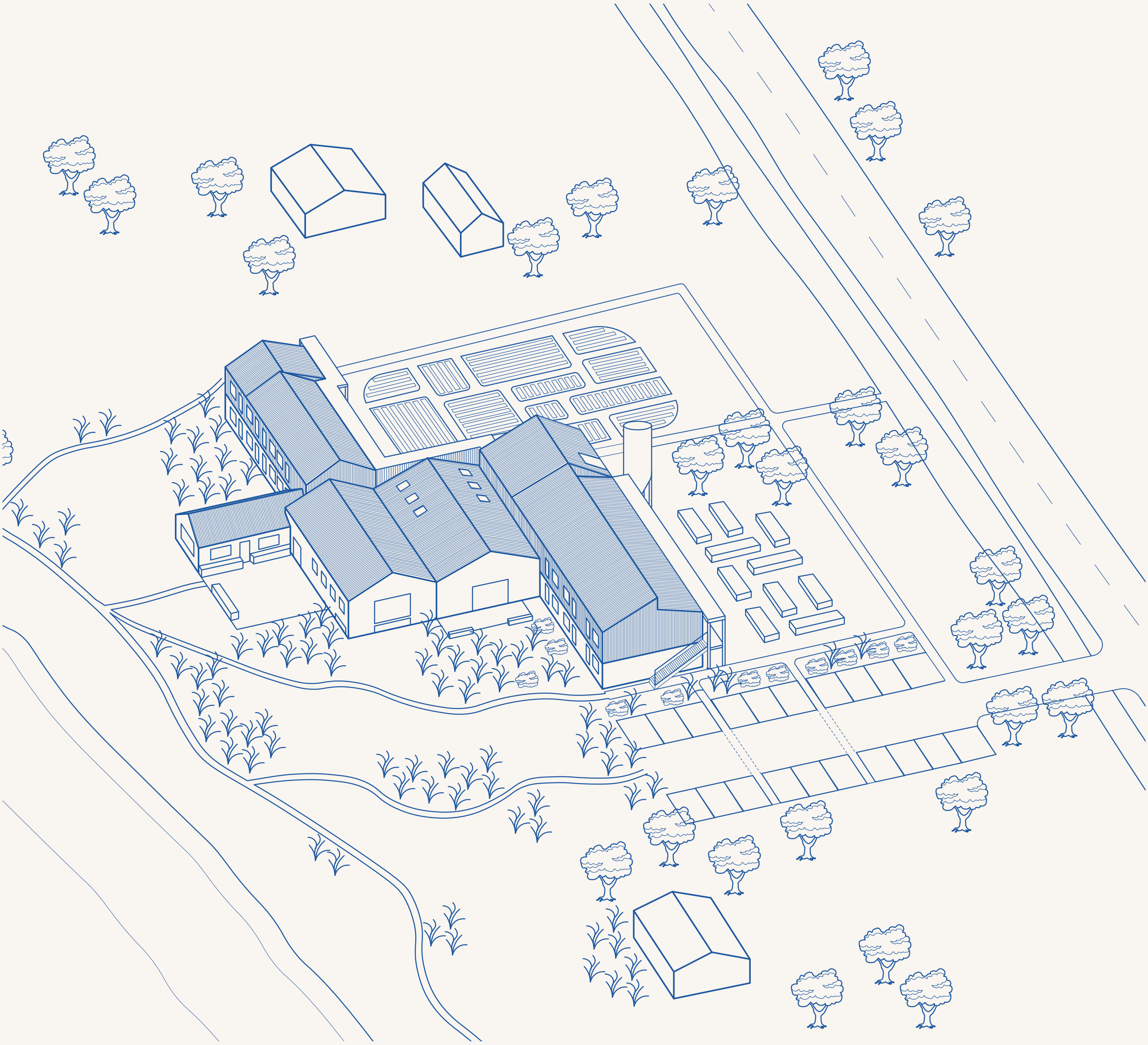


transformation to

SAMSØ BEACH HOTEL

Master Thesis Project
MSc04, May 2023, Aalborg University

ma4-arc4
Camilla Lynnerup Christensen
Kasper Vismar Chrestensen
Maria Lahn Jensen

TITLE PAGE

Titel	Transformation to Samsø Beach Hotel
Department	Architecture, Design and Media Technology Aalborg University
Semester	MSc04, May 2023
Group	ma4-arc4
Project period	01/02/2023 - 26/05/2023
Main supervisor	Joel Peter Weber Letkemann
Technical consultant	Endrit Hoxha
Report	Thesis project
Pages	147
Authors	Camilla Lynnerup Christensen Kasper Vismar Chrestensen Maria Lahn Jensen

ABSTRACT

The focus of this thesis project is to transform a former cement factory into a beach hotel that emphasizes Samsø's cultural heritage and traditional rural architecture. The existing building is a collage of various development stages, with the oldest sections in a detering state and in need of renovation. The project aims to reuse existing materials at the site to reduce global warming potential to express the building's history and preserve its original character, while incorporating new materials to highlight what was original and what is part of the transformation. The thesis proposes a matrix for selecting materials that best suit the building's atmospheric and spatial qualities. The matrix is based on a catalog of materials on site and additional materials collected from theories, serving as a lookup tool for technical and atmospheric information.

The thesis also examines the building envelope assemblies and details to optimize them according to current standards. By focusing on cultural heritage, atmospheric and materialistic potentials, the project seeks to optimize material selection and programming of the transformation of the former cement factory into an aesthetically appealing and sustainable beach hotel. In addition, the thesis investigates how optimization of the building envelope inwards will be detailed to minimize thermal bridges between construction elements. Finally, the sustainability of the project will be analyzed, and the total CO_2 equivalent will be calculated and compared to the same building constructed from only new materials.

READING GUIDE

This master thesis project consist of four reports:

- **Thesis project** *(main report)*
- **Catalog - Elaborated Material Exploration** *(secondary report)*
- **Appendix** *(appendix)*
- **Drawing folder** *(drawing folder)*

Thesis Project consists of a program, design process and presentation, and should be the first one reads. The **Thesis Report** is likewise divided into five parts:

- **Prologue**
- **Program**
    - *The scope*
    - *Theoretical framing*
    - *Site position*
    - *Users*
    - *Program delimitation*
- **Design process**
- **Presentation**
- **Epilogue**

The **Thesis Report** analyses, describes and presents the design of a beach hotel on Samsø. The report consists of research-informed and evidence-based information, which is referenced by the *Harvard reference method.* The literature will be referenced in the text by (name, year) and the reference list will be found in the back of the report.
The report consists of illustrations and iamges owned by the group. When analyzing and presenting the case studies, illustrations and images are approved by the owner of these. This will be shown in the illustration text by "credit: xx" and in the illustration list in the back of the report.

When reading the **Thesis project**, the report **Catalog - Elaborated Material Exploration** will be referenced to, during material and atmosphere studies of the cement factory. The report consists of an explanation of the matrix and the material method. For further information about the reports structure, see the report **Catalog - Elaborated Material Exploration**.

Likewise, when reading the **Thesis project**, the report **Appendix** will be referenced to in the text by "see appendix X". The appendix consists of calculations during the design process, and other relevant information for the report **Thesis Project**.
Drawing folder collects the drawings presented in the chapter *Presentation*.

CONTENTS

ill.1. image from project site

INTRODUCTION

Buildings, bridges and roads in Denmark account for *30% of CO_2 emissions comes from buildings' energy consumption, production of building materials and the construction process*, both in connection with new constructions and renovation. In addition, *10% of the CO_2 emission comes from the building and construction process*, where the production of building materials occurs. Likewise, *35% of all waste in Denmark comes from the construction industry* (Building and Construction Sector, 2019). This issue is addressed in this thesis project, where **a former industrial building will be transformed an redesigned**. Here the project will revolve around the idea of transformation versus new buildings, how to rethink sustainability, given the modern building materials being so efficient. **Is reuse a better or worse solution?** Therefore this project will reuse as close to every building element as possible and evaluate it against the same building that was built with modern materials with low and neutral global warming potentials.

The cement factory is located on Samsø and will be transformed into an attractive beach hotel, with a restaurant and spa as public facilities. The cement factory has existed since 1908 and was founded by local farmers on Samsø (Cementvarefabrikken Sælvig ApS, n.d). The cement factory's materials have developed their patina over the years and thus gives the place history and character, which the beach hotel supports in its design, choice of materials and use of outdoor areas, where the history of farmers is made clear through the use of the cultivation of vegetables and other plants.

A beach hotel on Samsø will thus contribute to the tourism group *coastal and nature tourism* in Denmark, and also to Samsø and the island's industry. Tourism is Samsø's largest industry, where approximately 1/3 of Samsø's added value comes from tourism (Samsø Municipality, 2021). The beach hotel will bring tourists to the island, which also will cause other existing tourist attractions on Samsø to **increase in growth**, as well give locals on Samsø a refuge close to everyday life, where they can enjoy the restaurant and spa at the beach hotel. The beach hotel is open through the year, and not only in the high season, and will therefore contribute to VisitDenmark's **sustainable tourism** (VisitDenmark, 2021), as the tourist season is extended from the high season to the whole year, due to the beach hotel's seasonally extended activity.

ill.2. Samsø

THE SCOPE

This chapter explains and highlights the theoretical and methodologies of this thesis project. Here the aspects will be introduced and explored of the themes of transformation and sustainability. The intention is to make the focus point and hierarchy clear for this thesis project, and start defining the project.
The methodologies and methods will be explained according to the integrated design process IDP and the different methods the thesis project investigate. In addition, the different analyses will develop a matrix for transformation, which will have an influence on the integrated design process.

MOTIVATION

Denmark's rural areas are home to a lot of architectural heritage, which is in danger of being lost due to the lack of economic incentives to preserve and transform these old factories and station buildings. As a result, many of these buildings have become vacant and are deteriorating rapidly. Despite the abundance of new architectural trends, such as parametric design, the missing historical element in modern architecture has become increasingly apparent. While sustainable architecture has gained momentum in recent years, there is still more work to be done, to fully incorporate the value of history and cultural heritage into this field.

This education *Architecture & Design* explores sustainable architecture through every semester projects, but the field of transformation has not been thoroughly investigated, which has motivated us to think about sustainable architecture in a new way. We aim to develop a material matrix and catalog for transforming buildings, considering their unique history, cultural heritage, atmospheric and material potentials. Our thesis project investigates transformation's potential to preserve Denmark's cultural heritage and create sustainable architecture that incorporates history and culture.
We hope to contribute to the discussion of architects' role in preserving and sharing cultural heritage.

METHODOLOGY

Integrated architecture is not a new way to do architecture. Integrated architecture has its roots back to Vitruvius, a Roman architect and engineer. Vitruvius described three parameters to assess architecture and what architecture must provide; Firmitas, Utilitas og Venustas [durability, utility and aesthetics]. These parameters create a triangle, Vitruvius Triangle, where all parameters are interdependent in creating architecture (DAC, n.d.).

Today it is a new methodology architecture consists of. Mary-Ann Knudstrup describes Integrated Design Process, IDP. Knudstrup means that, our intention of today's architecture is to integrate and combine knowledge from architecture and engineering, in order to solve a complex design problem. By using and following this process, the design solution will consist of integrated design and every phases will be optimized (Knudstrup, 2004).
Generally the IPD is based on problem -based-learning, PBL, the engineering program at Aalborg University (Knudstrup, 2004).
Knudstrup describes a process, consisting of five phases; ***Problem, Analysis, Sketching, Synthesis and Presentation*** (Knudstrup, 2004). In fact, the process is much more complex and in principle consists of a number of methods in each phase, because of the combined knowledge between architecture and engineering.

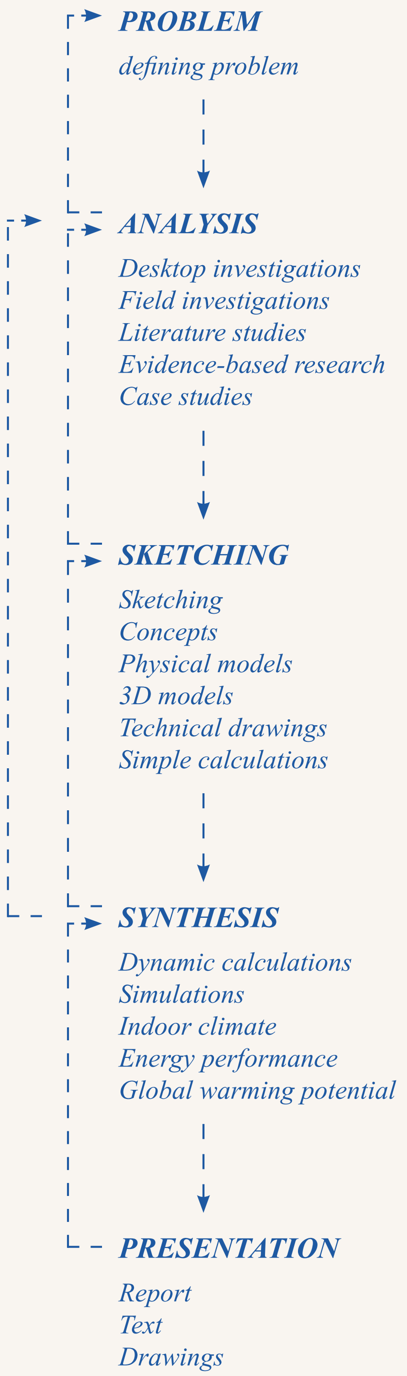
Problem, describes the problem, the project is oriented around and a formulation of the project idea.

Analysis, focusing on gathering and analyzing information and data based on desktop- and field investigations. These investigations will give knowledge from research and phenomenological experiences. The analysis also investigates the purpose of the project, which themes and theory the project should cover, with information from evidence-based research. In this phases, the user group is also investigated, to understand their needs and demands, based research and case studies of existing transformations project. All this information will create a basis for the final project.

Sketching, combines the achieved information from the analysis phase and creates possible ideas and solutions developed by sketches, physical models and 3D models. Technical sketching is also integrated, with simple calculations to test ideas, according to daylight, energy and indoor environment, to ensure integrated design.

Synthesis, collects all the elements from the previous phases. Functional, technical and aesthetic aspects combined and forms a final design. Various parameters of the project are detailed and documented by more complex calculations and simulation tools.

Presentation, presenting the project. The aim is to communicate the integrated architecture and the process and documentation behind. The communication is through plans, elevations, sections, visualizing and calculations. The thesis project is presented through the report.



ill.3. Integrated Design Process, IDP

“In a way, all architectural interventions are a transformation... The starting point for architecture’s transformation is that there is something in advance, physical or cultural, that you can relate to “

[translated from Danish to English]
(Harland, 2015, p. 81)

This thesis project investigates the transformation of a cement factory to a beach hotel, therefore the methodology behind transformation is important to investigate.
Later in this report the theories by Nicolai Bo Andersen **“5 principles of transformation”,** will be described to get an understanding of the different purposes in each method.

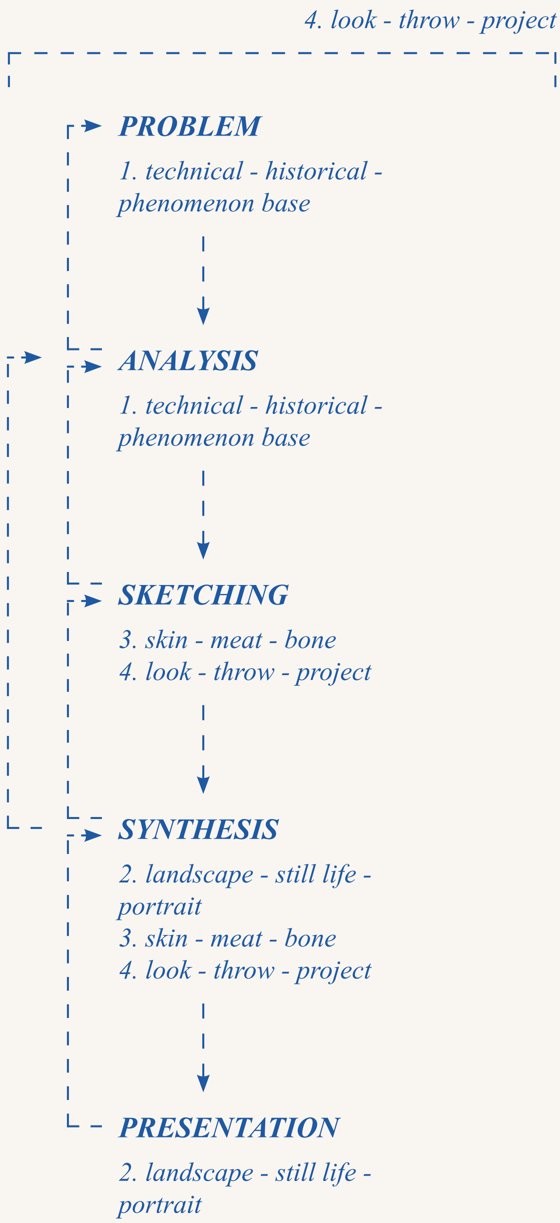
These five principles can also be used as methods combined with the **Integrated Design Process**. Integrated Design Process describes the structure, while the 5 principles of transformation works specifically with the methods when transforming. When combining these two methods in this thesis project, an integrated design process when transforming is ensured.

Nicolai Bo Andersen describes one method ***Look, Throw and Project***, as the overall method of transformation. General the method describes how a transformation project is structured by:

- ***Look***, registering, analyzing and valuing an existing situation
- ***Throw***, different options are outlined here, some of which form the basis for other proposals and others are rejected
- ***Project***, is about developing and clarifying the intentions behind the transformation and the connection between scale and building

(Harlang, 2015).

The method will be described more in relation to the other methods by Nicolai Bo Andersen in the chapter ***“Transformation”.***



ill.4. Design Process

METHOD

ANALYSIS

Desktop investigation: consists of mapping, where the access to Samsø are located, accommodation options, the site and the microclimate is investigated. Mapping is used to understand and describe the site and the following conditions in a big scale; *Samsø*, and a smaller scale; *site and microclimate*.

Literature studies: the different themes in this thesis project are investigated through literature studies, with focus on theoretical papers and books. Here ***evidence- and research based investigations*** is gathered from scientific research and data on the main themes and user group for this thesis project. Through literature studies all necessary information about the theories is gathered, likewise when studying the building requirements in the room program. Literature studies is likewise used for developing the user group, while investigating tourism.

Field investigation: to get a phenomenological understanding of the site. This is done through an excursion to the site, where pictures are documented of the site's exterior and interior potentials. Likewise, used for experiencing the cultural heritage and value-setting elements on the site.

Case studies: for understanding different details and the functionality of the thesis project, different case studies are developed. Here the theoretical information from literature studies is used in a case of an existing building. In this thesis project, case studies will be used to understand a specific detail, structure and the beach hotel's needs.

SKETCHING

Modeling: during a design process different models will be created. Models can both be done ***physical and digital***. Physical models can be a context model, where the building form can be seen in context, and can also show details in the building. Digital modeling is like digital sketching, where the final building will be modeled.

Simple calculations: during the early sketching phases, different simple calculations will be done. Here simple calculations such as daylight and indoor climate calculations. The simple calculations are an evaluation tool when designing to be more specific while designing.

Sketching: the sketching phases, and while doing the analysis phase, sketching is used for initial ideas. Sketching consists of plans, sections and details. Sketching occur both ***in-hand and digital***. Hand sketching is a quick method to generate ideas. Digital sketching is used later in the process, to investigate structure and is more in detail, and will be the background for simulations later in the process.

SYNTHESIS

Dynamic calculations: in the synthesis phase, the purpose is that the building follows different requirements. Here different dynamic calculations will be done, to ensure e.g. good indoor climate and a low global warming potential, while using ***BSim*** and ***LCAbyg***. Dynamic calculation is much more detailed than simple calculations, and can likewise be done through simulations.

Simulation tools: in the synthesis phase, simulations in ***BSim and Be18*** can be done, to ensure the indoor climate and the energy consumption. Simulation is likewise a tool which can be used in the whole process, to gather an understanding of the building. Simulations need, as dynamic calculations, lots of details for a more specific simulation.

defining
TRANSFORMATION

"When the past shapes the future "

[translated from Danish to English]
(BARK, 2023, front page).

Today, sustainability and sustainable solutions are a big focus throughout the world and in architecture. But sustainability is a broad term and can be understood and processed in different ways. In this thesis project, the project will delve into transformation as a sustainable strategy, and how it can create a new building with cultural heritage, atmospheric and materialistic potentials.

In recent years, new architecture has been built with sustainable solutions and architecture that will remain here for many years. But the old buildings are built with durable materials, and will remain standing until they are demolished. It is therefore important to take a closer look at these buildings, as they could be reused and add new value - and remain standing for many years.
Society is constantly changing and the need for buildings follows. **Many buildings have outlived their original function and no longer have the qualities there are expected today,** such as energy and indoor environment. This results in the demolition of many buildings which in principle may still be usable (BARK, 2023).

A transformation of a building can help contribute to the **building's identity, cultural heritage and promote a local community and their values**. A transformation can develop the site and bring **new activities** to an area with low activity. The transformation can help to contribute to a story from locals about what the building's former function was and how this can still be interpreted in the design of the new building (BARK, 2023).

There are different methods for how buildings can be transformed. These methods will be described in this thesis project. What these different methods have in common is that they focus on: **cultural heritage**, **atmosphere** and **materiality**. The point of origin is to investigate the properties of the materials, the history of architecture and how the building structure is constructed. Here a depth insight with significant architectural features and thus ensure that the building's conservation qualities are not destroyed (Harland, 2015). It is these qualities that will contribute to the choice of atmosphere and materials when the building is transformed. The transformation must consist of a standing characteristic, historical traces and the experiential qualities of the space, as these contribute to a nuanced building culture that is site-specific and present.

Through this thesis project, different methods will be used; **"5 principles of transformation"** by Nicolai Bo Andersen (Harland, 2015) and the **"SAVE method"** by Slots- og Kulturstyrelsen (Kulturministeriet, 2011). These methods will create an insight into how this project can be transformed, and likewise create parameters for a material matrix and catalog.

defining
SUSTAINABILITY

In 1987 the first report focusing on global sustainability was released called *"Our Common Future"* published by Brundtland Kommissionen. This report was a revolution within the field of sustainability, with a broad understanding on the term dividing sustainability into 3 different sectors. **Social-, Ecological- & Economical sustainability** (Our Common Future, 1987)

Ecological sustainability is the maintaining of health and productivity of natural systems over time without depleting them. This thesis project will use ecological sustainability terms, like GWP, LCA, Reuse and Indoor environment (Our Common Future, 1987). Relevant to the ecological development of buildings is transformation, creating more sustainable architecture by reusing old materials. It is important to see sustainability as a holistic approach and thereby taking multiple aspects of human lifes into account.

Social sustainability means creating a society that meets the users basic needs. Promotes well-being and equity, and respects human rights and cultural diversity. It is the concept of creating architecture that positively impacts human lives ensuring the physical surroundings and the social environment relate to each other creating areas suited for social interactions. Social sustainability works in close relation to atmospheres, throughout the thesis project phenomenological aspects will be used to create the desired atmosphere through senses, site- and cultural heritage by value setting elements, to find their preservation worth.

The two sustainability terms in relation to the existing building will create the basis for material choices and functionality of the transformation. The thesis project relevant elements described in the terms of sustainability will become the basis for a material matrix which will ensure that the elements are taken into account in relation to other aspects of architecture.

The ecological impact has been more incorporated within architecture throughout later years. Due to the building industry creating large contributions to the energy consumption in Denmark, Energy consumption within the building industry constitutes nearly 40% of the total energy consumption of the country. Therefore creating sustainable solutions within the building industry will heavily reduce the total consumption and ultimately help reach the energy goals of being independent in fossil fuels in the year of 2050 (Byggeri og renovering, 2021).

Statistics from, International energy agency (IEA) shows around 29 percent of the total consumption is from operating a building while the remaining 11 percent is from CO_2 storage within the material, this means the emission used to produce the specific material (IEA, 2020).

Operating the building involves the use of mechanical ventilation, light, electricity, cooling and heating ect. This highlights the importance of energy efficiency and helps paint a picture of what measures can be implemented to ensure more sustainable architecture. It is important to obtain a strategy to create the foundations for low energy buildings. Here passive strategies can be used as a cheap and low maintenance solution to lower a building's operation consumption. Clever design, and making use of the sun and wind to shape the structure will not only improve the ecological sustainability but when done correctly have a positive impact on the social and economical sustainability (Guzowski, 2010).

defining the
PROBLEM

How to transform a former cement factory along the coast of Samsø into a beach hotel, where cultural heritage, atmosphere and material potentials create sustainable architecture?

Likewise, how is a material matrix and catalog prepared for the determination of materials, based on ecological- and social sustainability, through the investigation of the site's atmospheric and materialistic potentials, which contribute to a site-bound beach hotel, where the site's history is preserved?

defining the

VISION

The vision for the thesis project is to transform a former cement factory into a beach hotel. The beach hotel will emphasize the cultural heritage of the site's history, but also the entirety of Samsø's heritage and architecture, to design site-bound architecture.

The thesis project will investigate how to transform, by developing a material matrix and catalog. The goal for the matrix is to create a point system, for when choosing materials according to the parameters in the matrix, which will then be based on cultural heritage, atmospheric and materialistic potentials. The material catalog will be with materials existing on the site and materials, which support the different theories.

This will be used when designing the beach hotel and choosing exterior and interior materials, and likewise, how to optimize the building envelope and structures, for today's environmental standards and energy consumption without compromising the atmosphere of the place.

Ultimately evaluating the global warming potential and energy consumption of the transformed building compared to new constructions. Developing research on an alternative approach to sustainability such as transformation of rural buildings.

THEORE-
TICAL
FRAM-
ING

This chapter frames the theoretical aspects of this thesis project; transformation, atmospheric- and materialistic potentials. The theories explain these aspects of architecture and experiences, and will be used for the development of a material matrix.
These aspects will create a point of origin when visiting the site, where architectural and cultural heritage qualities will be analyzed based on the theoretical framing. Likewise case studies will be incorporated, for creating an understanding of existing architecture, which consists of these three theoretical aspects.

TRANSFORMATION

“ The task of the transformation architect is thus to intervene in the world, to establish spatial characters created with the help of a specific material in a specific place “

[translated from Danish to English]
(Harland, 2015, p. 39)

In the book, Nicolai Bo Andersen describes:

“ Perhaps the question of new versus old is not interesting at all. It can be argued that the dividing line is not between new and old, but between good and bad. If it is not a question of making the building appear as faithful to the original starting point as possible, and is not a question of being historically correct, the transformation architect is not simply an interpreter of a historical object or another architect’s work, but an active (co)creator of a new whole. In this way, the transformation becomes a matter of architecture ”

[translated from Danish to English]
(Harland, 2015, p. 38)

As meantioned earlier, transformation can happen through different methods, where the focus also differs. In this chapter, the methods **5 principles of transformation** by Nicolai Bo Andersen (Harland, 2015) and the **SAVE method** by Slots- og Kulturstyrelsen (Kulturministeriet, 2011). These will be described and explained how they have an influence in this thesis project.

Nicolai Bo Andersen is an architect and graduated from the Royal Academy in Copenhagen and has conducted research in the fields of: Cultural heritage, Transformation, Restoration, Sustainability, Architecture and Aesthetics. In addition, he is a contributor to the book *“Om bygningskulturens transformation”*, where he describes five methods for working with **cultural heritage** and **transformation** (Harlang, 2015).

The starting point of these five methods is to **study the properties of the materials, the history of architecture and the existing building structure**. In addition, a number of significant **architectural characteristics** are studied, so that by carrying out a transformation, worthy preservation qualities are not destroyed.
The intention of these methods is to form an understanding of the physical characteristics, the history and the experiential qualities of the building, which are of great importance for the experience of the living building culture, site-specific and present architecture, to which a transformation contributes (Harlang, 2015).

In the book, Nicolai Bo Andersen describes **five principles of transformation**:

1. technical - historical - phenomenon base

2. landscape - still life - portrait

3. skin - meat - bone

4. look - throw - project

5. subtraction - reconstruction - repair - reformation - addition

(Harland, 2015)

1. Technical - historical - phenomenon base

There is a special element that characterizes the work of transformation: that there is something in advance - an urban context, an existing construction and structure, or historical traces. Knowing that there is something in advance, it is important to investigate and study whether this starting point is worth preserving quality. This is also the case if the existing is not worth preserving in an objective sense, there may still be strong architectural qualities that form the basis for new interventions - these qualities may consist of technical, historical or phenomenon-related characters (Harlang, 2015).

The three qualities often work together in an inseparable unit. An intervention must not weaken the building's worth preserving qualities, on the contrary, the interventions must strengthen them. In addition, it is important to obtain an exact technical and historical knowledge of the building, as well as an experiential understanding (Harlang, 2015).

The method starts by registering the existing building and the historical significance. This is analyzed to form an overview of the existing building, which is finally valued. This is made clear in the valuation of worthy preservation qualities (Harlang, 2015).

Technical, is based on an understanding of materials, the building's sub-elements, assemblies, for which the construction practices of the time are used to understand these. Here, the technical condition of an existing building is recorded, analyzed and valued (Harlang, 2015).

Historical, is based on an understanding of history as a living resource of inspiration, and can be used to describe the existing building in a larger architectural and cultural historical context (Harlang, 2015).

Phenomenon base, is based on an understanding of the building's qualities from a sensory and experiential perspective. The phenomenon-related quality has to do with how the architecture is experienced, through registration, analysis and valuation (Harlang, 2015).

2. Landscape - still life - portrait

This method helps to consider an architectural intervention on a large urban scale, at the same time with a close material and level of detail. This is appropriate in the sketching and synthesis phase, where one must consider the building's architectural properties through relationships the building is part of (Harlang, 2015).
The method is understood just like a painting, which consists of foreground, middle ground and background. The architecture is described and experienced differently in these areas, as the relationship between man and the building changes according to scale (Harlang, 2015).

Landscape, relates to the large scale, the relationship between the near and the far. It is about the building's relationship to the landscape and the city and which urban relationships occur (Harlang, 2015).

Still life, relates to the middle scale, where the relationship between the composition and the space is interesting. It is about the volume of the building, the space and the construction, in order to create a spatial understanding of the atmospheric qualities (Harlang, 2015).

Portrait, relates to the portrayed posture, characteristic details and perhaps state of mind. It is about the detail, the material qualities and the tectonic solutions, as well as the interaction between the materials (Harlang, 2015).

3. Skin - meat - bone
This method is about understanding the building as a tectonic whole, consisting of three different and independent elements: facade, space and structure. Skin represents the facade, meat describes the space and bone is about the structure (Harlang, 2015).

Skin, understood as the building's skin, the membrane that separates the outside from the inside. Here, the building's construction and load-bearing elements are examined. Skin is the part of architecture that most people experience and therefore has great expressive potential (Harlang, 2015).
Meat, is understood both as the volume, the shape of the house and the organization of the building's interior. Meat is about the building's coherence and the room's relationships to each other, as well as the atmosphere of each individual room. In other words, meat describes how people move around the building, and can be used for the preparation of function diagrams and floor plans (Harlang, 2015).
Bone, is understood as the construction and structure of the building, the skeleton of the building itself. The construction can appear independently and be a character-giving element that constitutes a significant part of the space, and also how the space is experienced (Harlang, 2015).

4. Look - throw - project
This method describes in a clear way three different main phases; Look, Throw and Project. This method is understood as the overall phasing of the approach to transformation (Harlang, 2015).

Look, is about registering, analyzing and valuing an existing situation. A landscape or building that is examined in relation to the first method; ***technical - historical - phenomenon base***. Registration consists of surveys and information and the existing building. Analysis of the three qualities helps to gather an overview of the information. Valuation takes place on the basis of registration and analysis, and designates conservation values which form the basis for the transformation (Harlang, 2015).

Throw, acts in the principle and design process that comes after Look. Different options are outlined here, some of which form the basis for other proposals and others are rejected. This is also where another method is incorporated: ***Landscape - still life - portrait***. Here, the different scales in which the building is located are outlined, in order to create relationships with the context (Harlang, 2015).
Project, is about developing and clarifying the intentions behind the transformation and the connection between scale and building (Harlang, 2015).

5. Subtraction - reconstruction - repair - reformation - addition
This method describes an architectural intervention, which transformation is and collects on the other four methods. The intention is that cultural heritage and transformation should not be understood as a limited field, but an intergrated part of the art of architecture (Harlang, 2015).
In general, this method is described as a link to the architecture we know today. Transformation relates to this contemporary architecture, through materials, sustainability and site-bounded architecture (Harlang, 2015).

At one end, architectural interventions consist of removing material, reconstructing them by re-establishing something that was there before. In the middle of these interventions, it is about repairing the existing, as well as changing the existing. Finally, the intervention consists of building a completely new structure in the existing building (Harlang, 2015).

SAVE-METHOD

Another method for registering and analyzing a building and its worthy preservation, is the SAVE-method (Survey of Architectural Values in the Environment). The method is carried out by registering and assessing the building's conservation value, by looking at the exterior (Kulturministeret, 2011).

SAVE-assessment consists of five principles:

- Architectural value
- Cultural history value
- Environmental value
- Originality
- Condition

(Kulturministeriet, 2011).

Architectural value
The architectural value is assessed based on the building's proportions, facade rhythm, the degree of detail and the interaction between form, material effect and function (Kulturministeret, 2011).

Cultural historical value
The cultural-historical value is assessed based if the building is from a specific architectural period, as well as the level of detail in the preparation. The construction is also studied to see if it consists of technical innovations in construction and choice of material (Kulturministeriet, 2011).

Environmental value
The environmental value is assessed based on the building's importance and support value for the adjacent buildings. This examines how the building is positioned and adapted to the landscape or the environment of which the building is a part (Kulturministeriet, 2011).

Originality
The originality is assessed by examining the extent to which the building's original expression has been preserved (Kulturministeriet, 2011).

Condition
The condition is assessed by examining whether the building is stable and maintained, including general building technical conditions (Kulturministeriet, 2011).

These five assessment parameters are finally combined into a common conservation value for the building.

TRANSFORMATION METHOD

For evaluation of this thesis project, the cement factory on Samsø, the method **Technical - historical - phenomenon base** will be combined with the **SAVE-method**.
These two methods have major features in common, which will contribute to understanding how elements from the cement factory can be transformed.
The transformation method the cement factory will be registered, analyzed and assessed based on is built on three parameters, where the principles of the two methods are integrated:

Architecture
Architectural value *(SAVE-method)*
Phenomenon base *(Technical - historical - phenomenon base)*

Cultural heritage
Cultural historical value *(SAVE-method)*
Environmental value *(SAVE-method)*
Historical *(Technical - historical - phenomenon base)*

Technical
Originality *(SAVE-method)*
Condition *(SAVE-method)*
Technical (*(Technical - historical - phenomenon base)*

ATMOSPHERIC TRANSFORMATION

> *“Because their structure tends to outlive their function, buildings have continuously been adapted to new uses, a fact which has enabled generation after generation to derive a sense of continuity and stability from their physical surroundings. When buildings were abandoned, pilfered for materials or condemned for political reasons, the process of destruction was often slow and incomplete compared to the effect of the modern bull-dozer.“*
>
> *Sherban Cantacuzino*
> *(Cantacuzino, 1972, p. 263)*

The concept of renovating buildings has been well-established for many years and has been subject to various opinions. Discussion throughout time on how to work with existing buildings, and whether or not to even transform existing buildings. Reuse has now become a profession within itself with a deeper understanding of how to transform buildings while preserving cultural heritage and accommodating user needs. However in the pre 1900s century the idea of reuse was simple. Altering existing buildings for new uses was handled pragmatically without necessarily considering heritage preservation. Instead, the driving force behind reuse was basically function and finance (Plevoets, 2019).

In modern methods these aspects are still fundamental when transforming architecture, while more modern methods focus on preserving cultural heritage while accommodating users needs. Bringing a building from a past existence into the present by understanding the use of the building and changing it so it fulfills all the users needs (Plevoets, 2019).

Viollet-le-Duc (1814-1879) describes; The best of all ways of preserving a building is to find a use for it, and then to satisfy so well the needs dictated by that use that there will never be any further need to make any further changes in the building. However, Sherban Cantacuzino (1928-2018) suggests that buildings often change uses multiple times throughout their lifetime, which challenges the idea that proper understanding of the user's needs eliminates the need for further changes (Plevoets, 2019).

Viollet-le-Duc's viewpoint on transformation has been controversial to a lot of other well known architects. Despite its international and historically long-term influence, the work and theories have not been free from criticism. Previous and present experts have been against the approach he promoted. John Ruskin (1819-1900), for example, described this kind of restoration as “**a destruction accompanied with false description of the thing destroyed”.** He also called it **“the most total destruction which a building can suffer”** (Plevoets, 2019).

“It is impossible, as impossible as to raise the dead, to restore anything that has ever been great or beautiful in architecture, ... Do not let us talk then of restoration. The thing is a lie from beginning to end. ... Take proper care of your monuments, and you will not need to restore them” John Ruskin (Ruskin, 1849, p. 184-186).

Ruskins approach to the topic is within the anti-restoration movement. This movement defines that monuments should not be touched, they should be allowed to exist untouched to show a sense of its history. These different opinions on the topic of adaptive reuse have been the center for the discussion throughout the nineteenth and twentieth century. This discussion could be described as based on a different understanding of the phase authenticity (Plevoets, 2019).

Austrian art historian Alois Riegl (1858-1905) created some of the most revolutionary theoretical work within the field. His objective was to understand both sides of the adaptive reuse movements. With this knowledge he provided some of the first contributions towards a more profound understanding of the term authenticity. Alois Riegl´s understanding of both parts of the discussion gave him a unique opportunity to reflect upon them. From his understanding the restoration movement strived to create new architecture that through clever design choices united the different styles within the transformation (both old and modern). Their goal was to create architecture that honors the building style, while incorporating new terms for a sustainable indoor environment while removing all traces of natural decay, to create a building suitable for the test of time. In contrast the anti-restoration supporters have an appreciation for the unique age-value of older buildings; they would not remove decayed building parts, given that the decay creates a sense of time which testifies the monumental status of the building showing that it was not created recently (Plevoets, 2019).
Whereas Riegl's approach was purely theoretical, Camillo Boito (1836-1914) has mostly the same ideology but with a higher level of practical use. In Boito´s search for a bridge between the two movements. He created a restoration method depending on the individual project, and that not all buildings should be renovated the same. The methodologies are antique-, medieval-, renaissance and other monuments. Besides this ideology he also created 8 principles:

1. Differentiating between the style of the new and the old

2. Differentiating between construction materials

3. Suppressing of profiles or decorations

4. Exhibiting removed old pieces, which could be installed next to the monument

5. Inscribing the date of restoration (or other conventional sign) in each restored piece

6. Using a descriptive epigraph carved on the monument

7. Describing and photographing the different phases of the work and placing the documentation within the building or nearby

8. Underlining notoriety

(Boito, 2009, p.76)

These principles could be used by architects to adapt buildings while limiting confusion as to what was new and what was old. He states that these principles should always be reflected in relation to the nature of the project (Plevoets, 2019).

All the previously mentioned theories have been reflected on by Bie Plevoets and Koenraad Van Cleempoel, Authors of the book "Adaptive Reuse of the Built Heritage ", with the intention of creating a method for developing adaptive reusable buildings.

From their extensive research they developed 4 principles for redesigning old buildings (Plevoets, 2019).

1. Monument versus palimpsest

There are two ways to approach old buildings: as **monuments** or as **palimpsests**. A monument is a building that is considered important and is preserved and restored as it was. The decision of what is considered a monument is determined by society. If a building needs to be used for a new purpose, any changes should be reversible so that the building can be restored to its original state. This approach is called the conservation approach. On the other hand, a palimpsest is a building that has been changed over time, and each change tells a story of its own. Approaching a building as a palimpsest allows for multiple narratives to coexist. This approach is called the a**daptive reuse approach**. Both approaches have their merits, and the choice between the two depends on the building's historical significance and the purpose it is going to serve. However, it is important to remember that any changes made to an old building should be made with care and respect for its historical value (Plevoets, 2019).

2. A classification into strategies

The approach is to treat the built environment as a palimpsest, revealing or hiding the layers of the past and their overwriting with a contemporary layer. They have different strategies for how to combine the old and new elements in the building, and how to create an aesthetically pleasing relationship between them (Plevoets, 2019).

One group of strategies involves physically changing the building, such as building within it, around it, or alongside it, while also recycling materials or adapting to a new function. Another group of strategies involves creating an aesthetic relationship between the old and new elements, such as building in the same style or creating a contrast between them (Plevoets, 2019).

The text also describes some new strategies that are being developed, such as **aemulatio**, which aims to blend the old and new to an extreme degree, **facadism**, which creates an extreme contrast between the old and new, and **ruination**, which embraces the crumbling and ephemeral nature of old buildings (Plevoets, 2019).

3. Aemulatio: copy and improvement as a strategy for adaptive reuse

Aemulatio is the idea that in modern projects when transforming old buildings it has become the norm to create a clear distinction between the new and old. Showing what is original and what is not. The idea of transformation is to preserve and reveal the aesthetic and historic value of the monument based on a respect for the original material (Plevoets, 2019).

However in recent projects a new approach has been more apparent. This is the idea that when transforming a building one should re-adjust the original rooms in accordance with the building's "genius loci". However a total remodeling should not be done, but to remake and re-think the original idea of the place using modern strategies and materials (Plevoets, 2019).

The entire discussion is built around the concept of coping, if it is the right way to do it or if this should not be done. According to Scott Pigman this dilemma can be categorized into three terms or steps that define the relationship between the new (copy) and the original (model) (Plevoets, 2019).

The first step, translatio, signifies clinging to a model's footsteps and aims at similarity; the second step, imitatio, aims at equality rather than similarity; and the final step, aemulatio, aims to improve upon the model itself (Plevoets, 2019).

Translatio involves a critical and creative approach to the original building, focusing on preserving its qualities and spirit.

Imitatio allows for a more liberal adaptation, selectively restoring certain elements and reinterpreting others to suit contemporary needs.

Aemulatio aims to surpass the original in aesthetics and functionality by subtly reinterpreting it, drawing on its decorum, materiality, and proportions.

4. Facadism: working with the dichotomy of interior and exterior

Facades have historically been seen as urban design. The idea that facade should fit into the city image. Therefore it has become the norm to design the facade in relation to the existing to maintain the relation to the context. Newer buildings have as well been "faking" the old expression creating historic facades on new buildings to fit into the context. This has however been seen poorly. Creating a mask that does not reflect the interior of the building. This "disneyfication" of facades leads to a misunderstanding of the historic monuments. However nether should we go back to the modernistic approach of showing the interior as the exterior. But find a method that works for the specific case in relation to the two extremes creating a building in between depending on its location and function (Plevoets, 2019).
In addition to facadism, the principle of contrast is also an important design. The contrast between the exterior and interior spaces is specifically interesting in the entrance creating a feeling of dimensional transcendence like seen in movies (Plevoets, 2019).

Another approach to facadism involves creating a new facade for an existing building. These designs, such as the Renaissance facade for the Sante Maria Novella in Florence and the Basilica Palladiana in Vicenza, hide the original structure behind a new facade that is better suited to the current use. In both cases, the building reached its full potential only after the completion of the new facade (Plevoets, 2019).

Overall, the principles of adaptive reuse and facadism show the importance of balancing the preservation of historical architecture with the need for functional and aesthetic improvements. By transforming existing structures, designers can create buildings that not only serve their intended purpose but also enhance the surrounding urban environment (Plevoets, 2019).

In the book *"The Rehabilitation and Re-Use of Old Buildings"* Highfield discusses the improvements necessary to adapted buildings in terms of fire resistance, thermal performance, acoustic properties, prevention of damp, condensation, and timber decay. This should always be seen as a priority, ensuring safety for people, this can however interfere with the desired expression of the building, therefore finding solutions relevant to safety and health while maintaining the genius loci of the building (Highfield's, 1987).

ill.5. Fabers Fabrikker
credit Arcgency

case study

FABERS FABRIKKER

Architect: *Arcgency*
Building typology: *smaller production building*
Location: *Ryslinge, Denmark*
Year: *1905, renovated in 2016-2020*

Denmark's rural areas have a rich building heritage that is at risk of being lost. Old factories and station buildings are left empty and deteriorating, as there is not the same economic incentive to transform them as in larger cities (Renover, n.d).
The building is originally an old factory, in which newer housing developments have taken shape within the existing envelope. The idea of building within a building creates rooms that honor the cultural heritage, while creating sustainable and affordable housing. Within the transformation the original building is part of the interior creating tactility and variation in materials. The variation in materials creates a clear understanding of what is newly developed and what is the original building, this is done through the use of contrast, by not trying to mimic the original materials in the new part, but finding materials that are used in modern building while taking into account how the different materials meet and the connection between them (BARK, 2023).

A key identification piece of the building was the original chimney, this chimney has through the development of the building been keeped in its original appearance making the building recognizable for the local community and maintaining the cultural heritage, the chimney does not have a function besides creating an identity for the development (BARK, 2023).

defining the

MATRIX

				atmospheric potential			site position
parameter				**Tactility**	**Patina**	**Reflection**	**Cultural heritage**
weight 0-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*
value point 1-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*

Result: ______________

When creating the matrix for choosing materials, the theories **Transformation** and **Atmospheric potentials**, has developed four parameters for the matrix.
These parameters will help decide the materials for the specific scenario the matrix will be used in - which will be described later.
The theories have developed these parameters: **tactility, patina, reflection and cultural heritage.**

Tactility, will describe the sensory experience of the material, through visual-, atmospheric-, acoustic qualities and interaction.

Patina, will be describe through the history and how the materials change expression over time

Reflection, will describe the materials color and how the specific scenario will be experienced, according to warm/cold and light/dark.

Cultural heritage, will be visible through value-setting elements on the specific site, according to their cultural heritage and the worth of preservation.

These parameters will get different weights from 0 to 5, which will describe the significance of the materials properties in the specific scenario.

MATERIALISTIC POTENTIAL

This chapter will touch upon Life Cycle Assessment, LCA, and material theory that will be used when creating the material catalog. Investigations made on how to calculate LCA and how different aspects of materials can have an impact on the building not just based on typical subjects like price and aesthetics but more in depth with specifically technical aspects of materials. This will all be included in the catalog.

WHAT IS LCA

LCA has been practiced since the early 1960s to assess the environmental impact of materials and other products. It was firstly referred to as the Resource and Environmental Profile Analysis (REPA) by the US environmental protection agency (Muthu, 2021). Later in the 1970s it was referred to as the *"cradle-to-grave assessment"* (Ling-Chin, 2015). This name was a reflection on the use of the assessment, it is used as an environment management tool that can assess the outcome of a specific product from cradle to grave. Cradle to grave is the academic term for an assessment that reflects a dataset from the early extraction of raw materials to the end of life of any specific product thereby assessing the entire lifetime of the materials.

LCA is often considered a decision-supporting tool evaluating the positive and negative effect of the product. This results in necessary information for understanding and decision-making, thereby creating the basis for material choices based on environmental considerations (Muthu, 2021).

METHODS

A series of standards were in 2000 conducted for the LCA assessment, these standards are listed in tabel 1.

STANDARDS	STAGES OF ASSESSMENT
Environmental Management 14040	LCA - principles and framework
Environmental Management 14041	LCA - goal and scope definition and inventory analysis
Environmental Management 14042	LCA - impact assessment

(Muthu, 2021, p.8, Tabel.1)

ISO 14067 is the basis for greenhouse gas assessment and incorporates the carbon footprint of products (Muthu, 2021).
The document also specifies the requirements and guidelines for the assessment on carbon footprint in relation to standards by International Standards On Life Cycle Assessment.
ISO 14067:2018 also divides the calculations into the different stages of LCA, and are the basis for all LCA based calculations. This is specified in Section 3.1.4.2. where it states the division of LCA calculations into 5 different categories: *"raw material acquisition, production, distribution, use and end-of-life treatment"* (Dansk Standard, 2018).

- Procurement of raw materials Manufacturing of building materials

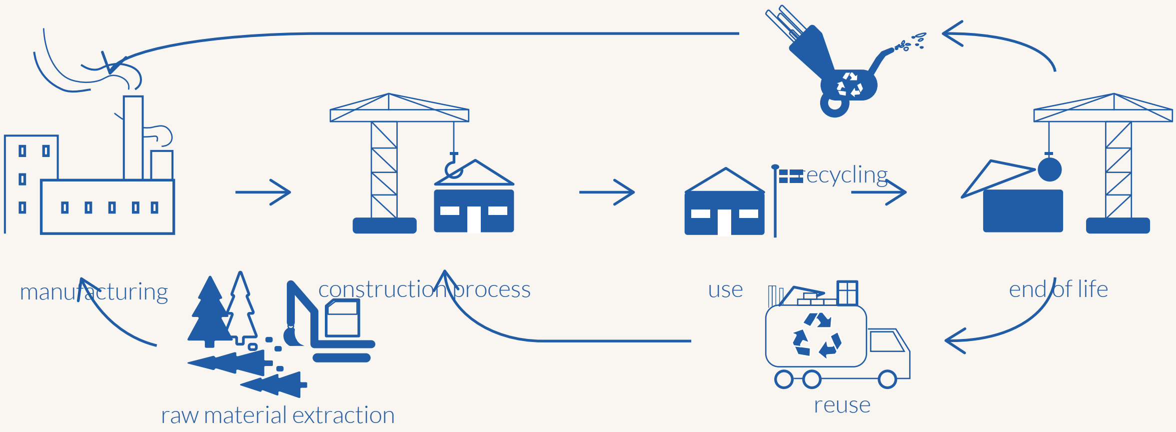
- Construction process - construction and transport

- Usage, energy and resource consumption for operation and replacement of building materials

- End of service life demolition, waste treatment and disposal

- Possible reuse and recycling of building parts and building materials

(Trafik-, Bygge- og Boligstyrelsen, 2020)

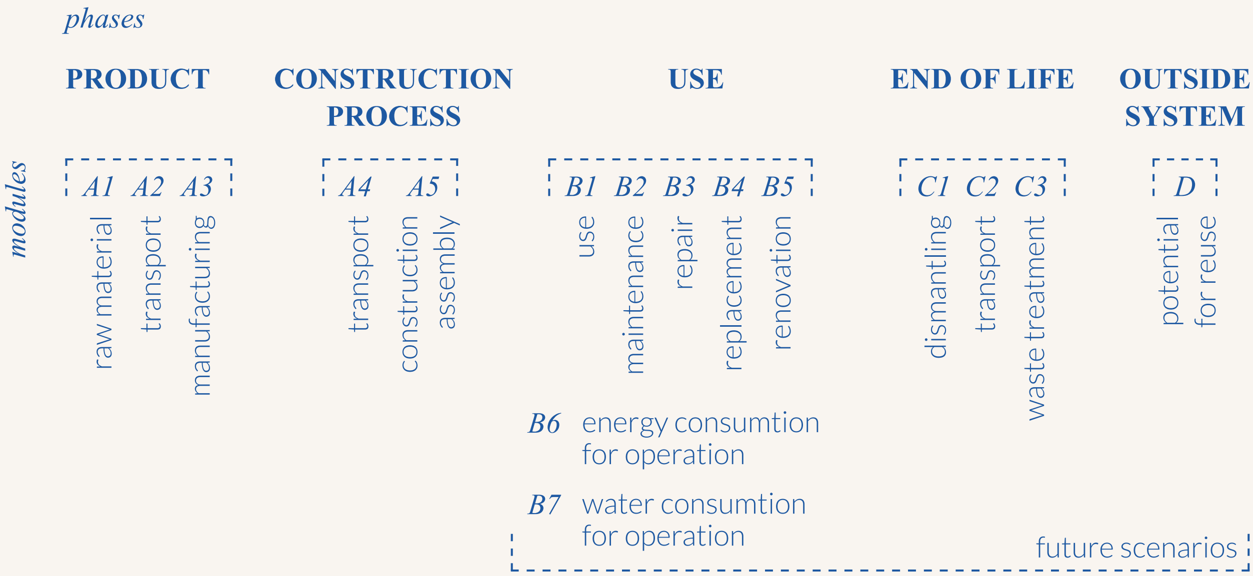


ill.6. life cycle assessment, LCA

In recent years, LCA has undergone significant development, which is reflected in the evolution of the LCA cycle. The original LCA cycle, as described in ISO 14067:2000, consisted of only five phases, while more recent iterations have added additional steps (Dansk Standard, 2018). The version presented here is based on the perspective of *"Den Frivillige Bæredygtighedsklasse"* in LCA. The different phases are described using letters to identify the stage within the product's lifetime (Trafik-, Bygge- og Boligstyrelsen, 2020).

These identification labels help locate necessary information within the Environmental Product Declaration (EPD), which is used to calculate emission produced throughout the life-cycle of the product. LCA calculations can be conducted within the program LCAbyg, based on the EPD database, *"EPD Denmark"*. LCAbyg takes into account the different stages for each product, while maintaining information on all products used within the building. In addition to this data transportation can also be described. With all necessary information in LCAbyg, calculations and charts will be developed to support the designers decision making. There is however one value that is not taken into account on the total calculated emission, this is the D-value, which describes the possibility for reuse or recycling of building elements (Jørgensen, 2020).

In recent years, recycling has become synonymous with sustainability. However, from the perspective of the LCA calculations, using new material with the intent of future recycling does not necessarily result in a lower CO_2 emission. Nevertheless, utilizing materials from existing buildings can lead to a reduction in the overall calculated CO_2 emission. This is due to the future recycling of materials will be part of calculation for the receiving building.



(Andersen, 2021)

DANISH 2023 REQUIREMENTS

In accordance with the requirements that become effective on January 1st, 2023, the calculation of climate impact must encompass the production of building materials (A1, A2, A3), the usage of the building (B4, B6), and the end-of-life treatment of the building (C3, C4). The requirement is set at 12 kg CO_2 / m^2 for buildings exceeding 1,000 m^2. Beginning in 2025, when the threshold value is tightened from 12 kg CO_2 / m^2 to 10.5 kg CO_2 / m^2, the building process including A4 and A5 must also be included in the calculation (DI Byggeri, 2022). Even though D-values are not part of the calculation for this specific building it can still be seen as a positive contribution to the world. Therefore even though it can in some cases increase the total calculated emission it would still be beneficial, when taken into account future building projects that might receive the materials.

MATERIALS CHOICES

Throughout the process of designing the beach hotel material exploration will take its basis in LCA, however these materials choices will reflect on multiple specifications within the materials. This includes durability, thermal conductivity, visual-, thermal- and atmospheric specifications ect. All these different aspects will be documented within a matrix taking into account all relevant qualities. This will help identify the most suitable materials based on the prioritized qualities for the specific project.

Material specifications can have a huge impact on the building, this is why throughout the project a focus will be put on identifying strengths and weaknesses for each material and then comparing them to other materials to get the best suited for the specific scenario. Even though sustainability is the main focus of the project, it is still highly relevant to dive deeper into the materials and gain an understanding for the qualities each material can offer.

Sustainability is often seen as the ecological result of a material's global warming potential (GWP). However the total carbon footprint should always be reflected in relation to time. This is the main basis for LCA calculation tools such as LCAbyg, oftentimes the period of analysis highly impacts the results, therefore it is relevant to reflect on a relevant time period and from there decide materials, understanding that replacing materials will have an impact on the total global warming potential (GWP).

Some materials have a long lifetime, these materials will however oftentimes create a bigger footprint, therefore analyzing the situation in which the building will be saturated and from there choosing materials that either will be replaced with a low footprint or durable materials that will last a lifetime but with a higher carbon footprint (Environ. Sci. Technol. 2010).

LOCATIONS, CORROSION AND WEAR

The beach hotel will be located in an area highly exposed to different elements, thereby durability is an important factor when selection exterior materials. Therefore finding durable materials with low emission will be the main objective. The proximity to the beach can lead to saltwater corrosion. This phenomenon is often discussed in relation to steel buildings located close to the ocean, here the process is already known of rust development if not designed properly

(Risk Logic, 2022). But just like the salts impact on steel buildings it also impacts wooden constructions, this is oftentimes not realized given that beachbridges and other constructions close to water are often constructed in wood. Wood constructions located close to seawater have a higher chance of rotting which will reduce the overall lifetime of the materials and therefore directly impacts the LCA calculations. However, reducing the salt's impact e.g. on wood can be achieved through various wood treatments. Rot often occurs when wood is directly exposed to ultraviolet (UV) radiation, causing cracks and splits which allow salt and water to penetrate and initiate the rotting (Modinex Group, n.d.).

PATINA

This exposure can however also be used efficiently to enhance the architectural quality by creating a space specific expression on the building. E.g. using steel well knowing that corrosion will happen, often this is used to create a maritime expression. This clever use of patina can make for quite interesting designs while promoting a sustainable approach where materials can live a full lifetime and will not be replaced based on appearance. Proximity specific elements such as saltwater and strong wind speeds can thereby help shape the building creating more holistic and site-bound design solutions. It is therefore important to understand the microclimate of an area before deciding materials. Another example of patina is Cedar wood, this woodtype is specifically known for its patina expression. Cedar wood is a red/yellow colored wood. However when in contact with UV the wood loses its color, turning it into a dull gray (Weather-wise, 2017).

Radiation can also impact materials in relation to the indoor environment. Some materials have a greater ability to store heat, these materials can help create a more stable indoor temperature throughout the day, thereby minimizing heating demands in the colder hours of the day (Pavlov, 2011).

Materials also impact the atmospheric, visual and acoustic indoor environment. Materials have a direct impact on a room's atmosphere. Air quality is impacted by the level of emission from the building materials measured in ohm (SBI-anvisning 182, 1995).

Creating a good atmospheric indoor environment is key factor in sustainable and great architecture. In relation light and sound reflectance should be investigated to create an understanding for which materials will optimize these aspects. Lighter materials are often reflecting light better around in the room, this can help lowering the operating emission from electric lighting. While understanding the acoustic qualities minimizes the need for additional supplies in the form of post construction absorbent material. Ultimately all these different aspects will when reflected upon in relation to each other create sustainable architecture with great functional usage. While always ensuring an aesthetic expression.

This extensive material understanding and reflection will be described within the **Catalog - Elaborated Material Exploration**. All previously mentioned aspects within this chapter will form as the theory when creating the matrix. While additionally add other aspects relevant to the specific project.

case study

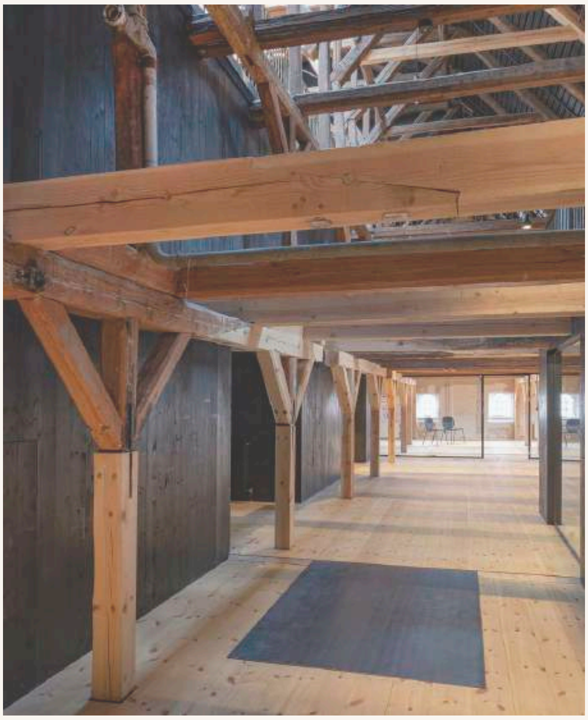
MALTFABRIKKEN

Architect: *Praksis Arkitekter*
Building typology: *Factory*
Location: *Ebeltoft, Denmark*
Year: *1905, renovated in 2016-2020*

The renovation project of the former town hall in Ebeltoft, led by Praksis Arkitekter, provides an excellent example for how to restore a historical building with great care and attention to the cultural heritage. The building's exterior is transformed by combining the old and the new, and by using Steni facades, they managed to create a modern interpretation that still blends seamlessly with the existing structure.

The strategy of preserving the original character while introducing new elements to the design is clearly shown throughout the renovation. The preservation of the cultural heritage is clearly seen in the building's exterior and interior by adding modern elements that fit with the genius loki of the existing building. The restoration included reviving details such as the original staircase and the intricate ceiling designs in the main hall. The renovation also introduced new facilities like a modern concert hall, exhibition spaces, and a café, which were carefully designed to complement the building's historic features (Praksis Arkitekter, n.d.).
When looking at the interior of the building almost all of the interior elements such as floor ceiling and walls were untouched, giving the building a very industrial look on the interior while serving as a landmark for Ebeltoft on the exterior. However this kind of transformation can easily become chaotic for the users of the rooms which fit very well the new use of the building, however this might not be in line with the kind of transformation needed in the cement factory. Therefore some elements from this case can be taken into account, when designing while others helped create an understanding for the importance of designing renovations projects individually. Do to the interior use of the building and the atmosphere for the people using it can differ (Praksis Arkitekter, n.d.).

Overall, the project serves as a remarkable example of how to renovate an old building while preserving its original charm. The architects paid great attention to detail, particularly with the exterior, and made sure that the new additions blended well with the existing structure. The end result is a functional, attractive space that beautifully honors the building's history while bringing it up to date with modern times.



ill.7. Maltfabrikken
credit Praksis Arkitekter, photo by: Jens Lindhe

ill.8. Det Danske Landsted
credit Norrøn, photo by: Hampus Berndtson

case study

DET DANSKE LANDSTED

Architect: *Norrøn*
Building typology: *Abandoned year-round residence*
Location: *Jungshoved, Denmark*
Year: *1939, renovated in 2020*

A Lot of buildings in Denmark's most nature filled areas outside the larger cities have become vacant, emptied of their former function as agricultural working areas or housing for employees of local businesses (BARK, 2023).

The building is originally an old agricultural year-round residential farmhouse, which has been given a new life, using the old buildings already existing in Denmark to create sustainable and beautiful architecture. Within this project a key element is the focus on telling a story of the original building. This is especially shown when looking at the facade. The facade has been divided into two contrasting materials showing the difference in the original and the extension. This case gives an example of an expression that could be implemented into the project, using new materials to identify extensions and to bring focus to the original building. However the new material is not decided solely based on the original building but also its context, trying to tell a story about the area and history (BARK, 2023).
The interior of the building is also quite interesting, as it incorporates both the original materials in walls and new elements made from the same materials but in different colors. This serves to highlight what's new and what's old, while maintaining the Genius loci of the interior design. Using the original building and what qualities it offers to ultimately lower the global warming potential, while incorporating sustainability when deciding new materials.

defining the

MATRIX

material potential

parameter

	GWP	Life time	Corrosion resistance				
weight 0-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*
value point 1-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*

Result: ______________

When creating the matrix for choosing materials, the theory **Materialistic potentials**, has developed four parameters for the matrix.
These parameters will help decide the materials for the specific scenario the matrix will be used in - which will be described later.
The theories have developed these parameters: **GWP, life time and corrosion resistance**.

GWP, will describe the materials global warming potential and life cycle assessment with focus on emission in the phases A, B and C.

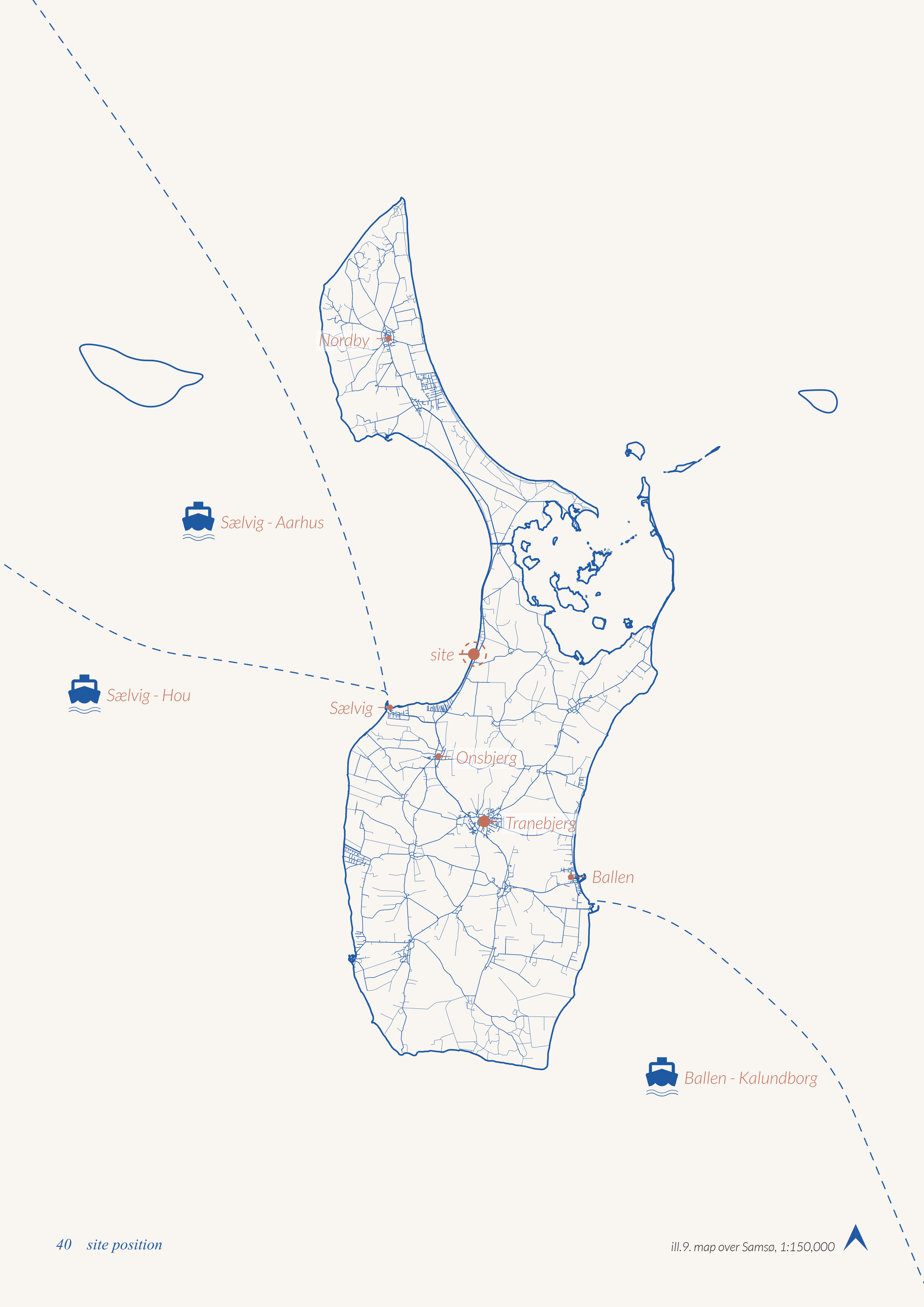
Life time, will describe the amount of time the specific material can be saturated at the site before the properties no longer meet the purpose and will be replaced.

Corrosion resistance, the durability of the material in relation to seawater exposure .

These parameters will get different weights from 0 to 5, which will describe the significance of the materials properties in the specific scenario.

SITE POSITION

*This chapter presents the site position and an analysis of the existing building, Cementvarefabrikken Sælvig. This chapter has a close relation to the catalog, **chapter Cement Factory page 12-23**, where a deeper description of the cement factory's atmosphere, structure, potentials and which elements should be maintained in the design process.*
In this chapter the existing construction, materials and atmosphere will be investigated, and the building's worthy of preservation according to the transformation method and the SAVE-method will be analyzed. Materials and atmosphere will be described shortly with focus on incorporating the previous theories.
This will create a point of origin for the design process, where the existing building will be transformed and redesigned. Likewise the microclimate on the site will be investigated, because of the close location to the coast and the future sea level rising.



ill.9. map over Samsø, 1:150,000

> “ *There is an island in the clear sea far closer to stars and clouds, yes, closer to morning and evening sun than noisy roads and cities* “

[translated from Danish to English]
Thorkild Bjørnvig: “Sang til indvielsen af Samsø Folkehøjskole”
(Koch, 2020 , p. 251)

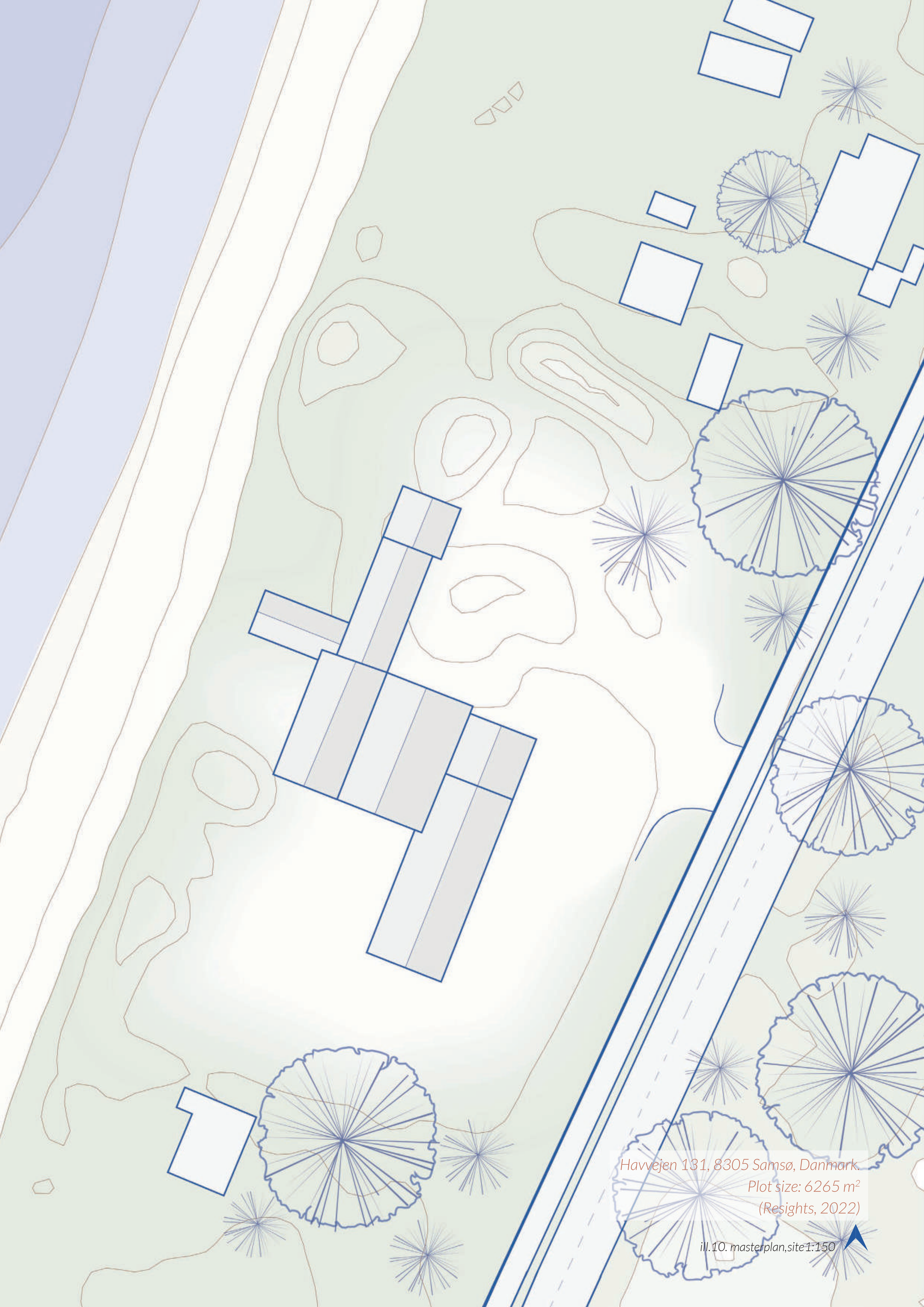
SAMSØ

Samsø is a small island in the southern Kattegat and is situated between Jutland and Sjælland, Denmark. Samsø is a part of Samsø Municipality and consists of several small islands (Koch, 2020). The island have a coastline of 100 km (VisitSamsø, 2022) and 60% of the municipality is covered by agriculture and horticulture (Koch, 2020). Historically Samsø is known as an agricultural island and has a strong brand with quality food products and large production of e.g. vegetables (Samsø Kommune, 2021). The nature of Samsø is appreciated by both residents and tourists and provides opportunities for activities all over the island.

The island is 114 m^2 with 3658 permanent people living there in 2020 (VisitSamsø, 2022). These people primarily settled in the main town Tranebjerg and the local towns Nordby, Ballen and Onsbjerg. Tranebjerg is the largest city on Samsø, with public institutions, healthcare, businesses, cultural and leisure activities. Tranebjerg is centrally located on the island, which means that the rest of the island is a reasonable distance from the city (Samsø Kommune, 2021).

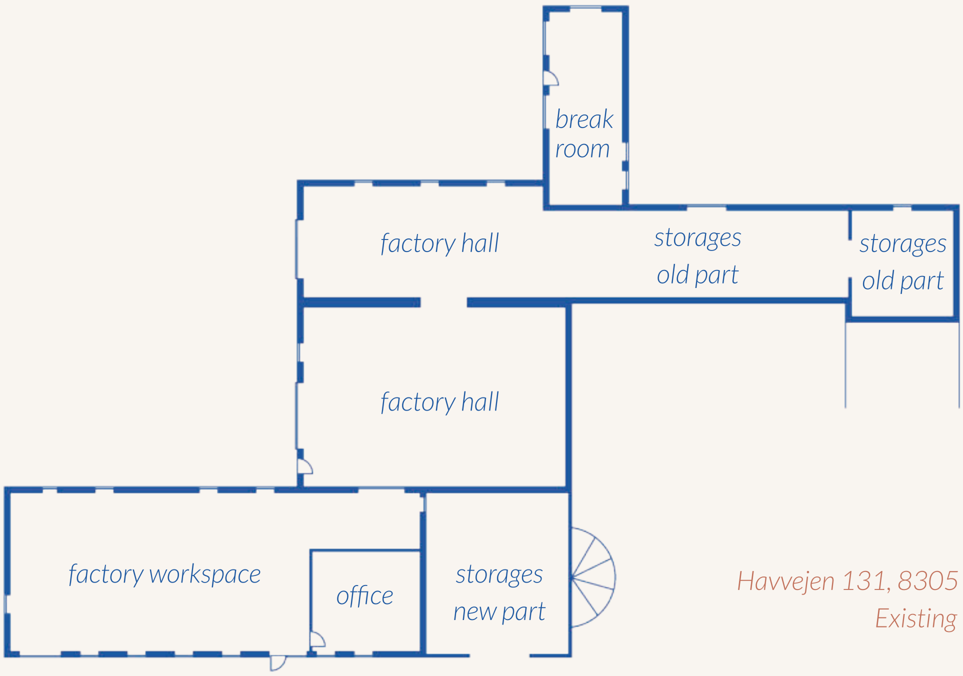
Nordby, Ballen and Onsbjerg are local towns and are attractive and safe settings for everyday citizens, with easy access to shopping. Nordby and Ballen are important tourist destinations, due to Nordby's authentic village environment and Ballen's maritime environment near the marinas. Likewise, Samsø consists of a number of villages, which are the island's special character and have an important role in the relationship with tourism (Samsø Kommune, 2021).

Transport to and from Samsø is with daily municipal ferry crossings, between Sælvig to Hou and Aarhus, and Ballen to Kalundborg. The marinas are also important arrival positions to Samsø, as many see these as the “gateway” to Samsø. Samsø has four well-functioning and attractive marinas and two ferry ports (VisitSamsø, 2022).
Samsø is also known for being self-sufficient. In 2007, Samsø became self-sufficient overall and has for many years produced renewable energy from wind, sun and biomass (Koch, 2020), and today produces more renewable energy than the island's residents and guests consume (Samsø Kommune, 2021).



