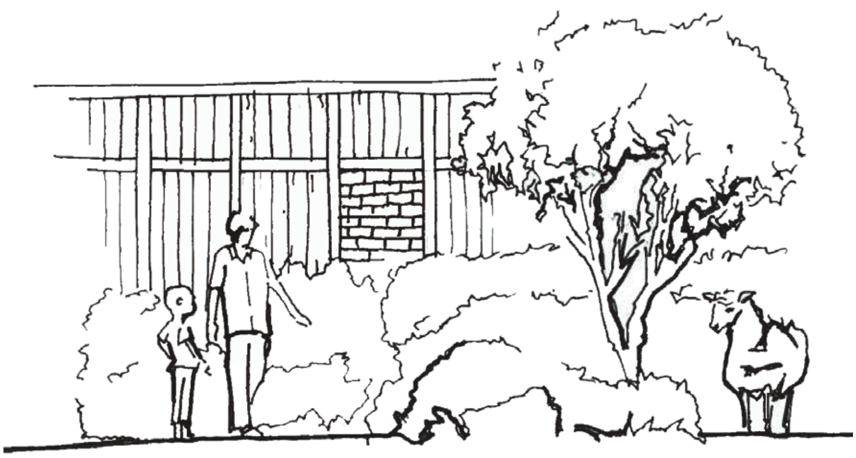

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THE MEADOW - A CHILDREN'S HOSPICE

MsC04 - ARCH19

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Title	The Meadow - Children's Hospice
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Appendix	52

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abstract

The report describes the project of a fictional hospice for children located on the outskirts of Holstebro, Denmark. The project is based on an open architectural competition from Bee Breeders, with the goal of gathering ideas on how to design good children's hospices.

The project showcases how to work with the method of the integrated design process by actively implementing aspects of social and environmental sustainability as well as technical aspects such as indoor climate throughout the project.

The project focuses on creating a comfortable safe haven for terminally ill children and their relatives, providing relief during their last time together. In addition, the project has also investigated how to minimize the global warming potential of the building through modular building and design for disassembly principles to reduce the CO_2 footprint for the hospice and potentially for future buildings.

table of contents

PROGRAM

theory and analysis

01.0

01.1 reading guide

The report is divided into three main parts: program (theory, user analysis, site analysis, program delamination), design process, and presentation, based on the phases of the integrated design process.

In the text, illustrations are referred to with: ”see illustration X”. The illustrations the group does not own are collected in an illustration list at the back of the report. All illustrations are north-facing unless other stated.
Throughout the report, the Harvard reference method is used. In the text, there will be referred to literature by: (name, year). The reference list can be found at the end of the report.

The appendix is referred to by: ”see Appendix X”. The references to the appendix can be found in the separate booklet. If this report is read digitally, it should be read as a two-page spread page display.

Used acronyms:
Design for disassembly - DfD
Global warming potential - GWP
Life cycle assessment - LCA
Deutsche Gesellschaft für Nachhaltiges Bauen – DGNB
Knowledge Center for Rehabilitation and Palliation - REHPA
World Health Organization - WHO
European Union - EU
Building Regulations 2018 - BR18
Draught rate - PPD
Environmental product declaration - EPD
Part per million - PPM

01.2 introduction

The master's thesis investigates how to design a children's hospice, accommodating both daycare and overnight stays for those who needs to stay for a longer period. Offering relief stays for patients and their relatives as well as facilitating a safe and homely environment during the patients last time. Besides designing to provide a comfortable stay, the project also focuses on minimizing the CO_2 footprint.

The project is also a submission to an open architecture competition hosted by Bee Breeders. The competition aims to investigate how to provide a place that supports families and provides care, facilitating this through architecture.

In Denmark, there are two designated children's hospices, and it is estimated that there need to be more hospices to accommodate the actual need. Therefore an additional children's hospice will be beneficial regarding both the overall capacity but also when it comes to the location.

The site of the children's hospice is located just outside the city of Holstebro, surrounded by trees and a lake, and is sheltered from the city. It is a quiet area with small paths for strolling. Even though being surrounded by nature, the site is near to the city. Furthermore, the hospice lies close to Herning Super Hospital, where patients who needs treatment and checkups, which can not be handled at the hospice, can go.

The design relies on palliative principles, a connection to nature, and a focus on environmental as well as social sustainability. Regarding environmental sustainability, the focus is to reduce the amount of materials used in construction and be aware of using reused and recycled materials. The aspect of the construction itself investigates how a modular construction system, focusing on design for disassembly, can be a tool to reduce, reuse and recycle materials.

01.3 integrated design

a holistic approach

Designing well-functioning architecture for people is a complex task. Incorporating sustainability and legislative demands for energy consumption in buildings requires a suitable structuring method to help lead the project toward achieving the best healthy and sustainable building. Here, the integrated design process method is advantageous to work with, as it allows one to incorporate knowledge from the engineering world and sustainability into the project from the start of the design process. This results in a more holistic design that solves various problems such as the functional aspects, energy consumption, indoor environment, technology, and construction all at once. The integrated design process is iterative and contains 5 phases: **problem, analysis, sketching, synthesis**, and **presentation**, see illustration 01 (Knudstrup, 2004).

In the first phase, the **problem** to be investigated is described. In the analysis phase, all the necessary knowledge and information about the building to be outlined is collected. Here, the building's functions, the users, the site, and the sense of the place are are generally examined, including indoor climate and sustainability.
The knowledge gained through the **analysis phase** is used in the **sketching phase** to develop a concept. Here, knowledge from both the world of engineering and architecture is included. In the **synthesis phase**, the building begins to find its final form.

The former Roman architect and engineer, Vitruvius, attributes architecture with three main principles: *firmitas (durability), utilitas (utility)*, and *venustas (delight)*, and believes that a well-functioning architecture is a combination of these principles and that one principle cannot be emphasized higher than the other principles (Bech-Danielsen et. al, 2012). The final design, which makes sure to fulfill the three principles, can now be presented in the **presentation phase** with renders, illustrations, and visualizations (Knudstrup, 2004).

ill. 01 integrated design process

gathering knowledge

litterature studies Different **literature studies** have been used to achieve the necessary theoretical background about hospice care, palliative design, atmosphere, and sustainability. This method was used in the earlier phase of the integrated design process, which helped give the project direction.

case-studies **Case studies** have also been used to achieve knowledge in the earlier phases. This evidence-based research method helped with getting an understanding of the users of the hospice, their needs, and which functions needs to be incorporated into the building. At the same time, it was valuable in creating a room program.

Tools: litterature, research articles, books, field trips, and general knowledge

site analysis

mapping Different studies have been made to find a suitable site for the hospice. Through the studies, the final site got chosen. **Mapping** helped with defining the strengths and weaknesses of the chosen building site. Data such as infrastructure, vegetation, functions, etc., have been presented through mapping. Microclimatic analysis was also made to gain knowledge about the site, in order to be aware of potential conditions which has an impact on how to design the building.

genius loci **Genius loci** is a method of describing the character of a place by looking at the qualities of the place. This method focuses on describing the scale of the place, its use, its history, its content elements, and its perceptibility (Buciek, 2015). This method was used by making site observations of the site and was documented through photographs. A desktop analysis of the site was also carried out to find the right building site as well as the different challenges the site has.

Tools: QGIS, dataforsyning.dk, site visit, photographs, Scalgo

technical methodology

simulations

calculations

To achieve a well-functional sustainable building with a healthy indoor environment, it is necessary to implement calculations and simulations already in the sketching phase. Here there will be made daylight analysis, materials CO2 emission analysis, ventilation, indoor climate, and acoustics.

Tools: BSim, Grashopper, LCAByg, Be18, hand calculations, Excel

idea generating

volume studies During the sketching phase, various image generation tools were used, such as hand sketches and 3D modeling to create volume studies in both Revit and Rhino. Inspiration was also drawn from existing buildings by creating mood boards.

Tools: Volumetric studies in Rhino and Revit, hand sketching, mood boards

design presentation

The final design will be presented through visualizations, renders, floorplans, sections, and facades. The entire process behind the final design, from the problem to the presentation phase, will be compiled as a report in InDesign. This report will provide a deeper understanding of the choice and the thoughts behind the design.

Tools: Rhino, Revit, Autocad, Photoshop, Illustrator, InDesign, Lumion

01.4 subconclusion

methodology

In order to design well-functioning architecture, three main principles must be combined: durability, usability, and aesthetics. To structure the design and apply various requirements, including sustainability and legal requirements, the Integrated Design Process method will be used. It will allow the incorporation of knowledge from the world of engineering and sustainability into the project from the beginning of the design process, resulting in a more holistic approach to solving various design problems.

02.0

ill. 02 picture from the site - Vandkræftsøen

ill. 03 sustainability

02.1 sustainability

past, present and the future

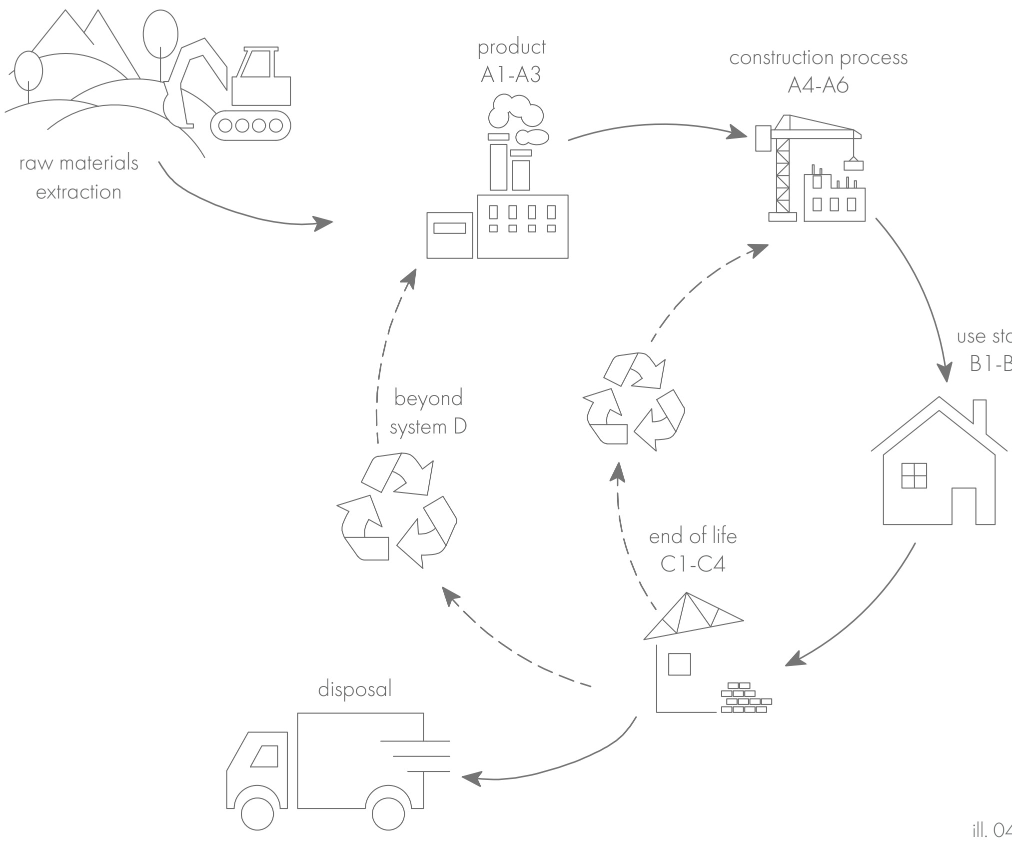
introduction "The Paris Agreement from COP 21 in December 2015 bids there average global temperature must not exceed 2°C, and the goal is to be well below 1,5°C increase. EU's contribution to achieve the goal was to reduce its carbon emissions by 40% by 2030 compared to the reference year 1990, for all member states (Paris Agreement, n.d.). In 2019 a majority of the parties in the Danish parliament agreed to a law on climate decreeing a 70% carbon emission reduction by 2030 and carbon neutrality by 2050 (L 117 Forslag til lov om klima, 2017).

Global Warming Potential and Life Cycle Assessment

In 2021, a national compromise was made to ensure the building sector will achieve the reduction goal. The National Compromise is a plan to slowly decrease the limit value of Global Warming Potential (GWP) from 12 kg CO_2 eq./m^2/year in 2023 down to 7,5 kg CO_2 eq./m^2/year in 2029. Besides the limit values, there have also been set limits regarding a voluntary limit value of 8 kg CO_2 eq./m^2/year in 2023, decreasing to a limit of 5 kg CO_2 eq./m^2/year in 2029 (Bolig- og Planstyrelsen, 2021).

Today the average building in Denmark has a GWP of just below 10 kg CO_2 eq./m^2/year based on a report by BUILD Aalborg University from 2020 (Regitze Kjær Zimmermann et al., 2020). The report establishes standard values of the GWP of different building types based on multiple examples. It gives a point of departure regarding how much CO_2 reduction will be needed to achieved the 2030 goal and which constructions are close to achieving the goal already.

Life Cycle Assessment (LCA) is the method to calculate the GWP of a building, and if implemented early in the process, can be a key factor in lowering the GWP without compromising the design, but be an active part of the process and contribute to the design." (Dupont, 2023).



ill. 04 LCA

Sustainability certifications
Where GWP quantifies the CO2 impact of buildings, there are other parameters to consider when assessing sustainability. Third party sustainability certifications such as DGNB and Nordic Swan Eco Label are tools to ensure a standard of high sustainability quality. It is a holistic approach, meaning it takes a lot of aspects into account, when making the sustainability assessment. In DGNB, Environmental,-Social and Economical sustainability makes up the most part of the assessment, where the factors Technical quality, Process quality, and the Site quality have a lower weighting in the assessment (Green Building Council Denmark, 2020).

This project can benefit from this holistic approach, being aware of incorporating different aspects of sustainability and actively integrating them in the design process.

Our approach
In this project, LCA will be an active part of the design process when determining which materials to be used. To make the process clear and ensure a holistic approach, a model will be used, (see page 23-26) which will evaluate different construction solutions, in all the parts of the construction. For an example will the GWP be quantified for different roof solutions and at the same time the atmospheric value will be assessed. The properties and additional comments will act as an opportunity to highlight if a material/construction excels at something extra, such as sedum roofs abilities when it comes to rainwater treatment or if the material/construction would have been preferred from a DGNB perspective.

This approach can easily be modified depending on the project. In the case of this master's thesis, the economical aspect is ignored.

ill. 05 Guillaume, (2020)

02.2 design for dissasembly

reduce, reuse, recycle

Back in 1960, the world extracted 21 billion tons of raw materials due to expanded urbanization and economic growth. In 2020, the amount of extracted raw materials has risen to 84 billion tons. To work against depleting the world's resources, we must reuse and recycle the already existing materials (Anastasiades, 2021).

Design for disassembly (DfD) is the principle where the materials used in construction will be taken apart and reused. This differentiates from recycling, where the materials potentially are made into something new. Where in recycling there is spent energy and resources on making something new, reusing the materials minimizes the need for producing new materials, and by that reduces the amount of raw materials extracted. When working towards DfD as a construction principle, the construction method and the whole supply chain are essential. DfD is hard, if not impossible, to implement if there is no industry to accept the materials and make sure the materials can be sent and used again. Therefore, as architects, creating the demand for supply chain systems is significant. Establishing take-back systems is crucial for DfD, and the industry must evolve towards reusing instead of only relying on producing new. These aspects have little to do with design, but architects and engineers need to be aware of what materials are used and how they are used. Standardization is crucial for DfD as it makes it easier to reuse materials if they have the same dimensions, construction methods, and making joints that do not damage the materials. This is already quite far from the implementation of Eurocode, widely standardizing the materials. Still, there is for now no standard on how to build, where the structural integration of materials is secured not to have deteriorated (Anastasiades, 2021).

case study Wooden Nursery by Djuric Tardio:
Located in a park with protected trees, the wooden nursery was not allowed to do any damage to the roots of the trees. The nursery's location was limited to two years and would be disassembled and moved to another location after this. Therefore the architects had the challenge of designing for disassembly. Their approach was a modular grid-based design where the individual modules are self-bearing, which allows the opportunity to reshape the building and easily change the function if needed. In addition to the modular approach, the idea was to "reverse" the building process by making it possible to dismantle the building.

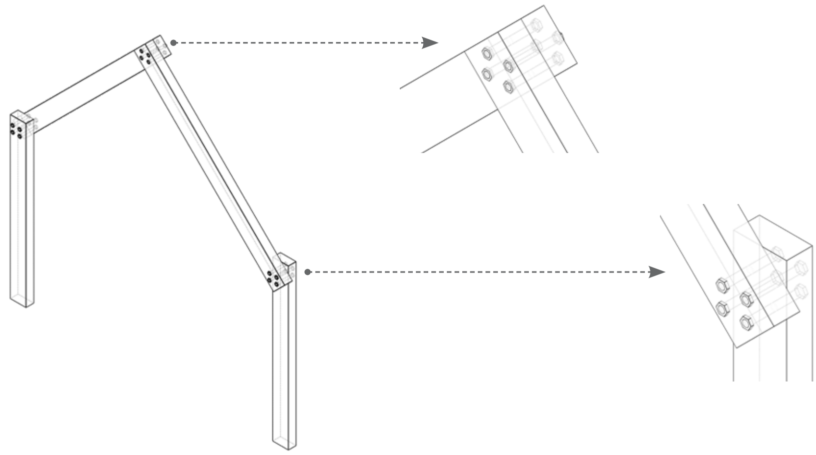
There is no standardized way of constructing joints and other parts of the building regarding DfD. As each design is unique in its own way, but in general, there are simple principles to use:

- Use nuts and bolts to assemble parts
- Do not use glue, screws, and nails as far as possible
- Create parts that can be completely dismantled into individual pieces or take the whole part to be reused elsewhere (Cutieru, 2020)

The following examples on joints and construction parts relies on the principles of DfD and will act as the point of departure when designing the final construction parts for the design.

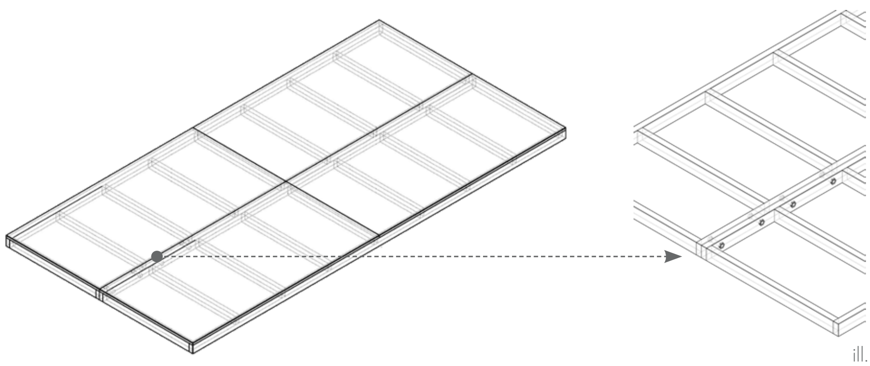
construction systems based on DfD

truss system Using nuts and bolts to join the truss with the columns. This system can be taken apart into all the different parts which are being used, see illustration 06.



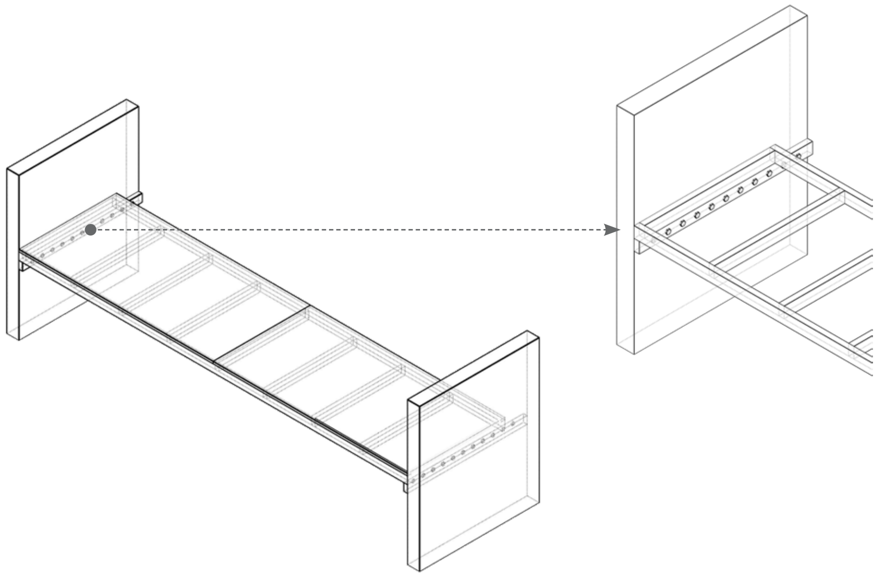
ill. 06 truss joints

ground deck The ground deck is in sections the size of two standard boards, such as OSB with the dimensions 1220 mm X 2440 mm per section, which in total becomes 1220mm X 4880 mm. The deck can be used on traditional concrete foundations as well as screw foundations. This construction part can not be disassembled into all the materials used, but the deck section can be reused with any other deck sections to create a new building. Two sections will be fastened together with nuts and bolts, see illustration 07.



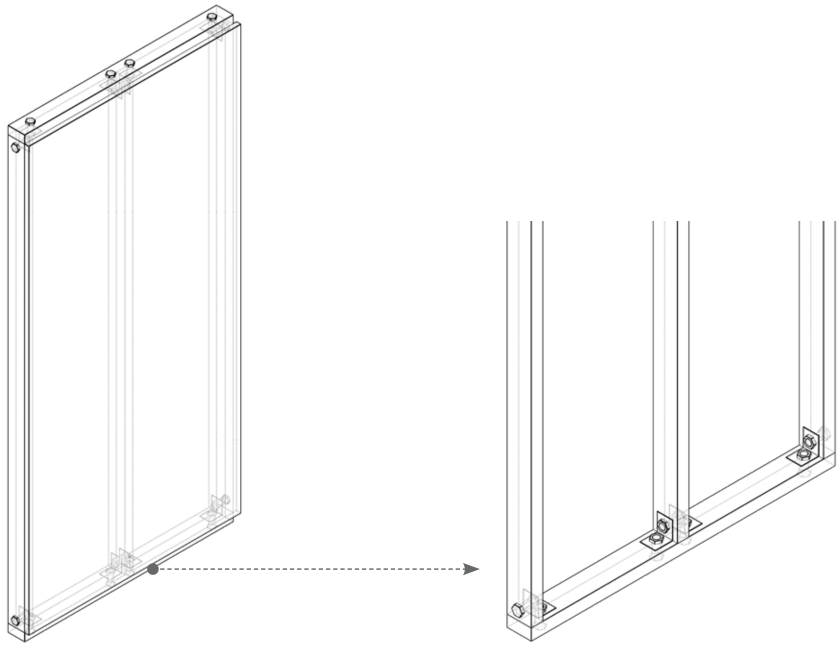
ill. 07 ground deck joints

horizontal division In this example, the horizontal division uses the example of a deck construction. The deck rests on beams attached to the wall with nuts and bolts, making it easy to disassemble, see illustration 08. The wall itself can be CLT or concrete, and if the holes from the bolts are filled, able to be used in a variety of other uses.



ill. 08 deck joints

light wall The wall construction is very similar to how a regular wall would be made, except using nuts and bolts instead of screws for easy disassembly, see illustration 09.



ill. 09 wall joints

02.3 japanese architecture

going back to the roots

Vernacular architecture, whose techniques were based on the relationship with the natural environment, is essential in the context of sustainable development methods. Traditional Japanese architecture is an example of design practices where construction methods have been adapted to improve the quality of life for residents, and many sustainable design techniques have been used. Japan experiences numerous natural disasters. Possibly because of these dangerous environmental features, Japanese architects recognized the importance of the natural properties of wind, sun, water, and materials and incorporated them into building designs. In this way, these features were used as part of the design for the benefit of users, not as something beyond their control (Angen, 2012).

Several fundamental principles can be distinguished in the complex history of Japanese architecture. Traditional architecture is characterized by a preference for natural settings and materials: reeds, bark, clay, and especially wood, which is appropriate for the Japanese climate. Traditional Japanese architecture is also characterized by attention to detail, even despite the possible apparent effect of a simple building form. This applies to both technological and design features. An example is the complicated joinery of a traditional building, which allows for its assembly without using nails and periodic disassembly for repairs. Repetitive patterns are also used to create a visual rhythm that is well-integrated and unified. The Japanese put a lot of effort into the protection and maintenance of buildings, so they know how to deal with the properties of wood. Renovation was common, consisting in replacing those parts of the building that had been destroyed by the forces of nature, or that had decayed over time and could not be saved. In traditional Japan, it was also the usual practice to reuse partially destroyed materials to construct or repair other buildings (Young and Young, 2007).

Contemporary architecture can benefit from using traditional techniques combined with modern technologies. However, people tend to associate tradition with obsolescence. An obstacle to the widespread use of vernacular styles is that many people may not want to reside in spaces where, e.g., natural materials have been used. Materials coming straight from the environment may be considered primitive or grimy by many people. This attitude is common to the modern concept of comfort. It is, therefore, important how traditional features are presented in the design, bearing in mind that the aim is to improve sustainability without sacrificing comfort. What can be drawn from the Japanese design tradition are the elements based on which a more sustainable design can be created, i.e., the availability of light, natural views, wind, flexible space, and natural materials, as well as how connections between elements are designed. The basic principles of traditional architecture should be applied, remembering to adapt it to a specific environment and culture (Angen, 2012).

02.4 tectonics

Marcus Vitruvius defined architecture as composed by three aspects venustas (delight), utilitas (utility), and firmitas (durability). Together these qualities give form and beauty to architecture by incorporating the construction, usage, and aesthetics into the design, actively using what they all bring, and showing their potential (Bech-Danielsen et. al, 2012).

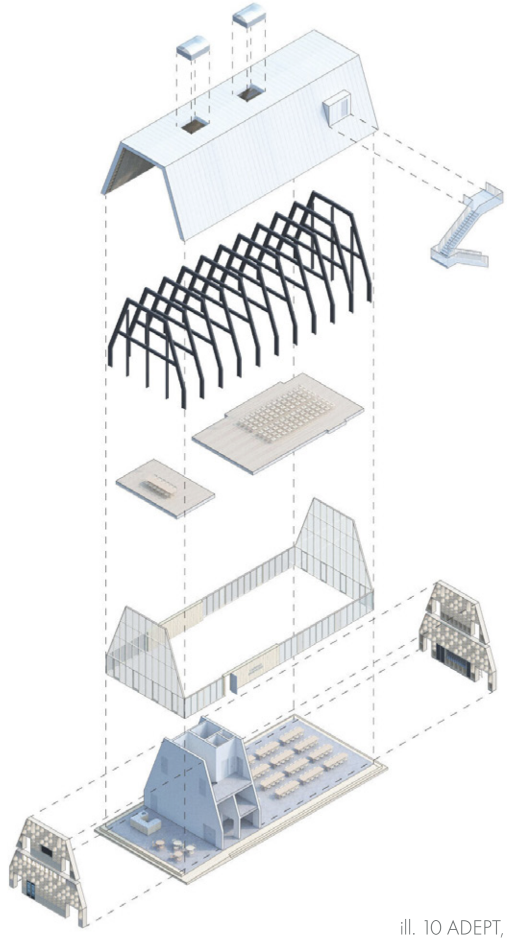
The principles when designing for disassembly has a significant impact on the structure of a building. The constructive system, as well as the other materials, must be able to be reused, and this affects the visual outcome of the design. Joints and materials must be integrated in the design process, for the constructive system to ensure the principles of DfD will not compromise on the design.

