HOSPICE IN RY

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Abstract

This thesis is a proposal for a hospice in Ry that will provide patients with the encouragement to face the death in a meaningful way. The project's first focus is the experience of its users that includes patients, relatives, and staff. Nature should be accessed easily visually and physically. The amount of daylight and the orientation of the rooms will also be carefully considered to ensure the patients have the chance to enjoy the daylight sun and a good view. The quality of each room with details such as the ceiling height, room area, and proportion are vital elements while designing. The indoor climate will ensure the best comfort of the users.

The architecture will try to create interventions to persuade people to be social and and become more active. For example it will attract patients to take a walk in the garden by designing a sensory garden with several seats in it, applying big glass windows on the side facing to the nature, and consider floor material which is non-slip and friendly for people with walking difficulty.

Sustainability on many aspects are taken into consideration by choosing sustainable materials and designing an effective energy building. Painting on the walls is avoided. Strategies which supports to reduce the energy consumption are applied such as passive solar heat, passive cooling strategy, or providing enough daylight during day time. The building elements like windows and the size of rooms are managed to have similar measurements as much as possible to reduce time, cost and labour of production.

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1 | Motivation

While travelling around the world, I have observed people through different countries, cultures, life conditions, ages and genders. Sometimes I put myself into their condition and emotion to understand how the world looks like. And I wonder what if we do not have that much time to live this life any more? What will matter most at the end of life? Will we become frightened and spend our last days with regrets and fear of the coming death?

Artist Maggie Keswick Jencks who was diagnosed with breast cancer in 1988 once said: "People should not lose the joy of living in the fear of dying" (Jencks, 1995). She died in July 1995, 2 months after finishing a "Blueprint" for the cancer caring center- the first Maggie's Center among its network (Jencks, 1995).

Through the lens of an architecture student together with my personal emotional experience with my beloved father's death of cancer, I want to start a thesis topic to propose a place to facilitate the transition between life and death. The design should support all of its users during a very difficult time both emotionally and physically. "Architecture should defend man at his weakest" as Alvar Aalto once wrote it (Aalto, cited in (Worpole, 2009)).

2 | Theme

2.1 Hospice

2.1.1 The movement of hospice

The topic of 'the right to a good death' has developed by time and become a demand in the society today. Baroness Julia Neuberger, a British leading campaigner on behalf of the elderly and the dying, has declared: 'Across the world we are seeing more and more disquiet about how we die. Even governments recognise it. So as concerned citizens we should be doing something to enable our fellow citizens and ourselves to die well when the time comes.' (Worpole, 2009).

To evaluate the quality of death, a study in 1988 made the comparison between hospice and non-hospice cancer patients and found out that the hospice patients in their last 3 days felt at peace and happier than those who received conventional care in traditional hospital settings. Their care providers also reported that the patients received hospice care were more free of pain and could physically able to do what he/she wanted to (Wallston et al., 1988).

The Hospice movement began with the opening of the St Christopher's Hospice in Sydenham, London, in 1967. Back in 1948 when the founder Dame Cicely Saunders met and befriended David Tasma, a Polish refugee, they discussed the idea of a more homely place where people can die in tranquillity and in better condition than at that time. They imagined it as a house where people could find relief from pain, find the encouragement for self-awareness and socialisation, and where the setting would be uplifting, not depressing (Worpole, 2009).

The majority of people today die in institutions rather than at home in developed countries. Based on visits to 23 hospitals a report published by the UK Healthcare Commission on 27 September 2007 found that there were only five places were complied with the government's core standards for dignity in care (Worpole, 2009). While dying at home may sounds like an ideal way for many people, survey have revealed that once when serious pain sets in or when people have experienced good hospice care on a temporary or respite basis the their attitude can quickly change. Some do not even have a choice of where to die. In Britain, up to 60 people die alone at home each week. (Worpole, 2009).

In Denmark, Most of severely ill patients wish to die at home or in homely surroundings, but only a few of them have this wish fulfilled. About 60,000 people die each year in Denmark, and a half of these end their lives at hospital, 25% die in a nursing home, hospice or sheltered housing, 4% somewhere else and only 22% die in their own home. The reasons for this probably because of the lack in capacity of palliative teams in Denmark, or lack in knowledge and capacity of the health services to make palliative care in the home of the patients' possible (SIGNAL architects, 2006).

2.1.2 Hospice in Denmark

In Denmark it was said that the 'hospitals of death' did not fit into Danish mentality when the debate about the hospice began. But this attitude changed after the first hospice Sankt Lukas was opened in 1992 (SIGNAL architects, 2006). Until late in 2005 there were seven hospices available in Denmark: Sankt Lukas Hospice in Hellerup (1992), Sct. Maria Hospice Center in Vejle (1995), Diakonissestiftelsens Hospice in Frederiksberg (1997), KamillianerGaardens Hospice in Aalborg (1999), Hospice Soeholm in Aarhus (1999), Hospice Fyn in Odense (2004) and Arresoedal Hospice in Frederiksvaerk (2005). Now there are 19 hospices for adults, two for children and there is another one for children expected to be open in 2020.

In 2004 a new 'hospice law' was passed in Denmark. The law stated that a hospice be available in each county. There should be at least 12 beds in each hospice, except for the Regional Municipality on Bornholm, due to the size of the population. The decision of putting a strong focus on the conditions of the terminally ill and dying patients has pushed the development of the hospice forward in the country (SIGNAL architects, 2006).

In the response to the rapid growth of the hospice movement at the beginning of the twenty-first century, the first national designing principles for hospices was published in Denmark in 2006.

> The programme for The Good Hospice in Denmark is aimed at consultants, decision makers, architects, engineers, project leaders and steering groups for local hospice projects, and it is intended to serve as inspiration, manual and check-list to ensure that sufficient thought has been given to the intention, function and expression of the physical framework in connection with planning and establishing new hospices (SIGNAL architects, 2006).

An annual report of patient statistics in 2004 from Sct. Maria Hospice in Vejle, Hospice Soeholm in Aarhus, KamillianerGaardens Hospice in Aalborg, Deaconess Hospice at Frederiksberg, Sankt Lukas Hospice, and Home hospice in Hellerup reported that the average duration of admission for the individual patient in a hospice in Denmark was 25.4 days and nights. It was 67.7 years is the average age for the admitted patients ranging from 29 to 90 years. The numbers of men and women were almost equal, with a slight predominance of women (47.1% men and 52.9% women.). The majority of the patients was diagnosed with cancer (SIGNAL architects, 2006).

In 2001 Danmarks Statistik (Danmarks Statistik, 2001) stated that the number of older people in Denmark will continually grow and in 2040 there will be 72% more older people than there is today. That means that in the future we will see more people suffering from, and living for a longer time with, chronic illness linked to heart, lung, kidney and neurological conditions as well as cancer. Therefore the need of expanding palliative care is important (SIGNAL architects, 2006).

2.1.3 The architecture of palliative care

Palliative architecture is the art of compassion. Palliative care aims to relieve stress, alleviate symptoms and suffering regarding to terminal diseases. It encompasses the entire interdisciplinary nursing, care and treatment offered to the patients who are terminally ill and their relatives. The architect while designing must be aware of 3 core dimensions which together constitute a language of palliation: the role of science (medicine, illness), the role of the person (well-being, spirituality, emotion) and the role of the built environment (intervention creation, comfort, assurance, delight) (Verderber and Refuerzo, 2003).

While the public face of a building is made up of a number of elements such as location, the architecture, perimeter boundaries, name and sign-board, the first impression at the arrival plays a very big role for a vulnerable place like hospices. The main entrance of a hospice should provide the feeling of the welcome assurance. It needs to be an expectation of a well organised, quality healthcare facility and on a scale that people can relate to (HfH Programme staffs, 2008).

A study was done in Canada to describe what seriously ill patients in hospitals and their family members consider to be the key elements of quality end-of-life care. The result has revealed that the elements rated most frequently as ”extremely important” were to have trust and confidence in their physicians, not to be kept alive on life support when there is little hope for a meaningful recovery, to have information about their disease be communicated by their doctor in an honest manner, symptom relief and to prepare for life’s end by resolving conflicts and saying goodbye (Heyland et al., 2006). The research has also shown that the rate linked to the needs of having the opportunities of contributing to other activities like experiences, knowledge, religion or being able to die in the location of choice were rated as less important to compare with other elements. This indicates that the outcomes and performance of staffs are extremely important and that they should receive a good environment in which they are responsible to give the care and treatment to the patients.

At St Patrick’s Hospital and Marymount Hospice in Cork, a project team was formally established in December 2000 and they had been developing the brief for the new hospice for over six years (SIGNAL architects, 2006). The brief said:

> A hospice is a very special place, where patients and families live lives that are special. In this context, time is precious because it is scarce and clearly finite. A hospice is a place where ordinary people face up to extraordinary challenges and with the help of skilled and dedicated health care professionals, triumph in the face of progressive physical deterioration and sequential losses. People live until they die and it is the job of the hospice to support and enable each patient to live their life as fully as possible. It is a place for refl ection and a place to search for meaning and purpose. For many, it is perhaps the first time that they have seriously addressed the fundamental issues of life and death. The hospice building must be sympathetic to, and supportive

> of, our best efforts. The building must be planned to the finest detail, because we cannot afford to get it wrong.

The design of New Hospice of St Francis in Berkhamsted in UK values the garden as a crucial aspect of their care. The garden is described like an escape or therapy from the anguish in the building. In the design statement mad by he medical director of St Francis, they proposed the intention to give the personal access to the garden for the sickest patients. For patients who are not well enough to be in the garden, the design would attempt to bring the outdoors directly to them. Traditional material such as timber and brick were taken into consideration to fit into the rural context at the site.