Havvejen 131, 8305 Samsø, Danmark.
Plot size: 6265 m^2
(Resights, 2022)

ill.10. masterplan,site 1:150



Havvejen 131, 8305 Samsø, Danmark.
Existing building: 642 m2,
(Resights, 2022)

ill.11. floor plan, 1:400

CEMENTVAREFABRIKKEN SÆLVIG

The project site is located outside the ferry town Sælvig along Samsø's west coast. The site is placed in an open landscape, with a sandy beach towards Kattegat to the west and light forest to the east. The site is located in the area of Samsø where the municipality does not want afforestation (Samsø Kommune, 2021).

In the landscape, a few homes are located with nature surrounding them, as a protection from noise from Havvejen, which stretches from Sælvig and along the coast towards Nordby.
When arriving at the site, the storage, new part, and the workshop, which have a sign of the cement factory's name, are the first to see.
On the site a cement factory is located. The cement factory has existed since 1908 and the factory was founded by local farmers, where they produced concrete bricks and concrete roof tiles. The location of the factory was ideal, because of the easy access to stone and gravel, due to the location of the site close to the coast. Today the factory is still in use and supplies quality concrete, in the form of finished concrete, paving stones, stones, gravel etc. to companies and private individuals on Samsø (Cementvarefabrikken Sælvig ApS, n.d).
The cement factory consists of three different building structures and storage, new part. For creating an understanding of the building and its structures, floorplans, elevations and envelopes will be investigated. This knowledge and drawings will be a part of the transformation of the building. It is important to understand the existing building's room program and construction parts, according to optimizing the building's envelope and energy consumption, likewise which elements to reuse.

ill.12. site,exterior

SITE POTENTIALS, *exterior*

The building's exterior reflects its time. It has a classic structure with a pitched roof and roof-tile cladding. The building is plastered and painted yellow, and is in relation with the architecture on the island. However, the general form of the building is based on its function, not just ornamental **"disneyfication".** Its shape is directly related to its purpose, likewise reflected in the materials used. The materials used on the exterior of the building are similar to those used on the interior and gives a better understanding of the building. This construction method is in line with the idea that architecture should not be **fake** and create a **mask** for urban purposes. However, there are still **contrasts** between the interior and exterior of the building, even though the materials and form are related to the interior. The exterior has a sense of history because of the yellow color, but the entrance and interior felt cold and industrial. The exterior of the building reflects the principle of ***Aemulatio*** and ***Imitatio***. This can be seen in the materials used for the different building parts, which were chosen based on the time of construction. The oldest parts of the factory are constructed in bricks, while the newer parts use different materials like lightweight aggregate and wooden facades. **Imitatio**, is seen when the different materials and construction strategies, when trying to make it look like the original building.

ill.13. site,interior

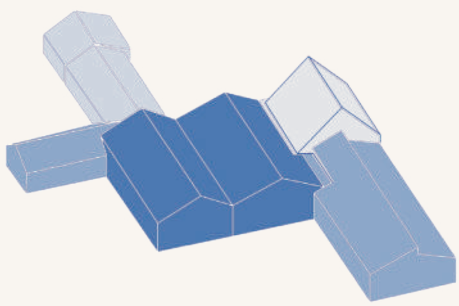
SITE POTENTIALS, *interior*

The building's interior is characterized by its use and time. Materials are heavily patinated from the work with cement, heavy duty equipment have created tear and marks in the ground and walls. When walking around within the construction the ideology of **palimpsest** is highly present. The different structures are constructed based on its time which implement the principles of **Aemulatio**. The roof structure is visible from the inside in part of the building while hidden in others. This gives an idea of the condition of the roof. In the storage, old part, the roofs are leaky and have sunken, these areas must be re-examined and either renovated or removed and remade based on **Highfields argument** that indoor health and safety is first priority. The worst situation within the roof construction is in a storage, old part, with hidden structural elements, therefore researching the state of the roof was not available. However given that it was hidden and nothing spectacular in the shape and construction methods **Translatio** might not be the most beneficial in this case. This goes for most parts of the construction elements within the cement factory. Only within special factory related construction methods could it be relevant to investigate **Translatio.** However for most of the building the focus when designing, based on the excursion, will be the principle of **Aemulatio**.

ENVELOPE

The cement factory can be divided into three building categories:

- **factory workspace**, consisting of a workshop, office and employee break room.
- **factory hall**, consisting of two large rooms with space for trucks etc.
- **storage**, consisting of two buildings with storages for trucks, materials etc.

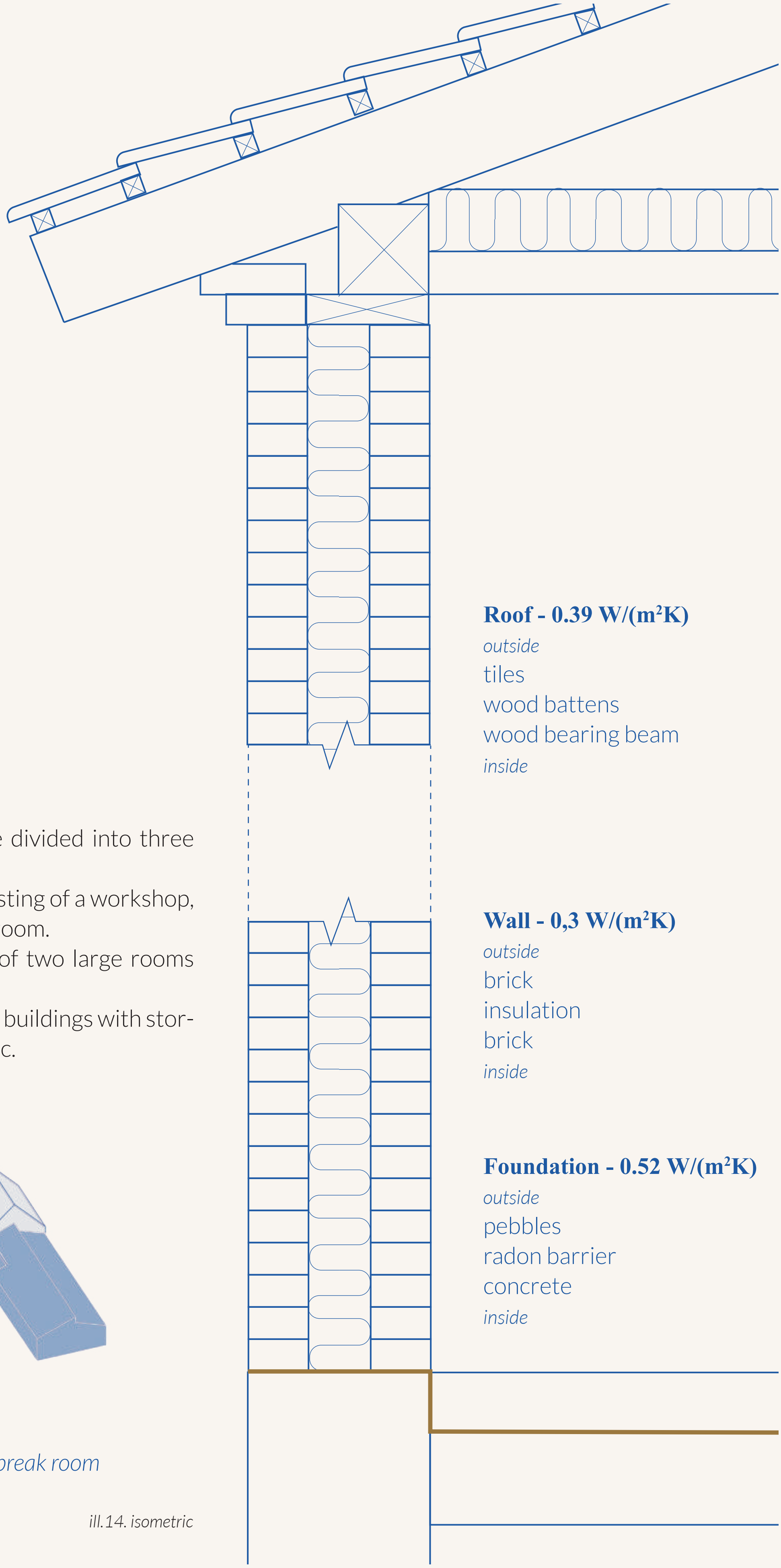


storages

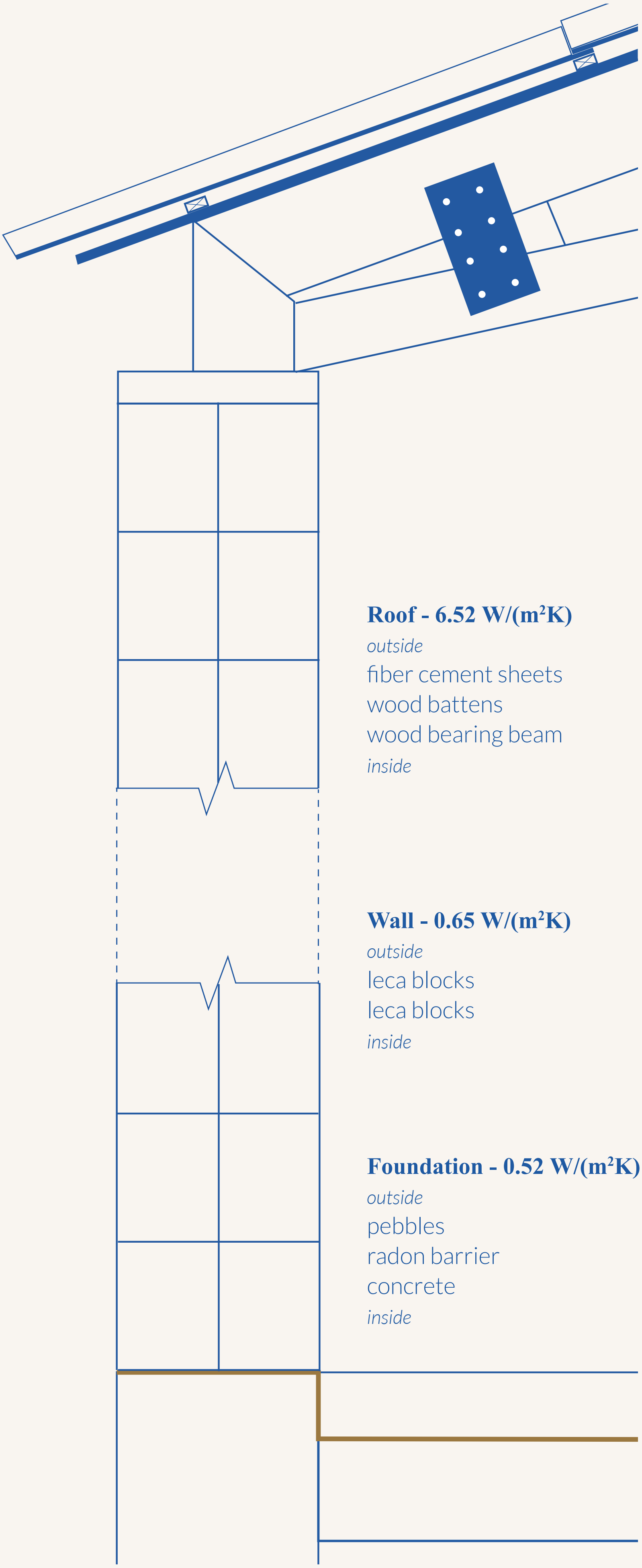
factory workspace and break room

factory hall

ill.14. isometric



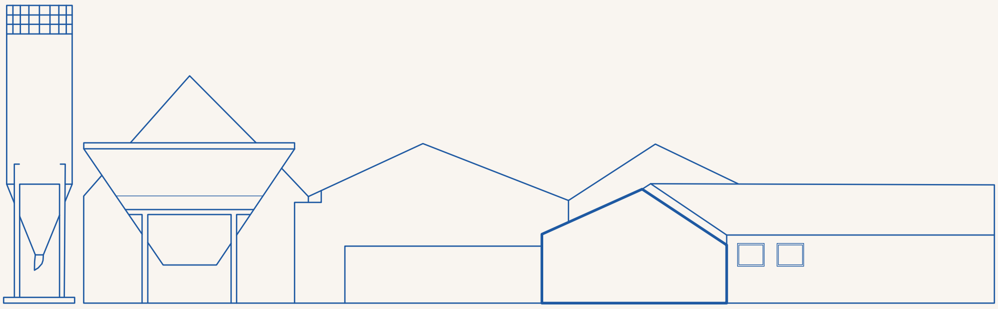
ill.15. envelope, factory workspace, 1:10



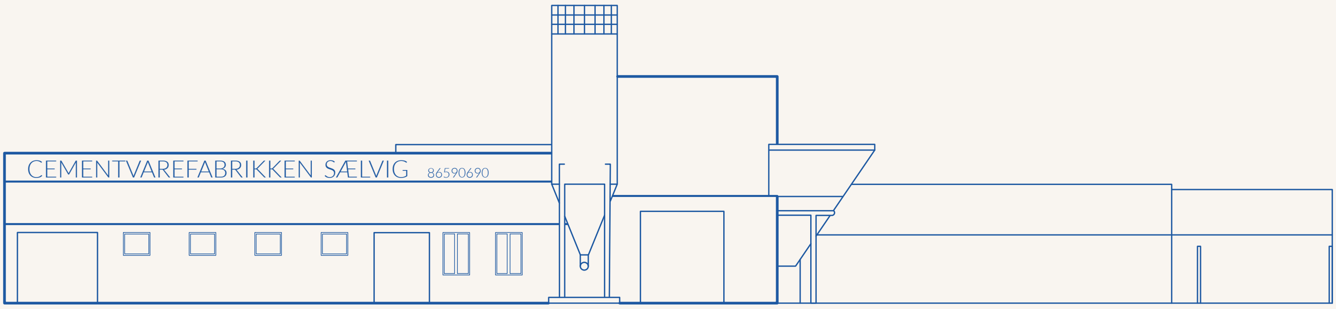
ill.16. envelope, factory hall, 1:10

The cement factory uses the principle of **palimpsest**, because it is clear to see how it changes over time, according to the different materials. The cement factory is plastered and painted yellow, but because of the weather, the materials underneath have become more visible over time.
The factory workspace is builded with bricks, where the two factory halls is built later with lightweight aggregate blocks. The cement factory is low on insulation in every building part.

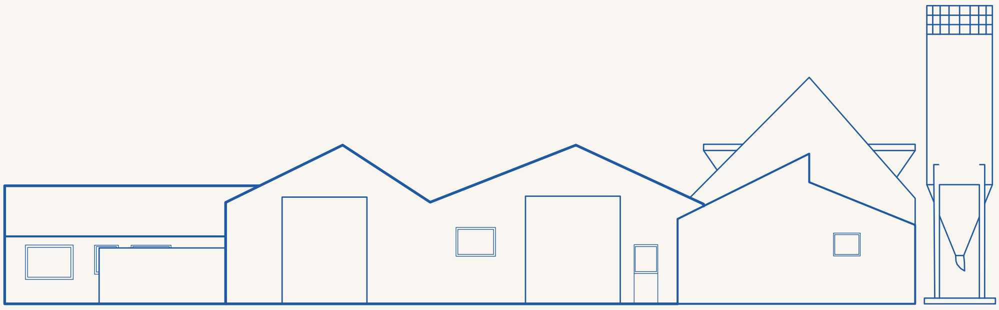
Two building envelopes have been developed with investigations from the excursion to the site and by information from Samsø municipality archives. When visiting the site, the building's structure and construction was investigated in depth, to create an understanding of which elements can be reused and which should be optimized, in regards to today's standards. In addition, U-values have been calculated, to understand the construction's thermal properties.



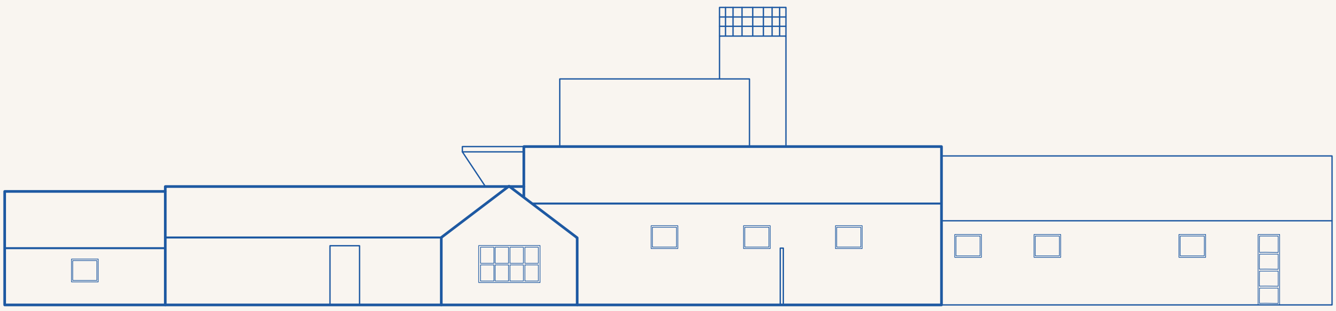
northeast elevation



southeast elevation



southwest elevation



northwest elevation

ill.17. Cementvarefabrikken Sælvig, elevations 1:150 *method*

TRANSFORMATION

During an excursion to the site, the cement factory's worthy preservation has been investigated based on the combined method between **Technical - historical - phenomenon base** and **SAVE method**. This method is carried out using registration from the site, both interior and exterior, desktop analyses, where floor plans, sections and elevations are studied. Together, this will form an understanding of the preservation worthy in the factory.

Architecture
Architectural value *(SAVE-method)*
Phenomenon base *(Technical - historical - phenomenon base)*

When arriving at the site, the yellow facade catches the eye and makes the cement factory stand out in its context. The yellow color helps to create warmth for the building. By moving around the building, the factory halls open up, allowing the roof structure to be seen. The large opening allows one to enter the factory and experience the play of the roof construction, where each building is marked with a roof ridge.
The location of the cement factory close to the coast allows for a relationship with the sea, where all the senses are engaged and creates a sensory experience.

Cultural heritage
Cultural historical value *(SAVE-method)*
Environmental value *(SAVE-method)*
Historical *(Technical - historical - phenomenon base)*

The yellow facade is also recognisable, as many houses on Samsø consist of similar yellow facades. This thus helps to create a cultural-historical relationship with Samsø.
The cement factory is from 1908, which can be seen in the use of bricks as a supporting element in the factory. The cement factory is also founded by local farmers, which creates a strong relationship with the site and the history of the factory, as an emotional connection is present for the local farmers.

Technical
Originality *(SAVE-method)*
Condition *(SAVE-method)*
Technical (*(Technical - historical - phenomenon base)*

When inspecting the factory, it was clear to see that the factory it is worn down and close to its end of life. The entire construction, structure and architecture are originally from when the factory was built and the factory halls were extended. However, it is important to emphasize that the building is characterized by its long life and low maintenance, as there are many holes in the walls, ceilings and floors around the building.

The chosen material for the construction of the factory is bricks, lightweight aggregate blocks and wooden rafters, which can last a long time. It varies in which form of rafter is used, because in the older parts of the building collar ties are used, and in the factory halls lattice trusses are used. This shift in the roof construction also divides the factory into smaller parts according to their functions - which from the outside gives play to the experience of the factory.
Therefore, it can be concluded that the condition is stable, and by a transformation and optimization of a building envelope, the building will be healthy for people to be in.

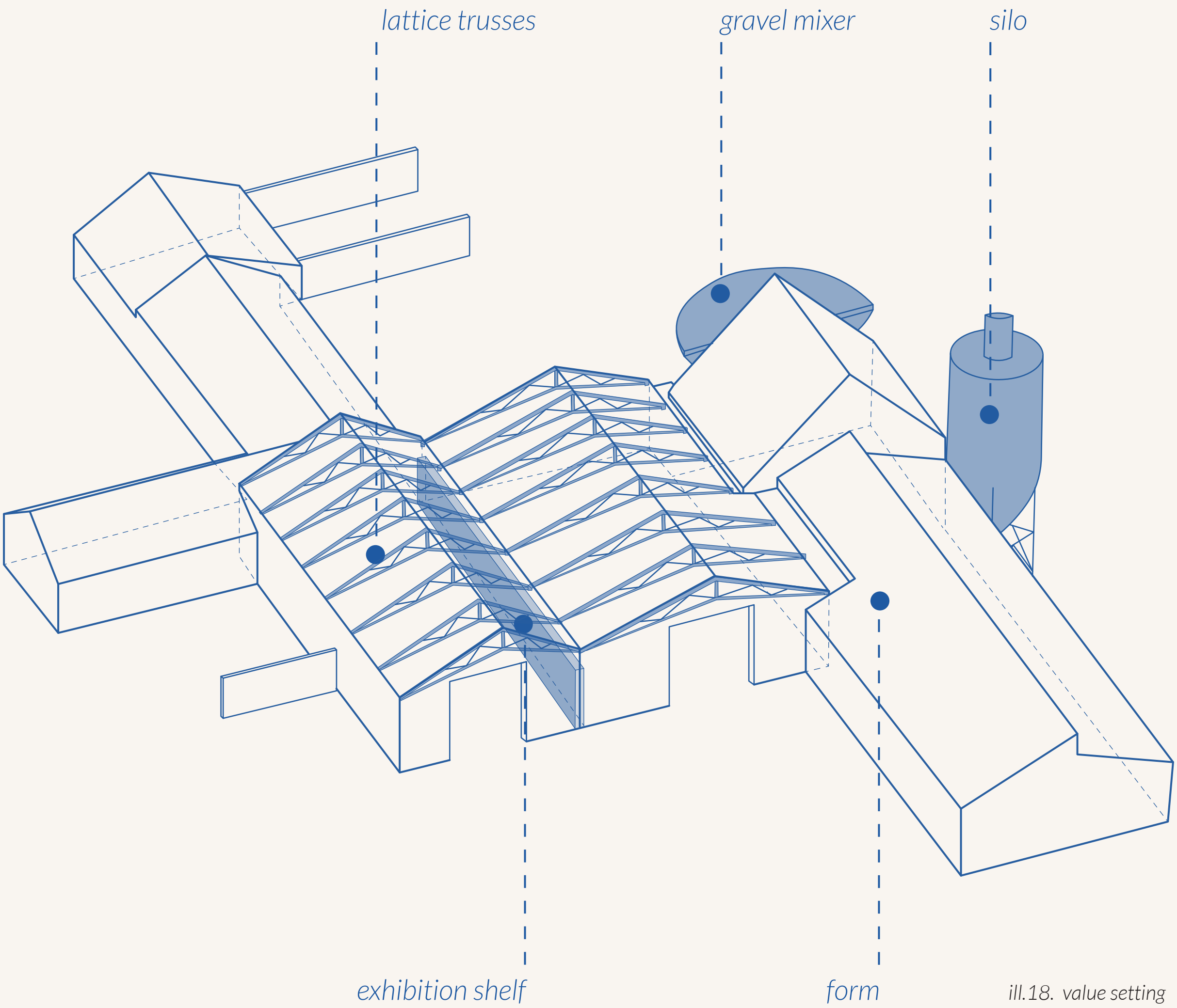
VALUE-SETTING

When **transforming** a specific building, it is important to understand the site's qualities and which elements have a strong connection to the site and the site's **history**.

The building is characterized by its *history* as a factory, different machinery with distinct shapes creating the identity on the building. Upon arrival at the site specific elements create the **atmosphere** of the building's **industrial era**, these elements should be honored and preserved to create stronger relation to the building for locals, but also for the users to understand the original identity of the building. Elements such as the **gravel mixer** and **silo** have distinct shapes that can help identify the building. However a complete preservation would result in the identity-defining elements being unusable and seen as historical **monuments** that might not correspond to the intended use of the building.
Therefore the 3 principle; ***Translatio, Imitatio*** and ***Aemulatio***, will be discussed doing the catalog to identify if an element has such a historical value that it should be left untouched, or if an optimization of the elements in relation to the modern use could be beneficial. However identical for all principles is to honor the element, doing a transformation of the element might remove some historical value but could also help make it a **landmark** though e.g. contrasts.

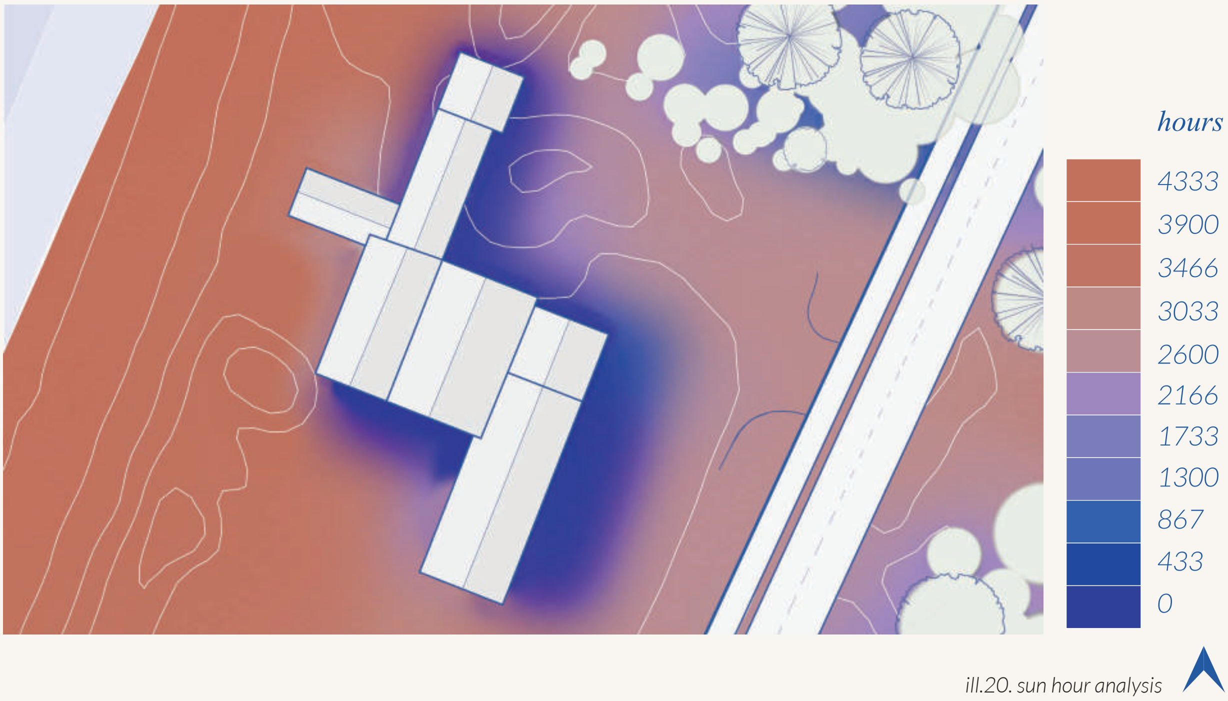
The building is likewise characterized by its shape, where the different functions in the building are its own structure. The roof construction helps support the understanding of a rooms function given the division of rooms using multiple pitched roofs. This overall shape of the building should be honored to insure the same identity when arriving at the building. From the exterior one volume in particular has a very unique identity; the factory workspace. The shape of this building should be considered **monumental** and atmospheric defining for the building. In order to keep the spirit of the place, and honor the nature, the renovation should remain humble on the exterior, relating to the existing building but should also implement the element of ***Aemulatio*** showing the relation between new and old. In order to keep as much nature as possible and to lower the **global warming potential** the building should be **renovated vertically** and not horizontally. This ensures no need for further expanding into the sounding nature, while making the new development visible though material choices. When renovating the walls should be optimized inwards to keep the humble exterior appearance and honor the patina created though its lifetime, while the interior should keep specific elements and implement them in new sensory architecture. When looking inside the building, many elements become characteristic for the building, however the visible roof construction within the factory-halls was a clear gesture upon entry.

This **gesture** should be kept to create the historical atmosphere of the room. In the same room a beautiful interior wall is located. This wall is an exhibition wall which could showcase different elements while remaining as a piece of history, this wall will therefore also be preserved.

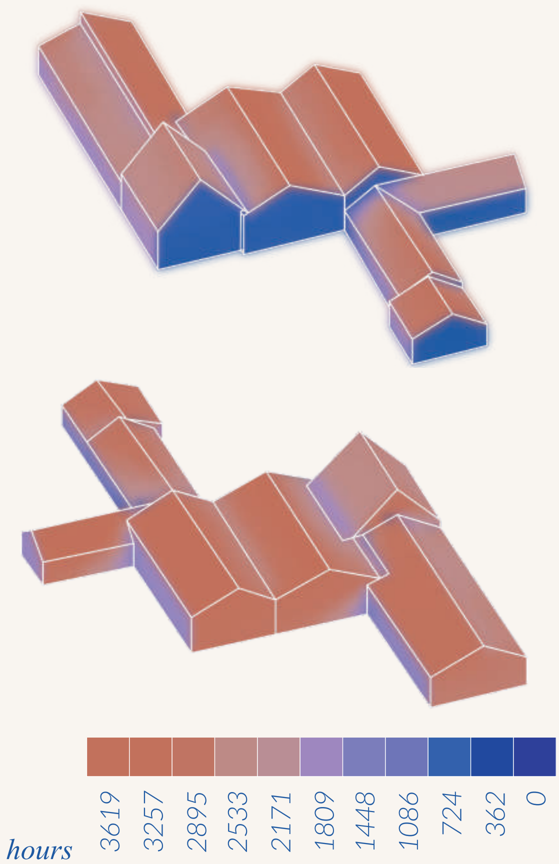


ill.18. value setting

ill.19. value setting, images from site



ill.20. sun hour analysis



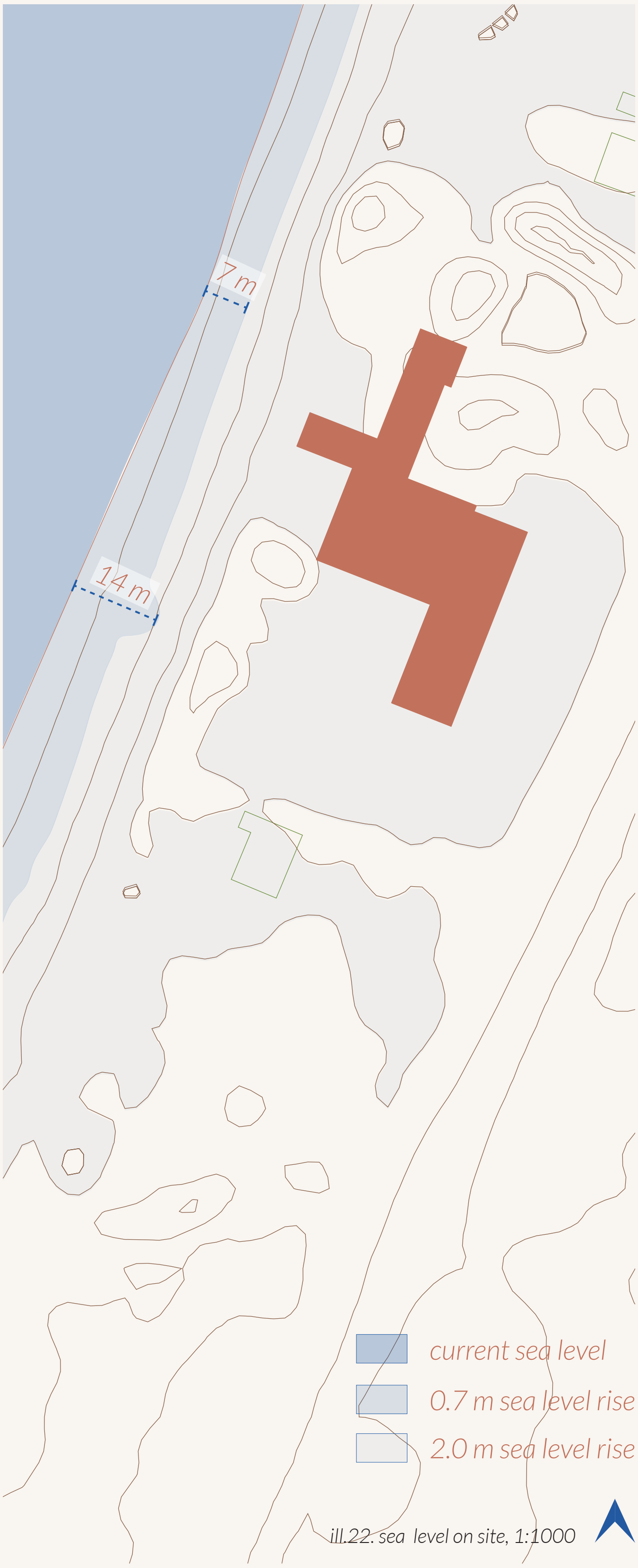
ill.21. sun hour analysis

MICROCLIMATE

SUN

The cement factory is located near a coastline, where it is exposed to sun and wind. In order to understand the site's microclimate qualities, sun and wind analysis have been conducted.
A **sun hour analysis** has been developed, to understand the sun conditions both at the context and on the building. The sun hour has been developed based on a year, to give opportunities to the design of a beach hotel that can be useful throughout a year.

The analysis shows that some trees on the site create shadows in the northeast and southeast corner of the site, but the sun still reaches the site 1/3 of the time of a year. The significant shadows on the site are caused by the building itself. This is the same with the amount of sun that reaches the facade directly, because it is primarily the building volume that creates shadows on the surfaces.



ill.22. sea level on site, 1:1000

COAST

Samsø is located in Kattegat and thus the coasts are exposed to rising seas. Coastal erosion is occurring on Samsø, to the extent that the island is getting smaller, especially around Ballen in the eastern part of the island. This area is also the most exposed on Samsø, in relation to storm surges (Samsø Kommune, 2020).
The site and the building are located 21.3 meters from the coastline, which means that investigation of sea level rise and coastal protection is important. Sea level rise will be a permanent problem, and therefore it is important to investigate in order to understand the site and how it can be utilized.

It is known with certainty that sea level rise will occur in the future, however it is uncertain to what extent it will occur. In the report *"Den Lille Blå Parlør om Havstigning"* from 2023, a scenario has been prepared for what sea level rise will be like in 2100. In this scenario, the expected sea level rise is 0.7 meters, where the worst case scenario is a 2 meter sea level rise (Wiberg, 2022).
This thesis project is focusing on the scenario with sea level rise of 0.7 meters. This is done to ensure that the design of the beach hotel is future-proof. Likewise, worst case scenarios are not taken as a point of departure, as it appears in the report that these analyzes have great uncertainty (Wiberg, 2022).

The map shows the sea level rise around the site, where it can be concluded that the expected sea level rise will not affect the existing building. The map shows that the coastline will rise between 7.0 - 14.0 meters.
This mapping will contribute to the design, as the plot size is connected so that the new building will be located within the future coastline, as well as the selection of materials must be able to withstand contact with seawater.

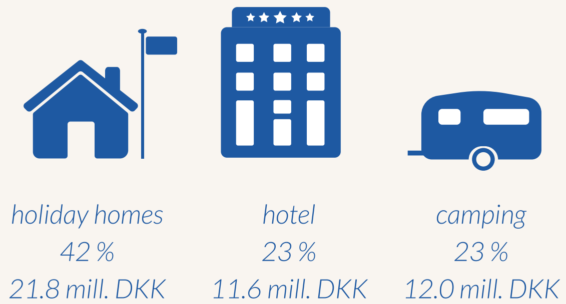
USERS

This chapter explains the users of the beach hotel. The chapter investigates tourism in Denmark and highlights three main target tourism groups: Coastal and nature tourism, Metropolis tourism and Business tourism.
Samsø is a holiday island with tourism from the target group coastal nature tourism, which has been investigated to clarify the user group, for creating and understanding for who the beach hotel should be designed to.

ill.23. Denmark

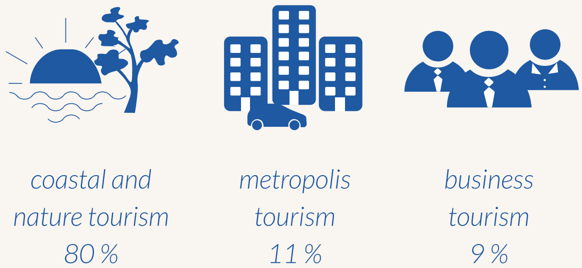
TOURISM IN DENMARK

Tourism is important for Denmark, both to show Denmark to national and international tourists, but also has an economic significance for Danish society.
Tourism revenue contributes to growth and the creation of more job opportunities. Tourism until 2020 (corona pandemic) was characterized by seven years of growth in the number of overnight stays (VisitDenmark, 2022).
Danish tourism generates revenue for the number of national and international overnight stays. National overnight stays in 2021 generated a revenue of 34.3 mill. DKK, which is an increase of 20.5% compared to 2020. International overnight stays in 2021 generated a revenue of 17.1 mill. DKK, which is an increase of 15.5% compared to 2020 (VisitDenmark, 2022).
This is an increase of 15.5%, with a total revenue of 51.5 mill. DKK in 2021 (VisitDenmark, 2022).



ill.24. distribution of overnight stays (VisitDenmark, 2022)

These overnight stays are spread over a variety of accommodation options, where the primary accommodation options are holiday homes, camping and hotels (VisitDenmark, 2022).

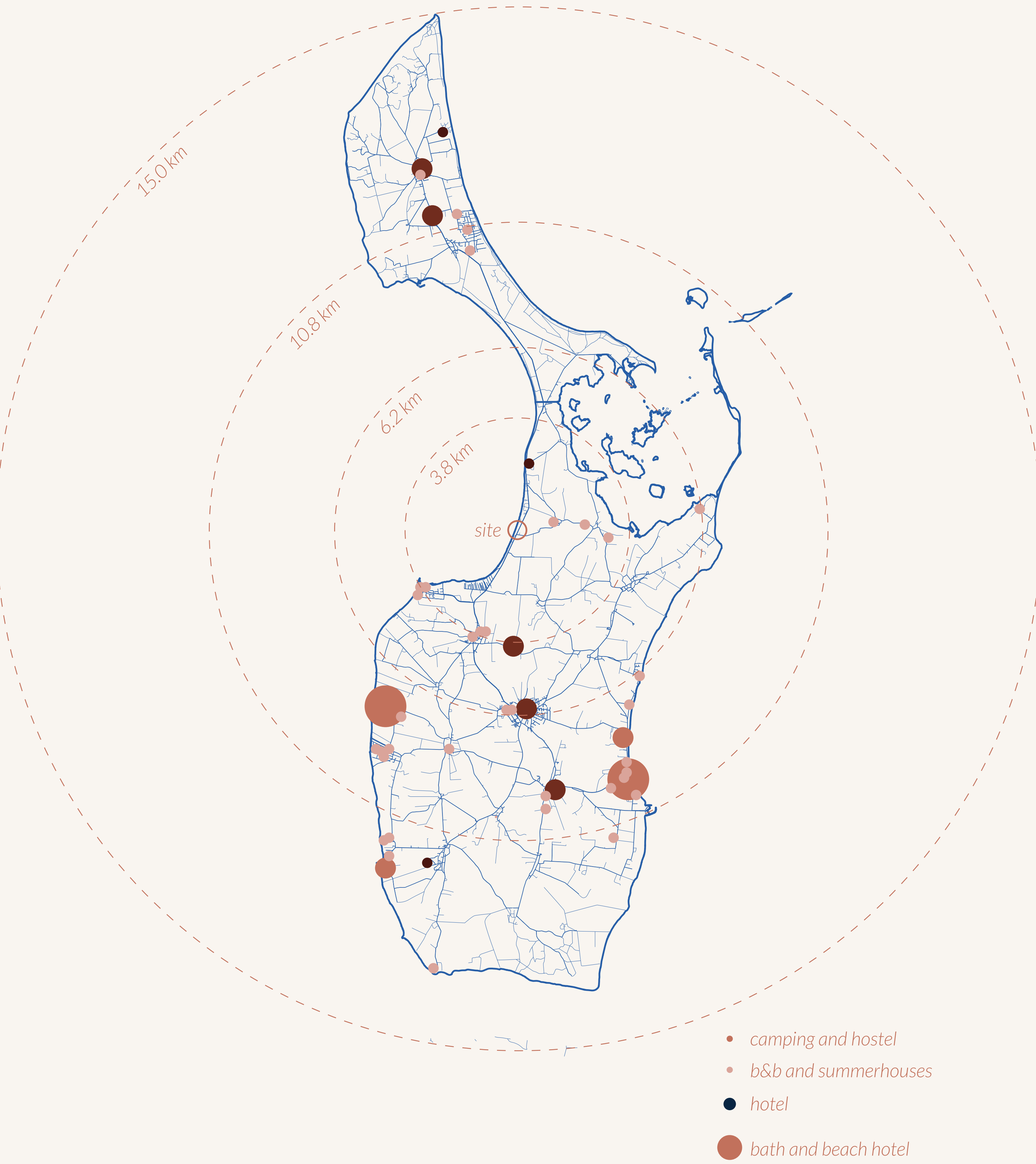


ill.25. 3 main target tourism (VisitDenmark, 2022)

Danish tourism can be divided into 3 main target tourism: ***Coastal and nature tourism, Metropolis tourism*** and ***Business tourism*** (VisitDenmark, 2022).

Coastal and nature tourism is the largest tourism within Danish tourism, and defines stays outside the four large Danish cities: Copenhagen, Aarhus, Aalborg and Odense (VisitDenmark, 2019).
This main target tourism choice is to relax and enjoy nature. Tourists spend their time on historical attractions and other experiences that the coast and nature can provide. 42% of the tourists' overnight stays are made in the high season in July and August (VisitDenmark, 2019).

VisitDenmark, the national tourism organization in Denmark, has in recent years promoted sustainable tourism through economic, social and environmental considerations. VisitDenmark takes the initiative to develop these considerations by spreading tourism over larger parts of the year and not just in the high season. Denmark is hereby marketed outside the high season and for seasonally extended activities (VisitDenmark, 2021).



ill.26. Samsø distances and map over accommodation options, 1:150,000

TOURISM ON SAMSØ

Tourism is Samsø's largest industry. The tourism revenue has a large influence on the island's value added, with tourism accounting for 19.8% of the total value added in 2016. This means that approximately 1/3 of Samsø's added value comes from tourism (Samsø Kommune, 2021).

Since the 1930s, tourism has been a part of Samsø's identity and business, where Samsø is today associated with holidays and experiences. In 2020, Samsø had 340,692 tourists, which is an increase of 40% from 2015, with 244,405 tourists. This growth has brought new business operators in tourism, where in 2020 there were more than 55 commercial accommodation options, 35 eating places, small and large retail outlets and numerous attractions spread over the island (Samsø Kommune, 2021).
These attractions are characterized by nature on the island and thus provide recreational opportunities for the tourists, such as hiking, cycling, primitive accommodation, horse riding, etc. Likewise, Samsø architecture is part of the island's attractions, where tourists get an insight into the island's history (Samsø Kommune, 2021) .
For the past 10 years, the tourist season has been extended as part of VisitDenmark's initiative for *"sustainable tourism"* (VisitDenmark, 2021), which means that Samsø tries to extend the tourism on the island. The tourist season used to be concentrated around the school summer holidays, but now extends from before easter to after the autumn holiday. This has led to greater businesses and more job opportunities, which provides the opportunity for greater settlement on the island (Samsø Kommune, 2021).

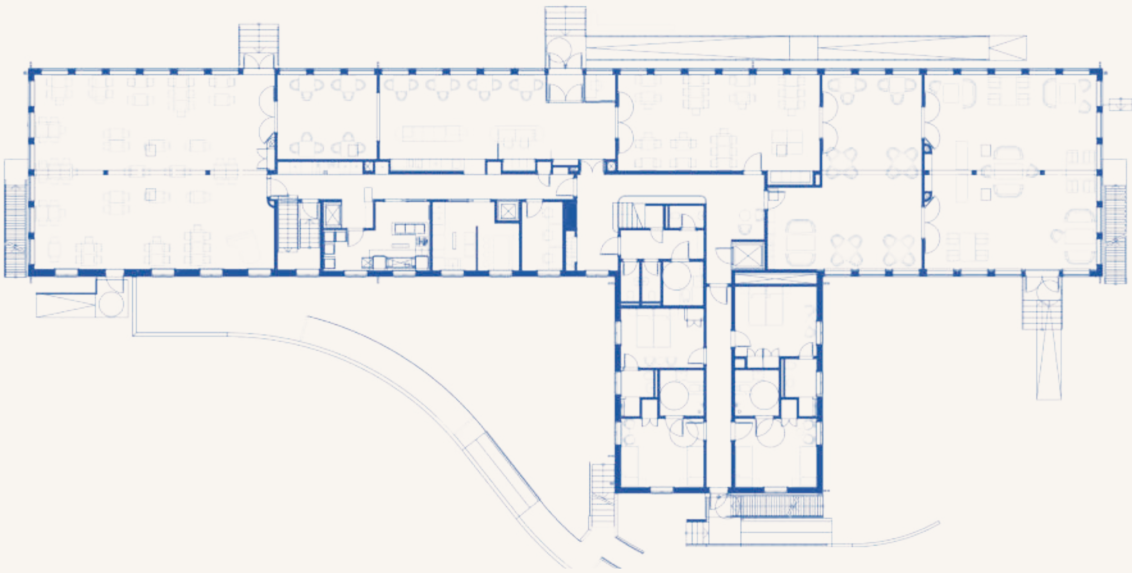
DANISH BEACH HOTELS

The Danish beach hotels are part of Denmark's cultural history, as they show a very special development of tourism in the late 1800s to the early 1900s.

In Denmark, the first beach hotels were built in the late 1800s and are the essence of Danish summer. The phenomenon behind beach hotels occurred when the middle classes, e.g. from Copenhagen, spent seasons at health resorts, country homes and especially beach hotels (Just, 2017).
Beach hotels thus became a place where the middle class spent their holidays, preferably one month at a time. The women in particular spent a whole season at the beach hotels, where they were installed with nannies who could take care of the children, while the women kept company with each other. For the men it was a different reality, they worked during the weekdays and visited their wives and children on the weekends. Thus, a holiday on the Danish coast marks the start of the era of tourism, where the historical glory of the beach hotel was between the first and second world wars (Just, 2017).

Holidays on the Danish coast were something other than the noise of the big city, where the wealthy citizens came from. By staying at a beach hotel on the Danish coast, one merge with the surroundings. The guests spent entire seasons together and thus gained a close relationship with each other, due to the fact that the beach hotel usually consisted of a small number of rooms (Elmquist, 2003).
However, it was atypical to be near the coast. Before the Age of Enlightenment (in Denmark, 1750-1800), people had a biblical fear of the sea. It was believed that the sea took life and was unclean. However, beach hotels changed this fear, as guests discovered the beach and how the calming sounds of the waves put one completely at ease and into gear (Just, 2017).
The food at the beach hotels was also something the guests looked forward to. When the doors opened to the dining room, all guests were excited about the chef's efforts, and the constant buzz in the dining room had a generative atmosphere for the beach hotel (Elmquist, 2003).
One can thus conclude that **beach hotels are characterized by location by the coast, close relationships between the guests and relaxation from the busy everyday life.**

The small beach hotels have since developed with time. In Denmark in the1920s, a number of summer houses were established, which gave the Danes the opportunity to extend their holiday stay. Likewise, around 1950, people wanted to go out and see the whole world and not just experience national areas. This was the starting point for the package holiday industry, which created a different type of beach hotels located on other exotic coasts and in other formats (Just, 2017).



ill.27. floor plan Svinkløv Badehotel, 1:400
credit: Praksis Arkitekter

case study

SVINKLØV BADEHOTEL

Architect: *Ejnar Packness*
Architect (renovation): *Praksis Arkitekter*
Location: *Fjerritslev, Denmark*
Area: *2180 m²*
Year: *1925, renovated in 2017-2019*

By studying Svinkløv Badehotel, the function of a beach hotel will be clarified, according to rooms and connections. The floor plan of Svinkløv Badehotel is studied, in order to form an overview of space, context and location. This will contribute to the preparation of the room program and function diagrams.

Svinkløv Badehotel was originally designed in 1925 by Ejnar Packness (1879-1952). Originally, the hotel was small, and today only forms a small part of Svinkløv Badehotel. In 2016, an unexpected and all-consuming fire occurred, which left many people with memories of the hotel's history, as the beach hotel is based on traditions far back in time and close friendships (Svinkløv Badehotel, 2023).

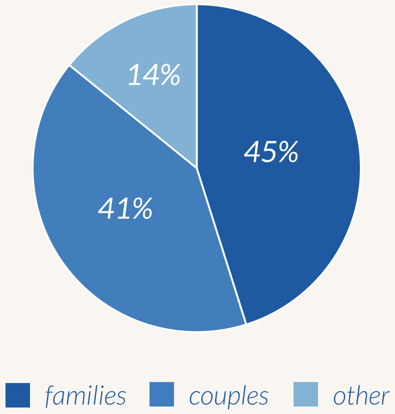
Svinkløv Badehotel, which stands today after the fire in 2016, is designed by Praksis Arkitekter, with great respect for Tackness' iconic wooden building, where several rooms have been added (Svinkløv Badehotel, 2023).
Svinkløv Badehotel consists of a large number of functions, distributed in the main building and an annex a few meters from the main building. The starting point is the main building's functions:

Ground floor
- 2 double bedrooms, with attached bathroom
- 2 disabled-friendly double bedrooms with attached disabled-friendly bathroom
- 4 dining rooms, with associated kitchen for cooking
- 2 living rooms
- Administration
- Reception

1. floor
- 23 double bedrooms, with attached bathroom

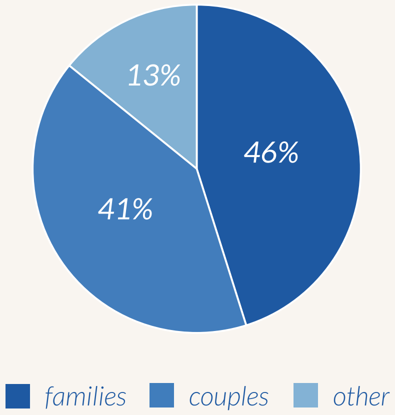
Basement
- Kitchen
- Kitchen storage and depot

See appendix 1 for Svinkløb Badehotel's floorplans.



ill.28. 3 main target tourism (VisitDenmark, 2022)

National tourist travel group in Denmark:
45% traveled as families with children under 18 years of age.
41% traveled as couples, friends or several couples together.
The remaining 14% travel alone or with a larger travel agent.
(VisitDenmark, 2019)



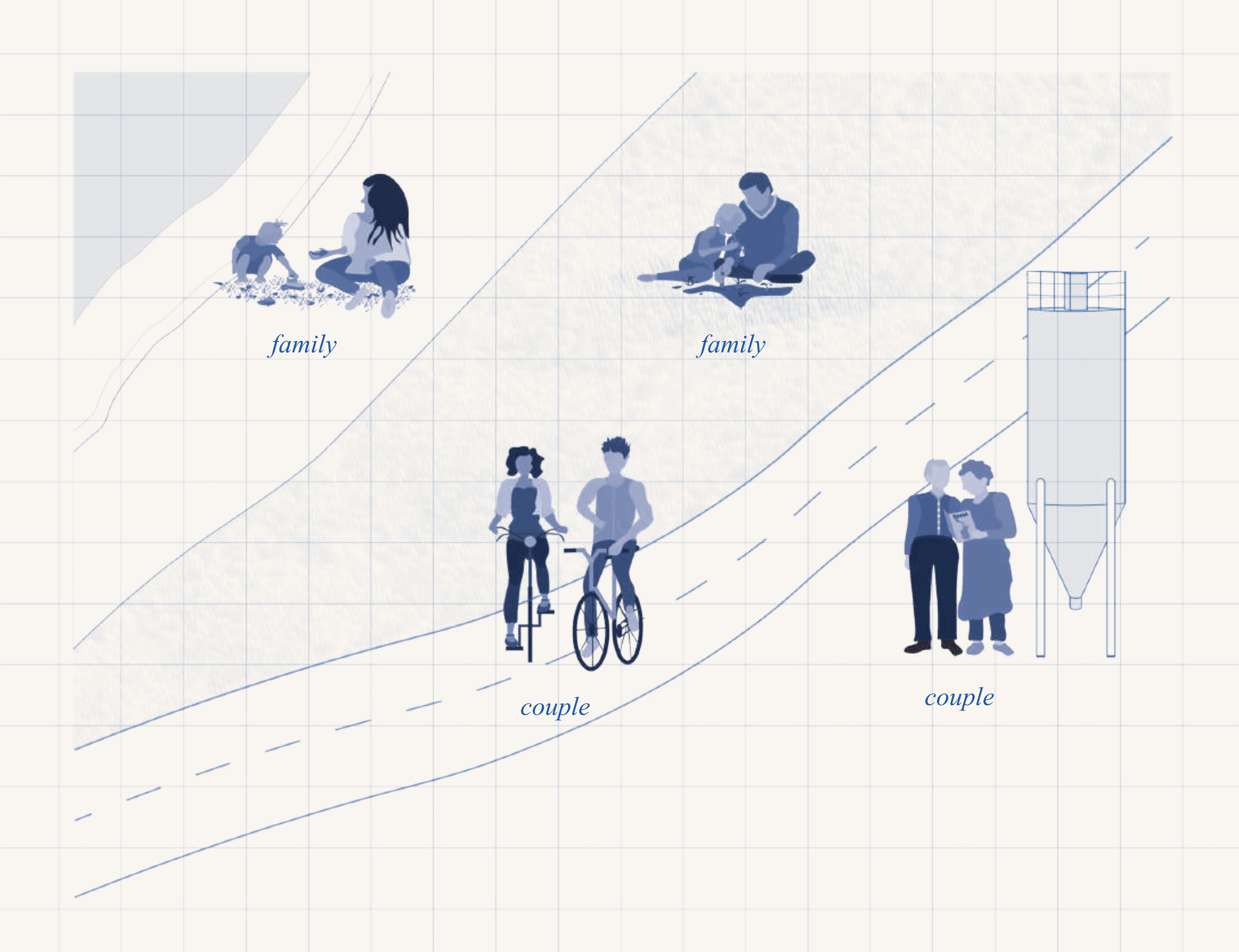
ill.29. 3 main target tourism (VisitDenmark, 2022)

International tourists travel group in Denmark:
46% traveled as families with children under 18 years of age.
41% traveled as couples, friends or several couples together.
The remaining 13% travel alone or with a larger travel agent.
(VisitDenmark, 2019)

USER PROFILE

To get an understanding of the user group of the beach hotel, research about the tourism has been investigated.
Samsø is a part of the main target of coastal and nature tourism, and these numbers from VisitDenmark' tourist survey from 2017 (VisitDenmark, 2019), will be presented and used for developing the user group.

The national tourism covers 48% of overnight stays in coastal and nature tourism in Denmark. Here the international tourism cover 52% of overnight stays, where 40% of these are German tourists (VisitDenmark, 2019).



ill.30. usergroup

USER GROUP

The user group on Samsø is a mix between national and international coastal and nature tourist. The tourists travel as families with children under 18 years old and couples, both as young and elderly (VisitDenmark, 2019). This broad user group is interested in and has chosen coastal and nature tourism and will therefore be in close contact with nature and the island's history. Likewise, they also choose this main target tourism to relax in the quiet and calming surroundings.
A beach hotel would therefore be an advantage to place on Samsø's coast, as it supports the feeling of coastal and nature, which the tourists and beach hotel guests seek. Today, beach hotels are not only designed for the middle class, but all user groups, which also supports the mix between families and couples.
Likewise, a beach hotel can create cultural heritage for the site and clarify the site's value setting, as a beach hotel is also part of the cultural history of Denmark.

Therefore the beach hotel should be designed with focus for cultural heritage, by using materials and atmospheres from the cement factory when transforming. Likewise designing a beach hotel with focus on the relation to the coast and nature and the close interplay between the guests.

PRO-
GRAM
DELIMI-
TATION

This chapter presents and concludes the previous chapters theoretical framing, site analysis and users into design criterias, function diagram and room program.
The chapter will be the start of the design process, where the design criterias will be a starting point when sketching and designing. The function diagram will create an organization of the rooms in the beach hotel and will be organized after different priorities. The room program gives a description of each room with both atmospheric and technical approaches, likewise the developed matrix will be described and how it will be used in the thesis project.

DESIGN CRITERIAS

goal

Designing a beach hotel with focus on preserving the phenomenological base of the existing cement factory, by:

- *Transforming based on the idea of* **palimpsest** *and* **aemulation***, to preserve the cultural heritage while doing adaptive reuse.*

- *Transforming using* **Translatio***, by preserving the* **sites values** *and their history through the materials patina.*

- *Creating a sensory connection between the coast and the hotel, by taking advantage of the buildings close relation to the coast.*

goal

Designing a beach hotel with focus on preserving the material identity, while incorporating present technologies, by:

- *Characterizing the catalog´s materials in the matrix, based on the parameters weights to ensure the optimal material is chosen given the circumstances.*

- *Preserving the existing buildings structure and materiality, while enhancing the quality of the building and ensuring a good indoor environment.*

- *Reusing the existing and carefully adding materials to ultimately lower the GWP by adaptive reuse.*

goal

Designing a beach hotel with facilities improving the local community, while creating a unique experience for tourists, by;

- *Dividing the beach hotel into public- and private zones, ensuring a diverse use of the building and extending the tourist season on Samsø, for sustainable tourism.*

- *Creating a link to the local community by having public functions, such as a restaurant and spa, giving them a sensory experience of the building's cultural history.*

- *Creating a link to the beach hotel's history with intimate relations between the guests.*

goal

Designing a beach hotel which meets today requirements for indoor environment and energy, by:

- *A total energy consumption under 30 kWh/m^2 per year.*

- *A total global warming potential GWP under 12 kg CO_2/ m^2 in the phases A, B and C*

- *A total daylight of minimum 300 lux in half the floor area on half the day.*

- A healthy atmosphering quality using smell as basis for calculating, creating higher air circulation compared to CO_2.

MATRIX

	material potential			*atmospheric potential*			*site position*
parameter	**GWP**	**Life time**	**Corrosion resistans**	**Tactility**	**Patina**	**Reflection**	**Cultural heritage**
weight 0-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*
value point 1-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*

Result: ______________

The purpose of the **matrix** is to identify spaces when designing in specific scenarios based on various parameters. In these scenarios, the weighting of these parameters can vary, which is also reflected in the matrix.

The matrix is closely related to **Catalog - Elaborated Material Exploration**, as materials from the catalog are inserted into the matrix. Likewise the catalog describes the different building parts of the cement factory, with focus on atmosphere and potentials that should be maintained when transforming.

This matrix will therefore help to determine a material according to a desired spatiality, that will be performed sufficiently in the specific scenario. This will possibly contribute to an alternative choice of material, as the matrix takes all parameters into account. This will contribute to a broader understanding of each material and their relationship to the site through their character and properties.

The matrix is structured by and based on:

- *Parameter*
- *Weight*
- *Value points*
- *Result*

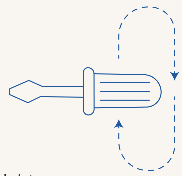
The atmosphere is categorized into distinct groups, based on the building element analyzed e.g. interior and exterior. When examining **exterior** surfaces, the atmospheric section is determined by the **cultural heritage** and the **vision** of the site. **Opposite** , when analyzing **interior** surfaces, the atmospheric section is created based on the description of the desired atmosphere in the **room program**. Due to the correlation between interior atmospheres and the room program, this section must be undertaken individually for each room. Nonetheless, in order to reduce the number of rooms to be examined based on atmosphere, rooms are categorized into groups based on their required atmosphere. **Hence, rooms that share similar atmospheric requirements are grouped together.**

WEIGHT (1 - 5)

The principle in ***weight*** is that the parameters can be adjusted, to ensure a material that completes the desired character and properties in the specific scenario.
This ensures a material where all parameters have been taken into account.
Weight is adapted to the individual scenario.

A weight at 0, is given if the parameter is not taken into account in a given situation.
A weight at 5, is given if the parameter is weighted the highest in the given situation.

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*5*	*3*	*0*	*4*	*4*	*2*	*4*



ill.31. arbitrary example, weight

VALUE POINT (1 - 5)

The principle of ***value point*** is that each material from the **Catalog** gets a value point. This factor cannot be changed, as it is based on data and observation in the catalog.
The value points will be distributed by taking all data from the given parameter and putting it into numerical order in relation to all other materials, and graded 1 - 5 based on its performance .

A value point at 1, is given if the material does not perform sufficiently.
A value point at 5, is given if the material does perform sufficiently.

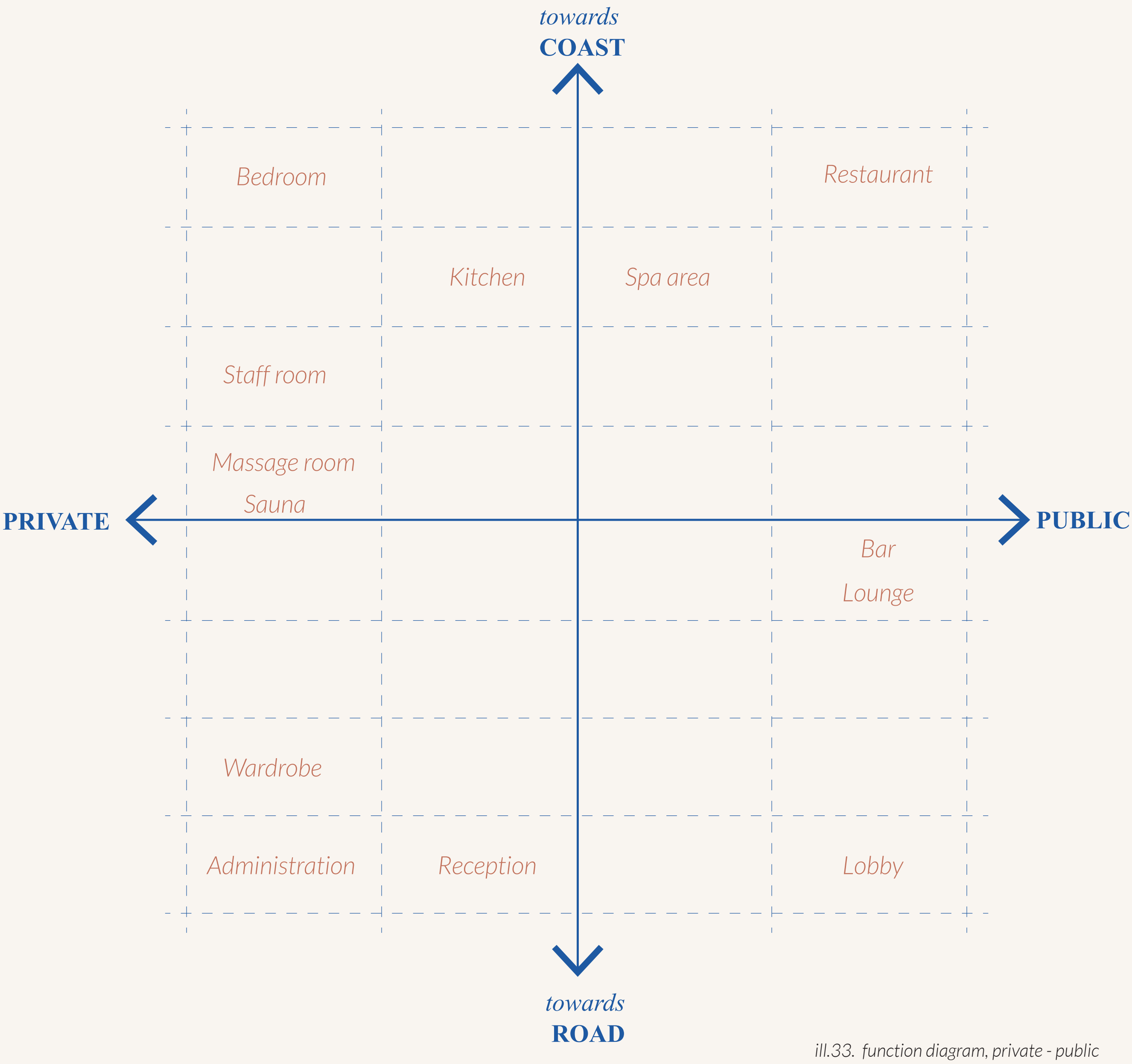
1 2 3 4 5	*6 7 8 9 10*	*11 12 13 14 15*	*16 17 18 19 20*	*21 22 23 24 25*
1	*2*	*3*	*4*	*5*

ill.32. arbitrary example, value point

RESULT

The result gives a number, which explains the most relevant material based on the weight in the specific scenario.
A material gets a value which is multiplied with the weight, thereby the highest value is the most relevant material. To find the result, addition of all the multiplied values are done and the best scoring material is the most relevant.

Result: *33*

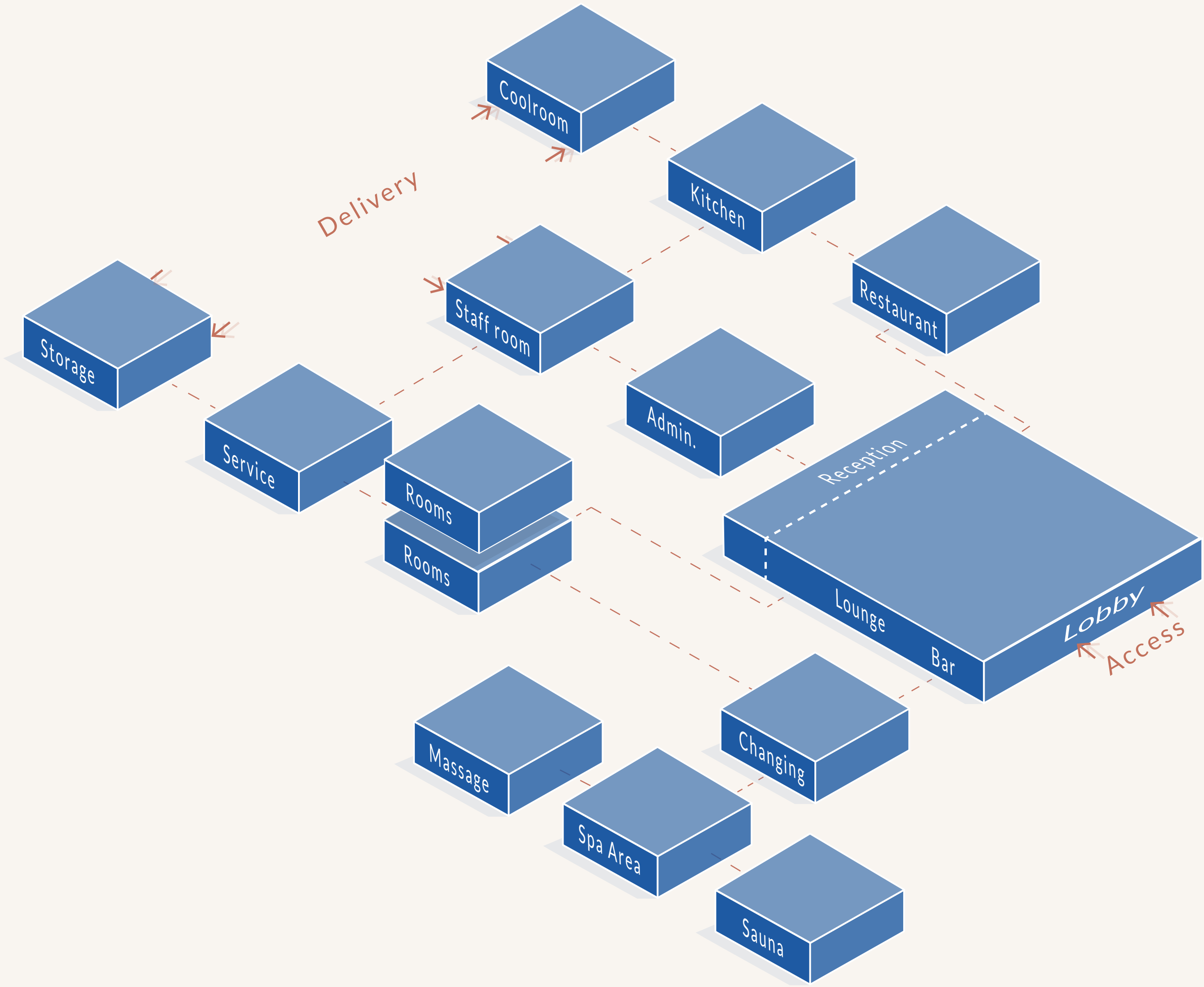


ill.33. function diagram, private - public

FUNCTION DIAGRAM

Two function diagrams have been developed to showcase the idea behind the flow of the building.

The first function diagram illustrates the relation between functions and their position on the site in relation to the road and coast in combination with the level of accessibility for the public, dividing areas into ***Private*** and ***Public***.



ill.34. *function diagram*

The second function diagram shows how the rooms are positioned in relation to one another, but also which rooms should have access to other rooms. This diagram is created based on architectural data from Neufert, a reference book published by architect Ernst Neufert in 1936. Firstly getting inspiration for the room program from here and later adjusting it to fit the specific project of creating a beach hotel.

Room	Amount	Occupants	Area [m²]	Usability	Atmosphere
PUBLIC					
Lobby	1	10	55	Node	Light, open
Lounge	1	12	60	Node, gathering point	Warm, calm
Restaurant	1	42	66	Eating, gathering point	Warm, socialization
Spa area	1	10	78	Relaxing, wellness	Warm, calm
Massage room	1	2	10	Wellness	Warm, calm
Changing room	2	5	13	Changing	Clinical
Sauna	1	5	12	Wellness	Warm, calm
Toilet	5	1	2	-	-
Disabled-friendly toilet	1	1	4	-	-
PRIVATE					
Couple bedroom	6	2	18	Relaxing, private	Warm, homely
Familiy bedroom	5	4	38	Relaxing, private	Warm, homely
Disabled-friendly couple bedroom	2	2	28	Relaxing, private	Warm, homely
Disabled-friendly family bedroom	1	4	38	Relaxing, private	Warm, homely
STAFF					
Reception	1	2	9	Welcoming / node	Light, open
Administration	1	5	40	Work	Light
Staff room	1	24	42	Break room	Light, socialization
Wardrobe	2	3	13	Changing	-
Toilet and bath	2	1	5	-	-
Kitchen	1	5 - 8	38	Cooking, preparing food	Clinical
Coolroom and storage	2	1	5	-	Clinical
Laundry and storage	1	1	12	-	Clinical
Technical room #1	1	1	18	-	-
Technical room #2	1	1	66	-	-

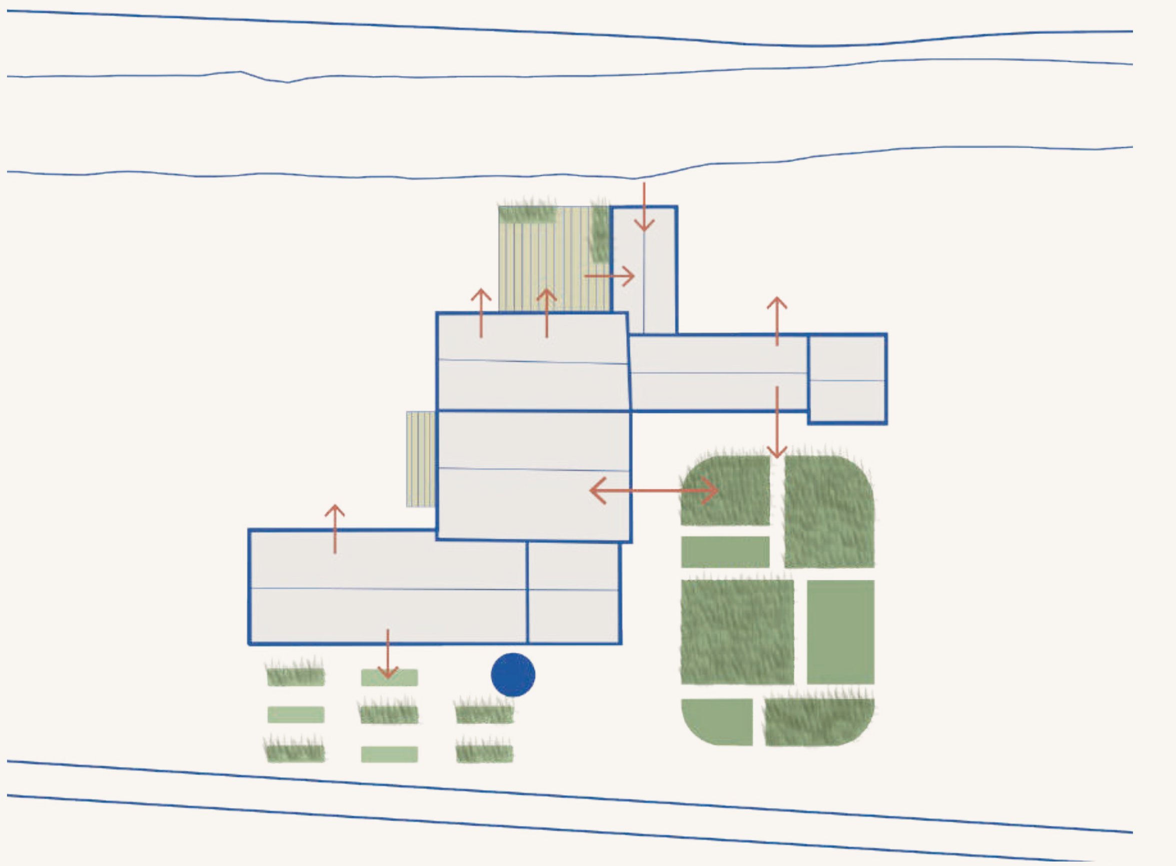
Thermal requirements	Visual requirements [lux]	Atmospheric requirements [ppm]	Air change [h^{-1}]	Operating time [hour / day]	Total area [m^2]
100 h > 26 °C, 25 h > 27 °C	200	1000	6.80	24	55
100 h > 26 °C, 25 h > 27 °C	200	1000	5.50	24	60
100 h > 26 °C, 25 h > 27 °C	300	1000	18.40	9	66
26 °C - 29 °C	500	1000	16.60	12	78
26 °C - 29 °C	-	1000	7.00	12	10
26 °C - 29 °C	-	1000	12.80	12	26
-	-	1000	31.80	12	12
100 h > 26 °C, 25 h > 27 °C	-	1000	15.40	24	10
100 h > 26 °C, 25 h > 27 °C	-	1000	9.90	24	4
100 h > 27 °C, 25 h > 28 °C	500	1000	5.90	12	108
100 h > 27 °C, 25 h > 28 °C	500	1000	5.90	12	190
100 h > 27 °C, 25 h > 28 °C	500	1000	5.40	12	56
100 h > 27 °C, 25 h > 28 °C	500	1000	7.91	12	38
100 h > 26 °C, 25 h > 27 °C	300	1000	9.30	24	9
100 h > 26 °C, 25 h > 27 °C	500	1000	6.60	9	40
100 h > 26 °C, 25 h > 27 °C	300	1000	12.25	24	42
100 h > 26 °C, 25 h > 27 °C	-	1000	9.50	24	26
100 h > 26 °C, 25 h > 27 °C	-	1000	11.00	24	10
100 h > 26 °C, 25 h > 27 °C	500	1000	6.60	12	38
-	-	1000	-	12	10
-	-	1000	5.80	12	12
-	-	-	-	-	18
-	-	-	-	-	66
(Bygningsreglementet, 2018c)	*(Dansk Standard, 2021)*	*(Bygningsreglementet, 2018b)*	*see sppendix 19*		

Total area: 979
Existing area: 670
Extension area: 309

DESIGN PROCESS

This chapter describes the design process of the transformation of the cement factory into a beach hotel. Throughout the chapter, reference will be made to ***Catalog - Elaborated Material Exploration****, where the existing building, preservation of elements and materials are described. This information and registrations will form the basis for design choices.*

The chapter describes through text and illustrations the various ideas and concepts behind the final design proposal. Throughout the process, technical solutions, such as principles for optimizing the building envelope, are integrated as an early part of the process. The design process is based on Mary-Ann Knudstrup's method ***Integrated Design Process, IDP,*** *where architecture and engineering art are integrated to create a realistic and complex design proposal.*



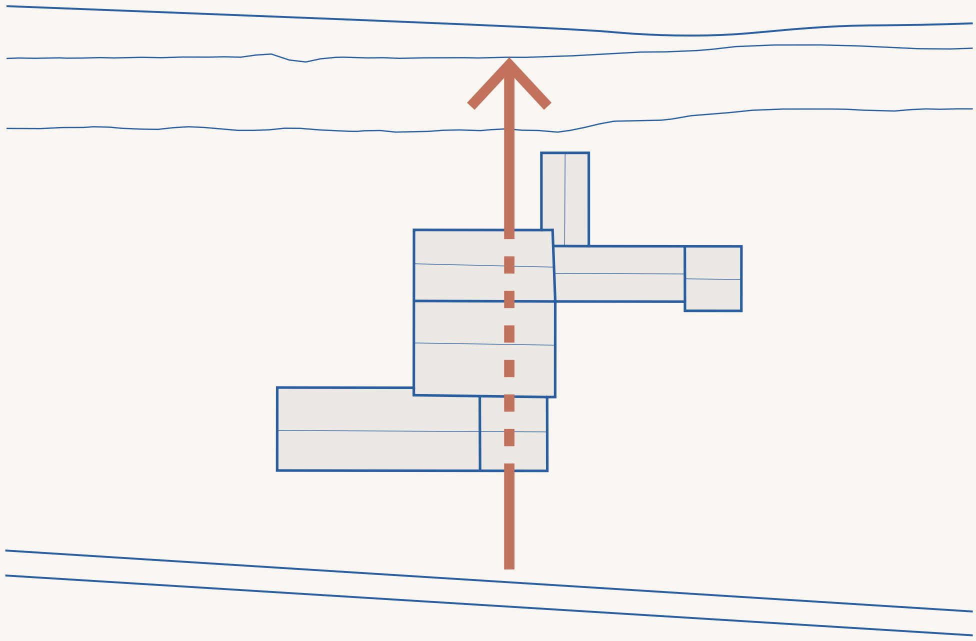
ill.35. programmering

PROGRAMMERING

In order to create a relation to the site, the outdoor areas will go all the way back to the building's origins. The cement factory was founded by local farmers, and this will create the framework for the outdoor areas and their functions, and at the same time give the outdoor areas a transformation.
The outdoor areas consist of a vegetables garden where the beach hotels and their chefs can grow vegetables to cook in the restaurant. Here, guests will be able to contribute to their experience and stay at the beach hotel, as they will be able to help water vegetables and other plants for the beach hotel.

