MORS Ø

Maritime center and Oyster Restaurant Situated on mors Ø

MAY 2021

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STUDENT REPORT

Figure 1 Aalborg University logo

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ABSTRACT

This master thesis presents the design proposal of the architectural competition 'Center for Experience and Water Sports', by Morsø Municipality. The result of the proposal is 'Mors Ø', Maritime center and Oyster Restaurant, located in Nykøbing Mors, situated in the rural area of Northern Jutland, Denmark, on the isle of Mors inside Limfjorden. This master thesis is written as a part of the master's education in Sustainable Architecture at Aalborg University, which results in an interdisciplinary approach, combining architecture and engineering into one practice of an architect-engineer. The master thesis focuses upon the implementation of value-creation in the design process with the aim to be designing purposeful architecture. Throughout the design process several investigations of the urban area, the experience of spaces, indoor climate together with the sustainable impact of the building has been conducted. All with the aim to create a purposeful piece of architecture for the society, building owner, and users of the building.

The design proposal is seen as the platform which contributes to the revitalization of Nykøbing Mors and reunites the city to the fiord and accommodates a new self-perception. Furthermore, the project aims to reverse an ongoing problem of urbanization, leaving smaller cities as Nykøbing Mors, inside the rural areas in decadence. The platform of shellfish gastronomy and water sports creates the basis for social coherence and local gastronomical experiences, attracting tourists, locals, and potential newcomers Nykøbing Mors.

READING GUIDE

This thesis consists of three parts. Firstly a program stating our architectural position together with users, interests, room program, and design criteria, second a presentation showcasing the competition proposal of 'Mors Ø', followed by the design process, initiated by a specific reading guide for that part. Throughout the program and design process subconclusions are written for each section. The thesis ends in an overall conclusion combined with a reflection.

Figure 2 Shoreline

TABLE OF CONTENT

1.0. INTRODUCTION

PROBLEM

Increasing emigration to bigger cities has left fragmented villages behind with a decreasing population, just like the major city of Mors. Today there are nine thousand inhabitants in Nykøbing, though the population consists of uneven age distribution in favor of 60+ years making the community facing financial struggles, on top of an already existing financial recession (Dingeo, n.d.;Morsø Kommune, 2020a;Vive, 2019). Nykøbing's self-perception has gone missing and the city has become disconnected from its former identity due to the vanished industries associated with the fiord.

OPPORTUNITIES

This thesis deals with two pivotal opportunities of reidentification and reconnection to the fiord.

Gastronomy

The European Oysters have a pivotal role for Nykøbing Mors and their self-perception. A high concentration of the European Oyster is to be found in the western part of the danish Limfjord and every year Denmark export 15 million European Oysters, which is an attractive gastronomic resource in foreign countries (Bjerregaard, 2013). Hence, Nykøbing has a brilliant opportunity to develope fiord-related delicacies, in collaboration with the Danish Shellfish Center, and to rebrand itself as the oyster capital of Denmark. The oyster can be the tourism- and export-generating resource, uniting people and strengthen their identity.

Water sports

Denmark is a proud sea sports nation and the Limfjord has a brilliant condition for water sports. Especially the coastal part of north-western Denmark has persuaded to rebrand themselves as an attractive place to practice water sports. Coastal cities like Thisted, Krik, and Klitmøller have experienced a societal transformation due to the Cold Hawaii project (Mandrup et al., n.d.). Mors has the opportunity to accommodate this transformation, through its relation to Limfjorden.

PLATFORM

This project contributes to the revitalization of Nykøbing Mors, allowing people to reunite with the fiord and accommodate a new self-perception. The project will contribute to the transition from being a shellfish fishing city, to a shellfish experience city, and will contribute to a transformation of the former industry harbor into a marina of water sports.

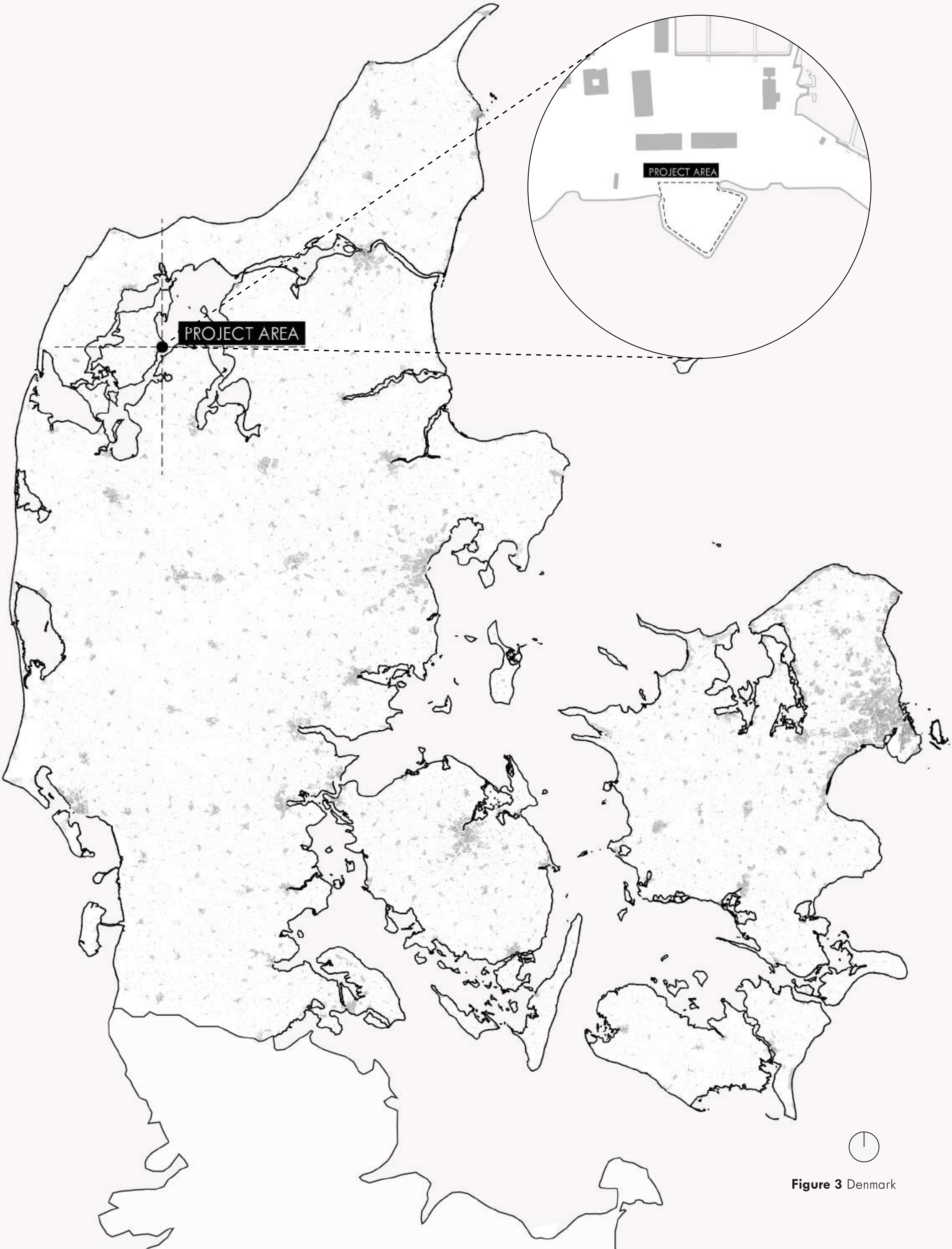


Figure 3 Denmark

Figure 4 Platform seen from East

Figure 5 Platform seen from West

Figure 6 Platform seen from North

Figure 7 On site view towards East

Figure 8 On site view towards West

Figure 9 On site view towards North

2.0. POSITION

2.1. THEORY INTRODUCTION

PRELIMINARY

In the following theoretical introduction, the coherent topics sustainability, tectonics, and value-creation will be presented to substantiate our fundamental understanding of architecture – our DNA.

WHY IS A THEORETICAL APPROACH IMPORTANT?

It is important to be conscious of the theoretical approach, as it provides continuity and direction in this project and the ones to come. Beneficially, this can be called our DNA, as it is supposed to be an approach – or a process - which should be able to repeat and reproduce itself for each project.

DNA OF AN ARCHITECTURAL ENGINEER SPECIALIZED IN SUSTAINABILITY

Our 'DNA' as architect-engineers is a consortium of sustainability, tectonics, and value-creation and is the basis of our critical way of thinking architecture. To understand the collaboration between these three basics within our critical way of thinking architecture:

Sustainability - a frame.

Tectonics - a medium.

Value-creation - an intention.

Sustainability is supposed to be the frame for every architectural project. Every project should address environmental consciousness, social improvement, and economic sustainability as a central part of the design. The frame of sustainability is also an acknowledgment of the enormous responsibility of being an architect-engineer, as we have the tools to engineer the aesthetics of architecture and integrate science within art.

Tectonics is the medium, as it is a manifestation of technical and aesthetical intentions. In the following theoretical section, the possibilities of sustainability and tectonics will be elaborated as it also becomes a catalyst for architectural value-creation.

Value-creation is a methodology for designing more purposeful architecture that creates value for the interests associated with the building. To scientifically assess architectural design proposals is a powerful tool for argumentation during the process.

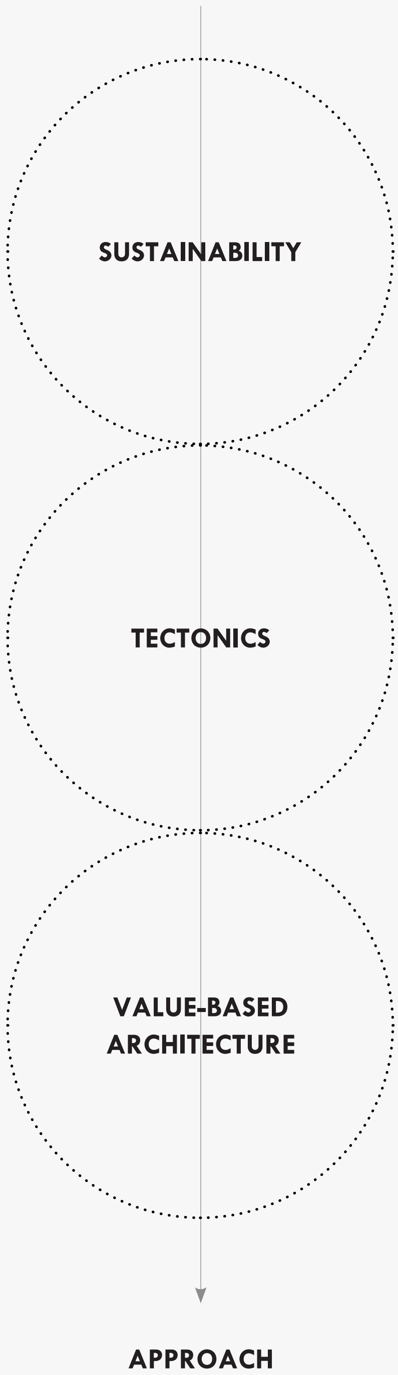


Figure 10 Our theoretical DNA

2.2. SUSTAINABILITY

PRELIMINARY

With the critical evolvement of climate changes, sustainable design within the building industry is quickly evolving and receives even more interest over time. This investigation into sustainability elaborates the importance of a sustainable design approach within the building sector and which tools we as architect-engineers are suitable for using to create architecture with a sustainable impact on the contemporary and the future society.

CONTEXT

The industrial revolution involved enormous prosperity and extraordinary improvement among people's lives, yet the twenty-first century seems to become the century where we must revolute and do penance of all the consequences accompanied by the industrial revolution in terms of climate changes. Hence, the historical UN conference in Stockholm in 1972 about international environmental politics was the acknowledgment that we have to do something about the environmental problems caused by the industrial revolution. This conference was followed by other conferences like the Rio Declaration and more recently the Paris Agreement that is a legally binding international treaty on climate change (UNFCCC, n.d.). With a focus on global sustainability, The World Commission on Environment and Development under influence of the UN made focus upon the biggest global environmental crisis' and possible solutions hereof. "Our common future" from 1987 is the result of the acknowledgment that interplay between development and environment was a possibility. Here the term sustainable development is considered as:

"… development that meets the needs of the present without compromising the ability of true generations to meet their own needs. It contains within it two concepts:

- The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given.

- The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

(Visser and Brundtland, 1987, Chapter 2)

RESPONSIBILITY

We as architect-engineers have acquired the tools to rethink sustainability, into a physical form, with a minimal impact upon the climate. When the designer positions him/herself within the sustainable approach, it is important to remember who we are designing spaces for. Though it is often seen that environmental sustainability is the one with the biggest focus, due to the critical climatic situation, though the social and economical aspects must not be forgotten. Therefore this master thesis is set to investigate and document both social, economic, and environmental aspects of the design process.

CERTIFICATION

Helping the danish building industry moving into a sustainable direction, the Danish Transport, Construction, and Housing Authority updated the minimum demands for new and renovated buildings called the Building Regulations 2018 [BR18] with the aim to obtain a satisfying standard to fire-, safety and health parameters for buildings. This meaning, that the building should obey the minimum demands of BR18 if the architect/engineering firms will get permission to build (Trafik- Bygge- Og Boligstyrelsen, 2018). Though when comparing BR18 to a certification system such as DGNB, the minimum demands from BR18 will only score 10, while the lowest DGNB score (silver) has a score of 50 (DK-GBC, 2018). This meaning that certifications such as DGNB are needed to push the limits towards sustainability within the building industry.

Different certification systems are utilized around the world where the German DGNB is implemented in Denmark (DK-GBC). The certification system is a holistic way of thinking sustainable architecture based on the Rio declaration's pillars of sustainable development; environmental, social, and economics and is represented in 3 scores, silver, gold, and platinum were last mentioned is the highest score (DK-GBC, n.d.). Furthermore, a new bonus systems have been implemented in the 2020 DGNB-version where the building has the possibility to achieve additional points for a building focusing on the well-being of the users, circular economy, and the global goals. Besides, it is planned to implement knockout criteria, meaning if the building is polluting the environment to a certain degree, the building will not achieve a DGNB certification, though this has not been implemented yet (DGNB, 2020). This meaning that even the DGNB is moving towards an even more sustainable agenda. As a government

BUILDING SECTOR IS RESPONSIBLE FOR:

40%

of the total energy consumption in the world. (Sattrup et al., 2018)

11%

of the total CO_2 emissions related to production, transport, demolition, and wast management of building supplies. (Sattrup et al., 2018)

180.000

People of occupancy, which is 6% of the danish working force. (Dansk Byggeri, 2020)

75%

of the national fortune bound to buildings and facilities. (Sattrup et al., 2018) strategy to reduce energy usage and unnecessary emissions, all new public buildings must have a DGNB certification. In addition, the biggest pension funds have a policy, demanding DGNB certification on new buildings as well (Nordicals, 2021). In Denmark, the pension funds owned a big part of the danish building mass, which means that private developers must consider the integration of building certifications to develop buildings for most of the pension funds.The DGNB has also implemented 15 of the total 17 global goals by the United Nations [UN] into their certification system (Green Building Council Denmark, 2019). The global goals have been enacted in 2015 to create sustainable development within the 17 areas, whereof life below water, climate action, and sustainable cities and communities are 3 focus areas of the total 17, which could be of interest in this thesis. The global goals aim to secure and acknowledge to promote social-, economic- and environmental development, peace, security, and international collaboration (United Nations, n.d.). These goals will need an interdisciplinary approach to achieve.

"The Global Goals is the most ambitious agreement for sustainable development that world leaders have ever made."
(The Global Goals For Sustainable Development, n.d.)

MATERIALS

Fortunately, there are no longer any excuses for not building in a sustainable matter. Declarations and valid improved certification systems have been introduced to the building sector, and among other things focusing on the building materials. Due to industrialization, mass production led to overproduction, and today there is a tremendous imbalance between supply and demand. Hence, this consumerism has become one of the most essential problems due to climate changes (Monbiot, 2017). We must therefore reconsider the use of our resources and account for the total environmental impact of a specific material or the whole building.

One of our contributions as architect-engineers is to investigate the potential of using recycled materials instead of new materials. The key architectural strategies of this thesis, in terms of reducing the CO_2 impact, are the production, transportation, usage, and end-of-life stages of materials. Inherent in the materials lies a wide range of unexploited potentials, as materials are the key strategy in creating genuinely sustainable buildings. Due to the political scene and the global climate changes, the priority will be to consider materials in relation to environmental aspects. Fortunately, increasing awareness of the environmental impact of the building materials is trending. Now we can navigate the different environmental impacts between a range of materials, through environmental product declarations [EPD], choosing the most favorable materials (Sphera, n.d.). Furthermore, circularity is the counter-movement of consumers, considering the resources within a closed 'eco system'. In the ecosystem, there is no waste, which now is much more a vision than a reality (Jensen and Sommer, 2018). Yet, we and the society attempt to move further towards circular thinking when designing architecture.

CONCLUSION

The investigation into sustainability gave an insight into the climatic problem of the contemporary world, together with the definition of sustainability. The term sustainability covers environmental-, social- and economical sustainability, which calls for a holistic and interdisciplinary approach towards architecture. The building industry and especially we as future architect-engineers needs to ratify the possibilities within architectural sustainability. Furthermore, by the implementation of DGNB it is possible to verify different design elements sustainable aspects compared to a reference building, throughout the process.

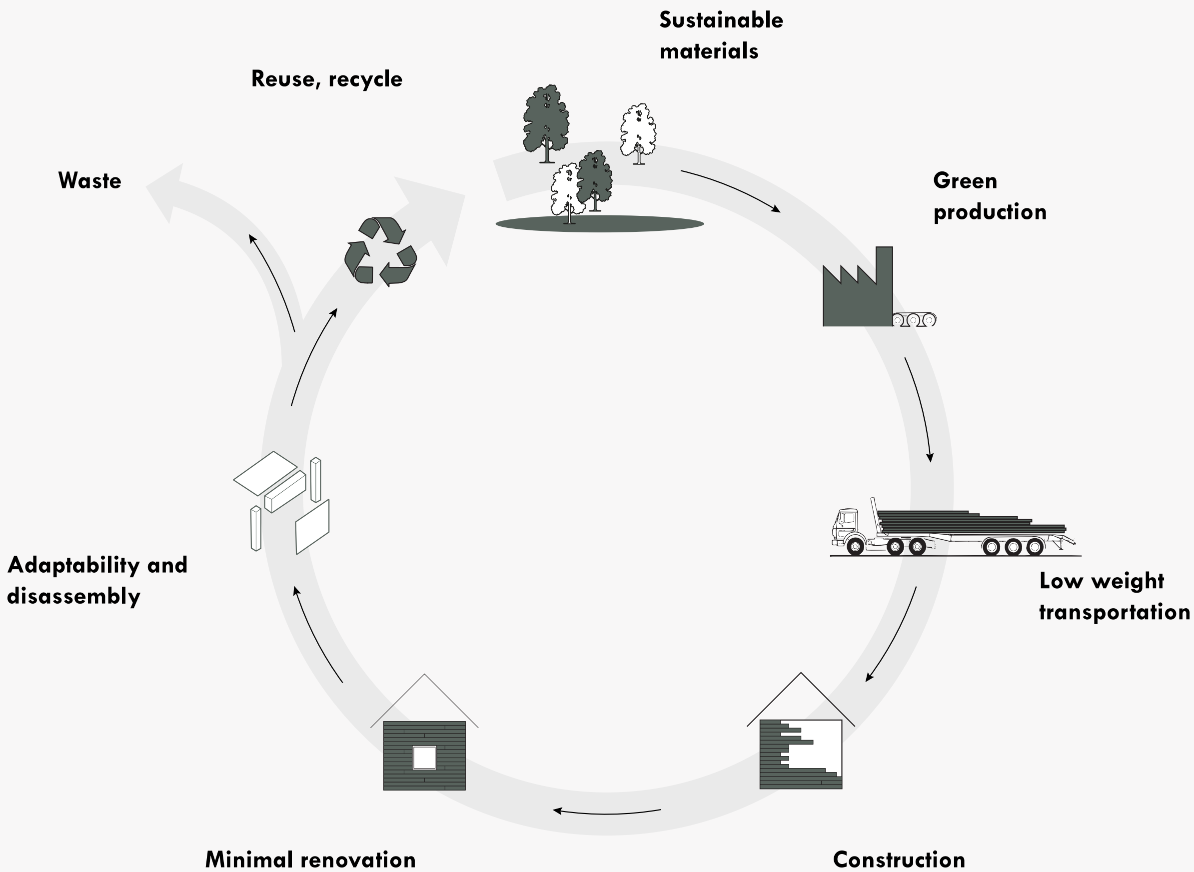


Figure 11 Circularity

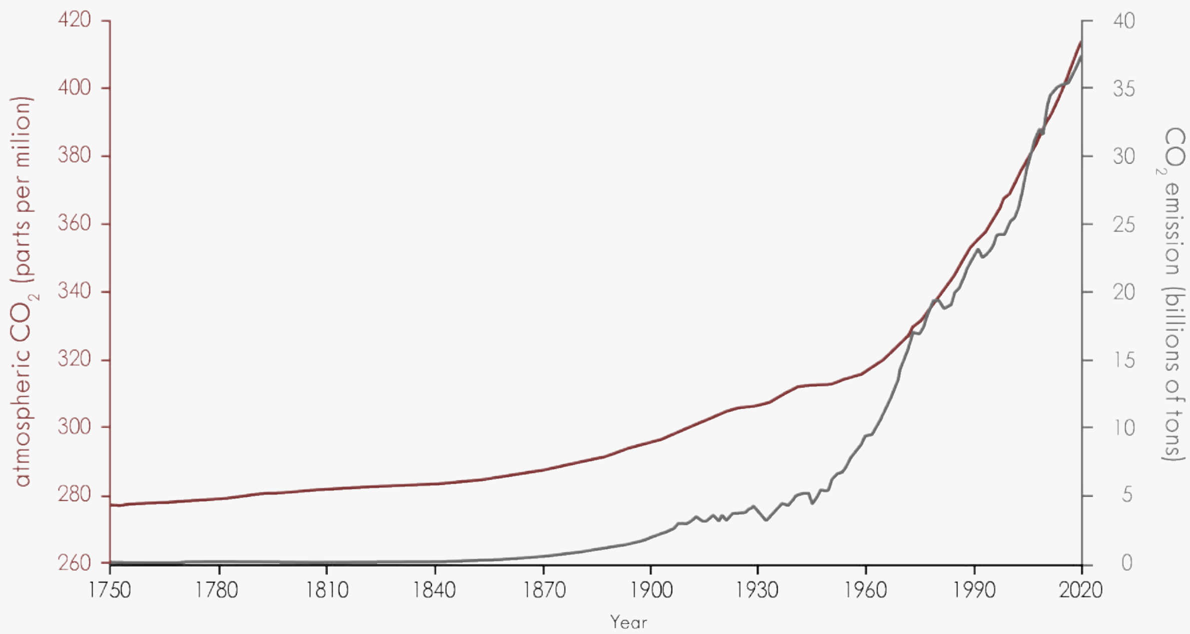


Figure 12 CO_2 in the atmosphere and annual emission (1750-2019)

2.3. TECTONICS A THEORETICAL BASE

PRELIMINARY

The objective of this theoretical topic is to unfold our perception of tectonics and its relation to architecture. An elaboration of the means by tectonics theory is important as there is no determined definition of the term. The term seems to evolve as theorists seek the meaning of the term. It is not an attempt to unfold the whole critical history of tectonics, but to emphasize the key theorists and practicians we find relevant for our practice.

CONTEXT

The contemporary understanding of tectonic must be understood in relation to the past. On the verge of the digital revolution in the 1970s, constructive rationalism seems to be dissolved. The architectural currents that influenced practice in most of the twenty's century, seemed to disappear approximately simultaneously with the arrival of the 8080 Chip, introduced by Intel in 1972 (Schwartz, 2017), igniting a new era of computational practice, which has been highly used during the studies as an architect-engineer.

THEORY

Vitruvius

Though long before the arrival of the 8080 chip, Vitruvius, who was a Roman architect and engineer, is acknowledged as the first to document the composition of architecture and engineering through materials, details, etc., in the shape of his books 'De Architectura' published around the year of 20 BC (Cartwright, n.d.). Through 'De Architectura', Vitruvius wanted to teach people in architecture, where the architect-engineer defines good architecture through a combination of utilitas, firmitas, and venustas (utility, strength, and beauty) (Nygaard, 2011). The works of Vitruvius and his Trinity have inspired several critical theorists from past to present.

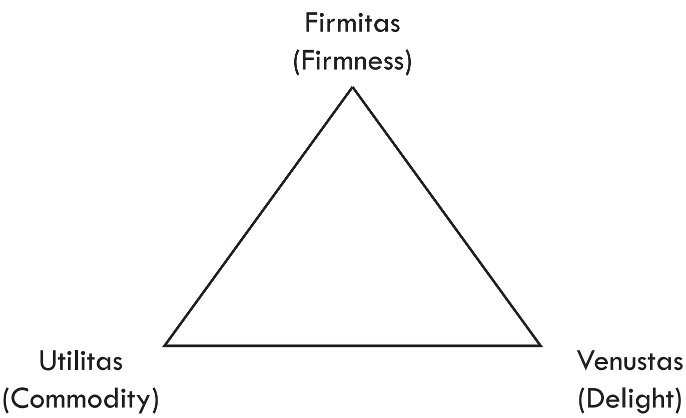


Figure 13 Vitruvian trinity

Gottfried Semper

Like Vitruvius, Gottfried Semper developed a classification system, where he could construe architecture through symbolic elements. Semper was a critical German architect and theorist who made a comprehensive contribution to tectonic theory in the 19th century (Foged and Hvejsel, 2018). Semper developed a seminal architectural theory, in his book 'The Four Elements of Architecture' where he unites materials and symbolics based on a scientific point of view. The symbolics contained functions (the hearth, the earthwork, the cladding, and the roof), techniques (ceramics, tectonic, weaving, and stereotomy's), and materials (Clay, wood, cloth, and stone). Inspired by Gottfried Semper, critics of postmodernism returned to the idea of materiality, techniques, and function should be dependent on each other, due to the dissolution of the poetics and architectural traditions caused by globalization (Nygaard, 2011).

Kenneth Frampton

One of the architects who was inspired by Semper was the British architect, critic, and architectural historian Kenneth Frampton. Frampton made himself particularly noticeable with the publishment of 'Modern Architecture. A Critical History' in 1980. Especially because of the postmodern influence of the regional architectural culture. His perception of architecture – a tectonic in particular – was based on topography, culture, history, and other idiolects (Nygaard, 2011). As an answer to Sempers system, Frampton writes:

"An archaic impulse continually changing across time."
(Frampton, 1995, p. 13 ll. 6-7)

Frampton concludes that Semper's system is adaptable to the contemporary, wherefore the theory is still relevant today. Furthermore, Semper defined the 'cladding' as space-making and classified it into two fundamental procedures: the heavy weight stereotomics identified as heavyweight masses

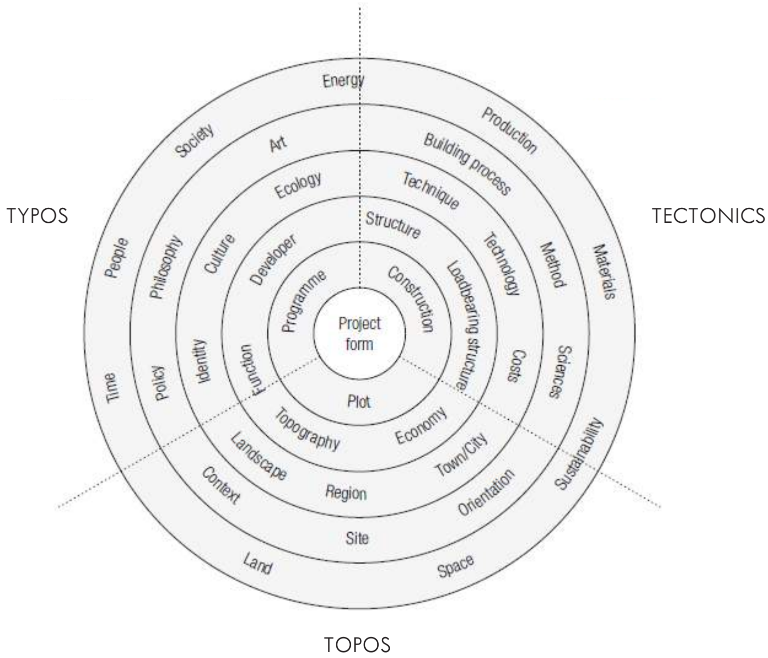


Figure 14 Deplazes coherence of typos, topos and tectonics

repetitiously laid on top of each other, and the lightweight tectonic as the sort of framework encompassing space. The additional functions (the earthwork and roofing) were much more practical in terms of protection and safety of the symbolic 'hearth' (Frampton, 1995). Frampton acknowledges that tectonics must be seen in conjunction with site and type:

"... *We may claim that the built invariably comes into existence out of the constantly evolving interplay of three converging vectors, the topos, the typos, and the tectonic. And while the tectonic does not necessarily favour any particular style, it does, in conjunction with site and type, serve to encounter the present tendency for architecture to derive its legitimacy from some other discourse.* "

(Frampton, 1995)

Frampton interprets the interplay between the tectonics, the topology, and the typology – referring to the culture, history, and people for instance - as the essence of the built.

Andrea Deplazes

Inspired by the works and theories of Kenneth Frampton, the swiss architect, and professor in architecture and construction, Andrea Deplazes interprets the coherence definition of Frampton's 'the topos, the typos and tectonics' in his book 'Constructing Architecture' uniting the topics in a holistic encapsulation of the architectural project (figure 14). According to Deplazes, tectonics always incorporates a conceptual link between physical assembly and the metaphysical, architectural space (Deplazes, 2005). Hence, we may think of tectonics as the link between structural elements and phenomenology that affects human emotions and senses.

Marco Frascari

Another architect who utilizes the tectonic term as the link between the building and the user is the Italian architect, Marco Frascari. Taking departure in his essay 'The-tell-the-tale Detail' the reader gets introduced to the detail as a condensed critical view upon architecture, and the signification of being the end process of realization. He notices details like a product of mathematical techniques (Foged and Hvejsel, 2018). Frascari writes:

"The process of designing, ordering the materials, and building a house, are techniques in the same way mathematics is a technique by which the designer (...) transforms the appropriate sign with a view to predicting the occurrence of certain events. Mathematical techniques provide us with a structure for describing the built world, a conceptual framework into which the designer (...) can fit their empirical experience."

(Foged and Hvejsel, 2018, p. 88)

Marco Frascari arranges grid-like mathematics as a technique for creating details. This grid-like geometry becomes the conceptual framework, wherein the designer embeds chosen intentions. A banal example is 'sitting' or grabbing a door handle, but potentially the detail could also be the catalysator for people acting in certain and predicted ways?

PHENOMENOLOGY

As postmodernism in 1980 caused an architectural effacement of building details, buildings were interpreted as superficial in relation to human values and contextual conditions. This caused an identity crisis as the conception of buildings became universal and the regional considerations disappeared. The critique was aimed towards universal, mass-produced architecture which often lacked contextual conception, simplistic detailing, and lacked art (Lefaivre, 2003). Therefore, several architects and theorists started investigating the term 'phenomenology', which covers the perception of the architecture, and not the measurable physical architectural aspect.

Martin Heidegger

The German theologian and philosopher Martin Heidegger is considered as one of the founding fathers of phenomenology as his philosophical publishment 'Sein und Zeit' from 1927, inspired architects to practice the meaning of being within architecture (Nygaard, 2011). As architect-engineers the term 'being within architecture' is important to remember, making sure that engineering solutions won't be the driving force of architecture, but these technical solutions need to take part in the architectural perceivance.

Christian Norberg-Schultz

Inspired by Heidegger and the philosophical approach towards phenomenology, the Norwegian architect and theorist, Christian Norberg-Schultz describes a phenomenological method used when examining cities and architecture in his book 'Genius Loci' in 1980. Furthermore, his book 'Stedskunst' from 1996, Norberg-Schultz writes about, the arrival, the meeting, the pause, the togetherness, the agreement, the explanation, and the aspects of 'being'. Norberg-Schultz is an interesting theorist to mention when talking about the evolvement from the universal modern theory to a more critical regional theory, as he moves the interest of the geometrical room towards an experienced and existential understanding of architecture. He indicates a 'place loss' due to postmodernism. Norberg-Schultz advocates for relational architecture, based on feelings, and stimuli through remembrance, orientation, and identification (Nygaard, 2011). Resulting in an understanding of an experience of the place/building that the observer are placed within.

Juhani Pallasmaa

Phenomenology also became the point of departure of architectural understanding by the architect Juhani Pallasmaa (Nygaard, 2011). Pallasmaa describes the relation between architecture and the sensual perception hereof in his book 'The Eyes of the Skin'. Especially materiality is essential in the sensual perception of architecture (Pallasmaa, 2013). Pallasmaa writes:

"The flatness of today's standard construction is strengthened by a weakened sense of materiality. Natural materials - stone, brick, and wood - allow our vision to penetrate their surfaces and enable us to become convinced of the veracity of matter. Natural materials express their age and history, as well as the story of their origins and their history of human use."

(Pallasmaa, 2013)

The simplicity of natural materials - and especially their patina - is enriched with experiences as it reflects the influential conditions over time. Although Pallasmaa acknowledges that sensuality extensively has been absent in the modern age, he emphasizes an increasing awareness of this matter:

"This new awareness is forcefully projected by numerous architects around the world today who are attempting to re-sensualize architecture through a strengthened sense of materiality and hapticity, texture and weight, density of space and materialized light".

(Pallasmaa, 2013)

ATMOSPHERE

Peter Zumthor

Peter Zumthor introduces the term 'atmosphere' as the fourth dimension to architecture, addressing the senses of the human body. In an interview he states:

"Atmosphere is the whole, it is a holistic approach. It is the way we experience architecture – just like Steen Eiler Rasmussen, who wrote his famous book Experiencing Architecture in the 1950s, which is maybe forgotten at present – Peter Zumthor."

(Kjeldsen et al., 2012, p. 67)

Zumthor expands the perception of phenomenology and has a contrast-full and sensuous architectural approach of designing spaces. His delicate combination of materiality, tactility, construction, lights, and smells is encapsulating this 'atmosphere'. The atmosphere is intuitively validated as based on the immediate impression and according to Zumthor, good architecture is when you got emotionally engaged with the building (Kjeldsen et al., 2012). Hence, the phenomenological way of thinking is inherent in the architectural practice of Zumthor.

Kenneth Frampton

Kenneth Frampton is interested in this sort of practice as well. Frampton would categorize Zumthor as being a critical regionalist, as his building often favors the small scale,

Figure 15 Bruder Klaus Feldkapelle, exterior

considers the location, the lightning, and the climate, focused upon the tactile experience, and implements the contemporary cultural orientation. He calls this the seven characteristics of critical regionalism (Frampton, 2007). According to Frampton the practice of being a critical regionalist is the ability to deconstruct the rational construction methods and afterward synthesize them in terms of the seven characteristics. The approach of construction may be described like this:

"... we may construe these different forms of concrete construction as setting the rationality of normative technique against the arationality of symbolic structure"
(Frampton, 2007)

Critical regionalism intends to rediscover the symbolism in architecture. The architect attempts to work against the rational construction methods and program the building for a much more relational agenda. In this case symbolism is ambiguous; Symbolism can be physical matter in terms of ornamentation, but it can also be a more phenomenological symbolism or meaning with the architecture.

Zumthors architecture is generally seen within brackets, in an elsewhere accelerating era of optimization, prefabrication, module production, and standard solutions, and the Brüder Klaus Chapel is no different. It is located on a hilltop and the objective is to provide religious consecration for the local monks. The work is not only adjusted to the contextual and cultural condition – it also accomplishes the hilltop and somehow creates a deeper meaning with this existing hilltop.
On another religious building, Bagsvaerd Church by Jørn Utzon, Frampton writes:
"Although the main Bagsvaerd vault spontaneously signifies its religious nature, it does so in such a way as to preclude an exclusively Occidental or Oriental reading of the code by which the public sacred space is constituted. The intent of this expression is, of course, to secularize the sacred form by precluding the usual set of semantic religious reference and thereby corresponding range of automatic responses that usually accompany them."
(Frampton, 1983 cited in Foster, 1985, p. 23)

Instead of altering the occidental reading, Zumthor has this more atmospheric reading of space which is constituted in the tectonics and thereby disconnects the normative construction techniques.

SYNTHESIS

Tectonics is the aesthetics when combining engineering and architectural practice. We perceive tectonics as the structural encapsulation of metaphysical intentions. This way, tectonic becomes the physical projection of spaces, functionality, materiality, and aesthetics. Especially the materiality explicitly and implicitly affects a wide range of process within the design process. Materiality plays a pivotal role due to the social, environmental, and economical aspects. Along with material comes a wide range of sustainable considerations such as manufacturing processes, transportation, maintenance, and disposal, but also the health and well-being considerations. Some materials have an ecological agenda, and others a more conventional agenda. Hence, choosing a certain material has a great influence on the architectural outcome.

Our perception of tectonics emanates from Frampton's acknowledgment of tectonics being influenced by the dynamics of society and users 'the typos', and the static of contextual conditions 'the topos'. Besides, Marco Frascari's idea of the detail being the linkage between the building and the user is also extremely interesting as it is within the detail, we can influence the user and the society. Tectonics has a sensual impact on people and addressing sensuality is key. People perceive the world through their senses; hence it is crucial to address the senses properly to create impactful architecture.

Ever since the digital revolution in the 1970s and the UN conference in Stockholm 1972, a tendency for more sensible and relational architecture has emerged. Taking Bruder Claus Chapel by Zumthor as an example where he addresses the sensuality through contrasts of lighting, smell, and temperature but also tectonic details like shifting materiality, tactility, room heights, and openings. He successfully rediscovers the architectural intimacy that Semper writes about and thereby creates a stronger relationship between the building program and the user through the tectonics.

The reason why so many people based critical tectonic theory on Semper's classification system is because it changes over time, referring to contemporary influential factors such as weather, contextual location, culture, tradition, people, and more. Hence, a tectonic approach is advantageous, as tectonics represents the interplay between form, structure, and materials, but it is also the link to the metaphysical – in this case, interpreted as the phenomenology within a building.

The perception of tectonics - and the atmosphere it creates - is individual. Yet some atmospheric perceptions are consensual, like the nave in a church is perceived as holy and religious. Some atmospheres and constellations are scientifically proven to improve the well-being of the human being. In this way, certain tectonic compositions can function as a 'catalyst' for improved conditions whether if it is an ocean view or the absorption of sound waves. In other words, tectonics can - to some extend – activate and manipulate feelings and emotions through atmospheres. Tectonics therefore becomes our holistic perception of architecture as it the link between aesthetics, techniques and performance.

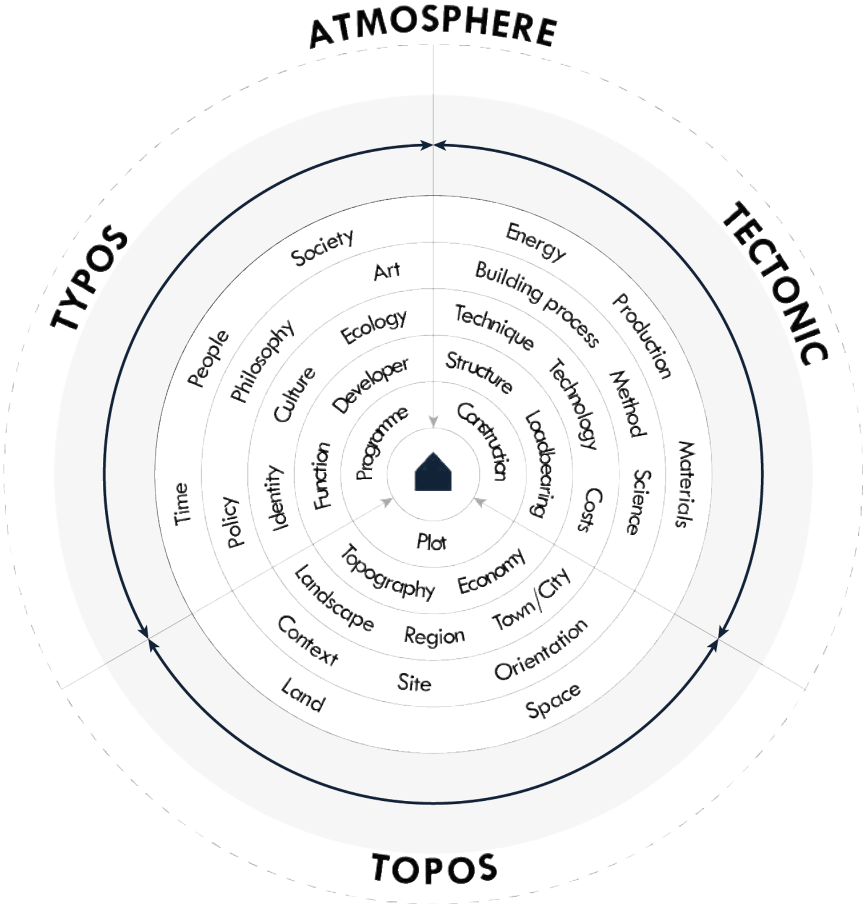


Figure 16 Theoretical synthesis

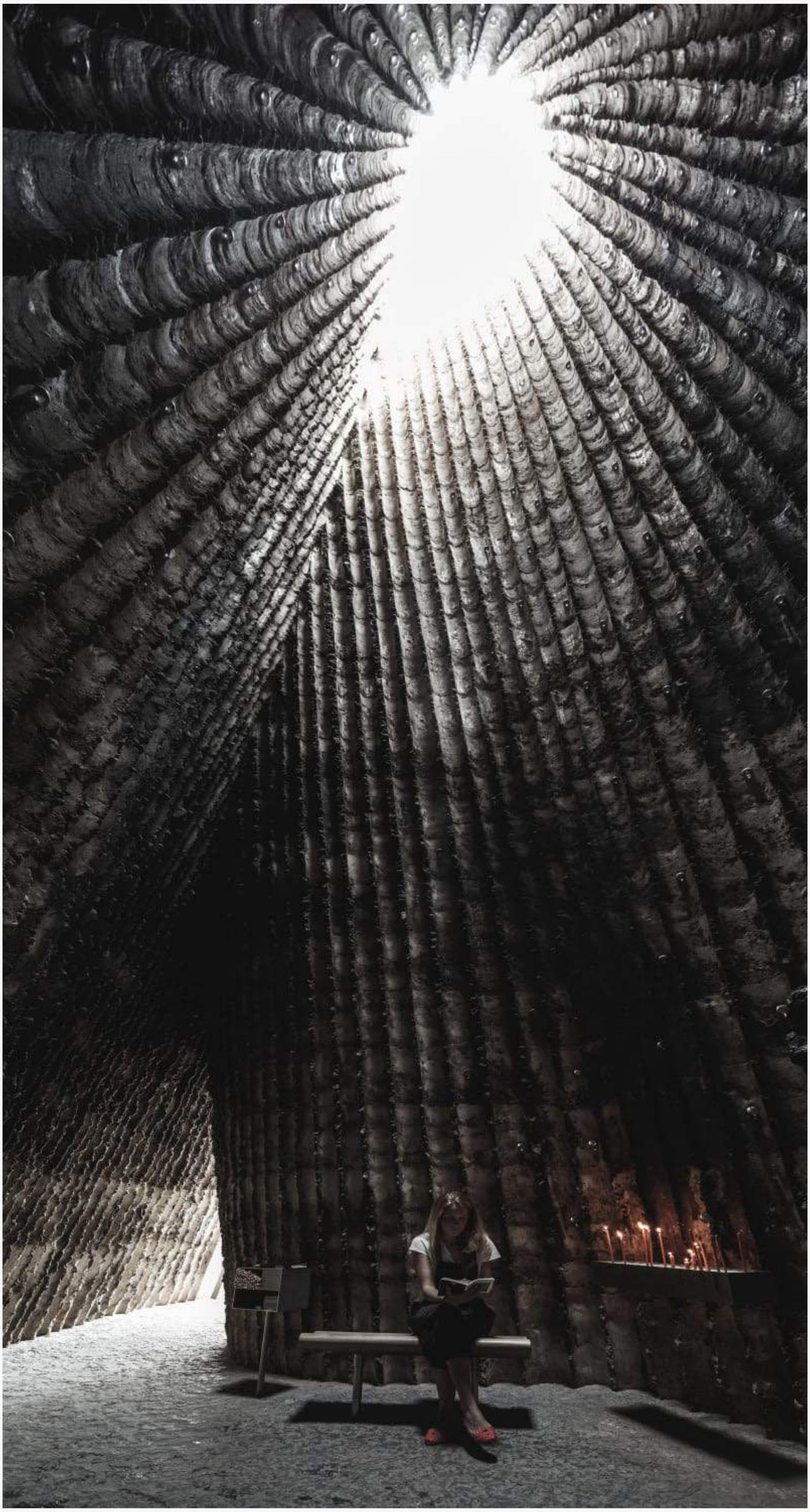


Figure 17 Bruder Klaus Feldkapelle, interior

2.4. ARCHITECTURAL VALUE CREATION

PRELIMINARY

We acknowledge that social, economic, and environmental sustainability in architecture emerges from the tectonics and atmospheres. Tectonics and the atmosphere are the membranes between architecture and value-creation, meaning that the architecture has an inherent performance. We can use this performance to change certain conditions for the building owner, the user, and society in general. Architectural performance costs, which is why we need a methodology to scientifically document these architectural performances.

CATALYST ARCHITECTURE

Catalyst Architecture is a conceptualization of architecture that can change certain conditions. The term catalyst is originally known from chemistry, causing a chemical reaction without changing itself. Hence, catalytic architecture becomes the link between two conditions and is favourable placed at the 'transition zone' intending to break down barriers and create democratic spaces. In the book 'Catalyst Architecture', catalytic architecture is described as the architectural ability to cause economic, social, or environmental reactions, also called 'performance'. 'Performance' is twofold; The internalized performance relating to the building program, the culture, and the people. The external performance relates to the immediate environment: context, usage, and safeness. Common for the two types of building performances, is the ability to interact and affect the contextual surroundings and the users (Kiib and Marling, 2015). Synthesizing the performances with Frampton's definition of tectonics, the internal performance is related to the 'typos', addressing a performance that accommodates the users of the building and thereby affects the program of the building. Besides, the external performances are related to the 'topos', addressing a performance that accommodates a more contextual agenda such as the region, the city, and the economy. Hence, the definition of tectonics has a pivotal position when designing for architectural performances.

DOCUMENTATION

It is important to document the performances to emphasize the legitimacy of a given design proposal. The documentation is a powerful tool for architectural argumentation.

The publishment 'Architect, document your value creation', which presents a methodology, documenting social, environmental, and economic value when designing buildings (Sattrup et al., 2018), questions the outcome of architecture:

"How do we draw attention and articulate the valuable outcome of architecture for the building owner and building user and having social and economic relevance?"

(Sattrup et al., 2018, p. 8)

We acknowledge that value is a difficult word. In mathematics, numeric values are often true or false and therefore objective. In terms of economy and social value, it becomes a much more subjective term and must be seen from a holistic point of view (Koch, 2017). Hence, to successfully create social, environmental, and economic value it is important to define the values together with the interests of the building referring to the building owner, the user, and the society.

Value documentation becomes a documentation of the architectural performances, caused by the tectonics and the atmosphere. It is an approach, securing a continuous critical view upon the design choices throughout the process, always focusing on relevant solutions for the interests in terms of social, economic, and environmental values. Social values are most effectively evaluated by post-occupancy evaluation, but due to the format of this thesis, we are only able to estimate the performances of social effects through case studies and evidence-based research. Fortunately, we are able to evaluate environmental and economical performances to some extent.

Architectual value creation

	PLANNING	DESIGN	USAGE	
Method	Define stakeholders and map out their values, needs and preferences. Define **assignment.** Define **criteria** by which the success of the project can be assessed. Some criteria need to be measurable Establish **Baseline**: Describe the stakeholders' present conditions, activities and organisation, or use references for making subsequent comparisons.	Define what **design features** and processrelated resources are going to be used in the project in dialogue with stakeholders. Assess and simulate the design's **qualities**. Assess what effects the solutions are expected to elicit, **adjusting** the solutions if necessary.	**Evaluate** the qualities of the design with the stakeholders. Measure **effects** in relation to success criteria. Include new criteria, where relevant. Document value creation by **comparing** measured and observed effects with the baseline and by relating these to costs.	BUILDING OWNER USERS SOCIETY Map out the value creation for these three groups of stakeholders
Social	Define social goals.	Design for social effects.	Document social effects.	Interviews Observations Questionnaires Document the social value creation
Environmet	Define environmental goals.	Design for environmental effects.	Document environmental effects.	Health and well-being Environmental qualities Life cycle assessments Document the envrionmental value creation
Economic	Define economical goals.	Design for economical effects.	Document economical effects.	Building economy Total economy Total value Document the economical value creation

Figure 18 Diagram from 'Architect, document your value-creation', explaining the linear porcess of value creation

3.0. APPROACH

PRELIMINARY

We want to synthesise sustainability, tectonics and value-creation into an approach that can be used in practice. We want to emphasize a methodology where the 'performances' is an integrated part of the design process. Together with the develop a methodology where we are able to document the 'architectural performance' which is why we in this section introduces the Value-Based Design Process.

METHODOLOGY

Tectonics is the transition between the human body and architecture. Hence, there is enormous potential in creating 'performance' through the detailing of tectonics.

When addressing social value the functionality, durability, and beauty must meet the requirements defined by the user. The three primary methods to document social value creation are interviews, observations, and questionnaires.

The idea of environmental value creation is twofold. First a focus upon the use of low-impact resources. The methodology of documenting low-impact materials is carried out by LCA analysis. Second, an indoor environment that focuses upon the health and well-being of the users. The methodology used for documenting a healthy indoor environment is to use computational simulation programs combined with evidence-based research focusing on health and well-being.
The initiating phases of a building project are the cheapest, compared to the actual building process and the subsequent operations. The initiating phases are also the most influential in terms of social, environmental value, and financial cost. At some point, an architectural concept will have to be subjected to the market forces and financial models. The discrepancy of the short-term financial models, and the duration of the building posterity, generally implies short-term determinations without long-term perspectives. Hence, the LCC analysis is a methodology to address the financial advantages of long-term perspectives.

We wish to merge the value-based design process with the instrumental map of the integrated design process by Mary-Ann Knudstrup (Knudstrup, 2005), illustrating the iterative processes of designing. In this way, we apply a value-creating layer upon the existing work structure that we have been dedicated to since the beginning of our education. The 'value-based design' becomes 'integrated value-based design' with the primary focus on creating architecture with tectonic details.

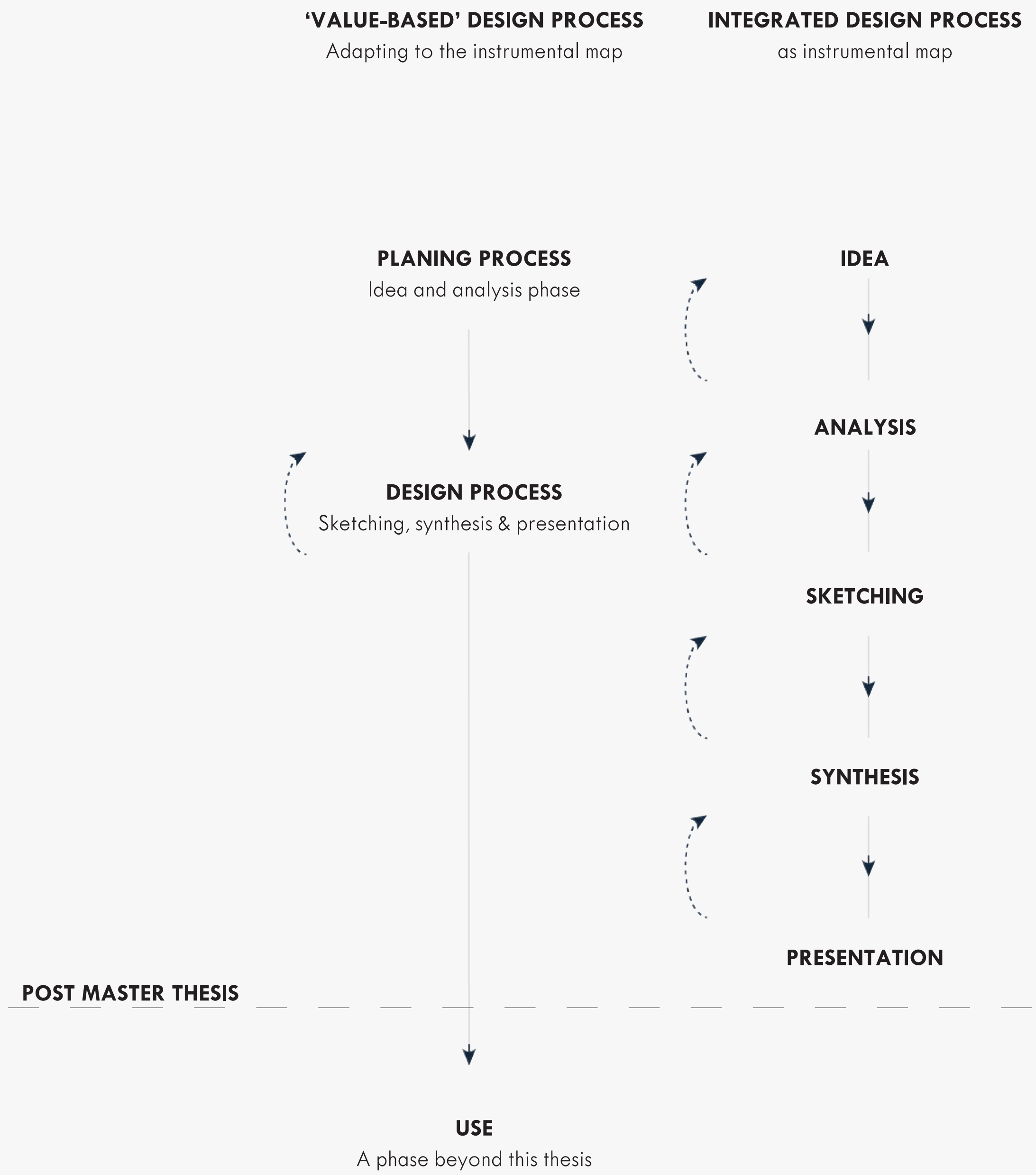


Figure 19 The merge of 'Value-based Design process' and the integrated design process

4.0. METHODOLOGY

	WHAT	HOW	WHY
SOCIAL VALUE-CREATION			
Interviews	Investigation of locals with interest in the building	A qualititative approach to the interview will be utilized	Creates a focus on the needs by the locals, while compiling design generators used in the room program/diagram
Observations	An in field investigation, observing the existing environment.	Investigation through field trips and photo registeration.	Achieving knowledge of the spatial composition, objects, activities, and behavior in and around the project site.
Persona	A fictive person	Created through research and evidence-based information.	Examplifying a user of the building, used as argumentation to conduct design decisions.
ENVIRONMENTAL VALUE-CREATION:			
Enviornmntal Impact: Life cylce assessment (LCA)	Quantification and estimation of the environmental impact of materials, from raw material supply to manufacturing (A1-A3 phases) and its end-of-life phase (C3 or C4).	Utilizing information from EPD in the LCAByg tool, assessing environmental data and outcome.	Evaluate and compare the different materials to DGNB reference building, securing a low impact material choice throughout the design process.
Health and well-being: Evidence-based Reseach	Achievement of general and state-of-the-art knowledge through research and evidence-based design.	Reading and collecting relevant interviews, scientific articles, journals, papers and other types of knowledge rewarding sources.	The achieved knowledge creates a basis as a decision-making tool throughout the design process, combined with different analyses.
Computational 3D modelling/ Simulations programs	Investigation of the building performance through digital programs, simulating a specific design.	Simulations through the programs BE18, BSim, Velux daylight visualizer and the Rhino plugins Ladybug and honeybee.	Creates the possibilities to adjust the design after a sustainable design approach, with a minimal environmental impact.
ECONOMIC VALUE-CREATION:			
LCC	An investigation into the economical aspect of material pricing from future cost to present cost.	Utilizing the LCCByg tool, converting the price of the total cost for initial cost, maintenance, operating, and disposal cost into present economical values.	Investigating which materials is the most advantageous in the long term, in regards of price.

DESIGN GENERATORING

	WHAT	HOW	WHY
Case studie	A national and international investigation of existing, planned buildings or the ideology behind, together with the context the buildings are placed within.	The different projects will be researched upon their approach and execution towards tectonics and their relations to the surroundings.	Creates inspiration for design approaches and aspects which will be a inspiration in the design process of the future center building.
Mapping	Investigation of the existing physical area and its relatable attributes.	Investigation of the project area through site visit, photo registration on foot and aerials.	Creates a site and context understanding, which will inform the designers of site relevant or critical objects.
Athmosphere	An investigation into the surrounding environment and the approach of the project areas.	Locating different routes towards the project site, while documenting the atmospheres, and the surrounding attributes of the area.	Creating inspiration for how the building should embrace the atmospheres of the different areas related to the project site.
Facade registration	Investigation of the existing physical area and its connecting attributes.	Walking through the area/city, documenting the facades and its specific expression, combined with line illustrations.	Creating inspiration for a site and context understanding piece of architecture, which will give an area and cultural understanding.
Reusable materials	Research of local architectural tradition s combined with an investigation and mapping of materials with the potential of being reused.	Field studies combined with statistics and research of local material history and tradition.	Minimizing the environmental impact discharged by building materials, while creating a piece of architecture, which is relatable to the city of Nykøbing Mors.
Legislation research	An investigation of the in-force local plans and municipality plan.	Locating and reading the specific plans and register the most important factors, which can affect the design.	It is important to know under which circumstances the architect-engineer is working within, making sure the building will be approved by the municipality.
Inspiration	Aesthetical and technical inspiration for the project in regards to the specific building typology, placement, and presentational techniques.	Investigation through online platforms as archdaily, dezeen, pinterest, etc.	Kicking off the design process, inspiration is important to map down early ideas, without having the inspiration coming from more in-depth case studies.

	WHAT	HOW	WHY
Flooding	Investigation of the water level in the fiord from the present time until the year 2100.	Researching statistics from the Danish Meteorological Institute together with predictions of the future water level as a result of climate changes.	With a project area located in connection with the fiord, it's important to achieve knowledge of existing and future water levels, in regards to protect the building and its surrounding areas.
Topography	City sections and site plan displaying the topography of the city and site.	Mapping down contour lines together with an investigation of the consequences of the surface height in regards to the project area.	Achieving knowledge of the build and natural environment with the result to achieve knowledge of the consequences or possibilities of the topography.
PROCESS AND PRESENTATION Visualization	Visualizations representing the final center building. Together with explanatory diagrams showing the functional aspect of the project.	A product of 3D modelling, photo editing programs (adobe) among others makes it possible to create diagrams and visualizations.	Its important to visualize the final product, with the aim to be easy understandable and communicative for the building owner.
Analoque sketching	Transformation and expression of thoughts into an internal and external communication tool.	Freehand sketching in different detailed levels, within building design, concepts, landscape and technical solutions.	Visualization and development of concepts, details and technical solutions.
Analoque modelling	Internal and external communication tool, expressing thoughts and ideas into physical forms.	Physically forming relevant building volumes, through different medias like cartoon, boards, paper etc.	Creates an understanding of the voluminal aspect of a specific volume, together with the appearance hereof.
Digital modelling	Investigation of volumes and their appearance	3D modelling programs such as SketchUp, Revit, and rhino are utilized to visualize concepts and see the concepts in the specific context.	Creates an understanding of a volume, and how this interacts with its surroundings. Furthermore, digital models are easy changeable to test volumes.
Calculation	Investigation of the building, upon its performance within several technical aspects as sound, u-value and ventilation.	Sheets is created in Microsoft excel to make an easy overview of the different calculations, where the building performance will be analyzed.	Creates a bigger understanding of the technical aspects, while making sure the center building will perform in a sustainable matter.

Figure 20 'Østerspigen' placed in Nykøbing Mors

PLANNING PROCESS

5.0 INTERESTS

It is important to know the interests, and their specific needs and values. Through the following chapter society, building owner, and the different users of the building will be presented. In the end, the analyses will position themselves as the basis of the interests design generators for the Center for Experience and Water sports.

5.1. SOCIETY

Preliminary:
The society are represented by governmental strategies. The danish society has some general agendas relevant for this particular project, taking departure in gastronomy and sustainability.

DENMARK AS LEADING GASTRONOMIC NATION
There is a national and local ambition of Nykøbing Mors becoming the shellfish capital of Denmark. This ambition emerges from the existing oyster-related activity in Nykøbing in terms of the Danish Shellfish Center [DSC] and the annual shellfish festival. In 2018, the government granted 30 MIO DKK for a project at the DSC called Grant Scale Oyster Hatchery, to stimulate the development of coastal gastronomic resources such as oysters and shellfish, but also seaweed (Stubgaard, 2018).

Besides, the government launched the Gastro 2025 initiative in 2019, concerning a general improvement of the national gastronomic effort. It is a national and international initiative, focusing on increased tourism, sale and marketing, and export, but also to improved dietary habits and food waste managing in a more sustainable way (Fødevareministeriet, 2019). Food waste has become a huge problem and todays' food supply account for 26% of the anthropogenic CO_2 emissions worldwide (Poore and Nemecek, 2019). Hence, to strengthen and support the general danish culinary and gastronomical development, a pool of 10 MIO DK has been scheduled from 2019 to 2022 with the aim to generally empower danish gastronomy (Fødevareministeriet, 2019).

In 2018, the government granted 17,7 MIO DKK to an 'oyster reception' also located in Nykøbing Mors, with the purpose of experience together with a research agenda related to gastronomy with shellfish at Danish Shellfish Center (Morsø Kommune, n.d.). The 'oyster reception' should be a place for tourists and locals to experience the delicacy of the fiord.

Oyster hatchery has the potential to expand even more, and become a brilliant investment for the local society, as the fiord is famous for having a big concentration of European Oysters - Ostrea edulis - and every year Denmark is exporting 15 million European Oysters. The oyster is extremely popular among foreign countries as the fiord provides unique water and temperature conditions (Bjerregaard, 2013).

SUSTAINABLE BUILDINGS
The Danish government also has an ambition of sustainable buildings in the future based on innovative solutions, skilled handicrafts, smooth processes, and reduced use of resources (Ministry of Transport and Housing, 2020). The government has several focus areas and initiatives, reducing the CO_2 footprint within the building sector to gain 70% CO_2 reduction and carbon dioxide neutrality in 2025. The focus areas are called:

1. More low-carbon building activity
2. Durable, high-quality buildings
3. Resource-efficient buildings.
4. Energy-efficient buildings
5. Digital supported buildings.

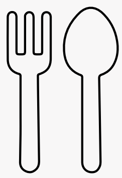
(Ministry of Transport and Housing, 2020)

These focus areas include a wide range of innovative initiatives concerning, resource consciousness, energy optimization, healthy environments, and the development of digital tools promoting the 'green transition'. One of the examples is the recent initiative agreements is the CO_2 limit and LCA-calculations on new buildings per 2023 (Valdimarsson, 2021).

CONCLUSION
Outcome of this building is to promote oysters as a catalyst for local prosperity and to reduce the emission and environmental impact:
- A building program that promotes the oyster, shellfish and other gastronomic resources from the Limfjord, focusing on sustainable eating habits and reduced food waste.
- A consciousness of the use of resources. Focusing on a durable building of high quality and reducing the pollution footprint to be lower than the DGNB reference building in LCAbyg.
- A low energy frame (33 kWh/year m^2)

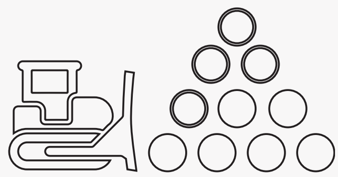
26%

Todays food supply account for 26% of the anthropogenic CO_2 emissions worldwide. (Poore and Nemecek, 2019)



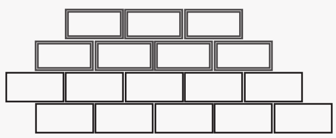
40%

of all waste in denmark comes from the building industry



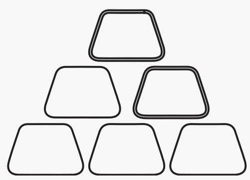
+70%

growth of demand for global construction in 10 years



+1,5%

more resources use than the planet can provide in 2015



35%

of the total materials used by the construction industry in the world

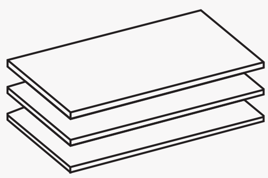


Figure 21 Climate crisis facts

5.2. BUILDING OWNER

Preliminary:
The building owner is the municipality of Nykøbing Mors, who handed over a prospect. The prospect includes project related ambitions, visions, issues and goals.

Social cohesion through watersports:
Morsø municipality is facing the consequences of urbanization resulting in the younger generation moving towards the bigger cities combined with a negative settlement and excess of deaths over births the population is decreasing (Morsø Kommune, 2020a). One of the ways of turning this tendency around is to attract non-average newcomers to the city. A non-average newcomer is defined as a younger couple in their thirties with kids, moving from the city to the rural area of Denmark. One of the main factors in the attraction of non-average newcomers is the social relations within associations (Cowi et al., n.d.), which is something that Morsø lack.
Furthermore, compared to others sports Denmark lacks water sports facilities and associations, in regards to the amount of water sports practitioners. Even though the isle of Mors, with its placement in the Limfjord and its calm waters, is ideal for different kinds of water sports, Mors is noted as a municipality with a lack of facilities (Lindemann, 2019). Compared to its water boundary, Morsø municipality fails to facilitate the frames for a physical and psychological community regarding water sports.

The neighboring municipality, Thisted municipality, saw the opportunity to expand its brand 'Cold Hawaii' to 'Cold Hawaii Inland' [CHI] with a connection to the Limfjord. 'Cold Hawaii' is known for its good surfing conditions along the west coast, though these conditions might scare practitioners, where the new 8 locations of CHI utilize Limfjorden as a calmer water sports area, aimed towards bathing, swimming, surfing, sailing, etc. but also introduce water sports, which are more common in calm waters, such as diving (Thisted Kommune, 2021). The facilities create the physical, psychological and practical frames of performing an outdoor activity in or on the water together with acting as a local meeting point, which is something despite its position, Nykøbing Mors needs.

Tourism:
According to tourism, all indicators show that the municipality faces a decrease in tourism. The municipality has no stray customers meaning the municipality needs to attract its tourists (Realdania et al., 2013). Hence the building project should address tourist attraction through gastronomy and water sports. Furthermore, the building owner wishes to strengthen the position as 'The Shellfish Capital', through the program of the building. The building owner wants to create a new experience area, containing functions which Morsø municipality cannot yet offer to the public, improving the social cohesion on Mors, as well as attracting tourist (Morsø Kommune, 2020b).

Due to scarce resources, Nykøbing Mors desires a building as cheap as possible without compromising architectural quality. In addition, the building owner demands a low operation costs in terms of heating, energy use and maintenance to accommodate the expenses for the future tenants.(Kommune, 2020b.) Increased activity by the harbor front is a strategy with provides the opportunity for the citizens of Nykøbing to reinvent their city identity. (Realdania et al., 2013)

CONCLUSION
According to the building owner, the valuable outcome of this building is social cohesion and ratification of Nykøbing being the oyster capital:

- The building should introduce an area offering a new experience to the city of Nykøbing Mors, which will not steal tourists from already existing attractions.
- Watersports facilities creating opportunities for associations an local educational institutions to expand the educational opportunities.
- Tourists should be able to try the dietary experience of oysters.
- Tourists should be able to try water sports.
- A conciousness to the building- and operational costs

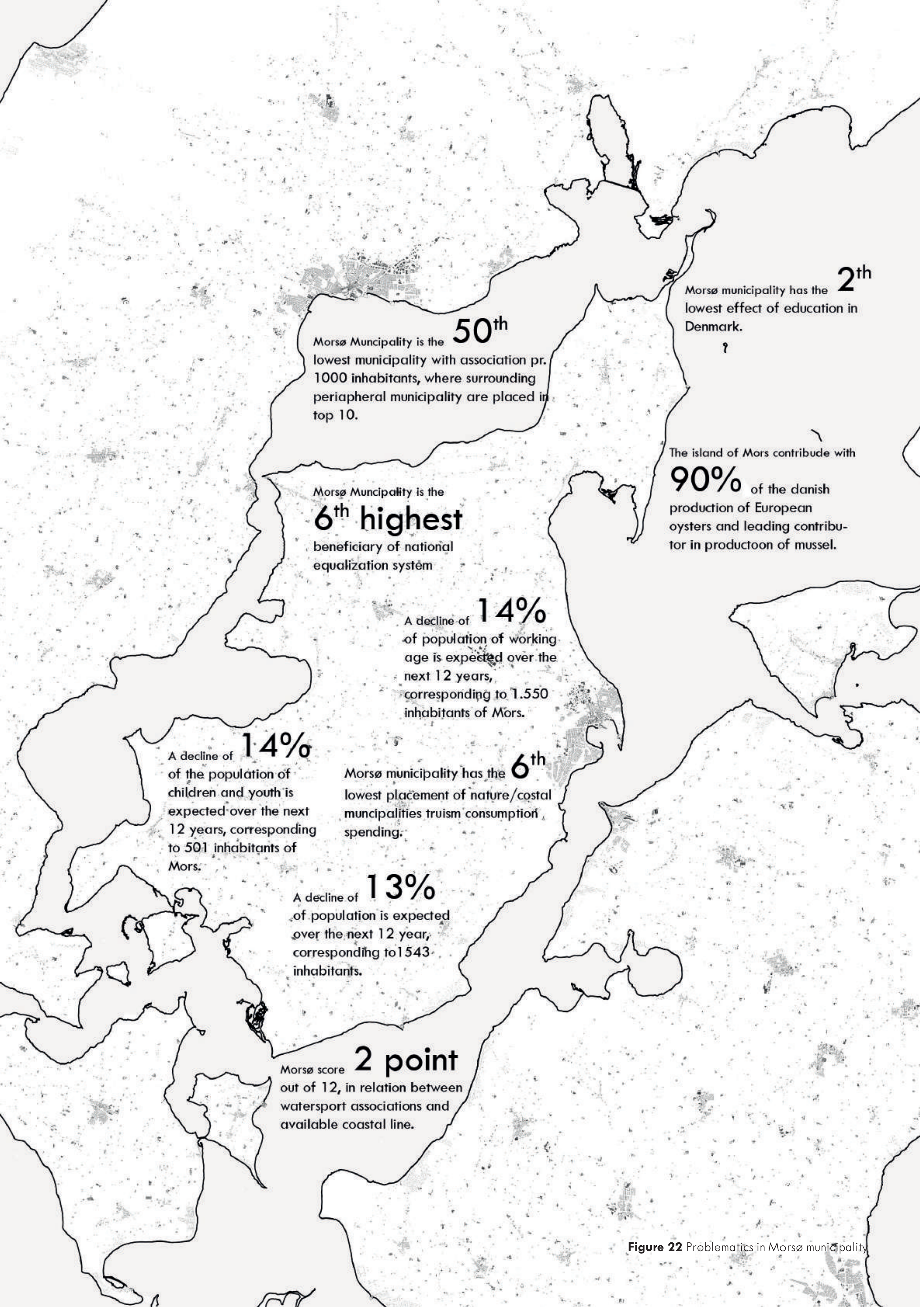


Figure 22 Problematics in Morsø municipality

5.3.1. PERSONA FOOD TOURIST

DATA

Gender	Woman
Age	33
Job	Salesperson

INTRODUCTION

Anna is a self-pronounced gastronome, meaning she is passionate and interested in food, not only out of hunger satisfaction but also as a hobby (Nichols, n.d.). She utilizes her multiple business trips exploring local restaurants and eating places. When entering a restaurant Anna is often meet with confusion about how she as a guest should locate herself. It is often seen that the waiting area, where the waiter will approach you if such exist, is in the pathway of the entrance/exit, blocking the exit of guests leaving the facility. Furthermore, when she has been seated, Anna points out that she prefers to know the location of the toilet, avoiding her asking a waiter and by that pointing out that she needs to go. During dining, which is often done alone regarding her business trips, Anna mentions noise disturbances. She likes the small talk conducted by the other guests, making her feel less lonely in this specific business visiting position, though in bigger rooms noise often travels across the room, creating other guests speaking louder, making a noisy and stressful environment to be eating and enjoying the food within.

KEY PROBLEMS

Navigation
Bad signposting and difficult to figure out the restaurant layout.

No defined entrance area
Experience of small-scale anxiety, not knowing how to situate herself resulting in a feeling of nervousness by doing a wrong action.

Noise
Noise from other guests sometimes gets too noisy, creating an uncomfortable dining experience.

DISCUSSION

As a guest at a restaurant, numerous different factors can have a big influence on the food experience. Most common is of course the meal, but especially also the treatment by the staff (Ryu and Jang, 2007), though these are factors, which cannot be addressed through building design, several factors are possible to address.

Mentioning a food experience, the reader will most likely relate 'the experience' to the sense of taste. The sense of taste is a very delicate system, which is highly affected by different factors such as anxiety. Anxiety and stress are highly relatable, though are not defined by the same conditions. Stress is a nonbiological response to stressors, which could be found in the elements surrounding the person, while anxiety is a cognitive response through feelings. Due to the correlation between anxiety and stress, being exposed to acute stress increases the baseline of anxiety, which creates an increased threshold towards salty tastes (Ileri-gurel et al., 2013). Due to the specific food experience of shellfish, which is often a briny experience, the food tourists mustn't be affected by acute stress before eating, securing the most reliable food experience. Nature can be used to create a faster recovery than a built environment of acute stressors, through view towards nature (Brown et al., 2013) and natural sounds (Alvarsson et al., 2010). Furthermore, bad orientation strategies affect the anxiety levels of humans (Lawton, 1996). Hence, it is important that the facility focuses on lowering the stress and anxiety levels of the tourists, achieving the best possible food experience.

As pointed out the sense of taste is highly active when eating and tasting food, though what is more important to the sense of taste, than the taste, is the sense of smell. Taste theoreticians estimate the nose to be more dominant in the sense of taste than the taste bud of the oral cavity, due to food components escaping through the soft part of the palate to the nose, where the components will be decoded by the olfactory organ, which is very essential to achieve a taste of the specific meal (Fisker, 2003). Furthermore, food odors create an increased appetite and especially an increased sensory-specific appetite, meaning that the guest will get a higher appetite towards the food creating the specific food odor (Ramaekers et al., 2014). The sense of smell, therefore, contains the ability to intensify the food experience.

Looking into customer satisfaction of restaurants, the ambiance, or so to say atmosphere, is an essential part of the experience, though the atmosphere is covering a broad perspective of several factors synthesizing into the perceiving of a room/area, provoking a set of feelings. Lighting is an element that highly defines the ambiance/atmosphere on an area, though according to Ryu and Jang, lighting must be defined as its element due to the high importance of how the customers perceive the room (Ryu and Jang, 2008). Lighting can be used to create a specific atmosphere, though also be a decision-making tool for the choice of food. According to Hoonhout bright lighting, will influence the guest to choose/ want a lighter and less fatty (Hoonhout et al., 2009), nudging the guest into the choice of food.

VALUE-BASED DESIGN GENERATORS

Odor

Odors inflect the appetize of the guest while taking a significant role in the tasting process of the food. The restaurant must therefore oblige to the distribution of shellfish food odor, resulting in an expectation of the specific food, creating a more intense food experience when the food is being consumed.

Wayfinding

An easily navigable wayfinding system must be utilized, minimizing the anxiety of guests in the area.

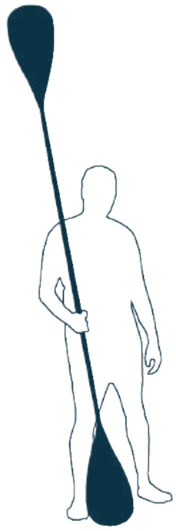
Lighting

A view towards nature together with its related sounds reduces the cortisol level, and thereby the acute stress response, of the guest in regard to being placed in a built environment, thus the most optimal food experience will be achieved.

View towards nature combined with the sound of nature

The restaurant should have bright lighting by day and night, nudging the users into a lighter and less fatty food, like shellfish.

5.3.2. PERSONA ROWER



DATA

Gender	Male
Age	26
Job	Engineer
Type	Kajak
Years of practice	9 years

INTRODUCTION

Søren is an experienced water sports practitioner and is a member of Morsø Rowingclub, and has sailed everything from, dinghies, kayaks, inriggers, etc. Furthermore, Søren is also an experienced wakeboard practitioner, though has his focus upon kayaking. The sport primarily takes place on the water, yet a lot of the preparation, reparation and social interaction takes place on the shore and at the clubhouse. The existing clubhouse is an overstatement to Søren, as it looks like an old parcel house from the '60s turned into boat storage and common room. The building is worn out in every single way and is not a place you want to use for social interaction, which is why most of the common activities are held on the front porch. Søren points out that the clubhouse has no value of attraction of some sort compared to other association facilities. Søren can use the clubhouse day and night but chooses to hang out elsewhere in the city because the clubhouse does not provide optimal functionalities for social interaction. Mainly because the atmosphere of the clubhouse is old, worn-out, moldy, and smelly. Besides, he avoids leaving his personal belongings in the clubhouse as there are no lockers.

In the beginning, Søren did not feel a social inclusion when he started to row, blaming the clubhouse facilities for being unwelcoming, with a lack of social programmed areas. Meaning, that on the cold and rainy days, people drove home directly after training to restore heat instead of socializing in the clubhouse. After each training, he felt alone which affected his mental state of mind, making him want to quit, which was something that changed when he became closer to the other rowers.

These missing stimulating factors of the clubhouse might be the partial explanation why Søren, in the beginning, felt socially absent, and why other people in general travel to other clubs, outside Mors, practicing water sports. Hence, the water sports center should have more value of attraction, advantageous functionalities, and some attractive spaces for social interaction.

KEY PROBLEMS

Misaffordance

Bad organized boat storage and indoor training facilities. The building program is too tight and dysfunctional, and unfit for pre- and post-training activities.

Personal

Bad deposits opportunities for personal belongings during training or competitions.

Social

No attractive rooms for social interaction before, during and after training sessions. Early establishment of strong social ties would have removed the feeling of quitting the sport.

DISCUSSION

Associations are created for social purposes, which is why the clubhouse facilities must accommodate the members in a socially sustainable way. Social sustainability takes departure in the mental and physical conditions and attempts to improve the welfare, well-being, and safeness of the individual. According to the study 'Making Healthy Places' by W.C. Sullivan and C. Chang, strong social ties reduce mortality, suicide rates, and the fear of crime. Besides, it causes better physical health (Dannenberg et al., 2011). The study concludes that architecture can decrease aggression, violence, mental fatigue, psychological distress, stress, depression, by creating a safer and more conducive environment for social ties to occur. Besides, the study concludes that designing for physical activities can prevent stress and depression.

When designing the environment, the primal human survival 'fight and flight' instinct should be taken into consideration. This instinct is a quick, pre-cognitive, rapid assessment of a shape, space, or environment based on its orientation and proportions, also called the 'global information' (Nanda et al., 2013).

Especially the locker room and the boat storage area become a part of a ritual, facilitating the transition from passive to being active – and the opposite way around. In these two rooms, people gather, changing clothes, and preparing themselves for what is about to happen. Besides, it is also here the members talk to each other, where the room becomes the conducive platform for social conversation.

'Affordances' is the mental and physical configuration between user and object (Evans and McCoy, 1998). Søren describes a 'misaffordance' between the existing boat storage system and himself. Also, he demands the possibility of depositing his personal belongings in the clubhouse. The 'misaffordance' occurs because the functionality of the existing boat storage contradicts his expectations of a smooth interaction between himself and the composition of the storing system. Misaffordance triggers negative reactions like frustration, annoyance, and in extreme cases hostility and helplessness (Evans and McCoy, 1998). Hence, addressing the processes of launching the boat, from the storing system into the fiord, prevent Søren and other members from being frustrated.

VALUE-BASED DESIGN GENERATORS

Functionality

A more coherent relation between the boat storage and the user to accommodate the struggles of storing a boat. In addition, easy accessibility from the storage area to the fiord. This will prevent conflict and unnecessary stress related behavior.

Social sustainability

Spaces with social programs, providing a good overview, good lighting, and good orientation, creating a feeling of safeness and a more conducive environment to establish strong social ties. In addition, create spaces for physically activity, prevents the human being for depression, contributing to a better social interactive foundation.

Deposit

The facility should provide lockers for the user to store personal belongings such as phone, wallet, keys, but preferably also stand up paddling boats, safety west, wetsuits and gear.

Transition

The locker room and the boat storage room should have a welcoming atmosphere, address the transition from being dry to become wet, and the opposite.

5.3.3. ADDITIONAL USERS

Preliminary:
Besides the personas, a wide range of other users is also represented in the building. The following pages the additional users are briefly presented together with two design generators from each association/user (despite the rowing association due to criterias presented in the persona) together with sizes of their specific vessels. These measurements will be used throughout the design process.

Rowers
The association 'Roklubben Mors' will be an annual user of the center, where during the summer they are mainly using the changing room and kayak storage facilities. During winter they are mainly using the fitness room equipped with rowing machines to maintain their form throughout the offseason.