The Irish government's Department of Health and Children published its Design Guidelines for Specialist Palliative Care Settings in 2005. The guideline indicate that:

> A hospice must be able to meet the needs of men and women, young and old, in-patients and out-patients, patients and families, those with cancer and those with other conditions, those who will be discharged home and those who will not, paid staff and volunteers. A hospice is a place where people can live, truly live, until they die.

Although there are several hospice designing guidelines have been developed through years focusing on the landscape and building, the majority of people treated by hospices are out-patients, day-patients or patients who spend most of their time at home and go to hospice when their carers needs a break themselves (Worpole, 2009). A good hospice is a place that provides a good working environment for the staffs, especially the nursing staffs who also also need to be supported emotionally. Studies have noted some cases of nursing staffs working at hospice/palliative care have suffered from stress and burn out with the sign of suicidal ideation, increased alcohol and drug usage, anxiety, depression, and difficulty in dealing with issues of death and dying Vachon (1995). The architecture of palliative care is usually at a scale and level of visual assurance which helps people to face with the their own death in a sense of peace, calm, light, space, and supportive order (Worpole, 2009).

2.2 Healing architecture

Hospice is often described as a place for the terminally ill people to spend their last days in peace and happiness. In another way we may say it is where the quality of death is improved. But the fact is that, the patients and and their families when being admitted to a hospice have not stopped to losing the hope. The quality of death is also a part of quality of life. It is the last part to fulfil a happy life. From all of above points, healing architecture is chosen to be the main theme for the project because of its purposes regarding to human well-being and health.

Studies have proven that architecture can create a positive effect on ill people (Ulrich et al., 2008). We can say that architecture allows us to shelter in place, and even allow us to shelter in time if the space creates the calmness of a relaxed domestic atmosphere and becomes a home where people feel safe and happy. In a long term, the quality of life can be improved by living in the built environment that supports human well-being Steemers (2015). The publication of Richard Thaler and Sustein in 2008 has revealed that behaviour can be strongly influenced by context Thaler and Sunstein (2009).

Professor Koen Steemers in his writing about five ways of well-being argued that the strategy for well-being and health should be that the design is good enough to meet all the qualitative health measures while also be able to be adaptable and integrated with a broader set of principles to support well-being. He also said that creating a perfect technically comfortable indoor environment will risk reducing the importance of encouraging people to be active, get engaged and be aware of surroundings.

Healing architecture is a design concept with the vision that architecture can affect human well-being and support the healing process. The concept aims to success to improve the 4 outcomes of the users: staff efficiency, stress and fatigue; patient safety; patient and relatives' stress and well-being; and overall clinical outcomes Zimring et al. (2004). The research project 'Helende Arkitektur' divided the factors that can affect the users' outcomes into 3 sections including: body section/human senses (Light and art, sound, odour and movement), relation section (personal space, social space, outdoor spaces), security section (Hygiene, Damage and faults) Frandsen et al. (2009).

2.2.1 Light

Having access to daylight is important to both patients and staffs. Daylight and windows are the most important physical elements for the users' well-being, several research have proved (Lawson et al., 2003). The daylight has the meaning for the patients to orient themselves in relation to time and place and increase the number of visions. Recent works have also proved that daylight as the effect of circadian rhythm and deeper sleep, reducing depression, pain and stress, shorten the hospital stay and avoid medical errors Frandsen et al. (2009).

A study in pharmacy found out that the pharmacists' prescription-dispensing errors was reduced when the condition of light levels were relatively high (Buchanan et al., 1991). To be more specific, the study examinated at three different illumination levels, including 450 lux, 1.100 lux, and 1.500 lux. Results revealed that medication-dispensing error rates 2.6% lower at an illumination level of 1.500 lux, compared to an error rate of 3.8% at 450 lux.

Another result from a study of exterminating the relation between the bright light exposure level and stress related to shift work among women showed that repeated, brief exposures to bright light during night shifts improved subjective well-being during and after night work , in both summer and winter. The experiment was made at an illumination level of over 5.000 lux. Bright light at over 2,500 lux is used for the treatment of seasonal affective disorder in winter as it has a positive effect on mood even in healthy people (Partonen and Lönnqvist, 1998).

2.2.2 Art

Art is suggested to integrated into the architecture planning from the beginning in all contexts Frandsen et al. (2009). It is viewed as a positive stimulation element and distractor for the patients as well as the staffs in the relation to the stress, pain and depression.

2.2.3 Sound

Sound at the healthcare context can be defined in 2 types, either the sound as the therapy or the unwanted noise. The unwanted noise can be from technical equipment or the discussion between staff, patients and relatives or from other activities. I may be continuous or sudden and can be significant sources. the sound source presents either close to the patient or in the adjacent rooms, such as walking area or nursing station (Frandsen et al., 2009). Too much noise and too persistent noise can cause stress, sleep problem and affect the privacy of patients, visitors and the staffs. On another hand, sound as music or other kind of therapy can be used as a positive factor in the healing process.

The recommended noise level is 30 dB for day and evening hours, and 40 dB maximum at night on general wards. Patients who are treated or observed in critical condition, the sound level should not exceed 35 dB. For patients who have problem with sleep disorder reported through a research made by WHO to sleep badly at sound levels above 30dB Schwela (2001).

2.2.4 Air

Air is one of the transmission routes of infection and airborne infection in the hospital environment. To prevent the problem, it is recommended to select the easy-to-clean material for floor, wall and furniture; provide single-bed rooms with private toilets; improve the indoor air quality through measures such as effective ventilation, filtration, and appropriate air flow direction and pressure (positive or negative) (Ulrich et al., 2008). The recommendations of ventilation flow rate in healthcare design since 2001 is based on the principle of dilution (Janssen, 1999). A ventilation flow rate of at least 12 air changes(of a room)/h is suggested for new isolation rooms (Chinn and Sehulster, 2003).

Temperature and fragrance have also some certain influences on the well-being of the users. Wrong temperatures and unpleasant odours cause irritation to people. Some patients may be specially sensitive to the quality of air due to their particular disease or medication.

The American Institute of Architects has published guidelines for the design and construction of new health-care facilities and for renovation of existing facilities in 2001. The guidelines addressed problems regarding to the indoor environment including ventilation rates, temperature levels, humidity levels, pressure relationships, and minimum air changes per hour (ACH). Temperature standards are given differently in the specific health-care zones. Cool temperature standards from 20°C to 23°C usually are for operating rooms, clean workrooms, and endoscopy suites. The patient rooms need warmer temperature at 24°C. Most of other zones use a temperature in the range of 21°C to 24°C of Architecture for Health et al. (2001).

The most common way to measure humidity is relative humidity. It is the ratio of the amount of water vapour in the air to the amount of water vapour air can hold at that temperature. At 100% relative humidity, the air is saturated. The ideal comfort for most areas within healthcare facilities ranges from 30% to 60% relative humidity of Architecture for Health et al. (2001) (Mathur et al., n.d.).

Most ventilation rates for healthcare facilities are expressed as room ACH. Ventilation rates vary among the different patient care areas of a healthcare facility of Architecture for Health et al. (2001). To remove the polluted air in the room, peak efficiency happens at 12 ACH to 15 ACH. Carbon dioxide level is believed to be good below at 1000 ppm Janssen (1999).

2.2.5 Way-finding

Studies have proven that way-finding problem can create stress for users, and economic consequences in terms of loss of time and efficiency of the staff (Frandsen et al., 2009). Solutions have been suggested to navigate in an unfamiliar building such as designing signage system. Not surprisingly, the conclusion drawn out after several studies on the way-finding topic is that it is easier to navigate in a building with a simple and uncomplicated plan than in a building with a complex plan (Frandsen et al., 2009).

2.3 Sustainable architecture

In Brundt Land Report, the definition of the sustainable development was described (Brundtland, 1987):

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Three co-equal elements are brought into the discussion: environment, economy and equity (Brundtland, 1987). In the context of architecture, sustainability focuses more on three parts: social, economic, environmental sustainability. Sustainability can in fact only be achieved by simultaneously combining these three elements while being aware of the point that it is should not be accomplished by compromising and sacrificing another.

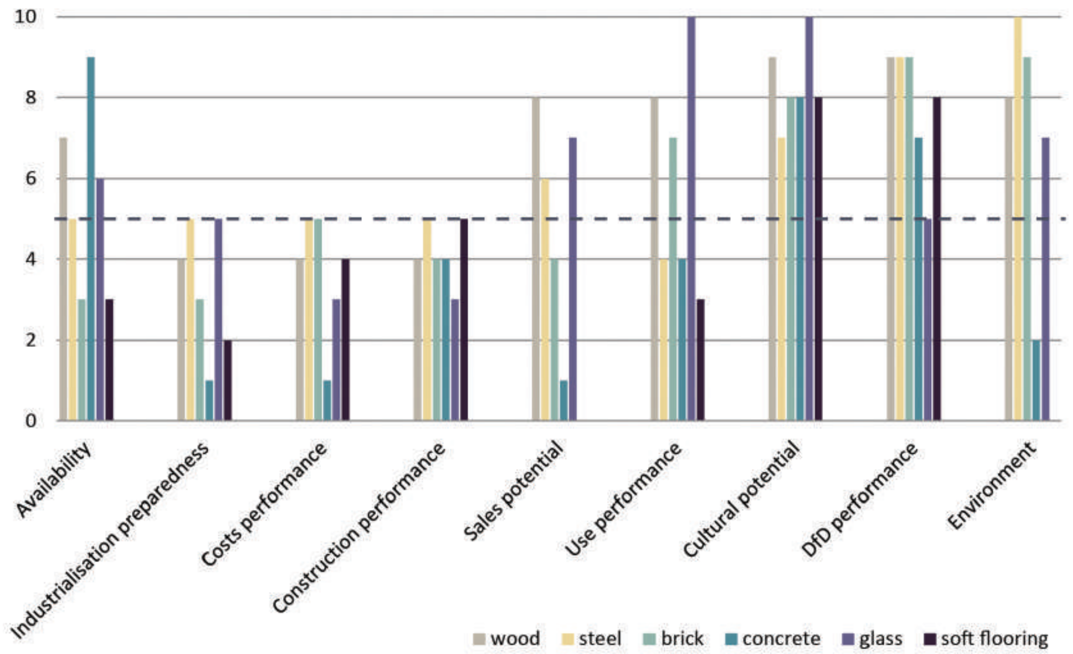

Figure 2.3.1: Assessment chart, main material categories. The dashed line indicates standard performance of new components. Everything on this line or above performs better than the conventional alternative (Manelius, n.d.)