The places where vegetables will grow are next to the beach hotel's bedrooms, so the cultivation of vegetables is obvious to guests, but also to the visitors, as the entrance to the hotel will also be located here.
North-east of the building a vegetables garden will be placed, where vegetables growing in shadows will be placed, because of the building's shadow. These vegetables will consist of carrots, potatoes, salads and radishes (idenyt, n.d.).
To the southeast of the building, the same vegetables are placed in garden boxes, so the bedrooms placed here have a view of the growing vegetables. The silo is preserved and will be be an eye catching element. The function of the silo will be changed to a water collection system for rainwater, where guests and staff will collect water for watering the vegetable garden and garden boxes.
To the south-west of the building, towards the coast, a terrace is placed in extension of the kitchen and restaurant. On the terrace, garden boxes with herbs will be placed, which the kitchen staff will collect during servings. Herbs are placed here as they require a lot of sunlight and will consist of chives, thyme, sage, dill, sedges, rosemary and mint (Bolius, 2020).

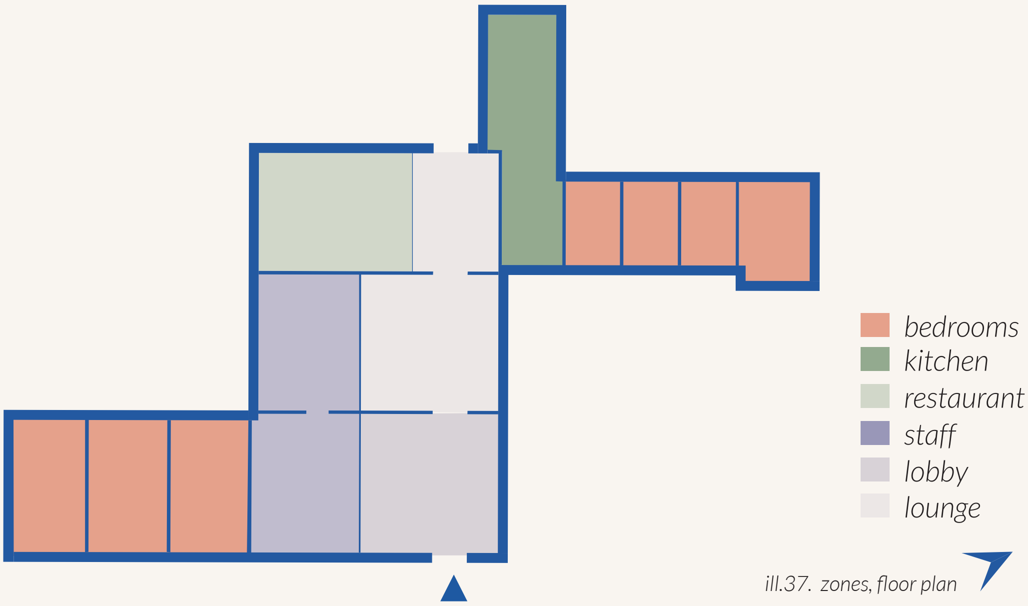
This in turn helps bring food in focus at the beach hotel and give the guests an insight into how their food is made and where it comes from.



ill.36. circulation path

CONNECTION AND CIRCULATION

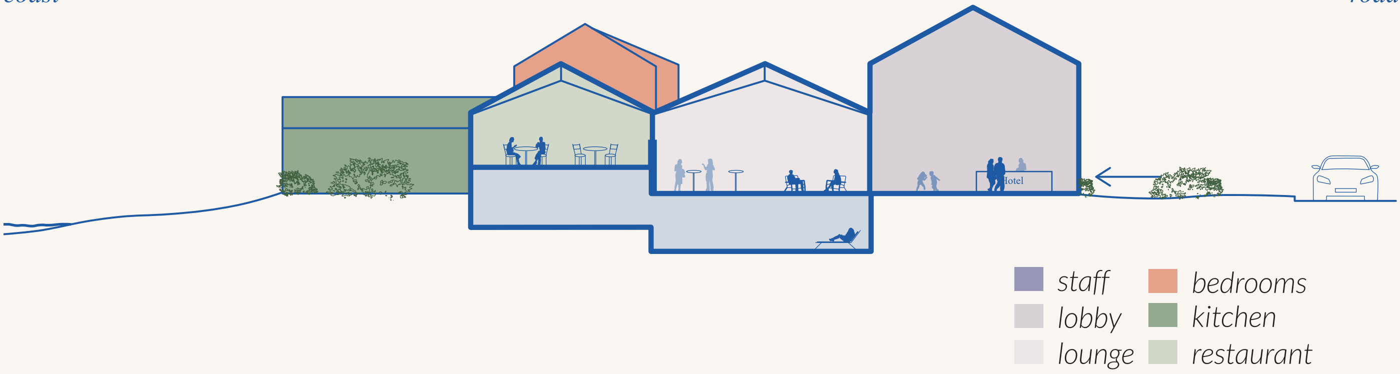
When entering the building one is met by a clear circulation path showing the flow through the building. From the entry a viewline towards the coast makes the understanding of the building clear and honors the prominent location. This affects the rooms placement, to ensure nothing disturbed the viewline, rooms are placed next to it making them easily visible.



ill.37. zones, floor plan

ZONES

A programming investigation has been developed, for creating zones for the different rooms in the building, where initial investigations can be seen in appendix 2.
Illustration 37 shows the existing building form divided into zones the beach hotel consists of: *lobby, lounge, restaurant, spa, staff facilities and bedrooms*. The bedrooms have a vertical extension, to preserve the facade and footprint.
The two factory halls will become the center and heart for the public functions in the beach hotel, where both the beach hotel guests and visitors for the spa and restaurant will meet and interact with each other. This makes the lobby into a node between the staff, guests and visitors.



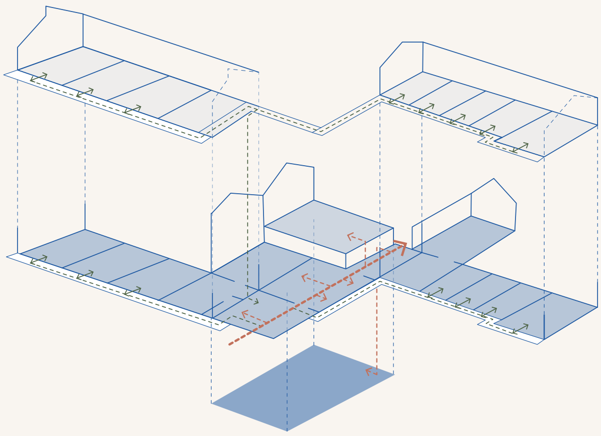
ill.38. zones, section

When entering from the road the highest ceiling height in the building is what one is immediately met by in the lobby setting the tone for the stay. Followed by a compression from the pitched roof before entering the high ceiling created by the gable in the lounge making it seem larger even though the existing structure is way smaller than the structure of the lobby. When looking at the functions placed towards the coastline, the building part furthest towards the coast accommodates the kitchen. This prominent position makes food the focus, showing the slow pace traffic following the beach how the food is processed, while having gardens showing how its produced. In relation to the kitchen is the seating for the restaurant. From here staff have to cross the previously mentioned flowline making the food come into focus for people walking on the circulation path. The restaurant is placed in one of the prior factory halls giving guests a view towards the coast, garden and kitchen while also being seated below the spatially special lattice trusses.

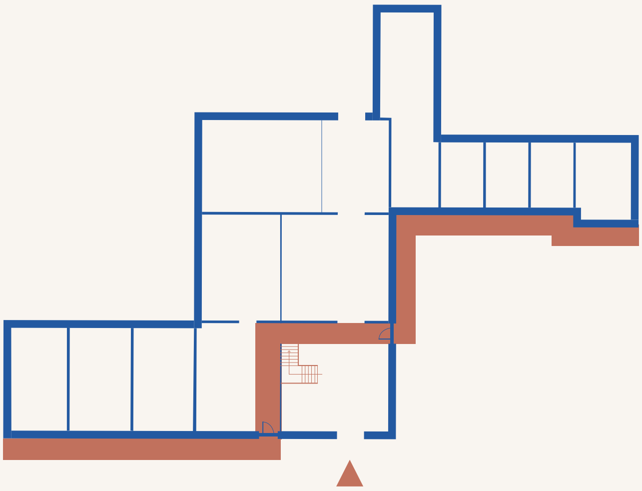
Below the restaurant is the spa. The spa is created in two different levels, when entering the spa one must go through the changing rooms, in these rooms the lighting will be clean and white. However to transition people from this light into a more cave ressemblent atmosphere intended in the spa, a transition zone is created. The zone is dug 1.5 meters down creating a small external facade in which light can be pulled down into the spa. This light should be diffused making the spa transition from clean, to diffuse and dark.

CIRCULATION

The circulation in the beach hotel follows the circulation path. This circulation path makes the circulation clear for both the guests and visitors visiting the lounge, restaurant and spa. These rooms are connected to the circulation path, with stairs down to the spa and up to the restaurant. Because of the zones in the floor plan, circulation from the lobby to the bedrooms will happen through an access balcony. All the building functions meeting along the circulation path will become a node, and act as the heart of the building creating room for interactions.



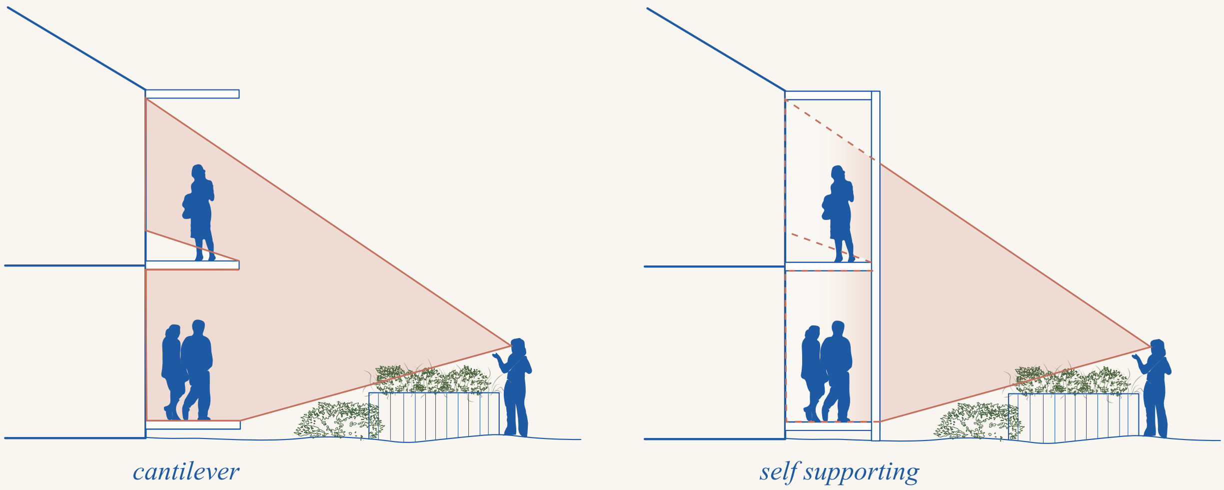
ill.39. circulation



ACCESS BALCONY

ill.41. *access balcony, circulation*

The main stair is located adjacent to the circulation path, and it is positioned in relation to the lobby and reception to facilitate clear circulation from the entrance of the building to the guest's room.
At the top of the stair, there is an access balcony that spans across the lobby and extends outside of the building. As the access balcony passes through the lobby, it acts as a compressing element, creating the illusion of higher ceiling height in the lounge.
This effect is important because the existing structure of the lounge is lower than the structure of the lobby.



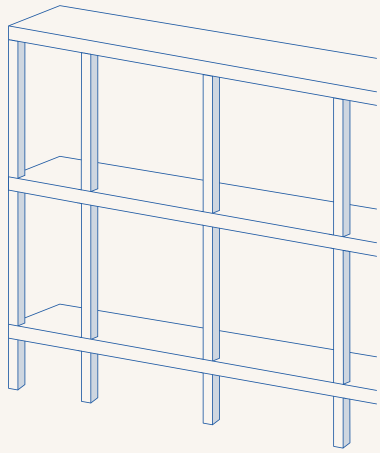
ill.40. *access balcony, privacy*

As the access balcony extends to the outside it begins to change appearance. Where from the inside it acts as a spatial element producing an experience, to outside where it is in relation to the building. The outdoor access balcony should relate to the building's humble expression, giving the surrounding nature the spotlight.
The placement of the access balcony should in relation to the bedrooms not take any of the view but still create privacy when entering the bedrooms. Thereby placing the circulation on the road site of the building, creating a place between the building and the urban areas surrounding it to create privacy.
The access balcony will be that create a private zones for the guests in their bedrooms, and likewise will have a close relation to the surrounding nature as soon as they go outside.

ACCESS BALCONY

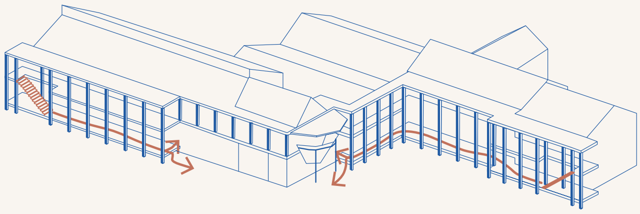
The layout of the access balcony has been investigated, according to the access balcony's design and the stairs placement.

The concept of the access balcony is an added element that clearly shows that it is new compared to the original building, this is why the balcony does not mimic the building shape. The access balcony are supported by columns placed two meters apart. The access balcony does on the parts located outside have a roof sheltering from the weather.

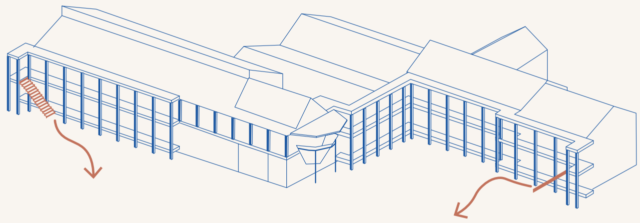


ill.42. construction principle

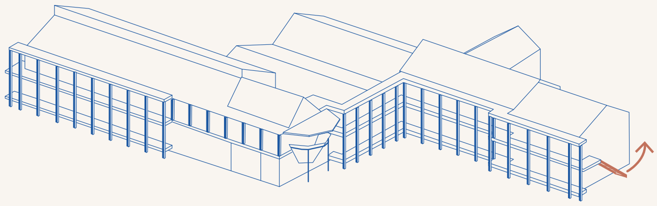
#1 When integrating the stairs into the access balcony, the path will be wider and more material will be used. An advantage is that the expression of the stairs and access balcony together is attached to the building.



#2 When adding the stairs outside of the access balcony, the path will be smaller and less material will be used. A disadvantage is that the stair is added to the access balcony, which is added to the building, which looks incomplete.



#3 When adding stairs to the end of the building, the guest will be able to move around the building and to have direct access to the coast. An advantage is the stairs are hidden and not take view to the bedrooms from the road.



ill.43. balcony access layout

After investigating the different solutions the shape of access balcony was decided. *#3* has the greatest potential in relation to the location, giving the guest a direct access to the coast making use of the building's nature. This design is also a great solution in relation to *Global Warming Potential* by not creating larger areas of material on the access balcony.

DEFINING MATERIALS

As the last step in the room organization, the rooms are placed into the building context with specific square meters mentioned in the room program. The building form and materials patinas will be preserved, which will be done by extending vertically. To honor this gesture of transforming vertically the meeting on the horizontal line becomes interesting, showing the new extension as a layer built on top of the existing structure showcasing the patina of the original building next to the new and modern materials. Therefore when optimizing the walls the added insulation should be added to the inside of the walls making sure this gesture becomes a main design principle when seeing the building from the outside.

This chapter will become the beginning of the transformation, developing the cement factory into a beach hotel, where the focus is to keep as much of the form, materials patina and structure as possible. The cement factory, as it is today, is not approved according to today's standards and requires an optimization.
First, the materials in the different rooms will be chosen, by evaluating the rooms atmospheres and spatial qualities in relation to the materials. Therefore, this chapter investigates materials by using the **matrix** and collage renderings, to visualize the materials in collaboration giving a better understanding of each room as a whole with all materials.

The matrix will be used as a design tool for defining materials, where the room's desired atmosphere and spatial qualities are in focus. The matrix uses different weights and value points (see the Catalog - Elaborated Material Exploration), to decide the most suitable materials in the specific scenario. In the **Catalog - Elaborated Material Exploration**, the beach hotels rooms has been divided into three groups;

- *group 1: Spa, Massage room, Sauna*
- *group 2: Restaurant, Lobby and lounge, Bedrooms*
- *group 3: Reception, Administration, Staff room, Kitchen, Toilets, Coolroom and storage, Laundry and storage, Wardrobe room*

This chapter focuses on group 1 and group 2.

When the materials in the different rooms are decided, the optimizing of the building envelope and how to preserve the building's structure, according to e.g. the lattice trusses, will be investigated.

RESTAURANT

The restaurant is a social area, where the room is open and light with a warm atmosphere. The materials should have a high reflection to make the room brighter and likewise have low acoustic properties, to ensure a comfortable environment. The restaurant has a close relation to the preserved exhibition shelf, which has a big influence on the collaboration between materials. The matrix investigations and results can be found in appendix 3.

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *70.25*

FLOOR
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*1*	*4*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *76.25*

CEILING
Pine

parameter

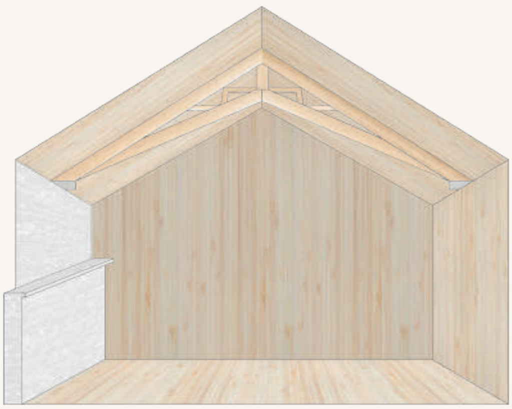
	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *68.25*

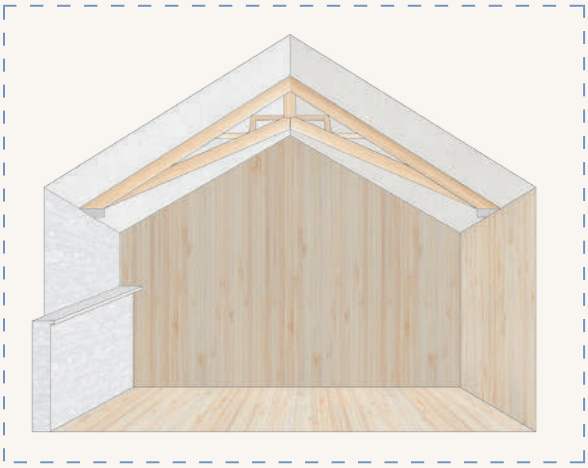
CEILING
Plaster

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
value point 1-5	*5*	*1*	*-*	*2.50*	*5*	*4*	*1*

Result: *45.50*



Best from matrix



Corrected

ill.44. restaurant, materials

The results from the matrix, shows that the most suitable materials in the restaurant would be pine on walls, floor and ceiling.
Because the exhibition shelf is preserved, plaster in the ceiling would create a focus on the exhibition shelf and likewise bright up the room. In relation to the exhibition shelf, plaster would create a more smooth transition to the white-painted brick wall, than wood-concrete panels with a more rough structure. Likewise plaster in the ceiling makes the lattice trusses becomes the focus, which is also a preserved element in the restaurant. The ceiling consists of plaster boards, where the floor and walls consist of pine boards, so the preserved exhibition shelf will become the focus.

LOBBY AND LOUNGE

The lobby is the first room the guest and visitors will meet, and extends to the lounge. Therefore these two rooms have a close connection and act as a node, which the materials should support. The lobby and lounge are socializing areas, where the room is open and light with a warm atmosphere. The materials should have a high reflection, to make the room brighter and likewise have low acoustic properties, to ensure a comfortable environment.
The matrix investigations and results can be found in appendix 4.

WALLS
Lightweight aggregate

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*3*	*-*	*4*	*5*	*1*	*5*

Result: *70.00*

WALLS
Pine

value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *68.25*

FLOOR
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*3*	*3*	*4*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *77.00*

CEILING
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

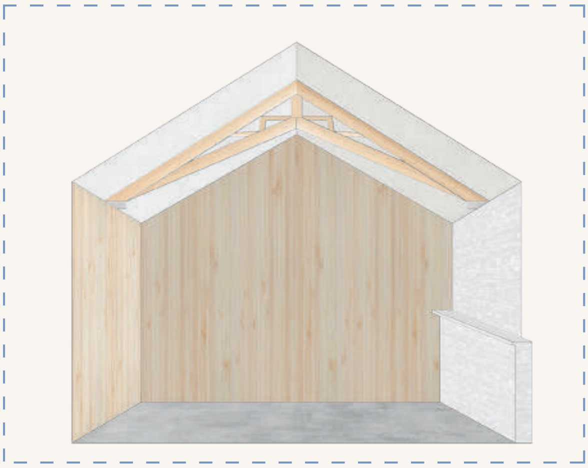
Result: *68.25*

CEILING
Plaster

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
value point 1-5	*5*	*1*	*-*	*2.50*	*5*	*5*	*1*

Result: *54.50*

Best from matrix



Corrected

ill.45. lobby and lounge, materials

The results from the matrix, shows that the most suitable materials in the lobby and lounge would be lightweight aggregate on walls, concrete on floor and pine on ceiling.
Because the lattice trusses in the ceiling are pine, the ceiling material will be plaster boards, to make the lattice trusses become the focus and likewise have a relation to the restaurant. Therefore the wall material will be pine boards, making the relation to the restaurant more clear.
Because the lobby and lounge function as a node, the concrete floor will be most suitable, according to its durability.

BEDROOMS

The bedrooms are where the family and couple can find privacy during their stay. The bedrooms should give the guest a warm and homely feeling through the materials.

The materials should have a high reflection, to make the room brighter.
The matrix investigations and results can be found in appendix 5.

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*2*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *60.25*

FLOOR
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*4*	*2*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *62.25*

CEILING
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*1*	*2*	*2*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *62.25*

The results from the matrix, shows that the most suitable materials in the bedrooms would be pine on walls, floor and ceiling. The floor will consist of pine planks, where the walls and ceiling will consist of pine boards. This is done to create a variation and contrast in the room, and likewise the pine planks on the floor lead to the window/view and will by that extend the bedroom. Likewise the pine planks support the feeling of a homely atmosphere in the bedrooms.

Best from matrix

ill.46. bedrooms, materials

SPA

The spa has focus on the mind with a calming atmosphere. Here the tactility has a huge effect on the experienced atmosphere in the room. The rooms' tactility gets in touch with the guests' skin, and should be comfortable to walk and sit on, and likewise create a warm atmosphere when walking around in the spa.
The matrix investigations and results can be found in appendix 6.

WALLS
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*5*	*1*	*1*	*4*
value point 1-5	*4*	*5*	*-*	*2.88*	*3*	*5*	*5*

Result: *69.40*

WALLS
Bricks

value point 1-5	*4*	*3*	*-*	*3.63*	*3*	*4*	*5*

Result: *66.15*

FLOOR
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*5*	*1*	*3*	*4*
value point 1-5	*4*	*5*	*-*	*2.88*	*3*	*5*	*5*

Result: *89.40*

CEILING
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	-	*3*	*1*	*1*	*4*
value point 1-5	*4*	*4*	-	*4.75*	*2*	*2*	*5*

Result: *66.25*

Best from matrix

Corrected

ill.47. spa, materials

The results from the matrix, shows that the most suitable materials in the spa would be concrete on walls, floor and pine on ceiling. The walls and floor consist of concrete boards and the ceiling consists of pine boards.
To break up the intense use of concrete and to introduce more textures into the spa, the preserved brick wall located between the lounge and restaurant, will be reintroduced in the spa. The idea is that the existing wall extends directly down and becomes a wall in the spa and gives associations to the exterior facades.

FACADES

In the process of detailing the material expression, various materials were considered and incorporated into the matrix to provide a foundation for a discussion.

Here new materials will meet the original materials from the facades.
The matrix investigations and results can be found in appendix 7.

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4.75*	*2*	*2*	*5*

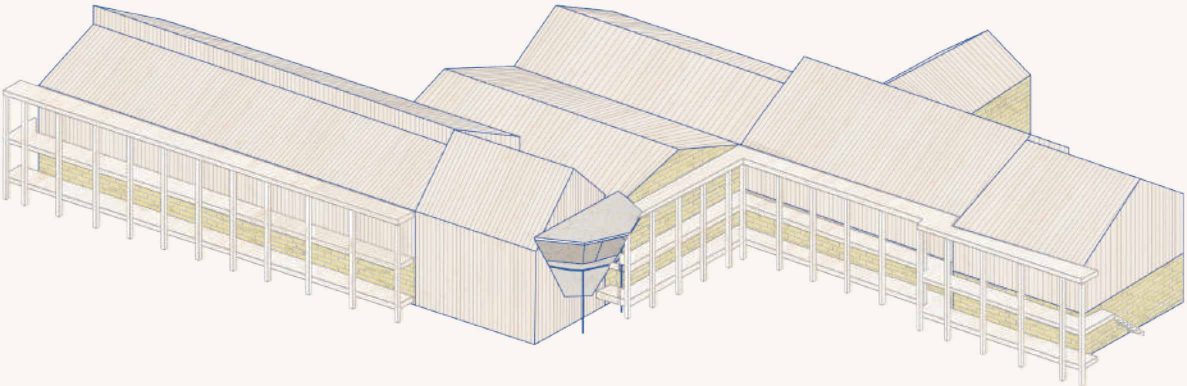
Result: *68.75*

ROOF
Pine

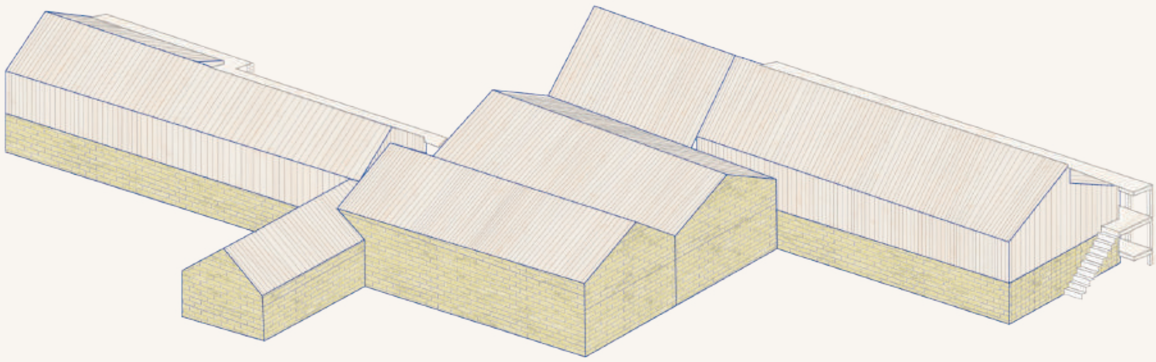
parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4.75*	*2*	*2*	*5*

Result: *68.75*



facades towards the road



facades towards the coast

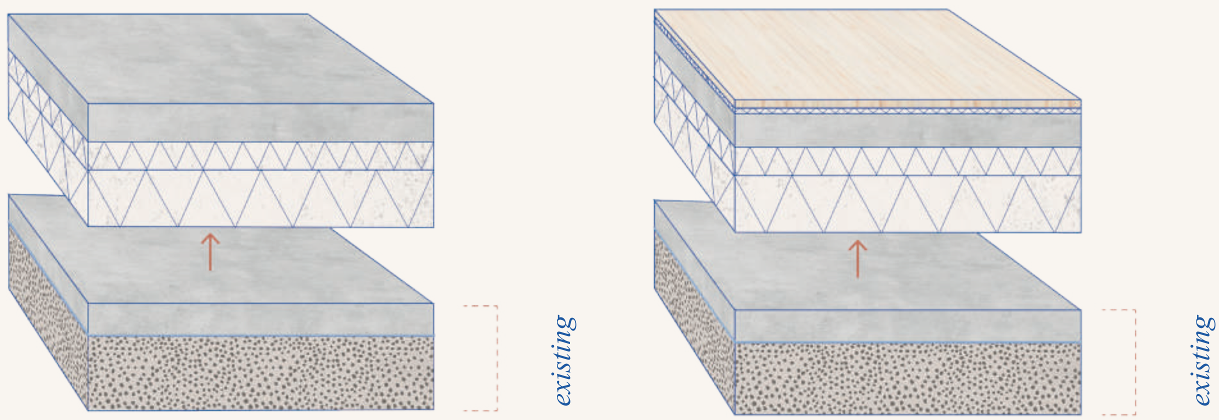
ill.48. facades and roof, materials

In the beginning of this chapter ***Defining materials***, the design choice to extend the walls inwards, served as a guide for determining the building's exterior. Rooms that are expanded vertically will be constructed using new materials selected from the matrix, while the original walls optimized inward will retain their original appearance as yellow bricks and lightweight aggregate. The external material for the rooms expanded vertically will be pine, attached as planks giving the new extension of the building a different appearance than the rest of the building. By using new modern materials, that are sustainable but which still remains within the cultural heritage of the site.
The access balcony attached to road facing facade will be constructed in wood relating them to the cultural heritage and the building facades while maintaining a low GWP.
As roof material wood will be used, due to the roof construction on the building in some areas being lifted while in others renovated. This means that the existing roof will no longer meet the requirements and therefore needs to be optimized. Wood is chosen due to its sustainability and the connection to the site and the new facades on the extensions of the building. The wooden roof will also blend the building into the nature, given that from the beach dunes in some areas hide the facades and therefore only shows the roof, thereby chosingwood helps the building melt directly into the color of the sand. The two material investigations for the roof can be seen in appendix 8.

BUILDING ENVELOPE

When optimizing the building all existing exterior walls will be preserved. This is done to keep the humble expression of the building while retaining the cultural heritage and gesture experience by the citizens of Samsø, but also for the guests of the beach hotel to see the original story with all exterior ornaments and machinery.
However on the inside the building will un-go a total renovation making the hotel attractive for the guest, but also to create another atmosphere upon entry.
Optimized inwards can result in challenging detail sections, which will in this chapter be investigated.
The building needs some added square meters, this is done by the vertical extensions, making the new expansion clear by making use of modern materials, to support the idea of ***Aemulatio***.
Likewise so the guest and visitors clearly can see the difference in the original building and the new addition, like the case study ***Det Danske Landsted by Norrøn***.

The different constructions have been developed based on the requirements from BR18, see appendix 10.
Likewise the program *Rockwool Energy Design* is used to calculate the U-values of the different constructions optimizing and to ensure a strong moisture free construction, see appendix 9.



ill.49. Building envelope, foundation optimizing

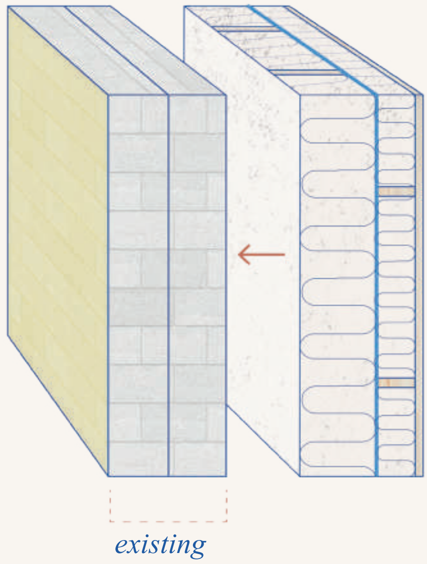
FOUNDATION OPTIMIZING

The existing foundation of the building will be kept and the optimization will be added on top of the existing and will raise the floor by 350 mm. This is done to make use of the already existing materials and thereby reducing GWP. The optimization is done by adding 250 mm XPS followed by a 100 mm concrete slab. These values were transferred into *Rockwool Energy Design*, to calculate the U-value.

Thickness: 687 mm
U-value: 0.09 W/m^2•K, with no risk of condensation neither internal nor on the surface, see appendix 9.
The floor in the lobby and lounge is constructed with concrete as the internal surface layer, however in the bedrooms the foundation will be the same but on top of the concrete layer an insulation layer reducing noise is placed covers by wooden planks.

LIGHTWEIGHT AGGREGATE WALL OPTIMIZING

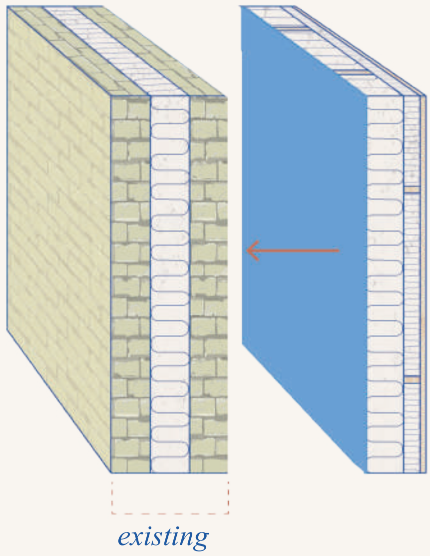
When optimizing the external walls, the main focus is to keep the building expression on the outside. This however will result in alternative connection of materials internally in the wall, this will therefore be done more in depth. The optimization is done by adding 300 mm straw insulation. These values were transferred into *Rockwool Energy Design*, to calculate the U-value.
Thickness: 554 mm
U-value: 0.13 W/m^2•K, with no risk of condensation neither internal nor on the surface, see appendix 9.



ill.50. building envelope, lightweight aggregate wall optimizing

BRICK WALL OPTIMIZING

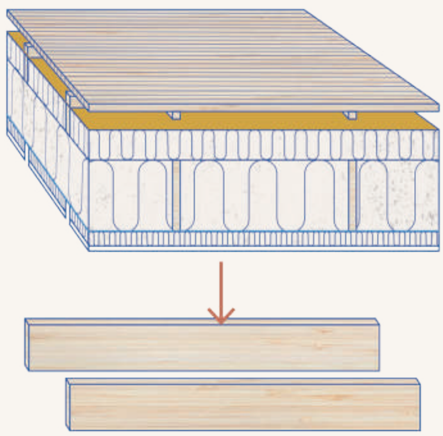
The optimization on the brick facade is done in the same principle as the lightweight aggregate walls with internal optimization. Due to the brick walls having 100 mm insulation between the two layers of bricks a lower amount of added insulation is needed on these walls, by adding 150 mm straw insulation. These values were transferred into *Rockwool Energy Design*, to calculate the U-value.
Thickness: 490 mm
U-value: 0.15 W/m^2•K, with no risk of condensation neither internal nor on the surface, see appendix 9.



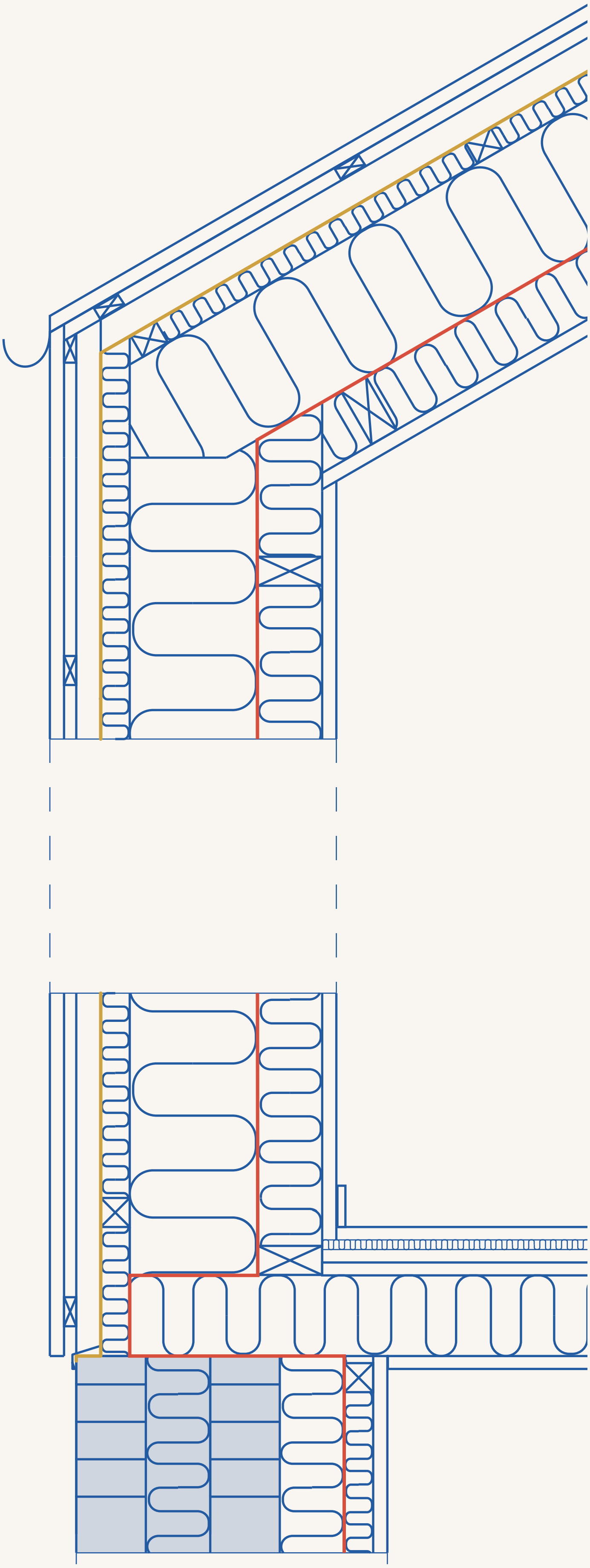
ill.51. building envelope, brick wall optimizing

ROOF OPTIMIZING

The roof in the factory halls have an old lattice truss construction which should be preserved, therefore the existing structure was calculated in relation to loadcarrieing capability the new optimized roof. The existing structure was adequate for the new construction with a BGT of 90%. This is calculated in appendix 11, case 3.
These values were transferred into *Rockwool Energy Design*, to calculate the U-value.
Thickness: 514 mm
U-value: 0.11 W/m^2• K, with no risk of condensation neither internal nor on the surface, see appendix 9.



ill.52. building envelope, roof optimizing

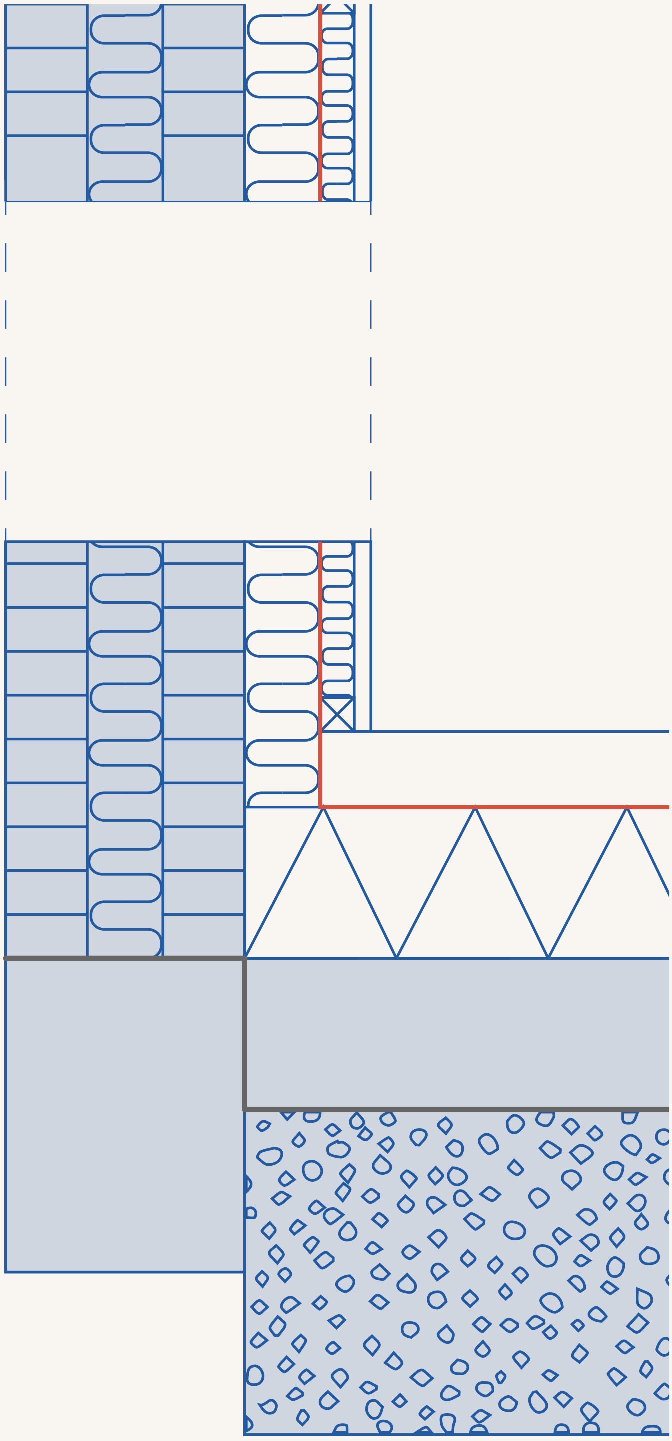


ill.53. building envelope, connection between brick wall, floor separator and new wood wall and roof. 1:10

existing building envelope

MEETING BETWEEN BRICK AND WOODEN WALL

When transforming vertically, the meeting between the existing brick wall and the new wood walls in combination with an added separation level, creates a rather interesting detail section. When adding the floor beam, it should be loaded onto both the layers of bricks, however to optimize the building envelope's total performance it will only just be able to be supported by both brick layers.
To ensure the least amount of thermal bridges insulation is added externally as well as internally of the new construction. The added floor is created in a frame construction. The calculated constructions dimensions can be seen in appendix 11.



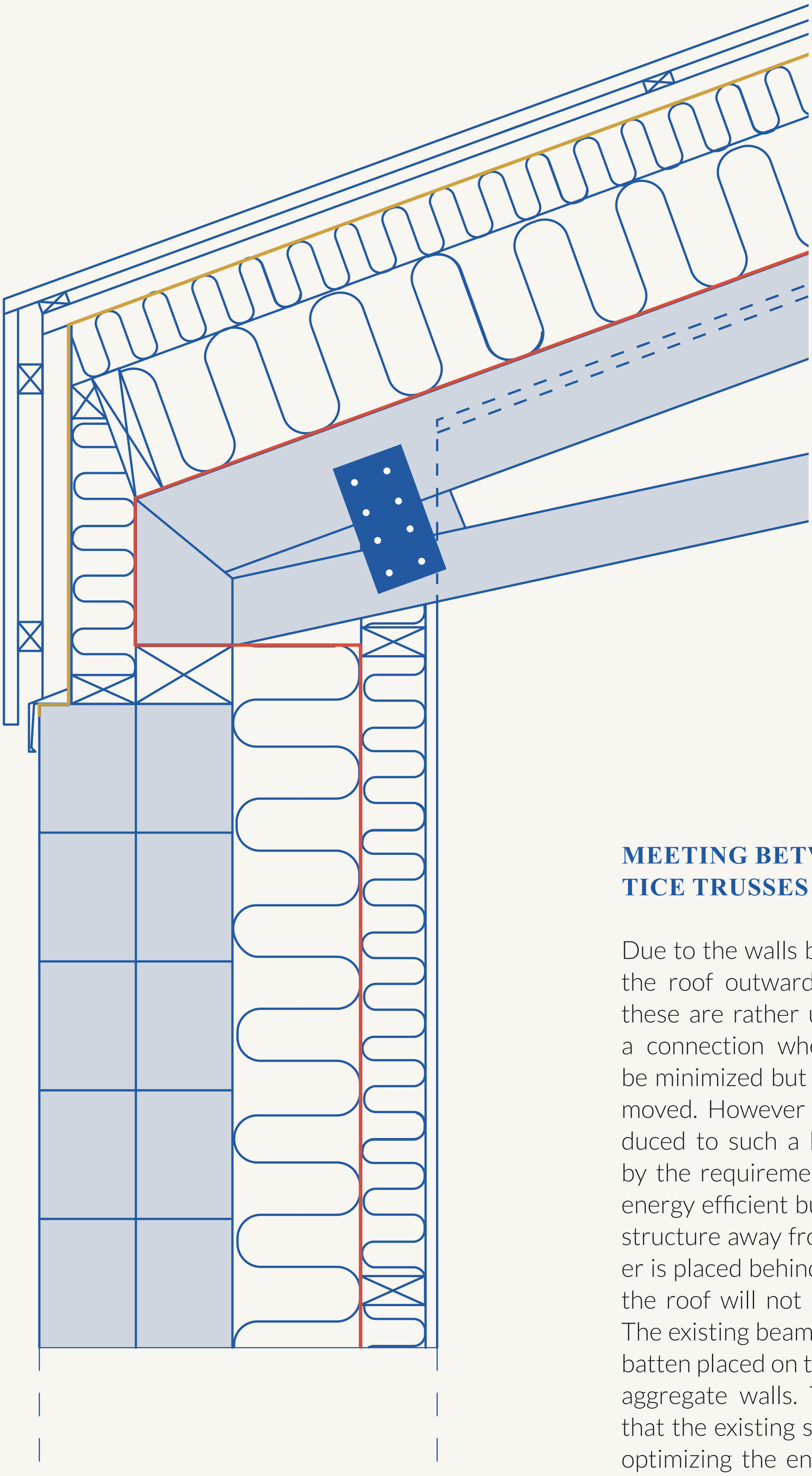
MEETING BETWEEN BRICK WALL AND FOUNDATION

Due to the foundation being optimized inwards and the walls being optimized inwards the connection between the two elements becomes rather efficient in terms of thermal efficiency, with no thermal bridges. This however comes at the cost of raising the floor by 300 mm making the entry from outside a bit irregular.

The floor is constructed as a sandwich element, making use of the existing concrete floor as one layer and a new added concrete slab. Between the slabs are XPS insulation, which is connected to the wall insulation directly, ensuring optimal indoor thermal quality.

ill.54. building envelope, connection between brick wall and foundation optimizing. 1:10

existing building envelope

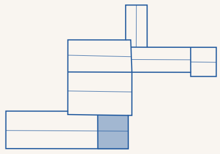


ill.55. building envelope, connection between brick wall and lattice trusses. 1:10

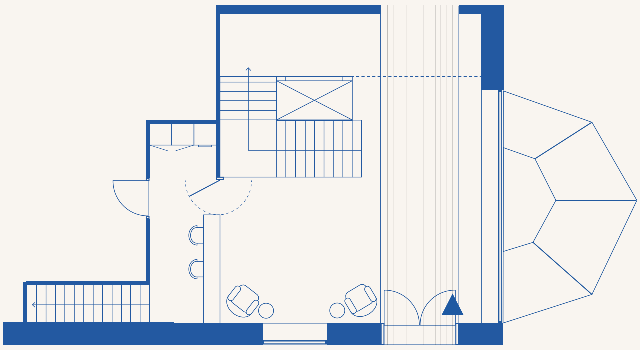
existing building envelope

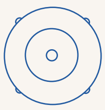
MEETING BETWEEN BRICK AND LATTICE TRUSSES

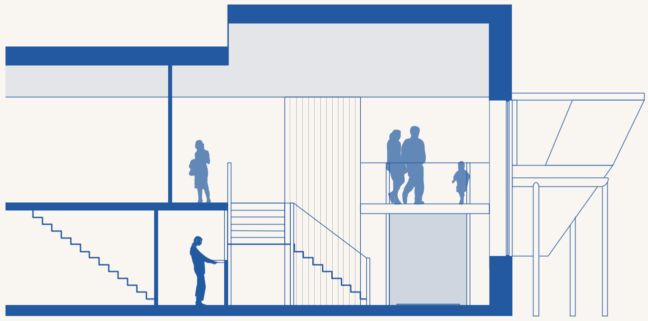
Due to the walls being optimized inwards, and the roof outwards the intersection between these are rather unorthodox. This resulted in a connection where thermal bridges should be minimized but were not able to be fully removed. However the thermal bridges are reduced to such a low level that it is accepted by the requirements but not optimal for new energy efficient buildings. In order to keep the structure away from moisture the vapor barrier is placed behind insulation making sure that the roof will not lose its structural capability. The existing beams will be placed on a wooden batten placed on top of the existing lightweight aggregate walls. This connection will ensure that the existing structure is kept visible while optimizing the energy efficiency of the room. ensuring both aesthetic and functional needs for the room.



LOBBY







ill.56. lobby, 1:200

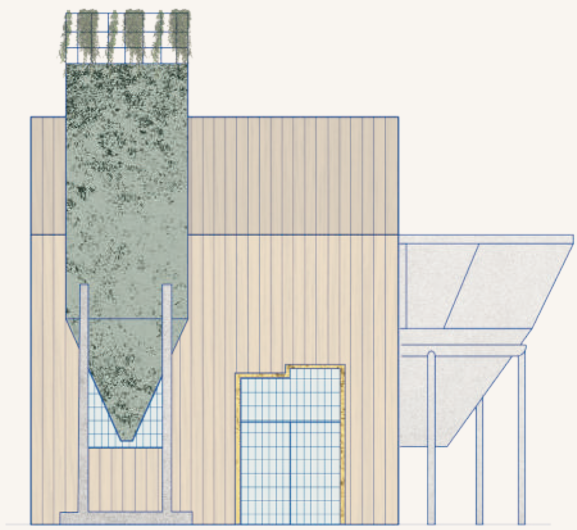
ill.57. lobby section, 1:200
access balcony over reception

FLOOR PLAN

The lobby is a node, where transitions between the private and public zones happen and guests and visitors have the first meeting with the beach hotel. This transition is supported by the access balcony, which is placed along the sides of the room, where an elevator and staircase is placed close to the reception. The access balcony supports the function as a node, because of movement in every level in the room.
Because of the placement of the room, in the previous storage where the silo and gravel mixer are located, cultural heritage will be expressed in the room.

ENTRANCE

The main entrance to the beach hotel is located at the front of the building in the old storage facility. This building did originally house a large semi-truck which was loading and unloading in this building. In order to fit the truck into the building the workers cut out a small piece of the door frame due to a crane on top of the truck, which can be seen in *Catalog - Elaborated Material Exploration*. This cut will be preserved in the new entrance as an ornament to the original shape. The door frame will be highlighted to bring focus to the main entrance and will be done by using the bricks that are removed to place windows.



ill.58. cut on elevation

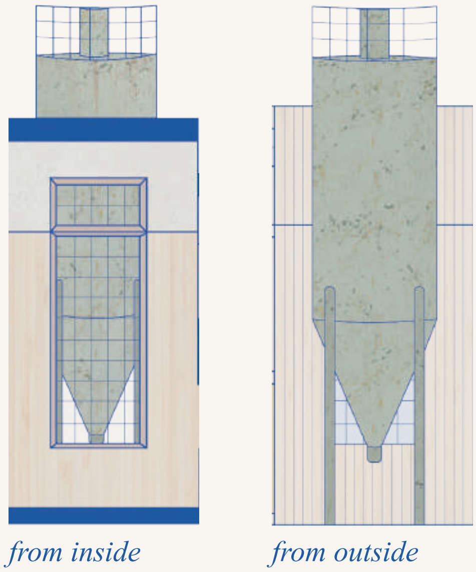
ATMOSPHERIC POTENTIALS - CULTURAL HERITAGE

The transformed beach hotel is characterized by its history as a former cement factory, which the *silo* and *gravel mixer* represent. The silo and gravel mixer is preserved, to keep the story telling of the site, because these specific elements create an experience of the building's *industrial era* and helps identify the building for the citizens on Samsø.

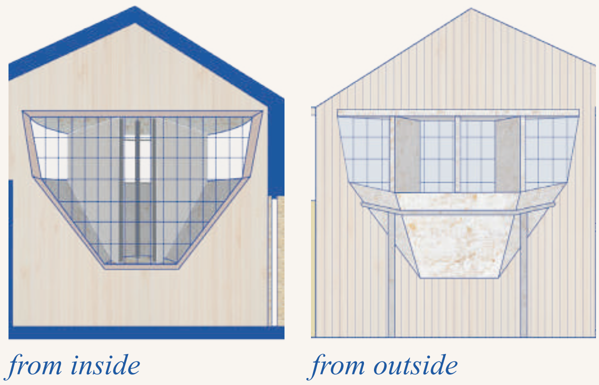
The silo, as mentioned earlier, will be transformed into a water collection system for rainwater, where guests, visitors, staff and people on Samsø can help water the vegetable garden and plant boxes. The silo is visible from inside the lobby through a large window, to visualize the industrial storytelling.

The gravel mixer will not be transformed, but kept as a monument on the building. The gravel mixer will have a large window towards the lobby, where the guest and visitors can look inside the gravel mixer. Likewise the gravel mixer will create an interesting light inside the lobby, because the gravel mixers form will catch light from different angles..

How the light illuminates into the lobby from the gravel mixer and the silo, has been investigated through a collage, to see how the shadows will be created. The desire is to preserve the gravel mixer and transform it to a new function which provides an atmospheric quality to the beach hotel and the lobby. The structure of the gravel mixer brings light into the room from different angles, and creates an interesting light in the lobby.
In addition a daylight analysis has been made, which concludes an approved daylight, see appendix 12.



ill.59. cultural heritage, silo from inside and outside



ill.60. cultural heritage, gravel mixer from inside and outside

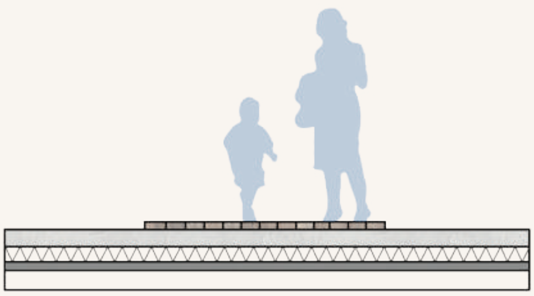
ill.61. atmospheric potentials, daylight in lobby

#1 #2 #3

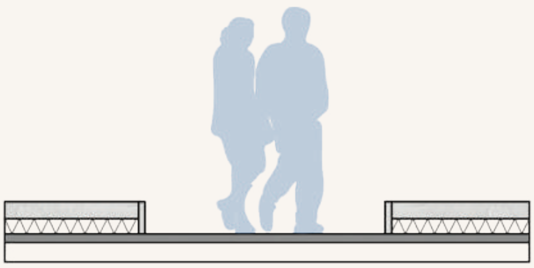
ill.62. circulation path, materials

CIRCULATION PATH

As mentioned earlier, when entering the building one is met by a clear circulation showing the flow through the building, with views along the path towards the garden and coast. This circulation path will likewise be shown in a different material, to make the path more clear.
The circulation path will be made from pine, which was previously used for the roof construction in the cement factory's workspace and storage, as described in **Catalog - Elaborated Material Exploration.**
The expression of the path has been investigated, through which directions the pine boards should have. The chosen direction is *#2*, because of the direction towards the coast and likewise through the building. Likewise the different length of the boards will be visible on the path, and by that express the previous function in the building.
When reusing the pine and pine boards, the patina will be preserved and give the building an expression of a monumental building.



#1

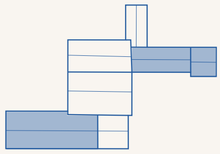


#2

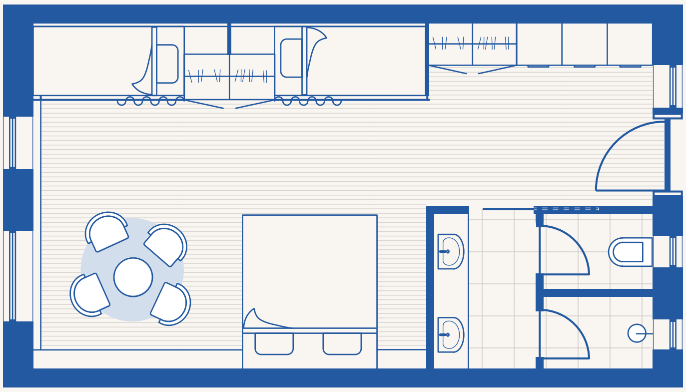
ill.63. circulation path, attachment to the floor

How the circulation path is attached has also been investigated, according to easy access for wheelchairs and likewise thermal bridges. The main idea was to preserve the existing concrete floor in the building to create a circulation path through the building, as investigation *#2*. This however will create thermal bridges, but will create an atmospheric potential by using elements from the existing building to create a monument inside the building.

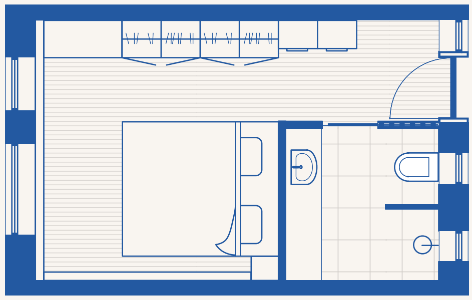
Because of universal design, where e.g. wheelchairs can have easy access, investigation *#1* is chosen. Here the circulation has a little height, to create the path even more clear in the building.



BEDROOMS



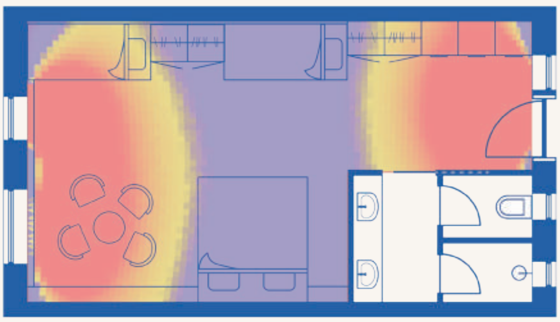
ill.64. family bedroom, 1:100



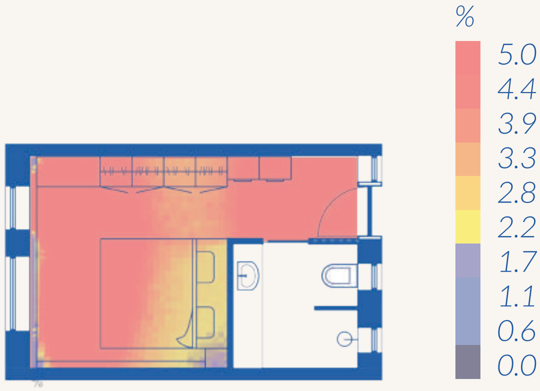
ill.65. couple bedroom, 1:100

FLOOR PLAN

When designing the floor and furniture plan for the bedrooms, the different user groups were taken into account. Given that family and couples have different needs the rooms should reflect this and provide different functions. Different floor plans can be seen in appendix 13. In the family bedrooms, the toilet and shower are separated making the family able to use it more people at a time. Families tend to value different things when on vacation compared to couples, therefore they have a table and chairs to play games while the couple rooms have a bed orientated towards the window, where the view of the coast and sea makes it more romantic. Likewise in the family rooms, the childrens beds have a curtain around, creating a flexible barrier, which gives the opportunity to divide the bedroom. When entering the bedrooms the first one sees are a vertical window framing the view towards the coast as an extension of the clear pathway. Both bedroom types have disabled-friendly bedrooms with slightly bigger floorplans, to make space for a wheelchair.



ill.66. family bedroom, daylight



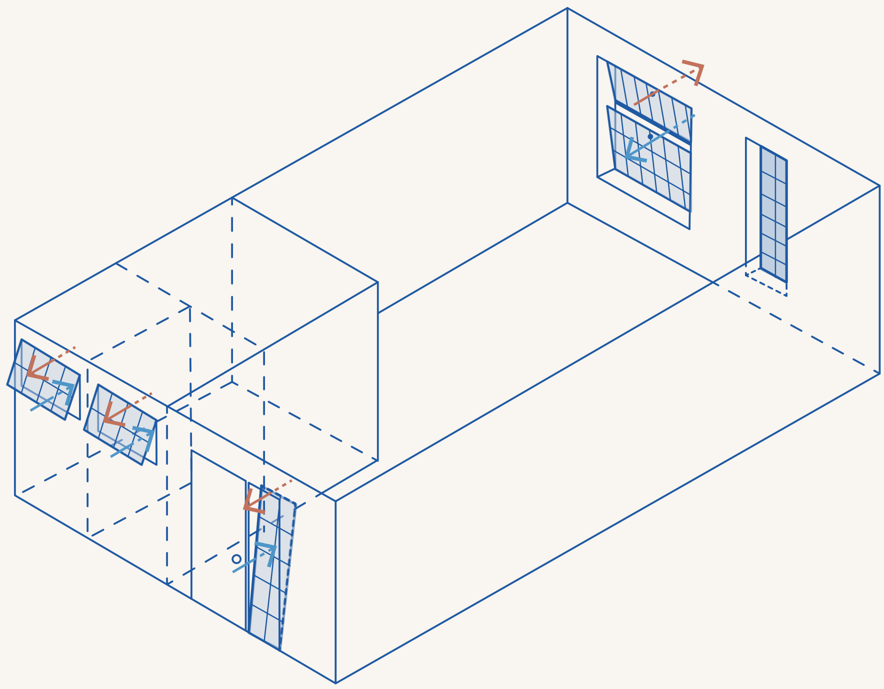
ill.67. couple bedroom, daylight

DAYLIGHT

Due to buildings existing walls already being on site the room size gave some difficulties in terms of daylight. The family rooms are 8.2 meters deep which meant that the daylight does not reach the middle of the building however it is well above the requirements.

window open at 25°C:
54 hours > 26°C
8 hours > 27°C
APPROVED

window open at 26°C:
93 hours > 26°C
26 hours > 27°C
NOT APPROVED

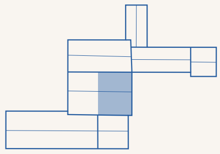


ill.68. facades and roof, materials

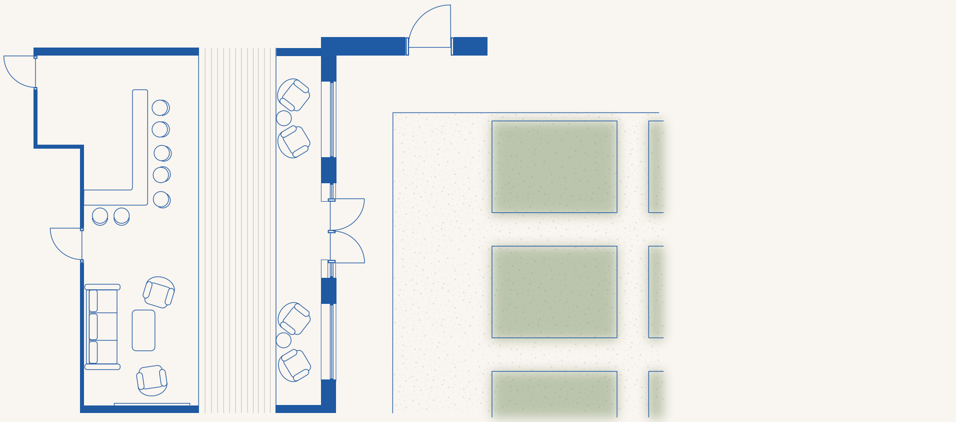
INDOOR ENVIRONMENT

When investigating the natural ventilation in the bedrooms. A general idea was based on the optimal placement of windows in relation to the rooms functions. This section describes the natural ventilation and indoor environment in a family bedroom, where the principle is the same in the couple bedrooms.
Here the principle was to have one large window on the west side of the building, and make use of thermal buoyancy to ensure a balanced air flow. The window should thereby be able to open in two directions. When deciding the two glazing sizes the window was investigated in relation to the top window should have the possibility to open, while a person is sitting in the window. This ensures that the requirements are achieved but also that the guests can change ventilation strategy based on the weather. This however did not create a balanced air flow given that the thermal buoyancy was not large enough to create enough negative air pressure on the otherwise positive air pressure side. Therefore a window was added changing the ventilation principle from thermal buoyancy to a combination thermal buoyancy and cross ventilation. The new window is placed on the opposite side of the room. This side has a negative wind pressure ensuring air flow balance after carefully changing the sizes of the window. The natural ventilation is calculated in an the excel sheet "Natural_ventilation_sheet", see appendix 14.

To determine if a specific room met the regulation, the desired windows were integrated into BSim. The integration aimed to assess whether any shading would be required. In this case, the room did not require any additional shading or shuttering. By having floor heating, heating the room to 23°C and natural ventilation it was able to be a sufficient room. However, since the windows are manually opened, optimal ventilation would not be achieved automatically. The guest can ensure optimal conditions by manually opening the windows when the indoor temperature reaches 25°C. By opening the windows when the indoor temperature is 25°C, the yearly hours above 26°C and 27°C would be approved. When increasing this to 26°C it would not be approved, but only by one hour. The regulation states a max. of 100 > 26°C and 25 > 27°C.



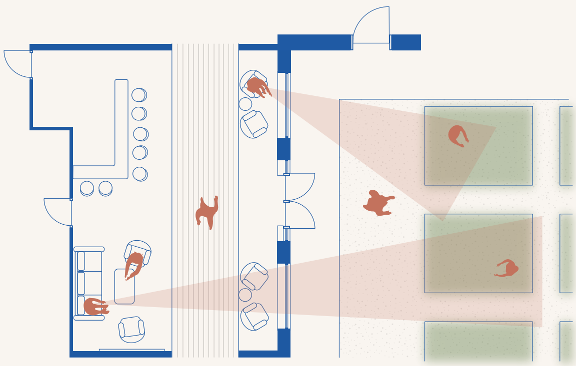
LOUNGE



ill.69. lounge, 1:200

FLOOR PLAN

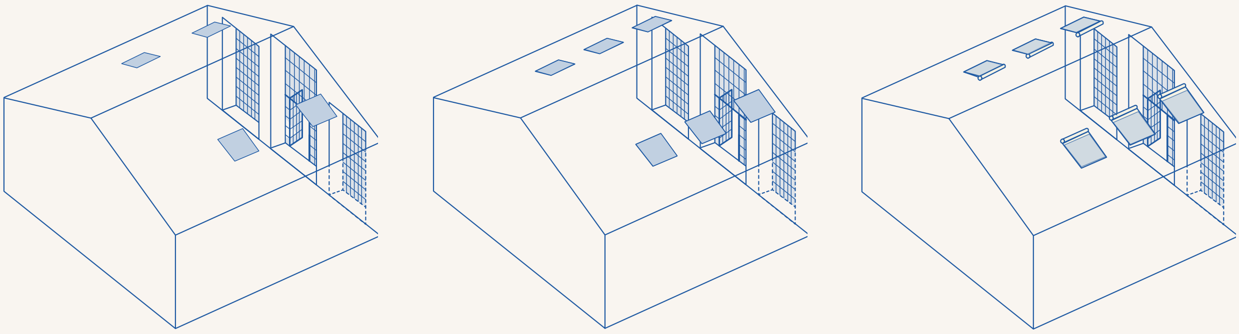
When designing the floor and furniture plan for the lounge, the interplay between staff and public functions and an interaction to the outdoor area, has been taken into account. The lounge is located in one of the factory halls, and placed between the lobby and restaurant. The circulation path goes through the lounge and divides the floor plan into two zones. These two zones are also divided due to the daylight, where at the windows towards northeast gives view to the vegetable garden, lounge furniture will be placed, to enjoy the view and natural daylight. The other part of the lounge area will create a zone for a bar, with belonging lounge furniture. Behind the bar, a door towards the staff area is placed, which creates an easy access for the staff to circulate in the beach hotel and likewise a semi private transition zone between private and public.



ill.70. visual interaction

VISUAL INTERACTION

When sitting inside the lounge, the guest and visitors have the opportunity to see the vegetable garden. Likewise the interaction between the kitchen and the garden is visible, because the kitchen staff will pick up vegetables for dinner in the restaurant.
The circulation path creates the circulation through the beach hotel, and by that connects the three public functions; *lobby, lounge and restaurant*, where views to the coast and garden are added during the circulation.



#1
56 hours > 26°C
18 hours > 27°C
APPROVED

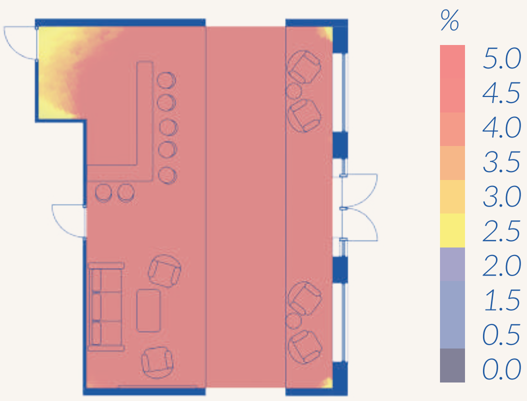
#2
81 hours > 26°C
29 hours > 27°C
NOT APPROVED

#2.1, with curtains
52 hours > 26°C
17 hours > 27°C
APPROVED

ill.71. BSim investigations

INDOOR ENVIRONMENT

Windows in the lounge are designed to create a view to the outdoor vegetable garden from the sitting area and circulation path, while illuminating the room. To determine if the lounge met the regulation, the desired windows were integrated into BSim, where three investigations were developed. The integration aimed to assess whether any shading would be required. In this case, the room did require additional shading in order to create a sufficient room, mechanical ventilation and active shading systems had to be integrated.
The room incorporated three different windows in the facade. Two with dimensions of 3.8 m x 2 m and one which is 4.6 m x 2.5 m, additionally to the facade windows are also skylights which will require mechanical shading. These windows can be opened to ventilate in the warmer seasons, using thermal buoyancy to enhance the suction. The facade windows are placed behind the exterior access balcony which gives a natural overhang both in the top of the big windows and in the center cantilevering 1.5 meters. The shading system in the rooms will activate if the room reaches 26°C. Here mechanical ventilating will be the main source of ventilation with an air flow of 0.3 m^3/s, while natural ventilation only will function as support.

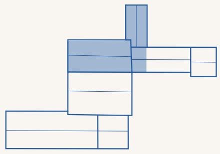


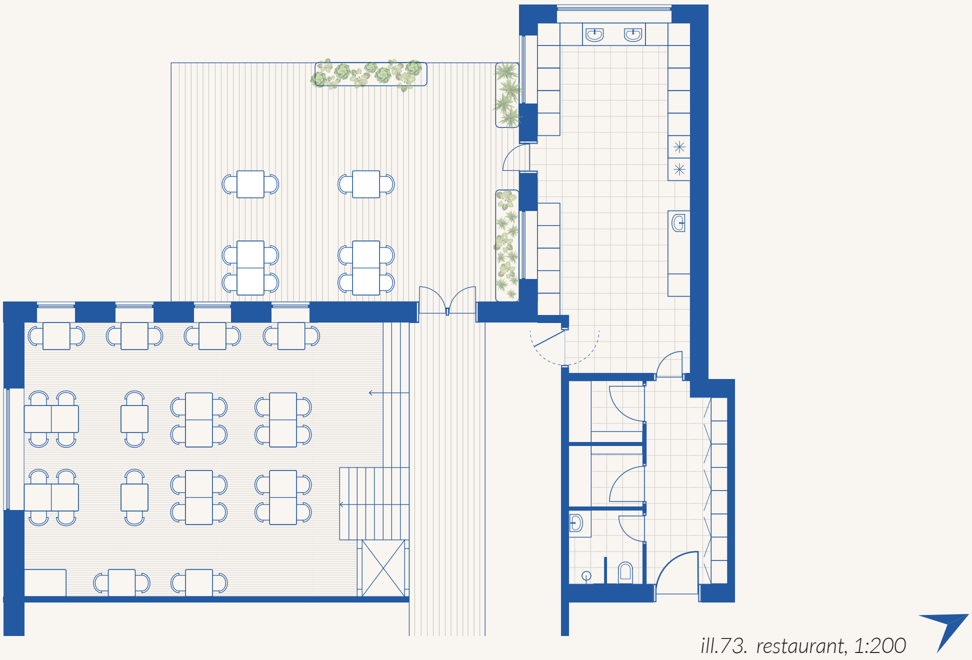
ill.72. lounge, daylight

DAYLIGHT

Within the lounge large windows towards northeast and skylights ensure a huge amount of daylight within the room, without creating overtemperature given the BSim simulation. The daylight in the lounge is over 2% in the entire room, creating one of the best zones in the building to stay, sit and interact. The exterior overhangs created by the access balcony does shield the room from direct sunlight but does not affect the daylight drastically given the skylights.

