistic practice, where the interest in the work with the cultural, the site-specific and the material-specific is central (Harlang & Andersen, 2015 p. 82).



Museum planning principles

Ill. 11

MUSEUM PLANNING

Museums are means of communication. They communicate the meanings of nature and humanity past and present to their visitors today and tomorrow (Lord et al., 2012, p.xxvii).

Gail and Barry Lord have in the preface of their book 'Manual of Museum Planning' stated that museums constantly are involved in change. Whether that is a need of quantitative change in the form of renovation, expansion or new construction of space and facilities, or qualitative change in exhibitions to meet the increasing expectations from visitors, it is still an interference with the existing. The standards of technological advancement as well as communication tools for museums have improved dramatically but have also resulted in more complex roles, skills and structural demands the museum is expected to fulfil. Due to the variety of museums, there is no standard formula or code that is applicable to all museums, but there is a substantial number of principles, guidelines and prior decisions that can be applied whether it is concerning a natural-historic museum or a contemporary art museum.

Gail Lord, Barry Lord, and Lindsay Martin have divided the Manual of Museum Planning into five primary sections: Planning for People, Planning for Collections, Planning for Operations, Planning for Building and Implementation. As this thesis' scope has excluded the economic and implementing aspects, a focus is merely put on parts I, II and IV (Lord et al., 2012).

I **Planning for People**

This section points out that museums may seem to be about objects, but they are truly about people. Though museums showcase objects they achieve aspects of social sustainability through their contribution and determination to stay relevant and be a meaningful member of society. Furthermore, this section details the various roles and capacities that a museum must take on to advance as a sustainable institution.

II **Planning for Collections**

As collections in a museum seem to be the fundamental backbone of the institution, it is in this section demonstrated how and why planning for collections is such a central part of the museum planning discipline. This section also highlights the controlled dynamics and changeable settings within a museum and why planning for this major issue is of great significance.

IV **Planning for Building**

This section acts as a critical part that utilizes the previous parts and their respective content in a way to link them to the final product. It also demonstrates how these elements can be applied in the eventual design. It may be applied to an existing building's space, or the projection of a new building (Lord et al., 2012).

THE SENSORY EXPERIENCE OF MUSEUM ARCHITECTURE

Architect Juhani Pallasmaa is driven by the perception of place; and the tactile and internal experiences in the spaces we inhabit. "*All senses, including vision, are extensions of the tactile sense; the senses are specialisations of skin tissue, and all sensory experiences are modes of touching and thus related to tactility*" (Pallasmaa, 2005, p. 10).

Pallasmaa addresses the primacy of the haptic realm; touch integrates our experience of the world; it is the parent of our eyes, ears, nose, and mouth, and visual perception is our reference, memory, imagination, and integration. The essential task of architecture is to accommodate those primal senses by articulating the experience into an integrated material, embodied and spiritual essence (Pallasmaa, 2005).

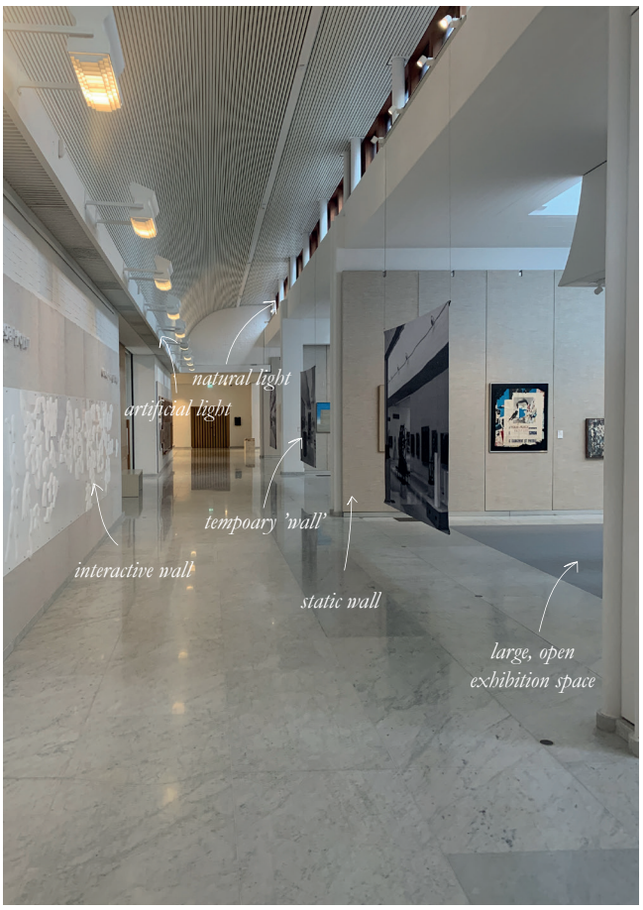
When experiencing museums, the sensory experience is different from museum to museum; from exhibition to exhibition. Every touching experience of architecture is multi-sensory; qualities of space, matter and scale are equally measured by the human senses (Pallasmaa, 2005). There is also a great difference in *what* is exhibited, whether it, in the case of the Viking Ship Museum, are large 30-meter-long ships or small maritime artefacts in glass display cases.

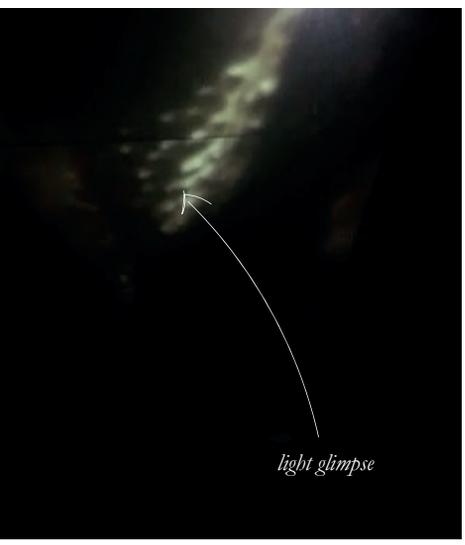
"*The authenticity of architectural experience is grounded in the tectonic language of building and the comprehensibility of the act of construction to the senses. We behold, touch, listen and measure the world with our entire bodily existence …*" (Pallasmaa, 2005, p. 64). The scale of the exhibition, the lighting, and the room height can differ radically when walking through a museum. The contrasts in these multisensory places are extreme; "*Understanding architectural scale implies the unconscious measuring of the object or the building with one's body, and of projecting one's body scheme into the space in question*" (Pallasmaa, 2005, p. 67).

When experiencing Aalborg Museum of Art, Kunsten, the senses were almost provocatively addressed; moving from the first exhibition with overwhelming light from the overhead light windows and white marble exhibition to an almost totally darkened basement exhibition with small glimpses of light showing the artist's films of insects.

Pallasmaa argues, architects often forget the senses beyond sight. The drastic shift in the atmosphere experienced at Kunsten makes it obvious to the experiencer how deeply rooted we are in using all senses at once when putting ourselves in a situation where some of the haptic senses are suppressed by the architecture.

Kunsten,
1st floor exhibition





Kunsten,
basement exhibition

Louvre,
greek statue exhibition

Utzon centeret,
architechture exhibition

Transformation

According to Terri Peters, transformation of old buildings is not only a concern of quantitative parameters such as environmental concerns but goes beyond what is built and unbuilt. Truly sustainable transformations need to be designed with social and cultural viewpoints in mind and be resistant towards these qualitative elements of assessment. These topics seem to be considered key aspects of general renovation.

This thesis seeks to address the act of transformation, the operation of redefinition and the art of incompletion. It is carried forwards through previously described theories, which are used to make spatial, social as well as cultural elements tangible. Understanding the architecture in question both in its material, tectonic, cultural and social existence as part of a bigger historic context enables an approach to alter architecture with intention of progress. Altering the existing architecture allows buildings to become an element of continuity and adds new purpose through their existence.

Public domain

The museum and the surrounding nature are a great example of a 'public domain'; the area surrounding the museum is widely used by both the museum guests and the rest of the city. It is a place where people gather in the summer for different events and where the residents in Roskilde take their daily walks. The path going from the harbour through the Museum Island is an example of the blurred boundary between private and public according to the competition prospectus. Today, the path is troublesome for the museum because many people do not realise the Museum Island is a payment zone. In the future development of the museum, we should strive for making the area suitable for public use, maintaining the interests of both the residents of Roskilde and the museum visitors in this diverse area.

Catalyst architecture

As 'Catalyst Architecture' suggests, architecture can change the space, scale and access to a given site. This will be an important move in the development of a new museum and accessibility concept. Buildings are a contributing factor in changing the experience of the structure of the place; setting the future framework of the intentional use and experience of architecture and its surroundings.

METHODOLOGICAL CONCLUSION

Double Diamond

Approaching the project through the nature of the Double Diamond design thinking tool's phases, the process may be streamlined to widen the architectural horizon whilst also narrowing the scope into key elements and not losing focus. Diverging in the process of solving problems should lead to pinning solutions into deliverance of a final design proposal.

Holistic transformation

Nicolai Bo Andersen's five methods of holistic transformation are to be employed throughout the project from assessing the existing structure, over generating ideas for intervention on the site, to reviewing chosen designs. They are a valuable way of ensuring attention to connection in the city- and landscape, atmospheric and structural relations, and the material qualities and syntaxes in different scales simultaneously – small through large.

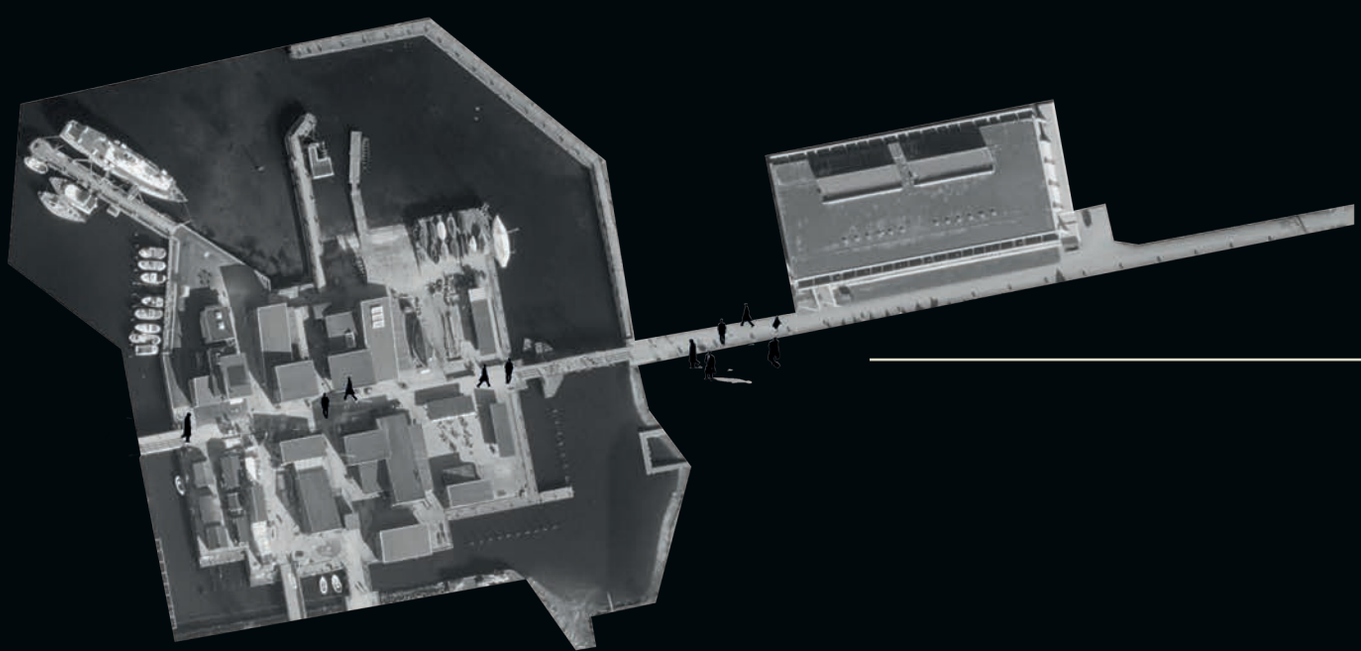
Museum planning

This thesis will utilise the theory presented in 'Manual of Museum Planning' around the chosen aspects of museum planning. The book will thus be used both as an active design tool for references on more tecnical aspects and as a parameter to evaluate the design.

Experience

Opposite the quantitative basis for the manual of museum planning, Pallasmaa offers a qualitative-oriented view of the museum experience rather than the functional demands that are tecnically required. The combination of the two approaches ensures a holistic basis for future design, where all senses and demands are addressed.

ANALYSIS OF THE PLACE



A QUALITATIVE AND QUANTITATIVE UNDERSTANDING OF THE STRUCTURES AND MICROCLIMATE

Aerial photo Roskilde
1:20.000

Ill. 13

SITE UNDERSTANDING

Differentiation between qualitative and quantitative analysis of the site

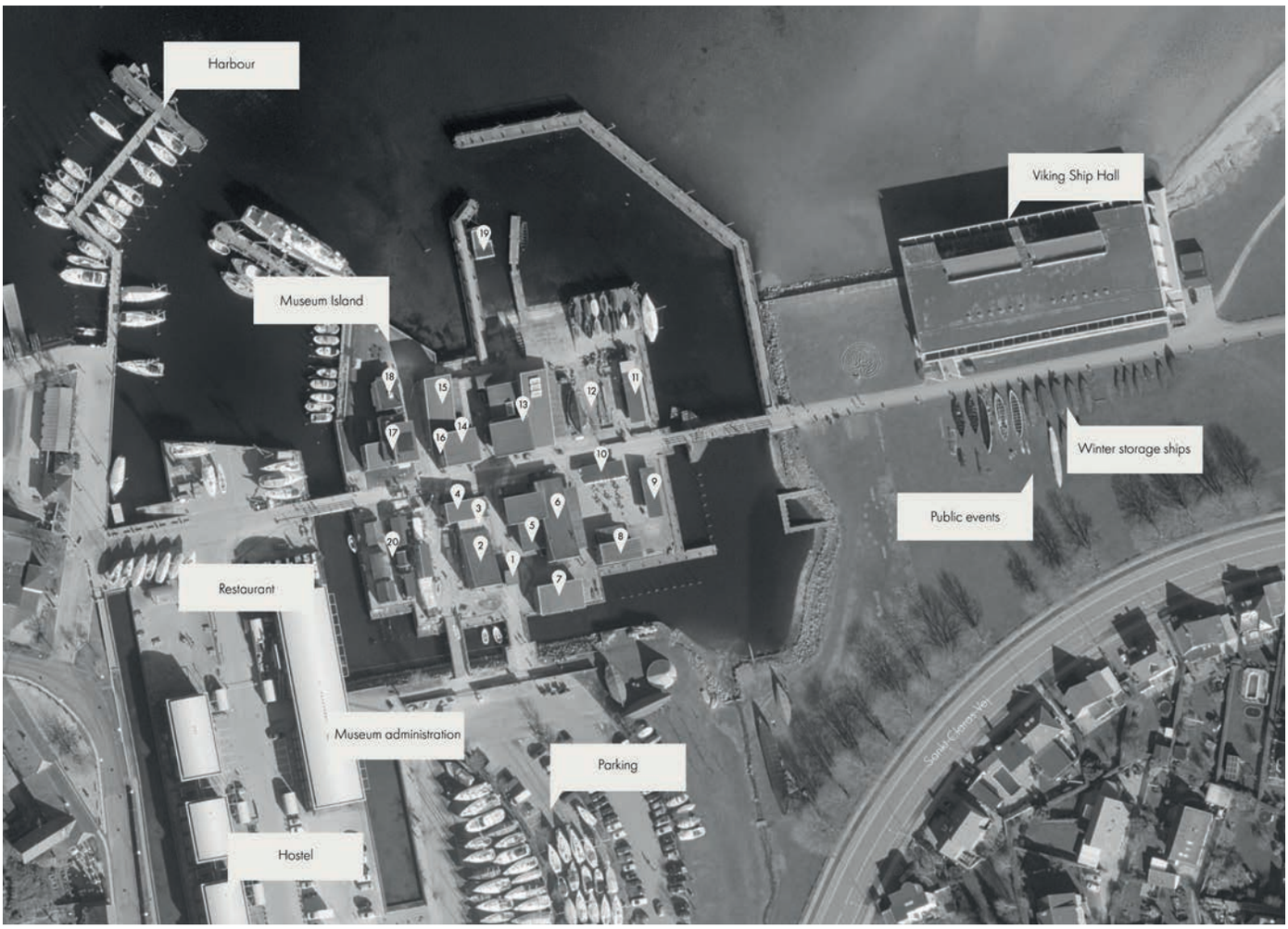
In order to understand the place and the *genius loci,* a qualitative and quantitative approach is utilised as two complementing analytical methods. The term genius loci is used as an ideal describing the spirit of a certain place; the distinctive atmospheres, qualities, and characteristics.

The quantitative information guarantees concrete data gained from various sources, which all have in common, that they are based on emperical data. The quantitative data seek *the large picture*; it is objective and concluding. However, these are incomplete without information based on human nature and senses.

Along with the qualitative information, an in-depth and detailed understanding of the structures is gained. The qualitative approach is a collection of information that seeks to describe rather than measure. From the methodological introduction of Pallasmaa, the importance of addressing the haptic senses is introduced; illustrating embodied impressions and perceptions of the place in a human scale.

The use and the users

The harbour area surrounding the museum is owned by the municipality, which reflects in the use and users of the area; being an umbrella organisation for the many associations and companies along the harbourfront. The winter swimmers, youth hostel guests, ateliers, kayakers, boat builders, cafés and



Aerial photo 1:2000
Introduction to the museum area

Ill. 14

many more are all contributing to creating a diverse environment all year round on and around the museum area.

Both the museum park in front of the Viking Ship Hall and the parking space between the hostel and the administration are widely used for different public events both in winter and summer; such as Christmas markets, jazz events, Viking markets, cultural exhibitions, and sports events (Roskilde Kommune, 2019).

The Museum Island and park are open and easily accessible environments both for the public and paying guests. The museum works with reconstructions of Viking ships all year round upholding old methods and building traditions; all at the spot where it all took place during the Viking Age. However, on a cold autumn day, the area is not very active except for a few people sitting in the cafes and the boat builders carving Viking ships inside the half-open workshop hall.

The museum does have an increasing number of visitors each year with around 160.000 paying guests in 2022; hereof more than 70% are international visitors from mainly North America, Germany, England, Italy, France and Spain in all ages. In the same year, more than 500.000 people crossed the Museum Island from east to west (Johansen, 2023).

ASSESSMENT MATRIX

Skin - meat - bone
representation

Ill. 15

Landscape – still life – portrait

Is looking at an existing building at different scales through their distinctive characteristics drawing inspiration from genres of painting. The landscape view in 1:500 specialises in urban relations and large connection in the built environment and describes the building's capability of coherence in its surroundings. Still life is depicting a moment in time and is good at describing volume, spatiality, and atmospheres as the scale 1:50. A building's tactility and tectonic links come into sight in the portrait, zooming in on structural elements and their syntax in 1:5.

Skin – meat – bone

Is an anatomical metaphor of describing a building in constituent levels, with skin being the aesthetic appearance of the building, the façade. It portrays the public's understanding of the building – how it is viewed from outside by people on an everyday basis. Meat is giving the structure form with its spatial organisation. It is how the building is experienced in a point of view, the rooms' specific atmosphere and their correlation. The structural skeleton is bone. It demonstrates the flow of gravitational forces from roof to foundation through tectonic details and joints.

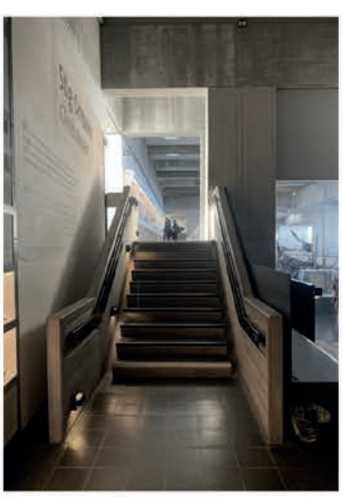
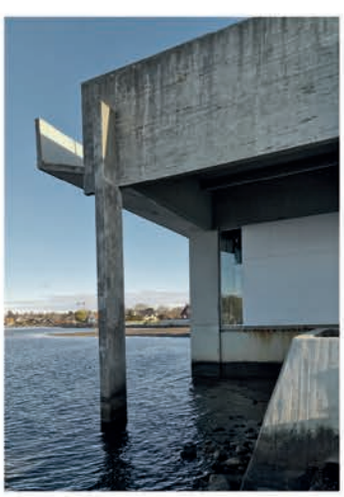
Skin - meat - bone
analysis of the Viking Ship Hall

Ill. 16

skin *meat* *bone*



land-scape

still life



por-trait

THE VIKING SHIP HALL PERCEPTION

From the first glance of the Viking Ship Hall the building's outer appearance looks cold and in a rather bad state. The building parts that was once clean, modernistic brutalist concrete elements are now cracking; making the building appear less majestic than originally thought in the 1960s.

However, the building has always been a subject of discussion. The Viking Ship Hall has been widely criticized, particularly for turning its back to the city, and generally being an eyesore towards the fjord (Fälling, nd.).

But as soon as you enter, the grandeur of the building accentuates with a majestic view over the fjord through the large window façade facing south, which is articulated by the monstrous beams and columns following the five Skuldelev ships exhibited inside.

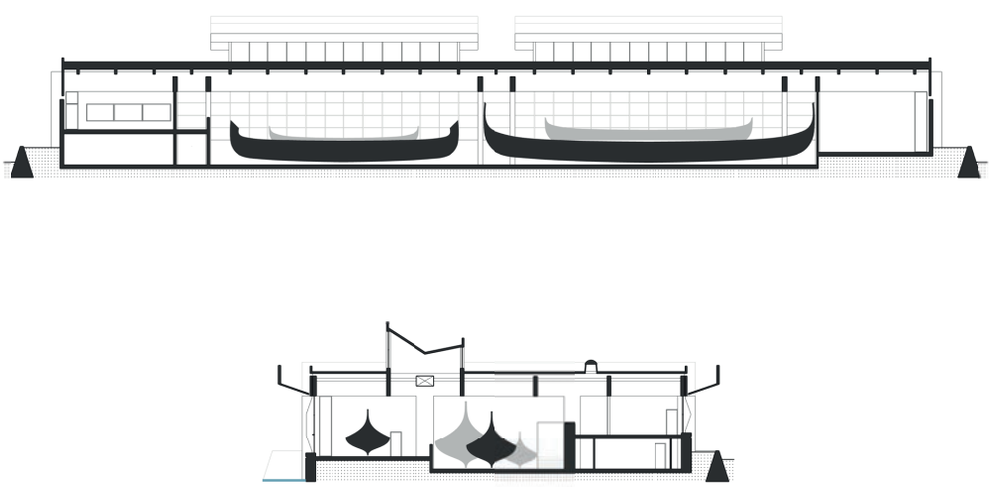
Erik Christian Sørensen described this gesture as a theatrical silhouette towards the water, where the ships should be seen as a triumph as the viewer enters the museum.

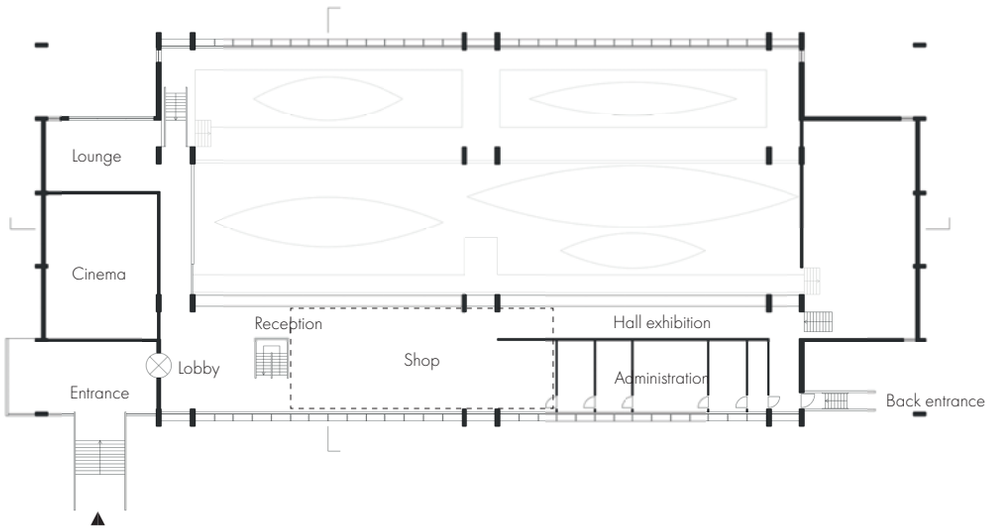
Yet for a structure that is so immediately impressive, it is surprisingly sensitive; which is clearly displayed in the perception of the hall today, where the formerly uninterrupted window façade towards the water is now barricaded by a wooden entrench of temporary wooden shuttering to withstand the enormous pressure from the fjord.

Also, the almost philosophic wooden marks in the in-situ concrete have disappeared over the years due to necessary maintenance, losing its originality toward material thoughts.

The sections show Erik Christian Sørensen's simple philosophy of exhibiting the Viking ships from different levels enabled by the layout of levels inside the building.

Sections
1:500
A museum for the ships
Ill. 16

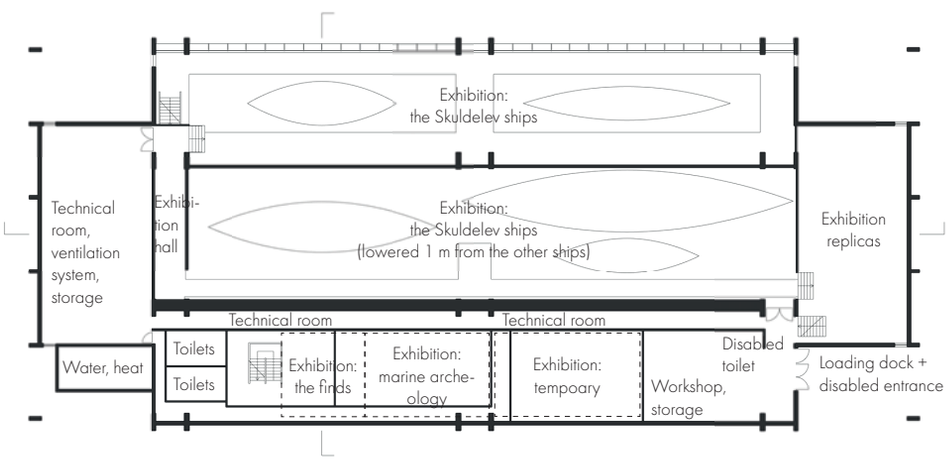




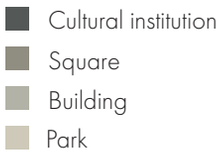
The plans illustrate the thought of watching the finds as a triumph towards the water, where the visitor looks above the ships placed in a lower floor, when entering the museum. However, these level leaps makes it impossible to access the entire museum if movement impaired.

Ill. Plan level1+2
1:500
Exhibitions
Ill. 17

Ill. Plan Basement 1:500
Entrance, cinema and museum shop
Ill. 18




Marina
RoS Gallery
Byparken
Folkeparken
Cathedral
Roskilde
Museum
Monastery
Main Street
Museum
of crafts
Station



Urban Roskilde
1:6000

Ill. 19

URBAN ROSKILDE

Roskilde's historic city centre was developed around the 12th century travertine Roskilde Cathedral, situated on a ridge sloping down towards the fjord (Langkilde, 2021). The urban road system of this first capital of Denmark remains largely the same as in medieval times, but is now quite scarce of paved squares for gathering and urban recreation. Most courtyards and plazas have been expropriated by masses of parked cars. The main street has been pedestrianised and has become the central commercial nerve for the city flanked by supermarkets, food joints, and boutiques.

In search of more peaceful surroundings, the old parks - Byparken and Folkeparken - serve as the lungs of the city, leading the way from the hectic city centre towards the harbour in north. These are comprised of both large open areas of grassy fields, wooden paths revolving around small lakes, and an athletic field. The small parks south of the cathedral are primarily graveyards or greenery in relation to monasteries.

The municipality is strategically planning on strengthening the connection between the city centre and the harbour through Byparken, using the natural springs as a catalyst for experiencing the characteristics of Roskilde (Roskilde Kommune, 2019).

The Viking Ship Hall lies on the edge between the city and the fjord as a final destination when following the open areas in the north-going axis departing from the cathedral. The Viking Ship Hall is surrounded by an open green area and the publicly available Museum Island. The marina immediately west of the museum offers a various range of maritime activities and is a popular locality for tourists and locals alike.

From the densely built city-block embossed centre, the city sprawls outwards with mainly villas and single-family dwellings towards northwest, mixed with multistorey housing towards northeast.

INFRASTRUCTURE

The area surrounding the museum is important for the residents of Roskilde since it is a vital part of the lively harbourfront. A part of the future structuring of the Museum Island suggests that the diversity in the area and its users should be preserved, conserving the public access to the fjord through the development of paths between the harbour and fjord without compromising the Museum Island's functions within the paywall (Roskilde Kommune, 2019).

The entrance to the Museum Island should be strengthened. Accessibility concepts must be developed as part of an overall approach that creates an obvious arrival point at the museum complex, resulting in a separation of areas with free admission and those that require a ticket, and a strong sense of coherency of the whole complex binding the Museum Island and the old and the new museum together as one experience. Today, it is not immediately apparent that the Museum Island and the Viking Ship Hall are related to each other.

The project aims to maintain accessibility and improve it, especially for pedestrians. It is important to maintain good paths on the site to create a connection and openness to the context and neighbours of the site.

Traffic type 1: cars, motorcycles, etc.

The site is very accessible, both for drivers, cyclists, and pedestrians and also with public transportation. Today, the immediate entrance is from the parking space south-west of the site towards the Museum Island, where there is a payment wall during the high season in the summer at the entrance point towards south.

Here, the visitor is greeted with an informational board of the museum area's disposition when arriving. However, it is not clear when walking around the Museum Island, in which direction to go. There is not a 'route' or storytelling throughout the island, rather than moving around in the labyrinth of buildings.

Traffic type 2: pedestrians, bikes, etc.

When walking or cycling there are several entries to the site. Today, pedestrians are crossing through the Museum Island on the public path going from east to west; some are simply following the harbour path, and others are there to experience the museum's facilities. The public and private facilities are not logically linked to the way guests move around the museum since they are not psychically or visually separated from each other.

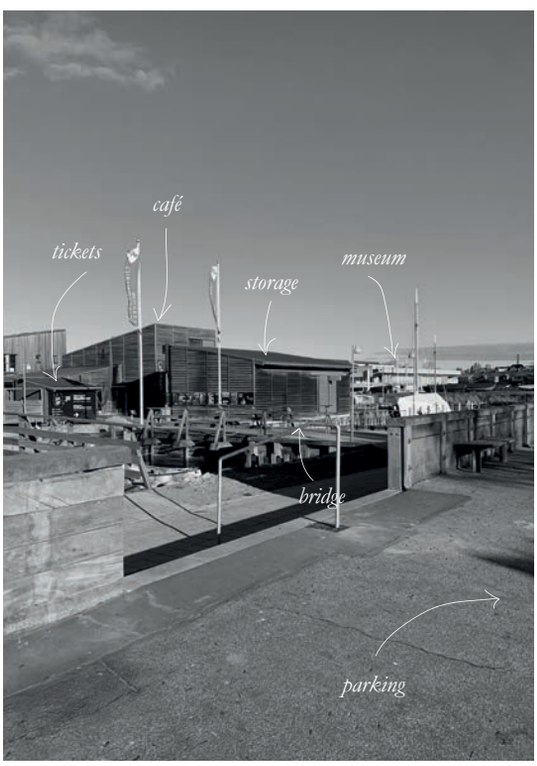
Public transportation is right at hand with bus stops right in front of the museum. When arriving on foot from south, either from the bus stops or the city, you either cross through the museum park's lawn to get to the Viking Ship Museum or the parking lot before entering the Museum Island. There is not a clear entrance point or direction when arriving at the harbour, and it is not clear that the two are linked to each other at the first glance.

Ill. 20

Infrastructure
1:2000

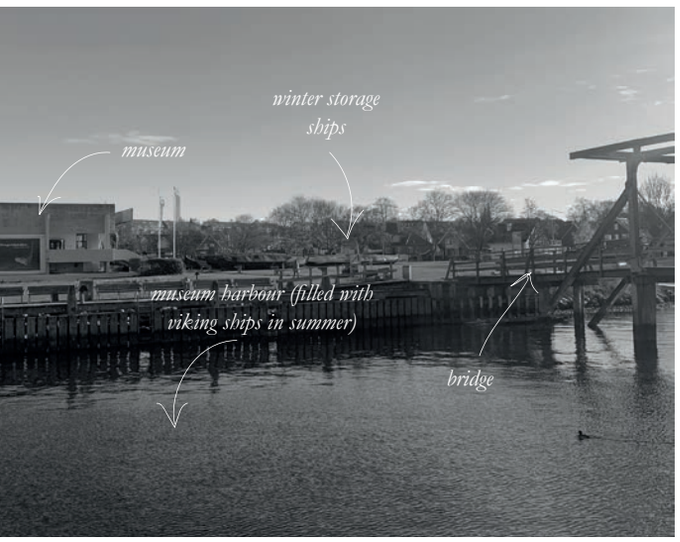
Viking Ship Hall entrance

Museum Island entrance
with paywall in summer

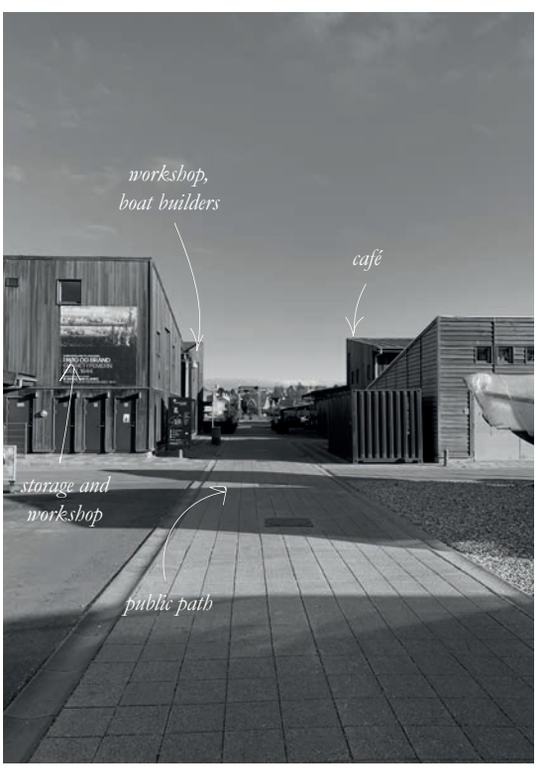


The public path seen
from west towards east

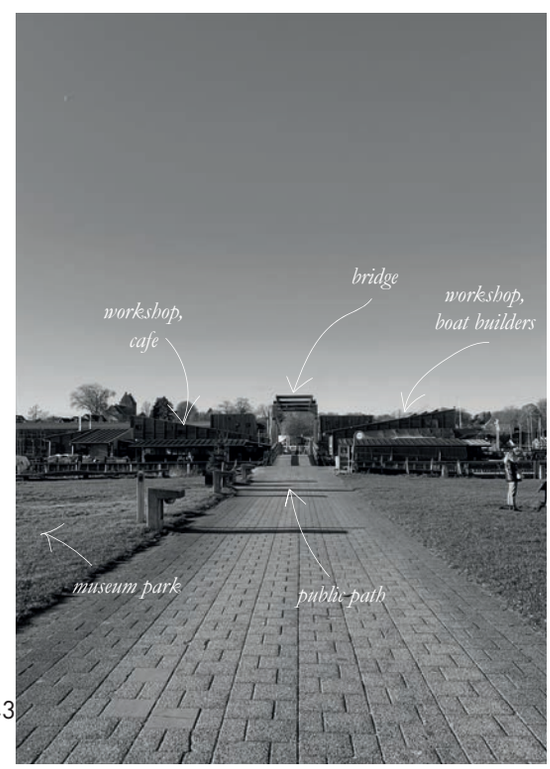
The museum after crossing the bridge



The bridge connecting the Museum Island to the Viking Ship Hall



The public path seen from west towards the museum in east



The public path seen from east towards the island in west

The museum area

III. 21

MICROCLIMATE

The microclimatic analyses are performed with ClimateStudio, a plugin to Rhinoceros, to attain knowledge on local climatic data. The developer describes it like this:

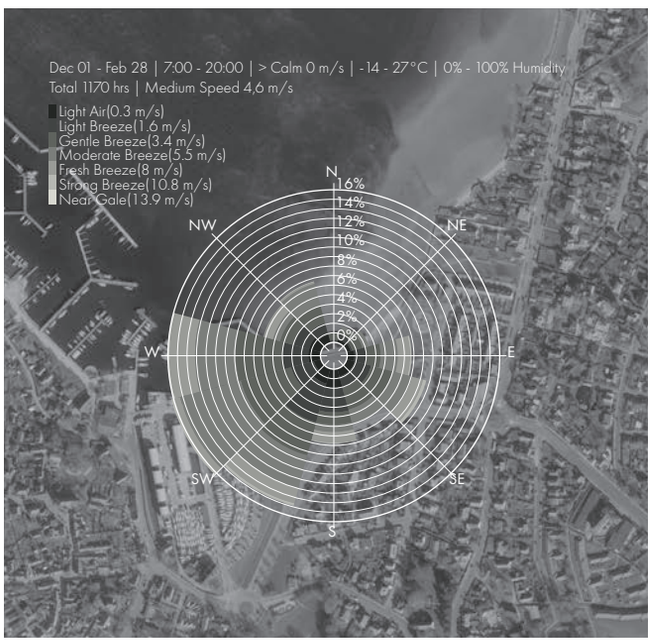
"*ClimateStudio uses Typical Meteorological Year (TMY) weather files, which contain measured hourly data for a variety of physical quantities that are required for environmental performance analysis, including direct and diffuse solar radiation, temperature, relative humidity, and wind speed and direction*" (ClimateStudio, 2020).

It allows for desktop analysis on different matters of climatic studies and is a useful tool for graphically depicting weather phenomena.

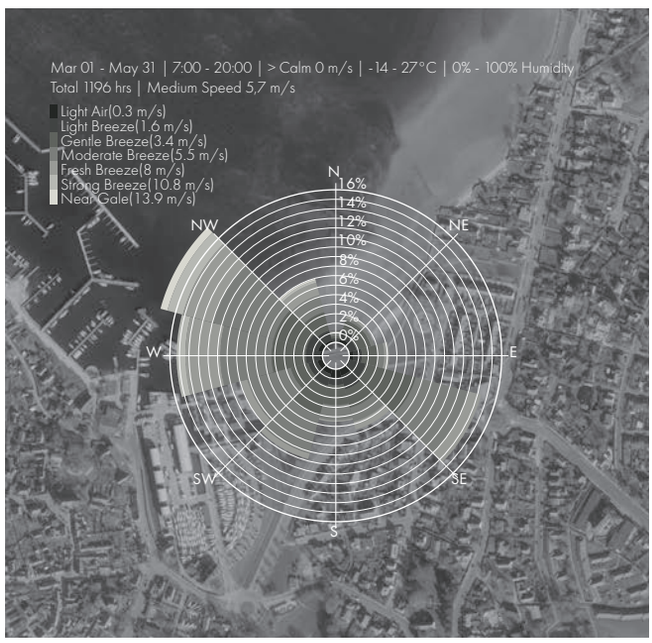
The wind roses are devised from the months of the four seasons in the interval from 7:00-20:00 – considered being the time of use of the area. The windiest season is spring where the strong winds mainly occur from the open fjord in west-northwest. In the cold beginning of this season of changes we cannot rely on deciduous vegetation for sheltering from the south-eastern winds. As pages turn in the almanac, the winds become less strong but more common and dispersed during the summer while the temperatures increase, making the wind more welcome. In autumn the wind direction gathers from southwest and west while steadily decreasing in pace all through the winter. The museum area is susceptible to wind given its solitary placement on the bank of the fjord and designing for outdoor activities calls for cautionary attention to not creating wind tunnels and general discomfort.

Meandering around the Museum Island on a windy November day leads to exposure to gusts of wind in this axial structure of pathways. Nooks and crannies for outdoor work and dissemination of the traditional handicraft offer shelter from the wind. It is arguably climatically authentic in terms of walking in coastal areas of Denmark to experience the harsh winds. The open area around the Viking Ship Hall is obviously more exposed to the continuous presence of wind and might benefit from wind-protection depending on the prospective programming of outdoor functions.

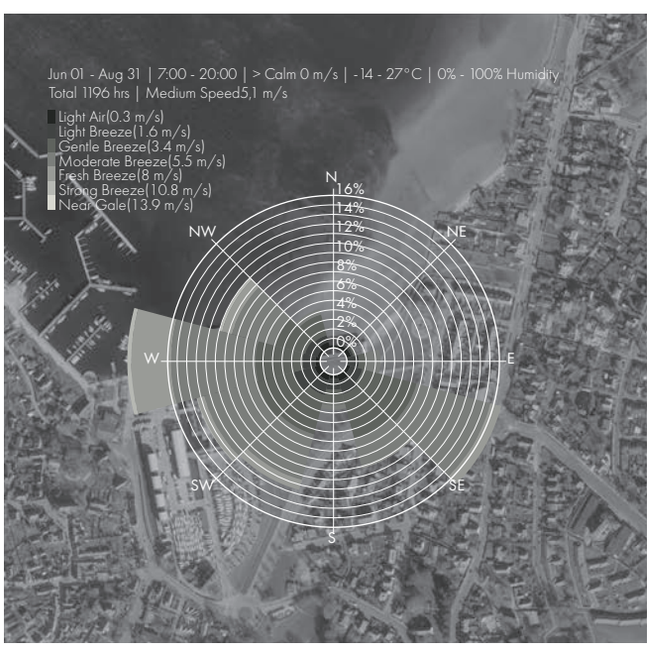
Wind directon: Winter
W-SW Moderate winds



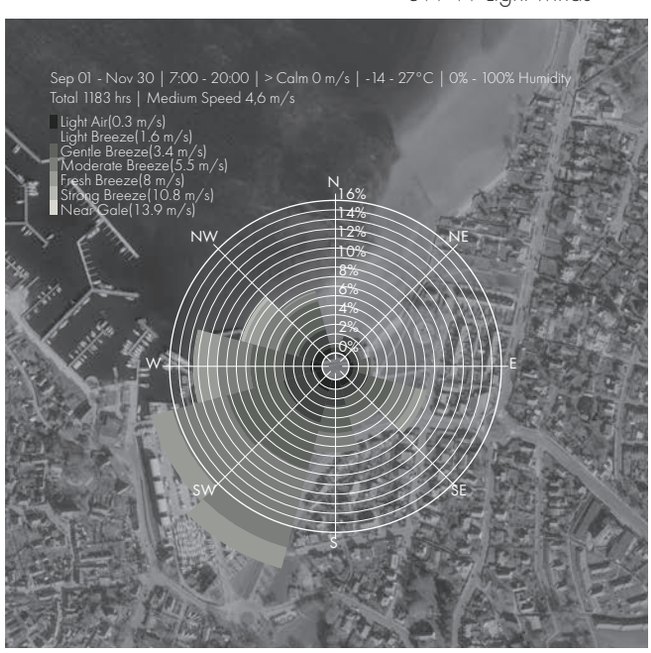
Wind directon: Spring
W-NW & SE Fresh breeze



Wind directon: Summer
W & SE Moderate

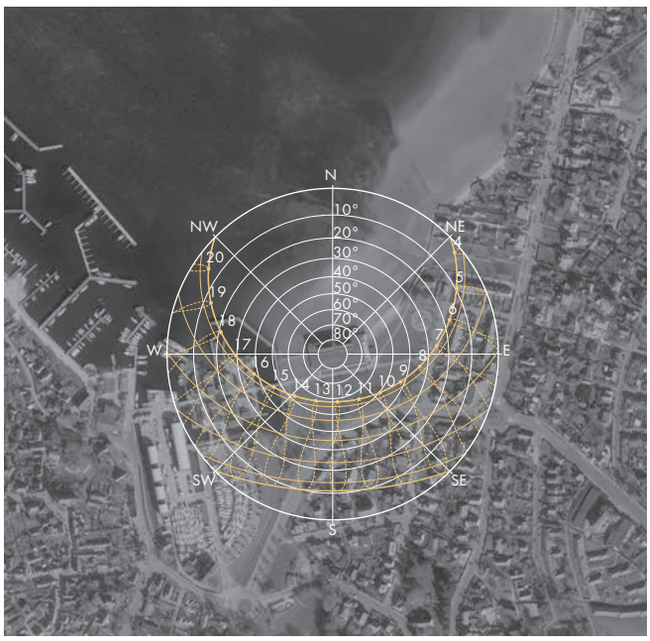


Wind directon: Autumn
SW-W Light winds



Wind conditions

Ill. 22



Sun path annual

Ill. 23

Sun path diagram

The latitude of this tempered climate results in great variation of the length of days in winter compared to summer, respectively approximately 8 and 16 hours with the maximum altitude of the high noon sun varying from 11° to 57°. This makes the minimum amount of daylight in the dark winter months a valuable asset to illuminating indoor spaces. The high summer sun is to be blocked from entering the exhibition spaces to prevent overheating in peak hours of museum visitors and to safeguard the delicate marine archaeological finds, thus minimising need for energy consumptive mechanical temperature regulation.

Shadow study

The shadow studies performed in ClimateStudio depict the shaded areas in the museum's open hours – at 10 when the museum opens, at noon when schoolchildren and kindergarteners have their lunch, and at 16 when the museum closes. The openness around the Viking Ship Hall is highlighted by the lack of shade from buildings and trees. No shadows are seemingly cast upon the hall at any time.

Shadow study

Ill. 24

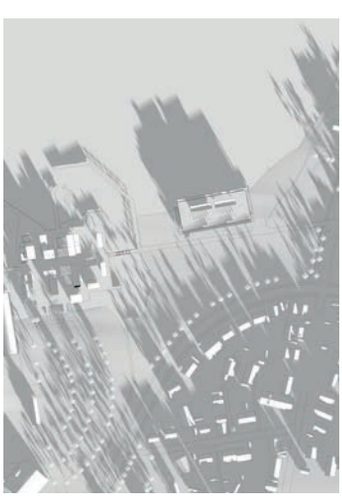
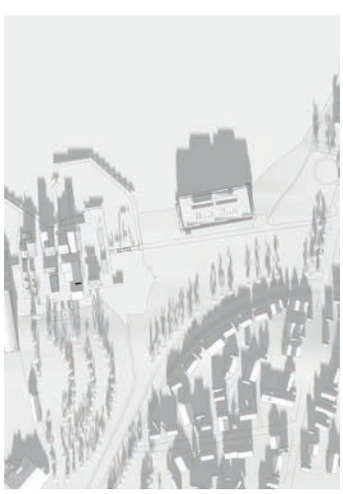
10.00 *12.00* *16.00*



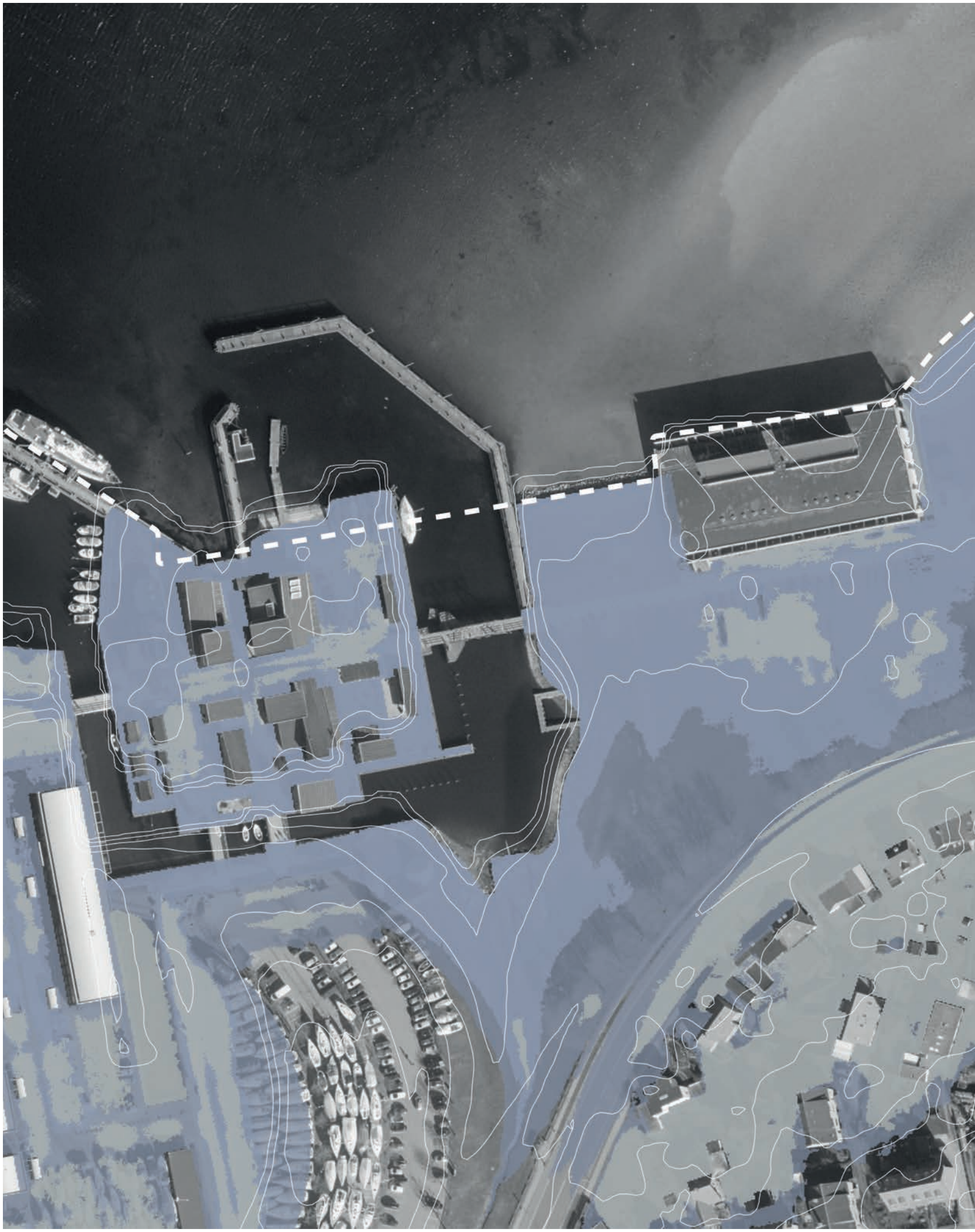
summer soltice



autunnal equinox


winter soltice



WATER MANAGEMENT

Rising water levels, extreme seasonal rain, and the Natura 2000 status of the fjord are all things that have an impact on the museum ground, which is placed low and exposed in the landscape.