The responsibility of the architects and planners is essential in the term of environment quality. The argument is that the building industry uses most materials and energy, produces more waste and contribute less to material recycling. On the market today, some materials have raised the cost of production and others were concerned by the negative effect on the environment and users. Resource scarcity is also a big problem that we need to think about (Hegger et al., 2012).

Robert Kaltenbrunner has discussed the difficult relationship between architecture and sustainability on several topics such as: quality of life, social cultural acceptance, lack of sensitivity. He stated that it has to be admitted that rational, scientifically based findings on how sustainable construction should be structured are already available. However, these findings transferring to the construction industry has not happened widely. No expert or media really make a clear commitment on this topic either (Hegger et al., 2012).

In 2014, a project was conducted by the architecture firm Vandkunsten and partners based on the idea of recycling used material by designing for disassembly (DfD). Material assessments were made by choosing the most common materials and evaluate them on different categories: availability/volume, industrialisation preparedness, production costs, sales potential, ease of construction (on site), in-use performance, cultural performance, environment (LCA), DfD performance. See figure 2.3.1

The main focus on this project is the user's experience and looking further into the value as well as its use for the long term regarding to patients' mentality. Therefore, recycled materials are not being used but "Rebeauty" has been used to consider the best materials for both aesthetic and life cycle assessment.

In the argument of the energy concept related to the topic of sustainable architecture, four groups of the boundary conditions were used as a starting point for the development: climatic boundary conditions, use-related boundary conditions, technical and legal boundary and architectural boundary conditions in the book "Energy manual: sustainable architecture", see table 2.3.1.

	Boundary condition Information	Area for action
Climate	Temperature, extreme values	Thermal quality of building envelope
	Temperature difference, day/night	Potential for natural cooling by night air
	Average annual temperature	Output potential for ground exchanger
	Relative humidity, summer/winter	Possibility of direct adiabatic cooling
	Average wind speeds	Electricity generation with wind power
	Distribution of wind directions	Wind-controlled natural ventilation
	Quantity and distribution of precipitation	Technical use of evaporative cooling
	Geological strata	Tapping the heat in the ground via boreholes

Table 2.3.1: Boundary conditions and areas for action in the development of energy concepts (Hegger et al., 2012)

	Boundary condition Information	Area for action
	Groundwater and surface waters	Use as heat source and for passive cooling
	Quantity of energy, solar radiation	Passive and active solar thermal usage and electricity generation
	Sun's trajectory	Optimisation of summertime thermal performance
Usage	Requirements for heated areas	Minimum and maximum temperatures
	Targets for summertime thermal performance	Room temperature and temperature range (e.g. 22 °C ± 2°C; 21–28°C)
	Air quality requirements	Max. workplace concentrations, max. CO^2 values
	Air humidity requirements	Relative humidity and range (e.g. 50% ± 10%)
	Lighting requirements – lux values	Sunshades and glare protection
Legislation	Development plan	Optimisation of land use up to maximum permissible development density
	Energy Conservation Act DIN 18599	Maximum primary energy consumption
	DIN 18599	Heat sources and sinks
	Compulsory connection	Infrastructure usage and increasing the utilisation

Table 2.3.1: Boundary conditions and areas for action in the development of energy concepts (Hegger et al., 2012)

	Boundary condition Information	Area for action
	Water legislation stipulations	Use of ground and groundwater as energy sources
	Legal stipulations due to usage	e.g. heat recovery if mechanical ventilation required
	Preservation of historic monuments	Preservation of identity, e.g. with internal insulation
Architecture	Neighbouring buildings and micro climatic boundary conditions	Architectural design in conjunction with use of environmental energy
	Ratio of plot size to building volume	Use of primary and secondary solar energy
	Ratio of usable floor area to potential solar area	Proportion of transparent wall surfaces according to compass direction

Table 2.3.1: Boundary conditions and areas for action in the development of energy concepts (Hegger et al., 2012)

2.4 User profiles

User groups	Length of stay	Emotional need	Physical need	Use of space
PATIENTS				

Table 2.4.1: User Groups

User groups	Length of stay	Emotional need	Physical need	Use of space
Day-patients	Hours	Welcoming, Homely feeling, Comfortable	Way-finding, contact with nature, private and social space, good indoor environments	Common area, care unit, garden
In-patients	Weeks, months	Welcoming, homely feeling, privacy, dignity	Way-finding, contact with nature, private and social space, good indoor environments	Common area, care unit, patient section, garden
RELATIVES				
Relatives	Hours, days, weeks, months	Welcoming	Way-finding, contact with nature, family space, private and social space	Common area, patient section, garden
STAFFS				
Staffs	Years	Restorative	Short travel distance, good working environment, contact with nature	Common area, staffs section, care unit, service rooms, patient rooms , garden

Table 2.4.1: User Groups

User groups	Length of stay	Emotional need	Physical need	Use of space
Volunteers	Days, weeks	Restorative	Short travel distance, good working environment, contact with nature	Common area, staffs section, care unit, service rooms, patient rooms , garden

Table 2.4.1: User Groups

2.5 Case studies

To design a good hospice, the architect and the designer need not only the real understanding of the needs of the users and deep knowledge of the goals of the palliative care, but also the unique value of the hospice movement. How the hospices have experienced and developed with time to provide a better environment for the patients, staffs and visitors to live and work in. The case studies in this section are given to show the evidence of learning from both the good elements and what need to be improved.

2.5.1 Northern Ireland Children's Hospice

Architect: Kennedy Fritzgerald Architects
Location: Belfast, Northern Ireland

Horizon House Children's Hospice in Belfast is a 10 units hospice combined with the accommodation for family. the building has the shape of a gentle arc which covers the garden and gives it the enclosure quality. All of the patient rooms face the south-west towards the garden. Each room has its own private patio. A single corridor links all the patient rooms without the impressions of an institutional corridor. The common area of the hospice is place in the heart of the building where the staff, patient and family spend a lot of time to sit and talk. The idea of the design is to bring the children together and be social. While designing a hospice for the adult, privacy needs to be taken care of beside the possibility of encouraging people to be more social.

Figure 2.5.1: Northern Children's Hospice in Northern Ireland (Photo: Kennedy Fritzgerald Architects)

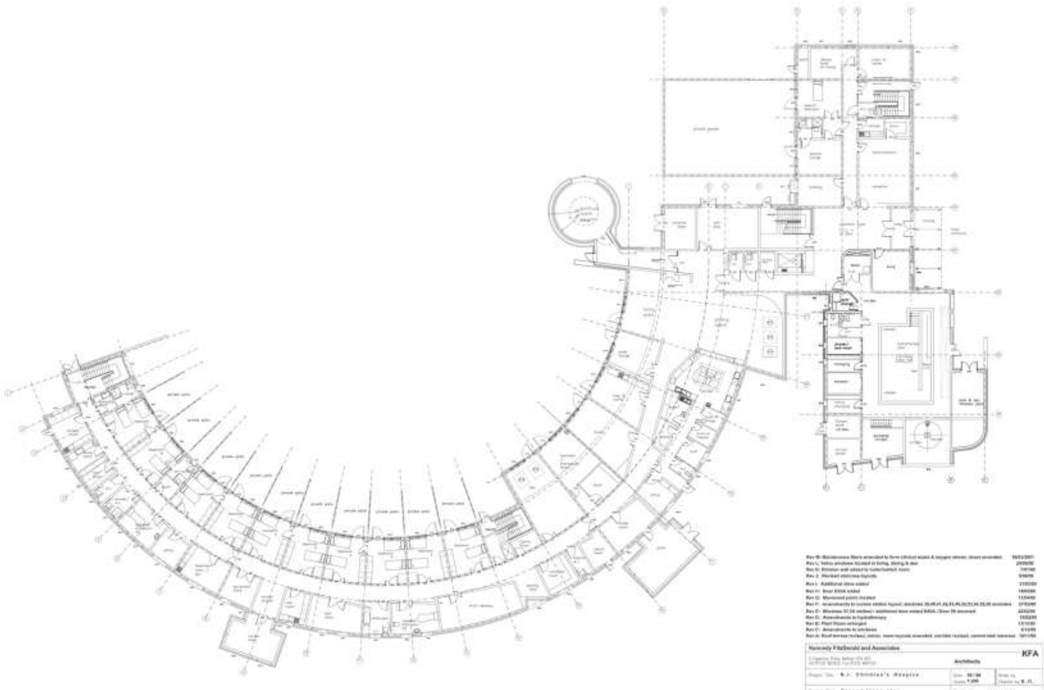

Figure 2.5.2: Ground floor plan of Northern Children's Hospice in Northern Ireland (Photo: Kennedy Fritzgerald Architects

2.5.2 Hjemdal - The Cancer Patient's House

Architect: Frank Gehry and CUBO Architects
Location: Aarhus, Denmark

Figure 2.5.3: The exterior view of Hejmdal

The Danish Cancer Society's counsellor center Hjemdal was transformed from an old building into a new cancer center which has a special atmosphere inside. Only the outer walls were kept. The old roof was removed and replaced by a new glass roof. By using massive Douglas timber beams and placed them in different angles to make the whole space looks like a forest, the project was successful to create such a warm feeling with a high artistic quality . The negative side of this design was it is not sustainable since the wooden beams were brought to Denmark from abroad and the cost to build it was expensive.