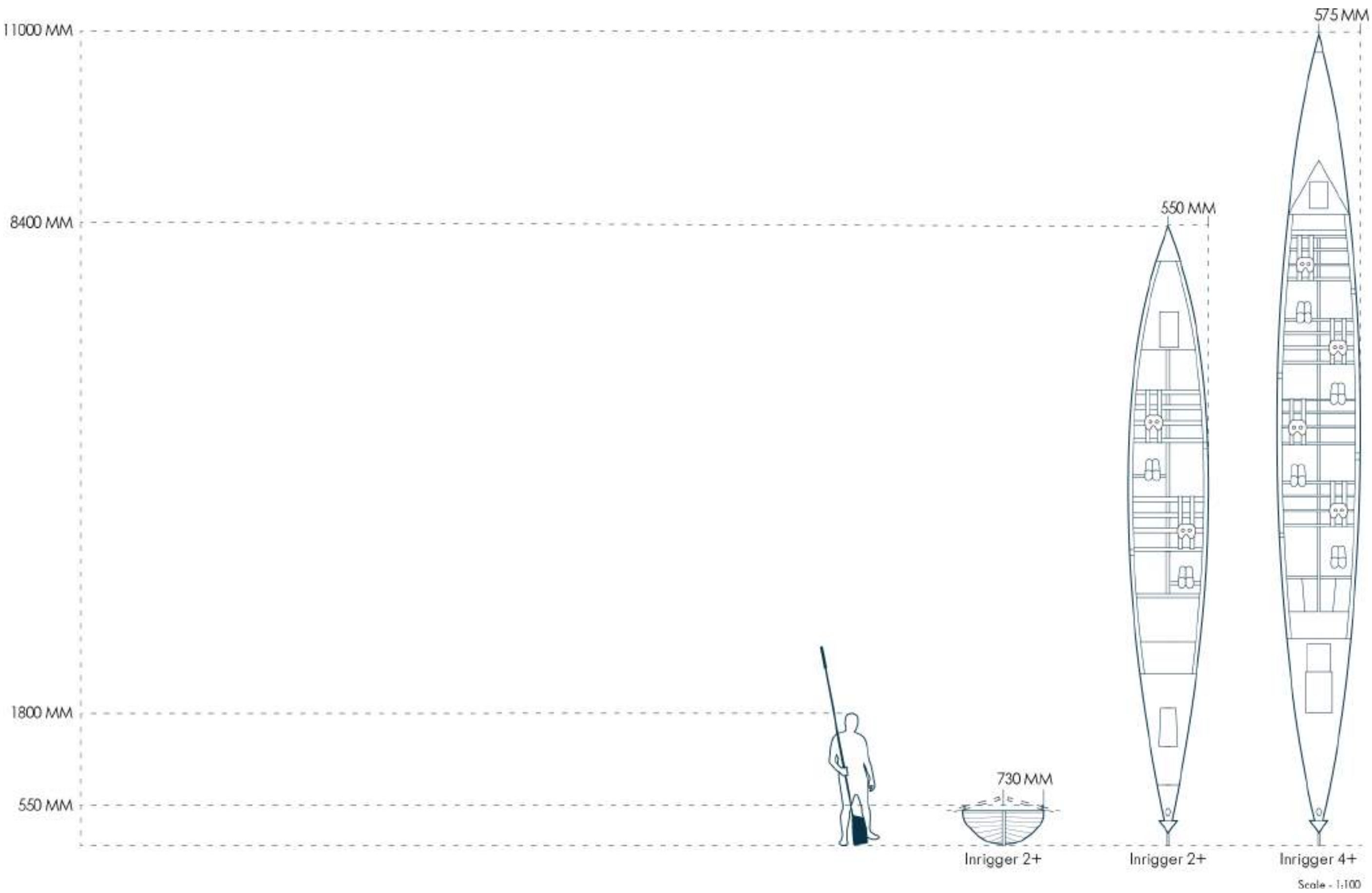


Figure 23 Inrigger sizes

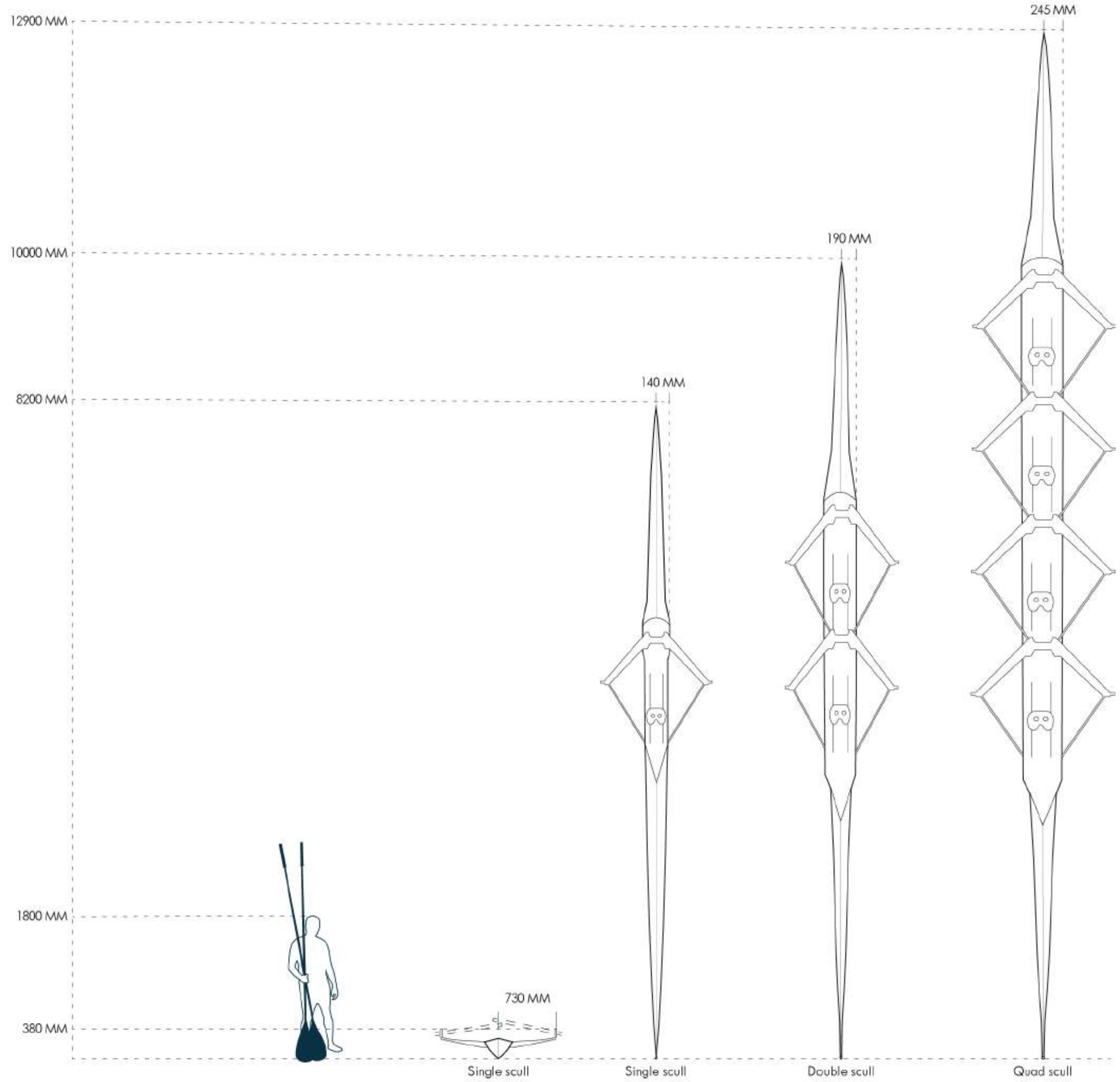


Figure 24 Outrigger sizes

Primary school students

The primary schools will use the center facilities in regards to open schools with the aim to create diversified teaching. The primary schools will utilize the facilities through biology lessons, but also give the students an introduction to water sports, through their physical education. The primary schools will mainly be using the center through the summer months.

Design generators

Safe access to calm and shallow waters.

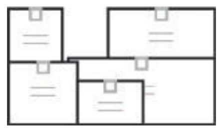
An area where the students can meet and get information/be taught.

Youth school

The youth school 'Ungdomskolen Mors' attends various activities on and off the water, which is why outdoor programming is important to this specific association. Besides the kids attending the different events, the staff will need a small office for coordination and planning. Furthermore, several storage units will be needed. The youth school is only active during summer and late/early spring/fall.

Design generators

Outdoor facilities as an outdoor kitchen, grill/bonfire area, roofed terrace, shelters, etc.



Storage units for kayaks, SUP's, RHIB, wetsuits, life jackets, etc. .

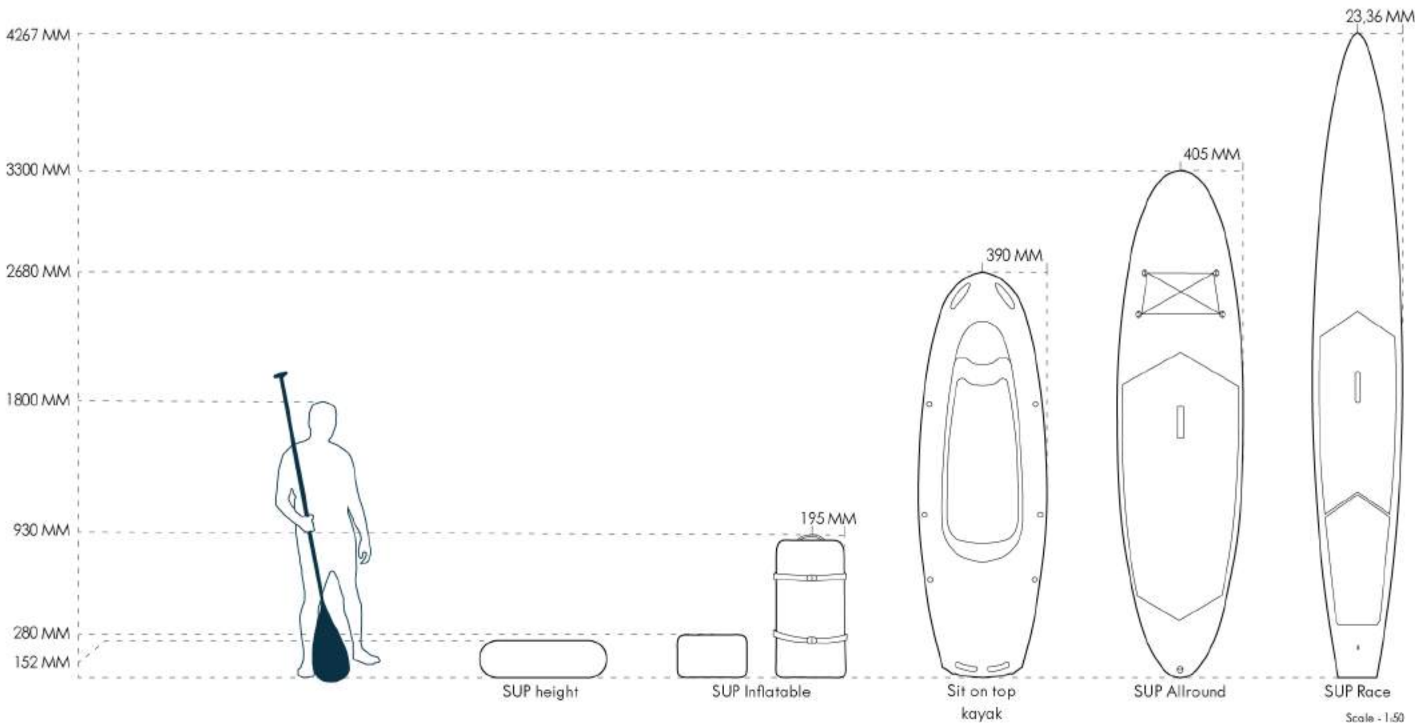
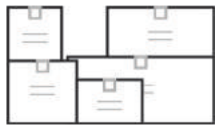


Figure 25 SUP and 'Sit-on-to' kayak sizes

High school student

Morsø Highschool's sports college aims to utilize the center annually, with the aim to teach the students of life by, on, and in the water. It's important for the high school to introduce the students to the social cohesion of sports facilities. Furthermore, by introducing the high school into the center it is also possible to expand the existing physical education with water sports.

Design generators



Storage for kayaks, life jacket, and snorkeling equipment

Facilities introducing the students to the social cohesion in and between the associations in the building.

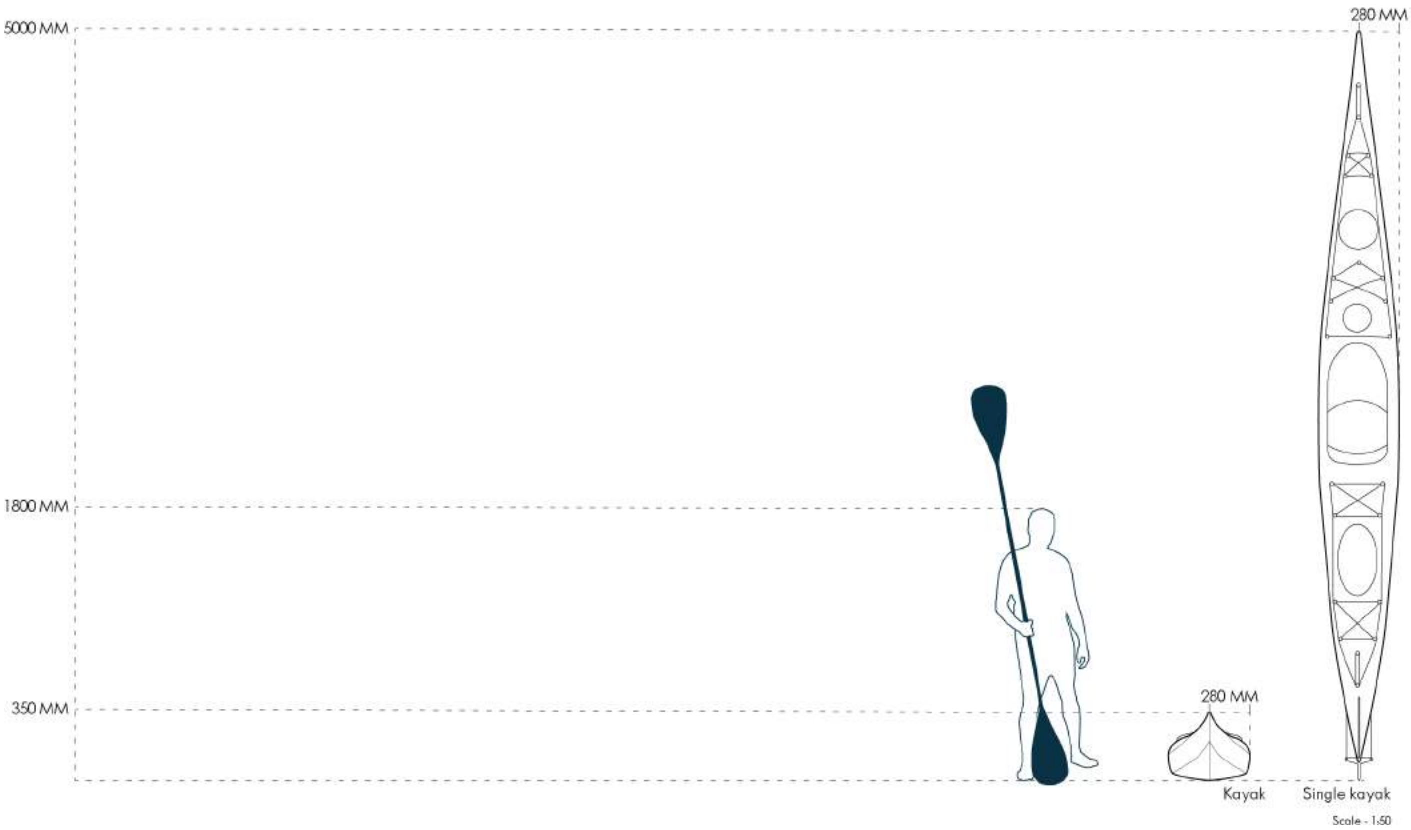


Figure 26 Kayak sizes

TOURIST

A tourist of the water sports facility can be everything from inhabitants of Morsø to visitors coming from far away. What is common for these people is the wish to try water sports. This could be at a newcomer or experienced leveled. Arriving as a tourist it is important to have an easily navigable area together with lockers for safekeeping.

Design generators

Toilet facilities, locker rooms with shower, and lockers for safekeeping of personal belongings.

The navigation of the area should be clear.

DIVER

The diving club 'Krabben' is an annual user of the facility. Through the summer season, the club is mainly preparing gear and themselves for diving. The preparations are mainly done through changing into a wetsuit and checking diving bottles, etc. before carrying these onto the Rigid-hull inflatable boat [RHIB]. Throughout the winter season, the center facility will be used for theoretical teaching.

Design generators

A room to be facilitating theoretical diving lessons.

Short distance between the diving storage and RHIB garage.

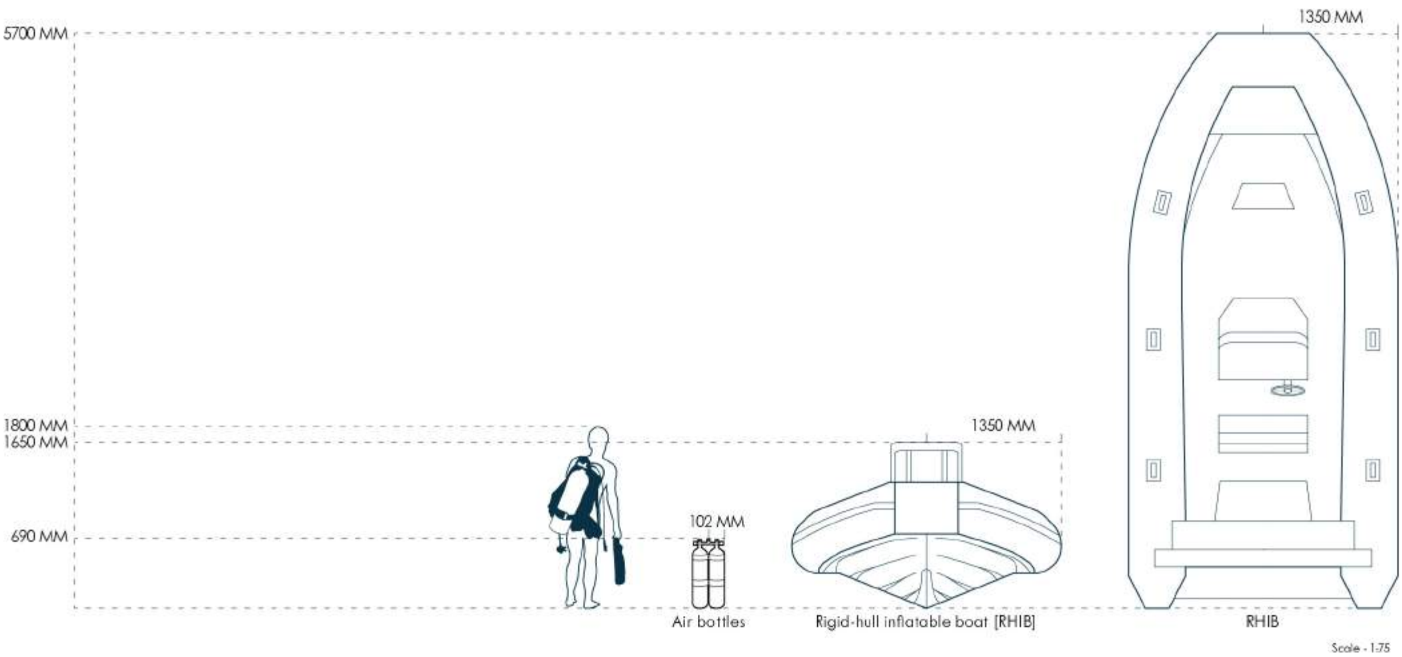


Figure 27 Diving equipment sizes

Bather

The bathing club 'Året rundt' aims to engage in bathing annually together with raising awareness of bathing in nature. Furthermore, the association has a focus to show and experience the social bonds with other club members in the presence of nature in all kinds of weather (Året Rundt, n.d.). Social cohesion is an important factor for the club members.

Design generators

A sauna is needed during the winter months.

Easy access from club facilities to water.

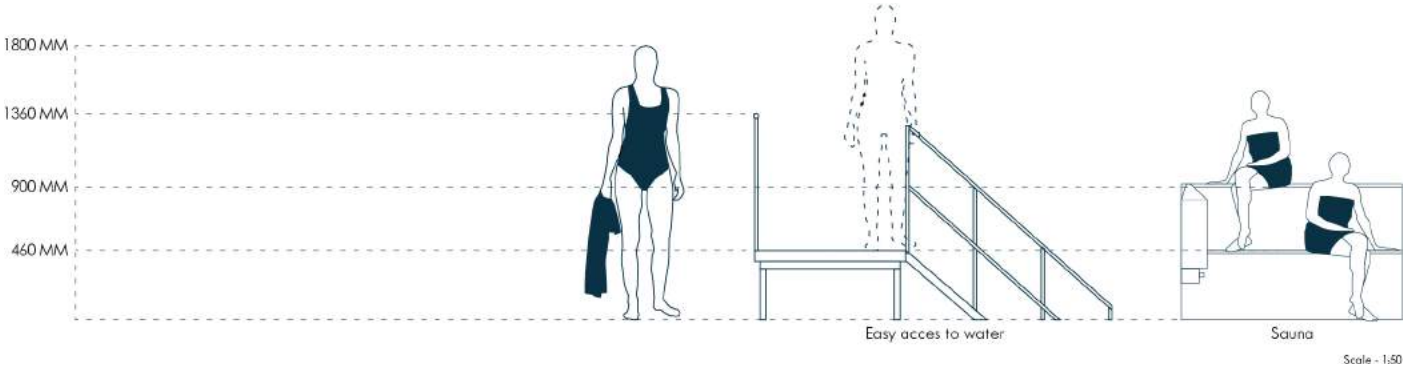


Figure 29 Bathing facility sizes

Wakeboarder

The wakeboard association 'Wakeboard Mors' is a newly started association that has recently started establishing itself on the project site. The association is storing their equipment in trailers, containers, etc. placed on site. Wakeboard Mors do not need a club room, but needs access to storage facilities with a short distance to the cable system, pulling the wakeboarders. Furthermore, the association will need a safe and easy access to the water, replacing the present alternative access point.

Design generators

Storage area for rentable and private wakeboard equipment, together with changing facilities.

Easy access/exit to the start ramp.

Figure 28 Wakeboard equipment sizes

THE SHELLFISH FESTIVAL

The Shellfish Festival is an annual event which expected 20.000 guests on the harbor of Nykøbing in 2020. The festival aims to inform the guests of the 'from fiord to table'-concept and the overall interest in shellfish (Skaldyrsfestival, n.d.). The association would like the possibility to utilize the restaurant, hosting smaller events throughout the year, but also the possibility to utilize the restaurant as a dining area during the shellfish festival. The festival has a fixed date, the first weekend of June, and starts of the tourist season on Mors.

Design generators

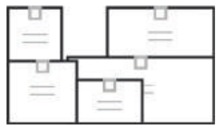
Expansion of the restaurant outdoors, creating more seating possibilities

Visual view to the fiord, intensifying the ideology of 'from fiord to table'-concept.

CLEANING PERSONAL

The cleaning personal keep the building clean and in orderly condition. This includes performing smaller maintenance activities, gather and empty trash, service, and cleaning facilities, etc., while being responsible for the overall cleaning and hygiene of the facilities (Careerplanner, n.d.). The cleaning personal has flexible working hours depending on the specific facility.

Design generators



Storage room for cleaning articles connected to a delivery entrance.

Robust and easily cleanable surfaces.

WAITER

The waiter/-tress is responsible for approaching the guests, taking orders, and serving food and beverages to guests. This includes making sure that the guests are enjoying their meals, removal of dishes and cutlery for cleaning, and informing customers of their meals (Careerplanner, n.d. a). The waiters are working within opening hours of the restaurant

Design generators

Direct access from the kitchen to the dining area.

Waiting area for guests to be met by the waiter.

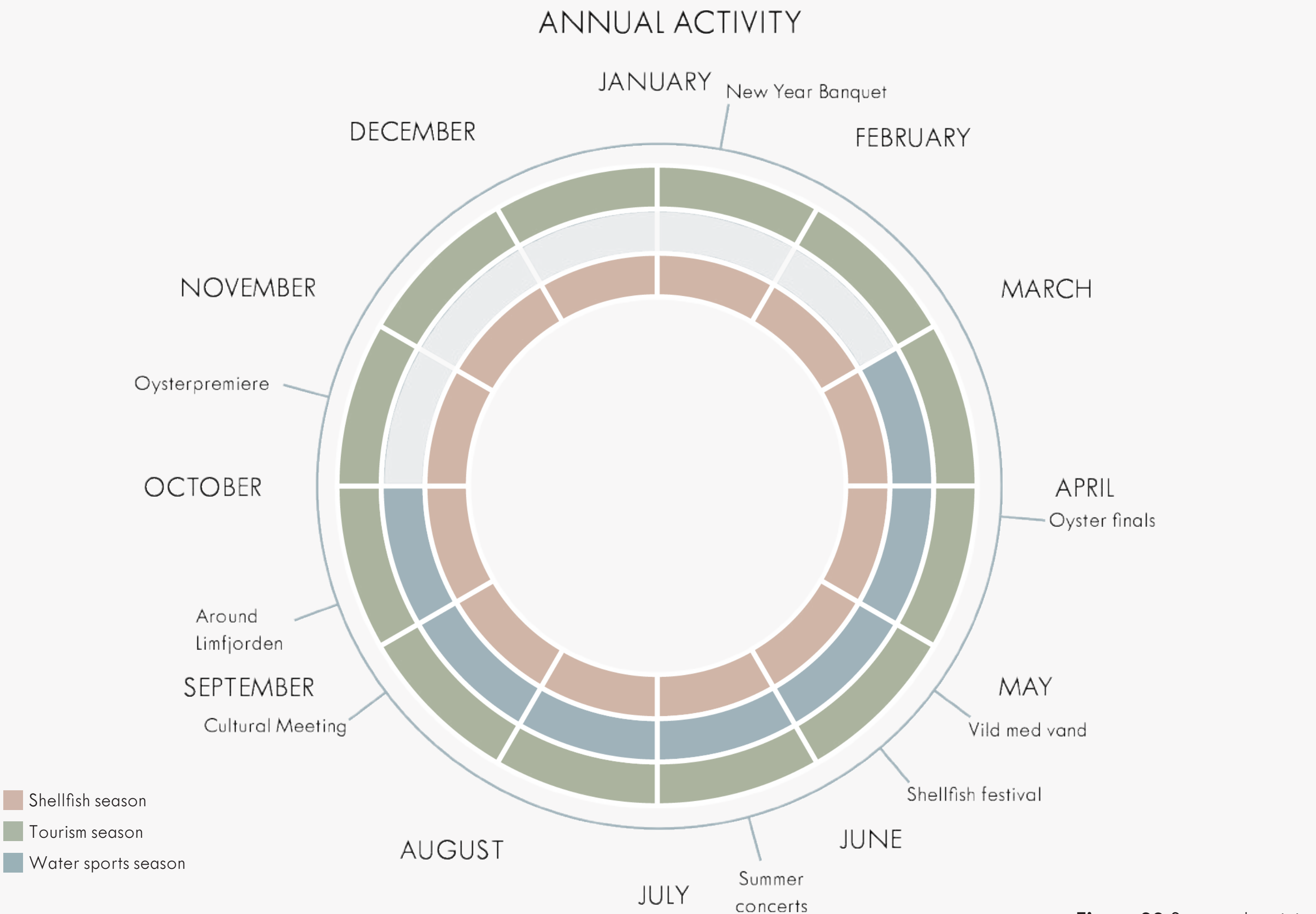


Figure 30 Seasonal activity

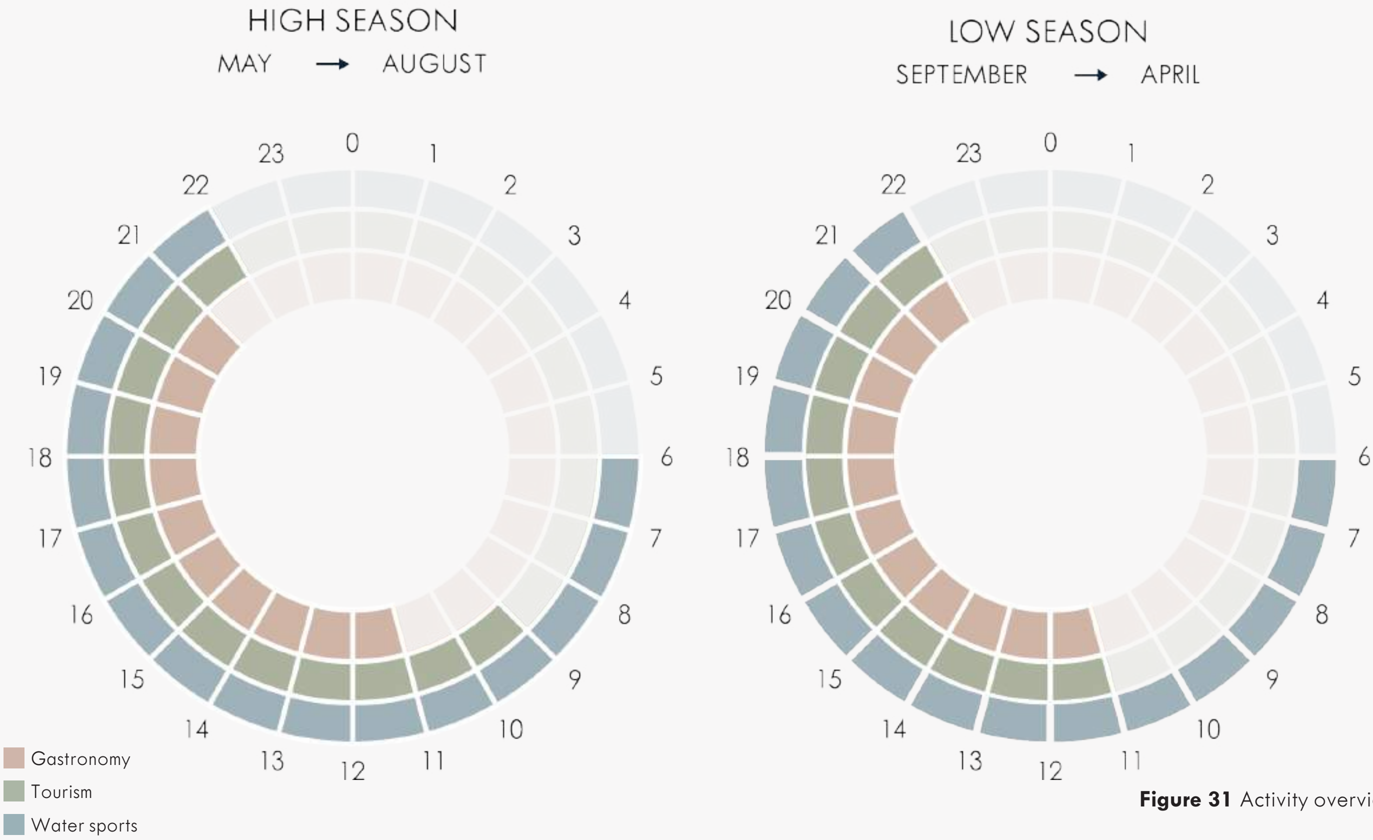


Figure 31 Activity overview

6.0 TYPOLOGY

The city of Nykøbing Mors and its urban and historical elements such as architectural traditions, the built environment, and future projects in and around the building site are to be analyzed.

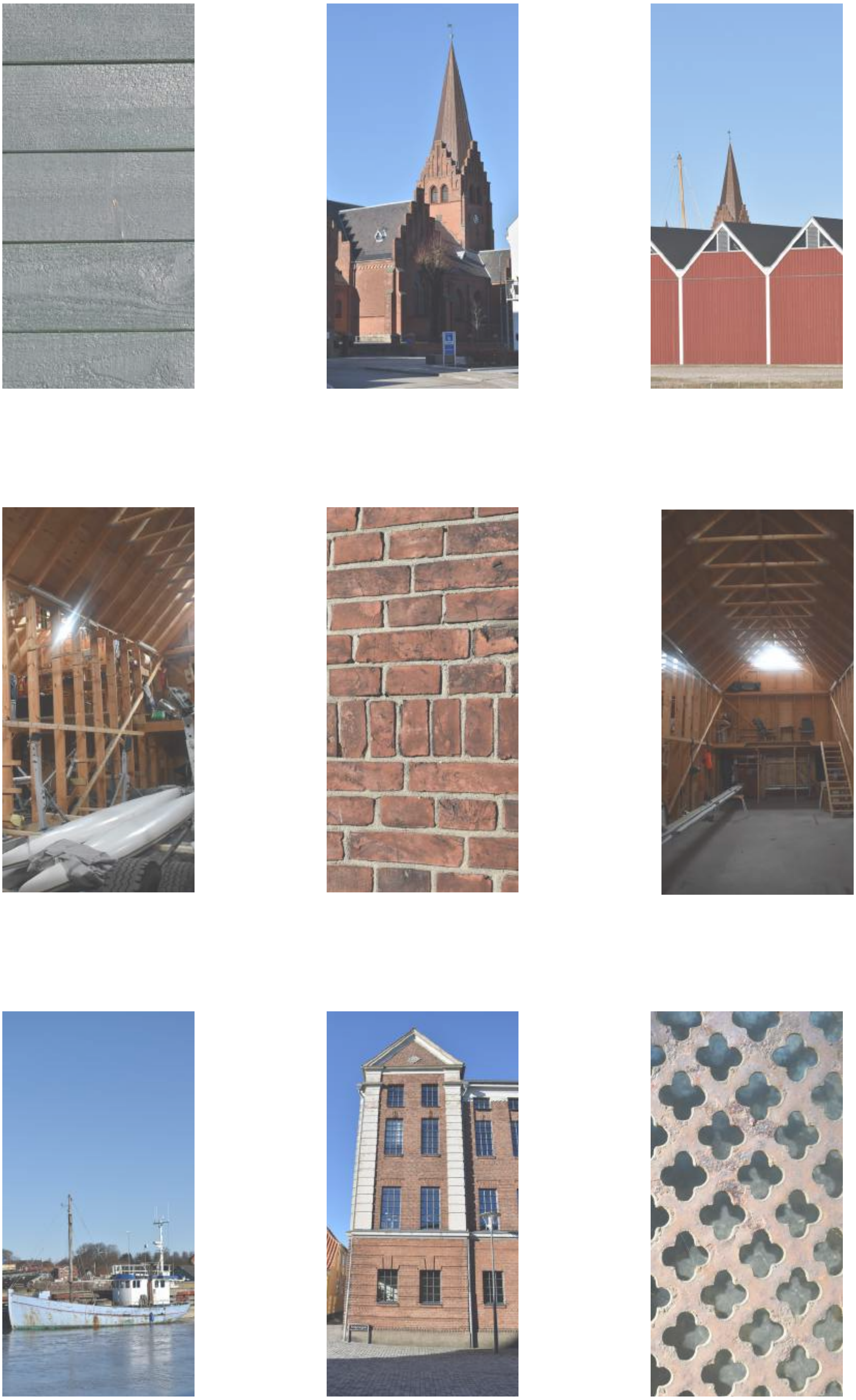


Figure 32 Field trip pictures

6.1. HISTORY AND CULTURE

PRELIMINARY

To get a deeper understanding of the area we are designing within, which in this case is Nykøbing Mors, we need to get a historical understanding. This understanding is used as an inspiration towards the programming, potentials of the building together with an understanding of the context the building will be placed within.

PAST

Nykøbing Mors had its first appearance as a market town in year 1299, though the exact time of its origin is unknown. Located on the isle of Mors situated in Limfjorden, the town was the center for trading and fishing. Furthermore, the soil, on the isle of Mors, consisted of a rich clay mix, which made the island suitable for agriculture, an especially the production of corn. However, the trading of Limfjorden was controlled by the harbor city, Aalborg. The city of Aalborg had a key position at the only entrance to Limfjorden and utilized this position to make earnings from trading vessels departed of the Limfjord area.

The city managed to maintain a profitable trading route, consisting of fish and crops, through the port of Aalborg until around year 1600, where Nykøbing suffered from devastating fires and one of the biggest trading products of Limfjorden, the herring vanished.

In the end of year 1700 Nykøbing Mors, with a population of 500 people, mainly exported corn, though difficulties with storms and waterflow were sanding-up the channels at Løgstør and Hals (Den Digitale Byport, 2012), making the transport of corn difficult, placing Mors in a critical financial situation.

Until the year of 1825 the towns connected the Limfjorden were dependent on the fishing industry together with the connection to the Kattegat. In 1825 a storm hit the west coast and broke through Agger isthmus, opening a travel route to England in the west, who in the 17th century invented cast iron. Through the upcoming years, several storms changed the isthmus' geographical placement, making the access point towards the North Sea difficult to navigate. Besides the new Trading position of Nykøbing Mors, the town faced new challenges, effecting the fishing industry enduringly. When the Agger isthmus broke, the ecosystem of Limfjorden was changed from the existing brackish water to salt water. This change in water flowing through the fiord, also change the conditions for fish and invasive species in the fiord. This meaning the fishermen, should face a new and unknown reality, whereof saltwater oysters were one of the new invasive species.

The new trading route, with access to England, accelerated the industrialization which resulted in a stabilization of the Agger isthmus in 1860's. Iron foundries started to emerge in the market towns, creating a market for coal and iron, which was the main ingredients of cast iron (Poulsen, 2019). Nykøbing Mors had an increase of inhabitants from 500 people in year 1790 to 2200 people in 1860 (Den Digitale Byport, 2012), as a result of the economic growth by the introduction of the iron foundry.

In the 1850's, a development was scheduled for the harbor of Nykøbing Mors complying to a bigger trading market, which became the best harbor of the western part of Limfjorden. With a development of the harbor N. A. Christensen saw an opportunity, with the harbor expansion, to found N.A. Christensen & Co. Iron foundry in 1853. With a placement next to the harbors, the coal and iron imported from England, had an easy access to the factory (Poulsen, 2019). Besides several other factories, as a product of the industrialization emerged e.g. tilery, cigar- and tobacco factory, coulter factory etc. (Trap, 1906). The factories were often constructed in bricks, and still stands this day today in Nykøbing as a cultural heritage. Furthermore, the changes in the ecosystem of the fiord introduced the European oyster, which resulted in an explosive increase of oyster fishing, culminating in a catch of 7,5 million oysters during the year of 1872.

PRESENT

The new fishing strategy was not sustainable driven, leading to a collapse, where the occupation as an oyster fisherman entered a precarious future. A new strategy was introduced at Nykøbing Mors, where oyster spawn was placed in the fiord, trying to start a new era of oyster fishing, until 1920 where the industry once again collapsed. Oyster and shellfish started to be a niche fishing, and not profitable (Poulsen, 2019). Nykøbing Mors, increased its population to 8200 people in 1920 (Den Digitale Byport, 2012), as a result of the new fishing industry.

Post industrialization Nykøbing didn't expand it's borders or industry, resulting in a still stand of its physical size, population and economic growth (Den Digitale Byport, 2012). Nykøbing

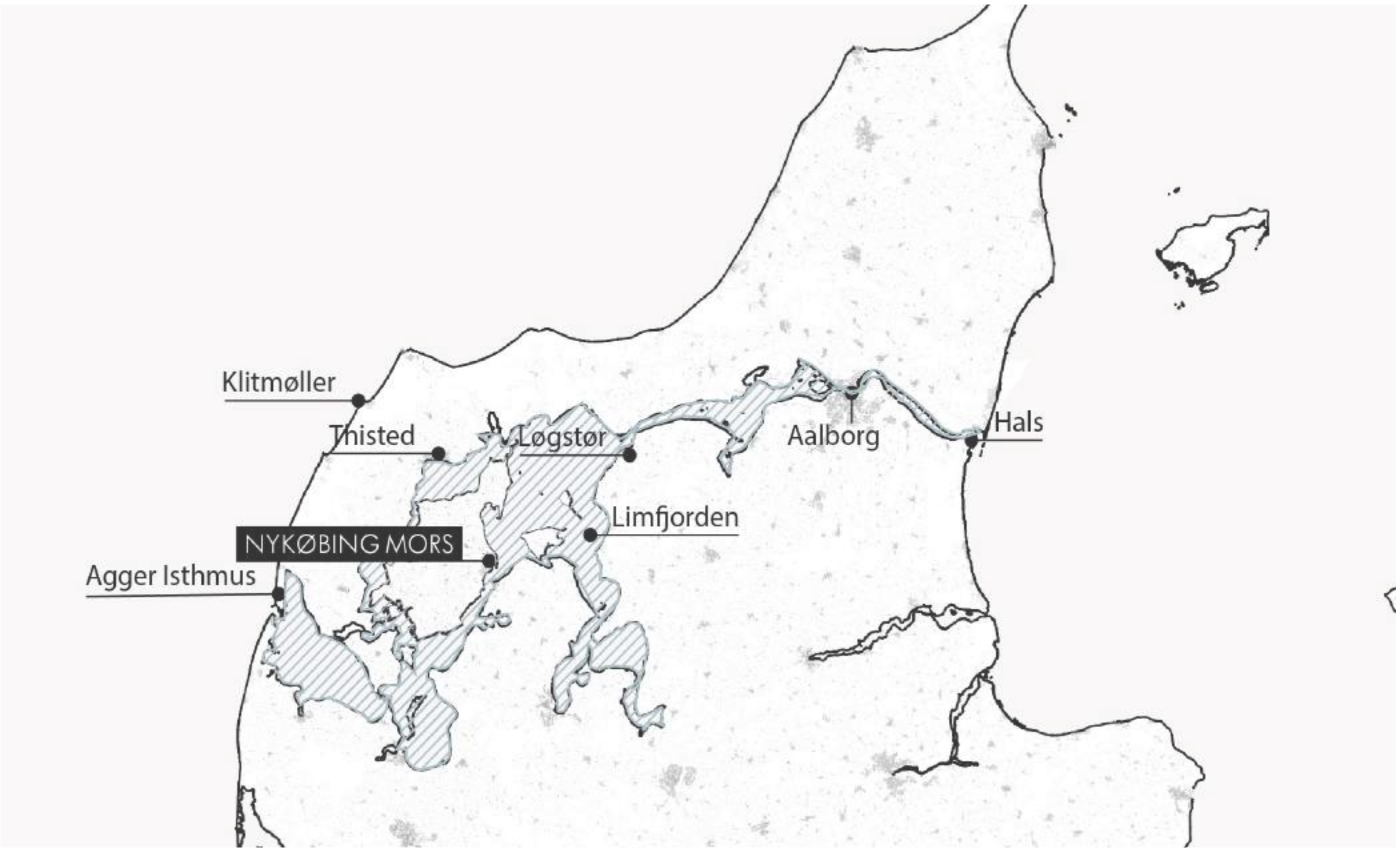


Figure 33 Historical locations

was a market town, until the term was terminated in the 1970 municipal reform, where Nykøbing Mors was announced as the main city of the Morsø municipality (Indenrigs og sundhedsministeriet, 2005). During the 1980's the European oyster once again was fishable in Limfjorden, and shellfish became the dominant resource of Limfjorden compared to fish (Poulsen, 2019), where the European oyster is a world recognized food product. With its strong position as shellfish farmers in Limfjorden, Nykøbing Mors is the, self-pronounced, shellfish capital of Denmark, and wants to ratify this position (Morsø Kommune, n.d.). The population of 9600 people in Nykøbing peaked in 1990 (Den Digitale Byport, 2012), making Nykøbing face a new threat against the local society.

The isle of Mors and Nykøbing, has been facing a decreasing population since 1990 until present time. Smaller towns in the rural areas are suffering from urbanization, resulting in people moving away from the rural areas to the bigger cities. Even though Nykøbing Mors have been facing a double urbanization, the population is still decreasing (Nørtoft, 2017), and is expected to stagnate the coming 10 years (Morsø Kommune, 2020). In the meantime, some of the surrounding cities are experiencing growth such as Klitmøller and Thisted, which gives these cities the opportunity to develop the city further, through CHI projects.

FUTURE

The city of Nykøbing Mors is founded upon a long history of major challenges, that forced the population to adjust to several historical situations. The city is now facing the challenge of urbanization, within a geographical area where development is important. Though to create the major developments, the city needs to somehow reverse the descending population of the island and the city. The harbor of the old market town Nykøbing, has been the center of the main supply for the whole island in a 600-years period. The harbor has a long history of life in the shape of local and foreign traders, dock workers, fishing vessels etc., all professions which is highly dependent on Limfjorden and the life herein. Though facing the new challenges as urbanization, the harbor is losing its activity and life. Nykøbing needs a piece of architecture that helps the city growing and at the same time showcasing and bringing back parts of the historical aspects of the Nykøbing harbor.

6.2. LOCAL BUILDING TRADITITIONS

PRELIMINARY

With the aim to create a local material understanding an investigation of the architectural traditions is conducted. Through the investigation knowledge of material composition, colors, and the source of local materials are examined.

The Island of bricks

The isle of Mors has historically had a lack of trees, which resulted in a low amount of buildings constructed by wood, and the ones that were, was constructed with slight timber. Though despite the low amount of wood, the soil stored a high amount of clay, which with the industrialization became the main building material in the shape of red and yellow clay bricks. Throughout history, the brick changed size going from the medieval large brick to the present well-known brick measured 228x108x54 mm. due to the baroque period, which demanded a more detailed building form. The builders utilized the different stages of burned brick and its abilities in specific areas, which matched the specifications of the brick (Morsø Kulturmiljøatlas, n.d.), showcasing an understanding of the brick as a material. Taking a stroll through the central Nykøbing Mors, it is especially the red brick that dominates the city image. The utilization of bricks as façade material creates a specific façade detailing dominated by horizontal though mainly vertical lines. Furthermore, various buildings have been equipped with sand plaster mainly in the colors yellow, blue, and white.

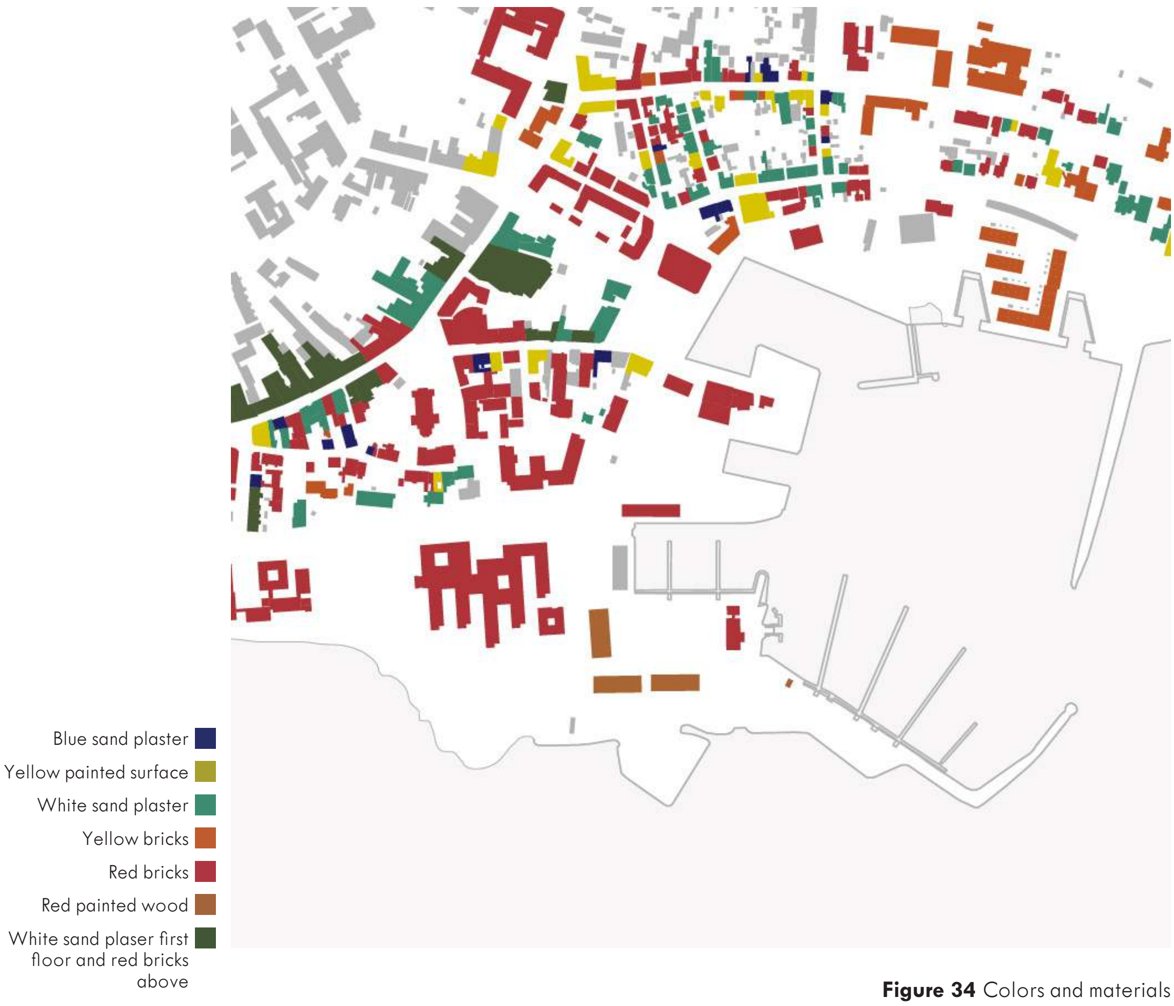


Figure 34 Colors and materials

Figure 35 Field trip pictures

6.3. FACADE REGISTRATION

PRELIMINARY

Investigation of the built environment is conducte achieving knowledge of the existing facade expressions generating inspiration for the center facade. The investigation is mainly conducted through line drawings achieving a thorough understanding of the different facades.

Brick detailing

The different buildings in Nykøbing are constructed with a high façade detailing. The buildings are often built with a detailing principle of a low detailed base, followed by a detailed body ending in an often-lower detailed top, depending on the building and its bay. Furthermore, the buildings are dominated by vertical and symmetrical elements.

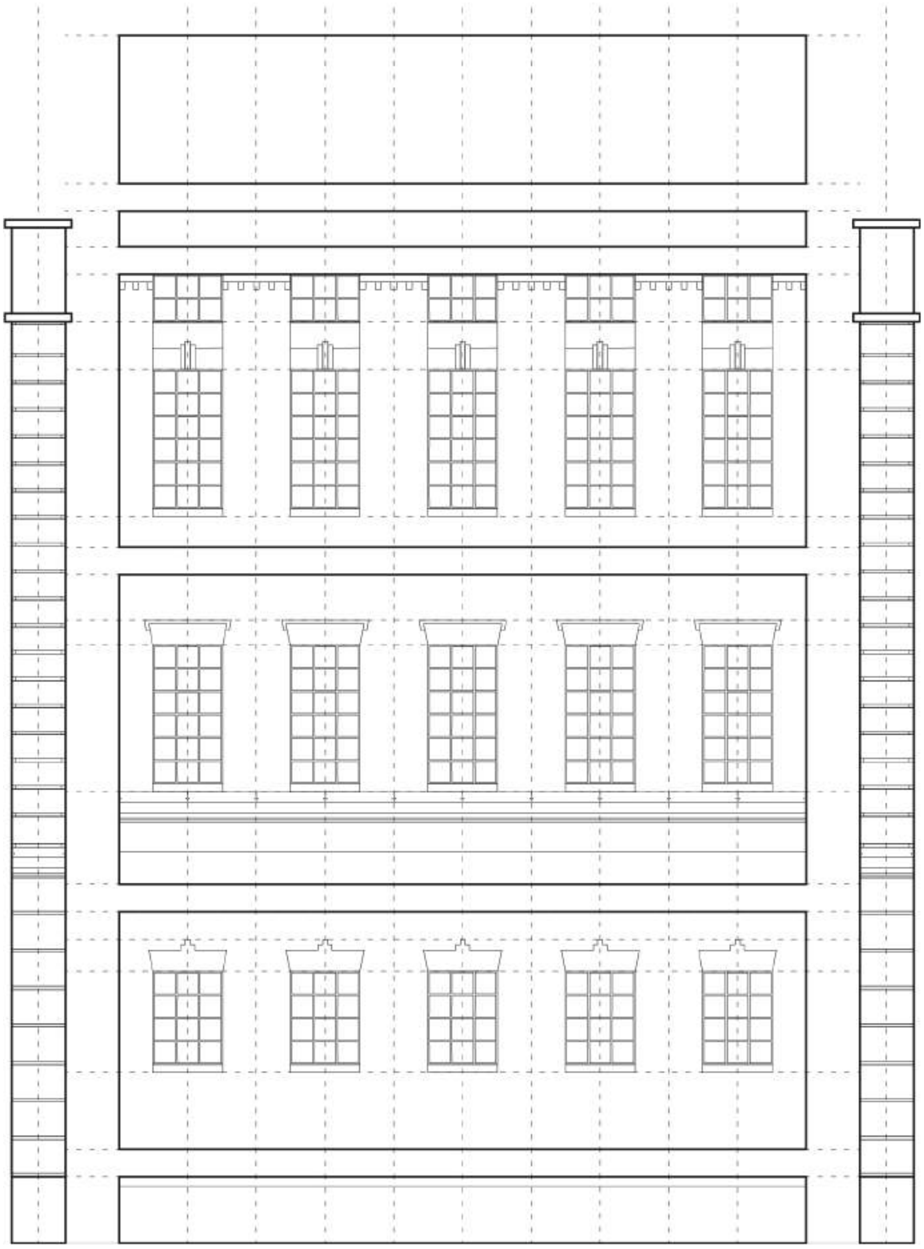


Figure 36 Facade - level of detail

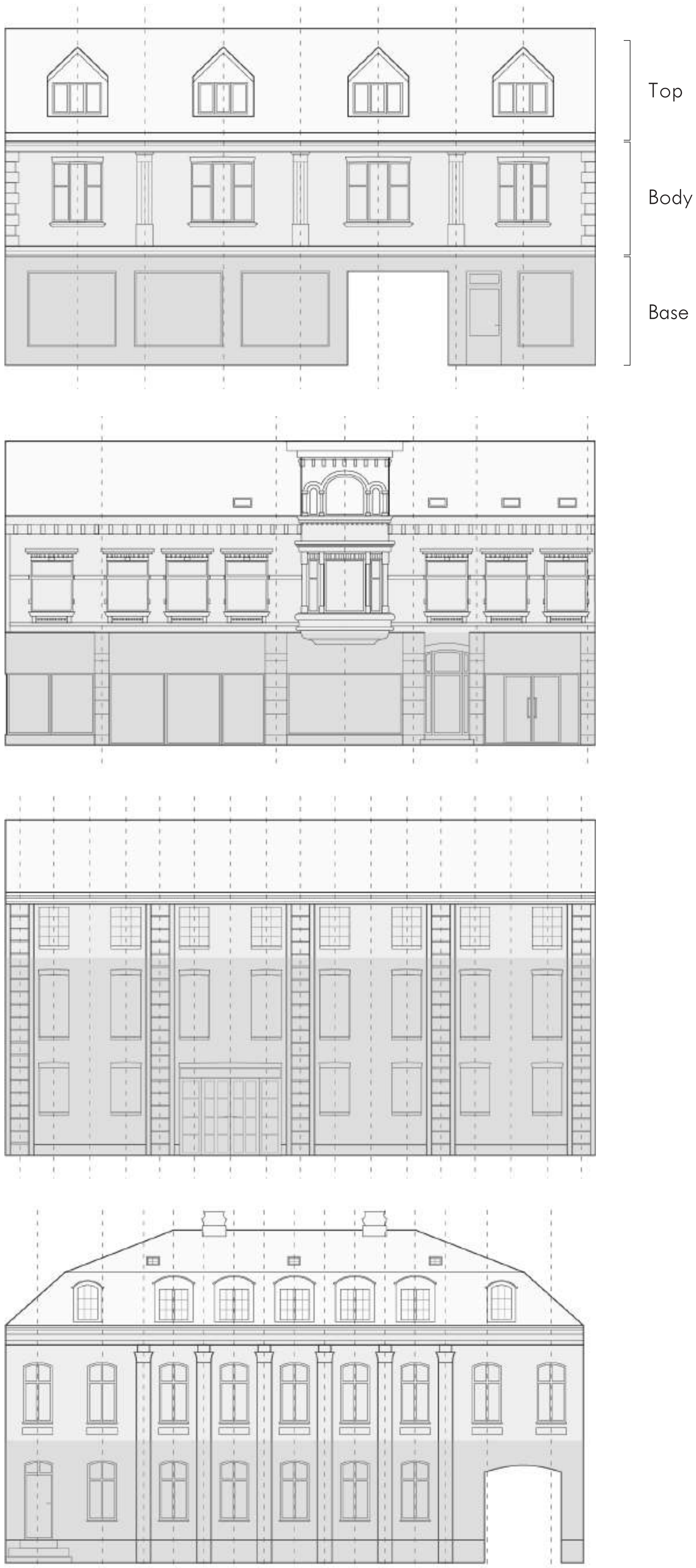


Figure 37 Facade registration

6.4. ATMOSPHERE

PRELIMINARY

This chapter addresses the potential spatial qualities and the experienced atmosphere by the arrival of the project site. Through a combination of the methods 'serial vision' by Gordon Cullen (Ehlers et al., 2010) and describing the atmospheres inspired by 'Genius loci', a phenomenologic approach by Christian Norberg-Schulz (Norberg-Schulz, 1979). The investigation will be used as a guidance tool simplifying the perceived city image.

ROUTE POTENTIAL

Arriving from Jernbanevej, which is one of the main entrances to the city, the path gives a clear vision of the city being connected to the fiord (1), where the project area is exposed at the beginning of the route. Moving along the path the arrival welcomes you through an avenue with trees leading the viewer towards the harbor (3), where the harbor is met as an open area (4). Moving around the corner brings the viewer from Jernbanegade and onto the only accessing road by car towards the project area (5). Where the viewer experiences the fiord being framed between the red boat house and the town hall of Morsø municipality (6-7). Ending up with a view upon the fiord and the project area (8). The final perceived atmosphere is a mix of being connected to the fiord while being located in an abandoned area of the city.

The project area seems disconnected from the city, and contains a positive atmosphere of being connected to nature but also the more negative aspect of being in an abandoned part of the city despite of its prime location next to the fiord.

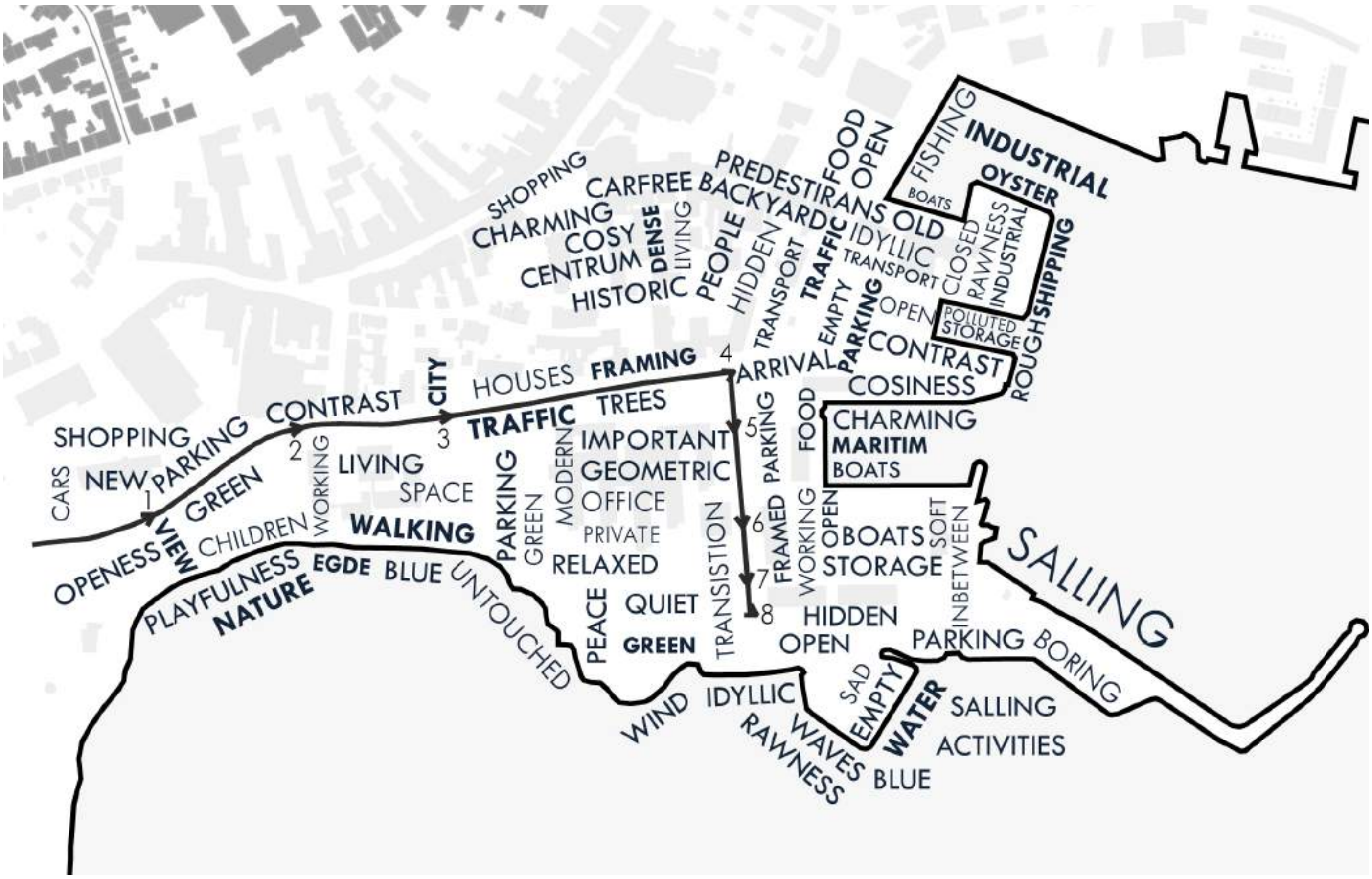
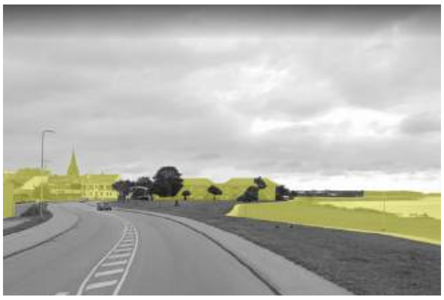


Figure 38 Mappings



1 - close to nature

2 - old and new

3 - nature framing

4 - harbor atmosphere

5 - nature framing

6 - boat houses

7 - nature connected

8 - open nature

Figure 39 Atmosphere

6.5. **FIORD** PROMENADE

PRELIMINARY

Morsø municipality is investing in fiord related projects, with the aim to improve the relation to the fiord. One of these projects is a promenade, having its end close to the project site, which means this project and its possibilities should be analyzed. This analysis should determine how the promenade should be implemented in the design proposal.

Kulturfjorden

With the vision to create a connection between the city and the fiord, Morsø municipality is realizing fiord related projects around the city, such as the project "Kulturfjorden" (Kystdirektoratet, 2020) The project concerns an extension of an existing gravel path alongside Klosterbugten, turning it into a promenade. Along the path, different hubs are located which all have in common to communicate or connect the shore to the fiord, which is seen in a maritime-styled playground, a new bridge for kayaks and crab fishing (Morsø Kommune and Niras, 2008). The project starts at the bottom of Klosterbugten, where most of the project activities are located, where the pathway is supposed to create a visual connection to the fiord ending in front of the city hall next to the project site.

The 'fiord promenade' ends behind the marina, though with no access points to the marina, creating an undefined ending on a gravel road. By introducing this specific project into the storytelling of the 'fiord promenade', the project will take the position as the culminating point, showcasing different activities associated with the fiord.

Figure 40 Focus areas of the fiord promenade

Figure 41 Field trip pictures

7.0 TOPOLOGY

Having achieved an understanding of the culture, it is important to analyze the landscape and its orientation, together with possible difficulties the project area is facing. Furthermore, with the placement just next to the fiord, it is important to investigate the fiord as well as land. This will be done through mappings, macroclimate, topography together with an assessment of the risk of flooding.

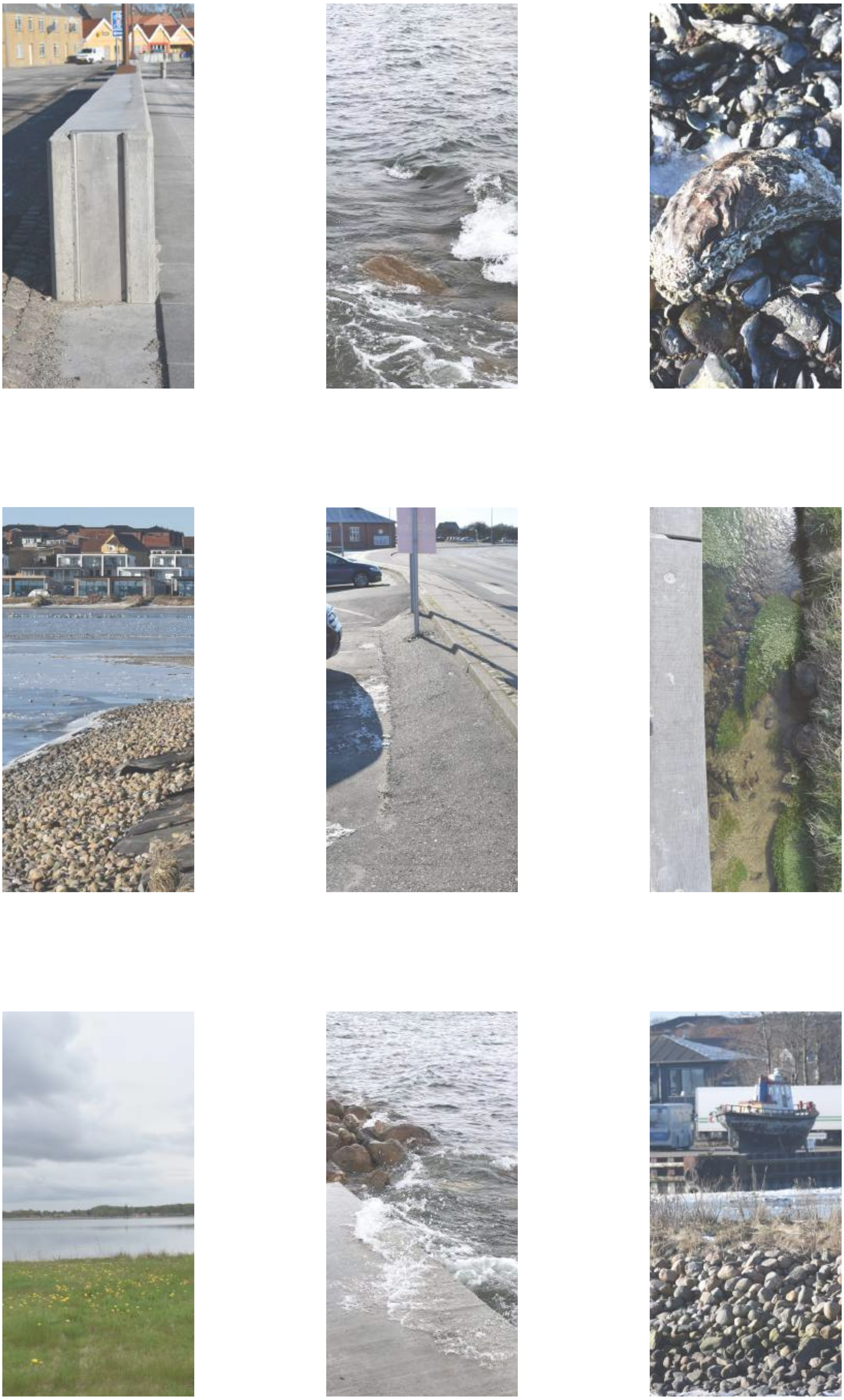


Figure 42 Field trip pictures

7.1.1. MAPPINGS LAND

PRELIMINARY
This chapter will investigate different aspects associated with 'the land' creating a basic knowledge of the built surroundings of the project area.

DISTRICTS
The waterfront area of Nykøbing Mors consists of different districts, where the project site is placed within the marina district. Furthermore, the city center is placed north of the project site, though the pathway towards the center is unclear.

Industry
Residential
Public
City center/shopping
Marina

Figure 43 District

INFRASTRUCTURE
The project area is located alongside an undeveloped gravel road leading towards the marina and its docking areas. Due to the undeveloped road, a low amount of traffic is seen on the road north of the project side. Besides the road, a path alongside the fiord is some of the only leading routes towards the project site, meaning these routes should be of importance.

Less loaded roads
Truck traffic
Loaded roads
Pedestrian
Bus station

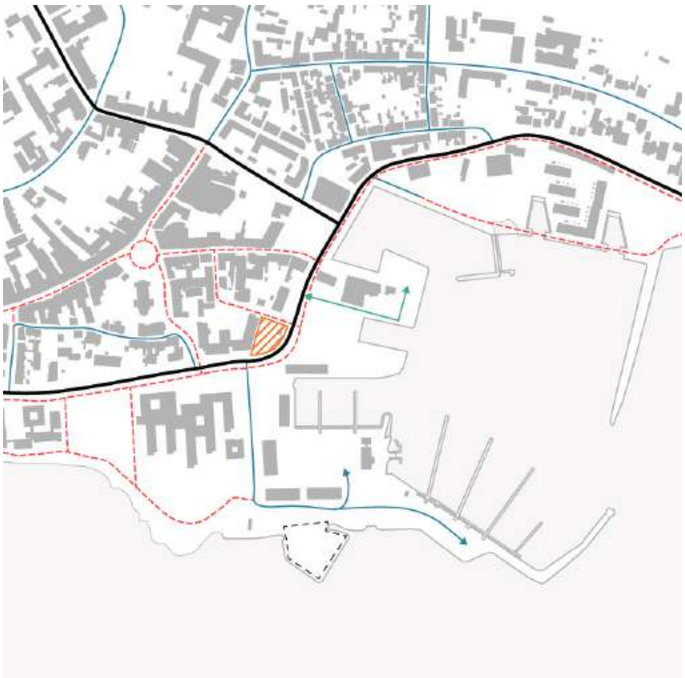


Figure 44 Infrastructure

FUNCTIONS

The project area is placed behind existing boat houses, which creates a wall towards the project area, disconnecting the project area from the marina and city center.

Figure 45 Functions

GREEN & PARKING

The project area is placed in some of the few remaining green areas, towards the fiord, though according to the master plan of Nykøbing Mors the project area is planned to contain a sea sports center (Morsø Kommune and Niras, 2008). Furthermore, several unused parking areas, are in close distance to the project site, meaning that creating even more parking spaces are not of high importance.

Figure 46 Green & parking

7.1.2. MAPPINGS WATER

PRELIMINARY

This chapter will investigate different aspects associated with 'the fiord' creating a basic knowledge of the watery surroundings of the project area.

FIORD DISTRICT

The project area is positioned between the marina and the bight, where the bight represents a protected watersports area, with calm waters.

Fishing port
Storage
Marina
Watersports
Cargo un-/loading area

Figure 47 Fiord district

FLOODING & HIGH TIDE

The industrial harbor area possesses two different flood protections in the shape of curved edged pavement and a geometrical concrete/steel wall. Furthermore, slope protection is utilized at the project site. Despite the existing flood protections, flooding is still a risk of the project site and major parts of the city (Miljøstyrelsen, n.d.).

1 m. hightide
1,5 m. hightide
2 m. hightide
2,5 m. hightide

Figure 48 Flooding & high tide

FIORD INFRASTRUCTURE

With the location towards the bight, the project area is located towards an area with less ship traffic, than inside the harbor. The bight is mainly used as an entrance/exit, through an existing slipway, for dinghies together with Rigid Hull Inflatable Boats [RHIB], where the last mentioned are exiting the bight immediately. Furthermore, the bight is occasionally used by kayakers and stand-up paddlers.

Fishing vessel
Sailboat/Motorboat
Dinghy
Cargo ship
Exit/Entrance to the harbor ---

Figure 49 Fiord infrastructure

FIORD DEPTH

The project area is located towards shallow waters with a depth of 0-1 meters west of the project area and 1-2 meters east of the project area.

0 -1 m. deep
1 - 2 m. deep
2 - 3 m. deep
4,5 m. deep

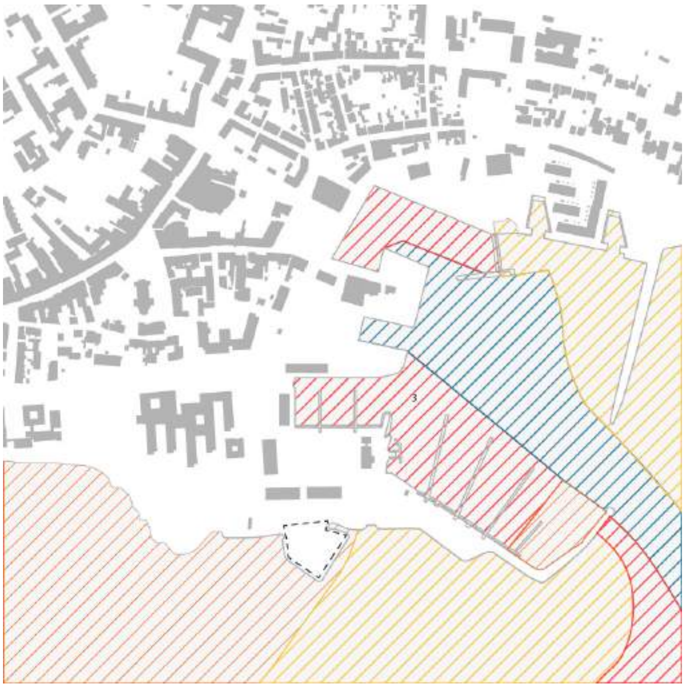


Figure 50 Fiord depth

7.2. MACROCLIMATE

PRELIMINARY

The macroclimate of the project area is an important factor of sustainable design. The sun and wind will have an impact on the building design in regards to heating/cooling and ventilation opportunities.

SUN CONDITIONS

Investigating the daily and annual sun position is relevant for this specific project due to the large user group composition, and the fact that most of the users are performing outdoor activities. This meaning the building mass should not shade eventually strategically placed outdoor areas. Furthermore, it is important to utilize or minimize the amount of energy received within the building mass regarding the indoor climate and the highly associated energy consumption of the building.

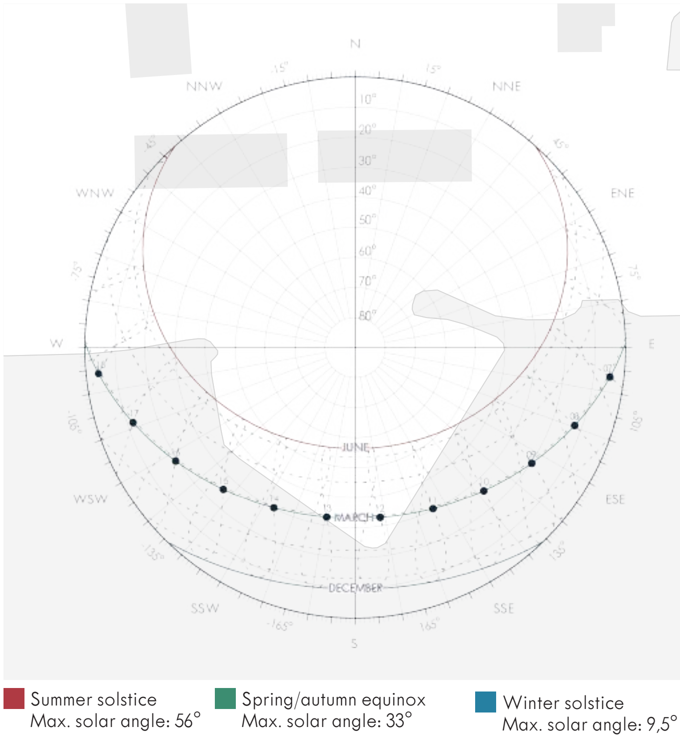


Figure 51 Sunrose

WIND CONDITIONS

Due to the lack of wind registration on the isle of Mors, data from Silstrup west of Mors is utilized. The predominately wind direction is westerly, however, occasionally winds from the east are also present (Ceppelen et al., 1999). Furthermore, the temperature differences from land and fiord, create a higher wind-swept area, than a building placement with no relation to water. The dominant wind direction can be utilized as a passive ventilation strategy, where the wind and the air temperatures are the driving forces for a natural, low energy ventilation strategy.

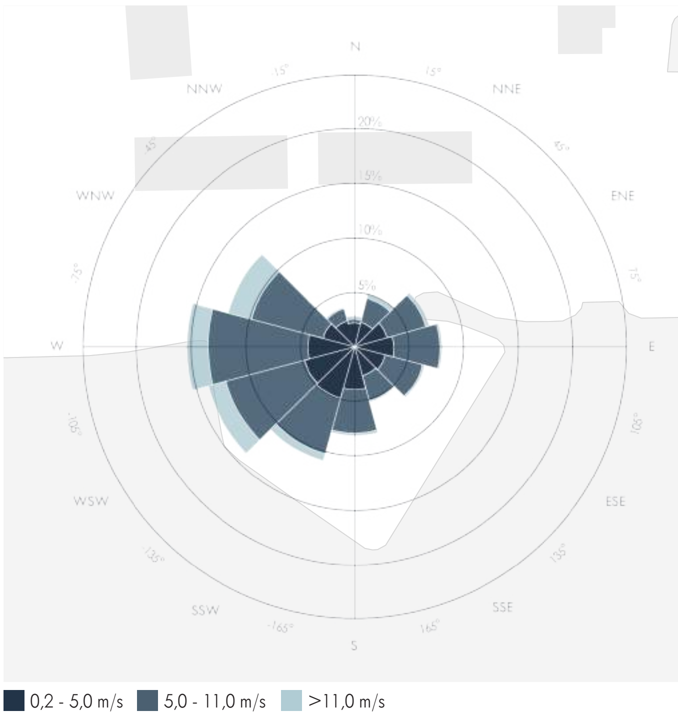


Figure 52 Windrose

7.3. TOPOGRAPHY

PRELIMINARY

By investigating the topography an understanding of the built and unbuilt environment is achieved. This way the analysis will create an understanding of site-related challenges or opportunities in regards to wind and shadows.

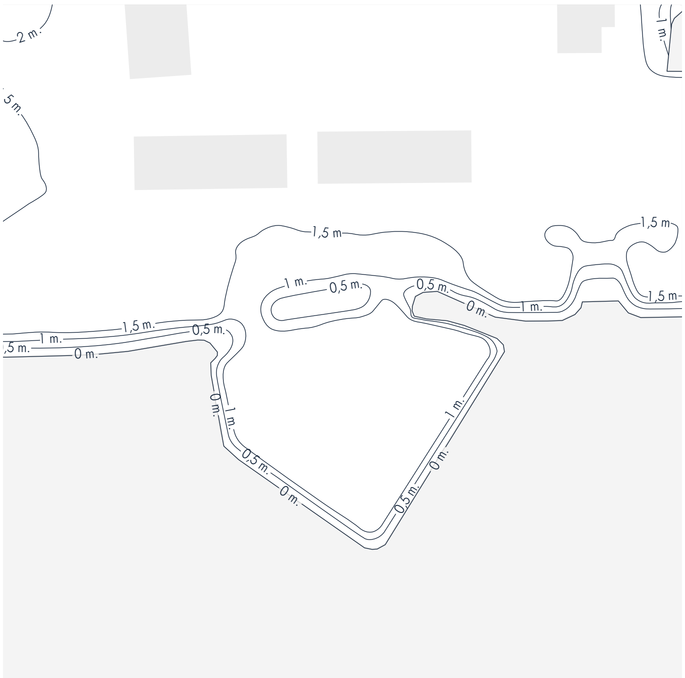


Figure 53 Contour lines

Terrain Category

With a placement in an elevation of 1,5 meters above the water level, except a cavity in the elevation of 0,5 meters above water level, which creates two natural entrances to the area. With the placement north of the project area, and a height of 8,5 meters, combined with a predominant westerly wind direction, the buildings will not affect the solar or wind conditions drastically on the project site.

Approx. 700 meters west of the project area, a housing area is located on top of a smaller hill peaking at 12 meters above water level. The surface including buildings reaches a total height of approx. 23 meters above water level. Even though the bight, with a leeward placement of the hill creating lower wind speeds, the hill will not affect the terrain category of the project area. Due to the distance of the hill the terrain category of the project area is placed in category 2, which defines an area with low vegetation and singular obstacles as buildings or trees (Dansk Standard, 2015). The terrain category defines how the wind will affect the construction of the building.

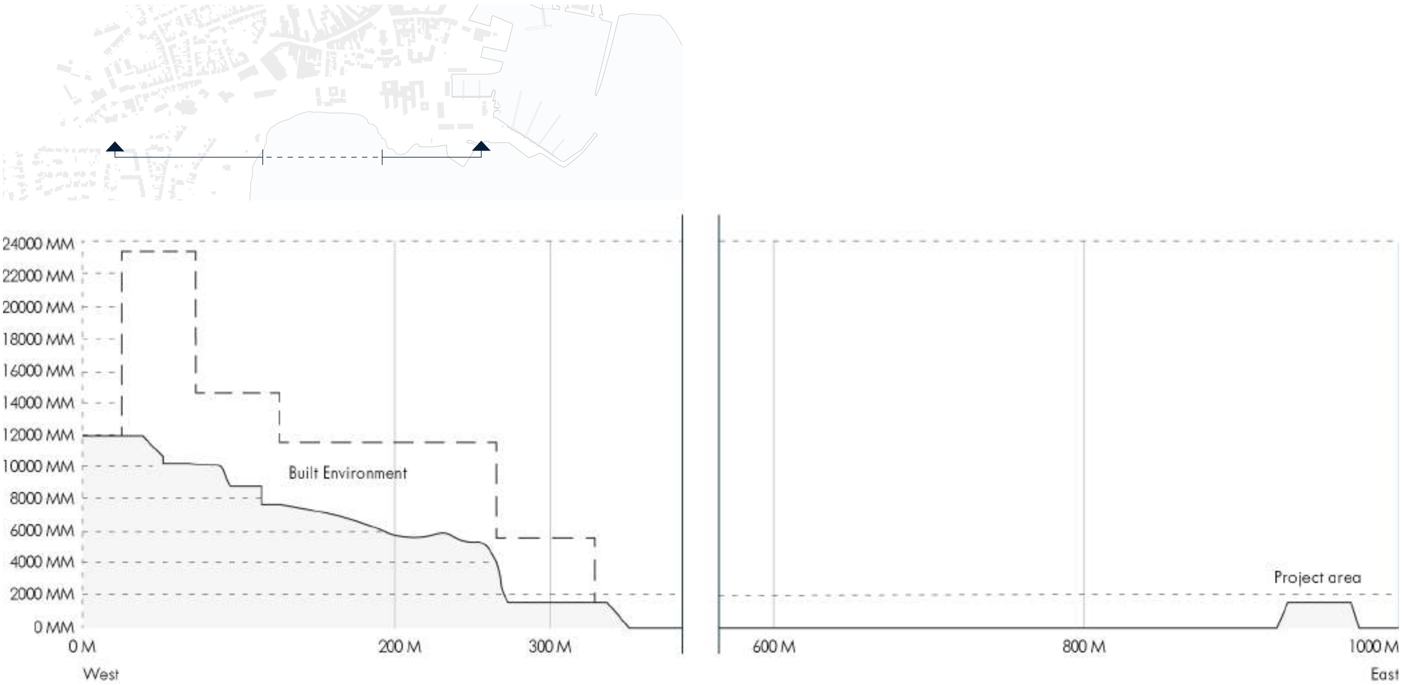


Figure 54 City section

7.4. FLOODING

PRELIMINARY

This analysis focus upon a potential risk of flooding on the project site. With the placement on the edge, towards the fiord, with minimal flood protections and eventually climate changes causing rising sea levels, an investigation of the water level is conducted. Initial inspiration of flooding strategies can be seen in appendix 16.2.

The project area is placed upon a point of land raised 1,5 meters above the surface of the water equipped with slope protection. The 'slope protection' protects the area for present conditions with a tide ranging between -0,3 to 0,3 meters above/under present water levels (Danish Meteorological Institute, 2021) in regards to the reference year of 1990. Furthermore, the water level range between the highest point of 1 m. above normal water level and -0,4 m. beneath the normal water level, resulting in a satisfying implementation of the current flood protection, though with a mind on climate changes and 20-, 50-, and 100-year occurrences the flood protection will not be sufficient. According to computations mixed with predictions, the Danish Meteorological Institute predicts a mean sea level rise of 0,8 meters (Miljø- og Fødevareministeriet, 2018), though taking the uncertainties of the current climate changes in mind, this future sea-level risks to be even higher. Taking the predicted sea-level increase in mind, combining it with a more frequent happening of 20-, 50- and 100-year occurrences (Klimatilpasning, 2015), the worst-case scenario of the project site (without taking cloud burst into mind) will be a water level of 2,7 meters. This meaning that the building or the urban area should be able to withstand a sea-level rise of 2,7 meters, and preferably a higher sea-level rise, in case of an increase of the climate change consequences.