02.5 Braunstein Taphouse

Location: Køge, Denmark
Build: 2018-2020
Architects: ADEPT

The Braunstein Taphouse is a 1000m2 restaurant and event house. TThe harbor heavily influences the building it is located at, taking inspiration from the nearby old warehouses. The taphouse is designed with the idea of it being able to be disassembled into smaller construction parts if there is no more need for the building as it is, see illustration 10. The construction parts can be taken apart and reassembled at another location, or the individual parts can be part of a new building. The building is split into different main construction parts, and to make recycling more accessible, a few different materials have been used. The building is divided into the load-bearing system, roof, glass facade, floor separation, and inner walls. The construction parts are all assembled with mechanical joints only (ADEPT, 2020).

The building itself has its load-bearing construction visible. The glass facade and the visible construction system gives an impression of an open, welcoming, and honest building. Nothing is left to the imagination, as the design shows the potential beauty the load-bearing system can contribute. In addition, in-built furniture contributes to the idea of integrated design, as the function, technical and aesthetic aspects all contributes to the final form of the taphouse.



ill. 10 ADEPT, (n.d.)

daylight and view	atmospheric comfort	thermal comfort	acoustics
• 10% glass area of relevant floor area • 300 lux	• air supply 0,3 l/s • 20% draught rate • Max. 1000 ppm CO_2	• max. 100 hours above 27°C and 25 hours above 28°C	• Reverberation time T ≤ 0,9 seconds at 125 Hz • Reverberation time T ≤ 0,6 seconds at 250-4000 Hz

table. 01 regulations for indoor climate

02.6 indoor climate

for a healthy home

The indoor climate must ensure the well-being of the people using the hospice and avoid discomfort and hazards.

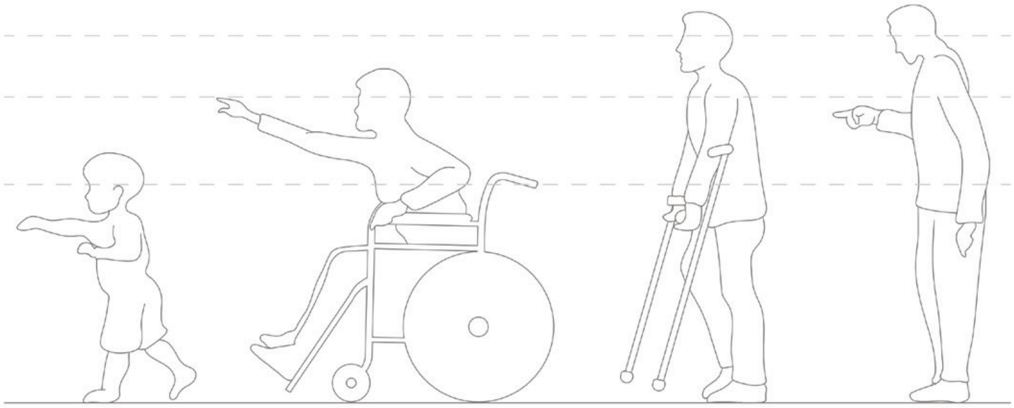
Daylight and view
In buildings, there must be light conditions which ensures there does not occur risk of personal safety or discomfort. There must be sufficient daylight, vision, and artificial light regarding function.
Sufficient daylight can be documented by having a glass, without shadowing elements, an area equal to at least 10% of the relevant floor area. The glass area must be corrected in regard to surrounding shadowing elements, reducing light transmission, etc. Alternatively, it can be documented by proving at least 300 lux, from daylight, in at least half of the relevant floor area. For working spaces, the relevant floor area is the workstations (BR18: §377 - §384, n.d).

Atmospheric comfort
The building must secure sufficient air quality and humidity regarding function. There must be an outdoor air supply of at least 0,3 l/s per m^2, and the airflow must be calculated depending on which category building it is. Furthermore the draught rate (PPD) must not exceed 20% PPD, which depends on temperature and activity level. Air quality must not exceed 1000 ppm CO_2 (BR18: §420 - §452, n.d.).

Thermal comfort
Buildings need to have a healthy and comfort satisfactory thermal indoor climate regarding their function. In the hospice, it is also important to control the temperature due to the scenario where a patient dies, it is important to be able to lower the temperature in the patient's bedroom.

In general, for thermal indoor climate, the temperature in the used time, must not exceed 27°C for more than 100 hours/year and 28°C for more than 25 hours/year (BR18: §385 - §392, n.d.).

Acoustics
Buildings must have healthy, comfortable, and satisfactory acoustic conditions regarding function. It is important to remember that some of the patients at the hospice are very sensitive to sound, which is essential to take into account in their private rooms. The reverberation time must be less than 0,9 seconds at 125 Hz and less than 0,6 seconds if the sound is 250-4000 Hz in occupied rooms (BR18: §377 - §384, n.d.).



ill. 11 universal design

02.7 universal design

a house for everyone

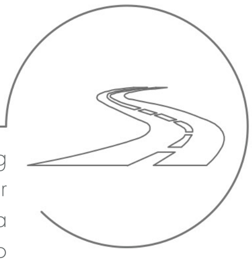
The design process should be related to the concept of building a society based on equal opportunities and non-discrimination. Such action requires empathy to consider the needs of people who may be socially excluded due to their disabilities.

Universal design can be defined as a process that aims to improve human performance, health, and well-being, allowing for participation in social life. This process aims to make life simpler and friendlier for all, with the goal of universal access to resources and benefits. (Steinfeld, et al., 2012)

People vary in size and height, from children to adults. This means that the arrangement of elements in the building and their height should to consider in the design process. For developing children, it is crucial to create an environment that is safe and accessible to them. Elements of this environment should be safe and age-appropriate (The National Disability Authority's Centre, n.d.).
It is worth remembering that designing for one group may result in solutions that meet the needs of others. Elements that, among others, are worth paying attention to during the design process are:

- stepless level entry facilitating movement not only for people in wheelchairs and with prams, it will also be helpful for people with suitcases or people with sight problems
- larger toilets that provide easier access for wheelchair users, parents with pushchairs or accompanying young children, or those using walking or mobility aids
- clear, well-placed signage to assist those with reading or cognitive difficulties
- ensuring equal access from the street adapted for wheelchairs
- installing a series of counters at different heights. (The National Disability Authority's Centre, n.d.)

The Building Regulations (BR18) contain requirements relating to the principles of Universal Design to be followed during the design process:



- An appropriate number of parking spaces for vehicles adapted for disabled people with a usable area of 3,5 m x 5,0 m, located as close to the entrance as possible.
- Level differences in the access zone from the parking to other zones are to be a maximum of 2,5 cm.
- Common access routes leading to two or more buildings must be at least 1,30 m wide, marked with different materials, colors, or lighting, and any level or height differences must be leveled with ramps.

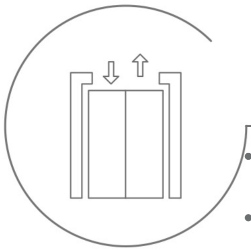
(BR18: §56, §401, n.d.)

- A free area with a diameter of 1,5 m in front of the toilet and free from the opening range of the door.
- The passage through the door to the toilet rooms must be a minimum of 0,77 m.
- Folding armrests must be set at a height of 0,80 m on both sides of the toilet.

(BR18: §52, §223, n.d.).

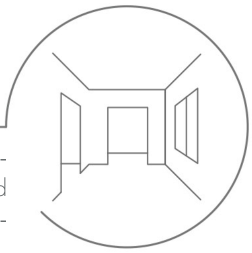
- External doors must have a free passage width of at least 0,77 m, on the side of the door opening towards the person, there should be at least 0,50 m of free space.
- At the building entrance, a horizontal, hard and even area of 1,5 x 1,5 m outside outer doors, measured from the hinged side of the door, should be provided.

(BR18: §51- §52, n.d.)



- Access to elevators, including people with disabilities
- In new buildings with 3 or more storeys, at least one lift providing access to each storey.
- Differences in levels should be compensated in the access area to the elevators on the ground floor of the building.

(BR18: §244- §246, n.d.)



- Corridors, stairs, and ramps in shared access routes must be equipped with grip-friendly handrails at approximately a height of 0,80 m.
- Corridors, staircases, and ramps must be protected with fencing. The height of fencing/railings are min 1,0 m, at staircases with a clearance over 0,30 m and balcony corridors is min. 1,20 m.
- Corridors, anterooms, etc., must have a free passage width of min. 1,0 m.

(BR18: §52, §58, §209, n.d.)

ill. 12 requirements to universal design

02.8 hospice care

a historical review

Saying goodbye to life, should be in the best conditions as possible for the suffering person and those close to them. These conditions can be achieved by hospices covering the needs and setting frameworks and values for the patients and their relatives.

Creating well-functioning hospices requires a deeper understanding of the building's actual purpose, the needs and wishes of the building's users, and the work processes that will take place in the building. The development of the hospices through a historical perspective as well as the understanding of hospices today, can give an idea of what the building needs to fulfill.

The understanding and meaning of hospices have changed over the years. The word "hospice" comes from the Latin word Hospitium, which refers to "a house of shelter or rest for pilgrims, strangers, etc." (Definition of hospice, n.d.).Today's modern hospice can be defined as a house that provides care and quality of life for terminally ill people and their relatives. This modern hospice development was inspired by Dame Cicely Saunders, a 20th-century British nurse and social worker interested in caring for terminally ill patients. Her experiences through the years led her to develop the first modern hospice, St Christopher's Hospice in London in 1967, and to focus on palliative care.

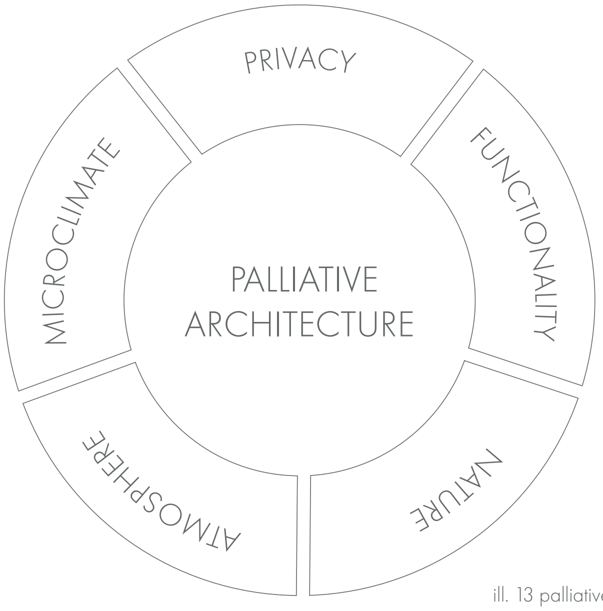
Hospices and palliative care came to Denmark in the 1990s. Denmark's first hospice opened in 1992, Sankt Lukas Hospice in Hellerup, and since then, 55 specialized palliative care units have been established in Denmark. Twenty of them are regular hospices, where two of them are children's hospices, nine specialized palliative wards, and 26 palliative teams (Ældresagen, 2022).

Palliative care:
Although medical treatment methods have improved in later years, not all diagnosed diseases can be cured. When facing these kinds of problems, palliative care greatly relieves symptoms and suffering associated with an incurable disease.

Palliative care uses a team approach to support patients and their caregivers. The work is based on a high degree of interaction between different professions, such as doctors, nurses, psychologists, dieticians, social workers, and music/light therapists.

Saunders' development of the hospice philosophy has influenced and inspired the World Health Organization's (WHO) definitions of palliative care. In 1990, the WHO defined palliative care as the total care of patients whose disease is not responsive to curative treatment. (WHO,1990). This definition indicates that palliative care is used when all other curative solutions have failed. However the WHO redefined the understanding of palliative care as an approach that improves the quality of life of patients and their families who are facing problems associated with a life-threatening illness. It prevents and relieves suffering through the early identification, correct assessment, and treatment of pain and other problems, whether physical, psychosocial, or spiritual (WHO, 2020).

Today's hospices do not only have patients with life-threatening illnesses but also patients with chronic conditions that are not life-threatening. These patients need temporary care and pain relief and are not long term residents in the hospice. Typically, they will be in the hospice during critical periods of their illness and be sent home again, but still be in contact with the hospice, see appendix 01 (Højer, 2023).



ill. 13 palliative architecture

02.9 palliative architecture

a house for hope

Palliative architecture focuses on architecture's influence and interplays with the palliative efforts of people affected by life-threatening illnesses, their relatives, and the staff in the various units.

Knowledge center for rehabilitation (REHPA), has developed five design principles for palliative architecture; functionality, light-sound-air-temperature, nature, privacy-relations, and atmosphere. Design principles are seen as a whole, where all perspectives are equally relevant (REHPA, 2017).

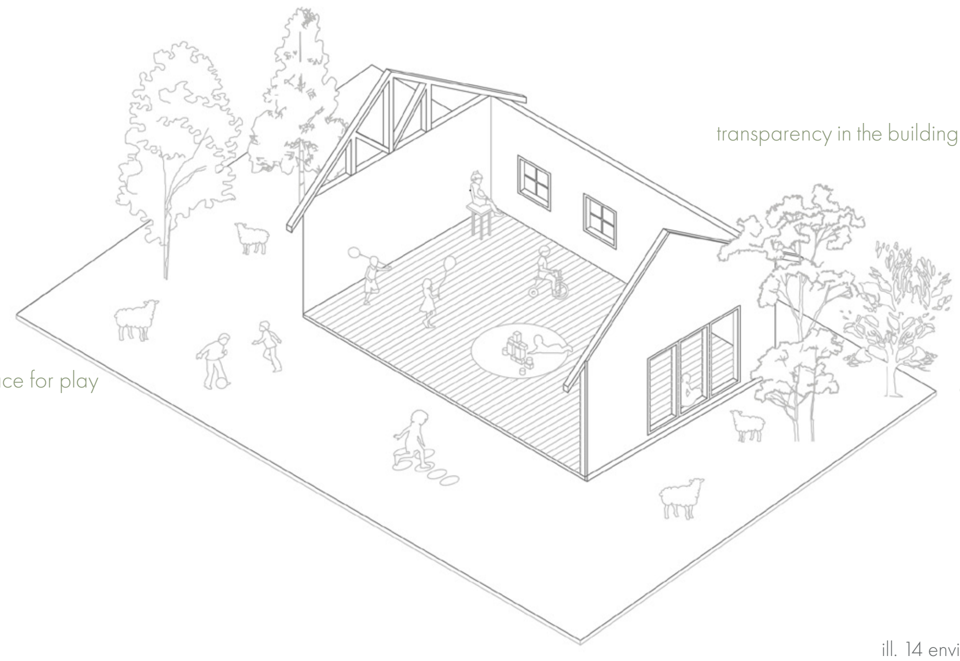
Functionality:
The design criteria, functionality, covers the influence of the surroundings on the staff's work processes and working environment, the patient's safety, the possibility of orientation (way-finding), and the flexibility of the design (Funktionalitet, REHPA, 2017).

Light-sound-air-temperature:
It is important to have a healthy indoor climate, especially when working with healthcare buildings. This design criterion focuses on the importance of light to improve sleep quality, mental disorders, pain, etc., sound to be able to provide a peaceful and quiet environment for users, good air quality and good ventilation possibilities, and suitable room temperature (Lys-lyd-luft-temperatur, REHPA, 2017).

Nature:
It is essential to emphasize nature in architecture to relieve of stress, pain and depression. It is, therefore, essential to have access to outdoor areas/nature, which is an important element both for patients and relatives. The design principle of nature can be incorporated into architecture through everything from staying in a garden, being surrounded by a city, and having a view of wild nature such as a forest, to having plants inside the building, to some extent also images of nature in living areas (Natur, REHPA, 2017).

Atmosphere:
The atmosphere in a hospice has great significance for the experience both the patients, their relatives, and the staff have during their stay. A calm, homely, bright, and dignified atmosphere can help to create a happy and well-being environment for the users of the building (Stemning, REHPA, 2017).

Private life relationships:
Patients, relatives, and staff have social and private needs that must be satisfied. The design criterion focuses on creating a framework for privacy when there is a need to be alone and also social spaces where different sizes of groups can integrate and create pleasant and social activities (Privatliv - relationer, REHPA, 2015).



ill. 14 environment for children

02.10 environment for children

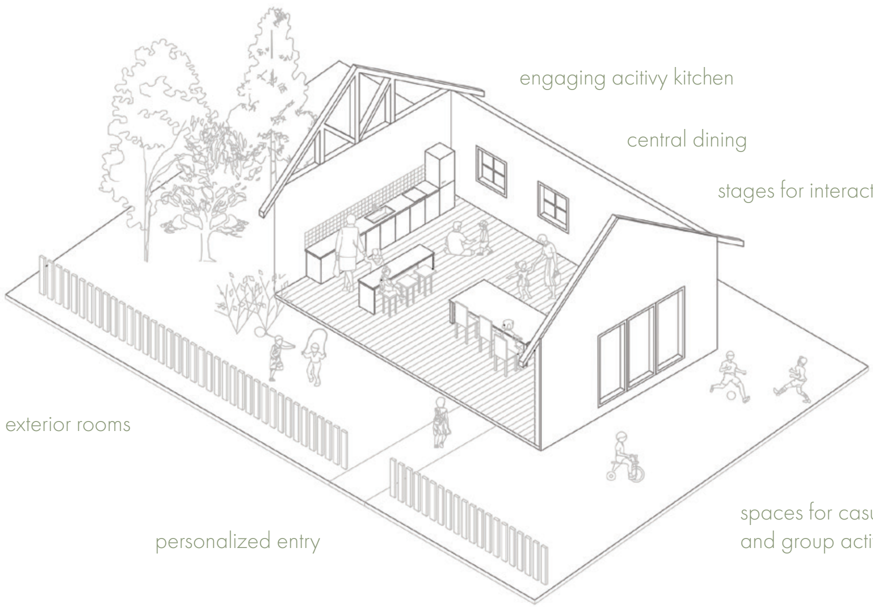
healing while playing

People of different age groups have different needs. Current hospice programs are based mostly on adults, however, the needs of children vary from adults, which has to be considered. How they perceive and interact with their surroundings is different, and it is necessary to create a framework with only children in focus (Dudek, 2005), (Scott, 2010).

When children go through an illness, they will also be exposed to pain. These pains can stress and can manipulate behavior change. It is important to incorporate different parameters into the building to change their focus to something else and stimulate them. Children are constantly trying out new things by investigating and experimenting, so to support this, it is beneficial to create room for these needs. Observing and learning from the elderly is also part of children's nature. It is therefore, important to create spaces for children where they can be in contact with the elderly both formally and informally (Dudek, 2005), (Scott, 2010).

Children are exceedingly aware of the symbolic messages which buildings transmit, thus it is important to incorporate different parameters in the building such as (Dudek, 2005), (Scott, 2010):

- Transparency between different areas in the building, so the children can have an understanding of what is happening in the building
- Creating outdoor spaces close to nature so the children can explore and be stimulated
- Spaces that are easy to adapt for play
- Opportunity to connect with outside from inside by low-placed windows
- Private spaces, such as small niches in the walls to give a sense of security
- Scale of both the building and different inventory which can allow stay and curiosity
- Multisensory rooms
- Playrooms with tv and videogames for older children
- Materials and colors that can develop the child's different senses



ill. 15 homely environment

02.11 homely environment

the essence of home

Planning facilities where young patients and their families seek help and support requires a sensitive approach. It should be remembered that during illness, a person has a sense of loss of control and danger. In this case, care should be taken to minimize the sense of anxiety that hospice spaces can create. Architects must ensure that the space is properly shaped, giving a sense of security, dignity, privacy, peace, and comfort, taking into patients' individual needs. That is why it is important for patients to feel at home in the hospice (Bielak-Zasadzka et al., 2021).

To understand the essence of home, it is necessary to consider that it is a complex state that integrates memories and images, past and present. It is also a set of rituals and a private routine of everyday life. This means that such a building is not something that can be created at once. It is a gradual product of the child's adaptation to the world (Pallasmaa, 1995).

The physical environment of health institutions plays a vital role in influencing the psyche, and thus well-being. To create a home environment that supports the activities and concepts that make a place home, considers:

Identification

A home is a place where: one can express one's identity, where a person gives and receives love and support. It is a place that offers opportunities for meaningful connections with peers and other communities.

Orientation

Home is a permanent and stable center where a person feels comfortable, uninhibited, and relaxed, and alleviates anxieties. Here one can find moments of reflection and rest.

Qualification

A Home is a place of refuge from threats, where one can safely perform selected activities and rest. Man has reasonable control over the characteristics of the environment here (Brummett, 1997).

These concepts together form the symbolic content of "home" and can be considered generators of designs that speak about the essence of home. They can be accommodated through the supporting architectural characteristics of the home.

ill. 16 atmosphere

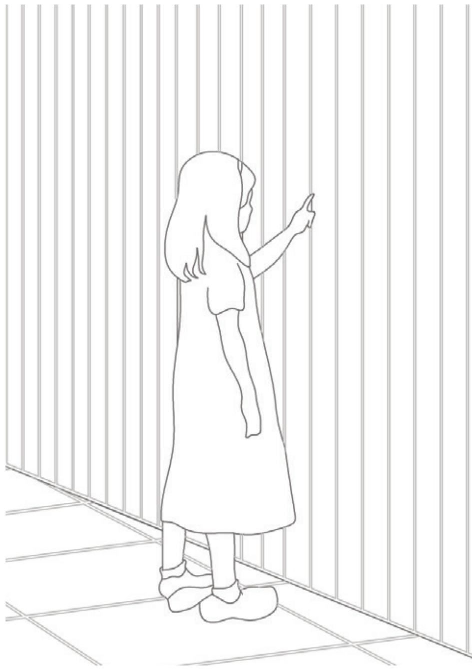
02.12 atmosphere

sensory aspects

To understand how to create an atmosphere in a building, one must consider how the human body perceives it. Many senses experience architecture, and the sensory organs measure the characteristics of matter, space, and scale equally. Architecture encompasses all seven spheres of sensory experience, and these experiences interact with each other (Pallasmaa, 2005).

Swiss architect Peter Zumthor describes the atmosphere as the factor that makes the building manage to move him. Zumthor also defines the essential components of designing the atmosphere in a project. These physical considerations are

- Body - how the building is created, its physical elements, and components.
- Materials - how materials can be used, their appearance, and how they interact. The materials do not create an atmosphere, but the architect decides how they complement and interact to create a meaningful situation.
- Sound - sound can affect mood. Appropriate interior design (their shape, surface of materials, method of using materials) allows for transmitting, collecting sound, amplifying it, etc.
- Temperature - has an immediate effect, depending on the room's temperature, different emotions can be stimulated. It is also created by the materials, colors, textures (rough / smooth) used.
- Surrounding - contents of a building, a way of arranging objects in a room, not just the space itself. Imagination of how the room will be used in the future.
- Movement - the way people move around a building. Aspects that can encourage people to move around space differently - an architect can create freedom or direction.
- Interior/Exterior - how one enters the building and passes between the public and private spheres.
- Intimacy - refers to various aspects, such as building's mass, size, etc. Examining the relationship between the designed building and the user's scale is essential.
- Light - light can create spaces, make a room feel homely or festive. Light also allows us to perceive the properties of materials and surfaces (Zumthor, 2003).


ill. 17 materiality

02.13 LCA - material research

CO_2, atmosphere and properties

The sensory reactions of the user, the way of perceiving the atmosphere, can become a driving factor for the project. Focusing on the physical components, such as the used materials, is necessary to introduce a particular atmosphere to the project. There needs to be focused on the materials that can soothe and relax the patients and their relatives who will stay at the hospice. The materials should be analyzed and adjusted to the desired effect. This will be done using life cycle assessment (LCA), where in this project the focus will be on materials global warming potential (GWP) and the atmosphere the materials create.

The following tables show the GWP for different materials and construction parts that can be used on the building. The majority of the data is generic data from LCAByg, with a few exceptions where the data is product specific because of the intention to assess a wider variety of possibilities than what LCAByg has as standard library.

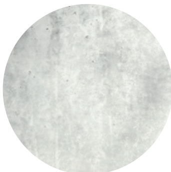
These analyzes will act as the foundation for the selection of materials in the design process. Later in the process, when the final life cycle assessment is made, the data will be much more specific. Therefore the values will change due to using product-specific EPD's as well as having the precise amounts of material used. This will not answer which materials will be used, before the design process, but be used as a reference when making decisions when designing, so LCA can be integrated into the design already from the beginning.

foundation

	screw pile	strip foundation concrete	L-shape EPS/Sundolitt
GWP (kg CO_2 eq./m^2/year)	0,054	0,160	0,037
Atmosphere	can raise the building from the ground and give a floating feeling	visually solid to look at	visually solid to look at
Additonal comments	gives the opportunity to ventilate radon away	drying time when casting concrete must be taken into account	can only take the loads of a building up to two stories

table. 02 foundation

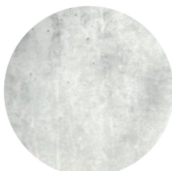
terrain deck



	concrete	wood
GWP (kg CO_2 eq./m^2/year)	3,074	0,618
Atmosphere	in general, out of sight	in general, out of sight
Additonal comments	if at least 10 cm thick, it acts as radon retarder	light construction

table. 03 terrain deck

exterior wall construction



	CLT with 150 mm mineral wool	concrete element with 150 mm mineral wool	wooden frame with 150 mm mineral wool
GWP (kg CO_2 eq./m^2/year)	0,636	1,310	0,162
Atmosphere	relation to site	cold overpowering impression	gives a feeling of being close to nature
Additonal comments	uses a lot of material compared to wooden frame	heavy construction	light construction

table. 04 exterior wall construction

exterior wall cladding

	brick	reused brick	untreated wood	heat treated wood	aluminium
GWP (kg CO_2 eq./m^2/ year)	1,155	0,020	0,127	0,765	1,155
Atmosphere	nonuniformed texture, bringing richy colors	feeling of relation to the past	close relation to nature	becomes slightly darker due to heat treatment	close relation to nature. Ages like untreated wood
Additonal comments	long lifespan	fits in the idea of DfD	very low GWP	resistant to fungus without using chemicals	more resistant to fire

table. 05 exterior wall cladding

interior wall surface

	gypsum	plywood	brick	lamellas	CLT
GWP (kg CO_2 eq./m^2/ year)	0,097	0,069	1,155	0,050	0,128
Atmosphere	anonymous feeling, light and calming material	homely feeling of warmth and comfort, smooth	nonuniformed texture, bringing richy colors	warm, texture and depth	homely feeling of warmth and comfort
Additonal comments	some gypsum boards can be used in wet rooms	can be treated to withstand moisture	also acts as the structural part of the wall	great for acoustics	also acts as the structural part of the wall

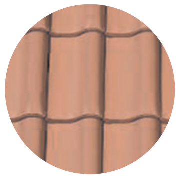
table. 06 interior wall surface

floor decks

	concrete	CLT	wood
GWP (kg CO_2 eq./m^2/year)	1,299	0,320	0,099
Atmosphere	cold, the smooth surface makes the room feel open	homely feeling of warmth and comfort	the gaps between the boards add texture and create sound
Additonal comments	heavy construction	medium construction	light construction

table. 07 floor decks

roof contructions and coverings

	 wooden flat	 wooden 25 truss	 wooden 45 collar	 roof asphalt	 tile
GWP (kg CO_2 eq./m^2/ year)	0,200	0,045	0,026	0,524	0,333
Atmosphere	relation to the mate-rials on the site	relation to the mate-rials on the site	relation to the mate-rials on the site	does not blend with the surroundings	relation to the resi-dentals on the site
Additonal comments	few roof coatings can be used on roofs with a small slope	some roof coatings can´t be used e.g. green roof	some roof coatings can´t be used e.g. green roof	can be used on flat roof	comes in many colors and shapes

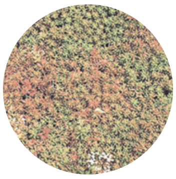
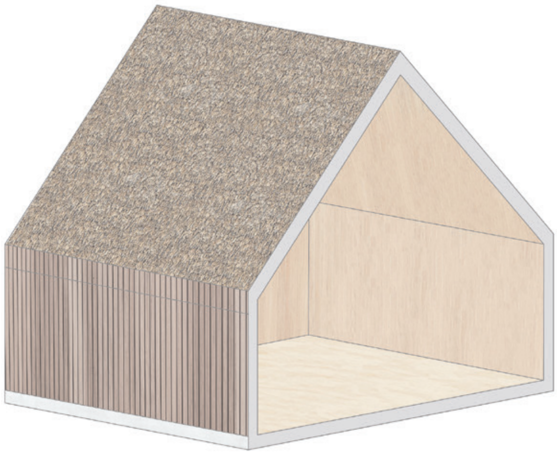
	 slate	 green roof	 steel plate	 straw	 zink
GWP (kg CO_2 eq./m^2/ year)	0,314	1,103	0,581	0,283	0,27
Atmosphere	rough texture, natural	will blend in with its surroundings	eyecatching, can reflect the light	relation to the mate-rials on the site	eyecatching, can reflect the light
Additonal comments	have a long lifespan	is able to withhold rainwater until it evaporates, preven-ting flooding	very flexible regar-ding colour	can be used on all roof shapes	easy to recycle, therefore low GWP

table. 08 roof construction and coverings

windows

	wood 3-layer glass	wood/alu 3-layer
GWP (kg CO_2 eq./m^2/year)	1,693	3,250
Atmosphere	warm and natural	better U-value
Additonal comments	eyecatching, can reflect the light	less maintenance than wood solution

table. 09 windows



ill. 18 simple building for LCA-calculation

Materials/construction part	Amount	GWP pr. unit	GWP total
foundation: concrete strip	30 meters	0,160	4,803
Terrain deck: Wood	38 m^2	0,618	23,494
Floor: wood	50 m^2	0,129	6,494
Exterior walls: wooden frame	75 m^2	0,162	9,557
Exterior cladding: lamellas	75 m^2	0,076	5,70
Interior walls: CLT	22,5 m^2	0,128	2,88
Roof construction: 45 saddle roof	50 m^2	0,026	1,307
Roof cladding: straw	70 m^2	0,283	19,799
Total GWP			52,93
GWP pr. m^2			1,39

table. 10 simple LCA calculation

02.14 how to use LCA

calculating CO_2 footprint

A way to get a more precise idea of how the total GWP (kg CO2 eq./m^2/year) for the whole building will be, a simplified 50 m^2 (5m x 10m) building with three rooms and a room height of 2,5 m, will be a test scenario when finding out the outcome when choosing different materials. A disclaimer for this calculation will be that, it is very simplified and does not include all of the components a final LCA should consist of. It gives an idea of the parameters which take up the most essential part, excluding energy usage.



ill. 19 Strandbakkehuset

02.15 Strandbakkehuset

Location: Rønde, Denmark
Build: 2019-2020
Architects: AART Architects
Engineer: Rambøll

Strandbakkehuset is a children's hospice located in Rønde in Jutland Denmark, and is an additional facility next to an existing hospice. The children's hospice is 1300 m^2 and can accommodate four people, including their parents. The Hospice is organized into four main departments, the family, common, treatment, and staff area. The family department are where the families can have privacy and relax in their two-bedroom apartments with their own kitchenette and bathroom. The common area has a kitchen, and families can eat together or bring it to their own apartment if needed. The common area also houses a multi-room for different activities, a sitting room and an additional guest room. TThe treatment area consists of a therapy, sensual, and wellness room. The staff area consists of offices, medicine, and assistive technology depot, a cleaning room, and a plant room (Thomsen, 2019).