Figure 2.5.4: The warm and home feeling atmosphere inside of Hejmdal, photo: architekturbilleder.dk

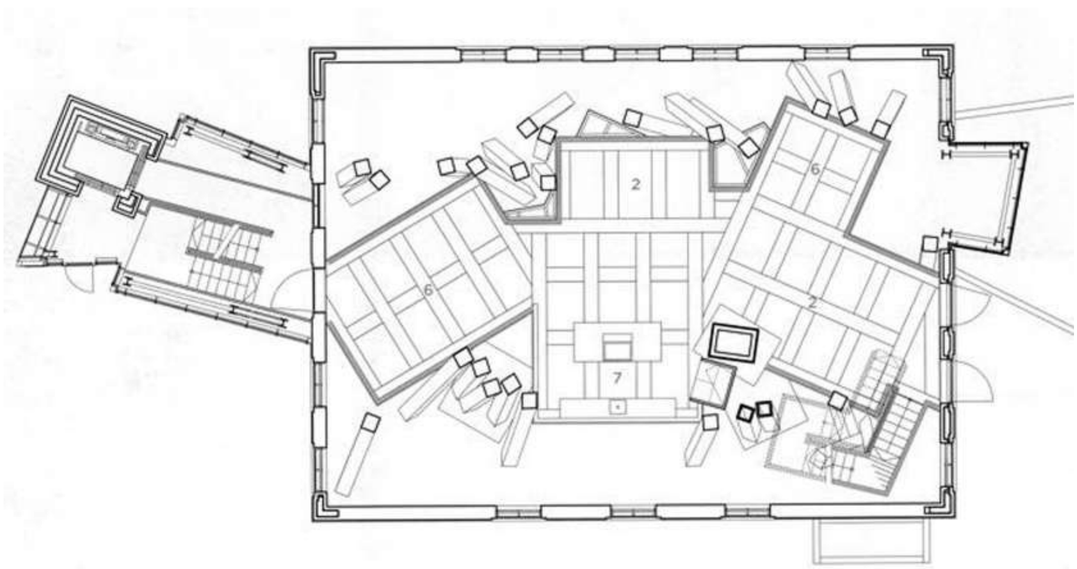

Figure 2.5.5: The floor plan of Hejmdal, photo: architekturbilleder.dk

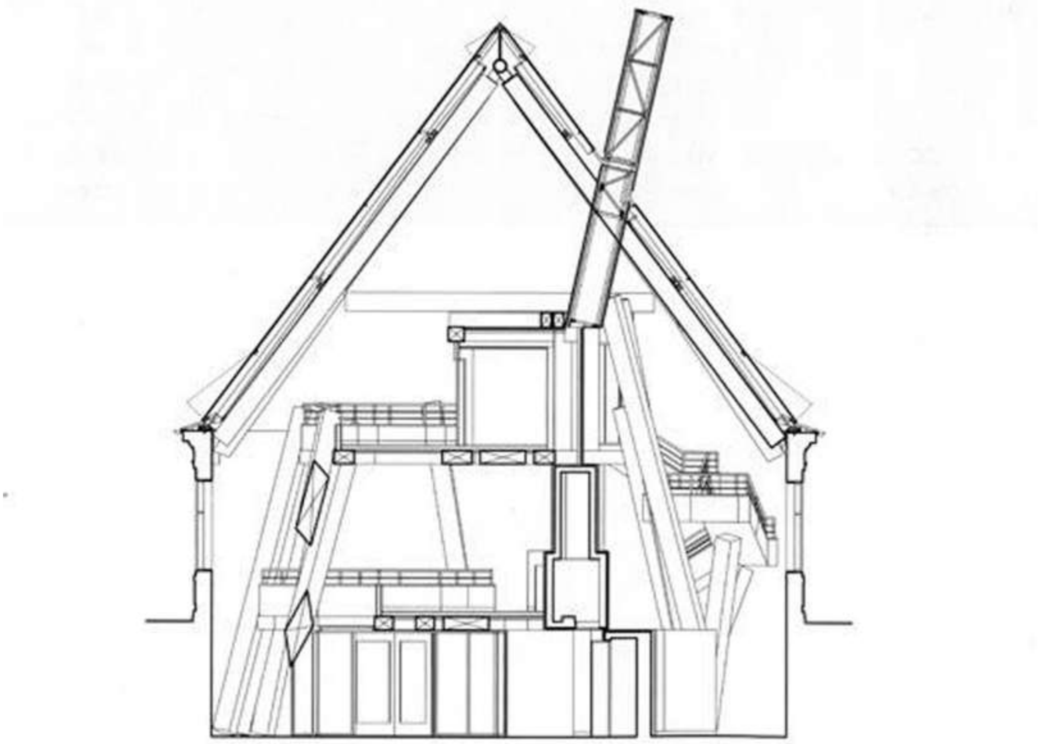

Figure 2.5.6: The cross section of Hejmdal, photo: architekturbilleder.dk

2.5.3 Can Lis - Utzon's house in Mallorca

Architect: Jørn Utzon
Location: Mallorca, Spain

Figure 2.5.7: The design of the house Can Lis stimulates the effect of light, blurring the limit between the dark interior of the house and the blistering Mediterranean sun, photo: Utzon Center

Utzon built Can Lis in 1972. The house was built along the cliffs, faced towards the Mediterranean to maximize the view to the beautiful nature. Utzon designed the furnitures in the house fixed, built on site and finished with shiny ceramic tiles. The windows frames were intended to appear to be invisible from inside by being mounted on the outside surface of the wall to stimulate the effect of sunlight, increase the contrast between the shadow and the blistering Mediterranean sunlight. When the sun moves from east to west during the day and in different seasons, the angle of the sun ray marked on the wall gradually changes. For all these reasons, it seems like the family life pursue the passage of the sun.

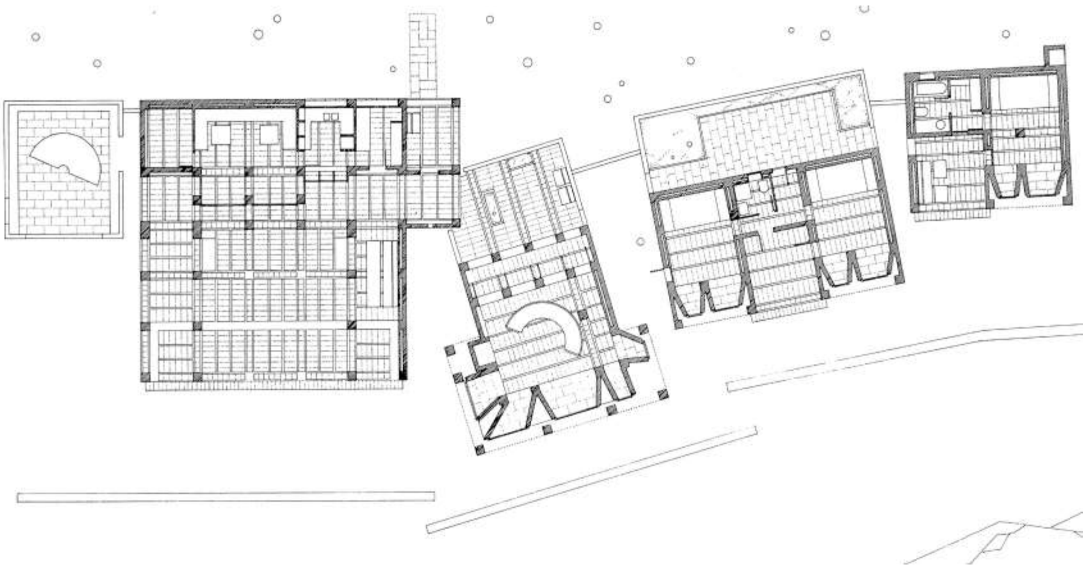

Figure 2.5.8: The floor plan of Can Lis, photo: Utzon Archives Aalborg University & Utzon Center

Figure 2.5.9: The house blends into the nature by using the local materials, photo: Utzon Center

3 | Methodology

The project will be based on the theme of Healing Architecture, Sustainability, Evidenced based Design and follow the Integrated Design Process method (IDP) to make the process and the final result strong in the architectural quality, fulfill the technical requirements as well as emphasize the outcomes of the users by using scientific evidences.

3.1 Integrated Design Process method (IDP)

IDP is a common method which is developed and taught at Aalborg University to guide the students to create a secure design process. The method aims to integrate the competencies both architecture and engineering aspects during the process. The structure is divided into five phases: Problem/Idea - Analysis - Sketching - Synthesis - Presentation. The five phases in figure 3.1.1 is an interactive process which continuously reverses to previous phases to check up on the quality of the design until it reach the coherence (Hansen and Knudstrup, 2005).