In 2013 a large storm ravaged Roskilde. The water pressure and a water level above 2,10 above mean sea level (AMSL) were more than the Viking Ship Hall could manage. This affected the Museum Island too, where barricades of sandbags were placed at doors and gates to proof the interiors from water and moisture damage. According to the prospectus, the new flood-proof museum should withstand a water level of 2,5 meters in even more extreme cases in the future (Efter stormfloden, 2014).

Roskilde's municipality does have a plan for the coastal defences, securing both the Museum Island and the Viking Ship Hall of the water pressure and water levels, including both permanent and mobile measures. However, the fjord is classified as a protected Natura 2000 area; meaning it is simply not possible to make the possible local dikes that would protect the museum ground from rising water levels (Vikingeskibsmuseet, 2019).

2,1 m AMSL
2,5 m AMSL
>150 mm rain
Natura 2000 area

Water management
1:1500

Ill. 25

ANALYTICAL CONCLUSION

The Viking Ship Hall

The museum is a child of its time with its open floor plan and raw appearance. The structuring of the museum makes it possible to experience the main exhibition from different angles, providing different atmospheres and levels of detail. The original thoughts and reflections on how to present the Viking ships should be implemented and refined in the new museum exhibition, making sure the ships are never to be moved again.

However, the museum as it is structured today is facing a problem regarding movement-impaired people, which needs to be implemented in the transformation in order to make the museum accessible for all.

Assessment matrix

Using the assessment matrix as a method in the perception of the museum in different still photographs, key elements of the existing hall are depicted to value and register the essence of the monolithic structure. It shows the interrelationship of components of a whole building and guides the way of approaching the structure through transformation. By showcasing what is found preservable, possibilities of transformation appear.

Urban Roskilde

There lies a strength within the unprogrammed nature of the museum park regarding the public use of the museum area with events emanating from the openness of this green field – such as bike rallies, a jazz festival, and Christmas markets. A strong link from the harbour and other cultural institutions is already present through the visual connection - the object is to balance the outlining of the payment zone with consideration for the use of the general public.

Infrastruture

The Museum Island is easily accessed; whether you arrive by foot, bicycle, car or public traffic, it is easy to find your way towards the water. The problem occurs when trying to orientate oneself in the harbour area. The goal is to make an intervention in the Museum Island; maintaining easy access to the area but clarifying the functions and the paths at the harbour, to create a place with a public space of higher quality and cohesiveness throughout the different routes and arrival points – both for the museum functions and its neighbours.

Wind

Wind-sheltered areas are favourable for disseminating knowledge to groups in case of guided outdoor tours. Natural barriers of vegetation or interventions in the landscape may contribute to these calm outdoor spaces, not necessarily having to block wind with building mass as is the case of the Museum Island. The amount of appreciated wind needs to be measured according to the function of the zone – the wind is welcome by default in this place of telling the tales of Vikings.

Sun

Recreational outdoor areas and those for contemplation might also benefit from sheltered and sunbathed conditions when pre-schoolers are having their lunch in springtime or when companies attend teambuilding courses on the premises. Daylight needs to be heavily regulated in the exhibition areas of the new museum building, since the ships cannot withstand exposure to UV-light. The decision to move the Skuldelev ships to a new and darkened Shrine allows for a revitalisation of the Viking Ship Hall and the utilised daylight inside.

Water management

The museum area is very exposed to water due to rising water levels and extreme seasonal flooding. The future museum must be protected from these extreme cases, resulting in a building elevated by at least a quota of 2,5 meters AMSL where the Viking ships are exhibited.

DESIGN BRIEF

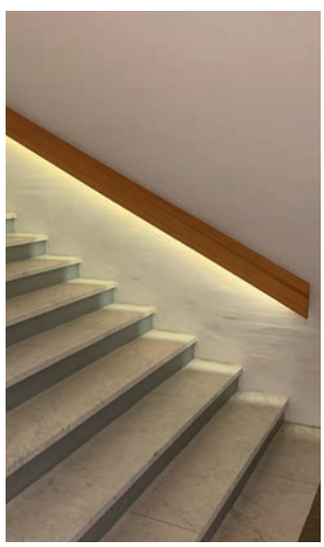
A QUANTITATIVE
AND QUALITATIVE
UNDERSTANDING
OF FUNCTIONALITY
AND TECHNICAL DEMANDS

Ill. 26

Direct light (accent light)

Direct light is light shining on an object. Direct light determines the colour and quantity of light that reaches a surface from a light source. It also determines the amount of light absorbed and reflected by the illuminated surface itself (Kim, 2022).

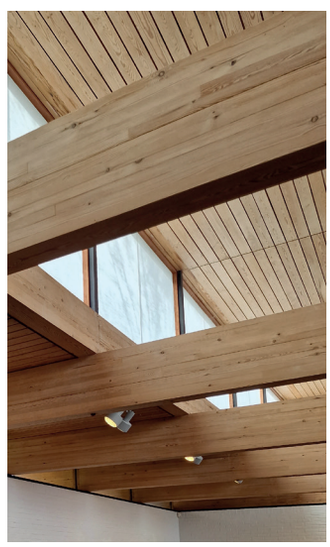
In a museum setting, this type of lighting is commonly used to highlight and emphasize art or artefacts. Brighter objects in darker surroundings attract attention and can be used to separate the important from the unimportant.



Indirect light

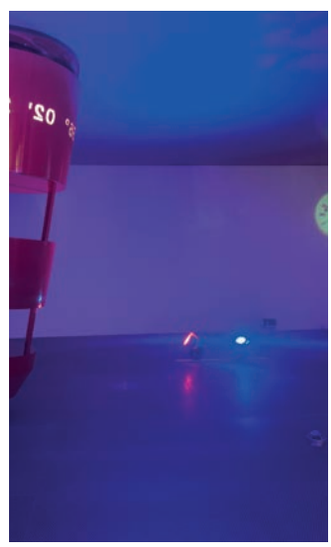
Light bouncing off a surface and illuminating other objects and spaces is called indirect lighting. Unlike direct lighting, it determines the quantity of all other light that arrives at a surface. Usually, indirect light is reflected from one surface onto other surfaces (Kim, 2022).

In museums, indirect light is often used as a guidance tool in contrast to direct and accent light which is drawing the viewer's attention. Indirect is therefore often seen on floors and staircases, which are spaces of transport and movement.



Diffuse light (ambient light)

Diffuse light is passed through a translucent diffuser which softens and disperses the light, creating a more even illumination. This type of light is in many situations used to heighten the overall illuminance in a room and eliminates glare and narrow beams of light. Too much diffuse light in a room can make glossy objects appear paler (Thomson et al., 1986).



Effect light

Effect light is coloured light often used to create a certain atmosphere. This type of light can be used as direct, indirect, or diffuse light. In this case, the light is intentionally used to enhance the exhibited item and create a maritime setting.

QUANTITATIVE LIGHT, QUALITATIVE LIGHT

Lighting is an essential part of museum design and can effectively create different settings, depending on the desired atmospheres. Museums rely on natural and artificial light sources and usually have a specific set of requirements for light allowed in certain museum areas. Light is distinguished into natural and artificial types. Most types of museum pieces are vulnerable to overexposure and must be in less illuminated areas. Different types of light of various characteristics need to be used correctly to prevent damage to the exhibited objects. This section partitions the work with light into a quantitative and qualitative basis to ensure that the limitations of one type of data are balanced by the strengths of another.

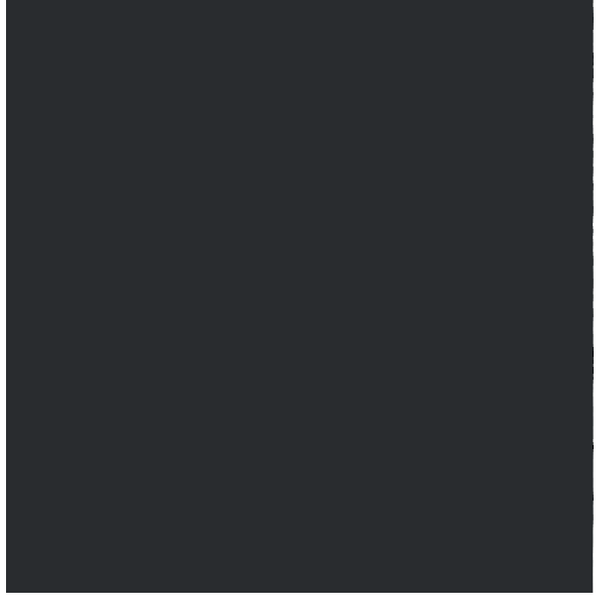
The new Viking Ship Museum has several physical demands and recommendations regarding light that are worth considering when designing. For instance, measuring the amount of light is a very important part of monitoring the conditions, which can disintegrate museum pieces over time. A significant part of the data collection is also about knowing the materials that objects and pieces consist of, and from there, their sensitivity to light is assessed. The Skuldelev ships are allowed to be exposed to 1500 lux-hours per day, which is equivalent 3000 hours of annual illuminance at 200 lux. 200 lux is the recommended minimum illuminance for tasks like reading. Daylight contains shortwave UV radiation, but this is filtered out by ordinary glass, and shortwave UV radiation can therefore usually be disregarded in a conservation context. Therefore, limited amounts of natural daylight will not be damaging the Skuldelev ships. Direct and reflected sunlight must not encounter the ships at any time (Kejser, 2023).

Juhani Pallasmaa reflects on the role that light, and its accompanying shadow, has in architecture and art to enhance the lives of human beings through great architecture. Natural light is vital to human senses of space and time, yet most of the time, its presence is in general taken for granted. Furthermore, he argues that great architecture and art works let us experience light in all its nuances, colours and interaction with material and space (Pallasmaa, 2021).

Experiencing space is a correlation between matter, space and light which are inseparable. In almost all cases spatiality is experienced and grasped through multiple senses. A parallel can therefore be drawn to the acoustic perception of space because it almost always is experienced multisensory. Steen Eiler Rasmussen's last chapter of 'Experiencing Architecture' is called Hearing Architecture and amongst other examples highlights when a room is referred to as warm or cold. He argues that it is seldom a description of the actual temperature. Describing rooms with temperatures can be a result of different sensory impressions. A room can be described as cold because of impressions of shapes and material - in other words, something we feel. Or maybe the colours are cold, in which case something we see. Or lastly, the reverberation time is long and thereby echoing sounds leave a cold impression, in which case something we hear (Rasmussen, 1964).

Even though space is almost always experienced multisensory, light is often the quality that most directly conditions the atmosphere and mood of space, place and setting. Juhani Pallasmaa describes light as the most subtle and emotive of the means of architectural expression and that "*No other medium of architecture - spatial configuration, form, geometry, proportion, colour or detail - can express equally deep and subtle extremes of emotion, ranging from melancholy to joy, grief to ecstasy, sorrow to bliss*" (Pallasmaa, 2021).

Because light is the most prominent medium to create certain atmospheres, the exterior as well as the interior designs are evaluated interactively and repeatedly both on quantitative and qualitative parameters of light.



© Vikingeskibsmuseet i Roskilde
Excavation of the Skuldelev ships, 1962

Ill. 27

COMPETITION BRIEF

The design brief is based on the tender documents from the international architectural competition (2022) and the prospectus (2019), which suggest;

The Viking Ship Museum in Roskilde is to be developed and transformed. The museum's five original Viking ships, which are part of the world's cultural heritage and of unique national importance, can no longer be secured in the existing Viking Ship Hall, where they are threatened by storm surges and degraded by daylight. Therefore, a new Viking Ship Museum is to be realized with a new future-proof exhibition building for the five Viking ships. The area must be fit for experiencing temporary flooding. Due to the site being in proximity to a Natura 2000 area, extensive flood protection cannot be constructed.

The National Museum has decreed that the ships are never to be moved again and no further than 500 meters away from their current position.

The new exhibition building, together with a new entrance/welcome building, a transformation of the original Viking Ship Hall and the processing of landscape and outdoor areas, will ensure that visitors get a coherent museum experience; communicating the history of the five Viking ships as a collective find: the excavation, the recovery of the ships, the documentation, the conservation, and the huge work of assembling the many thousands of parts so they can be experienced as ships today.

Accessibility and payment concepts must be developed as part of an overall approach that creates an obvious arrival point at the Museum, and a strong sense of coherency of the whole complex. At the same time, the project will give the public even better access to the coast and fjord than is the case today.

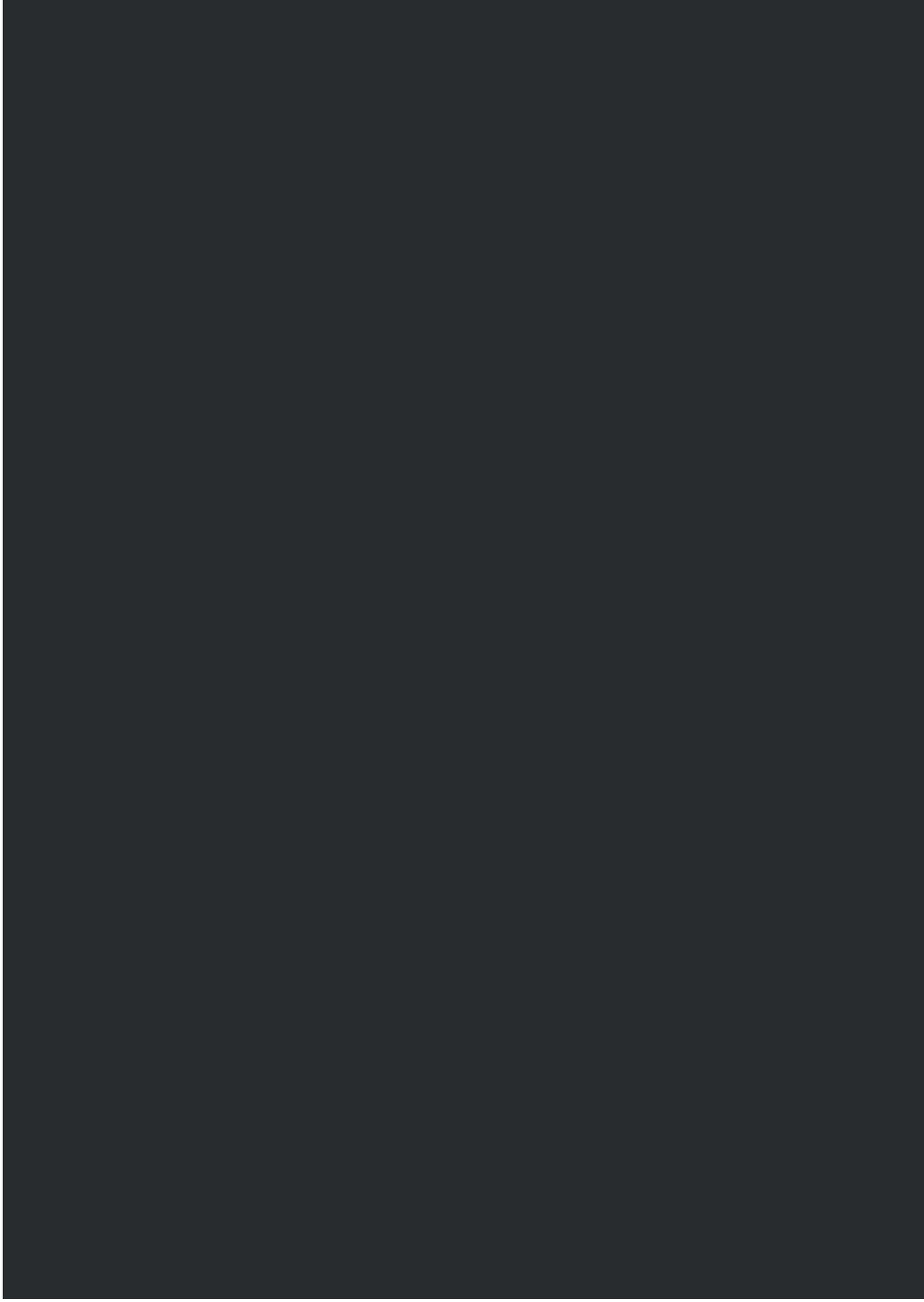
The museum will be of high architectural and experiential quality that vividly and actively conveys the history of the Viking Age, ships, shipping, and boatbuilding culture.

The construction of one or more buildings and redevelopment of the Museum landscape will embody the Museum's profile and dissemination universe, safeguarding the ships and the Museum's potential for future development.

The new space will make room for the dissemination of the five Skuldelev ships and the museum's three primary narratives: Vikings, ships and the museum's work with underwater cultural heritage.

The museum must balance a visible architectural identity with a close reading and interpretation of the place – on the edge between the fjord and the city. Buildings, content, and place must be experienced as a whole. Architecture, interior design, communication, and landscape will, in interaction with the existing active Museum Harbour and Museum Island, create the ideal setting for bringing to life the story of how the Vikings changed the world with their ships.

The vision for a new Viking Ship Museum generates the need for more space and room for exhibitions, activities, and teaching. The total area required is estimated at 3,300 m^2 for the new museum and a transformation of the existing hall at 2,400 m^2 (Roskilde Kommune, 2022), (Vikingeskibsmuseet, 2019).



Ill. 28

Excavation of the Skuldelev ships in the 1960s
© Vikingeskibsmuseet i Roskilde

INTERNAL MOVEMENT; FUNCTION DIAGRAM

The purpose of the function diagram is to illustrate the coherence and connection between the museum area's many experiences. The room program will substantiate the functional diagram with technical, atmospheric, and aesthetical demands.

The prospectus requests that the new museum concept should introduce the visitors to a cohesive universe built on three narratives of Vikings, ships, and the museum's work with underwater cultural heritage (Vikingeskibsmuseet, 2019).

The overall structure of the museum is divided into five exhibitions and an entrance. The placement and relation between these functions are important when addressing the perception and the experience of the museum and the exhibitions. The exhibition should be aware of the recurring guest, making two tracks:

A fast track; which makes it possible for the recurring museum guest to see the highlights such as the temporary exhibitions or the Skuldelev ships.

A slow track; which is for the museum guest who wants to have the full experience and historic insight into the Viking Age.

Section 1: Welcome

The entrance is the immediate starting point of the museum journey. Tickets and informational area with space for larger groups.

Section 2: The auditorium

Lectures and dissemination on relevant subjects. Outside opening hours a flexible space for other activities or lectures.

Section 3: The exhibitions

The new museum's exhibition storyline provides a simple and orderly structure of the progress of the Viking Age; from the finding of ships to a timeline of the Viking Age ranging from around 800 to 1100 AD. The overall structure of the museum is split into five exhibition areas and additional experience areas for further dissemination.

Exhibition 1: The find of the Viking ships and the Roskilde ships.

An introduction to the research and premises for the extensive knowledge of the Vikings and the Viking ships. The story of the excavation, the recovery of the ships, the documentation, the conservation, and the assembling of the many thousand parts. This should be disseminated through video footage and pictures from the excavation of the Skuldelev ships from 1962-1968, the assembling of the ships inside the Viking Ship Hall from 1968-1993, the excavation of the Roskilde Ships in 1997, and the move of the ships in 2023.

Exhibition 2: The Viking Age

Showcasing artefacts in a chronological timeline.
An interactive experience of the sea on Viking ship replicas.

*Exhibition 3: Around 1000 – The Skuldelev Ship*s

An exhibition of the five original Skuldelev ships from 1030-1042 AD.

*Exhibition 4: Temporar*y

Temporary exhibitions are generally changed once a year. The current temporary exhibition from 2022 is a storytelling of the battle at Femern Bælt in 1643-1645 between Denmark and Sweden, where three ships are sunk and later found by marine archaeologists.

FUNCTIONAL DEMANDS

Section 4: The transformation of the Viking Ship Hall into a museum of maritime archaeology

The existing Viking Ship Hall is to be repurposed into an expansion of the marine archaeological wing of the museum.

Exhibition 5: Maritime archaeology

Dissemination of maritime archaeology methods and finds.

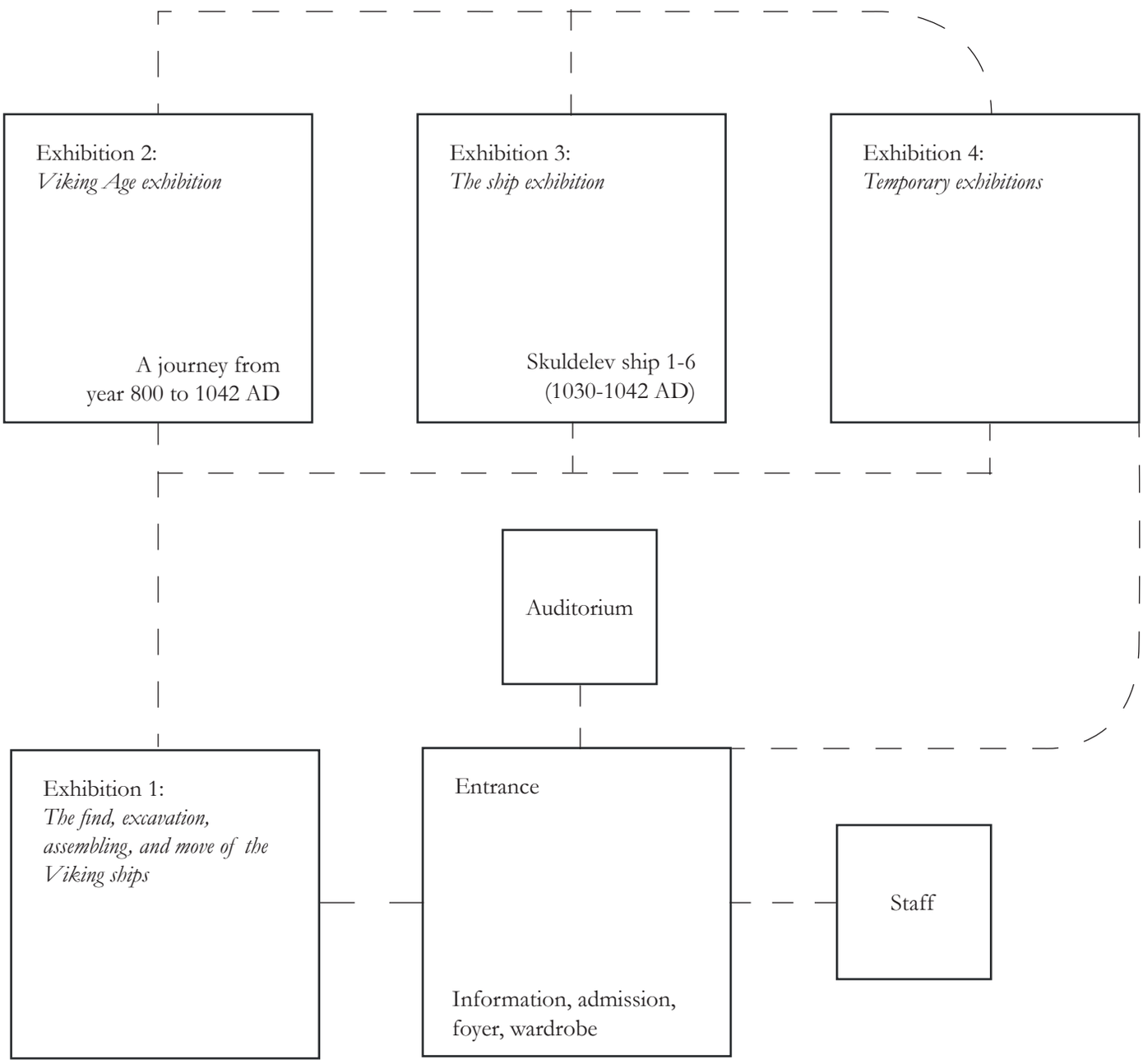
Research, cinema, and workshop: laboratories and research workshops where visitors can get close to the research and participate in the work of marine archaeologists.

Section 5: Outdoor areas

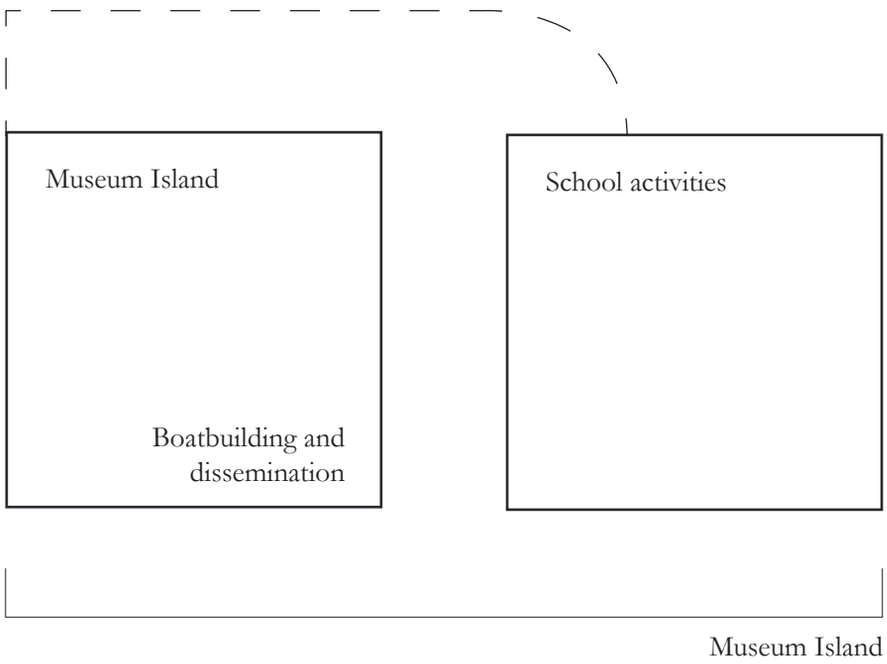
The outdoor areas are divided into two main activity zones. The museum park is open and free to the public and offers an open and playful approach to the Viking universe. The Museum Island is part of the museum's payment zone, where the world of boatbuilding and life in the Viking Age is disseminated.

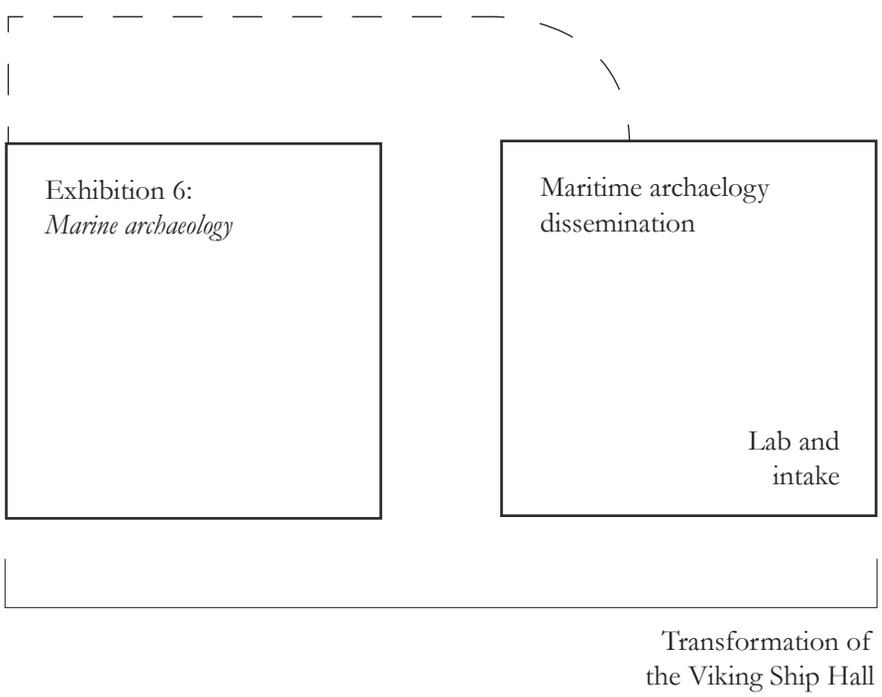
Section 6: Museum Island

The island functions remain the same as today; raising awareness of form and design by showing the Viking Age boatbuilding traditions; for specific purposes and sailing conditions such as trade, war, fishing, crossing the ocean and transport (Vikingeskibsmuseet, 2019).



A new Viking Ship Museum


Museum Island
Boatbuilding and dissemination
School activities
Museum Island


Exhibition 6:
Marine archaeology
Maritime archaelogy dissemination
Lab and intake
Transformation of the Viking Ship Hall

PROJECT VISION

The new Viking Ship Museum complex will accommodate a collection of public- and museum activities in a cohesive museum experience that highlights the different exhibitions throughout the area. Dynamic research and learning environments for staff and for visitors of all ages and backgrounds will be integrated into the constituent elements of interventions.

The Viking Ship Hall

Carefully improving the durability of Erik Christian Sørensen's brutalist masterpiece will fortify its existence on the bank of the fjord for many years to come, and by making it universally accessible its relevance may endure. A revitalization of the hall occurs through the repurposing towards an exhibition for marine archaeological findings.

Urban transformation

Through planning an easily navigable network of paths for both museum visitors and the public, the spatial organisation will be enhanced, and the sense of place increased as a result. An urban transformation of advancing the flow and framing experiences in plazas between the buildings in a flood-prone area prolongs and combines the use and users of the site.

New Viking Ship Museum

Creating a narrative worthy of the cultural history curated within the museum through flexible temporary exhibition areas and the permanent, safe dissemination of the museum's crown jewels: the Skuldelev ships. Reflecting on the functions through the architectural tectonic principles will foster a fulfilling museum experience.

PROBLEM STATEMENT

"DISSEMINATING MARITIME HISTORY IN A CONTEMPORARY MUSEUM OF CULTURAL HERITAGE THROUGH TRANSFORMATION OF THE MUSEUM AREA AND A NEW CLIMATE-RESILIENT MUSEUM SHOWCASING THE SKULDELEV SHIPS AND THE HISTORY OF THE VIKING AGE"

D E S I G N P R O C E S S

Q U A L I T A T I V E D E S I G N
Q U A N T I T A T I V E D E S I G N
I N T E G R A T E D D E S I G N
H O L I S T I C D E S I G N
T E C T O N I C D E S I G N
A E S T H E T I C A L D E S I G N

“The museum guest should enter a largely dimensioned room and see the entire find as a triumph. The ships should be a theatrical silhouette towards the water, and later to be discovered in a walkabout to see them properly”

Erik Christian Sørensen

PLANNING FOR PEOPLE, BUILDING, EXHIBITION

The theoretical, methodological, and analytical positions have provided great insight into both the problems the museum is facing today as well as solutions to optimising the area as a coherent experience. It is now our job to create a solution that is fitting the prospects; planning for the people, planning for the existing buildings, planning for the new building, and for the exhibitions.

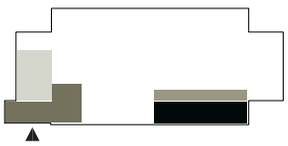
Firstly, focusing on the people of the museum area; diverting between the public and the museum guest as main users. We are placed in an intersection between the people of Roskilde enjoying the harbour in their city and the museum guest experiencing the world of the Vikings. This conflict of the right of use of the harbour should be considered in the new masterplan.

Secondly, focusing on the buildings; both the transformation of the existing buildings on the island and the Viking Ship Hall by Erik Christian Sørensen, and the new and improved museum building to disseminate the history of the Viking Age and exhibit the Skuldelev ships in a secure environment.

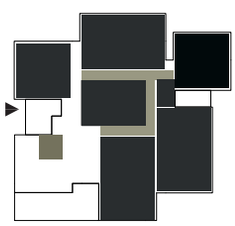
Here the process should consider the existing museum inside-out reflecting the technical demands and the new functions. The island should be connected visually to the remaining museum area creating a coherent area for the dissemination of Viking history.

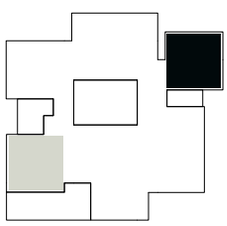
Lastly, the layout of the new museum and the transformation of the existing museum should reflect and articulate the exhibitions and how they are experienced. Especially the Skuldelev ships require a large exhibition space, which would affect and dictate the building to a higher degree than the smaller artefactual exhibitions.

As a method of getting a visual understanding of museum planning, a catalogue of five different museums has been created as a tool for inspiration of the organisation of the future museum. The museums have been divided into five categories: entrance, exhibitions, active hallways, dissemination and backstage (administration, storage). This diagrammatic, quantitative approach combined with a qualitative approach when visiting the museums create a foundation of knowledge in museum planning that has not been possible to get from the competition prospect since the room program have not been disclosed publicly.

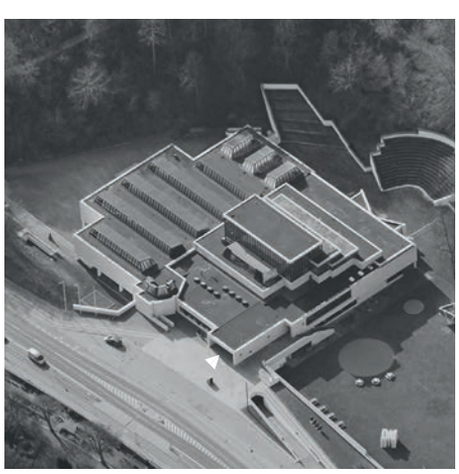


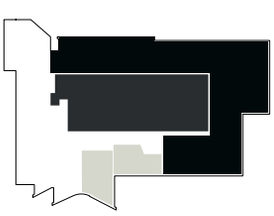
The Viking Ship Museum 1962,
2400 m², Erik Christian Sørensen

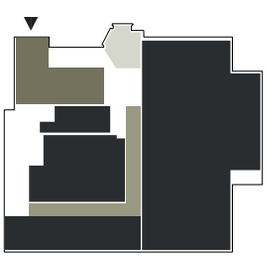




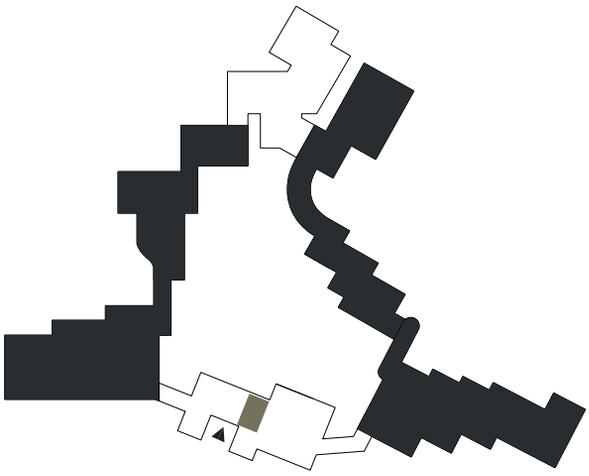
Utzon Center, 2008
2800 m², Jørn Utzon, Kim Utzon



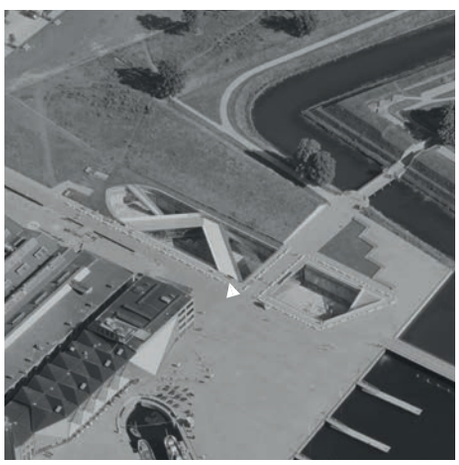


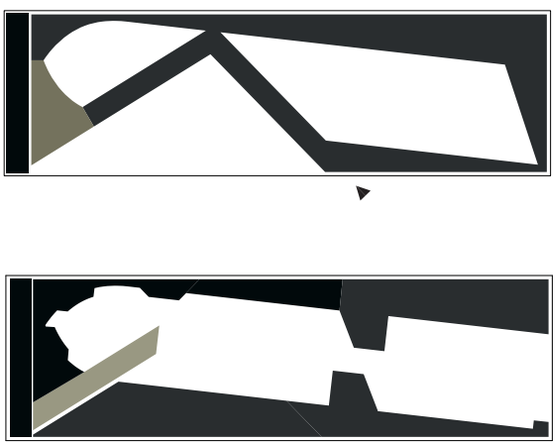


Kunsten Museum of Modern Art, 1972
6000 m², Alvar Aalto, Elissa Aalto,
Jean-Jacques Baruël



Louisiana Museum of Modern Art, 1958
10.000 m², Jørgen Bo and Vilhelm Wohlert





Maritime Museum of Denmark, 2013
7600 m², BIG architects

Museum catalogue

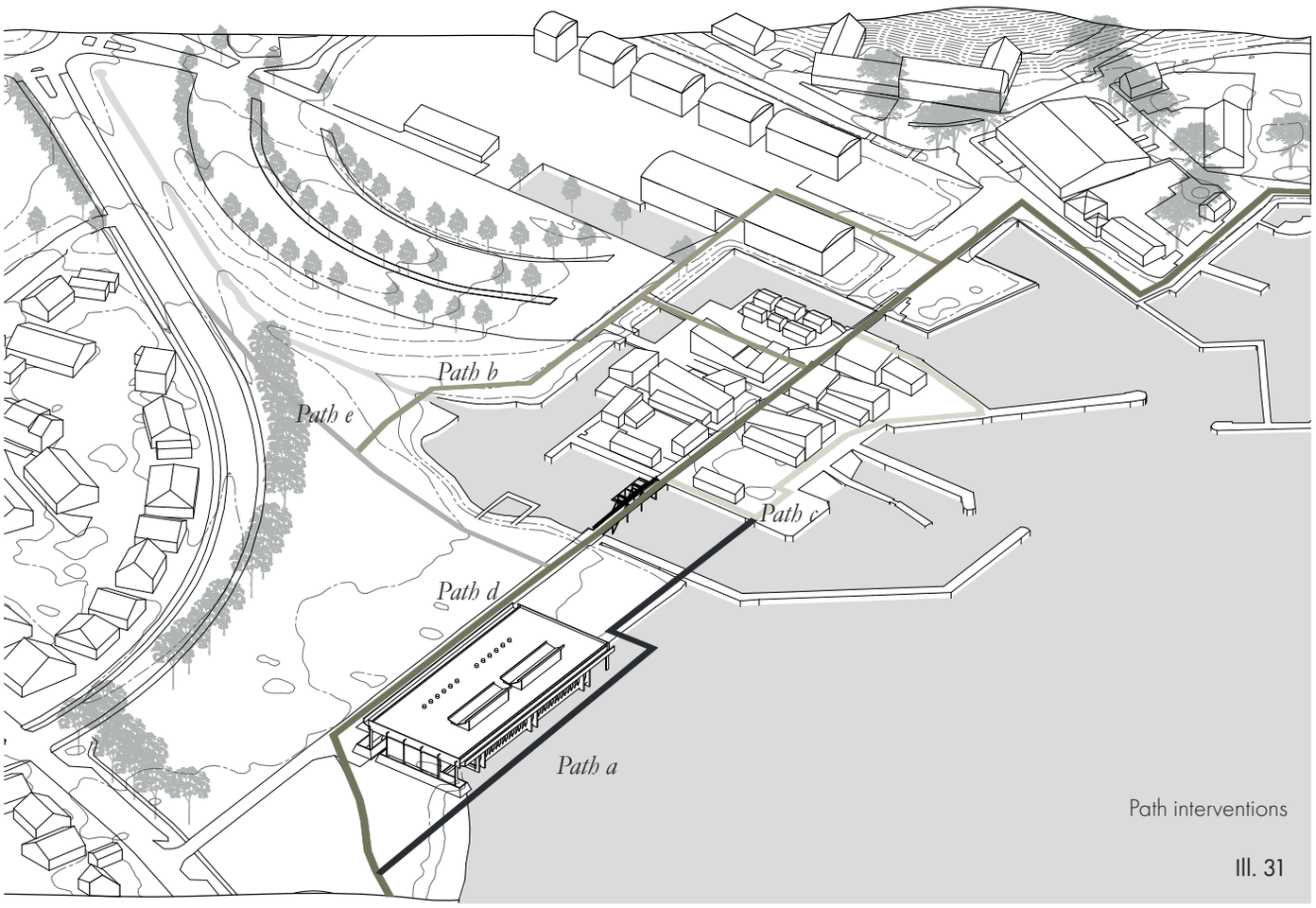
Ill. 30

- Entrance
- Active hallways
- Exhibitions
- Dissemination
- Backstage

These practical considerations of museum planning lay the foundation for the spatiality of the future museum. In the existing Viking Ship Hall there is a great focus on the arrival; looking over the ships as a triumph to be examined closer through the different levels affording both a view from a distance and up close.

Kunsten, Utzon and Louisiana are designed around a similar movement principle; leading the experiencer around a centre. In Utzon and Louisiana the centre is an outdoor exhibition space and in Kunsten the movement is around an indoor exhibition space. The centre and the hall give access to a series of sub-routes, which one can either choose to pass or explore in further depth.

The Maritime Museum on the other hand does not provide many movement possibilities other than along the one main movement axis, which presents a very orderly, chronological sequence of exhibition elements circling around the old dry dock. The museum is built in two levels that are connected through ramps with such a small slope it is not registered that one is moving from one level to another.



Path interventions

Ill. 31

INTERVENTION OF PUBLIC PATHS

The path investigation is based on the municipality of Roskilde's vision of strengthening the harbour front, and a qualitative kinaesthetic approach; experiencing a place through targeted movements with a great focus on bodily embedding, to place the paths.

Option 1:

The municipality of Roskilde suggested at a city council meeting that two new paths (*path a and path b*) going around the museum area should be established, whilst reserving the existing path d from west to east for the museum guests. This proposal would create a solution to the problem of the public going through the payment zone on the Museum Island, but would create a new problem; the need for a separate path on the water, going around the Museum Island and the Viking Ship Museum in order to separate the payment zone and the public zone from each other, and a public bridge beside the private bridge if the goal is to seperate completely.

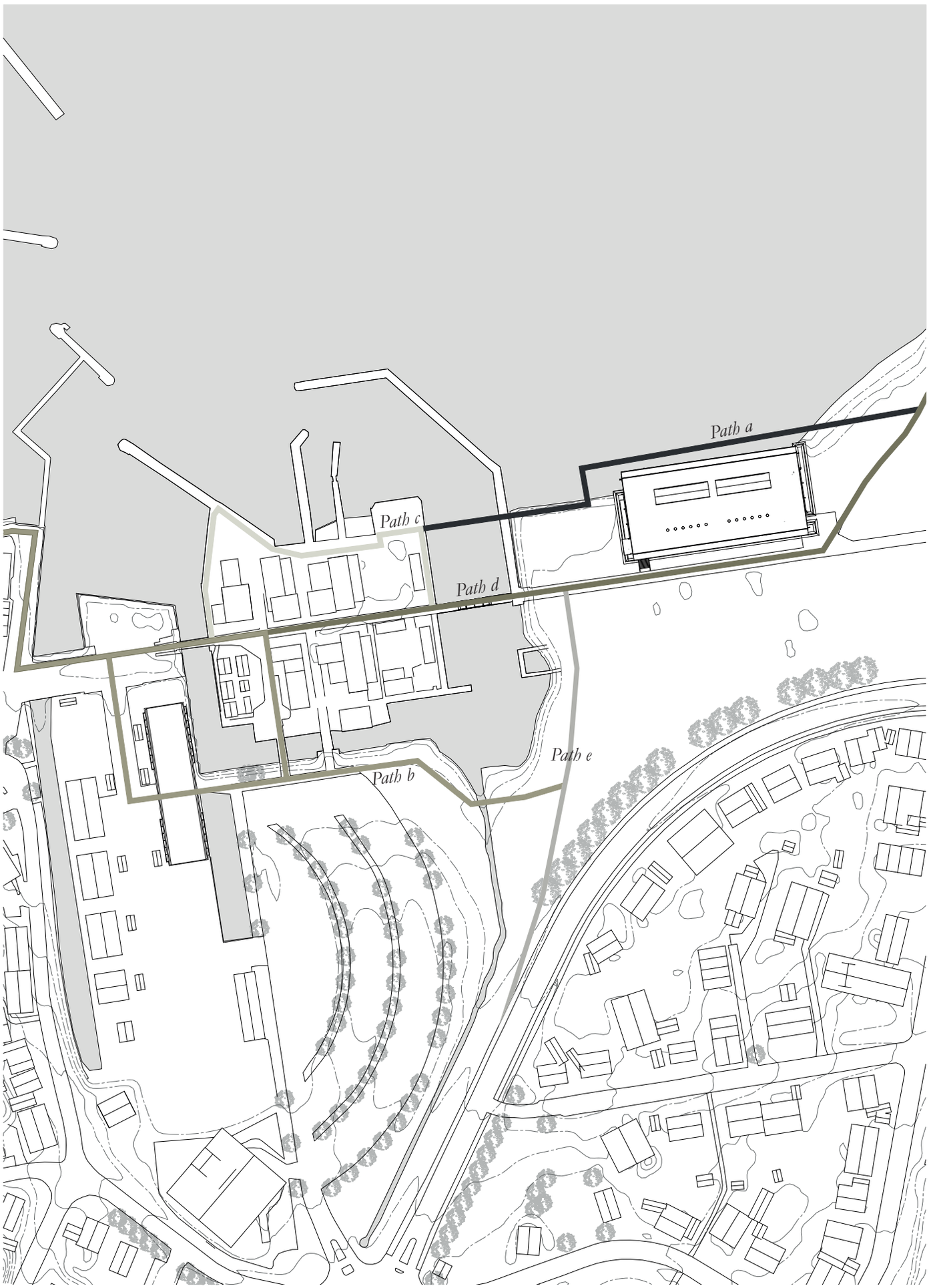
This solution would create an almost encapsulated Museum Island, where the public would be able to observe from a distance instead of up-close through the original layout.

Option 2:

Path a going around the museum area on the water is excluded. Making *path d* private would result in the public only having the opportunity to see the fjord from *path b* in this specific part of the harbour area, which is not in the municipality's interest.

Option 3:

Making the entire area public. Maintaining *path b*, creating a more obvious path to the museum park from the parking space, and rethinking path a from the municipality by giving access to the fjord on the island; going north around the Museum Island, strengthening the connection to the fjord without having to make another bridge, becoming *path c.*
Additionally, *path e* is introduced strengthening the connection from south, from the bus stop and the city, by creating a path from the road towards the museum entrances.



III. 32

Path interventions
1:2000

APPROACH TO THE TRANSFORMATION OF THE VIKING SHIP HALL

Given the nature of the competition, focusing on an extension to an existing museum, the utilisation of the original building and how it will feature in the greater context of the future museum complex will be examined.

When considering buildings deemed worthy of preservation due to their historical and cultural value, as is the case with the Viking Ship Hall, three design approaches are considered; a transformation of the use and functions, a transformation of the movement concept making it universal, and a transformation of the structure making it possible to withstand the water pressure.

Exhibition and dissemination

The initial transformation of the use of the building is utilising the space for the future marine archaeology department showcasing finds at sea and how they are excavated and processed. The museum is responsible for all marine archaeology finds east of Lillebælt, and the museum does not have the necessary space for exhibiting the finds as it is today.

The museum has a vision of creating an exhibition with the purpose of entering a dialogue about the marine archaeologist's work in the future – from the finds to the exhibitions. This can be possible by utilising the Viking Ship Hall's space.

The hall, where the Skuldelev ships are exhibited today, is in two levels with a height difference of 1 meter. This dynamic could be utilised, making two different zones in the hall; making an exhibition in the upper half with a viewing platform for guests to overlook the marine archaeologists' process of preservation in the lower half.

The basement has a larger space used for exhibitions today but was originally thought of as a space for storage and goods intake, with direct access from the east façade. As the museum is central for the marine archaeology finds, the future use could find its roots back to the original plan layout, having to handle many artefacts.

Museum shop

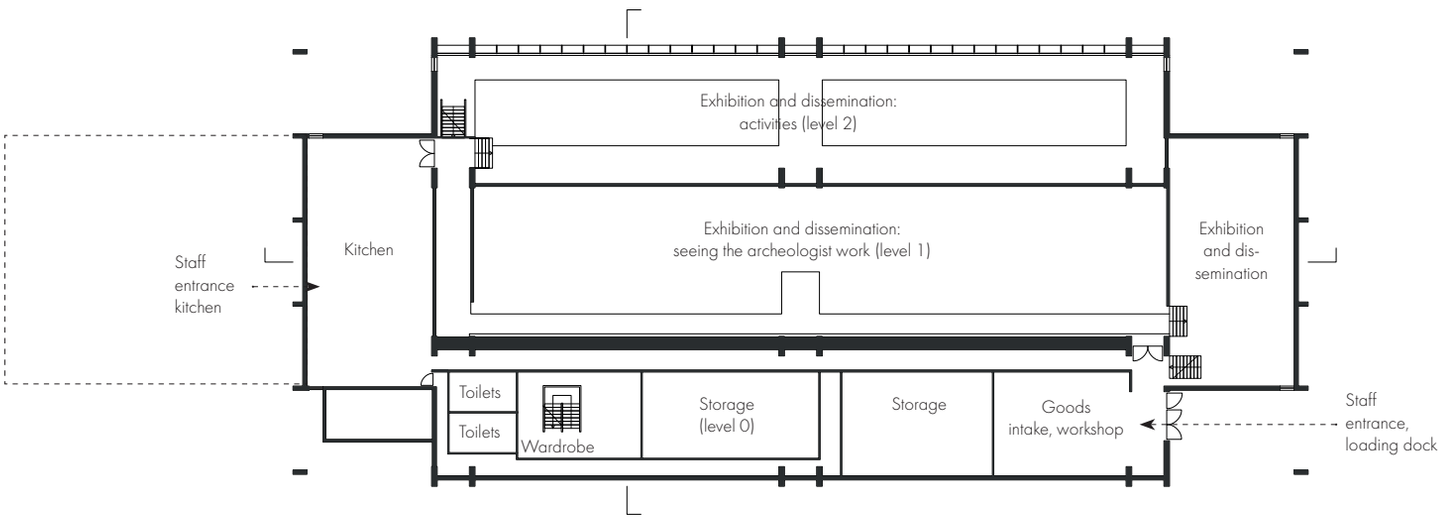
Today the immediate entrance leads to a large foyer with a reception and a museum shop, placed along the south-facing window façade towards the park. The placement of the museum shop could be maintained, as it has a shopping street atmosphere both inside and outside and can handle being exposed to a lot of direct sunlight.