RESTAURANT





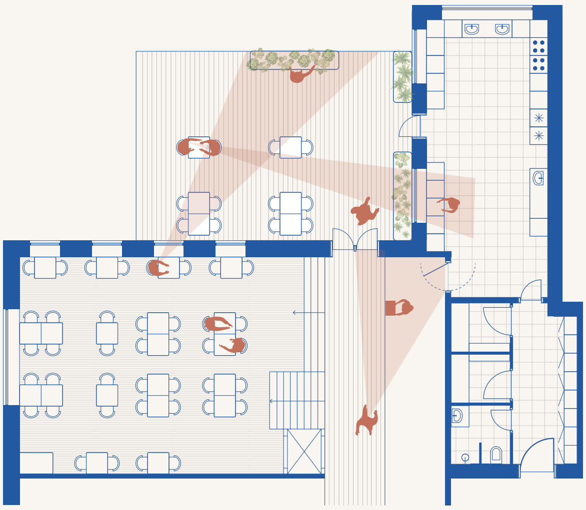
ill.73. restaurant, 1:200

FLOOR PLAN

When designing the floor and furniture plan for the restaurant, the different user groups were taken into account. The restaurants furniture plan is flexible which means the furniture can be moved if there is a larger gathering of visitors.

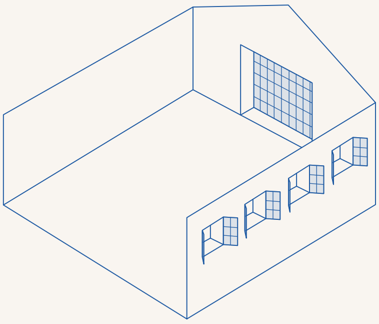
The primarily floor plan consists of six family tables of four persons and eight couple tables for two persons. Likewise a lift for people in wheelchair is placed in the corner, to make an easy access to tables and by that make the restaurant disabled-friendly.

VISUAL INTERACTION

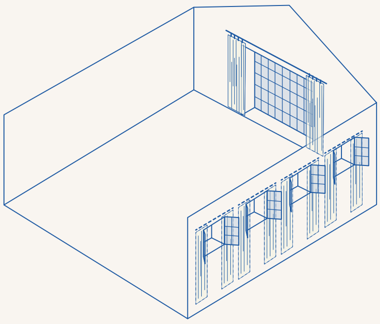


ill.74. visual interaction

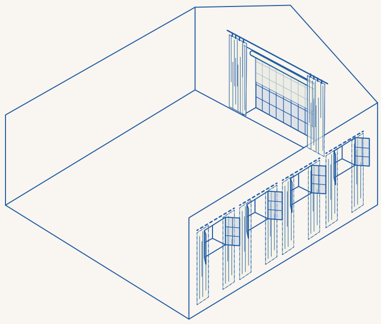
The restaurant and kitchen is placed on different sides of the circulation path through the building and bring the food in focus, and will show the relation to the site's agriculture history inside the building, because the waiter crosses the circulation when serving food.
Likewise a terrace is an extension of the restaurant and kitchen, where the visitors and guests can enjoy their food outside and follow the chef's preparation of food when they pick up herbs from the garden boxes. This will create a visual interaction between the guest and the chefs, because the preparation and production of the food is visible and has a clear relation to the outdoor areas, where the vegetables are growing. Likewise because of the raised restaurant, the guest on the terrace will not block the view towards the coast from the restaurant.



window without curtains
170 hours > 26°C
98 hours > 27°C
NOT APPROVED



window with curtains #1
110 hours > 26°C
52 hours > 27°C
NOT APPROVED

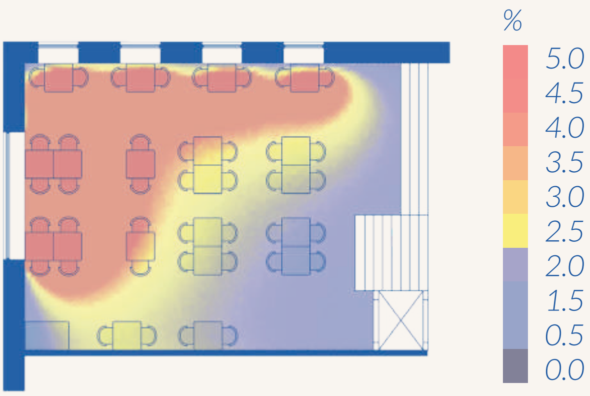


window with curtains #2
51 hours > 26°C
23 hours > 27°C
APPROVED

ill.75. BSim investigations

INDOOR ENVIRONMENT

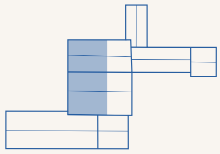
The windows in the restaurant are designed to provide a view to the coast. The existing windows will not be preserved due to their lifespan and condition. In order to preserve the expression of the existing windows, the windows are designed with bars and at the same time contribute to the atmosphere of a beach hotel. This is supported by the previously described *case study of Svinkløv Badehotel*, where the windows consist of bars.
To determine if the restaurant met the regulation, the desired windows were integrated into BSim, where three investigations were developed. The integration aimed to assess whether any shading would be required. In this case, the room did require additional shading and enhanced ventilation strategy. In order to create a sufficient room, mechanical ventilation and natural ventilation in combination with shading systems had to be integrated.
By using the previous floor heating prefix, a ventilation amount of 0.8 m^3/s , and natural ventilation in the summer periods, the room would still not be below the requirements thereby adding shading systems was necessary given the rooms position. The shading system is located on the big window, and will only activate when the room temperature reaches 26°C. Additionally curtains are added on all windows in the restaurant.



ill.76. restaurant, daylight

DAYLIGHT

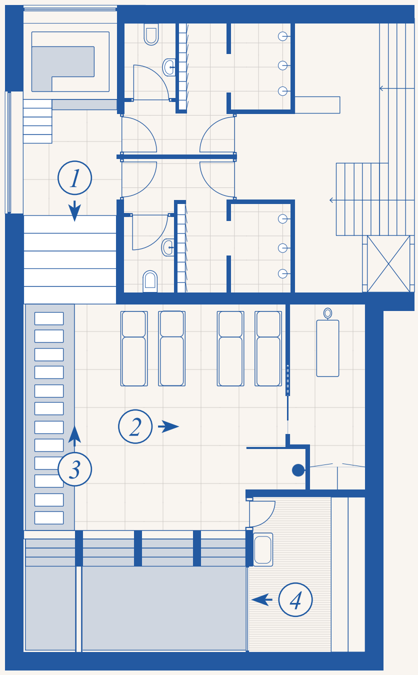
By using the existing gate, as a window in the restaurant it creates a good opportunity for sufficient daylight even though the floor area of the room is quite large. The chosen window solution does only leave a dark spot in the walking area where no tables are placed. The daylight for the restaurant is equivalent to 63% of the floor area being above 2%, which is approved.



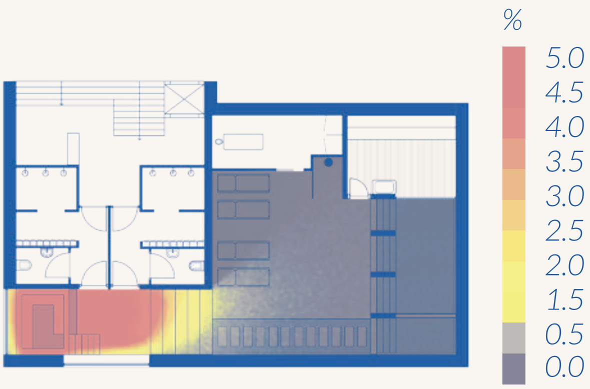
SPA

FLOOR PLAN

As described earlier, the spa area is dug down beneath the building. The spa shall have a full sensory experience, when entering from the circulation path, and all the way down to the pool area. The daylight must follow this atmosphere, it should get darker the further one goes into the spa. Therefore, the hot water basin and regular basin are located furthest away from where daylight iluminates, where in this area artificial lighting will illuminate the materials and the basins. At the entrance from the changing room to the spa area, a hot tub is located where the natural light dominates and contributes to the view towards the coast.
In the spa area, a massage room and a sauna is placed, where guests and visitors can get treatments during their stay. Likewise, the exhibition wall will be continued down into the spa area, where the existing yellow brick will be built up and create a relation to the place.
The process of the spa area floor plan can be seen in appendix 16.



ill.77. spa area, 1:200



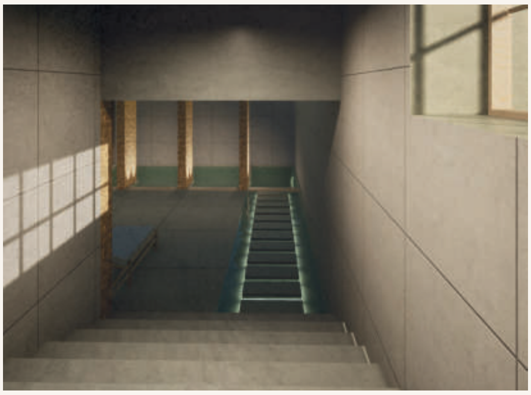
ill.78. spa area, daylight

DAYLIGHT

In the spa a lower amount of daylight was intended, this can also be seen in the illustration. The idea of the spa is that one enter the changing rooms with clinical lighting, and then upon entry to the spa is transitioned through light. Creating zones with daylight and diffuse sunlight, which then as one walk further down the spa is slowly fading. This creats the feeling of walking deeper into a cave, which is also supported by the material choices in the spa. Here the daylight is not sufficient in terms of BR18, however given the circumstances this room is not used for living and is therefore viewed as approved in terms of the intended feeling for the room.

ATMOSPHERIC POTENTIALS

1 The progress through the spa is supported by how daylight illuminates through the room, as shown in the daylight analysis carried out. On arrival from the changing room, which divides the spa area with the beach hotel, a hot tub is placed where two large windows let daylight onto the plateau. At this location, the daylight makes the room clear and bright, where the windows give a view towards the coast.



ill.79. spa atmosphere: exiting changing rooms

2 The artificial lighting in the spa will be lowered giving it a darker tone, this is done through spots in the ceiling, however spots are also located in the floor in all places of brick walls illuminating them to highlight the texture of the material. At the end of the collage is shown a cold water dunk which is highlighted with a more intense spot. The sunbeds will be located next to the big brick walls where the ceiling light illuminates less, creating a cozy area.

ill.80. spa atmosphere: spa area

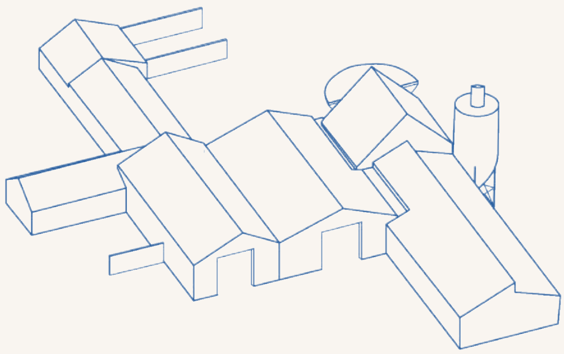
3 The experience of light from the entry to the main spa area can be seen on this collage, where sunlight goes through the windows and hits the opposite wall. As one moves further into the spa the natural light slowly dissipates creating the feeling of moving deeper into a cave. At the end of the image can the hot tub be seen. This hot tub has flowing water running down the side creating reflection when hit by the sunlight in noon.

ill.81. spa atmosphere: daylight towards the hot tub

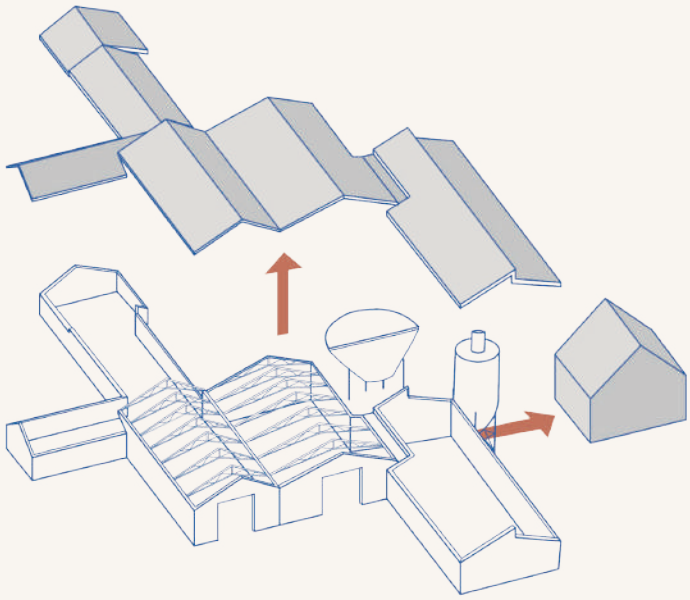
4 A dark one way glass wall is placed between the sauna and the spa areas basins, which makes it possible to have a view from the sauna towards the basins while preserving privacy inside the sauna. From the sauna one can see the tactile bricks pillars which should be associated with the facade.

ill.82. spa atmosphere: view from sauna

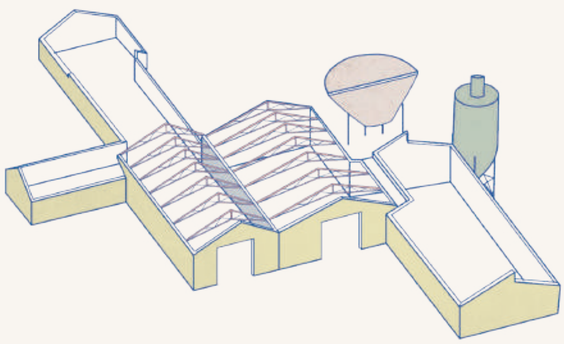
CONCEPT DIAGRAM



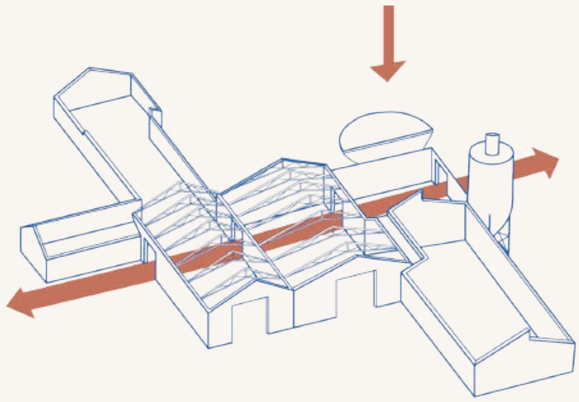
1 *The existing cement factory*



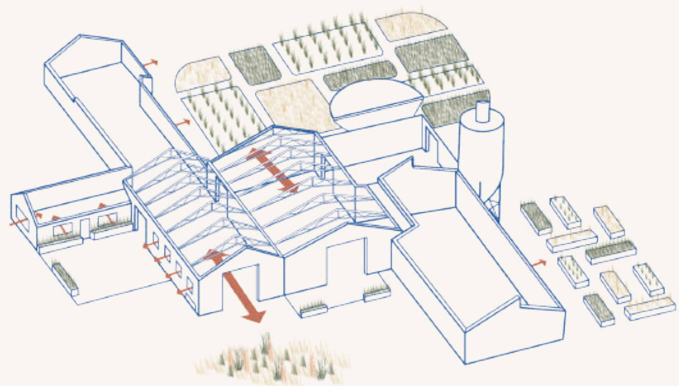
2 *Removing damaged materials and/or in poor condition*



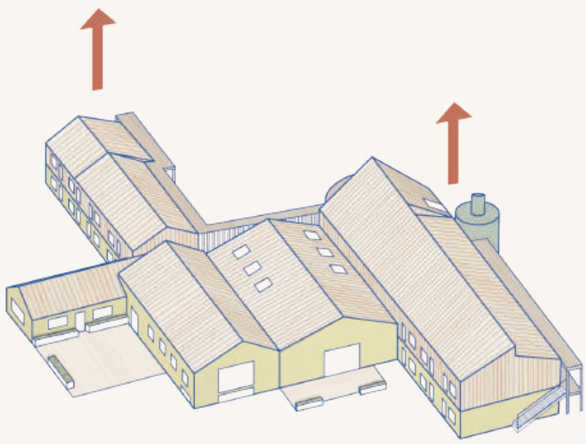
3 *Preserving value-setting elements, to preserve the materials patina and recognisability on the island*



④ *Circulation path through the building to visually and physically connect road and coast*



⑤ *Room organization in relation to the outdoor areas, with reference to the sites history*



⑥ *Extending vertically to preserve the materials patina and change in materials*

ill.83. concept diagrams

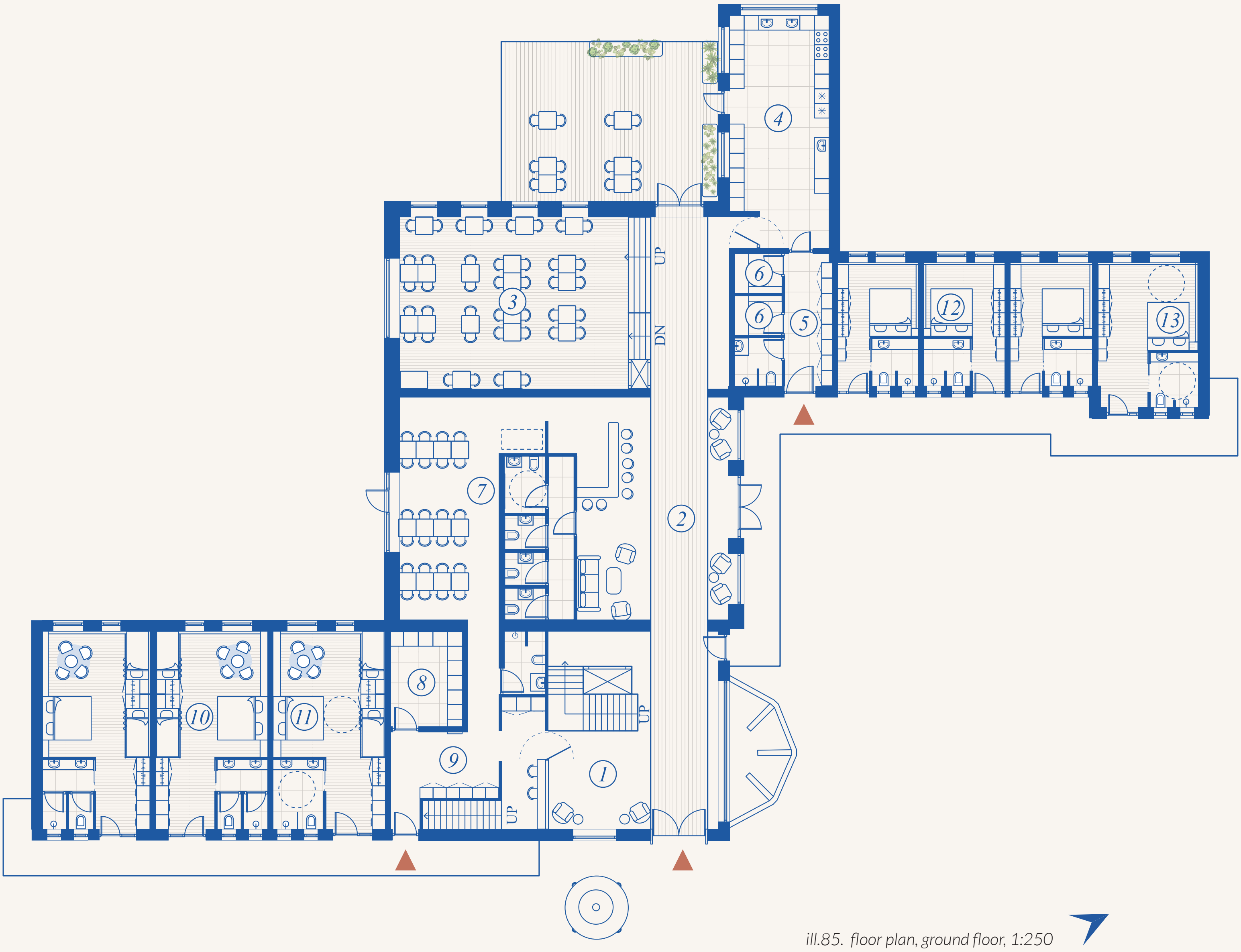
PRESEN-
TATION

This chapter describes and visualizes the final design of the transformation of the cement factory into a beach hotel. The final design will be presented through a masterplan, where the connection to the site and surrounding is visualized. Likewise floor plans, sections and elevations will describe and visualize the beach hotel, where spatial qualities and materials will be shown. The drawings will be found in the **Drawing folder**.
Technical aspects of the project, here indoor environment and global warming potential GWP, will be described and documented - with a comparison between the transformed beach hotel and a new build beach hotel. This will be done to mark the focus on sustainability through transformation and its climate influence.
Through the chapter several visualizations will be shown, where atmospheric and spatial qualities are shown and likewise the connection to materials.

MASTERPLAN

Samsø Beach Hotel
Plot size: *6265 m^2*
Total floor area: *1031 m^2*
Total floor ground area: *670 m^2*
Level: *2*
Parkering:
2 disabled parking lots
18 parking lots
12 bicycle parking lots

ill.84. Masterplan, 1:400

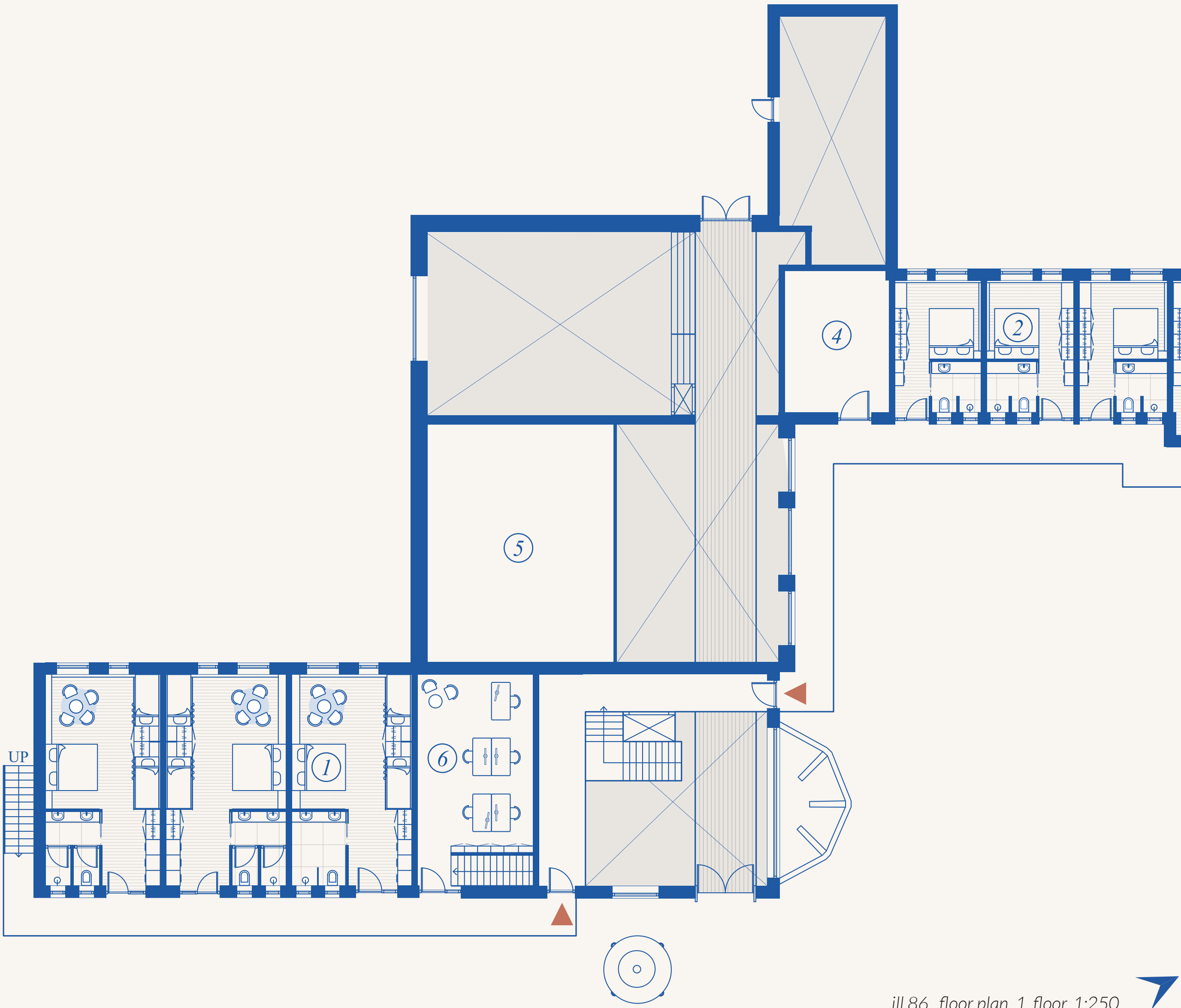


ill.85. floor plan, ground floor, 1:250

FLOOR PLANS

GROUND FLOOR

1. *Lobby, 55 m²*
2. *Lounge, 60 m²*
3. *Restaurant, 66 m²*
4. *Kitchen, 38 m²*
5. *Wardrobe room and delivery, 13 m²*
6. *Coolroom and storage, 5 m²*
7. *Staff room, 42 m²*
8. *Laundry and storage, 12 m²*
9. *Wardrobe room and staff entrance, 13 m²*
10. *Family bedroom, 38 m²*
11. *Disabled-friendly family bedroom, 38 m²*
12. *Couple bedroom, 18 m²*
13. *Disabled-friendly couple bedroom, 28 m²*



ill.86. floor plan, 1. floor, 1:250

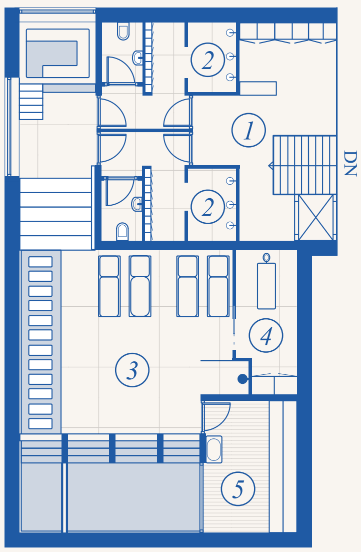
1. FLOOR

1. *Family bedroom, 38 m²*
2. *Couple bedroom, 18 m²*
3. *Disabled-friendly couple bedroom, 28 m²*
4. *Technical room #1, 18 m²*
5. *Technical room #2, 66 m²*
6. *Administration, 40 m²*

Administration

BASEMENT

1. *Spa reception, 25 m²*
2. *Changing room, 13 m²*
3. *Spa area, 78 m²*
4. *Massage room, 10 m²*
5. *Sauna, 12 m²*



ill.87. floor plan, basement, 1:250

ELEVATIONS

NORTHEAST ELEVATION
1:200

SOUTHEAST ELEVATION
1:200

SOUTHWEST ELEVATION
1:200

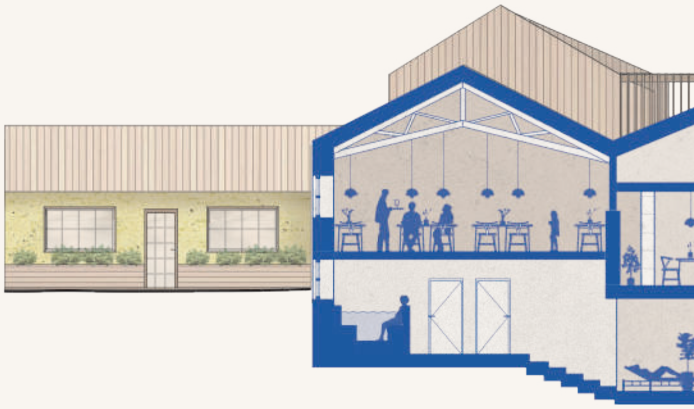
NORTHWEST ELEVATION
1:200

ill.88. elevations, 1:200

SECTIONS

SECTION A-AA
1:200

A



restaurant

SECTION B-BB
1:200

B

restaurant

SECTION C-CC
1:200

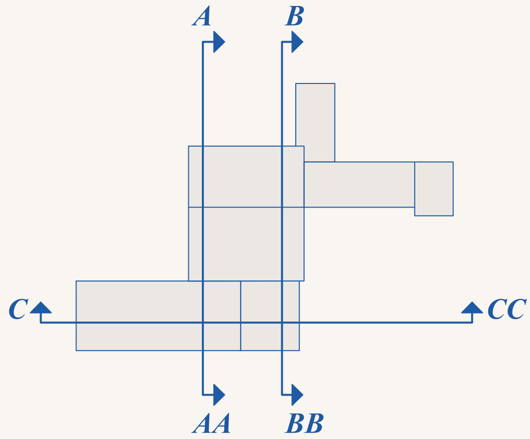
C

family bedrooms

administration

wardrobe

reception



AA

staff room

spa

administration

cleaning room

wardrobe

BB

staff room

lobby

CC

lobby

ill.89. sections, 1:200

ill.90. visualization of lobby

When guests and visitors arrives at the beach hotel, the lobby is the first room they enter. The expression of the room is to visually tell the story of a transformation from a former cement factory to a beach hotel. The silo and gravel mixer plays a huge role in the room experience and atmospheric quality with a reference to the industrial era, by how the daylight and shadows illuminate the room. The reception consists of roof tiles reused from the cement factory's roof.

ill.91. visualization of restaurant

The restaurant is placed in one of the former factory halls, where the existing gate is transformed into a window, with a view towards the coast. The window creates a visual connection to the outdoor areas.

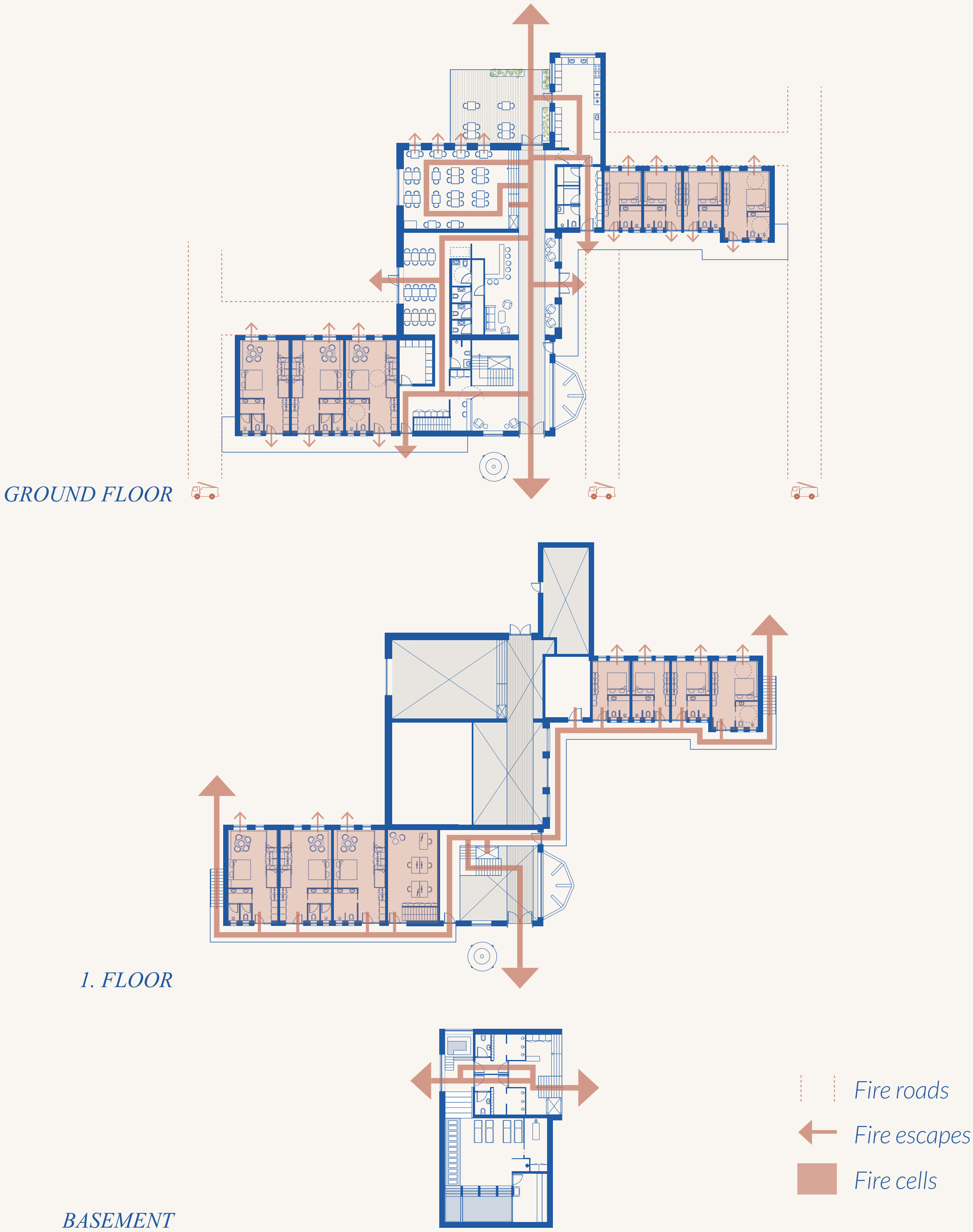
In the former factory hall, the lattice trusses are preserved, creating a relation to the industrial era prior to the transformation. Between the trusses are ventilation canals located, running along the openings in the trusses.

ill.92. visualization of lounge

The lounge is detailed with focus on cultural heritage and references to the site. The circulation path creates a path through the room towards the coast. Along the circulation path, large windows are placed for views towards the vegetable garden, where the kitchen staff pick up the vegetables. A sliding door from the factory workspace to the factory is preserved as a monument on the wall. The bar consists of roof tiles reused from the cement factory's roof.

ill.93. visualization of outdoor area, vegetable garden

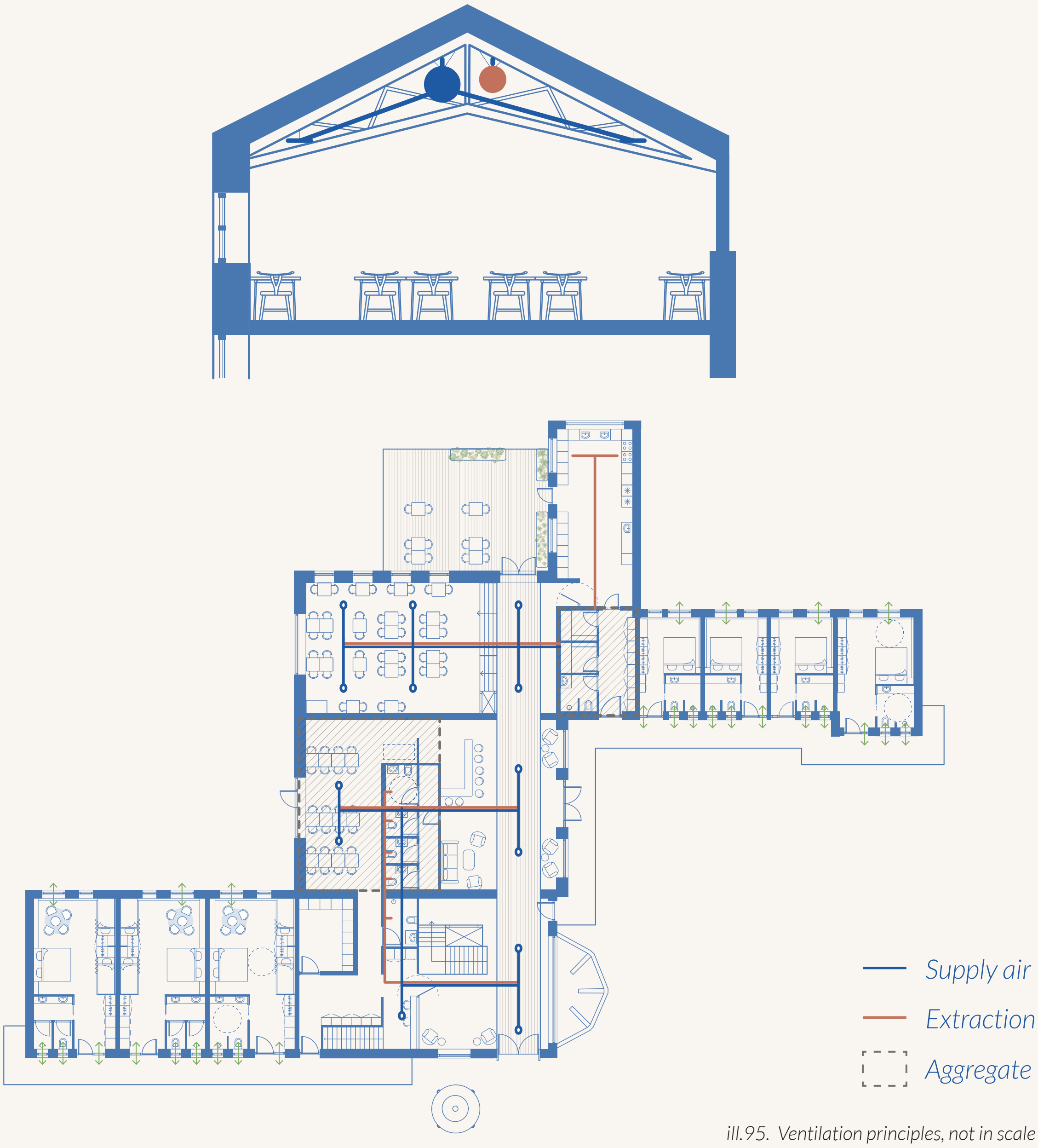
For creating a reference to the history of the site, a vegetable garden and garden boxes have been integrated into the beach hotel early and have formed the room organization. The cement factory was founded by local farmers, which will be visible in the use of a vegetable garden to grow vegetables for the kitchen to serve in the restaurant. By this food production is in focus in the beach hotel, and will be experienced inside and outside.



ill.94. fire escapes, not in scale

FIRE

All areas of the building are constructed with two escape points ensuring security and making sure people have multiple ways of leaving an area in case of fire blocking one. These exit points are either main circulation or escape windows. All fire escape circulation paths and windows are constructed in regards to the BR18 requirements (Bygningsreglementet, 2018a). Around the building is a fire road, with a width of 3 meters, for fire trucks to rescue people from these areas on 1. floor. Each bedroom is constructed as its own firecell and the main areas are one big firezone with multiple escape points ensuring safety in all areas of the building.



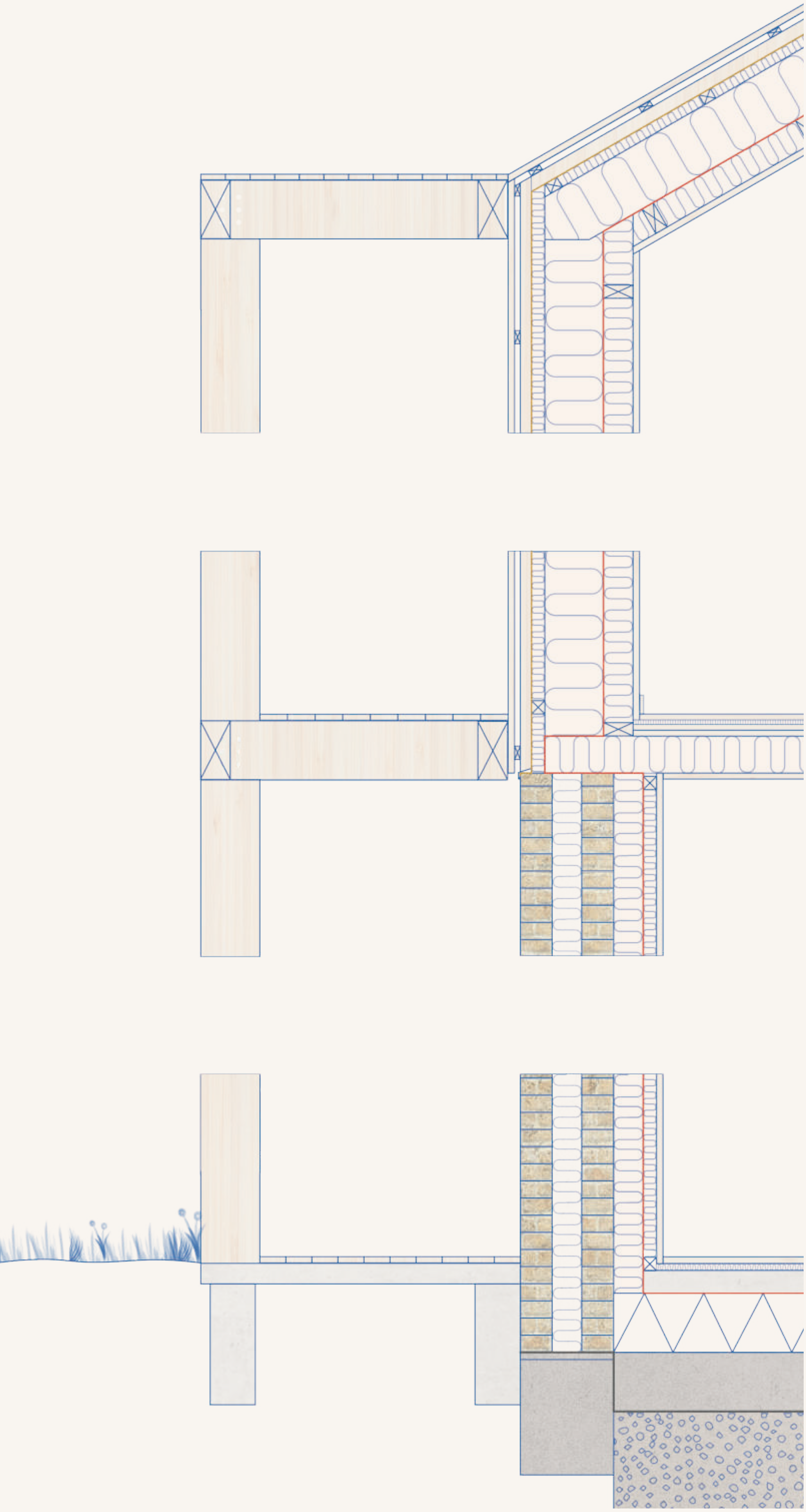
ill.95. Ventilation principles, not in scale

VENTILATION

In the building two different central aggregates have been placed, where one ensures air quality in the restaurant and kitchen while the other serves the spa, staff room, lounge and lobby. These aggregates are placed directly above the given zones on the 1. floor. This is done to minimize the length of travel for the air flow and to minimize the pressure loss, which ultimately reduces the overall size of the channeling systems. This also helps to reduce the overall amount of bends needed in the ventilation. Both aggregates are placed in rooms with one or more external faces ensuring intake from outside.
The ventilation principle is mix ventilation with a central extraction and supply from ventilation fixtures running outwards towards the rooms' boundering walls. The fixtures are simple and small to reduce the attention on these to ensure the lattice trusses are the main focus in these rooms. The ventilation principle in the spa has not been drawn given the complexity of this room. However the central aggregate responsible for the spa is sufficient and can supply enough air, thereby leaving the channeling principle undeveloped.
Mechanical ventilation is not extended to the bedroom, these rooms will be fully independent on natural ventilation.

ill.96. visualization of access balcony

The access balcony connects the bedrooms with the lobby. The access balcony is an attachment to the building, both to preserve the existing materials, but also to visually show the access balcony as a new element on the building. This is shown in the way it is assembled to the building, where visual assemblies create an affixed look. The access balcony creates a clear horizontal line in the meeting between the new and existing materials further segmenting this.



ROOF

0.13 $W/m^2 \cdot K$, 514 mm

Pine lamellas, 22 mm
Ventilated layer, 20 mm
Ventilated layer, 30 mm
Wind barrier
Straw insulation, 45 mm
Straw insulation, 200 mm
Vapour barrier
Straw insulation, 95 mm
Pine boards, 22 mm

WOOD WALL

0.13 $W/m^2 \cdot K$, 400 mm

Pine boards, 22 mm
Straw insulation, 100 mm
Vapour barrier
Straw insulation, 150 mm
Straw insulation, 45 mm
Wind barrier
Ventilated layer, 38 mm
Ventilated layer, 19 mm
Pine lamelles, 22 mm

FLOOR SEPARATION

200 mm

Pine plankes, 22 mm
Step reducing insulation, 15 mm
Particle board, 22 mm
Straw insulation, 125 mm
Pine boards, 22 mm

BRICK WALL

0.15 $W/m^2 \cdot K$, 490 mm

Pine boards, 22 mm
Straw insulation, 45 mm
Vapor barrier
Straw insulation, 100 mm
Wind barrier
Bricks, 108 mm
Rockwool insulation, 100 mm *existing*
Bricks, 108 mm

FOUNDATION

0.09 $W/m^2 \cdot K$, 687 mm

Pine plankes, 22 mm
Step reducing insulation, 15 mm
Concrete, 100 mm
Vapour barrier
EPS Insulation, 250 mm
Concrete, 100 mm *existing*
Leca granules

ill.97. envelope, 1:20

ill.98. visualization of family bedroom

Every bedroom is oriented towards the coast, to ensure the guest have a view to the coast and sea. This view is supported by the vertical window placed in line with the door. When entering the bedroom, the first thing seen by the guests is the view. The big window in the bedrooms is designed as a sitting window, where the guests can enjoy the view. The family bedrooms on 1. floor has a skylight window where light illuminates the room.

ill.99. visualization of outdoor area

The building is located close to the coast in a vegetated area, which creates calming surroundings for the guests. The beach hotel provides great nature and coast which creates areas for outdoor activity and beautiful views from every room in the building. Towards the coast a terrace is placed in relation to the restaurant with outdoor seating and creates a visual connection between guest and kitchen, where chefs are performing and producing the food.

ill.100. visualization of spa

The hot tub in the spa is located next to the windows towards the outdoor area and coast. The view brings a calm atmosphere into the hot tub, where the guest can enjoy themselves and the view.

This area is likewise the only area in the spa, where daylight enters and illuminates the room. The window gives a view towards the coast, while the side window gives a view towards a more wild vegetation and trees.

ill.101. visualization of spa

The spa has references to the former cement factory's materials, by using concrete on the floor and walls. The concrete floor is concrete elements the factory has produced, and was stored outside the building, which people could see when passing by. Reused bricks have been used as an extension of the exhibition shelf and as pillars. The dark room and diffuse lightning brings a tactility to the spa, which gives the guest a calm feeling to relax.

ENERGY

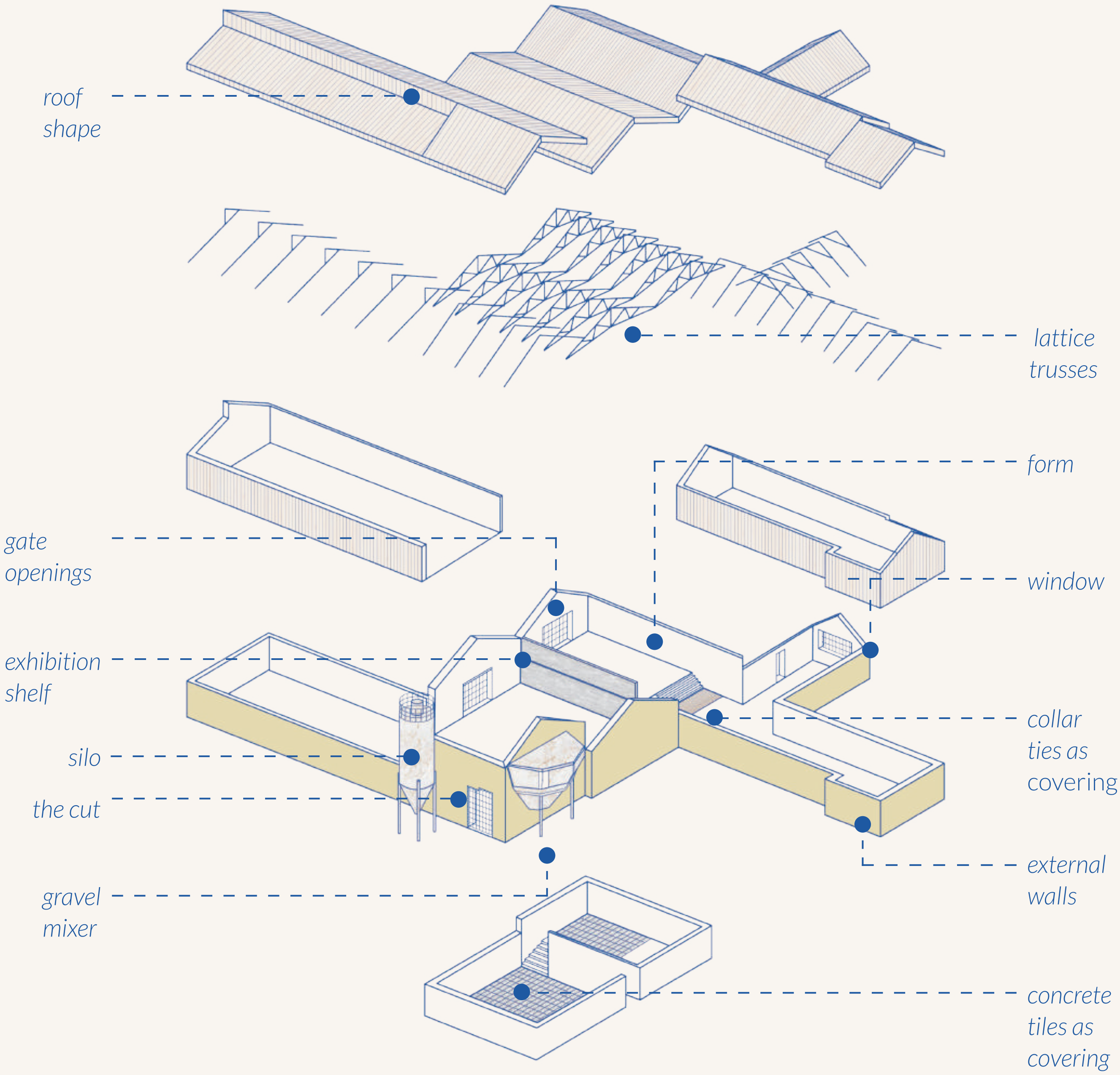
Passive strategies have been the main focus during the transformation when creating a sustainable building, which also complies with today's standards. When renovating, account has been taken on the BR18 requirements for *"building envelope, in case of change of use and additions"*, with U-values for the different building elements, see appendix 10. The passive strategies consist of internal shading as curtains, to ensure the atmosphere of a beach hotel and likewise to give the room an approved indoor temperature. Natural ventilation is integrated in the bedrooms, where the guests can manage the indoor climate by themself, and likewise here internal curtains are placed for shading. In the public zones of the building, mechanical ventilation is integrated, to ensure a good indoor environment for the guest and visitors. These passive and active strategies are simulated in the program BSim.

Samsø Beach Hotel is a result of integrated design, where simulations have been done in the program Be18, to understand the energy use of the building. Be18 has been used according to the optimization of the building envelopes, to ensure a final energy consumption of 30 kWh/m^2 per year.
The final **energy consumption for the building is 29.1 kWh/m^2 per year**, seen in appendix 17.

Samsø has a strong focus on green energy and on being a *"Renewable Energy Island"* and uses district heating, as it is more energy efficient and places a significantly lower burden on the environment. The district heating comes from burning CO_2 neutral fuel from locally produced wood chips and straw at the heating plant in Norby-Mårup (Grøn Varme Samsø, n.d.). Samsø Beach Hotel will be on-grid and contribute to the *"Renewable Energy Island"*.

ADAPTIVE REUSE

Within the transformation of the existing cement factory numerous construction elements have been preserved in order to create a more sustainable and recognizable building in relation to cultural heritage. The exterior walls have been preserved from the outside and optimized inwards, to preserve the materials patina overtime and ensure the rural community and visitors can easily see original parts of the building from outside. This combined with the use of *facadism* will create facades in which users can easily distinct time periods and thereby imagine the original building state, this is furthermore emphasized by the fact that the building does not extend beyond the original foundation, creating a clear horizontal line between the new and original. Beyond the external walls some interior walls have been preserved, these walls had a unique design as exhibition walls, constructed from raw materials like bricks. Besides these walls all existing load bearing interior walls have been preserved as the structural elements while the finish on both sides of the wall have been exchanged for more modern materials suitable for sustainability and the atmosphere intended to recreate the theories from **Aemulatio**. Outside industrial equipment have been preserved given these are defined as ***monumental***, these should not be interfered with beyond preserving their original appearance while incorporating them cleverly. These have been transformed using the theory of **Translatio** and are elements such as the gravel mixer and silo.
Overall the reuse of existing structures and materials is based upon the environmental impact combined with the interconnected cultural heritage of the elements. The beach hotel encountered the global warming potential of the building industry while trying to solve it, using alternative methods of sustainability while creating a site-bound and historically interpretation of the original building.



ill.102. adaptive reuse - value setting

SCENARIO 1	SCENARIO 2
Transformation incl. B6	**New build incl. B6**
7.137 kg CO2-eq/m2 per year	*8.743 kg CO2-eq/m2 per year*
Transformation encl. B6	**New build encl. B6**
2.615 kg CO2-eq/m2 per year	*4.220 kg CO2-eq/m2 per year*

LIFE CYCLE ASSESSMENT, LCA

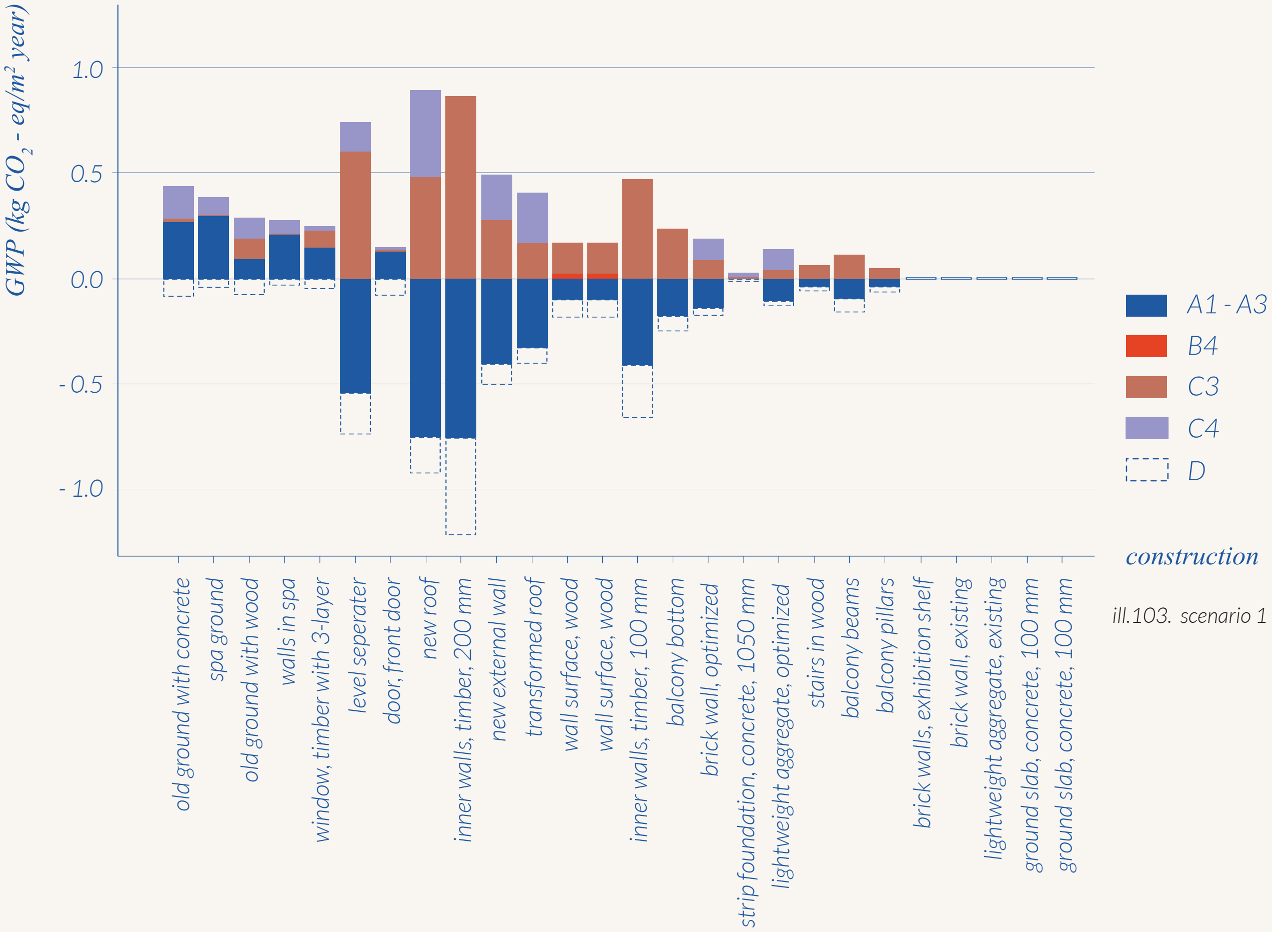
To ensure the methodology of reusing materials works in relation to ecological sustainability based on circular life, an analysis has been conducted to examine the overall difference in performance, in terms of Life Cycle Assessment (LCA). The analysis is based on the building designed throughout the thesis project compared to the same building being newly constructed, by not reusing existing materials and structures.

Transforming is a rather new alternative in the field of sustainably using what is already existing to minimize the total global warming potential (GWP) by eliminating the production phase of certain elements. This analysis is based on the difference between two scenarios, both including all structural elements, interior and exterior walls, roofs and foundations. The two scenarios were constructed based on LOD300, which is the level of detail. In this case the model is specified in accurate measurements but does not include detailing and assembly elements. The precise materials and amounts are specified in appendix 18.

The calculated GWP for the transformation project was equal to ***7.137 kg CO_2-eq/m^2 per year***, but as previously stated this does not include mechanical systems and exterior ground work ect. While the newly built version of the building was equal to ***8.734 kg CO_2-eq/m^2 per year***, with the same parameters as the first scenario. However this does not include the demolishment of the existing structure. These numbers include the values from B6 which is the energy used for operating the building. This is equal to **4.522 kg CO_2-eq/m^2 per year** for both scenarios, if this phase is not included and the analysis solely evaluate the difference between the production and end of life of the materials. The GWP values would be equal to ***2.615 kg CO_2-eq/m^2 per year*** for the transformation and ***4.220 kg CO_2-eq/m^2 per year*** for the new building. This gives an absolute reduction of **1.606 kg CO_2-eq/m^2 per year**, equal to a relative reduction of **38%** looking primarily on the materials however including the operation of the building (B6) the relative reduction is equal to **18.38%**.

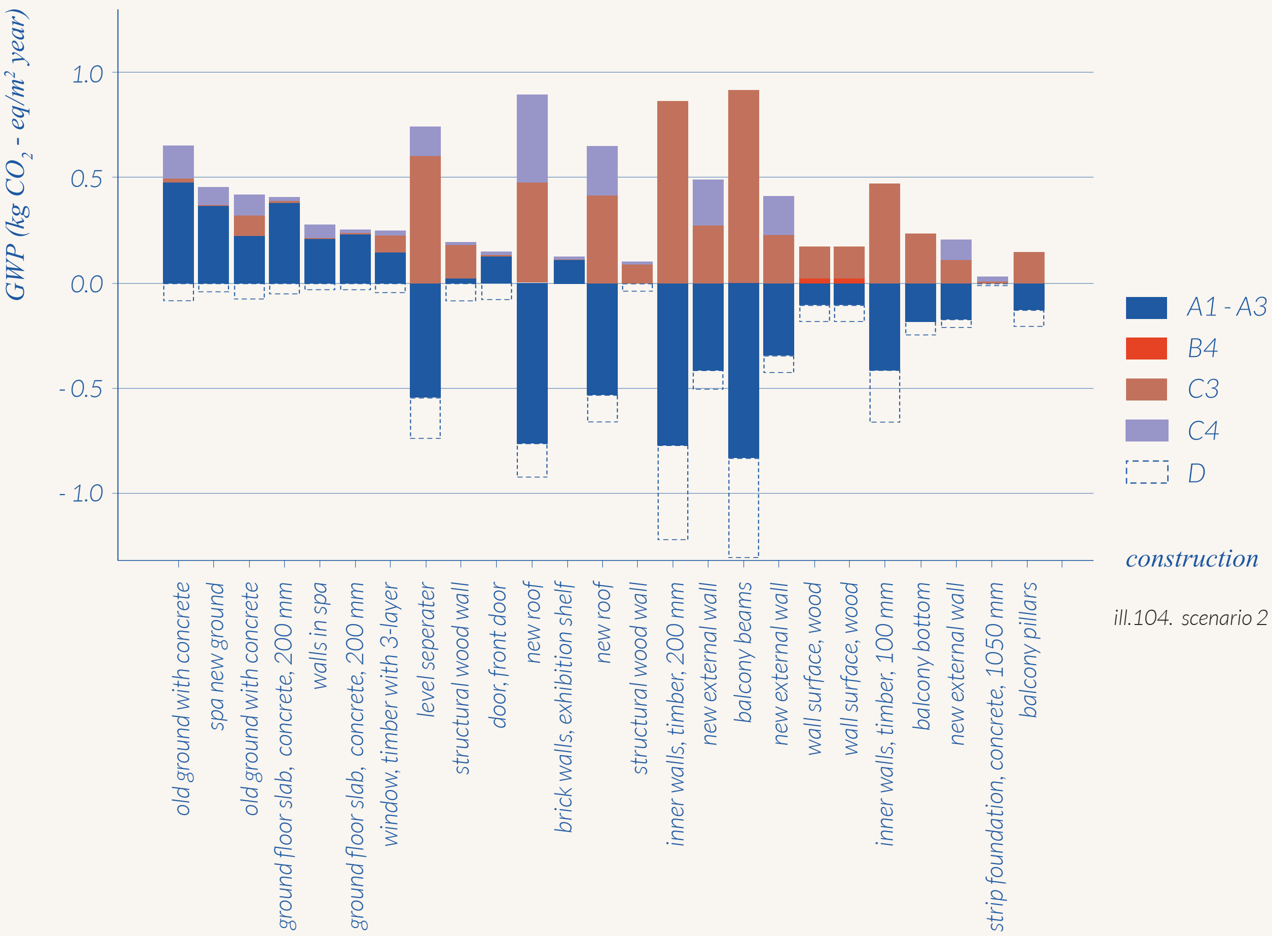
The analysis shows that transforming old buildings can significantly reduce carbon emissions and have a positive impact on the environment, while preserving cultural heritage. Reusing materials and eliminating the production phase of certain elements leads to an absolute reduction of 1.606 kg CO_2-eq/m^2 per year, equal to a relative reduction of 38% looking primarily at the materials. **This highlights the importance of sustainable practices and circular life in the construction industry for a greener future.**

SCENARIO 1 - *transfromation*



ill.103. scenario 1

SCENARIO 2 - *new build*



ill.104. scenario 2

EPI-
LOGUE

This chapter concludes and reflects on the master thesis project. The conclusion will describe how the project responds to the problem, design criteria and the vision for the project, defined in the chapters ***The scope*** *and* ***Program delimitation****. The reflection will describe elements in the project that have had major impacts, both positive and negative, for the final design.*
Finally, a reference and illustration list is compiled.

CONCLUSION

The aim of the thesis project was ***to transform a previous cement factory, an existing industrial building, into a beach hotel on Samsø and likewise a material matrix and catalog for determination of materials when transforming***. The thesis project investigated the understanding of an existing building and structure and how this will be transformed into a new function and likewise optimized to today's standards.

Transforming architecture offers a sustainable approach to designing buildings by preserving relevant elements ultimately reducing the carbon emission associated with new constructions. Given that the production phase will not be part of the calculation based on the elements already existing on site, the A1-A3 phases can be eliminated which accounts for 10% of the CO_2 emissions in Denmark. Additionally, reusing existing building elements can have aesthetic factors, such as preserving cultural heritage, and play a role in defining the atmospheric potentials of the site.
The beach hotel on Samsø is located along the west coast of the island and is recognized for its yellow external walls, which has developed a patina over the years, reflecting the building's past as an industrial building. When transforming from a former cement factory to a beach hotel, the building envelope needs to be optimized to ensure an approved indoor environment. This optimization focuses on preserving the yellow external patina, cultural heritage, and maintaining the locals' sense of belonging to the building.

In the thesis project a material matrix has been developed for determining materials on the specific site, where different parameters can be adjusted according to the specific rooms atmospheric potentials, in both technical and aesthetics perspectives.
In addition a **Catalog - Elaborated Material Exploration**, has been developed highlighting materials on site, where they are located and the materials condition, according to reusability in the transformation. The matrix and catalog ensures ecological- and social sustainability, because of the site-bounded transformation, where the site's history and cultural heritage is in focus.

Samsø's tourism has primarily been active during the summer months, while the winter season experiences little activity due to the harsh weather conditions. By introducing a beach hotel, tourism can be extended to the entire year, supporting VisitsDenmark's sustainable tourism initiative, leading to more businesses and job opportunities on the island, and promoting greater settlement on Samsø. All while introducing an alternative sustainable methodology, which lowered the emission of the building by 1.972 kg CO_2 eq/m^2 per year compared to the same building being newly constructed, and this value gets inevitably higher when including the demolition of the existing structure.

In conclusion, "transformation architecture" presents a sustainable approach to building design by preserving existing building elements and reducing the carbon footprint associated with new construction. While technical considerations are important, aesthetic aspects play a critical role in defining the atmospheric potentials of a site and preserving cultural heritage, relating back to the risk of losing the rich building heritage in rural areas of Denmark.
Samsø Beach Hotel provides an excellent example of site-bounded transformation, where the matrix and catalog ensure ecological- and social sustainability while preserving the island and site's history and cultural heritage. By extending tourism to the winter season, the beach hotel contributes to sustainable tourism initiatives and supports greater economic growth and job opportunities for Samsø's residents.

REFLECTION

This thesis project has investigated and designed a transformation of a former cement factory on Samsø. During the process from start to end, different elements have had an influence on the final design. Likewise the first intention of the project has slightly changed during the analysis phase and the beginning of the design process.
The intention of this thesis project was to create an understanding of transformation, as a sustainable point of view during architecture, and by that develop a tool, ***the matrix***, which should be used in any kinds of transformations projects. During the development of the matrix, it was clear that the specific site and the existing structure was a larger part of the transformation, then first expected, and because of that an universal tool could not be developed. Therefore the matrix is more site-bounded, where site and atmospheric analysis needs to be made first, to have a better understanding of the transformation.
A catalog was developed, where the existing structure and materials were pointed out, to create an overview over the existing building and to understand which parts could be transformed and which should be renovated.
During the catalog and the materials descriptions, it was clear to see that the condition of the cement factory was not great and the materials and structures life time was close to an end. Therefore the building needs to be renovated and optimized according to today's standard in BR18, which also has an influence on the transformation.
When calculating the total GWP for the building it became clear the amount of data needed to conduct such an analysis. Creating a focus primarily on specific elements of the building with a LOD300 to simplify the analysis, this means that the total GWP value calculated does not states the total GWP for the entire building, and can therefore only be used when comparing the two scenarios with each other, given that these are constructed based on the same parameters.
The optimization of the building envelope was a huge topic during the project and likewise to choose which elements that has the biggest preservation value, according to the specific project. It was chosen to optimize the external walls inwards, to preserve the recognisable yellow external wall, where the materials patina has developed over time. This was chosen because of the iconic color and to keep the relation to other yellow buildings on Samsø.

By optimizing inwards, several thermal bridges would accor in assemblies between the external wall and roof, and external wall and foundation. This could have been solved by optimizing the external wall outwards, which is a more *"normal"* way to optimize envelopes, but then the elevations need to be designed again in a new way to keep the yellow elevation, which was not decided to investigate further.
During the design process of transformation, it was decided only to build vertically to preserve the form and footprint of the existing building. The disadvantage of this was that the room sizes was different than first assumed and a basement floor plan for the spa area had to be designed so that the beach hotel could accommodate a spa. Likewise, when preparing the bedrooms, especially family bedrooms, the depths of the rooms were a problem according to daylight. In addition, a different design of windows at both ends of the room was done, in order to achieve as much daylight as possible in the bedrooms, within the limits that follow confined spaces of a transformation project.

When designing a beach hotel, the focus was that all target groups would be able to use the beach hotel, including target groups with less accessibility, such as users in wheelchairs etc. Throughout the design process, consideration has been given to wheelchair users being able to move around with equal accessibility in the building, without having to compromise their stay at the beach hotel. However, this was not possible to complete in all rooms to the same degree, as wheelchair users take up a lot of space in the rooms and due to a basement with a spa, accessibility had to be considered in other ways, for which a balance of accessibility in the building should have been more precise from start.

Accessibility has also been a disadvantage for the design of the circulation path through the building, as the idea here was to preserve the existing concrete foundation, and thus have a single step up to the rest of the building's optimized foundation. This was to preserve and highlight an industrial element in the building, because the existing concrete foundation also consists of wheel tracks and would bring an industrial atmosphere through the building. How this circulation path would be designed to avoid too large thermal bridges, has not been investigated further

REFERENCE LIST

Andersen, C. M. E. et al. 2021. Klimapåvirkning fra 20 træbyggerier : LCA på eksisterende træbyggerier. BUILD, Aalborg Universitet.

BARK Rådgivning A/S. 2023. Inspirerende bygninger - Når fortiden former fremtiden. BARK Rådgivning A/S. ISBN: 978-87-993419-8-6

Boito, C. 2009 [1893]. Restoration in architecture. First Dialogue. Future Anterior,6(1), 69–83

Bolius, 2020, Så let får du dine egne krydderurter. Videncentret Bolius Internet address: https://www.bolius.dk/saa-let-faar-du-dine-egne-krydderurter-8525?gclid=Cj0KCQjwiZqhBhCJARIsACHHEH-aGZPepWIIeQUqYH3ffAwn_yf7QQNgg2Sx82iScSrVthPBJq1M8MUaAoTCEALw_wcB viewed: 03/04/23

Bygningsreglementet. 2018a. Brand (§ 82 - § 158), Bilag 6 - Præ-accepterede løsninger - Hoteller mv. Internet adress: https://bygningsreglementet.dk/Tekniske-bestemmelser/05/Vejledninger/Generel_Brand/Hoteller viewed: 26/04/2023

Bygningsreglementet. 2018b. Kap. 1.8 Generel vejledning. Internet address: https://bygningsreglementet.dk/Tekniske-bestemmelser/22/Vejledninger/Generel-vejledning/Kap-1_8 viewed: 22/02/2023

Bygningsreglementet. 2018c. Termisk Indeklima og installationer til varme- og køleanlæg (§ 385 - § 392). Internet adress: https://bygningsreglementet.dk/Tekniske-bestemmelser/19/Vejledninger/Termisk-indeklima viewed: 22/02/2023

Cantacuzino, S. 1972. New uses for old buildings. Architectural Review. CLI(903).

Cementvarefabrikken Sælvig ApS. n.d. Cementvarefabrikkens historie. Internet adress: https://cementvarefabrikkensaelvig.dk/om viewed: 09/02/2023

DAC, n.d. Den klassiske vurdering af arkitektur. Dansk Arkitektur Center. Internet adress: https://dac.dk/viden/artikler/den-klassiske-vurdering-af-arkitektur/ viewed: 27/02/2023

Dansk Standard. 2018. Drivhusgasser - Produkters CO2-fodaftryk - Krav til og vejledning om kvantificering = Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification (ISO 14067:2018). Elektronisk udgave. Charlottenlund: Dansk Standard.

Dansk Standard. 2021. Light and lighting - Lighting of work places - Part 1: Indoor work places. DS/EN 12464-1:2021.

DI byggeri. 2022. Sådan beregnes bygningers klimapåvirkning. Dansk industri. Internet adress: https://www.danskindustri.dk/brancher/di-byggeri/baeredygtighed-i-byggeriet/artikler/11/sadan-beregnes-bygningers-klimapavirkning/ viewed: 03/02/2023.

Elmquist, D. Drejer, B. W.. 2003. Klassiske danske badehoteller. Aschehoug Dansk Forlag A/S. Denmark. ISBN: 87-617-3181-1

Energistyrelsen. 2021. Byggeri og renovering. Energistyrelsen. Internet adress: https://ens.dk/ansvarsomraader/energibesparelser/byggeri-og-renovering viewed: 02/02/2023

Environ. Sci. Technol. 2010. 44, 8, 31693174. Publication Date: March 19, 2010. Internet adress: https://pubs.acs.org/doi/10.1021/es9030003 viewed: 02/02/2023

Grøn Varme Samsø. n.d. Grøn-neutral varme på Samsø. Internet adress: https://gronvarme.samsoe.dk/ viewed: 02/05/2023

Guzowski, M. 2010. "7-9," in Towards zero energy architecture: New solar design. London: Laurence King.

Harlang, C. Algreen-Petersen, A. 2015. Om bygningskulturens transformation. 1. udgave. Kbh: Gekko.

Highfield, D. 1987. The rehabilitation and re-use of old buildings. London and New York: Spon Press, Taylor & Francis.

IEA. 2020. Denmark - Countries & Regions. IEA. Internet adress: https://www.iea.org/countries/denmark viewed: 02/02/2023

idenyt, n.d. 10 grønsager der kan gro i skyggen. Bonnier Publications. Internet adress: https://idenyt.dk/haven/koekkenhaven/10-groentsager-der-kan-gro-i-skygge/ viewed: 03/04/23

Just, G Termansen, J. 2017. Nordeuropæiske Badehoteller. 1. udgave. Jepsen & Co. Denmark. ISBN: 978-87-9 l 770-35-7

Jørgensen, E. B. et al. 2020. Brugervejledning til LCAbyg version 5.2. BUILD, Aalborg Universitet.

Knudstrup, M. 2004, Integrated Design Process in Problem-Based Learning: Integrated Design Process in PBL. i Kolmos, Anette : Fink, Flemming K. : Krogh, Lone (eds.) (red.), The Aalborg PBL Model : Progress, Diversity and Challenges. Aalborg Universitetsforlag, Aalborg, s. 221-234.

Koch, N. E. 2020. Trap Danmark: Horsens, Odder, Samsø, Hedensted. 6. udgave, bind 13. Trap Danmark. ISBN:978-87-7181-017-2. p. 251

Kulturministeriet. 2011. SAVE - Kortlægning og registrering af bymiljøers og bygningers bevaringsværdi. Kulturarvsstyrelsen. ISBN: 978-87-91298-77-6

Ling-Chin, J., Roskilly, A.P. and Heidrich, O. 2015. Life cycle assessment (LCA) – from analysing methodology development to introducing an LCA framework for marine photovoltaic (PV) systems. rep. UK: Newcastle University.

Modinex Group. n.d. Does Saltwater Affect Timber? Modinex Group. Internet adress: https://www.modinex.com.au/does-saltwater-affect-timber/ viewed: 08/02/2023

Muthu, S. S. 2021. LCA based carbon footprint assessment. 1st ed. 2021. Subramanian Senthilkannan Muthu (ed.). Gateway East, Singapore: Springer.

Our common future. 1987.Our common future. Oxford: Oxford University Press.

Pavlov G. K., Olesen, B. W. 2011. Building Thermal Energy Storage - Concepts and Applications. Proceedings

Plevoets, B. & Van Cleempoel, K. 2019. Adaptive Reuse of the Built Heritage: Concepts and Cases of an Emerging Discipline. 1st edition. [Online]. Milton: Routledge.

Resights, 2022, Havvejen 131. Internet adress: https://resights.dk/ejendom/havvejen-131-8305-sams%C3%B8/2485475 viewed: 04/11/2022

Risk Logic. 2022. Saltwater Corrosion. Risk Logic. Internet adress: https://risklogic.com/

saltwater-corrosion/ viewed: 08/02/2023

Praksis Arkitekter, n.d. Maltfabrikken. Praksis Arkitekter. Internet address: https://praksisarkitekter.dk/maltfabrikken viewed: 24/03/2023

Ruskin, J. 1849.The seven lamps of architecture. London: Smith, Elder.

Samsø Kommune. 2020. Samsø Klimahandlingsplan 2020. Samsø Kommune. Denmark.