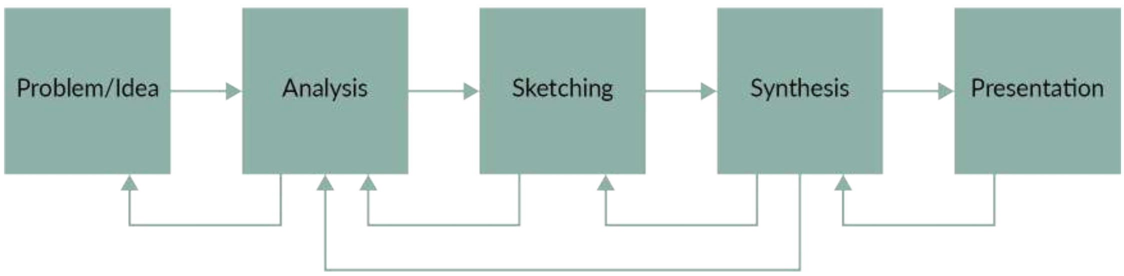

Figure 3.1.1: Integrated Design Process

Problem/Idea

The first step is about the idea and existing problems that the project would like to solve. In this case, it is to design a hospice on the river bank in Ry.

Analysis

The analysis phase includes building requirements and references gathering, site analysis with history of the local area, analysis of local climate, user profiles, using state-of-the-art evidenced based knowledge, construction, strategies for energy, indoor climate and atmosphere, case studies, and studies in materials, details, aesthetics, colors, and shapes.

Sketching

The sketching phase will later on link the ideas with the strategies for construction, energy, indoor climate, functions by using hand-sketching, digital drawing (Autocad or Revit), 3D modeling (Sketchup or Revit), simulation (Rhino, Ladybug, Bsim, Be18, SimView or Velux).

Synthesis

The synthesis phase when the final result is found will be checked thoroughly with design criteria and documented to provide the target values using simulation programs (Bsim), calculation on energy (Be18). LCA and LCC calculation will be considered through the design process.

Presentation

The design process ends up in a presentation of the project where all the materials including technical drawings, calculation and simulation results, graphical diagrams, visualizations, physical model and the final report are shown.

3.2 Evidence-based design (EBD)

In the effort of improving the quality of well-being for both patients and staffs in the healthcare environment, EBD has become a popular approach which relies on robust evidence or credible data deriving from rigorous methods and studies in order to influence both the design process and its outcomes (Phiri and Chen, 2014).

EBD are used in the healthcare architecture to create the therapeutic environment in which the family feel involved and supported, the staff performance become efficient and restorative under stress. An evidence-based designer makes decisions together with an informed client based on the best information available from research and project evaluations (Hamilton, 2003).

Studies have proven the relationship between the physical environment and the patient outcome for some time: natural light, quiet surroundings and scenes of nature can, among other things, reduce patients' stress and aid recovery. In 1984 Ulrich conducted a research between the patients assigned to rooms with windows looking out on a natural scene and the another group of patients assigned to rooms with windows facing a brick building wall. The result showed that those had the ability to get contact with the nature in vision had shorter postoperative hospital stays (Ulrich, 1984).

In architectural healthcare design, it is important to make the decision based on the best available evidence whenever possible. To successfully implement EBD principles, the designer must learn to adopt approaches that create an environment of care that incorporates streamlined processes, new technologies and nurturing design elements by identifying proven evidence-based strategies, creating interventions to emphasize the outcomes: patient safety, patient outcomes and staff outcomes (Phiri and Chen, 2014)

4 | Context

4.1 Location

Figure 4.1.1: Site location

The chosen area for the project of a Hospice is a small town called Ry located in the Municipality of Skanderborg and belongs to Central Denmark Region, Denmark. Ry is a station town which has a population of 6,149 people (Dansk Statistik, 2019). The town stands between the lakes Gudensø, Birksø, Vessø, Rye Mølle Sø and Knudsø by the Gudenå River.

Ry is a new city that has emerged around the railway and for a number of years the city was called Ry Station. Ry has a very attractive nature and a cozy atmosphere thanks to the lakes surrounding the town and the diversity of the vegetation as well as the large forests. Because of the characteristics mentioned above, Ry was chosen to be the location for this project of a hospice.

The project is located on the eastern bank of Ry Mølle lake with a 270 degree view of the

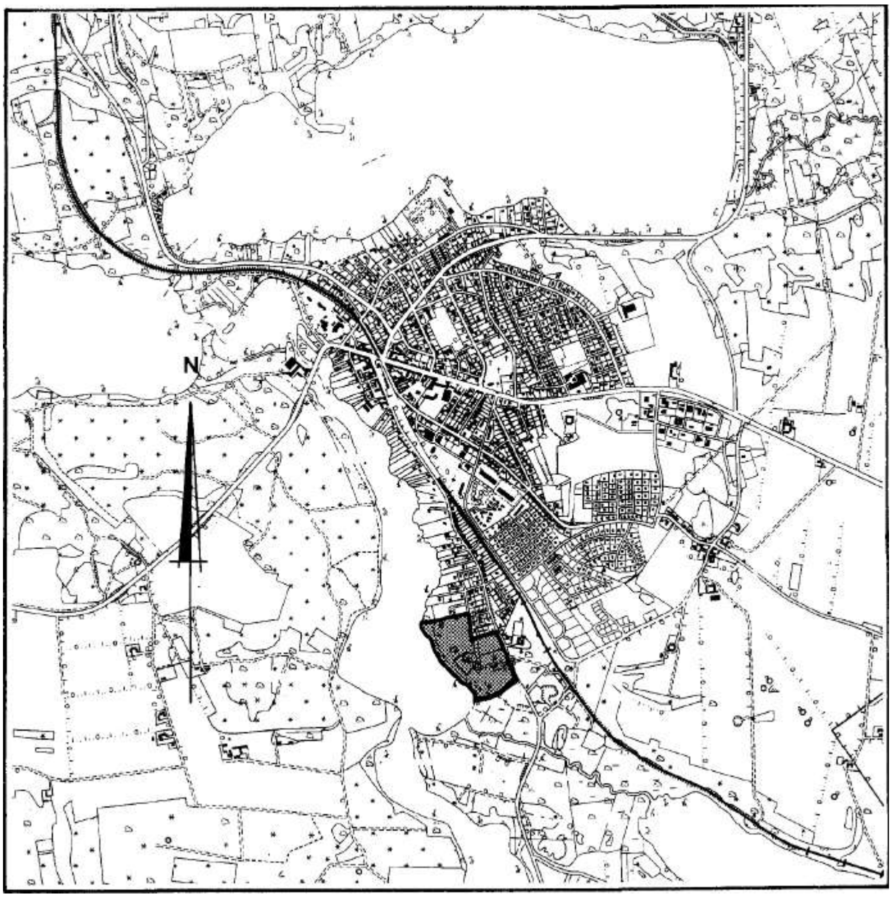

Figure 4.1.2: Illustration of the site area's location from Local Plan nr. 30

nature which includes water and forest ranging from the north to the east counter clockwise. At the site, there is a local hospital called Sclerosis hospital Ry which is considered to be demolished and replaced by a new hospice, see figure 4.1.3. The north-eastern side of the site is a horse farm and is considered to be kept because of the calming and relaxing quality, see figure 4.1.4.

The site faces Sanatorievej on the east, however the main approach to reach the site is from Klostervej which is the primary local road. The center of the town is around 1,7 kilometers away towards the south. On the north and the east is the residential area while to the South of the site is the forest. Figure 4.1.5 explains the condition of the site area.

The total area of the land is 90.827 m^2 with around two thirds of that as forest. It is not allowed to place a construction in the forest area according to the local plan nr. 30. The area where it is allowed to build a construction on can be seen in figure 4.1.5 in the yellow color which is estimated to be around 35.000 m^2.

Figure 4.1.3: Sclerosis hospital Ry to be demolished

Figure 4.1.4: The horse farm at the site to be kept

According to the Local Plan nr. 30 and the District Plan 16, the site is used for buildings that is associated with treatment, training or other functions related to the above mentioned functions. Maximum 25% of the area for public purpose, which is shown in the figure 4.1.5, is allowed to be used for construction. The construction may not be more

Figure 4.1.5: The illustration for the area number 50.O.11 - District plan 16

than 2.5 floors and not higher than 10 meters.

4.2 Terrain and height

One of the best elements of the location is the terrain condition. Towards the south west of the site area the terrain is very steep with the height around 9 meters counted from the site ground level down to the pathway between the water and the site. Figure 4.2.2 explains more in details the slope and height of the terrains towards the water. The height between the terrains in this section drawing is 0,5 meter instead of 2,5 meters which is shown in figure 4.2.1.