Administration and welfare functions

Today there is a separate entrance to the administration from east, which could be maintained as well. With the administration towards south there could be a good visual connection between the new museum and the existing one.

A new café

In the original drawings of the museum, a cafeteria towards the fjord was part of the plan. Today, the area covers a smaller lounge area and a cinema behind a curtain wall. These will be replaced by a new, vibrant café area.

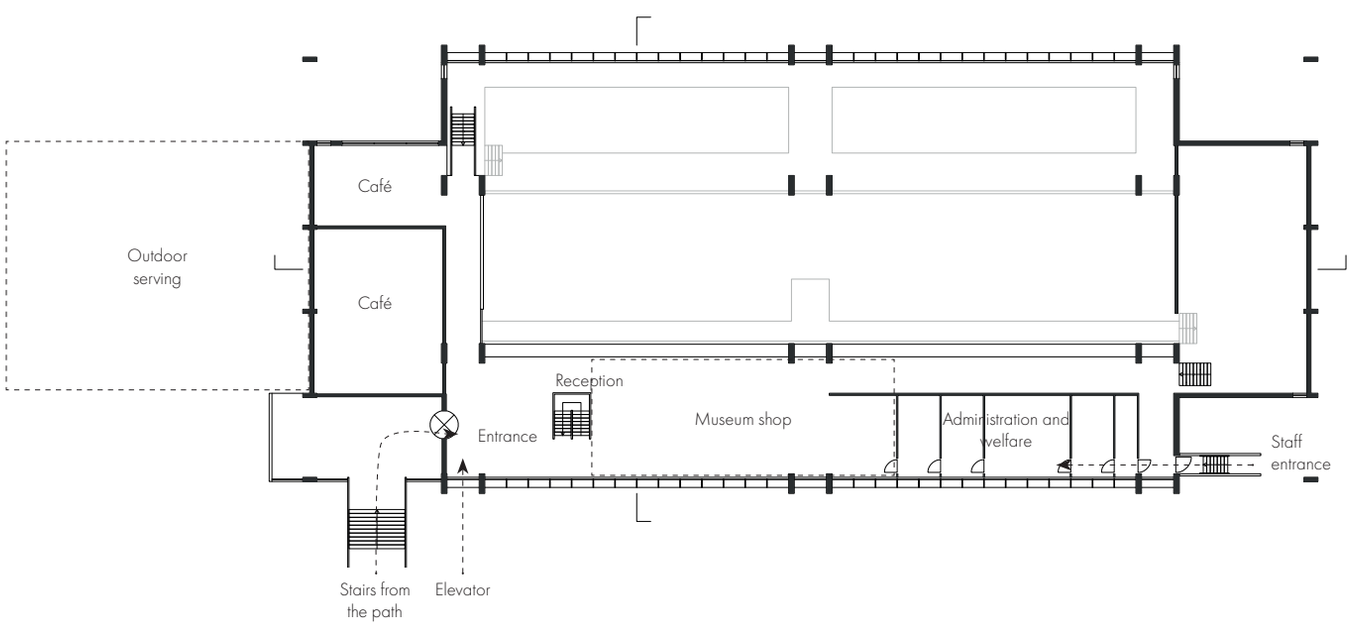


Plan ground floor
1:500
Exhibition and dissemenation, restrooms,
storage and goods intake

Ill. 33

Plan 1st floor
1:500
Universal entrances, museum shop,
administration and welfare for employees

Ill. 34



Universal design

The museum does not have any elevators or ramps, which makes it impossible for mobility-impaired people to experience the entire museum. The solution today is to transport disabled people from the loading dock in the eastern façade into the lowered part of the Viking Ship Hall, meaning most of the museum cannot be seen as the remaining exhibitions are only accessible by stairs.

The transformation of the Viking Ship Hall should accommodate a natural flow and experience of the transformed museum for movement-impaired people with a new entrance and an elevator making the entire museum accessible.

Introducing elevators and lifts in the existing building mainly within the structural framework. Creating a new parkour for persons with walking impairment and those with them. Unlike the original narrative for the building showcasing the Skuldelev Ships in all of their glory, the new flow for the building allows for a more inquisitive exploration of the transformed hall.

Structural transformation

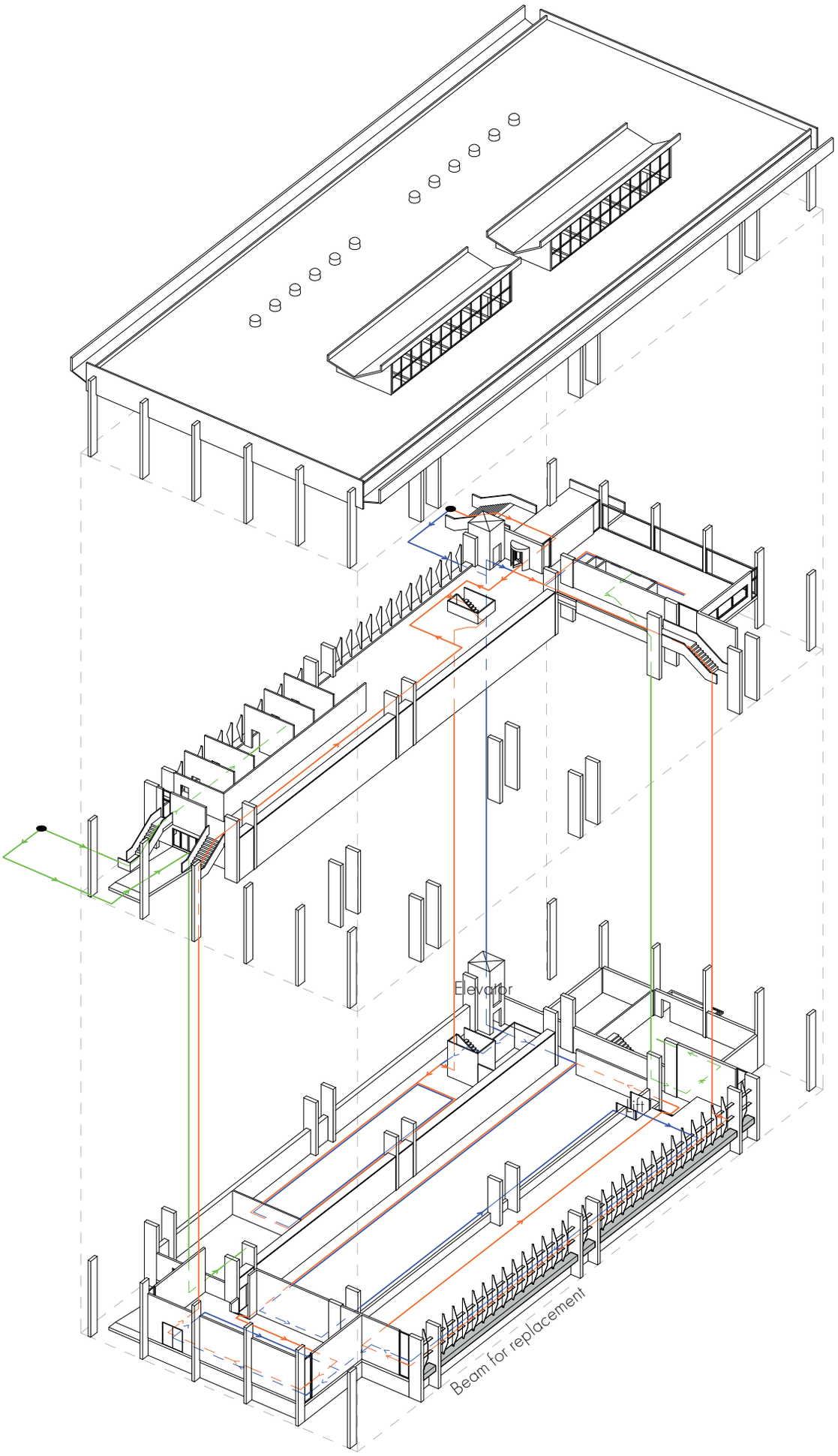
Several reports during the last 15 years lay the foundation of the structural interference of the building. The structure has some weak points that need to be replaced or strengthened throughout the building.
Especially the glass north façade needs to be secured from the enormous water pressure to remove the temporary wooden shuttering in front of the lower windows. To deal with this in the most respectful manner in accordance to maintaining the cultural importance of the building, beams have been added along the window frames to increase their resistance towards the weather.

The highlighted façade beam needs to be replaced due to deflection, and mostly elsewhere a protective layer of concrete will be added to restore the façade expression to its former glory with wooden formwork.

Functional isometric
flow and access

Ill. 35

Staff
Stair access
Elevator/lift access


Elevator
Beam for replacement

Ill. 36

EXTERNAL MOVEMENT

The movement ~~in~~ the museum area is important for the experience and the coherence of the museum complex since the different functions by default are separated. The intervention of paths solves the problems of access to the museum experiences from different angles by implementing a clearer system of paths and access routes to the museum complex.

The coherence of the entire complex should be addressed in the transformation of the urban landscape, the placement and the architecture of the new museum.

On the given site there are multiple possibilities for placement and coherency of the existing museum. The immediate placement studies suggest placing the museum in the western part of the park, reserving space for the public events unfolding throughout the year in the opposite end of the park.

As it has not been decided whether the new museum should be attached or detached from the existing volume, studies of shape and placement have been carried out.

AND THE PLACEMENT OF A NEW MUSEUM

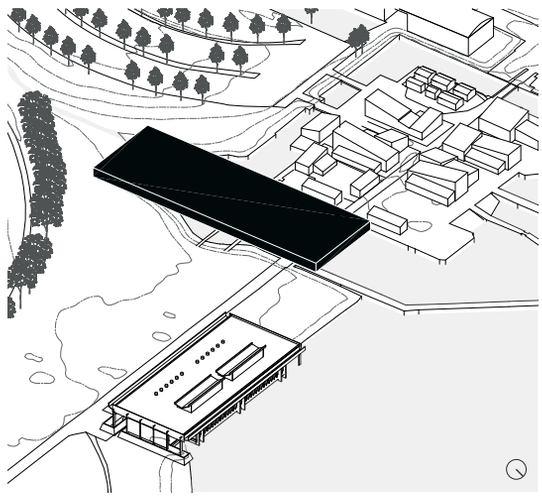
The placement diagram represents three possible placements of the new museum in the coherence of the existing museum and island; placed on the water, placed in the park west of the existing museum, or placed in the park south of the existing museum in either one or two floors with a representation of 3.300 m^2 in total.

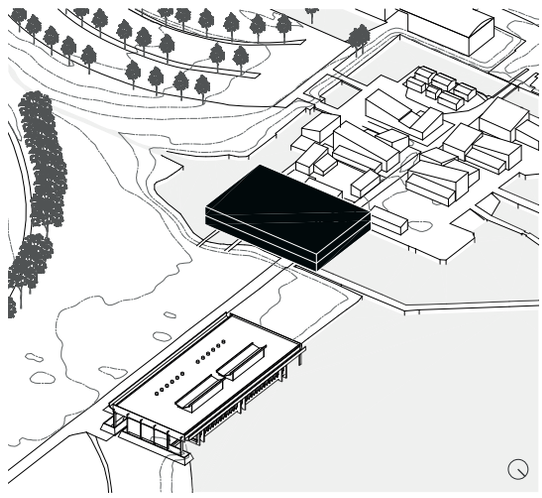
Option 1: placing the new museum on the water might conflict with the problems the area is facing today, not being able to withstand the water pressure from the fjord. This could make either a clear coherence between the Museum Island and the park or do the opposite by dividing the two with a volume. Could reduce access to the fjord for the public.

Option 2: placing the new museum west of the existing museum would probably result in an add-on to the existing museum due to the lesser space. This could make the payment concept clearer, as it would be within one volume. This option would also reduce public access to the fjord.

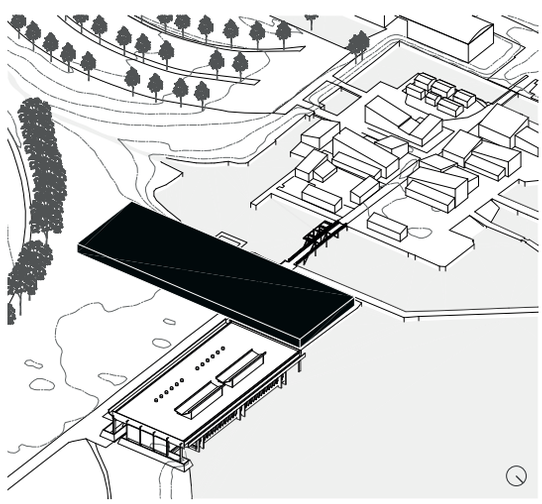
Option 3: placing the new museum south of the existing museum could make a more coherent museum complex by creating a liaison which could make it more obvious the area is connected. This could obstruct the view of the existing museum.

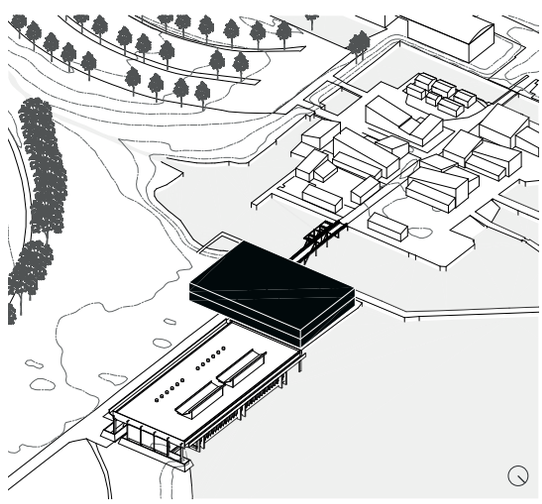
Option 1:
on the water



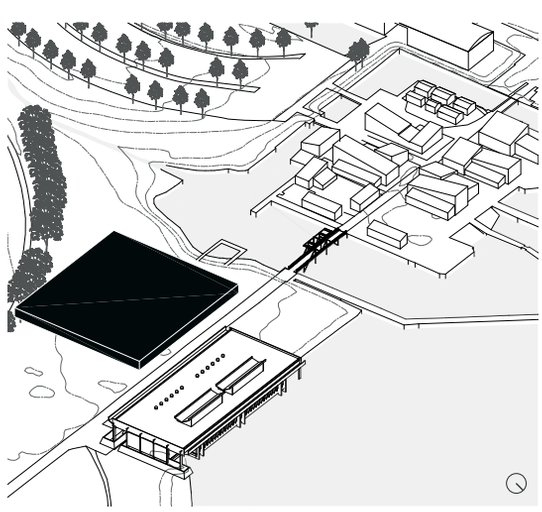


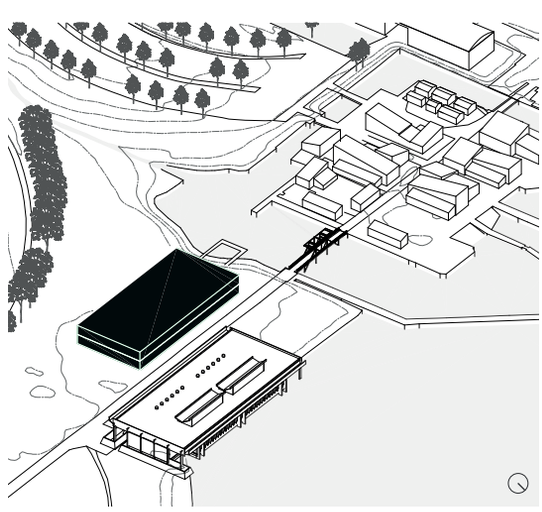
Option 2:
next to the museum





Option 3:
in front of the museum





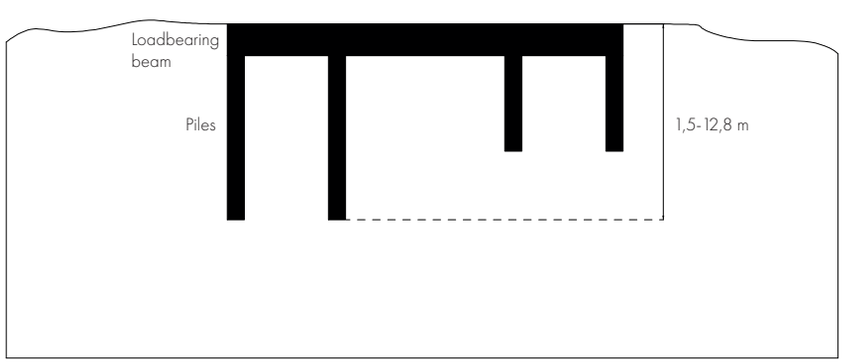
TECTONIC APPROACH

The site is under risk of flooding in events of storm surge and in the future due to rising sea levels. Due to the proximity to the fjord, the ground water is expected to follow these rising levels, which may increase up to 1,5 m in the next 100 years (Roskilde Kommune, 2019). Therefore, it will be in the best interest of securing the ships to avoid direct foundation types, thus minimising the risk of contact with water.

Furthermore, the geotechnical conditions in the municipal report state that the stable deposits of glaciofluvial sand and gravel lie between 1,5 m – 12,8 m underneath the current terrain, making a type of pile foundation the obvious choice for founding the building (Roskilde Kommune, 2019).

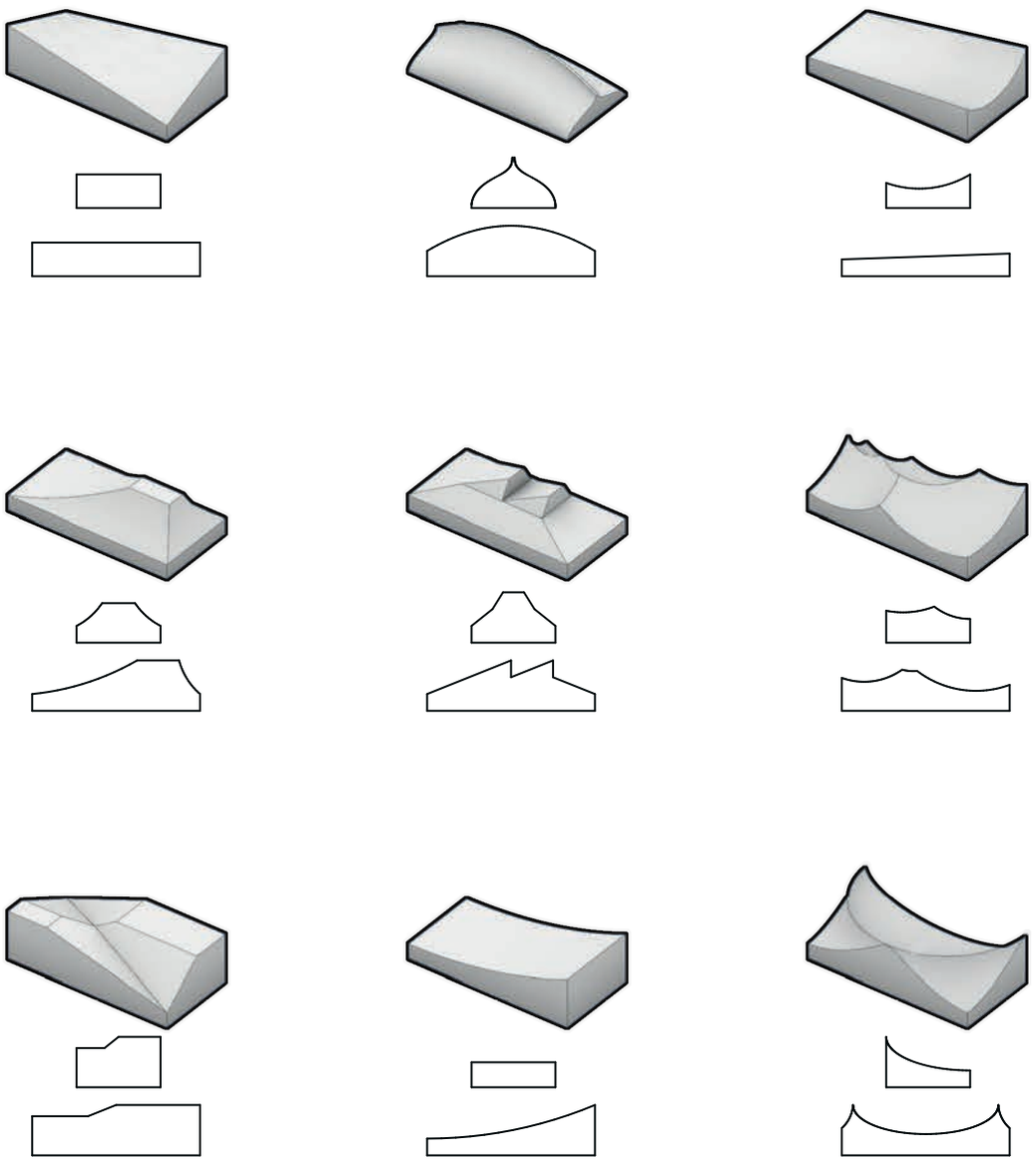
As previously mentioned, the floor level must be at a minimum 2,5 m AMSL, which is approximately 0,6 m above the current terrain, why there will be a need for a plinth covering the pile foundation.

Different roof shapes have been investigated after exploring the placement of the new museum building. With all initial building footprints being rectangular or squared to maintain a simple and conceptual plan layout, there was an intention of expressing the contents of this culturally important building through the roof formation. The roof designs were to accommodate a few criteria: reflecting the maritime setting, relating in scale to exhibiting ships of different sizes, letting in diffuse daylight, and addressing both the existing Viking Ship Hall and the Museum Island.



Pile foundation
principle

Ill. 37



Roof study
tectonic implementation

Ill. 38

01. Separated buildings with two entrances. Connected by the path facing each other. This proposal emphasises that the museums are separated by the museum type and coherent in the way they address each other. The ship exhibition facing towards the fjord and the boat builders on the island.

02. Connected buildings with two entrances; but can be experienced from start to finish using only one. This proposal emphasises that the museums are coherent by physically connecting the volumes and framing the entire area together with the museum with the path as a museum axis.

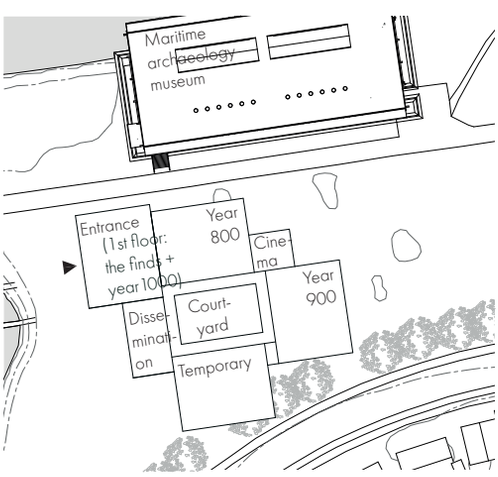
03. The dynamic functions such as the temporary exhibitions and a workshop/dissemination area are facing towards the public path west of the building, luring in the attention of passers-by. Activities directed to short-term visitors such as an auditorium/ conference room and the workshop are in proximity to the entrance while the ships – belonging to the slow-track – are placed furthest away and with the least attractive view given the lack of need for windows

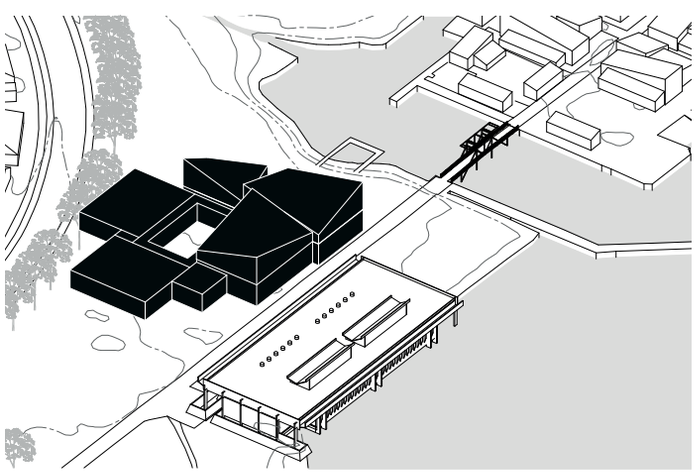
04. This proposal works with the museum as one volume. This means combining the old Viking Ship Hall with the new building. This choice means that a path must appear beneath the new building to ensure no interference with the existing path.

05. The entrance is clear from all the angles the park can be approached from. From here, the other functions follow according to the flow from the functional diagram. The volumes follow the existing ideom from the Museum Island, but in a deconstructed coherent volume.

06. The volume follows the forms created by the urban landscape, imitating the road and the water's curves. The soft curves do not make a clear hierarchy of the back and front of the volume.

Ill. 39





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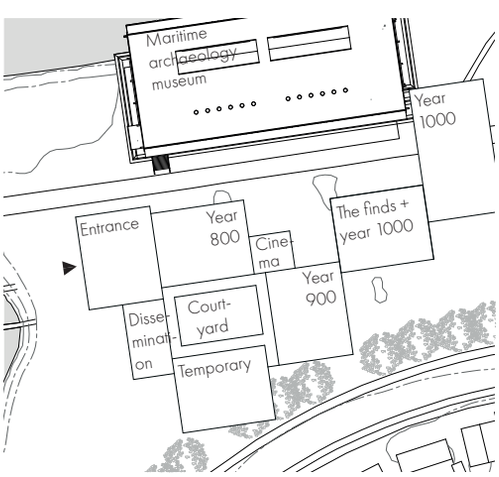

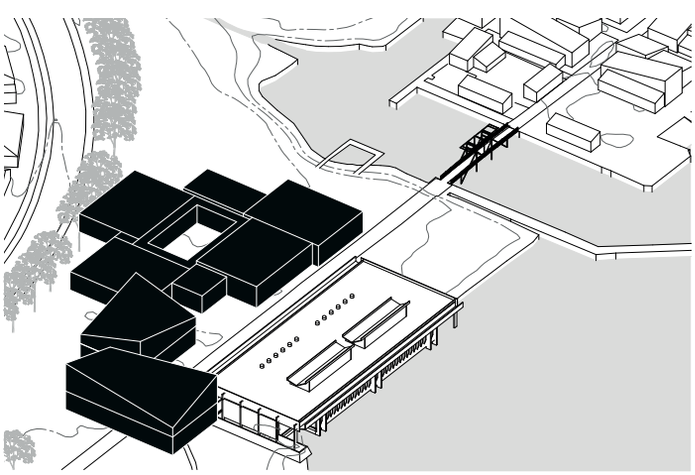

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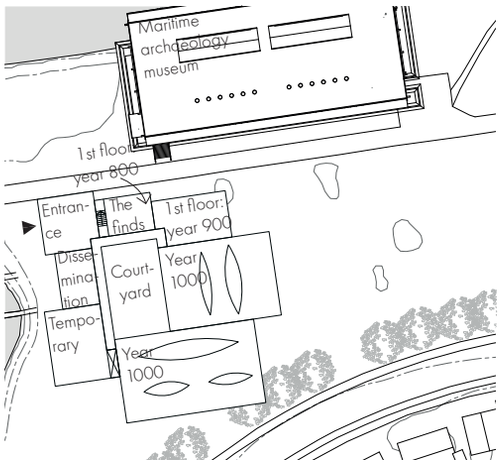
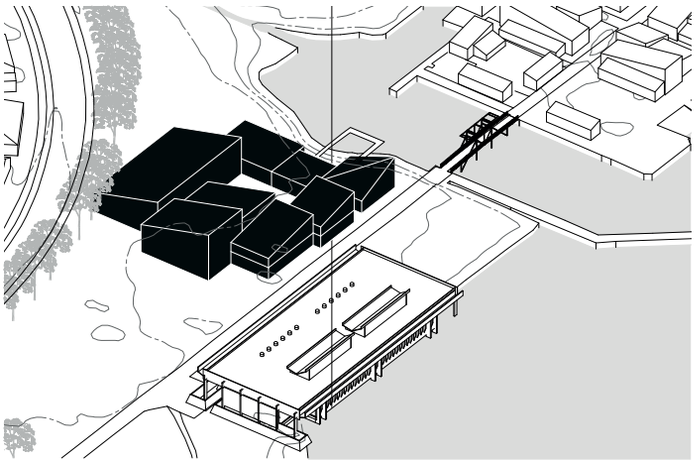

Maritime archaeology museum
1st floor: year 800
Entrance
The finds
1st floor: year 900
Dissemination
Courtyard
Year 1000
Temporary
Year 1000



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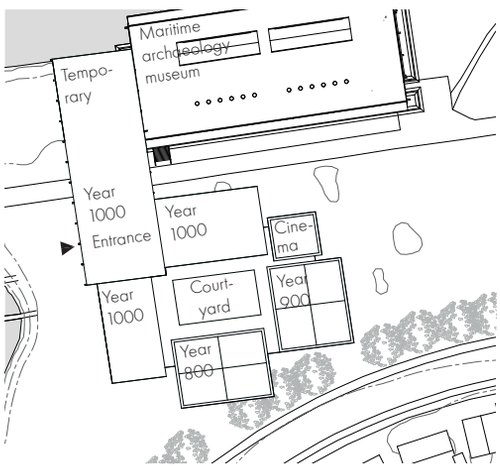
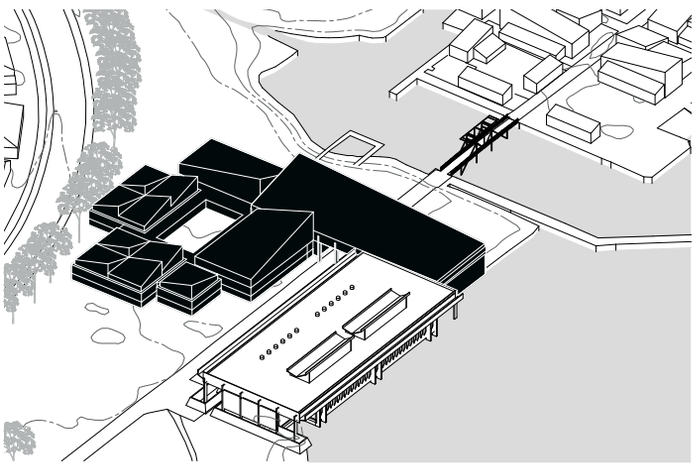

Maritime archaeology museum
Temporary
Year 1000
Entrance
Year 1000
Cinema
Courtyard
Year 900
Year 1000
Year 800



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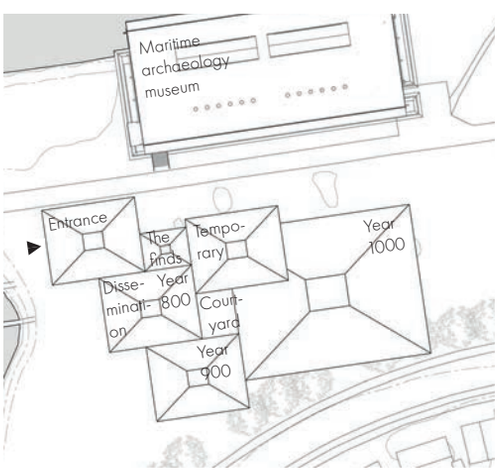
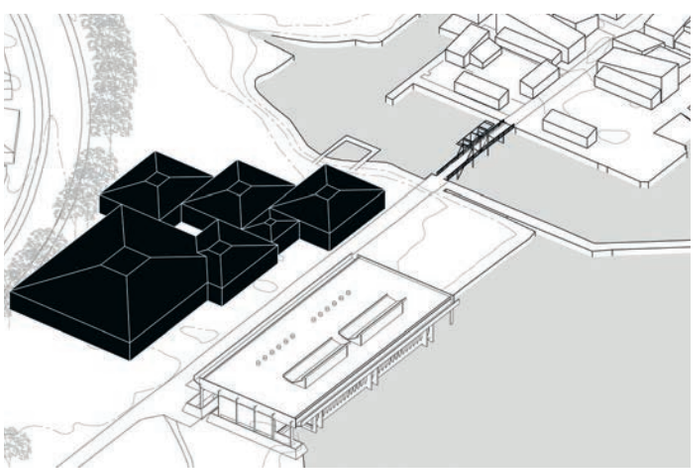

Maritime archaeology museum
Entrance
The finds
Temporary
Year 1000
Dissemination
Year 800
Courtyard
Year 900



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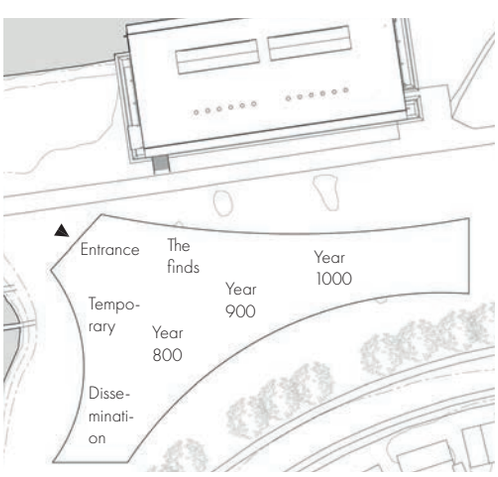
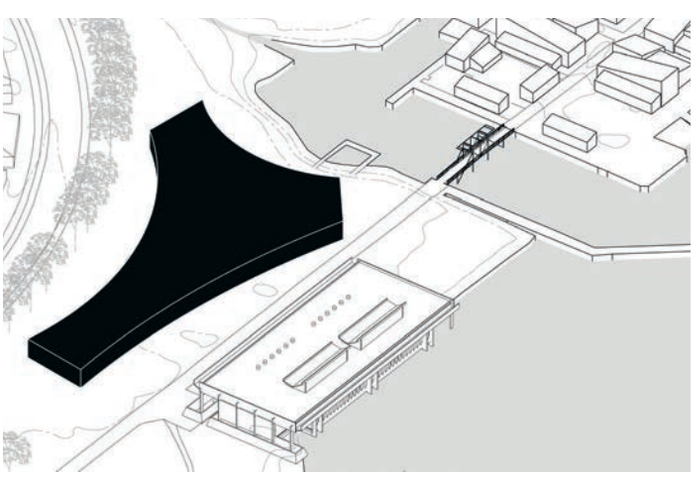

Entrance
The finds
Year 1000
Year 900
Temporary
Year 800
Dissemination



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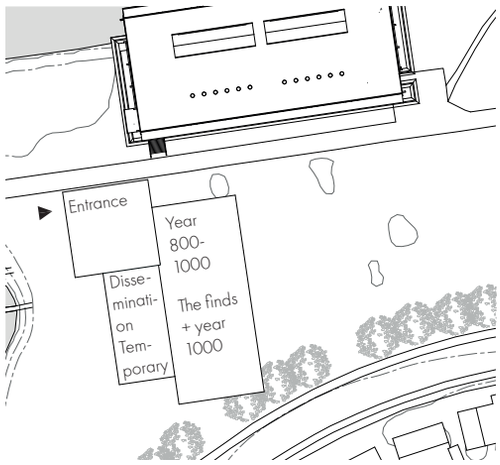
Entrance
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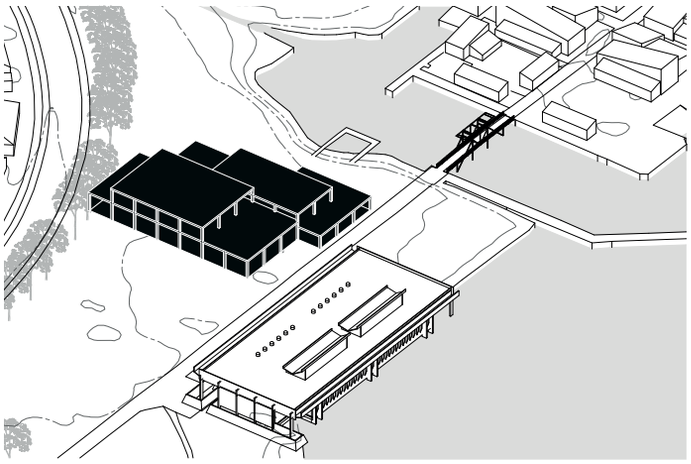

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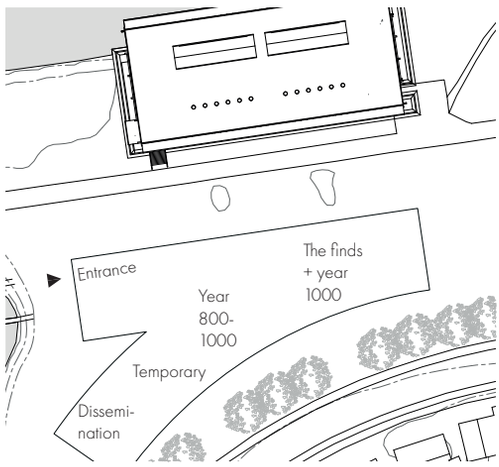
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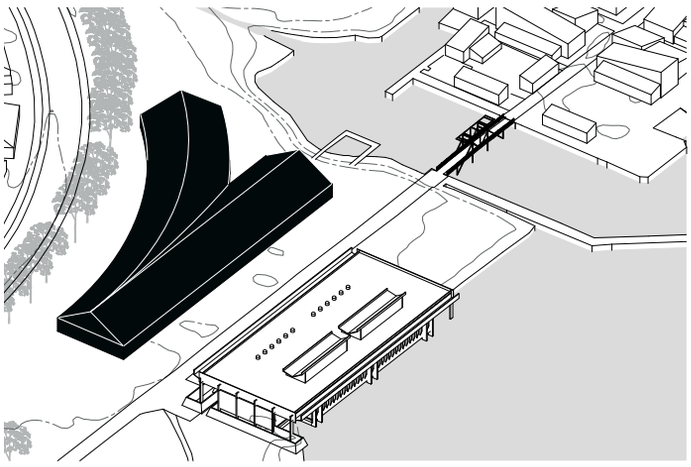

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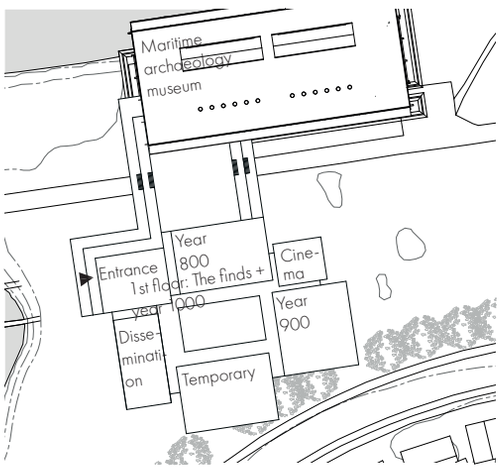
Maritime
archaeology
museum
Entrance
1st floor
Year
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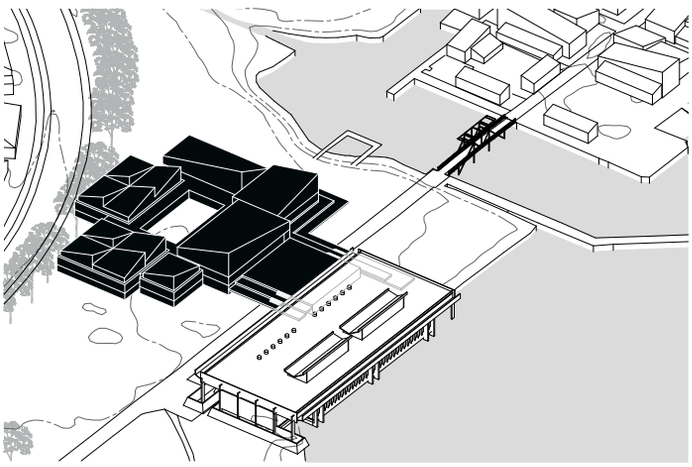


9.

07. It operates within a strict 7,5 x 7,5 m grid-formation enabling rich opportunities for dynamic spaces within. Functions in two floors, looking from the upper floor towards the lower floor's functions.

08. The volume follow the forms from the surroundings; a straight façade towards the path along the Viking Ship Hall and a soft curve along the road.

09. The new museum and the Viking Ship Hall is being connected with a hall to the current basement level. With the ground level of the existing being rather low this would result in a non-leveled underpass.

FORM FOLLOWS FUNCTIONS

To simplify the study of narratives the museum has been divided into five environments following the functional diagram; the entrance, the Viking Age from around 800 to 900, the Viking Age from around 1000 consisting of the Skuldelev ships, a temporary exhibition, an auditorium, and a dissemination zone.

To accentuate this journey through the Viking Age the form-giving process of the building is related to iterations of sequences of experiences. Placing the exhibition 'around 800 and 900' in immediate relation to the ships either on the ground floor or introducing it on a second floor looking down at the ships from the exhibition.

The studies resulted in a main entrance facing towards the existing museum complex to enhance the connection of the volumes facing towards each other.

The narrative supports the journey throughout the Viking Age with a decision of having a hall as a connector between functions in a circular movement. Doing this offers a great overview of the entire museum, and the opportunity to choose another experience route than the chronological journey. A museum catalogue of different museum plans was constructed to seek inspiration in existing cases on how to offer secondary connections, creating the possibility for e.g., the recurring museum visitor, going straight to the temporary exhibition or the main attraction consisting of the ship collection.

Design solution 6 supports this movement and exhibition principle by offering a dynamic space for exhibiting through the organic forms resembling the shapes from the surrounding landscape and roots to boatbuilding and the ship's curves.

To achieve an even clearer coherence to the existing museum complex, the urban environment will be addressed through coherent landscape mediation.

URBAN INTERVENTIONS

As the analysis of the place seeks to interpret, there is a comprehensive problem in the structure and logic of the urban landscape connecting the different functions spread over the museum area.

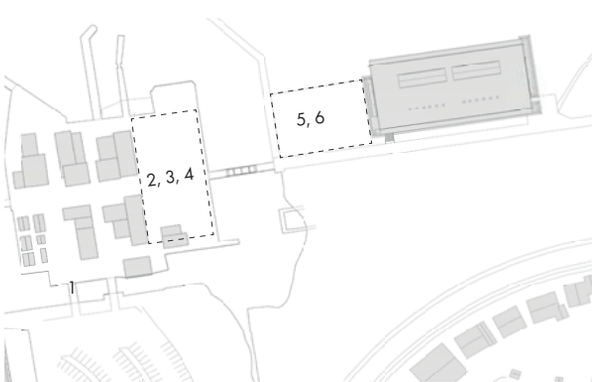
1. Firstly, there is a great misdirection in the flow when entering the Museum Island. This is caused by the lack of experiential progress, as the museum guests are led from the parking lot to the backside of the Museum Island's buildings and dissemination areas. To solve the flow the museum guests are led to the very start of the main path from where the different functions derive.

2. Secondly, the many sheds and canopies attached to the buildings are removed. This will create a more open and welcoming atmosphere both when being on the island as well as making it possible to have a visual connection to the museums on the other side of the fjord.

These initial interventions of the urban landscape will open the entire area to make it more cohesive and create a natural flow into the world of Vikings. Also, implementing an attractive path toward the fjord could attract the locals passing by, using this path instead of the one going directly through the museum dissemination area. This does not entirely solve the payment concept issues, as addressed earlier, but allows the public to be part of the museum area from a distance without having to exclude anyone from the harbourfront.

3+4. Removing the existing sheds, a new urban concept is implemented with a dynamic canopy solution accommodating different needs in summer and winter situations. For the boat- and rope builders these will be creating shade if necessary, and in the winter the canopies will be protecting the ships from the harsh winter weather when being stored on land outside.

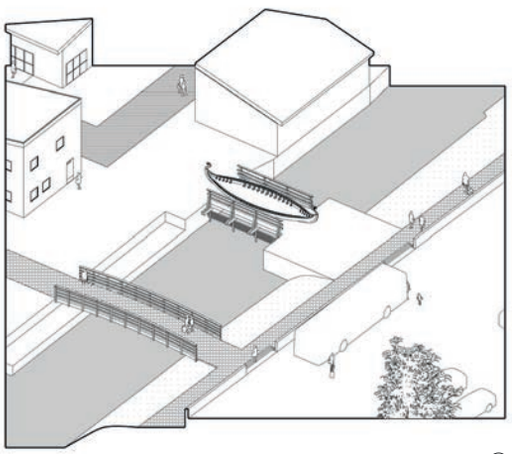
5+6. The same principle is implemented on the eastern side of the fjord where a new outdoor plaza will be creating the frame of an outdoor café in the and rooms for other unprogrammed activites in summer, and storage of ships in the winter season as seen on the Museum Island.



1. New entrance and paths
2. Removing sheds
3. Dynamic canopy winter
4. Dynamic canopy summer
5. Dynamic canopy winter
6. Dynamic canopy summer

Ill. 40

1.