The design builds on the idea of the building to accommodate life, play, and alleviation to give the patients, as well as their relatives, the best possible physical surroundings in a tough time of their lives. The hospice has been designed to feel like a home and the apartments having inlaid oxygen have been hidden to stray away from a clinical hospital feeling. This is also applicable in the sensual and therapy room to make it easier for the patients to feel calm and, by that enhance treatment (Strandbakkehuset, n.d.).

The relationships between patients, families, and staff are crucial for giving the help both patients and families need. It takes time to build relations, and therefore, the design of Strandbakkehuset focuses on gathering everyone in the common areas, as this benefits relationships, whereas having everything in the families' private apartments would make it harder for staff to meet the families. Talks between staff and families occur at random times of the day and can be everywhere. Therefore, the small crooks and nannies scattered throughout the building are helpful for having a place to sit when conversations happen, see appendix 01 (Højer, 2023).

ill. 20 Noah's Ark, (n.d.)

02.16 Noah's ark children's hospice

Location: Barnet, England
Build: 2017-2019
Architects: Squire and Partners

Noah's Ark Children's Hospice provides daycare, where the child can come with their parents, with treatment facilities for terminally ill children up to the age of 18. In addition, the Ark also provides three family apartments if a longer stay is needed, as well as post-death care. The hospice functions are accessible from the atrium, which has a café where people can purchase food, and leads out to the staff area, including offices and meeting rooms, different types of activity rooms such as a soft playroom, arts/crafts, and games room. The other areas are a treatment area with music therapy, a sensory room, etc. Here a multi-faith room is also located and the last area is the family apartments. They differ in size and usergroup, as there are teenage rooms, small children's rooms, and some apartments have private bedrooms for siblings. All of the apartments have a private kitchen for cooking meals (Noah's Ark, n.d.).

At Noah's Ark, they focus on palliative treatment and providing the facilities for many families to get help and relief not only from nursing staff and volunteers, but creating a space where people in similar situations can meet, interact, talk, and feel part of a community. The open atrium expresses the community mindset, with room for activities and connections to the different zones. However, at the same time, Noah's Ark provides the quiet and protected surrounding other patients might need. In addition to the indoor facilities, the hospice is surrounded by a huge plot of land, with a sensory garden, playground, and a 1,2 km long path passing through meadows and ponds to watch wildlife (Noah's Ark, n.d.).

Case comparison:
Where both hospices have a focus on palliative care, relief and offer the opportunity for overnight stays, they differ when it comes to capacity. Noah's Ark provides daycare and Strandbakkehuset only accommodates four families. Strandbakkehuset nudges interactions between the families and staff by making the families, as a minimum interaction, go to the common kitchen to grab the food, allowing them to bring it to their apartment. The number of people to interact with is much less than at Noah's Ark, where the ones staying at an apartment cook, if they don't want to purchase food from the café. In Noahs Ark, there are many more people at present, and the more private apartments are disjoined from the more active areas. If need be, it is easy for the families to go and interact with a lot of people from the "Noah's Ark community".

02.17 subconclusion

of theory chapter

During the design process, attention should be paid to the joints and constructions in such a way that the materials are not damaged and are easy to disassemble. It is important to standardize the design, using the same materials, design principles, and connections in as many rooms as possible. Use as much reused materials as possible and secondly recycled, if there is a lack of reused materials.

The design process should be related to the concept of building a society based on equal opportunities and non-discrimination. Such action requires empathy to consider the needs of people who may be socially excluded due to their disabilities.

The home is the basis of the child's identity and the family. Therefore the hospice facility must provide a homely atmosphere and space for social interaction between patients. The hospice must give a private place for the children to withdraw to as well as accommodate room for creativity and play. Architectural elements should be implemented to allow personalization and create a friendly, family atmosphere. The role of staff is also crucial to create the basis for a good working environment for them. Common areas are essential for the relationships between the families living there as well as between families and staff.

It is essential to be aware of how to design to achieve a specific atmosphere. Taking materials, form, and indoor environment into use can heavily influence the perception of the atmosphere. GWP of materials, aesthetics, and potential properties should be considered when designing.

ill. 21 picture from the site - the lake

03.0

ill. 22 persona

03.1 persona

understanding the users

When designing a new building, it is essential to know who it will be designed for and how users can be influenced, interact and experience the space they are surrounded by. This knowledge can be achieved by user group analysis, which is based on interviews, research, and evidence-based theory.

A user group analysis was conducted to understand the influence of users on the hospice project. It is necessary to understand the interactions between these groups and their individual demands and needs to create a project that will satisfy them.

Users are divided into four main categories: staff, parents, family members, and patients. This division represents a narrow group of hospice users, but it is representative. Each person portraying a given category was described, and on this basis, its demands and needs were determined. It is worth remembering that an individual user's requirements and the ones presented below have been generalized.

The personas are presented below: nurse Lisbeth, parent Margaret, family member Alexandra and patient Nikolai. These analyses were mainly based on the semi-structured interviews, which can be found in Appendix 01.1, 01.2, and 01.3.

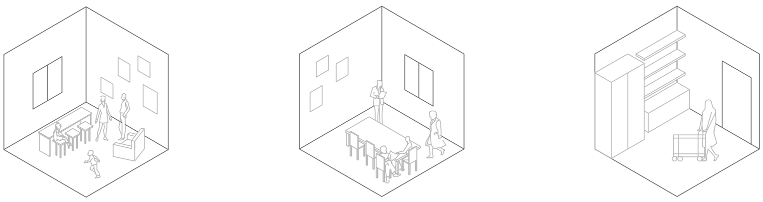
03.2 user group - staff

The staff is of great importance for the operation of hospices. They must help relieve the patients' severe pain and care for them and their parents with psychological, emotional, and spiritual needs.
Staff caring for terminally ill children also have many needs that, if unmet, affect the care they provide and job satisfaction. Their needs should be taken into account during the design process. (Morgan, 2009)
Staff's ability to perform well and have the energy to fulfill their hard work requires a well-organized room program that makes their work easier. It is important to have a good and efficient work environment with room for privacy.

name: Nanna
position: nurse
architectural challenges: stairs, not enough resting spaces, more storage

Nanna is a full-time nurse. She values social interactions and believes these relationships can help to understand patients and their family members' needs. Therefore, it is essential for her to have spaces that can create casual social interactions. Her work can sometimes be challenging, therefore she does also need a space for rest, so that she can get energy for her work, see appendix 01 (Højer, 2023).

needs and demands



social rooms meeting rooms for staff storage rooms

ill. 23 persona - staff

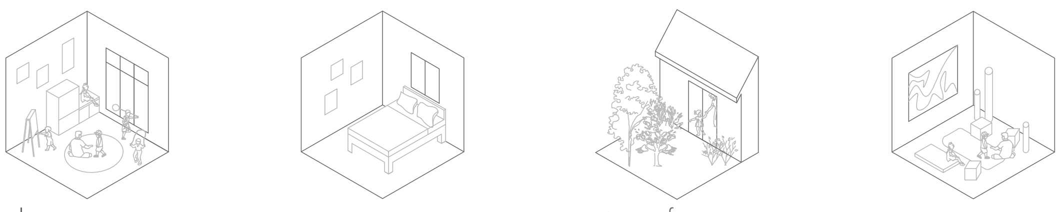
03.3 user group - patient

To meet the needs of a terminally ill child, it is important to provide the greatest possible comfort while maintaining his privacy and dignity. In the case of a child's illness, one of the greatest fears is pain, so measures should be taken to help eliminate it. (Stanford Medicine, n.d.)
Patients staying at the hospice will receive palliative care focusing on physical, psychological, social, and spiritual elements. For patients, it is important to feel at home to create a close relationship with the place and the staff.

name and age: Nikolai, 5 years old
condition: heart disease
architectural challenges: hospital feeling, not enough spae for visits

Nikolai, who is 5 years old, was born with a heart condition and has received treatment all his life. Driving back and forth to the hospital takes a lot of his and his family's energy. He wants to be in a permanent place where he can receive his treatment, have his family close to him, and have the opportunity to play and experiment with new things.

needs and demands



playrooms private room view of nature sensory room

ill. 24 persona - patient

03.4 user group - parent

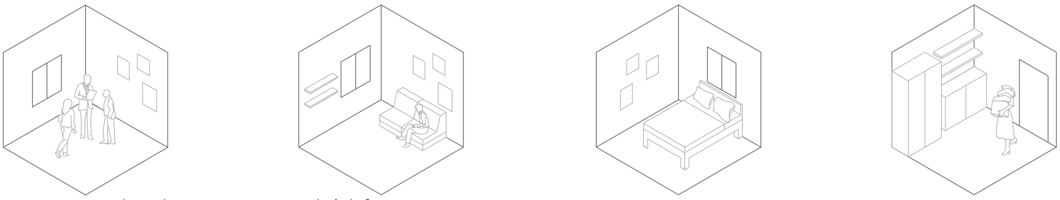
Raising a terminally ill child puts parents in difficult tasks. They must not only take care of their child, but also try to take care of themselves. Parents of sick children should be supported by talking to care teams and professionals who are available to help (George Mark Children's House, n.d.).

Parents often do not have time for themselves because they are constantly with the child or their thoughts revolve around the child. It is important to find a place for them where they can be alone or where they can talk to other parents (see appendix 01.3).

name: Margaret
age: 52
architectural challenges: not enough resting spaces, more storage

Margaret is a mother whose child had cancer for the last five years. During this period, she was with him almost constantly. Sometimes she lacks time with herself to rest for a while. She spent her days driving back and forth from home to the hospital. The hospital became a second home not only for her child but also for her. She mainly associates it with an unfriendly atmosphere and misses the family warmth of home. She also lacks contact with other parents so that they can offer advice together.

needs and demands



contact with other parents /close contact with staff | child-free space | private room | storage rooms

ill. 25 persona - parent

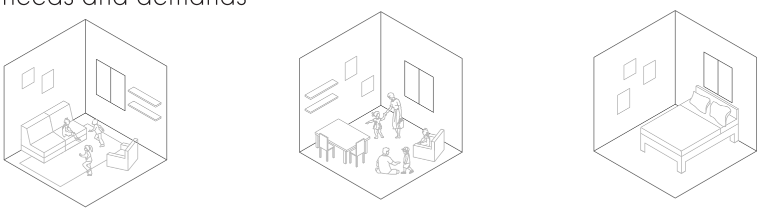
03.5 user group - family member

The disease affects not only the sick child, but also the rest of the family. This also causes a difficult situation for a healthy child of parents who may feel neglected due to the time devoted to the illness of a brother or sister. It is frequent for siblings of a terminally ill child to become sullen and angry. This can result in behavioral problems. Parents must therefore take care that other children do not feel pushed away. Including siblings in treatment will give them more time to spend together (George Mark Children's House, n.d.).

name and age: Alexandra
age: 12 years old
architectural challenges: not enough place to spend time with family

Alexandra is the sister of a girl who has been suffering from cancer for the last few years. Many of her teenage years' memories are of hospital visits, caring for her sister, and the lack of attention from her parents. She remembers times when she could not see her sister for a long time, or only occasionally once a week for a few hours. Alexandra really wanted to be with her sister and her parents more often, to be together with her family (see appendix 01.2).

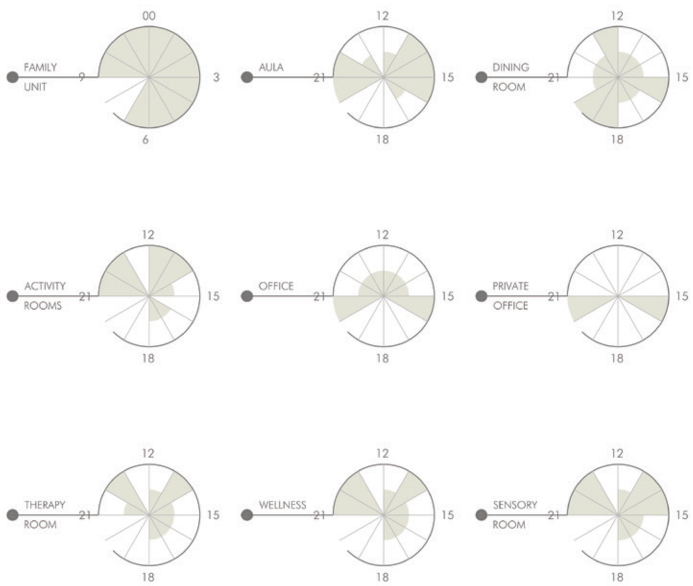
needs and demands



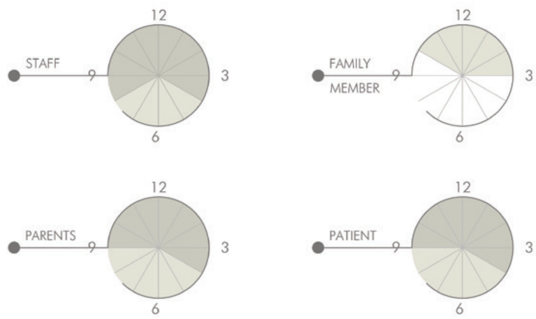
contact with other siblings | close contact with family | private room

ill. 26 persona - family member

time table of room functions



time table of users



ill. 27 active hours

03.6 user group flow

From the persona chapter, it can be concluded that the users of the building can be divided into four groups:

Staff: The staff in hospices can be divided into categories of the palliative team, doctors, caretakers, and volunteers. The caretakers consist of one nurse per patient during work, and during the night, the amount will be one nurse for every second patient.

Parents: Some parents of patients stay with them permanently in the facility, and some visit their children for a few hours without spending the night in the facility.

Family members: They mainly visit patients on certain days of the week for a few hours or stay with them.

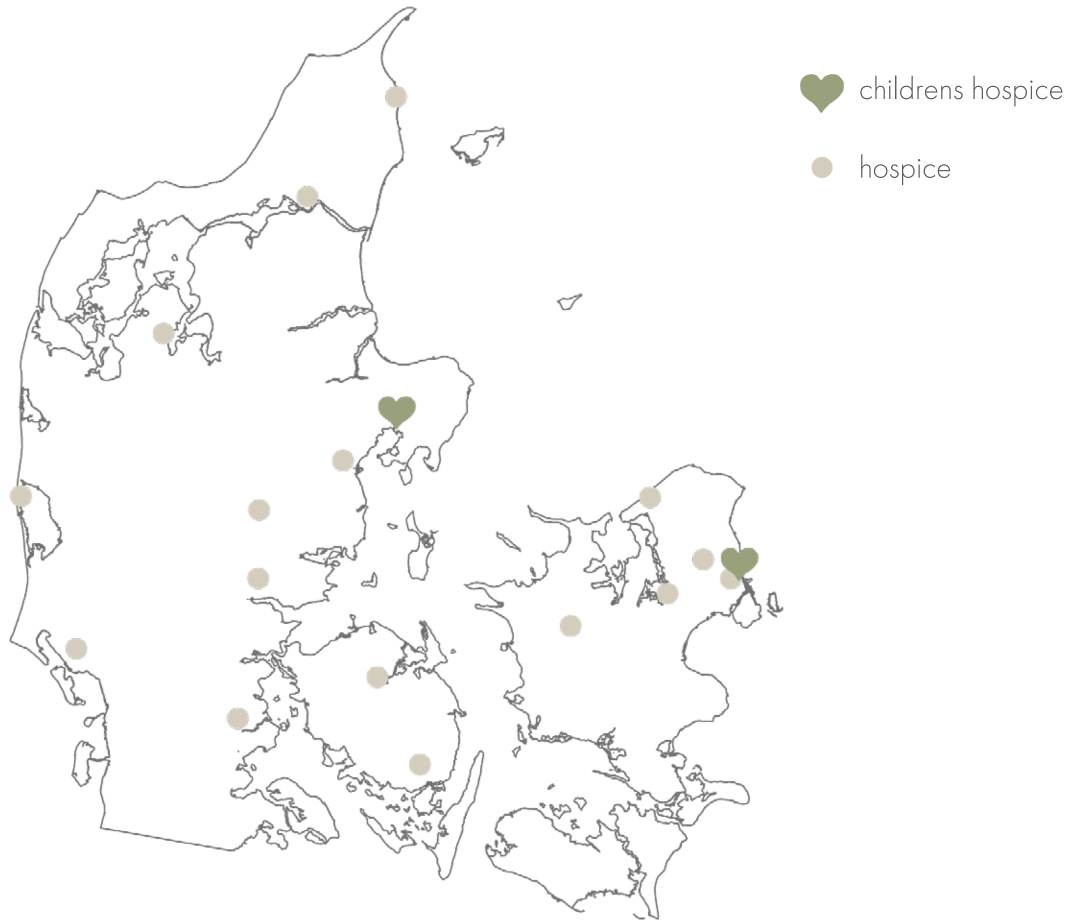
Patient: Some patients stay in the hospice 24 hours a day, and some use it only during the day on all days or only on certain days of the week. Patients can therefore be divided into permanent residents of the facility and visitors.

03.7 subconclusion

of user analysis

Different users have their unique demands and requirements. To meet these individuals' needs, it is necessary to consider different functions in the room program of the building. Therefore, the facility should offer various activities to satisfy all users. It will also be essential to plan the arrangement of all functions in the facility, considering users' privacy.

ill. 28 picture from the site - the meadow



ill. 29 hospices in Denmark

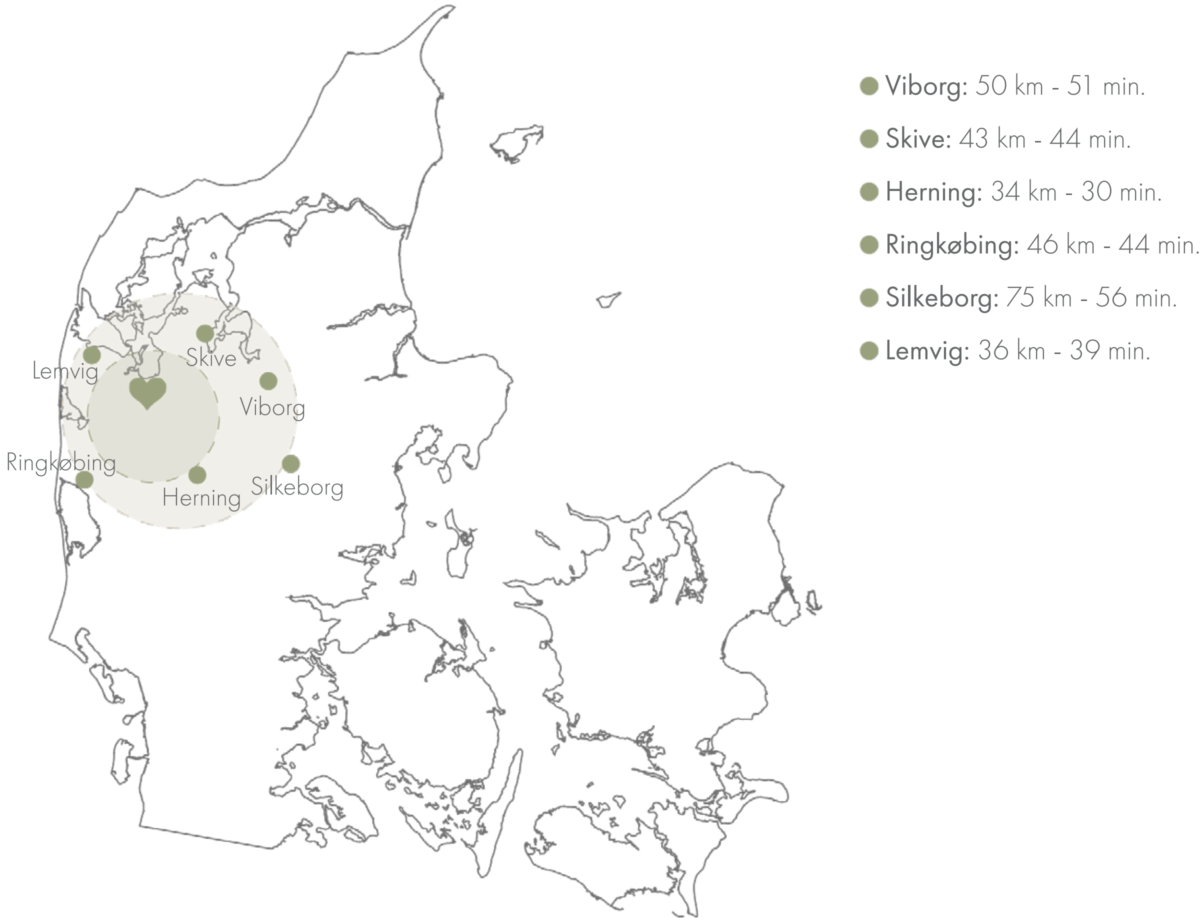
04.1 choosing a site

The understanding and importance of hospices have changed over the years. Children and young people are exposed to incurable diseases, which not only affect the patient but also their relatives. As described in the theory chapter, there is a great need for physical, psychological, and spiritual support when people go through such progress, which can be obtained in a hospice consisting of a palliative care team.

There are 20 hospices in Denmark with an accumulated capacity of 257 people. (Lack of hospice places, n.d.). However, only 2 of the 20 hospices are designated for children and young people, see illustration 29. The theory chapter also highlights the importance of dividing children's hospices from hospices for the elderly, as children and young people have wildly different needs and wishes regarding the place they are staying at.

Denmark's two children's hospices are located in East Jutland and Zealand. Strandbakkehuset, which can accommodate four patients, covers the need for palliative care for Jutland and partly Fyn, see appendix 01 (Højer, 2023). This may mean that there is a need for more children's and young people's hospices in Jutland.

During the interview, see appendix 01 (Højer, 2023), as well as the literature search, the importance of a close relationship with nature was also pointed out. Being able to get out and be in a close relationship with nature and using nature as a stimulating and relieving side is essential.



ill. 30 location of site and distance

04.2 the chosen site

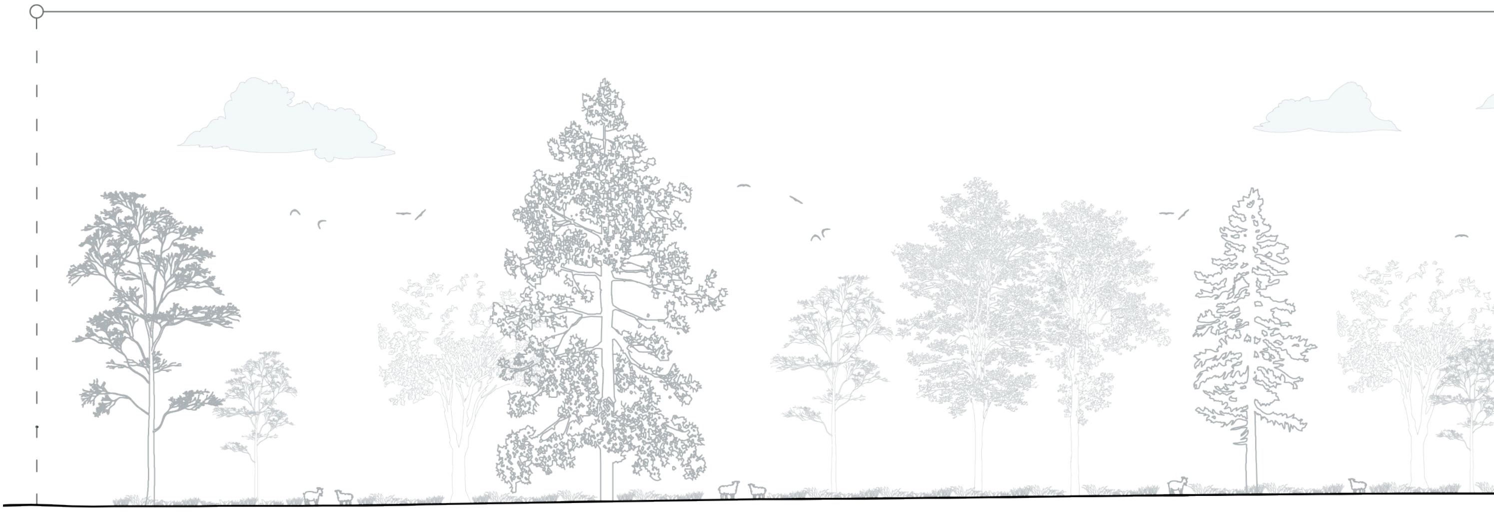
Based on the previous analyses, theoretical research, and interviews, a site along Vandkraftsøen in Mejdal, Holstebro was selected. The site, as needed, has a close relationship with nature but also all the necessary functions such as shopping, city center, hospital, church, etc. In addition to that, the site enables patients from several cities to come to the hospice and receive palliative care easily. Illustration 30, shows the cities that are half an hour and an hour away from the site. Here it can be seen that the hospice will cover the needs of many smaller towns but at the same time also larger towns such as Herning, Viborg, and Ringkøbing. In addition, Regionshospitalet Gødstrup is 30 kilometers (30 minutes) away from the site, which will make it easier for patients who need additional support to go to and from the Hospice.