The view from the site area towards the south east across Ry Mølle lake is Sanatorium Bay. It is a calming view with nature and wild animals. There are stairs to allow people to walk from the site down to the walking path. Even though this part of forest belongs to

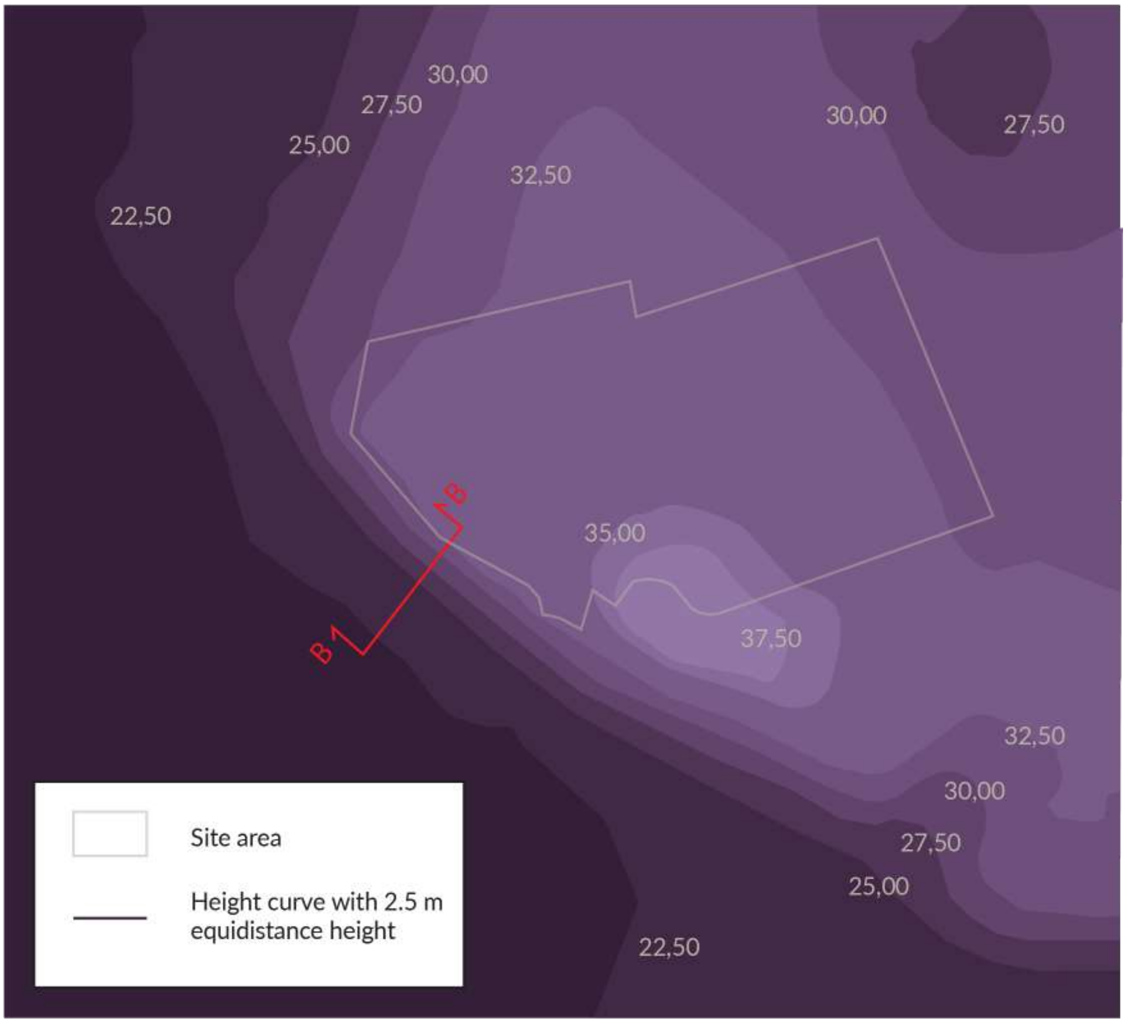

Figure 4.2.1: The terrain condition of the site

the site, it is open to the public.

Conclusion: The different height of terrains provides a nice location for the hospice design to situate on and creates a nice view of it looking from a lower level such as the walking path. The beautiful view of nature can be taken into consideration of designing the view from inside the Hospice in spaces such as the common area and the patient rooms.

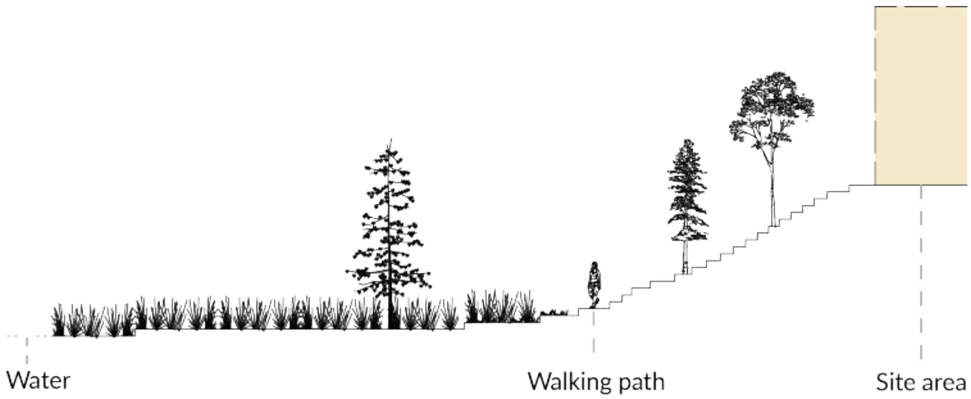

Figure 4.2.2: Section BB, 1-350

4.3 Local climate analyses

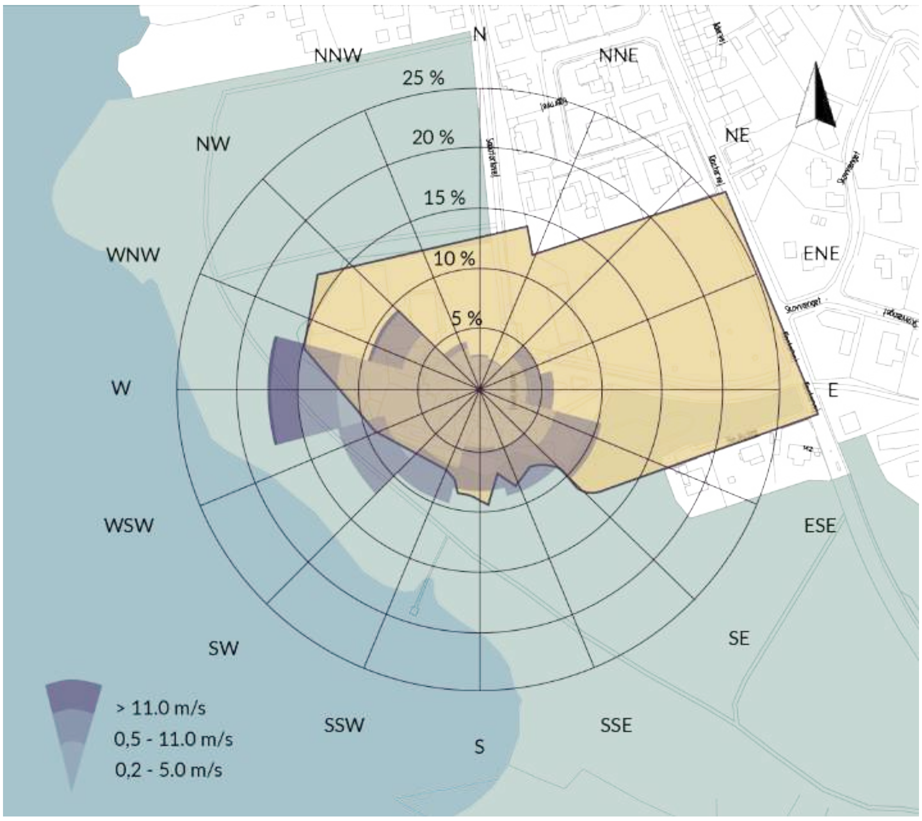

Figure 4.3.1: Wind rose analysis

Based on the data of observed Wind Speed and Direction in Denmark during the period from 1961-1990 from Danish Meteorological Institute and comparing between 3 measured points which are near Ry including FSN Karup, Kølkær and Ødum, Ødum has the most familiar condition of wind with Ry. The conditions were compared within 3 elements: Wind direction, average wind speed and the highest wind speed Danish Meteorological Institute (1999).

From the wind rose, it shows the direction of the wind is mainly from the west and the south. During summer months the wind blows strongest from the west and the south west while in the winter, it tends to comes from from the south and the south west.

Conclusion: From knowing the direction of the wind is from the west in the summer, windward side is easily defined for the natural ventilation. In the winter, there should be a solution to shield the cold wind from the south for the use of outdoor space.

4.4 Vegetation

Figure 4.4.1: Top view of the site area in the summer and in the spring

Vegetation plays a big role functioning as the green barrier to shade, cool down, and reduce the temperature in the summer. The use of vegetation as a modifier of the effect of wind on the building will protect the building from cold winds in the winter, however it is important not to obstruct the ventilation in the summer.

The photos figure 4.4.1 were taken by COWI in the summer 2017 and the spring 2017 and shows the vegetation distribution and the difference between the summer and the spring. Together with other analyses in this chapter, the forest can give a big advantage of providing a relaxing view for users and a better climate for the area.

The height of vegetation of the site is around 10 - 15 meters. There are both vegetation which lose the leaves in the winter and some which still keep the green color during winter. They both give some meaning for the design. The trees which have no leave in the winter can enable the sun to heat up the inner space by using the passive solar heating strategy and cool down the temperature in the summer by shading and blocking direct sunlight. The trees such as evergreen trees contribute the green color for the view to nature in the winter.

From figure 4.4.1 it can be seen that, in the summer the trees cover around the site and can protect the site from hot temperature by shading and cooling down the air. From the analyse of the wind we know that the wind blows mainly from the west and the south west. Fortunately the proportion of the tree distribution on this direction is not too thick. A small number of trees be can taken into consideration of removing to give the best view to the lake.

The vegetation seems to cover less without the leaves in the spring. It can be used to analyse the vegetation in the winter as well since in the spring the leaves only start to come back. The vegetation on the south still keep some of the green color and should be able to somewhat reduce the wind speed and wind cold in the winter. The solution for wind shield should still be kept in mind in the case of using outdoor space during cold seasons.

Conclusion: The site area is surrounded by a lot of trees which is a big advantage for the building to be shade from the direct sunlight in the summer and to weaken the cold wind in the winter. While designing the space towards the south where sunlight is favoured in the summer such as garden, the shadow of the vegetation should be kept in mind. It is applied the same way for the passive solar heating strategy in the winter.

4.5 Accessibility

The infrastructure condition surrounding the site area is described in the figure 4.5.1. From the diagram, it can be easily seen that there is no bus stop or other public transportation near the site. Thus to approach the site people have to use other transportation such as cars, scooters, bikes or walking.