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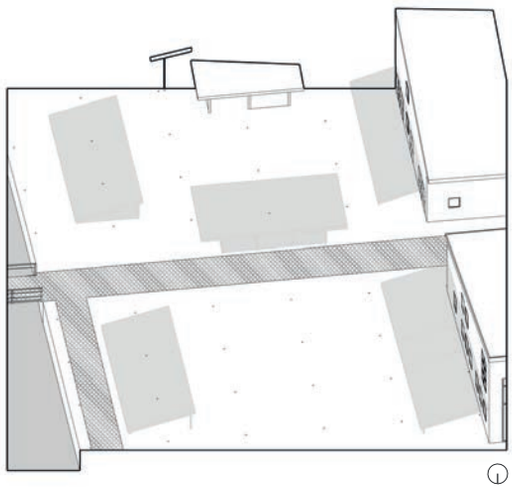

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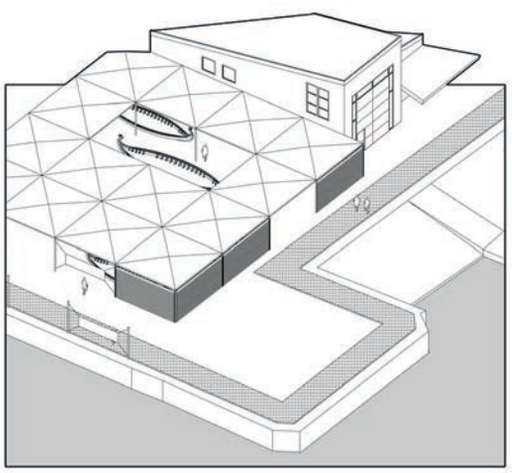

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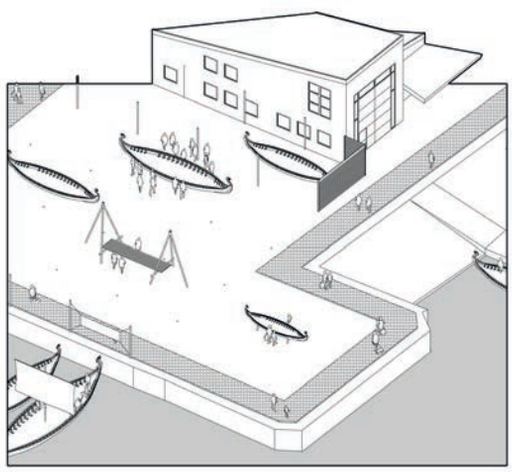

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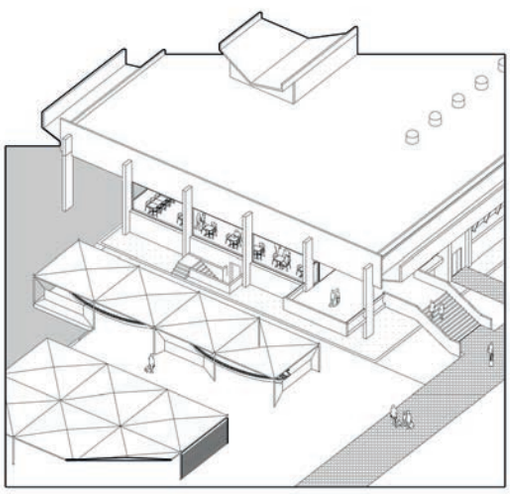

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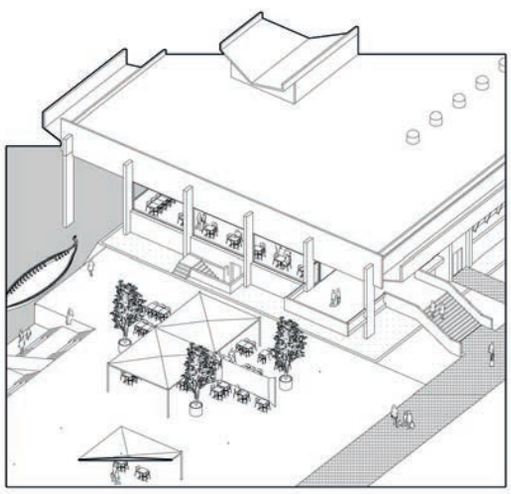
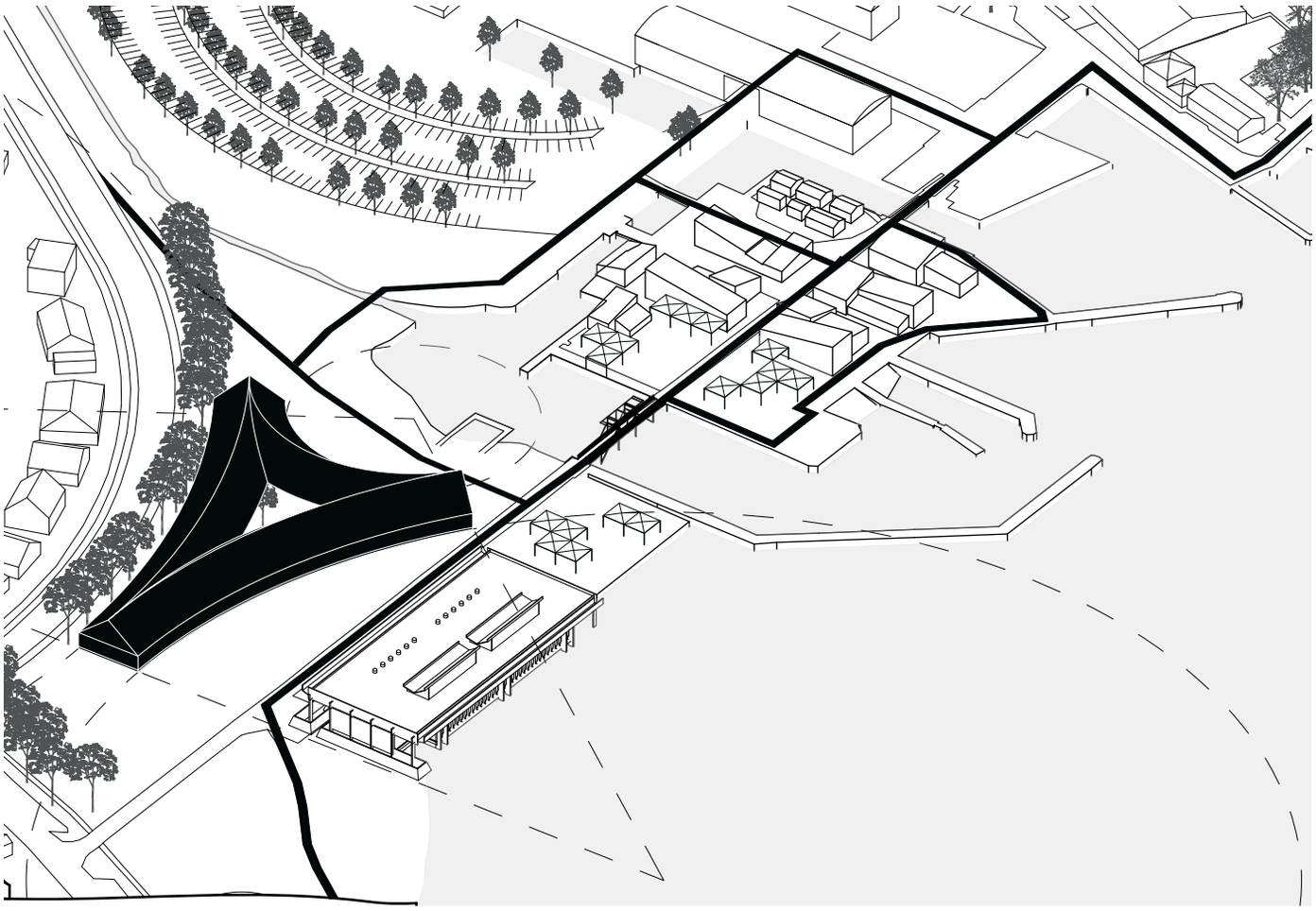


D E S I G N P R O C E S S

DETAILING THE MUSEUM AND MUSEUM AREA

MAKING ENDS MEET



Isometric representation

Ill. 41

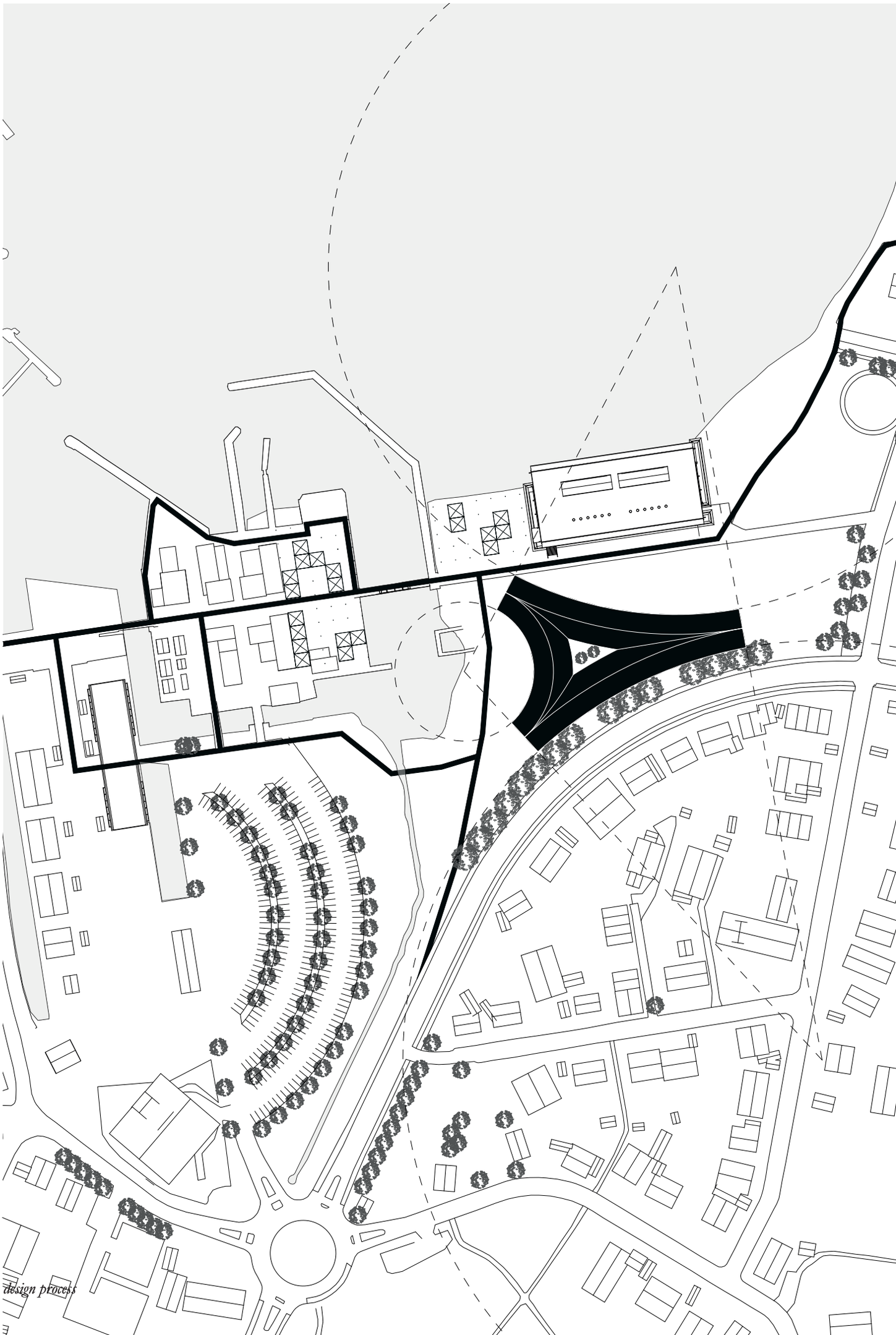
Chosen design
from the design process
1:2000

Ill. 42

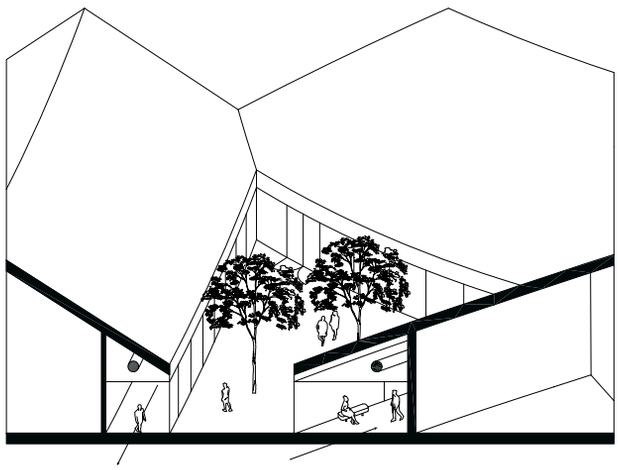
DETAIL DETAIL DETAIL

The chosen design is an interpretation of the surrounding landscape by following the curves of the fjord and the outline of the road south of the building. The building is based on the previous iteration with the same main concept and optimised through geometrical fine-tuning, where three differently sized circles derived from the landscape form the facades. A triangle generated through the circle center points forms the gables. By stretching a double-pitched roof from the gable as an ode to vernacular Danish architecture and traditional Viking longhouses, the form achieved a maritime sensitivity suitable for the Skuldelev ships.

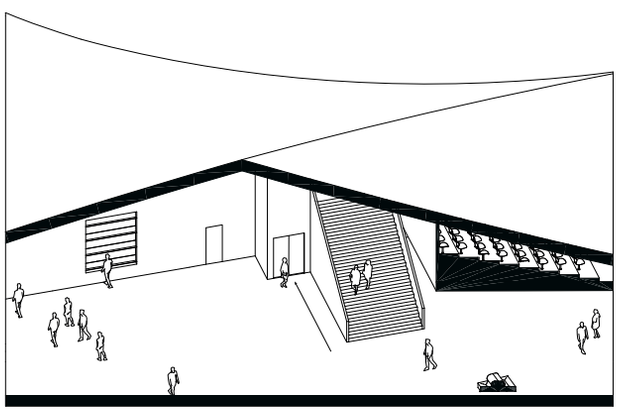
The entrance is facing the corner towards the path that connects the new museum with the Viking Ship Hall and the Museum Island. To make the arrival a part of the experience, there are no additional roads for heavy traffic leading to the building.



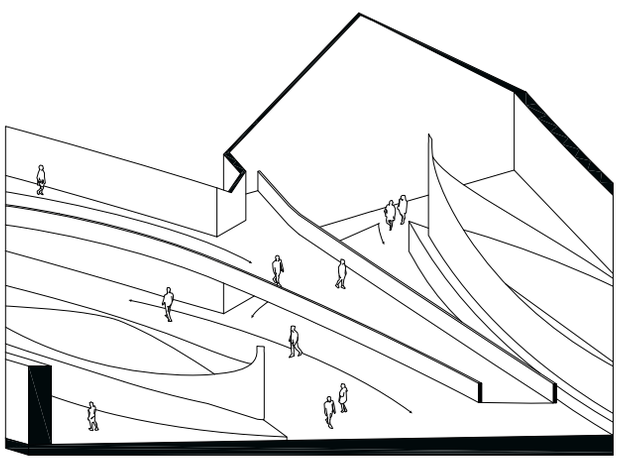
General movement around a core



Universal design through ramps and elevators



Movement around the ships in different levels to enhance the experience



INTERNAL MOVEMENT

General movement

The movement principle from Kunsten Museum of Modern Art, Utzon Center, and Louisiana Museum of Modern Art revolves around a centre, where the museum guest follows the hall around the centre to experience the different exhibition halls. This makes it possible to introduce the museum guests to a fast track and a slow track. When separating the halls, there is a limit to how many different narratives can be created, why this option has been chosen. By moving through the hall when transitioning from one exhibition to the other, the narrative is divided into four chapters offering a pause between them.

The principle of a fast track makes it possible for the recurring museum guest to fast forward to the highlights, such as the temporary exhibitions or the Skuldelev ships.

The slow track on the other hand is for the museum guest who wants to have the full experience and historic insight into the Viking Age.

Universal design

As seen in the transformation proposal of the Viking Ship Hall from the 1960s there is a great focus of creating universal design as history and culture should be accessible for all people. In the new design the access both inside and outside the museum is being levelled. The only exception is the auditorium and staff facilities placed on the first floor, which can be accessed through an elevator.

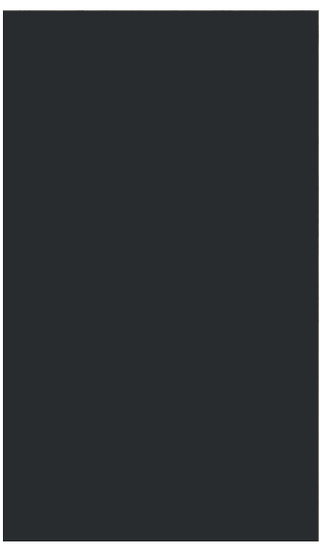
Around the ships

The Skuldelev ships are the main exhibition in the museum, and the experience of these have been a turning point throughout the design process; since they are tremendously space-consuming in terms of height and length. The principle of the movement is based on the perception of the ships; making it possible to see the ships from a distance, seen up close, seen from a top view, seen from the bottom. To make this possible a great ceiling height is crucial as well as different levels to experience from. Therefore, a ramp going from one end to the other has been introduced; creating first a magnificent view over the ships at first wherefrom the ships are seen in a closer relation as the museum guest moves down the ramp and down to the ground level where the ships are placed.

Isometric
Movement and access

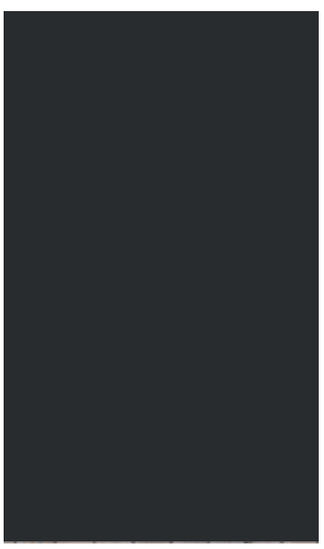
Ill. 43

Ill. 44



In-situ concrete

Concrete is a hard, strong material that can withstand massive compressive loads. Concrete is also if mixed correctly, very resistant to water (Nielsen, 2016). Therefore, the foundation is planned to be made of concrete, so that the safety of the Skuldelev ships is in top priority. The Viking Ship Hall was originally made of in-situ concrete, which has a wood-like expression due to the formwork. This aesthetic is preserved many places inside the Viking Ship Hall, why a continued use in the new building would support the cohesion ~~of~~ the existing.

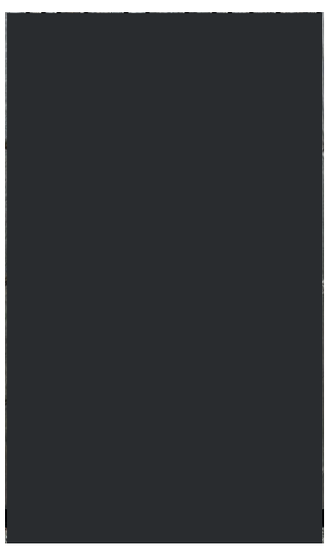


Cedar wood slabs

The oily nature of cedar wood makes it very resistant to Danish weather. In addition, unlike other types of wood, it is excellent at resisting both fungus and rot. Over time, cedar acquires silver-grey patination, which supports a characteristic Nordic expression. The slim nature of the slabs is often used to give a more contemporary expression.

Cedar wood shingles

Like the cedarwood slabs the cedar wood shingles are very resistant to the Danish climate. This method is however even more durable and is an old Norwegian tradition to cut the wood with an axe instead of a saw. A saw cuts the fibres in the wood which expedites the putrefactive process, whereas the wood is split up naturally with an axe. This results in a more durable product that can withstand wet climates for longer periods.



Burnt wood, Shou-Sugi-Ban

Shou-Sugi-Ban is an ancient Japanese method and technique used to preserve wood by burning the surface of the wood. The process consists of burning the surface of the wood, cooling it, and removing soot or burnt residues on the surface. The technique increases the wood's durability without using chemicals, paints and other surface treatments.

EXTERIOR MATERIALITY

The project should in many ways support the coherence of the whole area. It is assessed that the new museum can gesticulate resemblance through materials and references to the existing. The articulation between different materials is an ideal tool to form a bond of union between new and old. To increase this coherence the primary materials are wood, concrete and stone. Wood as an element from the Museum Island and the Skuldelev ships. Concrete and stone as elements from the Viking Ship Hall.

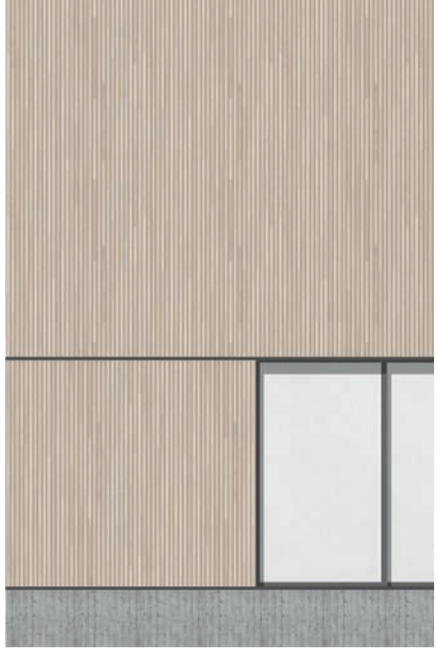
These materials are first and foremost a product of the existing but are also some of the most used building materials on site. As wood, concrete and stone are manifested in many kinds and types, the Life Cycle Assessment is largely dependent on these parameters. The use and ways of articulation between wood, concrete and stone are investigated and measured on aesthetic and environmental levels as well as functional purposes.

To provide a deeper understanding of the use of materials, various versions of façade compositions were designed. These compositions gave insight into the aesthetic outcome and contributed to assessing each composition's performance in Global Warming Potential (GWP), lifetime and maintenance.

EXTERIOR MATERIAL COMPOSITION

This exercise emphasized the possibilities of the aesthetic outcome of the final design. Though it is difficult to infer something final without seeing the compositions in the final design and context, it is safe to say that the second composition entails most of the desired elements wished. The use of materials is assessed to strengthen the coherence to both the Museum Island and the Viking Ship Hall. Combined with a playful articulation and offsets in the façade this composition is revealing and appetizing in terms of what to expect from the construction.

The LCA calculations are based on a rough estimate of the needed areas for wall and roof cladding. The calculations are based on the production and waste management of the materials.



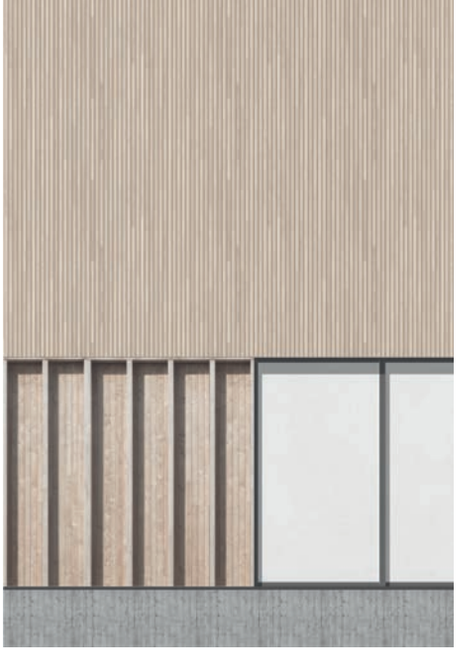
In-situ casted concrete foundation,
wooden slab facade,
wooden slab roof

GWP: 21.500 kg CO_2-eq.

Lifetime: 50 years

Maintenance: Maintenance is very dependent on the surface treatment and the desired appearance. Cedar wood patinates in a grey tone, and if that is the desired appearance then maintenance can be carried out once every 5-12 years. If a more glowing and colored appearance is desired, then maintenance should be expected every 1-3 years (Froeslev, 2022).

Aesthetic: The result of vertical wooden slabs for both the roof and façade is an expression of continuous lines. This composition is however not assessed to be playful in joints and articulation between materials. The combination of natural wood and in-situ concrete in the foundation is a good reference to both the Museum Island and the Viking Ship Hall.



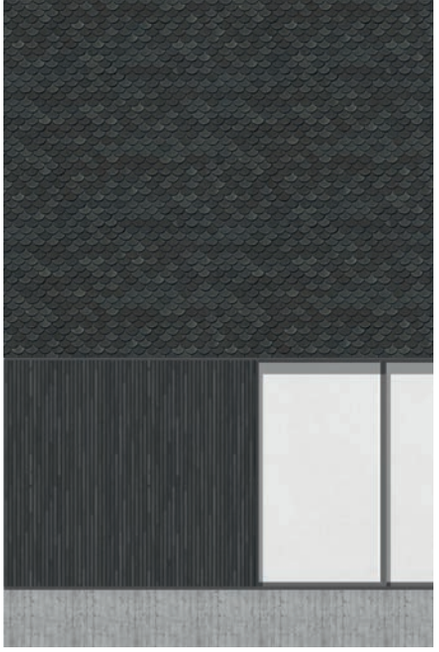
In-situ concrete foundation,
timber relief façade,
wooden slab roof

GWP 36.300 kg CO_2-eq.

Lifetime: 60 years

Maintenance: Like the first composition maintenance is very dependent on the desired appearance. However, this composition's depth results in a façade that is retracted and thus protected by the roof structure. On this basis, this composition's expected lifetime is 10 years longer. why?

Aesthetic: Like composition 1, this combination gesticulates coherence to the existing using natural wood and in-situ concrete. This composition is assessed to articulate the use and transition of materials in a more distinctive manner. The façade offsets and is retracted beneath the roof structure which enables the possibility of showcasing some of the structural principles happening inside the building.



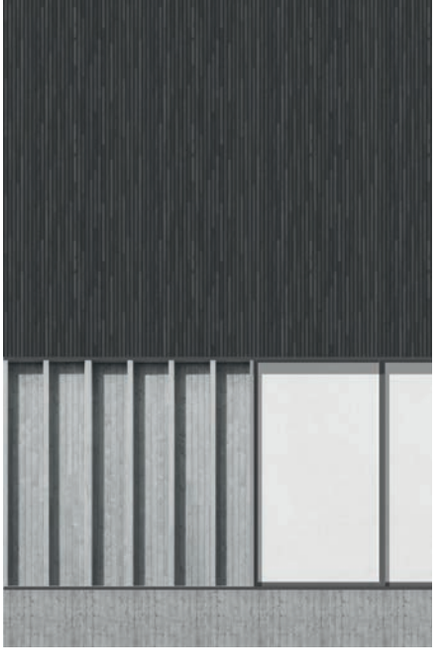
In-situ concrete foundation,
burnt wooden slab façade,
burnt wooden shingle roof

GWP: 38.700 kg CO_2-eq.

Lifetime: 70 years

Maintenance: All wood used in this composition is Shou-Sugi-Ban which can be a maintenance-free material. It also patinates in a grey and matte tone. However, if the color from the manufacturer is desired, then the material should be treated every 2-3 years. There are reports of Shou-Sugi-Ban wood facades that are 150 years old, which indicates that the GWP could be well spent compared to composition 1 (Beleck, 2022).

Aesthetic: The dominating use of Shou-Sugi-Ban wood entails a very dark and dense aesthetic. Despite having brilliant performance and resistance to the Danish climate, this composition also introduces a new tone to an already aesthetically chaotic area.



In-situ concrete foundation,
burnt timber relief façade,
burnt wooden slab roof

GWP: 43.500 kg CO_2-eq.

Lifetime: 80 years

Maintenance: As in composition 3, all wood used in this composition is Shou-Sugi-Ban. Both the façade and roof can in this case be maintenance-free dependent on the desired appearance. Like composition 2 the façade is retracted and protected by the roof and combined with the Shou-Sugi-Ban technique. This results in a composition with the longest lifespan, but also the biggest GWP.

Aesthetic: Some of the same problematics applies to this composition. The grey tone from the burnt and treated wood in the façade introduces a grey tone which clearly stands in relation to the in-situ concrete on the Viking Ship Hall. The roof structure suffers from the same issues regarding color scheme as composition 3 and is assessed to be a very dense and heavy volume, aesthetically speaking.

Chosen design

Material considerations

Ill. 45

STRUCTURE

The structure has derived from circular strokes in the landscape with frames placed perpendicular to the exterior facades, generating an atrium in the middle. The difference in distance from the center points results in the distance between the frames not being equal along the three wings. The frames are therefore distributed from the largest circle with a C-C distance of approx. 3 meters and meet in an angled joint where the roofs meet.

It has been a invariable design decision not to have bare beams or rafters over the Skuldelev ships, on which dust and dirt can accumulate, which over time can settle on the ships' surfaces.

In the next chapters, the iterations and developments in the design of the structure via static systems, basic design sections, force diagrams, and iterations of structural expressions are reviewed. The starting point is three different sections of the structure, representing the three framework principles used in the construction.

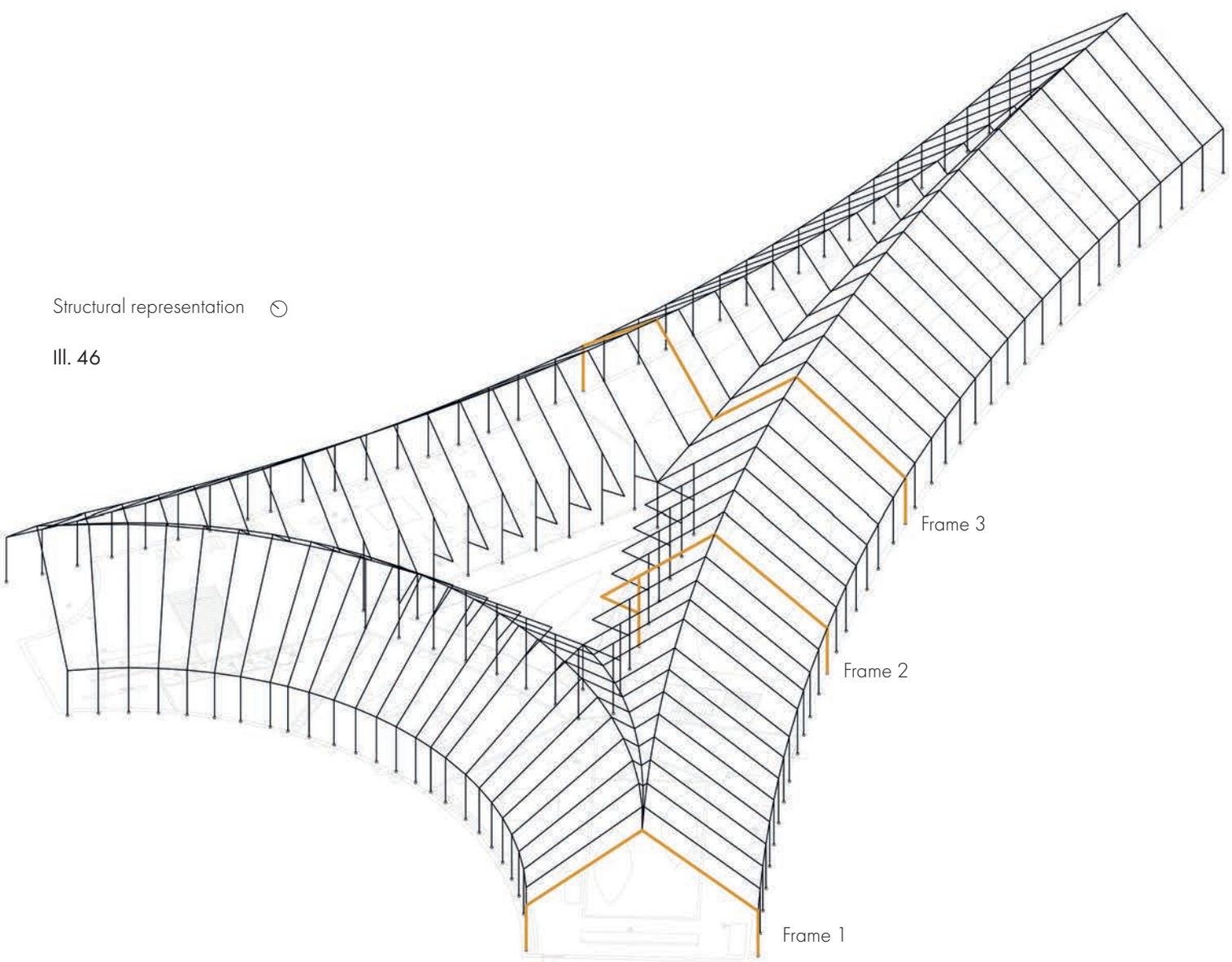
The building's three gables follow the same principle, where the northwest-facing gable stands out slightly since 5 meters of the length of the building body have been cut at this end, which is why there is a longer gap between the supports. The other two are similar in dimensions.

The next framework principle applies to all frames that form the atrium courtyard. These are all similar in dimensions and principles.

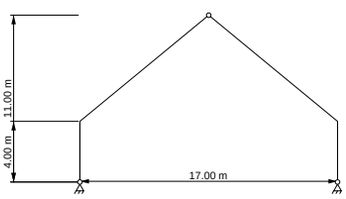
The remaining frames stand out by not following the same plane. They stand at varying angles to each other and are all different. This angle occurs as the frames run perpendicular to the façade where they are supported. It is assumed that this angle can help stabilize the structure, as it occurs in the meeting of all three roofs and points towards the same center point.

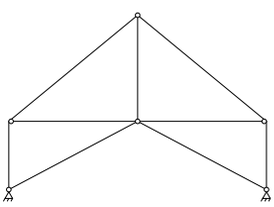
Structural representation

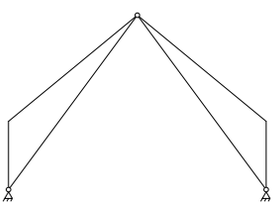
Ill. 46

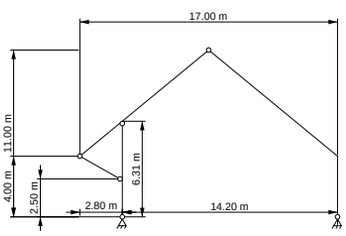


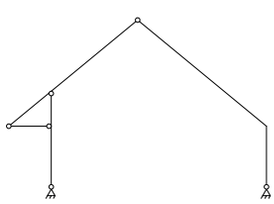
Ill. 47

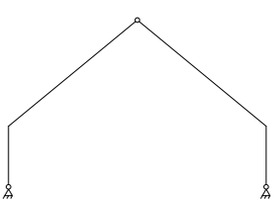


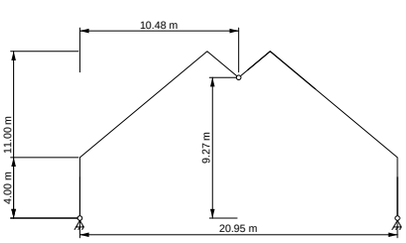


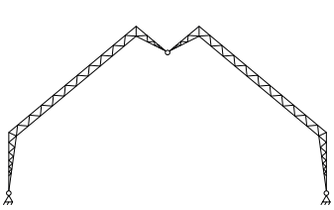












Chosen design

THE STATIC SYSTEMA

Section 1: The gable

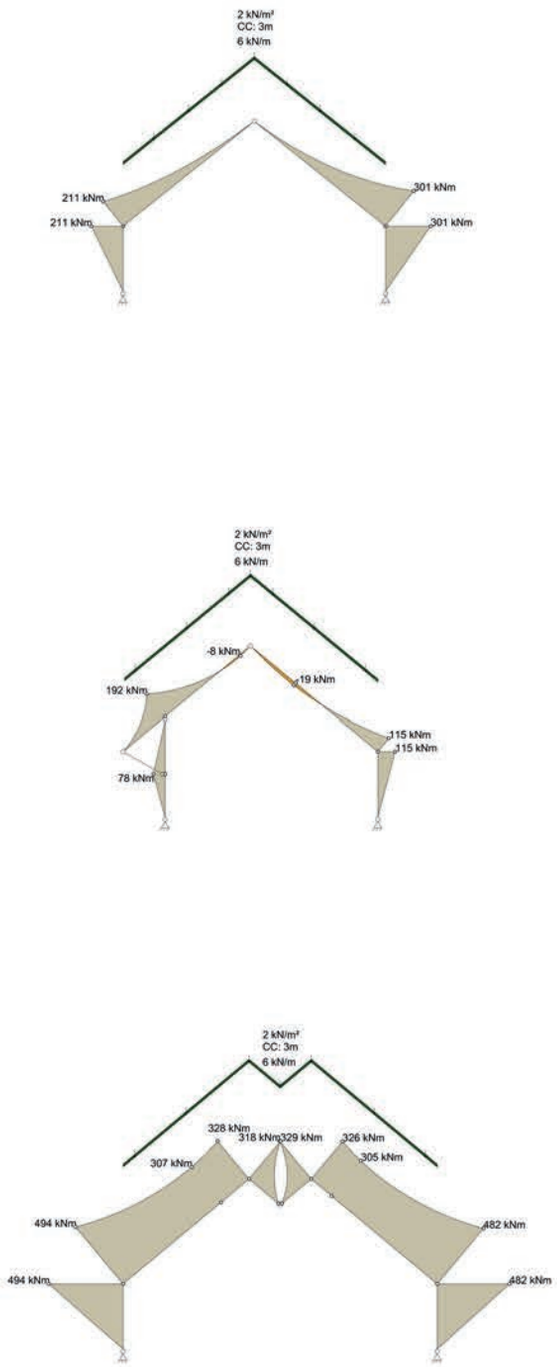
There has been a desire to keep the facades relatively light and simple in expression. The clear concept of the building body should shine through and be easy to read. At the same time, a certain transparency is desired in the northwest-facing gable, where the building's entrance and auditorium are located. In this context, there has been a concern about the need to strengthen the frames with several elements, where the forces from the weight of the roof can be carried down through the structure. Through iterations in Karamba3D, this has proven not to be a critical issue, which is why the simplest system has been chosen (Appendix 5: Construction in Karamba).

Section 2: The courtyard

The atrium courtyard should let light into the building and serves a kinaesthetic purpose in the movement through the museum. Therefore, a light and undisturbed expression is desired, which can be accommodated by moving the load-bearing elements further into the structure and promoting the view from the exhibition space around the atrium courtyard. In addition, a slope has been chosen on the inclined braces to open further into the room and at the same time distribute the load more evenly on the column.

Section 3: The Shrine

To meet the desire for an open floor plan without bare beams, a large load-bearing capacity of the beam frames is required, as the span between the supports is up to 30 meters. One way to save material on these frames could be to make a lattice beam solution, but it is considered that a solid beam frame better expresses the boat metaphor in the desired final expression.



Force diagrams

Ill. 48

IMPACT OF FORCES

The construction has been drawn into Karamba3D and has undergone a lot of iterations in everything from material type, material cross-sections, joints and supports. The final situation, where it can be demonstrated with Karamba3D that Serviceability Limit State and Ultimate Limit State are complied with for all elements of the structure, results in these force diagrams. Of these, the most heavily loaded frame in relation to bending around the y-axis is the one with the largest span – presumably, as these have the largest tributary area due to the angle between the facades.

To ensure consistency with reality, the results from Karamba3D are checked by hand for the roof beam in facing the atrium (Appendix 6: Construction calculations).

As can be seen from the force diagrams, the greatest moment stresses occur in the meeting between façade and wall, which will thus be the place where the largest cross section is needed.

In Karamba3D, it is assumed that the cross-section of the element is the same lengthwise of the entire element – however, it can be assumed that gradually decreasing cross-sectional area can be used at hinges or overhangs.

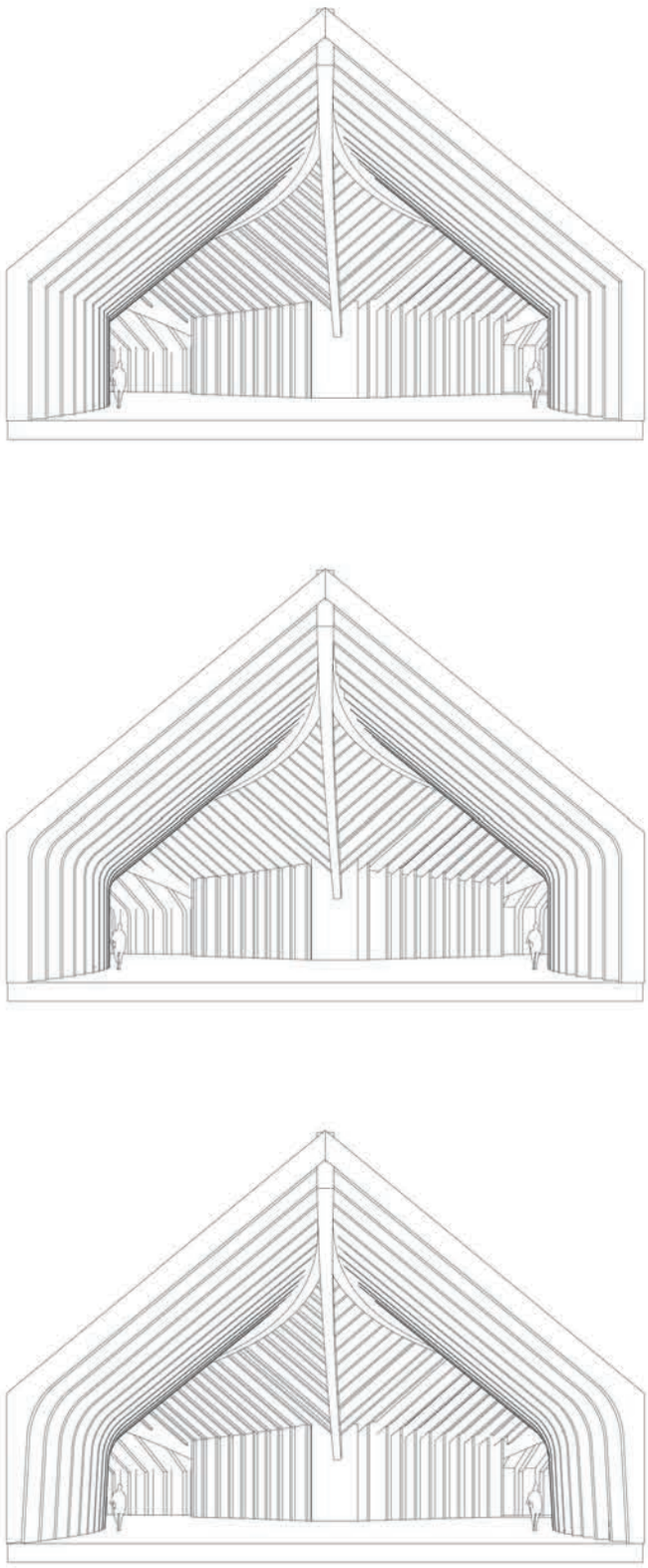
STRUCTURAL EXPRESSION

The characteristic elements of the construction are clearly the large frames as well as the massive beams that run along the roof ridges and where they meet. Due to their size and design, these will be built in glulam elements, as they are less rigid than standard structural wood and can also achieve higher strength classes. The frames will be visible and quite distinctive indoors along the building's external facades, which is why they should be treated to such an extent that they reflect the simple elegance that characterizes Viking Age boatbuilding.

In the first illustration, the frame elements appear as calculated in Karamba3D – with a cross section of 400 x 675 mm lengthwise of the entire element.

In the next illustration, these elements have been filleted to create a softer transition between wall and roof as well as a reference to the curved shapes of boatbuilding. At the same time, rounding the frames results in a larger cross-sectional area in the corner as an extra dimensioning, which, all other things being equal, will mean a stronger frame in the critical situation.

In the last illustration, the filleting has been designed with a larger radius to make the boat reference even clearer. In addition, the cross section is minimized to 400 x 475 mm in the meeting with the supports, which means that they have a decreasing significance in the expression of the room the closer you move to the floor.



Chosen design

Expressions of strucuture

Ill. 49

CONSTRUCTION IN SECTIONS

To avoid meter-thick walls, parts of the insulation will overlap with the load-bearing structure. This also means that the beam frames appear lighter, but still portray the additive construction expression of a maritime character. As a result, the exterior walls and roof structure become relatively inhomogeneous, which is compensated for by adding more insulation than necessary. In addition, the thickness of the glulam beams does not cause a significant loss of heat (Appendix 7: Wall detail).

Section 1: The gable

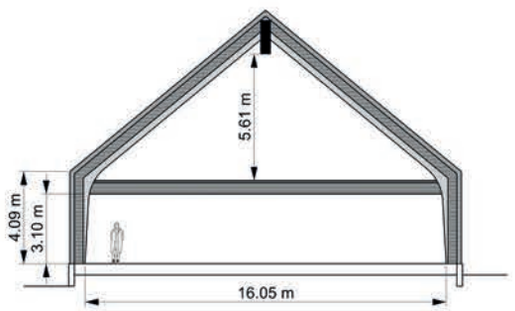
The first section at the gable illustrates a situation at the entrance with an auditorium on the first floor. Here, the beams are not visible under the floor deck, but are still visible along walls and the pitched roof. In the situation without floor partition, the beams are visible all the way up.

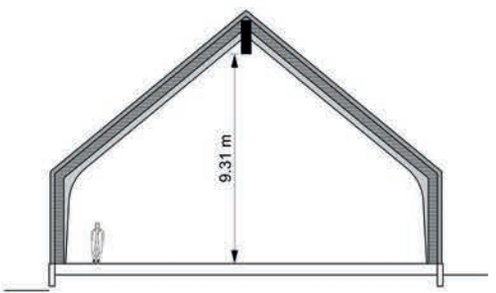
Section 2: The courtyard

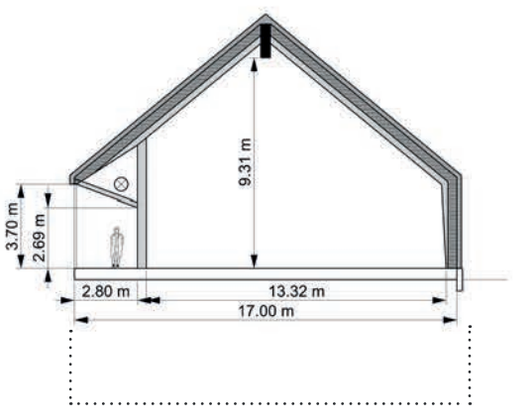
The middle sections show two versions of a structural section in the frames bordering the atrium courtyard. Here it is illustrated that ventilation and other installations can be swept through the cavity in the overhang. The version with the angled brace has been chosen rather than the horizontal one, as this opens more up towards the outdoor space and provides a direction in the exhibition corridor.

Section 3: The Shrine

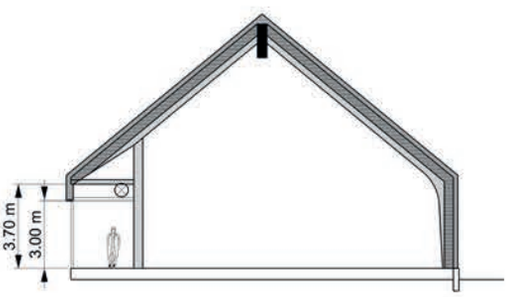
The last illustration makes it clear with a planar section that the frames are angled to each other and the insulation lies between the frames.

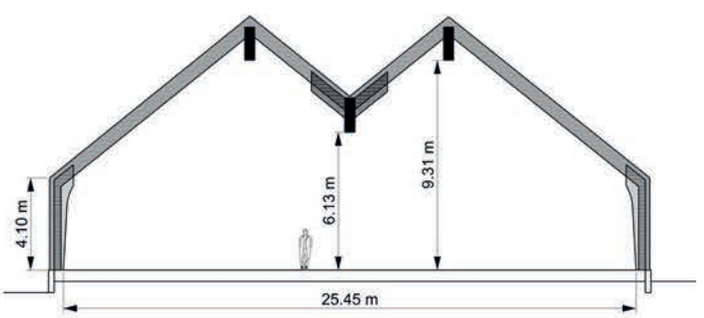






Chosen design





Construction

Ill. 50

JOINTS

Ill. 51

The load absorptive nature of the joints is defined in connection with the modelling in Karamba3D to optimize the load-bearing capacity of the structure. In this section, the expression of the joints is considered based on aesthetics, which is found best suited to the elegant, maritime experience desired in the museum.

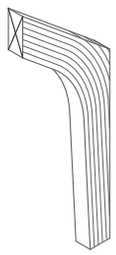
A1: Accentuates the curved shape of the beam while maintaining the biggest effective area by its absence of bolts.

B2: These joints will be covered inside the wall construction. The steel plate inside the roof beam relieves some of the massive moment in the connection to the column.

C2: By carving material out from the ridge in the connection to the frames, the expression of a continuous beam is maintained.

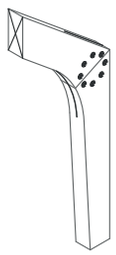
D1: Keeping these joints discrete will make sure that the meetings between the roofs are elegantly connected in a non-distractive way.

Joint A1

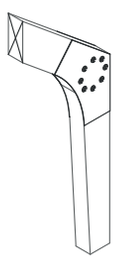


Chosen joint

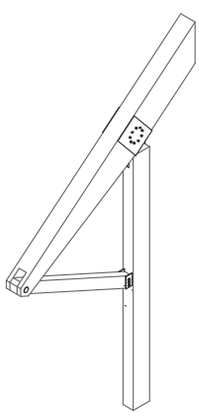
Joint A2



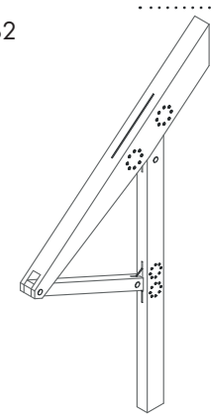
Joint A3



Joint B1

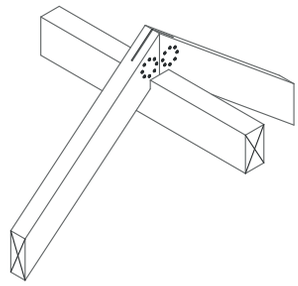


Joint B2



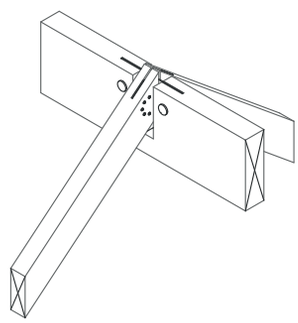
Chosen joint

Joint C1

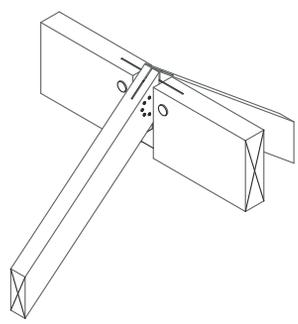


Chosen joint

Joint C2

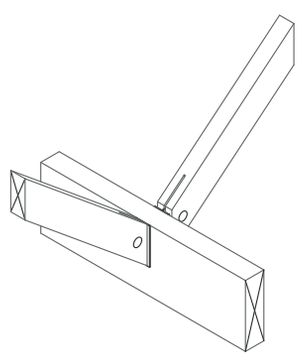


Joint C3

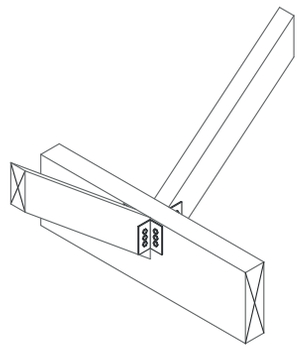


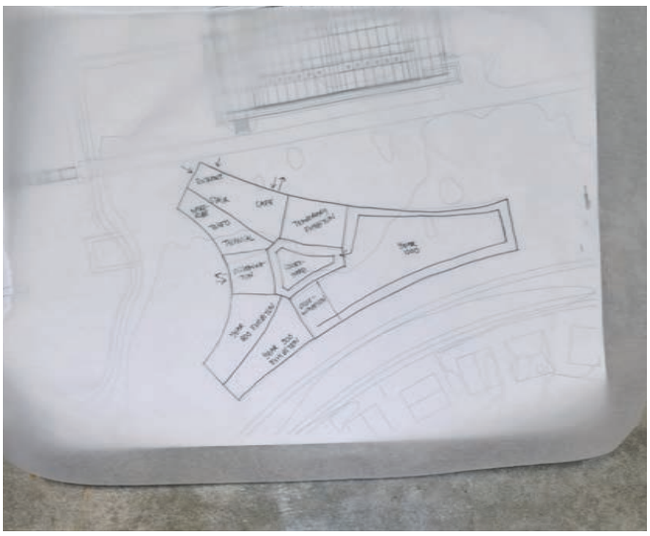
Chosen joint

Joint D1

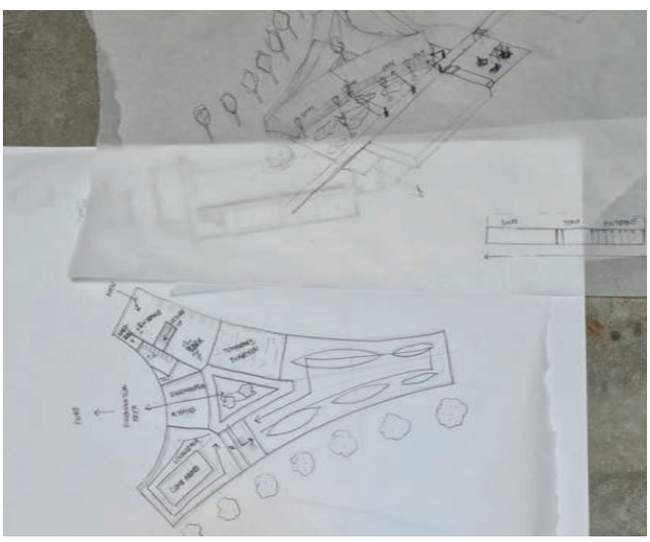


Joint D2

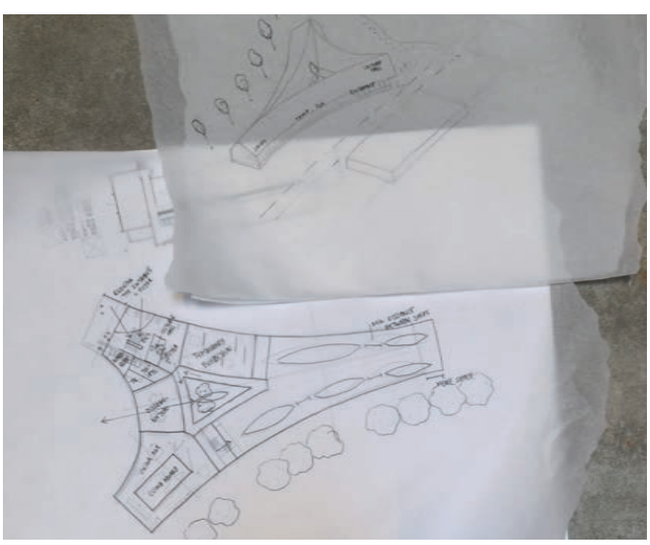




First iterations of flow and movement narratives in the new museum.



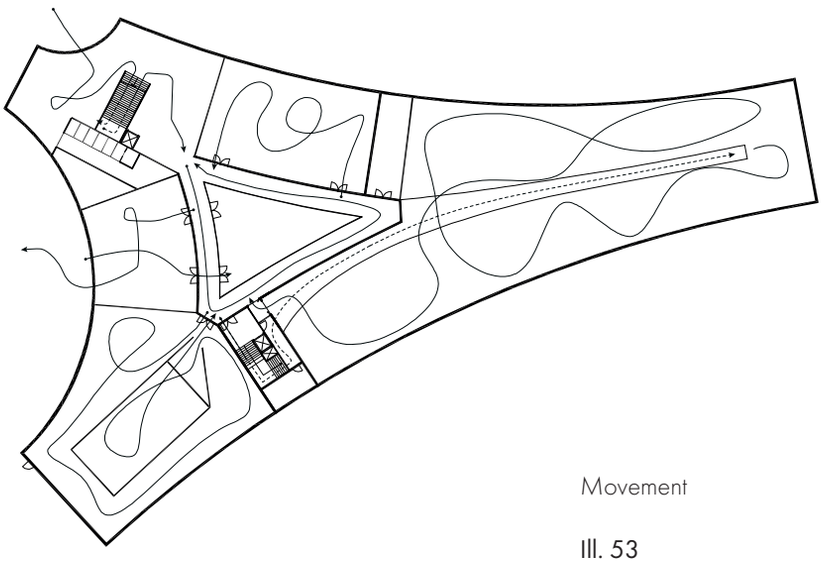
Detailing and separating the volume further. Implementing more functions.