This place is mainly used by local residents for daily walks, as well as a place for grazing sheep. It is thus possible to be met by people when you are on the site. A fire pit can also be found on the site, which everyone can use. This will make it possible to create activities with residents around the site and hospice users. This will increase social interaction and make sure that patients do not feel too excluded from the outside world, but will still be able to sense a connection with everyone else.


residentals

ill. 31 Skråfoto, (n.d.)

83,187 m
SITE

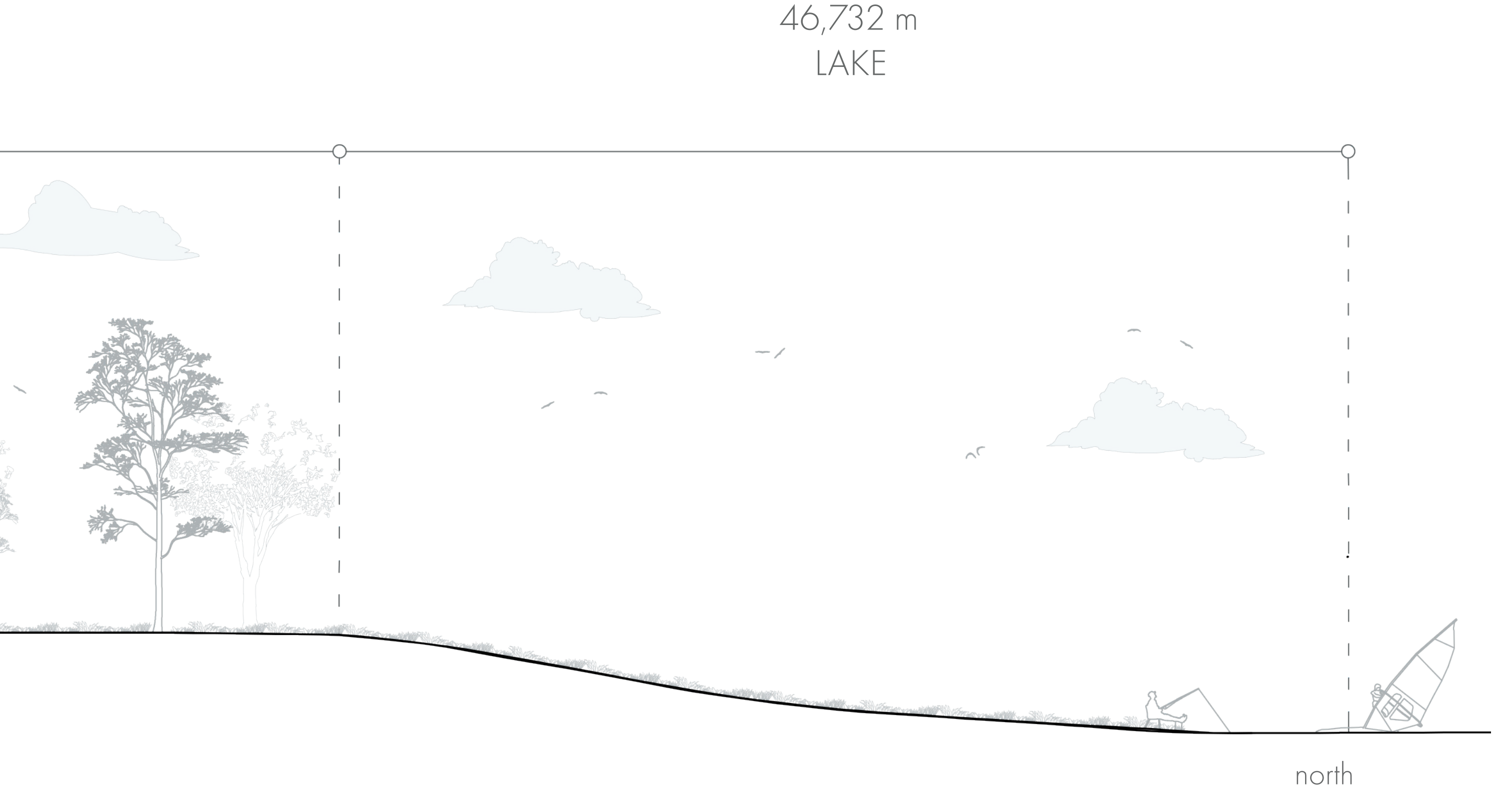


04.3 atmosphere of the site

genius loci

When arriving at the site, it is easy to be absorbed by how the green color of the grass and trees dazzle together with the blue colors of the lake. The silence on the site allows for hearing the birds chirping, the wind shaking the trees, and the waves on the water. As the site is still quite close to the city, it is possible to hear ambient sounds from the busy everyday life of the city. This gives a feeling of not being excluded too much from the city but still having the opportunity to be surrounded by a quiet and peaceful environment.

While moving around the site, you will be able to sense the paths that have been created for pedestrians clearly. The paths consist of gravel and stones, whereas when one moves toward the site, the ground becomes softer due to the presence of moss. The site provides space for the animals to move around freely.



ill. 32 section of the site

The flat layout of the site makes it possible to regard and see what is happening throughout the site. This also makes it possible to see the building as soon as you arrive at the site. Here it is important to design a building that will blend in with its surroundings through a suitable form and use of materials, while adding additional quality to the site.

As seen on the section, see illustration 32, there is a slope towards the lake. The closer the observer is to the water, the lower he is in the terrain. By the lake, there is the possibility of isolating and disconnecting from everything that happens on the site. Here, the only thing that can be seen is the roof of the building, which will be an important aspect for the project.

04.4 the site

getting close to nature

functions around the site

building site

activities

ill. 33 pictures from the site I

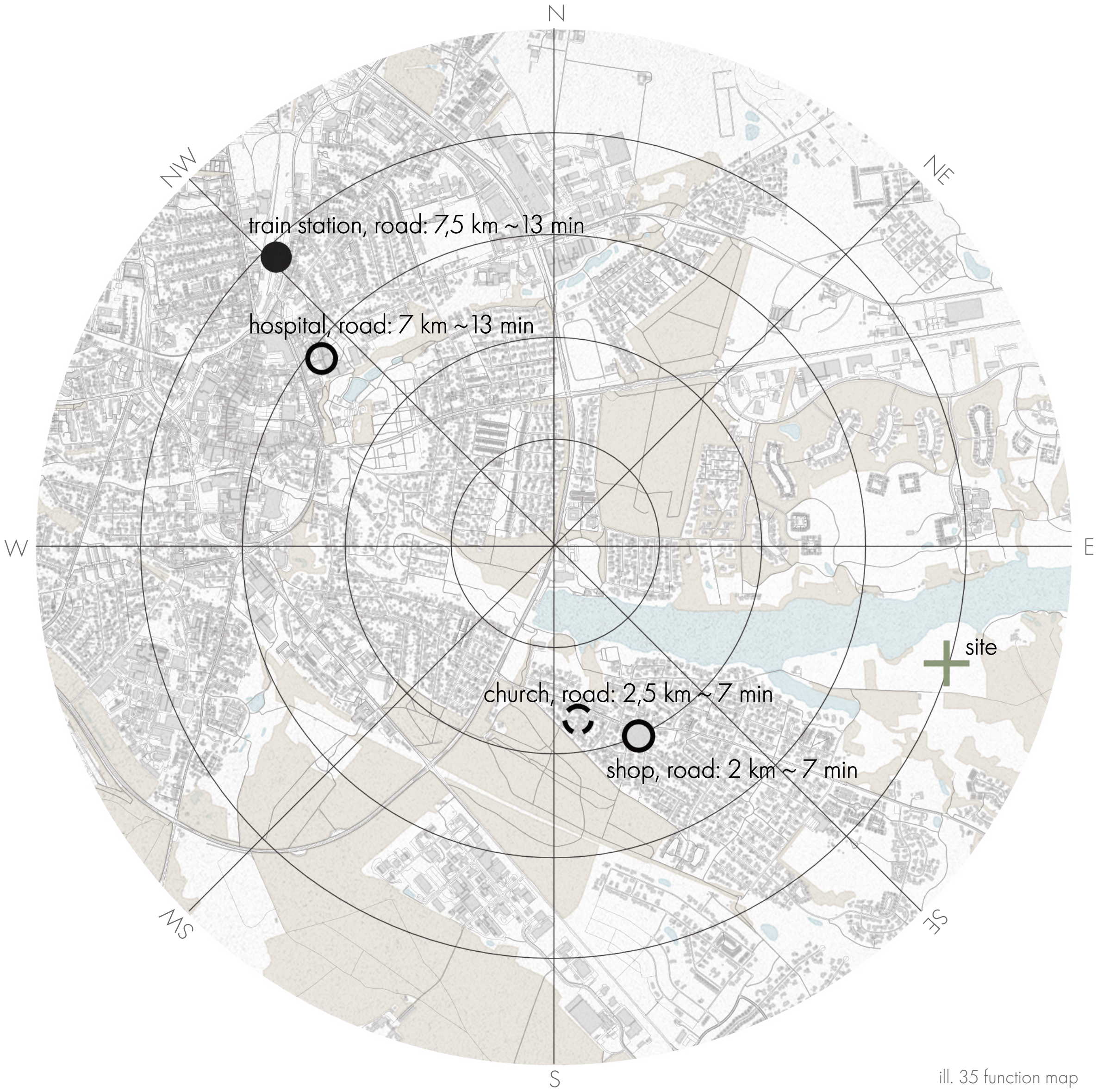
path arround the site

nature around the site

activities

ill. 34 pictures from the site II

function map 1: 30 000

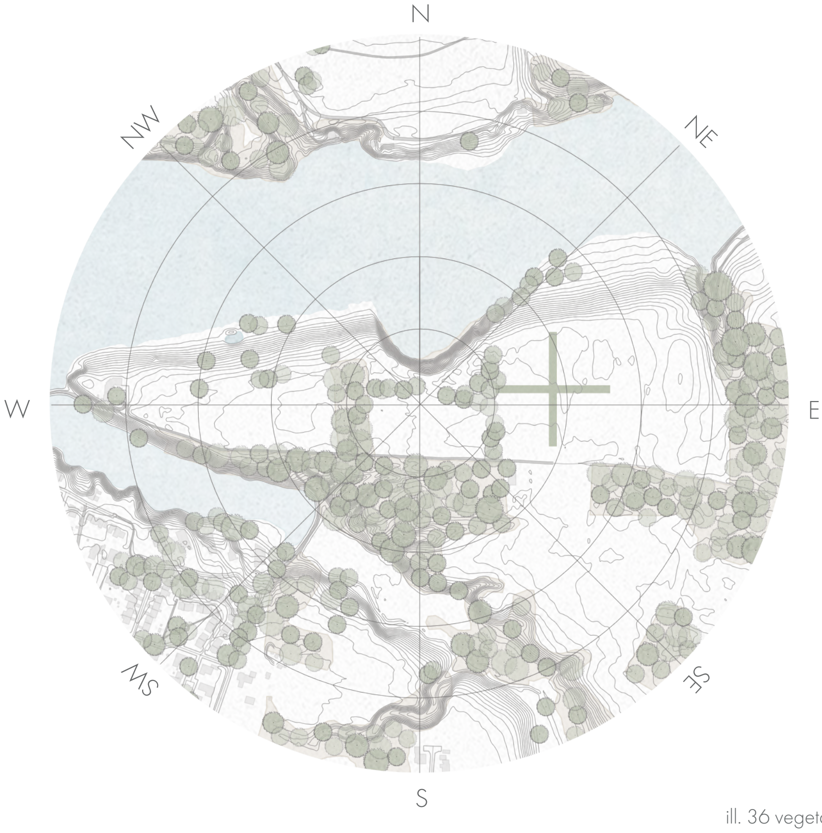


ill. 35 function map

04.5 mapping

Mapping the site and context helps to visualize and by that understand the possibilities and boundaries for the design phase. The mappings show the functions in the nearby city, such as shops, churches, and public transportation, as well as the accessibility to these functions and how easy it is to get to the site.

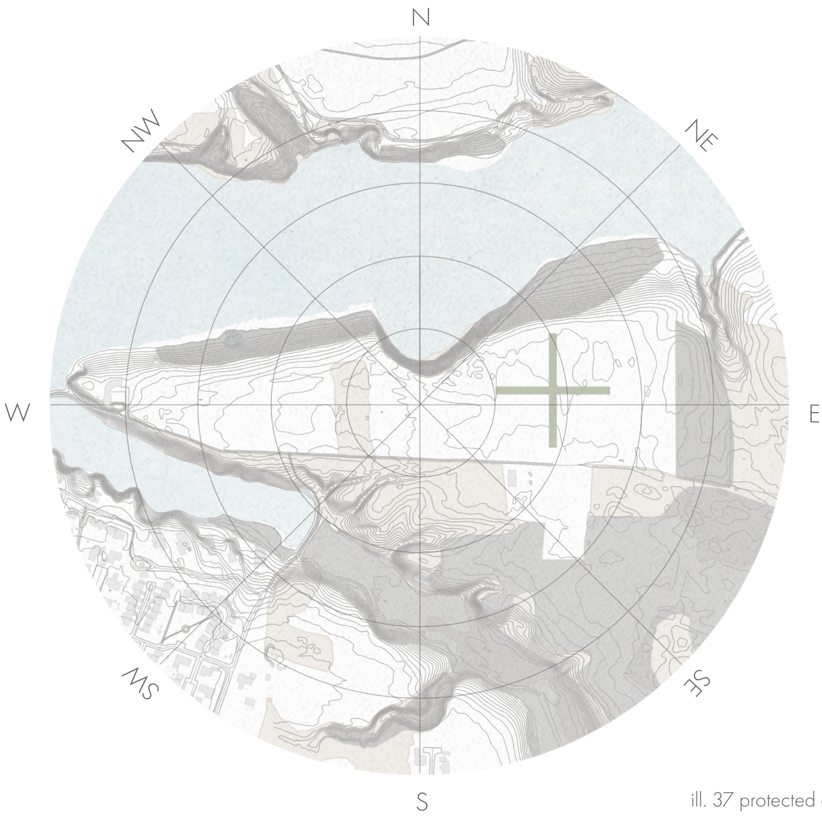
The vegetation and protected area maps show where trees and clusters of vegetation exist and which areas are forbidden to build on. Together these maps show the physical boundaries of the site and give an idea of where to place buildings, roads, and other functions based on the free space left on site.



vegetation 1:10 000

- site
- water
- vegetation
- trees

ill. 36 vegetation



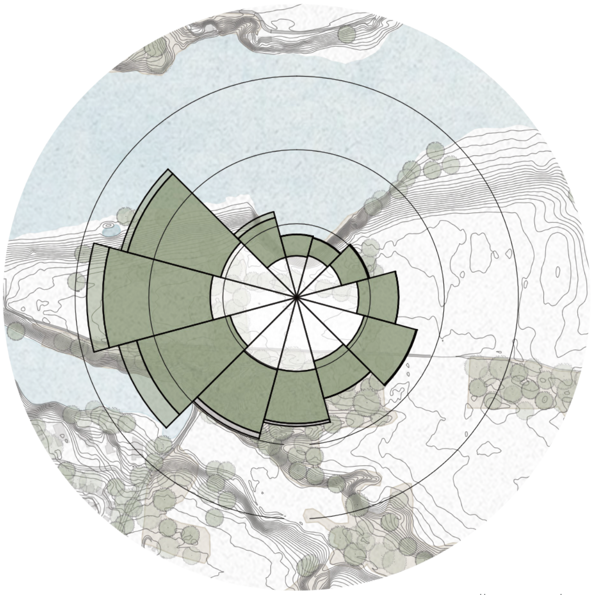
protected area 1:10 000

- site
- water
- vegetation
- trees

ill. 37 protected area

04.6 microclimatic conditions

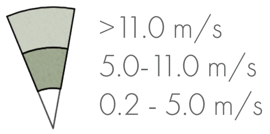
Analyzing a building site's microclimate allows one to consider materials and strategies for dealing with potential challenges that may arise in connection with its location. Therefore, an analysis of wind, precipitation, sun path, and topography was carried out. Due to the location of the building site at a significant distance from the city center and major traffic roads, it was decided not to carry out a noise analysis.

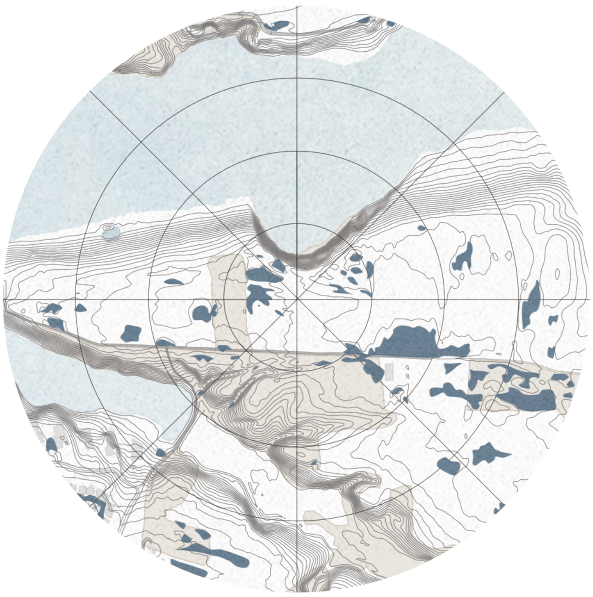


ill. 38 wind map

wind 1:10 000

Due to the building site's geographical location, the wind's dominant direction is west during the year, but it changes slightly. The windrose is an average of the wind direction throughout the year and is measured in Mejrup, a few km east of the site (Cappelen, 1999).



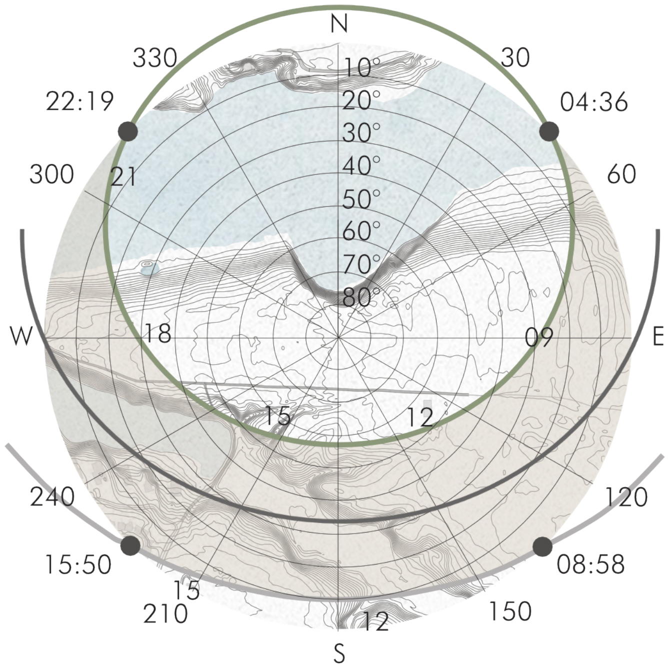


ill. 39 bluespot map

bluespot 1:10 000

Due to the amount of precipitation in Denmark and the location of the building site by the river, it was decided to perform a blue spot analysis on the plot. Analyzes were carried out for 2, 5, and 10 cm of rain. The software Scalgo gives an idea of flood risks. As it can be seen on illustration 38, there is no flooding risk on the site.

rainwater 10 cm



sun 1:10 000

In Denmark, when the sun is at its lowest in December, the sun is 11º over the horizon and at the longest day, it stands 57º over the horizon (Holstebro, n.d.).

annual variation

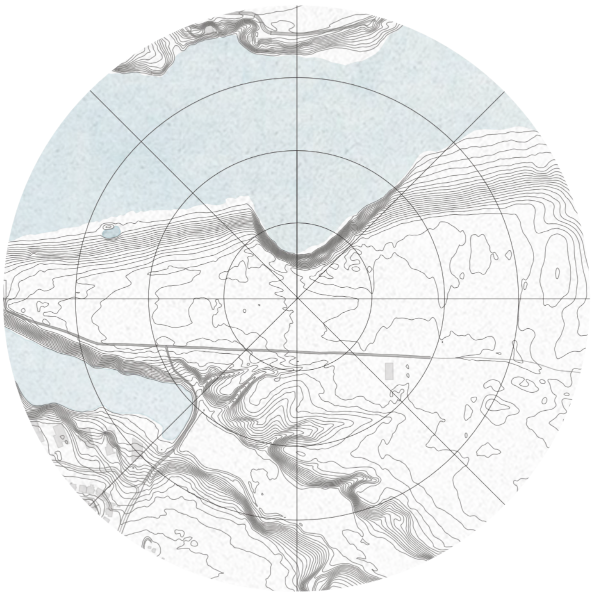
june solstice

december solstice

equinox (march and september)

sunrise / sunset

ill. 40 sun path



terrain 1:10 000

The terrain on site is quite leveled, with an elevation difference of 1 meter. The terrain becomes steeper next to the site towards the water.

terrain level difference 0,5 m

ill. 41 terrain

04.7 subconclusion

of site analysis

Based on the map of hospices in Denmark, it was decided to choose a location in Jutland. This choice was also influenced by the close relationship with nature, which has a stimulating and soothing effect on patients, and such conditions are provided by the location. The site is located very close to Holstebro, specifically the area Mejdal, which consists of detached houses, a few shops, and a church. The surrounding nature, both the water and vegetation, shelters the site and makes it feel calm and secluded, with only small paths close to it.

Considering the comparative context, looking at materials, shapes and using it actively in the design, will make the building blend in with its surroundings and look like it is part of the site.

The different mappings of both functions, context and microclimate, visualizes possibilities as well as boundaries and conditions on the site, which must be taken into consideration in the design process.

Taking into account the maps shown above, prior the analysis of bluespots and the terrain do not show any problems with the hospice construction, as the site is quite flat and there is very little water gathering on it. There is not much covering direct sunlight except on the eastern side of the site, but this will only have an impact in the morning during summer. Most of the wind comes from the west, where there is very little vegetation sheltering from it.

The analysis of functions shows that the necessary places, such as a shop, church, hospital are located in the vicinity, possible to cover by car in a few minutes. In addition, to reach the hospice and receive palliative care easily. The hospice will be able to meet the needs of many smaller towns, but also larger ones, such as Herning, Viborg, and Ringkøbing.

ill. 42 picture from the site - meadow

05.1 vision

The need for hospices has changed through the years in Denmark. Since 1992, more hospices have been opened, but inly two are designated for children. This thesis visions to create another children's hospice at Tingagervej in Mejdal, Holstebro, to provide necessarry palliative care.
The building needs to be an example of how to design and build sustainably, minimizing unnecessary CO_2 emissions, as well as being aware of its surroundings. The hospice needs to be designed according to the principles of design for disassembly, ensuring the possibility of using the materials used for construction later, after the end of the building's life, in a new and innovative way.

The Hospice needs to provide the setting for patients suffering from terminally ill diseases and their relatives going through this difficult time. The building should fulfill their needs regarding treatment and palliative care while giving a homely feeling to make their stay easier.

The location in the context of the Danish natural landscape should have a positive effect on the healing process, as well as affect the perceived atmosphere of the building through materiality and architectural composition.

During the design process, parameters such as:
- materials GWP, aesthetic and potential properties
- microclimate conditions: wind, sun, and rain protected nature areas
- sensory reactions of the user, the way of perceiving the atmosphere
- physical elements: thresholds and relationship to the environment, temperature, materials, light, sound, and structural elements
- joints and constructions in a way where materials are not damaged and are easy to disassemble
- five parameters from REHPA, to ensure the quality for all the different users of the hospice

needs to be taken into consideration.

05.2 problem

a home full of life, joy and hope

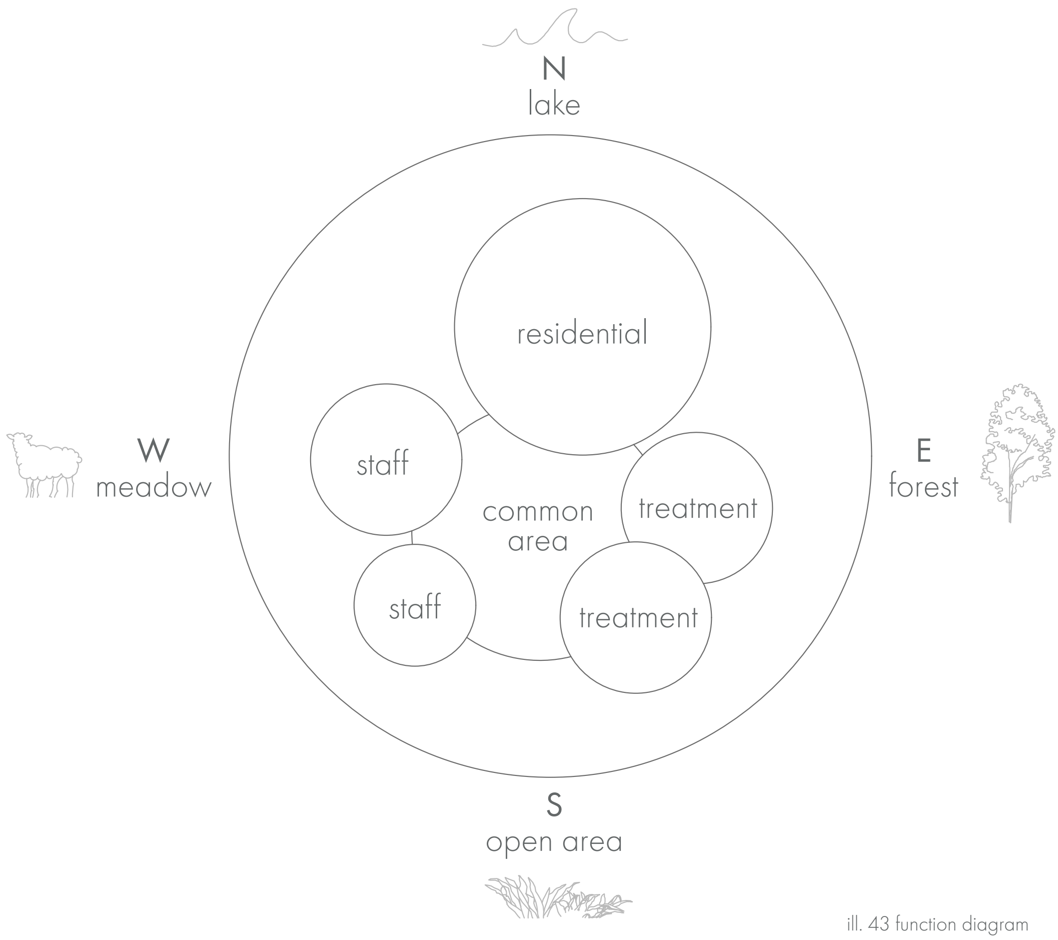
How can architecture create a safe, lively, and homely environment, enrich the quality of children and their families who face a life-threatening illness, and help relieve suffering through physical, psychosocial, and spiritual treatments?

As well, how can sustainability be incorporated, including healthy indoor climate and materiality regarding minimizing the CO_2 footprint of the hospice, while enriching the design?