Figure 55 Existing slope protection

Figure 56 Existing flood wall protection

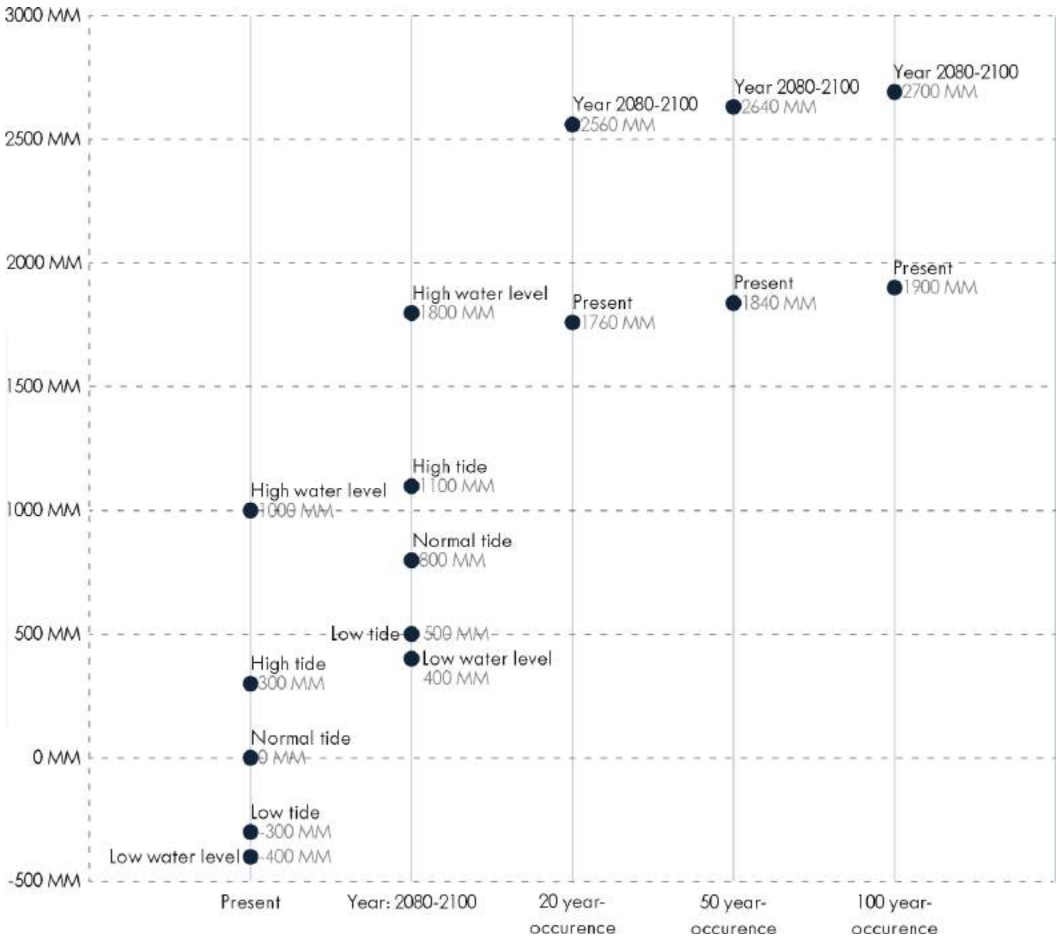


Figure 57 Water level

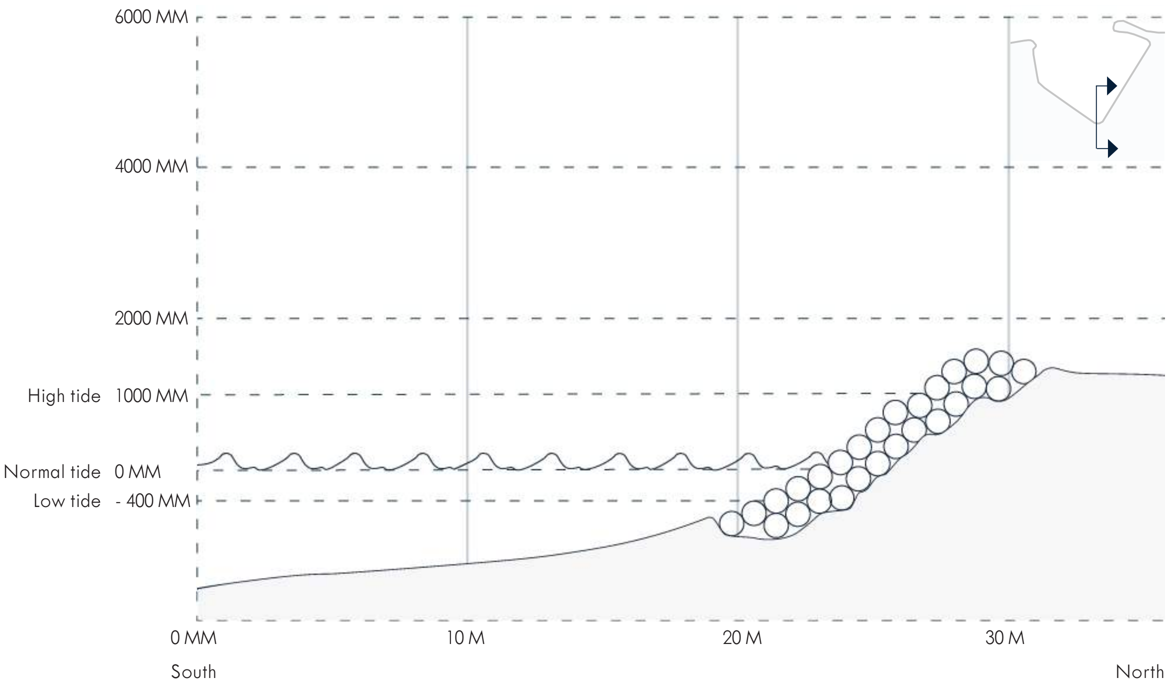


Figure 58 Water levels at the project area

8.0 **SYNTHESIS**

The different analyses will position themselves as the basis of the room program, vision of the project, problem statement together with design generators.

8.1. VISION & PROBLEM

PRELIMINARY

This chapter elaborates the visions set for the competition proposal of 'Center for Experience and Water Sports' in Nykøbing Mors, together with the problem statement.

VISION

The vision of this master thesis is to create a competition proposal for 'Center for Experience and Water Sports' placed on the isle of Mors in the rural area of Denmark. The thesis sets to investigate the possibilities of implementing a 'Value based' design process, documenting the value creation of the design initiatives taken throughout the process, with the aim to design a building with a positive impact upon the different interests of this specific project. The project should be a contribution to a renewed self-perception of the connection Mors has to Limfjorden, with its placement in the middle of it. Furthermore, the project should contribute to economic and social growth in an else declining society, with a building that focuses upon social cohesion and experiences of shellfish and water sports, both relating to Limfjorden. In extension, the project should respond to the climate changes, through a low environmental impact.

PROBLEM STATEMENT

How can value creation be integrated and documented throughout the design process of the competition proposal 'Center for Experience and Water Sports'?

And

How can such a center utilize Limfjorden as an initiator for social cohesion and increased tourism, whilst providing the setting for gastronomical experiences relating to the fiord and the city?

8.2. ROOM PROGRAM

GASTRONOMY

ROOM	AMOUNT	SIZE [m²]	HEATED	ORIENTATION [Interior or Exterior]	ACTIVITY LEVEL	VENTILATION [Natural/Mechanical]	SPATIAL EXPERIENCE	NOTE
Lounge	1	80	Yes	Exterior	Low	M/N	A relaxed atmosphere with a visual connection to the fiord. The lounge area should reflect a temporary stay for quick drop-in visits, tasting shellfish.	—
Workshop	1	80	Yes	Exterior	Medium	M/N	A space with rough materiality, with a high connection to the fiord, creating a deeper connection between the preparation/cooking of shellfish and its origin.	—
Restaurant	1	130	Yes	Exterior/Interior	Low	M/N	A space of multisensory experience through the sense of taste, smell, touch, and sight. Furthermore, the fifth sense of hearing should be activated through the sound of water in outdoor areas accessible from the restaurant.	—
Bar/reception	1	15	Yes	Exterior	Low	M/N	A welcoming atmosphere, greeting the guests, framing a view to the fiord.	—
Office	1	10	Yes	Interior	Low	M/N	—	—
Staff room	1	25	Yes	Interior/Exterior	Low	M/N	A relaxed space, with warm and soft materiality, slowing and embracing the staff during their break.	—
Industrial fridge	1	5	No	Interior	—	—	—	—
Dry storage	1	10	Yes	Interior	—	M	—	—
Kitchen	1	60	Yes	Interior	High	M	A hard tactile space, with easily cleanable surfaces producing the fragrance of shellfish. Parts of the kitchen can be public showcasing the preparation of shellfish while spreading the odor of prepared shellfish to the room, while guests have the chance to experience professionals handle shellfish.	—
Wardrobe	1	10	Yes	Interior	—	M	—	—
Staff toilet	2	3	Yes	Interior	—	M	—	—
Cleaning storage	1	5	Yes	Interior	—	M	—	—
Toilet	4	3	Yes	Interior	—	M	—	—
HC toilet	1	5	Yes	Interior	—	M	—	—
Technic	1	10	Yes	Interior	—	M	—	—

WATERSPORTS

Common

ROOM	AMOUNT	SIZE [m²]	HEATED	ORIENTATION [Interior or Exterior]	ACTIVITY LEVEL	VENTILATION [Natural/Mechanical]	SPATIAL EXPERIENCE	NOTE
Kitchen/social area	1	80	Yes	Interior/Exterior	Low	M/N	An open bright tall space, with a high connection towards the fiord, and the related activities of the area. The room should accommodate the meeting between the associations.	—
Changing room	1	50	Yes	Interior	Medium	M	—	—
Garage	1	150	Yes	Interior	High	N	—	Should be capable of storing: 2x RHIBs and 3x trailers
HC Toilet	3	5	No	Interior	—	M	—	—
Technic	1	10	Yes	Interior	—	M	—	—

Diving association - Krabben

ROOM	AMOUNT	SIZE [m²]	HEATED	ORIENTATION [Interior or Exterior]	ACTIVITY LEVEL	VENTILATION [Natural/Mechanical]	SPATIAL EXPERIENCE	NOTE
Club room	1	60	Yes	Interior/Exterior	Low	M/N	A flexible bright space acting as a club area for briefing and debriefing between dives, while being a place of learning of the theoretical part of diving.	—
Wet depot	1	5	No	Interior	—	N	—	—
Dry depot	1	20	No	Interior	—	N	—	Should be placed in connection to the boat storage, making it easier to carry heavy diving bottles.
Compressor room	1	5	No	Interior	—	N	—	—

Bathing association - Året rundt

ROOM	AMOUNT	SIZE [m²]	HEATED	ORIENTATION [Interior or Exterior]	ACTIVITY LEVEL	VENTILATION [Natural/Mechanical]	SPATIAL EXPERIENCE	NOTE
Club room	1	30	Yes	Interior/Exterior	Low	M/N	A flexible space with possibilities of social gatherings, board meetings, individual training strategy meetings, etc. The room height should be smaller, accommodating more private talks. Furthermore, the room could potentially be overtaken by other associations, due to the low activity demand of the bathing club.	—
Sauna	1	20	yes	Exterior	Low	M	A space which should be in connection to the fiord, making the water experience of the bathers (and other users), last longer through a visual connection.	—

	ROOM	AMOUNT	SIZE [m^2]	HEATED	ORIENTATION [Interior or Exterior]	ACTIVITY LEVEL	VENTILATION [Natural/Mechanical]	SPATIAL EXPERIENCE	NOTE
WATERSPORTS	Youth school								
	Office	1	15	Yes	Interior	Low	M/N	—	Should be placed in connection to the club rooms of the associations.
	Boat storage	1	100	No	Exterior	High	N	A space that acts as the 'in between' space between being still and active. There should be a mix in the tactility symbolizing the transition going from still to active.	—
	Depot	1	30	No	Interior	—	N	—	Should be placed in connection to the boat storage, making it easier to carry heavy diving bottles.
	Morsø Highschool								
	Combined primary and highschool storage	1	20	No	Interior/Exterior	—	N	—	—
	Boat storage	1	70	No	Exterior	High	N	A space that acts as the 'in between' space between being still and active. There should be a mix in the tactility symbolizing the transition going from still to active.	Should be capable of storing: 20x kayaks
	Rowing association - Roklubben Mors								
	Club room	1	35	Yes	Exterior	Low	M/N	A flexible space with possibilities of social gatherings, board meetings, individual training strategy meetings etc. The room height should be smaller, accommodating more private talks.	—
	Boat storage	1	300	No	Exterior	High	N	A space that acts as the 'in between' space between being still and active. There should be a mix in the tactility symbolizing the transition going from still to active.	Should be capable to store: 2x K4, 2x K2, 8x K1, 2x 2 p. Inrigger, 2x 4p. Inrigger, and 20x kayaks
	Boat workshop	1	70	No	Interior/Exterior	High	N	—	—
	Fitness	1	30	Yes	Exterior	High	M/N	A bright and hard tactile room, with a visual connection to the fiord, making sure the rowers have the possibility to scout the ocean while maintaining their form during winter	Should as a minimum be equiped with rowing machines
	Wakeboard association - Wakeboard Mors								
	Private storage	1	25	No	Interior/Exterior	Medium	N	A space that acts as the 'in between' space between being still and active. There should be a mix in the tactility symbolizing the transition going from still to active.	Should be capable of storing: min. 40x wakeboards
	Rental storage	1	40	No	Interior/Exterior	Medium	N	A space that acts as the 'in between' space between being still and active. There should be a mix in the tactility symbolizing the transition going from still to active.	Should be capable of storing: min. 10x wakeboards, wetsuits, helmets and safety jackets
	Depot	1	5	No	Interior		N	—	—
	Changing room - Single	2	3	No	Interior		N	—	—
	Changing room - HC	2	5	No	Interior		N	—	—
	SUP storage	1	30	No	Exterior	High	N	—	Should be capable of storing: 20x SUPs
	Lockers	1	5	No	Interior		N	—	—
	Toilet	1	3	No	Interior		N	—	—
	Toilet HC	1	5	No	Interior		N	—	—
OUTDOORS	Gathering/Social area	—	—	—	—	Low/Medium	—	—	
	Preparation/washing area	—	—	—	—	High	—	—	—
	Easy acces to the fiord	—	—	—	—	Low/High	—	—	—
	Outdoors seating	—	—	—	—	Low	—	—	—

Total gastronomy	463 m^2
Total watersports	1414 m^2
Total	1877 m^2

8.3. ROOM DIAGRAM

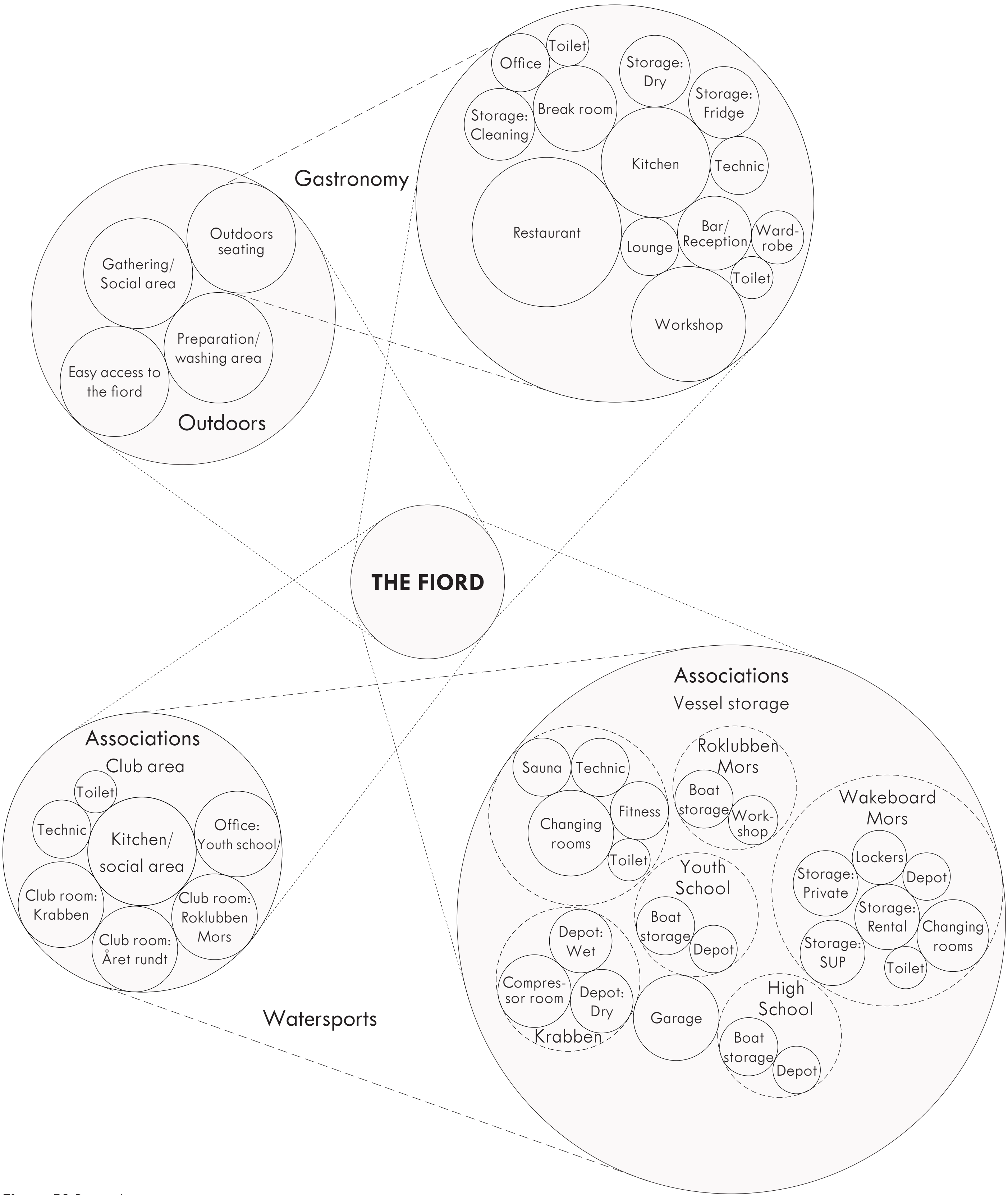


Figure 59 Room diagram

8.4. DESIGN CRITERIA

PRELIMINARY

As a reflection upon the former presented investigations and analyses, design criterias is put together creating a guideline, which can be utilized throughout the design process. The criterias are sorted into categories derived from the overall method utilized in the project.

1 FUNCTIONALITY

Functional connection between the different layouts to accommodate the different users. Focus on accessibility, flow and flexibility within the programming and room

2 COHESION

Create spaces with different social programs, providing a good overview, sufficient lighting, and good orientation, creating a feeling of safeness and a more conducive environment to establish strong social ties and cohesion.

3 ACCESSIBILITY

People should be able to access the building from land and the fiord, creating a link between the two. In addition, the building should be easily navigable, minimizing potential frustration.

4 TYPOLOGY

The building should address a maritme typology and relate to the local context in terms of culture, tradition and materials.

5 GASTRONOMY

Promote the oyster, the shellfish, and other gastronomic ressources from the Fiord. Engage the 'From fiord to table' concept by introducing indoor food programs, contributing to a renewed local self-perception through shellfish breeding and being the shellfish capital.

6 TOTAL ECONOMY

Expensive design choices should be evaluated by a life cycle cost analysis to obtain the cheapest solution without compromising on architectural quality, maintenance and lifespan

7 EXPERIENCE ECONOMY

Nykøbing has no 'passing' tourists, hence the building should have a value of attraction bringing people to the city. The building should be inspired by the Cold Hawaii Inland project and its branding strategy to attract people to the city and generate economy through food- and water experiences

8 LIFE CYCLE ASSESSMENT

Materials should be evaluated by a Life Cycle Assessment analysis and have a environmental impact beneath the DGNB reference building, securing a sustainable and healthy building. In addition, the construction process stage (A4-A5), the end-of-life (C1-C4), and the recycling potential (D) must be carefully considered to reduce the pollution level.

9 LOW ENERGY INITIATIVES

The building should meet the low energy frame of 33 kWh/ m^2 year. In addition, the building should address low energy strategies by utilizing the contextual conditions.

10 DURABILITY

A sustainable building is durable, which is why the building design must consider the exposure to the climate and the risk of flooding.

11 ADAPT

The building should adapt to the contextual position, creating a soft transition between the indoor spaces and outdoor spaces. In addition, the building should activate the site by a degree of extroversity.

12 FRAMING

The building should frame the contextual scene in different ways and strengthen the beauty of the landscape.

13 URBAN REGENERATION

Food connects context, the culture and 'the place' to our senses. Arrange outdoor areas for different types of fiord related food events, which should be used as a strategy for urban conviviality and sociability.

14 ATMOSPHERE

The spatial design must address the senses in a purposfull way in order to strengthening the programmatic experiences. Especially the lighting, the smell and the general sensuality of the space should be address in order to create an impactfull experience.

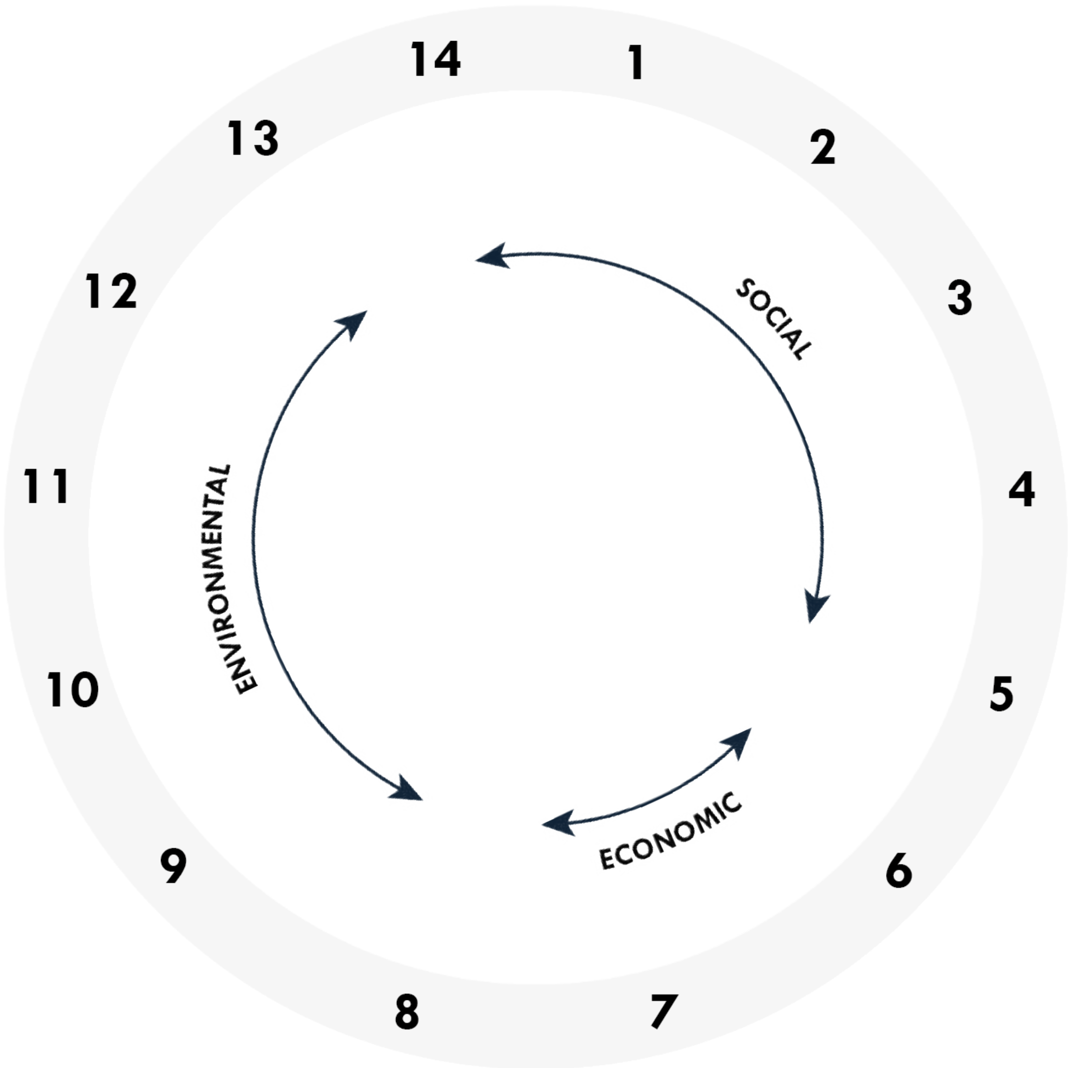


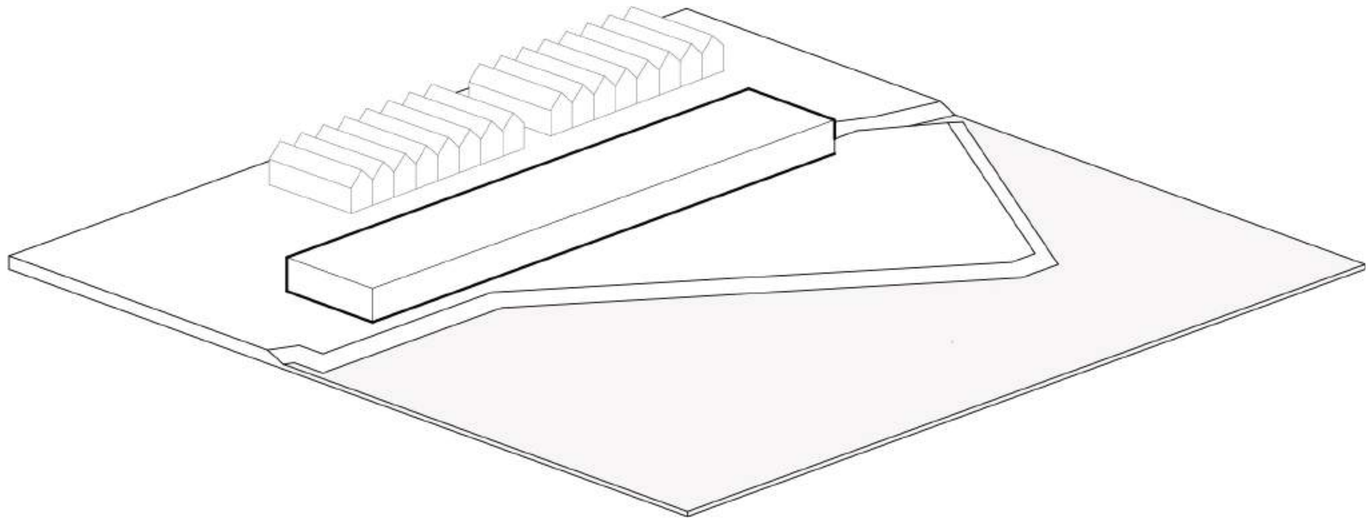
Figure 60 Design generators

PRESENTATION

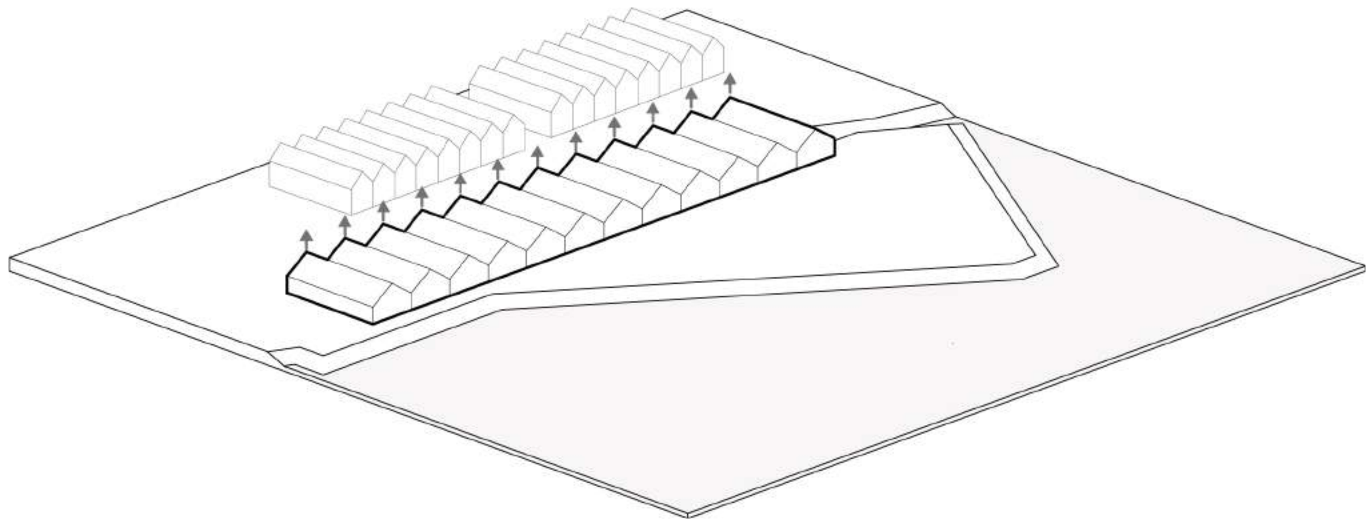
MORS Ø

Imagine walking along the fiord promenade, viewing the city of Nykøbing Mors to the left and the fiord to the right. In the distance 'MORS Ø' rises and blends in with the existing build environment through environmental consciousness, being a modern and sustainable interpretation of surrounding façade expressions and building typologies. The center is constructed of a wooden frame system that in extension also functions as an integrated furniture for storage systems.

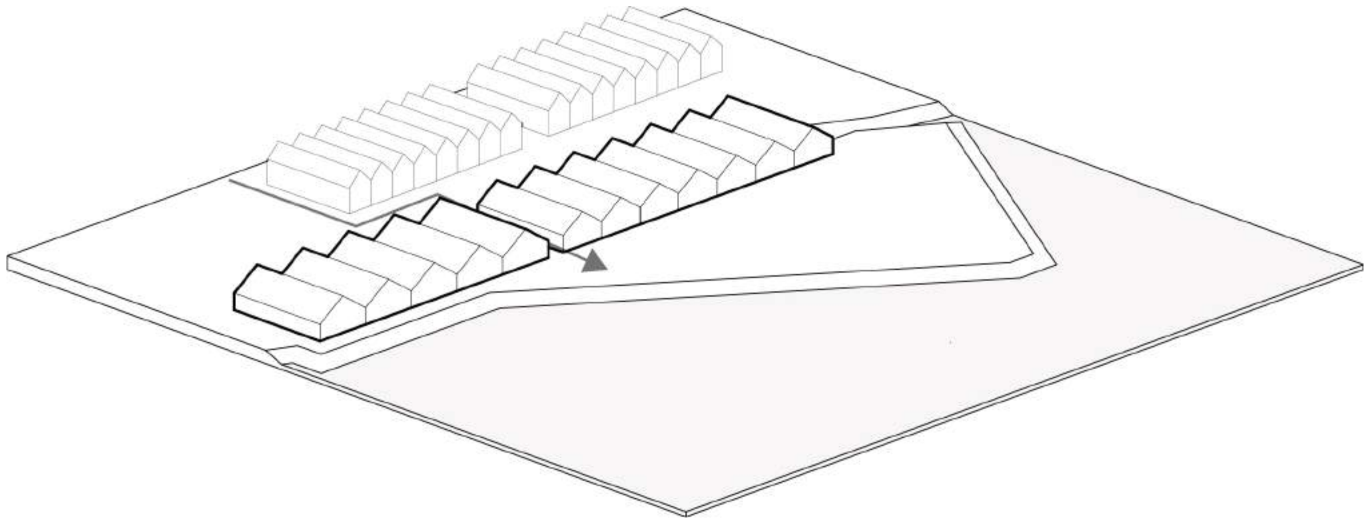
'MORS Ø' facilitates various activities, from gastronomical experiences to watersports, all initiating in the fiord. It is a place for social interactions, where both citizens and visitors can meet across associations and interests. Located in Nykøbing Mors, the self-pronounced shellfish capital of Denmark, the center becomes a place where visitors can get a taste of the European Oyster, close to its origin. The restaurant facilitates multiple settings for gastronomical experiences and can easily be expanded in relation to the annual shellfish festival. 'MORS Ø' has the potential to be used as a medium to reinvent and strengthen the identity of the city of Nykøbing Mors.



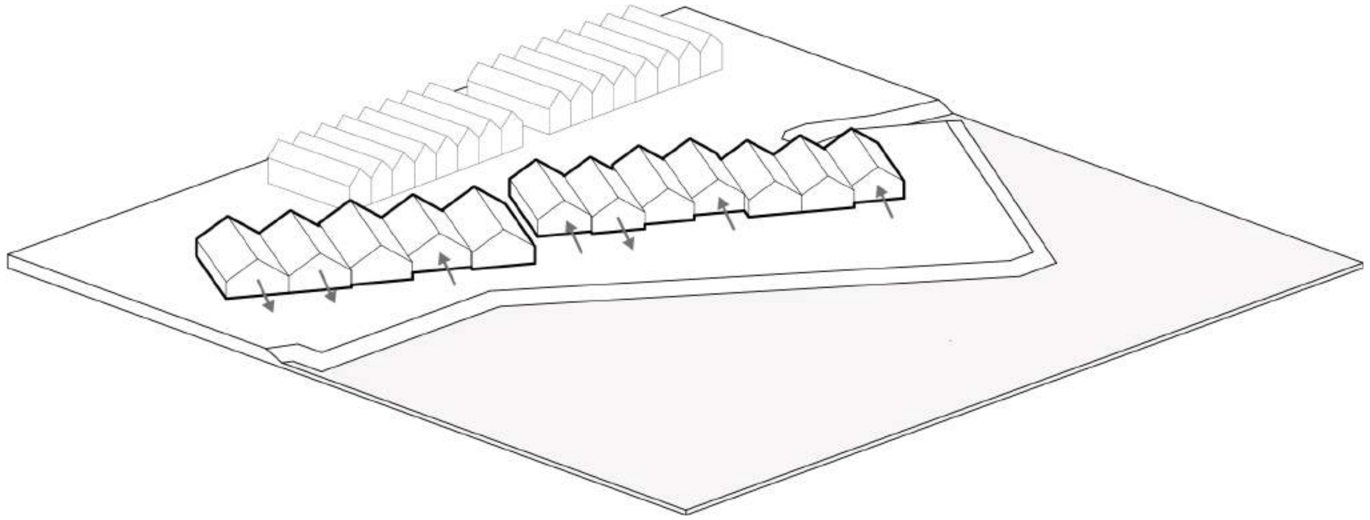
1. PLACEMENT OF VOLUME



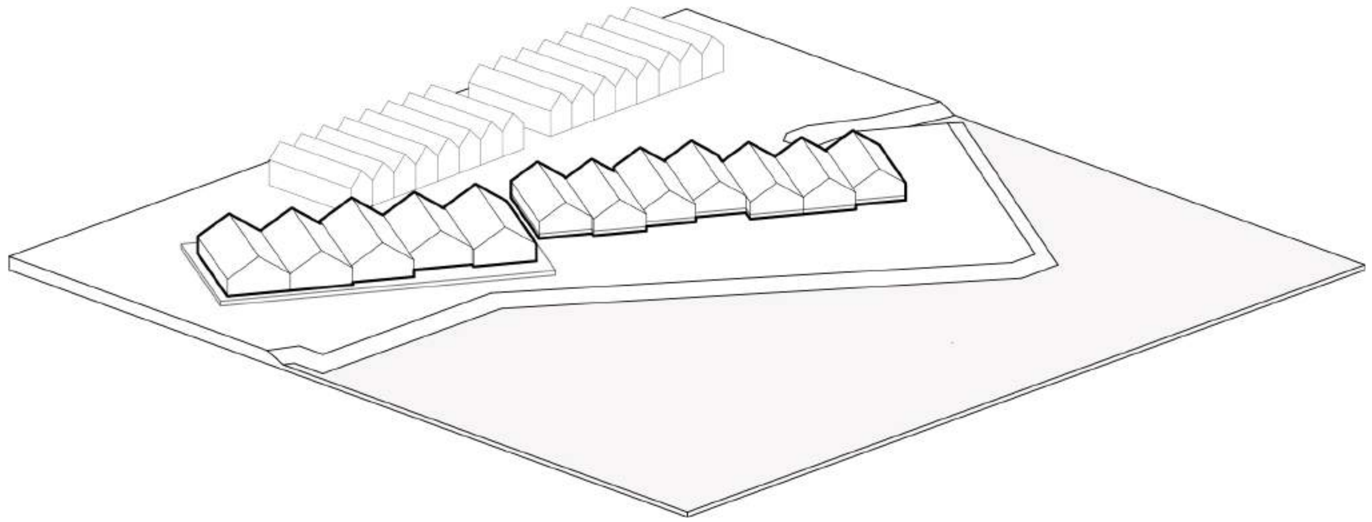
2. ADJUSTMENT TO THE EXISTING TYPOLOGY



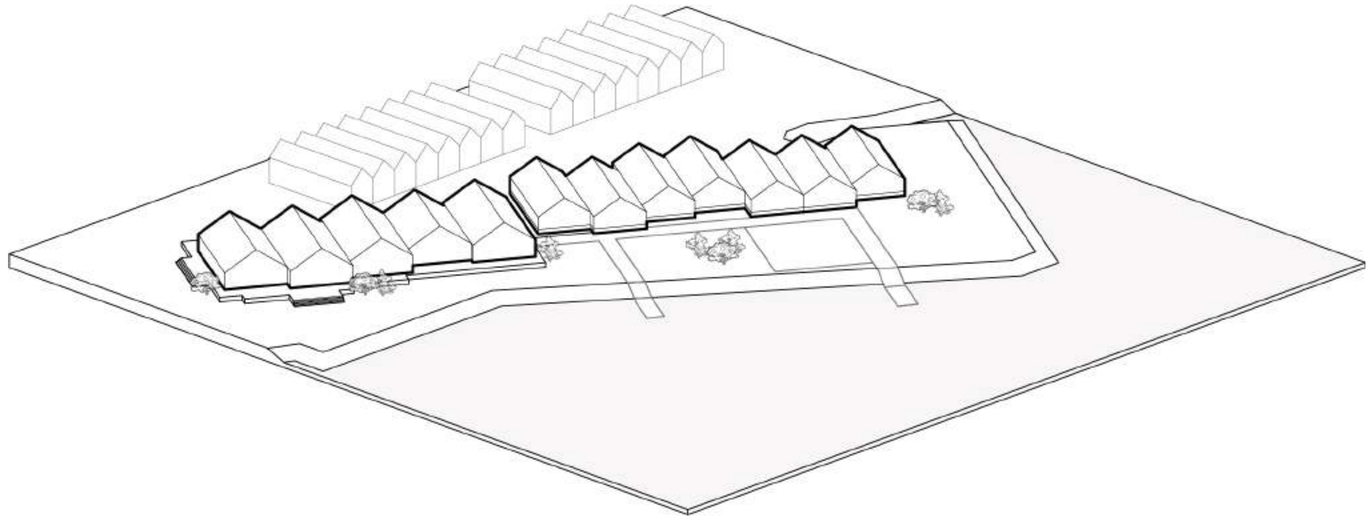
3. IMPLEMENTATION OF THE BUILDING PROGRAM



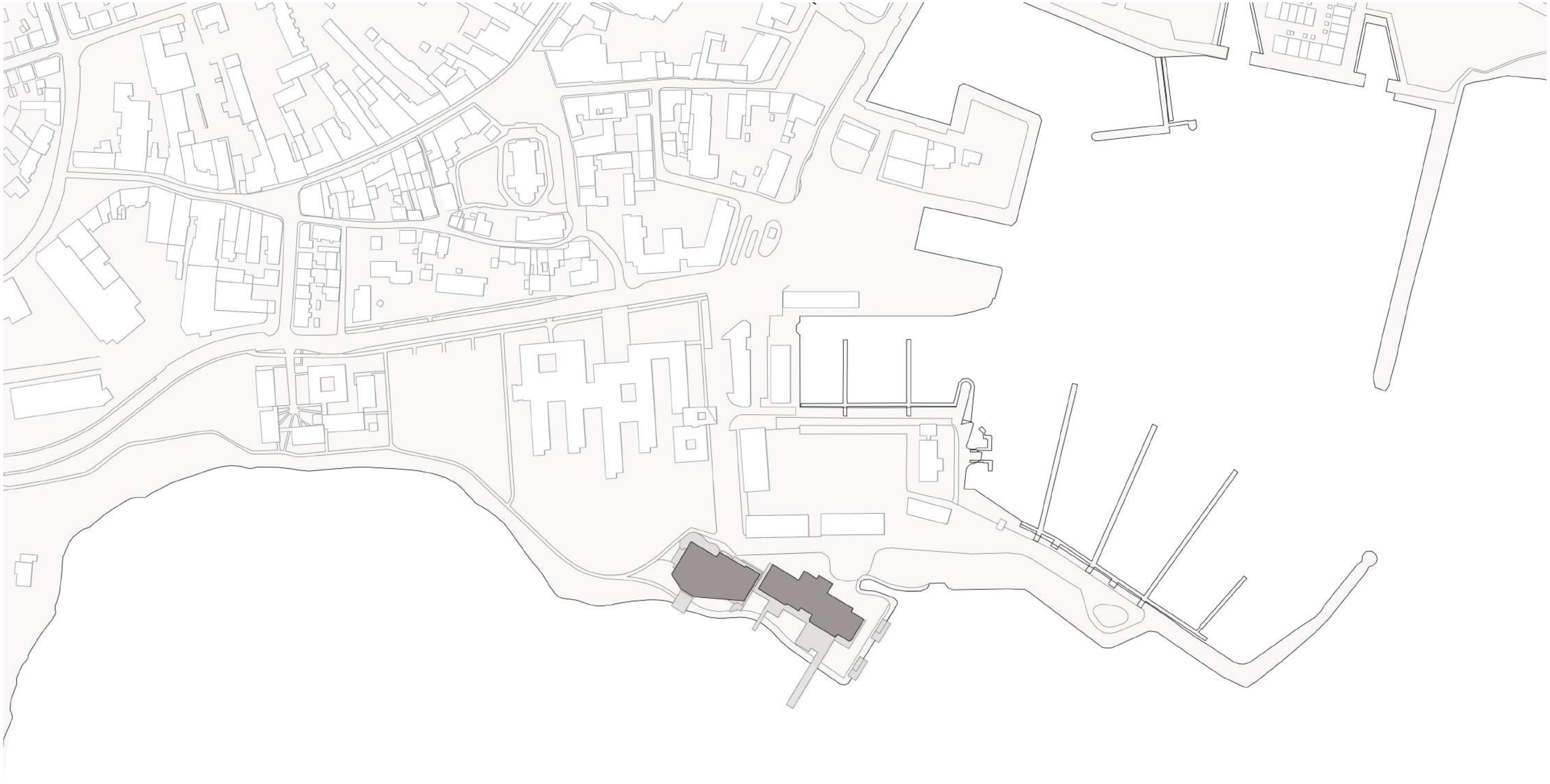
4. IMPLEMENTATION OF DISPLACEMENTS



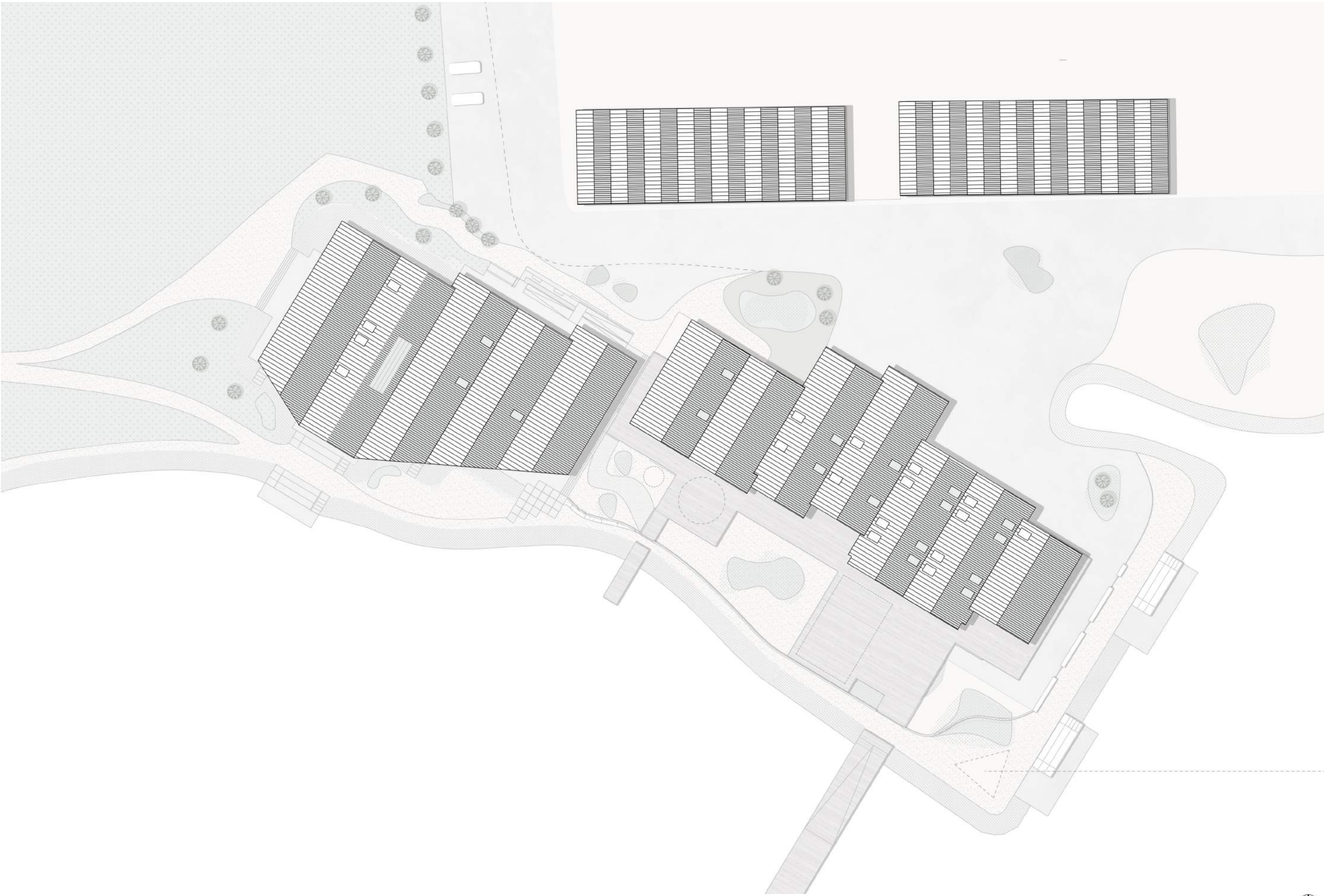
5. ADJUSTING TO TOPOLOGY



6. URBAN REGENERATION



MASTERPLAN 1:2500

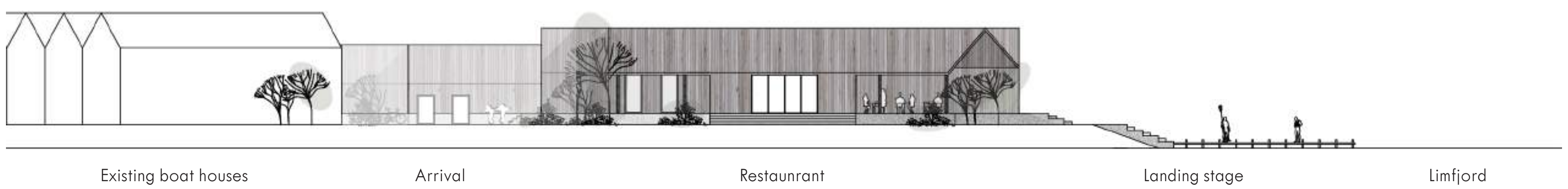


MASTERPLAN 1:500

SOUTH ELEVATION 1:500

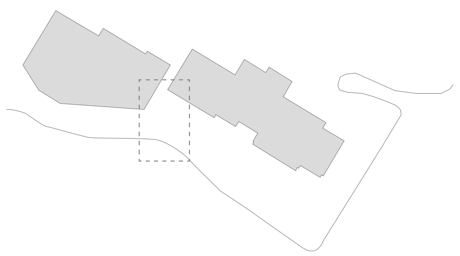
NORTH ELEVATION 1:500

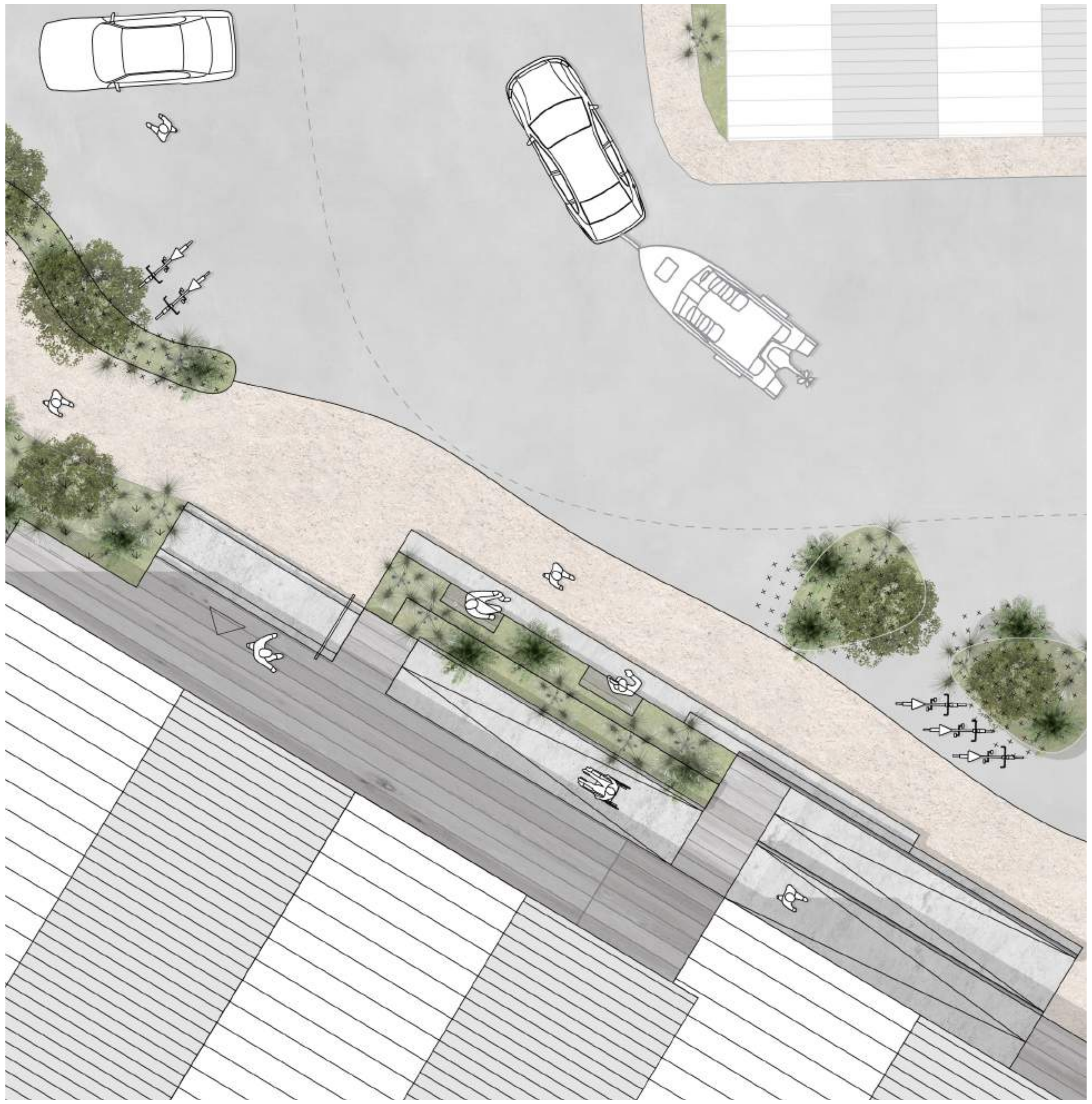
EAST ELEVATION 1:500



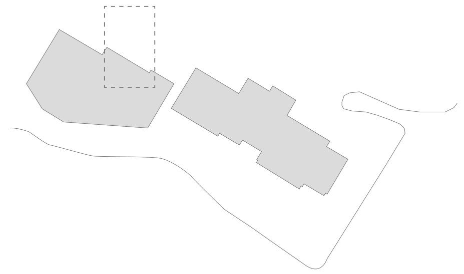
WEST ELEVATION 1:500

COMMON OUTDOOR AREA

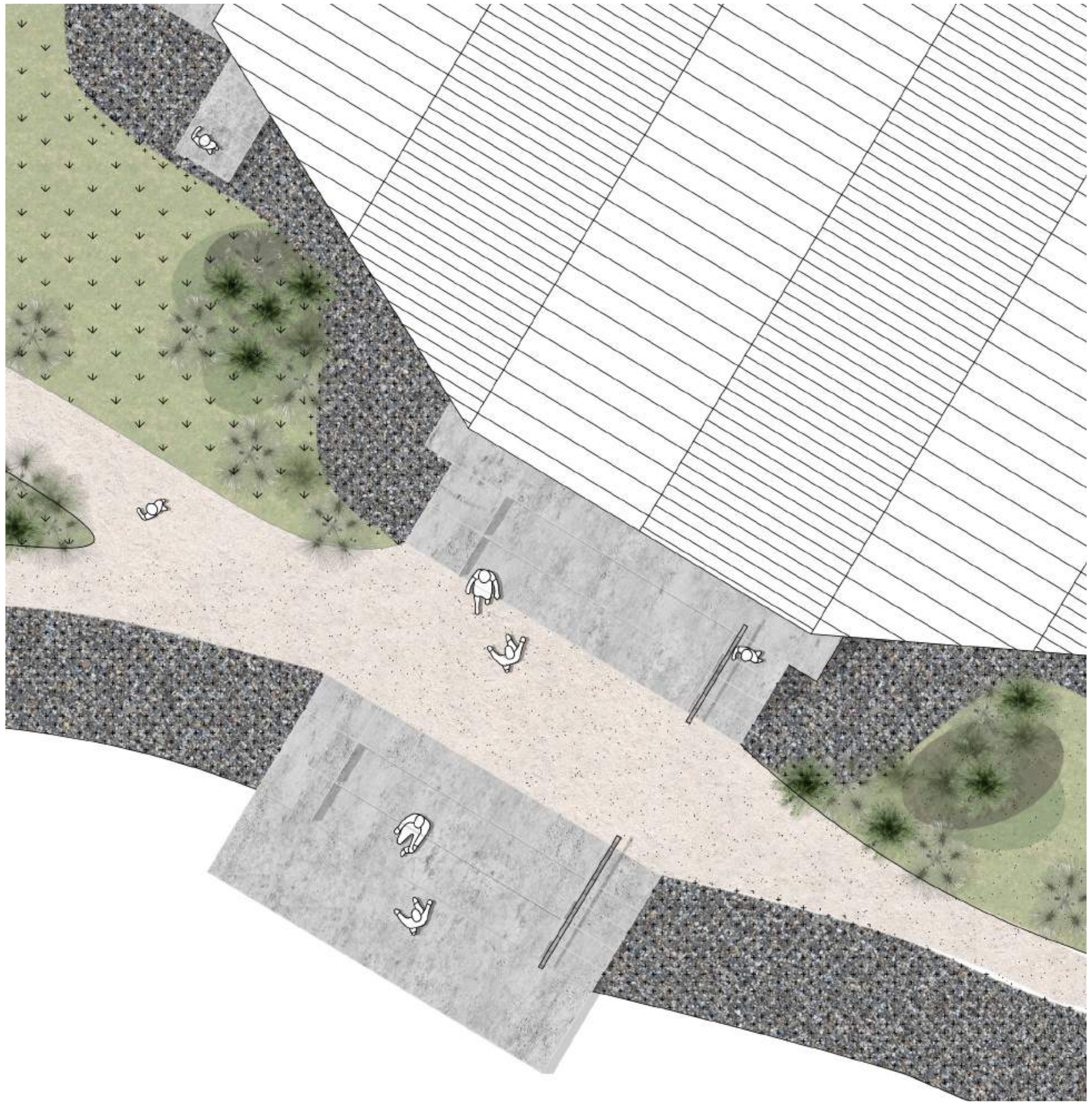




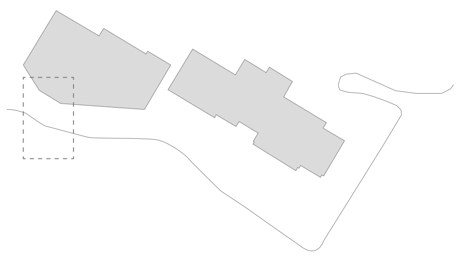
OUTDOOR RESTAURANT ARRIVAL

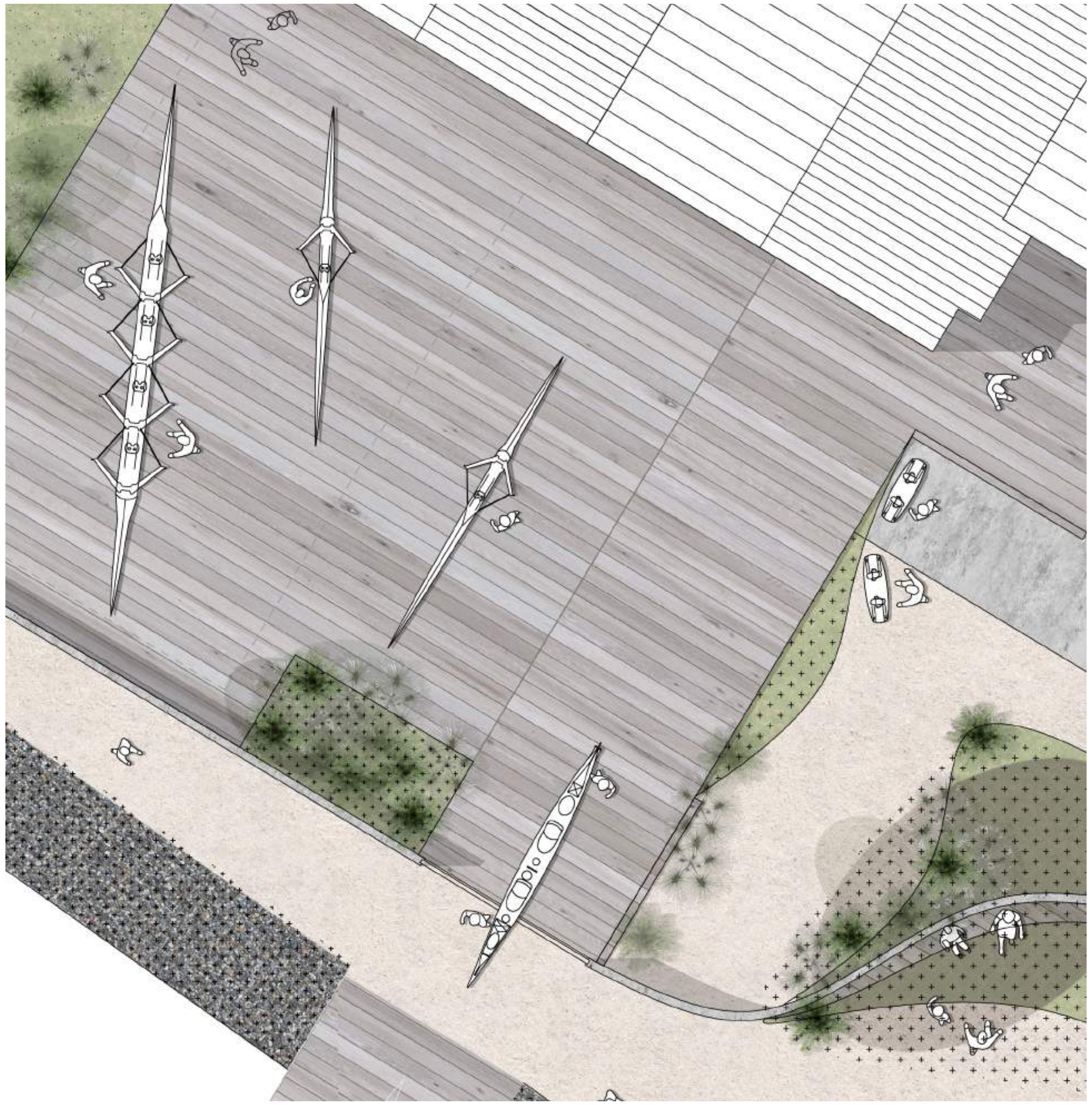


URBAN CLOSE-UPS 1:150

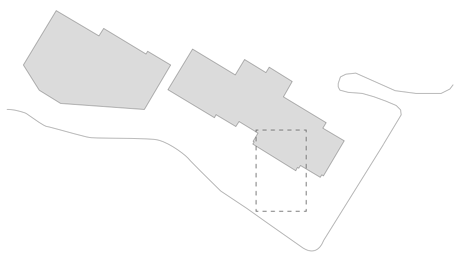


FLEX OUTDOOR AREA (RESTAURANT)





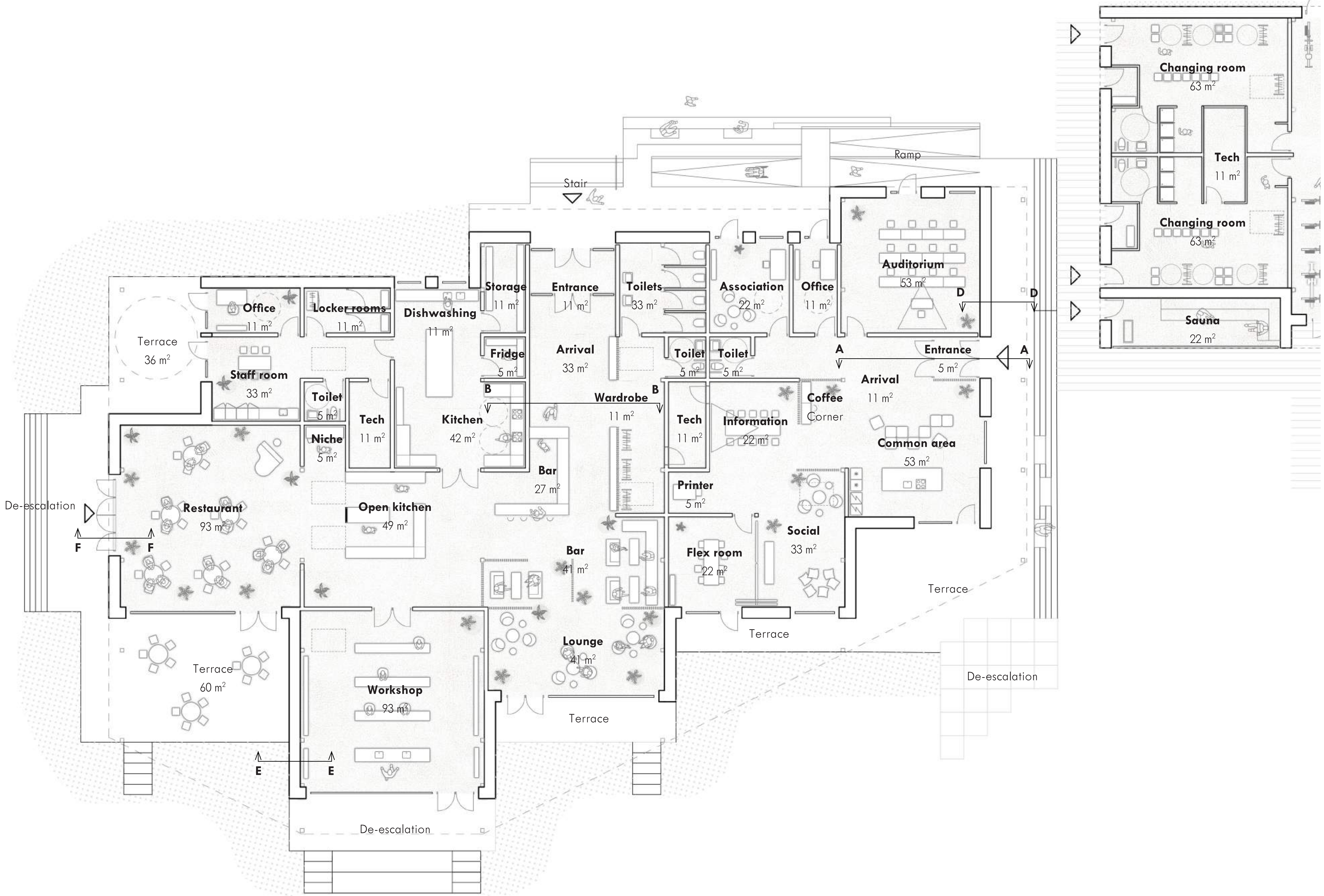
OUTDOOR RESTAURANT ARRIVAL



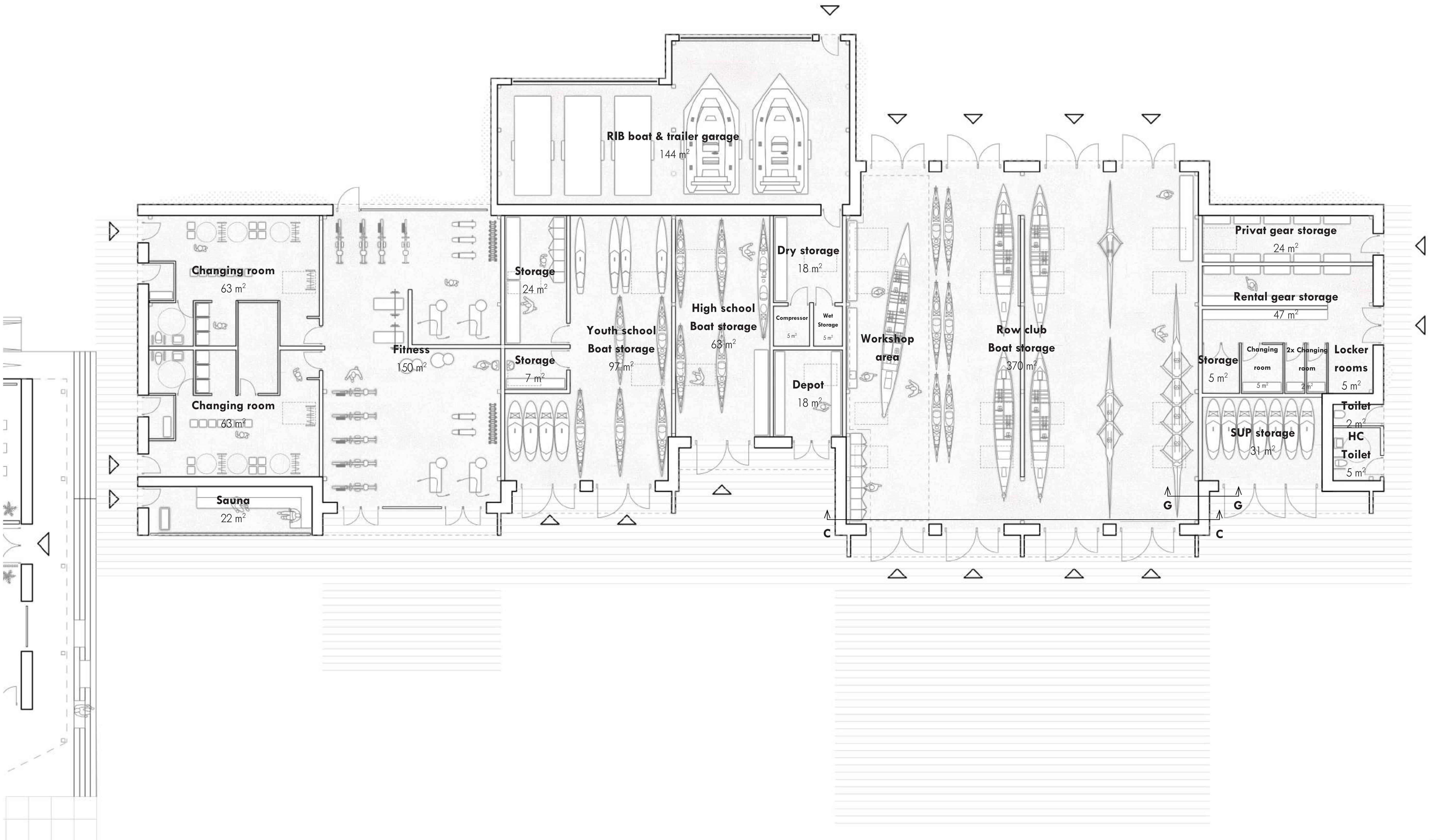
URBAN CLOSE-UPS 1:150

RESTAURANT ENTRANCE AREA

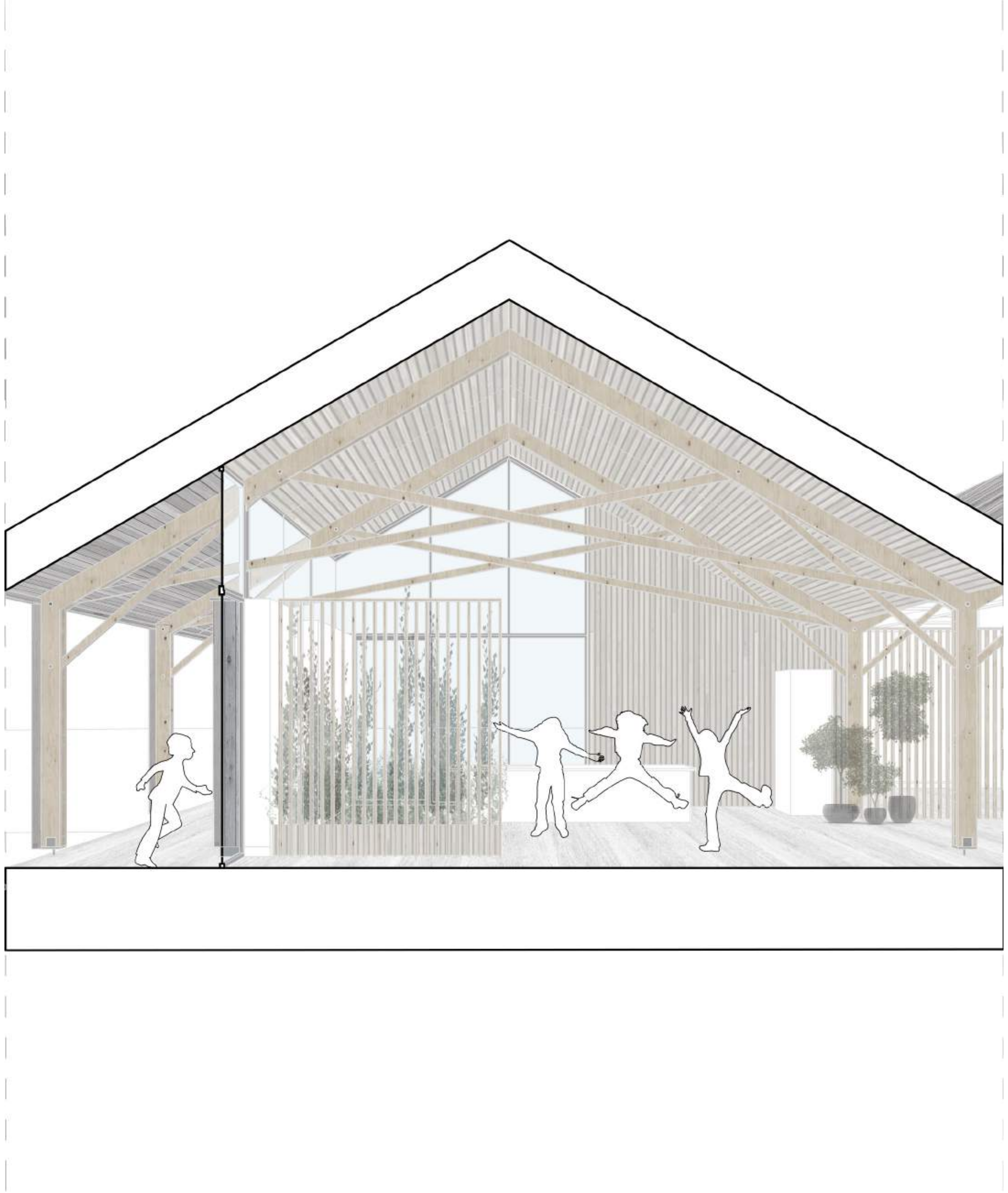
BOAT AREA



MAIN HOUSE 1:200

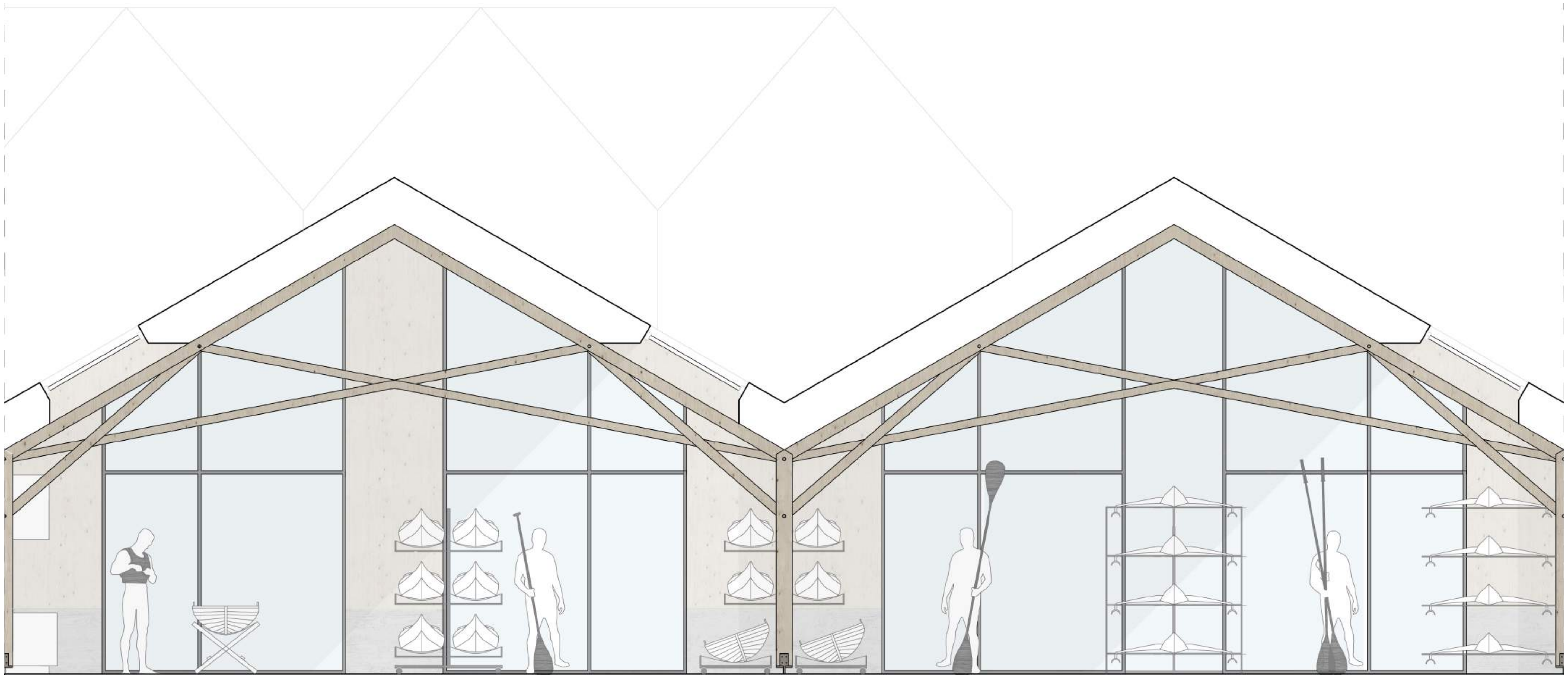


BOAT HOUSE 1:200



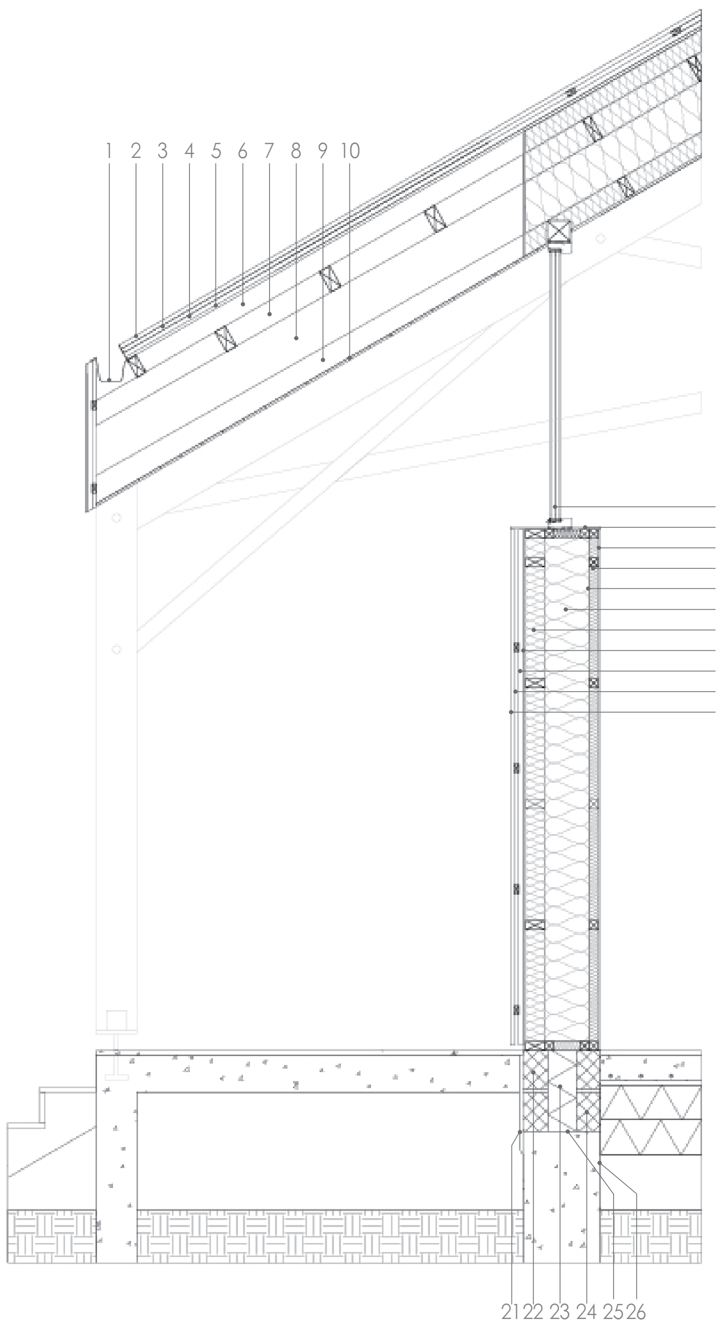
SECTION A-A: ASSOCIATION ENTRANCE AREA 1:50

SECTION B-B RESTAURANT ENTRANCE AREA 1:50



SECTION C-C BOAT STORAGE 1:50

ENVELOPE DETAILS



Overhang - 636 mm

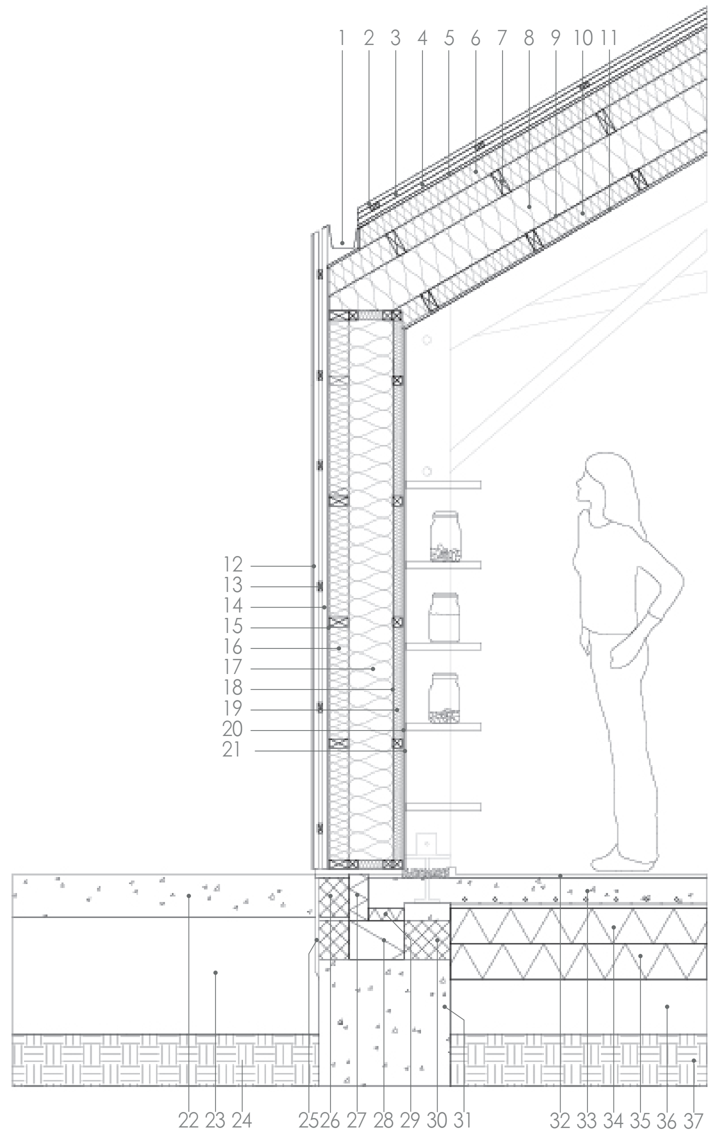
1 Rain gutter // 100x150mm
2 Superwood cladding// 22 mm
3 Counter batts cc. 600/ 25 mm
4 Ventilated air gap & 25x25 Counter batts cc. 600// 25 mm
5 Huntonit wood fiberboard// 15 mm
6 95x45mm counter batts cc. 600// 95 mm
7 Counter batts cc. 600// 125 mm
8 Counter batts cc. 600// 220 mm
9 Counter batts cc. 600// 95 mm
9 Superwood cladding//12 mm

Wood wall - 449 mm

11 Velfac 200 Energy - 3-layer glass
12 Window still // 16 mm
13 Vertical wood cladding // 12 mm
14 Eelgrass insulation & 45x45mm counter batts cc. 600// 45 mm
15 Vapor barrier// 0,2 mm
16 Eelgrass insulation & 220x45mm counter batts cc. 600// 220 mm
17 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
18 Hunton wood fiber windbreaker board// 12 mm
19 Ventilated air gap & 25x25 Counter batts cc. 600// 25 mm
20 Counter batts cc. 600/ 25 mm
21 Superwood cladding// 22-32 mm

Foundation - 405 mm

21 Plinth plaster// 20 mm
22 Leca block// 190x120 mm
23 EPS Pressure-resistant insulation // 145mm
24 Leca block// 190x120 mmm
25 Radon barrier// 1 mm
26 Cast concrete stripe foundation // 385 mm



Roof - 636 mm

1 Rain gutter // 100x150mm
2 Superwood cladding// 22 mm
3 Counter batts cc. 600/ 25 mm
4 Ventilated air gap & 25x25 Counter batts cc. 600// 25 mm
5 Huntonit wood fiberboard// 15 mm
6 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
7 Eelgrass insulation & 125x45mm counter batts cc. 600// 125 mm
8 Eelgrass insulation & 220x45mm counter batts cc. 600// 220 mm
9 Vapor barrier// 0,2 mm
10 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
11 Troldtek board//12 mm

Wood wall - 455 mm

12 Superwood cladding// 22-32 mm
13 Counter batts cc. 600/ 25 mm
14 Ventilated air gap & 25x25 Counter batts cc. 600// 25 mm
15 Hunton wood fiber windbreaker board// 12 mm
16 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
17 Eelgrass insulation & 220x45mm counter batts cc. 600// 220 mm
18 Vapor barrier// 0,2 mm
19 Eelgrass insulation & 45x45mm counter batts cc. 600// 45 mm
20 Claytec board // 16 mm
21 Clayplaster // 2 mm