Adjusting the volume according to the room functions and internal movement; reducing the entrance and expanding the Shrine.

Plan development using Manifold

Ill. 52



Movement

Ill. 53

PLAN DEVELOPMENT

The overall structure of the museum is divided into four exhibitions and an entrance. The placement and relation between these functions are important when addressing the perception and the experience of the museum and the exhibitions. A study of different arrangement principles has been carried out to determine the internal flow based on the volume and functional studies that determined a joint volume with a hall connecting the different zones.

The development of the plans has resolved in a natural flow according to the internal movement and museum planning in general.

The entrance should be divided into different zones; arrival and admission, wardrobe, waiting area, and a larger area for groups before entering the exhibitions.

The hall is both a place for circulation as well as a space for telling a story of the finds of the ships; the excavation, the assembling and now – the moving of the ships from the old to the new museum.

Dissemination's main purpose is to have a creative space with plenty of room and table space to tell the stories of the Vikings through different activities in an learning environment. Here, a direct access to the active fjord is important.

The Viking Age exhibition should have a large area for exhibiting artefacts and telling the stories of the Vikings utilising the wall space. As represented in the current museum there should be a dark-room with visual light effects to experience a Viking's journey at sea.

The Skuldelev ship exhibition is the crown jewel and should be treated as such. The perception of the ships are important so they can be experienced from all heights and distances.

The temporary exhibition should be a naked room – a room without any permanent exhibition facilities or inner walls. It should be adaptable to the current situation.

The auditorium has a beautiful view over the fjord and the other museum facilities which should be embraced by large windows towards the view. In addition, it should utilise the space for disseminating history or even local events.

BSim process	Hours > 26 °C	Hours > 27 °C	Mean CO_2 [ppm]	Max CO_2 [ppm]	Mean air change [h^{-1}]	Max air change [h^{-1}]
Demands	< 100	< 25	-	< 800	-	-
Step 1	579	287	593	1378	0,96	1,88
Step 2	91	30	438	832	3,31	6,88
Step 3	87	28	438	832	3,31	6,88
Step 4	70	21	438	832	3,31	6,88

BSim results
Table 1

FACADE ITERATIONS

The windows in the facades are defined by the construction where large columns divide the window area into smaller segments. The window height and the number of windows is defined by the daylight requirements creating a good visual indoor climate. The indoor climate tool BSim has been used to verify a good thermal indoor climate with the foyer being the most critical room in terms of thermal comfort with the largest window area in the museum.

Indoor climate calculations

In its general sense, indoor climate is a major and important topic in museum design. In particular, the indoor climate is an overriding topic in the Shrine where the Skuldelev ships will be stored. As the topic is also a complex and extensive process, indoor climatic considerations are included in the project on a conceptual level. Through performance analysis and optimization of the northwest corner of the new museum building, the indoor climate has been conceptually introduced to the project. The corner is considered to be the critical and therefore dimensioning space in relation to several indoor climatic aspects.

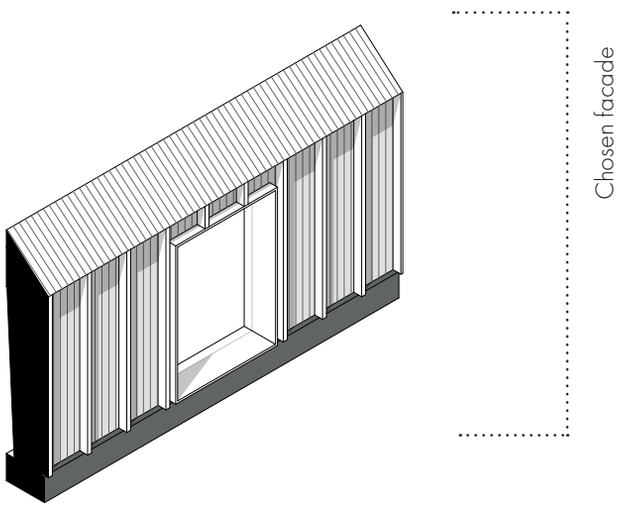
The entrance and hall are located in the northwest corner of the building. The entrance consists of several transparent surfaces, so that the area is clearly marked as an entrance and that the user is in no doubt about where the entrance is located. However, the transparent surfaces can cause a number of challenges in relation to indoor climatic issues inside the building.

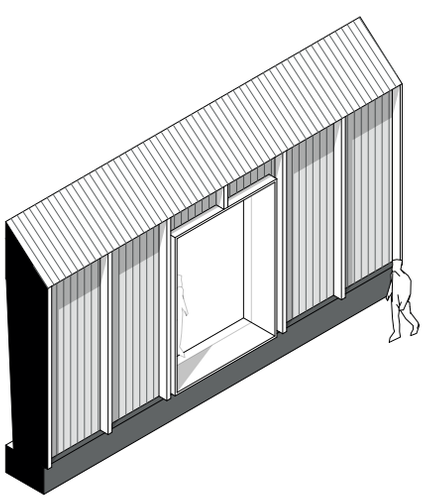
To get an overview of the maximum number of windows in this part of the building and how to design the building with both active and passive strategies, a principal model is drawn in the simulation software BSim. The BSim model can reveal a number of challenges and issues. It can also be used to optimize volume so that it complies with requirements and regulations for overheating, overall air quality and air change.

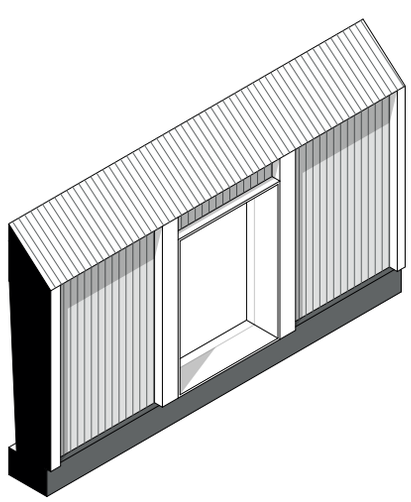
The volume in BSim is designed with more windows than intended (Appendix 3: BSim). This is carried out to test how the volume will react with an overload of transparent surfaces and how it performs in terms of indoor climate qualities. In step 1 the volume is defined with windows, heating, mechanical ventilation, infiltration and a people load of 50 people in the foyer and 80 people in the auditorium.

In step 2 natural ventilation is added and it is obvious that the difference is significant and that a hybrid solution between mechanical- and natural ventilation is needed to ensure satisfactory values.

Even though the results after step 2 are significantly improved it is assessed that the values in terms of overheating can be optimized further with the installation of sidefins and overhangs in step 3. Furthermore, solar shading is added in step 4 to bring the hours above 26 and 27 degrees Celsius further down.







Facade iterations

Ill. 54

The construction frames dictate where the windows are placed in the façade. The following iterations visualize different spacing in the timber relief façade, varying from only showing the relief where the construction is behind the wall, to breaking the façade further by implementing additional wood slabs in between.

The chosen façade does not show the exact spacing of the timber construction, however, it seems to be the best solution to have a shorter distance between the spacing to visually break the long façades, especially when working with a volume that does not have other means of interruption through many windows or displaced volumes.

Daylight calculations

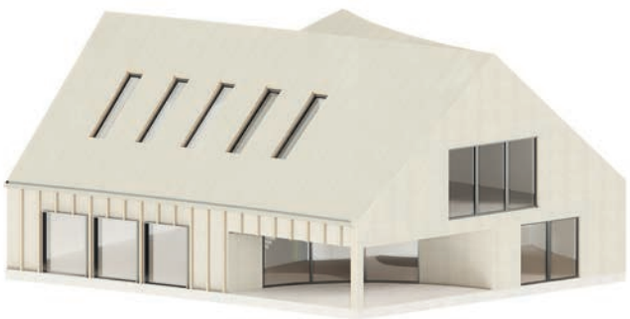
Though problems regarding overheating are brought below the satisfactory number of hours, these values can still get even lower. In this next phase, three different versions of the entrance and auditorium will be investigated and evaluated. The three different proposals differ in the areas of windows. As aforementioned, the model in BSim was designed with more windows than intended, and these three proposals will have the same amount or less. On that behalf, all the designs are expected to ensure the same or better indoor climate on a principal level. Because it is important to maintain a sufficient amount of daylight, the upcoming designs have been tested in terms of daylight values both on the ground floor and first floor. The purpose of this study is to find the perfect balance between aesthetic qualities and technical parameters such as daylight and indoor climate quality.

To quality check these three façade illustrations, daylight calculations have been made for each case. Since the Danish Building Regulations impose requirements on the amount of daylight and given that not all places in the museum can be illuminated with natural light, it seems relevant to document the performance of the different iterations regarding daylight. The building regulations point out that the glazing area without shading conditions corresponds to at least 10 % of the relevant floor area. Alternatively, sufficient daylight can be demonstrated by displaying that the internal illumination of daylight is 300 lux or more at least half of the relevant floor area for at least half of the daylight hours (Bygningsreglementet, n.d.).

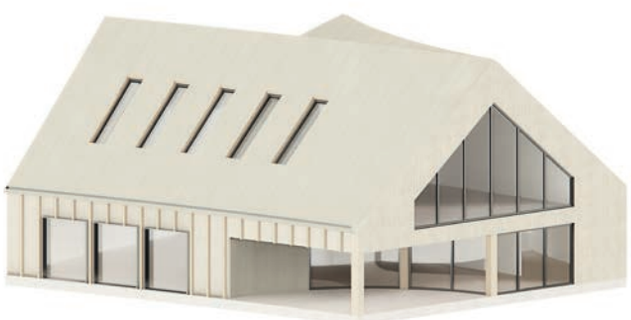
The three façade iterations are all measured on an aesthetic as well as on a technical level. The BSim calculation on the previous page is done with a glazed area of 30 % of the relevant floor area. This means that all cases pass basic requirements in relation to BSim, but also the amount of daylight. This is therefore made almost entirely on the basis of aesthetic parameters.

The sufficient amount of daylight is calculated with Ladybug/Honeybee in Rhino/Grasshopper (Appendix 4: Daylight analysis).

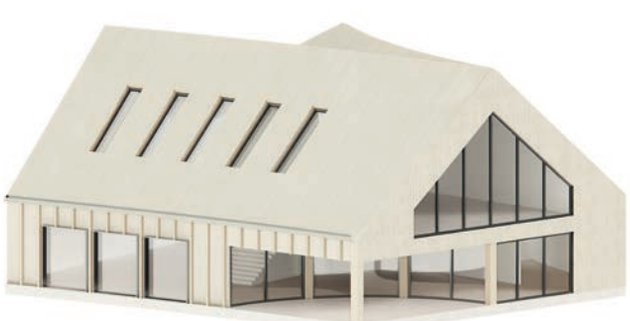
Iteration 1: 114 m^2 glazing
= 21% of the relevant floor area



Iteration 2: 143 m^2 glazing
= 26% of the relevant floor area



Iteration 3: 161 m^2 glazing
= 30% of the relevant floor area

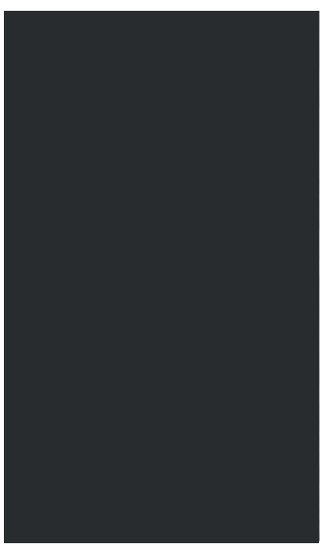


Facade iterations

Ill. 55

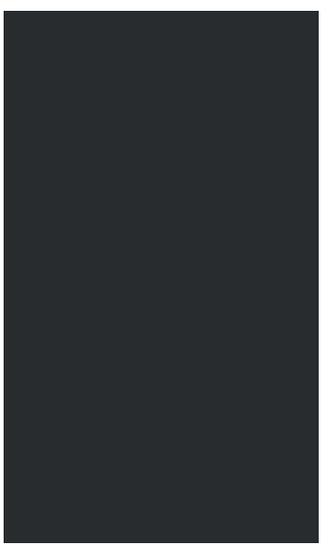
INTERIOR MATERIALITY

The material index reflects the materials at hand in the Viking Age; and how they were used in the Viking Age. The materials tell a story of the Danish craft and materials, which should be implemented in a museum articulating one of Denmark's most significant historic eras. An empathetic relationship with material reality inspired by and for life as it was lived.



Oak

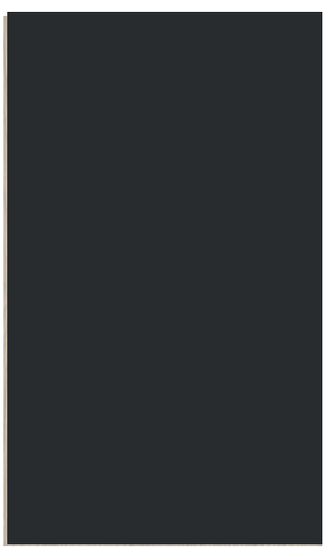
The Skuldelev ships are all built of oak. Already 1000 years ago, oak was valued for its hardness and resistance to moisture, which is why it was used for ships. In addition, oak is one of the most commonly used wood in joinery and interior design. The durability of oak also means the material is ideal for flooring and manufacturing durable furniture (Teknologisk Institut, 2020).



Concrete

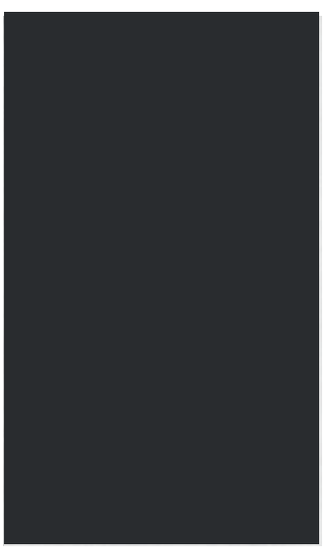
A clear reference to the Viking Ship Hall use of concrete distinguished by its wooden marks telling a story of the in-situ cast concrete building.

Due to its robustness and resistance, concrete flooring is very common in commercial as well as residential buildings. Concrete flooring comes in a variety of types and appearances. Mixture with larger stones can create an alternation and path in the flooring, which can be used to guide the visitor in a museum a certain way (Pereira, 2022).



Pinewood

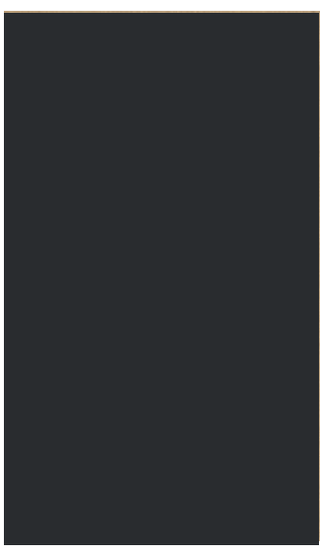
Pinewood is the most used type of wood for construction. Wood is one of the most sustainable building materials, are maintenance-friendly, easy to disassemble and are recyclable (Molio, 2019). The climate footprint of the construction industry is significantly reduced by building more in wood instead of concrete (Krarup, 2020). Besides being a material for construction, a visible articulation between beams and columns in wood can create a characteristic atmosphere. A visible construction in wood can in some cases reflect a maritime aesthetic.



White clay

In the new museum, pale surfaces on the walls are desired to contrast the dark Skuldelev ships. In addition to the fact that white clay plaster has several good properties to improve the indoor climate, clay plaster also seems to be the best solution with the lowest GWP compared to similar alternatives such as lime plaster and paint. This applies both to the manufacture of the material as well as to its disposal (Energistyrelsen, 2016).

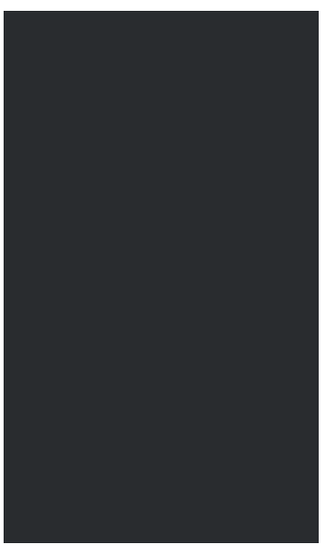
Ill. 56



Fabrics and leather

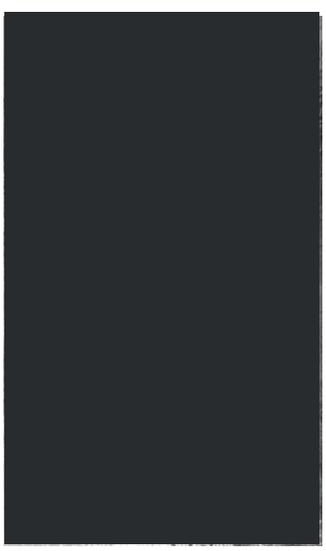
A strong reference to the Viking's hand-crafted sails in different fabrics is either linen, wool or hemp as the original sails were made of. The sails were often characterised by their natural orange and yellow hues deriving from ochre. Also, the ropes used for the ships were either made from fabrics, animal skin- or hair.

The Vikings clothes were often made of fabrics as well. Shoes, hats, scabbards, and other more durable clothing were made from leather from sheep and goats (Vikingeskibsmuseet, n.d.).



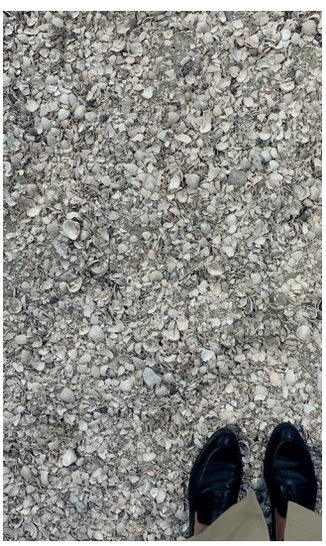
Rocks

Today the Skuldelev ships are exhibited on a bed of rocks. The same rocks are also seen outside the museum as a buffer between the museum and the public path. Different types of rocks are also a great part of Viking history, as they have been used for making ornaments in, among others, amber and fossil coal. Other materials used for this purpose were animal bones or antlers (Vikingeskibsmuseet, n.d.).



Metals

Metals such as cobber, silver, gold and iron were also used as materials for different ornaments. Iron was the preferred material for making weapons and shields (Vikingeskibsmuseet, n.d.).



Shells

The universe of the Vikings and marine archaeology has its roots in the deep sea filled with sand, shells and marine life. These shells will be brought to life as a tactile flooring material.

Ill. 57

INTERIOR MATERIAL COMPOSITION

The materiality chosen in this project affects the atmosphere inside the building. The composition is decided on a basis of assessing each composition's aesthetic values, performance in GWP, maintenance and durability. To provide a deeper understanding of the use of materials, various versions of material compositions were designed.

The assessment of the created compositions emphasizes quantitative as well as qualitative aspects of the interior design. Horizontal lamellas in the ceiling and white clay walls seem to perform best in the combined evaluation, whereas a combination of concrete and terrazzo flooring is assessed to be the preferred solution.

Concrete flooring,
white clay walls,
horizontal lamella ceiling

GWP: 133.800 kg CO_2-eq.

Maintenance: This composition is assessed to have a very low demand for maintenance. The concrete needs to be cleaned thoroughly regularly and can in some cases last for a century or more (Black Bear Concrete & Coatings, 2015). The white clay walls don't harden as paint, and can be repaired locally if needed, which means that the materials on the walls has a long lifetime as well.

Durability: The concrete flooring is very wear-resistant and only needs cleaning with the right soaps to keep it in an almost new condition for many years. Because the floor is exposed to the most contact, this is a highly valued quality. The white clay on the walls is not very durable in its nature. It is more sensitive to impacts and is more susceptible to small dents than concrete and gypsum (Byg Sundt ApS, 2023).

Aesthetic: Aesthetically, this composition fulfils some of the wishes regarding bright hues on the vertical surfaces. Not only do the horizontally placed lamellas add a bit of warmth compared to the concrete flooring but they also create a maritime feel to the ceiling structure.

Chosen design

Oak flooring on top of concrete,
white clay walls
horizontal lamella ceiling

GWP: 159.300 kg CO_2-eq.

Maintenance: The oak flooring needs more maintenance than concrete flooring. Depending on the treatment the wood receives, it needs regular treatment. If it is a lacquered floor it needs to be grinded and re-lacquered every 5-10 years. If it is oil-treated, the oak needs oil every 2 years (Salimanov, 2022).

Durability: The Skuldelev ships bear witness to the durability of oak as a material. However, when it is used as flooring and the museum is visited by hundreds of thousands of people each year, it will affect its lifetime.

Aesthetic: The oak flooring is what differs from composition 1. The oak used in this composition stands as a tribute to the Skuldelev ships and their ability to survive for almost 1000 years beneath the surface of Roskilde fjord. However, oak is compared to even more durable floor materials such as concrete and terrazzo flooring which is of vital importance.

Terrazzo flooring,
white clay walls,
vertical lamella ceiling

GWP: 148.600 kg CO_2-eq.

Maintenance: Terrazzo flooring is very comparable with concrete flooring and thus the material doesn't need that much maintenance. The maintenance needed is a thorough cleaning with the right soap to keep the concrete mixed up with stone as water-repellent as possible.

Durability: Due to the material properties of the stone, terrazzo flooring is even more durable than concrete floors. Especially in areas which are exposed to wear and tear from shoes, dirt etc. The increased GWP this composition entails, can in this case be worth the while, as the lifespan and durability are longer than concrete and oak flooring.

Aesthetic: The vertical lamellas following the beams in the ceiling creates a stringent appearance. Many qualities apply from composition 1 applies to this composition and the terrazzo flooring is a way of breaking the streamlined and stringent appearance of the ceiling.

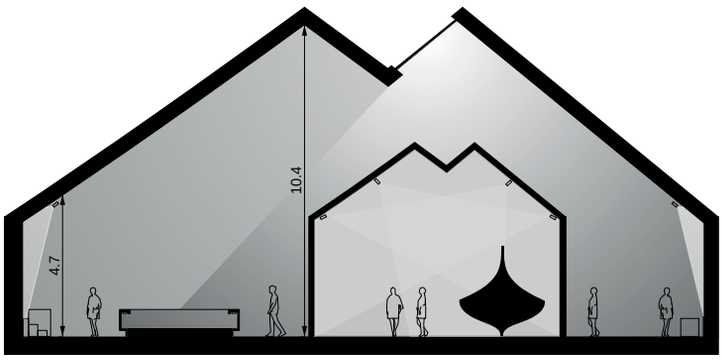
Concrete flooring,
plywood panel walls,
vertilcal lamella ceiling

GWP: 152.400 kg CO_2-eq.

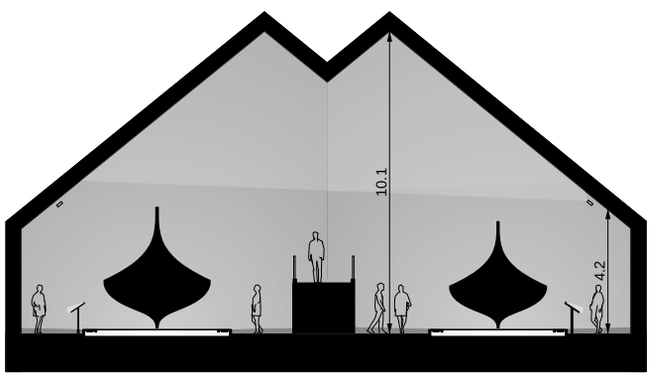
Maintenance: Plywood panel are less susceptible to denting and thus have an lower operating expense than white clay walls. Larger bumps and dents are however not as easy to repair (Vandkunsten, 2017).

Durability: Plywood panels can have a lifespan of up to 100 years (Oekobeudat, 2018).

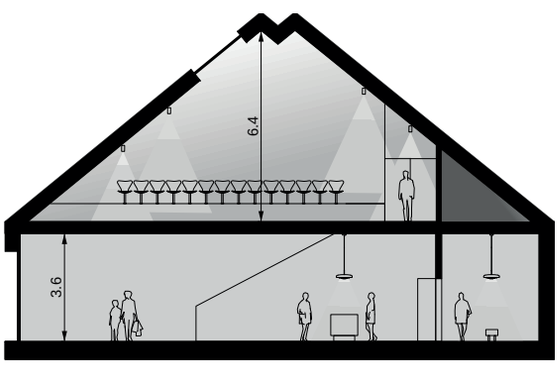
Aesthetic: The introduction of plywood panels adds warm hues to the walls. It is doubtful whether the Skuldelev ships might be highlighted as much as desired with this backdrop, the white clay walls are a preferred element in creating the right atmosphere.



Section 1: Viking Age exhibtion
Accent light
Diffuse light
Effect light

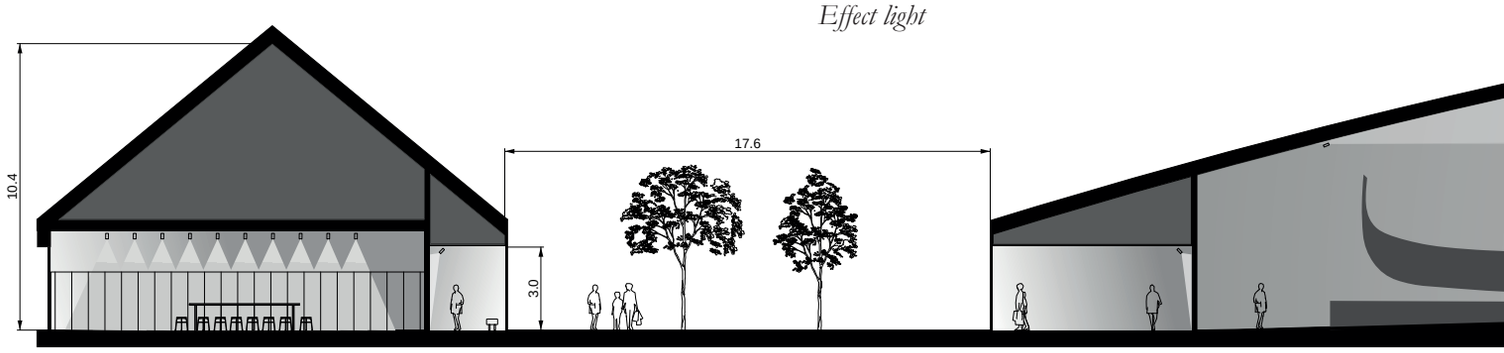


Section 2: The Shrine
Indirect light
Effect light



Section 3: Entrance and auditorium
Accent light
Diffuse light

Section 4: Dissemination, atrium and the Shrine
Accent light
Indirect light
Effect light



Ill. 58

ATMOSPHERES IN LIGHT

Section 1: Viking Age exhibtion

This exhibition contains various types of artefacts. The authentic and original pieces from the Viking Age are exhibited in showcases lit up by accent lights. Most of the space is illuminated up by daylight from the skylights placed towards north. To include fragments of the haptic experience, a replica of a Viking ship is showcased in a smaller volume, as part of an interactive setting where users can climb aboard the ship. To create a more authentic atmosphere, walls and ceilings are lit up by projectors to create a feeling of sailing on the fjord like the Vikings did 1000 years ago.

Section 2: The Shrine

The Shrine contains the original Skuldelev ships. As these ships have a considerable sensibility to light, no daylight is allowed inside this part of the museum. To create a setting where the Skuldelev ships are the focal point of the museum, the ships are dimly lit by indirect light from the bottom. Indirect light is also contributing to illuminating paths for the visitors.

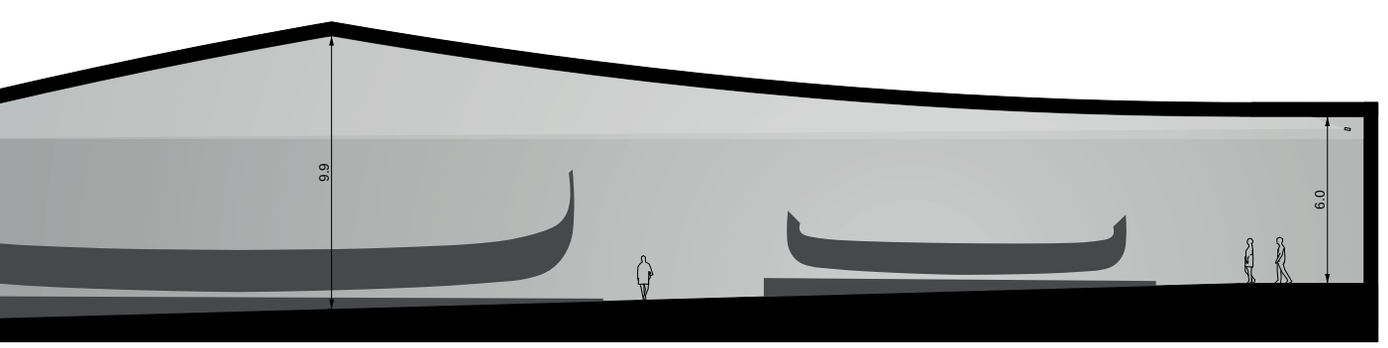
Effect lights are used to light up ceilings and walls. This is both to ensure an overall illuminance in the room, which makes it easier to navigate through the room and gives the opportunity to create certain atmospheres.

Section 3: Entrance and auditorium

The heights, widths, and lights are important elements to design the entrance and lecture hall, as these are the first impressions the visitor receives from the museum. Both rooms are lit by a mixture of accent and diffuse light to encompass these rooms with a balance of layered illumination. By doing so the rooms are not only filled with a combination of natural and artificial light, but also with an important blend of highlighted and equally distributed light.

Section 4: Dissemination, atrium and the Shrine

This section is cutting along the middle of the museum. It also shows the different needs of light throughout the building. The use of daylight and accent light is the most prominent in dissemination and the atrium, whereas the Shrine's darker space uses indirect- and effect light. This section also highlights the different heights and widths of the museum.



Urban transformation

In order to develop a coherent approach, a narrowed down focus proposed - acknowledging that all environments are contributing to some degree but claiming that some are more important than others.

The main driver of the urban transformation has focused on creating a natural flow and a coherent museum area through new paths and biaxial canopies referring to each side of the fjord canal. This selective approach has left out many other important parameters to shape the museum experience on an urban level; such as floodproofing the island, rethinking the introvert volumes into an even more dynamic dissemination area, or creating a clear payment concept as the design brief suggests.

In the last-mentioned criteria another option was chosen; preserving public access, and prioritising the public's right to the fjord and harbour, instead of dividing the Museum Island into two separate clusters.

Viking Ship Hall transformation

The same principle of prioritising some things over others is a recurrent thematic in the transformation of the Viking Ship Hall, ensuring a functional consideration in compliance with the museum's wishes and universal design rather than immense structural attention, which is reduced to a principal verification that the building, in fact, can be saved from the problems it is facing today.

The processing of the façade undergoes a restoration taking it closer to its original apperance with wooden formwork embedded into the façade; both ensuring the original aesthetic and protecting the underlying reinforced structure beneath.

The west-facing façade towards the island undergoes the most dramatic transformation; replacing the white walls with glass, opening the entire façade to the public, and introducing the area to a dynamic environment with a lively café, where many people are wandering by yearly, will be able to have a direct look inside the internal traffic of the building.

A new Viking Ship Museum

The design process of developing the new museum emanates from the relationship between artefact and narrative creation. The qualitative value of the embodied artefact is used as an essential part of the architectural design process by exploring the interwoven relationship between our material creation and the narrative potential through tectonic thinking.

This results in a museum focusing on the experiences, narratives, and tectonics, rather than a clear energy performance, sustainability, and indoor climate-driven project. In an ideal process, all things would have been implemented in a holistic and ready-to-built project.

And to you, dear reader, here is our proposal for the new Viking Ship Museum in Roskilde.

PRESENTATION

A NEW VIKING SHIP MUSEUM IN ROSKILDE

"Museums are sites for interaction between personal and collective identities, between memory and history, between information and knowledge production. A museum is more than a place for stored artefacts on display. It is an environment of informal learning, where the mind is activated in thought and processing, galvanizing mere factual information into knowledge".

Macleod et. al., 2012

A NEW VIKING SHIP MUSEUM

The vision of the Viking Ship Museum was to create a building and a square of extraordinary architectural quality, binding the growth of the harbour area of Roskilde together. The new museum is a manifestation of the place and the situation the building is placed within, however, different from its surrounding buildings in terms of its curved shapes.

It is a contemporary interpretation of the existing, representing the *genius loci*. Not only by speaking directly to the surrounding shapes of the landscape; but by paraphrasing everything surrounding it; from the rock beds on the edge of land and fjord, the boatbuilding houses from the 90s in untreated wood, to the concrete rhythm in the brutalist museum.

Living on the manifest of Erik Christian Sørensen, relying on the sculptural and classic - proportions, materiality, sensualism, light – the museum stages an interpretive, participating tectonic approach to the storytelling of the Viking Age, through a structure with a sympathetic insight into the exhibitions within.

The museum speaks with and not to the exhibitions. Relying on the same principle, the users of the museum and the surrounding area are welcomed and addressed individually, through design solutions lifting amenity value in city spaces and addressing the complexity of a shared area addressing all age- and societal groups in the built environment.

Larger plazas on both sides of the canal allow the provided space for public maturity to develop and dissemination of knowledge and workmanship to occur. The open plazas facing each other create a lively and dynamic area filled with activities on and across the fjord and reflect everything that is being carefully showcased inside the respective museums; a powerful expression of the Viking heritage.

A NEW MUSEUM EXPERIENCE

The new layout of the museum area embraces the multifunctionality representing Roskilde Harbour. The pavement submerges from directional paths into a dynamic area of dissemination, longer and shorter stays, and subtle greenery. An urban landscape where landscape and building flow out and merge together.

The vibrant and including harbour environment is a clash between the great story of the Vikings and the rich cultural life along the harbour deriving from the locals. Paths embracing both the museum's guests and locals meandering their way either around or directly into the Viking narratives.

The smaller pavement is a manifestation of a change in pace and function; going from a higher pace in the large, directional tiles to a lower pace in the smaller tiles, where dissemination activities, resting spaces and cafés occur from.

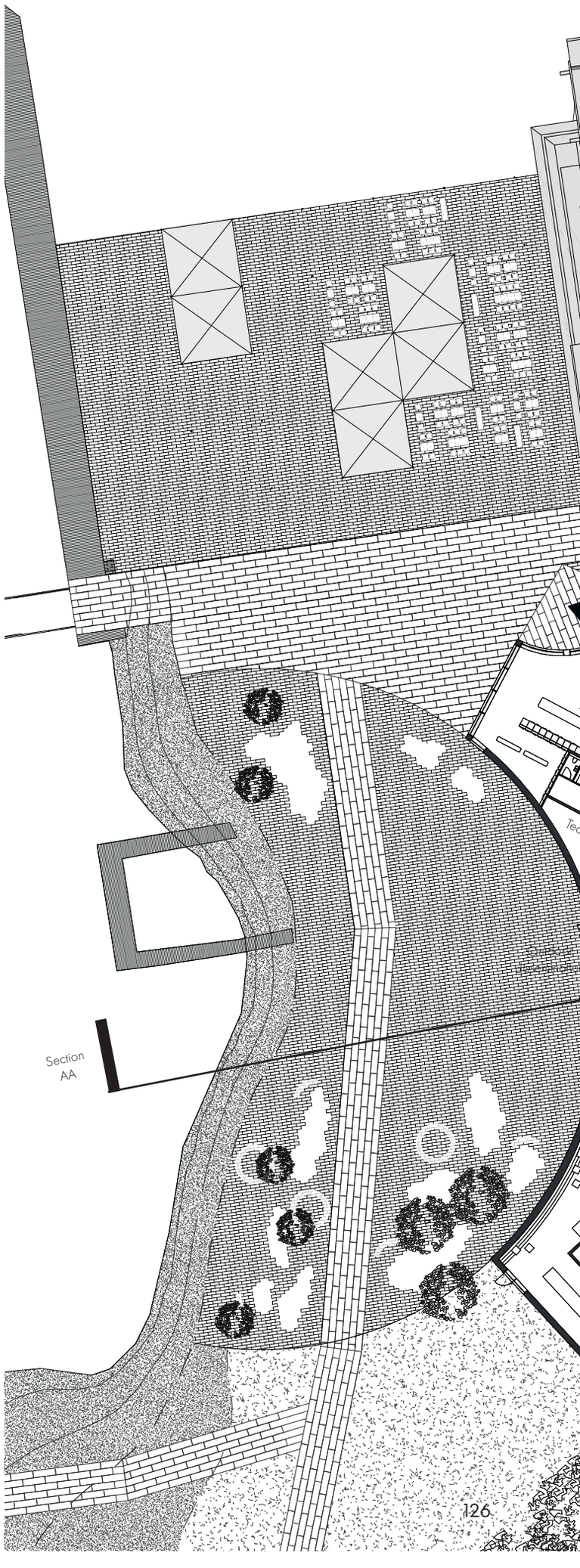
The smaller pavement breaks into integrated low greenery that lastly emerges into the large grass-covered park on the eastern part of the site. The low greenery does not obstruct the view but rather derives naturally as if it had busted untameable through the pavement with no forces to hold it down.

The park has an unobstructed view of the fjord in the north and the iconic cathedral towards south. This is an open space, or public domain, inviting different activities in the urban landscape welcoming all users of the site.

Masterplan
1:1500

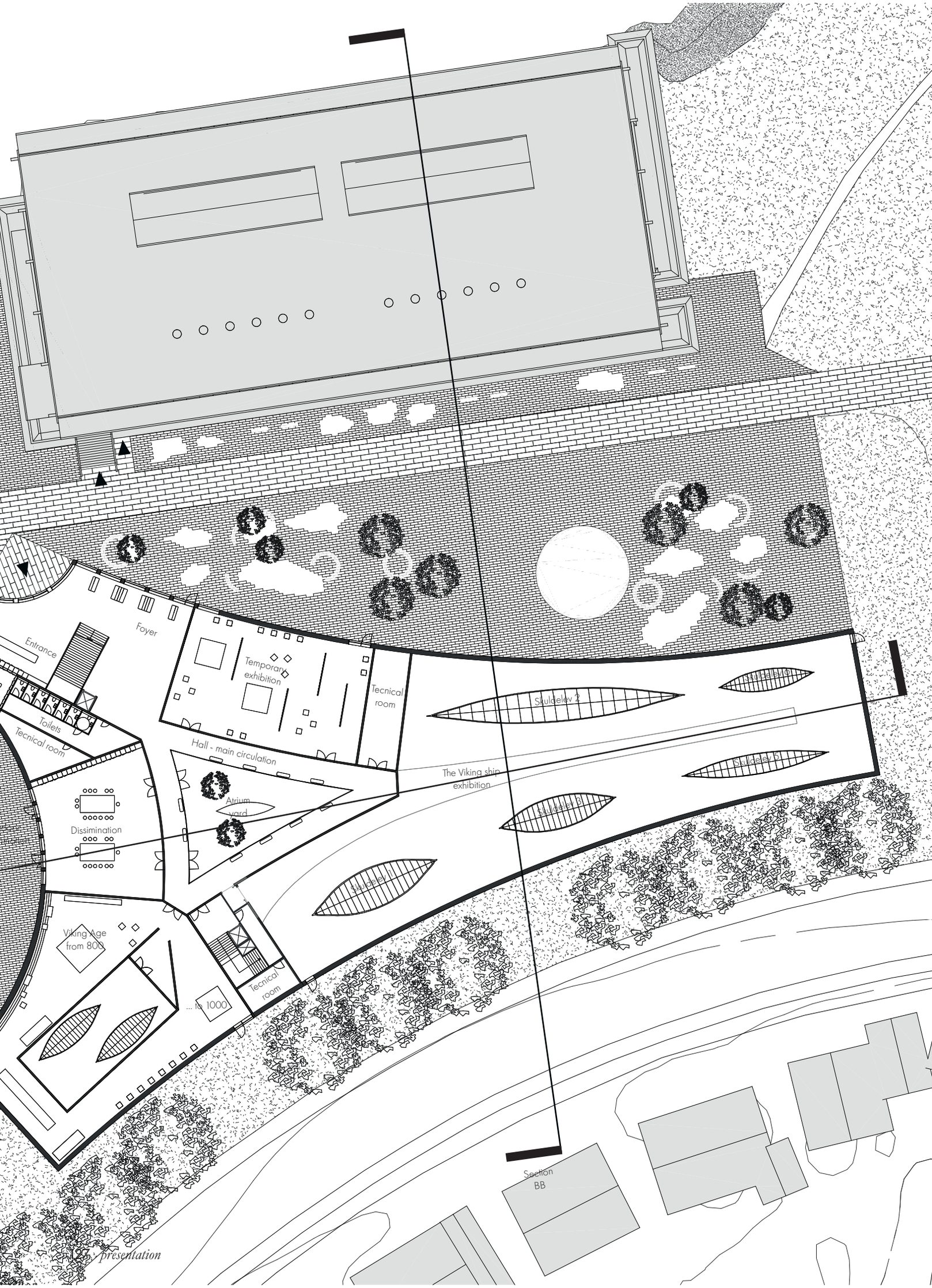
Ill. 59


Viking ship harbour
Water access
Café
Possibility for canopies
Play-ground
Public park
Museum path
Boatbuilding
Boatbuilding
Possibility for canopies
Café
Toilets
Museum path
Low greenery
Benches
Low greenery
Viking maze
Café
Boat houses
Meeting and dissemination
Rope-making
Dissemi-nation
Court -yard
Benches
Low greenery
Museum path
Bridge to the Museum Island
Bridge to the museum park
Museum park
Parking
Path from the city and bus



Plan drawing
Ground floor 1:500

Ill. 60


Foyer
Entrance
Temporary exhibition
Tecnical room
Toilets
Tecnical room
Hall - main circulation
Atrium yard
Dissimination
Skuldelev 1
Skuldelev 2
Skuldelev 3
Skuldelev 5
Skuldelev 6
The Viking ship exhibition
Viking Age from 800
... to 1000
Tecnical room
Section BB
presentation

A NARRATIVE THROUGH FLOW

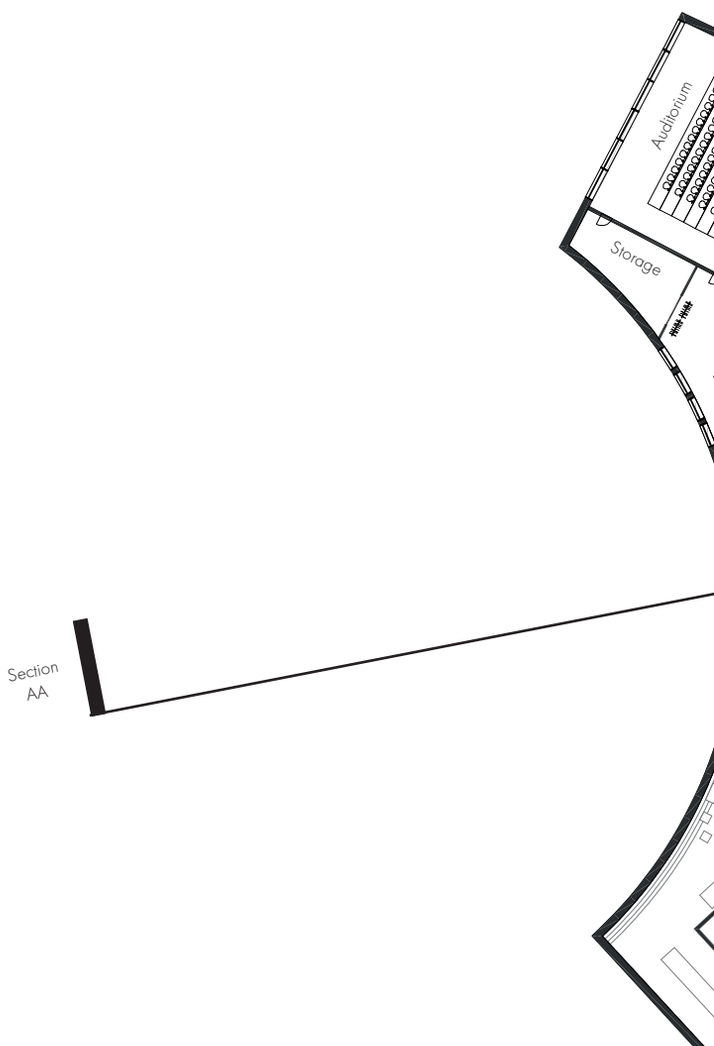
The entrance of the new museum attracts visiting guests through the directional pavement from all sides and encloses them under an overhanging roof structure. Facing the existing museum, now the Marine Archeology Museum, and the Museum Island, the entrance addresses the other Viking-related activities in the nearby area as a cohesive measure.

The circular cut into the building has been carefully made from the same principle as the form-giving processes in the museum volume, extracting part of the building mass to create an obvious entrance from the large volume.

The entrance manifests a universal design approach with a levelled entrance which can be accessed by wheelchairs and by walking impaired people as well. Entering the building, the visitors are led to the admission zone, and from there the visitors can either move to the first floor's auditorium or to the exhibition spaces through the atrium hall connecting the entire exhibition area.

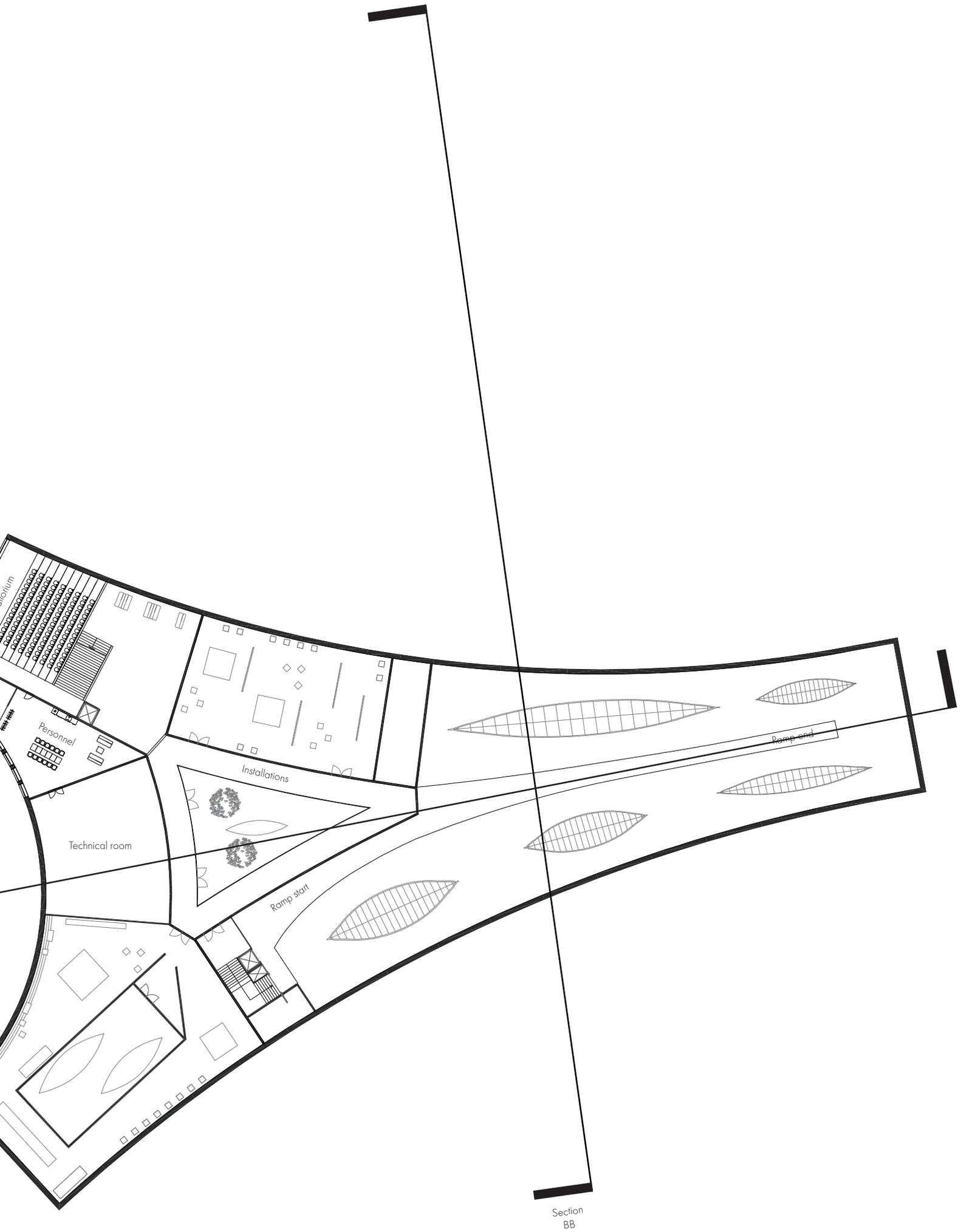
The atrium hall represents the main flow; a loop circulation. This type of circulation offers a great overview of the layout of the exhibitions, and the possibility to tailor the experience and empowers visitors, allowing them to choose a direction. The slow track; is an experimental journey for visitors seeking knowledge and an opportunity to immerse themselves into the full exhibition of Viking history and finds from the Viking Age through a chronological story.

The fast track; is an option for the recurring enthusiast looking for insight into their field of interest to be expanded through the alternating temporary exhibitions, or even to monitor closely their field of interest within the Viking Age. This could also be exploited as a highlight route, only seeing what you find most interesting.



Plan drawing
1st floor 1:500

Ill. 61


Personnel
Installations
Technical room
Ramp start
Ramp end

Section
BB

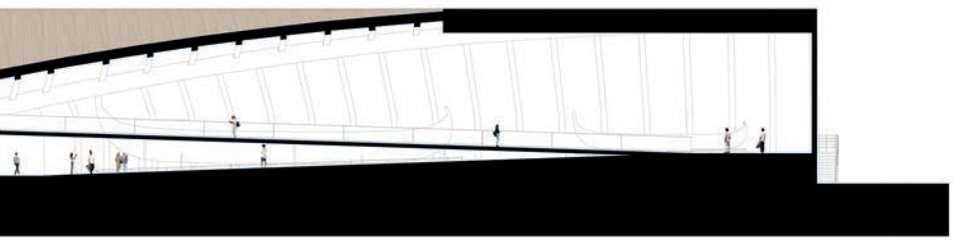
SECTIONS

The ceiling heights are a manifestation of the intended room functions and a measure to create different atmospheres appropriate to the intended use, with large ceiling heights when experiencing something extraordinary, and lower ceiling heights when seeking a level of comfort.