05.3 functional diagram

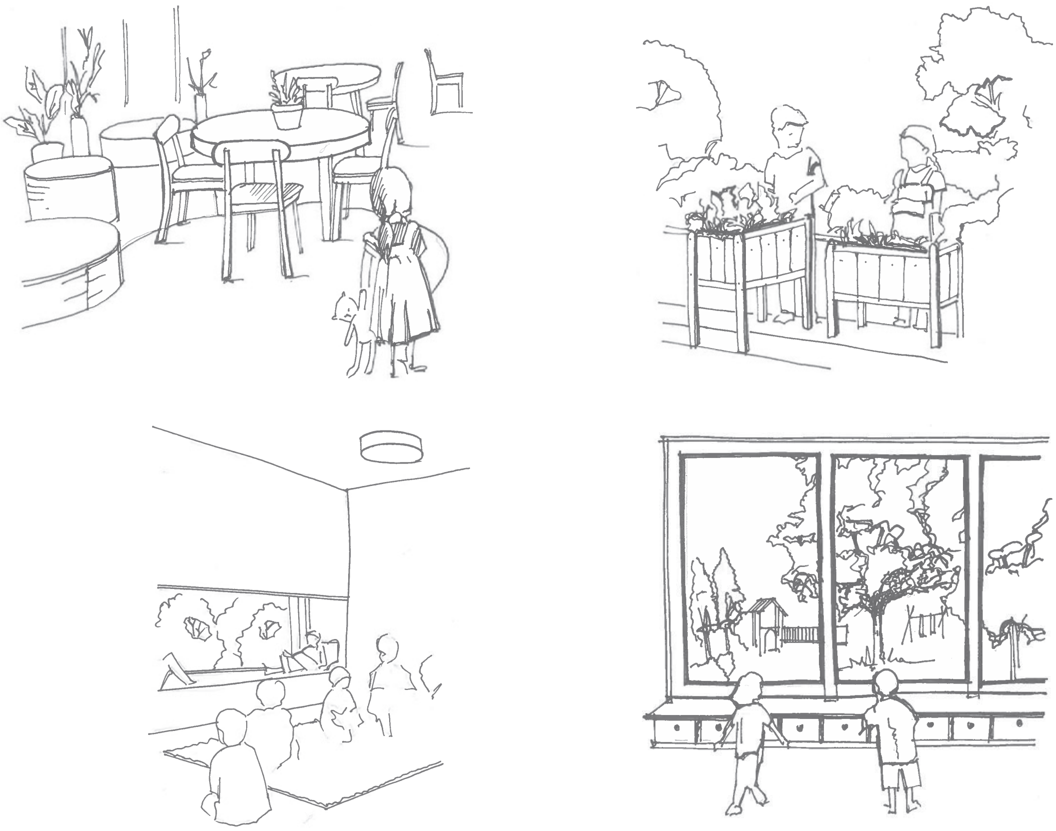
All users have different needs for the space they are surrounded by, which also impacts the orientation and location of the rooms they will use. Based on their needs and demands, an initial function diagram was created, see illustration 43, which shows the different functions that must be in the hospice and their locations based on the site and the persona analysis.

The functions of the building can be divided into three parts; private, social, and semi-social. Rooms, that will be used by patients and their relatives, must be excluded from other activities in order to create a calm environment for them. Based on the diagram, these functions are located to the north, overlooking the lake, as that is where the least activity is. Common facilities, which everyone must use, will be centrally located in the building to provide easy access to all users. The staff functions will be located to the west, as this is where arrival to the site will be. The treatment functions will be located along the east to provide a quieter environment and to place the rooms close to the forest.



ill. 43 function diagram

05.4 desired atmosphere



ill. 44 sketches of the desired atmosphere inside the building

common facilities

The common rooms will be the heart of the building. These rooms are the most essential parts of the facility and will function as a point of departure to all the other functions of the building, making it a place of both transitions and stay, nudging the users to meet and interact.

In these common rooms, the families will feel that everyday life can still be a part of their lives, despite illness. An everyday life where food is prepared, food is eaten together, you have guests over, wash dishes, etc. All the activities typically occur in a kitchen - in a home. At the same time, these rooms should create a framework for employees to eat together with families and guests to increase social interaction in the building. The kitchen must be the meeting point for meals, but it must also be a gathering place for the community and activities such as cooking, play, etc.

Atmospherically, the common rooms should be open, welcoming, and appealing to everyone: families, guests, volunteers, and employees. These spaces are the most important parts of the facility. Given such a high position in the hierarchy, these should have the greatest room heights. They should open up to the building's surroundings and nature. Flexible furniture must be used in these rooms to allow the rooms to be used for different events, such as birthdays, gatherings, etc.

residential

The residential area is the base for the individual family, ensuring security and peace during an turbulent period in life. Residentials are the rooms that must provide the framework for privacy for the patient and the family. In their apartments, there must be the possibility to eat meals together, watch television, work, and have guests over - as usual in their homes. This means that everyday situations must be considered in these homes.

The family constellations of these residents will vary, and therefore flexibility in the accommodation is essential. The home must have flexible furnishings that allow for various modifications and, at the same time, allow for personalization. This will help give the residents a homely feeling and remove the feeling of the hospital effect.

It is essential to design the apartments so they frame nature and invite it in by using large glass sections and doors. There must also be space for a small terrace for each family home, to allow the family to be one with nature without having to interact with others.

treatment

The treatment unit is essential for knowledge-sharing and collaboration between the palliative team that will take place in the building. The dialogue and knowledge sharing between the employees are important to promote and develop the palliative efforts and treatment of children. Therefore, a framework must be created for interaction between the employees and the residents, which can be done by incorporating a common area in the treatment part.

This area is essential for the building, as this is where palliative treatments will be carried out. The treatment area must be safe, calm, and at the same time inviting by avoiding the feeling of a hospital, so the patients and families will seek it out, using it preventively and not only when there is a need for treatment.

The shape, materials, and amount of light in the different treatment rooms must support the functions to be found in them.

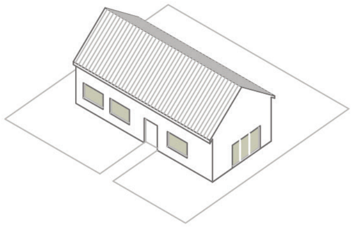
staff

The staff area for the palliative care team must be located as close as possible to the main entrance to welcome people to the hospice and a visual connection to the common areas, to help establish relations between the staff, patients, and families.
The office must be open and flexible allowing all employees to use it. In addition, two private staff rooms must be integrated, to give staff who need rest at work the opportunity to carry out their work without being disturbed.

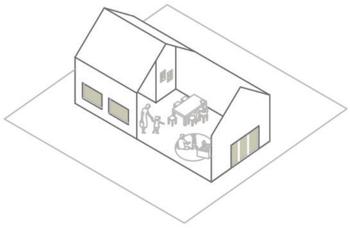
The other staff area, such as the industrial kitchen and cleaning room, must be separated from the other functions in the building to ease their working day by not needing to take the other users into any regard.

In relation to the offices, the necessary functions must be placed such as staff locker room, printer room, and a medicine room.
A large meeting room must also be integrated into the staff area, providing space for employees to share knowledge.

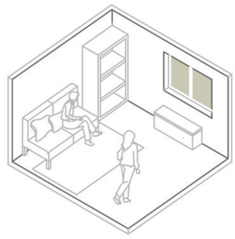
05.5 design parameters and strategies



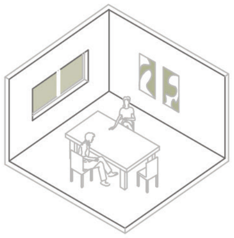
must give a feeling of home and reduce the elements of a hospital



must have inviting common areas to create an opportunity to socialize

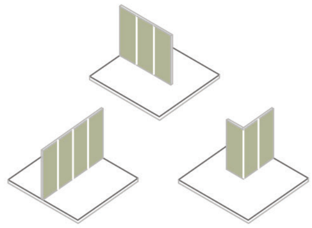


must have a connection with nature as well the possibility to interact with it

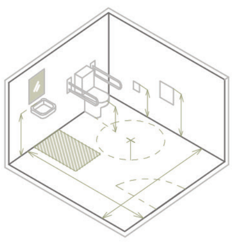


must have small intimate rooms for conversations

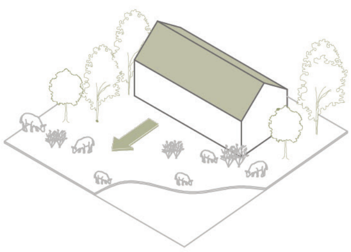
must include spaces for playing as well as creative activities



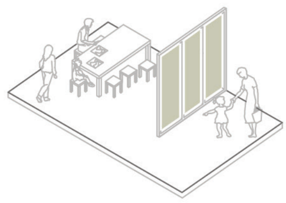
must design multi-purpose rooms to reduce the amount of rooms



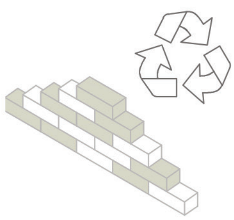
appropriate arrangement of elements



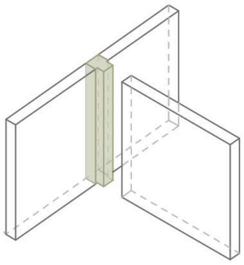
must have private places for both childrens and adults to withdraw



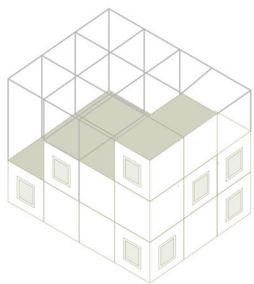
well defined building organiza-tion, with possibility to preview activities, before entering



use reused or recyclable materi-als and reduce waste



design connections and construc-tions so they can easily be dis-sasembled



standardize the design, using the same materials and construction

ill. 45 design strategies

05.6 room program

Room	Quantity	Area	Area total	Occupants	Atmosphere	Room height
Common facilities						
Main entrance	1	59	59	1-20	open, light	3,66 m
Common kitchen and dining room	1	119	119	1-50	warm, homely	3,66 m
Aula / gathering room	1	651	651	1-50	open, bright	4,88 m
Games/ play room	1	31	31	1-10	colorfull	2,44 m
Crafts room	1	41	41	1-10	colorfull	2,44 m
Respite room	2	13,4	26,8	1-2	cozy	2,44 m
Multifaith room	1	47	47	1-6	light, open	3,66 m
Common area with small library	1	45	45	1-10	cozy, warm light	3,66 m
Handicap toilet	4	6	24	1-2		2,44 m
Guest room (including bathroom)	2	26	52	1-2	homely	2,44 m
Residental						
Patient room	6	32	192	1-5	homely	2,44 m
Family room	6	18	108	1-4	homely	2,44 m
Bathroom	6	12	72	1-2		2,44 m
Laundry room	2	13	26	1-4		2,44 m
Lined room	1	9	9	1-2		2,44 m
Treatment						
Music therapy room	1	36	36	1-10	light, colorful	2,44 m
Sensual room	2	18	36	1-3	dark, closed	2,44 m
Wellness room	2	36	72	1-5	light	2,44 m
Physio therapy room	1	23	23	1-4	light	2,44 m
Threapy room	1	30	30	1-8	cozy, warm	2,44 m
Handicap toilet	2	6	12	1-2		2,44 m
Staff						
Office (open)	1	84	84	1-10	light, open	2,44 m
Private office	1	13	13	1-2		2,44 m
Archive and copy room	1	9	9	1-2		2,44 m
Staff toilet	2	3	6	1		2,44 m
Staff locker room	1	13	13	1-4		2,44 m
Medicine room	1	22	22	1-4		2,44 m
Meeting room	1	43	43	1-10	cozy	2,44 m
Break room	1	22	22	1-4	cozy	2,44 m
Industrial kitchen	1	53	53	1-5		2,44 m
Workshop	1	26	26	1-3		2,44 m
Cleaning room	1	13	13	1-2		2,44 m
Basement						
Technical room	1	93	80			2,30 m
Storage room/depot	1	245,9	239			2,30 m

DESIGN PROCESS

an integrated design process

06.0

06.1 introduction

The chapter will present simplified milestones of the design process, which will be presented through drawings, 3D models, graphs, etc. The design process is based on the analysis presented in the program.

phase 1 - finding a form

The form of the building will be investigated in the first phase. It will be inspired by the program chapter focusing on palliative architecture, universal design, homely atmosphere, and site analysis.
Based on the form analysis and the functional diagram, there will be investigated in different floorplan solutions. Here the important part will be the rotation of the rooms on the site, their iterations, and users' needs. While placing the different functions, there needs to be a focus on passive strategies such as daylight, ventilation, and fire safety.

Tools: Autocad, Rhino
Theory: Homely environment, universal design, palliative architecture

phase 2 - detailing

Different materials will be investigated in phase 2 based on the chosen form to achieve the desired atmosphere. Here will design for disassembly as well as LCA-calculations have an impact.
Firstly, different building envelopes will be investigated based on the materials' GWP-value and thermal transmittance.
The tectonic part, in cooperation with the design for disassembly, will help to find the proper structure for the building. Secondly, after the DfD is included in the project, another LCA calculation will be conducted to analyze how much the design for DfD affects the LCA results.

Tools: Ubakus, LCAbyg, Photoshop
Theory: Social and environmental sustainability, LCA, design for disassembly

phase 3 - indoor comfort, energy frame and LCA

In this section, the emphasis will be on the indoor climate. During this design phase, the focus will be on passive and active strategies. Passive strategies will be explored through daylight analysis for window placement and shading, and also ventilation will be calculated. Active strategies such as mechanical ventilation and the use of photovoltaics will be analyzed. Through active and passive strategies, there will be reached the desired indoor climate and energy consumption of the building. These results will be analyzed through BR18 regulations.
There will also be an investigation of the acoustics of the building based on the chosen materials.

Tools: Ubakus, LCAbyg, Photoshop
Theory: Social and environmental sustainability, LCA, design for disassembly

phase 4 - finalizing the design

The final phase of the design process will aim to finalize the design through indoor climate calculations and final LCA-calculations. This is the basis for creating the next chapter, i.e. the presentation.

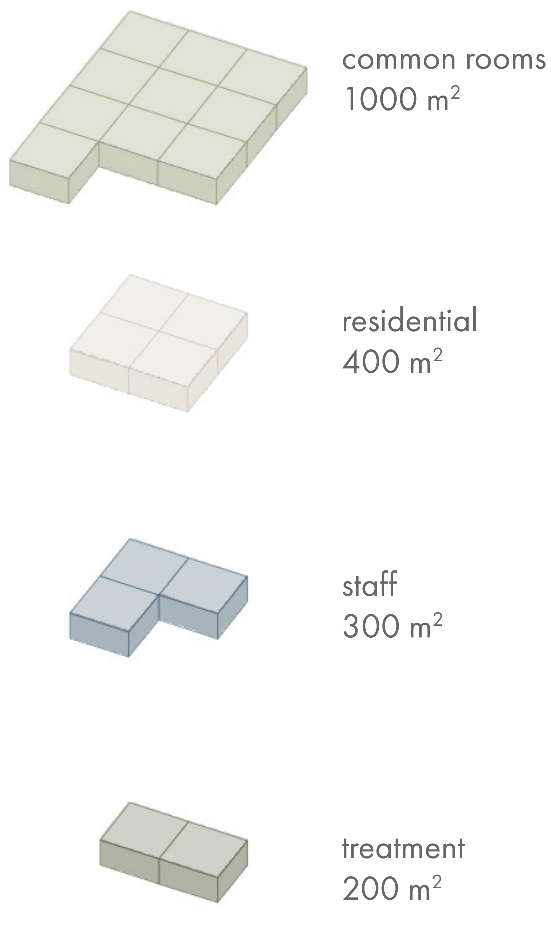
Tools: Autocad, Revit, Lumion, LCAByg, Rhino

06.2 volume studies

Based on the room program and functional diagram that was made earlier, several volume studies got investigated. The building got divided into four main zones: common facilities, residential, treatment, and staff. The total m^2 of the zones can be seen on illustration 46. Different zones got different colors to make it easy to read volume analysis as well as floorplans.

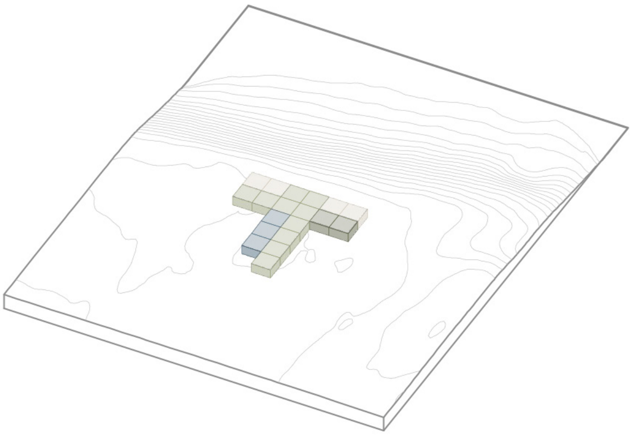
In the next chapter, various shapes of the building body that may constitute a starting point for the design process are presented. These forms will be explored mainly in terms of relationship to the context, LCA, design for disassembly, palliative architecture, universal design, homely and atmosphere. Pros and cons of the different volumes will be described, where in the end the final form will take shape based on these comments.

Based on the chapter about Universal Design, the iterations on floor plans were chosen to be on one level, for easy accessibility. Furthermore the site being 60000 m^2 the design has great potential for being on one level and blends with the context, in contrast to a design that dominates the context. The design must be compact and practical, benefitting both the palliative team as well as the children.



ill. 46 function sizes

T - shape

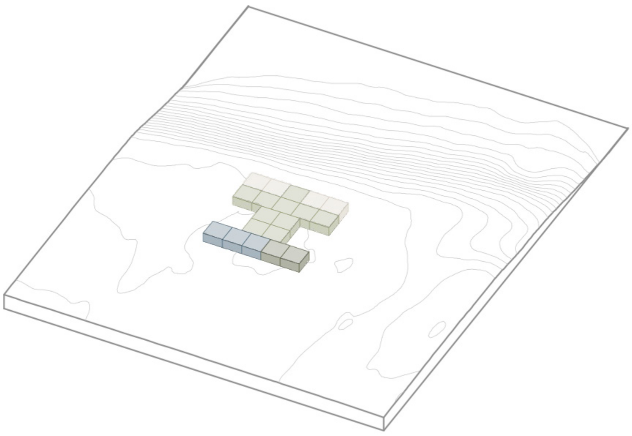


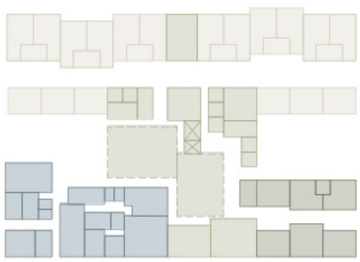
ill. 47 T-form study

Description:
This iteration has a clear division of functions and a centralized aula where everyone needs to pass by, which encourages socialization. There are several long corridors in the residential areas. Treatment zone, which is public, is included in the residental area. This will take the privacy away from the residents.

Pros and cons:
+ very linear shape that creates a lot of room with a view towards the lake
+ has the opportunity to have all apartments faced north, receiving only indirect sunlight
- creates long corridors

H - shape



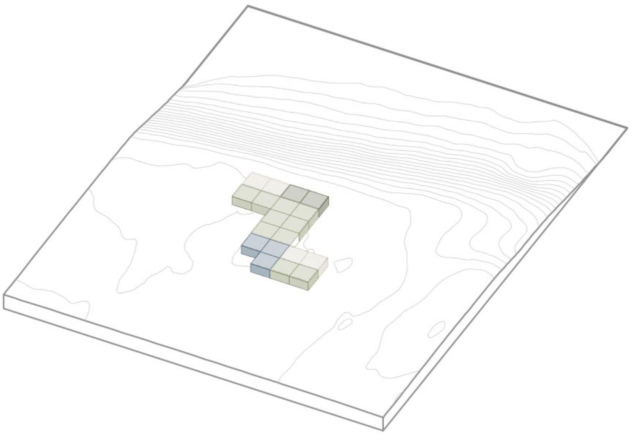


ill. 48 H-form study

Description:
This shape, as well as T-shape has a clear division of functions and a centralized aula. The staff and treatment zones feels more independent from the common zone, which gives the needed privacy to these zones.

Pros and cons:
+ very linear shape that creates a lot of room with a view towards the lake
+ has the opportunity to have all apartments faced north, receiving only indirect sunlight
- creates long corridors

Z - shape

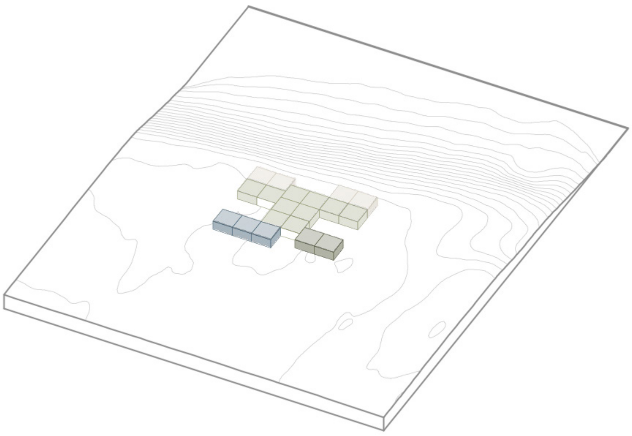


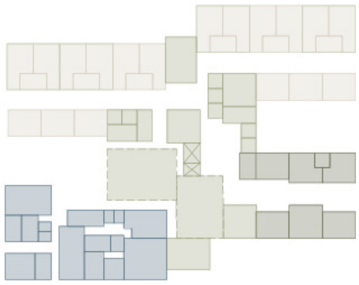
ill. 49 Z - form study

Description:
This shape has very long corridors, taking up an unnecessary amount of space, as well as amplifying the feeling of an institution and not having a homely feeling.

Pros and cons:
+ gives a large area with a view of the lake and the forest
+ prospect of placing the common spaces in the center of the building
- creates long corridors

Final shape





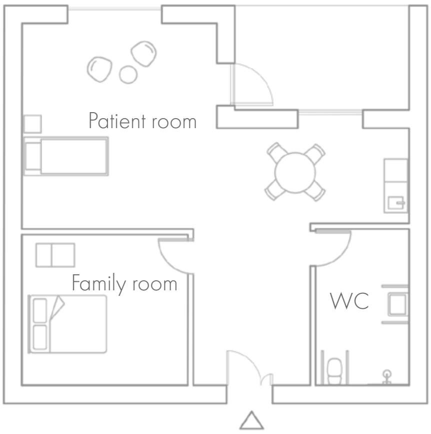
ill. 50 final form study

Description:
This shape is based on T and H-shape. It has been designed to reduce the number of corridors, while providing a good view of the lake and forest, and creating small niches for relaxation. The final shape has also a clear division of functions, which makes the building easy to understand

Pros and cons:
+ very linear shape that creates a lot of room with a view towards the lake
+ has the opportunity to have all apartments faced north, receiving only indirect sunlight
- creates long corridors

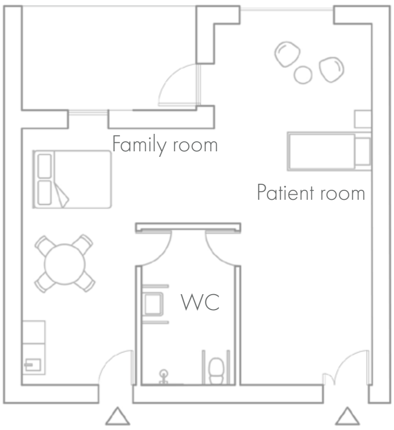
06.3 residential room analysis

The design of the residential rooms is of great importance to this project, as this is where the families will spend most of their time. The rooms must be practical, but at the same time give a homely feeling. One of the most important parameters here is to place the necessary functions without detailing too much, as it will be beneficial to allow the family to personalize the room to feel like home.
Compactness is also of great importance here to avoid unnecessary waste of space.



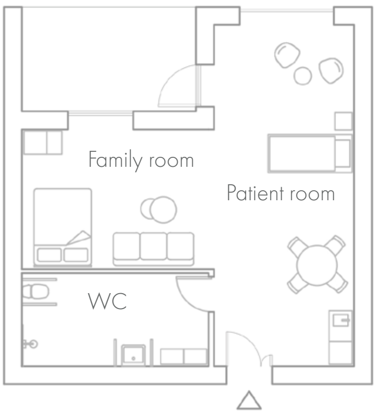
iteration 1

In this iteration, the family got a private room. The advantage of this division is that the parents can have the opportunity to withdraw and be to themselves behind closed doors. However, closeness is essential to the family in such a life-changing situation, and this design can give a feeling of separating the family from each other. Furthermore, flexibility is essential in the design of these spaces, which is not present here.



iteration 2

In iteration 2, the room got divided by the bathroom in the middle of the room. Here, both an entrance to the patient room and the parents' room are incorporated so that the parents or siblings do not disturb the patient every time they have to enter and leave the room. Here, it has been possible to create a connection between the patient and family rooms. However, this iteration takes up too much space, and the desired compactness is not achieved.



ill. 51 residential room iterations

iteration 3

In contrast to iteration 1, it was investigated to give the parents privacy without separating the rooms from each other too much. Here, the parents' room is an extension of the patient's room, which can be used simultaneously when the family wants to socialize. This iteration has been chosen to work further with, as it is more compact and, at the same time, fulfills the criteria that were set from the start. For the final design, it would be advantageous to integrate a sliding door in the room, allowing privacy for the parents when desired.



ill. 52 Kunsten Museum of Modern Art

06.4 Kunsten - Museum of Modern Art

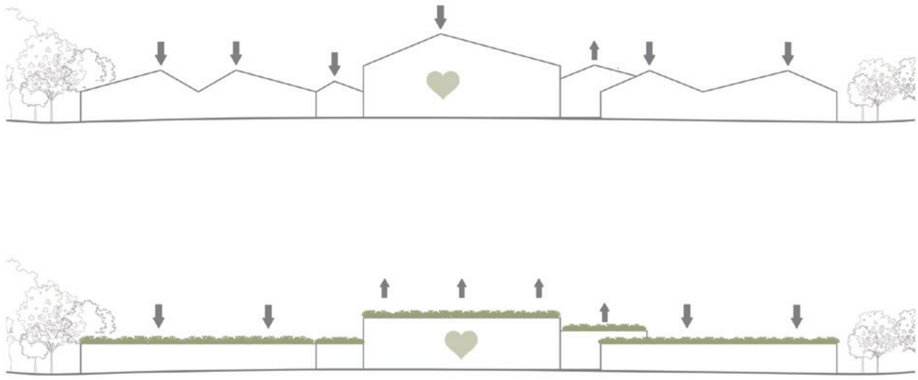
Location: Aalborg, Denmark
Build: 1972 (restored 2014-2016)
Architects: Alvar and Elissa Aalto and Jean-Jacques Baruël

The design of the museum Kunsten plays on how different ways of working with lights as well as room heights impact the experience throughout the building.

The four original rooms are: Small Hall, Skylight Hall, Sidelight Hall and the Great Hall. The Great Hall is located in the center of the building, having the highest room height, and already when arriving at the museum, it is emphasized that this is an important room. Inside the building, the flow from the entrance, walking through the exhibition rooms, and ending up in the Great Hall, the light changes. The light evolves from a slight dark entrance, slowly introducing more light, mainly through indirect sunlight, either through skylights or northern oriented windows.

These two principles of room height and lights, emphasize on the Great Halls as being the focal point of the building and what you as a visitor are striving for (Kunsten, n.d.).

The hospice, to make it easier for visitors to read the building, can use these principles to emphasize where the main activities are as well as the activity level.