Figure 4.5.2 illustrates how the road section is. The bike path and the car path are on the same ground level but with a dividing line to separate them. The bike path and side walk are on the opposite side of the path for cars. To access the site pedestrians have to cross the road, but since it is not a busy road it is safe to do so.

Conclusion Because there is no bus route along Klostervej it is important to provide enough car and bike parking lots at the sites for the visitors and staffs.

Figure 4.5.1: Accessibility map

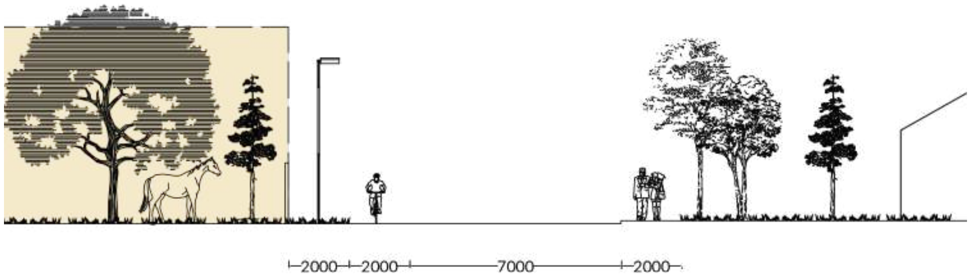

Figure 4.5.2: Section AA, 1-250

4.6 Noise

The site is located in a suburban area. The surroundings are residential areas and forest and therefore most noise comes from humans, animals, and transportation. Road traffic noise is the major source of noise, but Klostervej is not a big road. The width of the road is 9 meters while 2 meters is already taken for bike path. Figure 4.5.2 shows the section of the road. About 1 car pass by in 1 minute and the noise level ranges from 41.5dB to 61.3db in a small survey I conducted in 20 minutes shown in figure 4.6.1.

Time	Time between observations (minutes)	Number of cars	Noise level (dB)
14:19	-	1	48.4
14:24	5	2	51.3
14:25	1	2	52.8, 49.6
14:27	2	1	59.3
14:28	1	1	49.6
14:30	2	1	48.4
14:32	2	1	51.8
14:33	1	1	41.5
14:34	1	2	49.3 (together)
14:35	1	2	48.1, 53.2
14:37	2	1	44.1
14:38	1	3	61.3, 55.3, 55.5
14:39	1	1	51.1

Table 4.6.1: Traffic flow survey

There is no data of noise level in Ry from the Environment Department. The noise pollu-

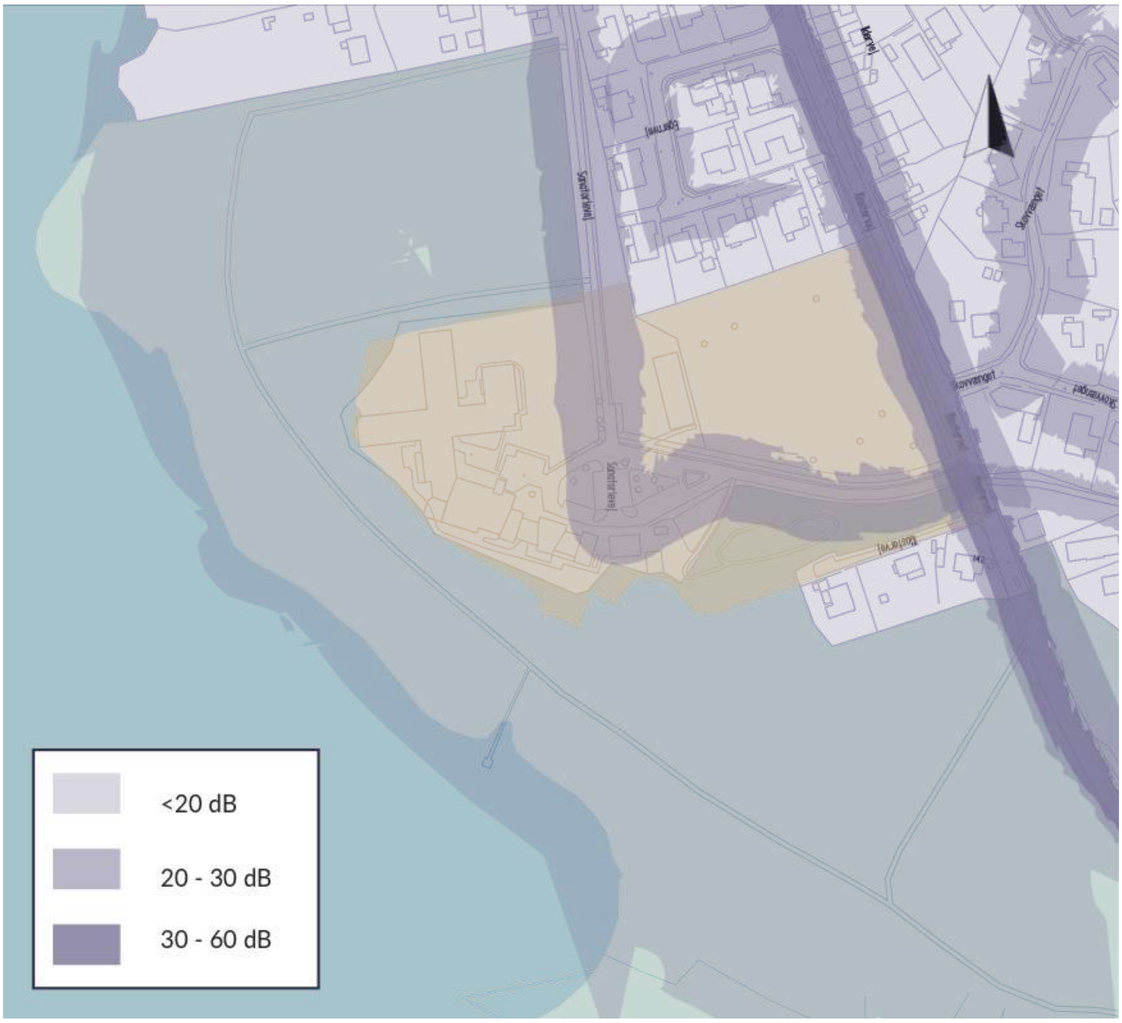

Figure 4.6.1: Noise level

tion is an important element to analyse when designing a healthcare building, so I went to the site and did measurements of the ambient noise levels by walking along the roads and pathways. The result shows that the noise level in general is as low as the noise level of people whispering (below 20 dB) up to the noise level of a normal conversation (50 - 60 dB).

Conclusion: By keeping the horse farm and design a new hospice on the west side of the site which is far away from the main road, noise from the traffic is not an issue. The forest surrounded the site is home to many species of birds and this can be used as an advantage to create a relaxing atmosphere for the outdoor space. The acoustic problem of the project therefore is only about controlling the sound level and reverberation time inside the designed hospice.

4.7 Local typology and architecture

Figure 4.7.1: Architectural typology analysed based on the shape of roofs

The buildings in the surroundings within 500 meters radius are open low houses with maximum 2 floors. The architecture in this area is mainly traditional Danish style. There is no building with special architecture than new modern flat roofed house. Therefore, the analysis is made based on the 3 different types of roof.

From figure 4.7.1 it shows that gable roof is the most dominant type. Around 30% of the houses within the analysed map have flat roof. Hip roof is the least common type in the surroundings.

Conclusion: The architecture in the surroundings has mainly the type of pitched roof, gable is the most common roof in the comparison with hip roof and flat roof. However hip roof is also seen as pitched roof. The hospice design should either try to keep the harmony of the area by using the most common architectural elements or it needs to have a special style which create a special architectural quality for the area.

4.8 Personal perception

Figure 4.8.1: The view to water from the site

I approached the site in a winter day. The temperature was 9 C but it felt like 3 C instead. The wind speed was said to be 28 - 38 kmh on the weather forecast, so it was mild.

Ry in my eyes was small and cosy. In another word, the town made a stranger like me feel like I had belonged to their community. To arrive the chosen site, people have to either use car or bike or walk from the train station for 20 minutes. There is no local bus in the town.

Figure 4.8.2: Vegetation at the site

At the arrival, my first impression was quite pleasant because of the horse farm and the surrounding forest. There was slightly smell from the farm but it was not something would bother me much to consider removing it. I saw two guys standing next to the fences of the farm looked happy and waved to the animals. Human in their nature loves animals and feels relaxed while seeing them in my opinion. That was why I decided to keep the horse farm in my design.

I then decided to take a walk down to the water before measuring the sound level at and around the site. The vegetation is mixed between the 2 types of trees: one has no leaves during he winter and another one still can keep the green colour. The site was quiet and isolated from the busy life. The most dominant sound I could hear was the ducks and the birds singing. It made my mood very good and I became excited to explore more.

When I walked around to the back yard of the existing hospital. I could see the ground level of the site is about 10 meters above the walking path which is close to the water. It therefore gives a great view towards the water. But maybe removing some of the trees can create even a better view from the site.

Afterwards, I walked down to the walking path along the water. The atmosphere there was very calming and relaxing thanks to both the nature view and the sound of the ducks from the lake together with the birds. I could see some local people were running and walking with the dog. They said hi and smiled to me even we did not know each other. It was such a nice feeling. I imagined this walking path could be a big advantage for the staffs to take a walk when being stressed from work, or for the family to calm themselves down after a long time having to deal with the truth that they are losing their beloved one. It could even be used for patients as well if they are well enough and would like to enjoy a trip on their wheelchair with their caregiver.

Figure 4.8.3: The walking path between the water and the site area

This location is perfect to build a hospice thanks to the high qualities provided from the nature.