The lowered ceilings are seen in the entrance, atrium hall, and dissemination room. In the entrance, the lowered ceiling height applies to the admission desk, the wardrobe, and the toilets, where the auditorium is placed right over, with a view towards Roskilde Fjord. When moving from the entrance towards the foyer, the ceiling height expands, and the journey begins.

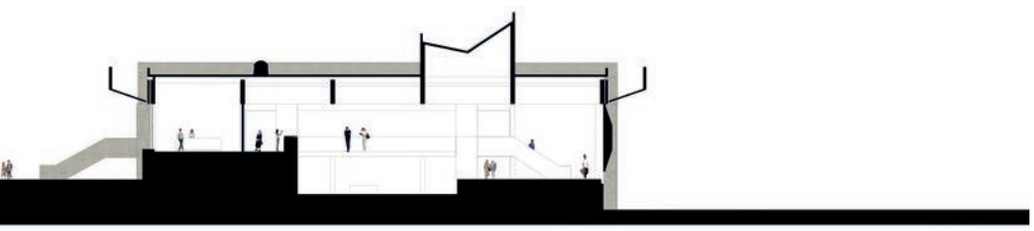
The hall is a place for exhibiting the story of the finds, but most importantly a place to move from one exhibition to another. By moving from the lowered ceilings in a narrower space, to entering voluminous rooms with large ceiling heights and artefacts from the Viking Age, creates an element of surprise and grandiosity.

The dissemination room also has a lowered ceiling height with a utilised first floor for technical installations. Lowering the ceiling height from 11 meters to 3 meters in spaces where visitors are sitting creates a stronger sense of comfort and scale in the room. Opposed to the lowered ceilings creating a sense of comfort, the remaining museum is highly defined by the ceilings and the strong expression created hereby.



Section AA
Through dissemination, the atrium hall, and the Shrine

Ill. 62

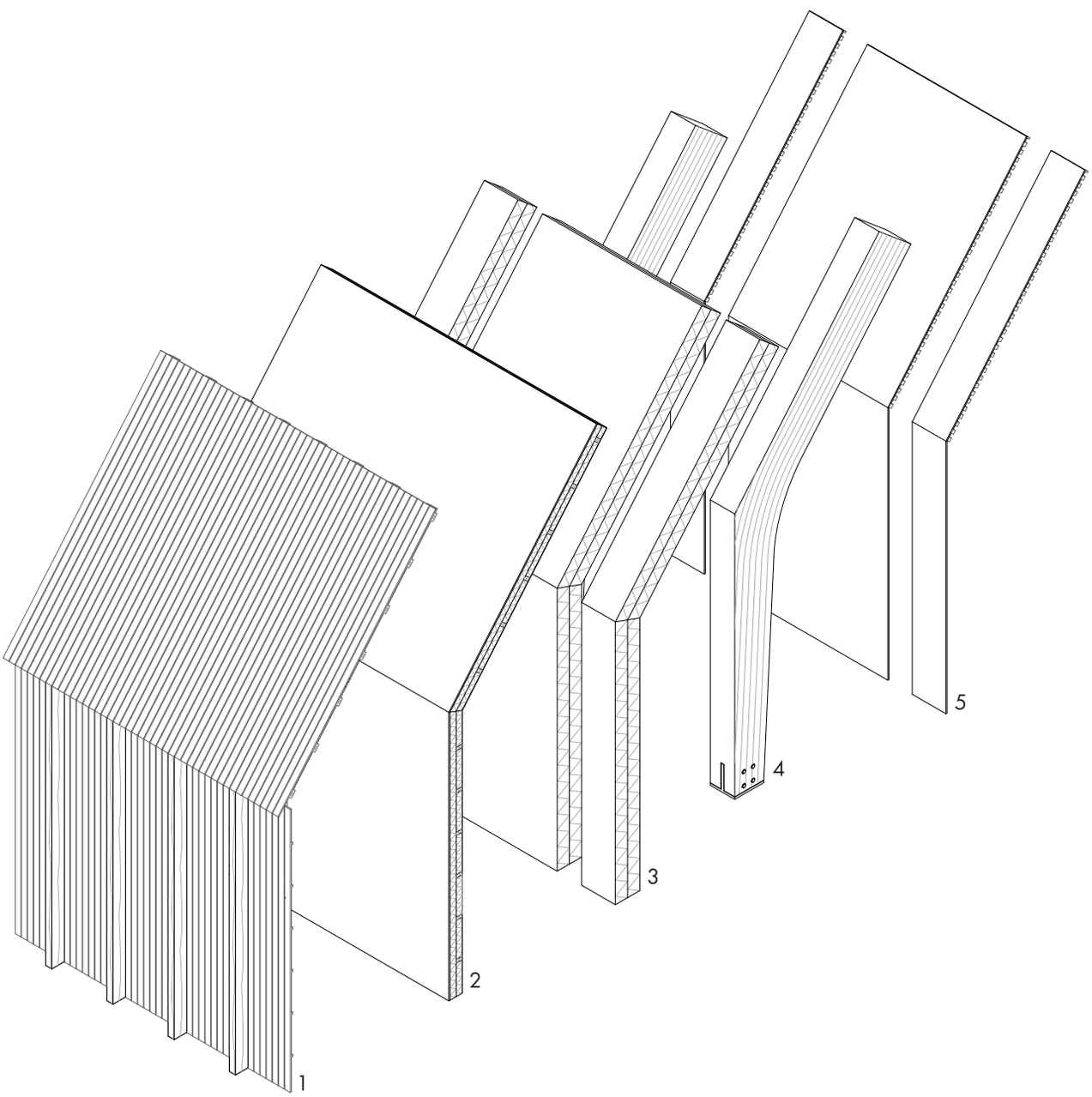


Section BB
Through the Shrine and the Marine Archeology Museum

Ill. 63

Exploded view
Wall section

Ill. 64



1. Wooden facade 2. Insulation and vapour barrier 3. Insulation 4. Gluelam 5. Clay plaster

SKIN
MEAT
BONE

In the notion of reflecting the structural elements, and as a respectful ode to the rhythmical façade of the Viking Ship Hall, timber columns mounted on the cedar-clad board façade follow the curved wings of the design proposal. The columns accentuate the curvature with the gradient amount of shading they project on the façade over the course of the day. A ventilated cavity allows for the breathability of the cladding.

The wind barrier separates the cladding from the first layer of insulation with cross spacers minimising the cold bridges in the construction. Between this layer of insulation and the next, the moisture barrier is attached, unobstructed by the load-bearing elements.

Two additional layers of insulation are mounted between the load-bearing frames, concealing most of the massive timber elements inside the wall construction.

The glulam frames act as a homage to boatbuilding in the Viking Age with their characteristic curves. They tell the tectonic tale of the building concept in their repetitive positioning and their unique angles. The frames are a juxtaposition as actors of both meat and bone in the sense, that they explicitly illustrate their structural function, while actively framing the spaces in a physical and phenomenological manner.

The interior wall appears elegantly simple with a pale clay plaster complementing the horizontal wood lamellas on the ceiling and concludes the aesthetic reference to the maritime.

Elevation 1:500
North

Ill. 65

The Shrine

Elevation 1:500
West

Ill. 66

Café

FACADES

The untreated wood facades refer to one of the most used materials in the Viking Age, where pine and oak were widely used for ships, houses and equipment. Besides being a sustainable material, wood also brings warmth to the museum, contrasting the large, brutalist building in concrete next to it.

The wooden lamellas in the façade are disrupted by vertical wood slabs, creating a relief and rhythm to the façades, which are defined by large spans without any windows to break with the volume, aside from the entrance and foyer.

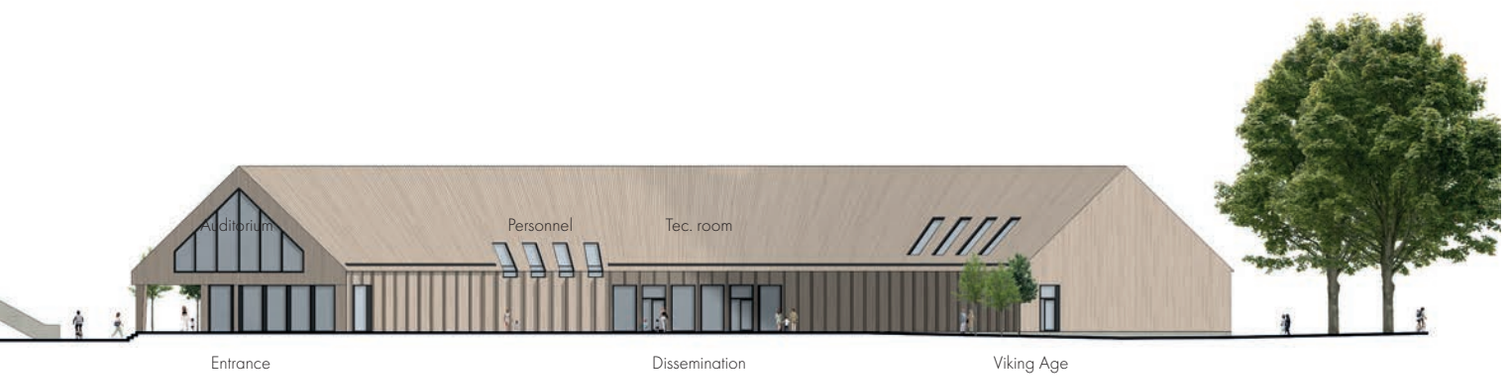
The new architecture respects the functions within being interpretive and participating in the storytelling; with many light-sensitive artefacts, not many windows can be introduced to the façade.

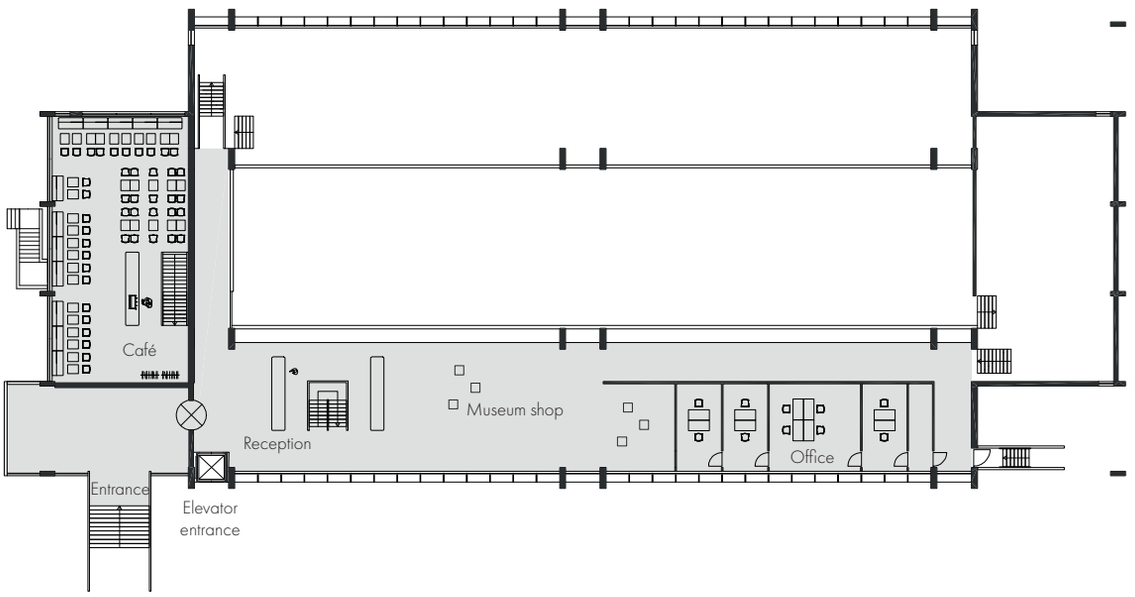
The vertical wooden slabs also reflect the construction made by large wooden frames in a fixed distance resembling the structural principle of the Maritime Archaeology Museum, with largely dimensioned concrete elements filling the large hall.

The foundation slowly rises towards east, following the assenting floors inside the Shrine.

The windows in the entrance and foyer offer transparency, inviting people into the museum. Having large windows makes it possible to see the grandiosity of the construction, as a teaser for what to come in the exhibition spaces. The dissemination room has an open façade towards the fjord, creating a dynamic between the dissemination spreading from the inside to out.

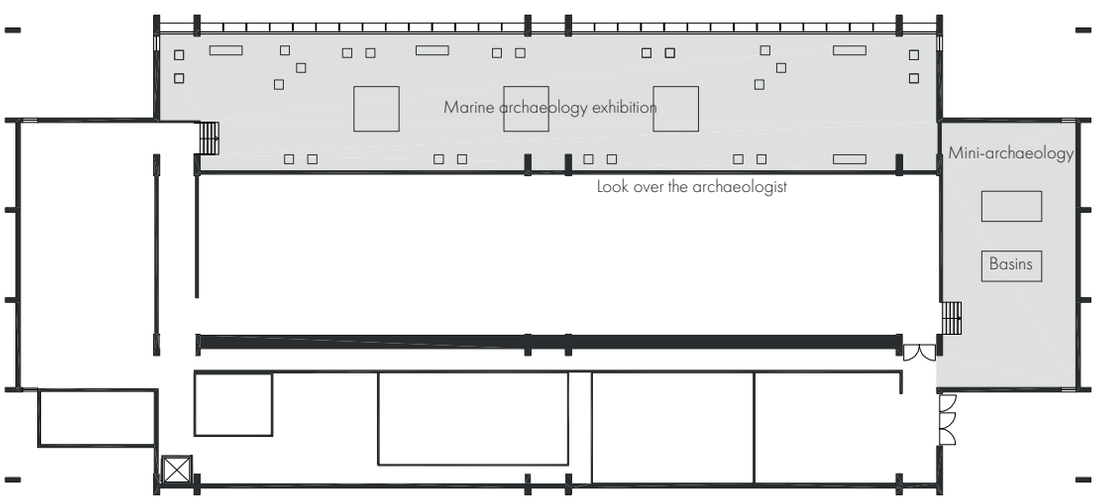

Auditorium
Temporary exhibitions
Foyer
Entrance


Auditorium
Personnel
Tec. room
Entrance
Dissemination
Viking Age



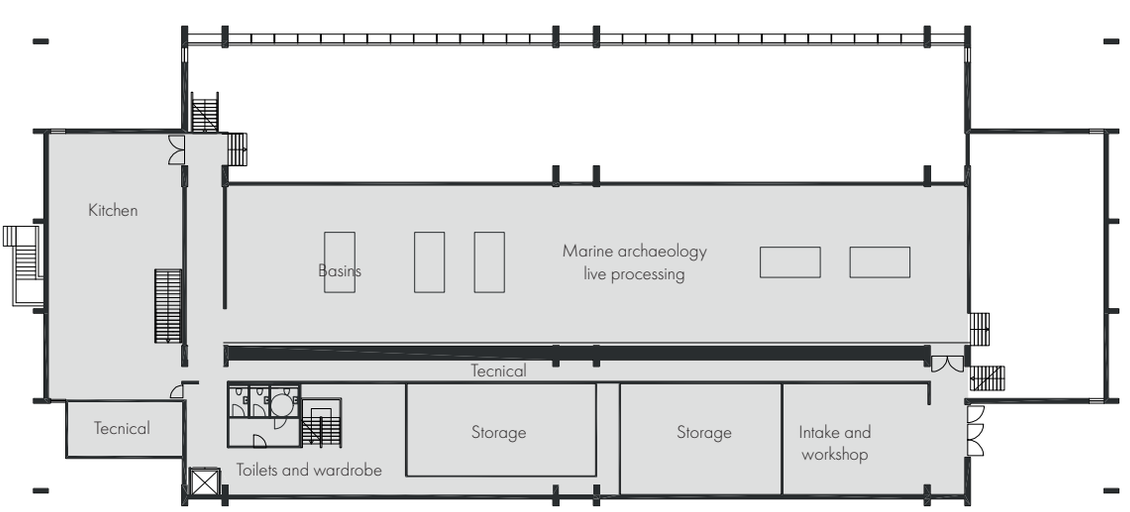
Plan drawing
Level 1 1:500

Ill. 67



Plan drawing
Level 2 1:500

Ill. 68



Plan drawing
Basement 1:500

Ill. 69

THE TRANSFORMATION

The entrance has been adapted to contemporary demands, allowing equal access to all parts of the building. This results in a gentle addition to the existing structure, introducing to an elevator on the façade facing the city and an internal lift in addition to the stairs.

The structure has been taken back to its original exterior presentation with marks wooden of wooden formwork in the outer layer of concrete; strengthening the building structurally and reflecting the inside of the building with the same consistent material tactility.

To accommodate new needs, the west façade, facing the fjord and Museum Island, has undergone an intervention, opening towards the vibrant life outside the walls. Here, the original thoughts of the space have been reborn, creating a relaxed café stretching from inside to outside the museum.

As the transformation theory describes, buildings are dynamic objects and exist through periods of time. Where the ships once stood tall, a functional intervention integrating a new marine archaeology exhibition and interactive dissemination of the subject is introduced to accommodate the future demands of an expansion of the marine archaeology department.

The levels in the buildings make it possible to view over the archaeologists work with underwater artefacts from above. The exhibition space allows us to explore and widen our knowledge of life at sea from ages ago.

The new café in the Marine Archeology Museum

Ill. 70

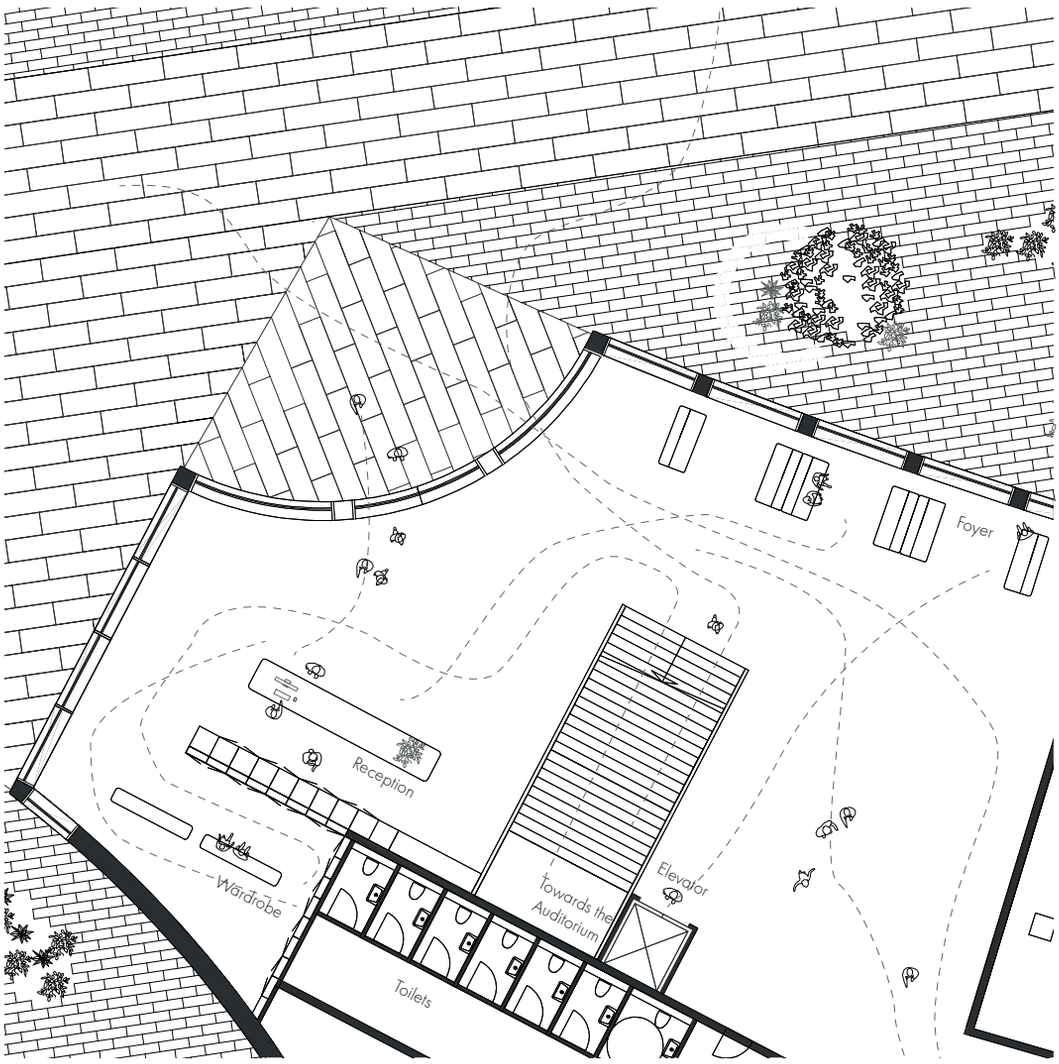
The new café is a representation of the art of bringing a building back to its original glory. As mentioned, this placement once was thought as a perfect stop mid-journey to have a rest, whilst looking over the active fjord. The original materials have been preserved with the large concrete structural system. To soften the rather cold materials, warmth has been brought in by the soft ochre sofas, where tourists and locals can enjoy refreshments while looking at the bright orange sails on the passing Viking ship replicas at Roskilde fjord on the horizon.

The new outdoors café

Ill. 71

View from the path toward the fjord and the dissemination zone.

Ill. 72



The entrance and foyer
1:200

Ill. 73

The entrance marks the beginning of the museum experience. The experience of entering a building is a teaser of what is to come. At first, when entering, the ceilings are lowered, and you buy your admission ticket and leave your belongings in the wardrobe. After this, the ceilings open to an extraordinary ceiling height in the foyer with visible beams.

The lowered ceiling also tells a story of functions above you. From the foyer, a concrete stair, inspired by the original museum, transfers you to the auditorium. Here, the visitor is immediately met with an extraordinary view towards the active and vibrant Museum Island and the fjord, with activities both on and off land. Here, exiting lectures about the Viking Age and marine archaeology take place, or other events at use for Roskilde's citizens.

The entrance and foyer

Ill. 74

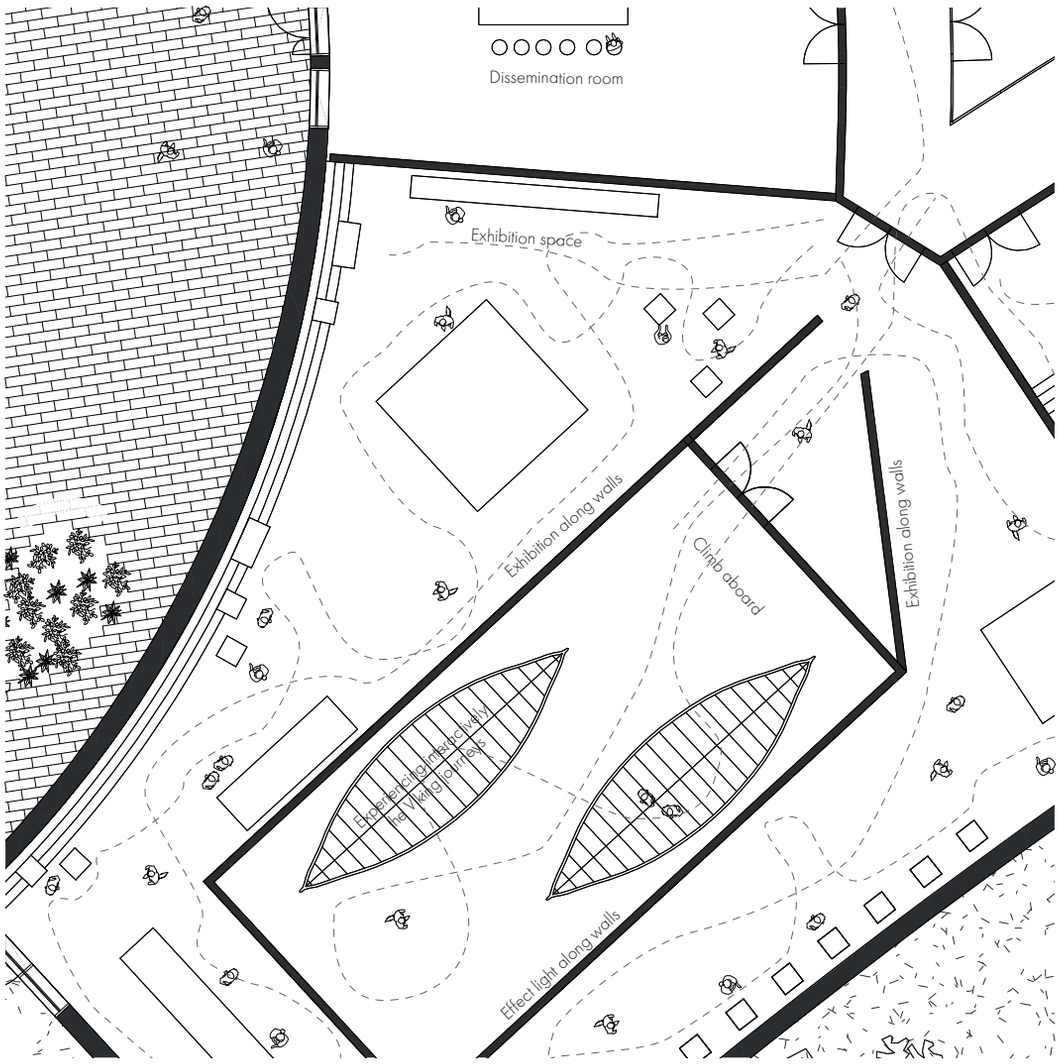
Leaving the entrance and foyer, the visitor enters the atrium hall. Along the walls, the exhibition of the find of the Viking ships occurs; from the excavation, preservation, assembling and now, the moving of the fragile Skuldelev ships. You can either sit and have the full story, or simply walk slowly by, absorbing the visual graphics. The story unfolds around a green atrium yard, letting light into the hall and inviting to have a breathing room outside.

The atrium hall

Ill. 75

The Viking Age exhibition

Ill. 76



Dissemination and Viking Age exhibition
1:200

Ill. 77

The Viking Age exhibition creates a linear narrative of the Viking Age from 800-1050 AD through a variety of artefacts and visual information going around a centre. In this centre, the 'Climb Aboard' exhibition is placed in an enclosed space.

The delivery of narrative can be subdivided into two basic forms; visual and textual. Climb Aboard is an interactive and interpretive exhibition of the Viking voyage on the sea. Through the scenography displayed on all surfaces, the visitor immerses into an interactive journey with changing weather at sea, whilst sitting in one of the Viking ship replicas. A total experience of projections, light, sound and objects.

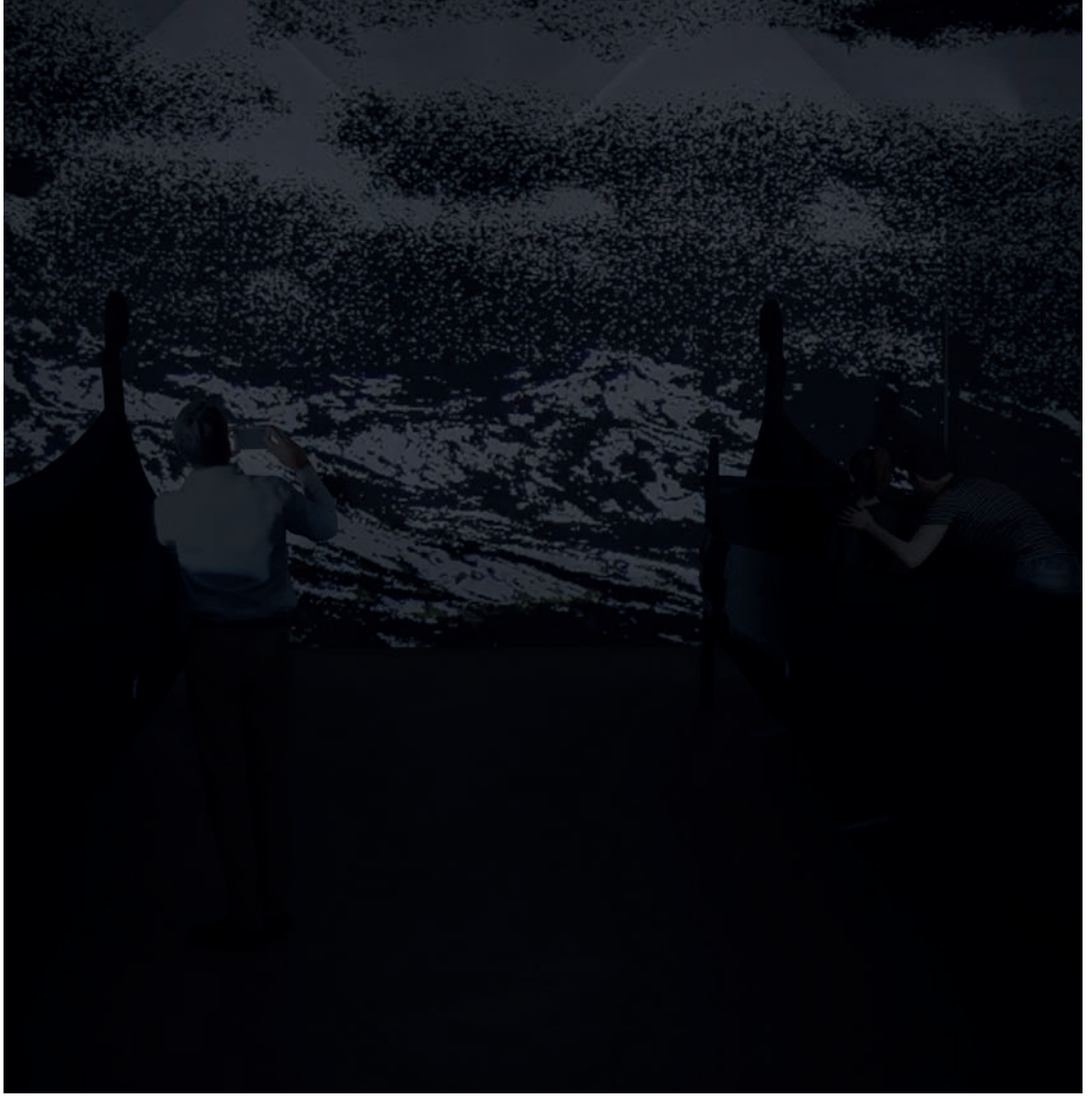
The exhibition space is a dynamic set of display cases in different sizes and heights depending on the artefacts exhibited. A linear narrative as opposed to a more labyrinthine way through the exhibition space, creates an understanding of the contexts to which the artefacts once belonged.

The structural system is visible and utilises the different sections with informative written narratives, and inventive forms of scenographic presentation directly on the bare walls. Exploring manifold relationships between text and museum space.

The integrated steps make it possible for children to have a closer look at the exhibited artefacts, or for visitors to have a short stay, whilst reading into the complex Viking history.

The exhibition space

Ill. 78

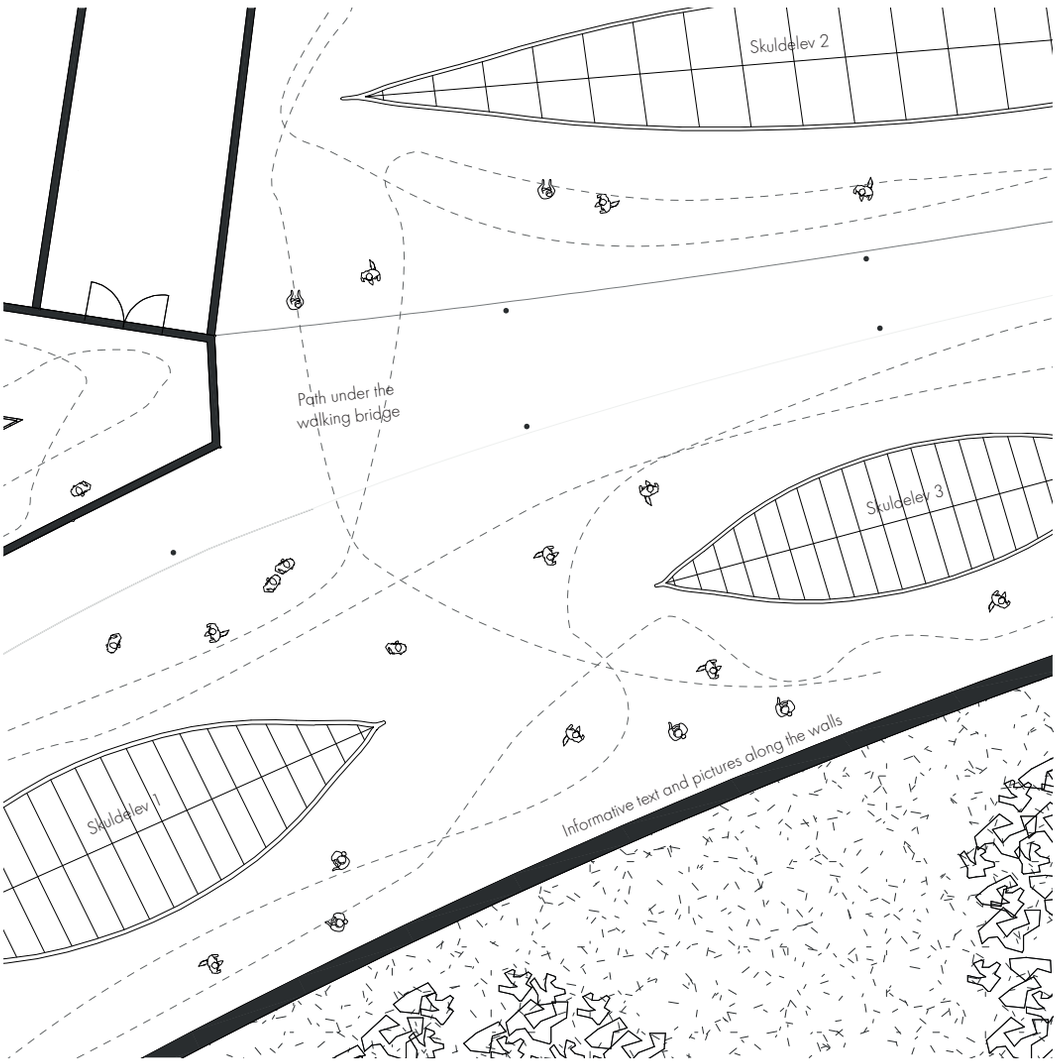


Climb Aboard

Ill. 79

The Climb Aboard exhibition is a story of Vikings voyaging across the open sea delivered through a total experience of projections on all walls accompanied by dramatic light and sound for a visual and audial experience.

The projections are taking the visitors on a voyage, starting in calm weather, which quickly changes to a dramatic storm. All while being aboard handcrafted replicas of Viking ships.



The Shrine
1:200

Ill. 81

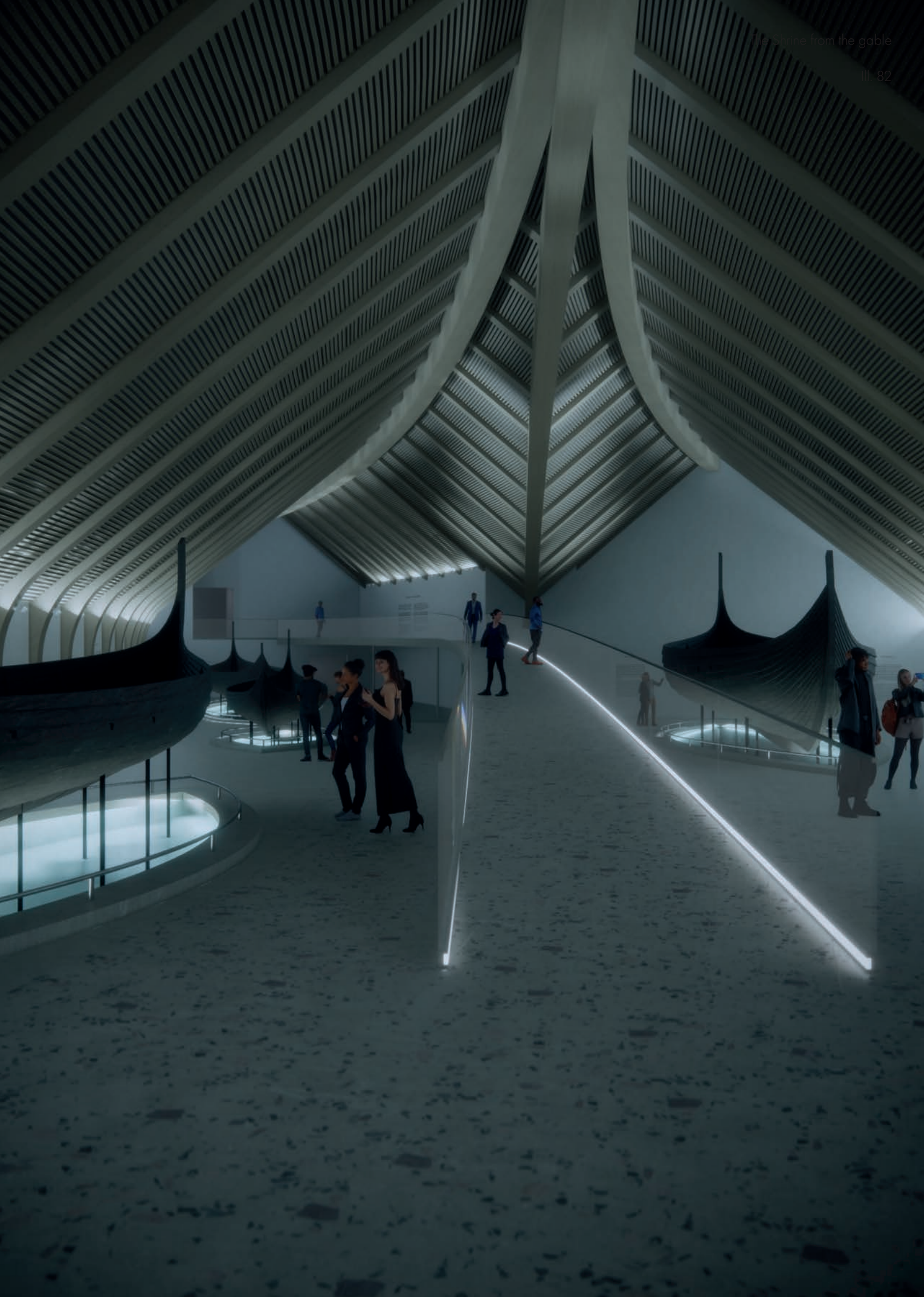
Drawing on the principles of Erik Christian Sørensen's narrative of a grand gesture, looking over the ships as a triumph in the large exhibition space, the entry of the Shrine is dramatized by overlooking the ships in a convoy formation.

The roof structure resembles the curves of a ship hull. A beam, imitating the keel of a ship, dictates the direction in the room.

As opposed to the linear narrative from the Viking Age exhibition and the Viking ship find exhibition, the experience of the ships is based on an adventurous approach rather than chronological order. The visitor can inspect the ships on their own premises when stepping off the descending track towards the gable.

Contrary to Erik Christian Sørensen's thoughts about experiencing the ships in levels from one side, the new museum offers a complete exploration of all ships. Here, there is no hierarchy in the inspection of the ships, as they are all approachable to investigate closely. The tempi in the room are set by highlighted tracks of terrazzo as a manifestation directly into the concrete floor, creating an idea of a stone path.

The ships are standing gently on plateaus, with effect light resembling the reflections of water underneath. The ships are also indirectly illuminated through light sources in the highlighted roof structure, creating a dramatic effect, whilst not exposing the ships from unnecessary, contaminating light.



The shrine from the gable

Ill. 82

OUTRO

CONCLUSION
REFLECTION
ACKNOWLEDGEMENT
APPENDIX

CONCLUSION

The design competition brief suggests a larger transformation of the museum area; including a new museum securing the five Skuldelev ships, processing of landscape and outdoor areas to enhance the collected museum experience, and lastly a full transformation of the original Viking Ship Museum.

Museums have a complex relation to sustainability issues. On one hand, we, as architectural engineers, seek to find innovative solutions mitigating environmental-, social-, and economic aspects of the built environment. However, despite the professional discourse, it is not always the environmentally sustainable solution that is the best solution for the exhibitions within, but first and foremost: to preserve tangible and intangible heritage. Therefore, the ships must be moved to a new museum designed for perpetuity.

Throughout the design process, a scale of foci has been addressed, acknowledging the competition brief's wish to solve the area as a whole and not through a single building. The goal was not to solve every matter of the design brief, but rather challenging the perceived problems emerging through our studies of the project. Designing a new museum is, in this case, undeniably a part of altering the existing, both on urban and building scale, as being part of something bigger.

Interventions in the urban areas focused on creating a natural flow and coherent museum area, designed through new paths and biaxial canopies referring to each side of the canal.

Altering the Viking Ship Hall with functional considerations in compliance with the museum' wishes and universal design is a deliberate recurrent thematic, leaving the structural challenges to a reduced principal level.

And what was the main driver for the new Viking Ship Museum then?

Above all, creating a museum participating in the storytelling of the Viking Age in atmospheres and narratives mediated by architecture. The Viking history is a great part of the Danish and Scandinavian self-consciousness and something many people associate Denmark with. The architecture represents a complex relation between narrative, space, and identity - culminating in a proposal for the dissemination of cultural heritage. Museums are means of communication. They communicate the meanings of nature's and humanity's past and present to visitors.

This thesis is pushing the limits of our architectural capabilities in an attempt to create holistic architecture in the fields of engineering and architectural design.

REFLECTION

This thesis has focused on two main topics within the scope of the new Viking Ship Museum; a tectonic and a phenomenological approach emphasising the intended use of the architecture, and the dissemination of the Viking Age through a variety of media.

The thesis has been through an iterative process, even though not immediately obvious to the reader, as the process is presented as being linear: one step follows the next, influencing the next part of the process, resulting in a beginning, middle, and end. The reiterative nature of an integrated design process undeniably results in a series of diverging phases, where applicable topics are sorted out for the sake of progression into synthesis.

Having narrowed the main topics, and the processes justifying the creation, of a holistic museum complex, causes thought for reflection. The character and theme of the project have changed throughout the process, due to different challenges. The extent of the assignment requiring specialists in different areas to achieve holistic design has resulted in an outcome characterized by conceptual solutions in most issues, while a few in-depth tectonic and phenomenological topics have been selected that characterize several facets of this thesis' outcome.

As a common denominator for projects within the university premise, many issues would be addressed before a museum design on this scale would be realisable, not to mention the need for several specialists within the fields of architecture, museums, and engineering. This results in many conceptual and principal solutions on certain subjects - acoustics, a full indoor climate profile, and energy consumption can be mentioned as contributing factors.

Though holistic design is a tall order, this thesis seeks to incorporate our architectural and engineering competencies. This is reflected in a highly explorative process beginning with the intention of altering the Viking Ship Hall extensively, pivoting towards creating a separate museum that supports the coherence in a distinctive manner. The explorative process also exercised a design approach in which quantitative and qualitative factors were constantly assessed in decision-making.

Although interdisciplinary approaches have been the intention, it can be argued that multiple parts of the final design have ended up being based on aesthetic- and phenomenological qualities such as scale, light, rhythm, proportions, and tactility, rather than being e.g., technically specified.

Having to narrow down the scope also resulted in a lesser degree of detailing of both the transformation of the urban settings and the existing Viking Ship Hall, though intended. However, in an attempt to create a cohesive museum complex, the relationship between the new and the existing is being addressed throughout the project – looking at the area as a whole, but with differentiating levels of detail.

Given the time of the year visiting the museum, November and March respectively, our idea of the current use might differ from reality, as the outdoor dissemination is closed during the cold months, when the ships are on land, and the boatbuilders are making ships inside the warm workshops. A full picture of the site would be beneficial in further detailing of the urban environment, including even more functions benefiting the city and the museum, such as active water management solutions, and making the suggested parks a greater part of the experience.

The initial idea of the Viking Ship Hall transformation was to integrate the new museum to the existing museum body, while the proposal, as a result of a revised position on architectural transformation in this particular case, ended up as a detached volume as a representation of our interpretation of the genius loci.

Restoration ethics revolves around the building body itself, but parallels can be drawn to the project area. In this thesis, restoration ethics cannot be used very often in its purest sense, due to the project moving towards transforming the museum area rather than the Viking Ship Hall. However, the theory in this field has had a great impact on our understanding and interpretation of the area and the project proposed. Christopher Wren's wish that buildings should aim for eternity and thus become elements of continuity is obviously the goal, but there are no guarantees that the building stands the test of time in the eyes of the beholder.

Could we in fact have optimised the Viking Ship Hall to go back to its former glory, presenting the ships as originally thought out by Erik Christian Sørensen? Or is it undeniably too big of a risk to keep irreplaceable artefacts inside? At least that is the conclusion from the National Museum.

Are we even sure, that we are building a permanent solution? This also sparks a debate on the premise of exhibiting artefacts – that are as extremely important as they are fragile – to the public, at the risk of them deteriorating for the cause of disseminating their cultural importance, instead of hermetically sealing them away for safekeeping.

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Other: Own illustrations by the authors Emilie Jensen, Matias Valsby-Koch and Tobias Møller Balle.

	Key information:	Est. Area:
The exsisting Viking Ship Musuem	Transformation of the exsisting museum	Total = 2400 m²

	Type	Quantity	Est. Area:	Ventilation strategy
Section 1:				
Entrance	*Foyer + admission*	1	~90 m²	Hybrid
	Museum shop	1	~190 m²	Hybrid
	Wardrobe	1	~12 m²	Hybrid
	Toilets	7	~3 m²	Mechanical
			Total = ~314 m²	

	Type	Quantity	Est. Area:	Ventilation strategy	Properties
Section 2:					
Marine archeology	*"Underwater" exhibition*	1	165 m²	Hybrid	Options for blackening, flexible
	Excavation workshop	1	130 m²	Hybrid	
	"Archaeological finds processing area"	1	540 m²	Hybrid	
	Knowledge centre	1	100 m²	Hybrid	
	Maritime archaeology	1	230 m²	Hybrid	
			Total = ~1165 m²		

	Type	Quantity	Est. Area:	Ventilation strategy
Section 3:				
Museum café	*Kitchen*	1	~160 m²	Hybrid
	Sitting area indoor	1	~160 m²	Hybrid
	Sitting area outdoor	1	~500 m²	-
			Total = 820 m²	

	Type	Quantity	Est. Area:	Ventilation strategy
Section 4:				
Personal	Office	5	~19 m²	Hybrid
	Storage	1	~220 m²	Hybrid
	Workshop	1	~90 m²	Hybrid
			Total = ~410 m²	

APPENDIX 1
ROOM PROGRAM

Fire indicatives

At least one exit door from each fire unit must be established to either free terrain, a balcony, a door to an escape route hall or an escape stair.

In fire cells equipped for more than 50 persons, the exits from a fire cell must lead to at least two escape routes leading independently of each other all the way to open ground.

Energy demand § 260

For buildings other than dwellings the total energy demand for heating, ventilation, cooling, domestic hot water and lighting per m^2 of heated floor area shall not exceed 41 kWh/m^2.

Energy, u-values § 257

Outer walls: 0,30 W/m^2K
Floor separation: 0,40 W/m^2K
Roof: 0,20 W/m^2K
Terrain deck: 0,20 W/m^2K

Daylight § 379

Sufficient access to daylight can be demonstrated by the glazing area without shading conditions corresponding to at least 10 percent of the relevant floor area.

Alternatively, sufficient daylight can be demonstrated by demonstrating that the internal illumination of daylight is 300 lux or more at least half of the relevant floor area for at least half of the daylight hours (Bygningsreglementet, nd.).