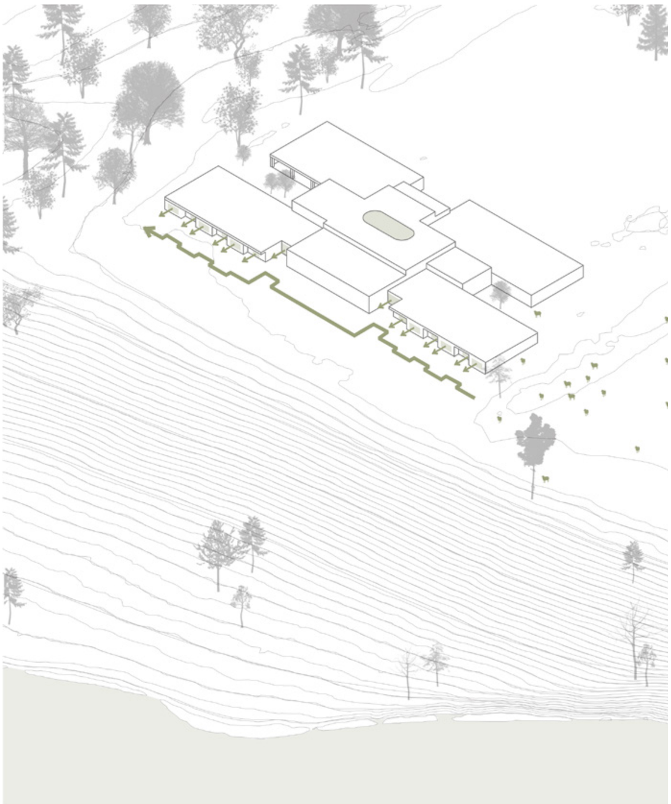
ill. 53 defining the roof

06.5 height differences

Due to the topographical conditions of the site, i.e. the slope of the land towards the lake, it is important to properly diversify the form. A crucial aspect of the building is the height difference, which affects the perception of a given space. From the water level, the observer will only see the roof of the hospice, which must be eye-catching. Therefore, it is beneficial to create level differences and use a green roof, which will allow the introduction of nature outside the building.

In order to maintain a human scale, three heights are used that correspond to the measure of plywood boards: 2,44 m, 3,66 m and 4,88 m. Using these heights will affect the perception of space and influence how it will be identified by users. In the rooms that will be the most accessible to the public, i.e. in the aula, the ceiling is the highest. This will emphasize the fact that this is the heart of the hospice, and that is where most of the activity will take place. More private rooms, such as residential units or the treatment part, will be "separated" from the public part by changing the height to a lower one. Such a hierarchy of space also makes it possible to increase the readability of the building and make it easier for users.

The next step is to determine the type of roof. The first iteration is pitched roofs. This form, despite the fact that it provides an interesting aesthetic experience, gives the impression of overwhelming the obserwer. The building has a relatively big footprint, and the many smaller pitched roofs enhance this effect. The second iteration shows a building with a flat roof. Looking at them, one gets the impression that the form of the facility corresponds more with the surroundings, and its minimalist form gives an elegant effect.



ill. 54 connection with nature

06.6 connection with nature

Designing a building, especially on such a unique plot site, which is of great value due to the fact that it is untouched in urban terms, requires adapting the facility to it and connecting it with nature.
To achieve this, several aspects need to be considered:

- view from the access road - due to the fact that the northern and western façades will be exposed, special attention should be paid to their design. The façade must encourage visitors to visit the facility, and thus be interesting and non-monotonous, preserving the human scale and blending in with the surroundings, without obscuring the site's natural potential.
- lake and forest view - the facility should provide a view from the residential rooms and other rooms to the lake and forest surrounding the site
- following the terrain - the facility should be adapted to the topography of the site. Due to the fact that the plot is relatively flat, the building can be adapted by imitating the shape of the shore of a lake.
- weather pattern response - the project is to be adapted to the location, e.g due to the daylight, through the appropriate arrangement of windows
- minimize visual impacts - natural materials should be used to blend into the terrain
- animals - due to the proximity of the building to the meadow where sheep are grazed, the building should not be isolated, but should allow users to come into contact with animals, which can have a positive impact on patients' health.
- organic shapes - to refer to organic shapes occurring in nature, curvilinear elements should be used in the building, e.g. furniture. This will also have a positive effect on the safety of children.
- transitions between outdoor and indoor spaces - the facility should be designed with the minimization of sensory boundaries between man and nature. Nature should be allowed both visually and acoustically, e.g. through windows

06.7 LCA and DfD process

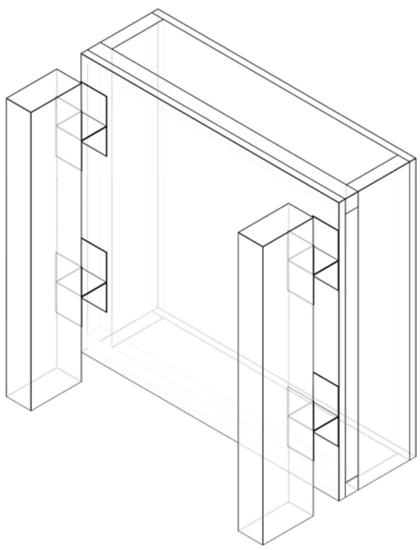
The process for incorporating DfD, minimizing the GWP of the hospice and investigating what impact this can have on a potential future building, reusing the building materials, have gone through the following process:

01 Reducing the amount of used materials and reducing GWP by choosing materials with low CO2 footprint, compared to conventional building methods.
02 Designing a modular building system for as many construction parts as possible.
   - Using the full size of standard materials, such as plywood.
03 Designing the facade in order for windows and door openings to create as little wastage in the other building materials as possible.
04 Calculating the final LCA for the hospice:
   - Using product specific EPD´s
   - Calculating energy consumption
   - Calculation waste
05 Calculating GWP for a future building, using reused modules.
06 Correcting the GWP of an average danish building, by calculating the wastage.
07 Comparing all tree values with each other to showcase the reduction in GWP on the hospice and in the future building.

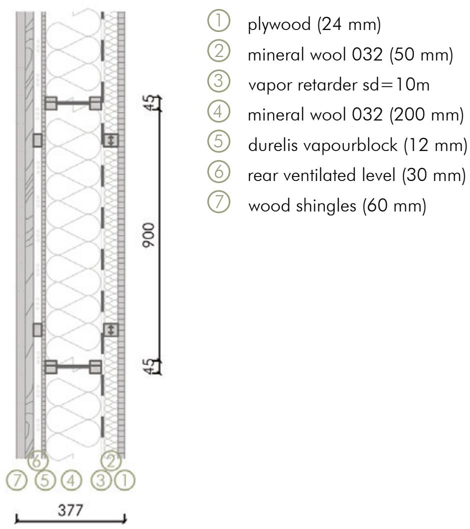
06.8 envelope and layers

To determine the envelope of the building, three iterations have been investigated. They all have in common that the facade cladding is a layer for itself, which is equally easy to disassemble from the construction part. This is partly to see how design for disassembly can be incorporated and see which possibilities it brings in the design.

iteration 1

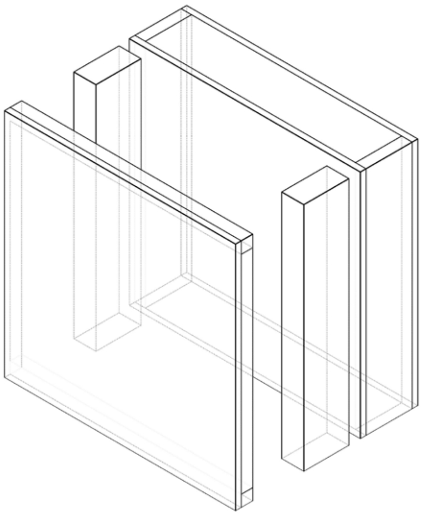


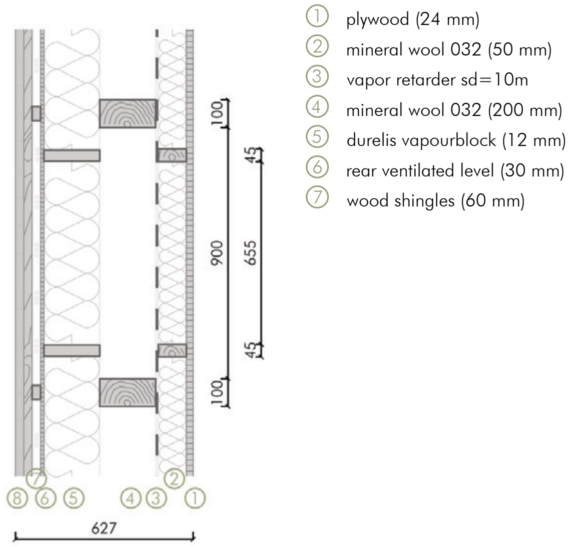
ill. 55 load bearing columns seperated from insulating envelope module



This iteration does not have the load bearing columns within the wall, instead being placed on the interior side, making them visible. The idea is to separate the load bearing structure from the envelope, keeping the envelope itself as one construction part. This makes it possible to be used as a wall in a new building and the columns being able to be reused in a variety of new functions.

iteration 2

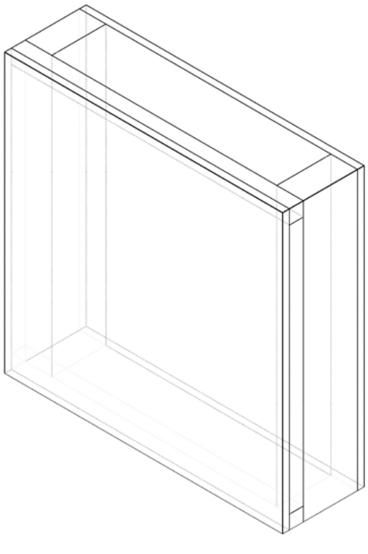


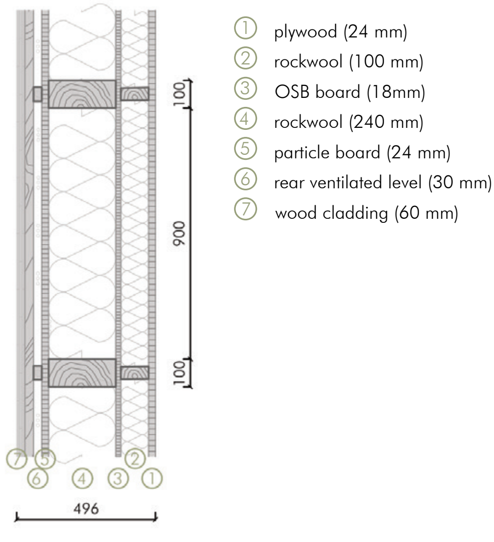


ill. 56 possibility to disassemble

In this iteration, the envelope is split into two parts, an interior, and an exterior part, and then being connected to the load-bearing columns in between them. This is to potentially create a system where it is easier to disassemble the different construction parts into three main parts: columns, inner waller and outer wall. After end use, where the inner wall potentially can become a not load bearing wall in a house for example.

iteration 3





ill. 57 compact module

This iteration is the more traditional way of constructing a wall with a wooden structure. The load bearing columns are placed inside the wall, making it more compact than the other two iterations. Regarding DfD this iteration might face bigger obstacles when it comes to disassembling it into its individual components. Potentially this wall construction can be made in modules as finished facade elements, where it can be reused as a whole, but not its individual parts.

06.9 design for disassembly - joints and connections

As DfD is a big part of the sustainable strategy of the project, it is important to incorporate it early in the design phase. The main principle which has been the foundation for choosing dimensions of rooms is the size of construction boards such as veneer,- and gypsum boards. The dimensions of these boards will define the dimensions to avoid cutting the materials and creating close to zero waste in the building process. The design principles from the chapter on DfD, lays the foundation for the design process.

Roughly speaking the building consists of a terrain deck, both load bearing and not inner walls, outer walls and ceiling/roof. These construction parts must be able to be assembled and disassembled to one another, to ensure the possibility for reuse

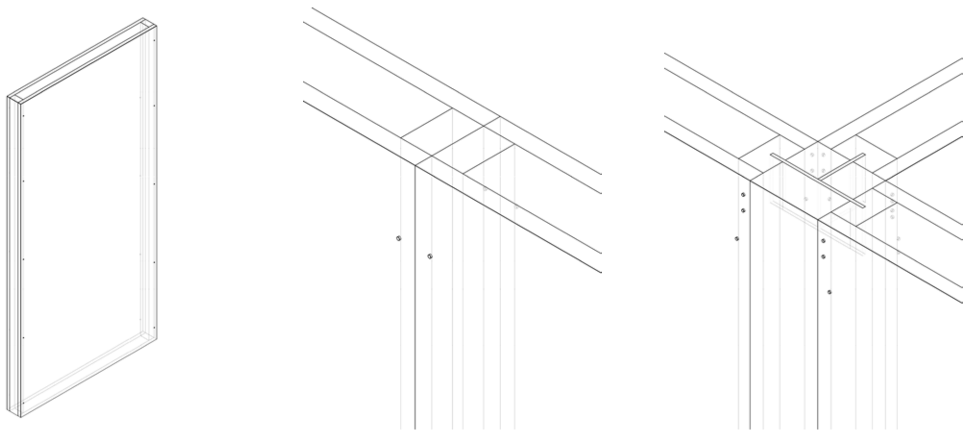
Designing a modular building system for the project consists of two main aspects:

- the buildup of the construction, ensuring that is possible to dismantle as much as possible
- joining two elements making sure they can be disassembled from one another.

The following investigation is a tree iteration of a wall element which shows how to assemble two and three modules together.

iteration 1 - assembling a wall

This first iteration shows which layer an internal wall must consist of. This module is not easy to assemble and disassemble, but gives an idea of what to be aware of when designing the module.



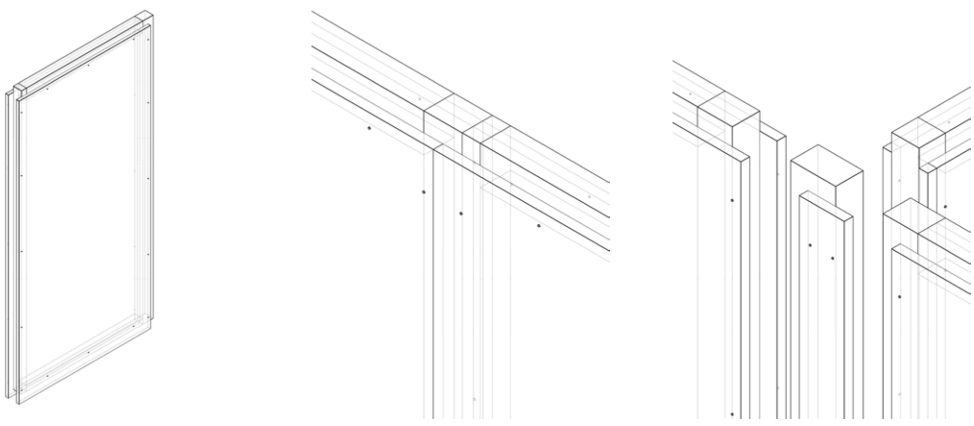
single module → *connecting two modules* → *connecting three modules*

ill. 58 iteration 1 - assembling a wall

iteration 2 - Ebb and flow

This iteration is designed to not use a third element when joining two walls together, as the module is designed with ebb and flow. When introducing a third wall, this design becomes harder to work with, as the joint is staggered, due to the ebb and flow design. This results in introducing multiple parts to make the joining work.

The GWP of the module is: 0,224 kg eq. $CO_2/m^2/yr$.



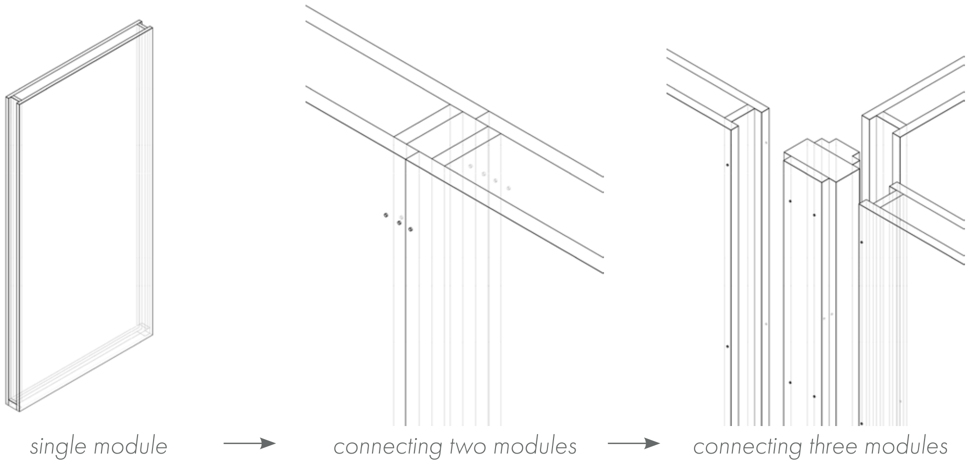
single module → *connecting two modules* → *connecting three modules*

ill. 59 iteration 2 - Ebb and flow

iteration 3 - optimizing joints

This iteration is very similar to the first one but differs as the studs in the sides are moved further inwards. This gives space to place a stud in between two wall elements to assemble them. When connecting three wall modules, a modules which the three wall modules can grab around is used, making it easy to assemble and disassemble with screws.

The GWP of the module is: 0,180 kg eq. $CO_2/m^2/yr$

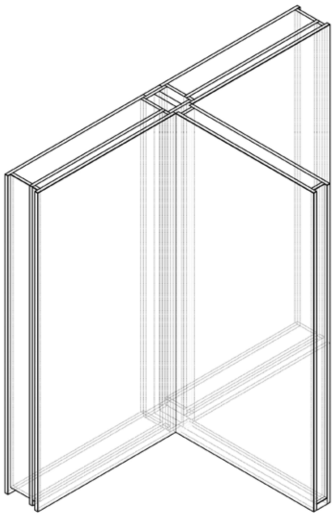


ill. 60 iteration 3 - optimizing joints

conclusion

The iterations for internal and exterior walls were assessed to see which solutions could work together and make a modular system. The construction of exterior wall one and interior wall two was very similar, making them more compatible.

The joining of two different walls was made possible by adjusting the joint-module from the internal walls. These principles will do as the underlying basis for all joint between modules in the project.

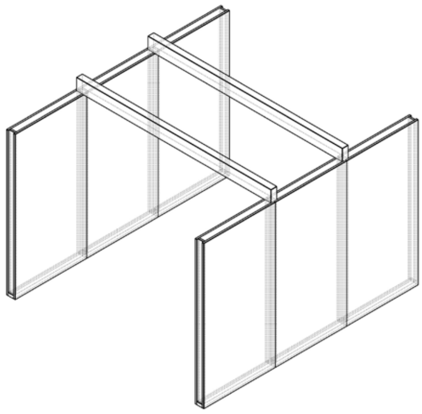


ill. 61 external and internal wall connection

06.10 design for disassembly - ceiling and roof construction

The chosen wall system gives a point of departure when it comes to further designing the modular system, as the load-bearing beams distance between them is determined by where the load-bearing columns are placed.

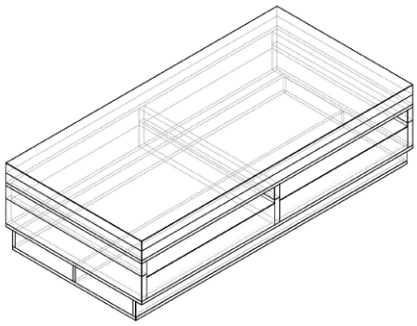
It was chosen to investigate the possibilities having visual beams, therefor only designs where the modules are placed on top of the beams were investigated.d how to assemble two and three modules together.



ill. 62 load-bearing beams concept

iteration 1 - hidden ducts

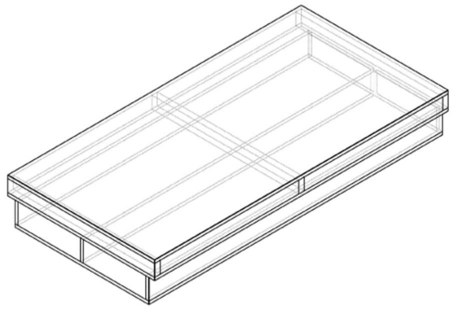
In the first iteration, the roof construction had room for ventilation ducts. This concept faces the obstacle of how to install the ducts, while still benefiting from the modular concepts of easy and fast construction, without working a lot on construction at the building site.



ill. 63 roof iteration 1

iteration 2 - minimizing the module

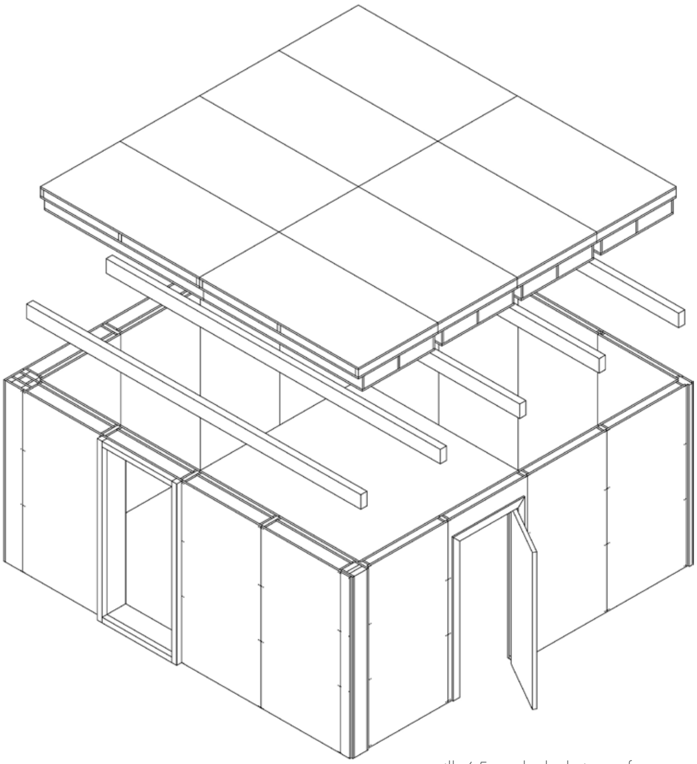
In the further development of the ceiling/roof module, it was to have visible ducts and by that choice, making it possible to reduce the thickness of the ceiling/roof module. This reduces the material usage, and makes the building lower than using the first iteration.



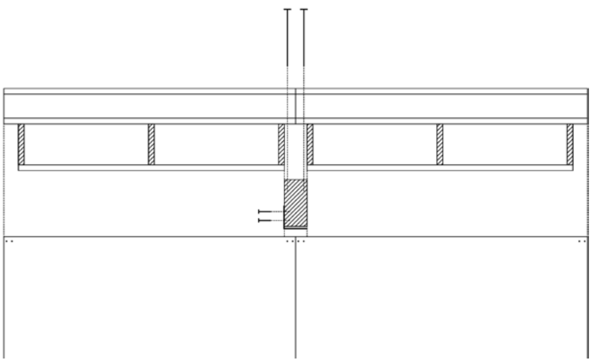
ill. 64 roof iteration 2

06.11 a whole room conclusion

To prove the concept viable, a room consisting of exterior walls, load-bearing inner walls as well as not load-bearing inner walls is put together with the roof. This proof of concept gives a reference point on how to solve future joints between the elements when the modules and the floor plan will be put together.



ill. 65 exploded view of a room



ill. 66 wall and roof connection in 2D

06.12 materiality - interior atmosphere

When choosing building materials, not only their environmental, acoustic and hygrothermal parameters are important, but also aesthetic ones. These aspects create a certain atmosphere in the room and affect sensory perception. The use of the proper material is essential for a multi-sensory architectural experience, and the tactile element is fundamental here. The tactile element is important whether the materiality is touched directly or not because the user can imagine or mentally simulate what it would be like to touch the surface. (Spence, 2020)

For this reason, various iterations of materials and the atmospheres they create have been investigated. The main validation factors were LCA, acoustics (see appendix 03.2) and aesthetic aspects.

chosen

wooden floor, plywood walls & plywood ceiling

atmosphere: A wooden floor is a natural material, warm to the touch and pleasant to walk on. It gives the opportunity to go barefoot, which is especially important in the case of children. Naturally grained hardwood preferably has naturally tempered surfaces. Similarly, the plywood surfaces of the walls and ceiling give a warm effect and give a feeling of a homely environment.

LCA: 0,23 kg CO_2 eq./m^2/year

Acoustics: 0,60 s

linoleum floor, gypsum board walls & plywood ceiling

atmosphere: The second iteration differs in the use of gypsum boards on the walls and linoleum on the floor. Flat and smooth expression of gypsum board can enhance the institutional effect. On the other hand, it is bright, so it can illuminate the room and make it more friendly. The used linoleum flooring is not a natural and colder material than wood, so walking barefoot can be less pleasant.

LCA: 1,40 kg CO_2 eq./m^2/year

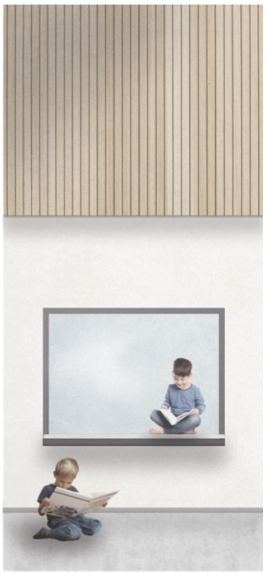
Acoustics: 0,87 s

wooden floor, lamellas walls & gypsum board ceiling

atmosphere: The third iteration includes lamellas on the walls. Their use can give a warm atmosphere and enhance the homely feeling in the hospice room. But at the same time is not dark because of the gypsum boards on the ceiling. The use of lamellas also enhances the tactile sensations, as patients feel the interesting texture of the wall.

LCA: 0,47 kg CO_2 eq./m^2/year

Acoustics: 0,27 s



ill. 67 interior materiality investigations

lineoleum floor, gypsum board walls & lamellas ceiling

atmosphere: The fourth iteration is a mix of previous materials. The use of such a combination gives a feeling of non-monotonous atmosphere. However, these transitions seem to be too strong and incoherent. The use of a wooden ceiling in combination with gypsum board on the walls draws attention to the ceiling. It can give the impression that the room is lower than it really is

LCA: 1,45 kg CO_2 eq./m^2/year

Acoustics: 0,38 s

wooden floor, reused brick walls & gypsum board ceiling

atmosphere: This iteration differs in the use of brick on the wall. Its use adds and enhances tactile elements due to the texture and color of this material. The use of multiple textures can reduce the sense of institutionality.

LCA: 0,39 kg CO_2 eq./m^2/year

Acoustics: 0,99 s

06.13 materiality - facades

Different iterations of material combinations were investigated to visualize what the facility might look like from the outside, and thus the atmosphere it could evoke. In the process of their evaluation, LCA and aesthetics were taken into account.

wooden wall & straw roof

atmosphere: The use of straw on the roof strengthens the bond with the place, due to the lake, around which grow straw-like plants with similar properties. Similarly, the wood on the façade may refer to the trees growing on the site. The combination of these materials makes it blend in nicely with the terrain.

LCA: 1,62 kg CO_2 eq./m^2/year

reused brick & metal roof

atmosphere: The use of metal sheets on the roof allows for reflection of light and highlighting this element of the building. This is an important aspect due to the fact that the roof will be the first element that will be visible in the distance. Reused brick on the facade walls have a texture which strengthens the tactile element.

LCA: 0,60 kg CO_2 eq./m^2/year

chosen

reused brick & green roof

atmosphere: This iteration combines the patina and tactility of the reused brick together with the green roof. The reused brick stands out as a contrast between the grass on the meadow and the green roof.