Outdoor deck

22 Cast concrete deck // 210 mm
23 Gravel // 585 mm
24 Existing ground

Foundation

25 Plinth plaster// 20 mm
26 Leca block// 190x150 mm
27 Cast concrete stripe foundation // 645 mm
28 EPS Pressure-resistant insulation // 90mm
29 EPS Pressure-resistant insulation // 120 mm
30 Radon barrier// 1 mm
31 Cast concrete strip foundation// 375 mm

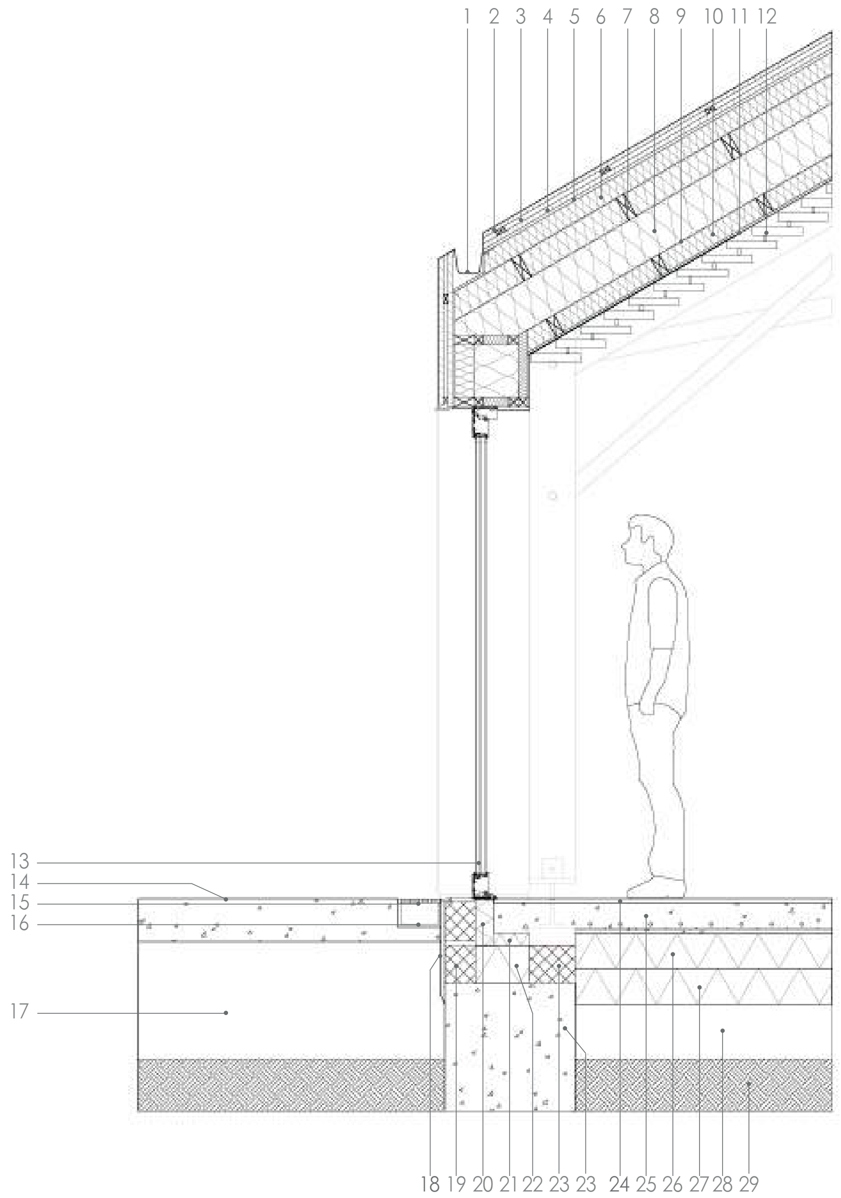
Terrain deck - 795 mm

32 Concrete flooring// 20 mm
33 Cast concrete layer w. underfloor heating // 150 mm
34 EPS Pressure-resistant insulation //175 mm
35 EPS Pressure-resistant insulation //175 mm
36 Gravel // 275mm
37Existing ground

SECTION D-D AUDITORIUM 1:50

SECTION E-E RESTAURANT WORKSHOP 1:75

RESTAURANT ENVELOPE



Roof - 636 mm

1 Rain gutter // 100x150mm
2 Superwood cladding// 22 mm
3 Counter batts cc. 600/ 25 mm
4 Ventilated air gap & 25x25 Counter batts cc. 600// 25 mm
5 Huntonit wood fiberboard// 15 mm
6 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
7 Eelgrass insulation & 125x45mm counter batts cc. 600// 125 mm
8 Eelgrass insulation & 220x45mm counter batts cc. 600// 220 mm
9 Vapor barrier// 0,2 mm
10 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
11 Plywood board//12 mm
12 Acoustic wood battens/ 50x250 mm

Outdoor deck

14 Cast concrete flooring // 210 mm
15 Aluminium lattice grate// 18x215mm
16 Plinth border water collector // 20 mm
17 Gravel // 585 mm

Foundation

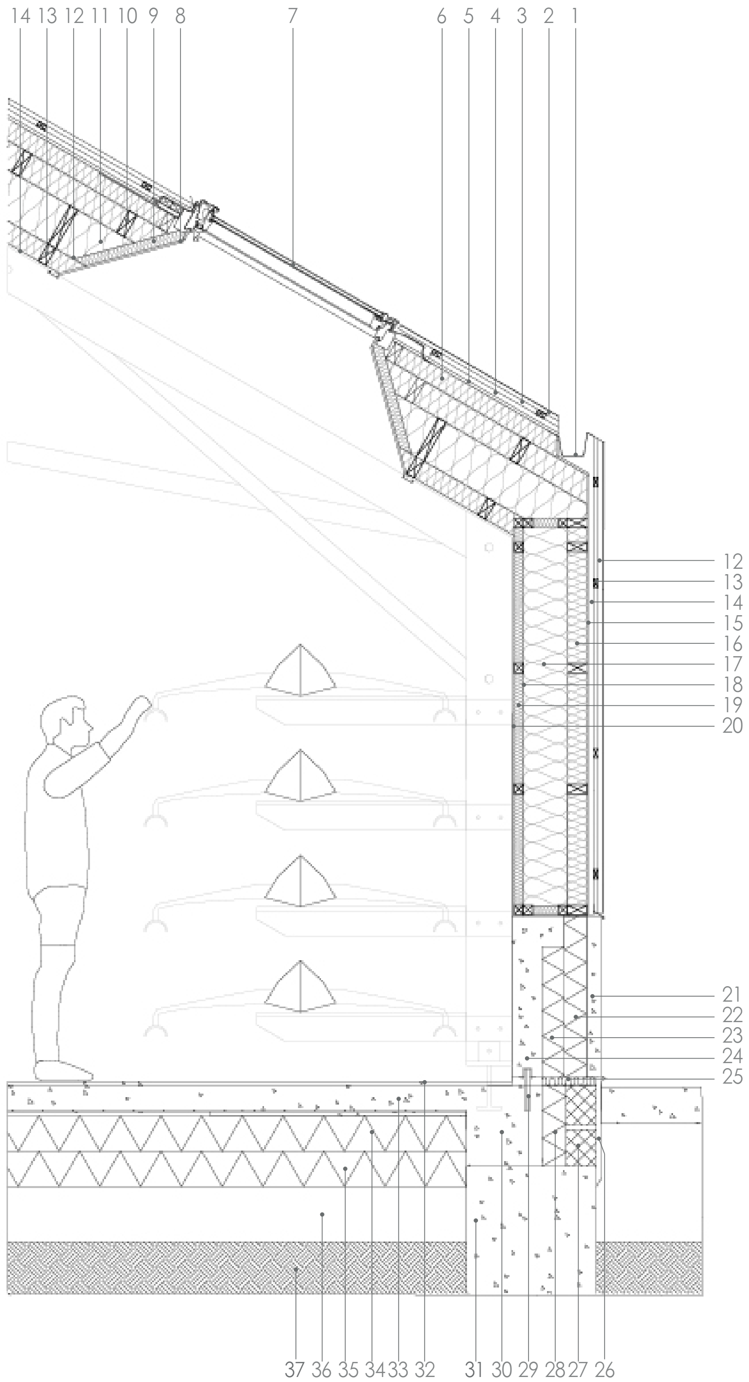
18 Plinth plaster// 20 mm
19 Leca block// 150x190mm
20 EPS Pressure-resistant insulation // 90mm
21 EPS Pressure-resistant insulation / 60 mm
22 EPS Pressure-resistant insulation // 270 mm
23 Leca block// 225x190mm
24 Cast concrete stripe foundation // 645 mm

Terrain deck - 795 mm

34 Wood flooring// 20 mm
35 Cast concrete layer w. underfloor heating // 150 mm
36 EPS Pressure-resistant insulation //175 mm
37 EPS Pressure-resistant insulation //175 mm
38 Gravel // 275mm
39 Existing ground

SECTION F-F RESTAURANT ENVELOPE 1:75

BOAT STORAGE ENVELOPE



Roof - 636 mm

1 Rain gutter // 100x150mm
2 Superwood cladding// 22 mm
3 Counter batts cc. 600/ 25 mm
4 Ventilated air gap & 25x25 Counter batts cc. 600// 25 mm
5 Huntonit wood fiberboard// 15 mm
6 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
7 Velux 3 layer skylight
8 Inner wood window still// 10 mm
9 Eelgrass insulation & 50x45mm counter batts cc. 600// 50 mm
10 Eelgrass insulation & 125x45mm counter batts cc. 600// 125 mm
11 Eelgrass insulation & 220x45mm counter batts cc. 600// 220 mm
12 Vapor barrier// 0,2 mm
13 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
14 Plywood board//12 mm

Wood wall - 449 mm

12 Superwood cladding// 22-32 mm
13 Counter batts cc. 600/ 25 mm
14 Ventilated air gap & 25x25 Counter batts cc. 600// 25 mm
15 Hunton wood fiber windbreaker board// 12 mm
16 Eelgrass insulation & 95x45mm counter batts cc. 600// 95 mm
17 Eelgrass insulation & 220x45mm counter batts cc. 600// 220 mm
18 Vapor barrier// 0,2 mm
19 Eelgrass insulation & 45x45mm counter batts cc. 600// 45 mm
20 plywood board // 12 mm

Concrete wall - 440 mm

21 Concrete front plate // 70mm
22 EPS Pressure-resistant insulation // 110mm
23 EPS Pressure-resistant insulation // 110mm
24 Concrete back plate // 150mm
25 EPS Pressure-resistant insulation // 40mm

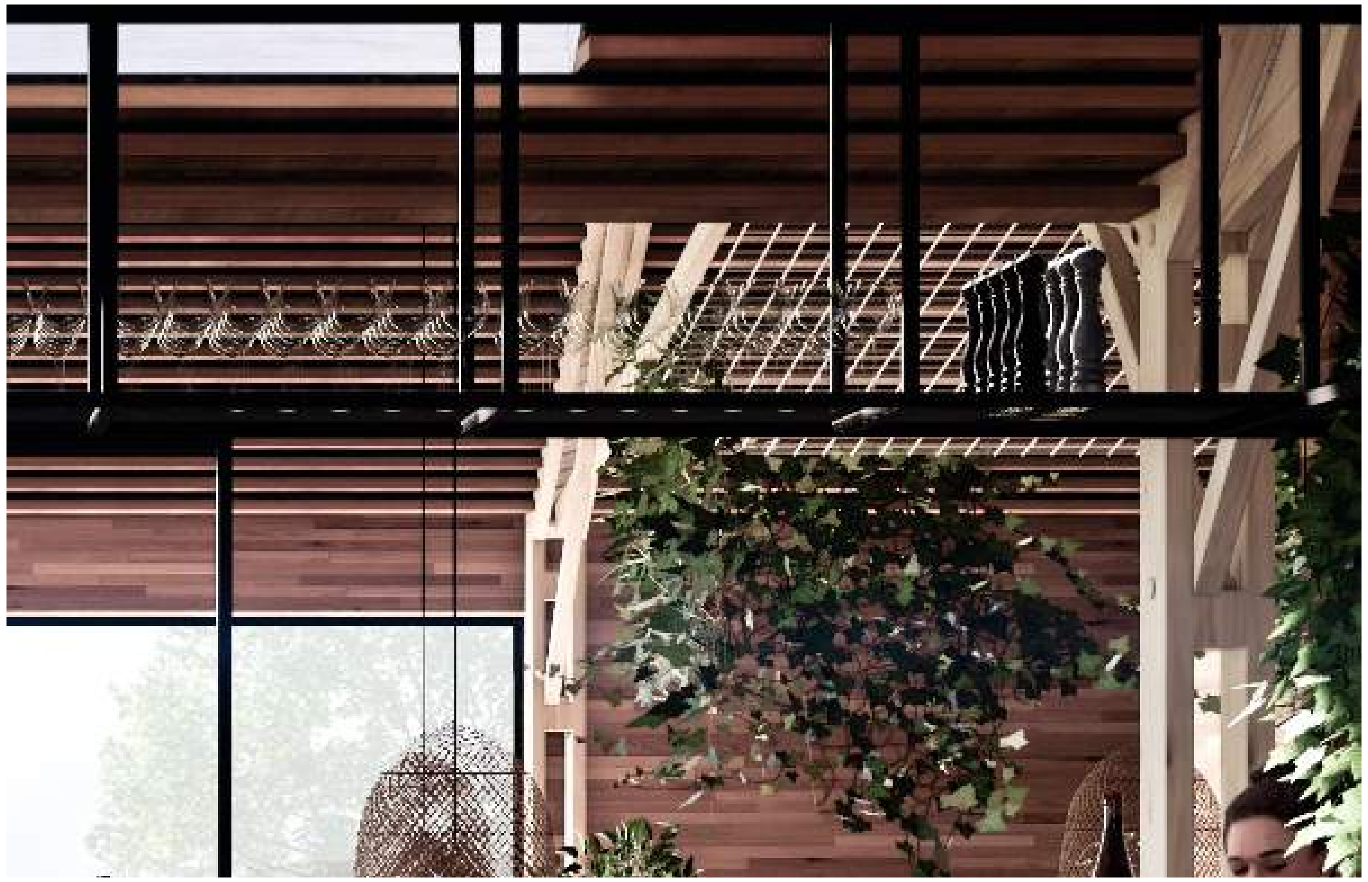
Foundation

26 Plinth plaster// 20 mm
27 Leca block// 150x190 mm
28 EPS Pressure-resistant insulation // 120mm
29 Mounting bolt // Ø30 mm
30 Cast concrete strip foundation// 375 mm
31 Cast concrete strip foundation// 645 mm

Terrain deck - 795 mm

32 Concrete flooring// 20 mm
33 Cast concrete layer w. underfloor heating // 150 mm
34 EPS Pressure-resistant insulation //175 mm
35 EPS Pressure-resistant insulation //175 mm
36 Gravel // 275mm
37 Existing ground

SECTION G-G BOAT STORAGE ENVELOPE 1:75

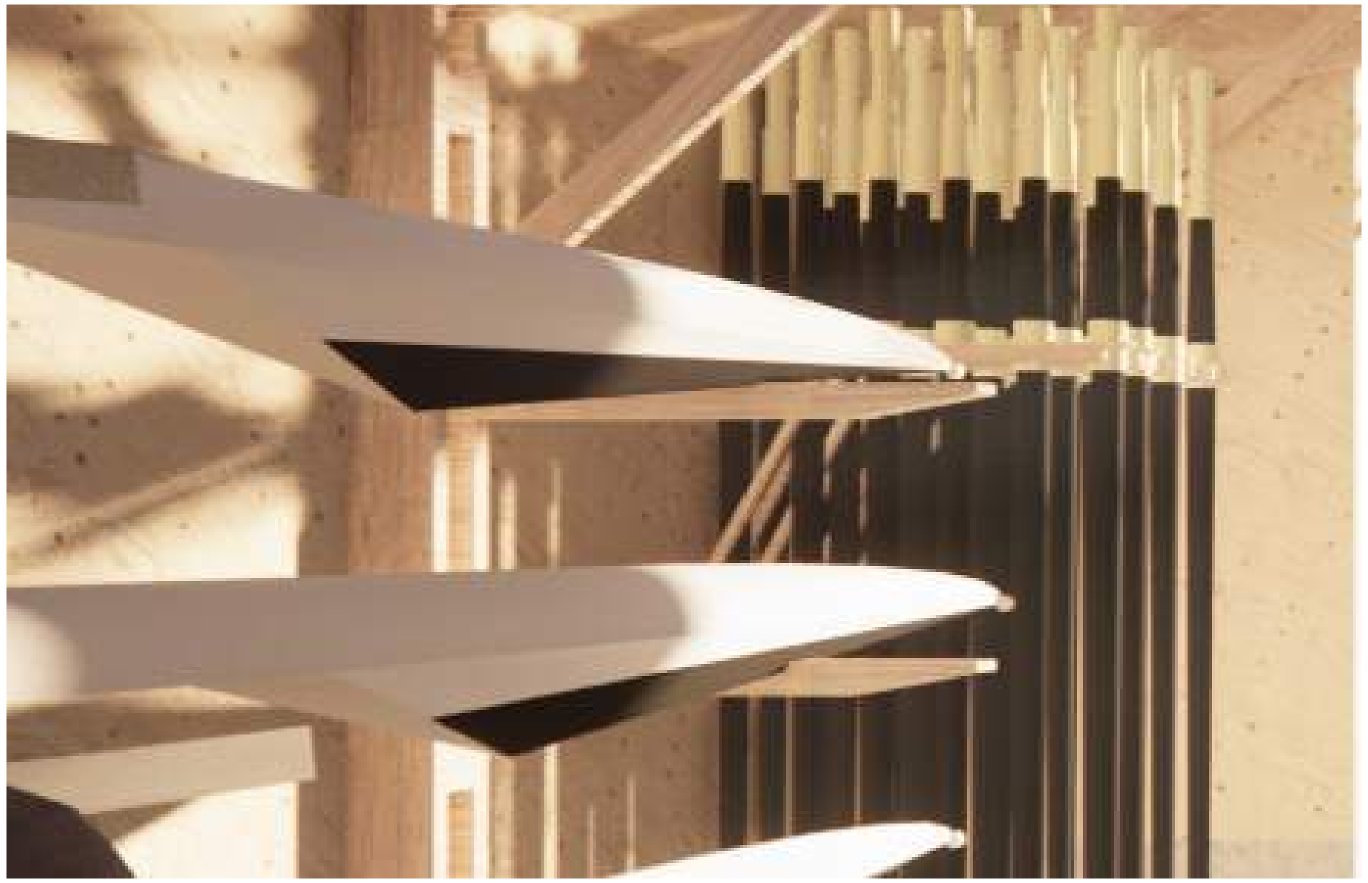


RESTAURANT WITH OPEN KITCHEN

The restaurant offers various eating settings, all initiating in the local shellfish. One of the spaces relates to the typical restaurant experience, in a soft and warm atmosphere as a result of shifting materials and framed views in-between construction elements, bringing the surrounding nature inside. The space facilitates an open kitchen, which relates especially to the senses of smell, taste, and vision, enhancing the eating experience. The space provides the possibility to seat a great amount of people, hence the construction provides an integrated and costume-made ceiling to adjust the acoustics for a peaceful and intimate eating experience. Furthermore, the restaurant area is located towards the larger grass area in front of the town hall, making the restaurant able to be flexible during e.g. the Shellfish Festival.

RESTAURANT WORKSHOP

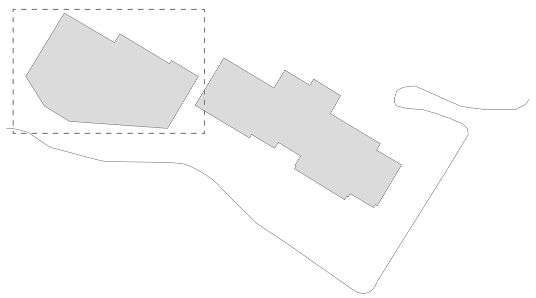
Through the workshop, the restaurant offers not only great food but a whole gastronomical experience. Located just by the shoreline and facilitating workshop tables, the workshop addresses the activity of picking up shellfish from the fiord and learning visitors to open and cook them properly themselves. The atmosphere within the workshop address especially the tactile sense, through raw and natural materi-als, imitating the natural environment of the shellfish, being the fiord.

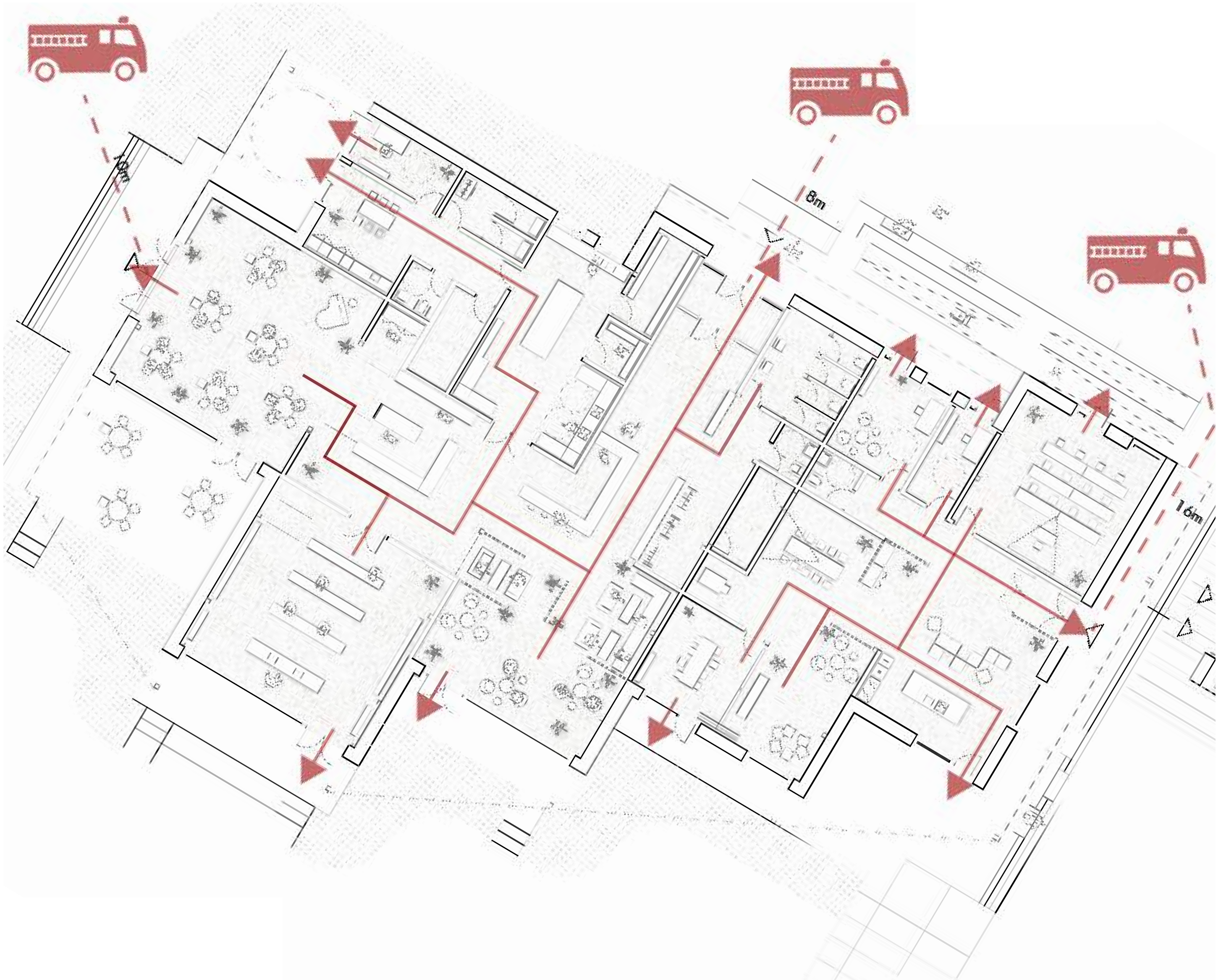


BOAT STORAGE - MORSØ ROKLUB

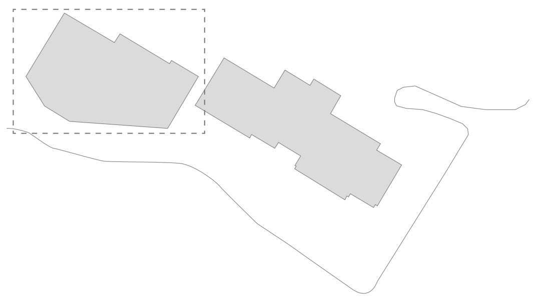
The boat houses are a large contributor to the activities at the center. Imitating the typically pitched roof typology, the boat houses frame the view of the water, enhanced by the wooden frame construction, which also doubles as a kayak rack. From the boat storage, uninterrupted access to the water is ensured, providing the best possible conditions for the users of the facilities. The shared space outside the boathouses creates the optimal environment for visitors and water sports enthusiasts to meet, across associations and interests.

DAYLIGHT FACTOR



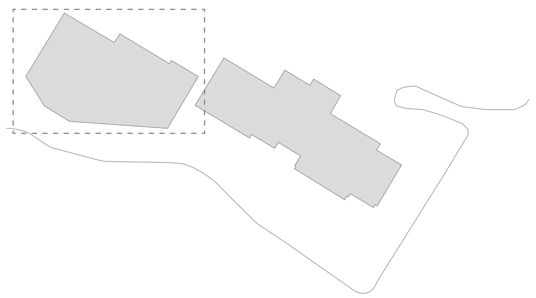


EMERGENCY EXITS

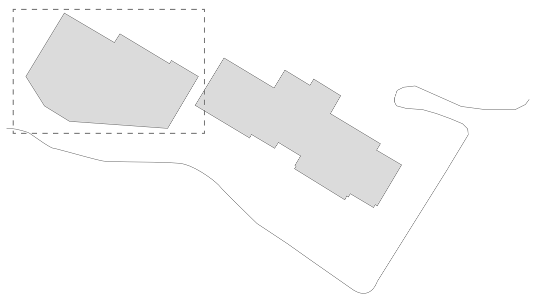


MAIN BUILDING - NO SCALE

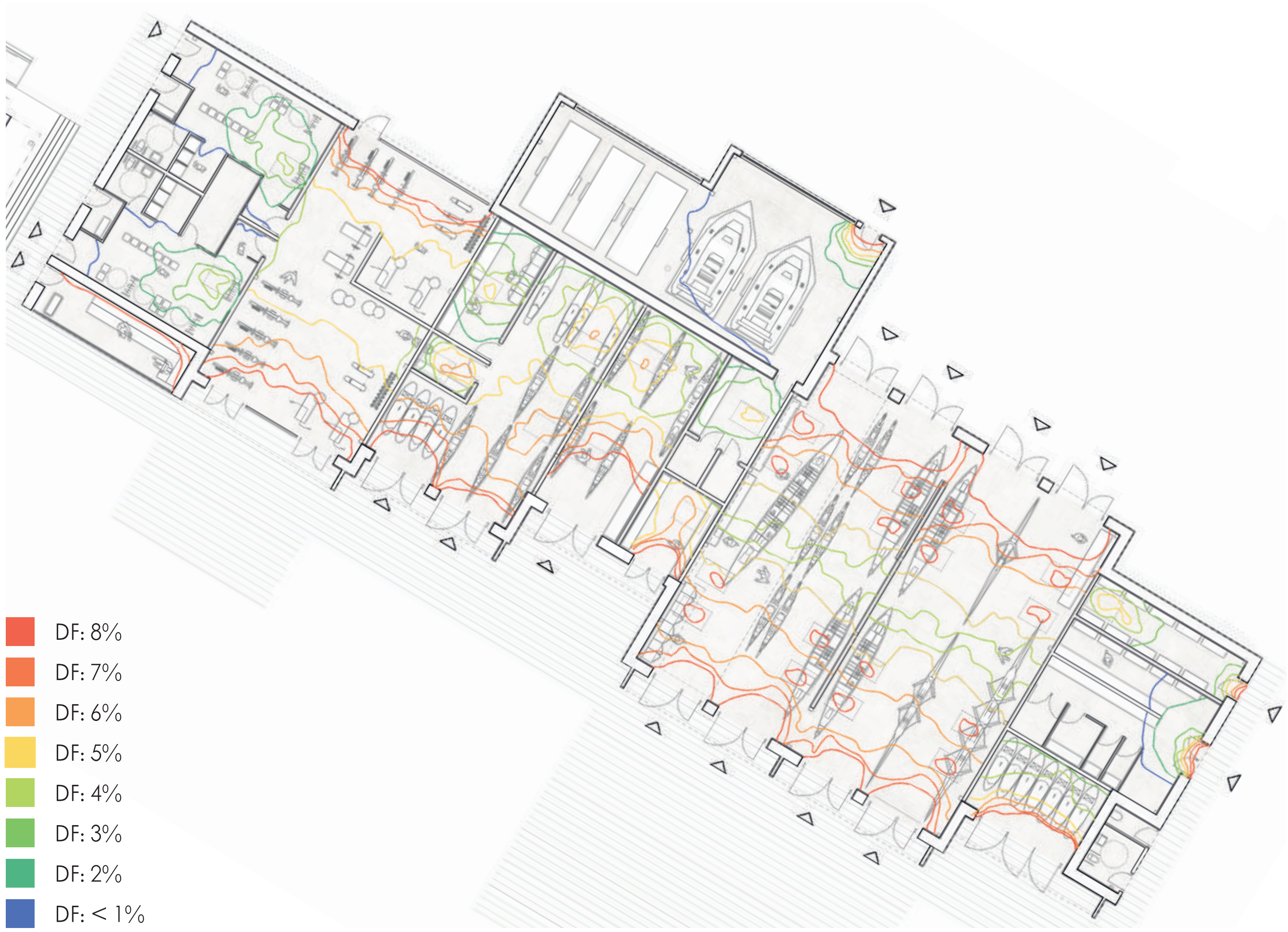
MECHANICAL VENTILATION STRATEGY



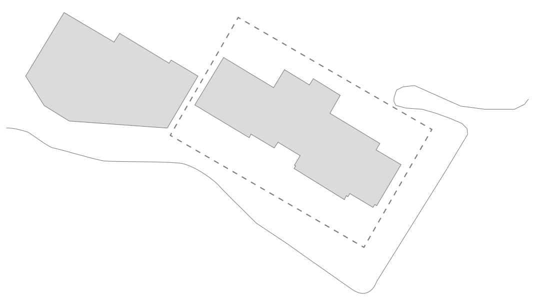
NATURAL VENTILATION STRATEGY



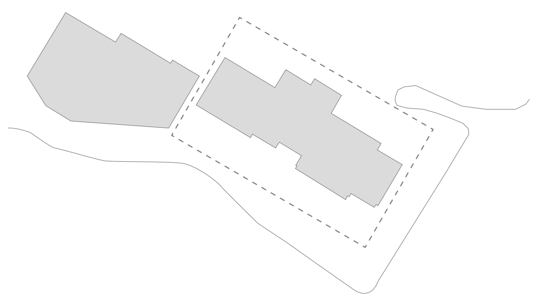
MAIN BUILDING - NO SCALE



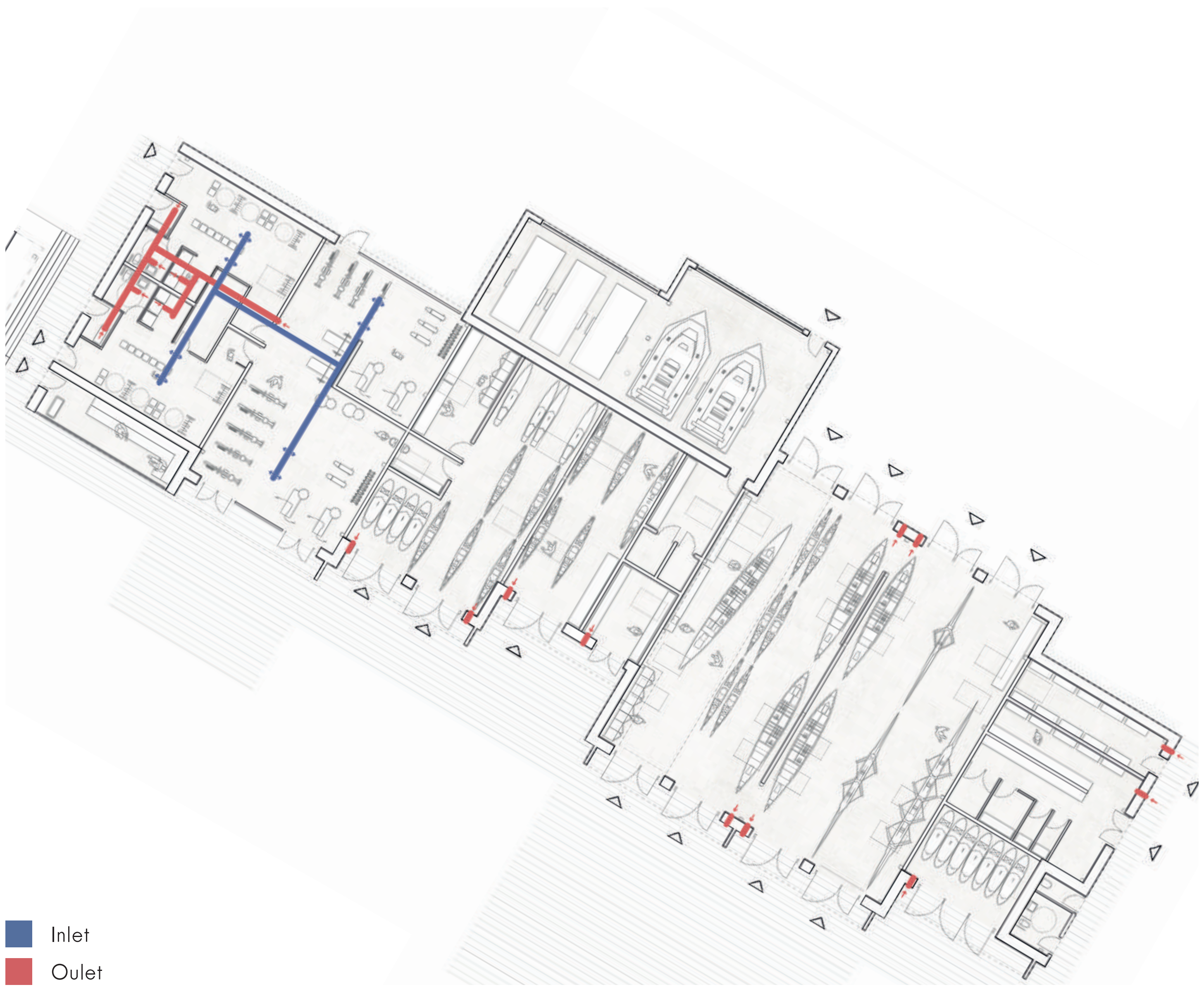
DAYLIGHT FACTOR

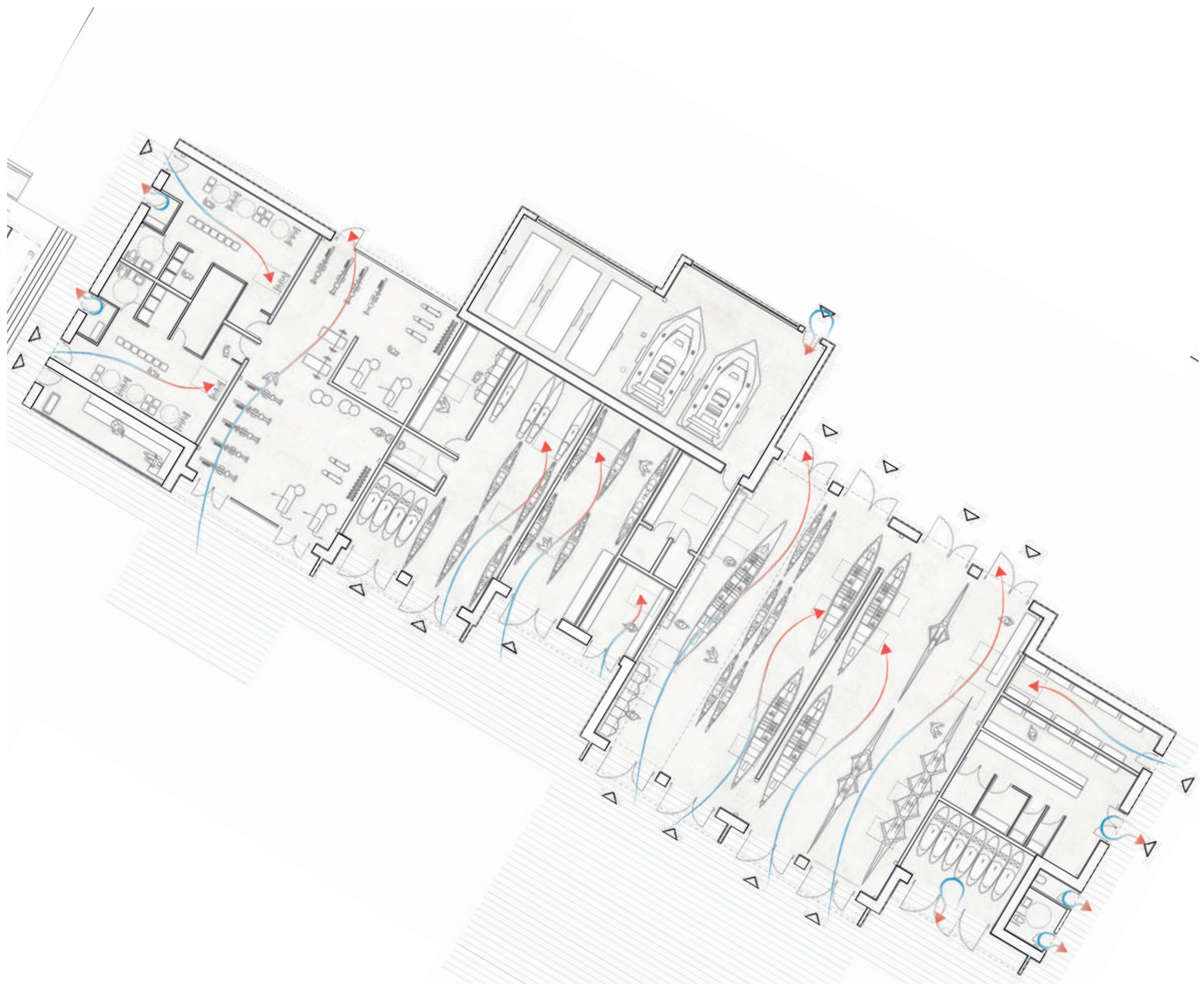


EMERGENCY EXITS

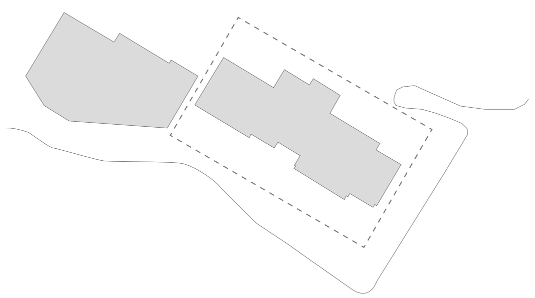


BOAT STORAGE - NO SCALE

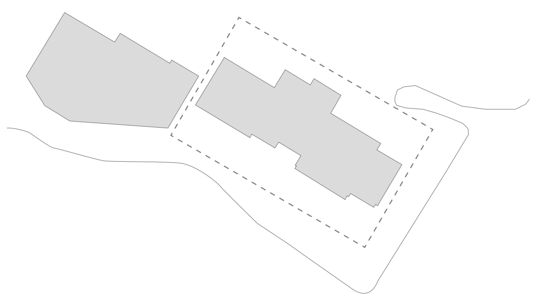




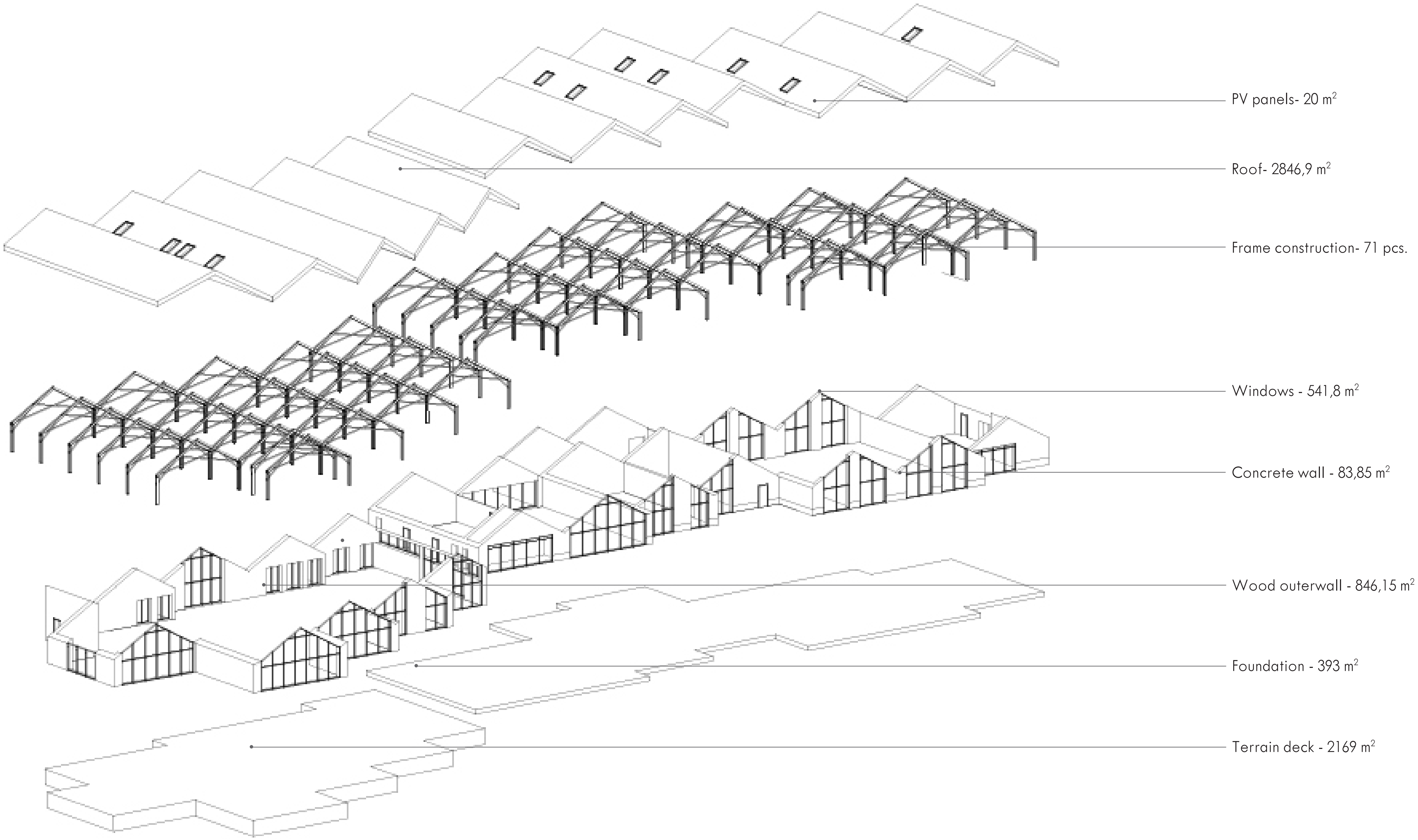
MECHANICAL VENTILATION STRATEGY



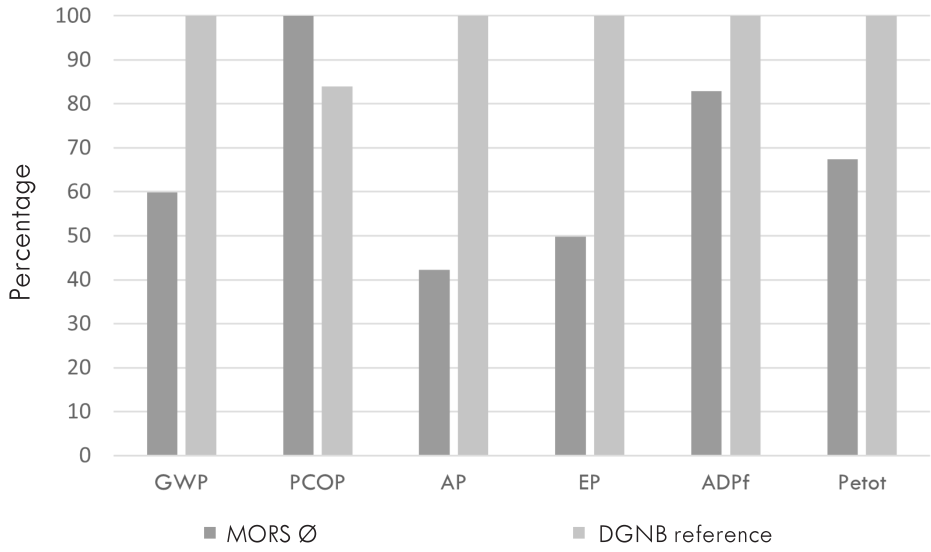
NATURAL VENTILATION STRATEGY

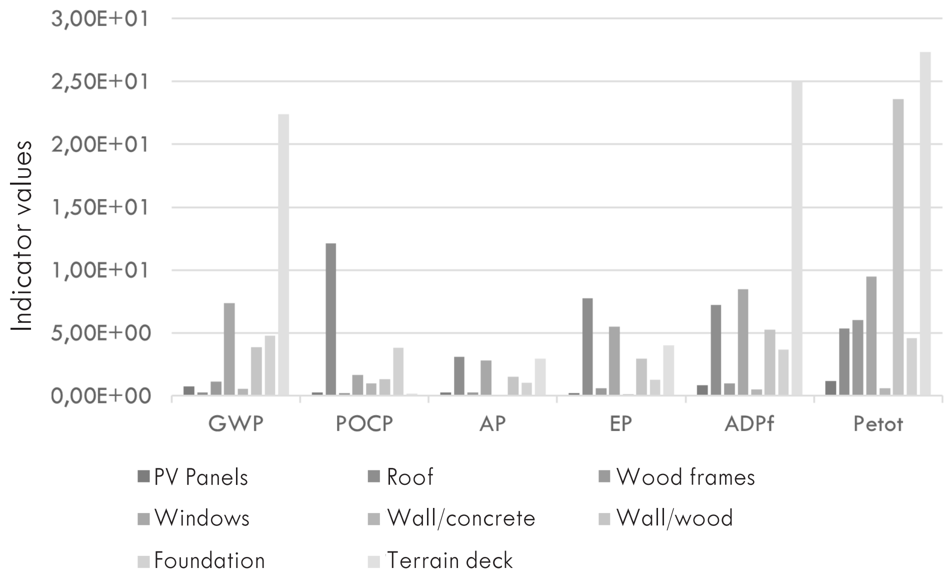


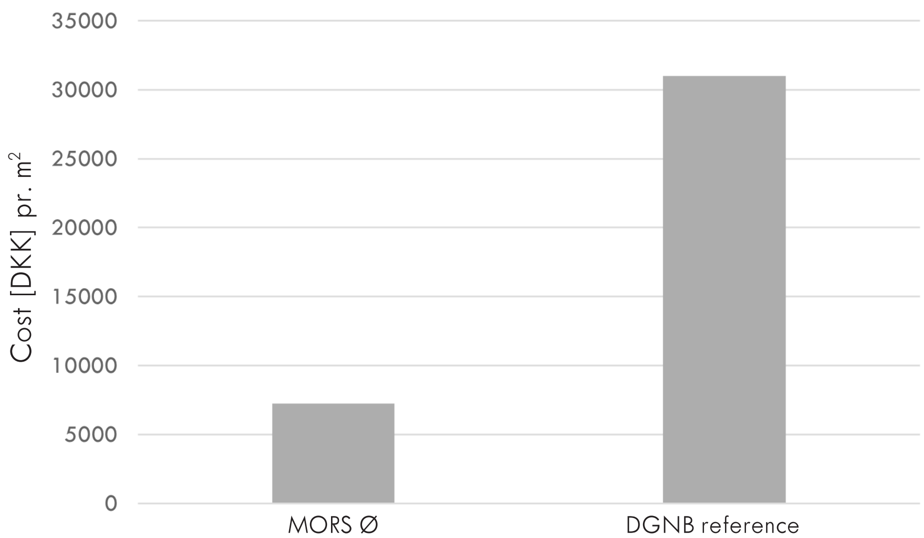
BOAT STORAGE - NO SCALE



EXPLODED CONSTRUCTION







LIFE CYCLE ASSESSMENT & COST

The life cycle assessments and life cycle costs of the design have been limited to its primary construction elements listed at the exploded diagram. Interior walls, heating system, and ventilations system are not included. The elements are compared with the 2020 DGNB reference with a 50 year lifespan. Due to the limitation basis of calculation, the numeric data is reduced and creates an inaccuracy in the DGNB score. Yet, the primary elements is of highest importance, and has the biggest impact on the DGNB indicators.

Environmental impact:

Comparing a building to the DGNB certification systems reference value, a maximum of points is 75. 'MORS Ø' rates 69,72, though it is important to state that ventilation system, heat system, and interior walls are not included in the life cycle assessment, and a realistic DGNB score of 'MORS Ø' will therefore score lower.

Economics:

The building costs 7193 DKK/m^2 based on the primary elements compared with the 2020 DGNB reference of 30000 DDK/m^2. This is the best performance possible as it is below 50% of the 2020 DGNB reference.

	GWP (x10)	POCP (x 10^4)	AP (x 10^3)	EP (x 10^4)	ADPf	Ptot
PV Panel	7,40e-01	2,53e-01	2,72e-01	2,19e-01	8,36e-01	1,20e+00
Roof	2,80e-01	1,21e+01	3,12e+00	7,76e+00	7,21e+00	5,38e+00
Frame construction	1,12e+00	2,31e+01	2,95e-01	5,90e+01	9,72e-01	6,05e+00
Window	7,39e+00	1,67e+00	2,83e+00	5,51e+00	9,72e-01	9,48e+00
Concrete wall	5,70e-01	1,00e+00	7,66e-02	1,13e-01	5,16e-01	6,08e-01
Wood wall	3,88e+00	1,00e+00	1,54e+00	2,96e+00	5,25e+00	2,36e+01
Terrain deck	2,24e+01	1,69e-01	2,98e+00	4,04e+00	2,50e+01	2,73e+01
Foundation	4,80e+00	3,80e+00	1,04e+00	1,25e+00	3,69e+00	4,60e+00

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
96,0	0,0	96,0
Total energy requirement		12,9

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
72,0	0,0	72,0
Total energy requirement		12,9

Energy frame BR 2018

Without supplement	Supplement for special conditions	Total energy frame
41,5	0,0	41,5
Total energy requirement		12,9

Energy frame low energy

Without supplement	Supplement for special conditions	Total energy frame
33,0	0,0	33,0
Total energy requirement		12,9

Contribution to energy requirement

Heat	15,2
El. for operation of bulding	-0,0
Excessive in rooms	0,0

Net requirement

Room heating	14,8
Domestic hot water	5,3
Cooling	0,0

Selected electricity requirements

Lighting	4,9
Heating of rooms	0,0
Heating of DHW	0,0
Heat pump	0,0
Ventilators	3,5
Pumps	0,2
Cooling	0,0
Total el. consumption	34,8

Heat loss from installations

Room heating	0,4
Domestic hot water	0,0

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	8,8
Wind mills	0,0

ENERGY PERFORMANCE

The building is categorized as a low energy building because of the utilization of various passive strategies such as natural ventilation, overhang, shading and optimization of window placement, and thermal mass. On the roof – orientated towards east – is 20 m^2 photovoltaic panel, producing the electricity used for building operation. The energy frame is 12,9 kWh/m^2 pr. year.

ROOM PROGRAM

GASTRONOMY

ROOM	SIZE [m²]
Entrance	11
Arrival	33
Wardrobe	11
Toilets	33
Hc toilet	5
Bar/reception	27
Bar	41
Lounge	41
Open kitchen	49
Kitchen	42
Frigde	5
Storage	11
Dishwashing	11
Locker rooms	11
technical room	11
Toilet	5
Staff room	33
Office	11
Resturante	93
Workshop	93

WATERSPORTS

ROOM	SIZE [m²]
Common	
Entrance	5
Arrival	11
Toilet	5
Technical room	11
Infomation	22
Printer	5
Social	33
Flex room	22
Common area	53
Changing room male	63
Changing room female	63
Sauna	22
Fitness	150
Garage	144
Toilet	7

WATERSPORTS

ROOM	SIZE [m²]
Youth school	
Office	11
Boat storage	97
Storage	24
Storage	7
Morsø Highschool	
Boat storage	11
Storage	97
Diving association - Krabben	
Auditorium	53
Dry storage	18
Wet storage	5
Compressor	5
Rowing association - Roklubben Mors	
Association	22
Boat storage	370
Wakeboard association	
Private gear storage	24
Rental gear storage	47
Depot	5
Changing room	9
Locker rooms	5
SUP storage	31

Total gastronomy	577 m²
Total watersports	1457m²
Total	2034 m²

DESIGN PROCESS

9.0. READING GUIDE

The following pages are a representation of 4 months of design process. The process is presented in three different phases where phase one consists of the process of locating a concept, building form, etc., where the second phase consists of different investigations conducted within the concept/ building form, ending in the third phase with different detailing processes. Even though the process could seem linear, it is important to state that the process has been going back and forth in an iterative process, where multiple subjects have been investigated at once, resulting in the final design.
Furthermore, the overall structure of the process pages start with an introduction of the investigation together with a representation of the three focused design criteria of the specific investigation, even though the investigation will involve in other design generators too. The investigations ends in a conclusion of which interest the specific investigation creates value for.

Introduction	FIGURE 1
Focused design criteria	FIGURE 2
Text related to figure 4	FIGURE 3
Diagram	FIGURE 4
Conclusion	FIGURE 5
Value creation of interest	FIGURE 6

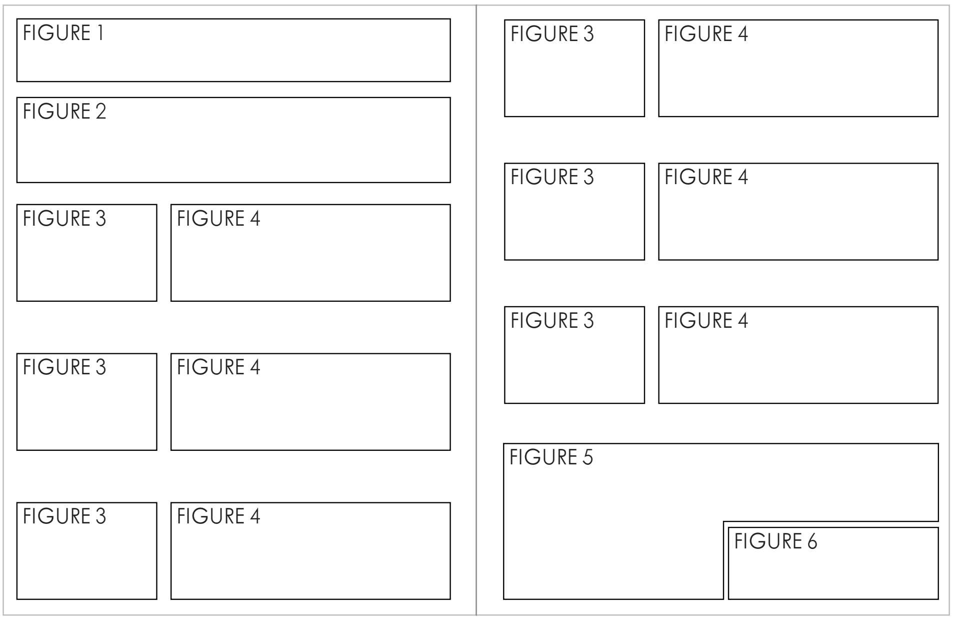


Figure 61 Page setting

9.1. PANDEMIC CHALLENGES

PRELIMINARY

Due to covid-19, the design process has been different from other semester projects conducted on AAU. Instead of meeting physically each day, the main parts of this project have been conducted digitally through digital models and Microsoft Teams meetings.

Adapting to Covid-19

When this master thesis began, it was not allowed to be working physically at CREATE, AAU, forcing us to be working in our student apartments with limited space. This resulted in difficulties working together efficiently, especially if a group member planned to make physical models this specific day. Though experience from the 8th semester and especially our internship period, which was also affected by covid-19, motivated us to make digital communication happen. Furthermore, through our internship, it has come up that shorter weeks at the office might be implemented in the future practice, due to new knowledge about the well-being and productivity of the employees. Though, It is important to stress that we have been meeting physically from time to time throughout the process, but mainly been working digitally.

Because of Covid-19, we needed to adapt to a new reality. Before Covid, we were able to stand close around the same model, sketches, etc. though these mediums together with the presentation of these have changed. As seen in the following pages, sketches have been used, though the physical modeling and the experience hereof is difficult to grasp if only one person should be touching it, or the people explaining it must not stand too close. Therefore a lot of digital modeling has been conducted through this thesis, which also clarifies that the analog and digital mediums consist of advantages and disadvantages. Therefore, it is concluded that even though our work methods have changed, it has not affected this master thesis negatively.

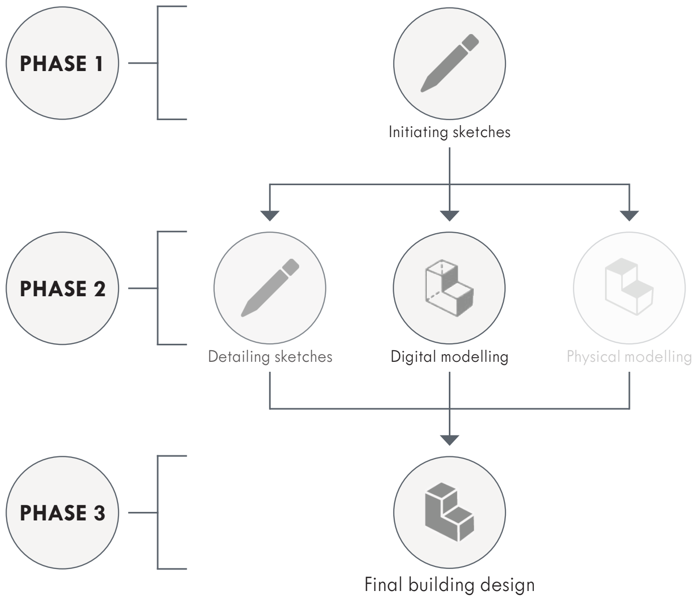


Figure 62 Covid process

10.0. PHASE 1 INTRO

PRELIMINARY

Phase one covers brainstorming and initial sketches, intending to find a direction for the project. This phase was conducted simultaneously with the composition of the program.

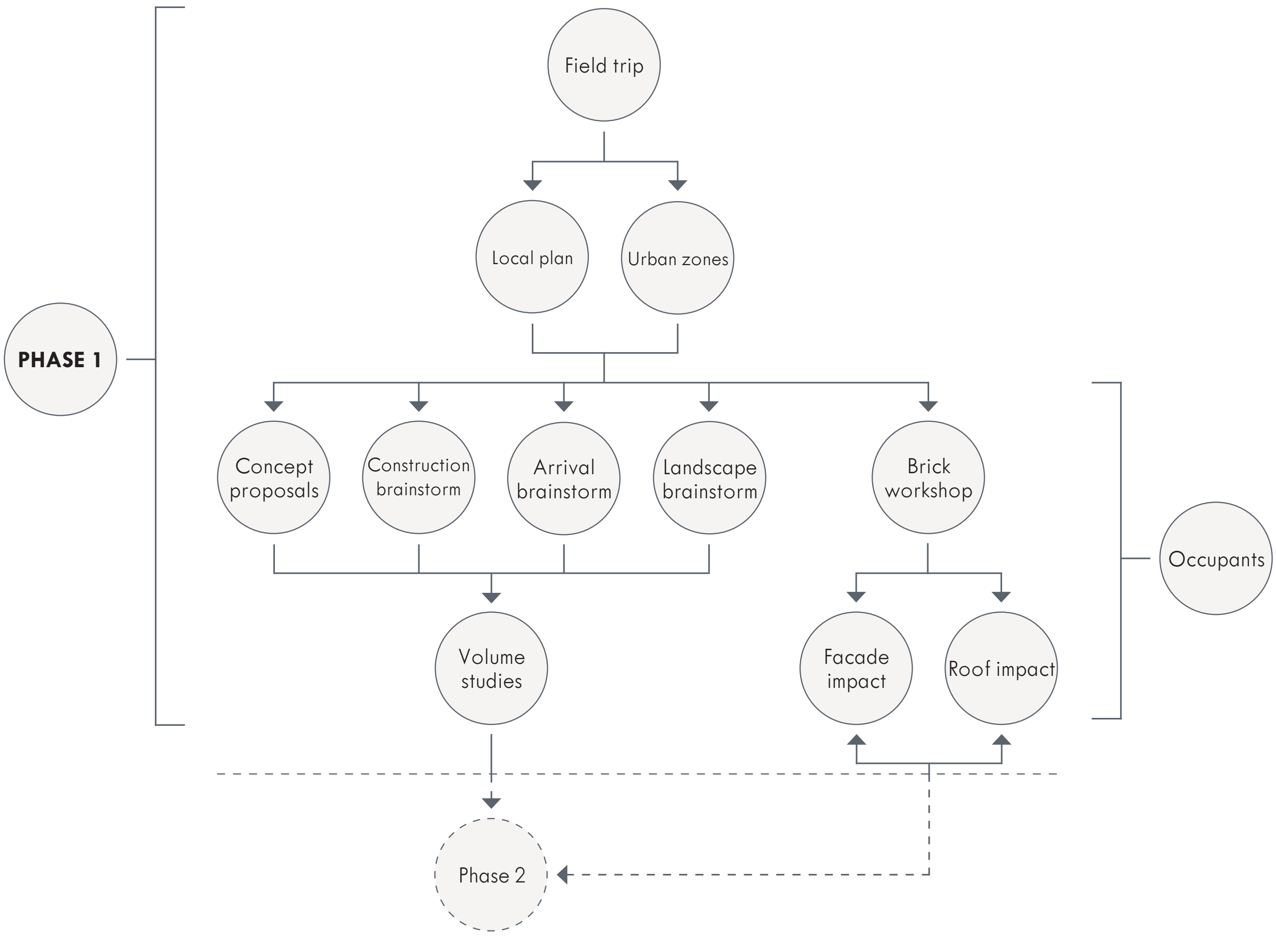


Figure 63 Phase 1 overview

10.1. FIELD TRIP

PRELIMINARY

Kicking off the project a field trip to Nykøbing Mors was conducted. On the way towards the island, several of the Cold Hawaii Inland projects located in Thy was visited. These projects were of great inspiration in regards to their contextual placement, and how the architects behind were able to utilize this throughout the design. The project which was visited was 'Synopal Havn' a cable park for wakeboarding practitioners, 'Thisted Promenade' which has several contemplation areas in connection to the fiord together with 'Vilsund', a meeting area for kayakers. Besides visiting the project area together with Nykøbing Mors, Glyngøre and its oyster bar were also visited, with the aim to start the design process of a gastronomical food experience.

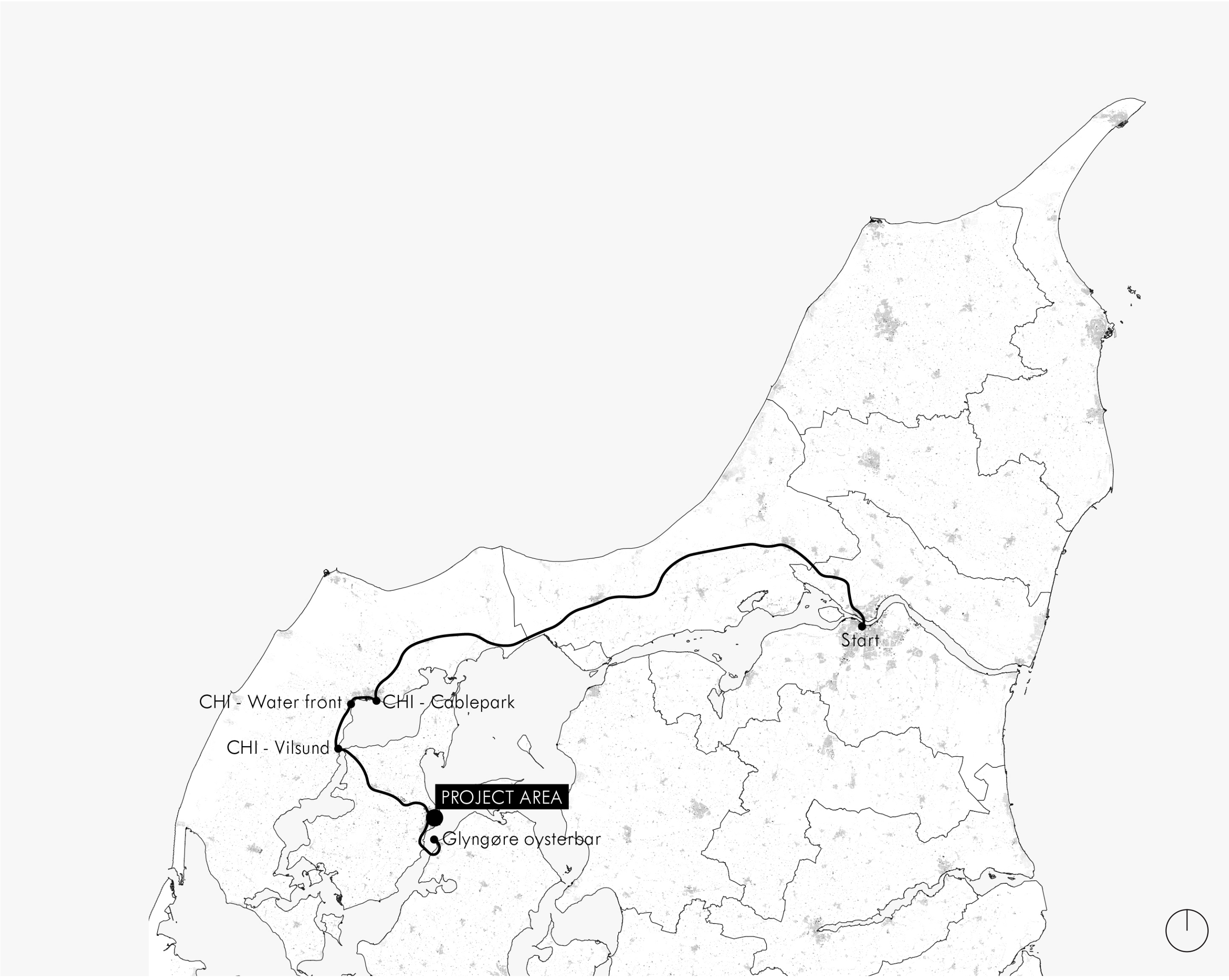


Figure 64 Field trip route

10.2. OCCUPANTS

PRELIMINARY

Throughout the process, a change of the user group has happened. Due to visions mentioned in the prospect by Morsø municipality, users as entrepreneurs and bigger educational offers were introduced into the facility design, based upon our own agenda, together with the primary users of gastronomy and water sports. Though throughout the process the building program and the intention with the building became blurry, which is why entrepreneurs and educational offers were discarded, making sure that the center was focusing upon the primary functions. This is also why throughout the process initial sketches may include these secondary users.

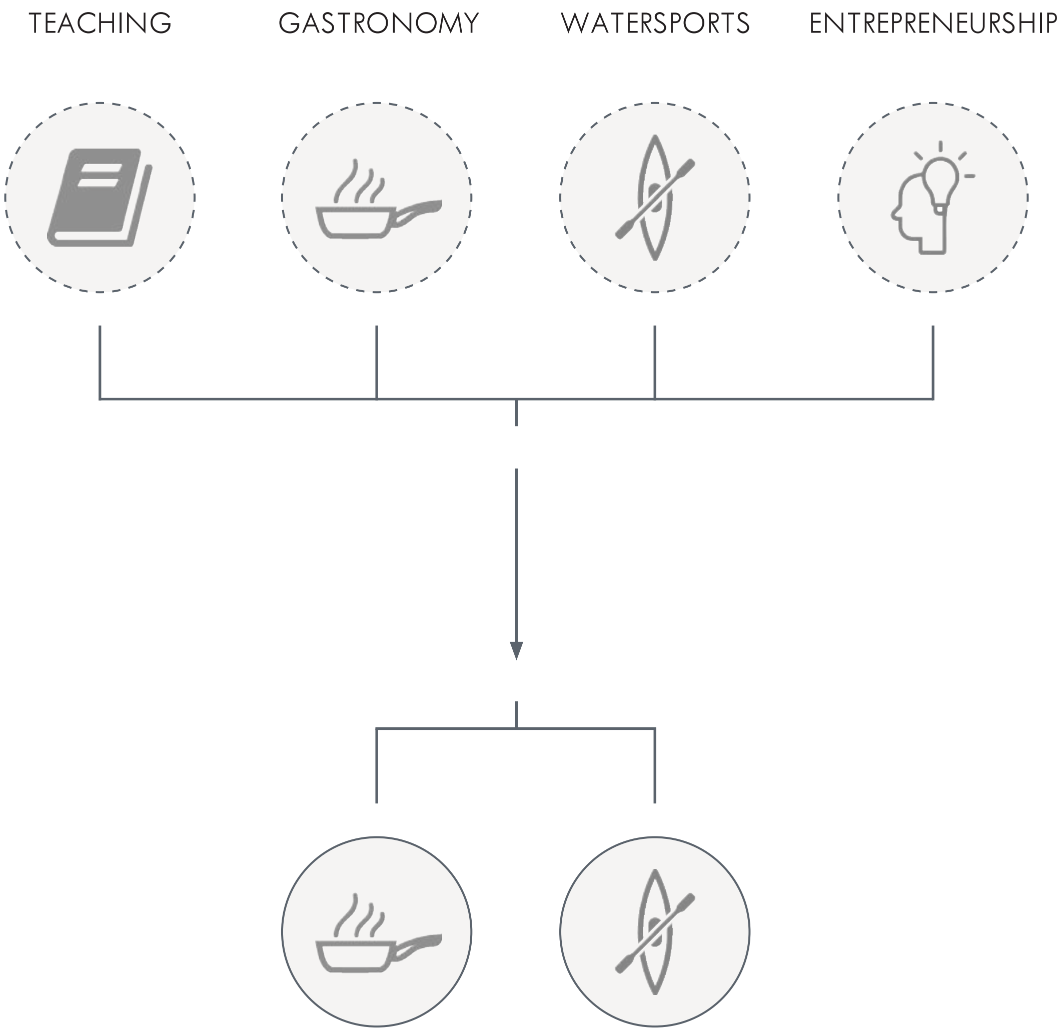


Figure 65 Occupants of the building

10.3. LOCAL PLAN

PRELIMINARY

This chapter investigates the demands of and the most important regulations for the project area, and how these demands will affect the project. The local plan is found at Morsø municipality's homepage (Morsø kommune, 2013).

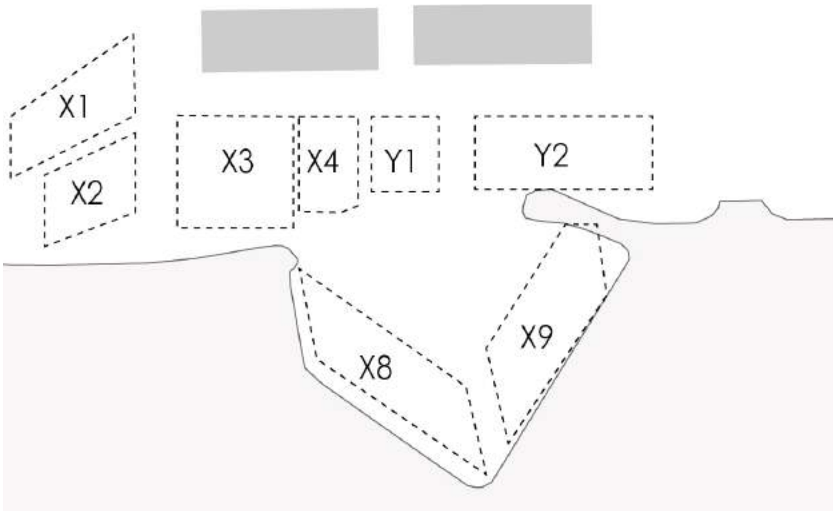


Figure 66 The local plan states the areas should contain an area for a sea sports center, spare-time activities, and buildings for holiday and leisure activities. Furthermore, it reviles that the chosen project area consists of multiply building sites, which have many of the same requirements such as the height of the urban areas and building sockets, together with different requirements such as building height.

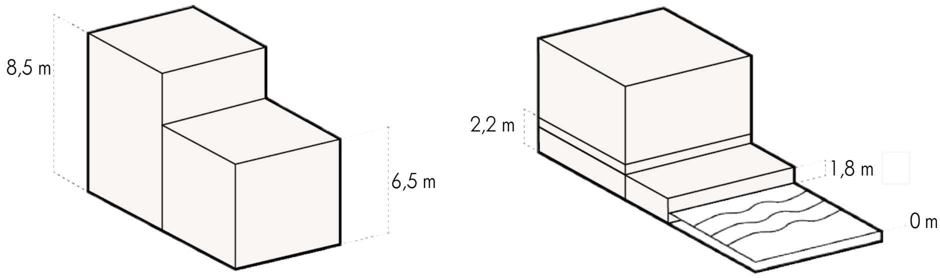
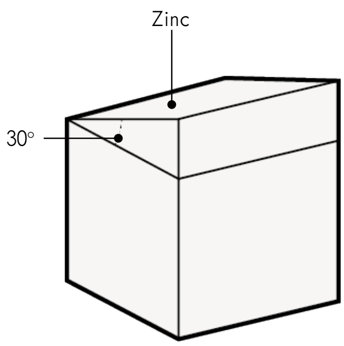


Figure 67 Building site Y1/Y2, is intended for the sea sports center to have a maximum height of 8,5 meters and must have a wood facade in light grey color. The building site X8/X9 must have a maximum height of 6,5 meters

Figure 68 The building socket must be constructed 2,2 meters above water level while the urban area must be constructed 1,8 m. above water level



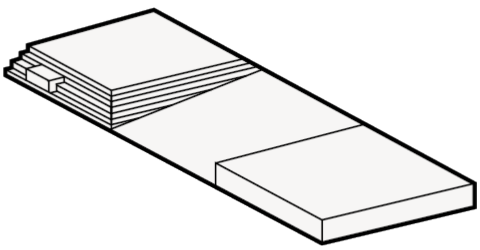


Figure 69 Roof angles must be constructed in zink in building site X1, X2, X3, X8 and X9 with a slope of maximum 30°.

Figure 70 The boat ramp must be accessible to the public.

10.4. URBAN ZONES

PRELIMINARY

The urban zone surrounding the project area consists of three zones, where all three of these zones are relevant for the project to address.

Figure 71 The position towards the east creates a connection to the marina and the sailing club. Though this position may create difficulties towards the demand for public access to the boat ramp.

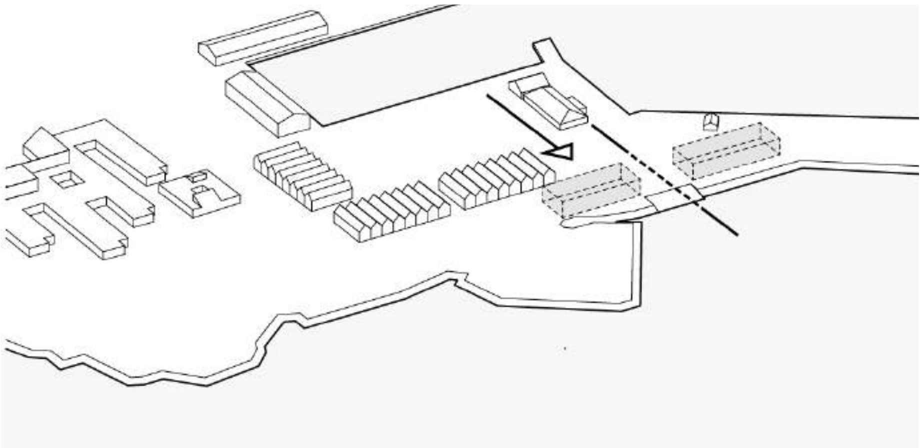


Figure 72 The position towards the west creates a connection to the city while making the building more visual to people arriving from the main road through the city together with the city center.

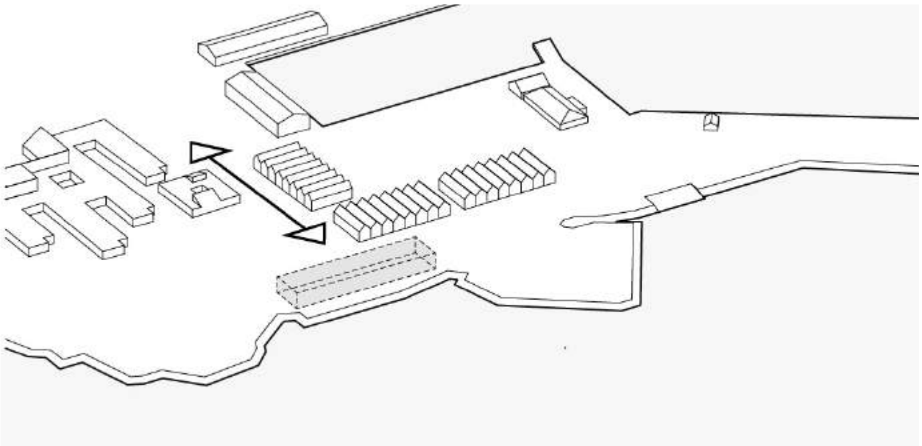
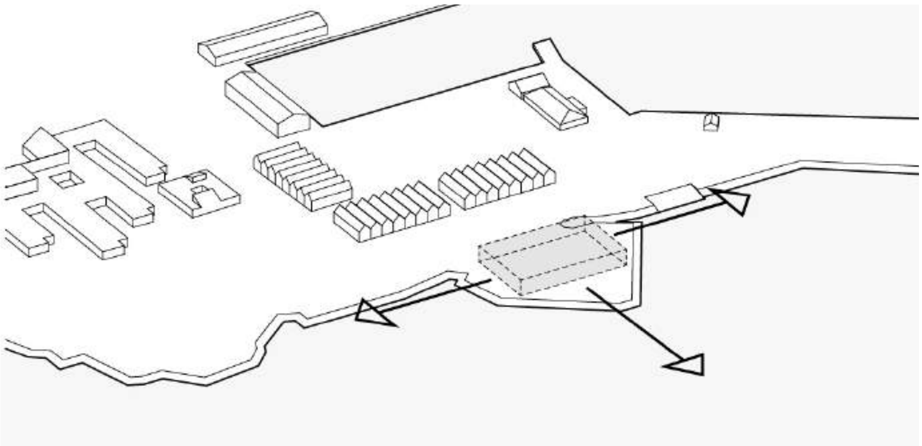


Figure 73 The project area stands as the extension into the fiord. By placing the building volume in this area, the building will surround itself with water in the majority of its orientations.



10.5. CONCEPT PROPOSALS

PRELIMINARY

The following pages represent the projects which had our interest throughout the sketching phase. Besides the following five iterations, several other building forms have been briefly investigated. Of the presented iterations, some are investigated more than others, which is especially seen in iteration three to five. Furhtermore, sketches based on an alternative project location can be seen in appendix 16.3.

FOCUSED DESIGN CRITERIA

LOW ENERGY INITIATIVES

URBAN REGENERATION

EXPERIENCE ECONOMY

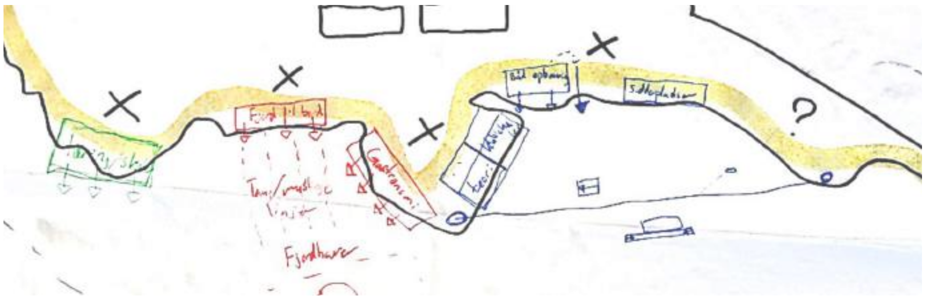
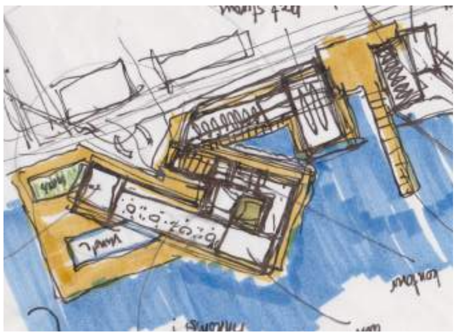


Figure 74 Iteration 1 focuses upon the activation of the waterfront through satelites programmed with watersports, educational of gastronomical function. The satellites should be connected to a central meeting point, where the main building is placed. The roof of the building slopes towards the fiord, creating an observation point, scouting upon the fiord, while the slope is opening the building towards the fiord it will greet guest arriving from this direction.



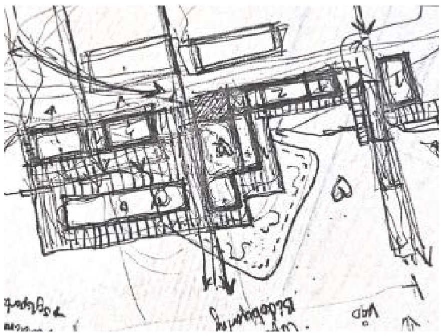
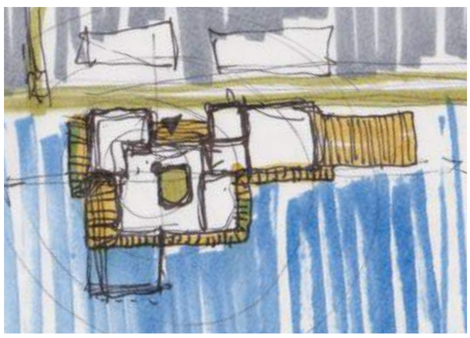


Figure 75 Iteration 2 focuses upon the creation of a bigger complex focusing on gastronomy, education, entrepreneurship, and watersports. The concept stands as several building volumes, creating different areas in and around the building, with different access points to the fiord, which is programmed differently



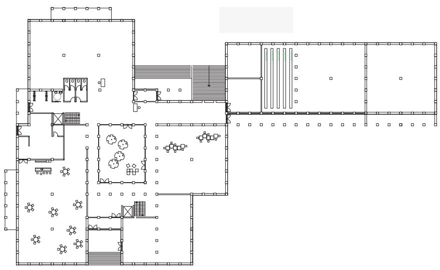


Figure 76 Iteration 3 takes departure in a central courtyard which should function as the central circulation system. The circulation system should be a central meeting point for the different users related to the building, creating cohesion between the different user groups. Furthermore, the atrium should be inspired by The Utzon Center, creating a visual connection between the different associations, restaurants, etc., through the courtyard. A plan process of this concept can be seen in appendix 16.4.

Figure 77 Iteration 4 has some similarities to iteration 3, taking departure in the concept of dividing the building into 'wet and dry' areas with a central atrium connection two levels. The watersports storages etc. is situated in level one, while the dry functions as clubrooms, restaurant, offices, educational offers, etc. are placed in the second level of the building. Concerns of this project not fitting into the context did occur due to the creation of one big volume with uncontrolled displacements, an introverted building mass was created through the atrium placement, together with doubts about creating a building in two stories. More sketches and illustrations of this concept can be seen in appendix 16.5.