	Key information:	Est. Area:
The new Viking Ship Musuem	*Museum* *Technical installations* *(10% of the floor area)*	3300 m² 330 m²

	Type	Quantity	Est. Area:	Ventilation strategy
Section 1: **Entrance**	*Admission* *Foyer + access* *Wardrobe* *Toilets*	1 1 1 7	~55 m² ~370 m² ~30 m² ~3 m² Total = ~457 m²	Hybrid Hybrid Hybrid Mechanical

	Type:	Quantity	Est. Area:	Ventilation strategy
Section 2: **Auditorium**	*Auditorium* *Storage* *Outside opening hours e.g., event room*	1 1	~180 m² ~40 m² Total = ~220 m²	Hybrid Mechanical

	Type	Quantity	Est. Area:	Ventilation strategy
Exhibition 1: **The finds of the Viking ships**	*The excavation* *The recovery* *The documentation* *The conservation* *The assembling*	1 1 1 1 1	- - - - - Total = ~205 m²	Hybrid Hybrid Hybrid Hybrid Hybrid

	Type:	Quantity	Est. Area:	Ventilation strategy
Exhibition 2: **The Viking Age: around 750-1050**	*Artefact exhibtion* *Climb aboard exhibition*	1 1	~430 m² ~140 m² Total = 570 m²	Mechanical Mechanical

Light requirements		
Lux/hr	Aesthetic	Light source
min. 300 min. 300 min. 300 min. 300 ...	Diffuse/indirect light	Combined Artificial and Natural light

Light requirements				
Lux/hr	Aesthetic	Light source	Temperature	Properties
min. 300	Diffuse/indirect light	Combined Artificial and Natural light	20-26 °C	

Light requirements				
Lux/hr	Aesthetic	Light source	Temperature	Properties
min. 200 min. 200 min. 200 min. 200 min. 200	Difuse/Accent light	Combined Artificial and Natural light	20-26 °C 20-26 °C 20-26 °C 20-26 °C 20-26 °C	Mainly digital media, requires minimum glare for screens

Light requirements				
Lux/hr	Aesthetic	Light source	Temperature	Properties
	Accent/effect light	Combined Artificial and Natural light	20-26 °C 20-26 °C	Posters and dioramas, narrative of sailing and exploring the world

	Type	Quantity	Est. Area:	Measure (l x w)	Ventilation strategy
Exhibition 3: **The ships; Around 1000**	*Skuldelev 1* *Skuldelev 2* *Skuldelev 3* *Skuldelev 5* *Skuldelev 6* *Arrival point + vestibule*	1 1 1 1 1 1	76 m² 114 m² 53 m² 43 m² 28 m² ~90 m² Total = ~1400 m²	15,84m x 4,8m 30m x 3,8m 14m x 3,8m 17,3m x 2,5 m 11,2m x 2,5 m	Mechanical Mechanical Mechanical Mechanical Mechanical Mechanical

	Type	Quantity	Est. Area:	Ventilation strategy
Exhibition 4: **Temporary exhibition**	*Event specific exhibition* *E.g., Siege on Paris, Battle at Femern, Pilgrimage to Uppsala*	1	300 m²	Mechanical

	Type	Quantity	Est. Area:	Ventilation strategy
Section 3: **Dissemination**	Dissemination area	1	215 m²	Hybrid

	Type	Quantity	Est. Area:	Ventilation strategy
Section 4: **Personal**	Office / break room Tea kitchen	1 1	~100 m² -	Hybrid Mechanical

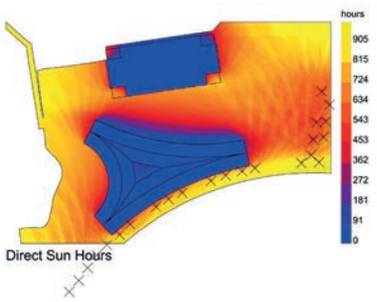
Light requirements				
Lux/hr/day	Aesthetic	Light source	UV	Temperature
Max 1500 Max 1500 Max 1500 Max 1500 Max 1500 -	Accent/indirect/effect light	Artificial light	0 microW/lumen 0 microW/lumen 0 microW/lumen 0 microW/lumen 0 microW/lumen	18-23 °C 18-23 °C 18-23 °C 18-23 °C 18-23 °C

Light requirements				
Lux/hr	Aesthetic	Light source	Temperature	Properties
	Diffuse/Accent light	Combined Artificial and Natural light	20-26 °C	Flexible space and lighting

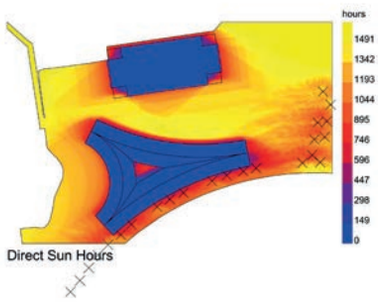
Light requirements				
Lux/hr	Aesthetic	Light source	Temperature	Properties
min. 300	Diffuse light	Combined Artificial and Natural light	20-26 °C	Lots of tablespace, opening up towards the water

Light requirements			
Lux	Aesthetic	Light source	Temperature
500 300	Diffuse light Diffuse light	Combined Artificial and	20-26 °C 20-26 °C

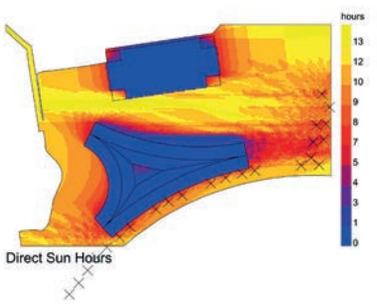
APPENDIX 2
SUN HOUR ANALYSIS



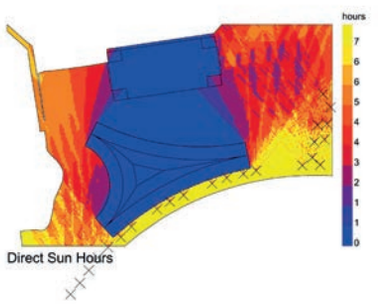
Autumn



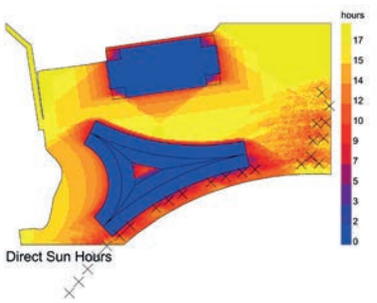
Summer



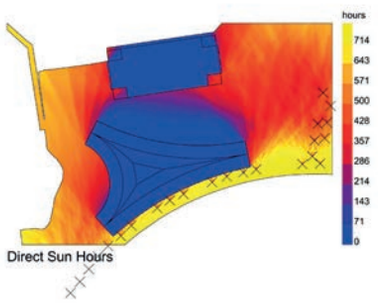
Equinox



Winter solstice



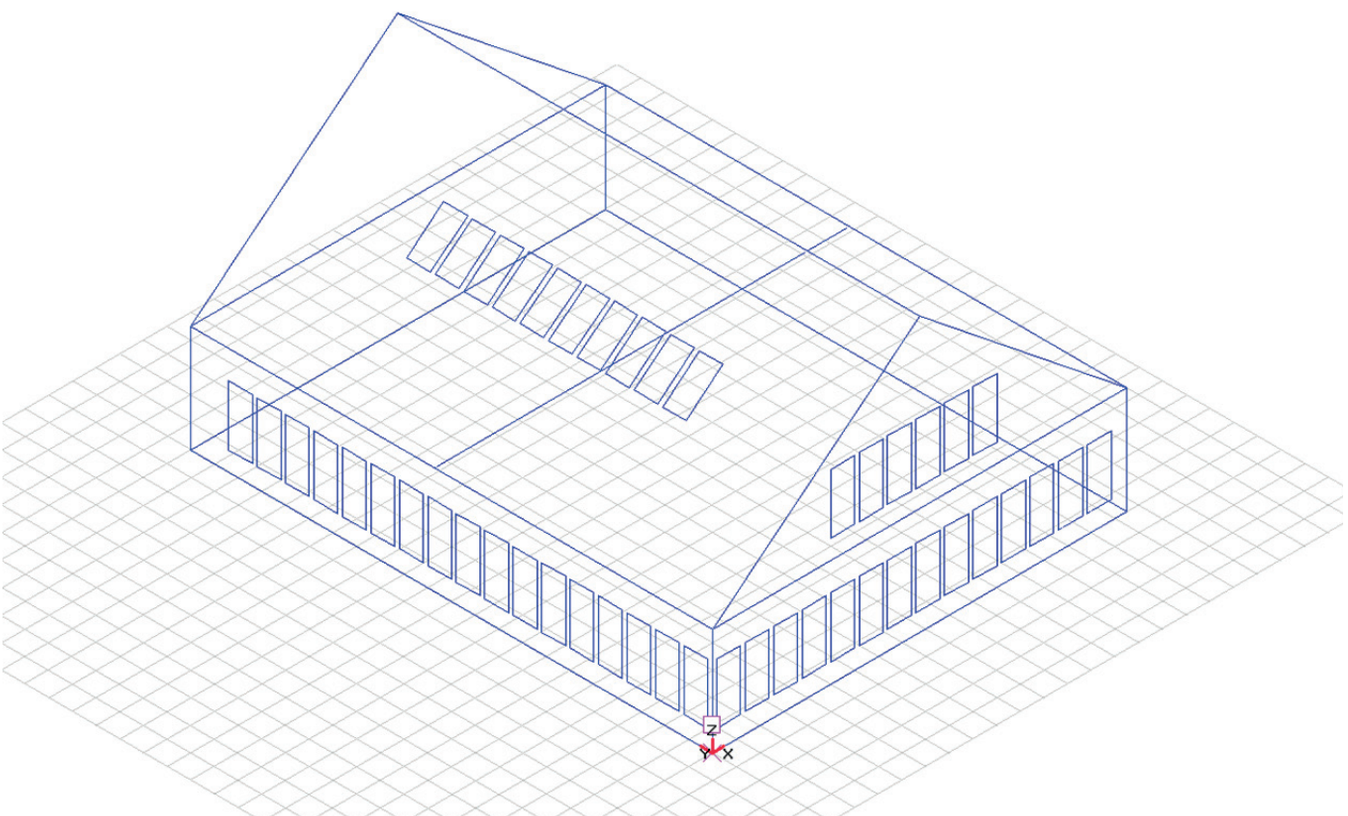
Summer solstice



Winter

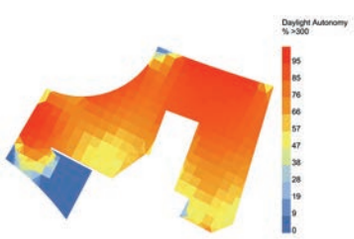
APPENDIX 3
BSIM

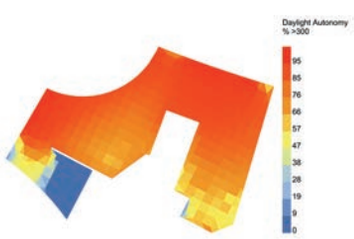
The iteration shows a simplified version of the north-western part of the new museum building. As stated on page 114, the BSim file consist of several steps to optimize indoor climatic qualities (Bygningsreglementet, n.d.).

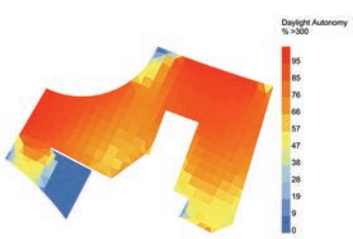


APPENDIX 4
DAYLIGHT ANALYSIS

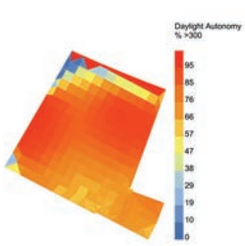
A more complete calculation of the façade iterations shown on page 117 has been done in this section. The calculation is done in a script with components from Ladybug/Honeybee in Rhino/Grasshopper. In the script, walls, floor, windows and ceiling must be defined, respectively. Then, the script executes a so-called heatmap as shown below. The heatmaps primarily show a grid of the defined floor area. In addition, they also show a percentage of how long during the daytime the floor is lit with 300 lux or more. As the Danish Building Regulations state that there must be 300 lux or more in at least half of the relevant floor area during at least half of the daylight hours, a median exists for all cases. Since the median finds the middle value in each of the façade iterations, the median needs to be above 50 to comply with the requirements of the Danish Building Regulations.

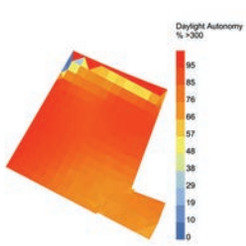


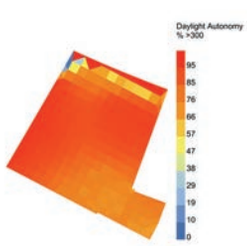




Entrance, foyer







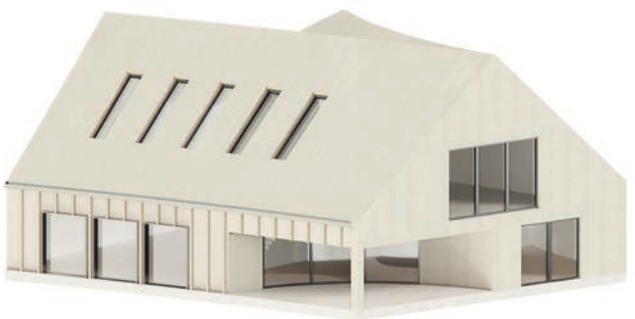
Lecture room

Iteration 1: 114 m² Glazed area = Median 65

Iteration 2: 143 m² Glazed area = Median 72

Iteration 1: 161 m² Glazed area = Median 75

Iteration 1: 114 m² Glazea area = Median 65



Iteration 2: 143 m² Glazed area = Median 72

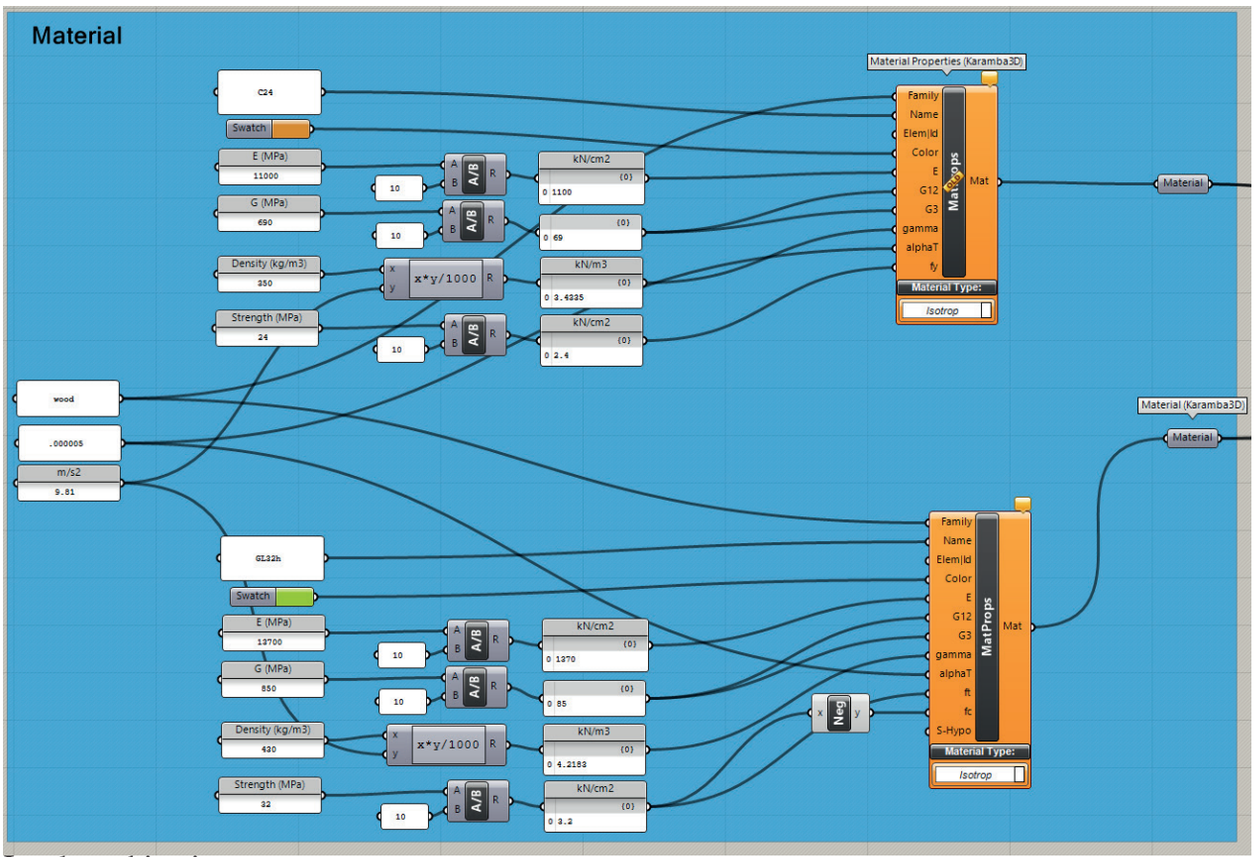
Iteration 1: 161 m² Glazed area = Median 75

APPENDIX 5
CONSTRUCTION IN KARAMBA

Karamba3D has been used for designing and dimensioning the construction and the load bearing elements of the final proposal. It has worked as an active tool for optimising the organisation of the structural system, i.e. the cross sections, joints, and supports.

	{0}
0	LC:0: Gravity:<0, 0, -1.32>;
1	LC:0: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/-7005.43)[kN];Load(0/0/-1.58)[kN/m2];
2	LC:0: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/0)[kN];Load(0/0/0)[kN/m2];
3	LC:0: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/0)[kN];Load(0/0/0)[kN/m2];
	{1}
0	LC:1: Gravity:<0, 0, -1.1>;
1	LC:1: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/-5837.86)[kN];Load(0/0/-1.32)[kN/m2];
2	LC:1: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/-7297.32)[kN];Load(0/0/-1.65)[kN/m2];
3	LC:1: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/-1379.19)[kN];Load(0/0/-0.31)[kN/m2];
	{2}
0	LC:2: Gravity:<0, 0, -1.1>;
1	LC:2: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/-5837.86)[kN];Load(0/0/-1.32)[kN/m2];
2	LC:2: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/-4378.39)[kN];Load(0/0/-0.99)[kN/m2];
3	LC:2: Mesh-load:global;Area:4422.6198[m2];Resultant:(0/0/-4597.31)[kN];Load(0/0/-1.04)[kN/m2];

Material properties - C24, GL32h

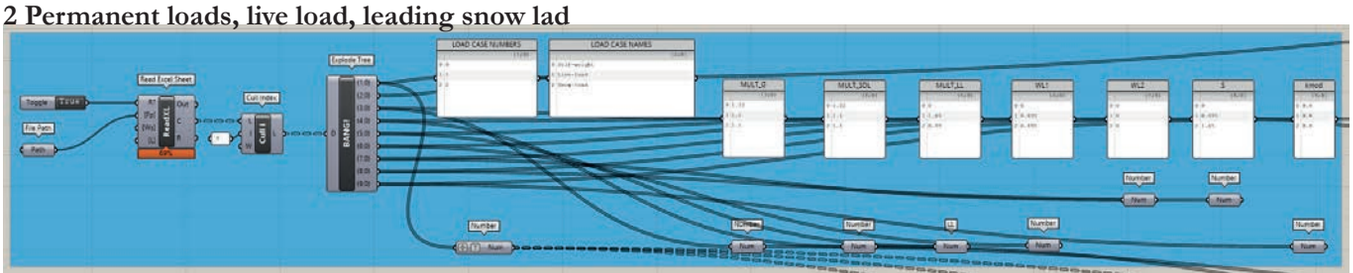


Load combinations.

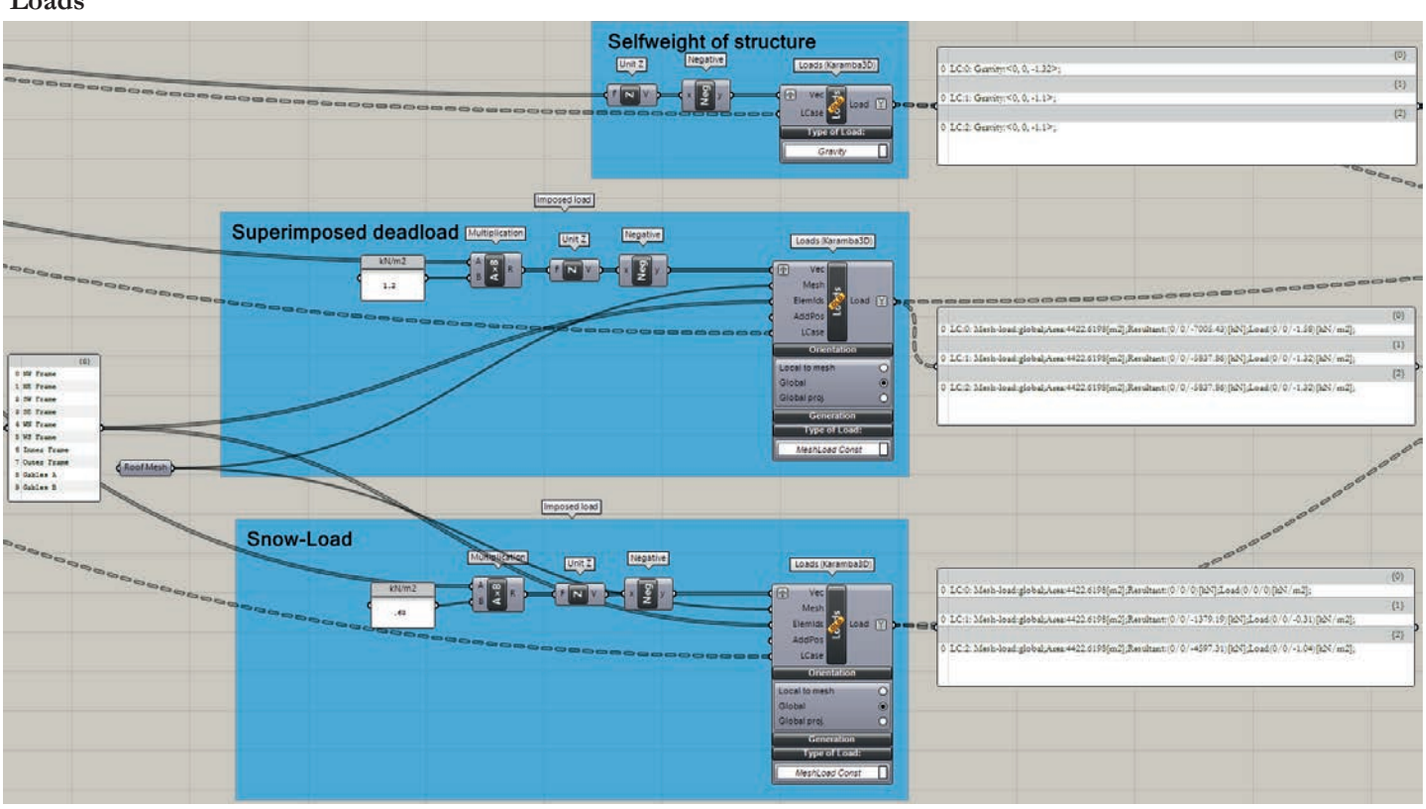
0 Permanent loads

1 Permanent loads, leading live load, snow load

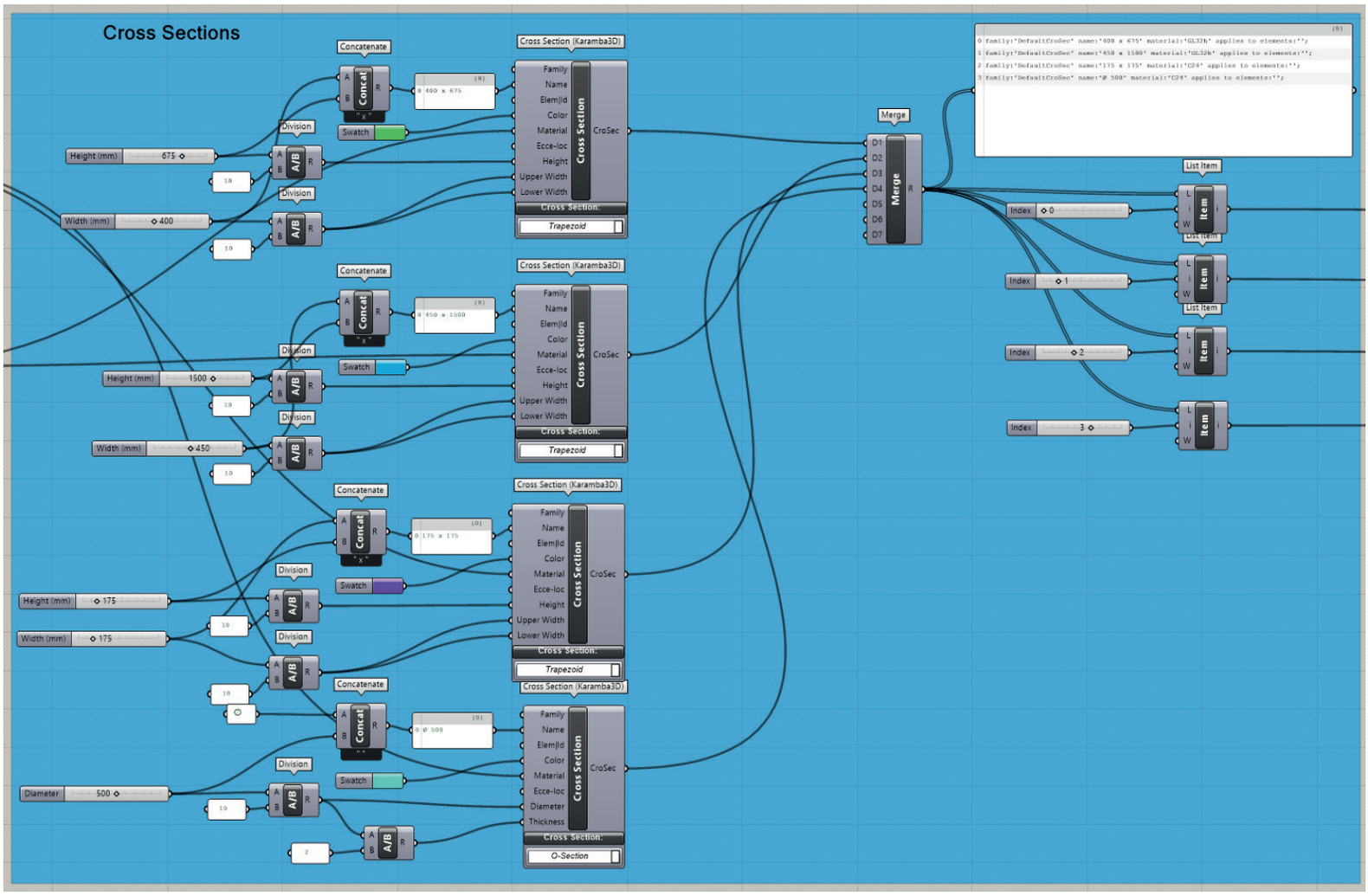
2 Permanent loads, live load, leading snow lad



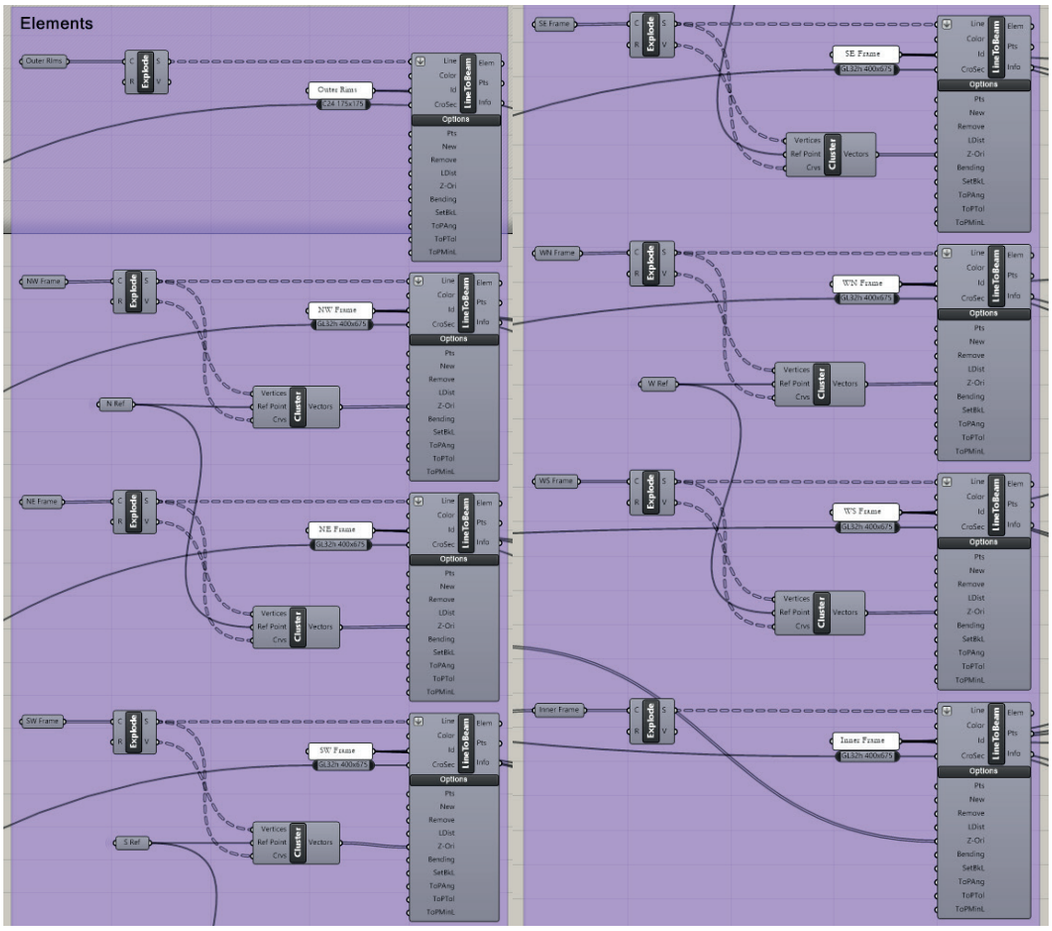
Loads

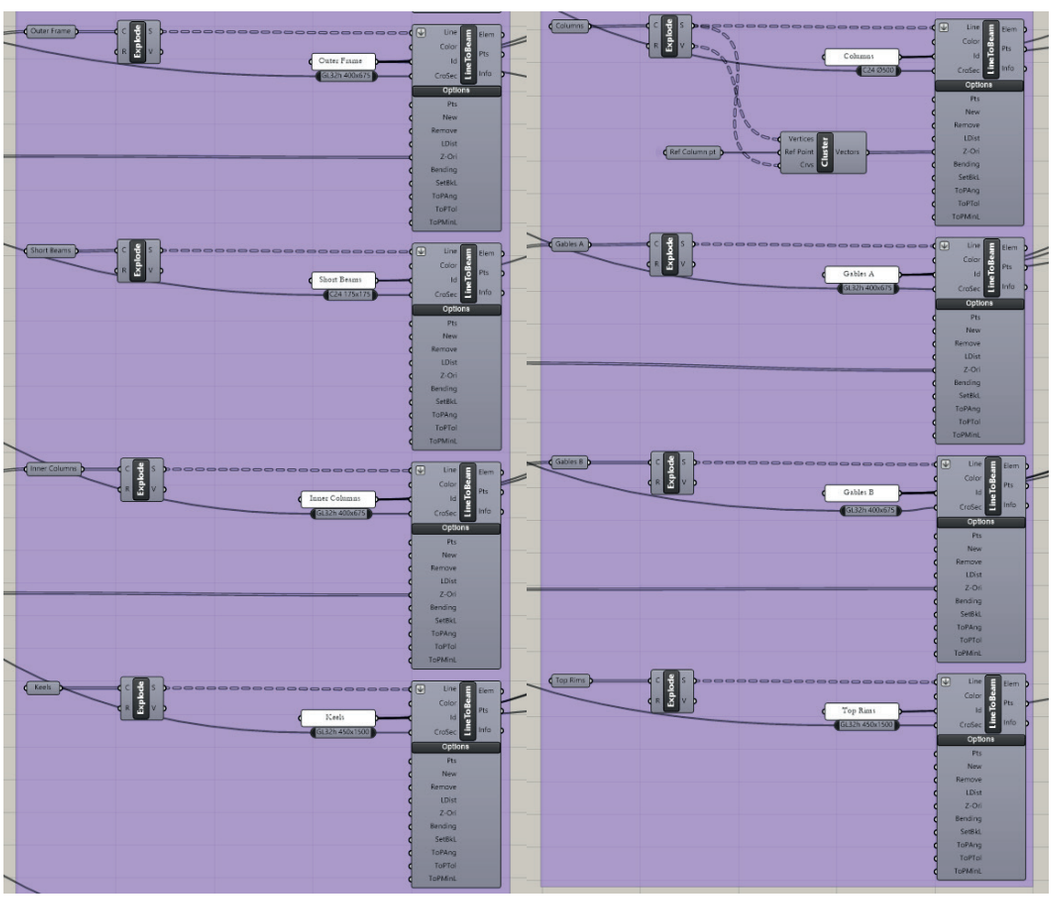


Material cross sections

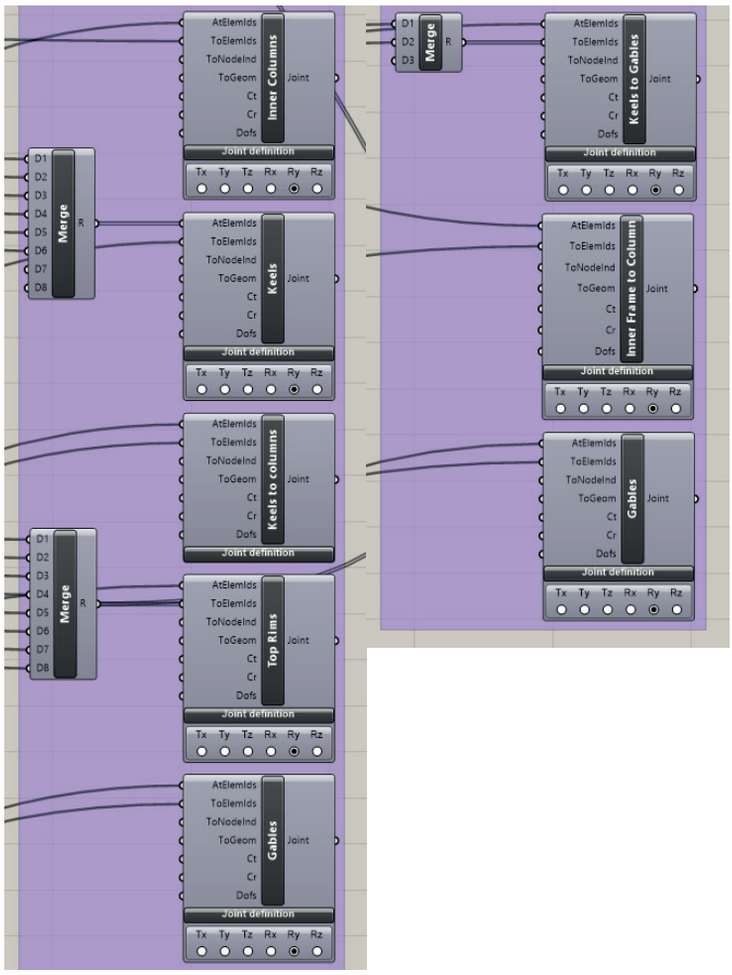


Conversion to elements

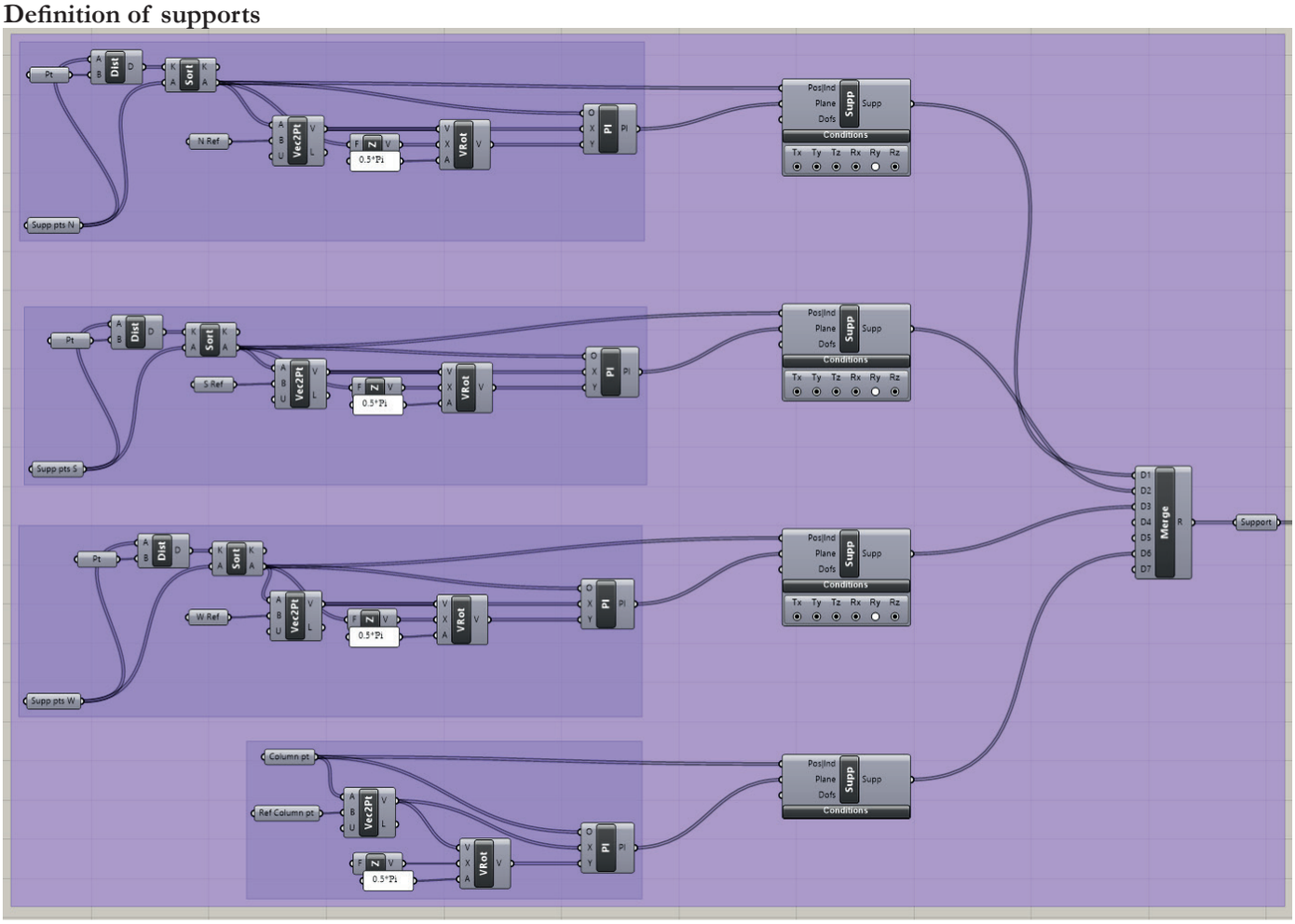




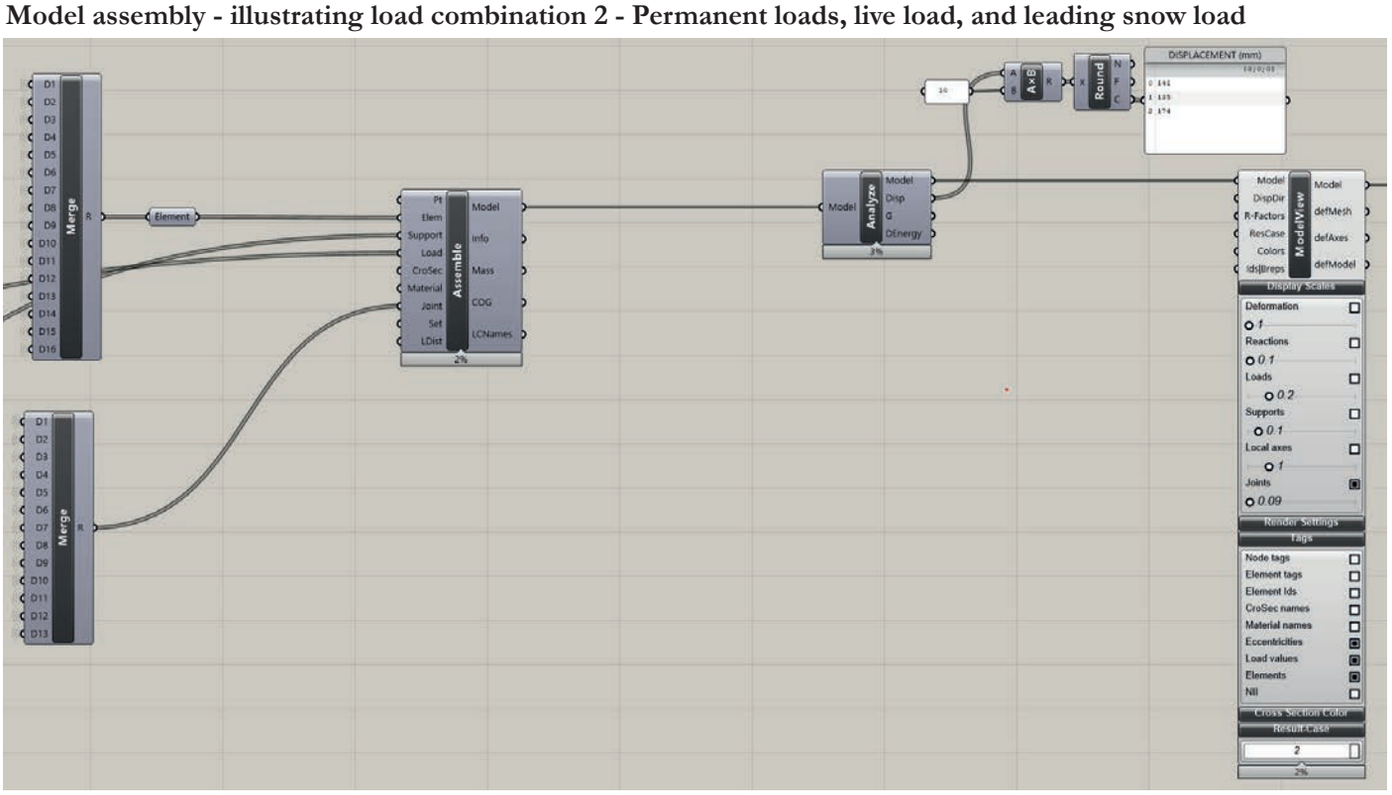
Definition of joints



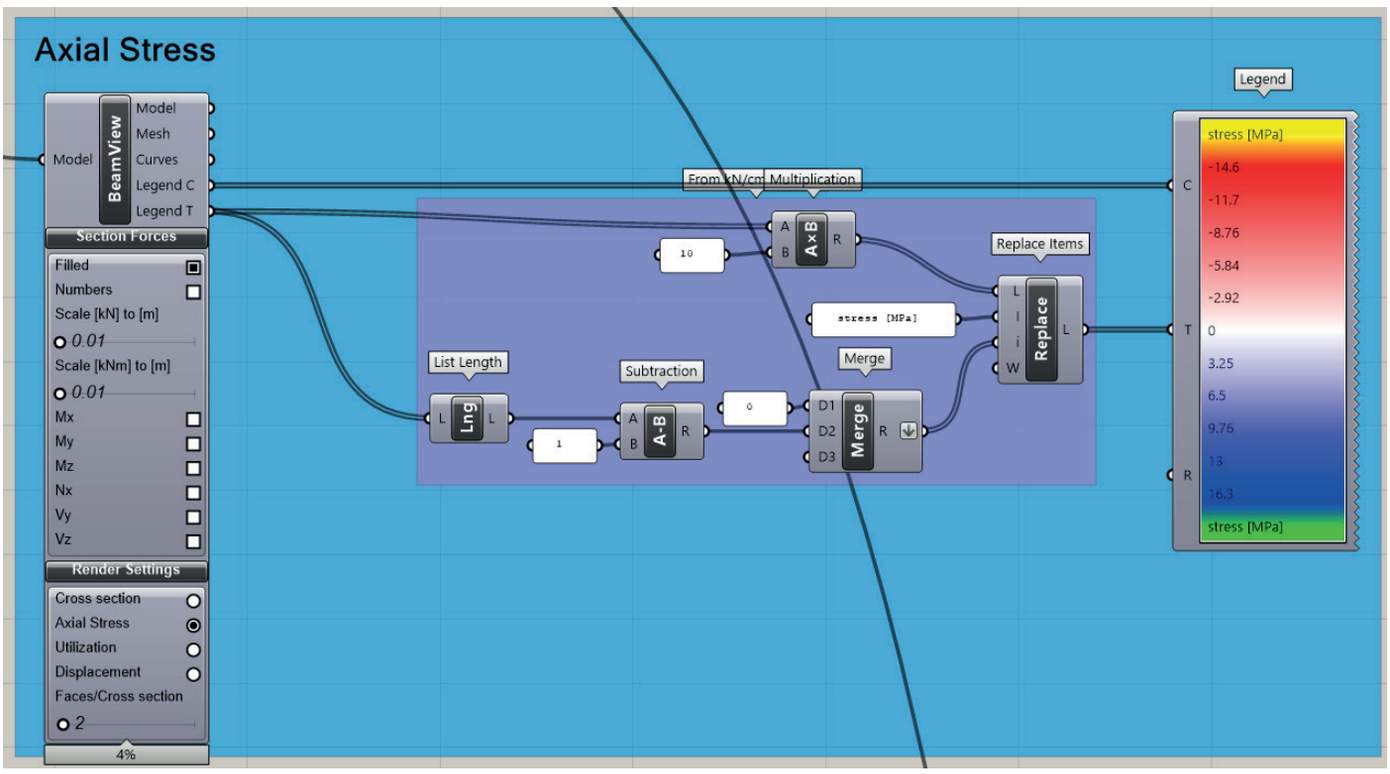
Definition of supports



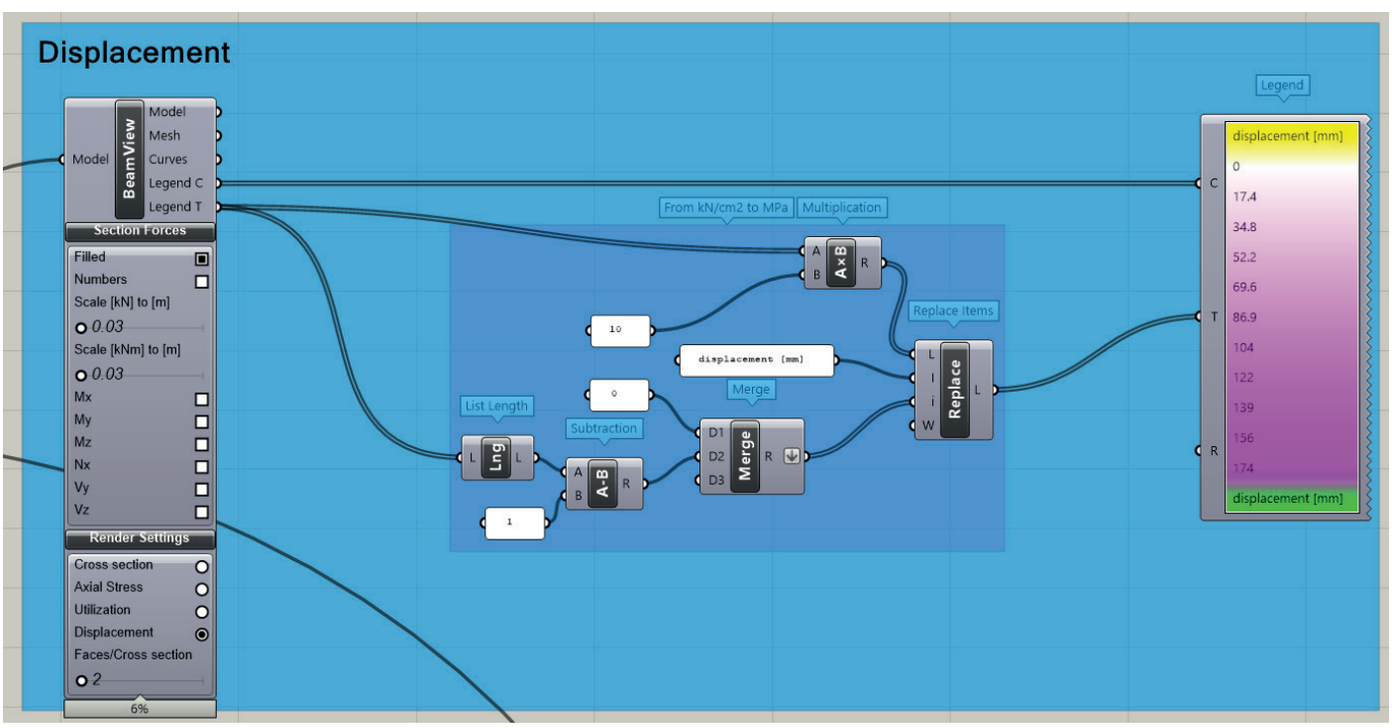
Model assembly - illustrating load combination 2 - Permanent loads, live load, and leading snow load