Samsø Kommune. 2021. Samsø Kommune, Kommuneplan 2021. Samsø Kommune, Denmark

SBI-anvisning 182. 1995. Indeklimahåndbogen. Statens Byggeforskningsinstitut. ISBN 87-563-0878-7. Chapter 12, page 184.

Svinkløv Badehotel. 2023.Om Svinkløv Badehotel. Internet adress: https://www.svinkloev-badehotel.dk/ viewed: 22/02/2023

Trafik-, Bygge- og Boligstyrelsen. 2020. Vejledning om den frivillige bæredygtighedsklasse, 1. edition, Trafik-, Bygge- og Boligstyrelsen, Copenhagen

VisitDenmark. 2019. Kyst- og naturturister i Danmark. VisitDenmark Videncenter, Denmark

VisitSamsø. 2022. Fakta om Samsø. VisitDenmark Videncenter. Internet adress: https://www.visitsamsoe.dk/inspiration/fakta-om-samsoe/ viwed: 02/02/2023

VisitDenmark. 2021. Fire spor mod en bæredygtig turismeudvikling. VisitDenmark Videncenter. Internet adress: https://www.visitdenmark.dk/corporate/om-os/nyheder/fire-spor-mod-en-baeredygtig-turismeudvikling viewed: 03/02/2023

VisitDenmark. 2022. Turismen i Danmark. VisitDenmark Videncenter, Denmark

Weather-wise. 2017. The Importance of Stain in Preventing Cedar from Turning Grey. Weather-wise. Internet adress: https://weatherwise.ca/2017/01/20/the-importance-of-stain-in-preventing-cedar-from-turning-grey/ viewed: 08/02/2023

Wiberg, K. et al. 2022. Den Lille Blå Parlør om Havstigning Rapport 2023. pdf. Lab1, Arkitektskolen Aarhus

ILLUSTRATION LIST

CATALOG - Elaborated Material Exploration

transformation to

SAMSØ BEACH HOTEL

Master Thesis Project
MSc04, May 2023, Aalborg University

ma4-arc4
Camilla Lynnerup Christensen
Kasper Vismar Chrestensen
Maria Lahn Jensen

TITLE PAGE

Titel	Transformation to Samsø Beach Hotel
Department	Architecture, Design and Media Technology Aalborg University
Semester	MSc04, May 2023
Group	ma4-arc4
Project period	01/02/2023 - 26/05/2023
Main supervisor	Joel Peter Weber Letkemann
Technical consultant	Endrit Hoxha
Report	Catalog - Elaborated Material Exploration
Pages	109
Authors	Camilla Lynnerup Christensen Kasper Vismar Chrestensen Maria Lahn Jensen

ABSTRACT

The focus of this thesis project is to transform a former cement factory into a beach hotel that emphasizes Samsø's cultural heritage and traditional rural architecture. The existing building is a collage of various development stages, with the oldest sections in a detering state and in need of renovation. The project aims to reuse existing materials at the site to reduce global warming potential to express the building's history and preserve its original character, while incorporating new materials to highlight what was original and what is part of the transformation. The thesis proposes a matrix for selecting materials that best suit the building's atmospheric and spatial qualities. The matrix is based on a catalog of materials on site and additional materials collected from theories, serving as a lookup tool for technical and atmospheric information.

The thesis also examines the building envelope assemblies and details to optimize them according to current standards. By focusing on cultural heritage, atmospheric and materialistic potentials, the project seeks to optimize material selection and programming of the transformation of the former cement factory into an aesthetically appealing and sustainable beach hotel.

In addition, the thesis investigates how optimization of the building envelope inwards will be detailed to minimize thermal bridges between construction elements. Finally, the sustainability of the project will be analyzed, and the total CO_2 equivalent will be calculated and compared to the same building constructed from only new materials.

CONTENTS

INTRODUCTION

The purpose of this catalog is to create a deeper understanding of materials. A deeper investigation of the cement factory's atmospheres and potentials is described, and will be used for value-setting. The value-setting will be used in the design process when designing, but also to choose which element that should be maintained during the transformation.
Likewise this report has a close relation to the analysis of the site and the design process in the main report **Thesis project**.

The catalog will investigate the relationship between materials and atmospheres. Identifying strengths and weaknesses in the existing system, connections of materials and help creating an understanding of atmospheric elements within the building. Which will be valued and thereby identified as fundamental for the understanding of the building's history.
The catalog will provide information on different existing materials on site, but also other relevant materials. The materials already existing on the site will be investigated both as individual materials, but also how the material is used on the site and what atmosphere it creates. The materials that are not already existing on the site will be discussed with the specific material individual qualities.

In this material catalog, **Catalog - Elaborated Material Exploration**, the focus is ecological sustainability and how the materials on the site relates to various properties, the material possesses in relation to the existing atmosphere. Creating knowledge for value-setting and understanding material expressions that could communicate the previous use of the building. To achieve this, a matrix has been prepared, with a focus on selecting materials that performs best in a given scenario. The material catalog collects more properties than those given in the matrix, which is due to the fact that the material catalog collects properties about a number of materials which are also relevant for other projects.

READING GUIDE

This master thesis project consist of four reports:

- **Thesis project** *(main report)*
- **Catalog - Elaborated Material Exploration** *(secondary report)*
- **Appendix** *(appendix)*
- **Drawing folder** *(drawing folder)*

Catalog - Elaborated Material Exploration consists of:

- **Cement factory**

*A deep investigation and registration of the cement factory's atmosphere and potentials which should be maintained. This is likewise described shortly and in relation to theories in the main report **Thesis project**.*

- **Material categories, with material data**

Where each material on site and other relevant materials will be described with data and tactility. Likewise a deeper description of where the materials are used on the site and which atmospheres and potentials there wants to be maintained.

- **Value point**

The material data will be collected in a table, which will be used in the matrix, when designing the different scenarios spatiality.

This report should be read as a "lookup tool" during the design process, especially when choosing materials within the matrix. Therefore the **Thesis project** is the main report, which needs to be read first.

This report part is a material catalog, which will be used in the design process in collaboration with the developed matrix. The catalog collects different material data divided into seven material categories:

- *Wood*
- *Concrete*
- *Metal*
- *Bricks*
- *Plaster*
- *Stone*
- *Insulation*

The catalog describes the different materials from the site and chosen materials from theories.
Each material consists of several data, which will be explained on the following pages.
Likewise the **matrix** will be explained on the following pages, and has a close relation to the main report **Thesis project**.

material category

MATRIAL NAME

ill.1. Images

TECHNICAL FACTS

Density

The different materials densities are found in Teknisk Ståbi (Jensen, 2013).
[kg/m^3]

Thermal conductivity

The different materials thermal conductivities are found in Teknisk Ståbi (Jensen, 2013)
[W/(m•K)]

Corrosion resistant

A description about the materials corrosion resistance, according to interaction with seawater. The resources to define the corrosions for a material, will be referred in the individual chapter for the specific material.

Structure qualities

A description about the materials structural qualities, based on load-bearing or stabilizing.

VISUAL / ATMOSPHERE

Tactility

Some categories within the catalog do **not** have a numerical value to define it by, therefore these elements will be defined based on site analysis and cultural heritage of the site.
Tactility will be defined as a value between 1-5 based on the chosen atmosphere in a specific scenario and how the qualities of the material fulfills it.

Some materials are within the non-visible part of the building envelope, therefore some material´s tactility will not be relevant and therefore not described.

Reflection (light)

All materials reflection are found in SBI-anvisning 203, Beregning af dagslys i bygninger (Christoffersen, 2002).

Some materials are within the non-visible part of the building envelope, therefore some material´s reflection will not be relevant and therefore not described.

Patina

Some categories within the catalog do **not** have a numerical value to define it by, therefore these elements will be defined based on site analysis and cultural heritage of the site.
Patina will be defined based on the materials aesthetic qualities across its lifetime, whether it changes appearance poorly or greatly in relation to the site and aesthetics and will therefore vary from project to project.

Some materials are within the non-visible part of the building envelope, therefore some material´s Patina will not be relevant and therefore not described.

ECOLOGICAL

Emission pr. phase A/C/D

Using LCAbyg to find data from EPD´s for each phase [kg CO_2-eq/m^3]. Because the B-value in regards to LCA is calculated based on a buildings operating system, this value is **not** be calculated in relation to a materials emission. This is due to phase B being calculateded for circular life of building but does not relate to materials. These calculations are based on m^3 of the specific material.

GWP

The global warming potentials will be found in LCAbyg with data from EPD [kg CO_2-eq/m^3]. The GWP will be calculated based on the materials A and C value added. These calculations are based on m^3 of the specific material.

Origin

Origin is based on the materials proximity of extraction or production based on the site, minimizing the transportation and ultimately the emission and will therefore vary from project to project.

ECONOMICAL

Lifetime

The materials lifetimes will be found in SBi 2013:30: Levetider af bygningsdele ved vurdering af bæredygtighed og totaløkonomi (Aagaard, 2013), and in LCC byg. Can the specific material not be found in a given source other sources will be described under that material section.

Cost

The data will be found in LCCbyg, Sigma and Molio prisdata, these calculations will be based on a purchased amount of 1 m^2, the value per m^2 drops based on the amount purchased. Therefore these prices can only be used in comparison to one another. The thickness of the m^2 is 10 cm. equal to 0.1 m^3 of the material as a solid mass. However when categorizing the materials it's important to keep in mind that materials all need different thicknesses to function, thereby this is a basis for calculating the price of a specific amount.

Reusable

This data will be based on the D value from LCAbyg.

INDOOR ENVIRONMENT

Absorbent factor

The materials absorbent factor will be found in SBi-anvisning 137, Rumakustik (Petersen, 1984.). Can the specific material not be found in a given source other sources will be described under that material section.

Heat capacity

All the accumulation values will be found in DS/EN ISO 10456, table 3 and 4 (Dansk Standard, 2008).

MATRIX

parameter	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
	material potential			*atmospheric potential*			*site position*
weight 0-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*
value point 1-5	*x*	*x*	*x*	*x*	*x*	*x*	*x*

Result: ______________

The purpose of the **matrix** is to identify spaces when designing in specific scenarios based on various parameters. In these scenarios, the weighting of these parameters can vary, which is also reflected in the matrix.

The matrix is closely related to **Catalog - Elaborated Material Exploration**, as materials from the catalog are inserted into the matrix. Likewise the catalog describes the different building parts of the cement factory, with focus on atmosphere and potentials that should be maintained when transforming.

This matrix will therefore help to determine a material according to a desired spatiality, that will be performed sufficiently in the specific scenario. This will possibly contribute to an alternative choice of material, as the matrix takes all parameters into account. This will contribute to a broader understanding of each material and their relationship to the site through their character and properties.

The matrix is structured by and based on:
- *Parameter*
- *Weight*
- *Value points*
- *Result*

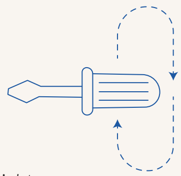
The atmosphere is categorized into distinct groups, based on the building element analyzed e.g. interior and exterior. When examining **exterior** surfaces, the atmospheric section is determined by the **cultural heritage** and the **vision** of the site. **Opposite** , when analyzing **interior** surfaces, the atmospheric section is created based on the description of the desired atmosphere in the **room program**. Due to the correlation between interior atmospheres and the room program, this section must be undertaken individually for each room. Nonetheless, in order to reduce the number of rooms to be examined based on atmosphere, rooms are categorized into groups based on their required atmosphere. **Hence, rooms that share similar atmospheric requirements are grouped together.**

WEIGHT (1 - 5)

The principle in ***weight*** is that the parameters can be adjusted, to ensure a material that completes the desired character and properties in the specific scenario.
This ensures a material where all parameters have been taken into account.
Weight is adapted to the individual scenario.

A weight at 0, is given if the parameter is not taken into account in a given situation.
A weight at 5, is given if the parameter is weighted the highest in the given situation.

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*5*	*3*	*0*	*4*	*4*	*2*	*4*



ill.2. arbitrary example, weight

VALUE POINT (1 - 5)

The principle of ***value point*** is that each material from the **Catalog** gets a value point. This factor cannot be changed, as it is based on data and observation in the catalog.
The value points will be distributed by taking all data from the given parameter and putting it into numerical order in relation to all other materials, and graded 1 - 5 based on its performance .

A value point at 1, is given if the material does not perform sufficiently.
A value point at 5, is given if the material does perform sufficiently.

1 2 3 4 5	*6 7 8 9 10*	*11 12 13 14 15*	*16 17 18 19 20*	*21 22 23 24 25*
1	*2*	*3*	*4*	*5*

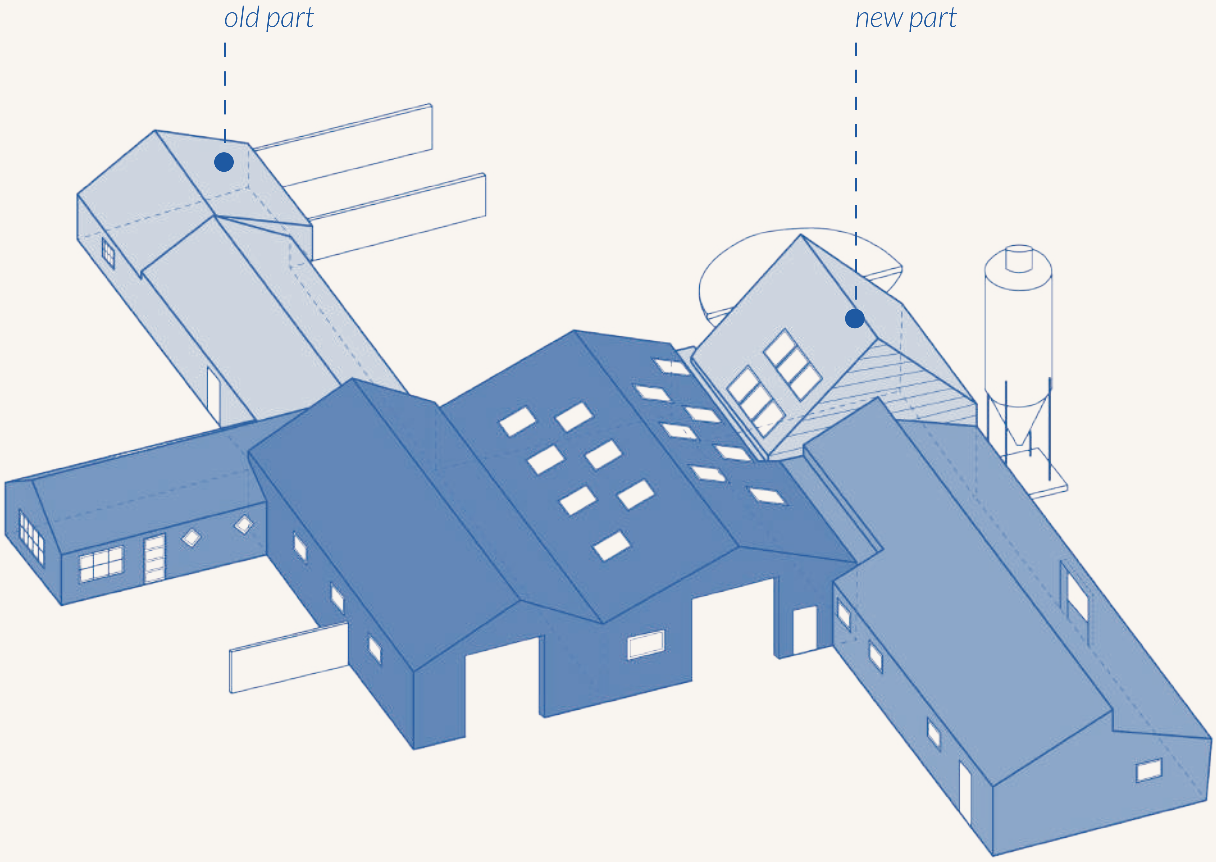
ill.3. arbitrary example, value point

RESULT

The result gives a number, which explains the most relevant material based on the weight in the specific scenario.
A material gets a value which is multiplied with the weight, thereby the highest value is the most relevant material. To find the result, addition of all the multiplied values are done and the best scoring material is the most relevant.

Result: *33*

CEMENT FACTORY



storages (old and new)

factory workspace

factory hall

ill.4. Cement factory, building parts

CEMENT FACTORY

To create an understanding of the cement factory, its qualities and potentials, as well as what needs to be reused or completely renovated, the entire cement factory is reviewed, based on the building's divisions: *factory workspace, factory hall and storage (old and new)*.

Here, the spatiality and experience of the rooms will be described and visualized through pictures from the excursion to the site. Likewise, the interaction between the room and the spaces inside and outside will be detailed. This will result in different value-setting that will be used in the design process of the transformation and will become the basis for what is preserved and renewed on the site. Likewise, this review of the cement factory will be the starting point for room organization of the beach hotel, based on the room program's requirements for the organization of the spaces.
This design process is described in the **Thesis Report** *(main report)*.

ill.5. arrival

ARRIVAL

When arriving at the site, it is clear to see that the factory is located far from the city and from the forest. The factory is clearly in focus from the road, as it is not shielded by either vegetation or buildings. When arriving, the silo is greeting. The silo is a characteristic element and describes that the site has been used for industry. Likewise when arriving, the first one see is the facade of the factory workspace, where the building's roof structure makes room for the factory's name; *Cementfabrikken Sælvig*. The eye also catches the yellow facade, which also has a strong connection to Samsø, where many houses consist of a similar yellow facade.
On the site, the function of the site and industry is also evident, as several materials such as concrete, tiles, sand and stone can be found in various places on the site facing the road.

Due to the various loose materials on the site and the industry, it is clear that hard work is being done on the site. At the entrance to the site, there is a transition between sand and asphalt, where the sand is spread out on the asphalt, due to a lot of driving in and out of the site. In addition, a truck is seen parked in a garage.

entrance

ill.6. entrance

ill.7. factory workspace

FACTORY WORKSPACE

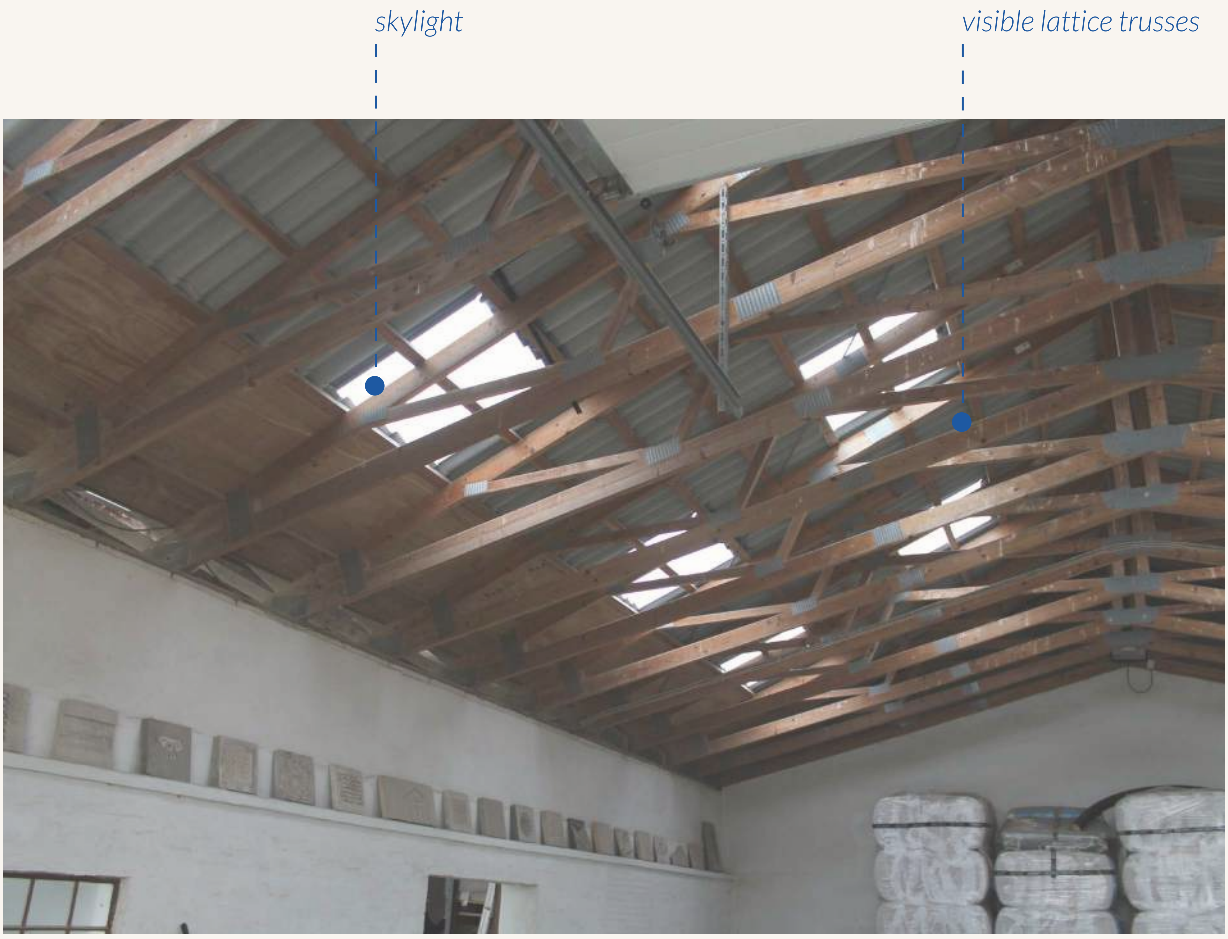
At the excursion, the registrations of the cement factory started in the factory workspace. Here one entrance was obvious, as it was the only entrance from the angle of arrival. The entrance did not invite people in, and seemed like a closed workplace.
Moving into the building, one was greeted by a dark room, where large tools placed in the ceiling and in the middle of the room took all the light from the windows. The room felt dark, due to the large machines, but also due to the low ceiling height. From the outside, upon arrival, the building appears spacious with high ceilings, which the building contradicts from the inside.

The room is supported by columns and beams, which also take up a lot of space, both in floorarea and room height, as the construction is visible. On arrival at the site, the structure of the roof was an eye-catcher, as it also provided the opportunity for the factory's name to face the road. This design is to be preserved and also created inside, where the space will be more illuminated and not enclosed.
The factory does not meet today's requirements for building envelopes, which can be felt throughout the building. The transition between the factory workspace and the factory hall is simply through a sliding door, where you are immediately met by a harsh cold from the factory hall.

storage in ceiling

visible col-umns and beams

ill.8. factory workspace

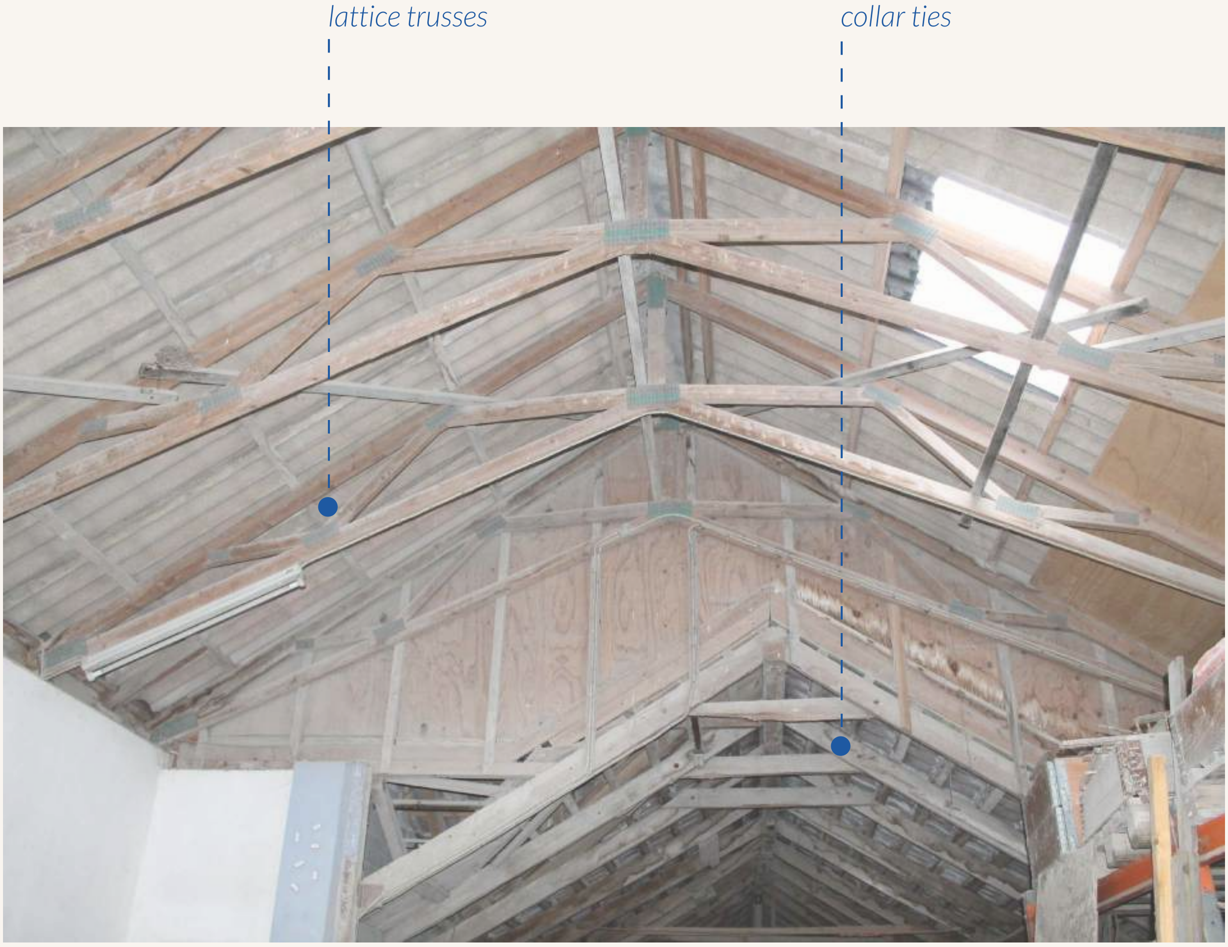


ill.9. visible lattice trusses

FACTORY HALL

On the excursion, we moved from the factory workspace to the factory hall through a sliding door. Here you were greeted by a brightly lit room, but a very bitter cold. Factory hall is two large halls and is connected by an opening, where another sliding door is located. The halls are for large trucks and machines. The room consists of white walls and visibles lattice trusses, where skylight windows are located. Factory hall is two spatial halls, as the ceiling is high and because the room is not full of storage, like the factory workspace.
The cement factory does not possess much detail in construction connections or construction practices. For example, the visibles lattice trusses are connected to the outer walls by a cast concrete joist hanger, which also does not have a high degree of detail.
However, the wall between the two halls is constructed as an exhibition shelf, where various concrete castings are exhibited. This exhibition shelf is to be preserved, as it creates a detail from the factory, but also provides the opportunity for exhibition in the beach hotel, depending on which functions the factory hall will have.
Likewise, it is desired to preserve the large open space, where the lattice trusses are the focus. Due to the massive volume and central location in the factory, it is desired to preserve and add more skylight windows, where light can enter and illuminate the room.

ill.10. factory hall



ill.11. transition between lattice trusses to collar ties

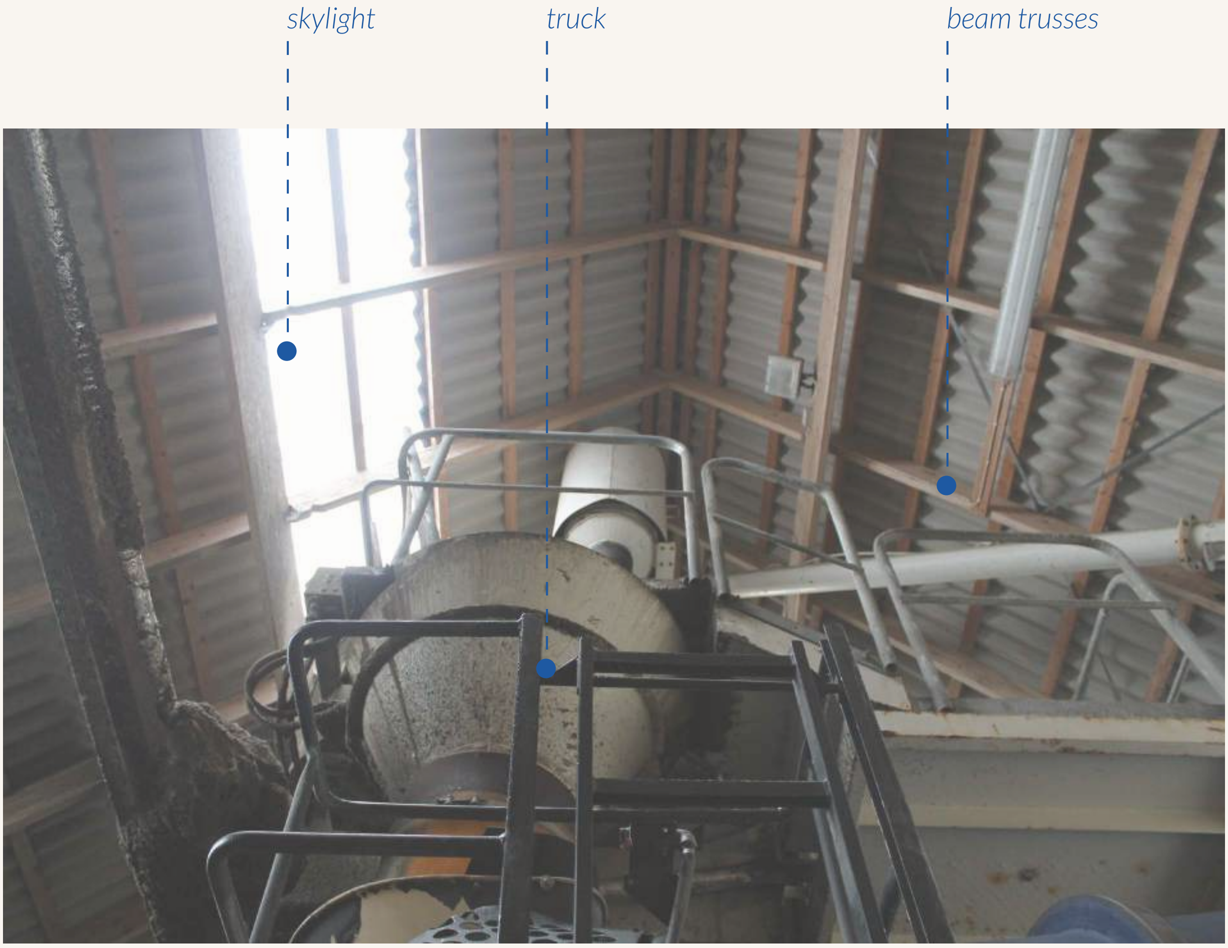
STORAGE, OLD PART

Between the old storage part and the factory hall, a transformation of the space is taking place. This happens both when changing the structure and the function of the room. The function of the room is to store materials that are not used, which contributes to a space that is not in use. The room is ramshackle, which can be seen both by the condition of the materials, but also by larger holes in the ground, at the end of the storage. When you move around this part of the cement factory on the outside, you also come across the part of the building whose condition is the worst. Windows are broken, doors cannot be opened and the condition of the materials has deteriorated.

The structure changes from lattice trusses in the factory hall to collar ties in the storage. This transition can already be seen in the factory hall, where the entire back wall shows how the structure is built and also where storage and the new building part begin.

In addition to the transition between structures, the trusses transform through the space. At the start of the room, the collar ties are open and give an open ceiling height, but the further you move, the smaller this ceiling height becomes. This transition and experience of a more intimate space is to be preserved. However, the condition of this part of the building is not great, and therefore the materials cannot be reused. Resulting in restoring the entire roof of the building, but based on the same design as the existing one.

ill.12. storage, old part



ill.13. storage, new part

STORAGE, NEW PART

When arriving at the site, it was not the storage that caught the eye first. Storage is painted light gray and means that on the day the excursion took place, it blended in with its surroundings, because of the weather. Likewise, a truck was located in the storage, which also took a lot of the view.
Like the silo, when arriving at the site, it creates an industrial atmosphere for the place. A gravel mixer is attached to this, where the storage facade is cut to fit the gravel mixer. This gravel mixer mixes the stone and sand that is used to make cement that the factory produces, and is thus an element that best describes the local industry.
When you move past the truck, which takes up half the space of the room, it is clear that the building's part is just a shed. There is still sand on the ground with no foundation, as in the rest of the factory. The room has a high ceiling height and the structure is beam trusses. The room is designed for the truck and the gravel mixer. All surfaces are filled with cement, which means that the room cannot be used for anything else. The facade facing the road has also been cropped so that the truck could be driven in.
It is desired to make this part of the building, a part of the beach hotel, to which a building envelope must be added. The room's ceiling height is to be maintained, as it will help create an eye-catcher from the road.
Likewise, it is desired to maintain the relation to the industry on the site. This is done by maintaining the gravel mixer and silo.

gravel mixer attachment to storage

cement on floor and walls

cropped facade for the truck

ill.14. storage, new part

WOOD

wood

PINE

on site

ill.15. Pine

TECHNICAL FACTS

Density
400-600 kg/m^3

Thermal conductivity
0.14 W/(m•K)

Corrosion resistant
Pine is a place between sensitive and moderate towards a salt water spray (McKenzie,2000).

Structure qualities
Pine can both be used as load-bearing material and as stabilizing.

VISUAL / ATMOSPHERE

Tactility
Visual: The material has a light brown/yellow color. Pine has distinct annual rings and more knots than other types of wood. Generally gives a warm visual expression, which is also the case with pine wood. The material gives associations to nature, where its visuals can give a calm feeling.

Atmospheric: Has a smell which is associated with nature. When the material gets wet, it gives a stronger smell that can be smelled from a bigger distance.

Acoustic: Pine has neither a high or a low absorbent factor. This means if a room primarily consists of wood as a material, the reverberation time will be less then concrete, but bigger then fabric.

Interaction: Directly touching pine wood will feel different depending on how the wood has been treated. The material can both be rough textured and smooth. Due to the fact that pine has a low thermal conductivity value, it does not conduct heat like other materials do. Therefore the material temperature will feel closer to the human temperature, then other materials such as metal.

Reflection
40% the first 3 months then it will reach a lower reflection percentage.

Patina
The first three months' pine have a light brown/yellow color, where the tree rings are a bit browner. After three months the pine becomes darker and develops a silver grayish color that becomes more dominant after time. The tree rings become wider and the cracks in the material changes the texture (Sandak, 2021).

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2-eq / m^3	-783.129	985.129	-260.334

GWP
2.019e+04 kg CO^2-eq/m^3

Origin
Pine is often imported from Sweden, this creates an approximate distance from the origin to the site of 651 km.

ECONOMICAL

Lifetime
The lifetime of wood is highly dependent on the surface treatment, however treated pine in connection to nature's elements have a lifetime of 60 years. And as a structural element 120 years.

Cost
The price is per 0.1 cubic meters and excludes VAT. The wood is cut and processed.

3898.66 kr. per 0.1 m^3.

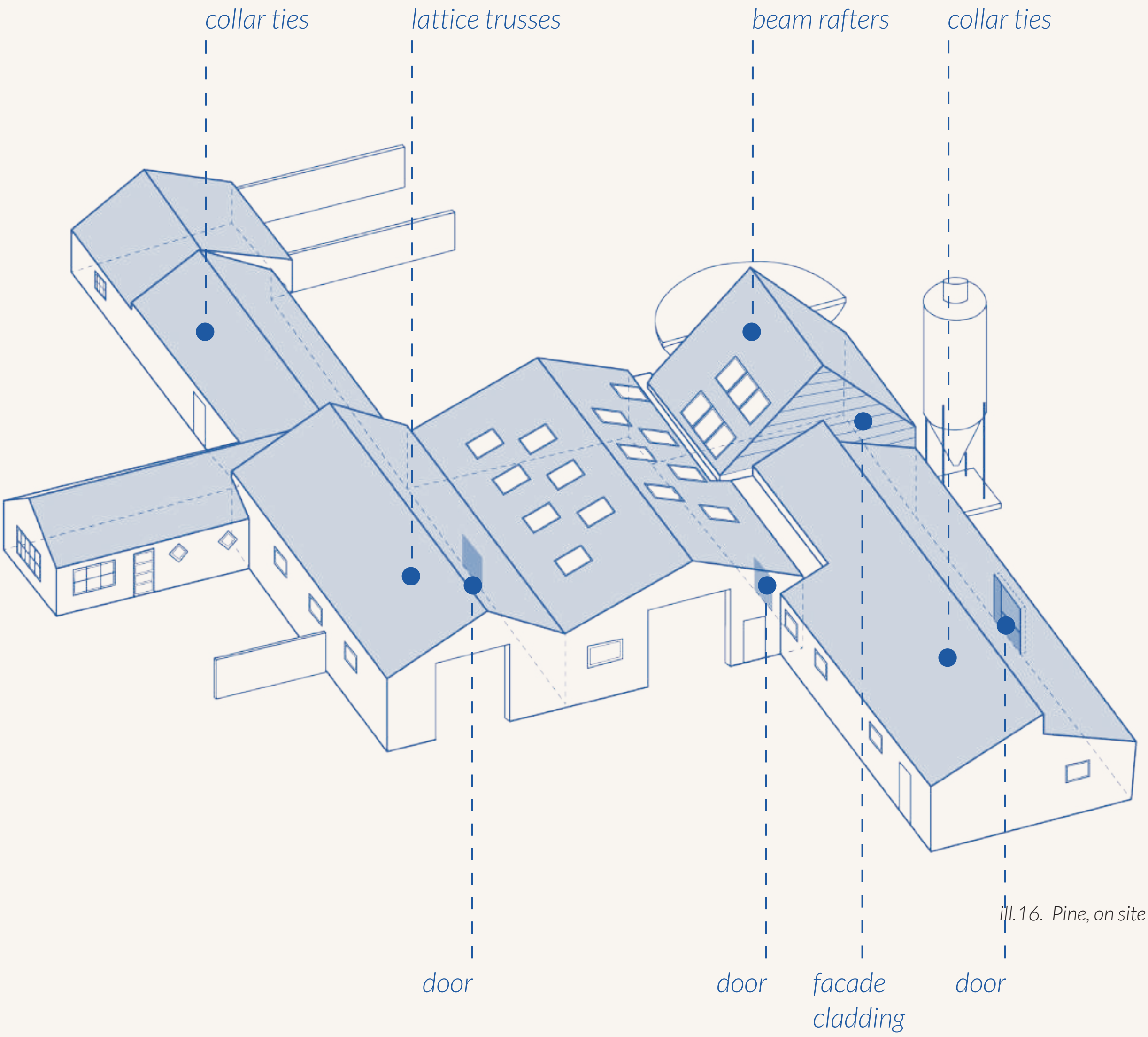
Reusable
-260.334 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.11
500	0.10
1000	0.07
2000	0.06

Heat capacity
1600 J/(kg•K)



ill.16. Pine, on site

PINE, *on site*

Pine can be found in various places in the cement factory and is mainly used as a load-bearing element in the roof construction.

Pine is also used as facade cladding on the storage new part, and doors in the factory hall and the entrance to the factory workspace.

The load-bearing element in the roof construction consists of:

- *Lattice trusses in the factory halls*
- *Collar ties in factory workspace and storage, old part*
- *Beam rafters in storage, new part*
- *Column/beam system in factory workspace*

Likewise, pine battens are used to stabilize the rafters in all scenarios.

ill.17. Pine, details

DETAILS

Pine is used for the sliding doors between the factory halls and between the factory hall and the factory workspace. Likewise, the main entrance is a pine door and gives associations to a rural environment, because the door can be opened completely or just at the top.
The doors are a detail in the cement factory which creates an industrial character within the cement factory.

ill.18. Pine, storage, old part

FACADE CLADDING - STORAGE, NEW PART

The cement factory's storage, new part, is for transporting and loading concrete and consists of a pine facade cladding. This is the only place where tree is used as facade cladding. The facade cladding has been painted in a light gray shade, which is in great contrast to the rest of the cement factory. The facade cladding is mounted on the pine columns in storage, to which the back of the facade cladding is also painted in a light gray shade. The assembly is made by screwing the facade cladding onto the columns, and is therefore not a greater degree of detail at the joints between materials.
The opening facade has also been cut so the truck could drive all the way into storage. This has resulted in a detail in the facade cladding, which shows that the function and use of the space is weighted higher than the degree of detail.

ill.19. pine lattice trusses

LATTICE TRUSSES

By using pine as a supporting element, the building is easily experienced. This feeling is further clarified by skylights through the lattice trusses. The skylights contribute to a lighted room that is easy to see.
The white walls in the factory hall and the large opening to outside also help to illuminate the room and highlight the pine lattice trusses. In this way, the lattice trusses become an eye-catcher in the room and thus give the room a special character. This character has a great relationship with the function of the room.
The roof construction consists of lattice trusses and roof cladding and thus makes the lattice trusses clear to see. This is desired to be preserved in the transformation, for the experience of a large light space with pine lattice trusses and will contribute to a relationship with the site and the building's former function as a cement factory.
The joints of the lattice trusses consist of metal plates, which join and hold the construction together. Likewise, the lattice truss is mounted directly on the outer wall, by a cast concrete joist hanger. This expresses a non-detailed processing of the structure and its joints and expresses a construction which had to be erected quickly. However, the joint between the lattice trusses and the outer wall supports that the roof construction is experienced easily. The assembly is experienced as two separate units, wall and roof construction, and does not have an interaction.

ill.20. pine collar ties

COLLAR TIES

Previously, the transition between lattice trusses and collar ties was described, therefore only collar ties will be described further in this section.
Collar ties can be found in the older parts of the cement factory, factory workspace and storage, old part. This construction is clearly characterized by the fact that the construction has stood for 100 years and the function of the room. The room is used for storing materials that are not used, and therefore you do not stay in that part of the building. The remaining materials in the condition of this part of the building are also characterized by having stood for a long time, and will be described continuously.
The collar ties construction change throughout the storage and gratually become more tight, as described earlier. This results in a dark room, which seems spooky, due to the lack of ceiling height and light. The room is experienced as a tunnel, as there is only light in the opening to the factory hall.

wood

CEDAR

ill.21. Cedar

TECHNICAL FACTS

Density
330-390 kg/m^3
(Dansk Standard, 2016)

Thermal conductivity
0.09 W/(m•K)
(Södra, 2019)

Corrosion resistant
Cedar is a place between sensitive and moderate towards a salt water spray (McKenzie,2000). The material durability is not strong enough to have a direct interaction with saltwater (Dansk Standard, 2016).

Structure qualities
Cedar has a low strength, therefore it is often used as facade cladding and roofing shingles (Teknologisk, n.d.).

VISUAL / ATMOSPHERE

Tactility
Visual: The material has a dark brown/reddish color, with tight annual rings. Wood generally gives a warm visual expression, this is especially the case with Cedar wood. The material gives associations to nature, where its visuals can give a calm feeling.

Atmospheric: Has a smell which is associated with nature. When the material gets wet, it gives a stronger smell that can be smelled from a bigger distance.

Acoustic: Cedar has neither a high or a low absorbent factor. This means if a room primarily consists of wood as a material, the reverberation time will be less then concrete, but bigger then fabric.

Interaction: Directly touching Cedar wood will feel different depending on how the wood has been treated. The material can both be rough textured and smooth. Due to the fact that Cedar has a low thermal conductivity value, it does not conduct heat like other materials do. Therefore the material temperature will feel closer to the human temperature, then other materials such as metal.

Reflection
20% over time it will reach a higher reflection percentage.

Patina
Cedar has a dark brown/reddish color and over time will become silver grayish.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	-809.968	1037.52	-282.581

GWP

2.276e+04 kg CO^2-eq/m^3

Origin

Cedar is often imported from Canada, this creates an approximate distance from the origin to the site of 6251 km.

ECONOMICAL

Lifetime

The lifetime of wood is highly dependent on the surface treatment, however treated pine in connection to nature's elements have a lifetime of 60 years. And as a structural element 120 years.

Cost

The price is per 0.1 cubic meters and excludes VAT. The wood is cut and processed.

5003.78 kr. per 0.1 m^3.

Reusable

-282.581 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.11
500	0.10
1000	0.07
2000	0.06

Heat capacity

1600 J/(kg•K)

wood

CONSTRUCTION TIMBER

ill.22. Constructiontimber

TECHNICAL FACTS

Density
420 kg/m^3
(Dansk Standard, 2003).

Thermal conductivity
0,14 W/(m•K)

Corrosion resistant
Construction timber is a place between sensitive and moderate towards a salt water spray (McKenzie,2000).

Structure qualities
Construction timber can both be used as load bearing material, or being stabilized.

VISUAL / ATMOSPHERE

Tactility
Visual: The material has a light brown/yellow color. Wood generally gives a warm visual expression, which is also the case with Construction timber wood. The material gives associations to nature, where its visuals can give a calm feeling. Construction timber is several pieces of wood that are glued together, which can be seen in the materials texture.

Atmospheric: Has a smell which is associated with nature. When the material gets wet, it gives a stronger smell that can be smelled from a bigger distance.

Acoustic: Construction timber has neither a high or a low absorbent factor. This means if a room primarily consists of wood as a material, the reverberation time will be less then concrete, but bigger then fabric.

Interaction: Directly touching construction timber wood will feel different depending on how the wood has been treated. The material can both be rough textured and smooth. Due to the fact that construction timber has a low thermal conductivity value, it does not conduct heat like other materials do. Therefore the material temperature will feel closer to the human temperature, then other materials such as metal.

Reflection
40% the first 3 months then it will reach a lower reflection percentage.

Patina
The first three months' the material has a light brown/yellow color, where the tree rings are a bit browner. After three months the Construction timber becomes darker and develops a silver grayish color that becomes more dominant after time (Sandak, 2021).

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	-640.276	928.549	-232.109

GWP

2.883e+04 kg CO^2-eq/m^3

Origin

Construction timber is often imported from Sweden or produced in Denmark, this creates an approximate distance from the origin to the site of 100-651 km.

ECONOMICAL

Lifetime

The lifetime of wood is highly dependent on the surface treatment, however treated construction timber in connection to nature's elements have a lifetime of 40 years. And as a structural element 120 years.

Cost

The price is per 0.1 cubic meters and excludes VAT. The wood is cut and processed.

3352,79 kr. per 0.1 m^3.

Reusable

-232.109 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.11
500	0.10
1000	0.07
2000	0.06

Heat capacity

1600 J/(kg•K)

wood

OAK

ill.23. Oak

TECHNICAL FACTS

Density
700-800 kg/m^3

Thermal conductivity
0.16 W/(m•K)

Corrosion resistant
Oak is a place between sensitive and moderate towards a salt water spray (McKenzie,2000).

Structure qualities
Oak can both be used as load bearing material, or being stabilized.

VISUAL / ATMOSPHERE

Tactility
Visual: The material has a varied color structure, with a blend of a light brown/grayish color. Wood generally gives a warm visual expression, this is especially the case with oak wood. The material gives associations to nature, where its visuals can give a calm feeling.

Atmospheric: Oak has a smell which is associated with nature. When the material gets wet, it gives a stronger smell that can be smelled from a bigger distance.

Acoustic: Oak has neither a high or a low absorbent factor. This means if a room primarily consists of wood as a material, the reverberation time will be less then concrete, but bigger then fabric.

Interaction: Directly touching oak wood will feel different depending on how the wood has been treated. The material can both be rough textured and smooth. Due to the fact that oak has a low thermal conductivity value, it does not conduct heat like other materials do. Therefore the material temperature will feel closer to the human temperature, then other materials such as metal.

Reflection
30% over time it will reach a lower reflection percentage.

Patina
Oak has a light brown/grayish color and over time will become a bit more brown. Oaks patina will not change as much as other wood types.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	-1063.00	1287.83	-341.221

GWP
2.248e+04 kg CO^2-eq/m^3

Origin
Oak is often imported from Canada/America, this creates an approximate distance from the origin to the site of 6.797 km.

ECONOMICAL

Lifetime
The lifetime of wood is highly dependent on the surface treatment, however treated oak in connection to nature's elements have a lifetime of 60 years. And as a structural element 120 years.

Cost
The price is per 0.1 cubic meters and excludes VAT. The wood is cut and processed.

6291.62 kr. per 0.1 m^3.

Reusable
-341.221 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.11
500	0.10
1000	0.07
2000	0.06

Heat capacity
1600 J/(kg K)

SURFACE TREATMENTS

Surface treatment of wood, protects the wood from weathering and prevents deterioration of the wood's surface. A surface treatment of a type of wood can also have a great aesthetic value for the experience of the material, as the treatment can change the color of the surface (Træ.dk, n.d).
It is important that wood is surface treated, as the sun's rays, rain and moisture will break down the cells in the wood. This will affect the structure and appearance of the wood and will slowly break down (Jacobsen, 2020).

Some types of wood can withstand being left untreated for many years without being damaged. This is because the types of wood, such as oak and cedar, are very robust. Over time, these types of wood will aesthetically change their appearance and acquire a silver-grey patina, which could also be used as an architectural feature (Jacobsen, 2020).

Wood is a sustainable material, as it absorbs CO_2 during growth and converts it into oxygen. In order to maintain the sustainability of wood, it is important to treat the surface, because if the wood is not maintained, it breaks down and releases CO_2 and rots. Therefore, from a sustainability angle, it is important to think about a surface treatment (Jacobsen, 2020).

Surface treatments of wood consists of two types:

- *Water based wood oil*
- *Oil-based wood oil*

Both types contain the properties that give the wood the best conditions for a good lifespan and maintenance (Flügger, n.d.b).

WATER BASED WOOD PROTECTION

Water-based wood protection is the easiest type of wood protection to work with, and can be used with advantage for all untreated wood and previously treated wood. Water based wood production contains water and resin, which provides a protective surface, with the woods structure visible. Water-based wood protection is environmentally friendly and does not contain and release organic solvents and is therefore healthy for the climate and the environment to use (Flügger, n.d.d).

Water-based wood protection also protects against moisture and fungus (Flügger, n.d.d), and provides a water-repellent surface that preserves the appearance of the wood, ensures good durability and protects the wood from the sun's UV rays. Likewise, water based wood protection does not stain the wood (Flügger, n.d.c).

3 reasons to choose water-based wood protection:

1. *Easy to work with*
2. *High durability*
3. *Environmentally friendly*

OIL-BASED WOOD PROTECTION

Oil-based wood protection penetrates deep into the wood and thus provides maximum protection and a smooth and durable surface. Oil-based wood protection contains a mixture of oils and solvents which provide deep penetration (Flügger, n.d.a).

Oil-based wood protection comes in two variants: transparent and covering. Transparent oil-based wood protection highlights the wood's natural character, including the wood's grain and structure, whereas a covering oil-based wood protection hides the wood's natural structure, but lasts longer. Oil-based wood protection cares for the wood and reduces the risk of cracking when drying out and protects the wood against rot and fungus. Oil based wood protection leaves the wood with a smooth surface which is water resistant (Flügger, n.d.a).

3 reasons to choose water-based wood protection:

1. *Penetrates deep into the wood*
2. *High durability*
3. *Better protection of the wood*

CONCRETE

concrete

CONCRETE *on site*

ill.24. concrete

TECHNICAL FACTS

Density
2400 kg/m^3

Thermal conductivity
1.70 W/(m•K)

Corrosion resistant
The seawater will damage the strength and durability of concrete over time. Even though concrete has been used in maritime areas for a century. To ensure concrete against corrosion according to saltwater, a high concrete quality will be beneficial and soon follow up maintenance (Qu, 2020).

Structure qualities
Concrete can both be used as a load bearing material, but is weak at tension and compression.

VISUAL / ATMOSPHERE

Tactility
Visual: Concrete can have different colors, but overall have a cold expression. In this investigation the concrete has a light gray color, with small holes from the air bubbles in the hardening process. The material's visual texture depends on how the material has been cast.

Atmospheric: When the concrete is fast, it has an earthy and chalky scent. The smell is not strong according to other materials.

Acoustic: Concrete has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: The texture and structure of the material can offer depending on how the material has been cast. Concrete is a hard material that can both be rough and smooch, according to the use of it. Concrete has a high thermal conductivity, which means that the material can feel hot or cold depending on the placement of the material.

Reflection
25 %.

Patina
The patina of concrete is often cracked, where other patina expressions are depending on the surroundings. Sometimes there will be plants growth, such as moss, algae or other types of organism. This will give the surface another expression, where a greenish color will become more dominant.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	228.618	15.8729	-4.8474

GWP
2.45e+02 kg CO^2-eq/m^3

Origin
Concrete is often produced in Denmark, this creates an approximate distance from the origin to the site of 100 km.

ECONOMICAL

Lifetime
Concrete has a lifetime of 120 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

1238.17 kr. per 0.1 m^3.

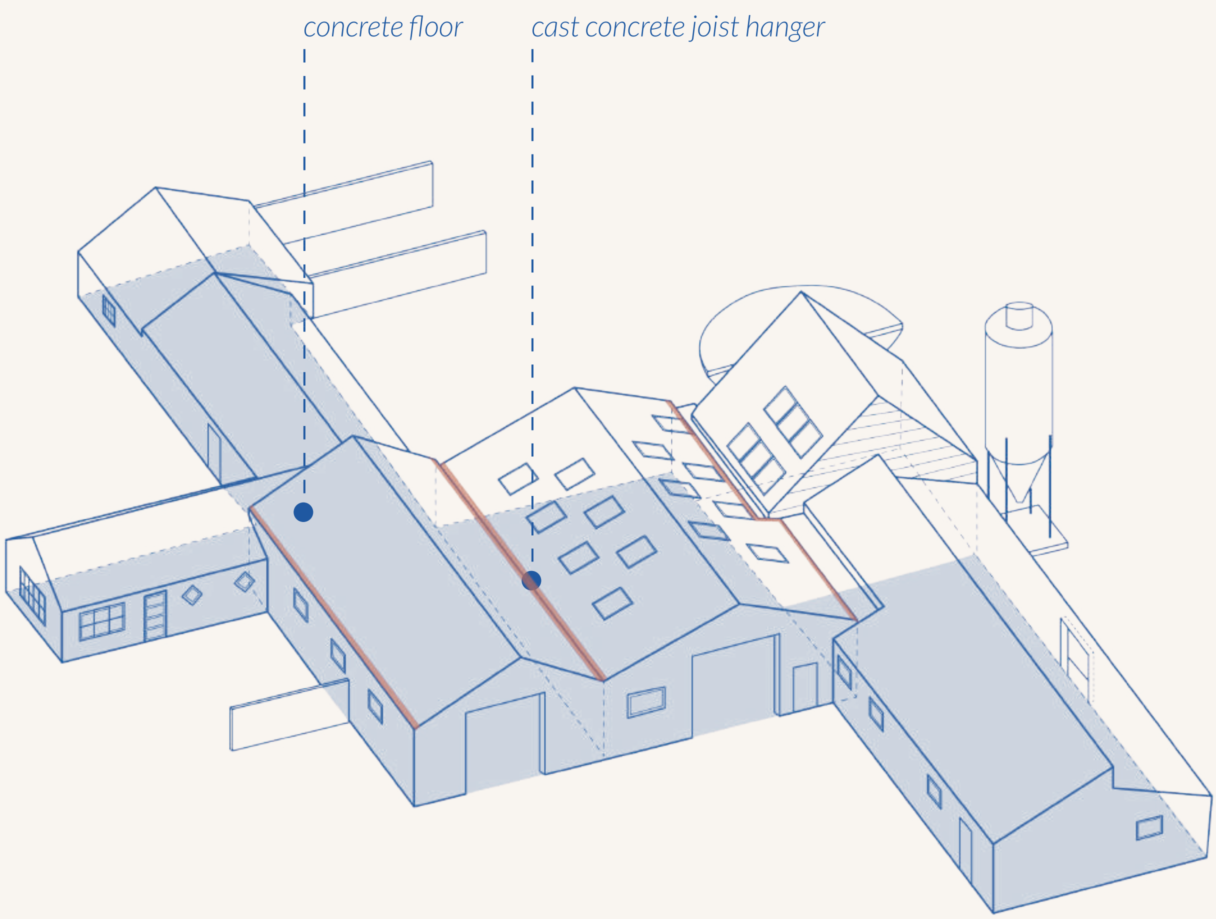
Reusable
-4.8474 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.01
500	0.02
1000	0.02
2000	0.02

Heat capacity
1000 J/(kg•K)



ill.25. Concrete, on site

CONCRETE, *on site*

Concrete can be found on the floor in most parts of the cement factory. Likewise, concrete is also used for a construction's joint between the outer wall and lattice trusses, by a cast concrete joist hanger, in the factory halls.

Concrete on the floor can be found in:

- *Factory workspace*
- *Factory hall*
- *Storage, old part*

ill.26. concrete floor

FLOOR

As illustrated on the previous page, most of the cement factory consists of a concrete floor. The concrete floor is ideal for use in industry and production buildings, as it is a durable material. The use of the cement factory is weighted much higher than the level of detail throughout the building, and the floor shows as well. All around on the floor is dust and other material remains, and also in the factory hall the floor is exposed to the weather, as two large openings allow rain, cold and sunlight to penetrate. In the factory halls larger trucks and machines can be stored, it is also possible to see on the floor that sand has been dragged in, because of the rooms function.
There is not a concrete floor in the storage new part, where it is again clear to see that the use of the factory was weighted higher than detailing and the preparation of rooms.

CAST CONCRETE JOIST HANGER

Construction joints are a quick solutions throughout the cement factory. The cement factory does not have a proper building envelope, and thus various thermal bridges in joints between structural parts are not taken into account.
In the factory hall, the lattice truss and outer wall are joined by a cast concrete joist hanger. It is a visible assembly, however, due to the height of the room, it is not possible to see the assembly unless you zoom in, as on the field trip.

ill.27. cast concrete joist hanger

concrete

PERFORATED CONCRETE

ill.28. Perforated concrete

TECHNICAL FACTS

Density
2600 kg/m^3

Thermal conductivity
1.70 W/(m•K)

Corrosion resistant
The seawater will damage the strength and durability of concrete over time. Even though concrete has been used in maritime areas for a century. To ensure concrete against corrosion according to saltwater, a high concrete quality will be beneficial and soon follow up maintenance (Qu, 2020). Corrosion occur in the reinforcements inside of the concrete. If the seawater is in a long term interaction with the reinforcements it will rust and then expand. This can result in the concrete around the reinforcements cracking, and the strength and durability will be weakened (Qu, 2020).

Structure qualities
Perforated concrete is often used as a load bearing material for the floor and ceiling.

VISUAL / ATMOSPHERE

Tactility
Visual: Concrete can have different colors, but overall have a cold expression. In this investigation the concrete has a light gray color, with small holes from the air bubbles in the hardening process. The material's visual texture depends on how the material has been cast.

Atmospheric: When the concrete is fast, it has an earthy and chalky scent. The smell is not strong according to other materials.

Acoustic: Concrete has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: The texture and structure of the material can offer depending on how the material has been cast. Concrete is a hard material that can both be rough and smooch, according to the use of it. Concrete has a high thermal conductivity, which means that the material can feel hot or cold depending on the placement of the material.

Reflection
25 %.

Patina
The patina of concrete is often cracked, where other patina expressions are depending on the surroundings. Sometimes there will be plant growth, such as moss, algae or other types of organisms. This will give the surface another expression, where a greenish color will become more dominant.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2-eq / m^3	300	6.01	-21.4

GWP
3.06e+02 kg CO^2-eq/m^3

Origin
Perforated concrete is often produced in Denmark, this creates an approximate distance from the origin to the site of 100 km.

ECONOMICAL

Lifetime
Perforated concrete has a lifetime of 120 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

889.90 kr. per 0.1 m^3.

Reusable
-21.4 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.01
500	0.02
1000	0.02
2000	0.02

Heat capacity
1000 J/(kg•K)

concrete

LIGHTWEIGHT AGGREGATE

on site

ill.29. Leca

TECHNICAL FACTS

Density
600 kg/m^3, with data from the program Rockwool Energy Design.

Thermal conductivity
0.22 W/(m•K), with data from the program Rockwool Energy Design.

Corrosion resistant
Corrosion for this material will not have an impact on the material, because the material is often inside of the wall envelope and therefore other materials withstand wind and weather.

Structure qualities
The material can both be used as load bearing material and being stabilized.

VISUAL / ATMOSPHERE

Tactility
Visual: The material has a cold experience due to its gray color. The organization of the leca, gives the texture an uneven structure.

Atmospheric: When the concrete is fast, it has an earthy and chalky scent. The smell is not strong according to other materials.

Acoustic: The structure of the materials results in a higher absorbent factor then other materials. This results in the material developing a shorter reverberation time then other materials such as wood, which is a softer material.

Interaction: The material is made from concrete and leca pellets, which gives it an uneven structure that is rough and itzy in a direct interaction.

Reflection
15 %.

Patina
The material's patina will not have a significant color change according to its original color. Because the material is often used inside of a wall envelope, where other materials withstand wind and weather.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	212.643	4.708	-1.42779

GWP

2.17e+02 kg CO^2-eq/m^3

Origin

A lightweight aggregate is often produced in Denmark by a firm called leca, this creates an approximate distance from the origin to the site of 100 km.

ECONOMICAL

Lifetime

The lifetime of leca blocks is highly dependent on the placement in the building, leca as a foundation have a lifetime of 50 years. And as a facade element 120 years.

Cost

The price is per 0.1 cubic meters and excludes VAT.

703.68 kr. per 0.1 m^3.

Reusable

-260.334 kg CO^2-eq/m^3

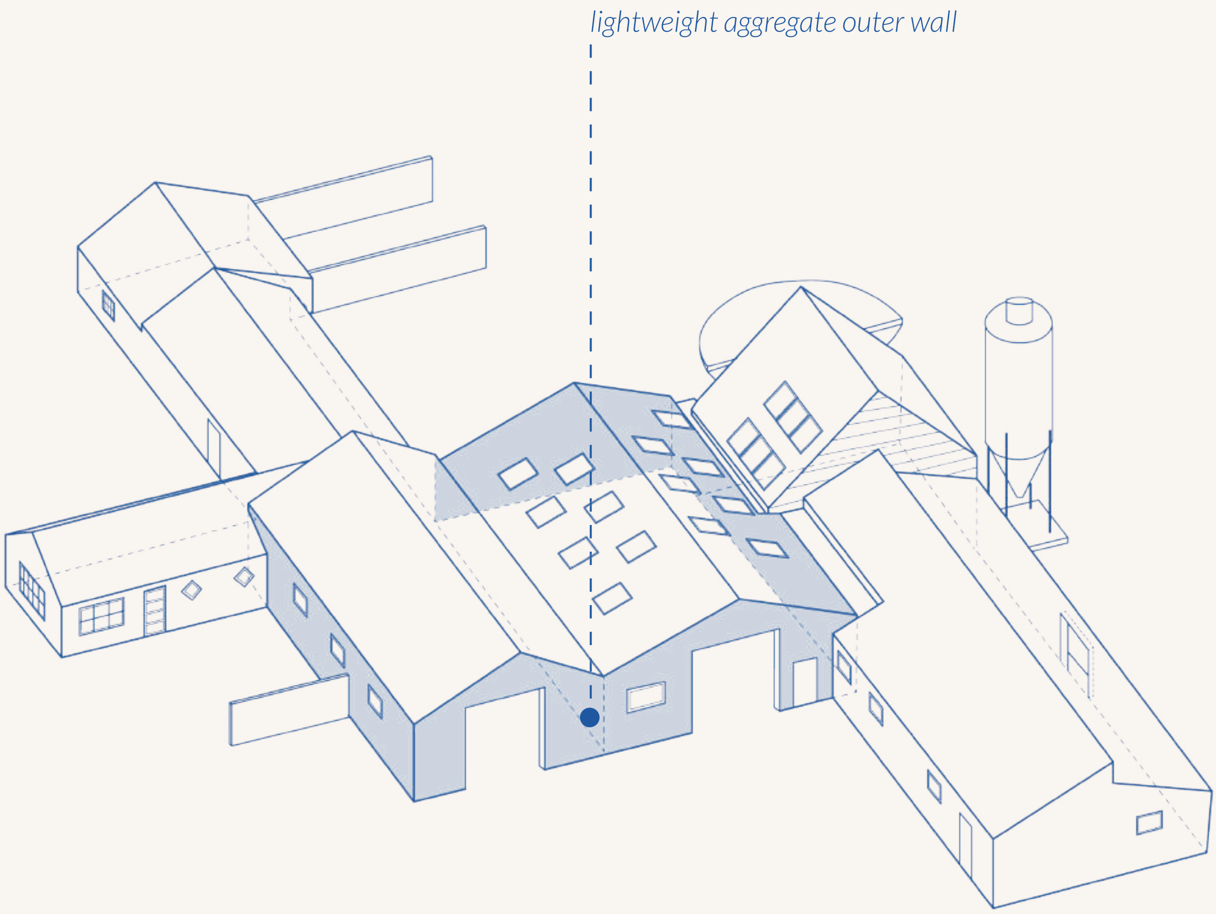
INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.19
500	0.44
1000	0.68
2000	0.52

Heat capacity

1000 J/(kg•K)



ill.30. Lightweight aggregate, on site

LIGHTWEIGHT AGGREGATE, *on site*

Lightweight aggregate can be found as the outer walls of the new parts of the cement factory, the two factory halls. These outer walls carrying the lattice trusses, as described earlier, are assembled with a concrete cast joist hanger.

Lightweight aggregate as outer walls can be found in:

- *Factory hall*

ill.31. Lightweight aggregate, outer walls

OUTER WALLS

The outer walls in the factory hall are constructed in lightweight aggregate blocks. This shows that construction had to go quickly, as the halls had to be in use as soon as possible. This supports the joint between the outer walls and lattice trusses. The rest of the cement factory consists of bricks, with yellow painted and plastered facades, with a strong connection to Samsø. This has also been done for the factory hall. During the excursion, it was only clear that there was a change in materials when you moved into the halls or examined the condition of the facades. Inside, the walls are white, where the joints between the lightweight aggregate blocks can be seen, as the lightweight aggregate blocks have a larger surface area than bricks. Outdoors, it was also clear to see the joints and structures of the lightweight aggregate blocks, as the yellow paint faded more and more due to the weather.

concrete

LIGHTWEIGHT AGGREGATE - POLYSTYRENE

ill.32. Lecaterm

TECHNICAL FACTS

Density
600 kg/m^3, with data from the program Rockwool Energy Design.

Thermal conductivity
5.84 W/(m•K), with data from the program Rockwool Energy Design.

Corrosion resistant
Corrosion for this material will not have an impact on the material, because the material is often inside of the wall envelope and therefore other materials withstand wind and weather.

Structure qualities
The material can both be used as load bearing material and being stabilized.

VISUAL / ATMOSPHERE

Tactility
Visual: The material has a cold experience due to its gray color. The organization of the leca, gives the texture an uneven structure.

Atmospheric: When the concrete is fast, it has an earthy and chalky scent. The smell is not strong according to other materials.

Acoustic: The structure of the materials results in a higher absorbent factor then other materials. This results in the material developing a shorter reverberation time then other materials such as wood, which is a softer material.

Interaction: The material is made from concrete and leca pellets, which gives it an uneven structure that is rough and itzy in a direct interaction.

Reflection
15 %.

Patina
The material's patina will not have a significant color change according to its original color. Because the material is often used inside of a wall envelope, where other materials withstand wind and weather.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	385.787	10.7613	3.28637

GWP
3.97e+02 kg CO^2-eq/m^3

Origin
A lightweight aggregate is often produced in Denmark by a firm called leca, this creates an approximate distance from the origin to the site of 100 km.

ECONOMICAL

Lifetime
The lifetime of leca blocks is highly dependent on the placement in the building, leca as a foundation have a lifetime of 50 years. And as a facade element 120 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

921.05 kr. per 0.1 m^3.

Reusable
3.28637 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.19
500	0.44
1000	0.63
2000	0.52

Heat capacity
1000 J/(kg•K)

concrete

WOOD-CONCRETE PANEL

ill.33. Troldtekt

VISUAL / ATMOSPHERE

Tactility
Visual: The material comes in different design solutions and colors. For that it can both be experienced as a warm or a cold material. By this the material can be adjusted depending on the wished visual experiences. The material is recognized for its texture which are small wires that are wrapped into each other and create an asymmetric pattern.

Atmospheric: The material has an earthy and chalky scent. The smell is not strong according to other materials.

Acoustic: The material is made to absorb sound, this is done by the structure of the materials that have a higher absorbent factor then other materials.

Interaction: The material is made from concrete and wood and by the organization of the material it gives an uneven structure that is rough and itzy in a direct interaction.

Reflection
70.8 % (Troldtekt, 2022).

Patina
The patina of the wood-concrete panel will typically not change, because the material is used the construction. Therefore the outdoor climate will not change its visual expression.

TECHNICAL FACTS

Density
388 kg/m^3 (Troldtekt, 2019).

Thermal conductivity
0.076 W/(m•K) (Troldtekt, 2019).

Corrosion resistant
Outside corrosion for this material will not have an impact on the material, because the material is often inside and not exposed to wind and weather.

Structure qualities
Troldtekt is made for a better acoustic indoor climate.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	-29.3699	317.455	-113.794

GWP

2.88e+042kg CO^2-eq/m^3

Origin

Wood from norway spruce tree forests mixed with portland cement mixed in denmark, however wood-concrete panel EPD states the distance to danish building sites are 160 km.

ECONOMICAL

Lifetime

Wood-concrete panels have a lifetime of 40 years.

Cost

The price is per 0.1 cubic meters and excludes VAT.

883.44 kr. per 0.1 m^3.

Reusable

-113.794 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.4
250	0.85
500	1.04
1000	0.98
2000	0.98

Heat capacity

1860 J/(kg•K)

METAL

metal

STEEL

on site

ill.34. Steel

TECHNICAL FACTS

Density
7850 kg/m^3

Thermal conductivity
50 W/(m•K)

Corrosion resistant
Seawater will speed up the corrosion of the steel, if the material gets wet it will rost and then weaken its strength and durability. There are different surface treatment, such as paint that will withstand wind and weather, so the material can be used outside (Mollerup, 1991).

Structure qualities
Steel can both be used as load bearing material, or being stabilized.

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is cold, due to its gray reflective color. The material can both be shiny or matt, depending on the desired visual expressions. After time the material gets more brown/reddish, which will give it a warmer and rough experience.

Atmospheric: Metal can not be smelled, unless it has been in direct contact with skin. Then stainless steel gets its metallic smell, which coins also are recognized for. The smell is typically not a strong scent, but it can be smelled in closed distances and on hands if they have been in contact with the material.

Acoustic: Steel has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Steel has a smooth and flat surface. The material has a high thermal conductivity according to wood, this means that the material has a great heat transport. Which by touching can feel freezing or burning, according to its surrounding temperature.

Reflection
50 %.

Patina
Steel has a gray reflective color and over time will become more matt brown/reddish and in some cases greenish in color.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 -eq / m^3	2.22e+04	5.38835	-3104.7

GWP
2.20e+04 kg CO^2-eq/m^3

Origin
Most of the iron and steel import is from germany, here materials weather comes as the foundation and are processed in denmark or imported as a complete item. This creates an approximate distance from the origin to the site of 600 km (Danmarks Statistik, n.d.).

ECONOMICAL

Lifetime
Steel has a calculated lifetime of 120 years. but are often seen outlive these numbers. As a facade element this material have a lifetime of 50 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

7100 kr. per 0.1 m^3 (Vejledende materialepriser, n.d.).

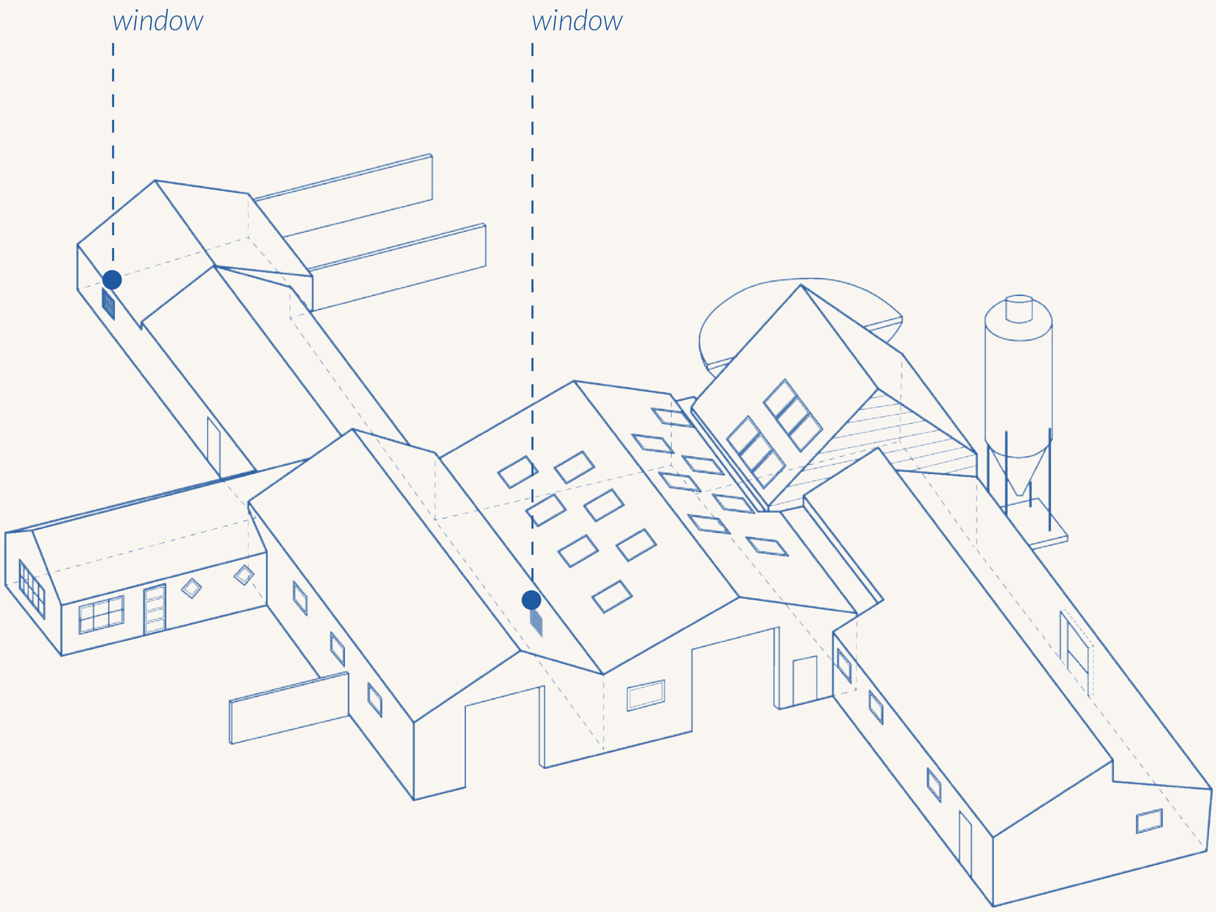
Reusable
-3104.7 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.02
500	0.03
1000	0.05
2000	0.1

Heat capacity
450 J/(kg•K)



ill.35. Steel, on site

STEEL, *on site*

The cement factory does not have steel as a construction material or other major areas. Steel can be found in the factory's older part, the storage old part, where the windows are made of steel and glass. Likewise, a window is placed between the factory halls, next to the sliding door.