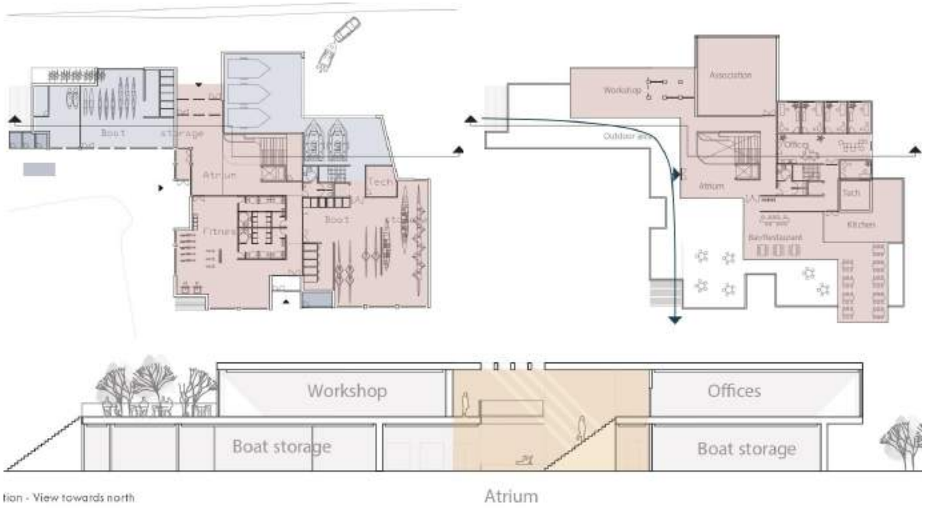
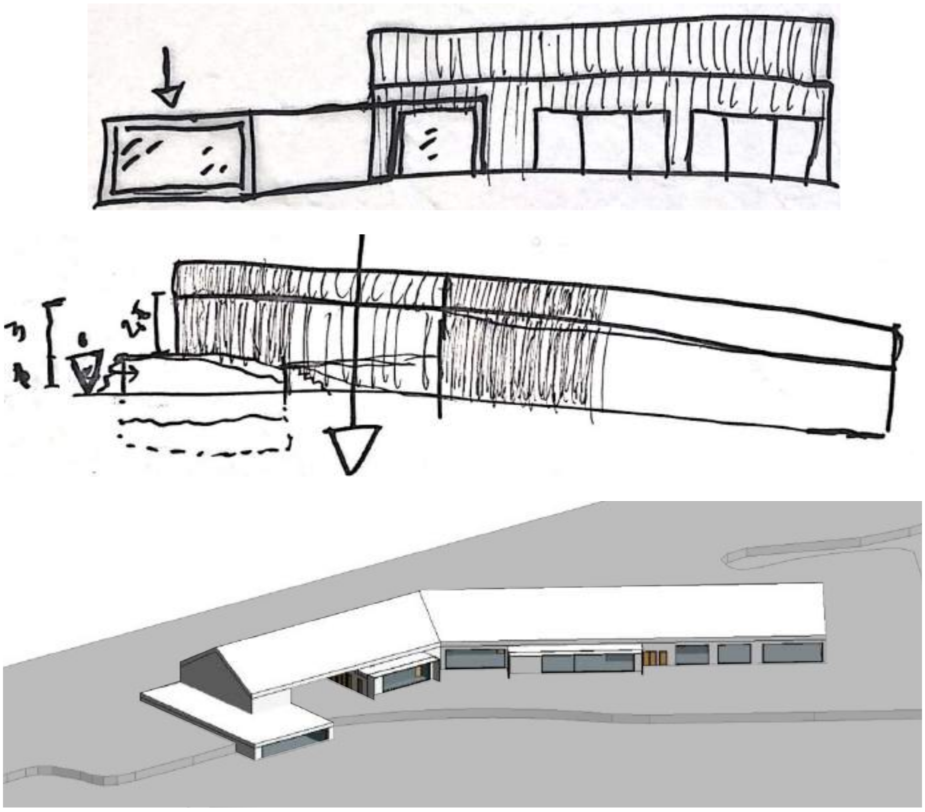


Figure 78 Iteration 5 takes departure in a much simpler volume than seen in the other iterations. The iteration is mixing the form language of the contextual position between the slope roofed boat houses and flat brick blocks shaping the city hall. By merging these typologies into each other a sloped roofed building with blocks emerging out of the façade is created. Furthermore, a semi-submerged restaurant is implemented with the aim to create a value of attraction within the building form.



CONCLUSION

The investigation of the different iterations has been an iterative process. Meaning that a concept was developed believing that it had the potential of becoming the initial concept. Despite several investigations being made, it was needed to move away from these concepts that potentially could work at some point. Leaving a concept behind, didn't mean that the next started from the beginning, instead, the next builds upon the knowledge derived throughout the different concepts, and preserved the value-creating design initiatives, and combined these into the initial concept. Though before choosing an initial concept material considerations, urban investigations and volume investigations needs to be conducted.

10.6. LANDSCAPE BRAINSTORM

PRELIMINARY

By designing a building in an area that is at high risk of getting flooded, while having users who need access to the fiord, the interplay between landscape and the building is important. Therefore, a brainstorm of the context was conducted, as the first step to start the urban design process.

FOCUSED DESIGN CRITERIA

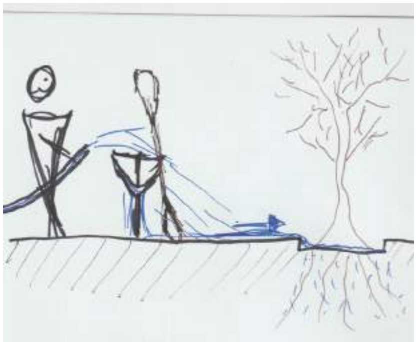

ACCESIBILITY


DURABILITY


ADAPT

Figure 79 Water from the hosing area can be strategically reused. Furthermore, a strong sewer system will be needed or plants to withhold the water.

Figure 80 An area for people to sit/ observe people bathing



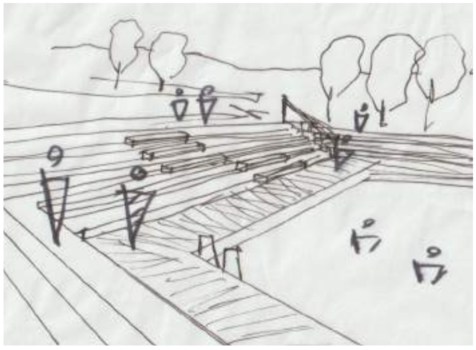


Figure 81 Flooding strategies can be implemented, with the aim to secure access to the water, no matter the tide.

Figure 82 Inspiration from harbors and the division of berths, round columns can be used defining areas or frame a specific view

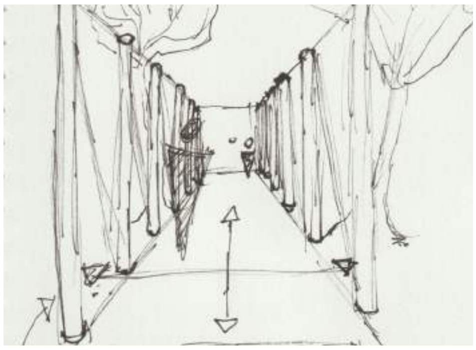
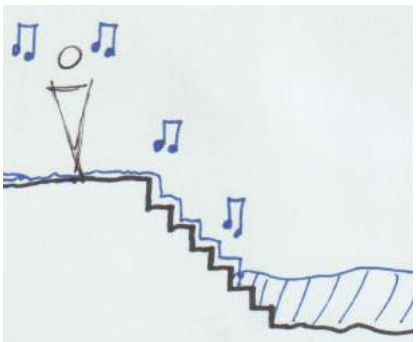


Figure 83 The sound of splashing water can be used as a design element. Furthermore, areas with running water through the landscape can be used to activate the context.

Figure 84 Floating shelters can be implemented, creating a possibility of tour kayakers stay overnight. Furthermore, these can easily be moved to another location if needed.



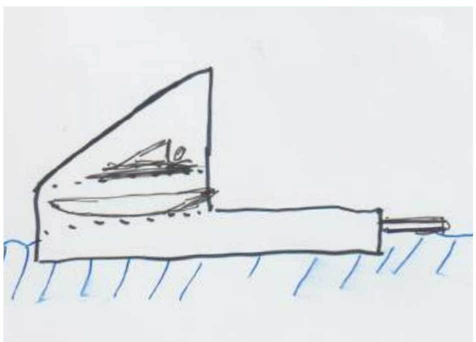


Figure 85 Gathering water from the city flowing towards the bight makes the landscape an active sculptural element.

Figure 86 Emphasizing the contrast between the built and natural environments through uncontrolled plantation in areas which is not used as an access point.

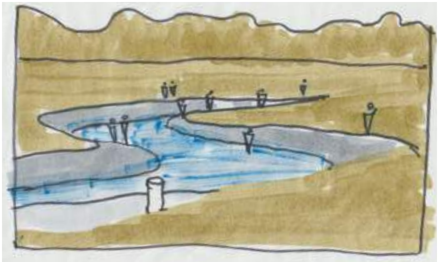


Figure 87 In the shallow part of the project area elements for activity can be placed in the water, creating a free activity for tourists and local users.

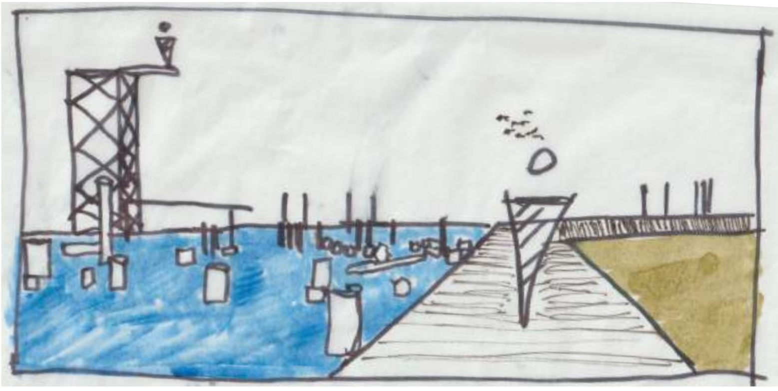


Figure 88 Different areas offering different kinds of activities can be implemented creating a range of activities with the aim to attract different users while creating smaller squares/areas with different atmospheres.

CONCLUSION

The brainstorm created a starting point for the urban landscape investigation, though different areas of the landscape are needed to be investigated further, such as flooding. Flooding initiatives are especially important to the building owner, due to the critical placement of the building towards the fiord. Furthermore, accessibility of the different watersports enthusiasts is important, creating untroubled access to the fiord, regardless of different tides.

10.7. ARRIVAL BRAINSTORM

PRELIMINARY

The arrival will typically be the first perception of the building. As Christian Norberg-Schultz clarifies, (cf. page 20) the arrival has the ability to create a specific experience of the building or the context, which it is placed within. This is something that is set to be investigated in the following sketches.

FOCUSED DESIGN CRITERIA


FRAMING


URBAN REGENERATION


EXPERIENCE ECONOMY

Figure 89 Framing of the fiord through openings in the façade. The perception of the fiord can be intensified by enclosing the opening from the sides and the top.

Figure 90 A stair leading to a roof terrace will create a soft transition into the created area. Views can be utilized from the roof area.

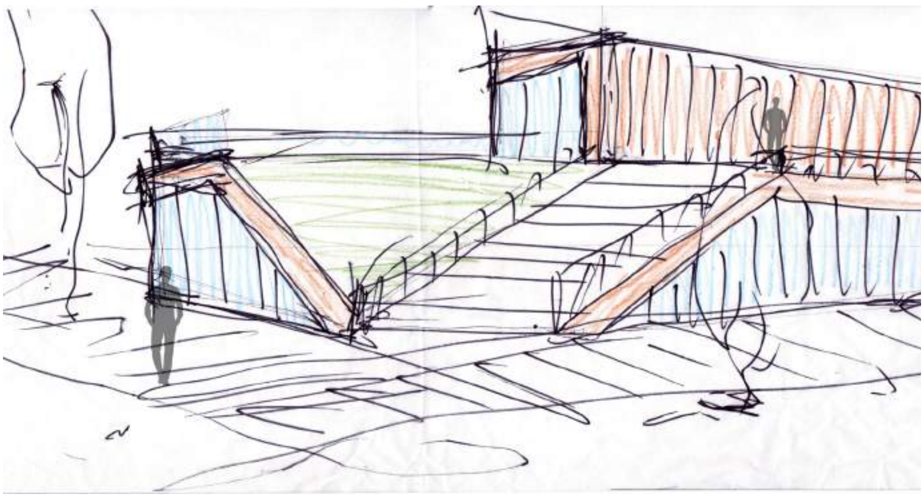
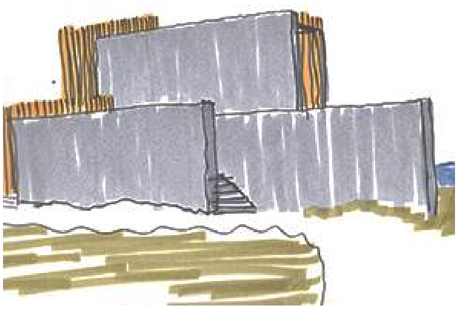


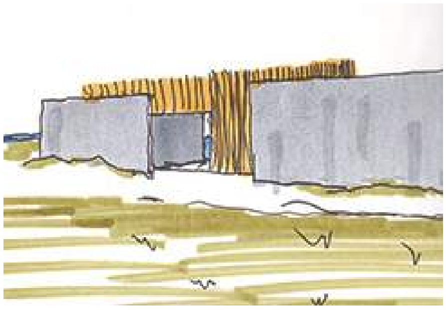
Figure 91 The façade can interact with the existing boat houses to the north. This could be done through a curvilinear design, standing as a contrast to the boat houses or geometric volumes creating different niches can be utilized, with the aim to avoid a linear expression.

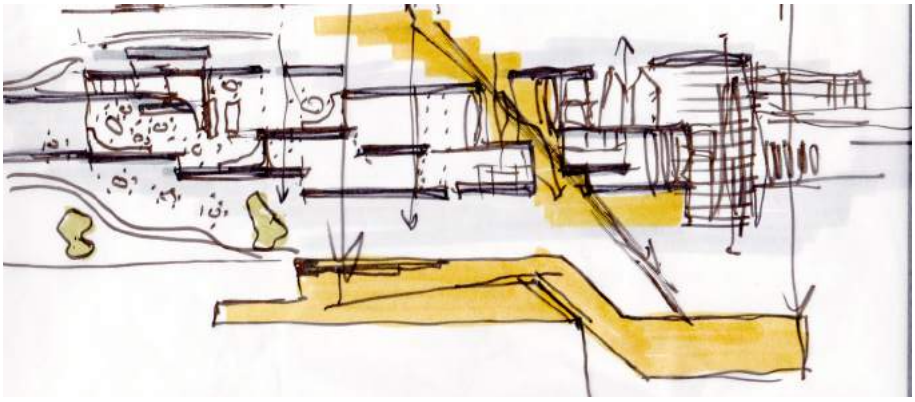
Curvilinear

Geometric displacements

Figure 92 Smaller views can be utilized in combination with stairs etc. These aspects create a value of attraction and might lead guests of the area into these specific areas.







CONCLUSION

The arrival can be a value of attraction leading guests and users into the area, which will create life in the area. Though due to this being a brainstorm, these effects need to be investigated in regards to a specific concept. Even though a stair will be a great way to greet the guest, the chosen concept might not need a stair design. During the arrival investigation, the perspetives drawings lead to questions about materiality, since the materiality have an influencce on the arrival and how the building fits into context.

10.8. BRICK WORKSHOP

PRELIMINARY

Based on analyses concerning local building traditions (Chapter 6.1.2.), a workshop focusing on the bond of the bricks was conducted. The bond has especially been investigated in regards to its ability to have a directional effect.

Figure 93 Iteration 1

Figure 94 Iteration 2

Figure 95 Iteration 3

Figure 96 Iteration 4

Figure 97 Iteration 5

Figure 98 Iteration 6

Figure 99 Iteration 7

Figure 100 Iteration 8

CONCLUSION

Through the investigations, several bonds have been investigated (full investigation can be seen in appendix 16.6.), though the possibilities of brick bonds seem endless. It can be concluded that if the brick is rotated and is placed transversing the bond, an adaption of the bricks is needed, which may cause material waste. Furthermore, an adaption of reused bricks will cause bigger labor when constructing the wall. Besides, material usage it can be concluded that brick bonds, can act as a leading element, which may be used for framing.

Through the workshop doubts about the context relation of bricks emerged. Most of the buildings in Nykøbing are built with bricks, though a brick building is often not seen in a maritime context. Furthermore, the brick needs to be investigated in regards to LCA and LCC.

10.9. FACADE IMPACT

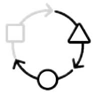
PRELIMINARY

With a project area next to the fiord and in a context of varied façade materials, an early investigation of façade materials was conducted. The investigation concerned the possibilities of the different materials to adapt into the contextual position with a focus on addressing a maritime typology while having a low environmental impact.

FOCUSED DESIGN CRITERIA

TYPOLOGY

ADAPT



LIFE CYCLE ASSESSMENT

Figure 103 A brick façade is the main façade material commonly used in Nykøbing Mors, which fits into the typology of the city, meanwhile, the brick doesn't fit into the maritime typology. A recycled brick façade has a minor environmental impact, compared to tthe other investigated materials

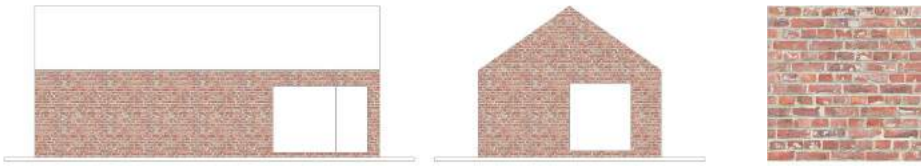


Figure 101 A wooden façade provides multiple possibilities concerning colors, orientation, and is typically used for a maritime typology like the existing boat houses. Wooden façades typically have a minor environmental impact but require high maintenance.

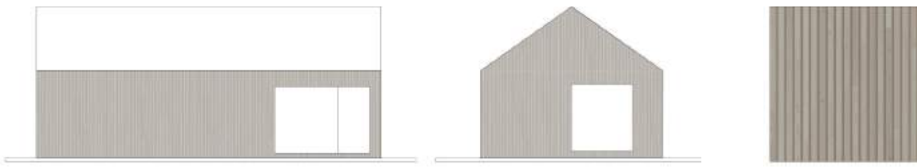


Figure 102 An aluminum façade can reflect the sun, in an interesting way, but has no relation to the context. Besides, an aluminum façade of recycled aluminum has a major environmental impact.

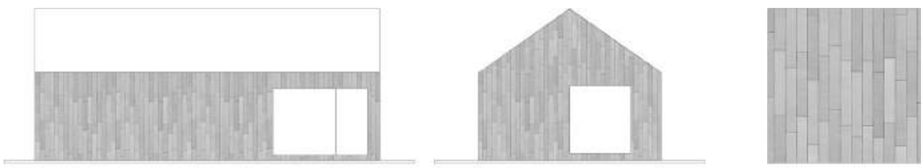


Figure 104 A concrete façade is a common material used in the building industry but is not seen in the surrounding area as a facade material but as foundation and flood protection. A concrete façade has a major environmental impact.

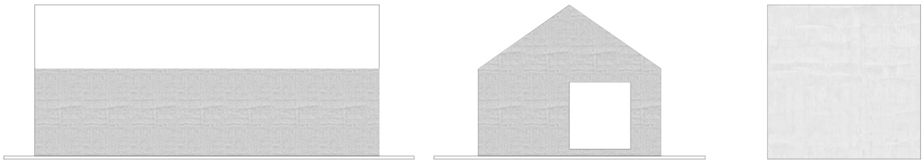
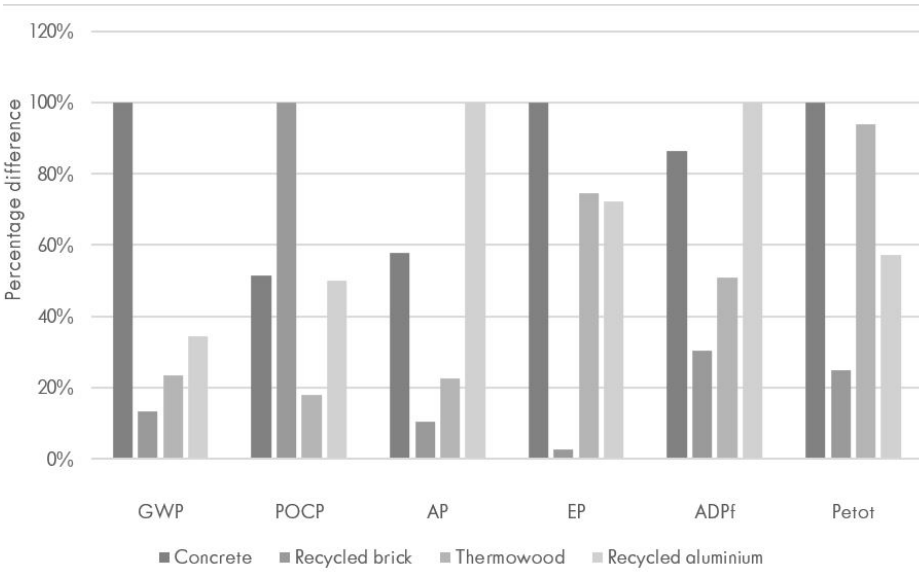


Figure 105 LCA results presented in percentages related to the biggest value in each category.

Furthermore, each material is rated on a scale of 1-3 upon their performance of each DGNB reference criteria in regards to their specific weighted score.



	GWP [Kg CO_2 eq.]	POCP [Kg C_2H_4 eq.]	AP [Kg SO_2 eq.]	EP [Kg PO_4^{3} eq.]	ADPf [MJ]	PEtot [MJ]	Rating
Recycled brick	1,03E-04	2,44E-07	2,13E-07	5,65E-09	1,57E-03	1,58E-03	2,8
Thermowood	1,80E-04	4,38E-08	4,56E-07	1,54E-07	2,63E-03	5,94E-03	2,45
Recycled aluminium	2,64E-04	1,22E-07	2,03E-06	1,54E-07	5,18E-03	3,62E-03	1,75
Concrete	7,66E-04	1,26E-07	1,17E-06	2,07E-07	4,47E-03	6,33E-03	1,2

CONCLUSION

Based on the values of the interest, the wood and recycled brick had the best environmental performances, maritime topology, and adapting into the context. Although wood and recycled bircks have the best environmental performance, concrete is the most durable in regards to flooding. A more detailed investigations is needed.

10.10. ROOF IMPACT

PRELIMINARY

Along with an exterior façade investigation, an early investigation of roof materials was conducted. Different potential roof materials were investigated in regards to its architectural expression and the possibilities of the different materials adapting into the contextual position with a focus on addressing a maritime typology while having a low environmental impact.

FOCUSED DESIGN CRITERIA

TYPOLOGY

ADAPT

LIFE CYCLE ASSESSMENT

Figure 106 Raw wood is an absent materiality on the Nykøbing harbor front. Yet, there is a tendency of implementing wooden roofs in the new built maritime typology, as it is durable and has a minor environemntal impact in regards to the investigated materials.

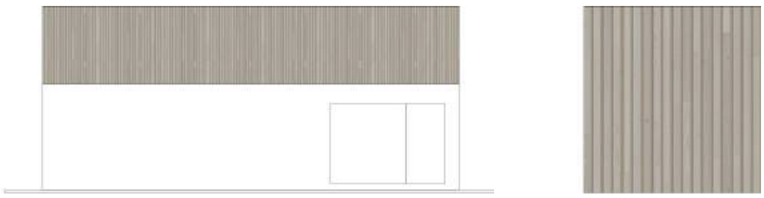


Figure 107 A zinc roof is one of the materials mentioned in the local plan, however a zinc roof is an absent materiality on the Nykøbing harbor front. Furthermore, a zinc roof has a major environmental impact.

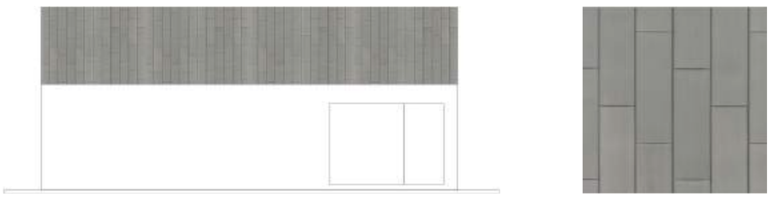


Figure 108 A tile roof is the most common roof type in Nykøbing Mors, but looking at a maritime typology the tile roof doesn't adapt to the boat houses north of the project site. The tile roof has a major environmental impact.

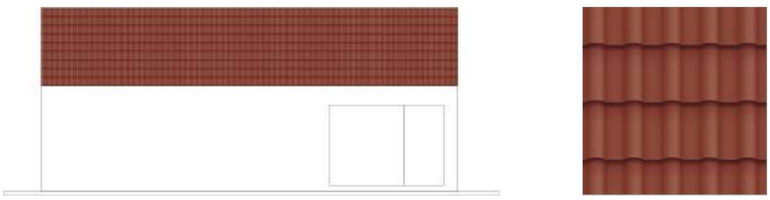


Figure 109 A bitumen roof is a very common roof type in the harbor area of Nykøbing M. The bitumen roof has a mediocre environmental impact.

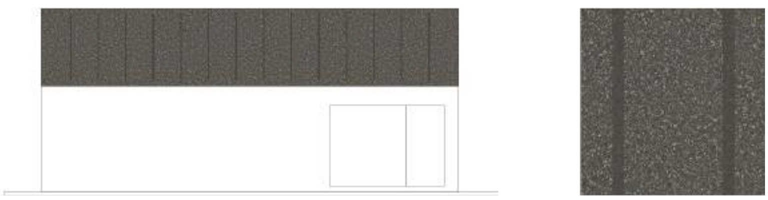


Figure 110 A sedum roof often gives a sustainable expression but looking into a maritime typology a sedum roof is not commonly used. The sedum roof has a mediocre environmental impact.

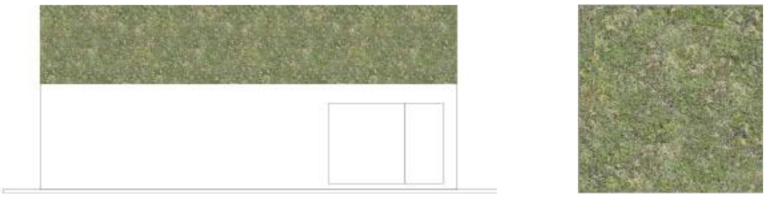
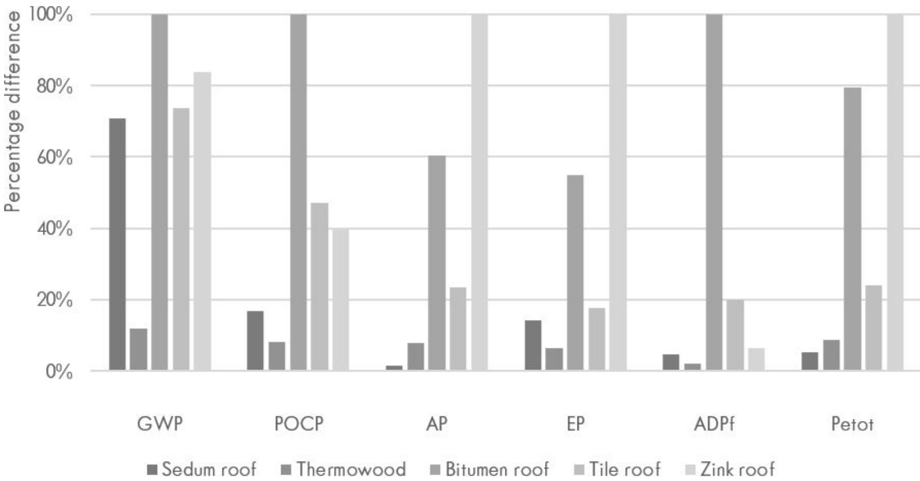


Figure 111 LCA results presented in per-centages related to the biggest value in each category.

Furthermore, each material is rated on a scale of 1-3 upon their performance of each DGNB reference criteria in regards to their specific weighted score.



	GWP [Kg CO_2 eq.]	POCP [Kg C_2H_4 eq.]	AP [Kg SO_2 eq.]	EP [Kg PO_4^3 eq.]	ADPf [MJ]	PEtot [MJ]	Rating
Thermowood	5,96e-05	1,27E-08	1,37E-07	2,96E-08	5,24E-04	2,94E-03	2,7
Zink roof	4,15e-04	6,15E-08	4,51E-06	4,51E-07	1,63E-03	3,41E-02	1,65
Tile roof	3,55e-04	7,34E-08	4,07E-07	7,99E-08	5,21E-03	8,16E-03	2,1
Bitumen roof	4,96e-04	1,56E-07	1,05E-06	2,48E-07	2,59E-02	2,71E-02	2,05
Sedum roof	3,51e-04	2,63E-08	2,89E-08	6,38E-08	1,22E-03	1,76E-03	2,35

CONCLUSION

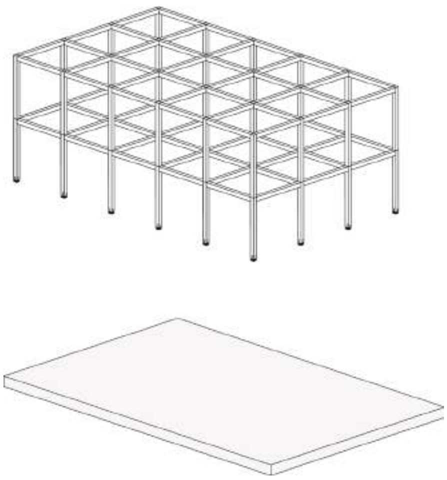
The investigation of potential roof materials showed that some of the materials will adapt to context, though some of the materials have a major envrionmental impact. The roof material has been investigated further with a full roof construction consisting of wood, zinc, and bitumen as surface material together with an LCC investigation (appendix 16.7). A minor environmental impact will have great value for the society, though it may be an expensive choice for the building owner. Furthermore, the roof material should adapt to the context.

10.11. CONSTRUCTION BRAINSTORM

PRELIMINARY

The construction functions as a load-bearing element, though the construction is able to do much more than that. Therefore, a brainstorm of the construction has been conducted. The construction will especially be investigated in regards to its ability to affect the observer.

FOCUSED DESIGN CRITERIA



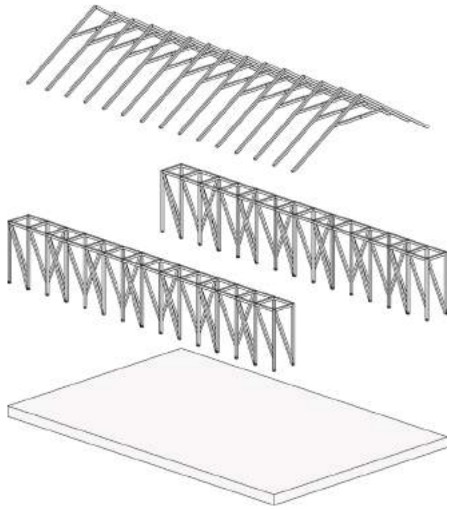
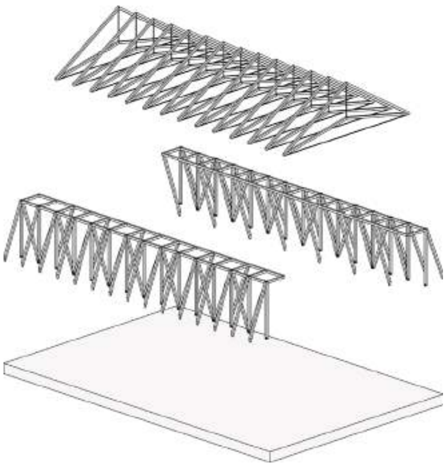


Figure 112 Iteration 1: Frame construction, for a concept with a flat roof. The construction could be created in modules, for easier production. Furthermore, with a grid-like system, typically a more flexible building can be designed.

Figure 113 Iteration 2: Frame system which the rafter will be loaded onto, creating a sloped roof building, with possibilities of utilizing the frame as storage, pathways etc.



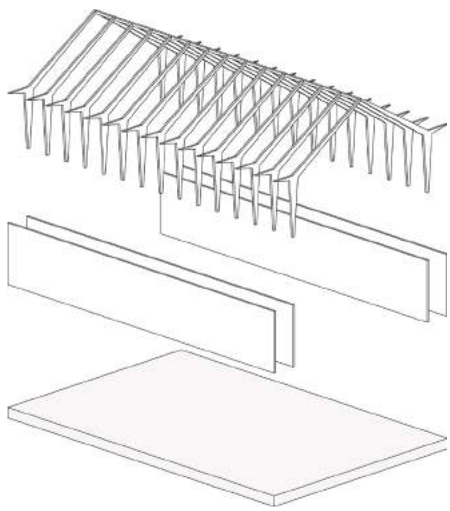


Figure 114 Iteration 3: Frame system with the rafters being connected through a wire system, as a reference to boats and their wire systems.

Figure 115 Iteration 4: Frame system which utilizes the cross-section in the areas, where the biggest loads are affecting the beam/ column.

Figure 116 Iteration 5: By introducing a beam at the top of the construction, the roof height, will be lowered slightly. Furthermore, the beam is needed to create a statically determined construction, making sure, that the frame will not be a mechanism (Static determination calculations can be seen in appendix 16.8.) . Furthermore, visuals of iteration 5, 6, and 7 can be seen on the following page.

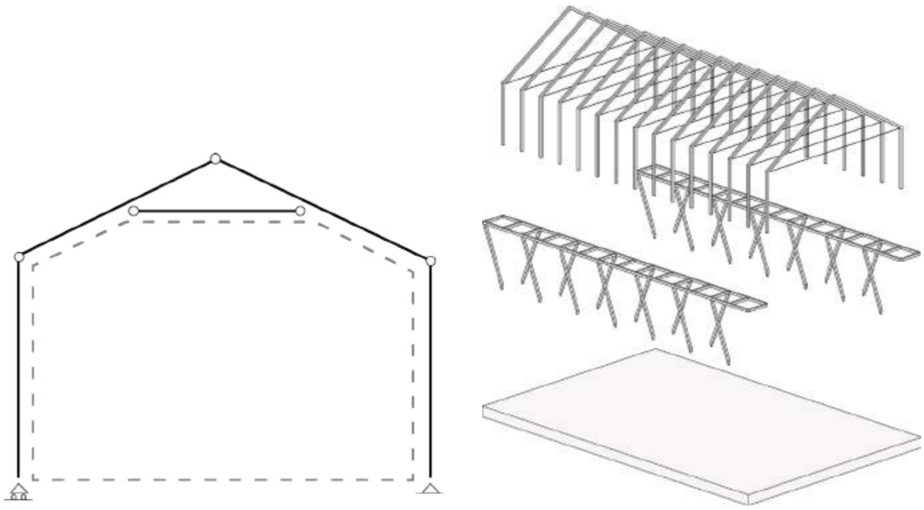


Figure 117 Iteration 6: By introducing two beams to the construction, the room height will seem lower without actually lowering the ceiling height with a low-hung ceiling. By 'lowering' the ceiling with the construction, it will be embracing the observer, which could be needed to create a specific atmosphere.

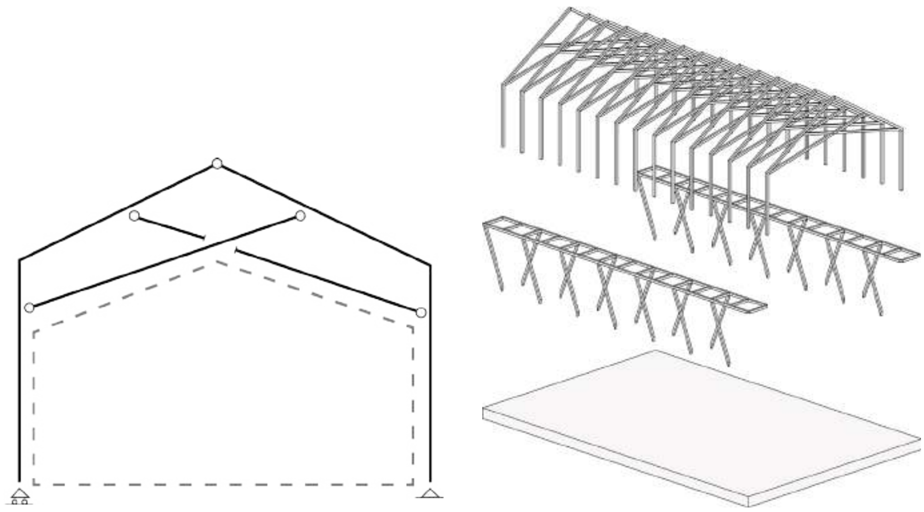


Figure 118 Iteration 7: With the introduction of 4 beams into the construction, the embracing of the observer will be intensified. Though, with this amount of elements in the construction, it will be statically undetermined of 2. degree. Meaning that the construction may be over-dimensioned in regards to elements.

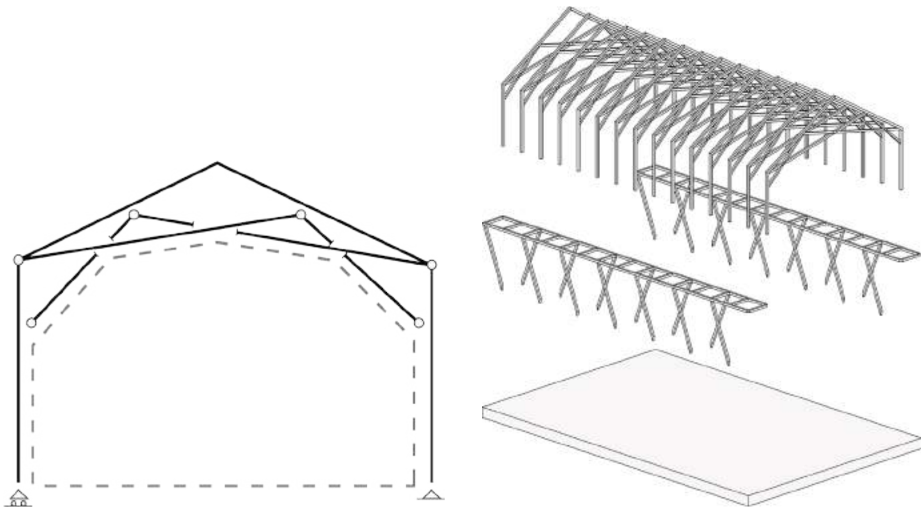
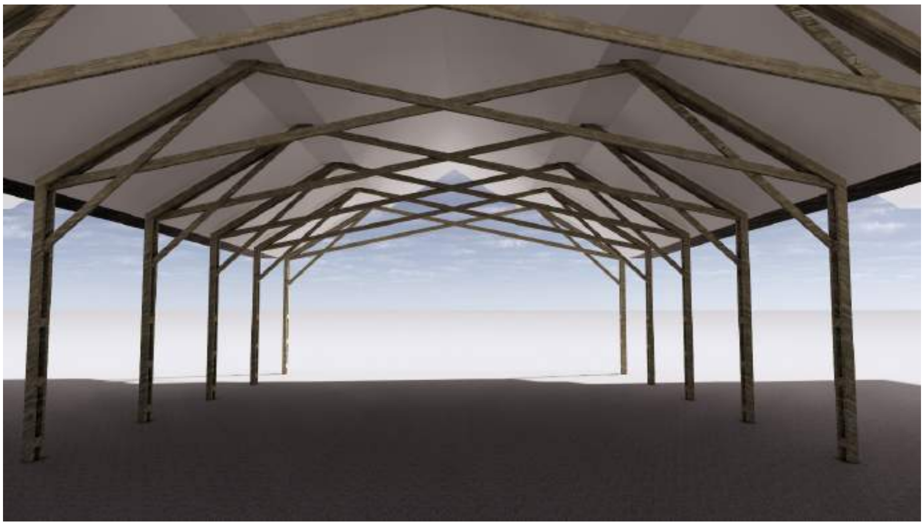


Figure 119 Iteration 5 visual

Figure 120 Iteration 6 visual

Figure 121 Iteration 7 visual



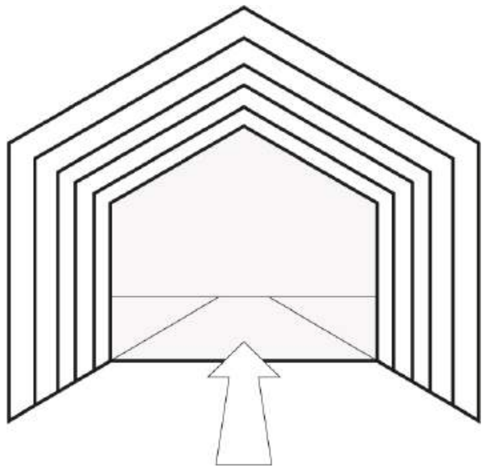


Figure 122 The frames can be used as a directional tool framing the fiord, while creating big openings, making an easy transportation strategy of boats from the storage and into the fiord.

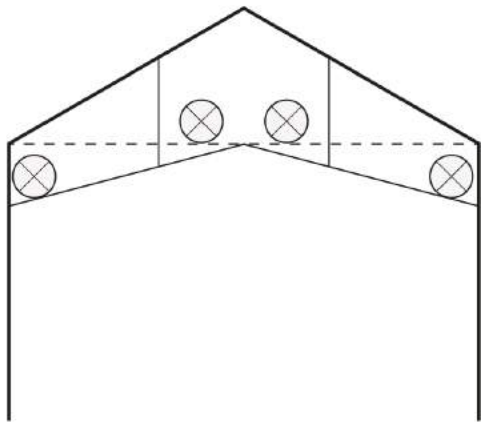


Figure 123 The construction can be constructed to be equipping the ventilation pipes, making these run inside the frame.

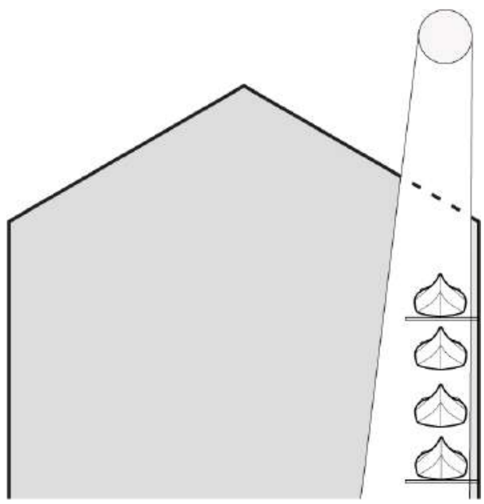


Figure 124 By integrating skylights, a symbolic framing of specific elements can be conducted. Furthermore, the construction can be utilized in the different storage units, as load-carrying elements.

CONCLUSION

The brainstorm mainly focuses upon the effect of sloped roof constructions. This is due to an initial thought to implement this type of building volume to the design. Several other volumes were investigated, before looking back into the sloped roof volume. Though it can be concluded that by adding elements to a simple construction the perception of a room can change. Furthermore, by utilizing frames as seen in the iterations, running perpendicular to the shoreline, big openings towards the fiord can be utilized, as the loadbearing system is placed inside the building, and not along the façade.

10.12. VOLUME STUDIES

PRELIMINARY

Chapter '10.5. Concept proposals' introduced several concepts investigated through this master thesis. Before concluding upon the different investigations choosing a concept, which will be the initial concept, the context awareness together with a conceptual BE18 will be conducted upon the different concepts. The BE18 is calculated upon the volumes with 40% of the facades being windows.

FOCUSED DESIGN CRITERIA

Figure 125 Iteration 1
Total Area: 1484 m^2
Total volume: 10327 m^3
Total façade area: 922 m^2
Total window area: 615 m^2

Be18 – result: 90,5 kWh/m^2 year

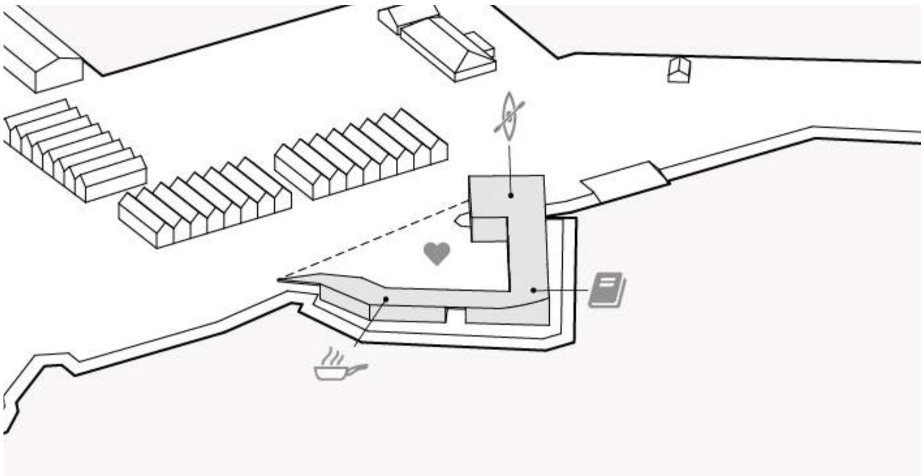


Figure 126 Iteration 2
Total Area: 2891 m^2
Total volume: 12026 m^3
Total façade area: 1251,6 m^2
Total window area: 834,8 m^2

Be18 – result: 70 kWh/m^2 year

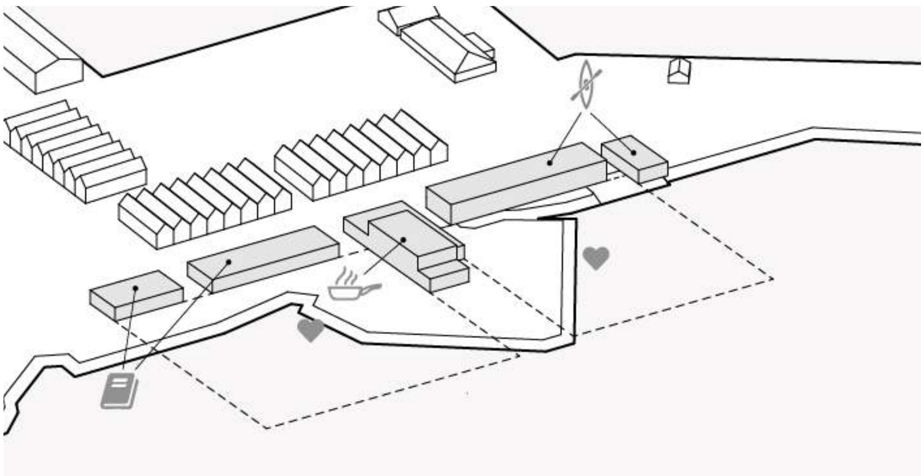


Figure 127 Itretaion 3
Total Area: 1476 m^2
Total volume: 7413 m^3
Total façade area: 945 m^2
Total window area: 630 m^2

Be18 – result: 87,6 kWh/m^2 year

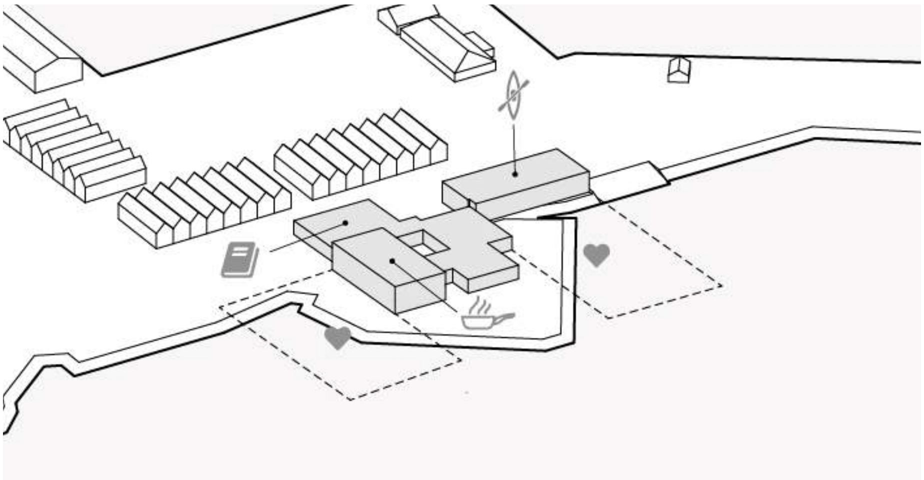


Figure 128 Iteration 4
Total Area: 2556 m^2
Total volume: 10327,4 m^3
Total façade area: 1003,6 m^2
Total window area: 668,9 m^2

Be18 – result: 66,7 kWh/m^2 year

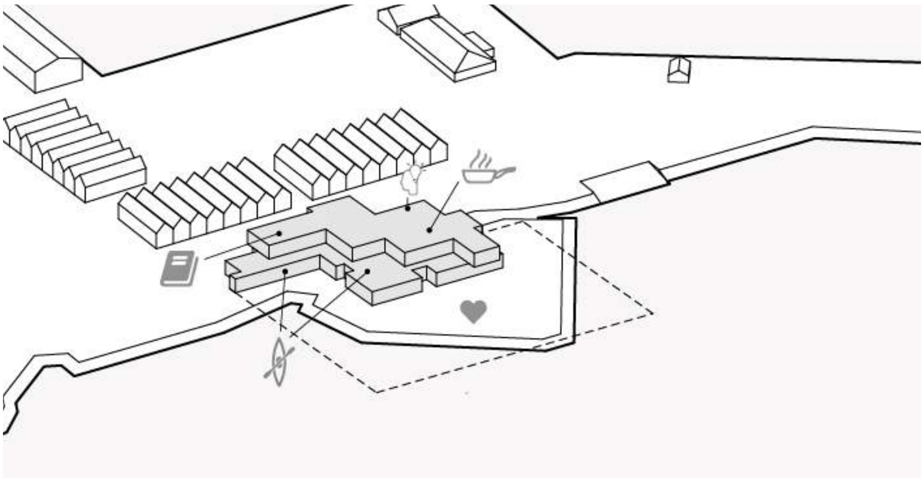
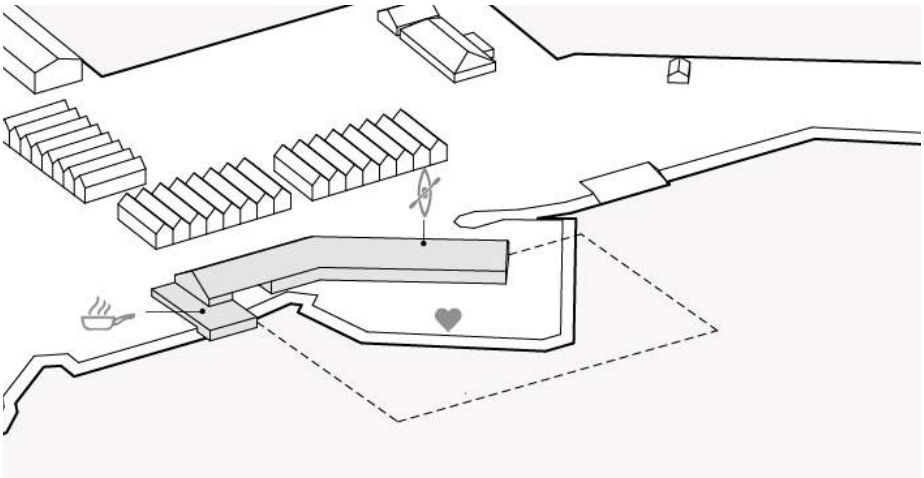


Figure 129 Iteration 5
Total Area: 1409 m^2
Total volume: 7372,5 m^3
Total façade area: 735 m^2
Total window area: 338,3 m^2

Be18 – result: 76 kWh/m^2 year



CONCLUSION

The different iterations have a quite high energy frame, though it is important to state, that the simulation is performed on a conceptual basis, getting an understanding of the performance of the volumes, where iteration two and four are the ones performing the best, which could be caused by them being multistoried. Furthermore, iteration four and five are creating a singular common area in connection to the fiord, which is in the interest of the users, and the building owner focusing on social cohesion, where the other concepts are oriented towards the city or have several urban areas, divided by building masses. Looking at the contextual position it is concept 5, which relates to the context the best, with a simple architectural expression, while being equipped with a sloped roof. Therefore, iteration 5 will be the initial concept for furhter investigaiton.

11.0. PHASE 2 INTRO

The initial concept is a merge of several brainstorm initiatives, whereof the construction can be used as a framing device towards the fiord, or the open land west of the building. Furthermore, the arrival has the possibility to frame and intensify the experience of the fiord, while gathering the outdoor area around one central exterior space.

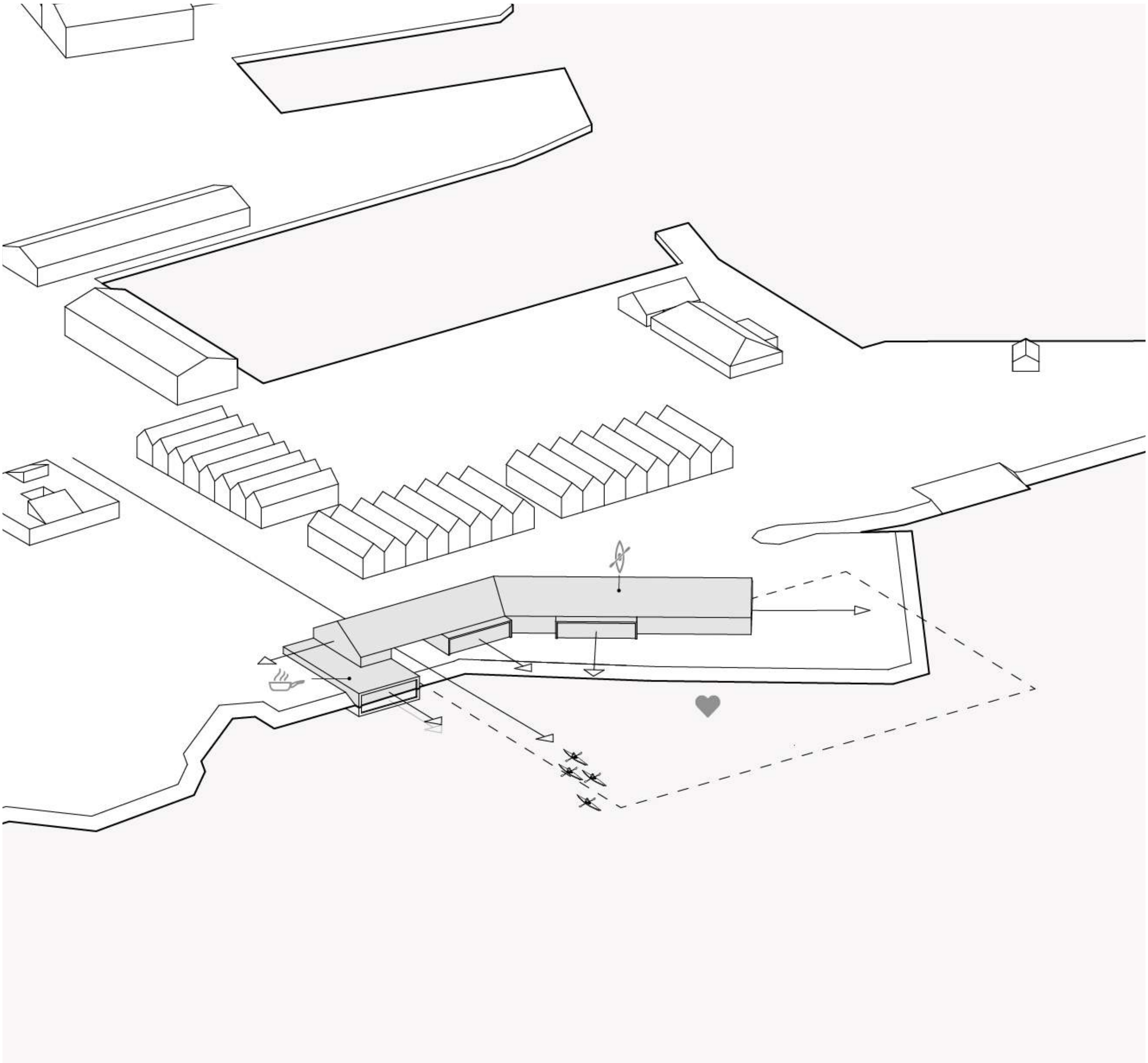


Figure 130 Initial concept

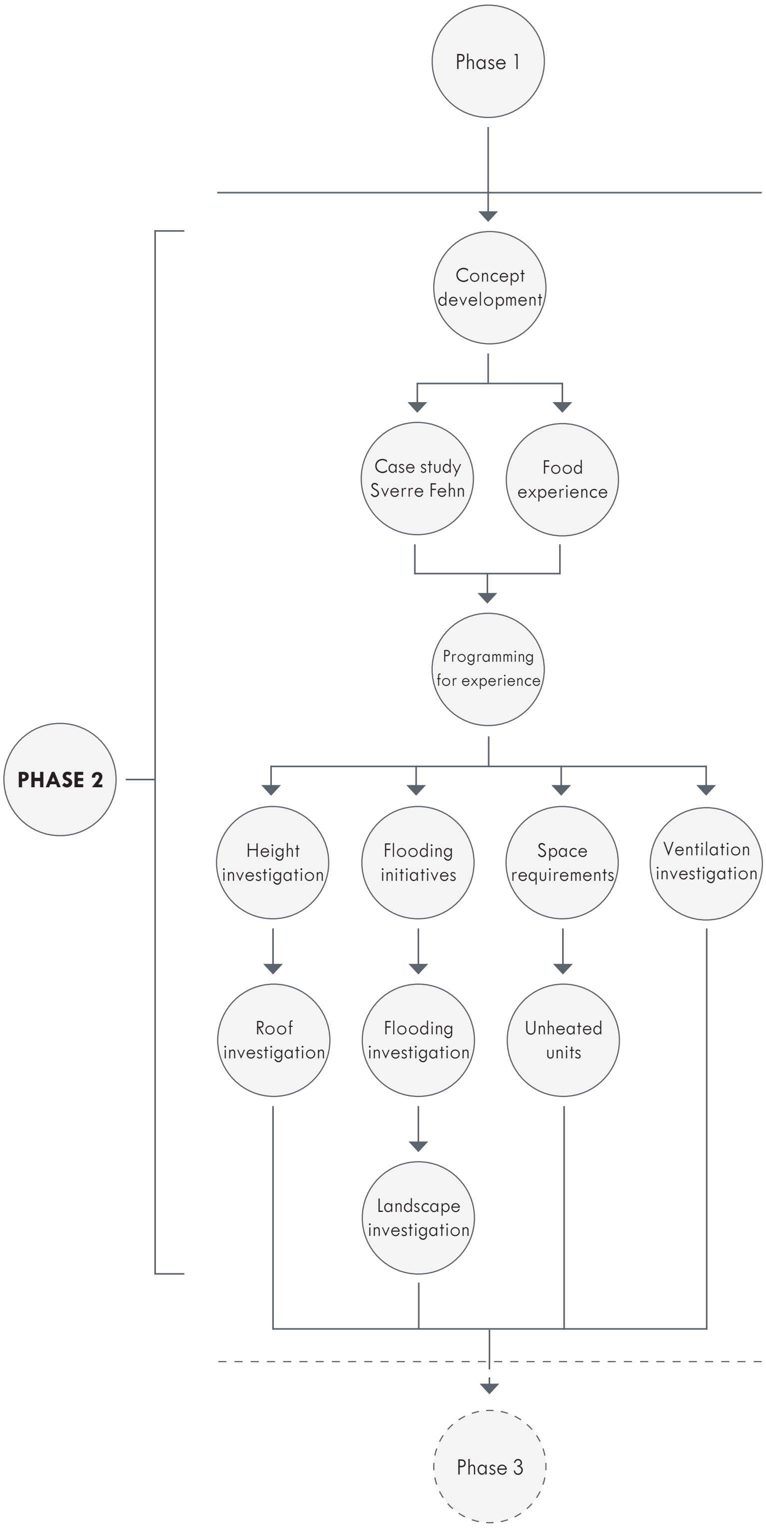


Figure 131 Overview of phase 2

11.1. CONCEPT DEVELOPMENT

PRELIMINARY

The first steps of detailing focuses upon contextual position, where different initiatives are applied to the concept, making it more relatable to the typology surrounding the building (additional process plan solutions can be seen in appendix 16.9.)

FOCUSED DESIGN CRITERIA

ACCESSIBILITY

LOW ENERGY INITIATIVES

FRAMING

Figure 132 The existing plan solution at this point of the process. The plan needed optimization, especially in regards to the corridor going along the center of the building, and the gesture the building creates in its bend. The bend is not programmed to be something specific in this case, which is an issue.

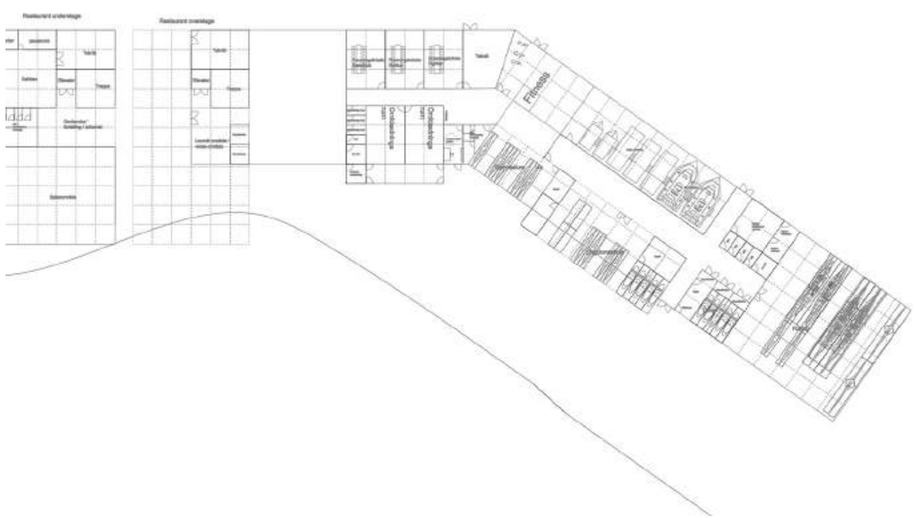
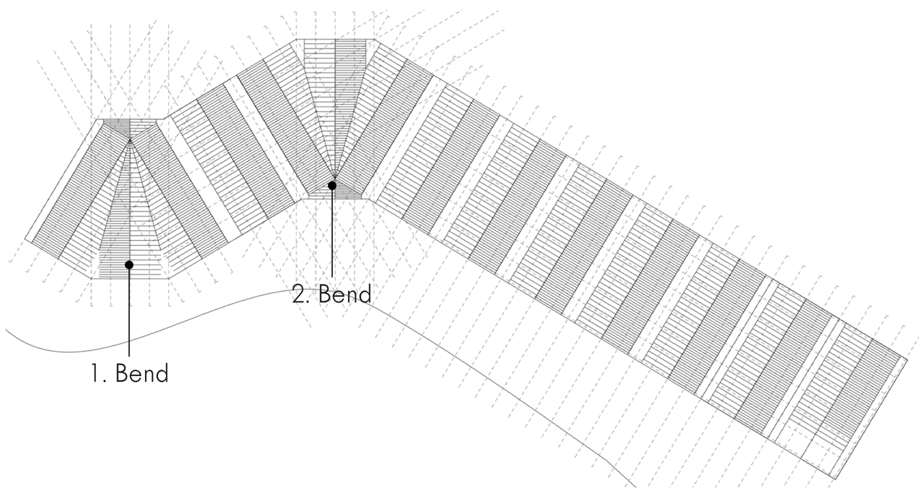


Figure 133 By introducing multiple sloped roofs rotated 90 degrees compared to the initial roof shape, the building will make a bigger relation to the boat house north from the building. Furthermore, the bends are now constructed through a combination of 3 roof elements, though the bends still need to be programmed accordingly to its gesture.



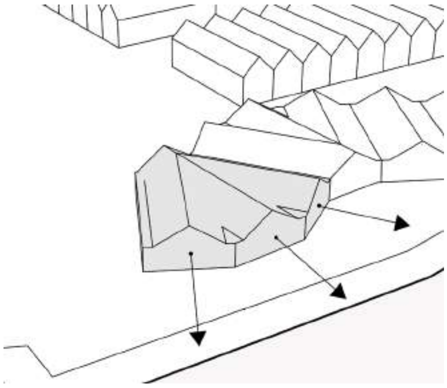


Figure 134 The first bend will act as a restaurant with views to the fiord, intensifying the perception hereof

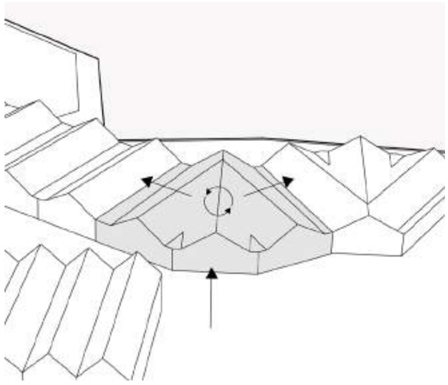


Figure 135 The second bend would act as a common entrance to the building, distributing the users towards both parts of the facility.

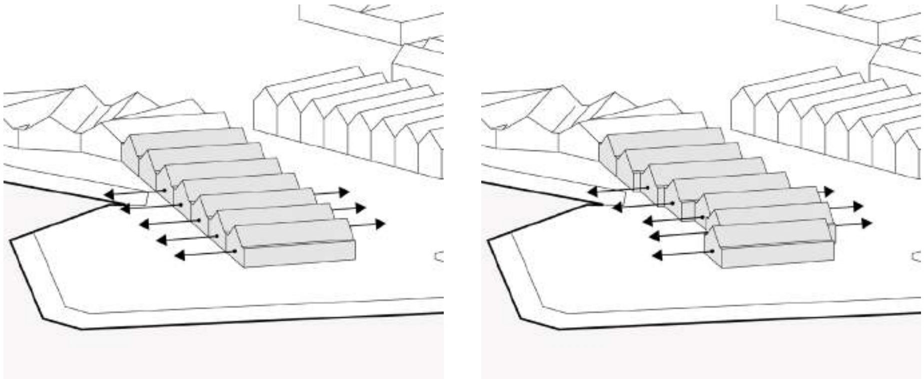


Figure 136 Taking departure in the '10.7. Arrival brainstorm', the façade towards the existing boat houses was one of the investigation areas. When introducing displacements to the façade it helped to break up the linear expression of this specific façade and created the possibility to implement 'in-between' zones in front of the affected volumes.

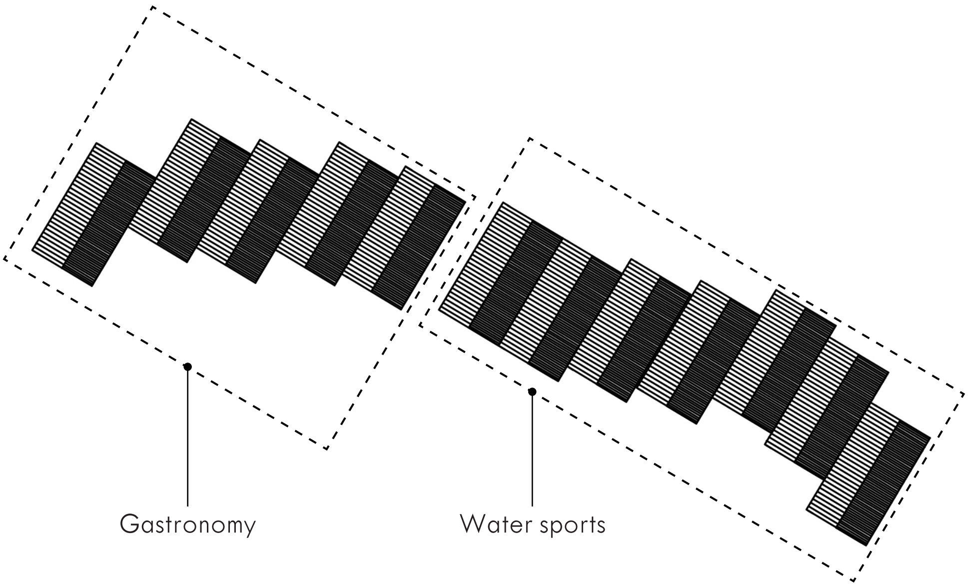


Figure 137 Throughout the plan process, the bends in the building form were removed, making a coherent building mass relating to the existing typology in the area. The sizes of the volumes needs adjustments, making sure that the gastronomy part of the building can accommodate the needed rooms.

CONCLUSION

Throughout the first concept development, the building volume has been altered adjusting to its contextual position. While the main parts of these adjustments have been conducted the plans have been adjusted, to the changes, while some of the plan changes, resulted in volume changes. Though through the plan process it came to our knowledge, that we lacked experience together with the professional inspiration of how to create rooms for experience throughout the programming of a building.

11.2. FOOD EXPERIENCE

PRELIMINARY

In regards to the building program, it is important to address what a food experience can accommodate. Hence, various existing food experiences and tourist tendencies are examined.

SOCIAL FOOD

Food connects people. Food traditions differ from country to country—and from culture to culture. The local food represents the culture and the neighborhood and is an informative key for cultural heritage as the way of living can be extracted from the local recipes.

"When the food we eat, grow or buy is local, we also experience a connection to the region, the seasons and the ground we inhabit."

(Franck, 2005, p. 9)

Food connects the context, the culture, and 'the place' to our senses. The sensory experience is mutually relatable and can be utilized as an architectural strategy for urban conviviality and sociability. Local food traditions become a cultural valuta that can be used as an exchange of cultural value.

"The public culture of food brings vitality and conviviality to urban life. People come together in public spaces to buy and eat … and to be with others"

(Franck, 2005, p. 7)

"In many cities, new food consumption venues are the forerunner for urbane regeneration."

(Franck, 2005, p. 9)

Hence, food has the ability to create a lively urbane environment and to gather people, creating social constellations and interactions.

In Copenhagen, the street food markets have been a huge success which has inspired other cities to do the same. They operate within the dogmas "Reduce and reuse" targeting ecology, reducing food waste, and packaging (Reffen, n.d.). Food sociologist Jon Fuglsang states the reason for success:

"It (ref. to the Street Food Market) creates social livability and active urbane spaces, that have not existed before (…) It is no doubt the food, that connects the people. It is the food, that creates mutual sensoric experiences via smell and taste. That is why the street food initiative is so popular"

(Esrom, 2015)

Another example of a more exclusive architectural experience is the Noma 2.0 by BIG. In 2010, 2011, 2012 and 2014 it was pronounced as the best restaurant in the world by Restaurant Magazine. The overall concept is 11 different volumes with different materiality, connected by glass galleries to emphasize the experience of shifting seasons, corresponding to the shifting seasonal food menu (Dansk Arkitektur Center, n.d.). The building is placed in a scenic landscape in the middle of Copenhagen and successfully encapsulates the phenomenological potential within the tectonics. The tectonics of shifting tactility, materiality, color, and lighting become the architectural foundation and lifts the sensory experience of eating to a more contemplating experience.

TOURISM

Every year tourists on Mors spend 80 million DKK on tourist products such as hotels, restaurants, and local transportation. Another 79 million DKK is spent on detail such as food, drinks, gas, etc. (Realdania et al., 2013). Food-related tourism has a huge potential to expand even more. During the past years, Nykøbing Mors has been hosting 'The Shellfish Festival' with a location on the harbor. The festival kickstarts the tourist season with locals and tourists as visitors. The festival had an expectation of 20.000 visitors in 2020 (Skaldyrsfestival, n.d.) and is placed on the first weekend of June. Here people experience exquisite seafood dishes, fishing cutters, sailing/safari trips together with various musicians playing. Furthermore, different activities concerning the fiord are practiced. Hence, the festival is a returning event, and the number of visitors is growing year by year, where the festival has the potential to be even bigger.

In 2015 the financial outcome of the biggest events and festivals on Mors was 24,2 million DKK. Here the Østers- and scallop premiere, and the shellfish festival represents 36,6% of the total trade (8,8 million DKK) (Realdania et al., 2013).

CONCLUSION

By implementing a restaurant to the building concept, promoting local food (oysters and shellfish), the building strengthens the local food culture and programmatically connects the building to the context. There is also a huge potential in creating a possibility for the building to facilitate gastronomic events, or participate and expands the current event: The shellfish festival and Oyster- and Scallop premier as there are financial profits in gastronomic tourism.

Figure 138 Dinning area in Noma 2.0

11.3. CASE STUDY SVERRE FEHN

PRELIMINARY

With the complexity of designing architecture that creates value for the user through a spatial experience, an extra case study has been conducted, with the aim to gain a better understanding of how architecture can amplify the essence of a project.

Hedmark museum

An example of architecture that includes multiple spatial experiences is the Hedmark museum designed in 1967 by Sverre Fehn (Atlasofplaces, 2019). The museum consists of a large pathway running through and above an old ruin, where the understanding of the contrast between old and new together with the different materials creates different spatial experiences. Especially the contrast between past and present is the essences of the project, explained by Fehn in his acceptance speech at the Pritzker architecture prize:

"only by the manifestation of the present, you can make the past speak."
(The Pritzker Architecture Prize, 1997, p. 2)

Materiality

Despite building onto an old ruin, being limited to the existing volume, Sverre Fehn managed to create multiple exhibition areas where the use of materials complements the existing materials in the ruin. The stone is brought to life through a dialogue with concrete, while a wooden roof construction creates warmness against the cold concrete and remaining stone ruins. Furthermore, the use of steel and glass becomes exhibition showcases creating a dialogue between display and object. In the assembly between the new and the existing building, Sverre Fehn succeeds in his use of concrete and wood creating different spatial experiences throughout the path running through the ruin.

Spatial understanding

Being introduced to a concrete ramp in the courtyard invites the guest on a journey through time, lifting the guest above the old ruin. Inside the building, the path runs along with the shape of the building, where two large concrete boxes create a transition from the ruin to a two-story exhibition area. Here the combination of dwarf walls, stairs, and level differences creates multiple rooms within an open room. Furthermore, the ratio between cold and warm materials creates different spatial experiences, which matches the exhibition. In between the old stone wall and wood façade, small window holes emerge, creating views, where other places' frosted roof windows create diffuse lighting. The understanding of using different materials while creating different spatial experiences stands as an inspiration for the further process of programming different experiences in this master thesis.

Figure 139 Pathway

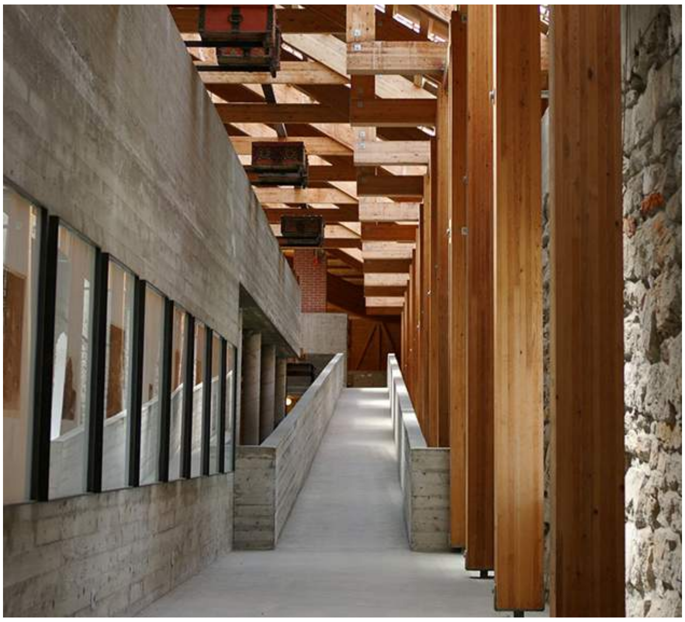


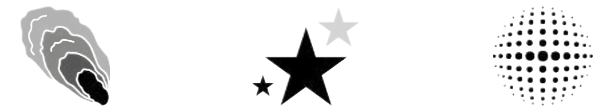
Figure 140 Relation between warm and cold materials

11.4. PROGRAMMING FOR EXPERIENCE

PRELIMINARY

With the newly earned knowledge through the case study Hedmark museum, the experience creation is further investigated through physical modeling. Firstly the experience relatable to material usage and construction is to be investigated.

FOCUSED DESIGN CRITERIA



GASTRONOMY

EXPERIENCE ECONOMY

ATMOSPHERE

Figure 141 The first iteration consisted of an experience through a semi-submerged restaurant, inspired by the project 'Under' by Snøhetta Architects. Though in this case the restaurant was planned to have a visual connection underneath and above the water surface, creating a deeper connection to the fiord and the life in and on top of it.

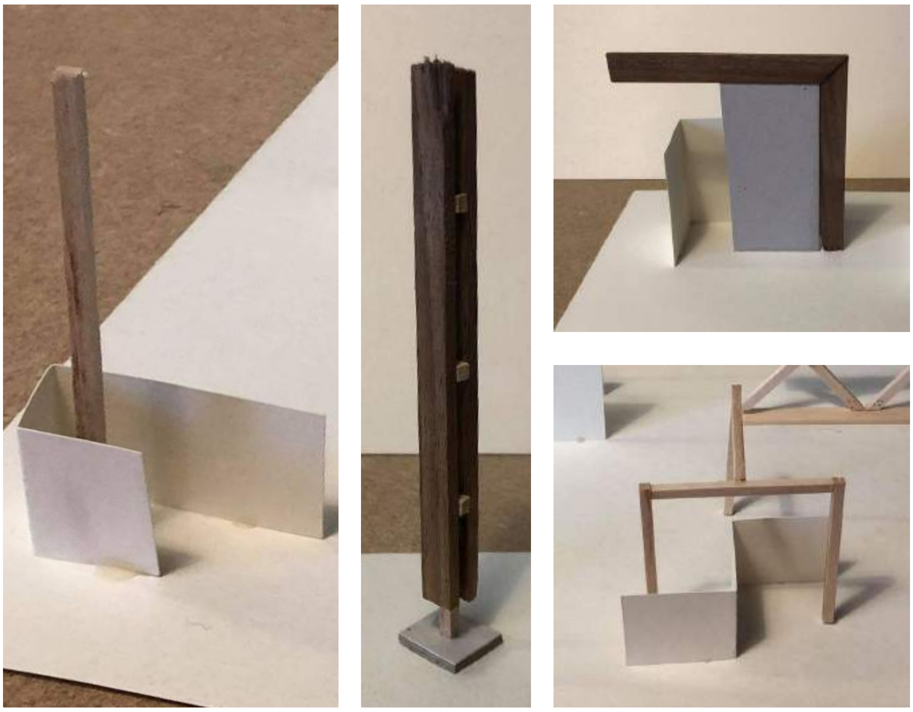


Figure 142 Constructional techniques affecting the room which was found interesting in the experience creation (additional models can be seen in 16.10.), mentioned from the left:

Framing the column.

Using the column as a sculpture,

Interplay between materials creating different perceptions of the surface.

Utilizing the construction as a space divider.

Figure 143 Contextual registration - Stone stereotomic protecting against erosion.

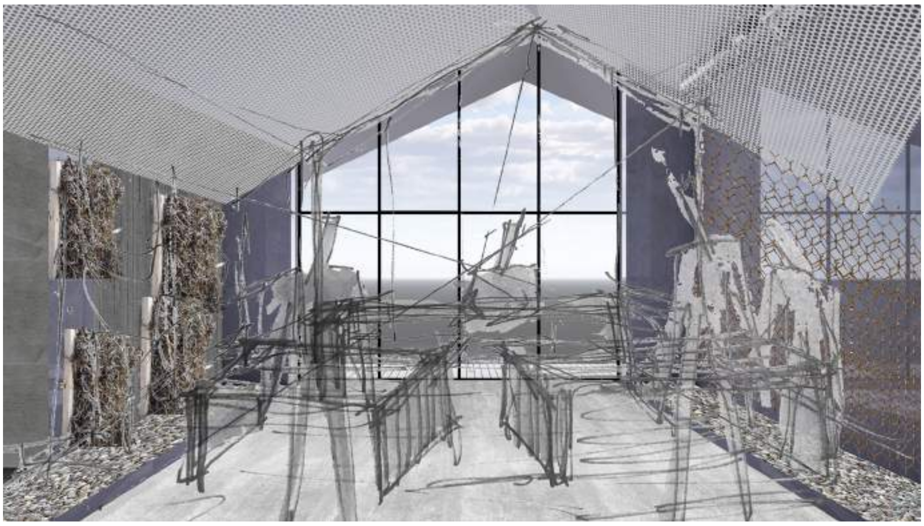
Figure 144 Contextual registration - Green unused falt area

Figure 145 Vision for Experience 1
Program: Dining area. Waiter serving food while the guests can observe how the food is prepared.
Activity: Sitting down, relaxing
Atmosphere: Visual connection to an open kitchen. The feeling of a spatial soft and warm embrace

Strategy:
Materiality: Wood, greenery
Reverberation time: Low, so people can easily have private conversations
Reflectance of materials: Low

Figure 146 Vision for Experience 2
Program: Workshop area. Participants preparing, tasting, and learning about oysters and shellfish.
Activity: Standing up, working
Atmosphere: The feeling of standing on the shoreline

Strategy:
Materiality: Stone, seaweed, metal
Reverberation time: High
Reflectance of materials: High



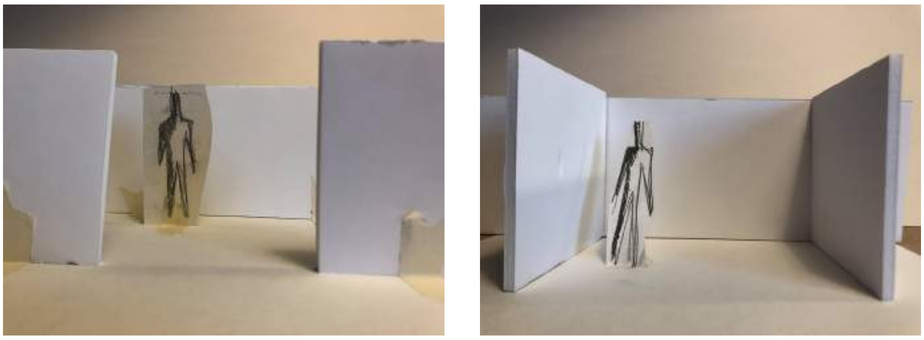


Figure 148 The arrival towards a room can be the experience in itself. Correct placement of walls can help to make the room behind look bigger.

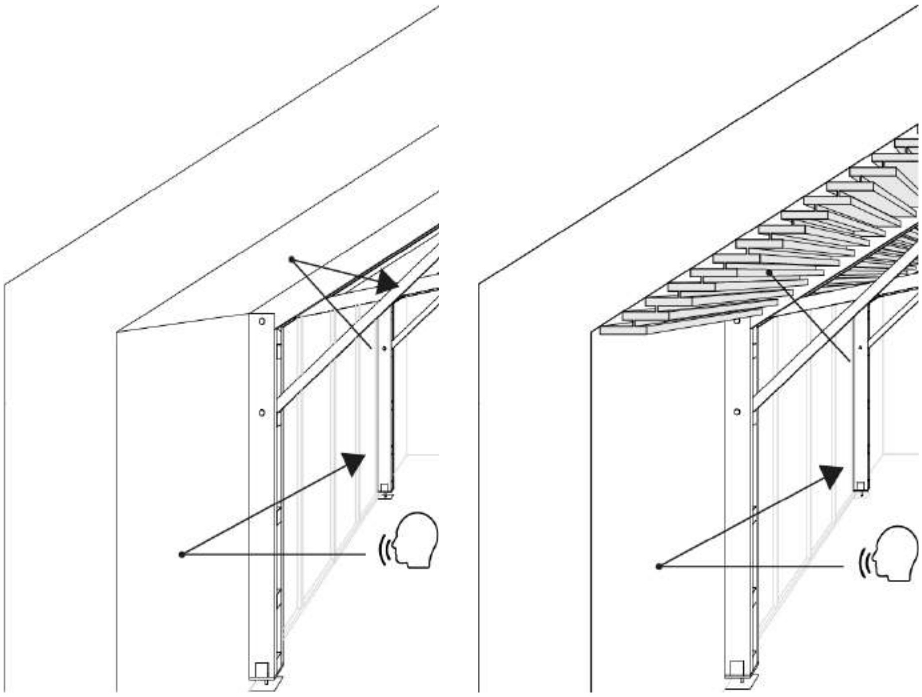


Figure 147 Reverberation time is a big part of the experience of a room. Taken to the extreme is the art space of Walter De Maria, at Chichu Art Museum, Naoshima, Japan (Benesse Artsite, n.d.). The art space is an experience of natural lighting together with the highly relevant sound. In this specific art piece, the room has a high reverberation time, because of full concrete faces, which in combination with the lighting and materials makes an almost spiritual place, where the observer doesn't even dare to speak. All this is a result of the reverberation time. Lowering the reverberation time in the restaurant area can be needed, due to the number of people speaking at the same time in the rooms. Soft material faces as wood can be utilized to lower the reflection of sound.