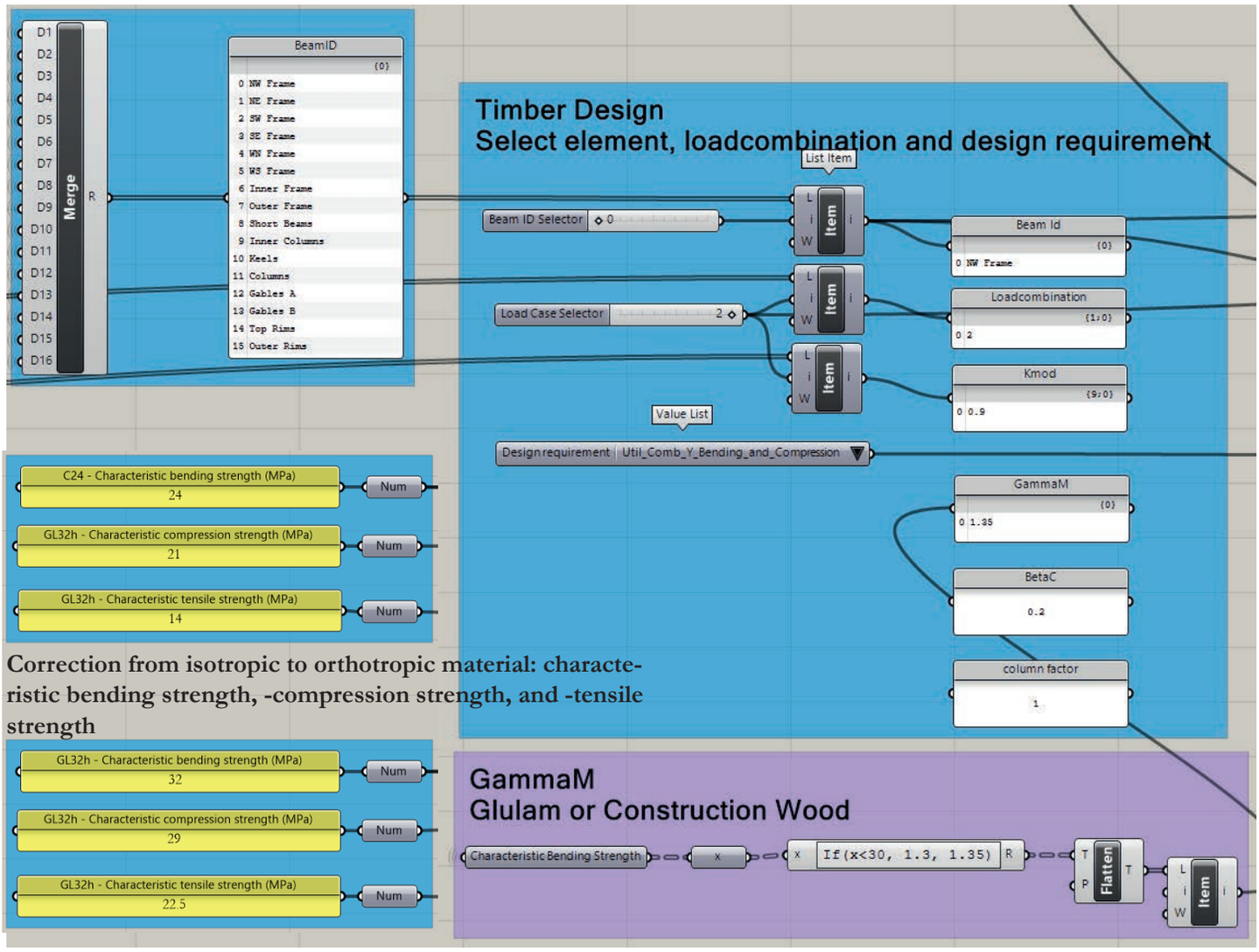
Axial stresses - load combination 2



Displacement - load combination 2

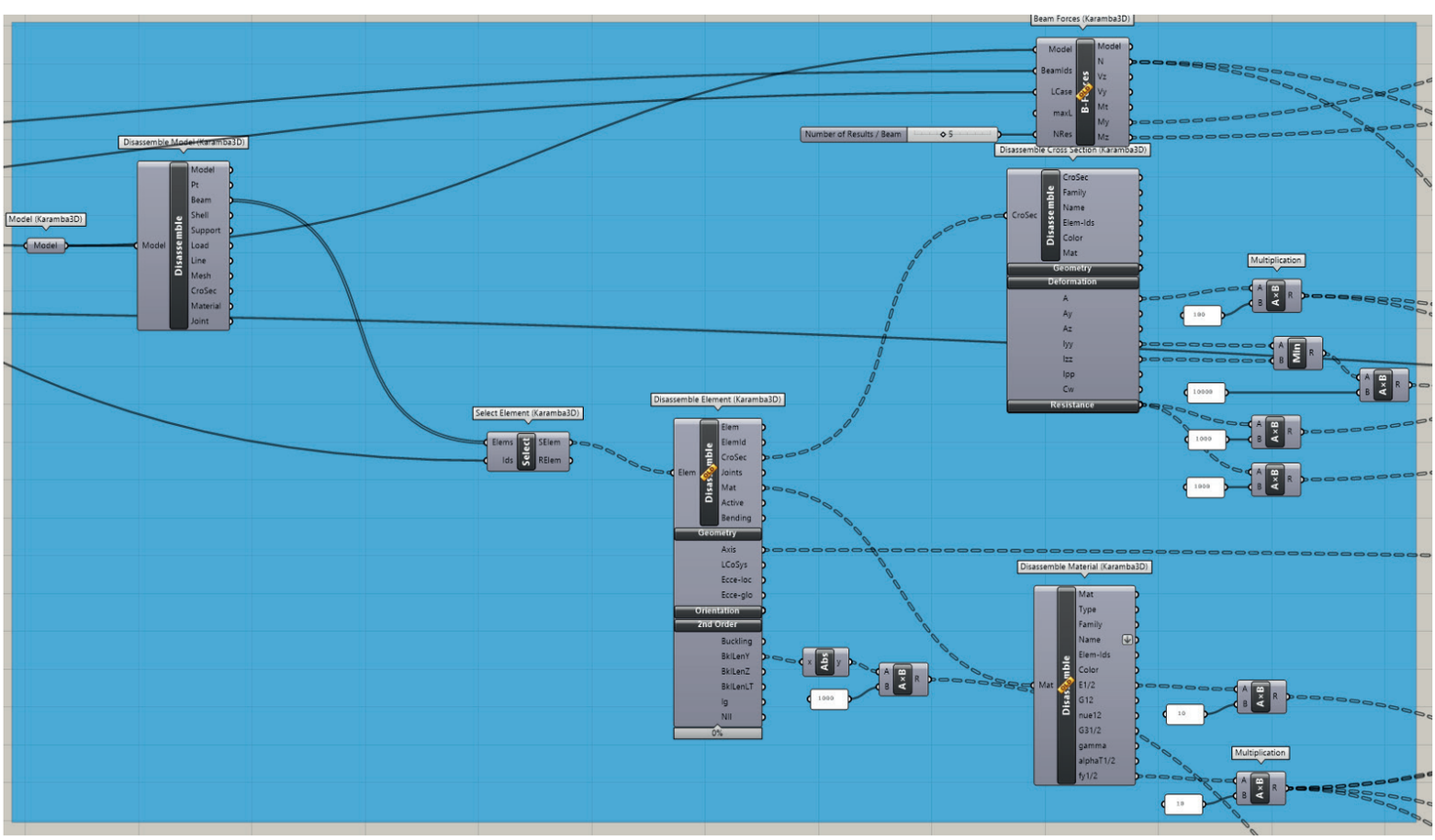


Selection of elements for inspection of utilisation

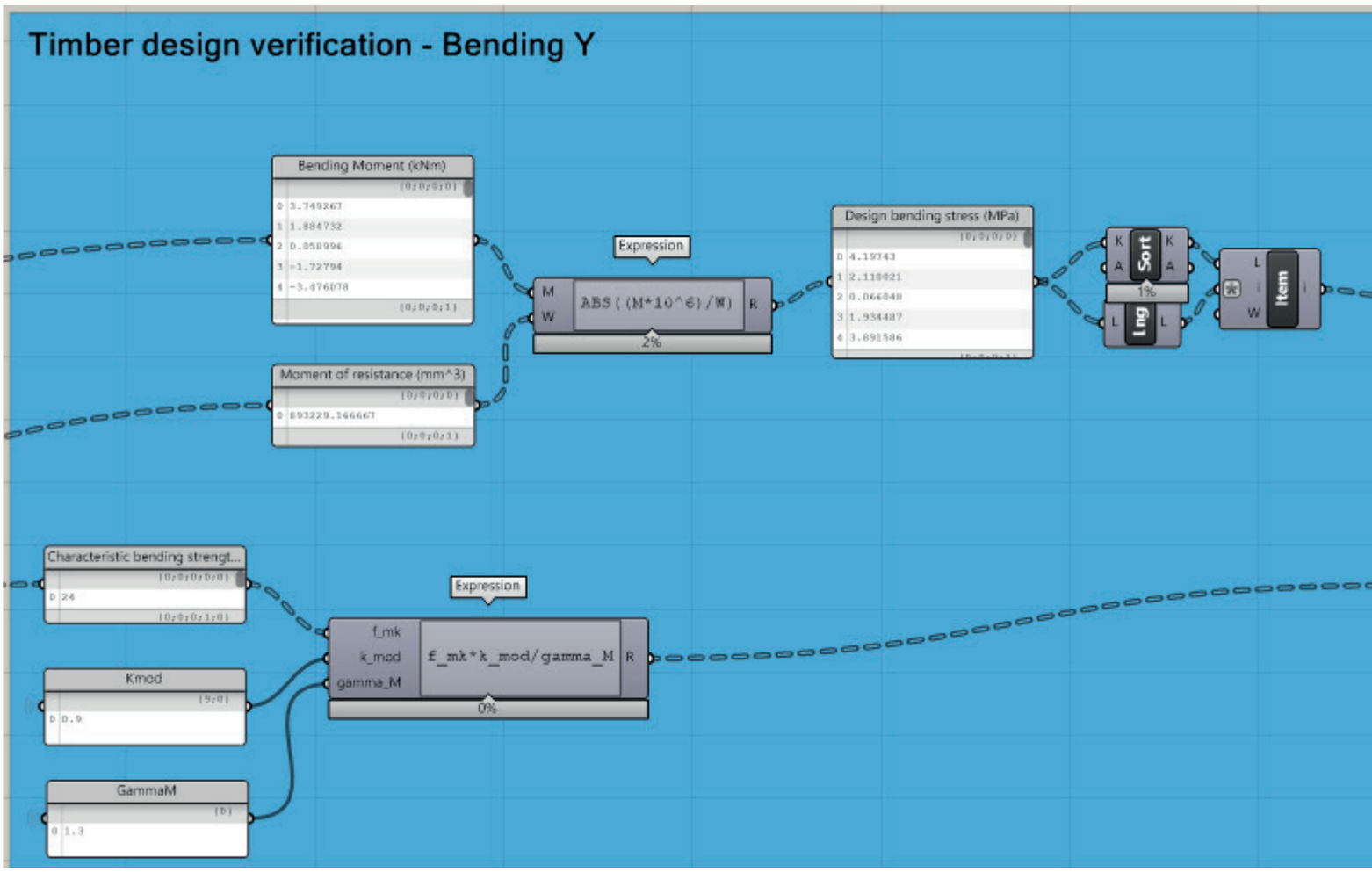


Correction from isotropic to orthotropic material: characteristic bending strength, -compression strength, and -tensile strength

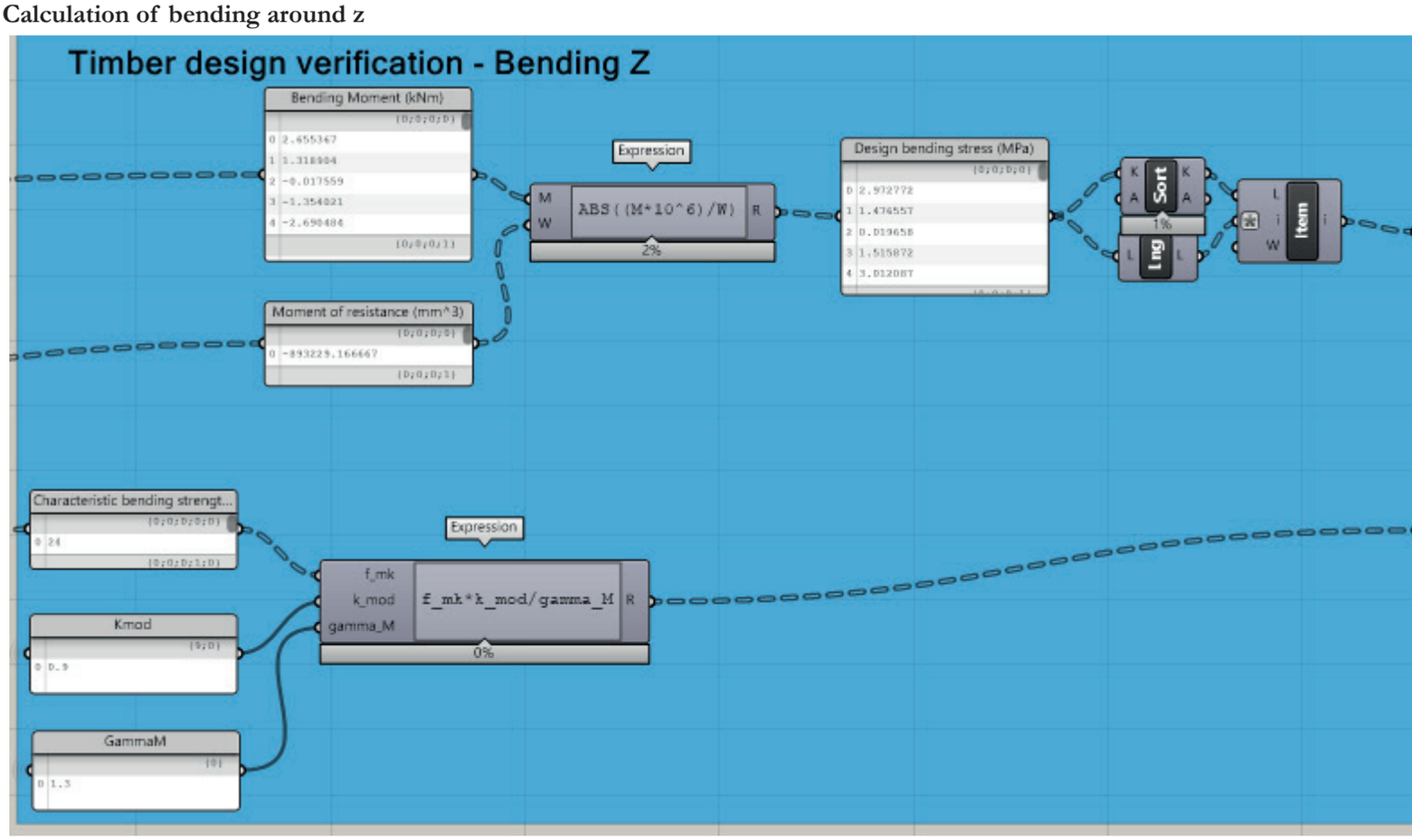
Model disassembly and conversion of units

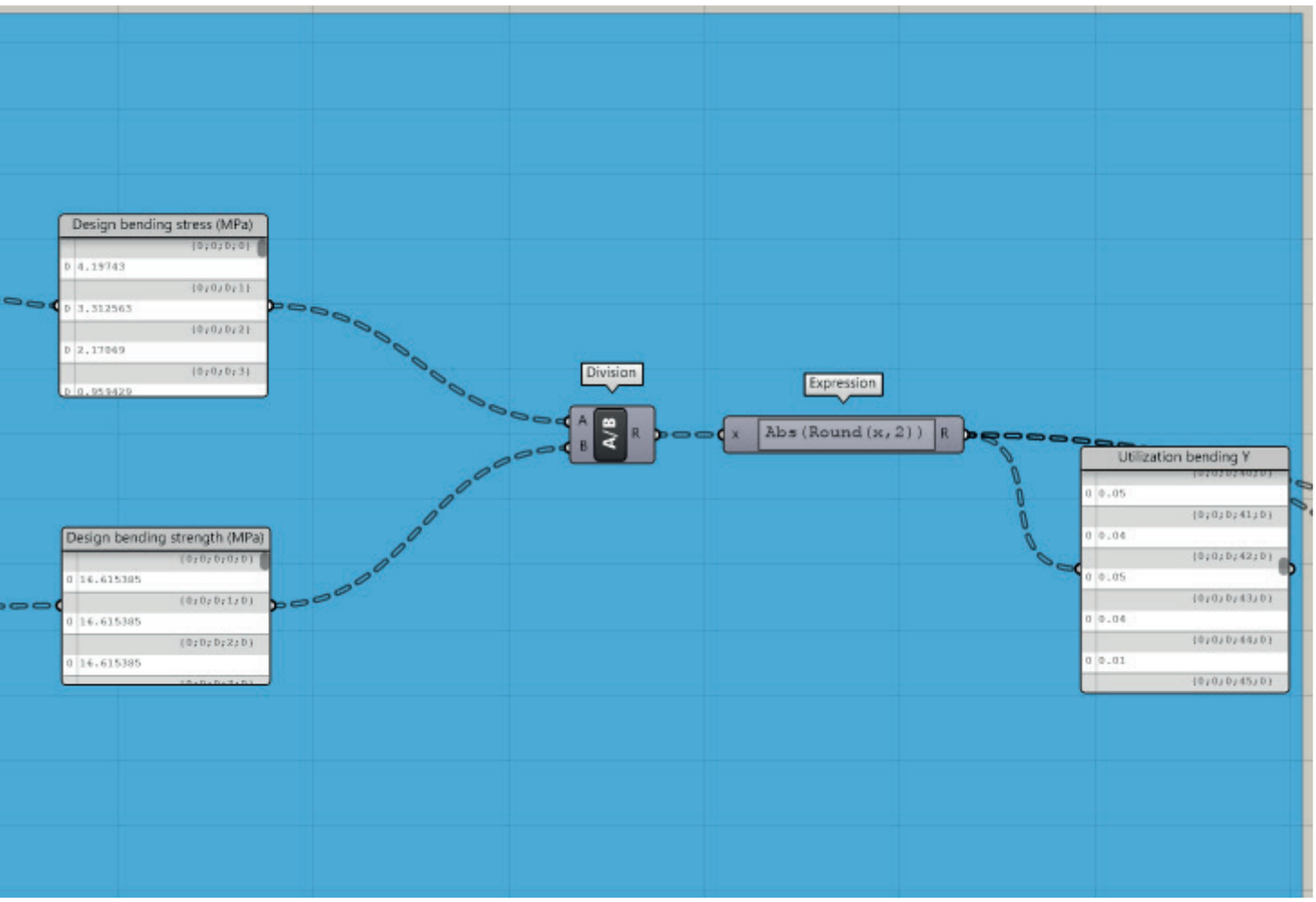


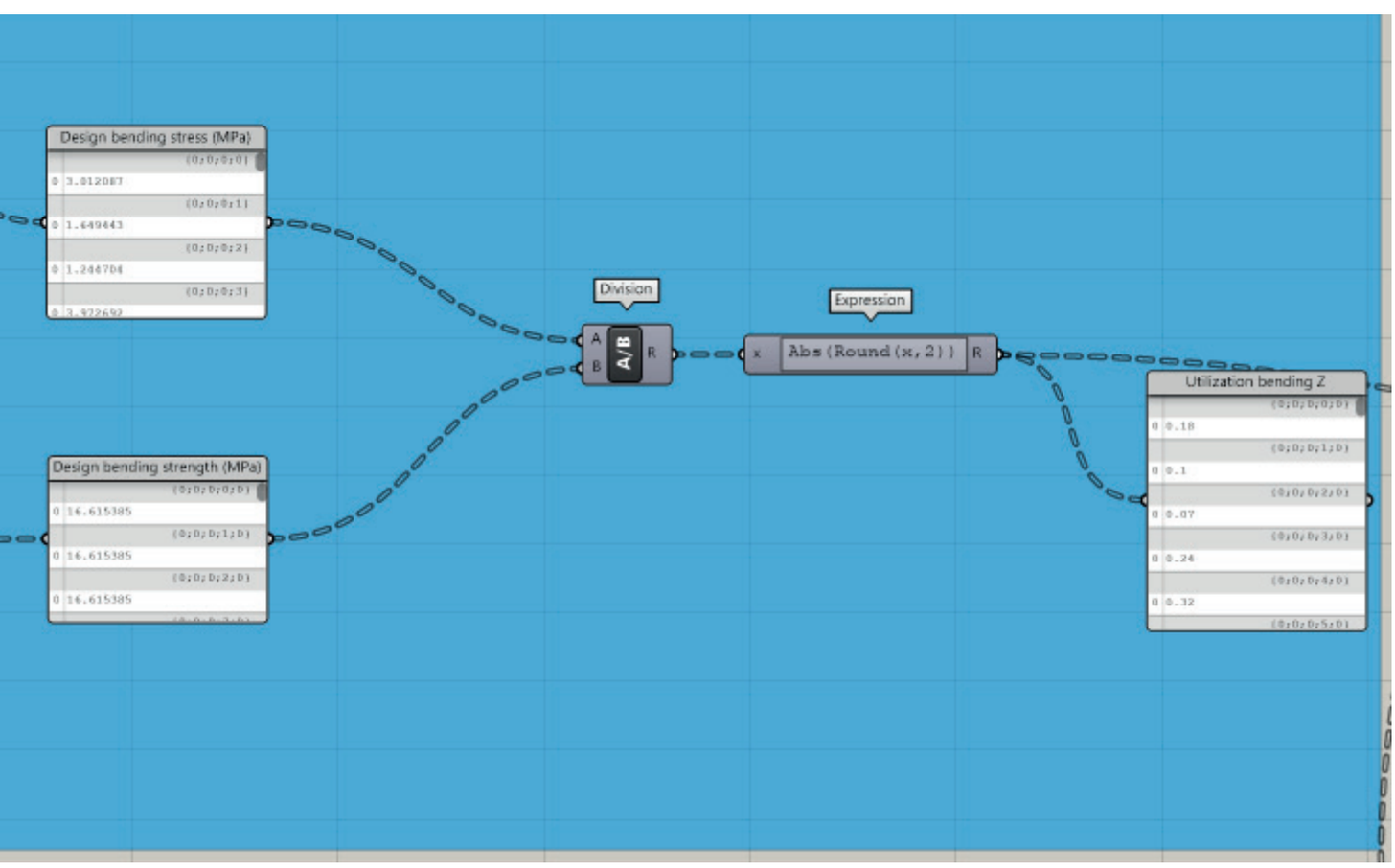
Calculation of bending around y

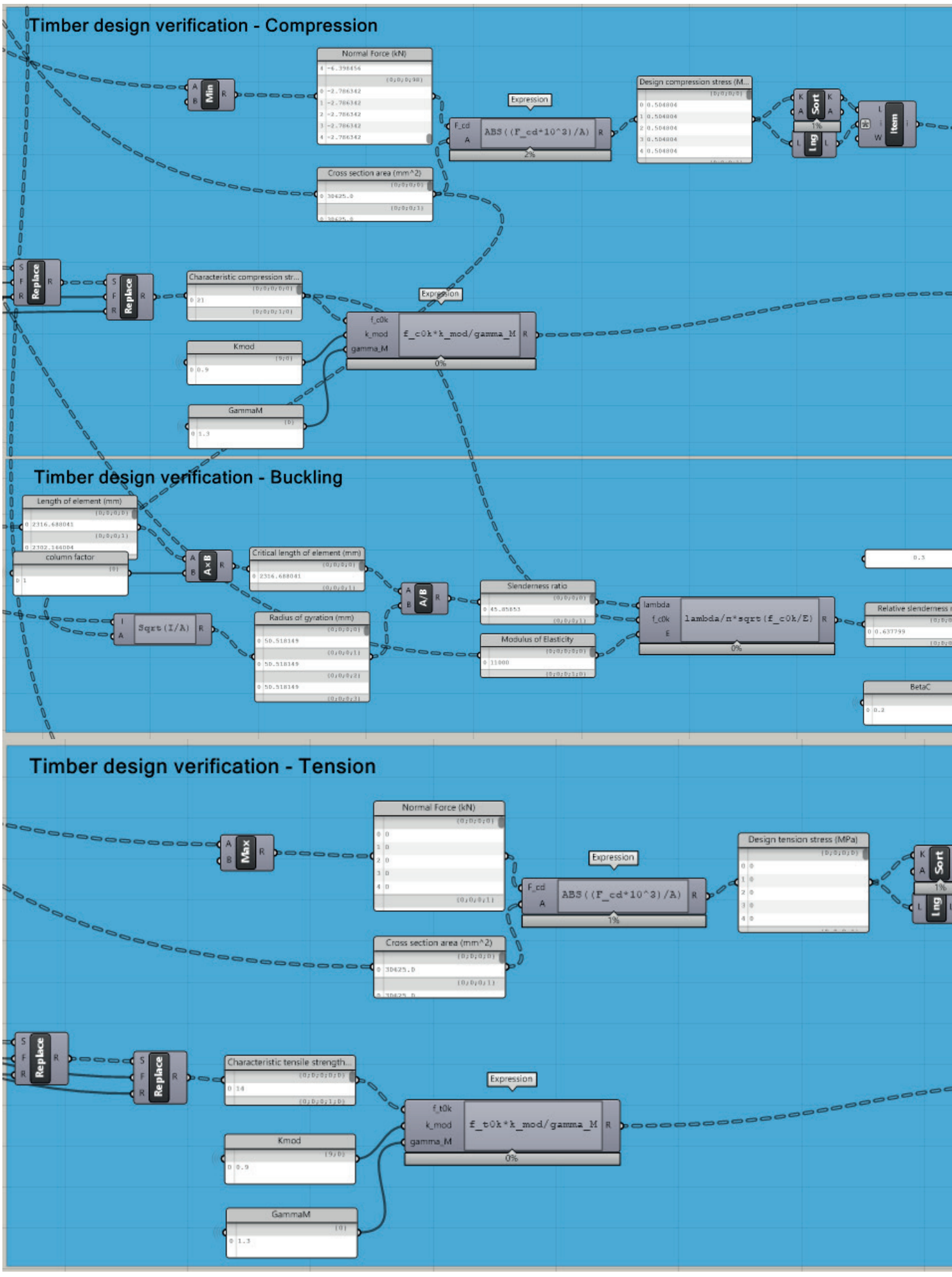


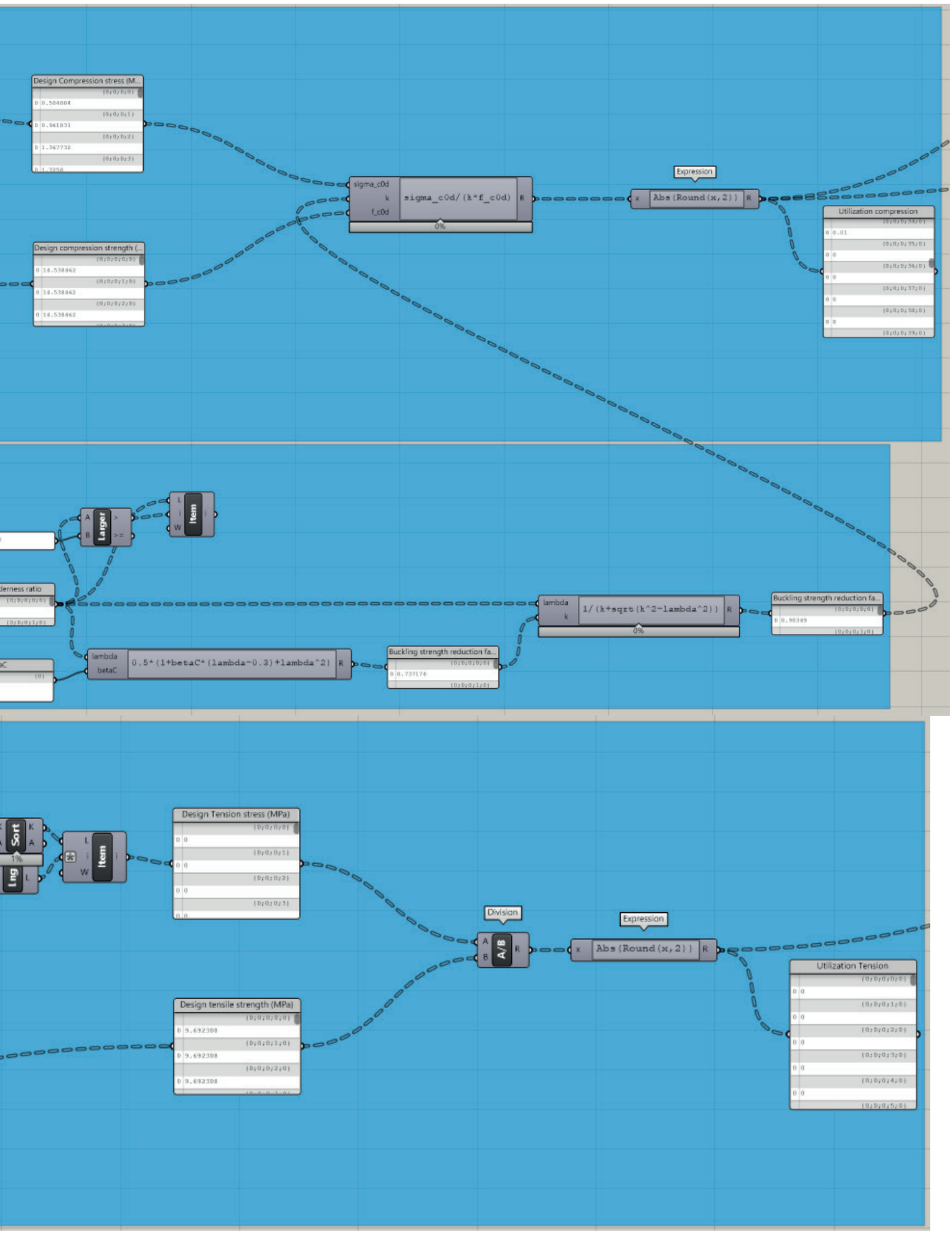
Calculation of bending around z




Design bending stress (MPa)
{0;0;0;0}
0 4.19743
{0;0;0;1}
0 3.312563
{0;0;0;2}
0 2.17049
{0;0;0;3}
0 0.959429
Division
A
B
A/B
R
Expression
x
Abs(Round(x,2))
R
Utilization bending Y
0 0.05
{0;0;0;41;0}
0 0.04
{0;0;0;42;0}
0 0.05
{0;0;0;43;0}
0 0.04
{0;0;0;44;0}
0 0.01
{0;0;0;45;0}
Design bending strength (MPa)
{0;0;0;0;0}
0 16.615385
{0;0;0;1;0}
0 16.615385
{0;0;0;2;0}
0 16.615385

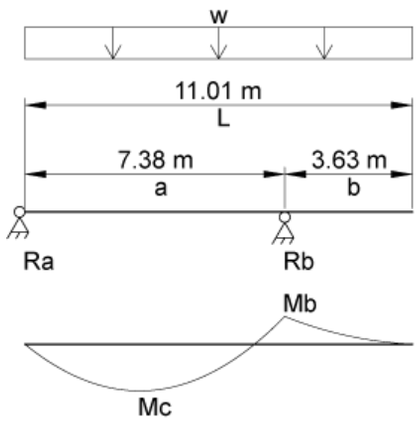

Design bending stress (MPa)
{0;0;0;0}
0 3.012087
{0;0;0;1}
0 1.649443
{0;0;0;2}
0 1.244704
{0;0;0;3}
0 3.922692
Division
A
B
A/B
R
Expression
x
Abs(Round(x,2))
R
Utilization bending Z
{0;0;0;0;0}
0 0.18
{0;0;0;1;0}
0 0.1
{0;0;0;2;0}
0 0.07
{0;0;0;3;0}
0 0.24
{0;0;0;4;0}
0 0.32
{0;0;0;5;0}
Design bending strength (MPa)
{0;0;0;0;0}
0 16.615385
{0;0;0;1;0}
0 16.615385
{0;0;0;2;0}
0 16.615385


Timber design verification - Compression
Normal Force (kN)
Min
Expression
F_cd
A
ABS((F_cd*10^3)/A)
2%
Design compression stress (M...
Sort
Lng
Item
Cross section area (mm^2)
Replace
Characteristic compression str...
f_c0k
k_mod
gamma_M
f_c0k*k_mod/gamma_M
0%
Kmod
GammaM
Timber design verification - Buckling
Length of element (mm)
column factor
A x B
Critical length of element (mm)
A/B
Slenderness ratio
lambda
lambda/n*sqrt(f_c0k/E)
Sqrt(I/A)
Radius of gyration (mm)
Modulus of Elasticity
Relative slenderness
BetaC
Timber design verification - Tension
Max
Normal Force (kN)
Expression
F_cd
A
ABS((F_cd*10^3)/A)
1%
Design tension stress (MPa)
Sort
Lng
Cross section area (mm^2)
Replace
Characteristic tensile strength...
f_t0k
k_mod
gamma_M
f_t0k*k_mod/gamma_M
0%
Kmod
GammaM


Design Compression stress (M...
0.584804
0.961831
1.367732
Design compression strength (...
14.538462
14.538462
14.538462
sigma_c0d
k
f_c0d
sigma_c0d/(k*f_c0d)
0%
Expression
x
Abs(Round(x,2))
Utilization compression
0.01
Larger
Item
lambda
k
1/(k+sqrt(k^2-lambda^2))
0%
Buckling strength reduction fa...
0.90349
lambda
betaC
0.5*(1+betaC*(lambda-0.3)+lambda^2)
Buckling strength reduction fa...
0.733174
Sort
1%
Design Tension stress (MPa)
Division
A/B
Expression
Abs(Round(x,2))
Utilization Tension
Design tensile strength (MPa)
9.692308
9.692308
9.692308

APPENDIX 6
CONSTRUCTION CALCULATIONS

Hand calculations of statics based on a beam in the roof construction.



Loads:

Self-weight of beam:

$$g = \frac{h * b * \rho * a}{1000}$$

$b = 400\ mm.$

$h = 675\ mm.$

ρ is the density of Glulam 32h, 510 kg/m³ (Table 7.1, Teknisk Ståbi, p. 304).

A is the gravitational acceleration in Denmark, 9,82 m/s².

$$g = 675mm * 400mm * 510\frac{kg}{m^3} * 9{,}82\frac{m}{s^2} = 1{,}4\frac{kN}{m}$$

Superimposed dead load – estimated from the UBAKUS (appendix 7: Wall detail)

$$g_{sdl} = 1{,}2\frac{kN}{m^2}$$

Live load – in case of maintenance on roof construction

$$q_l = 1{,}0\frac{kN}{m^2}$$

Snow load

$$q_s = \mu_i C_e C_t s_k$$

$$\mu_i = 0{,}8 * \frac{60 - \alpha}{30°} = \frac{60° - 40°}{30°} = 0{,}53$$

Ce is a factor of exposure, which is set to 1,0 in this case due to the relatively flat and unbuilt surroundings (table 5.1, Eurocode 1, FU:2010, p. 51).

$$C_e = 1{,}0$$

Ct is a thermal factor for reduction of snow loads on roofs with high thermal transmission, which is not the case in this design. (5.2 (8), Eurocode 1, FU:2010, p. 51).

$$C_t = 1{,}0$$

$$s_k = 1{,}2\frac{kN}{m^2}$$

Snow load at 0 m AMSL (Fig. C.3, Eurocode 1 1-3, p. 42)

$$q_s = 0{,}53 * 1{,}0 * 1{,}0 * 1{,}2 \frac{kN}{m^2} = 0{,}64 \frac{kN}{m^2}$$

Load combinations

CC-distance is 3 m

Superimposed dead load

$$G_{sdl} = 1{,}2 \frac{kN}{m^2} * 3\ m = 3{,}6 \frac{kN}{m}$$

Live load

$$Q_l = 1{,}0 \frac{kN}{m^2} * 3\ m = 3{,}0 \frac{kN}{m}$$

Snow load

$$Q_s = 0{,}64 \frac{kN}{m^2} * 3\ m = 1{,}9 \frac{kN}{m}$$

Ultimate Limit State (ULS) load combination formula (6.10, Eurocode 0 FU:2010, p. 35):

$$\sum \gamma_{G,j} G_{k,j} + \gamma_{Q,1} Q_{k,1} + \sum \gamma_{Q,i} \psi_{q,i} Q_{k,i}$$

Consequence class 3 – due to the high social consequence for damage to the Skuldelev ships (table B.1 NA, Eurocode 0 FU:2010, p. 38) (table A.1.2(A), Eurocode 0 FU:2010, p. 40).

$$K_{FI} = 1{,}1$$

Load combination factors, ψ_0, (table A.1.1 (NA), Eurocode 0 FU:2010, p. 38):

0,3 for snow in combination with live load.

0 for live load on roof in combination with snow load.

Partial factors, γ_M, (table A.1.2(B), Eurocode 0 FU 2010, p41)

1,2 for permanent loads exclusively.

1,0 for permanent loads in combination with variable loads.

1,5 for leading variable load.

1,5 for accompanying variable loads.

Load combination 1 – Self loads.

$$\sum \gamma_{G,supp} * K_{FI} * G + \gamma_{G,supp} * K_{FI} * G_{sdl}$$

$$\sum 1{,}2 * 1{,}1 * 1{,}4 \frac{kN}{m} + 1{,}2 * 1{,}1 * 3{,}6 \frac{kN}{m} = 6{,}5 \frac{kN}{m}$$

Load combination 2 – Self loads, dominating live load, and snow load.

$$\sum \gamma_{G,supp} * K_{FI} * G + \gamma_{G,supp} * K_{FI} * G_{sdl} + \gamma_{Q,1} * K_{FI} * Q_l + \sum \gamma_{Q,i} * K_{FI} * \psi_{0,i} * Q_s$$

$$\sum 1{,}0 * 1{,}1 * 1{,}4 \frac{kN}{m} + 1{,}0 * 1{,}1 * 3{,}6 \frac{kN}{m} + 1{,}5 * 1{,}1 * 1 \frac{kN}{m} + \sum 1{,}5 * 1{,}1 * 0{,}3 * 1{,}9 \frac{kN}{m} = 8{,}1 \frac{kN}{m}$$

Load combination 3 – Self loads, live load, and dominating snow load.

$$\sum \gamma_{G,supp} * K_{FI} * G + \gamma_{G,supp} * K_{FI} * G_{sdl} + \gamma_{Q,1} * K_{FI} * Q_s + \sum \gamma_{Q,i} * K_{FI} * \psi_{0,i} * Q_l$$

$$\sum 1{,}0 * 1{,}1 * 1{,}4\frac{kN}{m} + 1{,}0 * 1{,}1 * 3{,}6\frac{kN}{m} + 1{,}5 * 1{,}1 * 1{,}9\frac{kN}{m} + \sum 1{,}5 * 1{,}1 * 0 * 1{,}0\frac{kN}{m} = 8{,}6\frac{kN}{m}$$

The largest load combination is number 3 – Self loads, live load, and dominating snow load. This will be used for further ULS calculations.

Serviceability Limit State load combination formula (6.16(b), Eurocode 0 FU:2010, p. 37):

$$\sum G_{k,j} + Q_{k,1} + \sum \psi_{0,i} Q_{k,i}$$

Load combination 1 – Self loads.

$$\sum G + G_{sdl}$$

$$\sum 1{,}4\frac{kN}{m} + 1{,}2\frac{kN}{m} = 2{,}6\frac{kN}{m}$$

Load combination 2 - Self loads, dominating live load, and snow load.

$$\sum G + G_{sdl} + Q_l + \sum \psi_0 \, Q_s$$

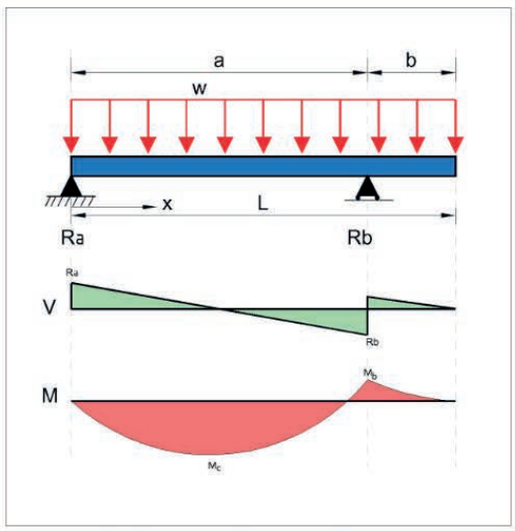
$$\sum 1{,}4\frac{kN}{m} + 1{,}2\frac{kN}{m} + 1{,}0\frac{kN}{m} + \sum 0{,}30 * 1{,}9\frac{kN}{m} = 4{,}2\frac{kN}{m}$$

Load combination 3 - Self loads, live load, and dominating snow load.

$$\sum G + G_{sdl} + Q_s + \sum \psi_0 * Q_l$$

$$\sum 1{,}4\frac{kN}{m} + 1{,}2\frac{kN}{m} + 1{,}9\frac{kN}{m} + \sum 0 * 1{,}0\frac{kN}{m} = 4{,}5\frac{kN}{m}$$

Dimensioning of beam, ULS:

Simple Supported Beams under a UDL with cantilever – (2 pin connections with a central pin)	 Simply Supported Beam - Cantilever UDL	**Moment:** $M_B = \frac{wb^2}{2}$ $M_C = \frac{w(a+b)^2(a+b)^2}{8a^2}$ maximum x = $\frac{a}{b}(1 - \frac{b^2}{a^2}$ **Beam Deflection Equation:** $\delta_c = \frac{wL}{24EI}(x^4 - 2ax^3 + \frac{2b^2}{a}x^3 + a^3x - 2ab^2x)$ $\delta_{freetip} = \frac{wb}{24EI}(3b^3 + 4ab^2 - a^3)$ **Shear Force and Reaction:** $R_A = \frac{wL}{2a}(a^2 - b^2)$ $R_B = \frac{wL}{2a}(a^2 + b^2)$

(civilsguide, 2021)

Moment around y at B:

$$M_B = \frac{wb^2}{2}$$

$$M_{y,b} = \frac{8{,}6\frac{kN}{m} * 3{,}63\ m^2}{2} = 57\ kNm$$

Moment around y at C:

$$M_{y,c} = \frac{w(a+b)^2(a+b)^2}{8a^2}$$

$$M_{y,c}\frac{8{,}6\frac{kN}{m} * (7{,}38\ m + 3{,}63\ m)^2(7{,}38\ m + 3{,}63\ m)^2}{8 * 7{,}38m^2} = 290\ kNm$$

The maximum moment occurs at C.

Due to the stability obtained through connection in the construction, it is assumed, that bending only occurs in one direction, y (6.1.6 (2), Eurocode 5 FU:2012, p. 39)

$$f_{m,d} = \frac{f_{m,k} * k_{mod}}{\gamma_M}$$

Characteristic bending strength (table 7.1, Teknisk Ståbi, p. 304):

$$f_{m,k} = 32\ MPa$$

k_{mod} (table 3.1, Eurocode 5 FU:2012, p. 28):

Service class 1 – indoor heated area.

Snow load and live load are both short term loads.

$$k_{mod,short\ term} = 0{,}9$$

$$k_{mod,perm} = 0{,}6$$

γ_M partial coefficient for timber type – in this case, glulam (table 2.3, Eurocode 5 FU:2012, p. 24):

$$\gamma_M = 1{,}3$$

Design bending strength (6.1.6, Eurocode 5 FU:2012, p.39)

$$f_{m,d} = \frac{32\ MPa * 0{,}9}{1{,}3} = 22{,}2\ MPa$$

$$\sigma_{m,d} = \frac{M_{y,c}}{W_y}$$

Moment of resistance:

$$W_y = \frac{1}{6} * 400\ mm * 675\ mm = 30{,}4 * 10^6\ mm^3$$

Design bending stress:

$$\sigma_{m,y,d} = \frac{290kNm}{30{,}4 * 10^6 mm^3} = 9{,}55\ MPa$$

$$\frac{\sigma_{m,y,d}}{f_{m,d}} = 0{,}43 \leq 1$$

The beam holds a utilization factor of **43%.**

Deformation of beam SLS:

Formula for deformation (2.2, Eurocode 5 FU:2012, p. 19):

$$u_{fin} = u_{fin,G} + u_{fin,Q_1} + \sum U_{fin,Q_i}$$

$$u_{fin,G} = u_{inst,G}(1 + k_{def})$$

$$u_{fin,Q_1} = u_{inst,Q_1}(1 + \psi_{2,1} + k_{def})$$

$$u_{fin,Q_i} = u_{inst,Q_i}(\psi_{0,i} + \psi_{2,i} + k_{def})$$

Safety coefficient for wood materials, k_{def}, (table 3.2, Eurocode 5 FU:2012, p. 30):

Service class 1, heated indoor situation.

$$k_{def} = 0{,}60$$

Load combination factor ,ψ_2:

0 for both live- and snow loads.

Instantaneous deformation at midpoint between support A and B: (civilguides, 2021)

$$u_{inst,C} = \frac{wL}{24EI}\left(x^4 - 2ax^3 + \frac{2b^2}{a}x^3 + a^3x - 2ab^2x\right)$$

Instantaneous deformation at endpoint at freetip on cantilever: (civilguides, 2021)

$$u_{inst,freetip} = \frac{wb}{24EI}(3b^3 + 4ab^2 - a^3)$$

Maximum deformation between support point A and B: (civilguides, 2021)

$$x_{max} = \frac{a}{b}\left(1 - \frac{b^2}{a^2}\right)$$

$$x_{max} = \frac{400\ mm}{675\ mm} * \left(1 - \frac{675\ mm^2}{400\ mm^2}\right) = 1540\ mm$$

Modulus of elasticity, E_0, (table 7.1, Teknisk Ståbi, p. 304).

$$E_0 = 1{,}37 * 10^6\ MPa$$

Moment of inertia around y in a rectangular cross-section, I_y:

$$I_y = \frac{1}{12} bh^3$$

$$I_y = \frac{1}{12} * 400\ mm * 675\ mm = 10{,}3 * 10^9 mm^4$$

Load combination 1 – Self loads

$$u_{inst,G,C} = \frac{6{,}5\frac{kN}{m} * 7{,}38\ m}{24 * 1{,}37 * 10^6 MPa * 10{,}3 * 10^9 mm^4}(1540\ mm^4 - 2 * (400\ mm)^3 + \frac{2 * (675\ mm)^2}{400\ mm} * (1540\ mm)^3 + (400\ mm)^3 * 1540\ mm - \ 2 * 400\ mm * (675\ mm)^2 * 1540\ mm = 2{,}72\ mm$$

$$u_{inst,G,freetip} = \frac{6{,}5\frac{kN}{m} * 675mm}{24 * 1{,}37 * 10^6 MPa * 10{,}3 * 10^9\ mm^4}(3 * (675\ mm)^3 + 4 * 400\ mm * (675\ mm)^2 - (400\ mm)^3) = 1{,}49\ mm$$

$$u_{fin,G,C} = 2{,}72\ mm * (1 + 0{,}6) = 4{,}3\ mm$$

$$u_{fin,G,freetip} = 1{,}49\ mm * (1 + 0{,}6) = 2{,}4\ mm$$

Load combination 2 – Self loads, dominating live loads, and snow loads.

$$u_{inst,Q_l,C} = \frac{8{,}1\frac{kN}{m} * 7{,}38\ m}{24 * 1{,}37 * 10^6 MPa * 10{,}3 * 10^9 mm^4}(1540\ mm^4 - 2 * (400\ mm)^3 + \frac{2 * (675\ mm)^2}{400\ mm} * (1540\ mm)^3 + (400\ mm)^3 * 1540\ mm - \ 2 * 400\ mm * (675\ mm)^2 * 1540\ mm = 4{,}39\ mm$$

$$u_{inst,Qs,freetip} = \frac{8{,}6\frac{kN}{m} * 675mm}{24 * 1{,}37 * 10^6 MPa * 10{,}3 * 10^9\ mm^4}(3 * (675\ mm)^3 + 4 * 400\ mm * (675\ mm)^2 - (400\ mm)^3) = 2{,}41\ mm$$

$$u_{fin,Q_l,C} = 2{,}72\ mm * (1 + 0{,}6) + 4{,}39\ mm * (1 + 0{,}6) + 4{,}7\ mm * (0{,}3 * 0{,}6) = 15{,}6\ mm$$

$$u_{fin,Q_l,freetip} = 1{,}49\ mm * (1 + 0{,}6) + 2{,}41\ mm * (1 + 0{,}6) + 2{,}58\ mm * (0{,}3 * 0{,}6) = 8{,}6\ mm$$

Load combination 3 – Self loads, live loads, and dominating snow loads.

$$u_{inst,Q_1,C} = \frac{8{,}6\frac{kN}{m} * 7{,}38\ m}{24 * 1{,}37 * 10^6 MPa * 10{,}3 * 10^9 mm^4}(1540\ mm^4 - 2 * (400\ mm)^3 + \frac{2 * (675\ mm)^2}{400\ mm} * (1540\ mm)^3 + (400\ mm)^3 * 1540\ mm - \ 2 * 400\ mm * (675\ mm)^2 * 1540\ mm = 4{,}70\ mm$$

$$u_{inst,Qs,freetip} = \frac{8{,}6\frac{kN}{m} * 675mm}{24 * 1{,}37 * 10^6 MPa * 10{,}3 * 10^9\ mm^4}(3 * (675\ mm)^3 + 4 * 400\ mm * (675\ mm)^2 - (400\ mm)^3) = 2{,}58\ mm$$

$$u_{fin,Q_s,C} = 2{,}72\ mm * (1 + 0{,}6) + 4{,}7\ mm * (1 + 0{,}6) + 4{,}39\ mm * (0{,}3 * 0{,}6) = 13{,}2\ mm$$

$$u_{fin,Q_l,freetip} = 1{,}49\ mm * (1 + 0{,}6) + 2{,}58\ mm * (1 + 0{,}6) + 2{,}41\ mm * (0{,}3 * 0{,}6) = 7{,}2\ mm$$

Final deformation, u_{fin}:

$$u_{fin,C} = 4{,}3\ mm + 15{,}6\ mm + 13{,}2\ mm = 33{,}1\ mm$$

$$u_{fin,freetip} = 2{,}41\ mm + 8{,}6\ mm + 7{,}2\ mm = 18{,}21\ mm$$

Maximum allowed deformation, u_{max}, (table 7.2, Eurocode 5, p.56):

Varies between $l/125$ to $l/175$ for cantilevering beams.

$$u_{max} = \frac{11010mm}{175} = 62{,}91\ mm$$

$$u_{fin,C} = 33{,}1\ mm \leq 62{,}91\ mm$$

$$u_{fin,freetip} = 18{,}21mm \leq 62{,}91\ mm$$

APPENDIX 7
WALL DETAIL

Ubakus has been used to calculate an U-value for the wall construction and to realise a wall depth.

The wall construction reaches a depth of 489 mm not counting the visible 175 mm of the frames from the building's interior and achieves a U-value of 0,08 W/(m²K) and is therefore also sufficient to be used for the roof construction cf. the BR18 low energy frame class requirement of 0,12 W/(m²K) for walls and 0,08 W/(m²K) for roofs (Rockwool, 2023. p. 34)

Ubakus has been used to calculate an U-value for the wall construction and to realise a wall depth.

Exterior wall

Exterior wall
created on 9.5.2023

Thermal protection

U = 0,08 W/(m²K)

GEG 2020 Bestand*: U<0,24 W/(m²K)

excellent insufficient

Moisture proofing

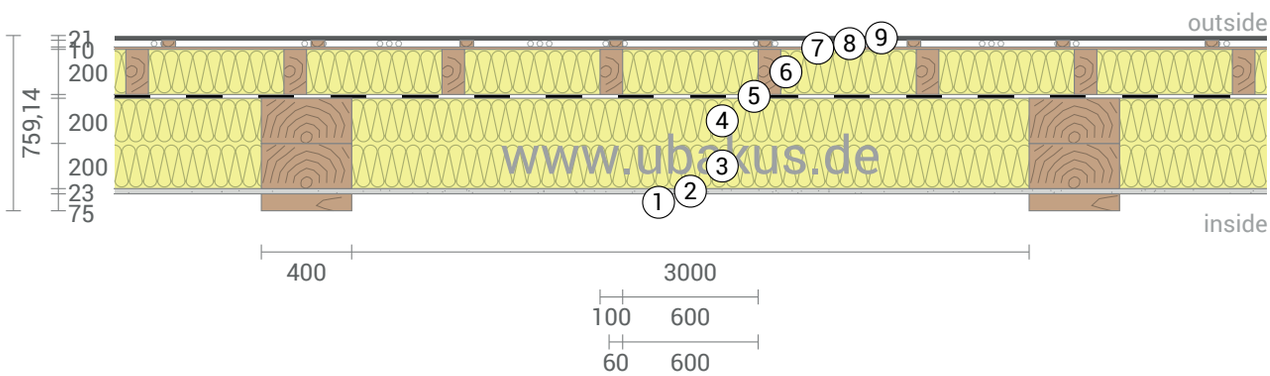
No condensate

excellent insufficient

Heat protection

Temperature amplitude damping: >100
phase shift: non relevant
Thermal capacity inside: 90 kJ/m²K

excellent insufficient



1. Spruce (75x400)
2. Lime-gypsum plaster (23 mm)
3. AGEPAN Flex (200 mm)
4. AGEPAN Flex (200 mm)
5. Knauf Insulation LDS FlexPlus
6. best wood FLEX 50 (200 mm)
7. MDF (10 mm)
8. Rear ventilated level (30 mm)
9. Tongue and groove siding (21 mm)