Steel can be found in:

- *Window between the factory halls*
- *Storage, old part, windows*

ill.36. Steel, windows

WINDOW

The windows are located in the part of the cement factory which is the oldest and thus most severely affected by the lifespan of the materials. Likewise, the storage, old part, has not been used properly in the last several years because the rooms are overflowing with storage that is not used sensibly. The condition of the windows thus plays a major role in the condition of the room. Here it is clearly seen that the glass of the windows are broken, but the steel still remains. Between the two factory halls, a window is located by the slide door. It is not possible to see through the window as it is frosted. However, the window gives a great connection to the history of the place as an industry, as the steel windows give associations to industrial era.

metal
ALUMINIUM

ill.37. Aluminium

TECHNICAL FACTS

Density
2750 kg/m^3

Thermal conductivity
170 W/(m•K)

Corrosion resistant
Aluminum is a strong material against corrosion. It can both be used inside and outside in humid climates. Even though corrosion can weaken the material, especially if it is in contact with wood and concrete (Mollerup, 1991).

Structure qualities
Can not be used as load bearing, but is often used in smaller elements, due to its low weight according to other metals (Mollerup, 1991).

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is cold, due to its gray reflective color. The material can both be almost mirror shiny or matt.

Atmospheric: Aluminum does not have a strong smell, it is less strong than other metal types.

Acoustic: Steel has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Aluminium has a smooth and flat surface. The material has a high thermal conductivity according to other metal types, this means that the material has a great heat transport. Which by touching can feel freezing or burning, according to its surrounding temperature.

Reflection
60 %.

Patina
Aluminum has a gray reflective color and can become more white over time.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	28351.2	1.84840	-22405.5

GWP
2.84e+04 kg CO^2-eq/m^3

Origin
Most of the iron and steel import is from germany, here materials weather comes as the foundation and are processed in denmark or imported as a complete item. This creates an approximate distance from the origin to the site of 600 km (Danmarks Statistik, n.d.).

ECONOMICAL

Lifetime
Aluminum has a calculated lifetime of 120 years. but are often seen outliving these numbers. As a facade element this material have a lifetime of 60 years

Cost
The price is per 0.1 cubic meters and excludes VAT.

11900 kr. per 0.1 m^3 (Vejledende materialepriser, n.d.).

Reusable
-22405.46 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.11
500	0.10
1000	0.07
2000	0.06

Heat capacity
880 J/(kg•K)

metal

STAINLESS STEEL

ill.38. Stainless steel

TECHNICAL FACTS

Density
7900 kg/m^3

Thermal conductivity
17 W/(m•K)

Corrosion resistant
Stainless steel is a strong material against corrosion. It can both be used inside and outside in humid climates. Even though the material is strong against corrosion, it can still rust that will change its strength and durability (Mollerup, 1991).

Structure qualities
Stainless steel can both be used as load bearing material, or being stabilized. The material is often used as plates and pipes (Mollerup, 1991).

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is cold, due to its gray reflective color. The material can both be almost mirror shiny or matt.

Atmospheric: Metal can not be smelled, unless it has been in direct contact with skin. Then stainless steel gets its metallic smell, which coins also are recognized for. The smell is typically not a strong scent, but it can be smelled in closed distances and on hands if they have been in contact with the material.

Acoustic: Stainless steel has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Steel has a smooth and flat surface. The material has a high thermal conductivity according to wood, this means that the material has a great heat transport. Which by touching can feel freezing or burning, according to its surrounding temperature.

Reflection
50 %.

Patina
Stainless steel has a gray reflective color and over time can become matt brown/reddish color, because it can rust. Stainless steel will not change its patina as much as steel.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	27418.6	5.45656	-21310.2

GWP
2.74e+04 kg CO^2-eq/m^3

Origin
Most of the iron and steel import is from germany, here materials weather comes as the foundation and are processed in denmark or imported as a complete item. This creates an approximate distance from the origin to the site of 600 km (Danmarks Statistik, n.d.).

ECONOMICAL

Lifetime
Stainless steel has a calculated lifetime of 120 years. but are often seen outliving these numbers. As a facade element this material have a lifetime of 50 years

Cost
The price is per 0.1 cubic meters and excludes VAT.

19800 kr. per 0.1 m^3 (Vejledende materialepriser, n.d.).

Reusable
-21310.16 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.02
500	0.03
1000	0.05
2000	0.1

Heat capacity
500 J/(kg•K)

metal

ZINC

ill.39. Reinzink

TECHNICAL FACTS

Density
7200 kg/m^3

Thermal conductivity
110 W/(m•K)

Corrosion resistant
Zinc is a strong material against corrosion. It can both be used inside and outside in humid climates (Mollerup, 1991).

Structure qualities
Zinc can both be used as load bearing material, or being stabilized. The material is often used as plates (Mollerup, 1991).

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is cold, due to its gray reflective color. The material can both be almost shiny or matt.

Atmospheric: Metal can not be smelled, unless it has been in direct contact with skin. Then zinc gets its metallic smell, which coins also are recognized for. The smell is typically not a strong scent, but it can be smelled in closed distances and on hands if they have been in contact with the material.

Acoustic: Zinc steel has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Zinc has a smooth and flat surface. The material has a high thermal conductivity according to other metal types, this means that the material has a great heat transport. Which by touching can feel freezing or burning, according to its surrounding temperature.

Reflection
60 %.

Patina
Zinc has a gray reflective color and over time can become darker. Zincs's patina will not change as much as other types of metals.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 -eq / m^3	15048	4.896	-13032

GWP
2.84e+04 kg CO^2-eq/m^3

Origin
Most of the iron and steel import is from germany, here materials weather comes as the foundation and are processed in denmark or imported as a complete item. This creates an approximate distance from the origin to the site of 600 km (Danmarks Statistik, n.d.).

ECONOMICAL

Lifetime
Zinc has a long lifetime but is dependent on maintenance, this material is used as a facade element and therefore needs to be taken care of. The estimated lifetime for zinc is 60 years with proper care.

Cost
The price is per 0.1 cubic meters and excludes VAT.

11900 kr. per 0.1 m^3 (NG Zink, n.d.).

Reusable
-13031 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

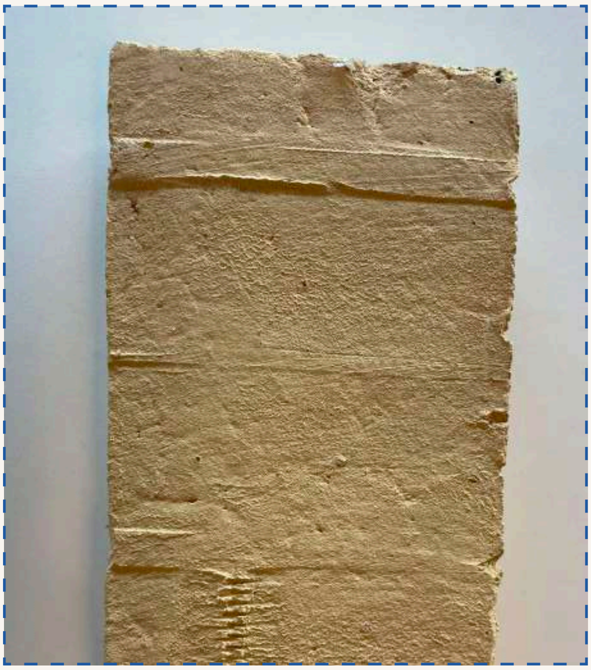
Hz	
125	0.01
250	0.02
500	0.03
1000	0.05
2000	0.1

Heat capacity
500 J/(kg•K)

BRICKS

bricks

BRICKS *on site*



ill.40. Bricks

TECHNICAL FACTS

Density
1400 kg/m^3, with data from the program Rockwool Energy Design.

Thermal conductivity
0.48 W/(m•K), with data from the program Rockwool Energy Design.

Corrosion resistant
It has been experienced that brick is a strong material that can withstand wind and weather. Brick has been used in Denmark as a cladding material, where some buildings have been standing for centuries. Because of a lack of sources, this knowledge is made by own experiences. .

Structure qualities
This material can both be used as load bearing material, or being stabilized.

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is a warm yellow color. Bricks can also be red or brownish, according to the chosen visual experience.

Atmospheric: Bricks have an earthy and chalky scent. The smell is not strong according to other materials.

Acoustic: Bricks have a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Bricks can have a matt sand texture, but can also be smooth. The material has a high heat capacity, this means that the material can feel warm, after the sun has gone down. Further bricks have a low thermal conductivity value. Which means that the material temperature will feel closer to the human temperature, then other materials such as metal.

Reflection
Old dusty bricks 5 %.
New yellow bricks 35 %.

Patina
Bricks have either a yellow or red/brownish color, the color of the material will not change much over time. Due to corrosion from the wind and weather, the bricks can get scratches and rounding corners.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2-eq / m^3	528.541	13.207	-3.69

GWP
5.42 e+02 kg CO^2-eq/m^3

Origin
Bricks are often produced in Denmark, this creates an approximate distance from the origin to the site of 100 km (Danske Tegl, n.d.).

ECONOMICAL

Lifetime
Bricks have a lifetime of 80 years if used as a facade element.

Cost
The price is per 0.1 cubic meters and excludes VAT. Prices for bricks are highly dependent on the type, this number is for simple yellow bricks with a price per piece of 7 DKK.

567.7 kr. per 0.1 m^3 (Randerstegl, n.d.a).

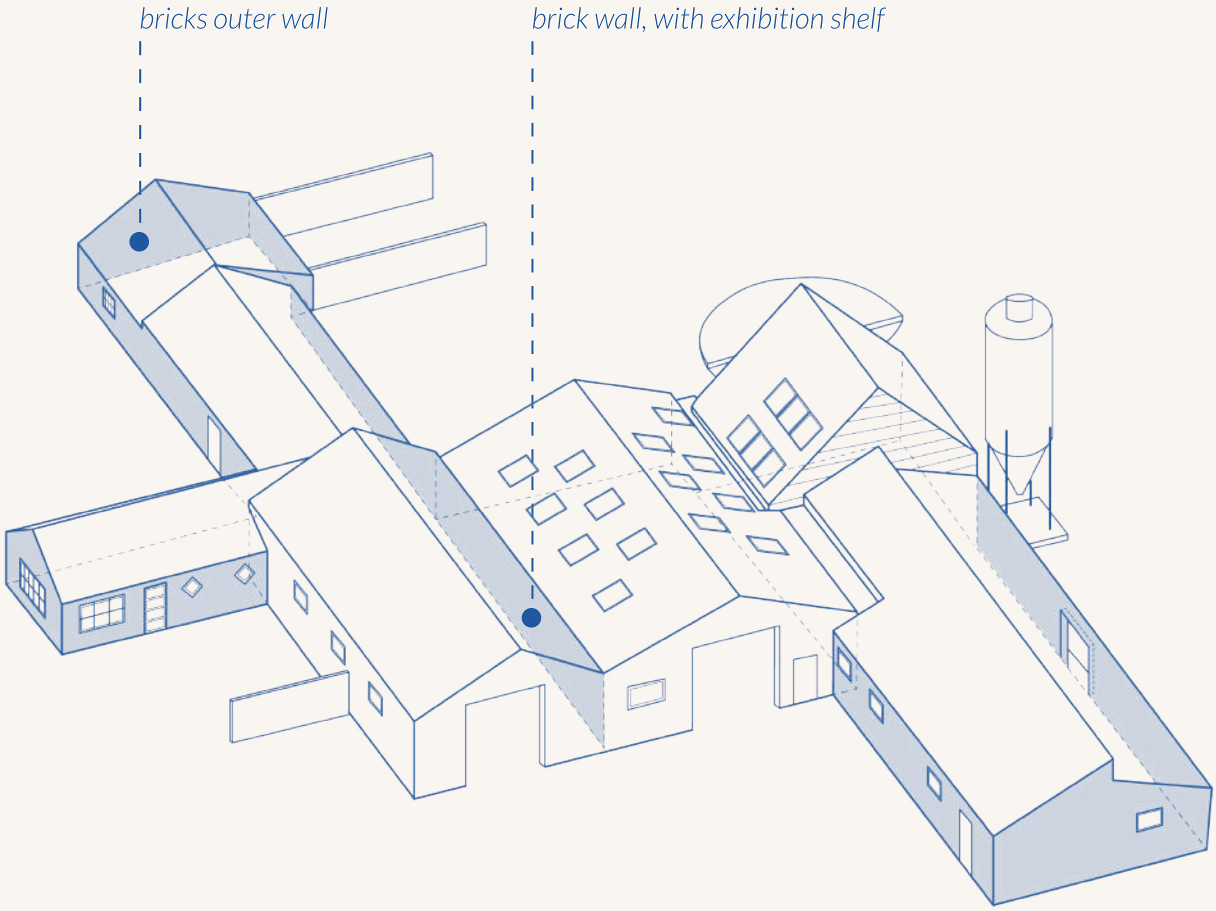
Reusable
-3.69 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.05
250	0.06
500	0.08
1000	0.08
2000	0.08

Heat capacity
840 J/(kg•K)



ill.41. Bricks, on site

BRICKS, *on site*

Bricks can be found on the outer walls of the old parts of the cement factory, the factory workspace and storage, old part. These outer walls carry the collar ties. These rooms have a low room height, and can thus be clearly experienced that it is the older part of the building that you are in. Likewise bricks are used to divide the two factory halls, where an exhibition shelf is created.

Bricks can be found in:

- *Factory workspace*
- *Storage, old part*
- *Factory hall, wall and exhibition shelf*

ill.42. brick outer wall

OUTER WALLS

Bricks are used in the outer walls in factory workspace and storage. It is clear to see that it is brick when you examine the facades more closely and compare it to the factory hall. Here, on the excursion, it was clear to see that the factory workspace and storage old part, consist of bricks.
In addition, the facade is plastered and painted yellow, with a strong connection to other houses on Samsø. The condition of this facade is reaching its end of life, as the paint had fallen off in various places on the facade, where the bricks underneath became apparent.

EXHIBITION SHELF

It is a brick wall that divides the two factory halls. In this wall is a sliding door and a window placed, as mentioned earlier. There is also an exhibition shelf above the door on both sides of the factory halls, where various concrete castings are exhibited. This is an important detail as the cement factory consists of very few details in the use of materials. This exhibition shelf enables cement factory workers to personalize their workplace and also select historical items to exhibit.

ill.43. brick exhibition shelf

bricks

ROOF TILES *on site*

ill.44. Roof tiles

TECHNICAL FACTS

Density
2000 kg/m^3, with data from the program Rockwool Energy Design.

Thermal conductivity
1 W/(m • K), with data from the program Rockwool Energy Design.

Corrosion resistant
It has been experienced that roof tiles are a strong material that can withstand wind and weather. Brick has been used in Denmark as a cladding material, where some buildings have been standing for centuries. Because of a lack of sources, this knowledge is made by own experiences.

Structure qualities
This material is a roof cladding that can withstand wind and weather.

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is a warm red color. The material's waving form gives a structure to the roof.

Atmospheric: Roof tiles have an earthy and chalky scent. The smell is not strong according to other materials.

Acoustic: Roof tiles have a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Roof tiles can have a matt sand texture, but can also be smooth. The material has a high heat capacity, this means that the material can feel warm, after the sun has gone down. Further roof tiles have a low thermal conductivity value. Which means that the material temperature will feel closer to the human temperature, then other materials such as metal.

Reflection
Old dusty roof tiles 5 %.
New red roof tiles 25 %.

Patina
Roof tiles have a red/brownish color and overtime will become red/brownish and greenish. Some of the patinas for roof tiles will be plants growth, such as moss, algae or other types of organism.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	793.9	15.15	-4.62

GWP
6.47e+02 kg CO^2-eq/m^3

Origin
Roof tiles are often produced in Denmark, this creates an approximate distance from the origin to the site of 100 km.

ECONOMICAL

Lifetime
Roof tiles have a lifetime of 60 years.

Cost
The price is per 0.1 cubic meter and excludes VAT. Prices for roof tiles are highly dependent on the type, this number is for simple red tiles.

956.7 kr. per 0.1 m^3 (Randerstegl n.d.b).

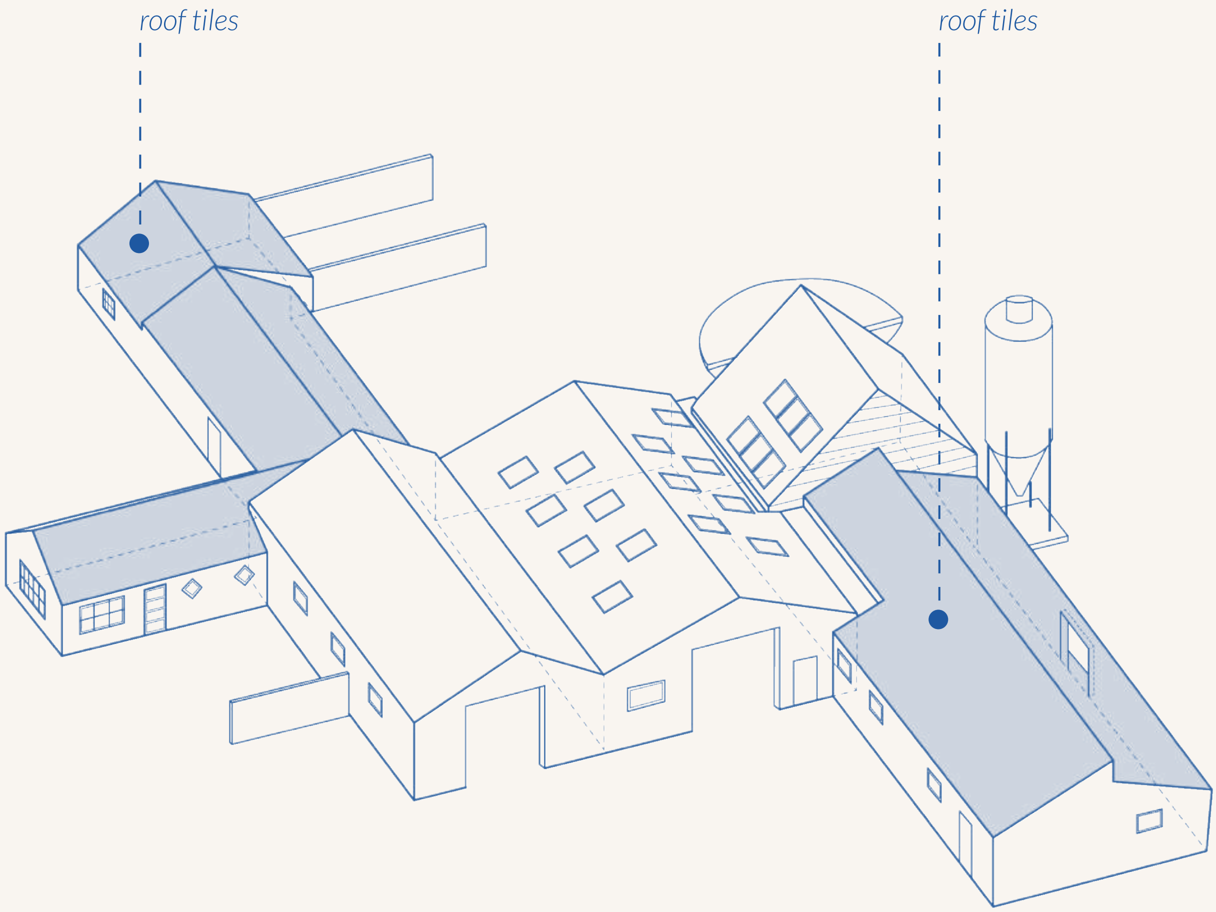
Reusable
-4.62 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.01
500	0.02
1000	0.02
2000	0.02

Heat capacity
800 J/(kg•K)



ill.45. Roof tiles, on site

ROOF TILES, *on site*

Roof tiles can be found on the roof of the old parts of the cement factory, the factory workspace and storage, old part. The roof tiles are assembled to the collar ties, as the roof construction. These rooms have a low room height, and can thus be clearly experienced that it is the older part of the building that you are in.

Roof tiles can be found in:

- *Factory workspace*
- *Storage, old part*

ill.46. Roof tiles

ROOF

It is clear to see by looking at the condition of the roof tiles that they are close to their end of life. They have been severely exposed to the weather and salt water, due to the close location to the coast. By moving around the building, where the roof tiles are roof cladding, there are some places where the sun goes through. This is because in some places the roof tiles are broken or their assembly is dissolved, thus allowing the sunlight to penetrate through the roof tiles.

PLASTER

plaster

FIBER PLASTER

ill.47. Fiber plaster

TECHNICAL FACTS

Density
600 kg/m^3, with data from the program Rockwool Energy Design.

Thermal conductivity
0.12 W/(m•K), with data from the program Rockwool Energy Design.

Corrosion resistant
Outside corrosion for this material will not have an impact on the material, because the material is often inside and not exposed to wind and weather.

Structure qualities
This material is used as interior cladding.

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is cold, due to its light white color. The material has a rough and uneven texture, but in distances it will be experienced as a flat white surface.

Atmospheric: Fiber plaster has a slightly dusty scent. The smell is not strong according to other materials.

Acoustic: Fiber plaster has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: The material has an uneven structure that feels rough when stroking the skin over it.

Reflection
85 %.

Patina
The patina of the fiber plaster will typically not change, because the material is used inside. Therefore the outdoor climate will not change its visual expression.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2-eq / m^3	318	11.4	15

GWP
3.36e+02 kg CO^2-eq/m^3

Origin
Industrial calcium is produced as a byproduct from industrial coal furnaces. This material is produced in Denmark, however with the industry being more sustainable, natural calcium is beginning to be used which is dug up from mines in countries like Spain. However in this case the material will be industrial calcium. This creates an approximate distance from the origin to the site of 100 km (Bæredygtigt Byggeri DK, n.d.)

ECONOMICAL

Lifetime
Fiber plaster have a lifetime of 50 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

787.92 kr. per 0.1 m^3.

Reusable
15kg CO^2-eq/m^3

INDOOR ENVIRONMENT

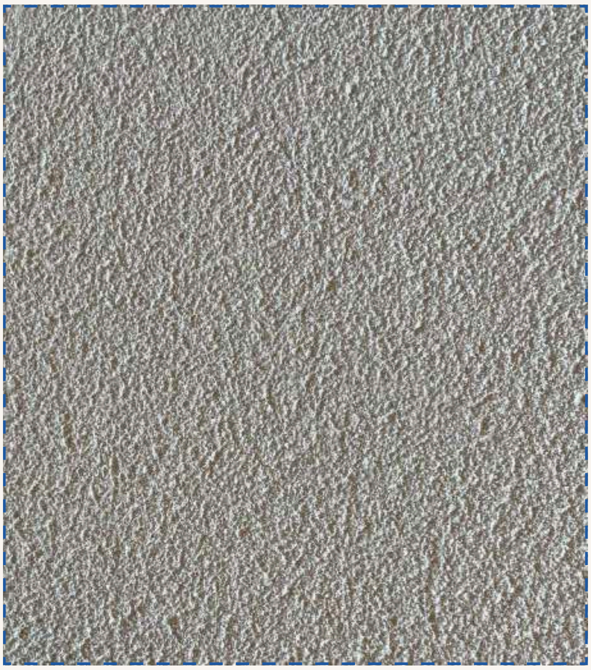
Absorbent factor

Hz	
125	0.15
250	0.10
500	0.06
1000	0.04
2000	0.04

Heat capacity
1000 J/(kg•K)

plaster

PLASTER



ill.48. Plaster

TECHNICAL FACTS

Density
900 kg/m^3, with data from the program Rockwool Energy Design.

Thermal conductivity
0.25 W/(m•K), with data from the program Rockwool Energy Design.

Corrosion resistant
Outside corrosion for this material will not have an impact on the material, because the material is often inside and not exposed to wind and weather.

Structure qualities
This material is used as interior cladding.

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is cold, due to its light white color. The material has a flat texture.

Atmospheric: Plaster has a slightly dusty scent. The smell is not strong according to other materials.

Acoustic: Plaster has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: The material has a flat texture that feels smooth when stroking the skin over it.

Reflection
85 %.

Patina
The patina of the plaster will typically not change, because the material is used inside. Therefore the outdoor climate will not change its visual expression.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2-eq / m^3	124.769	11.4	15

GWP
1.35e+02 kg CO^2-eq/m^3

Origin
Industrial calcium is produced as a byproduct from industrial coal furnaces. This material is produced in Denmark, however with the industry being more sustainable, natural calcium is beginning to be used which is dug up from mines in countries like Spain. However in this case the material will be industrial calcium. This creates an approximate distance from the origin to the site of 100 km (Bæredygtigt Byggeri DK, n.d.).

ECONOMICAL

Lifetime
Plaster have a lifetime of 50 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

787.92 kr. per 0.1 m^3.

Reusable
15 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.15
250	0.10
500	0.06
1000	0.04
2000	0.04

Heat capacity
1000 J/(kg•K)

STONE

stone

FIBER CEMENT SHEETS *on site*

ill.49. Fiber cement sheets

TECHNICAL FACTS

Density
1625 kg/m^3 (Briarwood supplies, n.d.).

Thermal conductivity
0.34 W/(m•K) (Briarwood supplies, n.d.).

Corrosion resistant
Fiber cement sheets is a strong material against corrosion. It can both be used inside and outside in humid climates.

Structure qualities
This material is a roof cladding that can withstand wind and weather.

VISUAL / ATMOSPHERE

Tactility
Visual: The expression of the material is a dark gray color. The material's waving form gives a structure to the roof.

Atmospheric: The material does not have a strong smell. Because fiber cement sheets will be used on the roof, the smell will not be noticeable.

Acoustic: Fiber cement sheets have a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: The material has an uneven structure that feels rough when stroking the skin over it. Due that the material is often used on the roof, the direct interaction will not happen often.

Reflection
35 %.

Patina
Fiber cement sheets have a dark gray color and over time will become dark gray, light gray and greenish. The patina for fiber cement sheets is plant growth, such as moss, algae or other types of organisms.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	699.3	19.5072	-

GWP
7.19e+02 kg CO^2-eq/m^3

Origin
Fiber cement sheets are often produced by Dansk Eternit Holding A/S, This creates an approximate distance from the origin to the site of 100 km (Rasmussen, 2003).

ECONOMICAL

Lifetime
Roof tiles have a lifetime of 60 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

563.74 kr. per 0.1 m^3.

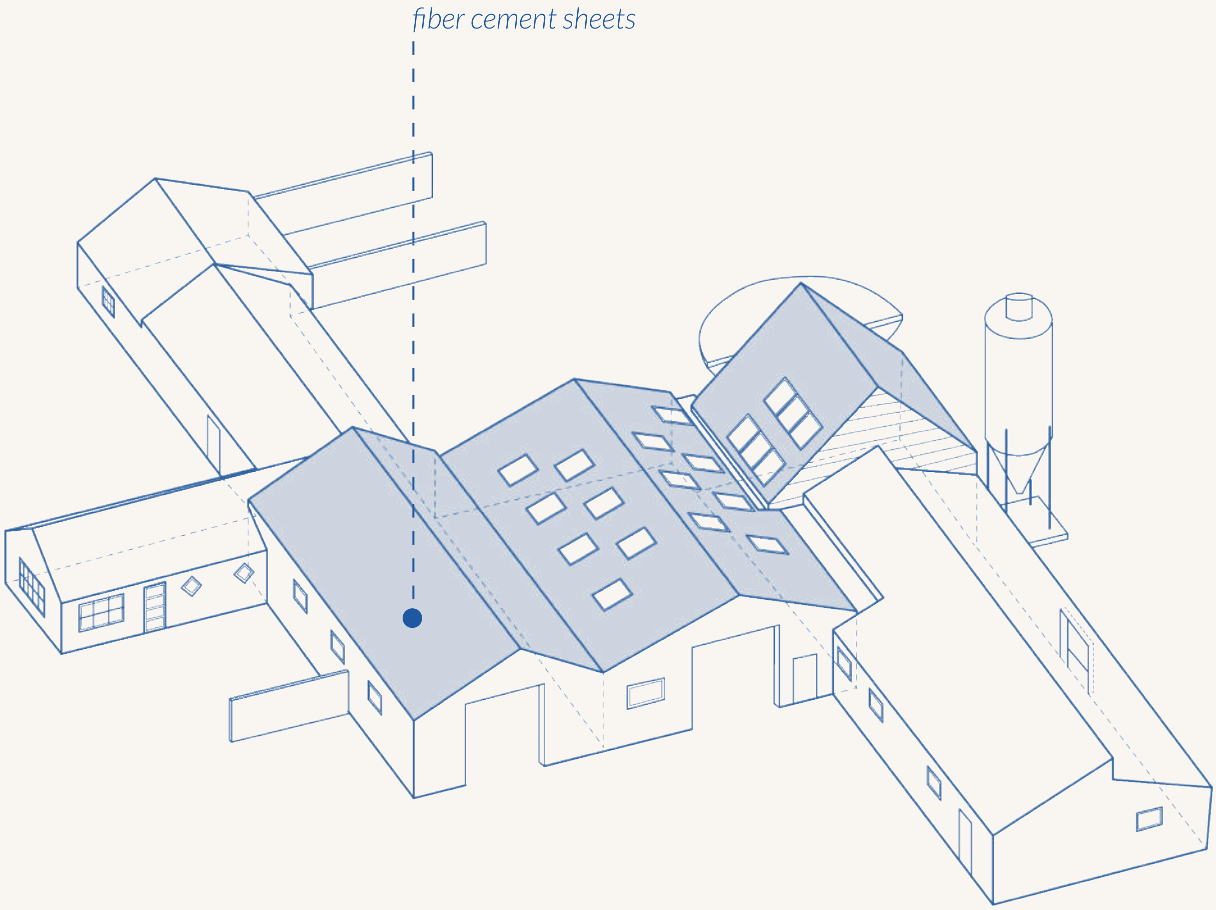
Reusable
Not defined

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.01
500	0.02
1000	0.02
2000	0.02

Heat capacity
800 J/(kg•K)



ill.50. Fiber cement sheets, on site

FIBER CEMENT SHEETS, *on site*

Fiber cement sheets can be found on the roof of the new parts of the cement factory, the factory halls and storage, new part. The fiber cement sheets are assembled to the lattice trusses in the factory halls and to the beam trusses in the storage, as the roof construction. These rooms have a high room height, and can thus be clearly experienced that it is the new part of the building that you are in.

Fiber cement sheets can be found in:

- *Factory hall*
- *Storage, new part*

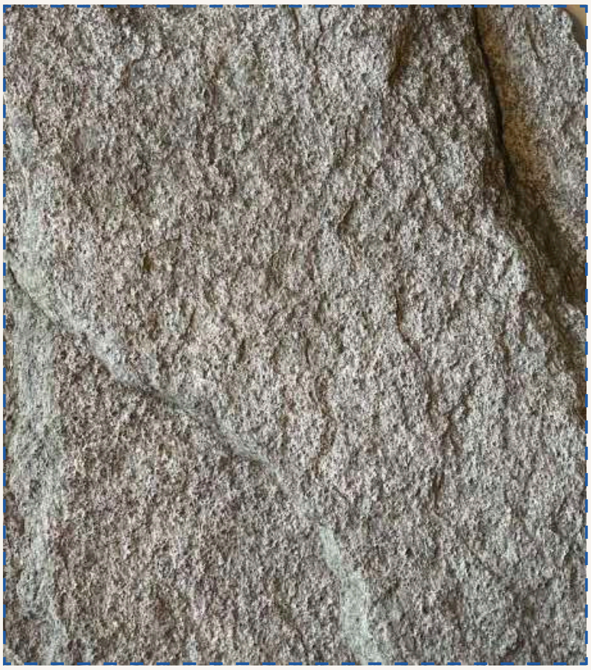
ill.51. Fiber cement sheets, roof

ROOF

The building part with fiber cement sheets as roof cladding, has a better condition than roof tiles. However, fiber cement sheets are also exposed to the weather and the saltwater, to which it is seen that algae is on fiber cement sheets. The condition inside the factory halls is also better, as the fiber cement sheets are not damaged and allow light to enter.

stone

GRANIT



ill.52. Granit

TECHNICAL FACTS

Density
2700 kg/m^3

Thermal conductivity
3.5 W/(m•K)

Corrosion resistant
Granit is a strong material against corrosion. It can both be used inside and outside in humid climates.

Structure qualities
This material is used as surfaces for floor covering, facade cladding etc.

VISUAL / ATMOSPHERE

Tactility
Visual: Granit can have various expressions, where its texture is often spotted by different colors. The color of the material differs from reddish, gray colored, white, beige and almost black. The material gives associations to nature, where its visuals can give a cold or warm expression depending on the color.

Atmospheric: Granit does not have a strong smell.

Acoustic: Granit has a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Granit can both have a smooth and flat surface, but also a rough uneven structure. It depends on how it has been treated. The material has a high thermal conductivity according to other metal types, this means that the material has a great heat transport. Which by touching can feel freezing or burning, according to its surrounding temperature.

Reflection
25 %.

Patina
Granits patina will not change much over time, as other materials.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	3007	40	-12.3238

GWP
3.05e+03 kg CO^2-eq/m^3

Origin
Granit is often imported from Brazil or China. This creates an approximate distance from the origin to the site of 9654 km (Flodeal, 2022).

ECONOMICAL

Lifetime
Nature Stone have a lifetime as a facade element of 120 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

978.53 kr. per 0.1 m^3.

Reusable
-12.3238 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.01
500	0.02
1000	0.02
2000	0.02

Heat capacity
800 J/(kg•K)

stone

STENI

ill.53. Steni

TECHNICAL FACTS

Density
1960 kg/m^3 (Steni, 2023).

Thermal conductivity
0.55W/(m•K) (Steni, 2023).

Corrosion resistant
Steni is a strong material against corrosion. It can both be used inside and outside in humid climates. The material will not be significantly damaged by the smaller amount of seawater, which it is exposed to (Byggematerialer, 2021).

Structure qualities
This material is a roof cladding that can withstand wind and weather.

VISUAL / ATMOSPHERE

Tactility
Visual: Steni can have various expressions, It differs from red, blue, green, yellow, white and black and in different tones and structures. The texture of the material can also differ from a smooth surface, to a rough and itchy surface. Because the material has that variation, the expression of the material can both feel warm and cold.

Atmospheric: The material does not have a strong smell. Because Steni will be used on the roof, the smell will not be noticeable.

Acoustic: Steni have a low absorbent factor, so the sound will reflect back when reaching the material. This can result in a high sound level, which will not feel comfortable to be in.

Interaction: Because Steni has a big variation of structures and textures the material directly interacts with the skin, can feel different. Generally the material has a low thermal conductivity according to other stones, this means that the materials temperature will feel closer to the human temperature then other stones.

Reflection
35 %.

Patina
Steni's patina will not change much over time, as other materials.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	699.3	19.5072	-

GWP
1.16e+3 kg CO^2-eq/m^3

Origin
Steni is produced in Lardal, Norway. This creates an approximate distance from the origin to the site of 385 km (Steni n.d.a).

ECONOMICAL

Lifetime
Steni have a lifetime as a facade element of 100 years (Steni n.d.b.).

Cost
Steni have a cost of 5000 dkk per 0.1 cubic meters, however the material has low to no waste material due to the stones being cut to specific projects.

Reusable
Not defined

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.01
250	0.01
500	0.02
1000	0.02
2000	0.02

Heat capacity
800 J/(kg•K)

INSULA-
TION

insulation

ROCKWOOL

on site

ill.54. Rockwool

TECHNICAL FACTS

Thermal conductivity
0.034 W/(m•K), with data from the program Rockwool Energy Design.

Corrosion resistant
Rockwool insulation is used in the wall and roof envelope.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	40.3055	0.721	-

GWP
4.14e+01 kg CO^2-eq/m^3

ECONOMICAL

Lifetime
Insulation materials have a lifetime of approximately 80 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

107.95 kr. per 0.1 m^3.

Reusable
Not defined

INDOOR ENVIRONMENT

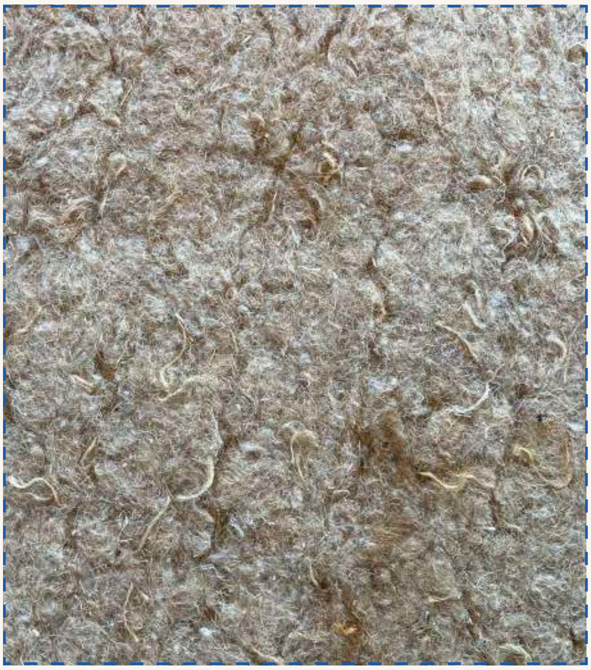
Absorbent factor

Hz	
125	0.15
250	0.11
500	0.10
1000	0.07
2000	0.06

Heat capacity
Due to insulation not being accessible to touch, this value will not be investigated.

insulation

HAMP



ill.55. Hamp

TECHNICAL FACTS

Thermal conductivity
0.044 W/(m•K), with data from the program Rockwool Energy Design.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	19.1569	86.1825	-12.0031

GWP
1.05e+02 kg CO^2-eq/m^3

Origin
Hamp insulation is produced in Germany by a company called Hempro, This creates an approximate distance from the origin to the site of 600 km.

ECONOMICAL

Lifetime
Insulation materials have a lifetime of approximately 80 years.

Cost
The price is per 0.1 cubic meters and excludes VAT.

310 kr. per 0.1 m^3 (Byggeladen, n.d.)

Reusable
-12.0031 kg CO^2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

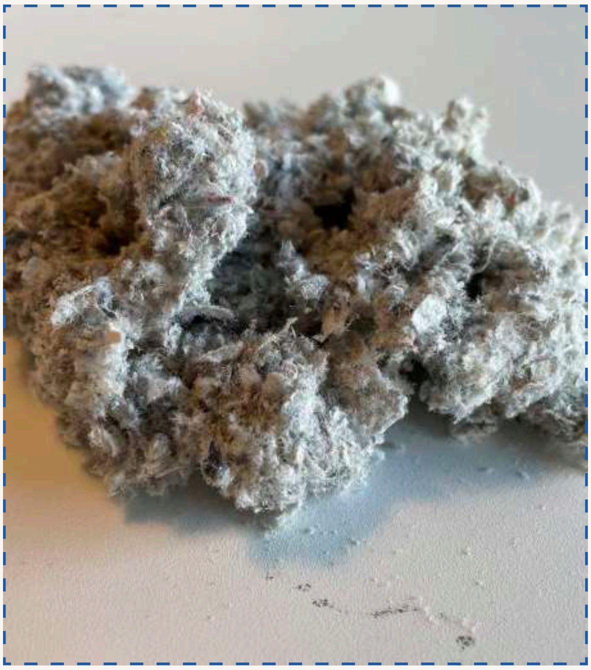
Hz	
125	0.22
250	0.65
500	0.84
1000	0.81
2000	0.86

(Gumanova, 2022.)

Heat capacity
Due to insulation not being accessible to touch, this value will not be investigated.

insulation

PAPERWOOL



ill.56. Paperwool

TECHNICAL FACTS

Thermal conductivity

0.04 W/(m•K), with data from the program Rockwool Energy Design.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 - eq / m^3	-73.3725	99.0818	-30.5055

GWP

2.57e+01 kg CO^2-eq/m^3

Origin

Paperwool insulation is often produced in Denmark. This creates an approximate distance from the origin to the site of 100 km.

ECONOMICAL

Lifetime

Insulation materials have a lifetime of approximately 80 years

Cost

The price is per 0.1 cubic meters and excludes VAT.

114 kr. per 0.1 m^3 (Greenmatch, 2023) .

Reusable

-30.5055 kg CO_2-eq/m^3

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.11
250	0.18
500	0.25
1000	0.52
2000	0.80

Heat capacity

Due to insulation not being accessible to touch, this value will not be investigated.

insulation

STRAW

ill.57. Straw

TECHNICAL FACTS

Thermal conductivity

0.08 W/(m•K), with data from the program Rockwool Energy Design.

ECOLOGICAL

Emission pr. phase A/C/D

	A1-3	C3	D
kg CO^2 -eq / m^3	-127	0	0

GWP

7.00e+00 kg CO^2-eq/m^3

Origin

Straw insulation is produced in Denmark however it is not as used and therefore harder to acquire. This creates an approximate distance from the origin to the site of 100 km.

ECONOMICAL

Lifetime

Straw insulation has a lifetime of approximately 50 years.

Cost

The price is per 0.1 cubic meters and excludes VAT.

440 kr. per 0.1 m^3.

Reusable

-The reason for missing numbers and imprecise GWP for this material is due to the material being a “Deposit” material.

INDOOR ENVIRONMENT

Absorbent factor

Hz	
125	0.22
250	0.3
500	0.78
1000	0.52
2000	0.86

(Lannace, 2017)

Heat capacity

Due to insulation not being accessible to touch, this value will not be investigated.

VALUE POINT

VALUE POINT

The value setting is based on the values described in the catalog for each material. The numerical values are graded based on their position to one another.

However, when analyzing the atmosphere, it is important to divide the areas into groups based on the desired ambiance.

GWP

1	3	4	5
Reinzin	*Cranit*	*Fiber cement sheets*	*Plaster*
Aluminium	*Steni*	*Roof tiles*	*Hamp*
Stainless steel		*Bricks*	*Rockwool*
Steel		*Lecaterm*	*Paperwool*
		Fiber plaster	*Straw*
		Perforated concrete	
		Troldtekt	
		Construction timper	
		Concrete	
		Cedar	
		Oak	
		Leca	
		Pine	

LIFETIME

1	2	3	4	5
Troldtekt	*Fiber cement sheets*	*Bricks*	*Aluminium*	*Concrete*
Fiber plaster	*Reinzin*	*Construction timper*	*Cedar*	*Cranit*
Plaster	*Roof tiles*	*Hamp*	*Oak*	*Perforated concrete*
Straw		*Paperwool*	*Pine*	
		Rockwool	*Steni*	
		Leca		
		Lecaterm		
		Stainless steel		
		Steel		

CORROSION RESISTANCE

2	3	4	5
Steel	*Cedar*	*Concrete*	*Aluminium*
	Construction timper	*Perforated concrete*	*Bricks*
	Oak		*Cranit*
	Pine		*Fiber cement sheets*
			Reinzin
			Roof tiles
			Stainless steel
			Steni
			Leca
			Lecaterm

CULTURAL HERITAGE

1	2	3	4	5
Straw	*Cedar*	*Cranit*	*Construction timper*	*Rockwool*
Paperwool		*Reinzin*		*Fiber cement sheets*
Hamp		*Stainless steel*		*Roof tiles*
Steni		*Aluminium*		*Bricks*
Plaster		*Oak*		*Steel*
Fiber plaster				*Lecaterm*
Troldtekt				*Leca*
				Perforated concrete
				Concrete
				Pine

GROUP 1

Rooms: Spa area, Massage room, Sauna

TACTILITY

In these rooms, the desired atmosphere is characterized by a dark tone, complemented by warm effects created by the use of darker colors. Materials that can contribute to the ambiance through scent are also considered a great addition. From a technical standpoint, the desired materials should enhance acoustics and provide a warm tactile sensation. Here the visual atmosphere is the most important and weighs [• 2] and the sense of touch [• 1.5].

1	*2*	*3*	*4*	*5*
Aluminium	*Reinzin*, *Stainless steel*, *Steel*	*Plaster*, *Fiber plaster*, *Perforated concrete*, *Concrete*, *Roof tiles*	*Leca*, *Cranit*, *Fiber cement sheets*, *Bricks*, *Lecaterm*, *Steni*, *Oak*, *Construction timper*, *Pine*	*Troldtekt*, *Cedar*

PANTINA

There is no need for a specific patina in these rooms.

1	*2*	*3*	*5*
Steel, *Cedar*	*Reinzin*, *Stainless steel*, *Aluminium*, *Oak*, *Construction timper*, *Pine*	*Fiber cement sheets*, *Roof tiles*, *Bricks*, *Perforated concrete*, *Concrete*	*Steni*, *Cranit*, *Plaster*, *Fiber plaster*, *Troldtekt*, *Leca*, *Lecaterm*

REFLECTION

Due to the desire to create a cozy and dark atmosphere the reflection should be low.

1	*2*	*3*	*4*	*5*
Plaster, *Fiber plaster*	*Reinzin*, *Aluminium*, *Troldtekt*	*Stainless steel*, *Steel*	*Fiber cement sheets*, *Bricks*, *Oak*, *Construction timper*, *Pine*	*Steni*, *Cranit*, *Roof tiles*, *Lecaterm*, *Leca*, *Perforated concrete*, *Concrete*, *Cedar*

GROUP 2

Rooms: Restaurant, Lobby, Bedrooms, Lounge

TACTILITY

The room should have a warm color scheme and low odor. It should also have materials with low acoustic properties, to create a comfortable and cozy environment. The thermal conductivity is not as relevant in this area.

2	*Aluminium, Reinzin, Stainless steel, Steel, Fiber cement sheets*
3	*Plaster, Fiber plaster, Cedar, Cranit, Perforated concrete, Concrete*
4	*Roof tiles, Steni, Bricks, Lecaterm, Leca, Oak*
5	*Troldekt, Construction timper, Pine*

PATINA

There is no need for a specific patina in these rooms.

1	*Steel, Cedar*
2	*Reinzin, Stainless steel, Aluminium, Oak, Construction timper, Pine*
3	*Fiber cement sheets, Roof tiles, Bricks, Perforated concrete, Concrete*
5	*Steni, Cranit, Plaster, Fiber plaster, Troldekt, Leca, Lecaterm*

REFLECTION

The area should have a warm expression, but light is still important in these rooms which is why the reflection should be high.

1	*Steni, Cranit, Roof tiles, Lecaterm, Leca, Perforated concrete, Concrete, Cedar*
2	*Fiber cement sheets, Bricks, Oak, Construction timper, Pine*
3	*Stainless steel, Steel*
4	*Reinzin, Aluminium, Troldekt*
5	*Plaster, Fiber plaster*

GROUP 3

Rooms: Reception, Administration, Staff room, Kitchen, Toilets, Coolroom and storage, Laundry storage, Wardrobe room

TACTILITY

The room should have a light color scheme, this will help make the rooms lighter and help light bounce around, creating a great work environment. There should be great acoustics, no additional smell from materials and a low thermal conductivity.

2	*Steel, Fiber cement sheets, Roof tiles, Reinzin, Stainless steel, Bricks, Aluminium, Perforated concrete, Concrete, Oak*
3	*Cranit, Construction timper, Cedar, Pine, Steni, Lecaterm, Leca, Plaster, Fiber plaster*
4	*Troldtekt*

PATINA

There is no need for a specific patina in these rooms.

1	*Steel, Cedar*
2	*Reinzin, Stainless steel, Aluminium, Oak, Construction timper, Pine*
3	*Fiber cement sheets, Roof tiles, Bricks, Perforated concrete, Concrete*
5	*Steni, Cranit, Plaster, Fiber plaster, Troldtekt, Leca, Lecaterm*

REFLECTION

High reflection creates optimal rooms for productivity.

1	*Steni, Cranit, Roof tiles, Lecaterm, Leca, Perforated concrete, Concrete, Cedar*
2	*Fiber cement sheets, Bricks, Oak, Construction timper, Pine*
3	*Stainless steel, Steel*
4	*Reinzin, Aluminium, Troldtekt*
5	*Plaster, Fiber plaster*

EPI-
LOGUE

REFERENCE LIST

Aagaard, N. et al. 2013. Levetider af bygningsdele ved vurdering af bæredygtighed og totaløkonomi. SBi 2013:30. Statens Byggeforskningsinstitut, Aalborg Universitet. Internet adress: https://build.dk/Assets/Levetider-af-bygningsdele-ved-vurdering-af-baeredygtighed-og-totaloekonomi/sbi-2013-30-rapport.pdf viewed :02/03/2023

Briarwood supplies. n.d. EUROSIX 6 Profile Fibre Cement Sheets in Meadowscape. Briarwood supplies. Internet address: https://www.briarwoodsupplies.co.uk/collections/fibre-cement-sheets/products/eurosix-6-profile-fibre-cement-profiled-sheets-in-anthracite viewed: 03/03/2023.

Byggeladen n.d. Hør isolering, Byggeladen.dk. Internet address: https://byggeladen.dk/shop/96-hoer-isolering/ viewed: 02/03/2023.

Byggematerialer. 2021. STENI - FACADEPLANDEN TIL EKSTREME KLIMAFORHOLD, Byggematerialer. Internet address: https://www.byggematerialer.dk/steni-facadepladen-til-ekstreme-klimaforhold-188811/nyhed.html viewed: 03/03/2023.

Bæredygtigt Byggeri DK n.d. Gips. Internet address: https://www.xn--bredygtigtbyggeri-rrb.dk/gips viewed: 02/03/2023.

Christoffersen, J. et al. 2002. Beregning af dagslys i bygninger. 1, udgave. By og Byg Statens Byggeforskningsinstitut, Hørsholm.

Dansk Standard. 2003. Code of Practice for the structural use of timber. DS 413:2003

Dansk Standard. 2008. Building materials and production - Hygrothermal properties - Tabulated design values and procedures for determining declared and design thermal values. DS/EN ISO 10456. Internet adress: https://sd.ds.dk/Viewer/Standard?ProjectNr=M204192&Status=90.20&VariantID=41&Page=0 viewed :02/03/2023

Dansk Standard. 2016. Durability of wood and wood-based products - Testing and classification of the durability to biological agents of wood and wood based materials. DS/EN 350:2016. 1. udgave.

Danmarks Statistik n.d. Detaljeret import og eksport. Internet adress: https://www.dst.dk/da/Statistik/emner/oekonomi/betalingsbalance-og-udenrigshandel/detaljeret-import-og-eksport viewed: 02/03/2023.

Danske Tegl n.d. Danske Tegl og Mursten produceres på Superliga-Niveau. Internet adress: https://www.dansketegl.dk/2016/10/17/danske-tegl-og-mursten-produceres-paa-superliga-niveau/ viewed: 02/03/2023.

Flodeal, 2022. Sådan importeres marmor og granit, Flodeal Private Limited. Internet address: https://flodeal.com/da/blog/how-to-import-marble-and-granite/ viewed: 02/03/2023.

Greenmatch. 2023, Papirisolering - Bestil skræddersyede tilbud , GreenMatch.dk. Internet address: https://www.greenmatch.dk/isolering/papirisolering viewed: 02/03/2023.

Gumanova, V. et al. 2022. Experimental Survey of the Sound Absorption Performance of Natural Fibres in Comparison with Conventional Insulating Materials. Sustainability. Basel, Switzerland. viewed 02/03/2023

Jacobsen, O.V, Sode, T.R. 2020. Overfladebehandling af udvendigt træ. Bolius Videncentret. Internet adress: https://www.bolius.dk/overfladebehandling-af-udvendigt-traevaerk-16198 viewed: 01/03/2023.

Jensen, B. 2013. Teknisk ståbi. 22, udgave. Nyt teknisk forlag. Copenhagen K.
Flügger. n.d.a. Oliebaseret træbeskyttelse. Flügger group A/S. Internet adress: https://www.flugger.dk/udendoers/traebeskyttelse/c-878693/?page=1 viewed: 01/03/2023

Flügger. n.d.b. Skal du vælge vand- eller oliebaseret træbeskyttelse. Flügger group A/S. Internet adress: https://www.flugger.dk/inspiration-guide/saadan-goer-du/vandbaseret-eller-oliebaseret-traebeskyttelse/ viewed: 01/03/2023

Flügger. n.d.c.Træolie. Flügger group A/S. Internet adress: https://www.flugger.dk/udendoers/traeolie/c-794835/?page=1#Hvad%20er%20tr%C3%A6olie viewed: 01/03/2023

Flügger. n.d.d. Vandbaseret træbeskyttelse.. Flügger group A/S. Internet adress: https://www.flugger.dk/udendoers/traebeskyttelse/c-878694/?page=1 viewed: 01/03/2023

Lannace, G. 2017. The acoustic characterization of green materials. Building acoustics. 24 (2), 101–113.

McKenzie, R. 2000. Right Tree - Right Place White Pine and Salt hite Pine and Salt hite Pine and Salt Tolerance. Department of Forestry & Natural Resources, Purdue University. West Lafayette.

Mollerup, J. 1991. Husbygnings materialer. Nyt bordisk forlag Arnold Busek. ISBN 87-17-06259-4

NG Zink n.d. Tag i Zink, kobber og aluminium: Fordele og Begrænsninger, Internet adress: https://ng-zink.dk/artikler/tag-i-zink-og-kobber viewed: 02/03/2023.
Petersen, J. 1984. Rumakustik. SBi 137. Statens Byggeforskningsinstitut, Aalborg Universitet. Internet adress: https://build-dk.zorac.aub.aau.dk/anvisninger/_layouts/15/Efips.SBi.Portal/Download.ashx/8ae699e269524033bd7833aa61108a23/bdbb1e91cc394b66a21bdd0745343cb7/Rumakustik.pdf viewed :02/03/2023

Randerstegl n.d.a. Mursten RT 202 alpha Gul Egepræg Maskinsten. Internet adress: https://www.randerstegl.dk/dk/mursten/produkt/rt202-alpha-gul-egepraeg?PID=53912 viewed:02/03/2023.

Randerstegl n.d.b. RT 806 Højslev Lille Dansk Format. Internet adress: https://www.randerstegl.dk/dk/tagsten/produkt/rt806-hoejslev-lille-dansk-format?PID=54177 viewed:02/03/2023.

Rasmussen, P.B. 2003 Dansk Eternit ER næststørst I Europa, Berlingske.dk. Internet adress: https://www.berlingske.dk/virksomheder/dansk-eternit-er-naeststoerst-i-europa viewed: 02/03/2023.

Rasmussen, T. V. et al. 2020. Anvendelse af træ i byggeriet: Potentialer og barrierer. Institut for Byggeri, By og Miljø (BUILD), Aalborg Universitet.

Sandak, A. Sandak, J. 2021. Wood Modification: Characterization, Modelling and Applications.

MDPI - Multidisciplinary Digital Publishing Institute. Basel, Switzerland.

Steni. 2023. TECHNICAL DATASHEET. Steni. Internet address: https://www.steni.dk/docs/steni.dk/02_teknisk%20dokumentation/teknisk%20datablad/03_technical%20datasheet%20steni%20nature%20fm_en_0223.pdf viewed: 02/03/2023.

Steni n.d.a. Om steni. Internet address: https://www.steni.dk/om-steni/ viewed: 02/03/2023.

Steni n.d.b. Hvorfor vælge steni. Internet address: https://www.steni.dk/hvor-for-vaelge-steni/miljoeet/ viewed: 02/03/2023.

Södra. 2019. Ydeevnedeklaration – DoP nr. 112 Western Red Ceder - Thuja plicata. Södra Wood A/S. Internet address: https://www.sodra.dk/sites/default/files/uploads/Downloads/ydeevnedeklaration-112-western-red-ceder-v2.pdf viewed: 27/02/2023.

Teknologisk Institut. n.d. THUJA (KÆMPETHUJA). Teknologisk Institut. Internet address: https://www.trae.dk/leksikon/thuja-kaempethuja/ viewed: 27/02/2023.

Troldtekt. 2019. Troldtekt ® agro, Tekniske data. Troldtekt A/S. Internet address: https://byggecenter.blob.core.windows.net/filer/Monteringsvejledninger/Produktdatablad%20-%20Troldtekt%20Agro%20tr%C3%A6beton.pdf viewed: 28/02/2023.

Troldtekt. 2022. Troldtekt ® akustik, Tekniske data. Troldtekt A/S. Internet address: https://www.troldtekt.dk/media/dj4jj54w/teknisk_datablad_akustik_dk_2022.pdf viewed: 28/02/2023.

Træ.dk. n.d. Overfladebehandling af træ - miljøforhold. Træ.dk, Danmarks træportal. Internet adress: https://www.trae.dk/leksikon/overfladebehandling-af-trae-miljoeforhold/ viewed: 01/03/2023.

Vejledende materialepriser n.d. internet address: http://metalintra.techcollege.dk/Html/Materialepriser.htm viewed 02/03/2023

Wulff, F. B. 2014. Opfattelsen af træ: En undersøgelse af forholdet mellem udseende og den perciperede pris af 7 udvalgte træsorter. Aalborg Universitet.

Qu, F. et al. 2020. Durability deterioration of concrete under marine environment from material to structure: A critical review. Elsevier. Internet address: https://www.sciencedirect.com/science/article/pii/S2352710220337062?ref=pdf_download&fr=RR-2&rr=7a102c3c6a20abc2 viewed: 01/03/2023.

ILLUSTRATION LIST

APPENDIX

transformation to
SAMSØ BEACH HOTEL

Master Thesis Project
MSc04, May 2023, Aalborg University

ma4-arc4
Camilla Lynnerup Christensen
Kasper Vismar Chrestensen
Maria Lahn Jensen

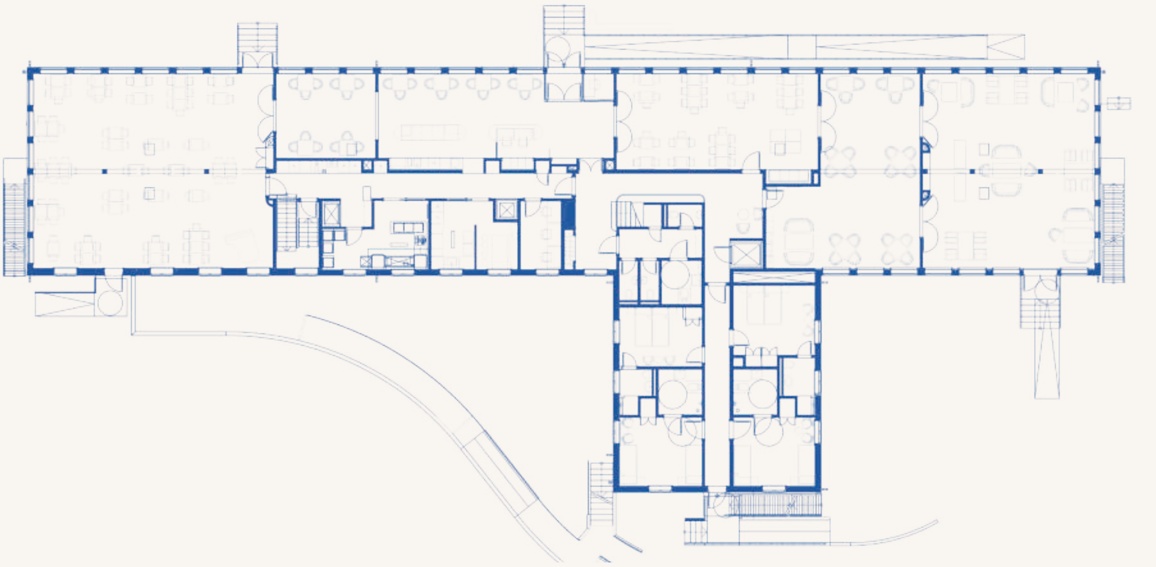
TITLE PAGE

Titel	Transformation to Samsø Beach Hotel
Department	Architecture, Design and Media Technology Aalborg University
Semester	MSc04, May 2023
Group	ma4-arc4
Project period	01/02/2023 - 26/05/2023
Main supervisor	Joel Peter Weber Letkemann
Technical consultant	Endrit Hoxha
Report	Appendix
Pages	78
Authors	Camilla Lynnerup Christensen Kasper Vismar Chrestensen Maria Lahn Jensen

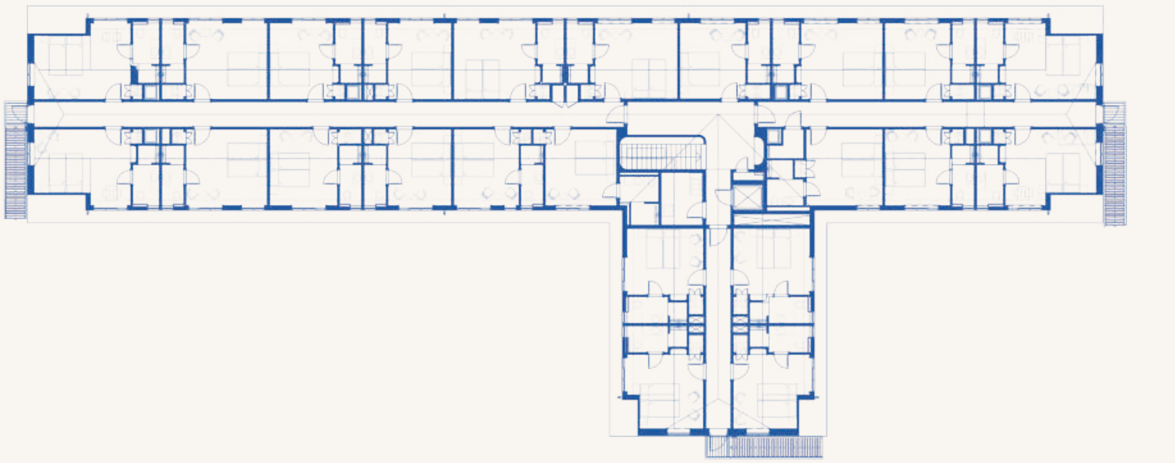
CONTENTS

appendix 1

SVINKLØV BADEHOTEL



ill.1. floor plan Svinkløv Badehotel, ground floor, 1:400
credit: Praksis Arkitekter



ill.2. floor plan Svinkløv Badehotel, 1. floor, 1:400
credit: Praksis Arkitekter

ill.3. floor plan Svinkløv Badehotel, basement, 1:400
credit: Praksis Arkitekter

appendix 2

PROGRAMMING

A programming investigation has been developed, with focus on overall zones in the building. The zones consist of: bedrooms, spa, restaurant, lounge, lobby and staff area.

The different programming ideas will be described according to ***advantages*** and ***disadvantages***.

Advantage

- restaurant orientated to the road
- spa oriented to the coast
- bedrooms placed the same place

Disadvantage

- public functions is spread throughout the building
- large footprint extension for bedrooms

Advantage

- restaurant orientated to the road
- spa oriented to the coast
- bedrooms oriented to the coast

Disadvantage

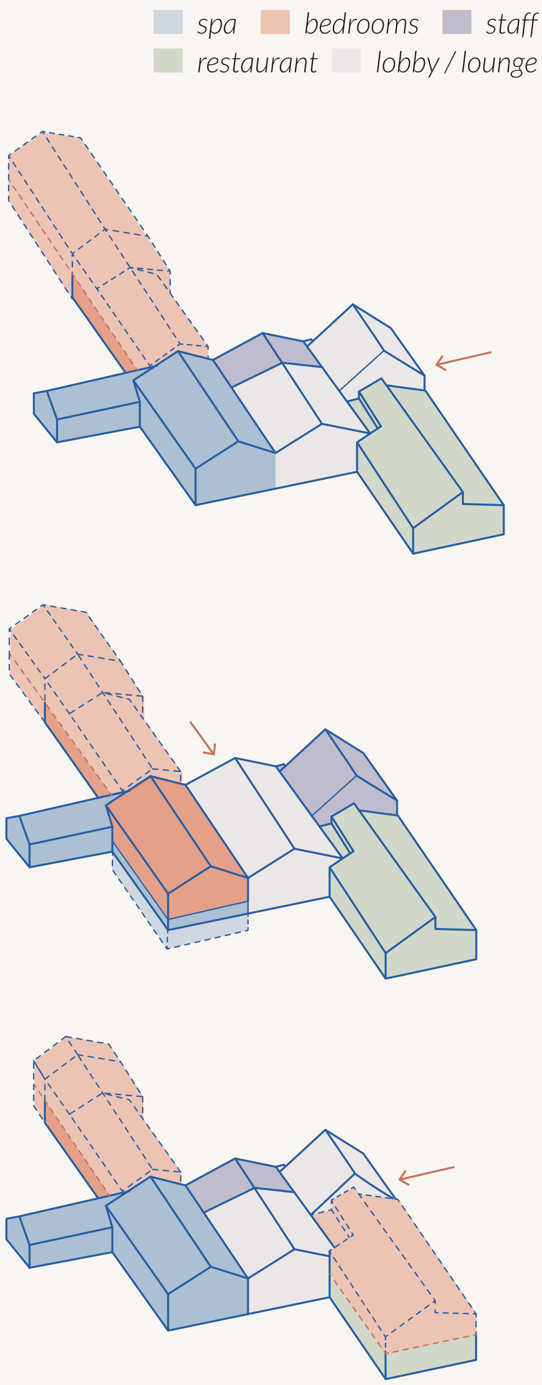
- public functions is spread throughout the building
- large footprint extension for bedrooms
- spa and bedrooms will blend in together

Advantage

- restaurant orientated to the road
- spa oriented to the coast
- bedrooms oriented to the coast
- spread bedrooms will divided the users, according to family and couple bedrooms

Disadvantage

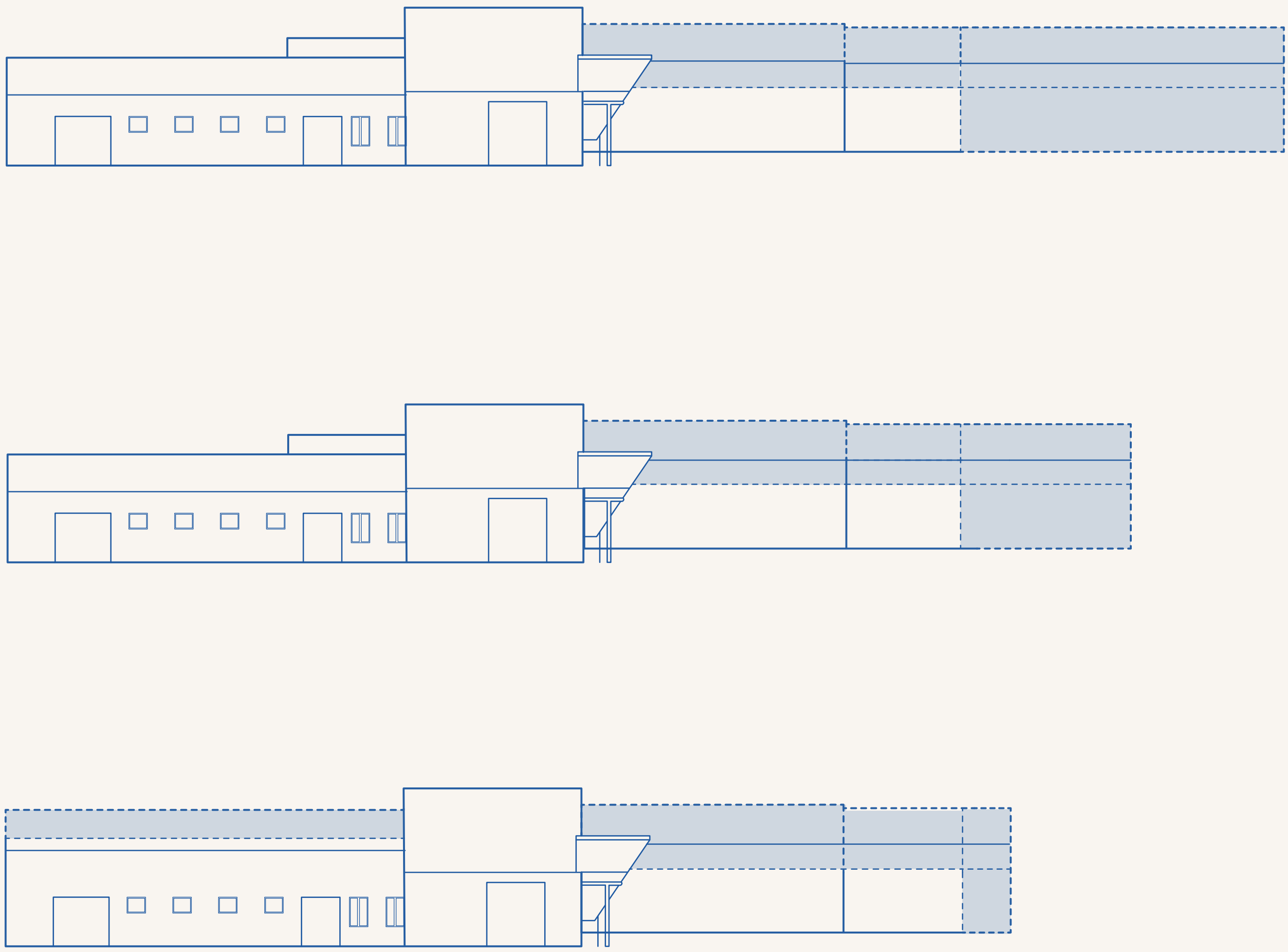
- public functions is spread throughout the building



ill.4. programming

□ *existing* ■ *extension*

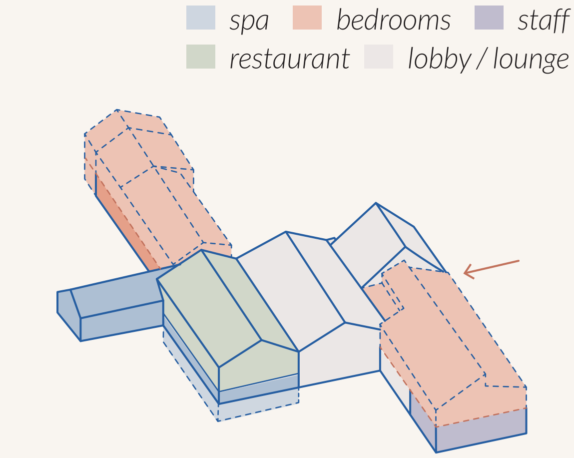
elevations from the road, arrival



ill.5. programming, elevation

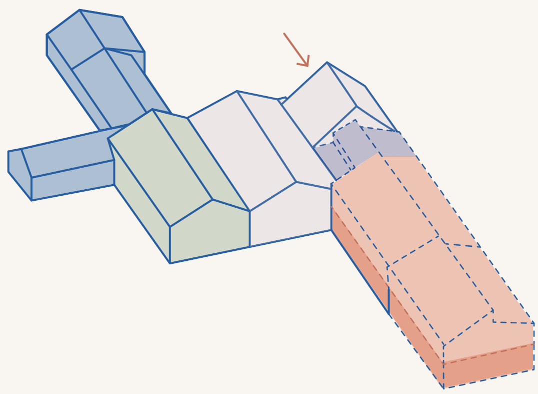
Advantage
- restaurant orientated to the road
- spa oriented to the coast
- bedrooms oriented to the coast
- spread bedrooms will divided the users, according to family and couple bedrooms
- public functions placed close to each other

Disadvantage
- staff placed away from the public functions



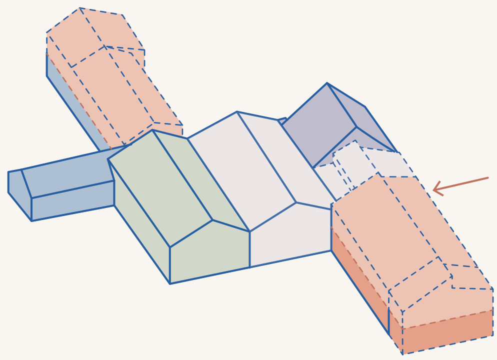
Advantage
- spa oriented to the coast
- bedrooms oriented to the coast
- public functions placed close to each other
- staff close to the public functions

Disadvantage
- entrance away from the road
- large footprint extension for bedrooms

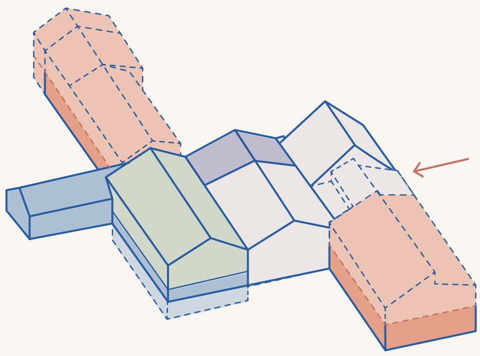


Advantage
- spa oriented to the coast
- bedrooms oriented to the coast
- spread bedrooms will divided the users, according to family and couple rooms
- public functions placed close to each other

Disadvantage
- restaurant orientated to the coast



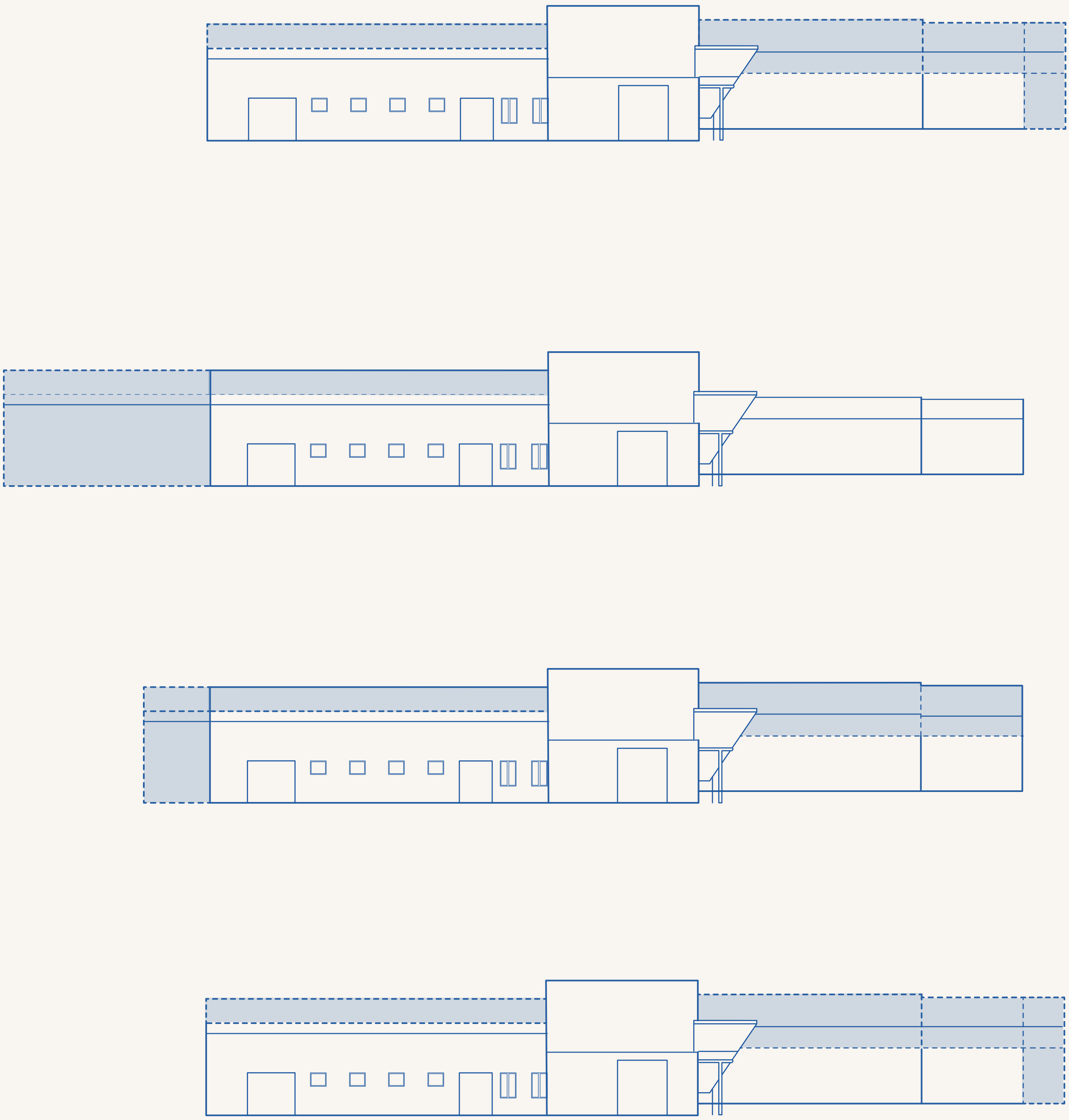
Advantage
- spa oriented to the coast
- bedrooms oriented to the coast
- spread bedrooms will divided the users, according to family and couple rooms
- public functions placed close to each other
- interplay between restaurant and spa



ill.6. programming

existing extension

elevations from the road, arrival



ill.7. programming, elevation

appendix 3

DEFINING MATERIALS - RESTAURANT

The different matrices are listed based on their performance from best to worst.