CONCLUSION

The intention is to create two different experiences within the restaurant. Each experience shall vary. The first experience should relate to the green area next to the building. The other experience should relate to the fiord. In addition, the programming of the rooms is going to be different as well. The first experience shall consist of a relaxed experience, enjoying the taste and smell of the food. The other experience shall address the activity of picking up oysters from the shoreline, learning to open the oysters, and how to cook them properly. The different spaces should address the senses in different ways focusing on the sense of vision, hearing, smelling, the tactile and kinetic senses, and of course the tasting sense. The combined experiences create a holistic food experience, especially to the users/guests of the restaurant/workshop.

11.5. HEIGHT INVESTIGATION

PRELIMINARY

Investigating the height of the building relates both to the urban context the building is placed within, but the height is also a big factor in material use and energy usage of the building. Furthermore, when investigating this, it is important to note that the building will be perceived from land and the water.

FOCUSED DESIGN CRITERIA

ACCESIBILITY

TYPOLOGY

LOW ENERGY INITIATIVES

Figure 149 Total building height of 5 meters.

Conceptual Energy frame: 42,1 kWh/m^2 year

(The energy frame is calculated upon building height with a total of 10% wall area being window.)

Figure 150 Total building height of 6 meters

Conceptual Energy frame: 42,4 kWh/m^2 year

Figure 151 Total building height of 7 meters

Conceptual Energy frame: 43,2 kWh/m^2 year

Figure 152 Total building height of 8 meters

Conceptual Energy frame: 44 kWh/m^2 year

Figure 153 Total building height of 9 meters

Conceptual Energy frame: 45,4 kWh/m^2 year

Figure 154 Creating a building with a total height lower than 8 meters, the built environment will gradually be reduced towards the fiord.

CONCLUSION

The investigation showed that by building above the height of the existing red boat houses (8 meters), the building will create a wall separating the fiord from the city. Therefore the aim should be to secure a building height below the existing boat house, gradually reducing the building height towards the fiord, which especially can be seen when walking along the 'Fiord promenade'. Furthermore, when building below 8 meters, the building will greet guests approaching from the fiord from a more relatable built scale. The height and the scale of the building are especially of interest to the local population of the Nykøbing Mors. The building should relate to the existing context and its height, and must not be separating the city and its population from the fiord. And must be inviting when arriving from the fiord.

11.6. ROOF INVESTIGAITON

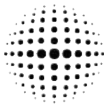
PRELIMINARY

The relation of the intermediate zone between the indoor and outdoor together with an overhang is to be investigated. Furthermore, we wished to investigate if we could add a diagonal cut through the roof, and thereby add something interesting according to indoor sun radiation and outdoor façade experience. In addition, a pitched roof building can easily seem monotone when approaching it from the side.

FOCUSED DESIGN CRITERIA

LOW ENERGY INITIATIVES

ADAPT



ATMOSPHERE

Figure 155 Iteraiton 1

Overhang: 2400-4800 mm

Rotation in y-axis: 5 degrees

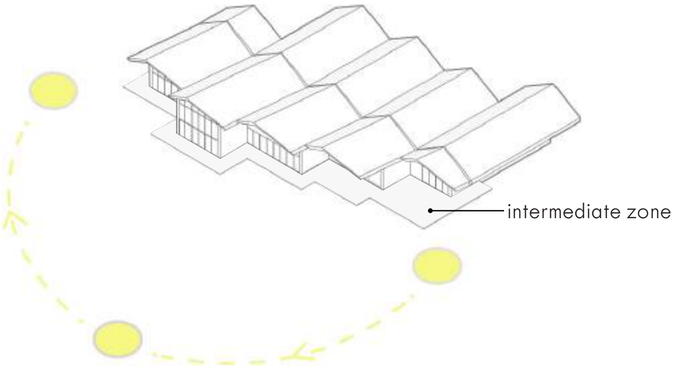


Figure 156 Iteraiton 1

Overhang: 2400-4800 mm

Rotation in y-axis: 5 degrees

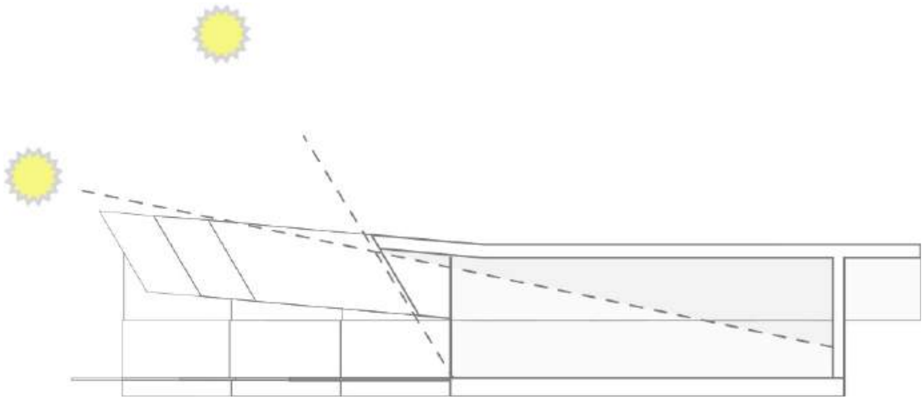


Figure 157 Iteraiton 2

Overhang: 480-7200 mm

Rotation in y-axis: 5 degrees

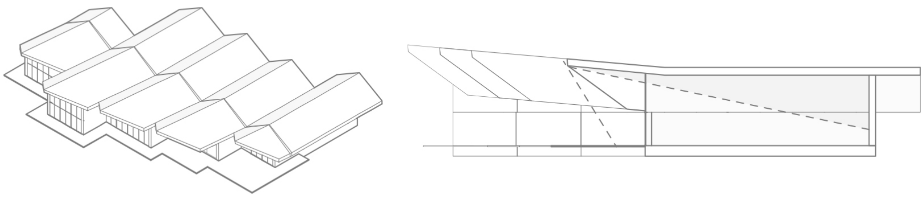


Figure 158 Iteraiton 3

Overhang: 2400-4800 mm

Rotation in y-axis: 0 degrees

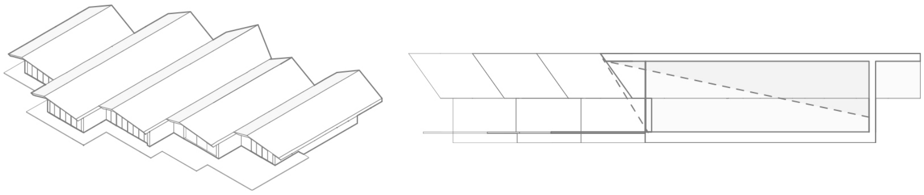


Figure 159 Iteraiton 4

Overhang: 4800-7200 mm

Rotation in y-axis: 0 degrees

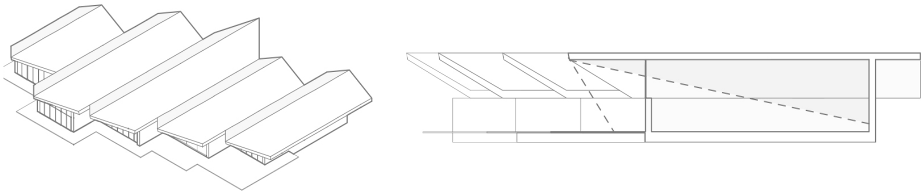
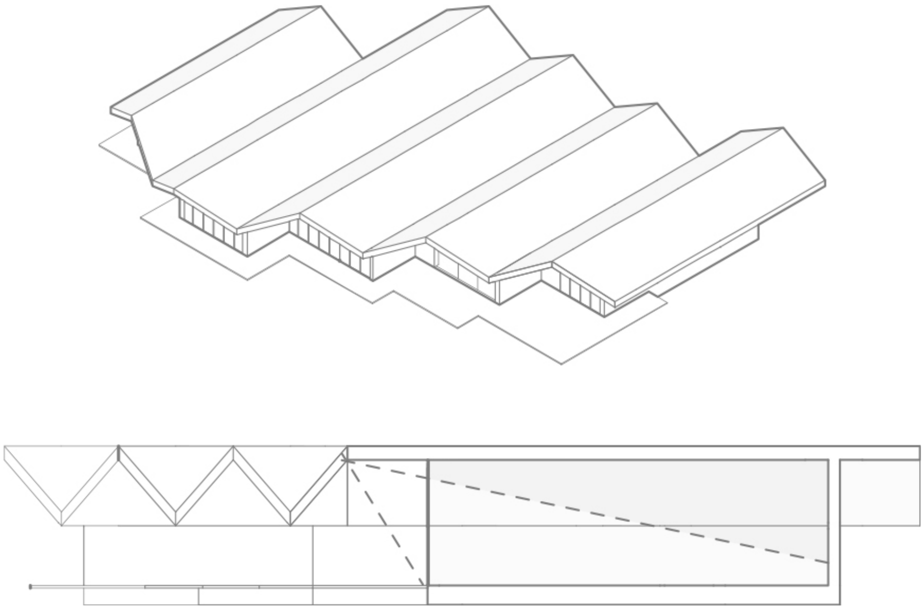


Figure 160 Iteraiton 5

Overhang: 2400-4800 mm

Rotation in y-axis: 5 degrees



CONCLUSION

It does not make sense to add an angled roof according to the cast of sun rays into the building spaces. In addition, there is a lot of constructional difficulties which cause more harm than good. Although an overhang is a favourable design solution in terms of passive solarheating during winter.

The diagonal cut through the pitched roof created an interesting visual experience when approaching the building from the east. The diagonal cut-through was added to the building design as it provided a much more interesting experience when approaching the building from the side, and by that, the entrance to the harbor, creating a much more interesting building to look at and thereby a value of attraction for the restaurant as it is supposed to attract tourists and local people.

11.7. SPACE REQUIREMENTS

PRELIMINARY

As shown in chapter '5.3.3 Additional users'. it is especially the watersports practitioners who states specific capacity demands. The arrangement of kayaks, sups, scullers, etc. needs to be investigated with the result to optimize the space used to store the practitioner's vessels.

FOCUSED DESIGN CRITERIA

FUNCTIONALITY TOTAL ECONOMY LIFE CYCLE ASSESSMENT

Figure 161 By creating a maneuver area it is easier for the practitioner to dismount his/her SUP board from the board rack. Though the maneuver area between every second board rack is space requiring.

Square meter/SUP board: 1,92 m^2

SUP board weight: 10-13 kg.

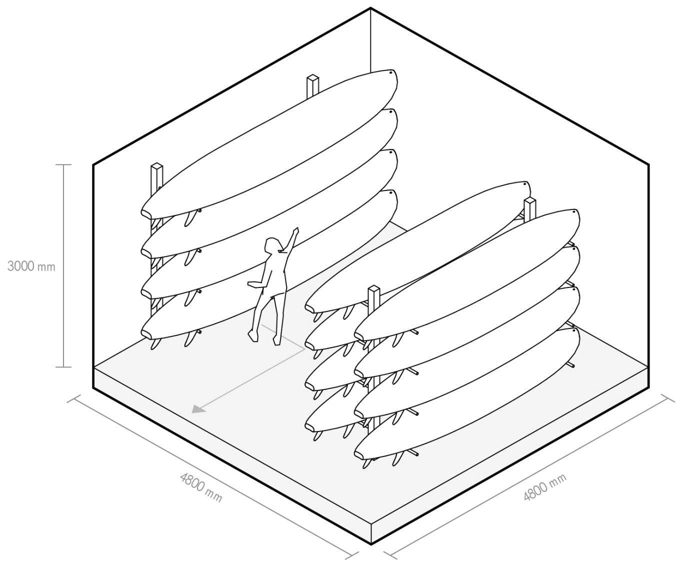


Figure 162 Stacking SUP boards in a closed rack system optimizes the capacity of SUP boards, though the topmost boards, may be difficult to get down to kids, due to the difficult dismount position making the board being pulled outwards.

Square meter/SUP board: 1,15 m2

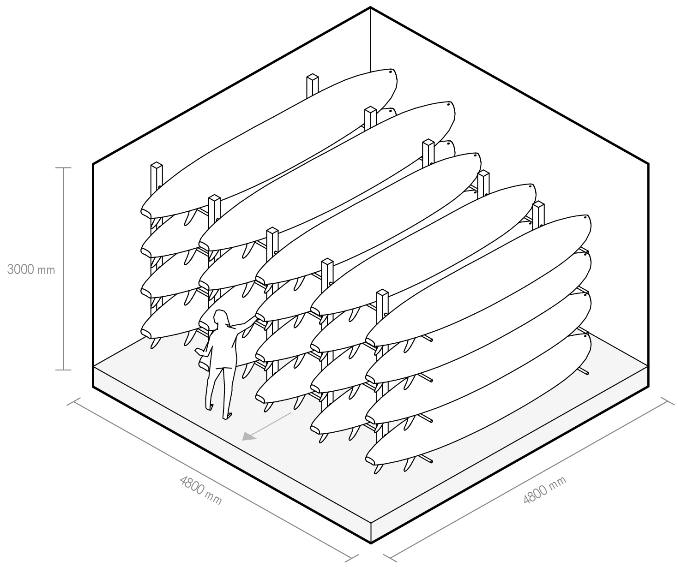


Figure 163 Kayaks are twice as heavy as sup boards, making them more difficult to dismount from the kayak rack. Therefore the maneuver area between the board racks is highly suitable for the dismount of kayaks.

Square meter/kayak: 1,8 m^2

Sea kayak weight: 27 kg.

Sit on top kayak weight: 28,5 kg.

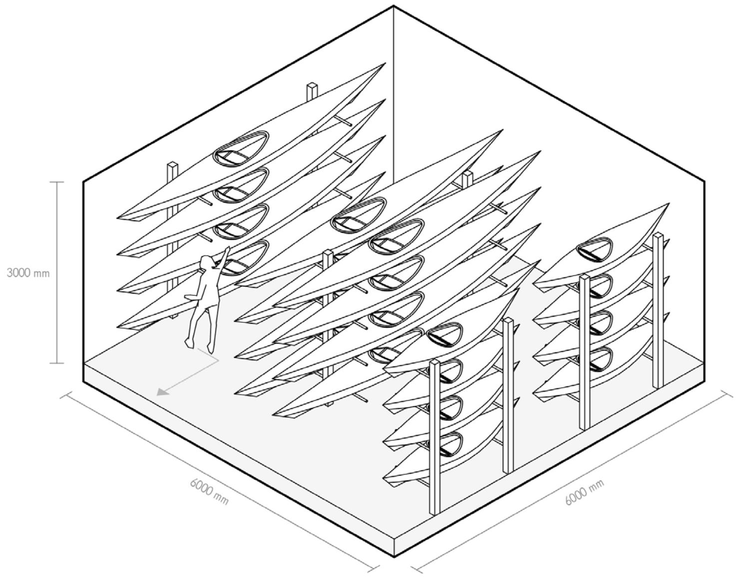
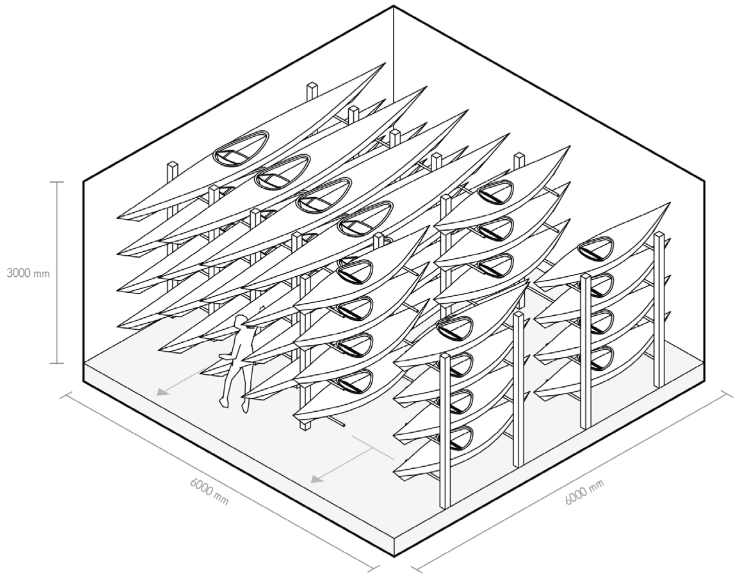


Figure 164 When stacking the kayaks in a closed rack system the square meter/kayak is highly optimized. Though sit on top kayaks are too short compared to a normal sea kayak, meaning that if the area for these types of kayaks should be optimized these will need to be in a single rack system with space in between at this specific room length. The length and the weight of the kayaks, make them difficult to dismount from a closed kayak rack.

Squaremeter/kayak: 1,13 m^2



CONCLUSION

Due to the differences in the specific vessel, these will need different storage strategies, meaning kayaks should be designed with space between every second rack, while SUP boards could be designed with a closed rack system, minimizing the space of SUP storage by 40% compared to a solution with maneuver space between every second rack. Optimization of space creates value for the building owner and society with a focus upon minimizing the usage of material resulting in a lower climatical impact and lower economic cost of the building. Furthermore, the functionality of the practitioners must not be forgotten in this process, which is why the users also are an important factor in this matter.

11.8. UNHEATED UNITS

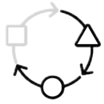
PRELIMINARY

The watersports associations demand facilities for storage, changing, toilets, etc. These facilities are investigated in regards to a grid, which the plan layout is based upon together with the functional demands of the rooms. The rooms are unheated and naturally ventilated, lowering the energy for heating.

FOCUSED DESIGN CRITERIA

FUNCTIONALITY

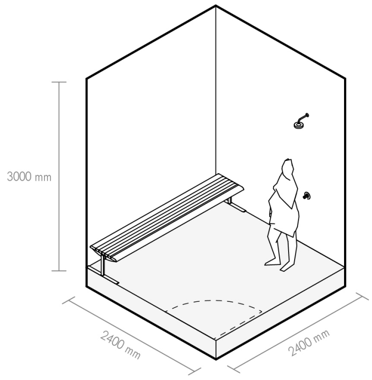
DURABILITY



LIFE CYCLE ASSESSMENT

Figure 165 Changing and shower facility with seating possibility.

Figure 166 Changing and shower facility.



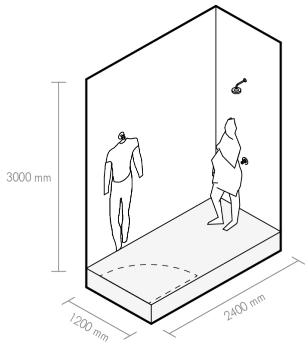
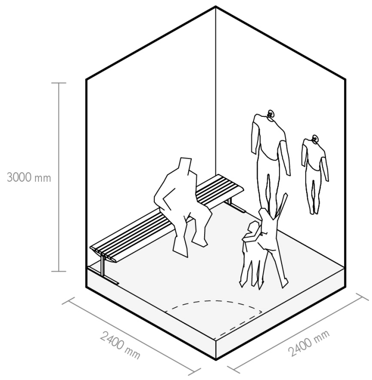


Figure 167 Family changing facility.

Figure 168 Single changing facility.



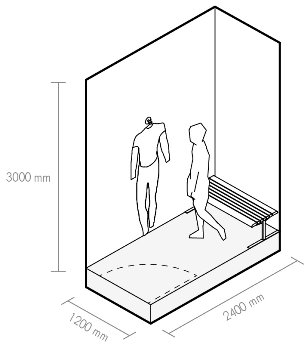
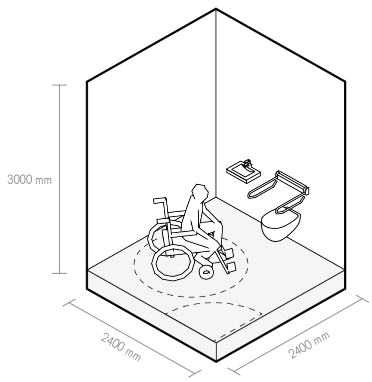


Figure 169 Toilet facility for wheelchair users.

Figure 170 Toilet facility.



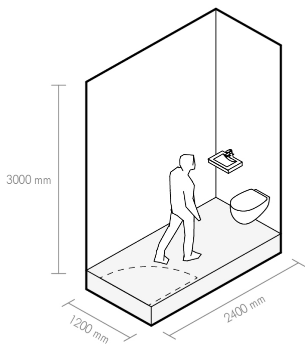
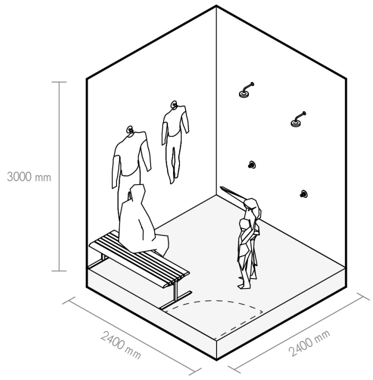


Figure 171 Family changing and shower facility with seating possibility.

Figure 172 Changing and shower facility and toilet facility for wheelchair users.



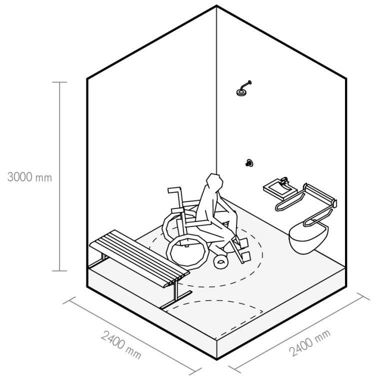
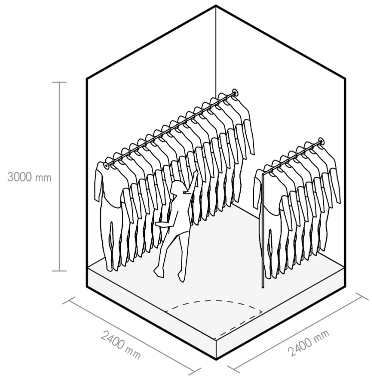


Figure 173 Wetsuits need to dry in shaded areas, which is why utilizing a natural ventilated storage area, will make the wetsuit last longer.

Figure 174 By implementing storage units, tourists, as well as locals, have the opportunity to store personal belongings safely when entering the fiord. In a square of 2400x2400 mm. 48 storage units can be implemented.



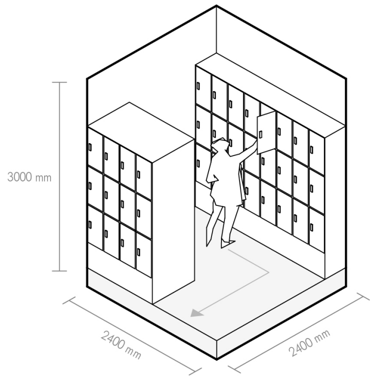
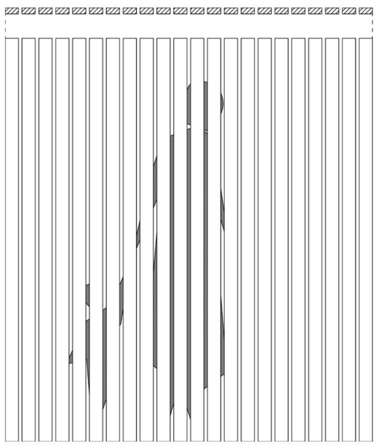
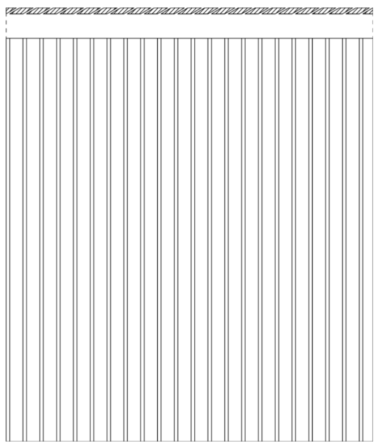


Figure 175 Keeping the units naturally ventilated, lamellas will be used. Though the lamella type is important. The utilization of square lamellas, will not be optimal due to the ability to see between the lamellas.

Figure 176 Strategically placed angled lamellas interrupt the direct sightline through the lamellas.





CONCLUSION

Looking at the functional aspects of the rooms, their size, and the fact they can be naturally ventilated it is to be conclud-ed, that several of these rooms/areas should be implemented in the design. The toilet facilities should not be implemented as a room separating the user from the outdoors by lamellas, though toilet facilities should be accessible to the public. Pub-lic toilet, changing and showering units creates an increased value for the society meaning that citizens of Nykøbing, tour-ists, etc. can change into a bathing suit, wetsuit, etc. without an economical consequence. Furthermore, the public accessible changing areas will also create value to the associations of the building, creating easily accessible changing facilities, es-pecially during the summertime.

11.9. FLOODING INITIATIVES

PRELIMINARY

According to chapter '7.5. Flooding', the project area is placed within a high-risk area of flooding as a result of climate changes. This meaning a flooding initiative needs to be introduced into the design process protecting it, its materials, and the exterior areas.

FOCUSED DESIGN CRITERIA

Figure 177 Without any flood protection, the building and the surrounding buildings will suffer from flooding.

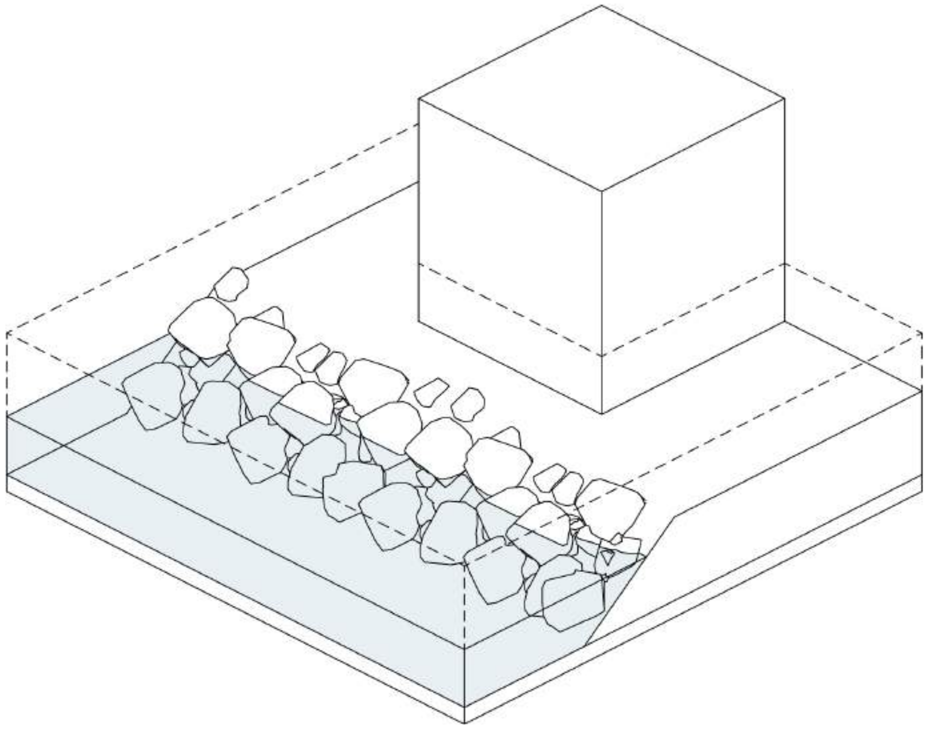


Figure 178 By lifting the building on a plateau the surrounding areas and access points will be flooded. Furthermore, this solution has a risk of high material usage.

Figure 179 By raising the building on columns, access points will be cut off, furthermore, a shaded room beneath the building will be created.

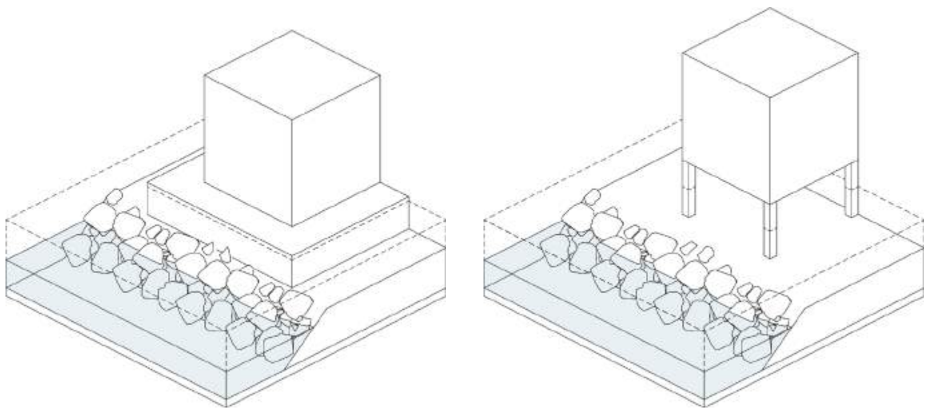


Figure 180 By utilizing the building as flood protection, the area encapsulated by the building will be protected, though this creates a demand for the construction of the building envelope

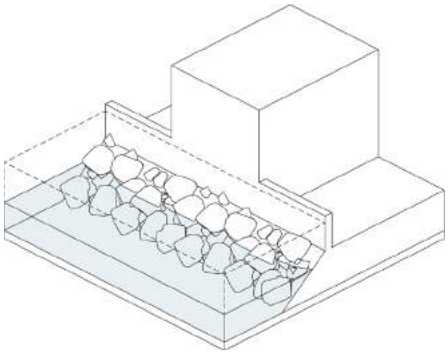


Figure 181 By utilizing a floodframe it is only the building that will be protected. Furthermore, the floodframe needs to be exchanged post-flooding (Floodframe, n.d.).

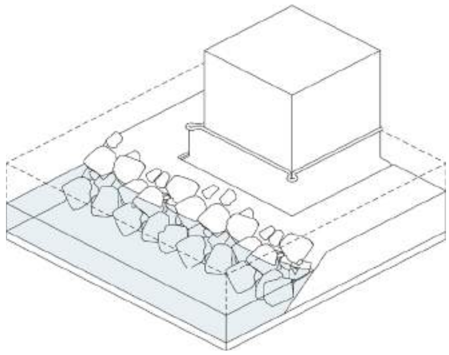
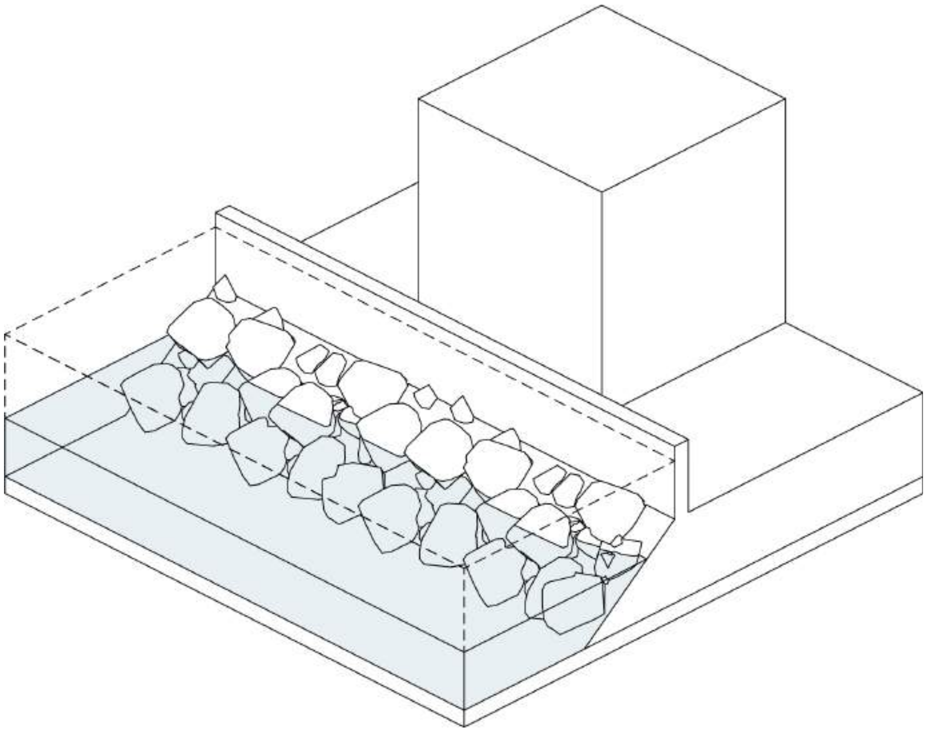


Figure 182 By utilizing wall protection, the building and the surrounding area will be protected, though the wall has the risk of disrupting the connection between land and fiord.



CONCLUSION

When investigating suitable flood protections, it is important to secure the building and the surrounding areas. Several of the flood protections investigated above results in the protection of the building, but not access points or the urban landscape. When looking at the bight, which the project area is located towards, several other buildings are located within a critical distance combined with unfavorable topography in regards to the bight being exposed to storm flooding. This meaning choosing flood protection protecting singular buildings is not seen as a sustainable choice. Therefore the wall protection will be investigated further. Furthermore, the wall protection creates value to all three interests, due to the topography and climate changes, which forces society and the building owner to invest in flood protection of the area in the close future, while the users, will have no trouble being active on the water, as long as they can drag equipment out of the building.

11.10. FLOODING INVESTIGATION

PRELIMINARY

An investigation of the wall protection is needed, due to the risk of altering the relation between land and fiord. The possibilities within the wall protection will be investigated, securing the relation between land and fiord will not get lost by implementing this specific flood protection.

FOCUSED DESIGN CRITERIA

ACCESSIBILITY TYOPLOGY DURABILITY

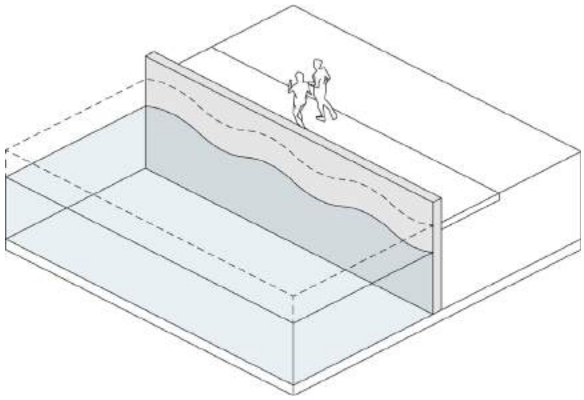


Figure 183 Due to the height of the wall, the view towards the fiord along the 'Fiord promenade' will be retained.

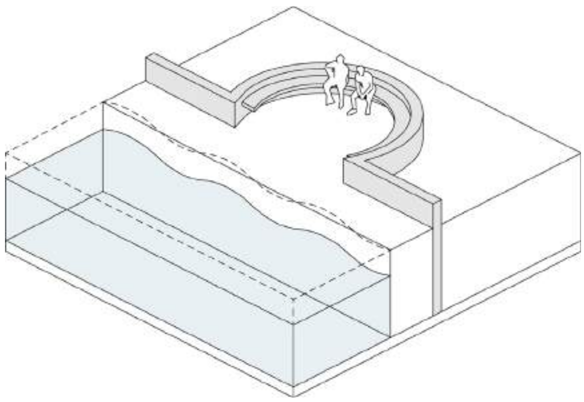


Figure 184 Niche areas can be implemented framing the view towards the fiord. Furthermore, the placement of the wall can vary creating a path system on each side of the wall.

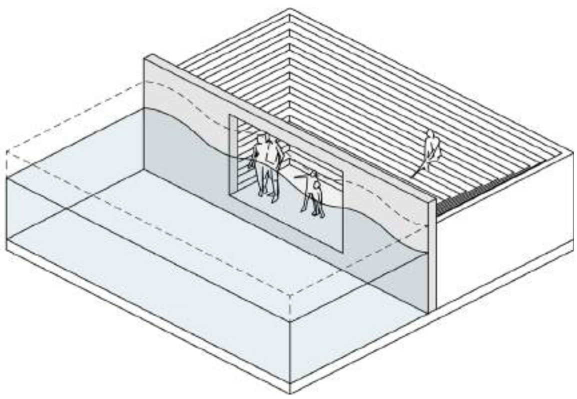


Figure 185 Experimental areas can be implemented, an example of this is a window creating the possibility to look underneath the water surface.

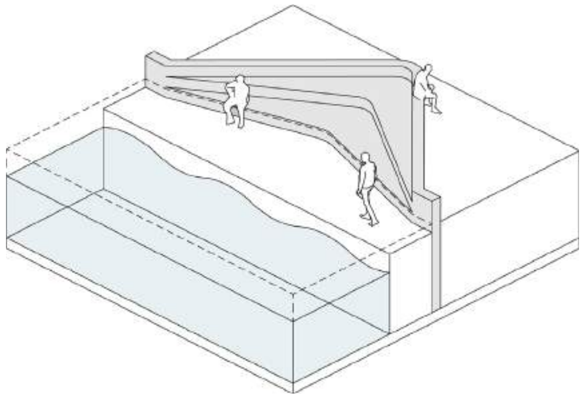


Figure 186 Seating possibilities can be implemented designed to be suitable for different water levels.

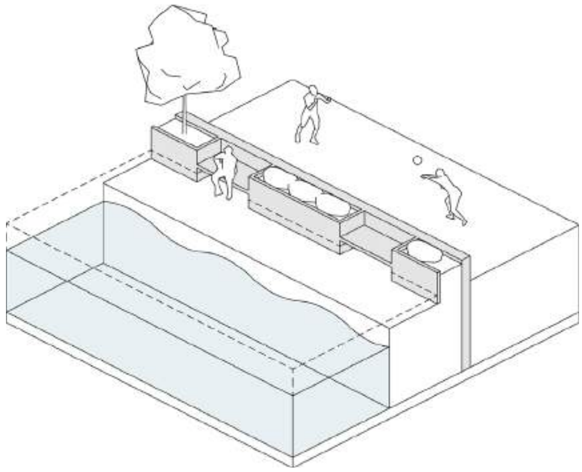


Figure 187 Green elements together with seating areas can be implemented, introducing greenery to the flat grassed area, while creating possibilities of more private contemplational areas.

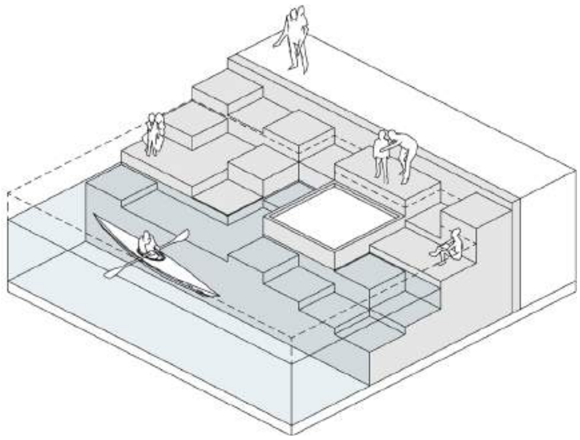


Figure 188 Access points towards the fiord can be implemented. Besides functioning as access points, these areas can be suitable as a waterline school, equipped with a wadding pool or different functional basins.

CONCLUSION

Based upon the flooding investigation, it can be concluded that flood protection in the shape of a wall, can be altered in such a way, that the relation between land and fiord is not disturbed, though through the alterations the relation can be strengthened. The flooding protection and different alterations hereof creates value to especially the building owner. An implementation of this specific flood protection can secure the shoreline where needed while creating an area for exploration or contemplation in relation to the fiord.
Besides the building owner, the flood protection also adds value to the users of the facility, by creating learning, experience, and access point within the urban landscape reinforcing the relation between the facility to the fiord. Furthermore, by using concrete which is a highly durable material the flood protection matches the already existing flood protection located in the harbor area.

11.11. LANDSCAPE INVESTIGATION

PRELIMINARY

Having determined an initial plan suggestion for the project, it's important to start exploring the surrounding context, especially in the meeting between land and fiord together with different access points to the fiord, without destroying the effect of the flood protection.

FOCUSED DESIGN CRITERIA

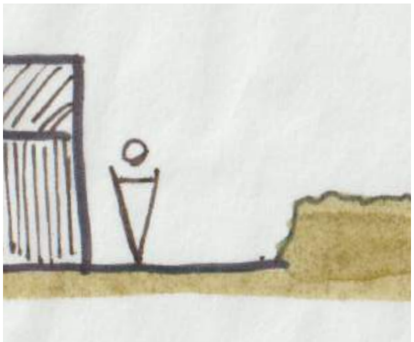

ACCESSIBILITY


DURABILITY


ADAPT

Figure 189 Landscape concept one takes departure in the plantation is only being pushed down, where the building and its pathways are being constructed. Outside these areas, the plantation will be uncontrolled in the form of bushes, etc.

Figure 190 The pathways are minimized around the building, making space for plantation.



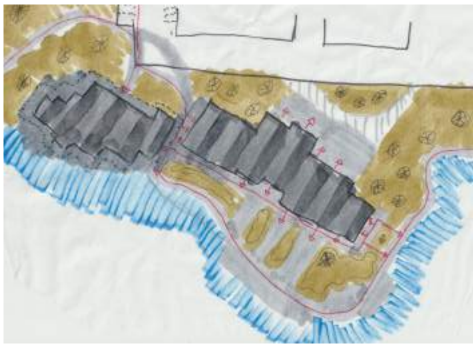


Figure 191 Landscape concept two takes departure in functionality and clear access around the building.

Figure 192 The context is dominated by concrete, making access with boat wagons easy. Furthermore, pathways are minimized creating an untroubled flow to the users.

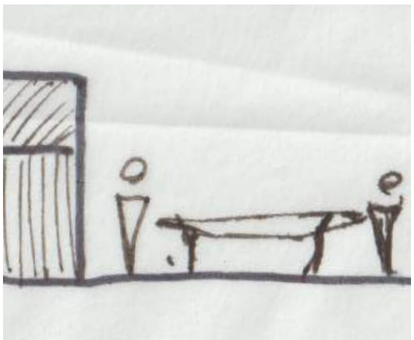
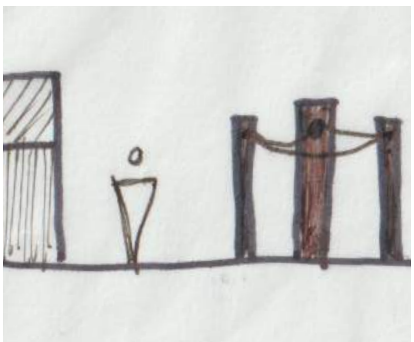


Figure 193 Landscape concept three takes departure in the circular poles placed in the harbor berth, separating the boats.

Figure 194 The poles can be used as a guidance system creating/encapsulating different zones in the landscape.



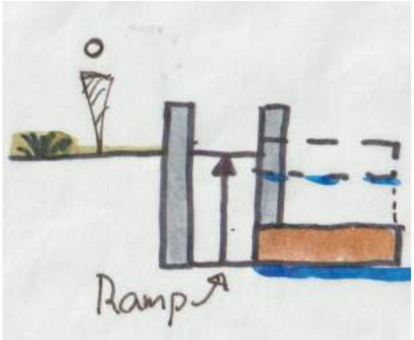


Figure 195 Fiord access concept one implements wood pontoon bridges, making sure the bridge floats according to the tides and sea-level rise, securing safe and easy access/exit to the fiord.

Figure 196 The concept creates several hubs alongside the shoreline, with different purposes. The different hubs are for access/exit of the fiord, observational sitting areas, etc.

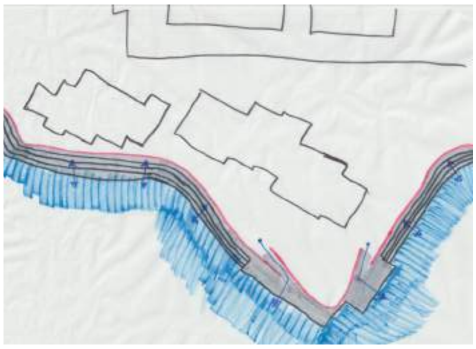


Figure 197 Fiord access concept two takes departure in one central staircase, which creates access along the whole shoreline while securing the project site against flooding.

Figure 198 The concept creates one big area with access to the fiord, though the docking ramps need to somehow be floating if the access to the fiord should be retained during floodings.

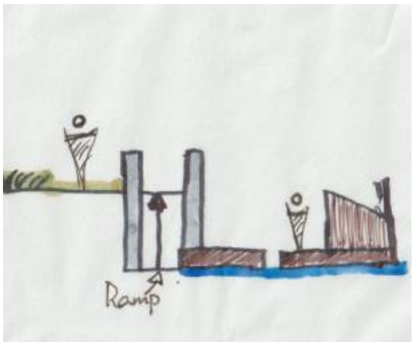


Figure 199 The third fiord access concept includes a secured fiord bath, while the barrier functions as an access point to water shelters.

Figure 200 The protected fiord bath is relevant to keep children secure in and around the water. Furthermore, the passage around the bath creates a possibility to walk into the bight, without standing in the way of the e.g. kayakers exiting/entering the water.

CONCLUSION

For the further process of landscape designing, parts of the different concepts will be implemented. The landscape will need a focus upon the functional aspect together with accessibility. Meaning a mix between landscape concepts one and two will be utilized. Furthermore, the idea of creating different zones within the landscape, together with the waterline will be implemented, creating zones for the users and citizens of Nykøbing to get in touch with the fiord. Furthermore, the pontoon bridges will also be implemented due to the ability to adjust to tides, while sitting areas alongside the shoreline will be constructed in concrete, due to wood and the risk of getting slippery when affected by water and algae. The landscape design is highly important to the users and their functionality demands, together with the building owner and the demand for building protection in case of flooding.

11.12. VENTILATION INVESTIGATION

PRELIMINARY

The following investigation concern placement of ventilation pipes, and the potential of the pipes supporting different atmospheres and low energy inititaives. Ventilation rates can be seen in appendix 16.11.

FOCUSED DESIGN CRITERIA

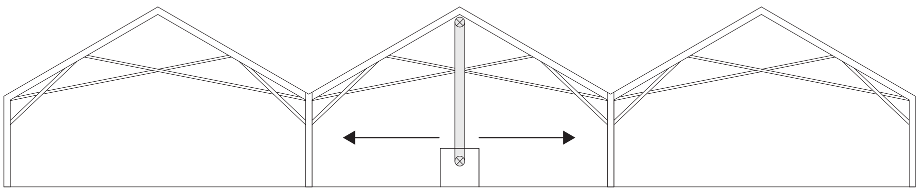


Figure 201 The chosen structural system creates the possibility to run ventilation pipes along and inside the frames creating an orientation towards a window at the end of the volume. But by using a centralized aggregate, the ventilation pipes must run transverse the roof ridge, which may cause problems.

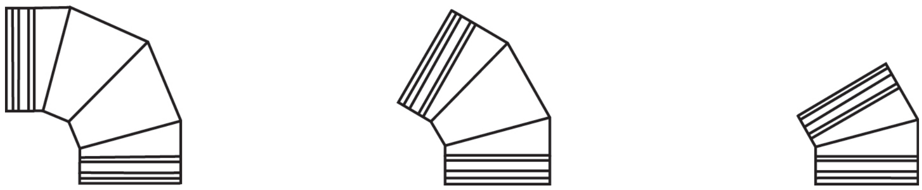


Figure 202 Obtaining a low-energy building, the energy consumption for mechanical ventilation must be kept at a minimum, which requires minimum pressure losses inside the pipes. The pressure loss occurs by the length and angle of pipe bends, where large angles have higher pressure losses. The calculated length and pressure loss can be found in appendix 16.12.

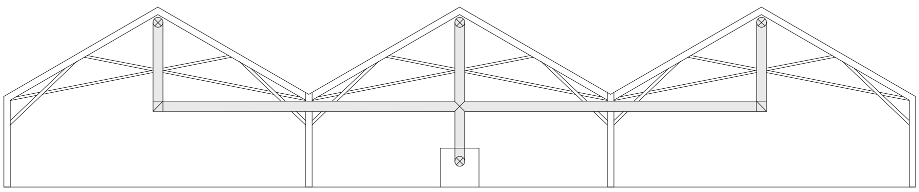


Figure 203 A linear ventilation pipe that connects the three frames, will have a minimum of bends but the connection is a 90-degree angle, which has the largest pressure losses. Meanwhile, it also creates ventilation pipes in the middle of the room. The total pressure loss from this solution is 13,2 PA.

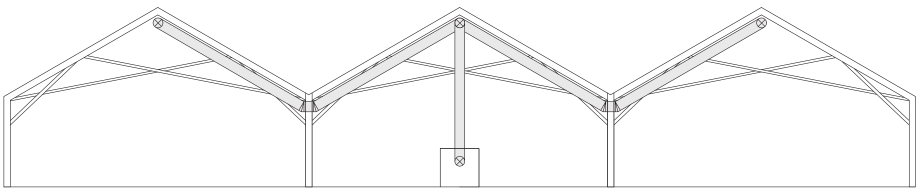


Figure 204 A ventilation strategy, where the pipes are running along the frames does not interfere with the height of the room, but this solution creates several smaller bends, which also creates a pressure loss on 8,43 PA.

Figure 207 A combination of the two former presented ventilation strategies, where the volume in the middle is equipped with a lowered ceiling creates a system that has a pressure loss on 8,3 PA.

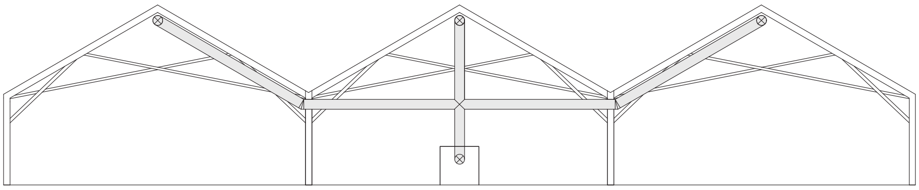


Figure 205 When looking into the spatial experience of visible ventilation pipes, the placement of the ventilation pipes along the roof ridge will amplify the directional effect towards the window. With visible ventilation pipes, there also is the opportunity of coloring it different colors if the raw metal does not fit into the atmosphere.

Figure 206 By implementing a lowered ceiling within the frames, which hides the pipes, also disturbs the framing of the fiord.

CONCLUSION

The ventilation should provide sensory comfort, where odor from people and the building is eliminated, creating the best possibility for a multi-sensory experience of the food.

By implementing a lower ceiling in the middle, the amount of pressure losses is lowered meanwhile creating a possible transition between rooms amplifying different spatial experiences. When using visual ventilation pipes along the roof ridge, the orientation towards the fiord is amplified, compared to the scenario where the ventilation pipes were hidden.

The ventilation strategy will create value for the society ensuring a low energy building while creating different spatial experiences inside the building, which will create value for the user of the building.

12.0. PHASE 3 INTRO

PRELIMINARY

Phase three covers a higher level of detailing than seen in the last two phases. This phase may seem to be containing mainly technical aspects, though it is important to note that, the different technical solutions are also determined upon architectural qualities.

Going into phase 3, the concept has gone through multiple changes in regards to its plan solution, roof, façade etc. at this time of the process the expression of the building has changed significantly than seen in chapter 'initial concept'.

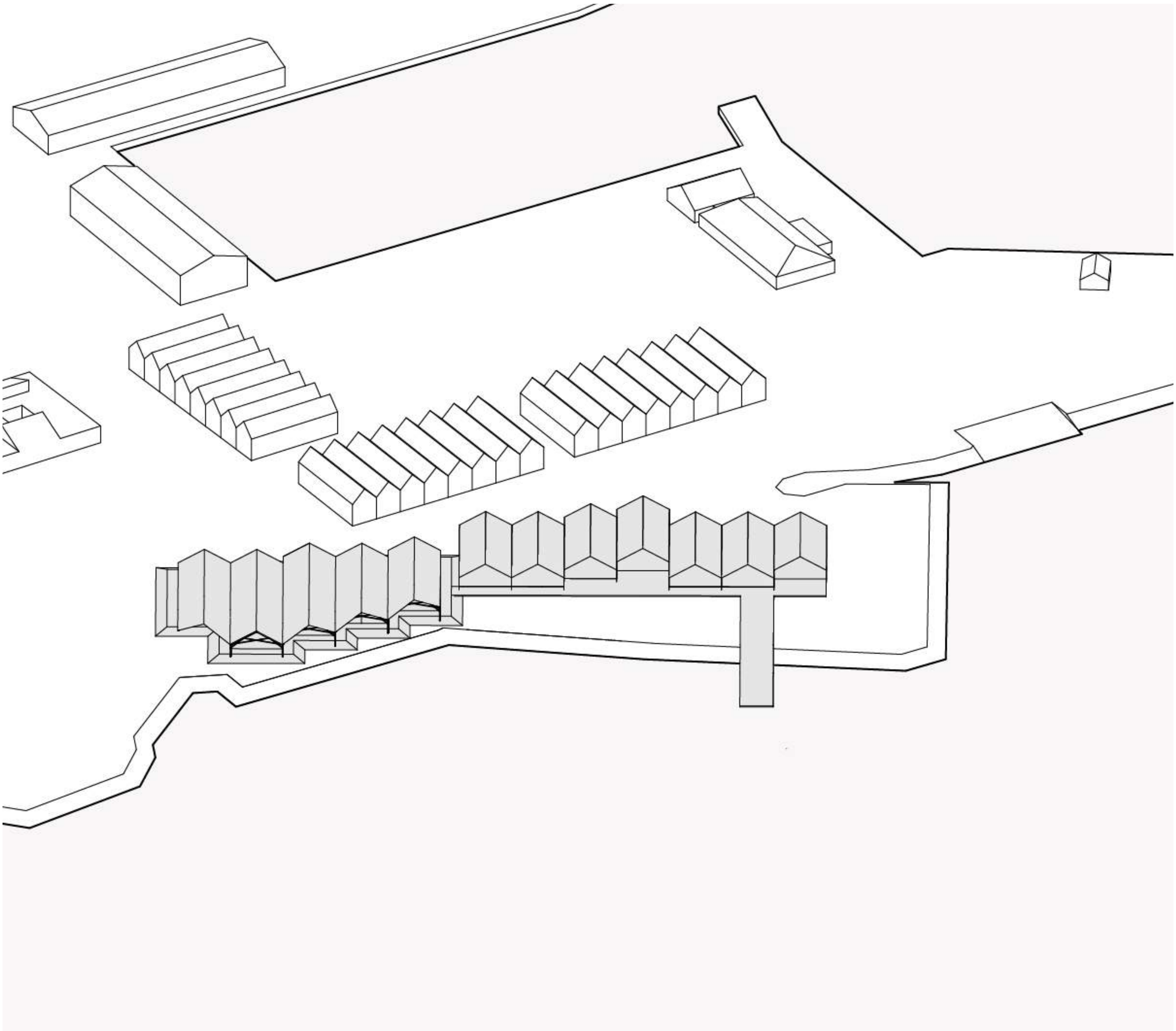
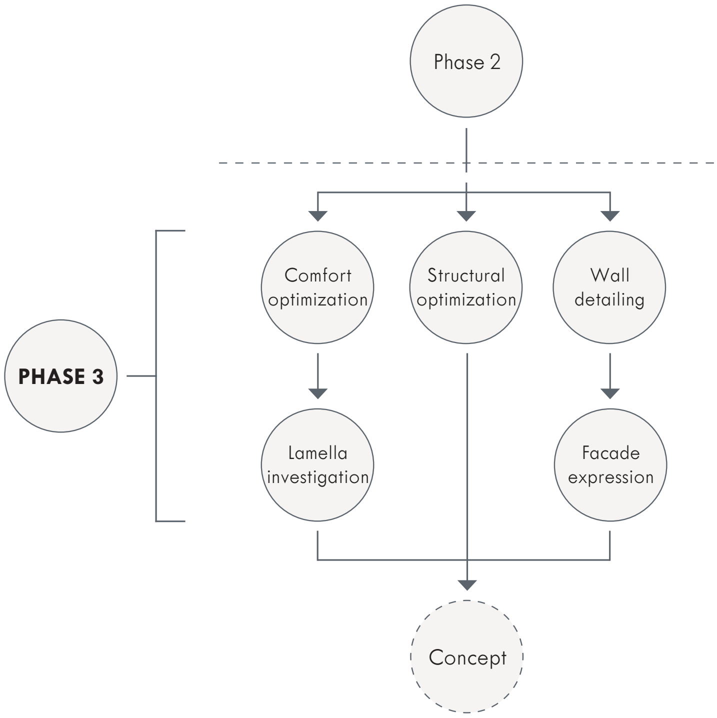


Figure 208 Initial concept



Phase 2
Comfort optimization
Structural optimization
Wall detailing
PHASE 3
Lamella investigation
Facade expression
Concept

12.1. COMFORT OPTIMIZATION FITNESS

PRELIMINARY

The relation to the fiord is highly focused, Having the fiord placed in a southern direction combined with a wish of framing the fiord, the indoor climate needs to be investigated with the focus upon overheating. The critical room is aspected to be the fitness room, due to the high metabolic rate of people occupying it.

FOCUSED DESIGN CRITERIA

LOW ENERGY INITIATIVES

ADAPT

FRAMING

Figure 209 Iteration 1 - The starting point of the investigation including on big south-southwestern window creating too many overheating hours and an insufficient daylight factor [DF].

Overheating hours > 26°C: 278 hours
Overheating hours > 27°C: 149 hours
Max CO_2 level: 500 ppm
Mean DF: 6,2%

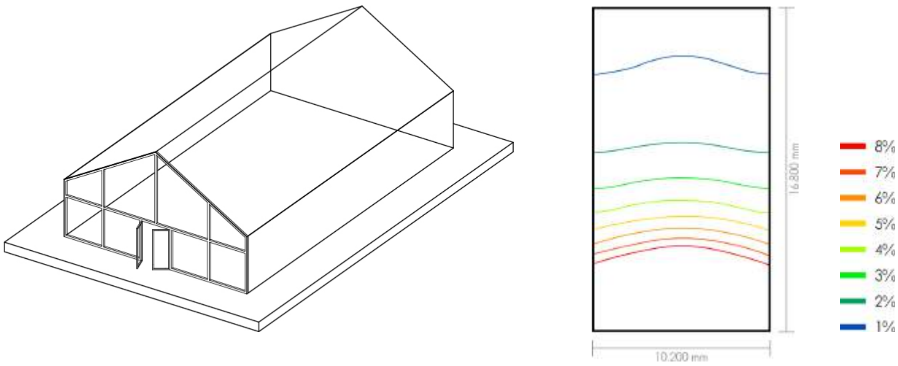


Figure 210 Iteration 2 - Addition of rooftop window bands parallel to the pitch of the roof. This solution had a sufficient DF, though resulted in almost 600 overheating hours to the room.

Overheating hours > 26°C: 852 hours
Overheating hours > 27°C: 564 hours
Max CO_2 level: 500 ppm
Mean DF: 20%

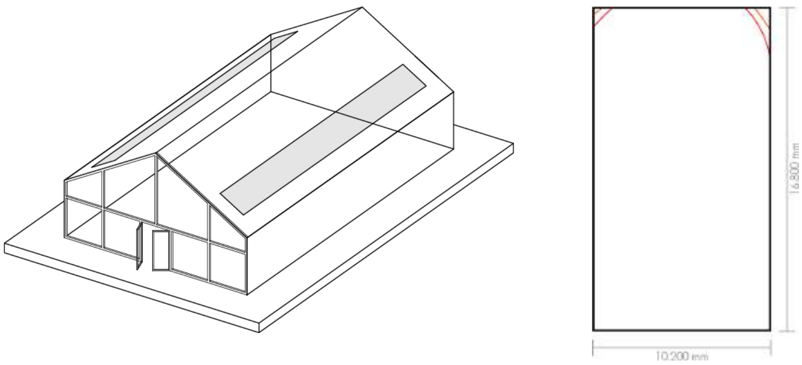


Figure 211 Iteration 3 - Limiting the rooftop windows in the northern part of the building, implementing more daylight in the area which needs it. This solution only creates 50 additional hours of overheating.

Overheating hours > 26°C: 327 hours
Overheating hours > 27°C: 182 hours
Max CO_2 level: 500 ppm
Mean DF: 10,6%

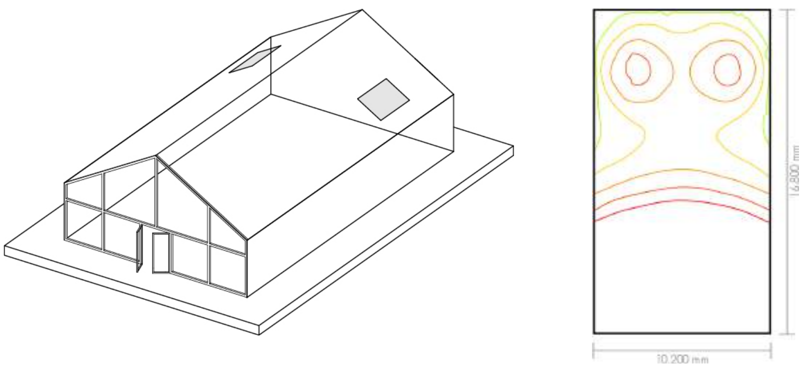
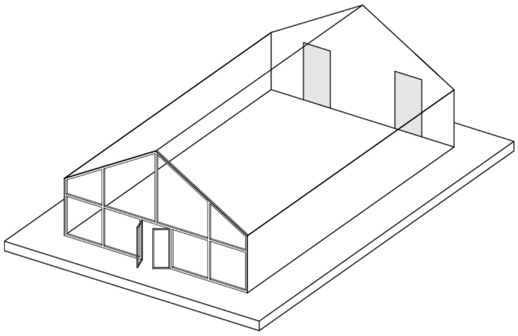


Figure 212 Iteration 4 - Due to the feeling of a misplaced and unaesthetic window placement, the northern façade is investigated. The windows are creating a sufficient DF together with the lowest addition of overheating hours, of 40 hours, of the first three iterations.

Overheating hours > 26°C: 314 hours
Overheating hours > 27°C: 171 hours
Max CO_2 level: 500 ppm
Mean DF: 10,3%



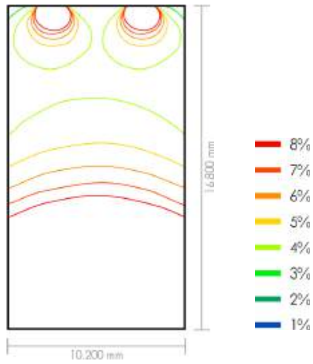


Figure 213 It is now known that the original design of the fitness did not create sufficient daylight in the room, though the second iteration, which was seen as the main iteration throughout the process to be how we would handle daylight, would risk overheating. By implementing windows to the northern façade, a discussion of the windows was started. By placing windows in this façade, an else closed facade surrounded by other closed faces, would be activated. This investigation suddenly gave a quite positive impact on the surrounding area. Furthermore, the idea of a "see-through" building mass, making it possible to see the fiord/square south of the fitness, framing the fiord from the southern part of the building, was worth investigating.

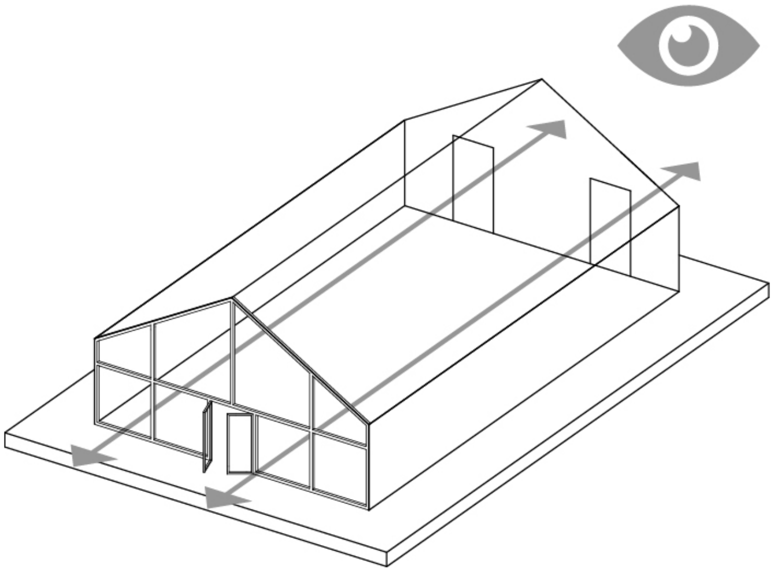
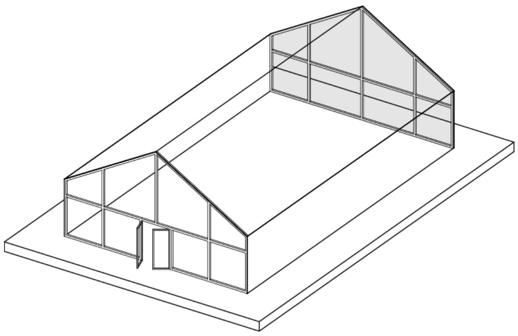


Figure 214 Iteration 5 - As a beginning, a similar window to the southern window façade was implemented. Due to the slight angle towards east, this design created 200 additional overheating hours, compared to iteration 1, together with a sufficient DF.

Overheating hours > 26°C: 460 hours
Overheating hours > 27°C: 254 hours
Max CO_2 level: 500 ppm
Mean DF: 17,5%



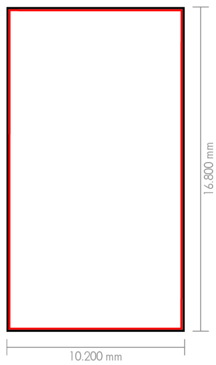


Figure 215 Iteration 6 - Lowering the window to a height of 3 meters lowers the overheating hours compared to iteration 5, while the view through the building mass will not be disturbed. Furthermore, a sufficient DF is still achieved.

Overheating hours > 26°C: 378 hours
Overheating hours > 27°C: 209 hours
Max CO_2 level: 500 ppm
Mean DF: 13,9%

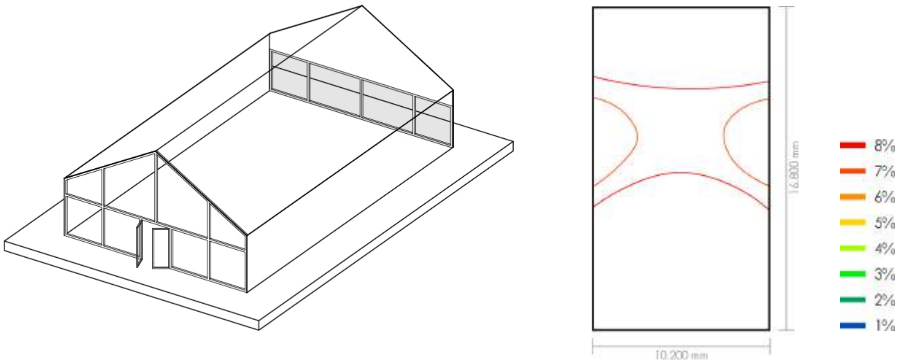


Figure 216 Iteration 7 - A wanted expression of the façade and the framing of the fiord is achieved, though the overheating hours are above the demands from BR18. Therefore openable windows are introduced to the glass faces, creating possibilities for natural cross-ventilation, lowering the overheating hours by 173 hours (above 26°C) (natural ventilation rates can be seen in appendix 16.13.).

Overheating hours > 26°C: 205 hours
Overheating hours > 27°C: 109 hours
Max CO_2 level: 500 ppm
Mean DF: 13,9%

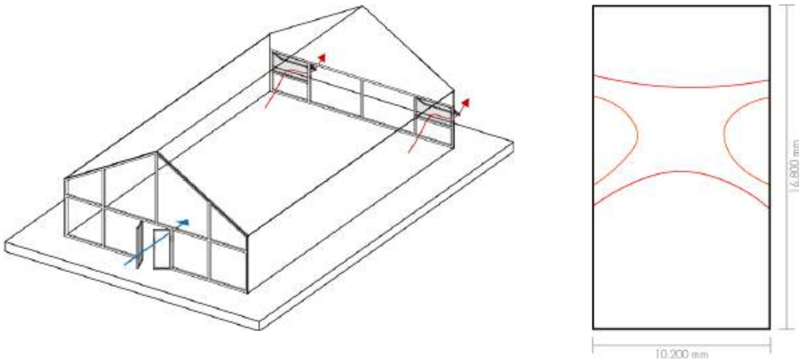
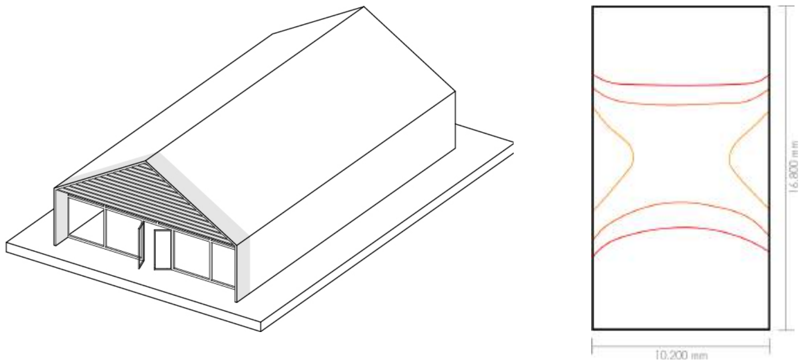


Figure 217 Iteration 8 - Lowering the overheating hours below the BR18 demands, and by that achieving a higher level of comfort to the users, lamella shading is introduced. With this passive strategy initiative, the overheating hours are below the BR18 demands.

Overheating hours > 26°C: 54 hours
Overheating hours > 27°C: 22 hours
Max CO_2 level: 500 ppm
Mean DF: 10,7%



CONCLUSION

By implementing different passive initiatives, it is possible to create a room with a big window towards the south. The window is wanted in this size due to the ability to achieve a higher amount of solar energy during winter, which lowers the amount of heating throughout this season. Therefore it is very important to investigate the lamellas, covering parts of the window. The lamellas should not shade during winter, though they must be shading during summer, minimizing overheating hours. The energy optimization creates value especially to the users of the fitness, creating a comfortable atmosphere to be working out withtin. Furthermore, the optimization creates value to the society by opening the building towards the public while framing the fiord from an else closed gravel road, leading towards the marina.


Figure 218 Iteration 1

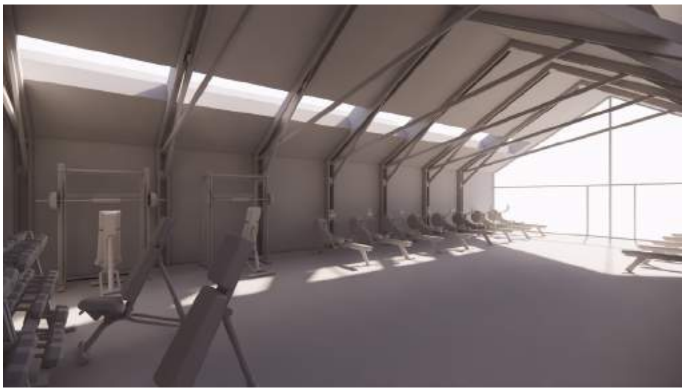


Figure 219 Iteration 2


Figure 220 Iteration 3

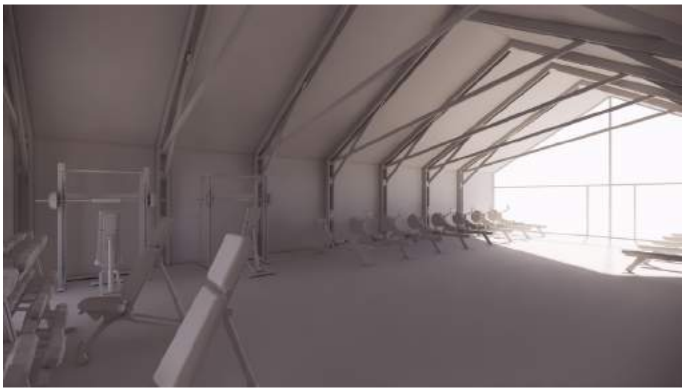


Figure 221 Iteration 4


Figure 222 Iteration 5


Figure 223 Iteration 6


Figure 224 Iteration 7


Figure 225 Iteration 8

12.2. LAMELLA INVESTIGATION

PRELIMINARY

As a result of the BSim process, it is now clear that by utilizing shading it's possible to lower the energy usage together with minimization of overheating hours. Therefore, an investigation of overheating is conducted.

FOCUSED DESIGN CRITERIA

LOW ENERGY INITIATIVES

DURABILITY

ADAPT

Figure 226 The aim is to minimize the heat obtained from the sun, during the warmer summer months (Suninfo, n.d.), but maintain the achieved heat during winter. A horizontal lamella shading will be introduced. The shading will take the position as the head of the building, introduced in chapter '6.1.3. facade registration'.

December	January November	February October	March September	April August	May Juli	June
11°	15°	24°	35°	47°	55°	58°

Figure 227 Lamella size: 19x50 mm.
Lamella distance: 59 mm.

The lamellas are minimizing the view at the top of the window, due to the short distance between each lamella.

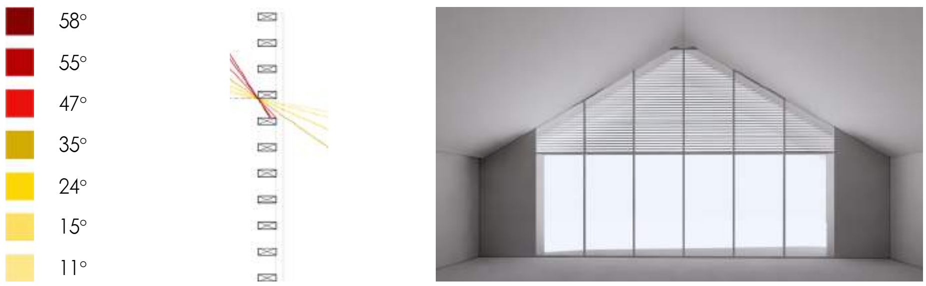


Figure 228 Lamella size: 19x100 mm.
Lamella distance: 107 mm.

Increasing the width of the lamellas makes it possible to create a bigger distance between the lamellas. Though, due to the distance between the lamellas, the window still seems closed at the top.

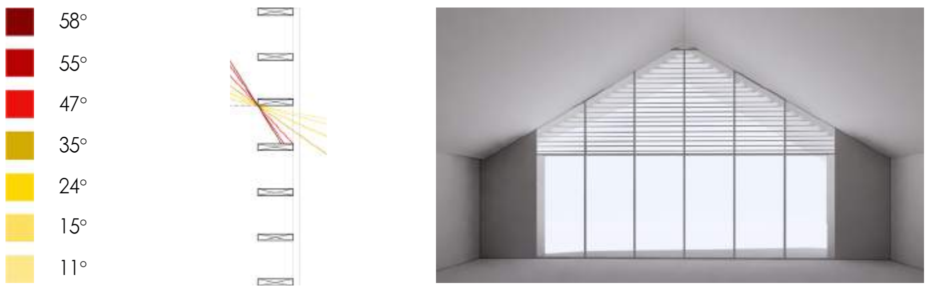


Figure 229 Lamella size: 19x150 mm.
Lamella distance: 160 mm.

By increasing the lamella width to 150 mm. it is possible to achieve a lamella distance of 160 mm. reducing the visual disturbance in the top window.

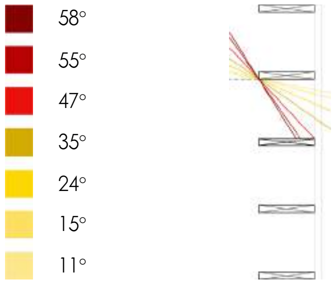
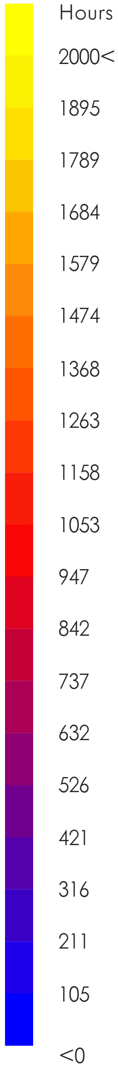


Figure 230 An average amount of sun hours is tested upon the lamella distance of 160 mm in the 3D program Rhino, through the grasshopper, ladybug, and honeybee plugins. Testing the efficiency of the lamellas.

Sun hours without shading.
Amount of hours where the sun is hitting the interior floor during a year: 864 hours

Amount of hours where the sun is hitting the interior floor April - August: 167 hours



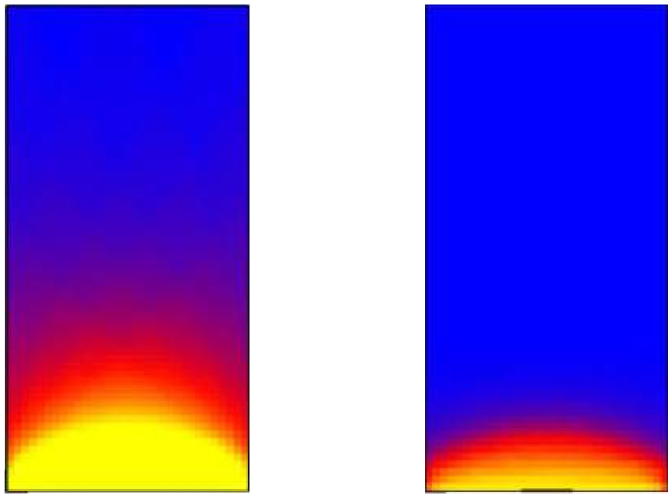
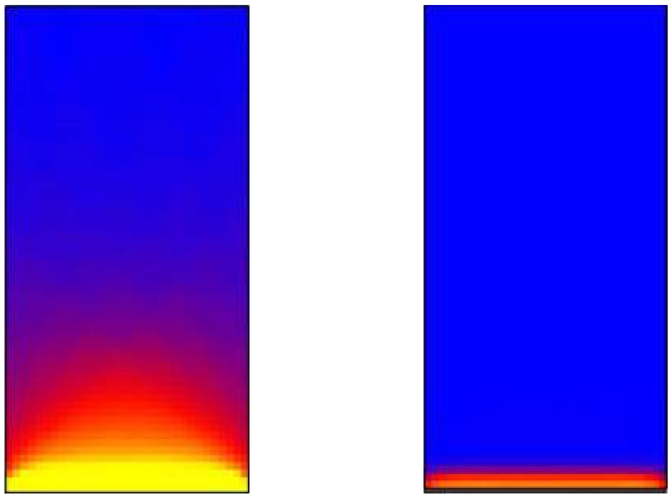


Figure 231 Sun hours with shading.
Amount of hours where the sun is hitting the interior floor during a year: 630 hours

Amount of hours where the sun is hitting the interior floor April - August: 62 hours



CONCLUSION

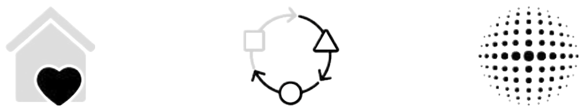
Horizontal lamellas with a distance of 160 mm. will be utilized in the final design, minimizing overheating hours while maintaining the framing of the fiord. The lamella distance is important, both in aesthetical expression, but also as a passive strategy for heating. Increasing the distance between the lamellas the visual disturbance towards the fiord will be reduced. Furthermore, fewer lamellas create a lower surface blocking the sun during winter months, where the energy is needed as a passive heating strategy. Lowering the overheating hours is of high interest to the users of the building, creating rooms where the user will be in comfort. Furthermore, by introducing passive strategies, as lamellas, the building will use less energy on heating and reduce energy for cooling significantly, which is of high societal interest.

12.3. STRUCTURAL OPTIMIZATION

PRELIMINARY

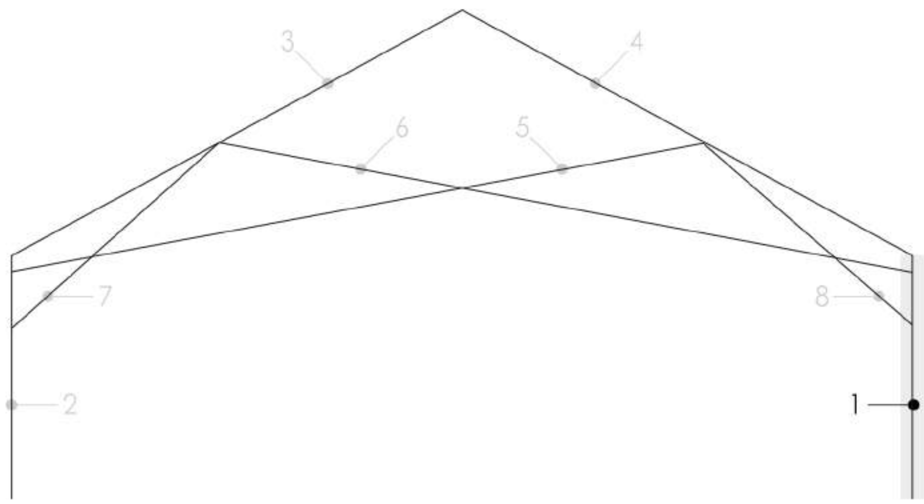
The elements of the frame need to be dimensioned making sure the structure will be withstanding the load affecting it. Furthermore, the aim is to minimize the structural elements, creating a structure that is not the dominant part of the room, though still psychologically lowers room height.

FOCUSED DESIGN CRITERIA



TYPOLOGY   LIFE CYCLE ASSESSMENT   ATMOSPHERE

Figure 232 The highlighted column is the one obtaining the biggest load. Therefore this column will be the dimensional element in this first iteration, making sure the construction withstands the loads. Simplifying the calculations the profile is calculated as a unified cross-section, though the profile is in-fact divided into two connected elements (Load combination calculations can be found in appendix 16.14.).



Class of strength	C24	C27	C30	C30
Cross section	100x150 mm	150x250 mm	100x200 mm	150x225 mm
Ratio ULS	3.97	0,87	1,81	0,97
Ratio SLS	4,14	0,67	1,75	0,87
Total wood amount for a single frame	0,552 m^3	1,380 m^3	0,736 m^3	1,242 m^3
Displacement	69 mm	11 mm	29 mm	14 mm

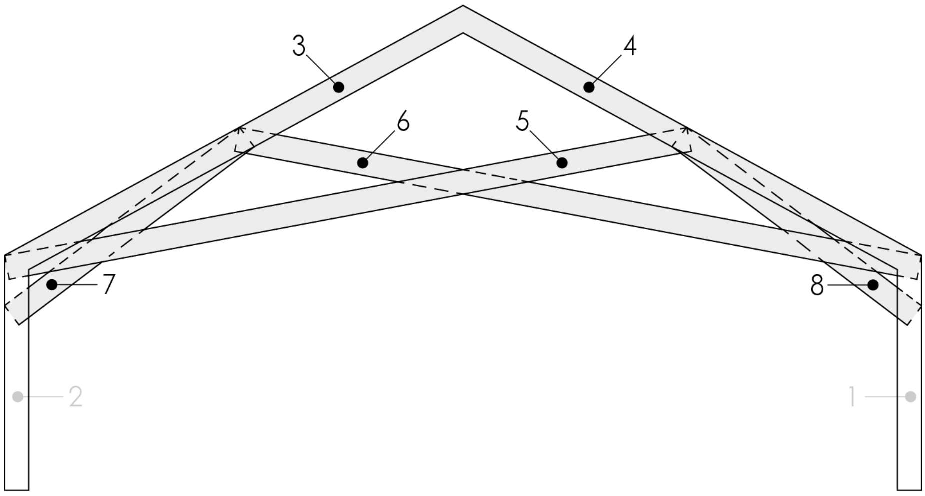
Figure 233 Next will be a ratio investigation of the different elements, locating which element can be optimized in regards to the forces affecting the element. As seen, most of the beams, especially the ones inside the frame have a too big cross-section in regards to the forces affecting it. Therefore a smaller profile will be chosen, minimizing the amount of material in the construction.