LCA: 1,12 kg CO_2 eq./m^2/year

ill. 68 facade materiality investigations

wooden shingles & wood

atmosphere: The fourth iteration has wooden shingles on the wall, which gives a dynamic expression. This material has a natural, rough texture and enhances the tactile element. Especially in combination with a wooden roof, it gives the building a more traditional look.

LCA: 0,46 kg CO_2 eq./m^2/year

brick wall & straw roof

atmosphere: The fifth iteration is a combination of the first and second, but with a new brick. This brick has a weaker texture than reused brick and less color variation, but still gives a tactile element. These materials contrast with each other, thanks to which the façade is not monotonous.

LCA: 1,36 kg CO_2 eq./m^2/year

wooden wall & green roof

atmosphere: The last iteration has a green roof and wood on the facade. This type of roof makes the façade blend in nicely with the terrain. Greenery can also increase biodiversity as it attracts bees, birds and butterflies, which adds a sound effect and positively affects the feeling and connection with nature.

LCA: 1,34 kg CO_2 eq./m^2/year

06.14 facades - windows

Striving for a hospice that will have a homely and warm atmosphere, and at the same time will be connected with nature, it was decided to perform facade studies. They focus primarily on the use of different shapes of windows and wood and brick in various combinations (thanks to previous research on external expression). Various iterations of the building's entrance facade are presented below. Mainly aesthetic aspects were assessed here.

chosen

In the first iteration, one material was used - wooden cladding. However, some planks are longer and go through the entire façade, so they can overlap windows and create solar shading.

The second iteration is a mix of wood and reused brick. This breaks the effect of monotony on a long façade. In addition, the vertical elements give the impression that the building is higher than it actually is, which is recommended. This arrangement of wooden panels gives a more official feeling and emphasizes the idea of the modularity of the building.

This version of the façade is designed with raw wood, which gives it a more raw but honest expression. In addition, it has an additional horizontal row of windows.

chosen

ill. 69 facade and window investigations

In the third iteration, wood and aluminum frames were used to extend the building and break the monotony thanks to contrasting color and material.

The fourth iteration is a mix of wood and brick. The facade seems to be very calm, but not monotonous thanks to the breaking of the rhythm of vertical elements. This arrangement gives a private feeling and emphasizes the idea of the modularity of the building.

The last iteration is a modification of the first, using raw wood to give it a more rugged look.

06.15 daylight, ventilation and BSim

Process:

- Dimensioning windows
- Initial daylight simulation
- Dimensioning windows regarding natural ventilation in three critical rooms (see appendix 02.3)
- Incorporating skylights as needed for natural ventilation.
- Testing window size in BSim, to check for overheating
- Incorporating mechanical ventilation to avoid overheating (see appendix 02.4)
- Creating final daylight simulation for whole building, with the final facade, based on window dimensioning from natural ventilation calculation.

Description:

In order to dimension the windows, calculations on the airflow and air change got calculated due to atmospheric comfort with a focus on emission, CO_2, and experienced air quality. The highest airflow, in this case, was experienced air quality, which determines the basis for the calculation of the dimension of the windows regarding natural ventilation.

Simultaneously with dimensioning the windows regarding natural ventilation, initial daylight simulations were computed, to give an idea of how big the windows should be and their placement, regarding achieving sufficient daylight.

The initial simulations showed that the size of the windows provided more than the demanded sufficient daylight and therefore the calculations on natural ventilation became the decisive factor on the window dimensions.

To ensure the indoor climate is comfortable and lives up to the Building Regulations when it comes to overheating, three critical areas were simulated in BSim. The three areas are an apartment, the staff consists of an open office, a private office, and meeting room as well as a south-facing therapy room.

First, a simulation was performed in BSim to see if natural ventilation alone would be sufficient for the rooms. This proved to be the case in the therapy room, and in the other rooms, it was needed to incorporate mechanical ventilation to reduce hours with overheating.

After proving overheating was not an issue in the building, a finalized daylight simulation was performed, based on the dimensioned windows from the natural ventilation calculations. The final simulation has more and larger windows than the initial one and shows that the building is well-lit with more than sufficient daylight.

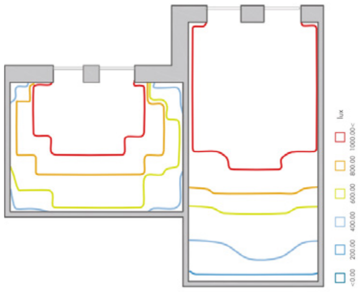
Room	Initial Bsim - without mechanical ventilation	Final Bsim - with mechanical ventilation
Apartment	Hours > 27°C: 206 Hours > 28°C: 119	Hours > 27°C: 41 Hours > 28°C: 21
Therapy room	Hours > 27°C: 87 Hours > 28°C: 20	Hours > 27°C: * Hours > 28°C: *
Office	Hours > 27°C: 449 Hours > 28°C: 279	Hours > 27°C: 34 Hours > 28°C: 9

table. 11 BSim results

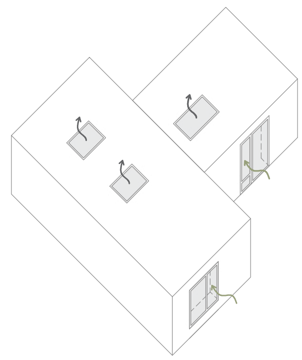
apartment

Initially the rooms in the apartment only had windows in the facade, which proved to be sufficient, regarding daylight. To ensure the experienced air quality is comfortable, by using natural ventilation, stacked ventilation was introduced, by using skylights. In order to avoid overheating, mechanical ventilation is needed.

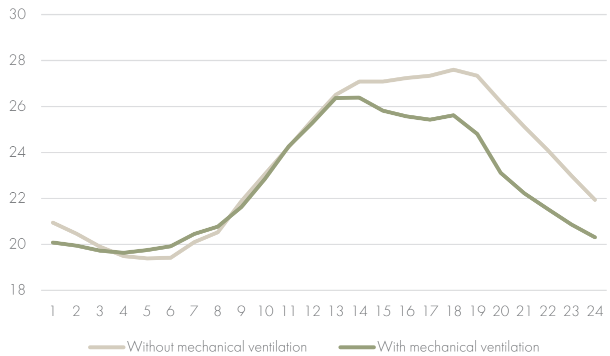
initial daylight analysis of the apartment



dimensioning windows by natural ventilation



final temperature profile

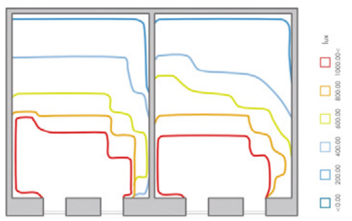


ill. 70 indoor climate for apartments

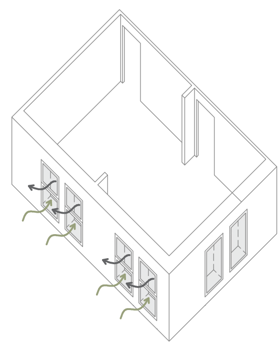
therapy room

The therapy room, having south orientated windows, has more than sufficient daylight. The room uses single sided ventilation to achieve atmospheric comfort. The room does not face chalanges regarding overheating, as simulated in BSim.

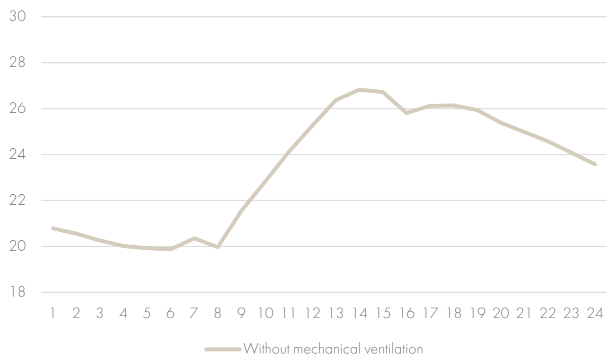
initial daylight analysis of the apartment



dimensioning windows by natural ventilation



final temperature profile

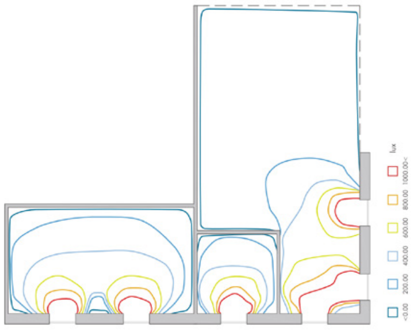


ill. 71 indoor climate for therapy room

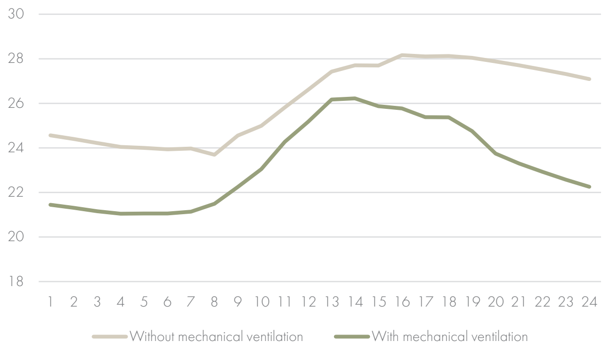
staff

The staff area in the initial daylight simulation shows a lack of sufficient daylight in half of the open office. In the final simulation, it is shown it achieves sufficient daylight due to it not having walls towards the aula. The rooms in the staff area use single sided natural ventilation and need mechanical ventilation to avoid overheating.

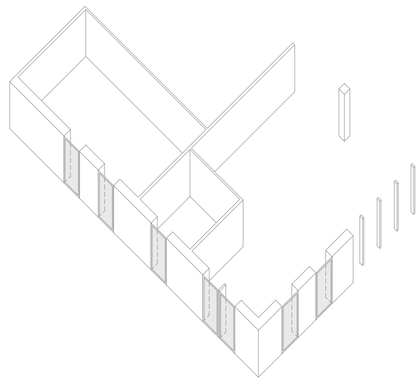
initial daylight analysis of the apartment



final temperature profile

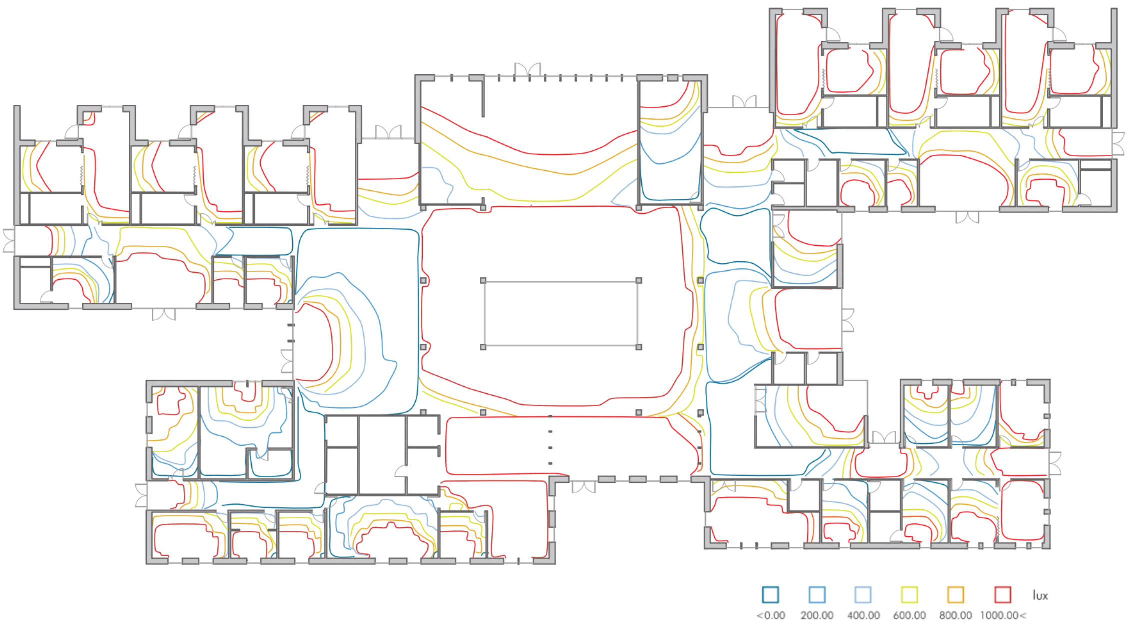


final window dimensions



ill. 72 indoor climate for staff area

06.16 final daylight



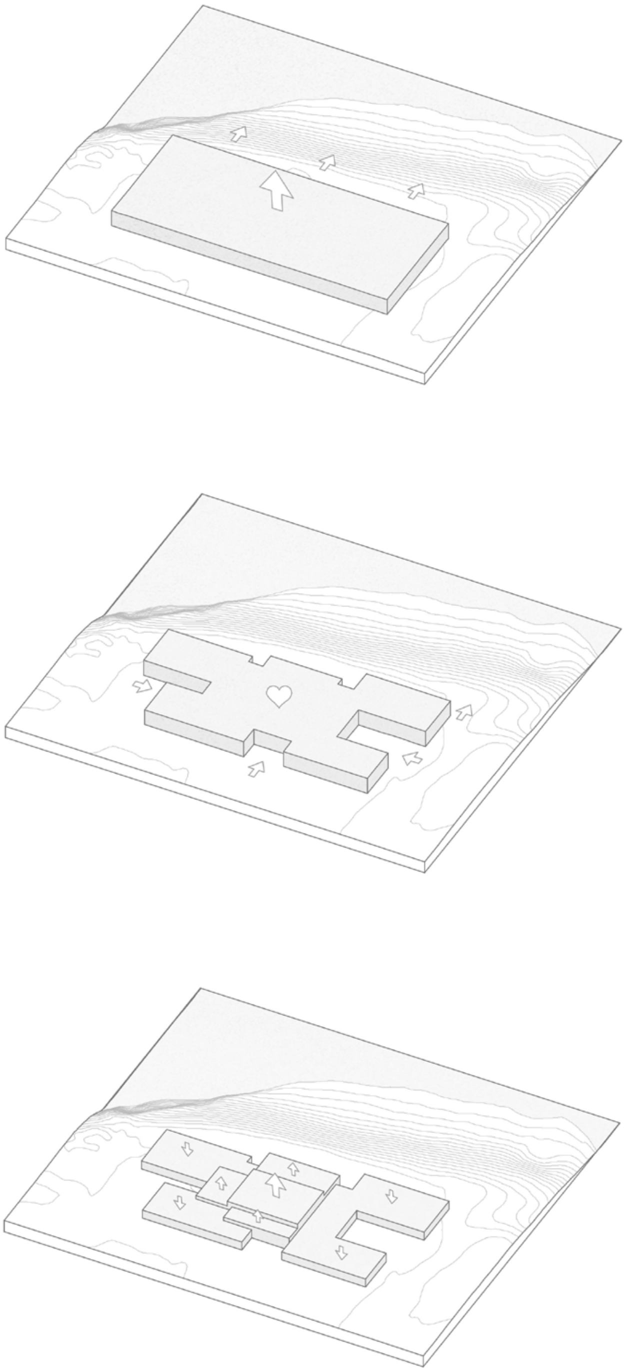
ill. 73 final daylight analysis

PRESENTATION

of the Meadow

07.0

07.1 concept



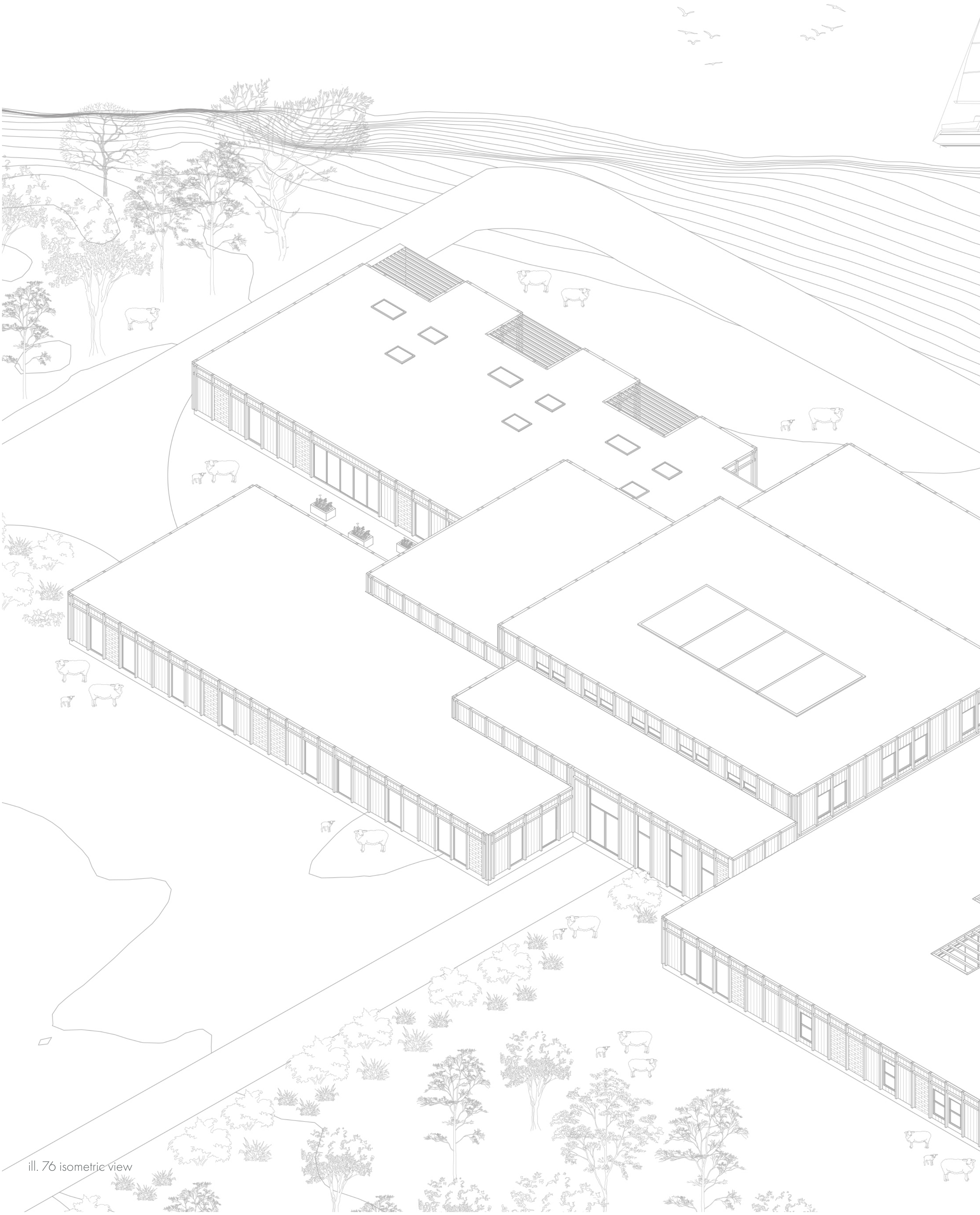
orientation towards the lake
- following the site

opening up for nature and defining
the heart of the building

emphasizing the heart of the
building through height differences

ill. 74 concept diagrams

ill. 75 render from sensory garden



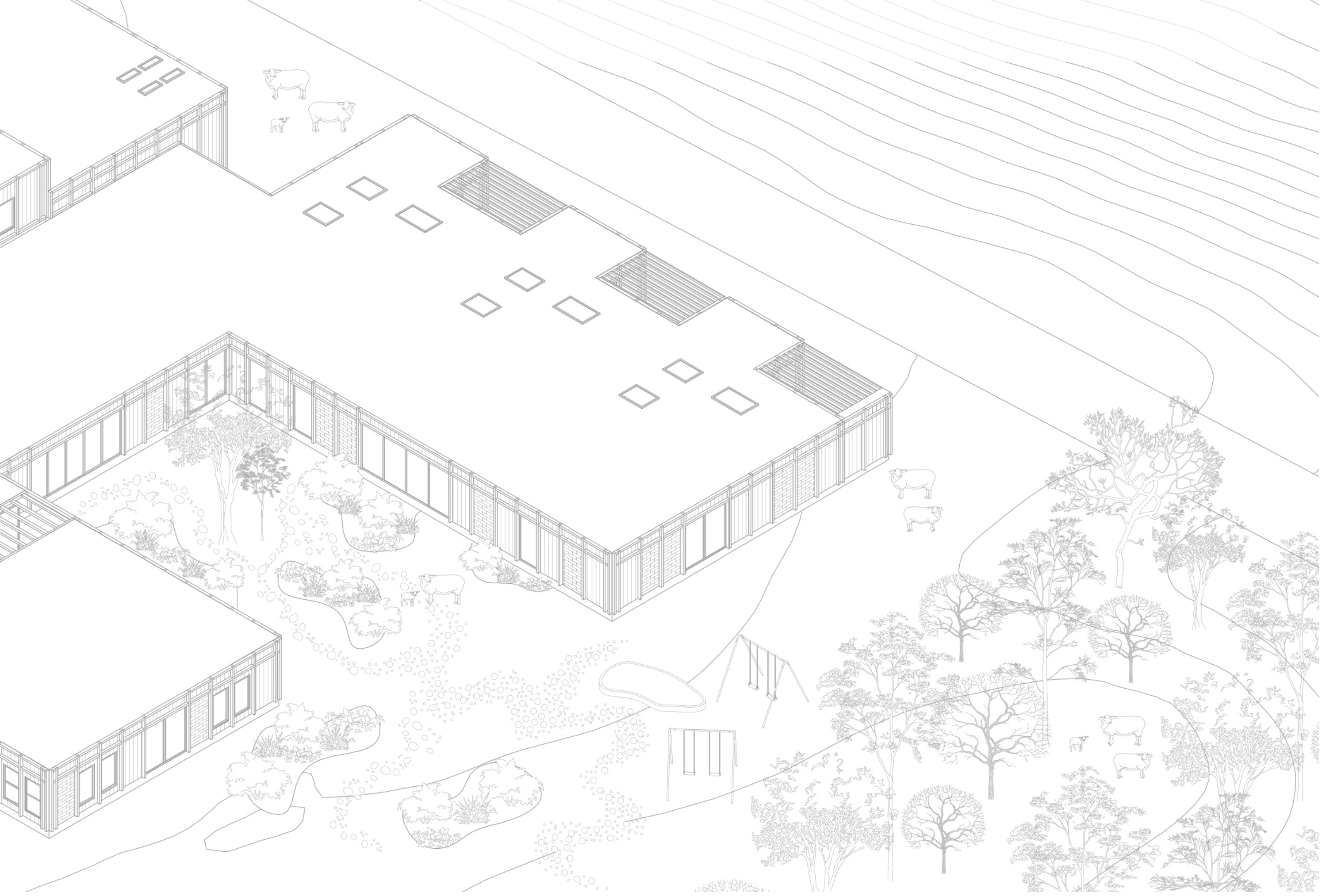
ill. 76 isometric view

The Meadow

The Meadow can be divided into four functional zones: residential, staff, treatment, and common. The layout of the facility is structured, and therefore easy, for users to read and navigate. The building includes residential rooms due to the desire to create a bond between staff and patients who are in need of more care than the daycare users. The Meadow provides both daycare as well as facilitates overnight stays for people who need extra care and relief. Here one can find six apartments, a large aula with separate play areas, a shared kitchen and dining room, therapy rooms, and multi-faith space among other functions.

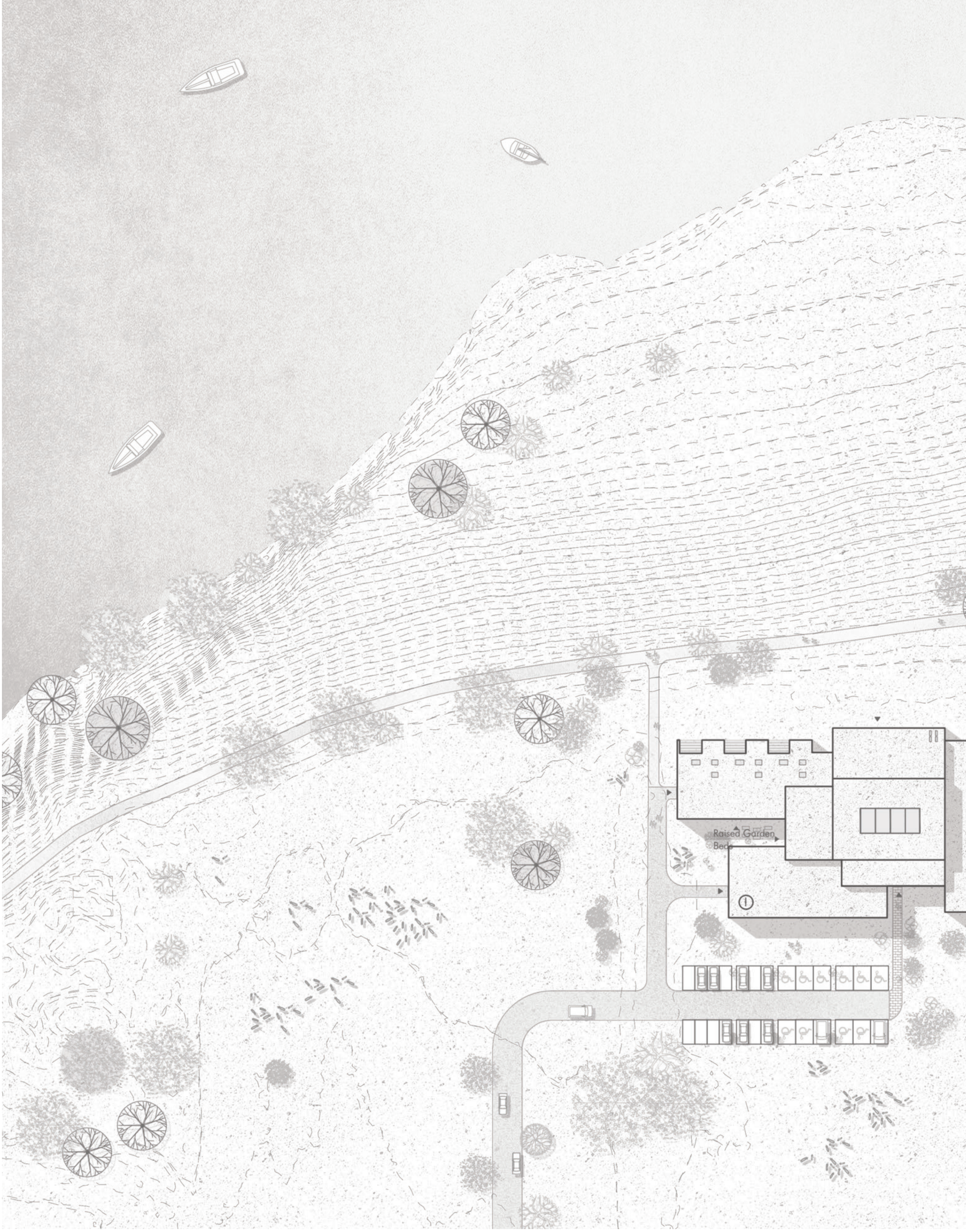
The external facades of the hospice have been designed to emphasize the modular nature of the building and use materials that will be honest, reflecting its true character. The facility embraces the surrounding nature and plays with the relation between the outdoors and indoors, inviting the meadow inside with its picturesque views, giving the children a feeling of being outside.