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *70.25*

WALLS
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*4*
value point 1-5	*4*	*4*	*-*	*4.25*	*2*	*2*	*3*

Result: *60.75*

WALLS
Plaster

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*4*
value point 1-5	*5*	*1*	*-*	*2.50*	*5*	*5*	*1*

Result: *59.50*

WALLS
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*4*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *50.00*

FLOOR
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*3*	*1*	*4*	*4*
value point 1-5	*4*	*4*	-	*4.75*	*2*	*2*	*5*

Result: *76.25*

FLOOR
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*3*	*1*	*4*	*4*
value point 1-5	*4*	*5*	-	*3*	*3*	*1*	*5*

Result: *73.00*

FLOOR
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*3*	*1*	*4*	*4*
value point 1-5	*4*	*4*	-	*4.25*	*2*	*2*	*3*

Result: *66.75*

FLOOR
Granit

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*1*	*4*	*4*
value point 1-5	*3*	*5*	*-*	*2.75*	*5*	*1*	*3*

Result: *63.25*

FLOOR
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*1*	*4*	*4*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *57.00*

CEILING
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *68.25*

CEILING
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*2*	*4*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *66.00*

CEILING
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.25*	*2*	*2*	*3*

Result: *58.75*

CEILING
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *51.00*

CEILING
Wood-concrete panel

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*2*	*4*
value point 1-5	*4*	*1*	*-*	*4.50*	*5*	*4*	*1*

Result: *46.50*

CEILING
Plaster

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*2*	*4*
value point 1-5	*5*	*1*	*-*	*2.50*	*5*	*4*	*1*

Result: *45.50*

appendix 4

DEFINING MATERIALS - LOBBY / LOUNGE

The different matrices are listed based on their performance from best to worst.

WALLS
Lightweight aggregate

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*3*	*-*	*4*	*5*	*1*	*5*

Result: *70.00*

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *68.25*

WALLS
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *67.00*

WALLS
Bricks

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*3*	*-*	*3.75*	*3*	*2*	*5*

Result: *65.25*

WALLS
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.25*	*2*	*2*	*3*

Result: *58.75*

WALLS
Plaster

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*5*	*1*	*-*	*4.75*	*5*	*5*	*1*

Result: *54.50*

WALLS
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *49.00*

FLOOR
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*3*	*3*	*4*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *77.00*

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *76.25*

WALLS
Granit

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*3*	*5*	*-*	*2.75*	*5*	*1*	*3*

Result: *71.25*

WALLS
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.25*	*2*	*2*	*3*

Result: *54.50*

WALLS
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *57.00*

CEILING
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *68.25*

CEILING
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *67.00*

CEILING
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4.25*	*2*	*2*	*3*

Result: *58.75*

CEILING
Wood-concrete panel

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*1*	*-*	*4.50*	*5*	*4*	*1*

Result: *55.50*

CEILING
Plaster

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*5*	*1*	*-*	*2.50*	*5*	*5*	*1*

Result: *54.50*

CEILING
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*3*	*2*	*4*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *49.00*

appendix 5

DEFINING MATERIALS - BEDROOMS

The different matrices are listed based on their performance from best to worst.

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*2*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *60.25*

WALLS
Plaster

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*2*
value point 1-5	*5*	*1*	*-*	*2.50*	*5*	*5*	*1*

Result: *57.50*

WALLS
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*2*
value point 1-5	*4*	*4*	*-*	*4.25*	*2*	*2*	*3*

Result: *54.75*

WALLS
Lightweight aggregate

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*2*
value point 1-5	*4*	*3*	*-*	*4*	*5*	*1*	*5*

Result: *53.00*

WALLS
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*3*	*1*	*5*	*2*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *46.00*

FLOOR
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*4*	*2*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *62.25*

FLOOR
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*4*	*2*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *58.00*

FLOOR
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*4*	*2*
value point 1-5	*4*	*4*	*-*	*4.25*	*2*	*2*	*3*

Result: *56.75*

FLOOR
Granit

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*4*	*2*
value point 1-5	*3*	*5*	*-*	*2.75*	*5*	*1*	*3*

Result: *52.25*

FLOOR
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*4*	*2*
value point 1-5	*4*	*4*	*-*	*4*	*1*	*1*	*2*

Result: *49.00*

CEILING
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*1*	*2*	*2*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *62.25*

CEILING
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*3*	*1*	*2*	*2*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *61.00*

CEILING
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*3*	*1*	*2*	*2*
value point 1-5	*4*	*4*	-	*4.25*	*2*	*2*	*3*

Result: *56.75*

CEILING
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*3*	*1*	*2*	*2*
value point 1-5	*4*	*4*	-	*4*	*1*	*1*	*2*

Result: *51.00*

CEILING
Plaster

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*3*	*1*	*2*	*2*
value point 1-5	*5*	*1*	-	*2.50*	*4*	*4*	*1*

Result: *44.50*

appendix 6

DEFINING MATERIALS - SPA

The different matrices are listed based on their performance from best to worst.

WALLS
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*5*	*1*	*1*	*4*
value point 1-5	*4*	*5*	*-*	*2.88*	*3*	*5*	*5*

Result: *69.40*

WALLS
Lightweight aggregate

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*5*	*1*	*1*	*4*
value point 1-5	*4*	*3*	*-*	*3.50*	*5*	*5*	*5*

Result: *68.50*

WALLS
Bricks

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*5*	*1*	*1*	*4*
value point 1-5	*4*	*3*	*-*	*3.63*	*3*	*4*	*5*

Result: *66.15*

WALLS
Granit

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	*-*	*5*	*1*	*1*	*4*
value point 1-5	*3*	*5*	*-*	*3.63*	*5*	*5*	*3*

Result: *64.15*

WALLS
Fiber cement sheets

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	-	*5*	*1*	*1*	*4*
value point 1-5	*4*	*2*	-	*3.63*	*3*	*4*	*5*

Result: *63.15*

WALLS
Steni

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*3*	-	*5*	*1*	*1*	*4*
value point 1-5	*3*	*4*	-	*4.13*	*5*	*5*	*1*

Result: *55.65*

FLOOR
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*5*	*1*	*3*	*4*
value point 1-5	*4*	*5*	*-*	*2.88*	*3*	*5*	*5*

Result: *89.40*

FLOOR
Granit

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	*-*	*5*	*1*	*3*	*4*
value point 1-5	*3*	*5*	*-*	*3.63*	*5*	*5*	*3*

Result: *84.15*

FLOOR
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*5*	*1*	*3*	*4*
value point 1-5	*4*	*4*	-	*4.75*	*2*	*2*	*5*

Result: *83.75*

FLOOR
Bricks

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*5*	-	*5*	*1*	*3*	*4*
value point 1-5	*4*	*3*	-	*3.63*	*3*	*4*	*5*

Result: *80.15*

CEILING
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*1*	*4*
value point 1-5	*4*	*4*	*-*	*4.75*	*2*	*2*	*5*

Result: *66.25*

FLOOR
Concrete

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	*-*	*3*	*1*	*1*	*4*
value point 1-5	*4*	*5*	*-*	*3*	*3*	*1*	*5*

Result: *65.00*

CEILING
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	-	*3*	*1*	*1*	*4*
value point 1-5	*4*	*4*	-	*4.25*	*2*	*2*	*3*

Result: *56.75*

CEILING
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	-	*3*	*1*	*1*	*4*
value point 1-5	*4*	*4*	-	*4*	*1*	*1*	*2*

Result: *50.00*

CEILING
Wood-concrete panel

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*3*	*4*	-	*3*	*1*	*1*	*4*
value point 1-5	*4*	*1*	-	*4.50*	*5*	*4*	*1*

Result: *42.50*

appendix 7

DEFINING MATERIALS - FACADES

The different matrices are listed based on their performance from best to worst.

WALLS
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4.75*	*2*	*2*	*5*

Result: *68.75*

WALLS
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4.25*	*2*	*2*	*3*

Result: *60.25*

WALLS
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4*	*1*	*1*	*2*

Result: *52.00*

WALLS
Steni

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*5*	*1*	*5*	*2.50*	*5*	*5*	*1*

Result: *51.50*

WALLS
Bricks

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*1*	*5*	*4.50*	*5*	*4*	*1*

Result: *48.50*

WALLS
Reinzink

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*1*	*5*	*4.50*	*5*	*4*	*1*

Result: *48.50*

ROOF
Pine

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4.75*	*2*	*2*	*5*

Result: *68.75*

ROOF
Oak

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4.25*	*2*	*2*	*3*

Result: *60.25*

ROOF
Cedar

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*4*	*3*	*4*	*1*	*1*	*2*

Result: *52.00*

ROOF
Steni

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*5*	*1*	*5*	*2.50*	*5*	*5*	*1*

Result: *51.50*

ROOF
Roof tiles

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*1*	*5*	*4.50*	*5*	*4*	*1*

Result: *48.50*

ROOF
Reinzink

parameter

	GWP	Life time	Corrosion resistans	Tactility	Patina	Reflection	Cultural heritage
weight 0-5	*4*	*5*	*4*	*1*	*3*	*1*	*4*
value point 1-5	*4*	*1*	*5*	*4.50*	*5*	*4*	*1*

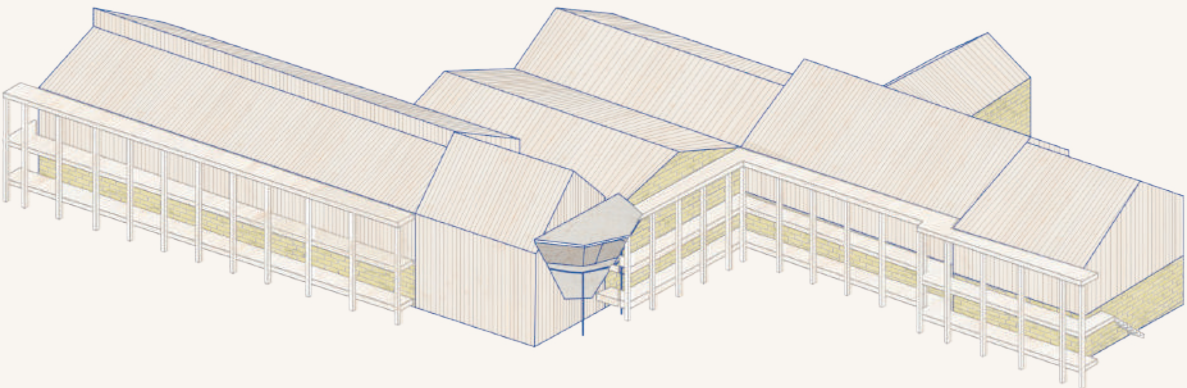
Result: *48.50*

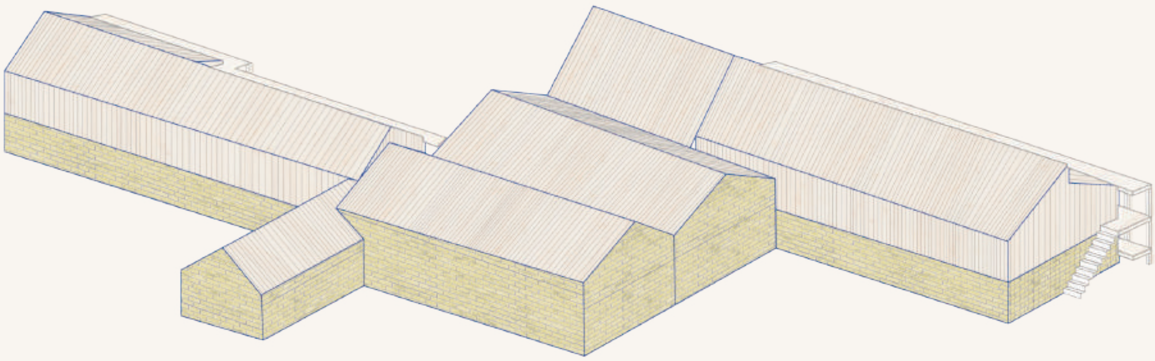
appendix 8

FACADES - MATERIAL TEST

#1 pine roof

A material test is investigated, according to the roof material of the building, because of an optimized roof envelope.
This material is chosen based on the lowest GWP, according to the catalog.

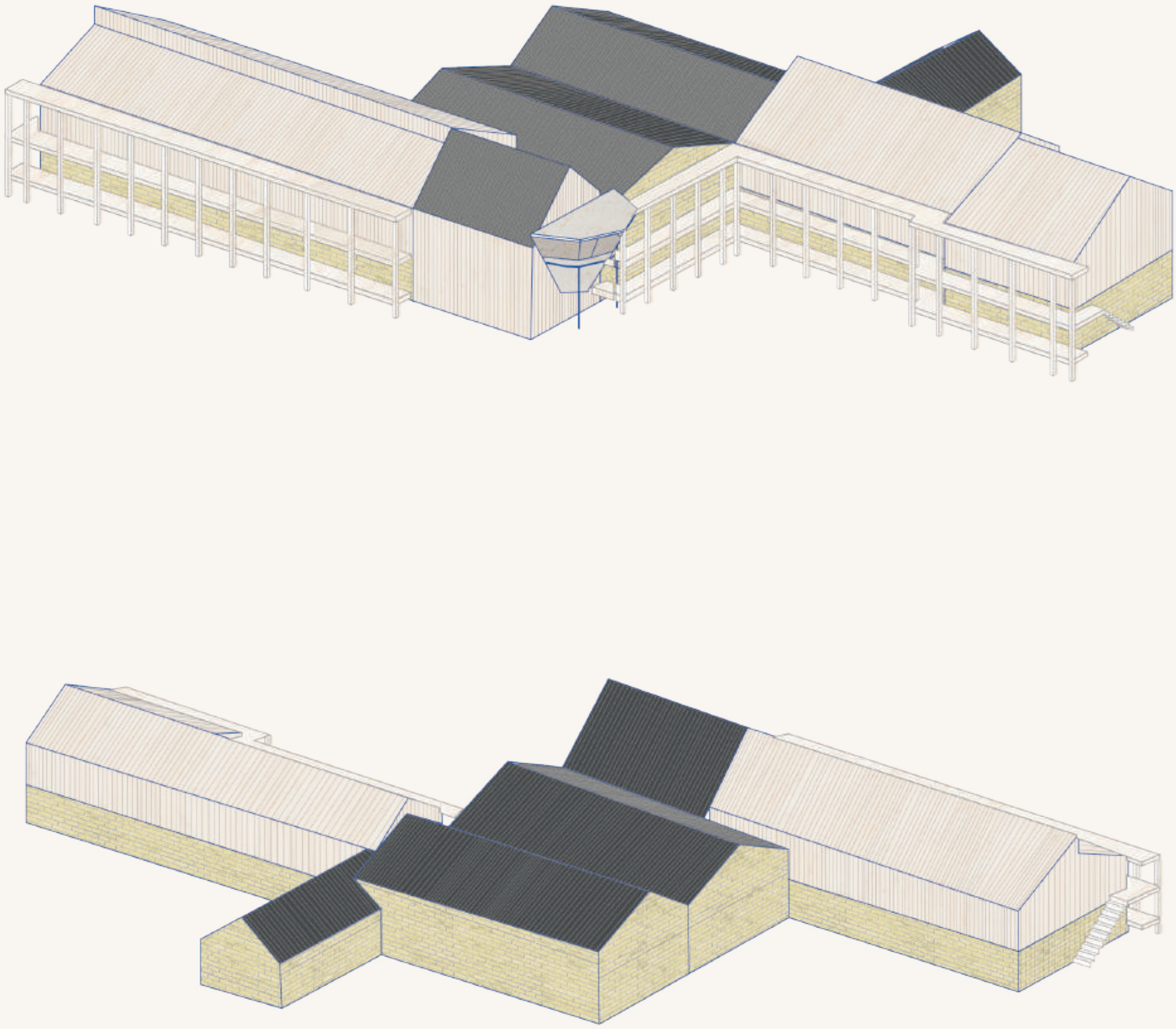




ill.8. facade 1

#2 pine roof in private zones and fiber cement sheets on public zones

This iteration investigates the meeting between the old and new materials. Here the extended bedrooms will have a wooden roof. Likewise this describes the private and public zones in the building. The public parts of the building will have the same roof as the existing building and because of the condition of the material (fiber cement sheets), they need to be replaced.
This material was not selected based on gwp from the catalog, and because it did not blend in as well with the sandy souroundings.



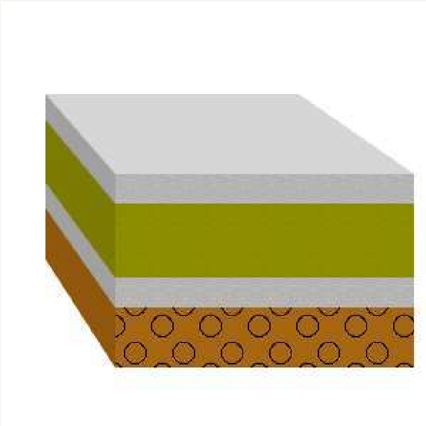
ill.9. facade 2

appendix 9

ROCKWOOL ENERGY DESIGN - RESULTS

Foundation, in lobby and lounge

INDE



UDE

	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rsi (inde)					0,17
☐ 1	Generisk materiale	Parket 20 mm	0,020	0,182	B	~~0,11~~
☐ 2	ROCKWOOL Danmark A/S	TRINLYDSBATTS	0,015	0,037	A	~~0,41~~
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
☑ 3	Generisk materiale	Beton, medium densitet 2000 kg/m3	0,100	1,420	B	0,07
☑ 4	ROCKWOOL Danmark A/S	TERRÆNBATTS	0,050	0,037	A	1,35
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
☑ 5	ROCKWOOL Danmark A/S	TERRÆNBATTS	0,200	0,037	A	5,41
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
☑ 6	Generisk materiale	Beton, medium densitet 2000 kg/m3	0,100	1,420	B	0,07
☑ 7	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
☑ 8	Kapillarbrydende lag	indeholder:	-	-		2,08
	Leca A/S (Saint-Gobain WeberA/S)	Leca 10-20	0,200	~~0,090~~	B	-
	Lambda forøget	faktor 1,2 for 75mm	-	0,096		-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Rj (jord)					1,50
			0,687			**10,65**

Begrundelse for ændring af overgangsisolanser:

Byggematerialerne er grupperet i 3 klasser. Disse klasser er:

A Data er indtastet og verificeret af ROCKWOOL A/S.

B Data er indtastet og verificeret af andre producenter eller leverandører.

C Egen indtastning af data.

U-værdikorrektion i henhold til DS 418

Korrektion for mekanisk fastgørelse — dUf = 0,000 W/(m²K)

Korrektion for luftspalter — dUg = 0,000 W/(m²K)

U = 1 / 10,65 + 0,000 + 0,000 = 0,09 W/(m²K)

U_{max} = 0,20 W/(m²K) U = 0,09 W/(m²K)

Overfladekondens

Ingen risiko for overfladekondens.

Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

	1	2	3	4	5	6	7	8	9	10	11	12
Måned	T_e [°C]	ϕ_e	T_i [°C]	ϕ_i	p_e [Pa]	Δp [Pa]	p_i [Pa]	p_s [Pa]	$T_{si,\,min}$ [°C]	f_{Rsi}	T_{si} [°C]	T_{se} [°C]
jan	6.0	1.000	20.0	0.581	616	743	1359	1698	14.9	0.638	19.7	8.0
feb	5.5	1.000	20.0	0.577	596	753	1349	1687	14.8	0.643	19.7	7.5
mar	5.4	1.000	20.0	0.571	638	696	1334	1668	14.7	0.635	19.7	7.4
apr	6.2	1.000	20.0	0.587	823	547	1371	1713	15.1	0.644	19.7	8.1
maj	8.3	1.000	20.0	0.626	1065	398	1463	1829	16.1	0.667	19.7	9.9
jun	10.4	1.000	20.0	0.691	1329	285	1614	2017	17.6	0.755	19.8	11.7
● jul	12.0	1.000	20.0	0.765	1609	178	1787	2234	19.3	0.910	19.8	13.1
aug	13.5	1.000	20.0	0.759	1589	185	1774	2218	19.2	0.871	19.8	14.4
sep	13.4	1.000	20.0	0.691	1320	295	1616	2019	17.7	0.647	19.8	14.3
okt	11.8	1.000	20.0	0.632	1026	451	1477	1846	16.2	0.541	19.8	13.0
nov	9.6	1.000	20.0	0.603	826	583	1409	1761	15.5	0.567	19.8	11.1
dec	7.8	1.000	20.0	0.586	662	707	1369	1711	15.1	0.596	19.7	9.5

● Den kritiske måned er **juli** med $f_{Rsi,max}$ = 0.910

f_{Rsi} = 0.977

$f_{Rsi} > f_{Rsi,max}$, konstruktionen overholder krav.

Nr	Forklaring
1	Temperatur - ude
2	Relativ fugtighed - ude
3	Temperatur - inde
4	Relativ fugtighed - inde
5	Udvendigt partialtryk $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
6	Forskel i partialtryk. Sikkerhedsfaktoren 1.10 i henhold til DS EN ISO 13788, kapitel 4.2.4 er allerede inkluderet
7	Damptryk - inde $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
8	Minimum mætningsdamptryk på overfladen beregnet som $p_{sat}(T_{si}) = p_i / \phi_{si}$,hvor ϕ_{si} = 0,8 (kritisk overfladekondens)
9	Min. overfladetemperatur som funktion af $p_{sat}(T_{si})$, formel E.9 og E.10 i DS EN ISO 13788
10	Temperaturfaktor i henhold til 3.1.2 i DS EN ISO 13788
11	Indvendig overfladetemperatur beregnet som $T_{si} = T_i - R_{si} * U * (T_i - T_e)$
12	Udvendig overfladetemperatur beregnet som $T_{se} = T_e - R_{se} * U * (T_i - T_e)$

Intern kondens

Ingen risiko for intern kondens.

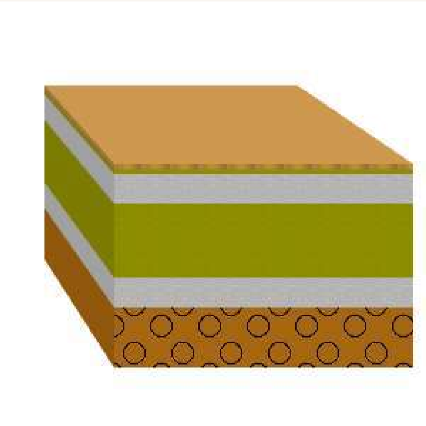
Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

		jan	feb	mar	apr	maj	jun	jul	aug	sep	okt	nov	dec
Temperatur - inde [°C]	T_i	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relativ fugtighed - inde [%]	ϕ_i	58.1	57.7	57.1	58.7	62.6	69.1	76.5	75.9	69.1	63.2	60.3	58.6
Temperatur - ude [°C]	T_e	6.0	5.5	5.4	6.2	8.3	10.4	12.0	13.5	13.4	11.8	9.6	7.8
Relativ fugtighed - ude[%]	ϕ_e	100	100	100	100	100	100	100	100	100	100	100	100

Foundation, in bedrooms

INDE



UDE

		Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
		Rsi (inde)					0,17
☑	1	Generisk materiale	Parket 20 mm	0,020	0,182	B	0,11
☑	2	ROCKWOOL Danmark A/S	TRINLYDSBATTS	0,015	0,037	A	0,41
		Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
☑	3	Generisk materiale	Beton, medium densitet 2000 kg/m3	0,100	1,420	B	0,07
☑	4	ROCKWOOL Danmark A/S	TERRÆNBATTS	0,050	0,037	A	1,35
		Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
☑	5	ROCKWOOL Danmark A/S	TERRÆNBATTS	0,200	0,037	A	5,41
		Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
☑	6	Generisk materiale	Beton, medium densitet 2000 kg/m3	0,100	1,420	B	0,07
☑	7	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
☑	8	Kapillarbrydende lag	indeholder:	-	-		2,08
		Leca A/S (Saint-Gobain WeberA/S)	Leca 10-20	0,200	~~0,090~~	B	-
		Lambda forøget	faktor 1,2 for 75mm	-	0,096		-
		Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
		Rj (jord)					1,50
				0,687			**11,17**

Begrundelse for ændring af overgangsisolanser:

Byggematerialerne er grupperet i 3 klasser. Disse klasser er:

A Data er indtastet og verificeret af ROCKWOOL A/S.
B Data er indtastet og verificeret af andre producenter eller leverandører.
C Egen indtastning af data.

U-værdikorrektion i henhold til DS 418
Korrektion for mekanisk fastgørelse — dUf = 0,000 W/(m²K)
Korrektion for luftspalter — dUg = 0,000 W/(m²K)

U = 1 / 11,17 + 0,000 + 0,000 = 0,09 W/(m²K)

U_{max} = 0,20 W/(m²K) U = 0,09 W/(m²K)

Overfladekondens

Ingen risiko for overfladekondens.

Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

	1	2	3	4	5	6	7	8	9	10	11	12
Måned	T_e [°C]	ϕ_e	T_i [°C]	ϕ_i	p_e [Pa]	Δp [Pa]	p_i [Pa]	p_s [Pa]	$T_{si,\,min}$ [°C]	f_{Rsi}	T_{si} [°C]	T_{se} [°C]
jan	6.0	1.000	20.0	0.581	616	743	1359	1698	14.9	0.638	19.7	7.9
feb	5.5	1.000	20.0	0.577	596	753	1349	1687	14.8	0.643	19.7	7.4
mar	5.4	1.000	20.0	0.571	638	696	1334	1668	14.7	0.635	19.7	7.3
apr	6.2	1.000	20.0	0.587	823	547	1371	1713	15.1	0.644	19.7	8.0
maj	8.3	1.000	20.0	0.626	1065	398	1463	1829	16.1	0.667	19.7	9.8
jun	10.4	1.000	20.0	0.691	1329	285	1614	2017	17.6	0.755	19.8	11.6
● jul	12.0	1.000	20.0	0.765	1609	178	1787	2234	19.3	0.910	19.8	13.0
aug	13.5	1.000	20.0	0.759	1589	185	1774	2218	19.2	0.871	19.9	14.3
sep	13.4	1.000	20.0	0.691	1320	295	1616	2019	17.7	0.647	19.9	14.2
okt	11.8	1.000	20.0	0.632	1026	451	1477	1846	16.2	0.541	19.8	12.9
nov	9.6	1.000	20.0	0.603	826	583	1409	1761	15.5	0.567	19.8	11.0
dec	7.8	1.000	20.0	0.586	662	707	1369	1711	15.1	0.596	19.7	9.4

● Den kritiske måned er **juli** med $f_{Rsi,max}$ = 0.910

f_{Rsi} = 0.978

f_{Rsi} > $f_{Rsi,max}$, konstruktionen overholder krav.

Nr	Forklaring
1	Temperatur - ude
2	Relativ fugtighed - ude
3	Temperatur - inde
4	Relativ fugtighed - inde
5	Udvendigt partialtryk $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
6	Forskel i partialtryk. Sikkerhedsfaktoren 1.10 i henhold til DS EN ISO 13788, kapitel 4.2.4 er allerede inkluderet
7	Damptryk - inde $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
8	Minimum mætningsdamptryk på overfladen beregnet som $p_{sat}(T_{si}) = p_i / \phi_{si}$,hvor ϕ_{si} = 0,8 (kritisk overfladekondens)
9	Min. overfladetemperatur som funktion af $p_{sat}(T_{si})$, formel E.9 og E.10 i DS EN ISO 13788
10	Temperaturfaktor i henhold til 3.1.2 i DS EN ISO 13788
11	Indvendig overfladetemperatur beregnet som $T_{si} = T_i - R_{si} * U * (T_i - T_e)$
12	Udvendig overfladetemperatur beregnet som $T_{se} = T_e - R_{se} * U * (T_i - T_e)$

Intern kondens

Ingen risiko for intern kondens.

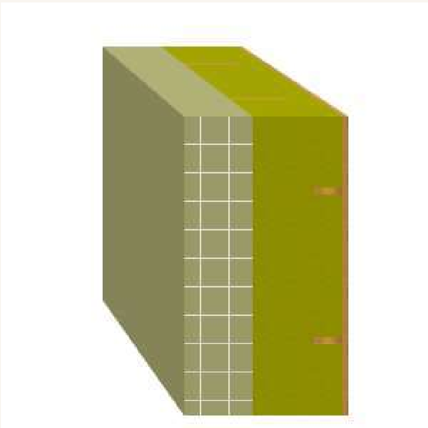
Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

		jan	feb	mar	apr	maj	jun	jul	aug	sep	okt	nov	dec
Temperatur - inde [°C]	T_i	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relativ fugtighed - inde [%]	ϕ_i	58.1	57.7	57.1	58.7	62.6	69.1	76.5	75.9	69.1	63.2	60.3	58.6
Temperatur - ude [°C]	T_e	6.0	5.5	5.4	6.2	8.3	10.4	12.0	13.5	13.4	11.8	9.6	7.8
Relativ fugtighed - ude[%]	ϕ_e	100	100	100	100	100	100	100	100	100	100	100	100

Lightweight aggregate wall

UDE



INDE

	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rse (ude)					0,04
1	Leca A/S (Saint-Gobain WeberA/S)	Leca blokke 800 indvendigt murværk. 10 mm mørtelfuger.	0,230	0,310	B	0,74
2	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
3	Inhomogent materialelag	bestående af:	0,200	0,045		4,45
	ROCKWOOL Danmark A/S	GRANULATE PRO	95,00%	0,041	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Generisk materiale	Træ 450kg/m3	5,00%	0,120	B	-
4	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
5	Inhomogent materialelag	bestående af:	0,100	0,045		2,22
	ROCKWOOL Danmark A/S	GRANULATE PRO	95,00%	0,041	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Generisk materiale	Træ 450kg/m3	5,00%	0,120	B	-
6	Generisk materiale	Spånplade, 900 kg/m3	0,020	0,180	B	0,11
	Rsi (inde)					0,13
			0,554			**7,70**

Begrundelse for ændring af overgangsisolanser:

Byggematerialerne er grupperet i 3 klasser. Disse klasser er:

A Data er indtastet og verificeret af ROCKWOOL A/S.

B Data er indtastet og verificeret af andre producenter eller leverandører.

C Egen indtastning af data.

U-værdikorrektion i henhold til DS 418
Korrektion for mekanisk fastgørelse dUf = 0,000 W/(m²K)
Korrektion for luftspalter dUg = 0,000 W/(m²K)

U = 1 / 7,70 + 0,000 + 0,000 = 0,13 W/(m²K)

U_{max} = 0,30 W/(m²K) U = 0,13 W/(m²K)

Overfladekondens

Ingen risiko for overfladekondens.

Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

	1	2	3	4	5	6	7	8	9	10	11	12
Måned	T_e [°C]	ϕ_e	T_i [°C]	ϕ_i	p_e [Pa]	Δp [Pa]	p_i [Pa]	p_s [Pa]	$T_{si, min}$ [°C]	f_{Rsi}	T_{si} [°C]	T_{se} [°C]
● jan	1.9	0.880	20.0	0.581	616	743	1359	1698	14.9	0.721	19.5	2.0
feb	1.6	0.870	20.0	0.577	596	753	1349	1687	14.8	0.720	19.5	1.7
mar	3.2	0.830	20.0	0.571	638	696	1334	1668	14.7	0.682	19.5	3.3
apr	7.4	0.800	20.0	0.587	823	547	1371	1713	15.1	0.610	19.6	7.5
maj	11.6	0.780	20.0	0.626	1065	398	1463	1829	16.1	0.536	19.8	11.6
jun	14.8	0.790	20.0	0.691	1329	285	1614	2017	17.6	0.547	19.8	14.8
jul	17.8	0.790	20.0	0.765	1609	178	1787	2234	19.3	0.671	19.9	17.8
aug	17.6	0.790	20.0	0.759	1589	185	1774	2218	19.2	0.649	19.9	17.6
sep	14.5	0.800	20.0	0.691	1320	295	1616	2019	17.7	0.575	19.8	14.5
okt	10.1	0.830	20.0	0.632	1026	451	1477	1846	16.2	0.621	19.7	10.1
nov	6.4	0.860	20.0	0.603	826	583	1409	1761	15.5	0.670	19.6	6.5
dec	2.9	0.880	20.0	0.586	662	707	1369	1711	15.1	0.711	19.5	3.0

● Den kritiske måned er **januar** med $f_{Rsi,max}$ = 0.721

f_{Rsi} = 0.970

f_{Rsi} > $f_{Rsi,max}$, konstruktionen overholder krav.

Nr	Forklaring
1	Temperatur - ude
2	Relativ fugtighed - ude
3	Temperatur - inde
4	Relativ fugtighed - inde
5	Udvendigt partialtryk $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
6	Forskel i partialtryk. Sikkerhedsfaktoren 1.10 i henhold til DS EN ISO 13788, kapitel 4.2.4 er allerede inkluderet
7	Damptryk - inde $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
8	Minimum mætningsdamptryk på overfladen beregnet som $p_{sat}(T_{si}) = p_i / \phi_{si}$,hvor ϕ_{si} = 0,8 (kritisk overfladekondens)
9	Min. overfladetemperatur som funktion af $p_{sat}(T_{si})$, formel E.9 og E.10 i DS EN ISO 13788
10	Temperaturfaktor i henhold til 3.1.2 i DS EN ISO 13788
11	Indvendig overfladetemperatur beregnet som $T_{si}= T_i - R_{si} * U * (T_i - T_e)$
12	Udvendig overfladetemperatur beregnet som $T_{se}= T_e - R_{se} * U * (T_i - T_e)$

Intern kondens

Ingen risiko for intern kondens.

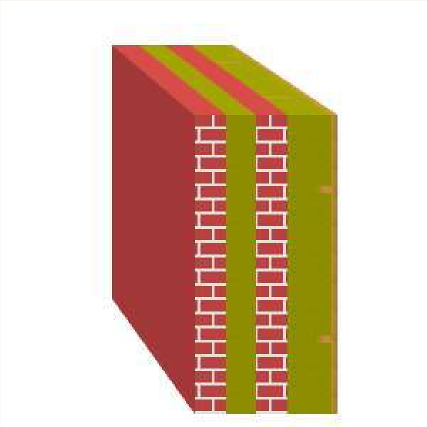
Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

		jan	feb	mar	apr	maj	jun	jul	aug	sep	okt	nov	dec
Temperatur - inde [°C]	T_i	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relativ fugtighed - inde [%]	ϕ_i	58.1	57.7	57.1	58.7	62.6	69.1	76.5	75.9	69.1	63.2	60.3	58.6
Temperatur - ude [°C]	T_e	1.9	1.6	3.2	7.4	11.6	14.8	17.8	17.6	14.5	10.1	6.4	2.9
Relativ fugtighed - ude[%]	ϕ_e	88	87	83	80	78	79	79	79	80	83	86	88

Brick wall

UDE



INDE

	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rse (ude)					0,04
1	Generisk materiale	Massiv teglsten 1600 kg/m3	0,108	0,550	B	0,20
2	ROCKWOOL Danmark A/S	MURBATTS 37	0,100	0,037	A	2,70
	Murbindere / Fastgørelse	Rustfast stål ø 4 mm	4,000	17,000		-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
3	Generisk materiale	Massiv teglsten 1600 kg/m3	0,108	0,550	B	0,20
4	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
5	Inhomogent materialelag	bestående af:	0,100	0,045		2,22
	ROCKWOOL Danmark A/S	GRANULATE PRO	95,00%	0,041	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Generisk materiale	Træ 450kg/m3	5,00%	0,120	B	-
6	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
7	Inhomogent materialelag	bestående af:	0,050	0,045		1,11
	ROCKWOOL Danmark A/S	GRANULATE PRO	95,00%	0,041	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Generisk materiale	Træ 450kg/m3	5,00%	0,120	B	-
8	Generisk materiale	Spånplade, 900 kg/m3	0,020	0,180	B	0,11
	Rsi (inde)					0,13
			0,490			**6,72**

Begrundelse for ændring af overgangsisolanser:

Byggematerialerne er grupperet i 3 klasser. Disse klasser er:

A Data er indtastet og verificeret af ROCKWOOL A/S.
B Data er indtastet og verificeret af andre producenter eller leverandører.
C Egen indtastning af data.

U-værdikorrektion i henhold til DS 418
Korrektion for mekanisk fastgørelse dUf = 0,000 W/(m²K)
Korrektion for luftspalter dUg = 0,000 W/(m²K)

U = 1 / 6,72 + 0,000 + 0,000 = 0,15 W/(m²K)

U_{max} = 0,30 W/(m²K)

U = 0,15 W/(m²K)

Overfladekondens

Ingen risiko for overfladekondens.

Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

	1	2	3	4	5	6	7	8	9	10	11	12
Måned	T_e [°C]	ϕ_e	T_i [°C]	ϕ_i	p_e [Pa]	Δp [Pa]	p_i [Pa]	p_s [Pa]	$T_{si,\,min}$ [°C]	f_{Rsi}	T_{si} [°C]	T_{se} [°C]
● jan	1.9	0.880	20.0	0.581	616	743	1359	1698	14.9	0.721	19.4	2.0
feb	1.6	0.870	20.0	0.577	596	753	1349	1687	14.8	0.720	19.4	1.7
mar	3.2	0.830	20.0	0.571	638	696	1334	1668	14.7	0.682	19.4	3.3
apr	7.4	0.800	20.0	0.587	823	547	1371	1713	15.1	0.610	19.6	7.5
maj	11.6	0.780	20.0	0.626	1065	398	1463	1829	16.1	0.536	19.7	11.6
jun	14.8	0.790	20.0	0.691	1329	285	1614	2017	17.6	0.547	19.8	14.8
jul	17.8	0.790	20.0	0.765	1609	178	1787	2234	19.3	0.671	19.9	17.8
aug	17.6	0.790	20.0	0.759	1589	185	1774	2218	19.2	0.649	19.9	17.6
sep	14.5	0.800	20.0	0.691	1320	295	1616	2019	17.7	0.575	19.8	14.5
okt	10.1	0.830	20.0	0.632	1026	451	1477	1846	16.2	0.621	19.7	10.2
nov	6.4	0.860	20.0	0.603	826	583	1409	1761	15.5	0.670	19.5	6.5
dec	2.9	0.880	20.0	0.586	662	707	1369	1711	15.1	0.711	19.4	3.0

- Den kritiske måned er **januar** med $f_{Rsi,max}$ = 0.721

  f_{Rsi} = 0.965

$f_{Rsi} > f_{Rsi,max}$, konstruktionen overholder krav.

Nr	Forklaring
1	Temperatur - ude
2	Relativ fugtighed - ude
3	Temperatur - inde
4	Relativ fugtighed - inde
5	Udvendigt partialtryk $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
6	Forskel i partialtryk. Sikkerhedsfaktoren 1.10 i henhold til DS EN ISO 13788, kapitel 4.2.4 er allerede inkluderet
7	Damptryk - inde $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
8	Minimum mætningsdamptryk på overfladen beregnet som $p_{sat}(T_{si}) = p_i / \phi_{si}$,hvor ϕ_{si} = 0,8 (kritisk overfladekondens)
9	Min. overfladetemperatur som funktion af $p_{sat}(T_{si})$, formel E.9 og E.10 i DS EN ISO 13788
10	Temperaturfaktor i henhold til 3.1.2 i DS EN ISO 13788
11	Indvendig overfladetemperatur beregnet som $T_{si} = T_i - R_{si} * U * (T_i - T_e)$
12	Udvendig overfladetemperatur beregnet som $T_{se} = T_e - R_{se} * U * (T_i - T_e)$

Intern kondens

Risiko for intern kondens. Det vurderes at kondensat vil fordampe i løbet af sommermånederne.

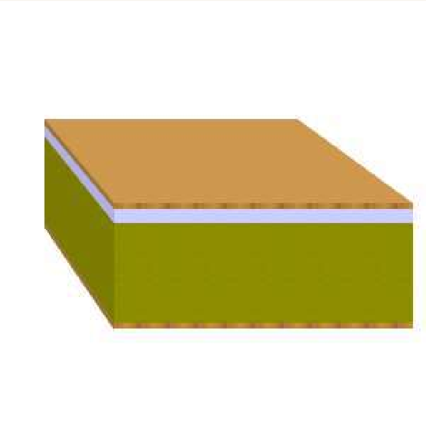
Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

		jan	feb	mar	apr	maj	jun	jul	aug	sep	okt	nov	dec
Temperatur - inde [°C]	T_i	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relativ fugtighed - inde [%]	ϕ_i	58.1	57.7	57.1	58.7	62.6	69.1	76.5	75.9	69.1	63.2	60.3	58.6
Temperatur - ude [°C]	T_e	1.9	1.6	3.2	7.4	11.6	14.8	17.8	17.6	14.5	10.1	6.4	2.9
Relativ fugtighed - ude[%]	ϕ_e	88	87	83	80	78	79	79	79	80	83	86	88

Roof

UDE



INDE

	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rse (ude)					0,13
1	Generisk materiale	Spånplade, 900 kg/m3	0,022	0,180	B	~~0,12~~
2	Generisk materiale	Ventileret lag	0,020	-	B	~~-~~
3	Generisk materiale	Ventileret lag	0,030	-	B	-
4	ROCKWOOL Danmark A/S	GRANULATE PRO	0,095	0,041	A	2,32
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
5	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
6	ROCKWOOL Danmark A/S	GRANULATE PRO	0,200	0,041	A	4,88
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
7	Generisk materiale	Vindpap (vindtæt afdækning)	0,002	1,000	B	0,00
8	ROCKWOOL Danmark A/S	GRANULATE PRO	0,045	0,041	A	1,10
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
9	Generisk materiale	Spånplade, 300 kg/m3	0,022	0,100	B	0,22
	Rsi (inde)					0,13
			0,438			**8,78**

Begrundelse for ændring af overgangsisolanser:

Byggematerialerne er grupperet i 3 klasser. Disse klasser er:

A Data er indtastet og verificeret af ROCKWOOL A/S.

B Data er indtastet og verificeret af andre producenter eller leverandører.

C Egen indtastning af data.

U-værdikorrektion i henhold til DS 418

Korrektion for mekanisk fastgørelse dUf = 0,000 W/(m²K)

Korrektion for luftspalter dUg = 0,000 W/(m²K)

U = 1 / 8,78 + 0,000 + 0,000 = 0,11 W/(m²K)

U_{max} = 0,20 W/(m²K)

U = 0,11 W/(m²K)

Overfladekondens

Ingen risiko for overfladekondens.

Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

	1	2	3	4	5	6	7	8	9	10	11	12
Måned	T_e [°C]	ϕ_e	T_i [°C]	ϕ_i	p_e [Pa]	Δp [Pa]	p_i [Pa]	p_s [Pa]	$T_{si, min}$ [°C]	f_{Rsi}	T_{si} [°C]	T_{se} [°C]
jan	-0.1	0.880	20.0	0.581	616	743	1359	1698	14.9	0.749	19.4	0.0
feb	-0.4	0.870	20.0	0.577	596	753	1349	1687	14.8	0.747	19.4	-0.3
mar	1.2	0.830	20.0	0.571	638	696	1334	1668	14.7	0.716	19.5	1.3
apr	5.4	0.800	20.0	0.587	823	547	1371	1713	15.1	0.663	19.6	5.5
maj	9.6	0.780	20.0	0.626	1065	398	1463	1829	16.1	0.625	19.7	9.6
jun	12.8	0.790	20.0	0.691	1329	285	1614	2017	17.6	0.673	19.8	12.8
● jul	15.8	0.790	20.0	0.765	1609	178	1787	2234	19.3	0.828	19.9	15.8
aug	15.6	0.790	20.0	0.759	1589	185	1774	2218	19.2	0.809	19.9	15.6
sep	12.5	0.800	20.0	0.691	1320	295	1616	2019	17.7	0.688	19.8	12.5
okt	8.1	0.830	20.0	0.632	1026	451	1477	1846	16.2	0.685	19.7	8.2
nov	4.4	0.860	20.0	0.603	826	583	1409	1761	15.5	0.712	19.6	4.5
dec	0.9	0.880	20.0	0.586	662	707	1369	1711	15.1	0.741	19.5	1.0

● Den kritiske måned er **juli** med $f_{Rsi,max}$ = 0.828

f_{Rsi} = 0.972

$f_{Rsi} > f_{Rsi,max}$, konstruktionen overholder krav.

Nr	Forklaring
1	Temperatur - ude
2	Relativ fugtighed - ude
3	Temperatur - inde
4	Relativ fugtighed - inde
5	Udvendigt partialtryk $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
6	Forskel i partialtryk. Sikkerhedsfaktoren 1.10 i henhold til DS EN ISO 13788, kapitel 4.2.4 er allerede inkluderet
7	Damptryk - inde $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ i henhold til formel E.7 og E.8 i DS EN ISO 13788
8	Minimum mætningsdamptryk på overfladen beregnet som $p_{sat}(T_{si}) = p_i / \phi_{si}$,hvor ϕ_{si} = 0,8 (kritisk overfladekondens)
9	Min. overfladetemperatur som funktion af $p_{sat}(T_{si})$, formel E.9 og E.10 i DS EN ISO 13788
10	Temperaturfaktor i henhold til 3.1.2 i DS EN ISO 13788
11	Indvendig overfladetemperatur beregnet som $T_{si} = T_i - R_{si} * U * (T_i - T_e)$
12	Udvendig overfladetemperatur beregnet som $T_{se} = T_e - R_{se} * U * (T_i - T_e)$

Intern kondens

Ingen risiko for intern kondens.

Sted: Tranebjerg

Fugtighedsklasse i henhold til DS EN ISO 13788 anneks A: Boliger med lav aktivitet

		jan	feb	mar	apr	maj	jun	jul	aug	sep	okt	nov	dec
Temperatur - inde [°C]	T_i	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relativ fugtighed - inde [%]	ϕ_i	58.1	57.7	57.1	58.7	62.6	69.1	76.5	75.9	69.1	63.2	60.3	58.6
Temperatur - ude [°C]	T_e	-0.1	-0.4	1.2	5.4	9.6	12.8	15.8	15.6	12.5	8.1	4.4	0.9
Relativ fugtighed - ude[%]	ϕ_e	88	87	83	80	78	79	79	79	80	83	86	88

appendix 10

BR18 REQUIREMENTS

Minimum requirements for building envelope, in case of change of use and additions - mindstekrav til klimaskærm ved ændret anvendelse og tilbygninger (Bygningsreglementet, 2018b).

Building element	U-value [W/m²• K]	
	room heated to T > 15°C	room heated to 5°C <T < 15°C
External walls and basement walls	0.15	0.25
Floor separations and partition walls	0.40	0.40
Foundation and basement floors	0.10	0.15
Roof construction	0.12	0.15

(Bygningsreglementet, 2018b)

Minimum requirements for building envelope (Bygningsreglementet, 2018a).

Building element	U-value [W/m²• K]
	room heated to 5°C <T < 15°C
External walls and basement walls	0.30
Floor separations and partition walls	0.40
Foundation and basement floors	0.20
Roof construction	0.20

(Bygningsreglementet, 2018a)

ENERGY CONSUMPTION

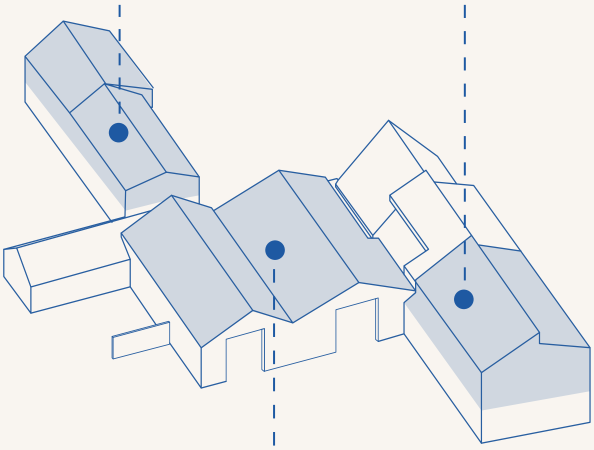
This project is a transformation project where the use of the building changes. In addition, the energy consumption for the beach hotel is based on *homes, dormitories and hotels*, where the building's energy consumption must not exceed **30.0 kWh / m² per year** (Bygningsreglementet, 2018c).

appendix 11

STRUCTURE DIMENSIONING

Here calculations on the new added construction are calculated and consist of two cases, because of constructions for the two different placements of bedrooms. All default values are found in Teknisk Ståbi and **Catalog - Elaborated Material Exploration**, and are marked with blue in the text.

The calculations are based on *deformations (AGT)* and *max forces (BGT)* calculated in Robot Structural Analysis.



ill.10. calculation

CALCULATION OF BEAM - CASE 1

Beam dimensions:
0.08 m width
0.20 m depth
4.082 m long
CC = 1 m

Material, density:
Construction wood C24: 420 kg / m^3
Straw insulation: 110 kg / m^3

DEAD LOAD - BEAM

Construction density
0.065 m^3 • 420 kg / m^3 = 27.4 kg

Conversion to N
33.6 kg • 9.82 m / s^2 = 269.37 N

Conversion to kN
$$\frac{269.37\text{ N}}{1000} = 0.269\text{ kN}$$

Line load
$$\frac{0.269\text{ kN}}{4.082} = 0.07\text{ kN / m}$$

DEAD LOAD - INSULATION

Construction density
1.359 m^3 • 110 kg / m^3 = 149.50 kg

Conversion to N
149.5 kg • 9.82 m / s^2 = 1468.09 N

Conversion to kN
$$\frac{1468.09\text{ N}}{1000} = 1.47\text{ kN}$$

Line load
$$\frac{1.47\text{ kN}}{4.082} = 0.36\text{ kN / m}$$

TOTAL DEAD LOAD

0.07 kN / m + 0.36 kN / m = **0.43 kN / m**

SNOW LOAD

0.8 kN / m^2 • 1 m = **0.8 kN / m**

AGT - CASE 1

$U_{max} > U_{fin}$

$$U_{max} = \frac{4082\ \text{mm}}{250} = 16.32\ \text{mm}$$

U_{fin} can be found in Robot results
$U_{fin} = 13$ mm

16.32 > 13

AGT APPROVED

BGT - CASE 1

$$\frac{\sigma_{m,d}}{f_{m,d}} < 1$$

$$f_{m,d} = \frac{f_{m,k} \quad k_{mod}}{Y_m}$$

$$f_{m,d} = \frac{24\ \text{MPa} \cdot 0.8}{1.35} = 14.22\ \text{MPa}$$

$$W_y = \frac{1}{6} \cdot 0.08\ \text{m} \cdot (0.20\ \text{m})^2$$

$$W_y = 0.00053\ \text{m}^3$$

$$\sigma_{m,d} = \frac{5.62\ \text{kN} \cdot 10^6\ \text{Nmm}}{0.00053\ \text{m}^3 \cdot 10^9\ \text{mm}^3} = 10.60\ \text{MPa}$$

$F_{z,max}$ is found in robot = 5.62 kN

$$\frac{10.60\ \text{MPa}}{14.22\ \text{MPa}} = 0.75 = \mathbf{75\%}$$

BGT APPROVED

CALCULATION OF BEAM - CASE 2

Beam dimensions:
0.08 m width
0.20 m depth
5.4 m long
CC = 1 m

Material, density:
Construction wood C24: 420 kg / m^3
Straw insulation: 110 kg / m^3

DEAD LOAD - BEAM

Construction density
0.0864 m^3 • 420 kg / m^3 = 36.28 kg

Conversion to N
36.28 kg • 9.82 m / s^2 = 356.34 N

Conversion to kN
$$\frac{356.34\ \text{N}}{1000} = 0.356\ \text{kN}$$

Line load
$$\frac{0.356\ \text{kN}}{5.4} = 0.066\ \text{kN / m}$$

DEAD LOAD - INSULATION

Construction density
1.782 m^3 • 110 kg / m^3 = 196 kg

Conversion to N
106 kg • 9.82 m / s^2 = 1924.90 N

Conversion to kN
$$\frac{1924.90\ \text{N}}{1000} = 1.92\ \text{kN}$$

Line load
$$\frac{1.92\ \text{kN}}{5.4} = 0.356\ \text{kN / m}$$

TOTAL DEAD LOAD

0.066 kN / m + 0.356 kN / m = **0.42 kN / m**

SNOW LOAD

0.8 kN / m^2 • 1 m = **0.8 kN / m**

AGT - CASE 2

$U_{max} > U_{fin}$

$$U_{max} = \frac{5400\ mm}{250} = 21.60\ mm$$

U_{fin} can be found in Robot results
$U_{fin} = 19\ mm$

21.60 > 19

AGT APPROVED

BGT - CASE 2

$$\frac{\sigma_{m,d}}{f_{m,d}} < 1$$

$$f_{m,d} = \frac{f_{m,k} \quad k_{mod}}{Y_m}$$

$$f_{m,d} = \frac{24\ MPa \cdot 0.8}{1.35} = 14.22\ MPa$$

$$W_y = \frac{1}{6} \cdot 0.08\ m \cdot (0.20\ m)^2$$

$W_y = 0.00053\ m^3$

$$\sigma_{m,d} = \frac{4.89\ kN \cdot 10^6\ Nmm}{0.00053\ m^3 \cdot 10^9\ mm^3} = 9.22\ MPa$$

$F_{z,max}$ is found in robot = 4.89 kN

$$\frac{9.22\ MPa}{14.22\ MPa} = 0.65 = \mathbf{65\%}$$

BGT APPROVED

CALCULATION OF BEAM - CASE 3

Beam dimensions:
0.045 m width
0.15 m depth
4.88 m long
CC = 1 m

Material, density:
Construction wood C24: 420 kg / m^3
Straw insulation: 110 kg / m^3

DEAD LOAD - BEAM

Construction density
0.033 m^3 • 420 kg / m^3 = 13.83 kg

Conversion to N
13.83 kg • 9.82 m / s^2 = 135.85 N

Conversion to kN
$\frac{135.85 \text{ N}}{1000} = 0.14 \text{ kN}$

Line load
$\frac{0.14 \text{ kN}}{4.88} = 0.028 \text{ kN / m}$

DEAD LOAD - BEAM BETWEEN INSULATION

Construction density
0.009 m^3 • 420 kg / m^3 = 3.78 kg

3.78 kg • 3 = 11.34 kg

Conversion to N
11.34 kg • 9.82 m / s^2 = 111.35 N

Conversion to kN
$\frac{111.35 \text{ N}}{1000} = 0.11 \text{ kN}$

Line load
$\frac{0.11 \text{ kN}}{4.88} = 0.022 \text{ kN / m}$

DEAD LOAD - INSULATION

Construction density
1.61 m^3 • 110 kg / m^3 = 177.1 kg

Conversion to N
177.1 kg • 9.82 m / s^2 = 1739.50 N

Conversion to kN
$\frac{1739.50 \text{ N}}{1000} = 1.74 \text{ kN}$

Line load
$\frac{1.74 \text{ kN}}{4.88} = 0.35 \text{ kN / m}$

TOTAL DEAD LOAD

0.028 kN / m + 0.35 kN / m + 0.022 kN / m
= **0.40 kN / m**

SNOW LOAD

0.8 kN / m^2 • 1 m = **0.8 kN / m**

AGT - CASE 3

$U_{max} > U_{fin}$

$$U_{max} = \frac{4880\ mm}{250} = 19.50\ mm$$

U_{fin} can be found in Robot results
$U_{fin} = 5\ mm$

10.50 > 5

AGT APPROVED

BGT - CASE 3

$$\frac{\sigma_{m,d}}{f_{m,d}} < 1$$

$$f_{m,d} = \frac{f_{m,k} \quad k_{mod}}{Y_m}$$

$$f_{m,d} = \frac{24\ MPa \cdot 0.8}{1.35} = 14.22\ MPa$$

$$W_y = \frac{1}{6} \cdot 0.045\ m \cdot (0.15\ m)^2$$

$$W_y = 0.000168\ m^3$$

$$\sigma_{m,d} = \frac{2.16\ kN \cdot 10^6\ Nmm}{0.000168\ m^3 \cdot 10^9\ mm^3} = 12.86\ MPa$$

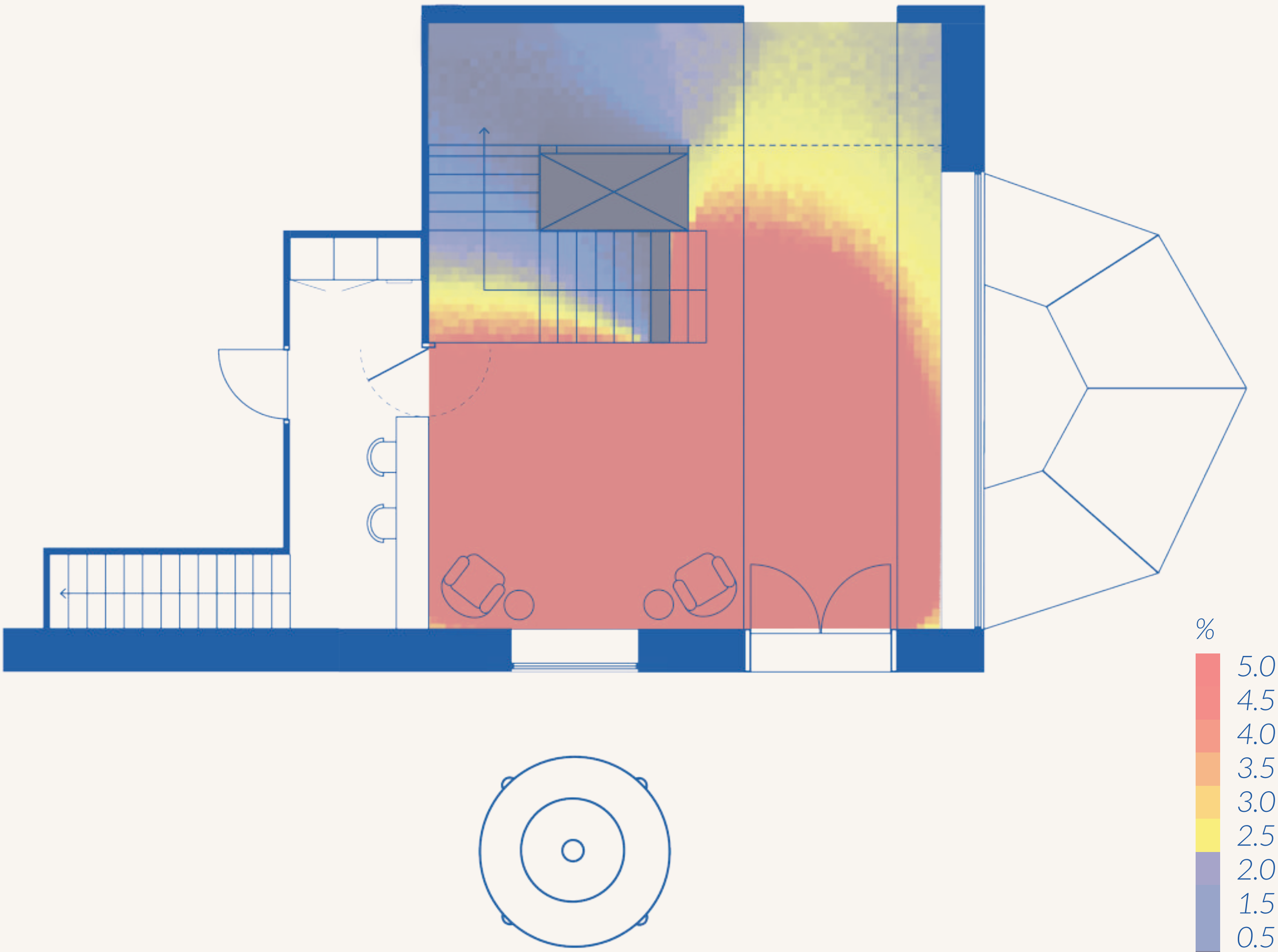
$F_{z,max}$ is found in robot = 2.16 kN

$$\frac{12.86\ MPa}{14.22\ MPa} = 0.905 = \mathbf{90.5\%}$$

BGT APPROVED

appendix 12

LOBBY, DAYLIGHT



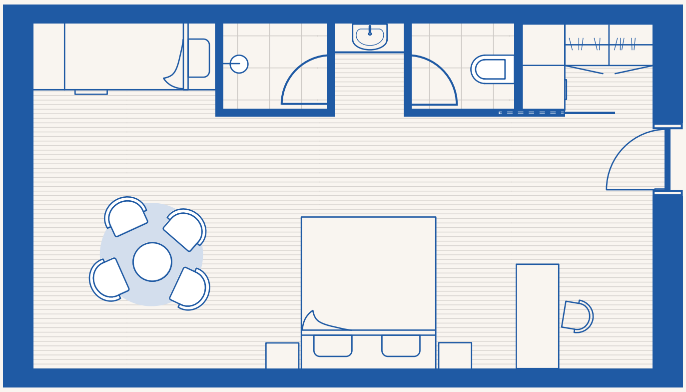
ill.11. lobby, daylight

appendix 13

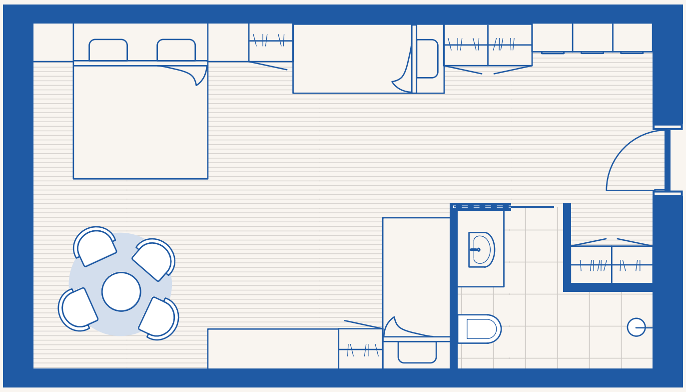
BEDROOMS, FLOOR PLANS

FAMILY BEDROOM #1

FAMILY BEDROOM #2

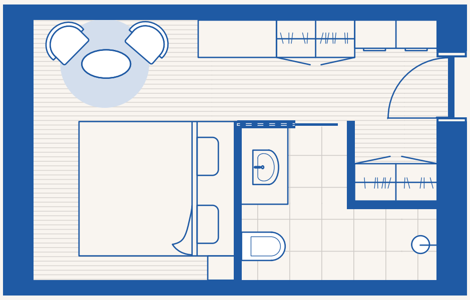


FAMILY BEDROOM #3

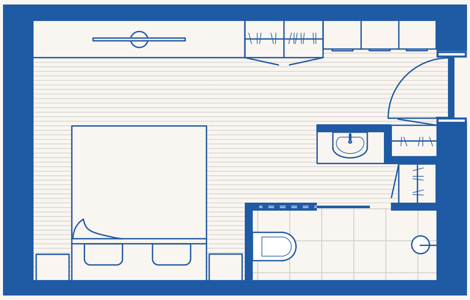


ill.12. family bedrooms process, 1:100

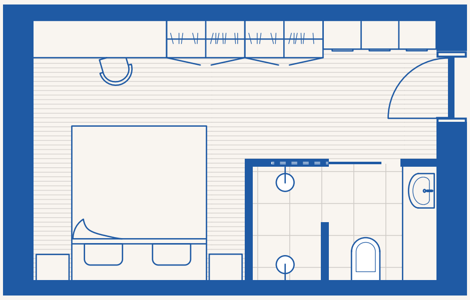
COUPLE BEDROOM #1



COUPLE BEDROOM #2



COUPLE BEDROOM #3

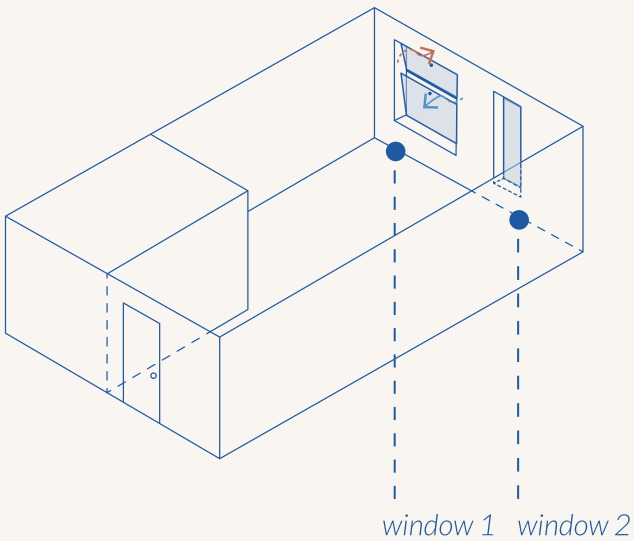


ill.13. couple bedrooms process, 1:100

appendix 14

BEDROOMS, NATURAL VENTILATION

FAMILY BEDROOM



ill.14. family bedrooms, windows

WINDOW DIMENSION

WINDOW 1: 1200 x 1200 mm

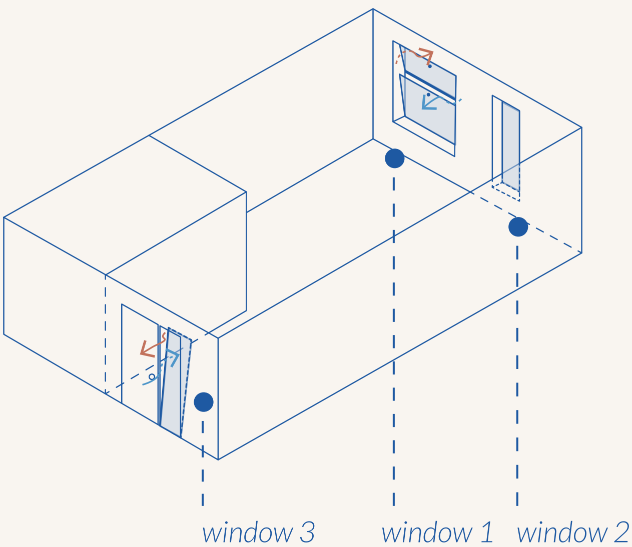
WINDOW 2: 700 x 1800 mm

EXCEL SHEET, RESULTS

Pressure Coefficient		**Windfactor**	0,5	**Pwind**	5,6 pa	
Windward	0,06	**Vmeteo**	6 m/s	**Pmin**	-2,1 pa	
Leeward	-0,38	**Vref**	3 m/s	**Pmax**	0,3 pa	
roof	-0,38					
Location of neutral plan, Ho	4,0 m	**Buildingvol.**	m3			
Outdoor temperature	12 C	**Volume**	m3/section/floor			
Zone temperature	22 C					
Discharge coefficient	0,11	**Internal pressure,**	pa	2,56		0,44
Air density	1,25 kg/m3					

	Area m2	**Eff. Area m2**	**Height m**	**Thermal Buoyancy pa**	**AFR (thermal) m3/s**	**Pres Coefficient**	**Wind pressure pa**	**AFR Wind) m3/s**	**Wind pressure pa**	**AFR total m3/s**
Window top	0,42	0,046	4,3	-0,125	-0,02	0,25	-1,154	-0,063	0,968	0,054
Window bottom	0,96	0,106	3,75	0,104	0,04	0,25	-1,154	-0,143	0,968	0,138
		0,000		1,664	0,00		-2,560	0,000	-0,438	0,000
		0,000	0	1,664	0,00	0	-2,560	0,000	-0,438	0,000
	0	0,000	0	1,664	0,00	0	-2,560	0,00	-0,438	0,000
	0,000	0,000		Massebalance	**0,02**		Massebalance	**-0,21**		**0,19**

FAMILY BEDROOM



ill.15. family bedrooms, windows

WINDOW DIMENSION

WINDOW 1: 1200 x 1200 mm

WINDOW 2: 700 x 1800 mm

WINDOW 3: 450 x 2100 mm

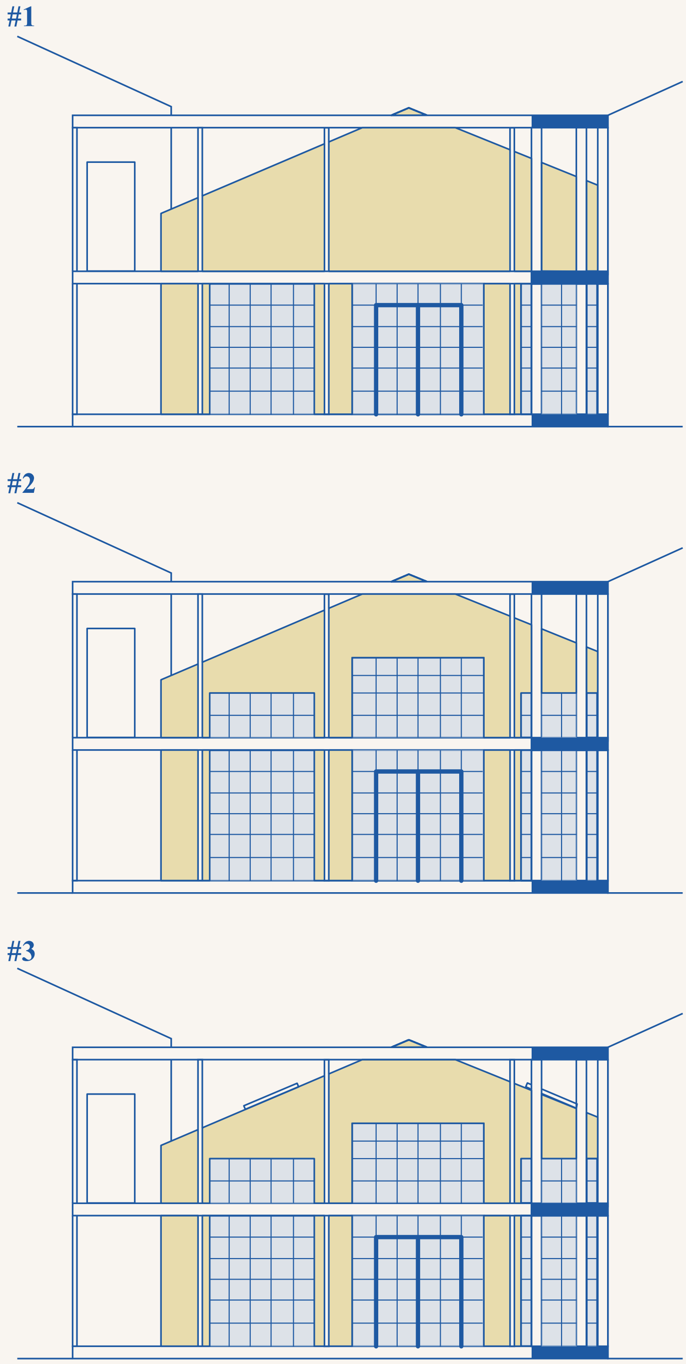
EXCEL SHEET, RESULTS

Pressure Coefficient		**Windfactor**	0,5		**Pwind**	5,6 pa	
Windward	0,06	**Vmeteo**	6 m/s		**Pmin**	-2,1 pa	
Leeward	-0,38	**Vref**	3 m/s		**Pmax**	0,3 pa	
roof	-0,38						
Location of neutral plan, Ho	4,0 m			**Buildingvol.**		m3	
Outdoor temperature	12 C			**Volume**		m3/section/floor	
Zone temperature	22 C						
Discharge coefficient	0,11			**Internal pressure,**	pa	2,56	0,44
Air density	1,25 kg/m3						

	Area m2	**Eff. Area** m2	**Height** m	**Thermal Buoyancy** pa	**AFR (thermal)** m3/s	**Pres Coefficient**	**Wind pressure** pa	**AFR Wind)** m3/s	**Wind pressure** pa	**AFR total** m3/s
Window top	0,42	0,046	4,3	-0,125	-0,02	0,25	-1,154	-0,063	0,968	0,054
Window bottom	0,96	0,106	3,75	0,104	0,04	0,25	-1,154	-0,143	0,968	0,138
window other si	0,92	0,083	4,55	-0,229	-0,05	-0,5	-5,373	-0,243	-3,251	-0,195
		0,000	0	1,664	0,00	0	-2,560	0,000	-0,438	0,000
	0	0,000	0	1,664	0,00	0	-2,560	0,00	-0,438	0,000
	0,000	0,000		Massebalance	**-0,03**		Massebalance	**-0,45**		**0,00**

appendix 15

LOUNGE, WINDOWS

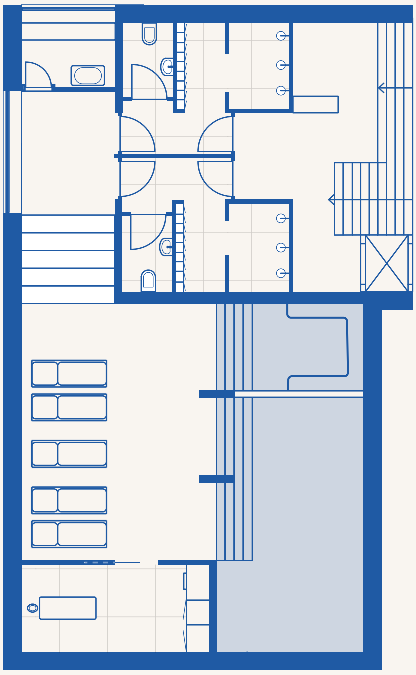


ill.16. lounge, window investigations

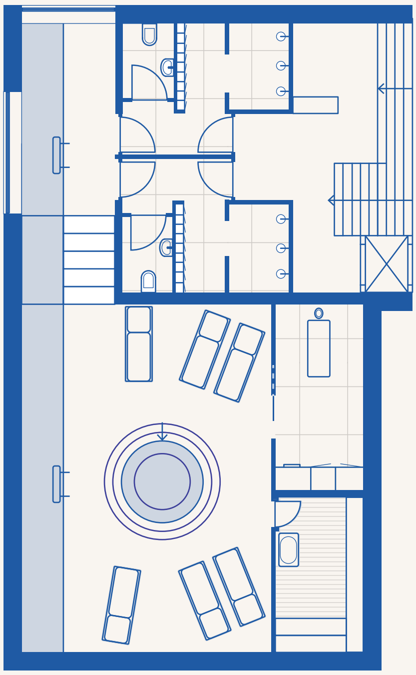
appendix 16

SPA, FLOOR PLAN

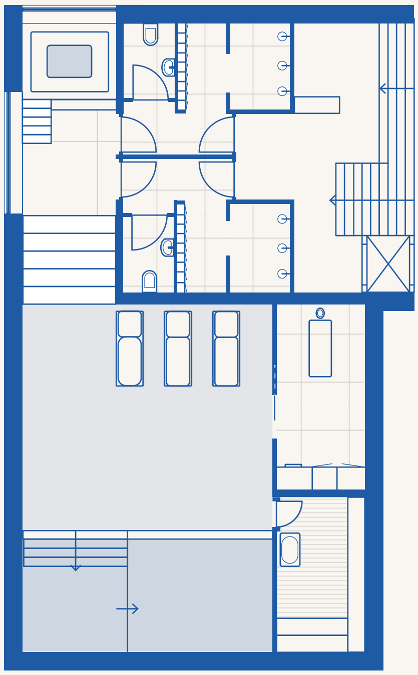
SPA #1



SPA #2



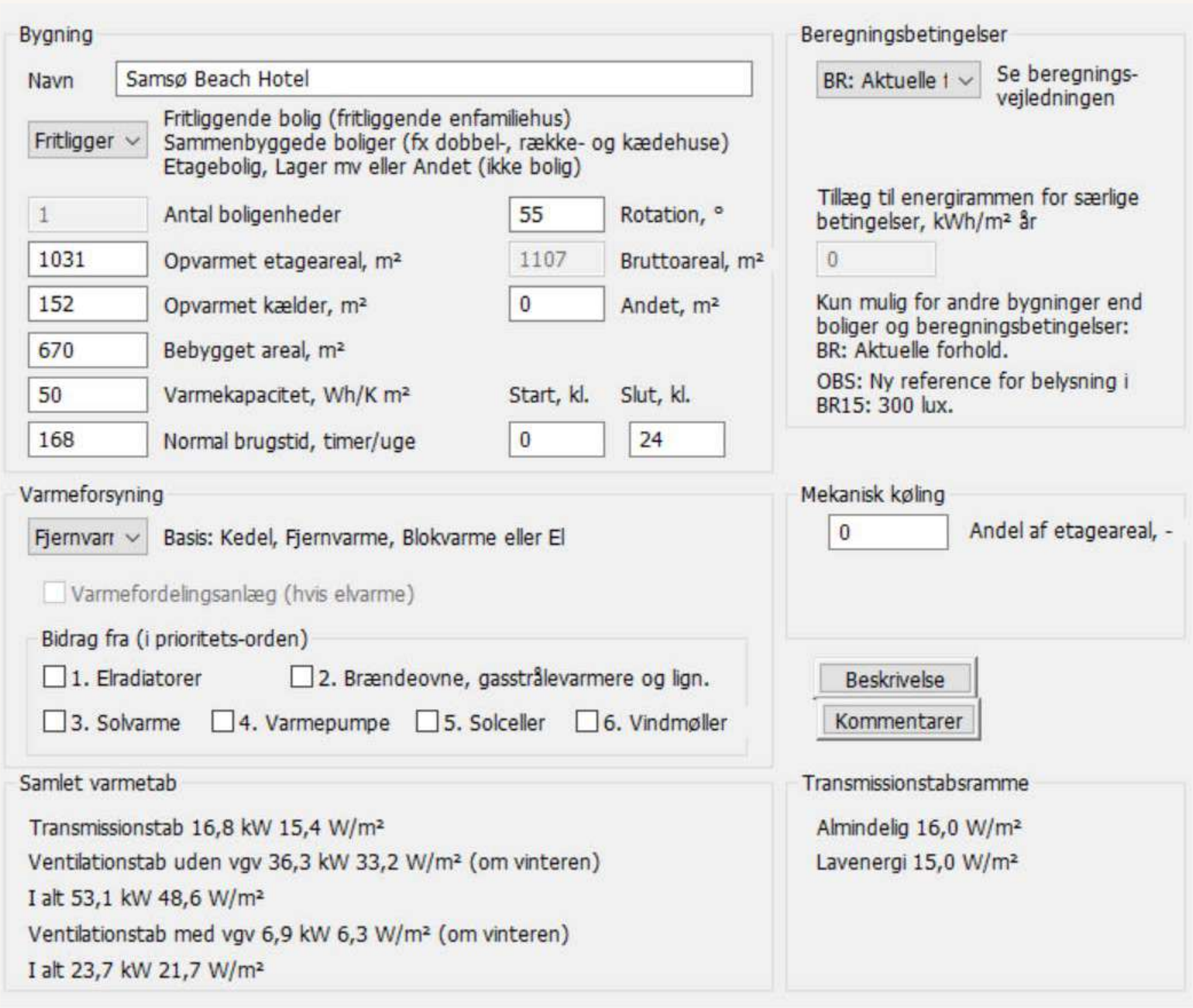
SPA #3



ill.17. spa process, 1:100

appendix 17

BE18


Bygning

Navn: Samsø Beach Hotel

Fritligger

Fritliggende bolig (fritliggende enfamiliehus)
Sammenbyggede boliger (fx dobbel-, række- og kædehuse)
Etagebolig, Lager mv eller Andet (ikke bolig)

1 Antal boligenheder — 55 Rotation, °

1031 Opvarmet etageareal, m² — 1107 Bruttoareal, m²

152 Opvarmet kælder, m² — 0 Andet, m²

670 Bebygget areal, m²

50 Varmekapacitet, Wh/K m² — Start, kl. — Slut, kl.

168 Normal brugstid, timer/uge — 0 — 24

Beregningsbetingelser

BR: Aktuelle f — Se beregnings-vejledningen

Tillæg til energirammen for særlige betingelser, kWh/m² år

0

Kun mulig for andre bygninger end boliger og beregningsbetingelser: BR: Aktuelle forhold.