	Ratio
Element 1 - Column	0,97
Element 2 - Column	0,61

	Ratio
Element 3 - beam	0,39
Element 4 - beam	0,39
Element 5 - beam	0,12
Element 6 - beam	0,08
Element 7 - beam	0,19
Element 8 - beam	0,12

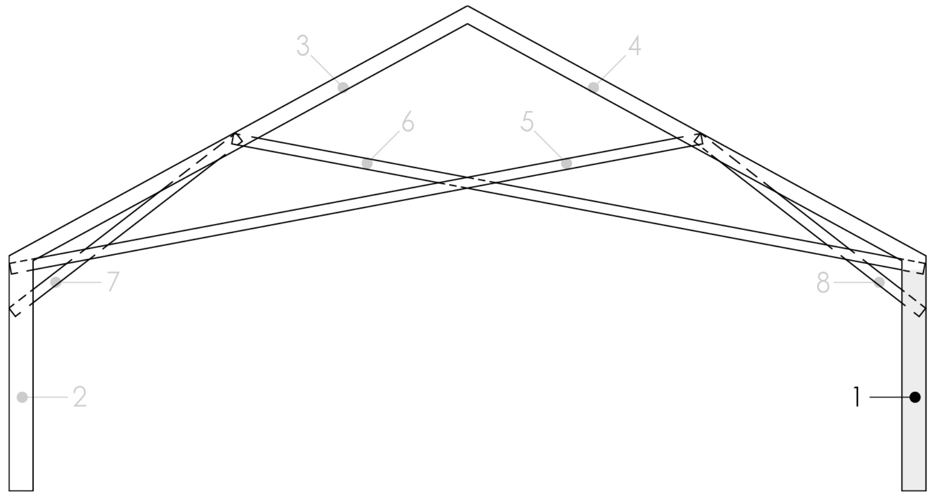
Figure 234 Due to symmetry in the construction, the beams will be dimensioned in pairs, where the element with the biggest load will be the dimensional element. It is important to state that the dimensional process is iterative and the wood amount in the construction is an evolving process through the dimensioning of each pair of elements. The pairs will be as follows:

3+4: Dimensional element will be element 4
5+6: Dimensional element will be element 5
7+8: Dimensional element will be element 7



	Class of strength	Section	Ratio	Displacement	Total wood amount for a single frame
Element 3 & 4					
	C24	100x150 mm	0,87	13 mm	1,037 m^3
	C24	75x150 mm	1,09	15 mm	0,996 m^3
	C24	100x125 mm	1,06	16 mm	1,010 m^3
Element 5 & 6					
	C24	50x75 mm	1,06	39 mm	0,598 m^3
	C24	45x95 mm	0,64	24 mm	0,606 m^3
	C30	50x75 mm	1,06	39 mm	0,598 m^3
Element 7 & 8					
	C24	45x95 mm	1,32	1 mm	0,421 m^3
	C24	45x120 mm	0,92	0 mm	0,428 m^3
	C24	50x100 mm	0,99	0 mm	0,426 m^3

Figure 235 Due the profile changes in the elements of 3,4,5,6,7 and 8, the columns no longer withstand the forces, due to the high ratio investigated on the last page. At this point of the process of dimensioning the ratio of element 1 is 1,11 ULS and 1,68 SLS. Therefore a new profile is needed for the columns. Despite this will add more volume to the frame, the columns are the shortest elements in the constructing and will therefore not be the big participator of volume, which is why the other elements are dimentioned as small as possible.



Element 1 & 2	Class of strength	Section	Ratio	Displacement	Wood amount for a single frame
	C30	175x225 mm	0,96	15 mm	0,456 m^3
	C30	200x250 mm	0,69	8 mm	0,508 m^3
	C30	200x200 mm	1,05	18 mm	0,458 m^3

CONCLUSION

By investigating the ratio of the element pairs, it was possible to reduce an amount of wood 2,7 times lower than the first dimensional iteration. This meaning that there will mainly be utilized the amount of material that is needed to withstand the different loads affecting the construction, and thereby lowers the amount of material drastically. Lowering the amount of material will be of interest to the building owner, as it can be used as a strategy to lower the budget of the construction. Furthermore, minimizing profiles, and thereby removing unnecessary material, is of high importance to the government/society due to a minimization of deforestation combined with a reduction of 294,5 kg CO_2 per wood frame. The reduction is caused by, among others, transportation and treatment of the material.

From the start of this optimization, the aim was to lower the elements, which will be visible in the rooms, making a more delicate and light room. Based upon visualizations of the before and after optimization, it can be concluded that making a construction with smaller profiles, creates a room with less tension between the elements. The room with over-dimensioned profiles draws attention to the construction, and not the framing of different views, while it tells the story of a construction with big and heavy loads affecting it, which in this case is false.

The construction with light profiles doesn't draw as much attention to itself as the over-dimensioned construction, and by that, the construction doesn't disturb the possibilities of framing the exterior. Furthermore, by minimizing the profiles of the frame, the idea of lowering the room is still maintained without the construction drawing too much attention. Robot and LCA results can be found in appendix 16.15.

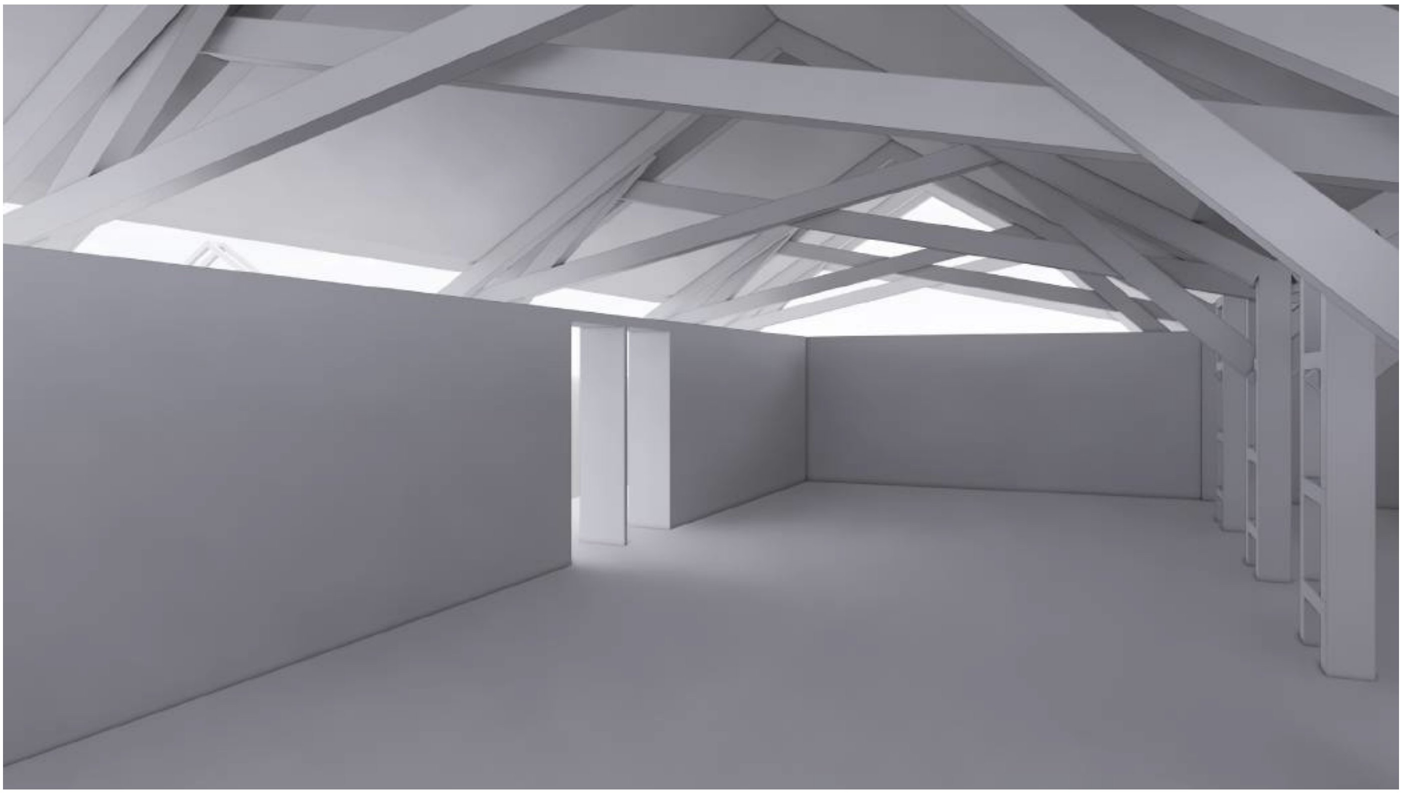


Figure 236 Before structure optimization

Figure 237 After structure optimization

12.4. WALL DETAILING

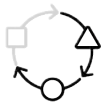
PRELIMINARY

A more in-depth wall built-up investigation was conducted, where all layers are included in the LCA and LCC investigation, to create an environment-friendly wall-built-up which is also economically beneficial. Furthermore, the materials should be considered in regards to saltwater exposure.

FOCUSED DESIGN CRITERIA

TYPOLOGY

ADAPT



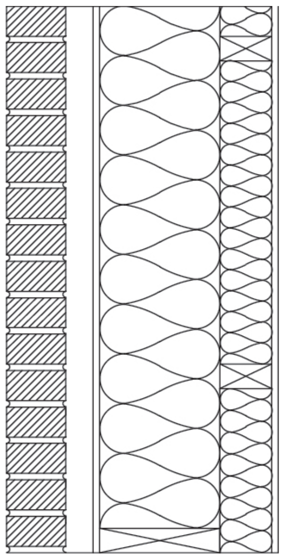
LIFE CYCLE ASSESSMENT

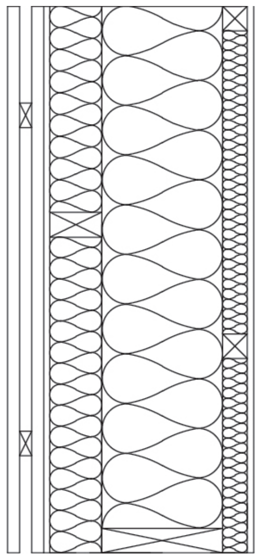
Figure 240 A recycled brick wall with a wooden skeleton is the best performing in LCA, in regards to the other walls. Regarding LCC the brick wall almost has the same cost as a wood wall, but the brick façade solution can't handle the risk of flooding.

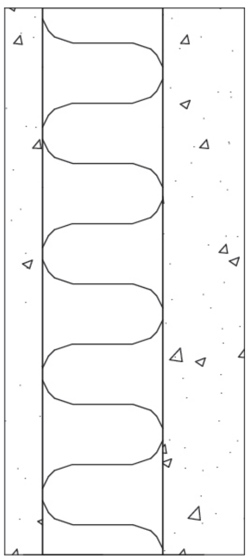
Figure 241 A wood wall, consisting of wood cladding and eelgrass insulation, has one of the best performances regarding LCA but has a high cost due to maintenance throughout the building's lifetime. Furthermore, a wood wall can't handle flooding, where there will be damage to the construction.

Figure 238 A prefabricated concrete wall consisting of a concrete outer wall, EPS insulation, and a concrete back wall, has a high impact on the environment, though consists of the cheapest materials. Furthermore, the concrete has the potential to withstand flooding and has a long lifetime.

Figure 239 A combination of the wood and concrete wall, where the wooden façade is combined with the cheap durable concrete wall. The investigation makes it possible to lower the price of the wall and the environmental impact while utilizing the properties of the different materials in regards to flooding.







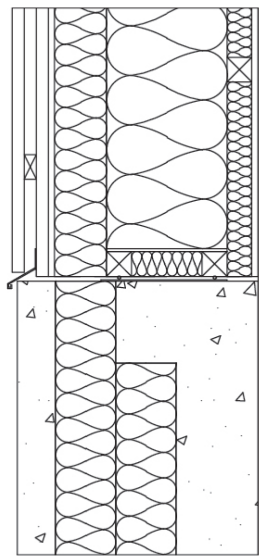


Figure 242 LCC analysis results from DGNB standard 50 years lifetime and 80 years lifetime.

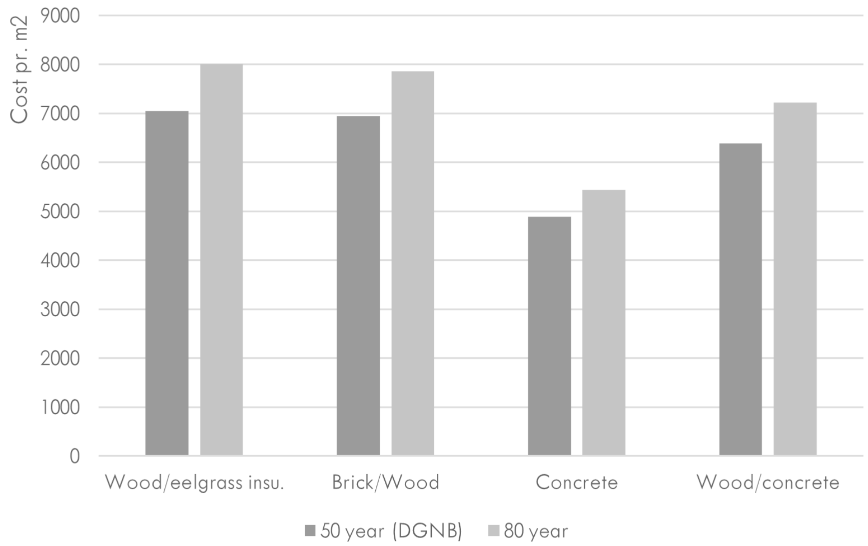
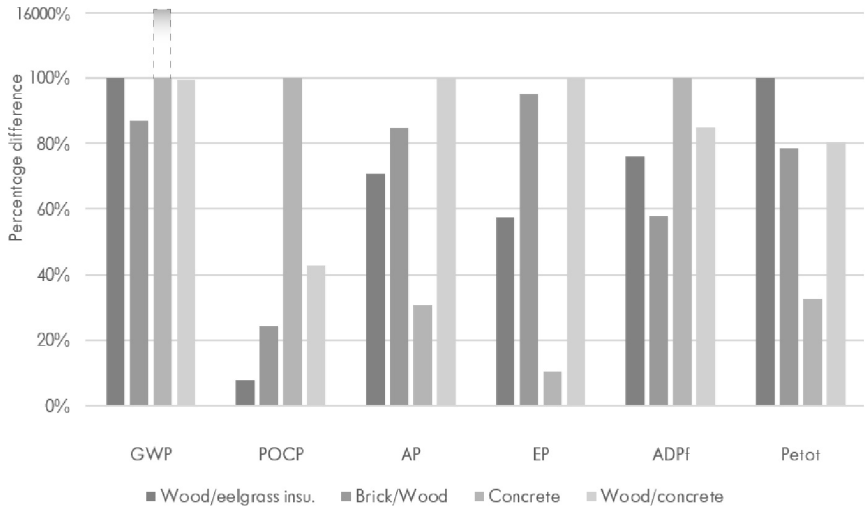


Figure 243 LCA analysis results percentage related to the biggest value in each category, except for GWP, where concrete has a much higher impact of CO_2 than the other investigated materials.

Furthermore, each material is rated on a scale of 1-3 upon their performance of each DGNB reference criteria in regards to their specific weighted score.



	GWP [Kg CO_2 eq.]	POCP [Kg C_2H_4 eq.]	AP [Kg SO_2 eq.]	EP [Kg PO_4^3 eq.]	ADPf [MJ]	PEtot [MJ]	LCA rating	LCC 50 year [kr]	LCC 80 year [kr]
Wood/Eelgrass insu.	-1,76e-01	1,50e-07	3,32e-06	1,18e-06	7,39e-02	3,51e-02	2,25	7367	8376
Brick/Eelgrass insu.	-1,53e-02	4,62e-07	3,97e-06	1,95e-06	5,64e-02	2,76e-02	2,55	6943	7862
Concrete	1,08e-03	1,89e-06	1,44e-06	2,05e-06	9,74e-02	1,15e-02	1,7	4895	5436
Wood/Concrete	-1,75e-01	8,09e-07	4,69e-06	2,12e-07	8,27e-02	2,82e-02	2,2	6389	7225

CONCLUSION

When investigating the different wall-built-ups with a focus on the environmental impact through LCA combined with the economic cost and the different materials ability to withstand flooding. The best performing wall is a combination between wood and concrete wall. Furthermore, concrete is a cheap material and can withstand flooding, though the amount of concrete needs to be held at a minimum, which is why by combining concrete with a wood wall, the environmental impact will be lowered which fulfills the environmental values set by the interests. Furthermore, the cost is lowered, which increases the value of the construction to the building owner. The combination of material also creates a good connection with the surrounding context, where the wood façade fits into the maritime harbor, while the concrete can withstand the exposure of water from e.g. the boat storages.

12.5. FACADE EXPRESSION

PRELIMINARY

As an extension of the previous wall detailing chapter, the architectural expression of the chosen wall will be investigated. The investigation will be based upon the chapters '6.1.2 Local Building traditions' and '6.1.3 Façade Registration'. The focus will be put on the wall detailing in the restaurant area and boat storage area together with a gable investigation. The investigation will especially investigate the possibilities to create a translation of the detailing principle typically seen in the brick buildings around Nykøbing Mors.

FOCUSED DESIGN CRITERIA

TYPOLOGY

ADAPT

LIFE CYCLE ASSESSMENT

Figure 244 Iteration 1.1. gradual detailing in the restaurant area.

Figure 245 Iteration 1.2. vertical detailing in the restaurant area.

Figure 246 Iteration 2.1. Horizontal detailing in the boat storage area.

Figure 247 Iteration 2.2. The wood construction grabbing the concrete part of the wall with a gradual detailing in the boat storage area.

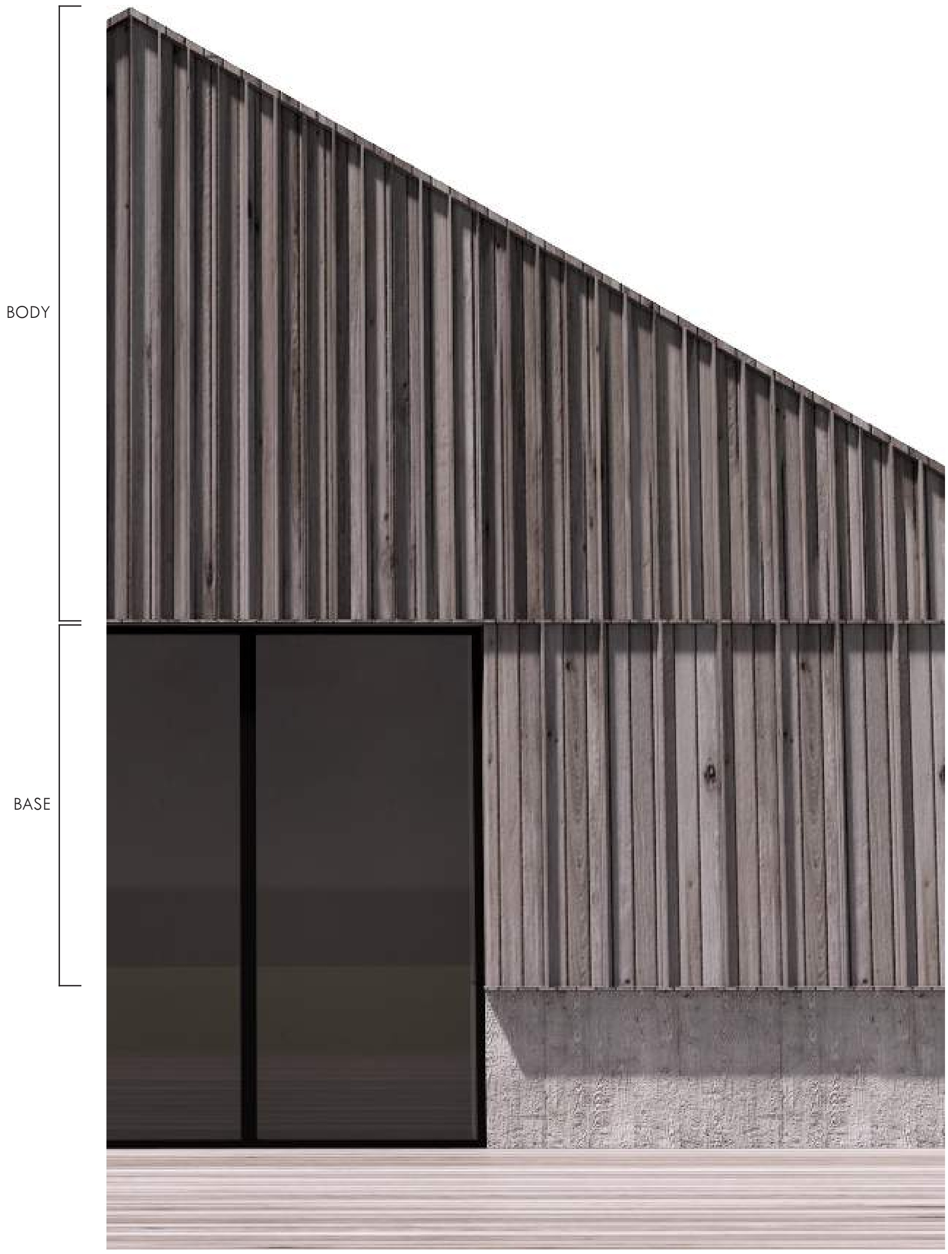
Figure 248 Iteration 2.3. Gradual detailing in the boat storage area.

Figure 249 Iteration 3.1. Gradual detailing on the gable.

Figure 250 Iteration 3.2. Gradual detailing with head piece on the gable.

Figure 251 Iteration 3.3. Gradual wall detailing with a plain gable.

Figure 252 Iteration 3.4. 3 level Gradual wall detailing on the gable.



CONCLUSION

Based upon this investigation it was found doable to translate the existing highly expressed brick detailing in the shape of a wood (/concrete) construction. For the final design iteration 1.2., 2.3. and 3.4. is the iterations that will be implemented into the building design. Besides relating to the base, body, head terms, achieved from chapter 6.1.3, the vertical expression of the wall, which was an important expression, was obtained. The façade study is of interest to the building owner achieving an environmentally friendly façade system, though keeping the historical and characteristical detailing system seen in the main parts of the buildings in the city center of Nykøbing Mors. Furthermore, the boat houses north of the building are also built with vertically placed wood planks, which will be relatable to the vertical dominated façade in the center facility.

12.6. ENERGY OPTIMIZATION

PRELIMINARY

The following investigation is an optimization process with the aim to be fulfilling the energy demands for a low energy building while maintaining the intended framing towards the fiord placed south/west from the building. The large windows create a risk of a high energy frame caused by over temperatures, which must be solved to maintain the connection to the fiord(detailed process investigations such as keynumbers, daylight factor etc. can be found in appendix 16.16).

FOCUSED DESIGN CRITERIA

LOW ENERGY INITIATIVES

FRAMING

DURABILITY

Figure 253 Firstly, the building geometry and necessary systems needed to obtain indoor comfort are entered into BE18, to give an indicator of how the building is performing without any optimizations. Here the building fulfills the normal energy frame, but not the low energy class.

37,3 kWh/m^2 year
9,5 kWh/m^2 year over temperature

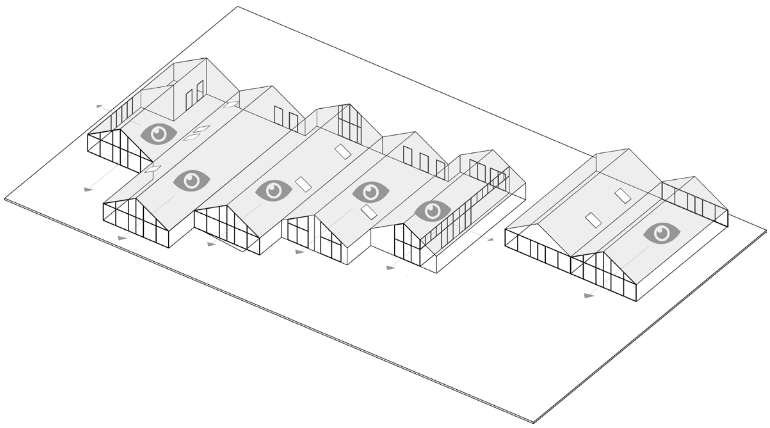


Figure 254 With a large amount of overtemperature in BE18, there is a need for passive shading, that can provide shading in the summer, while allowing sunlight in the winter, in this case, an implementation of an overhang.

32,3 kWh/m^2 year
2,2 kWh/m^2 year over temperature

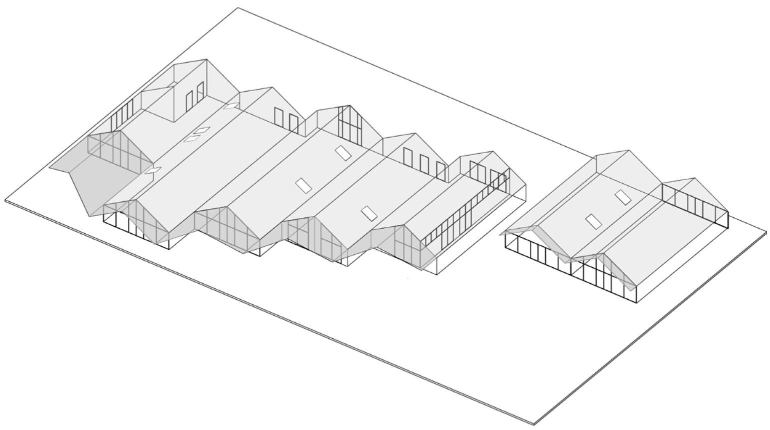


Figure 256 With the large windows to a south/ west orientation, the implementation of natural ventilation has a possibility to lower energy for ventilation during summer, meanwhile, providing natural cooling of the building.

30,1 kWh/m^2 year
0,8 kWh/m^2 year over temperature

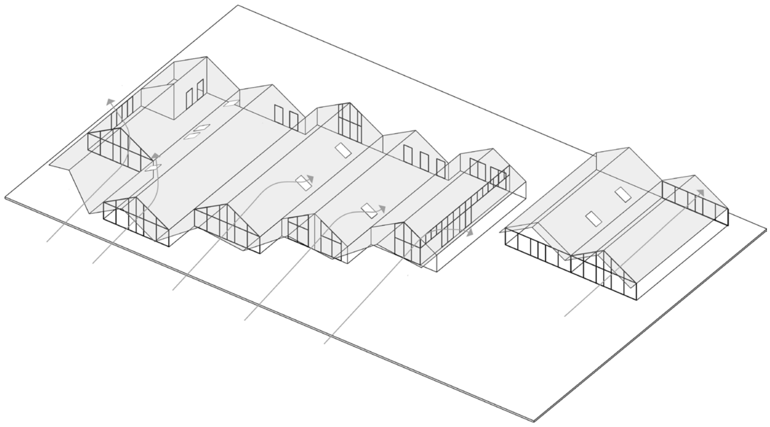


Figure 255 With a small amount of over temperatures, the implantation of passive shutters in the shape of slats reduces the amount of over temperatures in the places with a small overhang, which prevents over temperatures without increasing the heating demand, reaching the low energy frame.

29,6 kWh/m^2 year
0,0 kWh/m^2 year over temperature

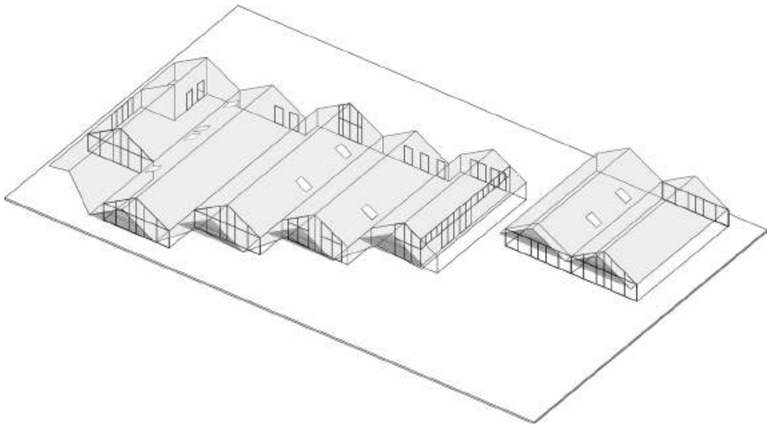
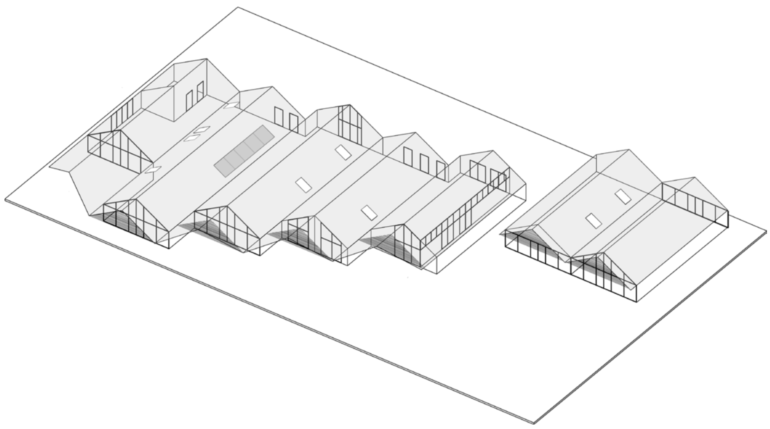


Figure 257 While reaching a low energy frame, there is a possibility to reduce the energy frame further by implementing 20 m^2 solar panel. Locating the optimal position making the solar panel be the most efficient, a radiation analysis of the roof was conducted, which can be seen in appendix 16.16.

12,9 kWh/m^2 year
0,0 kWh/m^2 year over temperature



CONCLUSION

When implementing some of the earlier design investigations of shading possibilities, overhang, and natural ventilation the strategies make it possible to have several larger windows towards the fiord, which realizes the architectural vision of framing the foord inside the building. Instead of compromising with the connection to the fiord, these passive solutions are introduced to make the architectural expression possible.
The transition between inside and outside is kept to the initial intention which benefits the user's experience of the building while making a building with low energy consumption, fulfilling the interest values the building owner and society.

13.0 EPILOGUE

13.1. CONCLUSION

Overall concept
The building design is inspired by traditional boat houses, that with their pitched roofs and wooden construction relates to the nearby maritime typology and culture. To avoid the building becoming a massive wall - blocking the access to the fjord - the structure has a pathway in the middle. This creates easy access from every direction for both tourists, guests, and members. Hence, the building adapts and extends the existing roads and pathways, creating an attractive area for people to stroll or to observe the activity.

The construction is a wooden frame designed with transverse rafts, stabilizing the frame, transferring forces from the pitched roof down the columns. The width of the frame follows a carefully developed grid, making the frame 9600 mm wide and 5675 mm tall. These measures create a favorable size for creating spaces. No matter if it is toilets, storage rooms, association premises, or restaurants. Within this grid size, you can compose a wide range of various compositions, matching the needs of the specific program. In this way the building encapsulates various programs, becoming internally inhomogeneous with a lot of different atmospheres and agendas. Externally, the building has the expression of repetition and homogeneity.

The column structure is intentionally designed with integrated gaps, as each room utilizes the gaps for accommodating purposes. In the boat storage, the gaps become a rack system for boat storage, and in the workshop area, a shelf system for ingredients. Hence, the structure accommodates the programmatic solutions as it creates advantageous plan layouts, but also accommodates the space itself, as the structure 'gestures' each room in a very sensible and pragmatic way.

Low environmental and economic impact
The design redeems the design criteria of having a general sustainable consciousness in terms of emissions and energy use. In addition, the building owner wanted a cheap building without compromising on architectural quality. Hence, the building has a wooden structure, a wooden envelope with a solid base of concrete. The economic and environmental aspects of using concrete and wood have been carefully optimized by life cycle assessment and life cycle cost analyses, to secure the lowest price and environmental impact possible. This resulted in an 800 mm concrete foundation above ground, to preserve the wood and decrease potential repairment associated with flooding. The composition of building materials has a lower environmental impact than the DGNB reference building.

Due to its placement next to the fjord, the building utilizes the windy conditions for natural ventilation and solar radiation for heating and energy. By engineering the shading, overhang, and window sizes, the building is categorized as a low energy building, using only 12,9 kwh/m2 year without compromising on favorable indoor temperatures, fresh air supply, optimal daylight conditions, and a beautiful view towards the fjord.
The low maintenance and operation costs are estimated to be attractive for the associations as it will affect their financial latitude. In addition, low energy use and low environmental impact are considered sustainable and are important for the government as they are supposed to meet the goal of a 70% reduction by 2030.

Dietary experience
It was important for the society and the building owner to promote the dietary experience of oysters as a strategy to gain increased tourism and the financial profits that follow. Hence, the concept of an oyster restaurant was implemented as food tourism is one of the most demanded types of tourist activities. In addition, the objectives of the society were to influence the general population with more sustainable food management in terms of eating habits and reducing food waste.

The restaurant consists of three overall concepts called the dining area, the workshop area, and the lounge. Although the three concepts have the dietary eating experience of oysters in common, each concept addresses the human body in different ways.

The atmosphere of the dining area is created by wooden surfaces, green scenery, and a visual connection to the kitchen. The experience takes place in a seated position with subdued acoustics gained from the integrated ceiling providing a low reverberation time. The dining area has a feature of flexibility as it can orchestrate an intimate experience for minor gatherings, but can be open towards the green field, participating in shellfish festival, Oyster- and mussel premiere, and summer concerts as well. In this way, the oysters can

enroll a strategy of urban conviviality and sociability as it will become the central experience for social arrangements.
The workshop concept is a space characterized by stone and rough materials. This concept emerges from the experience of standing at the shoreline, collecting oysters. The workshop experience takes place in a standing position and is designed for smaller events such as team-building, masterclasses, etc. The workshop has an informative and tutoring program, which is why the space includes production tables orientated towards a tutoring desk at the end of the room. This is a learning by doing experience, as it is intended for guests to be taught in preparing oysters themselves.

The lounge concept has the same materiality as the dining area but takes place in a laid back and soft seated position, creating a different experience while being orientated towards the fjord.

These dietary experiences are designed to have a high degree of stress-reducing factors such as wooden interior, green scenery, subdued acoustics, and bright lightning, creating the appropriate atmosphere for food experiences in terms of taste and fragrance. The learning by doing experience at the workshop, creating an experience through the tactile and motion of preparing oysters with the hands.

These sensual influences were prioritized as they would create value for the guest at the restaurant. The intention is to influence the guest in an informative and sensual way. The dietary experience will meet the tendency of food and restaurants being some of the most prioritized features of tourism on Nykøbing Mors and thereby cover those food-related demands pronounced by the society and the user.

Water sports

The building owner wanted a building that could generate tourism and contribute to the local society in terms of economy and social cohesion, which is why half of the project includes clubhouse and boat storage facilities for institutional, associations, rental, and private use. The intention is to create a maritime gathering point across organizations and to create a common spot for social cohesion to thrive, focusing on water sport. Unfortunately, we are not able to document the value-creation as it would require a 'post-occupancy evaluation' which can only be performed after the building has been built. Although, by analyzing the existing conditions for the local water sports associations, and the tendencies in the neighboring municipalities, the conclusion is that there is a huge potential in implementing water sports facilities as a local tourist attraction.

The building owner demanded a building that programmatically would contribute to increased tourism and strengthen the local social cohesion. A contribution to the reinvention of itself as a city and rural area through the gastronomical experiences associated with the oyster, but also water activities.

The boat storage units are placed in close relation to the shoreline, providing the easiest and fastest transition between the boat storage rack and the water. In addition, the interior floor of the boat storage has a concrete surface, making it durable against wet sailing gear. These are features that meet demands made by the row practitioners.

It is not sustainable to have a maritime building being empty during of season, hence the building program provides indoor training and clubhouse facilities as a strategy for social gatherings and annual activity. Now the associations can have indoor training seasons and social arrangements during the low season. In addition, the urban areas are designed to be open to the public by several access points and to attract tourists and local citizens to the harbor front to try wakeboarding, stand-up paddling, and kayaking. The urban features provide several places to sit for water sports observers. Hence, the water sport contemporarily becomes an additional feature for experience economy and a place for social gathering.

13.2. REFLECTION

Scoping the project
It was important for us to do the master thesis based on real competition. We wanted to do a competition and eventually participate when the competition got announced during summer 2021. Hence, we established a collaboration with Morsø Municipality, which was very engaged to our thesis, getting us off to a good start.

However, the competition program was not finished, so we received a so-called 'prospect'. Without knowing the difference, we used the 'prospect' as a competition program. This resulted in a research question, based on a wide range of desires for integration of museums and knowledge sharing, offices for entrepreneurs, tourist attractions, school activities, fishing industries, dietary experiences, and water sports associations. We used an enormous amount of time trying to fit every single wish from the prospect into the research question, but eventually, acknowledge that there were too many demands to fit into this thesis. It came to our attention that it is very important to initially sort out which specific interests and goals should be included in the project, and how to define the interests demand a valuable outcome.

Value creation
This master thesis is the product of our curiosity of how to document the valuable outcome – so-called architectural effects. Documentation of architectural effects seems to be an increasing tendency among architectural firms, as the field experiences a lowered priority of architectural quality in favor of investments and financial returns. Hence, we wanted to integrate the value-creating methodology with the integrated design process, and thereby add another layer on top of our design approach. Yet, we found it very hard to define 'value' as it is very subjective.

Due to the covid-19 restrictions, most of our work has been done at home, and we weren't able to perform physical interviews and meetings which made it challenging to communicate with the receive useful information from the municipality and other relevant user groups. Unfortunately, we did not hesitate to base our personas on research articles and personal experience, instead of investigating alternatives methods to get in touch with relevant user groups. We acknowledged, that our involvement of the interests were too vague and we instead should have made a more profound user group catalog, based on digital interviews and questionaires. Then we would have an even more appropriate foundation to determine the definition of valuable outcome, and to design more succesful value-based architecture.

We truly believe that our architect-engineering background is advantageous when documenting and evaluating the valuable outcome of architecture based on science. Especially the technical aspects of indoor comfort, affecting human behavior, but also the properties of different materials, affecting the environment. We are able to determine whether a building performs rationally or irrationally based on technical objectives. We just need to know more specifically which technical proficiencies that have the most valuable outcome to our interests.

In this thesis, we were able to evaluate whether the building was cheap or expensive due to the total expenses, or if the energy use and pollution levels were above the consent level. This is, to some extend, valuable information. Yet we wanted to be more profound; We wanted to scientifically prove that the effect of architecture could strengthen social cohesion and increase local tourism. Unfortunately, we were not able to scientifically document these effects. Frankly, we weren't able to perform a post-occupancy evaluation even though it is one of the methodologies used for documenting the social effects of architecture.

Instead, we should have looked into precedent post-occupancy evaluated buildings, and get inspired by those. That might would have supported and directed our design in a more valuable direction.

It came to our attention that our perception of the phrase 'creating value' has suffered some kind of 'word inflation', as it became a phrase we used for every design choice throughout the process. This caused a focus loss on the actual effect of the building. For instance, an overhang doesn't necessarily create value by itself, but in collaboration with a range of other design features, it might create a favorable indoor climate, affecting the well-being of the user. All in all, we acknowledge that we probably had too many value criteria – we simply wanted the building to meet too many demands. Instead, we should have defined one - or a very few - value criteria, which our 14 design criteria synergetically should try to achieve.

We spend a whole lot of time finding the 'best concept' based on our defined values. We went through several detailed concepts, but discarded the concepts due to the lack of 'value'. We acknowledged that the value emerged in the detailing when we designed the relation between the user and the tectonics. Hence, addressing a more profound catalog of evidence-based research would improve the value-based design process even more. Unfortunately, it took us a very long time to find relevant evidence-based research dealing with the relation between the human body and architectural performance. We found some, but we wanted to find even more. The effect of architectural environments is often measured on the human body by the cortisol level, heart rates, blood pressure, or other chemical processes within the human body. It is up to us, to determine whether these effects are the valuable outcome for the users.

A building will always have some sort of effect on their surroundings, and the people who use it, no matter the design. Hence, these effects must be carefully looked into in order to design the most appropriate building, suitable for its context and its users. Here, five years of interdisciplinary studies in architectural engineering have been very perceptive in how challenging it is to design an intentional architectural performs.

Digital collaboration

Another thing is that a lot of the information, inspiration, knowledge, and small-talking we previously gained from each other, and our fellow students - had been tremendously reduced. In fact, we experienced that this digital communication was ineffective and time-consuming. Unfortunately, it was almost impossible to establish some sort of common creative office at one of our homes, as all of us live in 40 square-meter apartments. The motivation for making the digital co-operation technique work was that it is probably going to be the same co-operation techniques, which we need to master when we are getting a job.

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Furthermore, the following digital programs has been utilized throughout this thesis:

Autodesk - Revit, AutoCAD, Robot

Adobe - Indesign, Photoshop, illustrator

SketchUP - Enscape

Rhino - Grashopper, ladybug & honeybee plugin

BSim

BE18

LCAByg

LCCByg

Molio prisdatabase

15.0 LIST OF ILLUSTRATIONS

All of the shown diagrams/figures are selfmade, except the following:

Figure 1: Aalborg University Logo

Aalborg University, n.d. Valg af Logo [WWW Document]. URL https://www.design.aau.dk/Valg+af+logo/ (accessed 5.21.21).

Figure 12: $C0_2$ in the atmosphere and annual emission (1750-2019)

Lindsey, R., 2020. Climate Change: Atmospheric Carbon Dioxide [WWW Document]. URL https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

Figure 14: Deplazes coherence of typos, topos and tectonics

Deplazes, A., 2005. Constructing architecture : materials, processes, structures : a handbook. Birkhauser Verlag AG, Basel.

Figure 15: Bruder Klaus Feldkapelle, exterior

Hjortshøj, R., 2017. PETER ZUMTHOR BRUDER KLAUS FELDKAPELLE [WWW Document]. URL https://divisare.com/projects/349303-peter-zumthor-rasmus-hjortshoj-bruder-klaus-feldkapelle (accessed 5.21.21).

Figure 17: Bruder Klaus Feldkapelle, interior

Hjortshøj, R., 2017. PETER ZUMTHOR BRUDER KLAUS FELDKAPELLE [WWW Document]. URL https://divisare.com/projects/349303-peter-zumthor-rasmus-hjortshoj-bruder-klaus-feldkapelle (accessed 5.21.21).

Figure 18: Diagram from 'Architect, document your value-creation', explaining the linear process of value creation

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Figure 21: Climate crisis facts

Jensen, K.G., Sommer, J., 2018. Building a circular future: essentials 309.

Figure 22: Problematic in Morsø municipality

Dingeo, n.d. Morsø Kommune [WWW Document]. URL https://www.dingeo.dk/kommune/morsoe?fbclid=IwAR0VEaLbN4RAkg47WzUGNw6KrYWyj1xgmGpkr-yaonwbEX9TaGZWU4szyhI (accessed 5.13.21).

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Figure 48: Flooding & hightide

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Figure 50: Fiord depth

krak, n.d. Krak til søs [WWW Document]. URL https://tilsos.krak.dk/#map=15.21/56.792725/8.868516 (accessed 5.21.21).

Figure 51: Sunrose

Gaisma, n.d. Aalborg, Denmark - Sun path diagram [WWW Document]. URL https://www.gaisma.com/en/location/aalborg.html (accessed 5.21.21).

Figure 52: Windrose

Ceppelen, J., Jørgensen, B., Danish Meteorological Institute, 1999. TECHNICAL REPORT 99-13 - Observed Wind Speed and Direction in Denmark - with Climatological Standard Normals , 1961-90 Observeret vindhastighed og -retning i Danmark - med klimanormaler 1961-90 296.

Figure 53: Contour lines

Styrelsen for Dataforsyning og Effektivisering, n.d. SDFE korviser [WWW Document]. URL https://sdfekort.dk/spatialmap (accessed 5.21.21).

Figure 57: Water level

Miljø- og Fødevareministeriet, 2019. Højvands- statistikker 2017.

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Figure 58: Water elvels at the project area
Hydrometri [WWW Document], 2021. URL http://www.hydrometri.dk/hyd/ (accessed 5.21.21).

Figure 138:

Hjortshøj, R., n.d. Noma 2.0: Et råt naturparadis i byen [WWW Document]. URL https://dac.dk/viden/arkitektur/noma-2-0-et-raat-naturparadis-i-byen/ (accessed 5.21.21).

Figure 139:

Atlasofplaces, 2019. Sverre Fehn [WWW Document]. URL https://www.atlasofplaces.com/architecture/hedmark-museum/ (accessed 5.15.21).

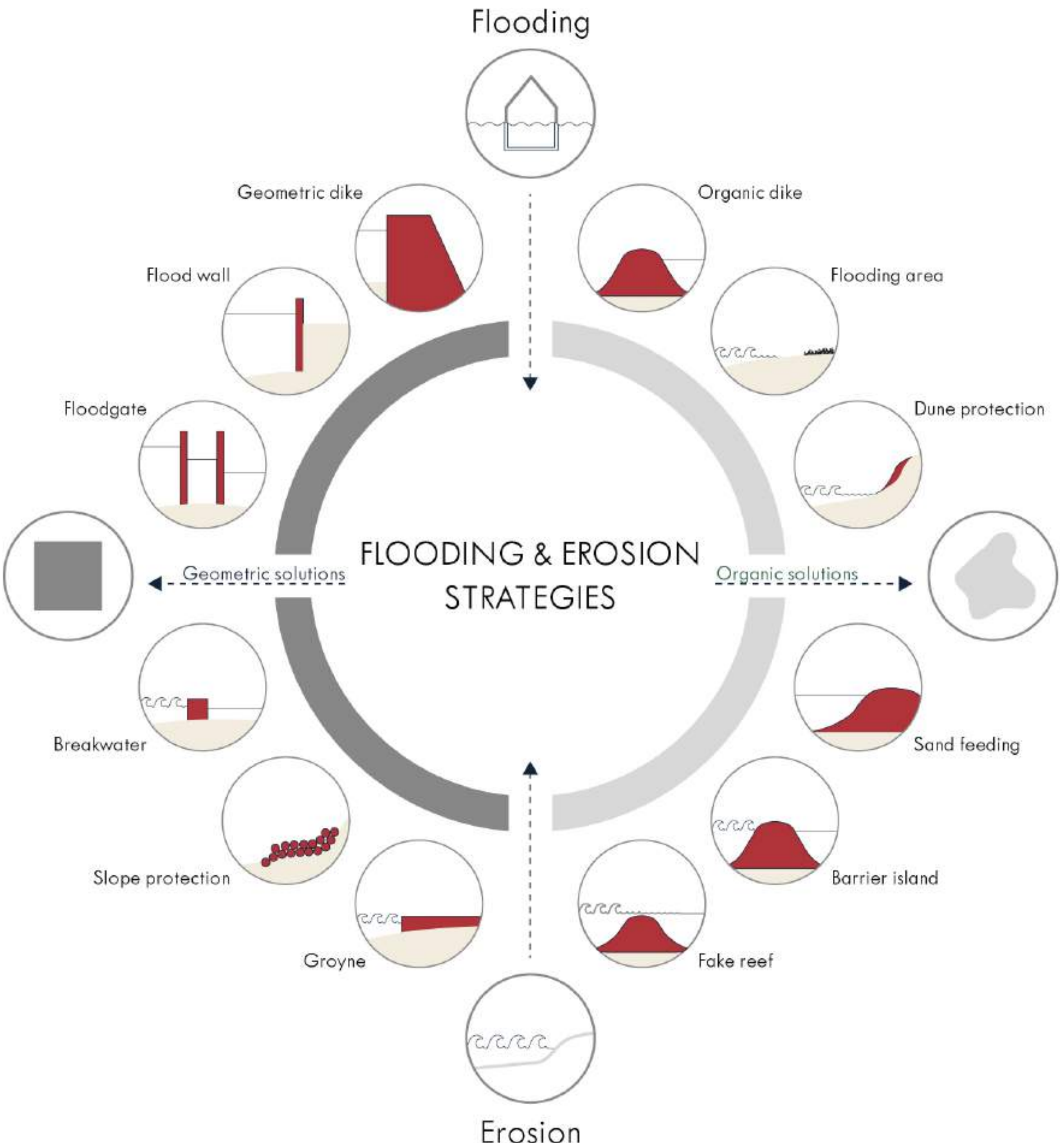
Figure 140:
Guthrie, P., 2013. Cathedral Museum of Hedmark [WWW Document]. URL https://arquiscopio.com/archivo/2013/07/27/museo-de-la-catedral-de-hedmark/?lang=en (accessed 5.15.21).

16.0 APPENDIX

16.1. APPENDIX TABLE OF CONTENT

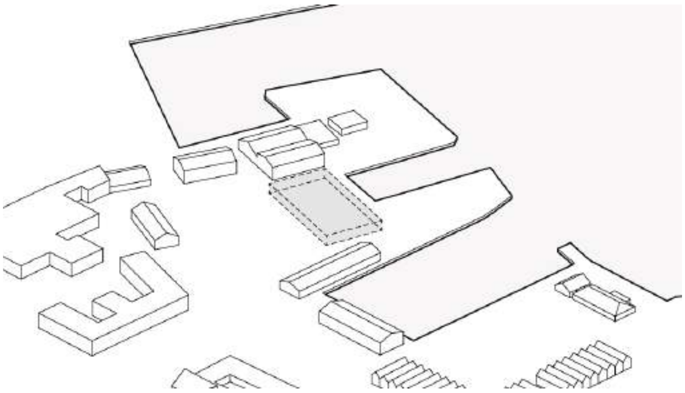
Appendix

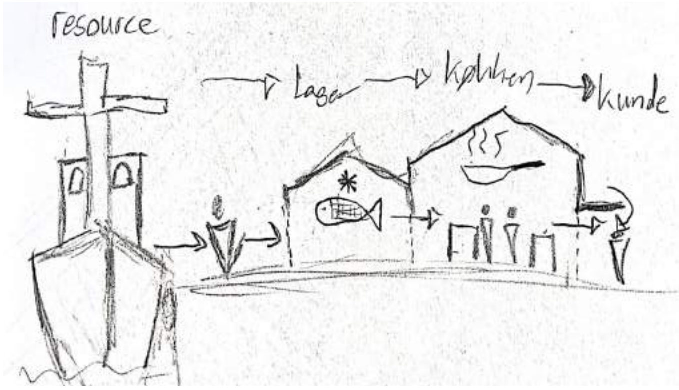
16.2. APPENDIX FLOODING & EROSION

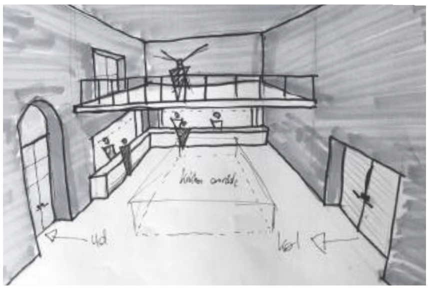


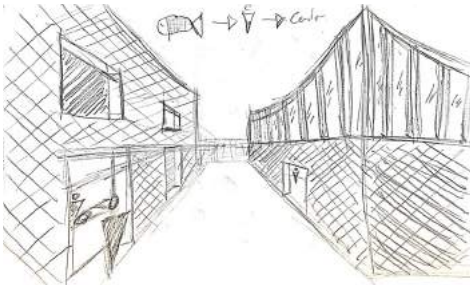
Source -
Dansk Kyst- & Naturturisme, 2020. DET REKREATIVE POTENTIALE I KLIMATILPASNING AF KYSTERNE.

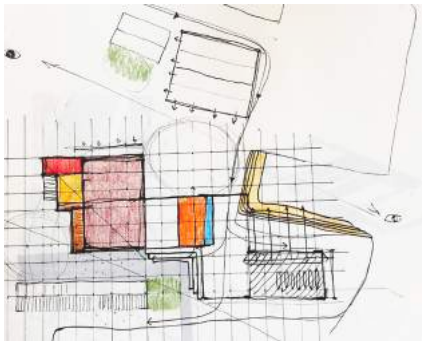
16.3. APPENDIX ALTERNATIVE LOCATION

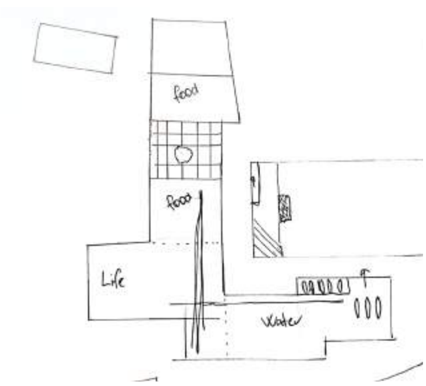


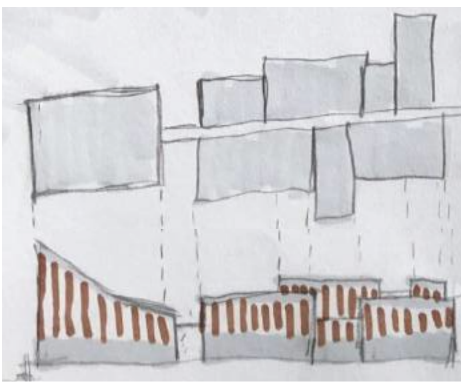


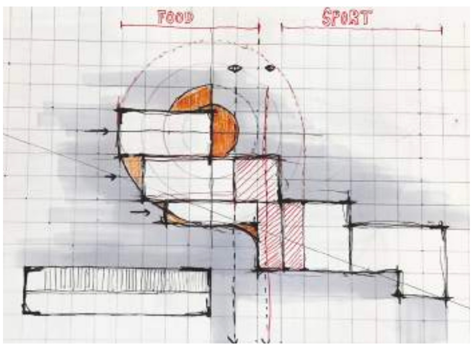




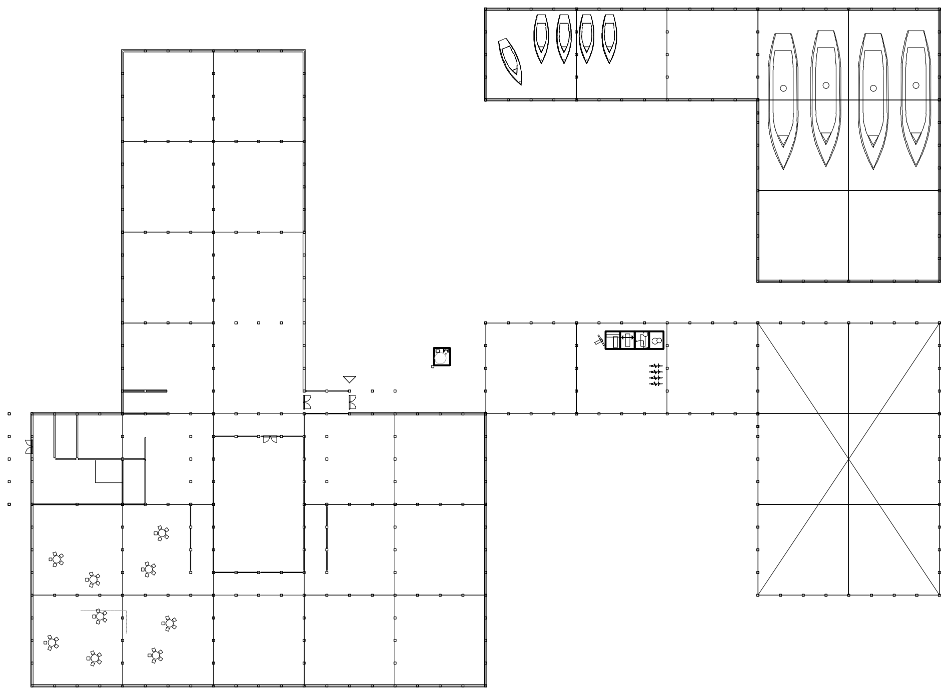


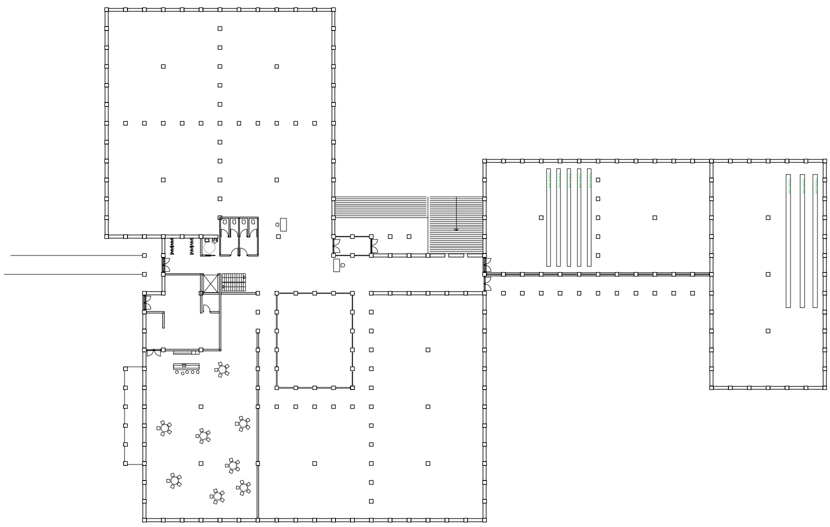


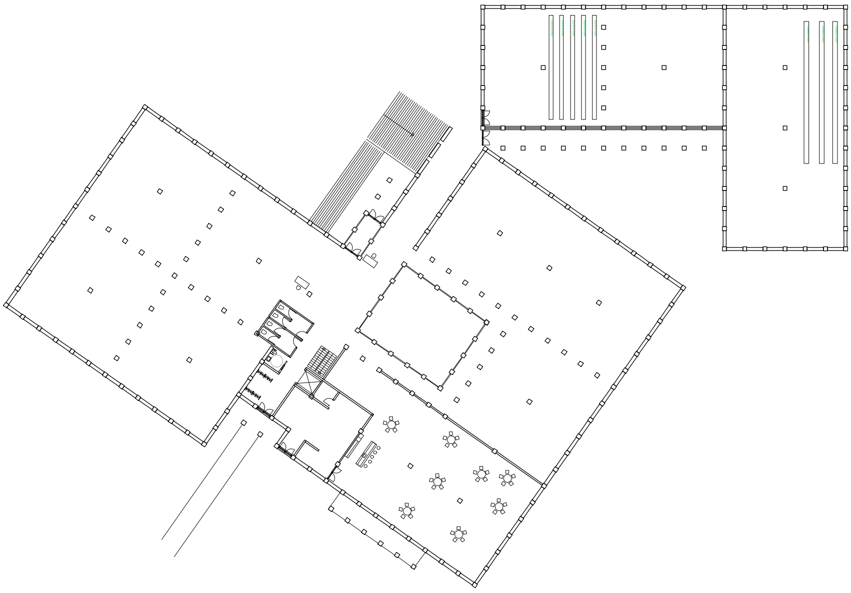


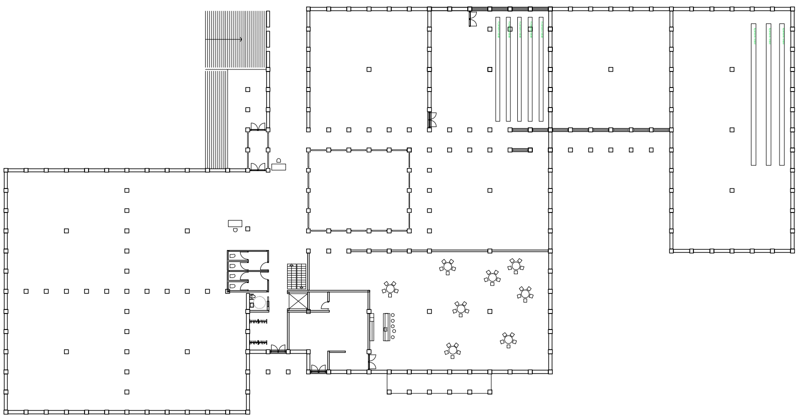


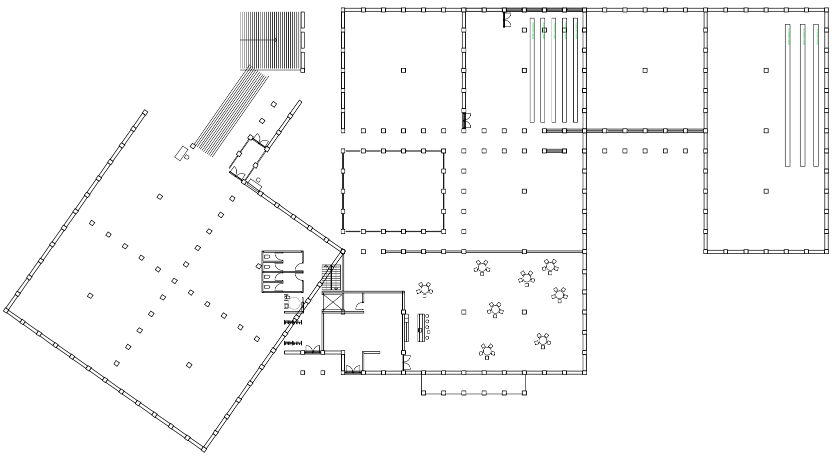
16.4. APPENDIX ITERATION 4 PROCESS

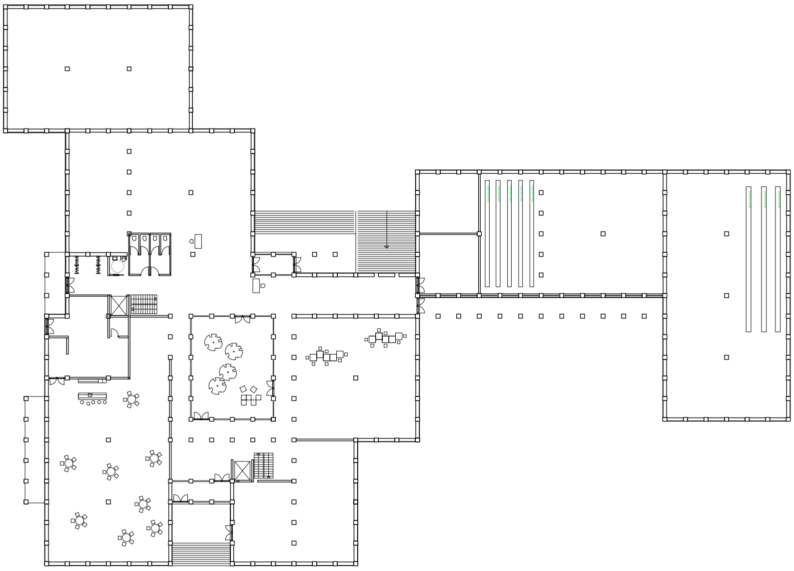


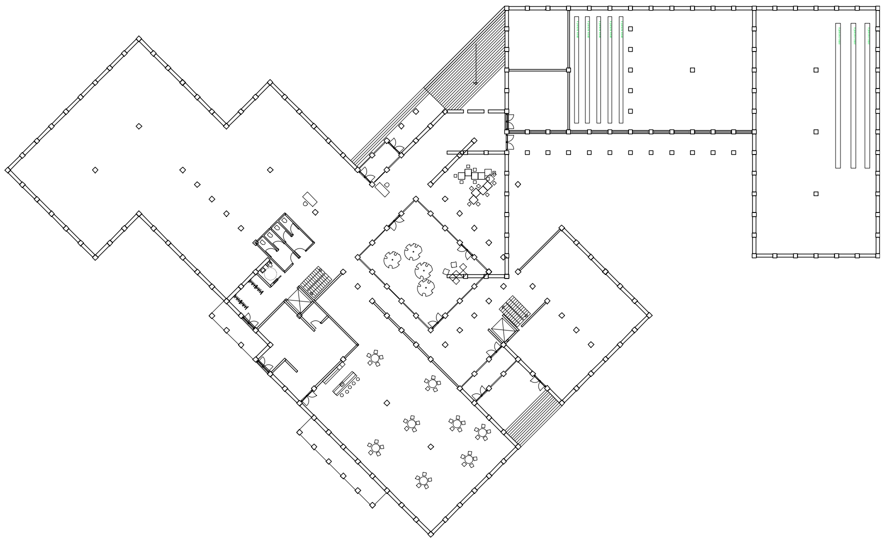




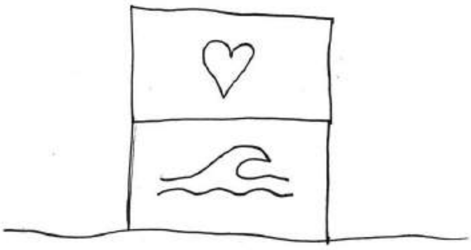


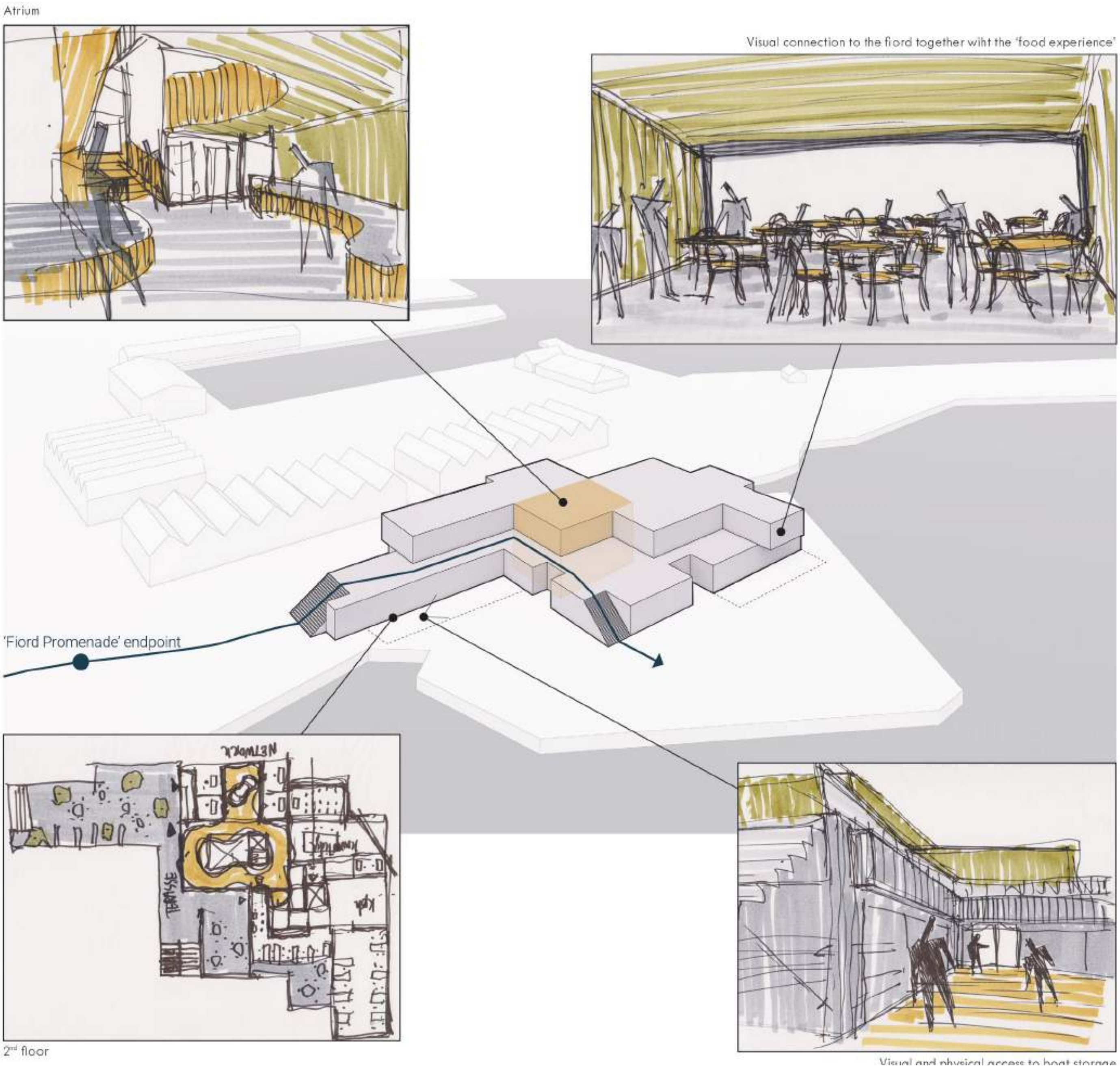


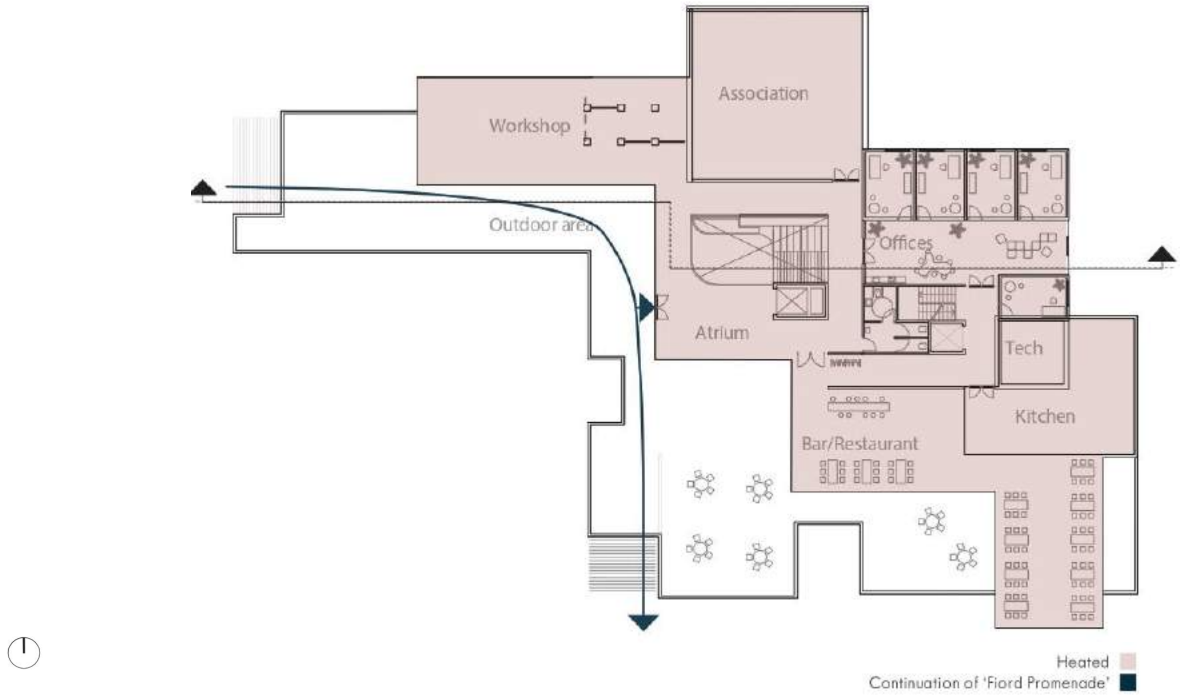


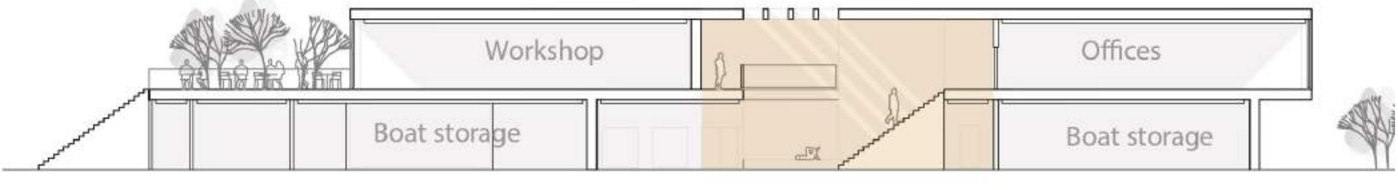


16.5. APPENDIX ITERATION 4 - PINUP CONCEPT









Section - View towards north

16.6. APPENDIX BRICK WORKSHOP





















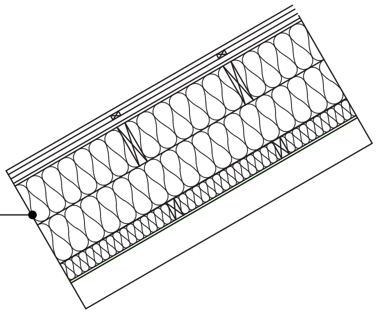


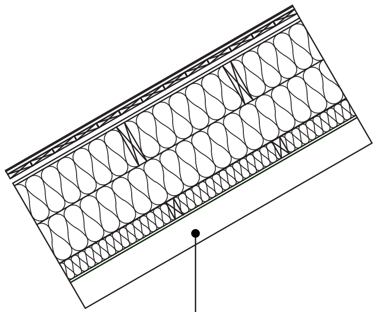

16.7. APPENDIX ROOF CONSTRUCTION

PRELIMINARY

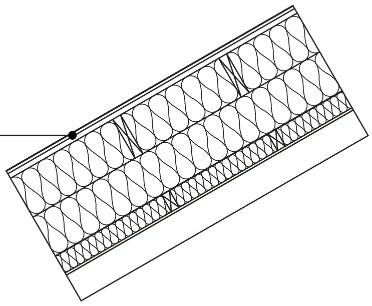
The following investigation concerns the environmental impact together with the economic cost of the different types of roof exterior. The investigation is an extention of chpater '10.10. roof impact', where the focus is to find the best sustainable material with minor impact along with a cheap solution to fit both the sociality and the building owner.

A wooden roof cladding consists of a water-resistant board, ventilated layer, a counter batts layer, and wood cladding. A wood roof has a minor environmental impact and has a medium cost even with high maintenance during the lifetime.



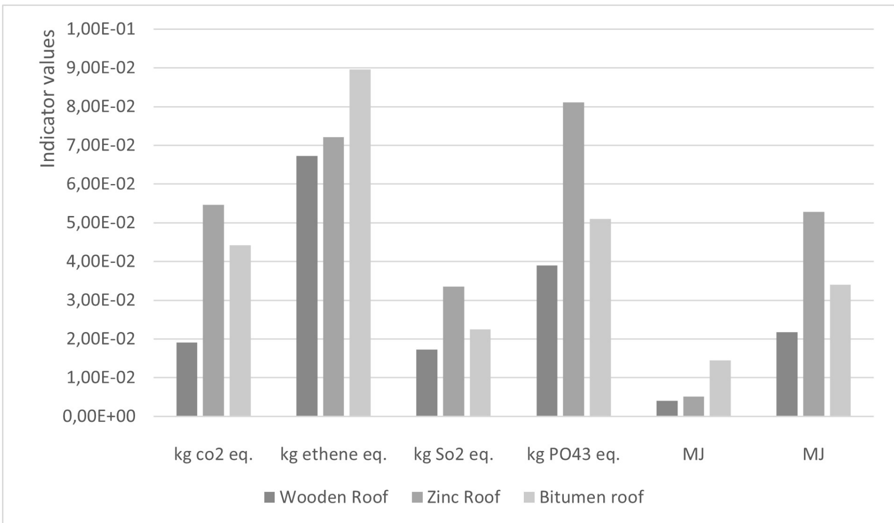


A zinc roof consists of a water-resistant board, ventilated layer, a layer of wood profiles where the zinc is applied for a smooth finish. A zinc roof has a major impact on the environment, while also being the most expensive material.



A bitumen roof consists of a thin layer of water-resistant membrane, ventilated layer, an OSB board along with 2 layers of bitumen. Bitumen roof is the cheapest material but has a major impact on the environment.

LCA analysis results, where each wall is rated on a scale 1-3 of the performance of each DGNB reference criteria and weighted score out from importance of DGNB.

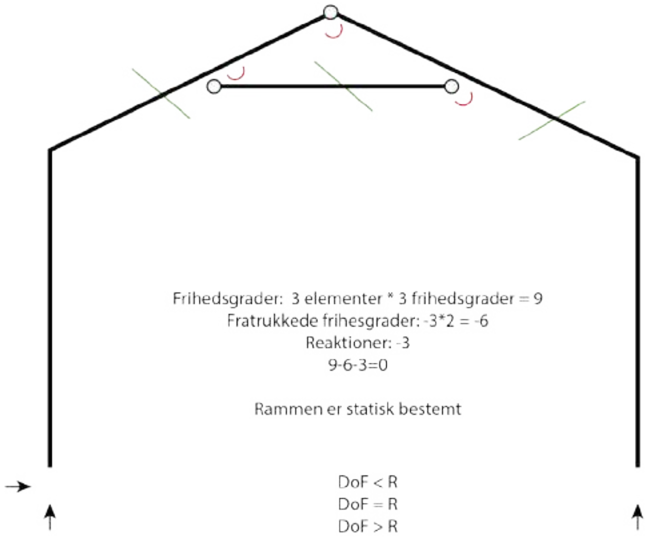


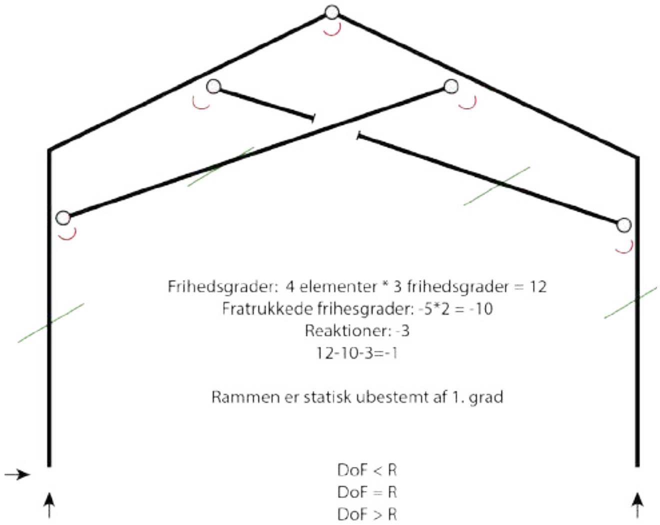
Conclusion

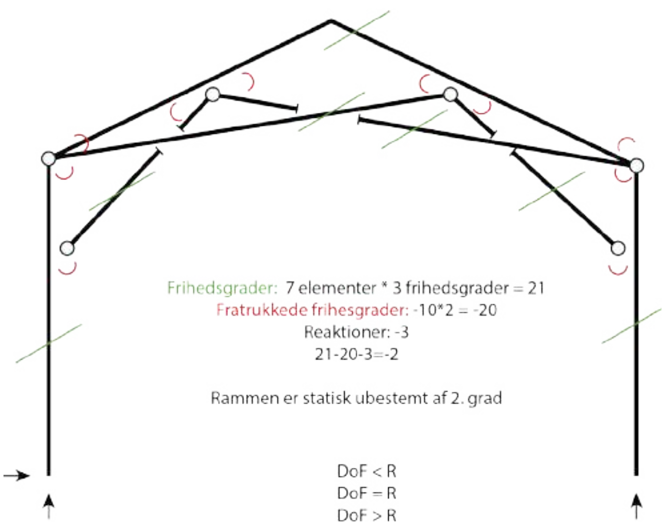
The analysis shows that the wooden roof cladding has a lowest environmental impact comapred to the other roof types, while having the lowest cost to the building owner. Which benefits both the sociality and building owner, while creating an expression that fits into a maritime context.