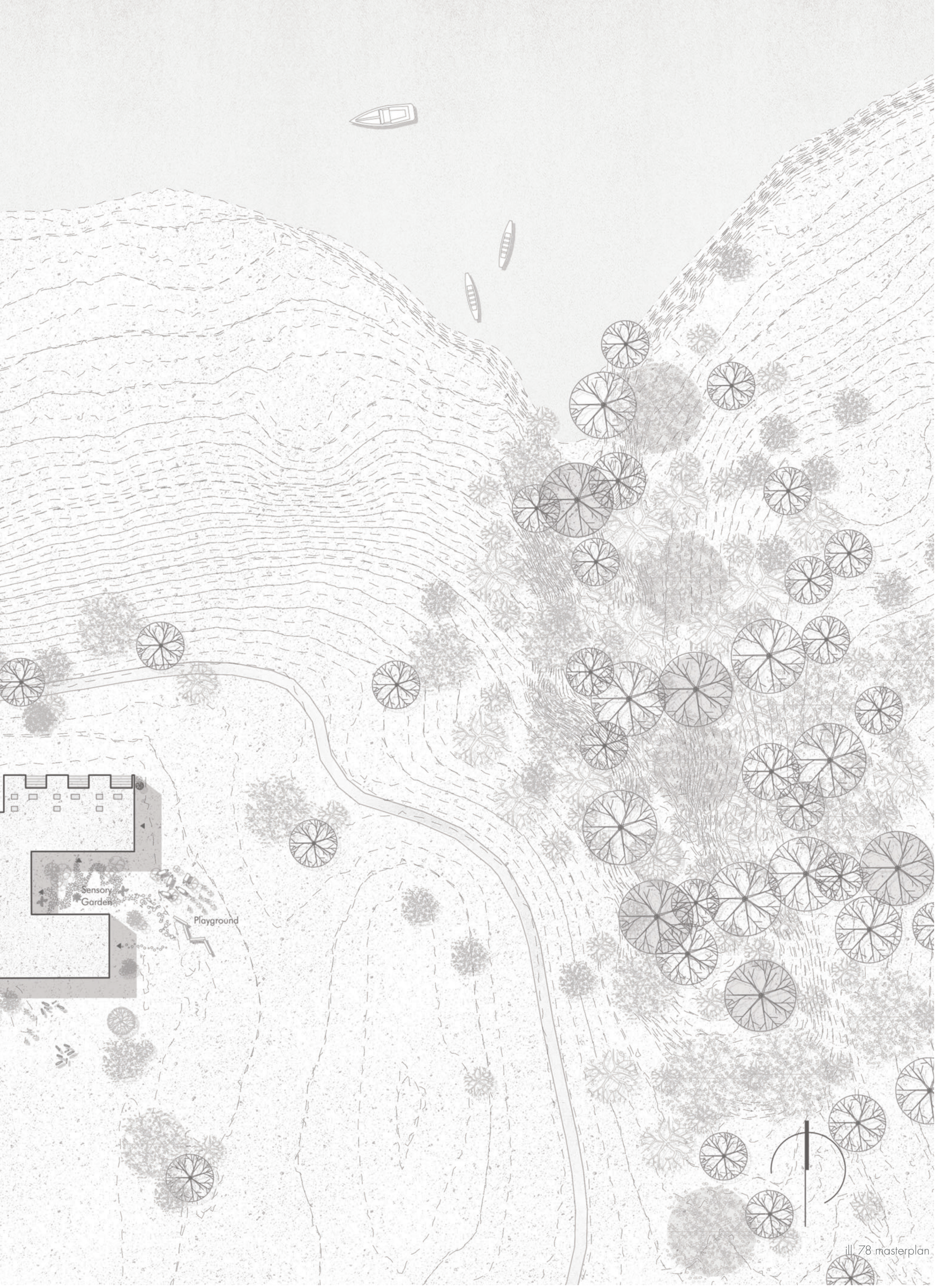
The building itself is constructed of a modular building system, based on the size of plywood boards. The modular approach has resulted in a lower GWP than conventional buildings in Denmark and has the potential to reduce the GWP for future buildings even more. The design showcases these modules as part of the visual expression both indoor as well as outdoor, to show homage to the construction, which is unique and defining for The Meadow.



ill. 77 render of the entrance

07.2 masterplan 1:1000



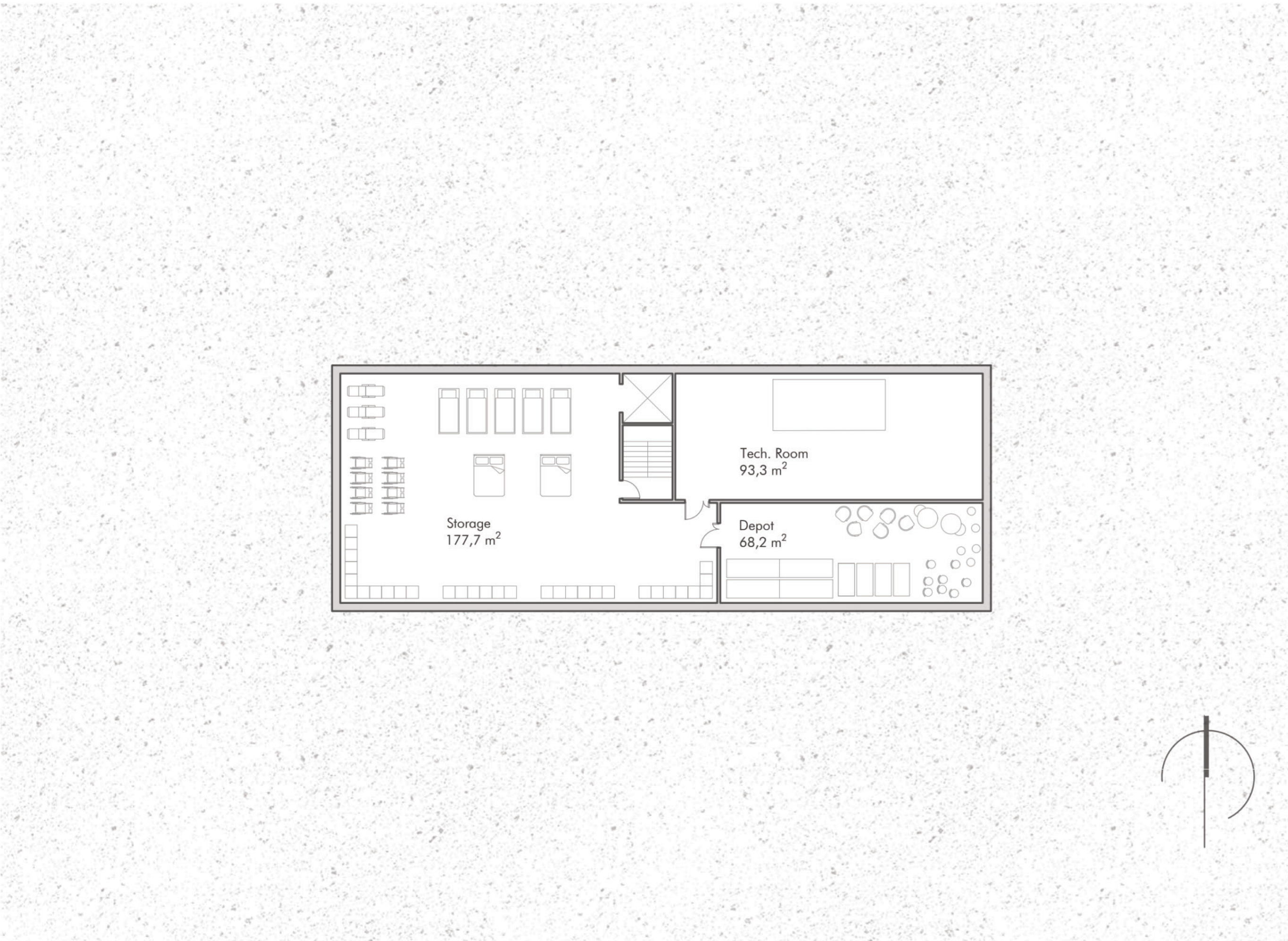


ill. 78 masterplan

07.3 ground level 1:350

ill. 79 floorplan, ground level

07.4 basement 1:350



ill. 80 basement plan

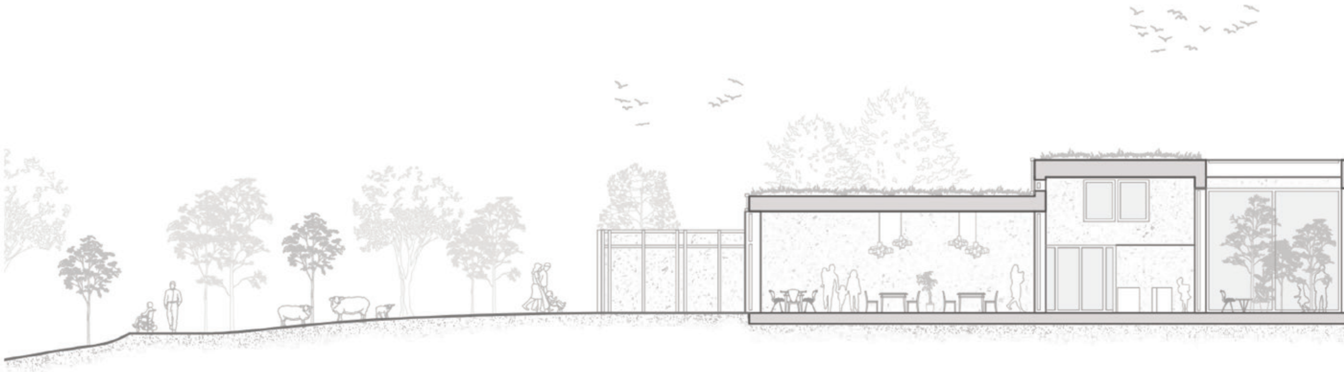
ill. 81 library render

ill. 82 niche render

view from the kitchen

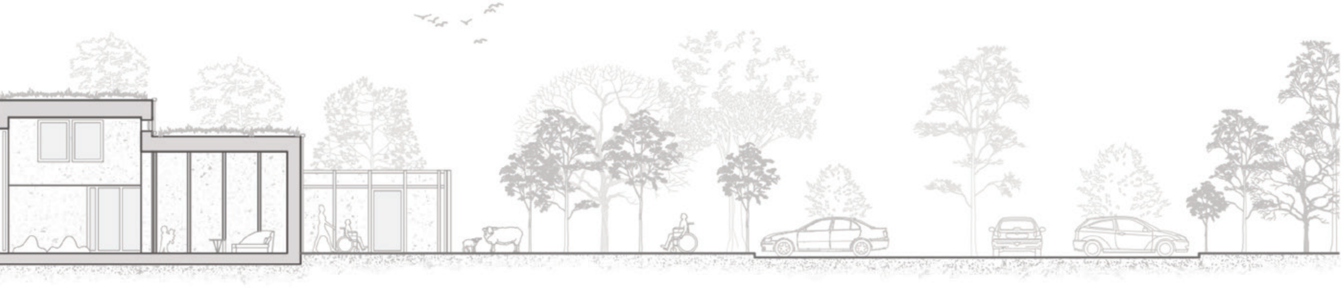
ill. 83 kitchen render

07.5 sections 1:250



SECTION A-A, 1:250

SECTION B-B, 1:250



ill. 84 sections

view of the aula

ill. 85 render of aula

07.6 facades 1:350

NORTH FACADE 1:350

WEST FACADE 1:350

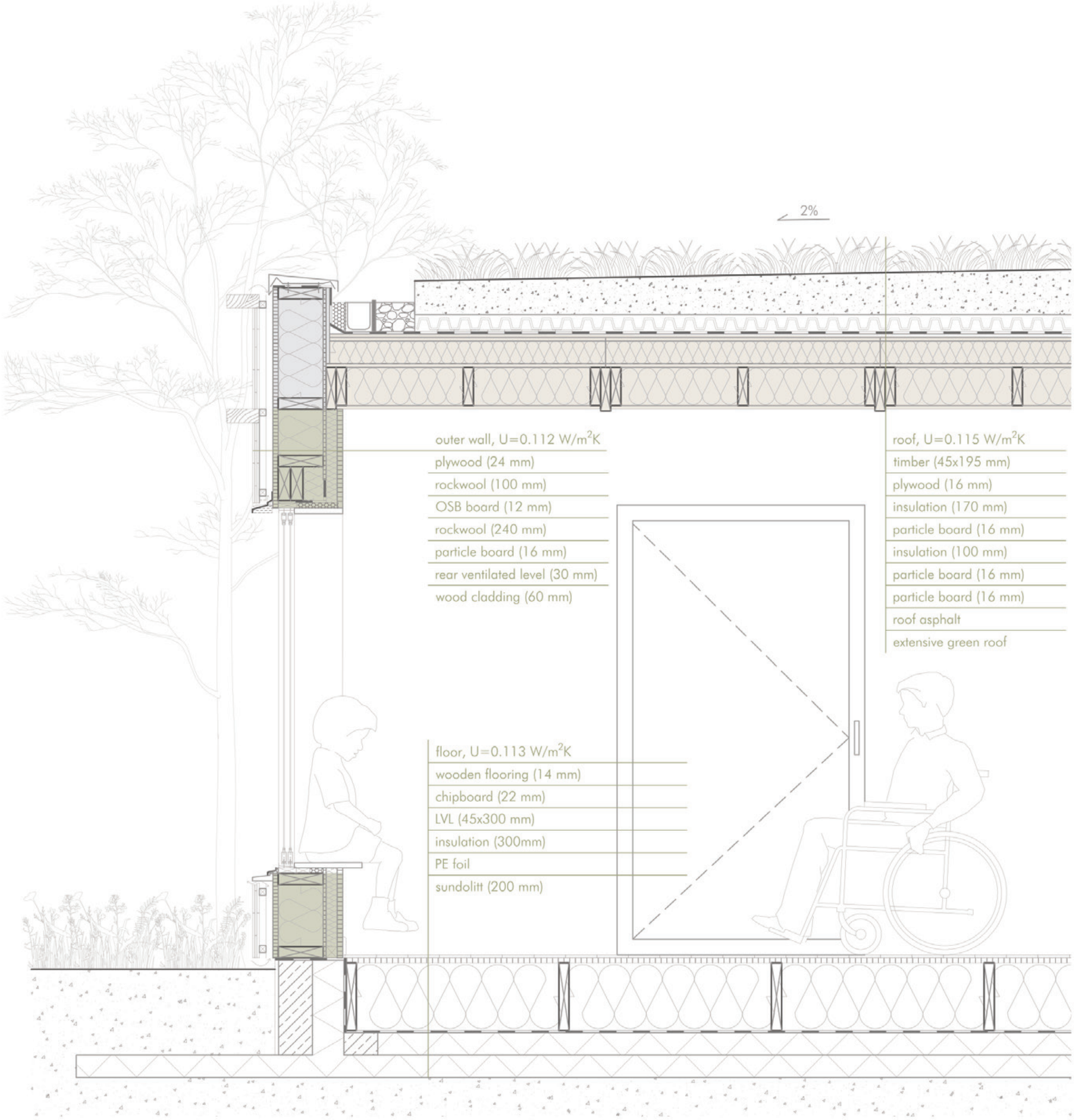
SOUTH FACADE 1:350

EAST FACADE 1:350

ill. 86 elevations

ill. 87 residential room facade render

07.7 envelope 1:25



ill. 88 envelope

ill. 89 residential room render

07.8 final LCA calculations

The LCA calculation (see appendix 04.4) for the hospice has followed the Danish Building Regulations. In addition, wastage has also been included as the project has focused on minimizing the amount of waste. The wastage percentage for the building has been calculated where it was possible. This was done where plywood and gypsum were used because the number of cutouts was easy to estimate using 3D models. Regardin to other materials, wastage percentages from the company BM Byggeindustri have been used. Their data has been used because they are a company producing modular buildings in a controlled factory. It is assumed that the production of modular system will as well be produced in a factory. Therefore BM's data on wastage can be used to give a more accurate idea of waste than the wastage percentages from conventional building methods.
This LCA includes the impact of disposal, also for the modules, even though they have been designed to be reused. It is impossible to know what would happen with the building after end use and how worn the construction parts have become. It also gives a more fair comparison with the conventional buildings and shows how much it is possible to lower the GWP of a building only by being aware of this aspect in the design process.

The average GWP of Danish buildings has been taken from the report "SBI 2020:04 Klimapåvirkning fra 60 bygninger". The LCA calculations for these 60 buildings, being the foundation of the average, do not include wastage. To make the comparison more accurate, the wastage for the average building must be calculated (see appendix 04.1).

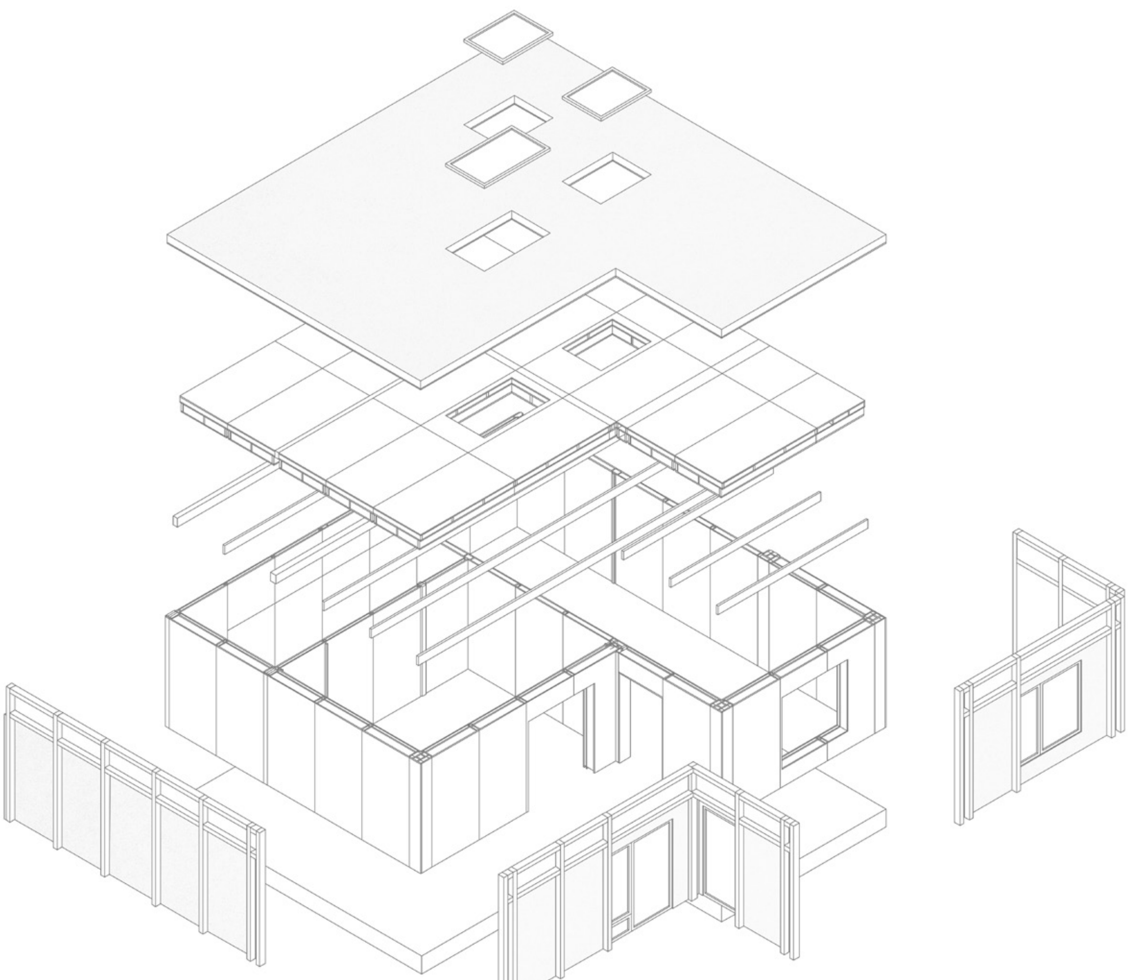
The report does not specify how many percent the different building materials constitute of the building. Therefore it was chosen to assume how much of the different materials constituted. LCAByg has an example building, this building is a one family home, but it is possible to see how much the different materials constitute the building, therefore these percentages were used to calculate wastage together with wastage percentages based on the two reports "Affaldsforebyggelse i byggeriet Forprojekt" and "Veileder for utarbeidelse av klimagassregnskap TEK17 § 17-1" (see appendix 04.3).

The future building, from reused modules, uses the same energy impact as the hospice. It is very likely that the GWP would be lower in the future, due to transition towards cleaner energy sources, but it is not possible to calculate a viable assumption. The GWP of the building materials is only from the parts which are not designed as part of the modular system, consisting of facade and roof cladding, foundation etc. (see appendix 04.2). This GWP will only be possible if there are enough modules to be reused in this future scenario, otherwise the GWP will increase due to manufacturing new materials.

The new present building has a lower GWP than the average Danish building, but the most remarkable is the impact the design has on the future. By designing for disassembly, it is possible to lower the GWP of a "new" building and reaching lower than what is going to be the voluntary CO_2 boundary of 5 kg CO_2 eq./m^2/yr by 2029.

	Average Danish building	The Meadow	Potential future building
Total GWP	10,03 kg CO_2 eq./m^2/yr	5,56 kg CO_2 eq./m^2/yr	2,66 kg CO_2 eq./m^2/yr
B6	2,26	1,38	1,38
A1-3, B4, C3-4 including wastage (A5)	7,77	4,19	1,28
Wastage (A5)	0,518	0,134	0,029

table. 12 LCA comparison



ill. 90 exploded view of residential room

07.9 conclusion and reflection

The Meadow is a proposition on how to design a childrens hospice, providing a homely setting, striving towards a comfortable place for families with a terminally ill child to have a peaceful and quiet last time together. In addition, environmental sustainability has been incorporated by using Life Cycle Assessment actively in the design process to reduce the carbon footprint.

When designing The Meadow contradcitions where faced, when it came to function and atmosphere. The hospice needs to be functional, provide treatment, and have space for a lot of patients as well as having an intimimate homely atmosphere. Some of these aspects are contradicting as a home and an institution are polar opposites. Some of the inevitable challenges were to be able to create space for the users to be alone, and at the same time, avoid the feeling of long hallways, which can amplify the institutional atmosphere of the building. The solution has been to divide the hospice into zones and strive to make the building compact. Dividing into zones and using differentiated room heights to give a faint insinuation on activity level makes it easier to read the building and find the areas for high activity and for calm and cozy activities such as reading, playing games etc. In this division, hallways show their potential as they put distance between different activity levels and sheltering the more calm activities.

Working with the floor plan and layout of the hospice also had the additional challenge of reducing the carbon footprint of the building and supplying a suggestion on how to, in general, design more sustainable. The investigation was to introduce the principles of Design for Disassembly working with the mantra reduce, reuse and recycle, see illustration 91. The proposal was a modular building system dimensioned by the standard sizes of a construction board, minimizing material waste and ending up with a global warming potential lower than the average GWP of a Danish building.

Combining the floor plan and a rough, unfinished concept for building modules showed its difficulties, despite having the dimensions of the main modules, but had not finished all the modules to join different thicknesses of walls and how to solve when multiple walls needed to be joined. Because solving the floor plan and designing the modular system, working with reducing GWP, was running simultaneously, the final floor plan had to be altered to fit, and in addition, there had to be made a lot of different small joint modules to solve the design. Some of these struggles might have been avoided if the modules had been designed and finished before even looking at the floor plan. Working with modules gives some limitations on what is possible to design and build, as every construction part is limited to the capabilities of the modules. These aspects can somehow be condensed to the dilemma, what is the main focus or most important for a given project:

- Complete free reign of design, potentially resulting in intricate constructions and massive material use

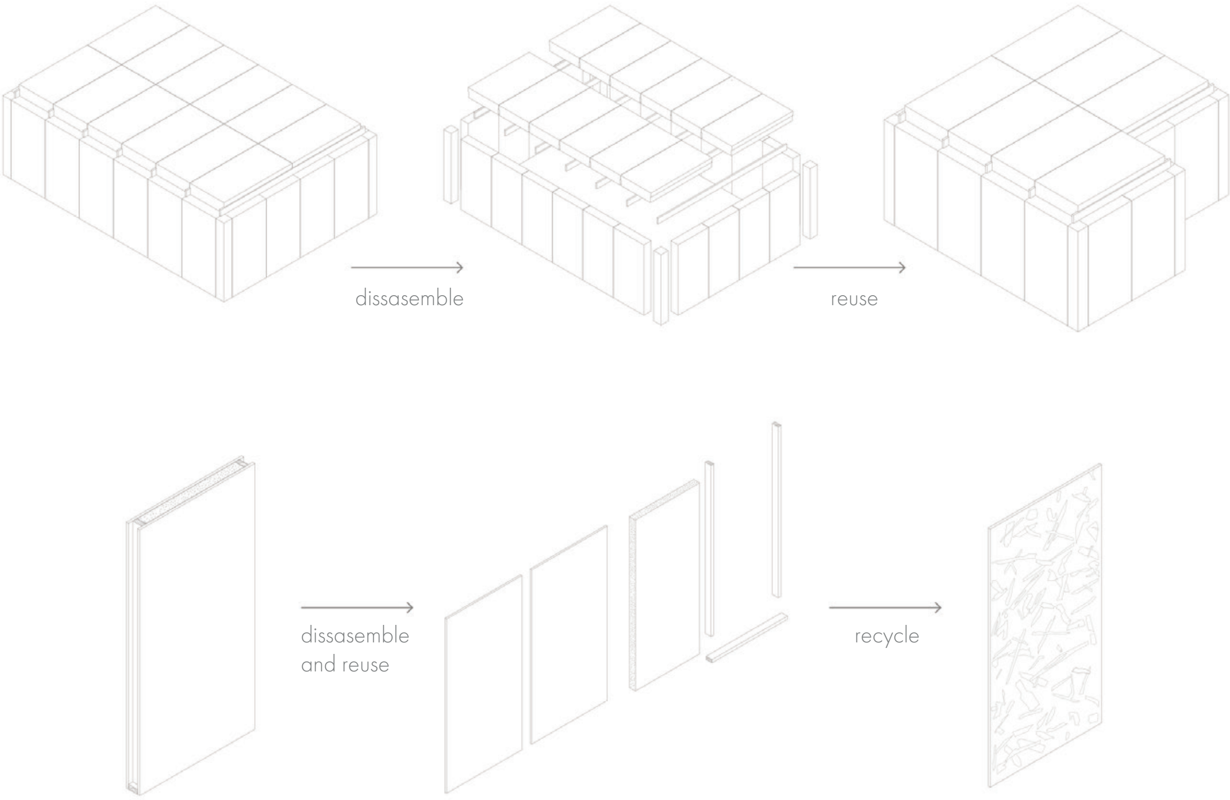
or

- Using a modular system, with focusing on optimizing the construction, investigating the possibilities the modules have and creating design from these possibilities.

Both approaches have their strengths and disadvantages , but here the overall goal of the individual project should be the factor in choosing how to approach the design. In our case, a focus on designing with a strong emphasis on sustainability resulted in the modular system, optimizing the construction, which was ideal to solve the problems of this project.

In addition to the LCA, the energy frame of the building impacts the total GWP of the building. In this project, the goal has been to reach low energy frame, which was achieved with an energy consumption of 26,2 kWh/m^2/yr. Optimizing the energy frame by looking more into passive strategies would lower the energy frame. However the main focus of the project's technical aspects was how to minimize the GWP by looking into the construction itself.

The hospice will be ventilated with a combination of natural and mechanical ventilation, called hybrid ventilation. The mechanical ventilation will be in operation during the winter season when heat recovery is advantageous. In addition, mechanical ventilation will be used in the rooms during the summer period, when natural ventilation does not cover the need alone, see appendix 02.0 for ventilation calculations.



ill. 91 reduce, reuse, recycle

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08.2 illustrations

All illustrations which are not listed below are our own illustrations or pictures taken by us:

Ill. 5 - Guillaume, C. (2020) Wooden Nursery. - Photograph Clément Guillaume (Image) Available at: https://www.archdaily.com/935476/wooden-nursery-djuric-tardio-architectes?ad_source=search&ad_medium=projects_tab&fbclid=IwAR2vTHPmZMnH_HyceoJgvwkJDmL2t1DxP8P3pdgjrubJ47vGgML59wLX8yA (Accessed: 20 April 2023).

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