OBS: Ny reference for belysning i BR15: 300 lux.

Varmeforsyning

Fjernvarr — Basis: Kedel, Fjernvarme, Blokvarme eller El

☐ Varmefordelingsanlæg (hvis elvarme)

Bidrag fra (i prioritets-orden)

☐ 1. Elradiatorer ☐ 2. Brændeovne, gasstrålevarmere og lign.

☐ 3. Solvarme ☐ 4. Varmepumpe ☐ 5. Solceller ☐ 6. Vindmøller

Mekanisk køling

0 Andel af etageareal, -

Beskrivelse

Kommentarer

Samlet varmetab

Transmissionstab 16,8 kW 15,4 W/m²

Ventilationstab uden vgv 36,3 kW 33,2 W/m² (om vinteren)

I alt 53,1 kW 48,6 W/m²

Ventilationstab med vgv 6,9 kW 6,3 W/m² (om vinteren)

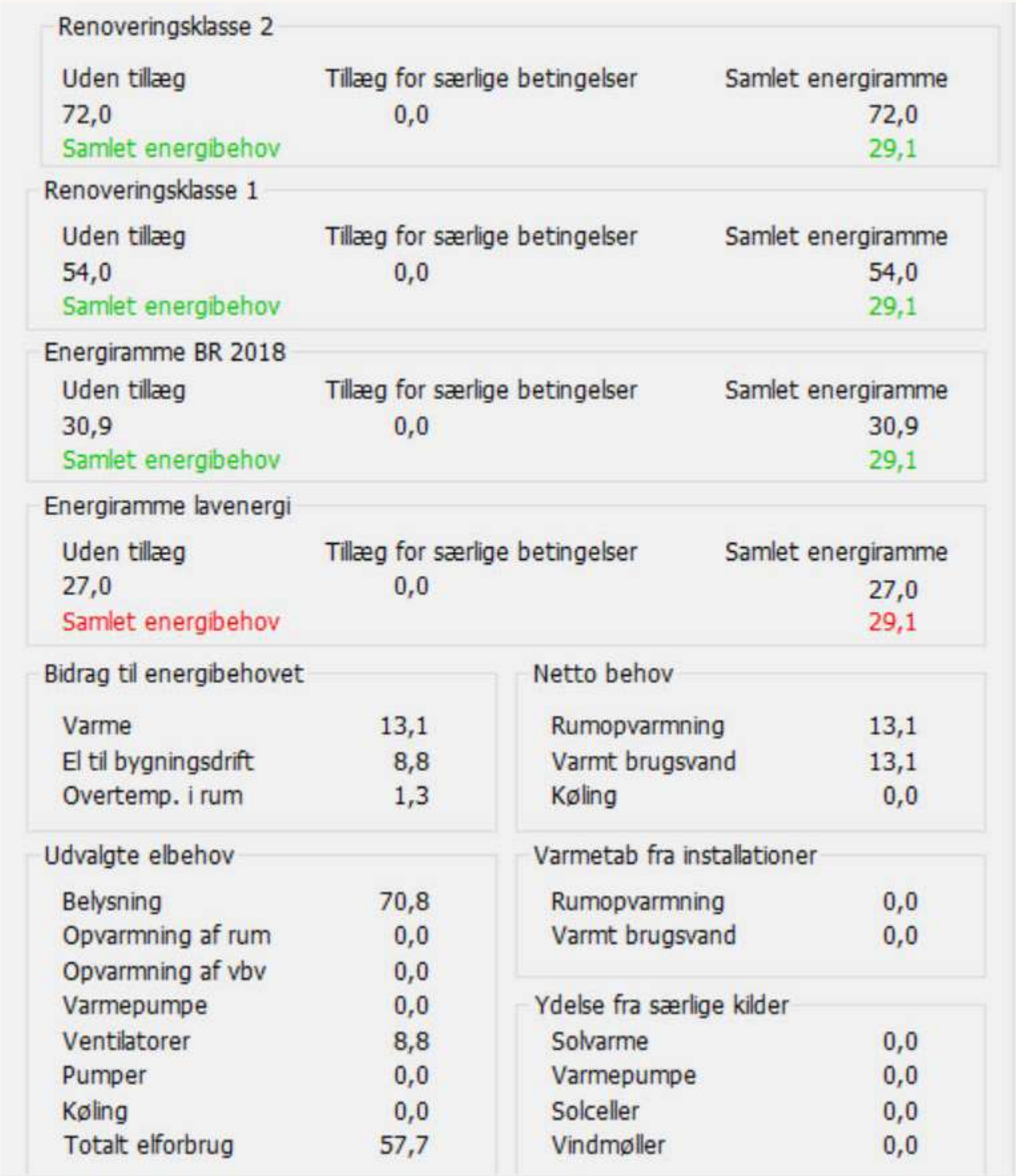
I alt 23,7 kW 21,7 W/m²

Transmissionstabsramme

Almindelig 16,0 W/m²

Lavenergi 15,0 W/m²

ill.18. Be18, introduction input



Renoveringsklasse 2

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
72,0	0,0	72,0
Samlet energibehov		29,1

Renoveringsklasse 1

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
54,0	0,0	54,0
Samlet energibehov		29,1

Energiramme BR 2018

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
30,9	0,0	30,9
Samlet energibehov		29,1

Energiramme lavenergi

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
27,0	0,0	27,0
Samlet energibehov		29,1

Bidrag til energibehovet

Varme	13,1
El til bygningsdrift	8,8
Overtemp. i rum	1,3

Netto behov

Rumopvarmning	13,1
Varmt brugsvand	13,1
Køling	0,0

Udvalgte elbehov

Belysning	70,8
Opvarmning af rum	0,0
Opvarmning af vbv	0,0
Varmepumpe	0,0
Ventilatorer	8,8
Pumper	0,0
Køling	0,0
Totalt elforbrug	57,7

Varmetab fra installationer

Rumopvarmning	0,0
Varmt brugsvand	0,0

Ydelse fra særlige kilder

Solvarme	0,0
Varmepumpe	0,0
Solceller	0,0
Vindmøller	0,0

ill.19. Be18, results

appendix 18

LCAbyg

SCENARIO 1 - *transfromation*

	Uncertainty factor	Input	Calculated quantity	Weight	Service life
Building	–	–	–	4,949e+05 kg	–
Elements	–	–	–	4,949e+05 kg	–
Balconies	–	–	–	1,261e+04 kg	–
Platform	–	–	–	1,261e+04 kg	–
Access balconies	–	–	–	1,261e+04 kg	–
Balcony beams	–	8,40 m³	–	3,830e+03 kg	–
Construction wood, pine and spruce, Planed (I...	1	1,00 m³/m³	8,40 m³	3,830e+03 kg	50 year
Balcony bottom	–	265,00 m²	–	7,272e+03 kg	–
Timber pine (12% moisture / 10.7% H2O cont...	1	0,05 m³/m²	13,25 m³	7,272e+03 kg	50 year
Balcony pillars	–	3,30 m³	–	1,505e+03 kg	–
Construction wood, pine and spruce, Planed (I...	1	1,00 m³/m³	3,30 m³	1,505e+03 kg	50 year
Floor decks	–	–	–	2,464e+04 kg	–
Floor deck	–	–	–	2,464e+04 kg	–
Etagedæk	–	–	–	2,464e+04 kg	–
Level seperater	–	431,00 m²	–	2,464e+04 kg	–
FASBA e.V. Baustroh 100 kg/m³	1	0,12 m³/m²	53,88 m³	5,388e+03 kg	50 year
Construction wood, pine and spruce, Planed (I...	1	0,02 m³/m²	6,46 m³	2,948e+03 kg	50 year
Oriented Strand Board, OSB	1	0,02 m³/m²	9,48 m³	5,689e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	9,48 m³	5,204e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	9,48 m³	5,204e+03 kg	50 year
Extruded polystyrene (XPS)	1	0,02 m³/m²	6,46 m³	2,069e+02 kg	50 year
Foundations	–	–	–	0	–
Strip footings below frost line	–	–	–	0	–
Line foundation	–	–	–	0	–
Ex. Strip foundation, concrete 1050 mm (4 1/2 b...	–	166,00 m	–	0	–
Ready mixed concrete C30/37	1	1544,10 kg/m	113,67 m³	0	120 year

Internal walls	–	–	–	5,576e+04 kg	–
Load-bearing walls	–	–	–	3,064e+04 kg	–
200 mm	–	–	–	3,064e+04 kg	–
Middle layer, timber, CLT element, load-bearing ...	–	326,00 m²	–	3,064e+04 kg	–
Cross Laminated Timber, CLT (Incineration EoL)	1	0,20 m³/m²	65,20 m³	3,064e+04 kg	100 year
Non-load-bearing walls	–	–	–	2,511e+04 kg	–
100 mm	–	–	–	2,511e+04 kg	–
Middle layer, timber, CLT element, load-bearing ...	–	353,00 m²	–	1,659e+04 kg	–
Cross Laminated Timber, CLT (Incineration EoL)	1	0,10 m³/m²	35,30 m³	1,659e+04 kg	100 year
Wall surface, board cladding (Clone)	–	353,00 m²	–	4,262e+03 kg	–
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	7,77 m³	4,262e+03 kg	40 year
Wall surface, board cladding (Clone)	–	353,00 m²	–	4,262e+03 kg	–
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	7,77 m³	4,262e+03 kg	40 year
Roofs	–	–	–	5,632e+04 kg	–
Roofs	–	–	–	5,632e+04 kg	–
Transformed roof	–	–	–	2,128e+04 kg	–
Optimized roof	–	277,00 m²	–	2,128e+04 kg	–
Kraft paper	1	1,00 m²/m²	277,00 m²	2,216e+01 kg	50 year
Bitumen sheets V 60 (thickness 0.005 m)	1	1,00 m²/m²	277,00 m²	1,585e+03 kg	50 year
Gypsum plaster board (perforated board) (12....	1	1,00 m²/m²	277,00 m²	2,354e+03 kg	50 year
Gypsum plaster board (perforated board) (12....	1	1,00 m²/m²	277,00 m²	2,354e+03 kg	50 year
FASBA e.V. Baustroh 100 kg/m³	1	0,34 m³/m²	94,18 m³	9,418e+03 kg	50 year
Construction wood, pine and spruce, Planed (I...	1	0,02 m³/m²	5,26 m³	2,400e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	6,09 m³	3,344e+03 kg	50 year
Nyt tag	–	–	–	3,504e+04 kg	–
New roof	–	495,00 m²	–	3,504e+04 kg	–
Kraft paper	1	1,00 m²/m²	495,00 m²	3,960e+01 kg	50 year
Bitumen sheets V 60 (thickness 0.005 m)	1	1,00 m²/m²	495,00 m²	2,475e+03 kg	50 year
FASBA e.V. Baustroh 100 kg/m³	1	0,34 m³/m²	168,30 m³	1,683e+04 kg	50 year
Construction wood, pine and spruce, Planed (I...	1	0,02 m³/m²	9,40 m³	4,289e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	9,90 m³	5,435e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	10,89 m³	5,976e+03 kg	50 year

Ground floor slabs	–	–	–	2,375e+05 kg	–
Ground floor slabs	–	–	–	2,375e+05 kg	–
Old ground with concrete finish	–	–	–	8,442e+04 kg	–
Old ground with concrete finish (Clone) (Clone)	–	370,00 m²	–	8,442e+04 kg	–
EPS insulation for ceilings / floors as edge insu...	1	0,25 m³/m²	92,50 m³	2,396e+03 kg	50 year
Ready-mixed concrete, C20/25 SCC (exposure ...	1	0,10 m³/m²	37,00 m³	8,184e+04 kg	50 year
Extruded polystyrene (XPS)	1	0,02 m³/m²	5,55 m³	1,776e+02 kg	50 year
new in spa	–	–	–	9,859e+04 kg	–
spa new ground	–	178,00 m²	–	9,859e+04 kg	–
Bitumen sheets V 60 (thickness 0.005 m)	1	1,00 m²/m²	178,00 m²	8,900e+02 kg	50 year
EPS insulation for ceilings / floors as edge insu...	1	0,25 m³/m²	44,50 m³	1,153e+03 kg	50 year
Ready-mixed concrete, C20/25 SCC (exposure ...	1	0,10 m³/m²	17,80 m³	3,937e+04 kg	50 year
Ready-mixed concrete, C20/25 SCC (exposure ...	1	0,10 m³/m²	17,80 m³	3,937e+04 kg	50 year
Expanded clay granulation	1	100,00 kg/m²	17800,00 kg	1,780e+04 kg	50 year
Old ground with wood finish	–	–	–	5,453e+04 kg	–
Old ground with concrete finish Optimized	–	227,00 m²	–	5,453e+04 kg	–
EPS insulation for ceilings / floors as edge insu...	1	0,25 m³/m²	56,75 m³	1,470e+03 kg	50 year
Ready-mixed concrete, C20/25 SCC (exposure ...	1	0,10 m³/m²	22,70 m³	5,021e+04 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	4,99 m³	2,741e+03 kg	50 year
Extruded polystyrene (XPS)	1	0,02 m³/m²	3,40 m³	1,090e+02 kg	50 year
Stairs and ramps	–	–	–	5,298e+03 kg	–
Stairs and ramps	–	–	–	5,298e+03 kg	–
Trapper	–	–	–	5,298e+03 kg	–
Stairs in wood, per floor	–	8,00 stk.	–	5,298e+03 kg	–
Clay plaster	1	436,96 kg/stk.	3,88 m³	3,496e+03 kg	100 year
Timber pine (12% moisture / 10.7% H2O cont...	1	60,31 kg/stk.	0,88 m³	4,825e+02 kg	100 year
Timber pine (12% moisture / 10.7% H2O cont...	1	165,00 kg/stk.	2,41 m³	1,320e+03 kg	100 year

Windows, doors, glazing systems	–	–	–	8,246e+03 kg	–
Doors	–	–	–	2,181e+03 kg	–
Døre	–	–	–	2,181e+03 kg	–
Door, front door	–	46,40 m²	–	2,181e+03 kg	–
Door, alu, front door	1	1,00 m²/m²	46,40 m²	2,181e+03 kg	50 year
Windows	–	–	–	6,065e+03 kg	–
Vinduer	–	–	–	6,065e+03 kg	–
window,timber with 3-layer pane	–	162,00 m²	–	6,065e+03 kg	–
EPDM sealing for aluminium section	1	5,78 m/m²	935,55 m	1,684e+02 kg	50 year
Insulated glazing, triple pane (thickness: 0.036...	1	0,80 m²/m²	129,60 m²	3,888e+03 kg	50 year
Window fitting for double sash window	1	0,52 kg/m²	83,08 stk.	8,424e+01 kg	50 year
Window frame (spruce)	1	2,87 m/m²	464,94 m	9,810e+02 kg	50 year
Window sash (spruce)	1	2,76 m/m²	447,12 m	9,434e+02 kg	50 year
External walls	–	–	–	9,446e+04 kg	–
Basement external walls	–	–	–	6,203e+04 kg	–
Walls in spa	–	–	–	6,203e+04 kg	–
Walls in spa	–	125,00 m²	–	6,203e+04 kg	–
Bitumen sheets V 60 (thickness 0.005 m)	1	1,00 m²/m²	125,00 m²	6,250e+02 kg	50 year
EPS insulation for ceilings / floors as edge insu...	1	0,25 m³/m²	31,25 m³	8,094e+02 kg	50 year
Precast lightweight concrete wall element, thic...	1	1,00 m²/m²	125,00 m²	3,030e+04 kg	50 year
Precast lightweight concrete wall element, thic...	1	1,00 m²/m²	125,00 m²	3,030e+04 kg	50 year

External walls	–	–	–	3,243e+04 kg	–
Brick wall optimized	–	–	–	7,692e+03 kg	–
Brickwall optimizing	–	243,00 m²	–	7,692e+03 kg	–
Kraft paper	1	1,00 m²/m²	243,00 m²	1,944e+01 kg	50 year
Bitumen sheets V 60 (thickness 0.005 m)	1	1,00 m²/m²	243,00 m²	1,215e+03 kg	50 year
FASBA e.V. Baustroh 100 kg/m³	1	0,14 m³/m²	35,24 m³	3,524e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	5,35 m³	2,934e+03 kg	50 year
Leca wall optimized	–	–	–	5,658e+03 kg	–
Brick wall optimizing	–	120,00 m²	–	5,658e+03 kg	–
Kraft paper	1	1,00 m²/m²	120,00 m²	9,600e+00 kg	50 year
Bitumen sheets V 60 (thickness 0.005 m)	1	1,00 m²/m²	120,00 m²	6,000e+02 kg	50 year
FASBA e.V. Baustroh 100 kg/m³	1	0,30 m³/m²	36,00 m³	3,600e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	2,64 m³	1,449e+03 kg	50 year
new exterior wall	–	–	–	1,908e+04 kg	–
New external wall	–	291,00 m²	–	1,908e+04 kg	–
Kraft paper	1	1,00 m²/m²	291,00 m²	2,328e+01 kg	50 year
Bitumen sheets V 60 (thickness 0.005 m)	1	1,00 m²/m²	291,00 m²	1,455e+03 kg	50 year
FASBA e.V. Baustroh 100 kg/m³	1	0,30 m³/m²	85,84 m³	8,584e+03 kg	50 year
Construction wood, pine and spruce, Planed (I...	1	0,02 m³/m²	4,36 m³	1,990e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	6,40 m³	3,513e+03 kg	50 year
Timber pine (12% moisture / 10.7% H2O cont...	1	0,02 m³/m²	6,40 m³	3,513e+03 kg	50 year

SCENARIO 2 - *new build*

	Usikkerhedsfaktor	Indtastet mængde	Udregnet mængde	Vægt	Levetid
Bygning	–	–	–	9,553e+05 kg	–
Bygningsdele	–	–	–	9,553e+05 kg	–
Altaner og altangange	–	–	–	4,441e+04 kg	–
Altanbund	–	–	–	4,441e+04 kg	–
Access balconies x	–	–	–	4,441e+04 kg	–
Balcony beams	–	8,40 m³	–	3,218e+04 kg	–
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	8,40 m³/m³	70,56 m³	3,218e+04 kg	50 år
Balcony bottom	–	265,00 m²	–	7,272e+03 kg	–
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,05 m³/m²	13,25 m³	7,272e+03 kg	50 år
Balcony pillars	–	3,30 m³	–	4,966e+03 kg	–
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	3,30 m³/m³	10,89 m³	4,966e+03 kg	50 år
Dæk	–	–	–	2,464e+04 kg	–
Etagedæk	–	–	–	2,464e+04 kg	–
Level seperation x	–	–	–	2,464e+04 kg	–
Level seperater	–	431,00 m²	–	2,464e+04 kg	–
Halm	1	0,12 m³/m²	53,88 m³	5,388e+03 kg	50 år
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,02 m³/m²	6,46 m³	2,948e+03 kg	50 år
OSB-plade	1	0,02 m³/m²	9,48 m³	5,689e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	9,48 m³	5,204e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O) (Klon)	1	0,02 m³/m²	9,48 m³	5,204e+03 kg	50 år
XPS isolering	1	0,02 m³/m²	6,46 m³	2,069e+02 kg	50 år
Fundamenter	–	–	–	0	–
Randfundamenter	–	–	–	0	–
Line foundation x	–	–	–	0	–
Ex. Linjefundament, beton 1050 mm (4 1/2 sten)	–	166,00 m	–	0	–
Fabriksbeton C30/37	1	1544,10 kg/m	113,67 m³	0	120 år
Indervægge	–	–	–	7,702e+04 kg	–
Bærende indervægge	–	–	–	5,191e+04 kg	–
200 mm x	–	–	–	3,064e+04 kg	–
Midterdel, træ, CLT-element, bærende 200 mm	–	326,00 m²	–	3,064e+04 kg	–
Krydslamineret træ, CLT (Forbrænding EoL)	1	0,20 m³/m²	65,20 m³	3,064e+04 kg	100 år
existing x	–	–	–	2,126e+04 kg	–
Midterdel, teglsten, bærende	–	116,00 m²	–	2,126e+04 kg	–
Mørtel, fliseklæber	1	55,50 kg/m²	6438,00 kg	6,438e+03 kg	100 år
Teglsten, formur	1	0,07 m³/m²	8,24 m³	1,482e+04 kg	100 år
Ikke-bærende indervægge	–	–	–	2,511e+04 kg	–
100 mm x	–	–	–	2,511e+04 kg	–
Midterdel, træ, CLT-element, bærende 100 mm	–	353,00 m²	–	1,659e+04 kg	–
Krydslamineret træ, CLT (Forbrænding EoL)	1	0,10 m³/m²	35,30 m³	1,659e+04 kg	100 år
Vægside, Bræddebeklædning (Klon)	–	353,00 m²	–	4,262e+03 kg	–
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	7,77 m³	4,262e+03 kg	40 år
Vægside, Bræddebeklædning (Klon)	–	353,00 m²	–	4,262e+03 kg	–
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	7,77 m³	4,262e+03 kg	40 år

Tage	–	–	–	6,392e+04 kg	–
Tage	–	–	–	6,392e+04 kg	–
Transformed roof x	–	–	–	2,888e+04 kg	–
Transformed roof	–	277,00 m²	–	2,888e+04 kg	–
Byggepap	1	1,00 m²/m²	277,00 m²	2,216e+01 kg	50 år
Dampspærre, bitumen	1	1,00 m²/m²	277,00 m²	1,385e+03 kg	50 år
Gipskartonplade 13 mm, hulplade	1	1,00 m²/m²	277,00 m²	2,354e+03 kg	50 år
Gipskartonplade 13 mm, hulplade	1	1,00 m²/m²	277,00 m²	2,354e+03 kg	50 år
Halm	1	0,34 m³/m²	94,18 m³	9,418e+03 kg	50 år
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,02 m³/m²	5,26 m³	2,400e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	6,09 m³	3,344e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O) (Klon)	1	0,05 m³/m²	13,85 m³	7,601e+03 kg	50 år
new roof x	–	–	–	3,504e+04 kg	–
New roof	–	495,00 m²	–	3,504e+04 kg	–
Byggepap	1	1,00 m²/m²	495,00 m²	3,960e+01 kg	50 år
Dampspærre, bitumen	1	1,00 m²/m²	495,00 m²	2,475e+03 kg	50 år
Halm	1	0,34 m³/m²	168,30 m³	1,683e+04 kg	50 år
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,02 m³/m²	9,40 m³	4,289e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	9,90 m³	5,433e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	10,89 m³	5,976e+03 kg	50 år

Terrændæk	–	–	–	6,143e+05 kg	–
Terrændæk	–	–	–	6,143e+05 kg	–
Old ground with concrete finish x	–	–	–	2,935e+05 kg	–
Old ground with concrete finish	–	370,00 m²	–	1,214e+05 kg	–
EPS isolering til lofter / gulve og kælderydervæ...	1	0,25 m³/m²	92,50 m³	2,396e+03 kg	50 år
Fabriksbeton (C20/25 SCC) i eksponeringsklas...	1	0,10 m³/m²	37,00 m³	8,184e+04 kg	50 år
Letklinker, ekspanderet ler, nødder	1	100,00 kg/m²	37000,00 kg	3,700e+04 kg	50 år
XPS isolering	1	0,02 m³/m²	5,55 m³	1,776e+02 kg	50 år
Terrændæk, beton, 200 mm	–	370,00 m²	–	1,721e+05 kg	–
Armeringsnet	1	16,00 kg/m²	5920,00 kg	5,920e+03 kg	100 år
Fabriksbeton (C25/30) i eksponeringsklasserne...	1	0,20 m³/m²	74,00 m³	1,662e+05 kg	100 år
Old ground with wood finish x	–	–	–	1,828e+05 kg	–
Old ground with wood finish	–	227,00 m²	–	7,723e+04 kg	–
EPS isolering til lofter / gulve og kælderydervæ...	1	0,25 m³/m²	56,75 m³	1,470e+03 kg	50 år
Fabriksbeton (C20/25 SCC) i eksponeringsklas...	1	0,10 m³/m²	22,70 m³	5,021e+04 kg	50 år
Letklinker, ekspanderet ler, nødder	1	100,00 kg/m²	22700,00 kg	2,270e+04 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	4,99 m³	2,741e+03 kg	50 år
XPS isolering	1	0,02 m³/m²	3,40 m³	1,090e+02 kg	50 år
Terrændæk, beton, 200 mm	–	227,00 m²	–	1,056e+05 kg	–
Armeringsnet	1	16,00 kg/m²	3632,00 kg	3,632e+03 kg	100 år
Fabriksbeton (C25/30) i eksponeringsklasserne...	1	0,20 m³/m²	45,40 m³	1,020e+05 kg	100 år
new in spa x	–	–	–	1,380e+05 kg	–
spa new ground	–	178,00 m²	–	1,380e+05 kg	–
Dampspærre, bitumen	1	1,00 m²/m²	178,00 m²	8,900e+02 kg	50 år
EPS isolering til lofter / gulve og kælderydervæ...	1	0,25 m³/m²	44,50 m³	1,153e+03 kg	50 år
Fabriksbeton (C20/25 SCC) i eksponeringsklas...	1	0,10 m³/m²	17,80 m³	3,937e+04 kg	50 år
Fabriksbeton (C20/25 SCC) i eksponeringsklas...	1	0,20 m³/m²	35,60 m³	7,875e+04 kg	50 år
Letklinker, ekspanderet ler, nødder	1	100,00 kg/m²	17800,00 kg	1,780e+04 kg	50 år

Vinduer, døre, glasfacader	–	–	–	8,246e+03 kg	–
Døre	–	–	–	2,181e+03 kg	–
Døre	–	–	–	2,181e+03 kg	–
Dør, hoveddør	–	46,40 m²	–	2,181e+03 kg	–
Dør, alu, hoveddør	1	1,00 m²/m²	46,40 m²	2,181e+03 kg	50 år
Vinduer	–	–	–	6,065e+03 kg	–
Vinduer	–	–	–	6,065e+03 kg	–
Vindue, træ med 3-lags rude	–	162,00 m²	–	6,065e+03 kg	–
EPDM-tætning til aluminiumsprofil	1	5,78 m/m²	935,55 m	1,684e+02 kg	50 år
Rude, 3-lags	1	0,80 m²/m²	129,60 m²	3,888e+03 kg	50 år
Vinduesbeslag, aluminium	1	0,52 kg/m²	83,08 stk.	8,424e+01 kg	50 år
Vindueskarm, træ	1	2,87 m/m²	464,94 m	9,810e+02 kg	50 år
Vinduesramme, træ	1	2,76 m/m²	447,12 m	9,434e+02 kg	50 år
Ydervægge	–	–	–	1,227e+05 kg	–
Kælderydervægge	–	–	–	6,203e+04 kg	–
Walls in spa x	–	–	–	6,203e+04 kg	–
Walls in spa	–	125,00 m²	–	6,203e+04 kg	–
Dampspærre, bitumen	1	1,00 m²/m²	125,00 m²	6,250e+02 kg	50 år
EPS isolering til lofter / gulve og kælderydervæ...	1	0,25 m³/m²	31,25 m³	8,094e+02 kg	50 år
Letbeton vægelement, 150 mm tyk væg (10% ...	1	1,00 m²/m²	125,00 m²	3,030e+04 kg	50 år
Letbeton vægelement, 150 mm tyk væg (10% ...	1	1,00 m²/m²	125,00 m²	3,030e+04 kg	50 år

Ydervægge	–	–	–	6,069e+04 kg	–
Brick wall optimized x	–	–	–	2,785e+04 kg	–
Brick wall replacement structural	–	243,00 m²	–	1,192e+04 kg	–
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,05 m³/m²	12,15 m³	5,540e+03 kg	50 år
Mineraluld, alm.	1	1,00 m²/m²	243,00 m²	6,379e+03 kg	50 år
New external wall	–	243,00 m²	–	1,593e+04 kg	–
Byggepap	1	1,00 m²/m²	243,00 m²	1,944e+01 kg	50 år
Dampspærre, bitumen	1	1,00 m²/m²	243,00 m²	1,215e+03 kg	50 år
Halm	1	0,30 m³/m²	71,68 m³	7,168e+03 kg	50 år
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,02 m³/m²	3,64 m³	1,662e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	5,35 m³	2,934e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	5,35 m³	2,934e+03 kg	50 år
Leca wall optimized x	–	–	–	1,375e+04 kg	–
Leca wall replacement structural	–	120,00 m²	–	5,886e+03 kg	–
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,05 m³/m²	6,00 m³	2,736e+03 kg	50 år
Mineraluld, alm.	1	1,00 m²/m²	120,00 m²	3,150e+03 kg	50 år
New external wall	–	120,00 m²	–	7,868e+03 kg	–
Byggepap	1	1,00 m²/m²	120,00 m²	9,600e+00 kg	50 år
Dampspærre, bitumen	1	1,00 m²/m²	120,00 m²	6,000e+02 kg	50 år
Halm	1	0,30 m³/m²	35,40 m³	3,540e+03 kg	50 år
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,02 m³/m²	1,80 m³	8,208e+02 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	2,64 m³	1,449e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	2,64 m³	1,449e+03 kg	50 år
new exterior wall x	–	–	–	1,908e+04 kg	–
New external wall	–	291,00 m²	–	1,908e+04 kg	–
Byggepap	1	1,00 m²/m²	291,00 m²	2,328e+01 kg	50 år
Dampspærre, bitumen	1	1,00 m²/m²	291,00 m²	1,455e+03 kg	50 år
Halm	1	0,30 m³/m²	85,84 m³	8,584e+03 kg	50 år
Konstruktionstræ af fyr og gran, Høvlet (Forbr...	1	0,02 m³/m²	4,36 m³	1,990e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	6,40 m³	3,513e+03 kg	50 år
Træ, fyrretræ (12% fugt / 10,7% H2O)	1	0,02 m³/m²	6,40 m³	3,513e+03 kg	50 år

appendix 19

DIMENSIONING OF FLOWRATE

Rooms	Building class					People load
		Amount	Height	Floor area	Volume	Amount of people
			m	[m2]	[m3]	[Children/Adult]
Lobby	B <= 20%	1	2,5	55	137,5	10
Restaurant	B <= 20%	1	2,5	66	165	42
Spa area	B <= 20%	1	2,5	78	195	5
Massage room	B <= 20%	1	2,5	10	25	2
Changing room	B <= 20%	2	2,5	13	32,5	5
Sauna	B <= 20%	1	2,5	12	30	5
Toilet	B <= 20%	5	2,5	2	5	1
Disabled-friendly toilet	B <= 20%	1	2,5	4	10	1
Lounge	B <= 20%	1	4	60	240	12
private						
Couple bedrooms	B <= 20%	6	2,5	18	45	2
Family bedroom	B <= 20%	5	2,5	38	95	4
Disabled-friendly couple bedrooms	B <= 20%	2	2,5	28	70	2
Disabled-friendly family bedrooms	B <= 20%	1	2,5	38	95	4
Staff						
Reception	B <= 20%	1	2,5	9	22,5	2
Administration	B <= 20%	1	2,5	40	100	5
Staff room	B <= 20%	1	2,5	42	105	10
Wardrobe room	B <= 20%	2	2,5	13	32,5	2
Toilet and Bath	B <= 20%	2	2,5	5	12,5	1
Kitchen	B <= 20%	1	2,5	38	95	6
Coolroom and storage	B <= 20%	1	2,5	5	12,5	1
Laundry and storage	B <= 20%	1	2,5	12	30	1
Technical room #1	B <= 20%	1	2,5	18	45	1
Technical room #2	B <= 20%	1	2,5	66	165	1

Rooms	DS447					BR18 - Minimum requirements				
	Basis for dimensioning			Supply air / Extraction		Basis for dimensioning			Supply air / Extraction	
	[l/s pr. pers]	[l/s pr. m2]	[l/s]	[l/s]	[h^-1]	[l/s pr. pers]	[l/s pr. m2]	[l/s]	[l/s]	[h^-1]
Lobby	7	0,7	108,5	**108,5**	**2,84**	5	0,35	69,25	**69,25**	**1,81**
Restaurant	7	0,7	340,2	**340,2**	**7,42**	5	0,35	233,1	**233,1**	**5,09**
Spa area	7	0,7	89,6	**89,6**	**1,65**	5	0,35	52,3	**52,3**	**0,97**
Massage room	7	0,7	21	**21**	**3,024**	5	0,35	13,5	**13,5**	**1,94**
Changing room	7	0,7	44,1	**44,1**	**4,884923077**	5	0,35	29,55	**29,55**	**3,27**
Sauna	7	0,7	43,4	**43,4**	**5,21**	5	0,35	29,2	**29,2**	**3,50**
Toilet	15	0,7	16,4	**16,4**	**11,81**	5	0,35	5,7	**5,7**	**4,10**
Disabled-friendly toilet	15	0,7	17,8	**17,8**	**6,408**	5	0,35	6,4	**6,4**	**2,304**
Lounge	15	0,7	222	**222**	**3,33**	5	0,35	81	**81**	**1,22**
private										
Couple bedrooms	7	0,7	26,6	**26,6**	**2,128**	5	0,35	16,3	**16,3**	**1,30**
Family bedroom	7	0,7	54,6	**54,6**	**2,069052632**	5	0,35	33,3	**33,3**	**1,26**
Disabled-friendly couple bedrooms	7	0,7	33,6	**33,6**	**1,728**	5	0,35	19,8	**19,8**	**1,02**
Disabled-friendly family bedrooms	7	0,7	54,6	**54,6**	**2,069052632**	5	0,35	33,3	**33,3**	**1,26**
Staff										
Reception	7	0,7	20,3	**20,3**	**3,248**	5	0,35	13,15	**13,15**	**2,10**
Administration	7	0,7	63	**63**	**2,268**	5	0,35	39	**39**	**1,40**
Staff room	7	0,7	99,4	**99,4**	**3,41**	5	0,35	64,7	**64,7**	**2,22**
Wardrobe room	7	0,7	23,1	**23,1**	**2,56**	5	0,35	14,55	**14,55**	**1,61**
Toilet and Bath	15	0,7	18,5	**18,5**	**5,33**	5	0,35	6,75	**6,75**	**1,94**
Kitchen	7	0,7	68,6	**68,6**	**2,60**	5	0,35	43,3	**43,3**	**1,64**
Coolroom and storage	7	0,7	10,5	**10,5**	**3,02**	5	0,35	6,75	**6,75**	**1,94**
Laundry and storage	7	0,7	15,4	**15,4**	**1,85**	5	0,35	9,2	**9,2**	**1,10**
Technical room #1	7	0,7	19,6	**19,6**	**1,57**	5	0,35	11,3	**11,3**	**0,90**
Technical room #2	7	0,7	53,2	**53,2**	**1,16**	5	0,35	28,1	**28,1**	**0,61**

Rooms	Ventilation dimensioned by smell					
	Concentration of pollution	Outdoor pollution	People load		Total pollution	Supply air / Extraction
	c [Decipol]	ci [Decipol]	[Olf pr. pers]	[Olf pr. m2]	q [Olf]	[l/s]
Lobby	1,4	0,09	1,2	0,4	34	**259,54**
Restaurant	1,4	0,09	2	0,4	110,4	**842,75**
Spa area	1,4	0,09	4	1	98	**748,09**
Massage room	1,4	0,09	1,2	0,4	6,4	**48,85**
Changing room	1,4	0,09	2	0,4	15,2	**116,03**
Sauna	1,4	0,09	6	0,4	34,8	**265,65**
Toilet	1,4	0,09	2	0,4	2,8	**21,37**
Disabled-friendly toilet	1,4	0,09	2	0,4	3,6	**27,48**
Lounge	1,4	0,09	2	0,4	48	**366,41**
private						
Couple bedrooms	1,4	0,09	1,3	0,4	9,8	**74,81**
Family bedroom	1,4	0,09	1,3	0,4	20,4	**155,73**
Disabled-friendly couple bedrooms	1,4	0,09	1,3	0,4	13,8	**105,34**
Disabled-friendly family bedrooms	1,4	0,09	1,3	0,4	20,4	**155,73**
Staff						
Reception	1,4	0,09	2	0,4	7,6	**58,02**
Administration	1,4	0,09	1,6	0,4	24	**183,21**
Staff room	1,4	0,09	3	0,4	46,8	**357,25**
Wardrobe room	1,4	0,09	3	0,4	11,2	**85,50**
Toilet and Bath	1,4	0,09	3	0,4	5	**38,17**
Kitchen	1,4	0,09	1,3	0,4	23	**175,57**
Coolroom and storage	1,4	0,09	1,6	0,4	3,6	**27,48**
Laundry and storage	1,4	0,09	1,6	0,4	6,4	**48,85**
Technical room #1	1,4	0,09	1,6	0,4	8,8	**67,18**
Technical room #2	1,4	0,09	1,6	0,4	28	**213,74**

Rooms	CO2		
	Max. CO2 content in air	Concentration of pollution	Outdoor air pollution CO2
	[ppm]	c [m3/m3]	[ppm]
Lobby	1000	0,001	400
Restaurant	1000	0,001	400
Spa area	1000	0,001	400
Massage room	1000	0,001	400
Changing room	1000	0,001	400
Sauna	1000	0,001	400
Toilet	1000	0,001	400
Disabled-friendly toilet	1000	0,001	400
Lounge	1000	0,001	400
private			
Couple bedrooms	1000	0,001	400
Family bedroom	1000	0,001	400
Disabled-friendly couple bedrooms	1000	0,001	400
Disabled-friendly family bedrooms	1000	0,001	400
Staff			
Reception	1000	0,001	400
Administration	1000	0,001	400
Staff room	1000	0,001	400
Wardrobe room	1000	0,001	400
Toilet and Bath	1000	0,001	400
Kitchen	1000	0,001	400
Coolroom and storage	1000	0,001	400
Laundry and storage	1000	0,001	400
Technical room #1	1000	0,001	400
Technical room #2	1000	0,001	400

Rooms						
	Outdoor air concentration	Activity level	Total pollution pr. pers		Supply air / Extraction	
	ci [m3/m3]	[Met]		q [l/s]	VL [l/s]	[h^-1]
Lobby	0,0004	1,5	255	0,07083333333	**118,0555556**	**3,09**
Restaurant	0,0004	6	4284	1,19	**1983,33**	**43,27272727**
Spa area	0,0004	2,2	187	0,05	**86,57**	**1,60**
Massage room	0,0004	2	68	0,02	**31,48**	**4,53**
Changing room	0,0004	2	170	0,05	**78,70**	**8,72**
Sauna	0,0004	1,2	102	0,03	**47,22**	**5,67**
Toilet	0,0004	1,2	20,4	0,01	**9,44**	**6,80**
Disabled-friendly toilet	0,0004	1,2	20,4	0,01	**9,44**	**3,40**
Lounge	0,0004	1,2	244,8	0,07	**113,33**	**1,70**
private						
Couple bedrooms	0,0004	1,2	40,8	0,01	**18,89**	**1,51**
Family bedroom	0,0004	1,2	81,6	0,02	**37,78**	**1,43**
Disabled-friendly couple bedroo	0,0004	1,2	40,8	0,01	**18,89**	**0,97**
Disabled-friendly family bedroon	0,0004	1,2	81,6	0,02	**37,78**	**1,43**
Staff						
Reception	0,0004	1,5	51	0,01	**23,61**	**3,78**
Administration	0,0004	1,5	127,5	0,035	**59,03**	**2,13**
Staff room	0,0004	1,5	255	0,07	**118,06**	**4,05**
Wardrobe room	0,0004	1,5	51	0,01	**23,61**	**2,62**
Toilet and Bath	0,0004	1,5	25,5	0,01	**11,81**	**3,40**
Kitchen	0,0004	1,2	122,4	0,03	**56,67**	**2,15**
Coolroom and storage	0,0004	1,2	20,4	0,01	**9,44**	**2,72**
Laundry and storage	0,0004	1,2	20,4	0,01	**9,44**	**1,13**
Technical room #1	0,0004	1,5	25,5	0,01	**11,81**	**0,94**
Technical room #2	0,0004	1,5	25,5	0,01	**11,81**	**0,26**

REFERENCE LIST

Bygningsreglementet. 2018a. Bilag 2: Tabeller til kapitel 11 - Energiforbrug. Tabel 2 - Generelle mindstekrav til klimaskærm. Internet address: https://bygningsreglementet.dk/Bilag/B2/Bilag_2 viewed: 05/04/2023

Bygningsreglementet. 2018b. Bilag 2: Tabeller til kapitel 11 - Energiforbrug. Tabel 2 - Mindstekrav til klimaskærm ved ændret anvendelse og tilbygninger. Internet address: https://bygningsreglementet.dk/Bilag/B2/Bilag_2 viewed: 05/04/2023

Bygningsreglementet. 2018c. Energiforbrug og klimapåvirkning (§250 - §29) - Energirammer for boliger, kollegier, hoteller og lignende. Internet address: https://bygningsreglementet.dk/Tekniske-bestemmelser/11/Krav/259 viewed: 05/04/2023

ILLUSTRATION LIST

DRAWING FOLDER

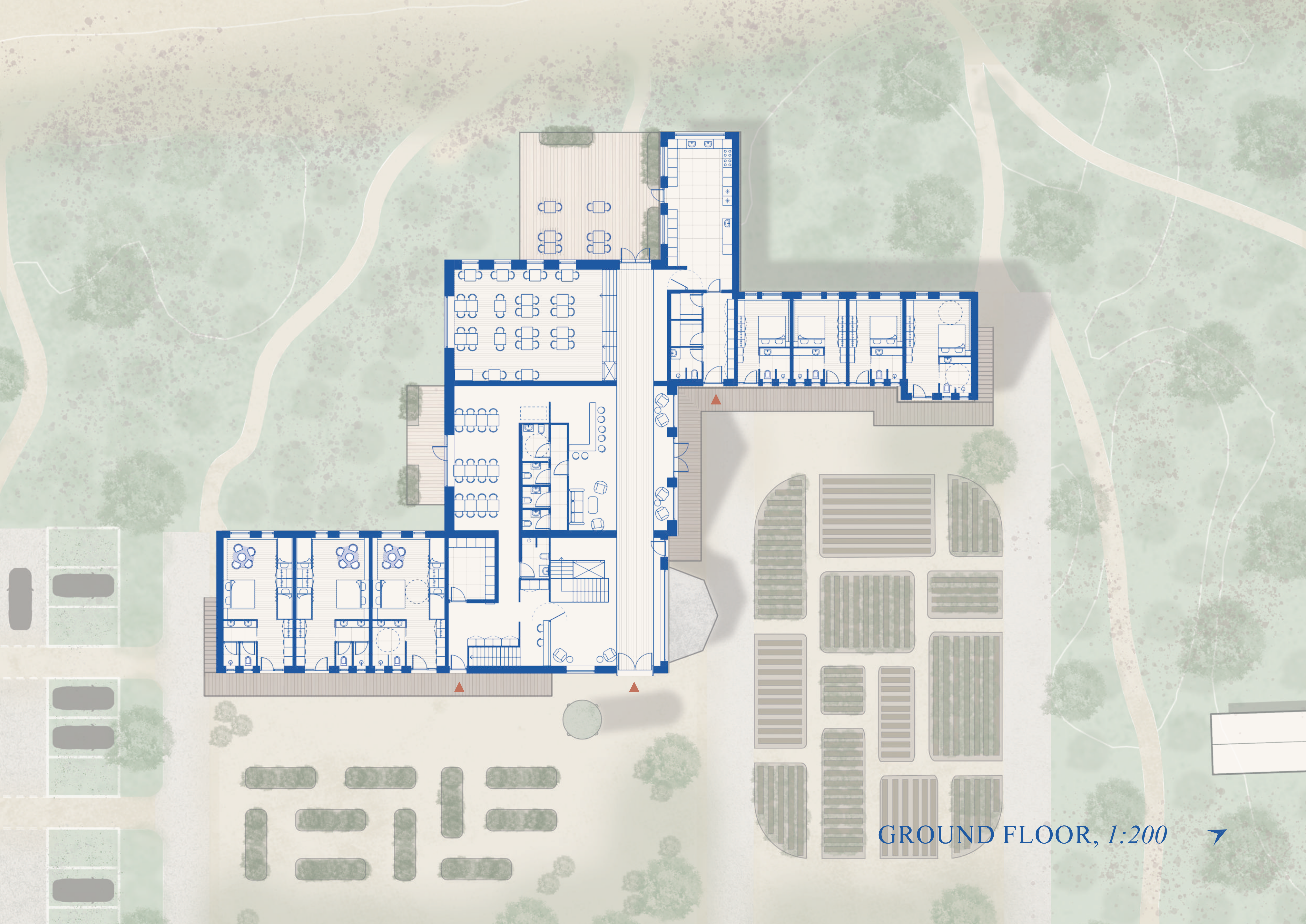
transformation to

SAMSØ BEACH HOTEL

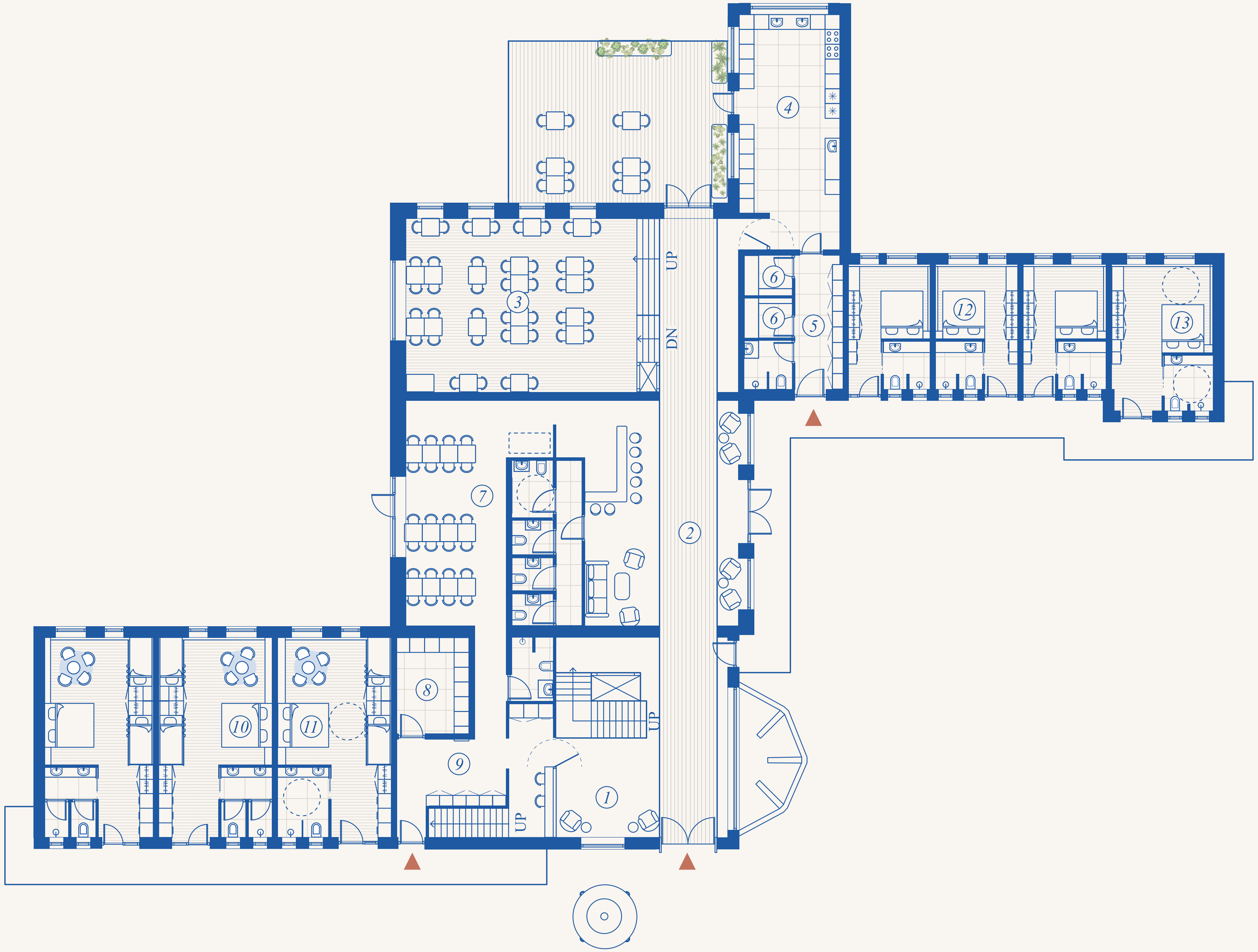
Master Thesis Project
MSc04, May 2023, Aalborg University

ma4-arc4
Camilla Lynnerup Christensen
Kasper Vismar Chrestensen
Maria Lahn Jensen


MASTERPLAN, *1:400*

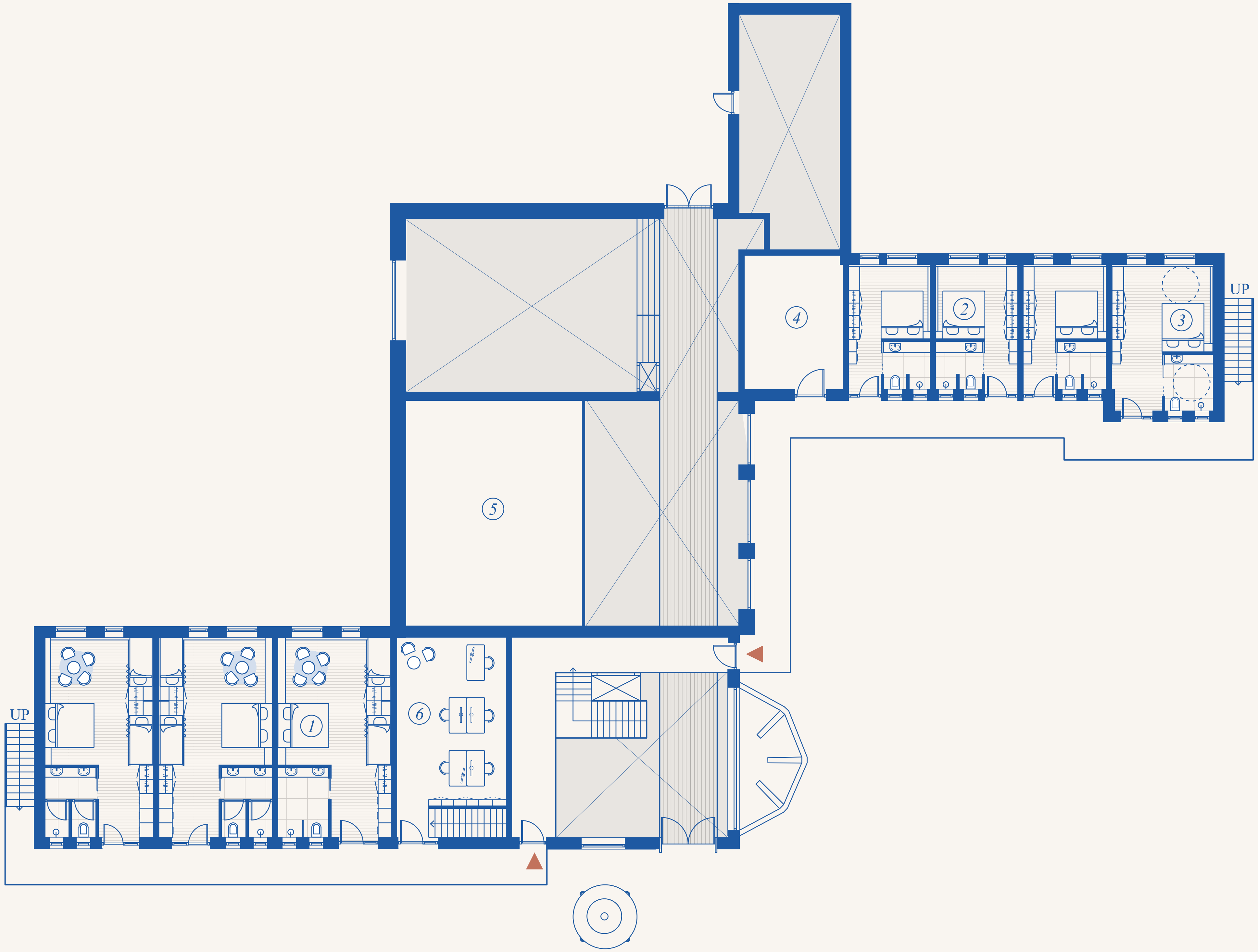


GROUND FLOOR, *1:200*



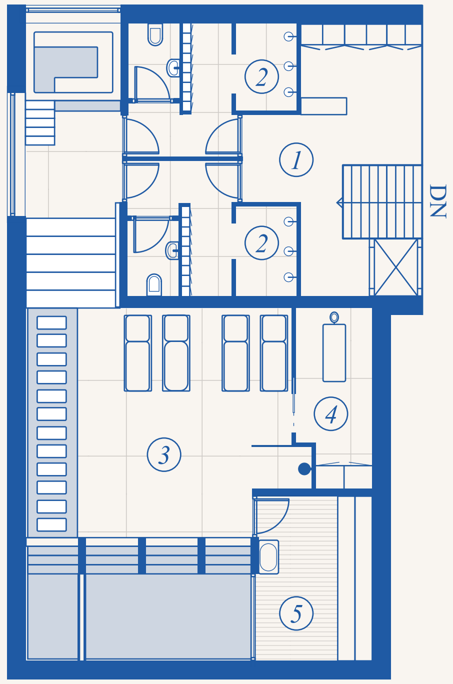
GROUND FLOOR, *1:200*

1. *Lobby, 55 m²*
2. *Lounge, 60 m²*
3. *Restaurant, 66 m²*
4. *Kitchen, 38 m²*
5. *Wardrobe room and delivery, 13 m²*
6. *Coolroom and storage, 5 m²*
7. *Staff room, 42 m²*
8. *Laundry and storage, 12 m²*
9. *Wardrobe room and staff entrance, 13 m²*
10. *Family bedroom, 38 m²*
11. *Disabled-friendly family bedroom, 38 m²*
12. *Couple bedroom, 18 m²*
13. *Disabled-friendly couple bedroom, 28 m²*



1. FLOOR, *1:200*

1. *Family bedroom, 38 m²*
2. *Couple bedroom, 18 m²*
3. *Disabled-friendly couple bedroom, 28 m²*
4. *Technical room #1, 18 m²*
5. *Technical room #2, 66 m²*
6. *Administration, 40 m²*

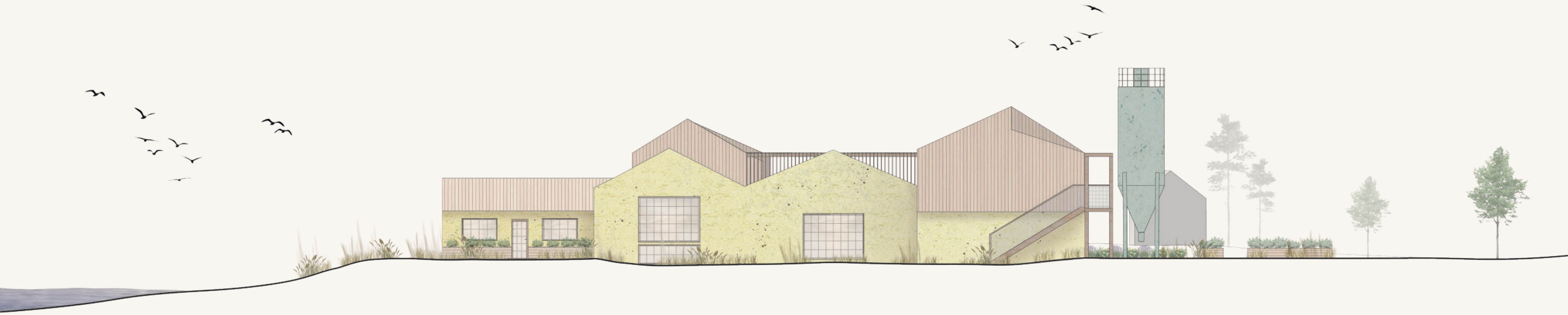


BASEMENT, *1:200*

1. *Spa reception, 25 m²*
2. *Changing room, 13 m²*
3. *Spa area, 78 m²*
4. *Massage room, 10 m²*
5. *Sauna, 12 m²*

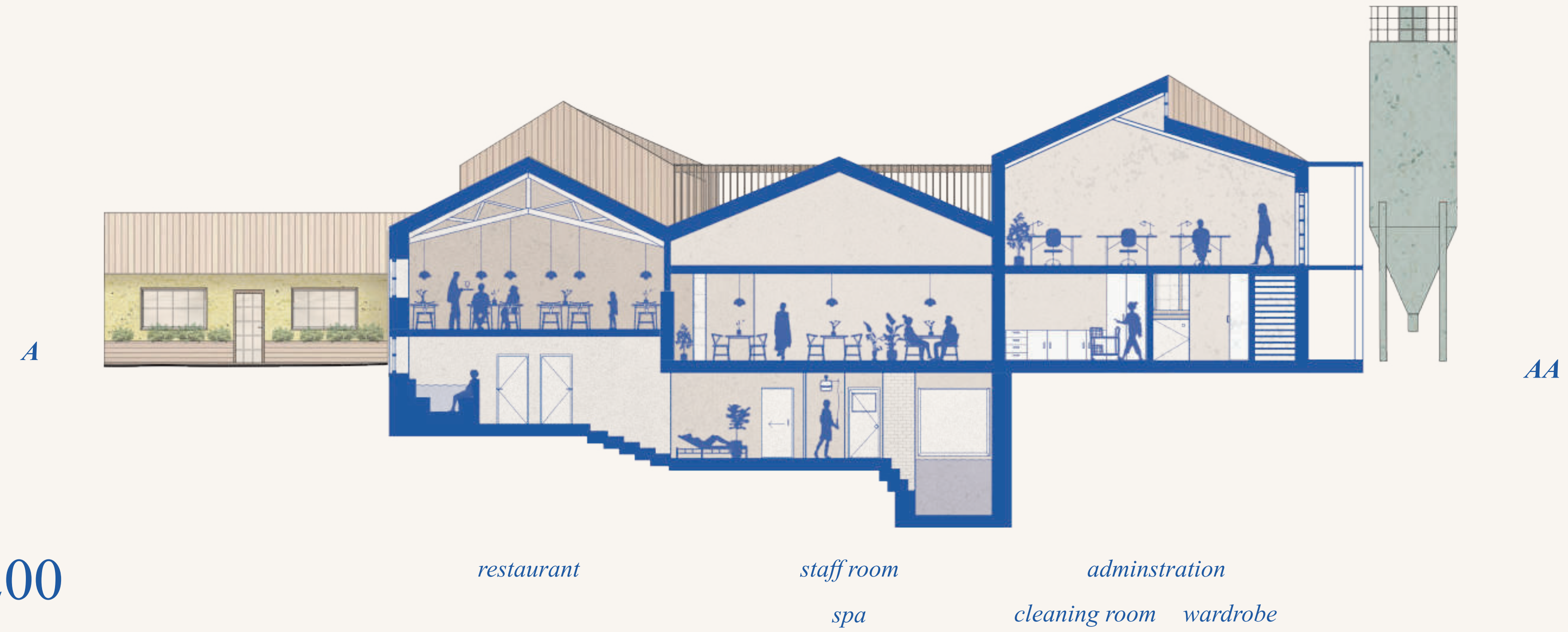
NORTHEAST ELEVATION, 1:200

SOUTHEAST ELEVATION, 1:200

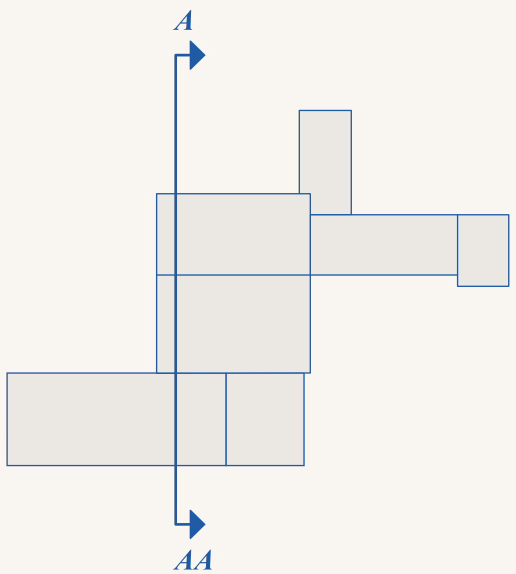


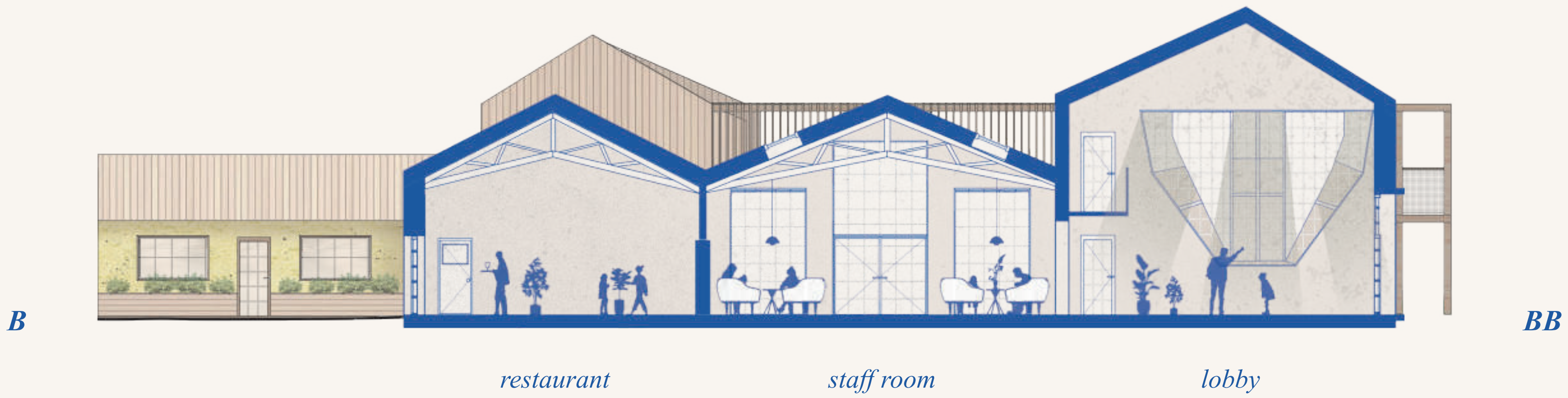
SOUTHWEST ELEVATION, 1:200

NORTHWEST ELEVATION, 1:200

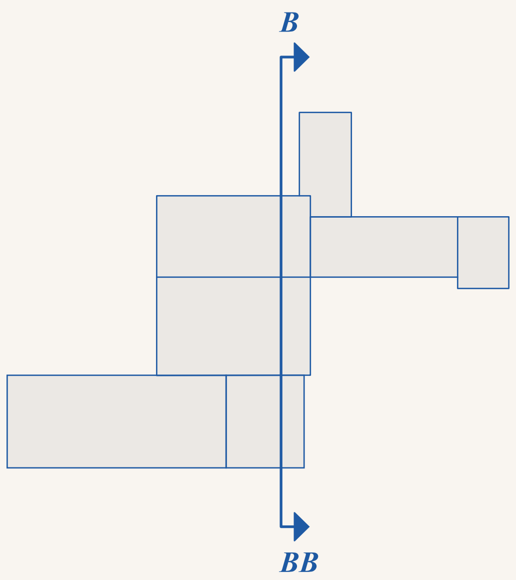


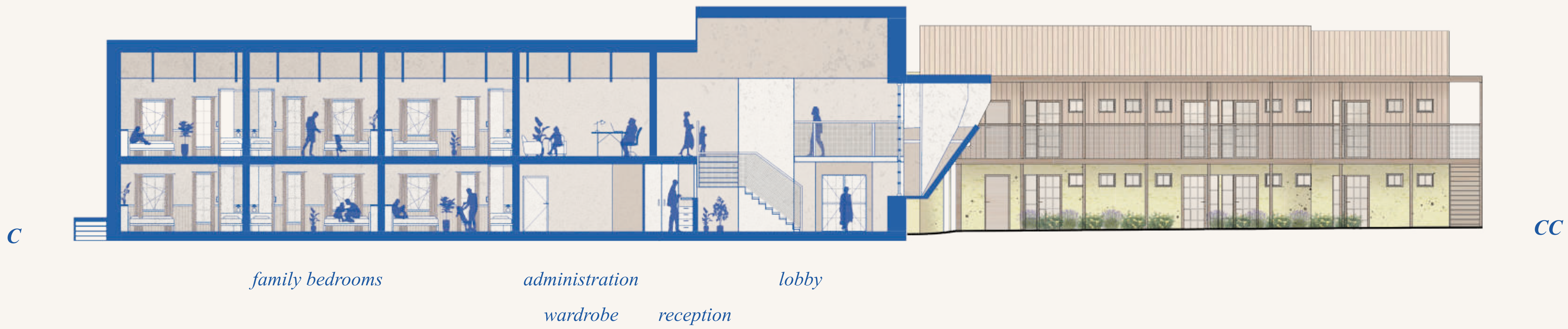
SECTION A-AA, 1:200



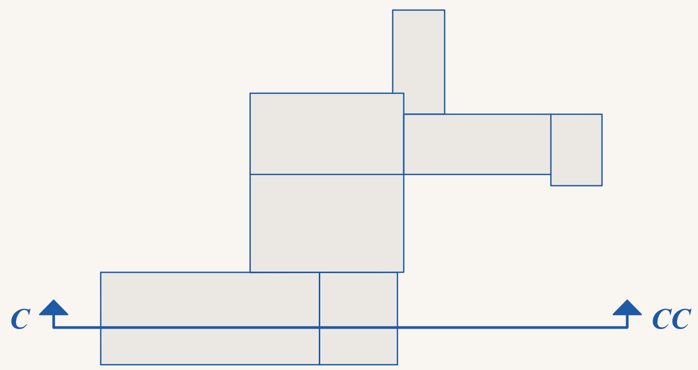


SECTION B-BB, 1:200

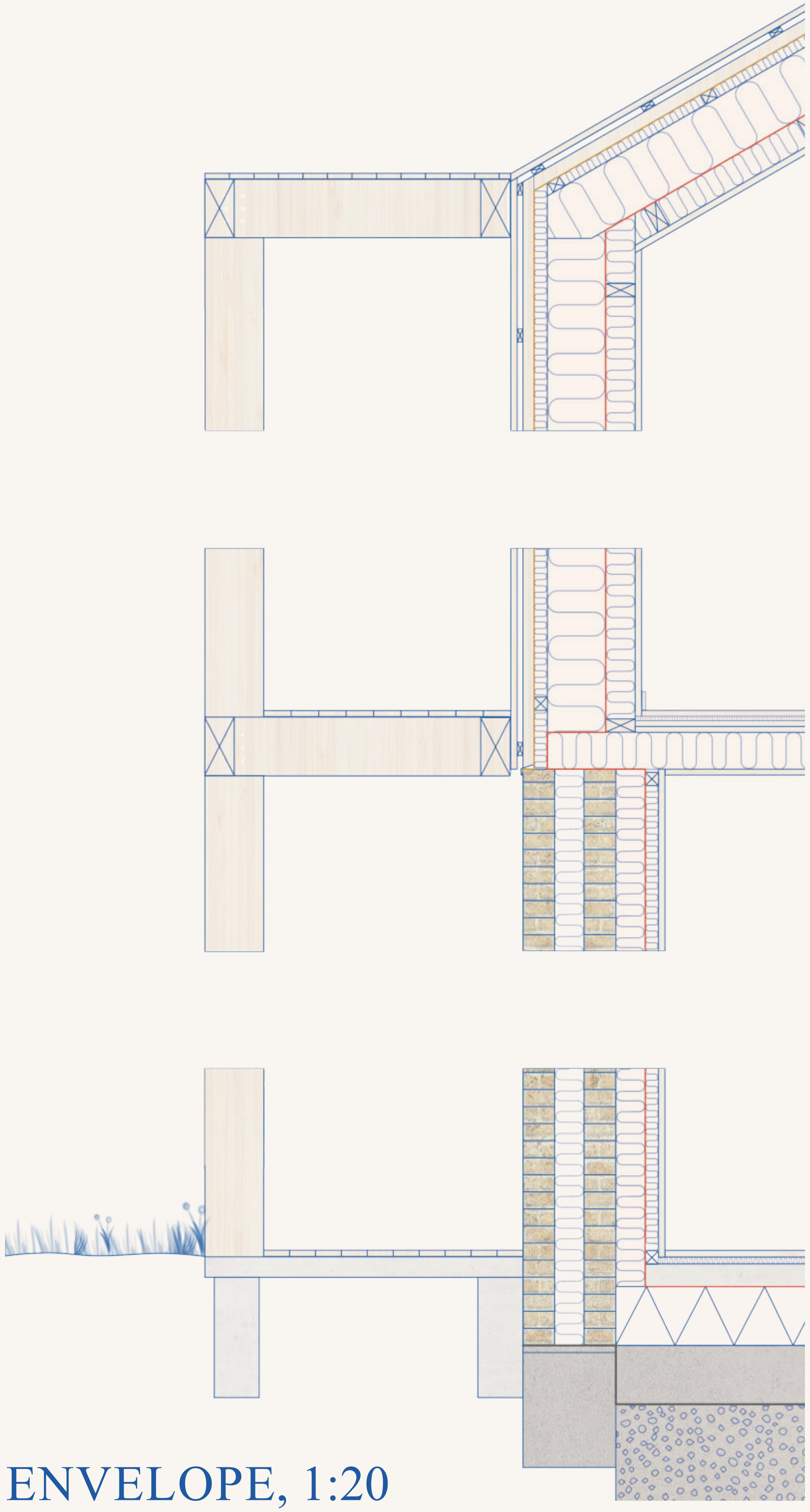




SECTION C-CC, 1:200



ENVELOPE, 1:20



ROOF

$0.13\ W/m^2 \cdot K$, 514 mm

Pine lamellas, 22 mm
Ventilated layer, 20 mm
Ventilated layer, 30 mm
Wind barrier
Straw insulation, 45 mm
Straw insulation, 200 mm
Vapour barrier
Straw insulation, 95 mm
Pine boards, 22 mm

WOOD WALL

$0.13\ W/m^2 \cdot K$, 400 mm

Pine boards, 22 mm
Straw insulation, 100 mm
Vapour barrier
Straw insulation, 150 mm
Straw insulation, 45 mm
Wind barrier
Ventilated layer, 38 mm
Ventilated layer, 19 mm
Pine lamelles, 22 mm

FLOOR SEPARATION

200 mm

Pine plankes, 22 mm
Step reducing insulation, 15 mm
Particle board, 22 mm
Straw insulation, 125 mm
Pine boards, 22 mm

BRICK WALL

$0.15\ W/m^2 \cdot K$, 490 mm

Pine boards, 22 mm
Straw insulation, 45 mm
Vapor barrier
Straw insulation, 100 mm
Wind barrier
Bricks, 108 mm
Rockwool insulation, 100 mm *existing*
Bricks, 108 mm

FOUNDATION

$0.09\ W/m^2 \cdot K$, 687 mm

Pine plankes, 22 mm
Step reducing insulation, 15 mm
Concrete, 100 mm
Vapour barrier
EPS Insulation, 250 mm
Concrete, 100 mm *existing*
Leca granules