	GWP (x 10^2)	POCP (x 10^5)	AP (x 10^4)	EP (x 10^5)	ADPf	Ptot	LCA Score	LCC 50 year	LCC 80 year
Wooden Roof	1,91e-02	6,72e-02	1,73e-02	3,90e-02	4,00e-03	2,17e-02	3	9889 kr	11261 kr
Zinc roof	5,47e-02	7,21e-02	3,35e-02	8,12e-02	5,11e-03	5,28e-02	1,25	10026 kr	11339 kr
Bitumen roof	4,42e-02	8,96e-02	2,25e-02	5,11e-02	1,45e-02	3,40e-02	1,75	9747 kr	11135 kr

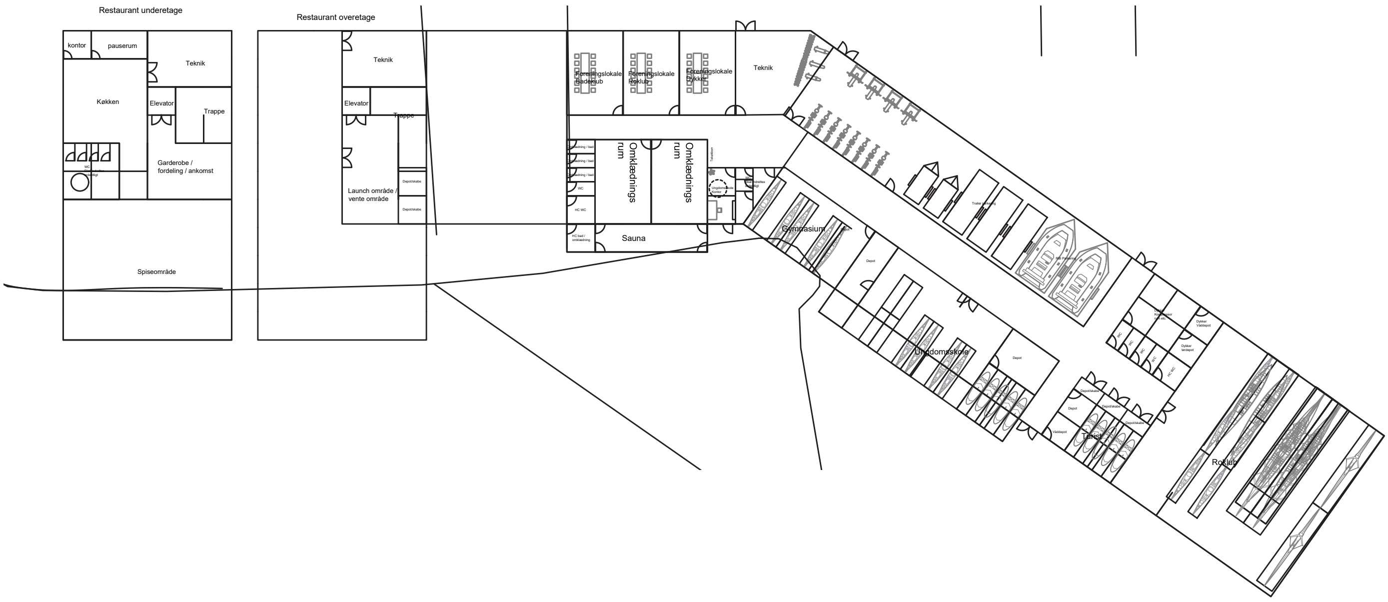
16.8. APPENDIX LEVEL OF FREEDOM

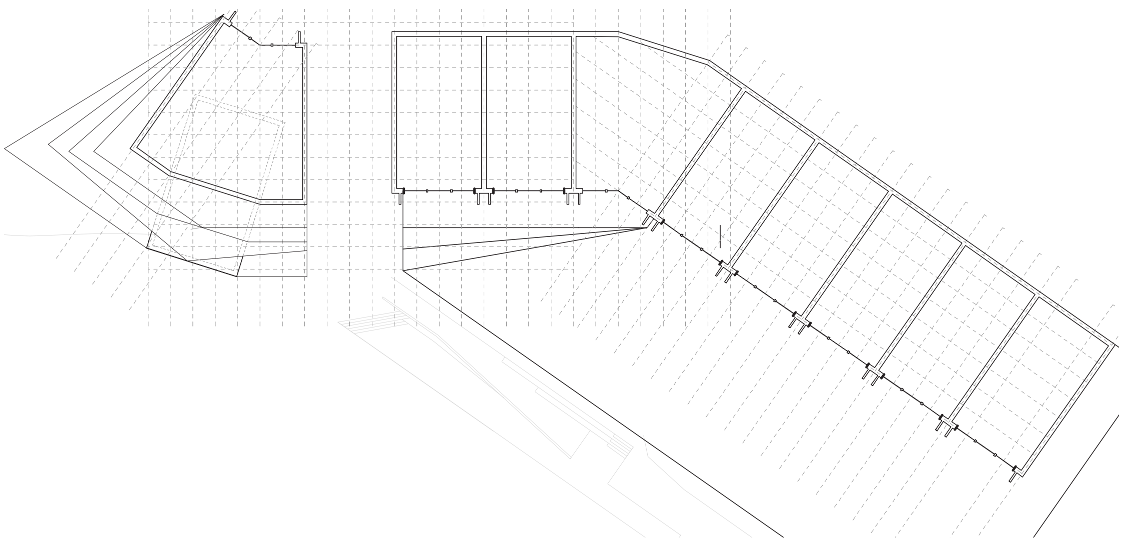


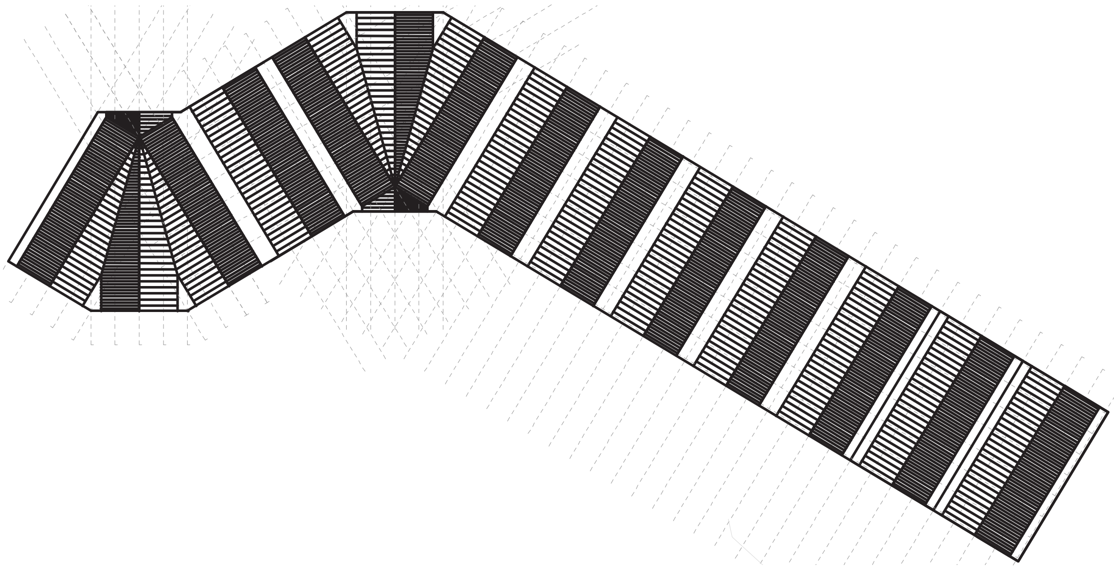


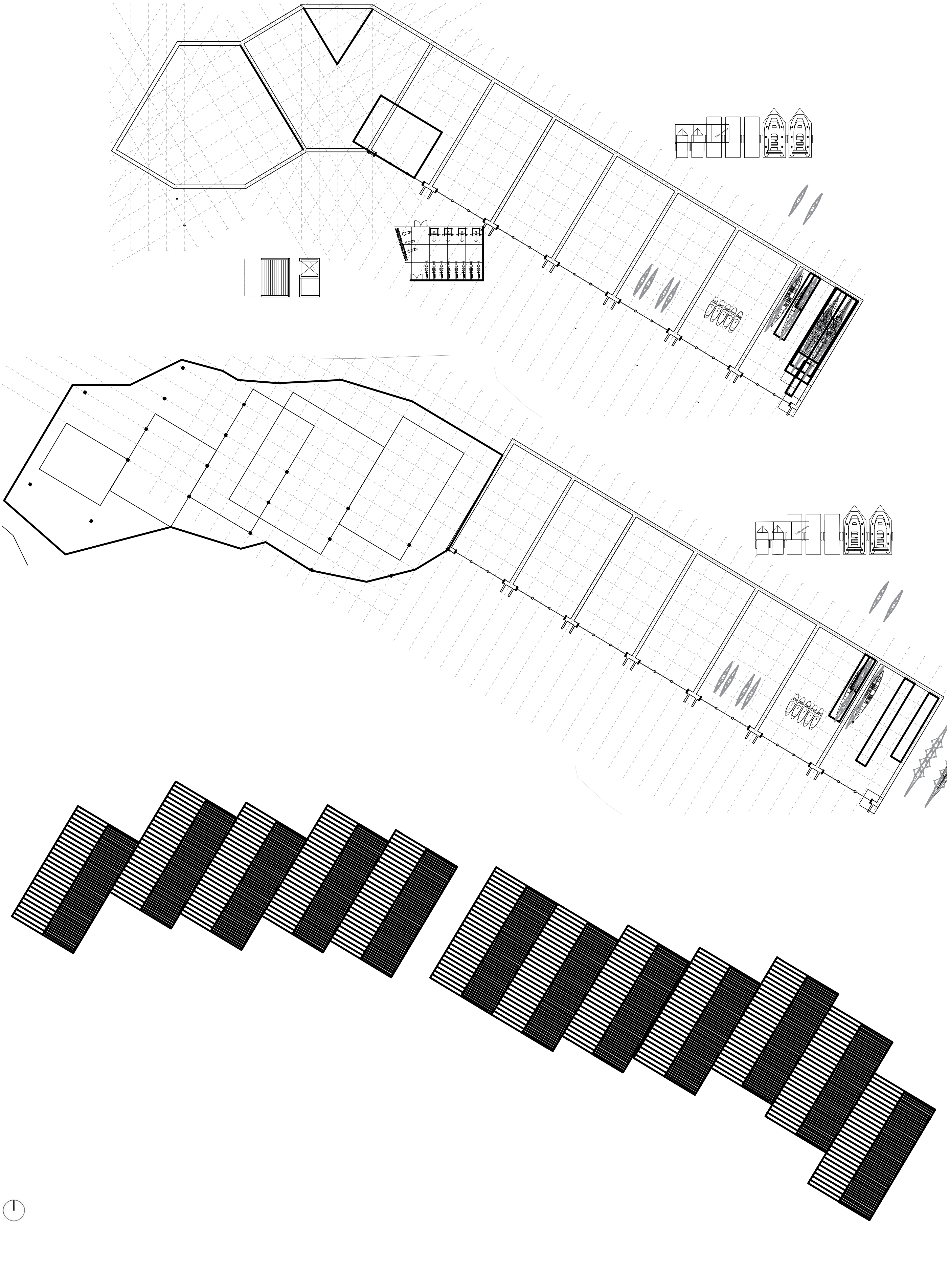


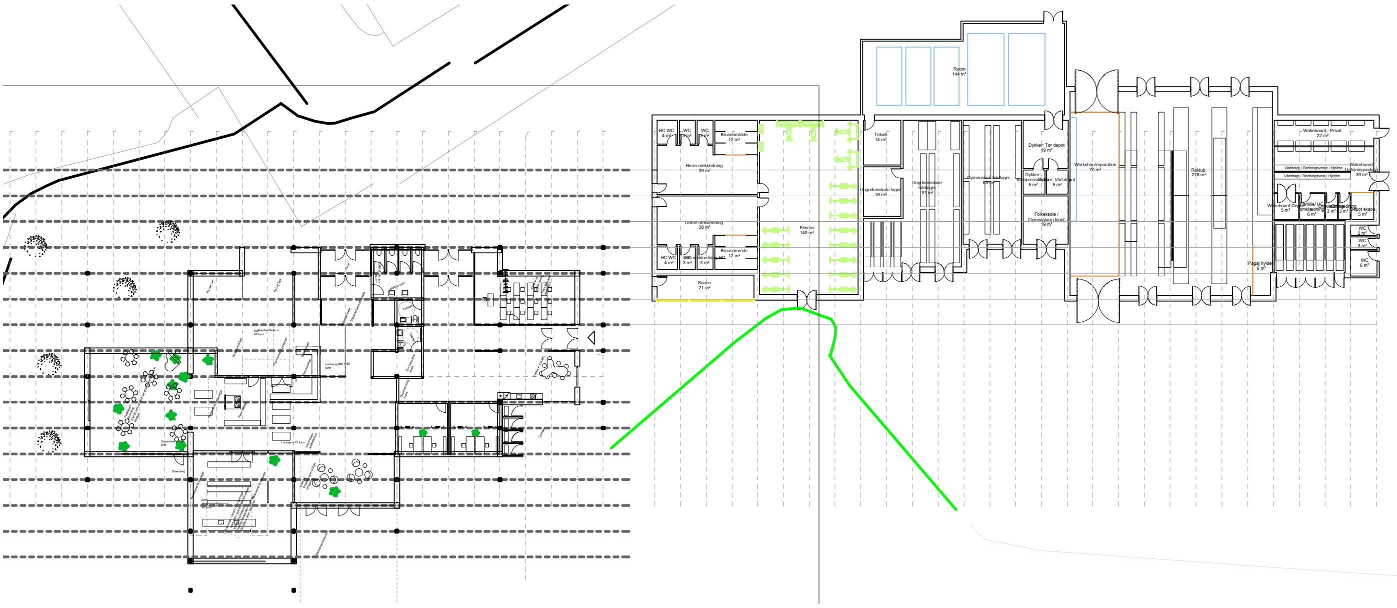
16.9. APPENDIX INITIAL CONCEPT PROCESS

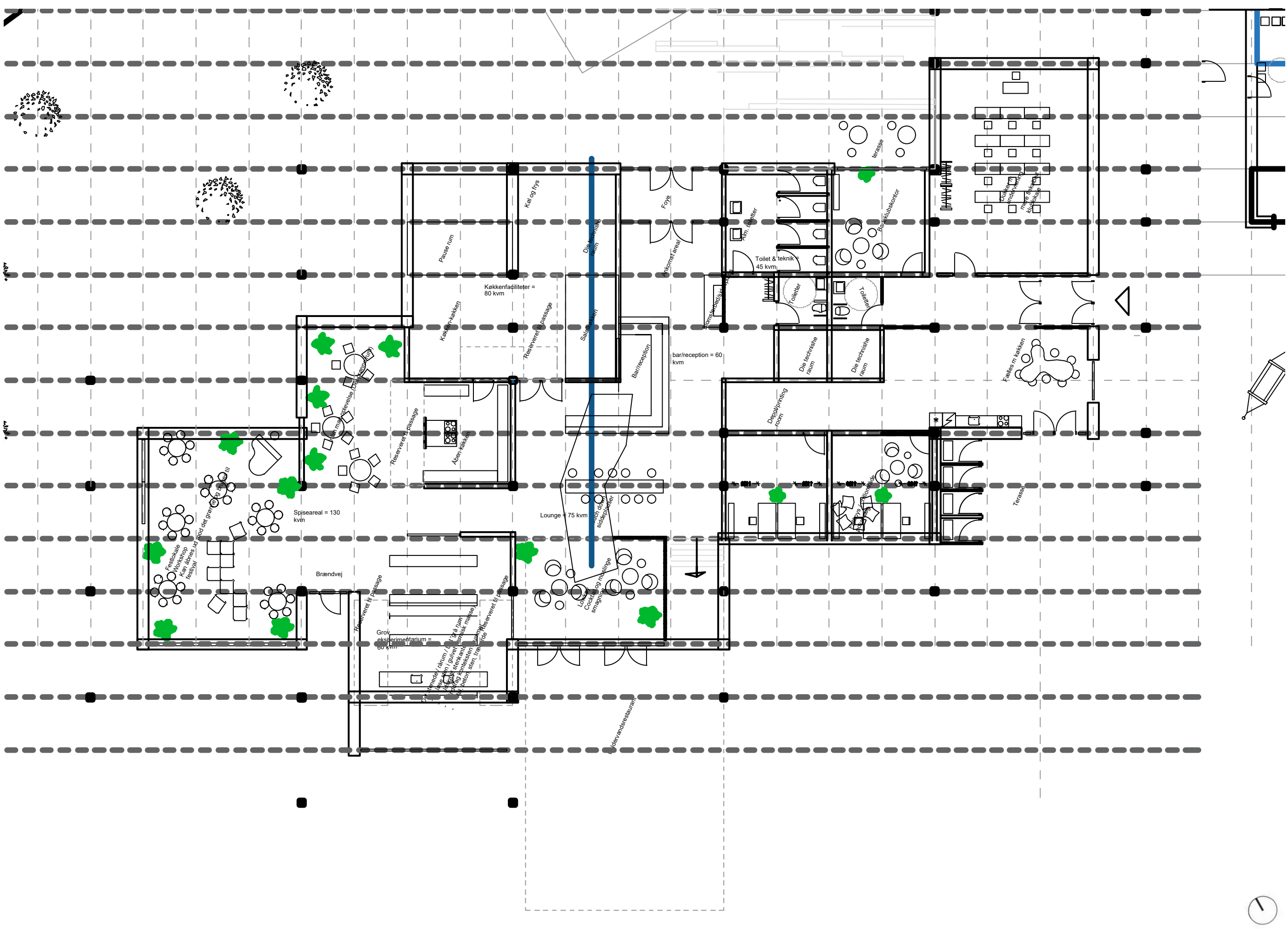


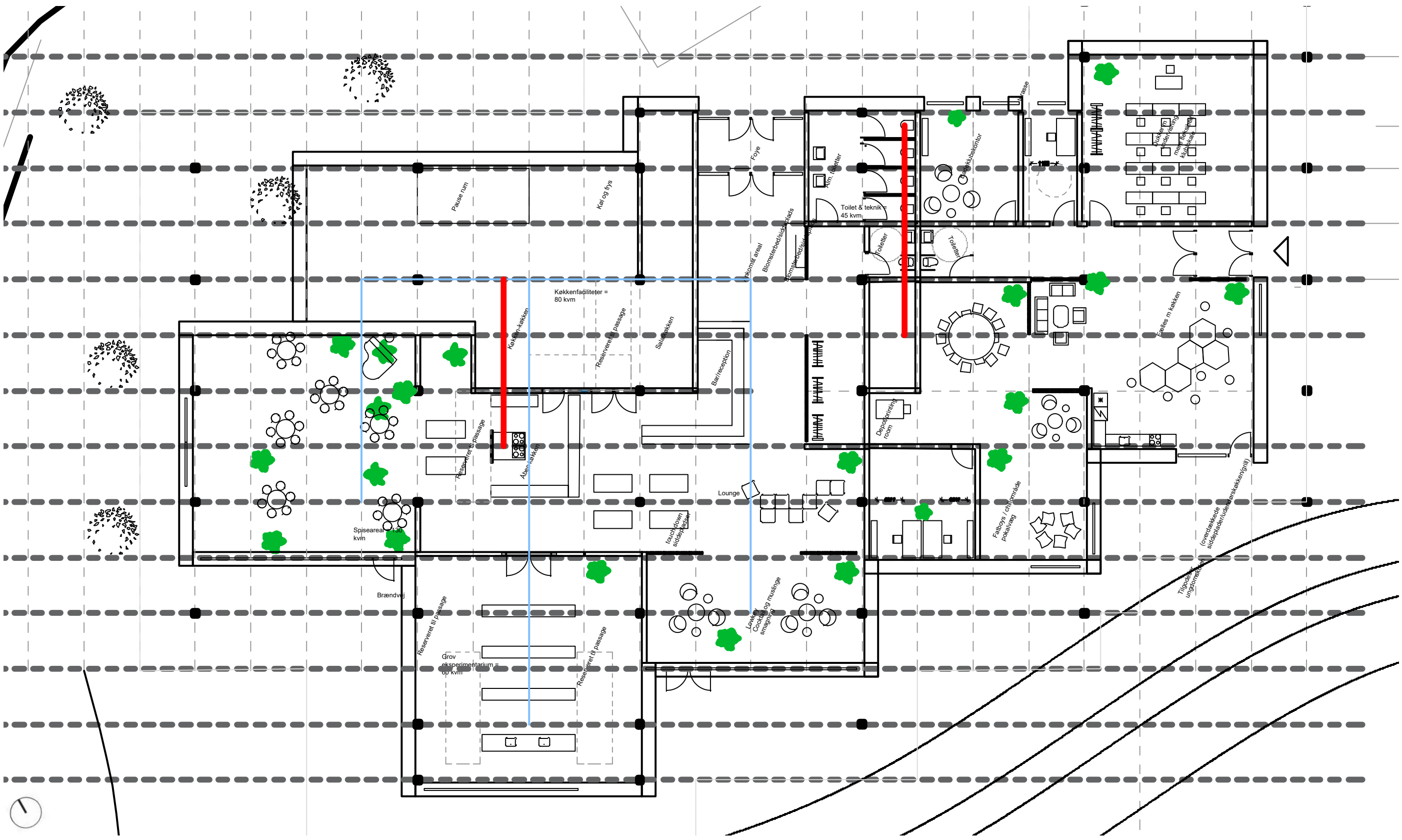




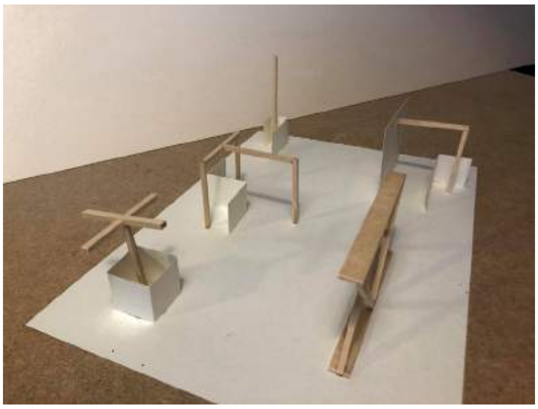


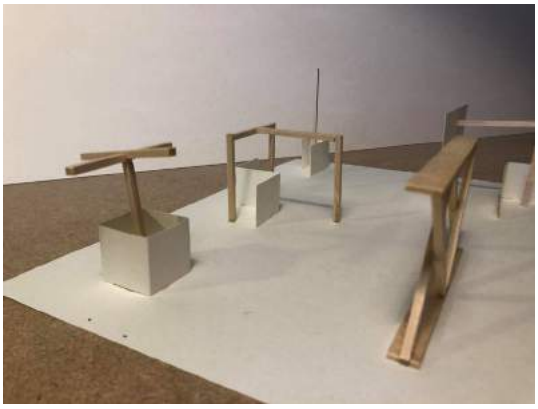


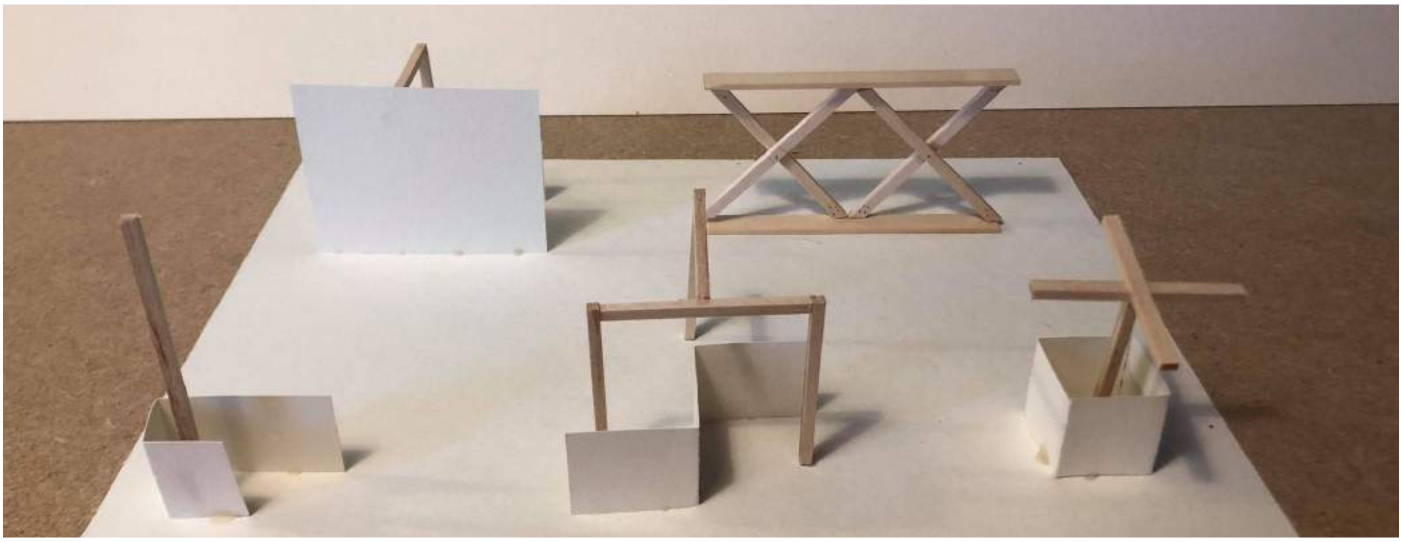


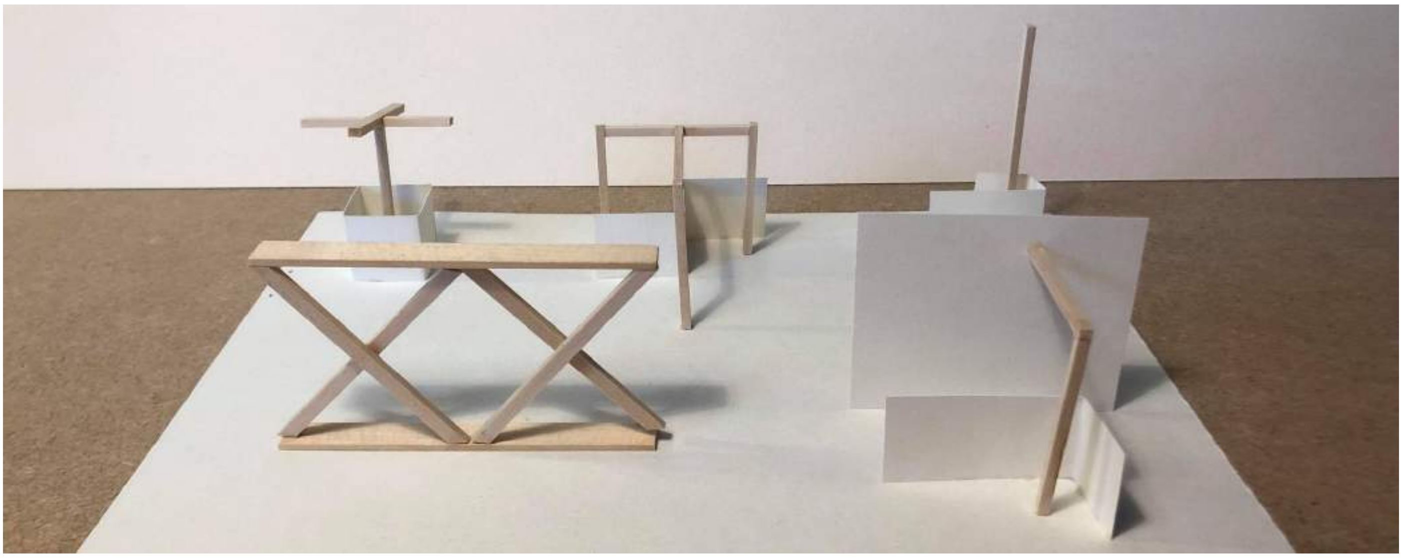


16.10. APPENDIX CONSTRUCTIONAL EXPERIENCE









16.11. APPENDIX VENTILATION RATES

Atmospheric comfort: Ventilation

To be able to obtain a good atmosphere comfort in the Center of experience and water sport, the ventilation rate is calculated to reach category B according to DS/CEN/CR 1752 standard. Where both the sensory and CO2 concentration are calculated to find the dimensioned ventilation required.

The calculations are made for the whole building, but the following example shows the restaurant which have a high number of users over the day.

The geometry of the restaurant consists of a 54 square meters room, with a max capacity of 15 persons.

Sensory ventilation

For calculation the sensory ventilation rate, the following equations are used:

$$Q_c = 10 * \frac{G_c}{C_{c,i} - C_{c,0}} * \frac{1}{\varepsilon_v}$$

(DS-CEN-CR 1752 – 2001, p. 28)

Where:

Q_c	Ventilation rate required for comfort (l/s)
G_c	The sensory pollution load (Olf)
$C_{c,i}$	Desired perceived indoor air quality (Decipol)
$C_{c,0}$	Perceived outdoor air quality (Decipol)
ε_v	Ventilation effectiveness.

For the calculation of the following sensory pollution loads are used:

Category B – 20% dissatisfaction	1,4 dp	Table A.5 - (Dansk Standard 1752, 2001, p.23)
One person with 1- 1,2 Met activity level	1 Olf	Table A.6 - (Dansk Standard 1752, 2001, p.29)
Low-polluting buildings	0,1 Olf pr. m^2	Table A.8 - (Dansk Standard 1752, 2001, p.27)
Outdoor quality – Nykøbing	0,10 dp	Table A.9 – (Dansk Standard 1752, 2001, p.27)

The ventilation efficiency is $\varepsilon_v = 1$, defined by the ventilation strategy of mixing ventilation giving a necessary ventilation rate for the restaurant of:

$$Q_c = 10 * \frac{(15 * 1\, olf) + (0{,}1\, olf * 54m^2)}{1{,}4dp - 0{,}10dp} * \frac{1}{1} = 145{,}81 \frac{l}{s}$$

The ventilation rate is calculated that there are 15 persons in the room all time, which is not realistic. Therefor the ventilation rate is recalculated based on the person profile of the room. Which in this case is found to be an average of 9,54 people in the room in 7 occupied hours, while the minimum requirement of 0,3 l/s pr. m^2 determined from the Danish building regulations for ventilation is used in the 17 unoccupied hours. This gives an average ventilation rate for the restaurant in the occupied hours on:

$$Q_c = 10 * \frac{(9{,}54 * 1\, olf) + (0{,}1\, olf * 54m^2)}{1{,}4dp - 0{,}10dp} * \frac{1}{1} = 106{,}81 \frac{l}{s}$$

While the average over the whole day gives following:

$$Q_c = \frac{\left(7h * 101{,}78\frac{l}{s}\right) + (17h * (0{,}3\frac{l}{s} * 60m^2)}{24h} = 42{,}62\frac{l}{s}$$

CO_2 ventilation rate calculation

The ventilation rate for sensory comfort, must be evaluated with the atmospheric comfort from a health point of view.

$$Q_h = \frac{G_h}{C_{h,i} - C_{h,0}} * \frac{1}{\varepsilon_v}$$

(Dansk Standard 1752, 2001, p.29)

Where:

Q_h	Ventilation rate required for Health (l/s)
G_h	The pollution load of a chemical (CO_2) ($\mu g/s$)
$C_{h,i}$	Guideline value of a chemical ($\mu g/l$l)
$C_{h,0}$	The outdoor concentration of a chemical at air intake($\mu g/l$l)
ε_v	Ventilation effectiveness

The ventilation rate is calculated to fulfill Category B, where the maximum CO_2 concentration must be 660 ppm higher than the outdoor CO_2 concentration according to Figure A.7– (Dansk Standard 1752, 2001, p.24) Meanwhile, an outdoor concentration of CO_2 is determined to be 350 ppm according to Table A.9 – (Dansk Standard 1752, 2001, p.27)

The CO_2 contamination from people can have calculated out from their Metabolism level with the following equation:

$$q_{V,CO_2} = 17 * M$$

(Andersen et al., 2002, p.48)

Where:

q_{V,CO_2}	CO_2 contamination (l/h)
M	Metabolism level (MET)

With people with a normal metabolism level on 1,2 Met gives following pollution:

$$q_{V,CO_2} = 17 * 1{,}2Met = 20{,}4\frac{l}{h}$$

This gives following necessary ventilation rate for obtain good health:

$$Q_h = \frac{20{,}4\frac{l}{h} * 15}{\left((660ppm + 350ppm) - 350ppm\right) * 10^{-6}} * \frac{1}{1} = 276{,}85\frac{l}{s}$$

The same averages ventilation rate is also found in this case, with 9,54 persons in the room and the minimums requirements for ventilation in the unoccupied hours.

$$Q_h = \frac{20{,}4\frac{l}{h} * 9{,}54}{\left((660ppm + 350ppm) - 350ppm\right) * 10^{-6}} * \frac{1}{1} = 174{,}31\frac{l}{s}$$

$$Q_c = \frac{\left(7h * 306\frac{l}{s}\right) + (17h * (0{,}3\frac{l}{s} * 60m^2)}{24h} = 60{,}83\frac{l}{s}$$

Conclusion

When knowing both necessary ventilation rates regarding sensory and CO2 concentrations, the dimensional ventilation rate is the highest value, which in this example is 60,83 l/s. The same calculation is made with the whole building, to obtain a good indoor air quality. The result can be seen in the following table:

	Area	Average person	Hours occupied	Ventilation rate – CO2	Ventilation rate - Sensory
Changing room/toilet	21	1,88	4	10,96 l/s	10 l/s
Staff breakroom	11	2,25	4	9,60 l/s	6,75 l/s
Kitchen	31	2,54	15	32,54 l/s	28,74 l/s
Restaurant	84	8,19	12	87,43 l/s	71,89 l/s
Workshop area	74	13,57	11	125,73 l/s	80,73 l/s
Restaurant	54	9,54	7	62,32 l/s	42,62 l/s
Lounge area	118	3,96	13	55,40 l/s	77,24 l/s
Foyer	35	0,48	1	10,43 l/s	11,25 l/s
Toilets	69	1	1	19,84 l/s	21,90 l/s
Diver - Association	47	11,52	4,3	49,18 l/s	49,18 l/s
Rower- Association	22	3,82	4,3	17,91 l/s	13,12 l/s
Youth Club - Association	21	0,57	1,7	6,60 l/s	7,22 l/s
Common - Association	110	7,92	9	74,92 l/s	71,34 l/s
Changing room	157	3,96	9	56,58 l/s	82,14 l/s
Fitness	164	5,94	9	91,83 l/s	233,84 l/s
Workshop - Boat	74	0,24	6	17,74 l/s	30,32 l/s
Boat storage	667	0,24	6	151,17 l/s	269,63 l/s

References:

Andersen, K. T., Heiselberg, P., & Aggerholm, S. (2002). *SBi Anvisning 202: Naturlig ventilation i erhvervsbygninger*.

Dansk Standard 1752. (2001). Ventilation i bygninger – Projekteringskriterier for indeklimaet Ventilation for buildings – Design criteria for the indoor environment Deskriptorer : *1*, 2920.

16.12. APPENDIX PRESSURE LOSS

For an optimalization the energy efficiency of ventilation system known as SEL-value, an investigation of minimalize the pressure loss have been conducted. The pressure loss has a relation with the length and bending of pips, which increase the energy needed to supply with the necessary ventilation rate.

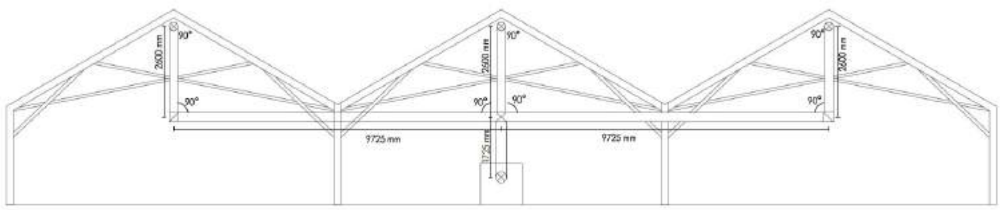
For the investigation, the necessary ventilation rate is 1000 m3/h, which divide up in three main pips, when knowing this, the pressure loss from the different bending can be found by datasheet from the manufacturer. (Safe & Dimension, 2020)

Pressure loss		
	Pip size - Ø 315 mm	Pip size - Ø 250 mm
Bending angle	1000 m3/h	300 m3/h
90	2,8	1,4
60	2	1
30	0,8	0,4

The other factors of pressure loss are the length of the ventilation pips, which also depends on the diameter of the ventilation pips, which is found out SBI Nomogram nr. 10 (Christensen, 1970)

Pressure loss	
Pip size - Ø 315 mm	Pip size - Ø 250 mm
1000 m3/h	300 m3/h
0,062	0,018

The Pressure loss with the example on following the linear system:



Here the pressure loss of length is first calculated, with two different pip sizes:

$$Ø315 = 1{,}725\ m * 0{,}062 \frac{Pa}{m} = 0{,}10695\ Pa$$

$$Ø250 = 27{,}25\ m * 0{,}018 \frac{Pa}{m} = 0{,}4905\ Pa$$

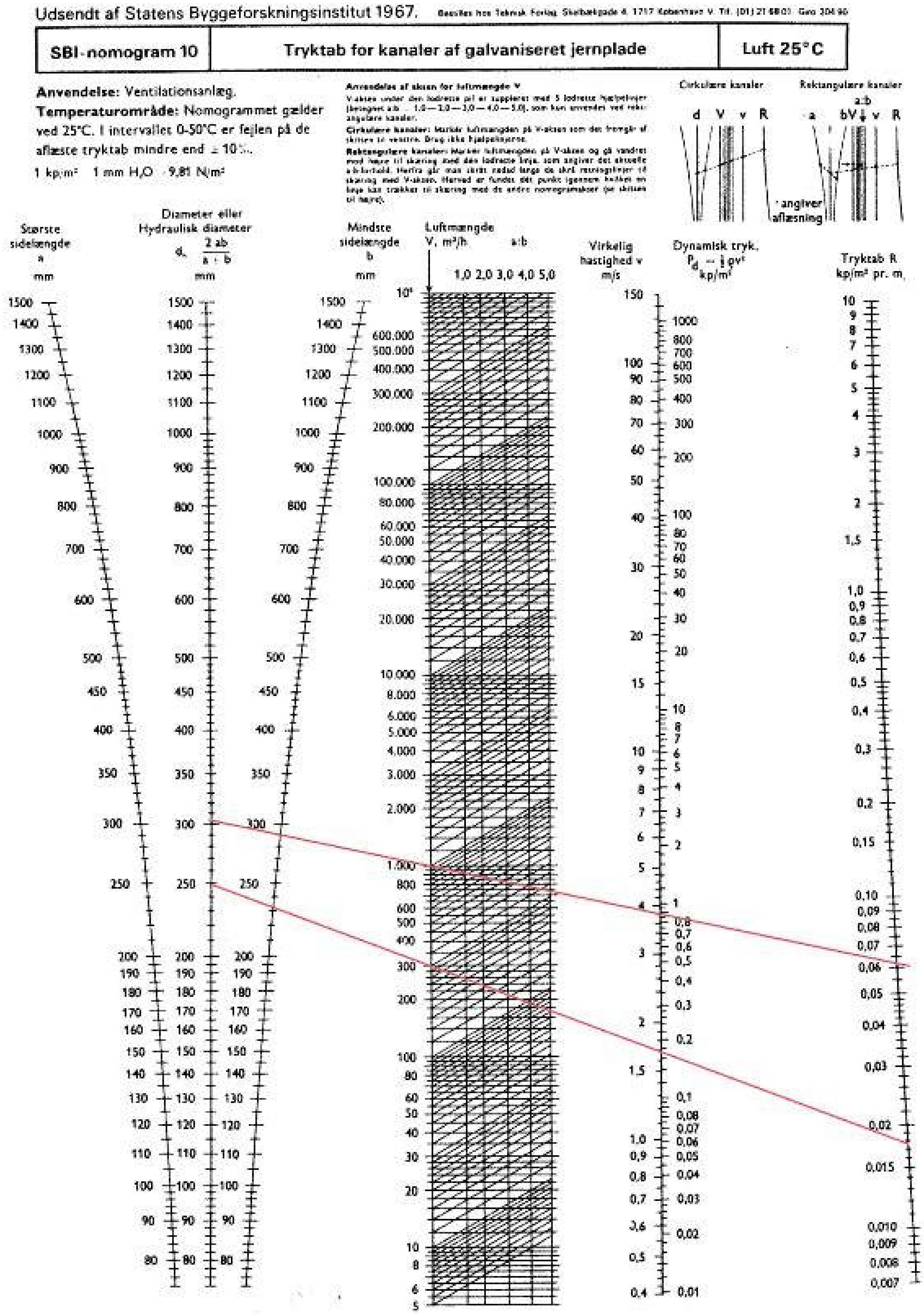
The pressure loss from the bending, here there is seven 90 degree bending, where two are located with a pipe size Ø315 mm and the rest is Ø250 mm:

$$Ø315 = 2 * 2{,}8 = 5{,}6\ Pa$$

$$Ø250 = 5 * 1{,}4 \frac{Pa}{m} = 7Pa$$

Which gives a total pressure loss for the system on:

$$Total\ pressure\ loss = 13{,}197\ Pa$$



Reference:

Christensen, G. (1970). *VENTIlATION AF BOLIGER*.

Safe, L., & Dimension, B. F. U. P. (2020). *Bøjning – falset*. *17*, 1–5.

16.13 APPENDIX NATURAL VENTILATION

Intro:

Lowering the energy demands for a ventilations system, natural ventilation can be utilized, especially during the spring, summer and fall months, when the air has an acceptable temperature. Therefore, the airflow rate for natural ventilation is to be calculated, with the aim to investigate the indoor climate in BSim. This way we can optimize the specific room in regards of heating, especially during the summer.

Due to uncertainties of the specific window placement at this point in the process, the assumption is that natural ventilation mainly works through single sided thermal buoyancy and single sided wind induced ventilation, though depending on the further process it may be relevant to calculate cross ventilation or thermal buoyancy through windows in different levels.

It is expected to be a combination of thermal buoyancy and wind will contain the dimensional air flow supply.

Thermal Buoyancy and wind:

Calculating the airflow supply through an open door will be done with the following formula:

$$q_v = A_{eff} \cdot v_m$$

(Andersen et al., 2002, p. 58)

Where:
q_v = air flow supply $\left[\frac{m}{s}\right]$
A_{eff} = Effective window opening area $[m^2]$
v_m = Mean wind speed $\left[\frac{m}{s}\right]$

First the effective area of the window will be calculated with the following formula:

$$\left(\frac{1}{A_{eff}}\right)^2 = \left(\frac{1}{C_{d,1} \cdot A_1}\right)^2 + \left(\frac{1}{C_{d,2} \cdot A_2 + 2 \cdot C_{d,3} \cdot A_3}\right)^2$$

(Andersen et al., 2002, p. 58)

Where:
A_1 = Window frame opening $[m^2]$
A_2 = Opening area window frame bottom and window $[m^2]$
A_3 = One of the two triangles in the side $[m^2]$
C_d = Discharge coefficient [-]

The discharges coefficient is determined to be C_d = 0,7. (Andersen et al., 2002, p. 58)

Size of window:
Width: 1,5 m
Height: 2,04 m

$$A_{eff} = \frac{1}{\sqrt{\left(\frac{1}{0,7 \cdot (1,5m \cdot 2,04m)}\right)^2 + \left(\frac{1}{0,7 \cdot (1,5m \cdot 2,04m) + 2 \cdot 0,7 \cdot (0,725m \cdot 1,5m)}\right)^2}} = 1,85\ m^2$$

Next the mean wind speed will be calculated:

$$v_m = (0,001 \cdot v_{10}^2 + 0,0035 \cdot h \cdot \Delta T + 0,01)^{\frac{1}{2}}$$

(Andersen et al., 2002, p. 58)

Where:
v_{10} = Windspeed in 10 meters height $\left[\frac{m}{s}\right]$
h = height of the window $[m]$
ΔT = Temperature differences $[C\ °]$

According to the Swiss wind power data website v_{10}=5 m/s (Wind Data, n.d.). Furthermore, the temperatures are expected to be at 21 degrees exterior for a summer day and 24,5 degrees exterior resulting in a mean wind speed:

$$v_m = \left(0,001 \cdot \left(5\frac{m}{s}\right)^2 + 0,0035 \cdot 2,04m \cdot 21C° - 24,4\ C° + 0,01\right)^{\frac{1}{2}} = 0,1\frac{m}{s}$$

(Andersen et al., 2002, p. 58)

$$q_v = 1,85\ m^2 \cdot 0,1\frac{m}{s} = 0,186\frac{m^3}{s}$$

Calculated into l/s pr. m^2

$$q_v = \frac{0,186\frac{m^3}{s} * 1000}{178\ m2} = 1,043\frac{l}{s}\ pr. m^2$$

References:

Andersen, K.T., Heiselberg, P., Aggerholm, S., 2002. Naturlig ventilation i erhvervsbygninger, 1st ed. Statens Byggeforskningsinstitut, Aalborg Universitet.

Wind Data, n.d. Wind Profile Calculator [WWW Document]. URL IwAR2udKYLmz6O9VoAO7yq7uu09lkJDa1FXPxyIWLgu60j_NHJlT2tYTCNS8Q (accessed 5.3.21).

16.14. APPENDIX LOAD COMBINATIONS

ULS: Load combination

Intro:

Before investigating if a beam or column can withstand the load effecting it, the loads need to be determined. This will be done through an investigation of different load combinations.

As a start the consequence and usage classes should be determined:

Class of consequence: CC2 (Dansk Standard, 2013, p. 18)
Class of usage: Class 2 (Dansk Standard, 2015a, p. 22)

Next, we will determine the different loads effecting the beam.

Dead load: $0{,}5\,\frac{kN}{m^2}$ (Gammel, 2005, p. 11)

Snow load: $0{,}8\,\frac{kN}{m^2}$

When calculating the snow load following formula will be used:

$$s = \mu_i \cdot C_e \cdot C_t \cdot s_k$$

(Dansk Standard, 2015b, p. 50)

Where:
S = snow load $\left[\frac{kN}{m^2}\right]$
μ_i = Form factor [-]
C_e = Exposure factor [-]
C_t = Thermal factor [-]
s_k = Characteristic terrain value $\left[\frac{kN}{m^2}\right]$

Determining the different factors according to Eurocode 1:

The form factor for a pitched roof with a 30° slope: $\mu_2 = 0{,}8$ (Dansk Standard, 2015b, p. 52)

The exposure factor is to be calculated with the following formula:

$$C_e = C_{top} \cdot C_s$$

(Dansk Standard, 2015b, p. 50)

Where:
C_{top} = Topography factor [-]
C_s = Size factor [-]

The topography factor for a normal topography: $C_{top} = 1$ (Dansk Standard, 2015b, p. 51)

Due to the building is placed in a normal category, the size factor is to be determined according to the longest, shortest and the height of the building.

Longest length of the building: $l_1 = 24200\ mm$.
Shortest length of the building: $l_2 = 9000\ mm$.
Height of the building: $h = 7000\ mm$.

Due to the expression: when $l_2 \leq 10h = C_s = 1{,}0$ (Dansk Standard, 2015b, p. 51)

$$C_e = 0{,}8 \cdot 1 = 0{,}8$$

Due to the low thermal transmission through the roof thermal factor $C_t = 1$ (Dansk Standard, 2015b, p. 52)

The characteristic terrain value: $s_k = 1{,}0 \frac{kN}{m^2}$. (Dansk Standard, 2015b, p. 49)

$$s = 0{,}8 \cdot 0{,}8 \cdot 1 \cdot 1 \frac{kN}{m^2} = 0{,}8 \frac{kN}{m^2}$$

Wind load: $0{,}62 \frac{kN}{m^2}$

When calculating wind load effecting the construction, the first step is to calculate the basic windspeed, which is done with the following formula:

$$v_b = c_{dir} \cdot c_{season} \cdot v_{b,0}$$

(Dansk Standard, 2015b, p. 75)

Where:
v_b = basic windspeed defined as a function of the wind direction, season in 10 meters height above terrain of category II $\left[\frac{m}{s}\right]$
c_{dir} = Factor of direction [-]
c_{season} = seasonal factor [-]
$v_{b,0}$ = basic value of the basic windspeed $\left[\frac{m}{s}\right]$

Determining the different factors according to Eurocode 1:

The factor of direction is determined upon the dominant wind direction. According to the macroclimate analysis the dominating wind direction is western resulting in the directional factor being $c_{dir}^2 = 1$, which $c_{dir} = \sqrt{1} = 1$ (Dansk Standard, 2015b, p. 75)

The seasonal factor is set to the highest value, due to construction which is being calculated upon is set as a permanent construction, which is why the construction must be able to withstand windspeeds between December - February (highest values). $c_{seasonal} = 1$ (Dansk Standard, 2015b, p. 75)

Due to the placement 25 kilometers away from the North sea and Ringkøbing fiord, the basic value of the basic windspeed is: $v_{b,0} = 24 \frac{m}{s}$ (Dansk Standard, 2015b, p. 75)

$$v_b = 1 \cdot 1 \cdot 24 \frac{m}{s} = 24 \frac{m}{s}$$

Next the mean wind velocity is to be calculated with following formula:

$$v_m(z) = c_r(z) \cdot c_o(z) \cdot v_b$$

(Dansk Standard, 2015b, p. 76)

Where:
$v_m(z)$ = Mean wind velocity $\left[\frac{m}{s}\right]$
$c_r(z)$= Roughness factor [-]

$c_0(z)$ = Orography factor [-]
v_b = basic windspeed defined as a function of the wind direction, season in 10 meters height above terrain of category II $\left[\frac{m}{s}\right]$

Determining the different factors according to Eurocode 1:

The Roughness factor is to be calculated with the following formula:

$$c_r(z) = k_r \cdot \ln\left(\frac{z}{z_0}\right)$$

(Dansk Standard, 2015b, p. 76)

Where:
k_r = Terrain factor dependent on the roughness length z_0 [-]
z = Height of the building [m]
z_0 = Roughness length [m]

Furthermore, the terrain factor dependen on the roughness length is to be calculated with the following formula:

$$k_r = 0{,}19 \cdot \left(\frac{z_0}{z_{0,II}}\right)^{0{,}07}$$

Where:
$z_{0,II}$ = Roughness length of terrain category II [m]
According to Eurocode 1, page 77 table 4.1, the building is located in terrain category I resulting in: $z_0 = 0{,}01$ m (Dansk Standard, 2015b, p. 76)

Resulting in the terrain factor being:

$$k_r = 0{,}19 \cdot \left(\frac{0{,}01\ m}{0{,}05\ m}\right)^{0{,}07} = 0{,}17$$

Resulting in the roughness factor being:

$$c_r(z) = 0{,}17 \cdot \ln\left(\frac{7\ m}{0{,}01\ m}\right) = 1{,}11$$

The Orography factor is set to: $c_0(z) = 1$ (Dansk Standard, 2015b, p. 76)

Resulting in the mean wind velocity being:

$$v_m(z) = 1{,}09 \cdot 1 \cdot 24\frac{m}{s} = 26{,}06\frac{m}{s}$$

Next to be calculated is the wind peak pressure with the following formula:

$$q_p(z) = \left(1 + 7 \cdot l_v(z)\right) \cdot \frac{1}{2} \cdot \rho \cdot v_m^2(z)$$

(Dansk Standard, 2015b, p. 81)

Where:
$q_p(z)$ = wind peak pressure $\left[\frac{kN}{m^2}\right]$
$l_v(z)$= Turbulent intensity [-]
ρ = Density of air in a specific heigh, temperature, barometric pressure which can be espected in the area during a storm $\left[\frac{kg}{m^3}\right]$

The turbulent intensity is needed to calculate the wind peak pressure. The turbulent intensity is calculated with the following formula:

$$l_v(z) = \frac{k_l}{c_o(z) \cdot \ln\left(\frac{z}{z_0}\right)}$$

Where:
k_l = Turbulent factor [-]

The turbulent factor is to be set at: $k_l = 1$ (Dansk Standard, 2015b, p. 80)

$$l_v(z) = \frac{1}{1 \cdot \ln\left(\frac{7\ m}{0{,}01\ m}\right)} = 0{,}17$$

The density of the air is to be set at: $\rho = 1{,}25\,\frac{\mathrm{kg}}{\mathrm{m}^3}$ (Dansk Standard, 2015b, p. 81)

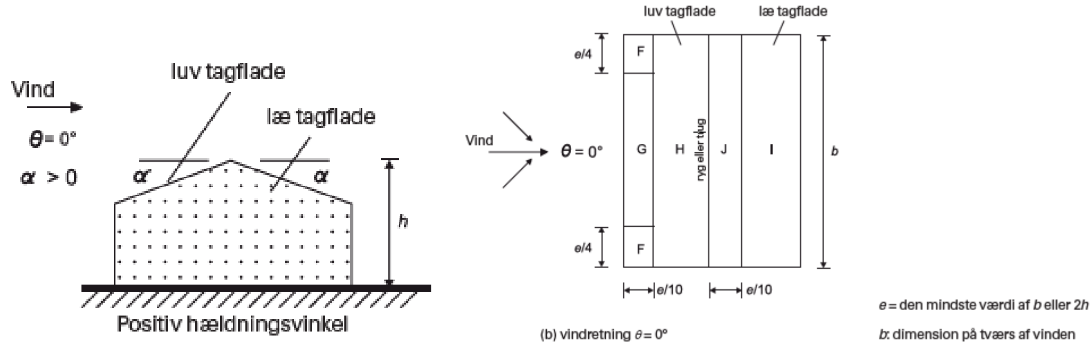
Resulting in the wind peak pressure being:

$$q_p(z) = (1 + 7 \cdot 0{,}16) \cdot \frac{1}{2} \cdot 1{,}25\,\frac{\mathrm{kg}}{\mathrm{m}^3} \cdot \left(26{,}06\,\frac{m}{s}\right)^2 = 920{,}96\,\frac{N}{m^2}$$

Paraphrasing $\frac{N}{m^2}$ to $\frac{kN}{m^2}$ making it easier to compare the loads will be done:

$$\frac{889{,}06\,\frac{N}{m^2}}{1000} = 0{,}92\,\frac{kN}{m^2}$$

Now wind loads effecting specific areas of the roof will be determined according to the Eurocode 1:



(Dansk Standard, 2015b, p. 109)

First we will need to determine the value of e:

$$e = the\ lowest\ value\ of\ the\ b\ (building\ dimension\ crosswise\ the\ wind) or\ 2 \cdot building\ height$$

h = 6000 mm.

b= 24600 mm.

$$2 \cdot b < h = 2 \cdot 7\,m < 24{,}6\,m$$

(Dansk Standard, 2015b, p. 109)

Meaning that 'e' will be:

$$e = 14\,m$$

A gable roof is divided into 5 different zones, with different zone factors. Meaning that the different zones will have different loads. The different zones are F, G, H, J, I. The corresponding formfactors is to be found in Eurocodes 1 (Dansk Standard, 2015b, p. 110).

The loads in the different zones will be calculated with the following formula:

$$w_e = q_p(z) \cdot c_{pe}$$

Where:
w_e = Wind pressure on a specific surface $\left[\frac{kN}{m^2}\right]$
c_{pe}= Form factor of the exterior pressure [-]

Surface F-G:

$$w_{e,F,G} = 0{,}92\frac{kN}{m^2} \cdot 0{,}7 = 0{,}64\frac{kN}{m^2}$$

Surface H:

$$w_{e,H} = 0{,}92\frac{kN}{m^2} \cdot 0{,}4 = 0{,}37\frac{kN}{m^2}$$

Surface I-J:

$$w_{e,I,J} = 0{,}92\frac{kN}{m^2} \cdot 0 = 0\frac{kN}{m^2}$$

Due to constructional security reasons the biggest of the three loads will be used as the dimensional wind load. In this case it is the wind load in the F and G zones on the roof.

Load combinations:

When knowing the loads, the next step will be to determine the different load combinations. Firstly, the beam will be investigated through Ultimate Limit State [ULS], where the first step will be to determine the specific load combinations, which exist of a permanent - P (g_k), short-term - S (s_k), and instantaneous - I (w_k) loads. this will be done with the following formulas:

$$P_{ULS} = \sum \Upsilon_{\mathrm{G,j}} G_{k,j} \text{ "} + \text{"} \Upsilon_p P \text{"} + \text{"} \Upsilon_{Q,1} Q_{k,1} \text{"} + \text{"} \sum \Upsilon_{\mathrm{Q,i}} \Psi_{\mathrm{Q,i}} Q_{k,i}$$

$$P_{d.ULS.P} = \Upsilon_{\mathrm{G,j,sup}} \cdot Q_{k,j,sup}$$

$$P_{d.ULS.S} = \Upsilon_{\mathrm{G,j}} \cdot G_{k,j} + \Upsilon_{Q,1} \cdot Q_{k,1} + (\Upsilon_{\mathrm{Q,w}} \cdot \Psi_{\mathrm{Q,w}} \cdot Q_{k,w})$$

$$P_{d.ULS.I} = \Upsilon_{\mathrm{G,j}} \cdot G_{k,j} + \Upsilon_{Q,1} \cdot Q_{k,1} + (\Upsilon_{\mathrm{Q,s}} \cdot \Psi_{\mathrm{Q,s}} \cdot Q_{k,s})$$

(Dansk Standard, 2013, p. 38)

Where:
Υ = partial factor [-]
Ψ = combination factor [-]
$G_{k,j}$ =Permanent load $\left[\frac{kN}{m}\right]$
$G_{k,1}$ = Leading variable load $\left[\frac{kN}{m}\right]$
$G_{k,i}$ = accompanying variable load $\left[\frac{kN}{m}\right]$

By calculating the four different load combinations, we will achieve the different load scenarios which is affecting the beam:

$$P_{d.ULS.P} = \mathrm{K_{FI}} \cdot 1{,}2 \cdot g_k$$

$$P_{d.ULS.S} = \mathrm{K_{FI}} \cdot 1 \cdot g_k + K_{FI} \cdot 1{,}5 \cdot s_k + (\mathrm{K_{FI}} \cdot 1{,}5 \cdot \Psi_{\mathrm{Q,w}} \cdot w_k)$$

$$P_{d.ULS.I} = \mathrm{K_{FI}} \cdot 1 \cdot g_k + K_{FI} \cdot 1{,}5 \cdot w_k + (\mathrm{K_{FI}} \cdot 1{,}5 \cdot \Psi_{\mathrm{Q,s}} \cdot s_k)$$

First the different factors will be determined:

$K_{FI} = 1$ (Dansk Standard, 2013, p. 44)
Ψ: Can be found in Eurocode 0 (Dansk Standard, 2013, p. 41)
Υ: Can be found in Eurocode 0 (Dansk Standard, 2013, p. 44)

$$P_{d.ULS.P} = 1 \cdot 1{,}2 \cdot 0{,}5 \frac{kN}{m^2} = 0{,}6 \frac{kN}{m^2}$$

$$P_{d.ULS.S} = 1 \cdot 1 \cdot 0{,}5 \frac{kN}{m^2} + 1{,}5 \cdot 1 \cdot 0{,}8 \frac{kN}{m^2} + (1 \cdot 1{,}5 \cdot 0{,}3 \cdot\ 0{,}62 \frac{kN}{m^2}) = 1{,}98 \frac{kN}{m^2}$$

$$P_{d.ULS.I} = 1 \cdot 1 \cdot 0{,}5 \frac{kN}{m^2} + 1{,}5 \cdot 1 \cdot\ 0{,}62 \frac{kN}{m^2} + (1 \cdot 1{,}5 \cdot 0 \cdot 0{,}8 \frac{kN}{m^2}) = 1{,}43 \frac{kN}{m^2}$$

SLS: Load combination

Load combinations:

Next to be investigated is the Serviceability Limit state [SLS]. It is the same load combinations which are calculated upon, though the difference is that when calculation SLS partial coefficients are NOT represented.

$$P_{SLS} = G_{k,j}" + "P" + "Q_{k,1}" + "\sum \Psi_{\mathrm{Q,i}} Q_{k,i}$$

$$P_{d.SLS.P} = G_{k,j,sup}$$

$$P_{d.SLS.S} = G_{k,j} + G_{k,1} + \Psi_{\mathrm{Q,w}} \cdot Q_{k,w}$$

$$P_{d.SLS.I} = G_{k,j} + G_{k,1} + \Psi_{\mathrm{Q,s}} \cdot Q_{k,s}$$

(Dansk Standard, 2013, p. 41)

Where:
Ψ = combination factor [-]
$G_{k,j}$ =Permanent load $\left[\frac{kN}{m}\right]$
$G_{k,1}$ = Leading variable load $\left[\frac{kN}{m}\right]$
$G_{k,i}$ = accompanying variable load $\left[\frac{kN}{m}\right]$

By calculating the four different load combinations, we will achieve the different load scenarios which is affecting the beam. First the different factors will be determined:

Ψ: Can be found in Eurocode 0 (Dansk Standard, 2013, p. 41)

$$P_{d.SLS.P} = 0{,}5\frac{kN}{m^2}$$

$$P_{d.SLS.S} = 0{,}5\frac{kN}{m^2} + 0{,}8\frac{kN}{m^2} + (0{,}3 \cdot\ 0{,}62\frac{kN}{m^2}) = 1{,}486\frac{kN}{m^2}$$

$$P_{d.SLS.I} = 0{,}5\frac{kN}{m^2} + 0{,}62\frac{kN}{m^2} + \left(0 \cdot 0{,}8\frac{kN}{m^2}\right) = 1{,}18\frac{kN}{m^2}$$

References:

Dansk Standard, 2013. DS-EN 1990 - Forkortet udgave af Eurocode 0 – Projekteringsgrundlag for konstruktioner.

Dansk Standard, 2015a. Forkortet udgave af Eurocode 5 – Trækonstruktioner.

Dansk Standard, 2015b. Forkortet udgave af eurocode 1 - Last på bærende konstruktioner.

Gammel, P., 2005. Statik og konstruktiv forståelse.

16.15 APPENDIX ROBOT OPTIMIZATION

Main dimension:

C27 - 150x250 mm

Member		Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	OK	C27 - 150x25	C27	34.64	57.74	0.87	5 Pd.ULS.S	-	-	-	-	0.67	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	OK	C27 - 150x25	C27	34.64	57.74	0.55	5 Pd.ULS.S	-	-	-	-	0.58	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK	C27 - 150x25	C27	75.64	126.07	0.36	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.23	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK	C27 - 150x25	C27	75.64	126.07	0.36	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.25	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK	C27 - 150x25	C27	101.38	168.97	0.08	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.09	(1+0.6)*1	-	-	-	-
11 Timber Beam	OK	C27 - 150x25	C27	101.38	168.97	0.04	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.09	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	OK	C27 - 150x25	C27	43.29	72.15	0.11	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	OK	C27 - 150x25	C27	43.29	72.15	0.07	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-

C30 - 100x200 mm

Member		Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	OK	C27 - 150x25	C27	34.64	57.74	0.87	5 Pd.ULS.S	-	-	-	-	0.67	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	OK	C27 - 150x25	C27	34.64	57.74	0.55	5 Pd.ULS.S	-	-	-	-	0.58	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK	C27 - 150x25	C27	75.64	126.07	0.36	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.23	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK	C27 - 150x25	C27	75.64	126.07	0.36	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.25	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK	C27 - 150x25	C27	101.38	168.97	0.08	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.09	(1+0.6)*1	-	-	-	-
11 Timber Beam	OK	C27 - 150x25	C27	101.38	168.97	0.04	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.09	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	OK	C27 - 150x25	C27	43.29	72.15	0.11	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	OK	C27 - 150x25	C27	43.29	72.15	0.07	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-

C30 - 100x200 mm

Member		Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	✗	C30 - 100x20	C30	43.30	86.60	1.81	5 Pd.ULS.S	-	-	-	-	1.75	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	✗	C30 - 100x20	C30	43.30	86.60	1.13	5 Pd.ULS.S	-	-	-	-	1.53	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK	C30 - 100x20	C30	94.55	189.10	0.73	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.64	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK	C30 - 100x20	C30	94.55	189.10	0.73	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.68	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK	C30 - 100x20	C30	126.72	253.45	0.12	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.15	(1+0.6)*1	-	-	-	-
11 Timber Beam	OK	C30 - 100x20	C30	126.72	253.45	0.08	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.15	(1+0.6)*1 + (0.3+0*	-	-	-	-
13 Timber Beam	OK	C30 - 100x20	C30	54.11	108.22	0.19	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1	-	-	-	-
14 Timber Beam	OK	C30 - 100x20	C30	54.11	108.22	0.12	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1	-	-	-	-

C30 - 150x225 mm

Member		Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	OK	C30 - 150x22	C30	38.49	57.74	0.97	5 Pd.ULS.S	-	-	-	-	0.87	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	OK	C30 - 150x22	C30	38.49	57.74	0.61	5 Pd.ULS.S	-	-	-	-	0.75	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK	C30 - 150x22	C30	84.05	126.07	0.39	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.32	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK	C30 - 150x22	C30	84.05	126.07	0.39	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.34	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK	C30 - 150x22	C30	112.64	168.97	0.08	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1	-	-	-	-
11 Timber Beam	OK	C30 - 150x22	C30	112.64	168.97	0.04	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	OK	C30 - 150x22	C30	48.10	72.15	0.11	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (0.3+0*	-	-	-	-
14 Timber Beam	OK	C30 - 150x22	C30	48.10	72.15	0.07	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1	-	-	-	-

Optimization:

Element 3+4:

C24 - 100x150 mm

Member		Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	✗	C30 - 150x22	C30	38.49	57.74	1.17	5 Pd.ULS.S	-	-	-	-	1.04	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	OK	C30 - 150x22	C30	38.49	57.74	0.81	5 Pd.ULS.S	-	-	-	-	0.87	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK	C24 - 100x15	C24	126.07	189.10	0.87	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.48	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK	C24 - 100x15	C24	126.07	189.10	0.79	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.55	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK	C30 - 150x22	C30	112.64	168.97	0.08	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	OK	C30 - 150x22	C30	112.64	168.97	0.05	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1 + (0.3+0*	-	-	-	-
13 Timber Beam	OK	C30 - 150x22	C30	48.10	72.15	0.14	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	OK	C30 - 150x22	C30	48.10	72.15	0.10	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-

C24 - 75x150 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	1.19	5 Pd.ULS.S	-	-	-	-	1.12	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	OK C30 - 150x22	C30	38.49	57.74	0.83	5 Pd.ULS.S	-	-	-	-	0.95	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	✗ C24 - 75x150	C24	126.07	252.14	1.09	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.54	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK C24 - 75x150	C24	126.07	252.14	0.99	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.62	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK C30 - 150x22	C30	112.64	168.97	0.08	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	OK C30 - 150x22	C30	112.64	168.97	0.05	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1 + (0.3+0*	-	-	-	-
13 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.14	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (0.3+0*	-	-	-	-
14 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.10	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-

C24 - 100x125 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	1.17	5 Pd.ULS.S	-	-	-	-	1.04	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	OK C30 - 150x22	C30	38.49	57.74	0.81	5 Pd.ULS.S	-	-	-	-	0.87	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.87	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.48	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.79	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.55	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK C30 - 150x22	C30	112.64	168.97	0.08	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	OK C30 - 150x22	C30	112.64	168.97	0.05	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.12	(1+0.6)*1 + (0.3+0*	-	-	-	-
13 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.14	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.10	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-

Element 5+6:

C24 - 50x75 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	1.16	5 Pd.ULS.S	-	-	-	-	1.29	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	0.80	5 Pd.ULS.S	-	-	-	-	1.15	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.84	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.43	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.80	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.58	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	✗ C24 - 50x75	C24	337.93	506.90	0.57	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	1.07	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	✗ C24 - 50x75	C24	337.93	506.90	0.46	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	1.07	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.14	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1	-	-	-	-
14 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.09	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (0.3+0*	-	-	-	-

C24 - 45x95 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	1.16	5 Pd.ULS.S	-	-	-	-	1.25	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	0.80	5 Pd.ULS.S	-	-	-	-	1.12	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.84	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.43	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.80	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.57	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	OK C24 - 45x95	C24	266.79	563.22	0.49	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	OK C24 - 45x95	C24	266.79	563.22	0.41	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.14	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1	-	-	-	-
14 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.09	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (0.3+0*	-	-	-	-

C30 - 50x75 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	1.16	5 Pd.ULS.S	-	-	-	-	1.26	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	✗ C30 - 150x22	C30	38.49	57.74	0.80	5 Pd.ULS.S	-	-	-	-	1.13	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.84	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.43	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	OK C24 - 100x15	C24	126.07	189.10	0.80	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.57	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	✗ C30 - 50x75	C30	337.93	506.90	0.45	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	1.06	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	✗ C30 - 50x75	C30	337.93	506.90	0.42	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	1.06	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.14	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	OK C30 - 150x22	C30	48.10	72.15	0.09	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.01	(1+0.6)*1 + (1+0*0.	-	-	-	-

Element 7+8:

C24 - 45x95 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	C30 - 150x22	C30	38.49	57.74	1.11	5 Pd.ULS.S	-	-	-	-	1.77	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	C30 - 150x22	C30	38.49	57.74	0.75	5 Pd.ULS.S	-	-	-	-	1.55	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.92	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.64	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.89	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.78	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	C24 - 45x95	C24	266.79	563.22	0.49	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	C24 - 45x95	C24	266.79	563.22	0.40	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	C24 - 45x95	C24	113.92	240.49	1.32	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	C24 - 45x95	C24	113.92	240.49	0.77	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (0.3+0*	-	-	-	-

C24 - 45x120 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	C30 - 150x22	C30	38.49	57.74	1.12	5 Pd.ULS.S	-	-	-	-	1.64	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	C30 - 150x22	C30	38.49	57.74	0.76	5 Pd.ULS.S	-	-	-	-	1.45	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.90	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.59	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.86	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.73	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	C24 - 45x95	C24	266.79	563.22	0.49	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (0.3+0*	-	-	-	-
11 Timber Beam	C24 - 45x95	C24	266.79	563.22	0.40	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	C24 - 45x120	C24	90.18	240.49	0.92	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.03	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	C24 - 45x120	C24	90.18	240.49	0.61	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.03	(1+0.6)*1 + (1+0*0.	-	-	-	-

C30 - 50x75 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	C30 - 150x22	C30	38.49	57.74	1.11	5 Pd.ULS.S	-	-	-	-	1.68	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	C30 - 150x22	C30	38.49	57.74	0.76	5 Pd.ULS.S	-	-	-	-	1.48	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.91	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.61	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.87	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.74	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	C24 - 45x95	C24	266.79	563.22	0.49	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	C24 - 45x95	C24	266.79	563.22	0.40	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
13 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.99	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.66	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (1+0*0.	-	-	-	-

Last optimization of columns:

Element 1+2:

C30 - 175x225 mm

Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	C30 - 175x22	C30	38.49	49.49	0.96	5 Pd.ULS.S	-	-	-	-	0.89	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	C30 - 175x22	C30	38.49	49.49	0.65	5 Pd.ULS.S	-	-	-	-	0.85	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.89	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.57	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.85	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.70	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	C24 - 45x95	C24	266.79	563.22	0.49	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	C24 - 45x95	C24	266.79	563.22	0.40	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (0.3+0*	-	-	-	-
13 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.99	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.67	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (0.3+0*	-	-	-	-

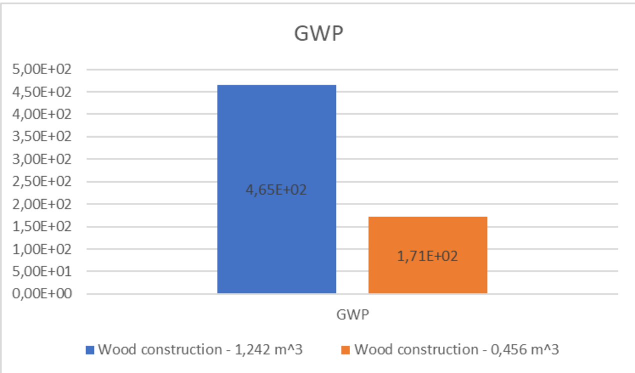
C30 - 200x250 mm

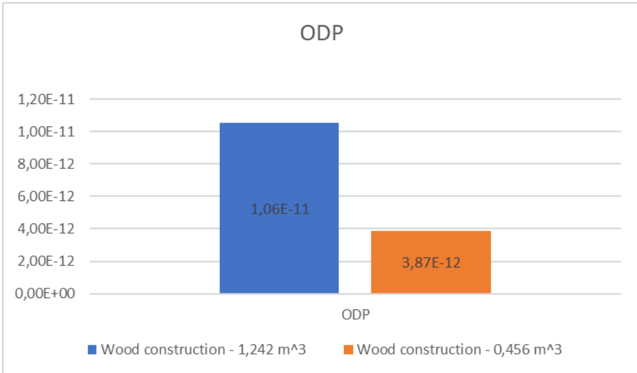
Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	C30 - 200x25	C30	34.64	43.30	0.69	5 Pd.ULS.S	-	-	-	-	0.49	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	C30 - 200x25	C30	34.64	43.30	0.48	5 Pd.ULS.S	-	-	-	-	0.41	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.86	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.48	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.82	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.62	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	C24 - 45x95	C24	266.79	563.22	0.49	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	C24 - 45x95	C24	266.79	563.22	0.41	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (0.3+0*	-	-	-	-
13 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.91	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (0.3+0*	-	-	-	-
14 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.68	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (0.3+0*	-	-	-	-

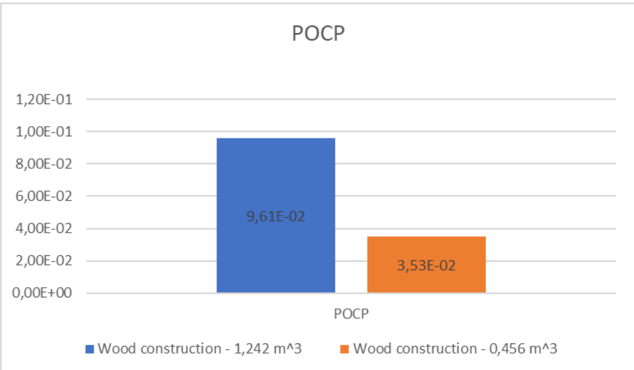
C30 - 200x200 mm

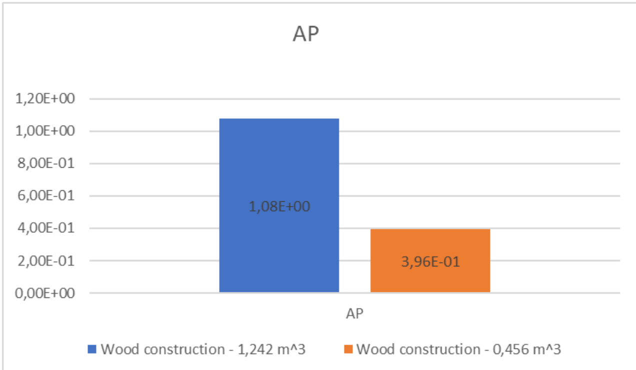
Member	Section	Material	Lay	Laz	Ratio	Case	Ratio(uy)	Case (uy)	Ratio(uz)	Case (uz)	Ratio(vx)	Case (vx)	Ratio(vy)	Case (vy)
1 Timber Column	C30 - 200x20	C30	43.30	43.30	1.05	5 Pd.ULS.S	-	-	-	-	1.22	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
2 Timber Column	C30 - 200x20	C30	43.30	43.30	0.71	5 Pd.ULS.S	-	-	-	-	0.86	Pd.SLS.I (1+2)*1.0	0.00	Pd.SLS.I (1+2)*1.0
4 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.91	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.63	(1+0.6)*1 + (0.3+0*	-	-	-	-
5 Timber Beam_	C24 - 100x15	C24	126.07	189.10	0.88	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.76	(1+0.6)*1 + (0.3+0*	-	-	-	-
8 Timber Beam_	C24 - 45x95	C24	266.79	563.22	0.49	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (1+0*0.	-	-	-	-
11 Timber Beam	C24 - 45x95	C24	266.79	563.22	0.40	6 Pd.ULS.I	0.00	(1+0.6)*1 + (1+0*0.	0.67	(1+0.6)*1 + (0.3+0*	-	-	-	-
13 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.98	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (1+0*0.	-	-	-	-
14 Timber Beam	C24 - 50x100	C24	108.22	216.44	0.66	5 Pd.ULS.S	0.00	(1+0.6)*1 + (1+0*0.	0.04	(1+0.6)*1 + (0.3+0*	-	-	-	-

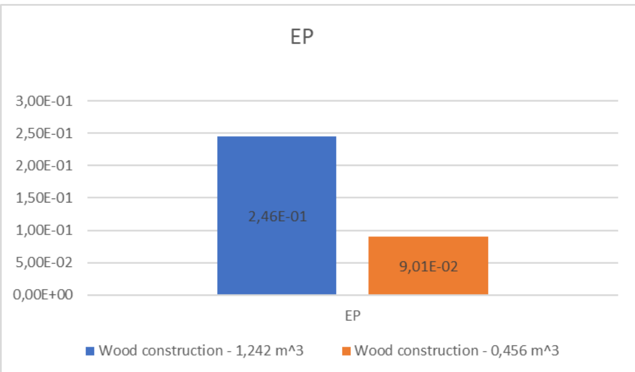
LCA Results of first and last dimensional iterations:

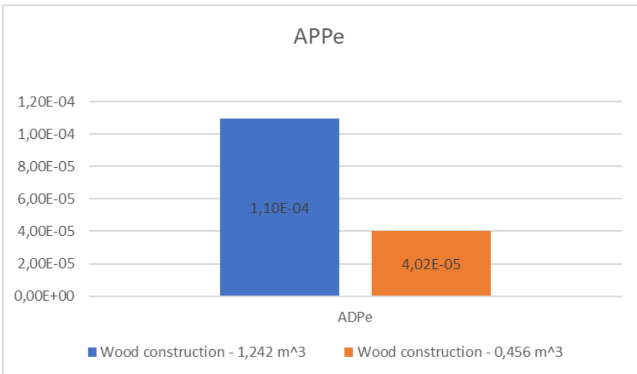












Programs used:
Autodesk Robot Structural Analysis Products
LCAByg

16.16. APPENDIX BE18 PROCESS

KEY NUMBERS

Iteration 1 - Starting point

Nøgletal, kWh/m² år

	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme	Samlet energibehov
Renoveringsklasse 2	96,0	0,0	96,0	37,3
Renoveringsklasse 1	72,0	0,0	72,0	37,3
Energiramme BR 2018	41,5	0,0	41,5	37,3
Energiramme lavenergi	33,0	0,0	33,0	37,3

Bidrag til energibehovet		Netto behov	
Varme	12,0	Rumopvarmning	11,7
El til bygningsdrift	9,5	Varmt brugsvand	5,3
Overtemp. i rum	9,0	Køling	0,0

Udvalgte elbehov		Varmetab fra installationer / Ydelse fra særlige kilder	
Belysning	4,9	Rumopvarmning	0,3
Opvarmning af rum	0,0	Varmt brugsvand	0,0
Opvarmning af vbv	0,0		
Varmepumpe	0,0	Ydelse fra særlige kilder	
Ventilatorer	4,4	Solvarme	0,0
Pumper	0,2	Varmepumpe	0,0
Køling	0,0	Solceller	0,0
Totalt elforbrug	35,6	Vindmøller	0,0

Iteration 2 - Adding shading

Nøgletal, kWh/m² år

	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme	Samlet energibehov
Renoveringsklasse 2	96,0	0,0	96,0	32,3
Renoveringsklasse 1	72,0	0,0	72,0	32,3
Energiramme BR 2018	41,5	0,0	41,5	32,3
Energiramme lavenergi	33,0	0,0	33,0	32,3

Bidrag til energibehovet		Netto behov	
Varme	14,7	Rumopvarmning	14,3
El til bygningsdrift	9,3	Varmt brugsvand	5,3
Overtemp. i rum	2,2	Køling	0,0

Udvalgte elbehov		Varmetab fra installationer / Ydelse fra særlige kilder	
Belysning	4,9	Rumopvarmning	0,4
Opvarmning af rum	0,0	Varmt brugsvand	0,0
Opvarmning af vbv	0,0		
Varmepumpe	0,0	Ydelse fra særlige kilder	
Ventilatorer	4,1	Solvarme	0,0
Pumper	0,2	Varmepumpe	0,0
Køling	0,0	Solceller	0,0
Totalt elforbrug	35,4	Vindmøller	0,0

Iteration 3 - Adding natural ventilation

Nøgletal, kWh/m² år

	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme	Samlet energibehov
Renoveringsklasse 2	96,0	0,0	96,0	30,1
Renoveringsklasse 1	72,0	0,0	72,0	30,1
Energiramme BR 2018	41,5	0,0	41,5	30,1
Energiramme lavenergi	33,0	0,0	33,0	30,1

Bidrag til energibehovet		Netto behov	
Varme	14,8	Rumopvarmning	14,4
El til bygningsdrift	8,8	Varmt brugsvand	5,3
Overtemp. i rum	0,8	Køling	0,0

Udvalgte elbehov		Varmetab fra installationer / Ydelse fra særlige kilder	
Belysning	4,9	Rumopvarmning	0,4
Opvarmning af rum	0,0	Varmt brugsvand	0,0
Opvarmning af vbv	0,0		
Varmepumpe	0,0	Ydelse fra særlige kilder	
Ventilatorer	3,6	Solvarme	0,0
Pumper	0,2	Varmepumpe	0,0
Køling	0,0	Solceller	0,0
Totalt elforbrug	34,9	Vindmøller	0,0

Iteration 4 - Adding shutters

Nøgletal, kWh/m² år

	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme	Samlet energibehov
Renoveringsklasse 2	96,0	0,0	96,0	29,6
Renoveringsklasse 1	72,0	0,0	72,0	29,6
Energiramme BR 2018	41,5	0,0	41,5	29,6
Energiramme lavenergi	33,0	0,0	33,0	29,6

Bidrag til energibehovet	
Varme	15,2
El til bygningsdrift	8,7
Overtemp. i rum	0,0

Netto behov	
Rumopvarmning	14,8
Varmt brugsvand	5,3
Køling	0,0

Udvalgte elbehov	
Belysning	4,9
Opvarmning af rum	0,0
Opvarmning af vbv	0,0
Varmepumpe	0,0
Ventilatorer	3,5
Pumper	0,2
Køling	0,0
Totalt elforbrug	34,8

Varmetab fra installationer	
Rumopvarmning	0,4
Varmt brugsvand	0,0

Ydelse fra særlige kilder	
Solvarme	0,0
Varmepumpe	0,0
Solceller	0,0
Vindmøller	0,0

Iteration 5 - Adding soler panels

Nøgletal, kWh/m² år

	Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme	Samlet energibehov
Renoveringsklasse 2	96,0	0,0	96,0	12,9
Renoveringsklasse 1	72,0	0,0	72,0	12,9
Energiramme BR 2018	41,5	0,0	41,5	12,9
Energiramme lavenergi	33,0	0,0	33,0	12,9

Bidrag til energibehovet	
Varme	15,2
El til bygningsdrift	-0,0
Overtemp. i rum	0,0

Netto behov	
Rumopvarmning	14,8
Varmt brugsvand	5,3
Køling	0,0

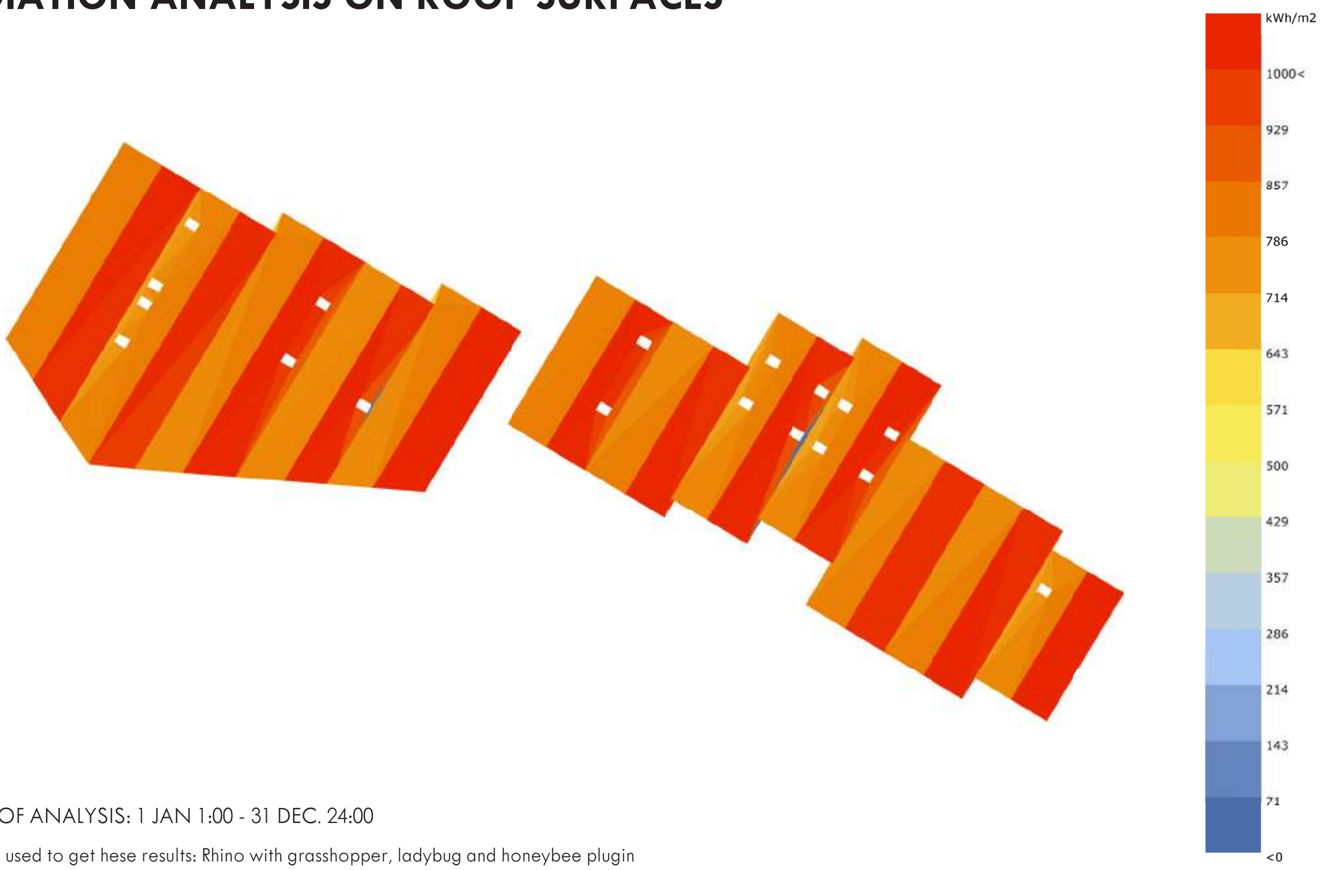
Udvalgte elbehov	
Belysning	4,9
Opvarmning af rum	0,0
Opvarmning af vbv	0,0
Varmepumpe	0,0
Ventilatorer	3,5
Pumper	0,2
Køling	0,0
Totalt elforbrug	34,8

Varmetab fra installationer	
Rumopvarmning	0,4
Varmt brugsvand	0,0

Ydelse fra særlige kilder	
Solvarme	0,0
Varmepumpe	0,0
Solceller	8,8
Vindmøller	0,0

*Program used to get hese results: BE18

RADIATION ANALYSIS ON ROOF SURFACES



PERIOD OF ANALYSIS: 1 JAN 1:00 - 31 DEC. 24:00

*Program used to get hese results: Rhino with grasshopper, ladybug and honeybee plugin

DAYLIGHT FACTORS THROUGHOUT THE BE18 PROCESS