5 | Design manual

5.1 Vision

Figure 5.1.1: The illustration of the arrival of a hospice designed by SIGNAL Architects for the Realdania Report on 'The Good Hospice in Denmark'

The vision for this thesis is to create a dedicated and sympathetic hospice with a homely atmosphere situated in the nature in Ry. It is highly prioritized that the hospice should provide the best possibilities to meet the needs and challenges of the palliative care sector. Users' experience is highlighted during the design process, rather than the aesthetic of the building in general. The architecture will be used as the tool to create the interventions, spatial experiences and a restorative environment. Sustainability in different aspects such as energy consumption, life cycle of the materials, natural ventilation, thought of the future use, and construction structure are taken into consideration.

5.2 Design parameters

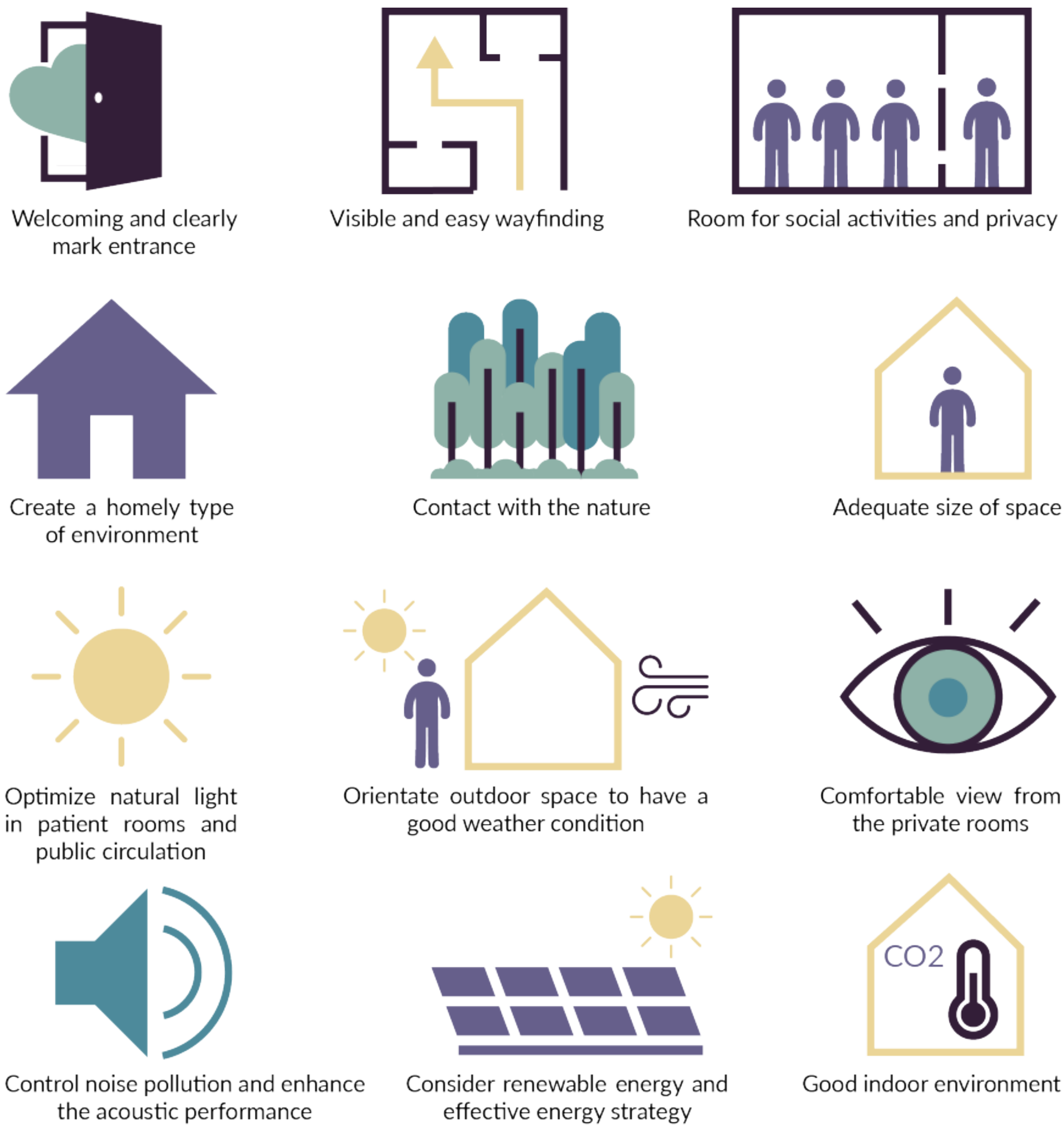

Figure 5.2.1: Design parameters

Public perception of a Hospice

The term 'hospice' is perceived in two different ways. For some the word stands for a place of professionalism and a peaceful environment for critically ill patients. In the same time many relatives feel a tremendous sense of anxiety when their loved one is admitted to a hospice as it refers somehow to death. Therefore we must be mindful of the opportunity to alleviate these common fears and anxieties in planning and designing a hospice building (Worpole, 2009).

Welcoming and clearly mark entrance

As the section 2.1 mentions the first impression of the patients and relatives is vitally important. The pathway before reaching the entrance should provide a good feeling by taking care of the landscape such as trees and flowers, the auditory, and the olfactory. The parking should be near the entrance and the entrance should be clearly marked not to confuse the newcomers.

Create a homely type of environment Homely feeling is what the patients need to feel while accommodating at a hospice. Beside the materials, atmosphere, view, and architecture it is important that the patients should have the possibilities to have their things around them. However, a hospice is still an acute healthcare facility where a complex array of medical and nursing problems should be supported and solved. It means that while trying to achieve the homely atmosphere for the hospice, the architecture must not lose sight of the fact that the building is primarily an acute healthcare facility (Worpole, 2009).

5.3 Room program

The room program was made based on case studies (net, volume, sizes of the rooms), Danish Standards (ventilation rate, air change per hours, thermal comfort, atmosphere comfort, sound level, reverberation time), BR 18 (light factor) and other references.

ROOM	No.	Net (m^2)	Total (m^2)	Ventilation rate (ls)	Ventilation ACH)	CO2 lv (ppm)	DF (%)	Sound lv (dB)	Rev time (s)	S/P
COMMON AREA										
Entrance	1	23	23	11.5	0.69	850	2	35-45	0.7-0.4	S
Reception	1	8	8	9.8	1.70	850	2	35-45	0.7-0.4	S
Administration room	1	17	17	19.95	1.62	850	2	25-35	0.7- 0.4	S
Waiting area	1	85	85	99.75	1.62	850	2	35-45	0.7-0.4	S
Children play room	1	21	21	35.35	2.33	850	2	35-45	0.4	S
Kitchen	1	98	98	384.3	5.43	850	2	35-45	0.8-0.4	S
Cafeteria	1	157	157	404.95	3.57	850	3	35-46	0.6-0.4	S
Common space	1	200	200	420	1.08	850	3	35-45	0.6-0.4	S
Toilets	3	11	33	20	2.52	850	-	-	-	S
Storage	1	24	24	20	1.15	850	-	-	-	P

Table 5.3.1: Room Program

ROOM	No.	Net (m2)	Total (m2)	Ventilation rate (ls)	Ventilation ACH)	CO2 lv (ppm)	DF (%)	Sound lv (dB)	Rev time (s)	S/P
CARE UNIT										
Quiet lounge	1	37	37	26.95	1.01	850	2	20-35	0.5	P
Treatment room	1	17	17	28.5	2.32	700	2	25-35	0.6-0.4	P
Rehabilitation	1	77	77	88.5	1.59	850	2	35-45	0.6-0.4	P
Meditation room	1	133	133	86.5	0.90	700	2	20-35	0.5	P
Spiritual room	1	26	26	33	1.76	700	2	20-35	0.5	P
Music therapy	1	37	37	38.5	1.44	700	2	35-45	1.2-0.9	P
Water therapy	1	323	323	211.5	0.47	700	3	25-35	0.5	P
Care unit toilet	2	11.8	23.6	15.9	1.87	700	-	25-35	-	P
STAFF										
Office	1	33	33	66.5	2.79	850	2	30-40	0.7-0.4	P
Nurse station	1	21	21	40.5	2.67	850	2	30-41	0.7-0.4	P

Table 5.3.1: Room Program

ROOM	No.	Net (m2)	Total (m2)	Ventilation rate (ls)	Ventilation ACH)	CO2 lv (ppm)	DF (%)	Sound lv (dB)	Rev time (s)	S/P
Nurse room	1	21	21	50.5	3.33	850	2	30-42	0.7-0.4	P
Staff overnight	1	33	33	66.5	2.79	850	2	25-35	0.7-0.5	P
Medication storage	1	13	13	6.5	0.69	850	2	-	-	P
Computer room	1	21	21	20.5	1.35	850	-	-	-	P
Staff break-room	1	40	40	170	5.88	850	2	35-45	0.8-0.4	P
Staff kitchen	1	11	11	25.5	3.21	850	2	35-45	0.8-0.4	P
Staff toilet	3	5	15	12.5	3.46	850	-	35-45	0.8-0.4	P
SERVICE										
Sluice room	1	15	15	5.25	0.48	850	-	35-45	0.8-0.4	P
Laundry	1	24	24	8.4	0.48	850	-	35-45	0.8-0.4	P
Linen storage	1	12	12	4.2	0.48	850	-	-	0.8-0.4	P

Table 5.3.1: Room Program

ROOM	No.	Net (m2)	Total (m2)	Ventilation rate (ls)	Ventilation ACH)	CO2 Iv (ppm)	DF (%)	Sound Iv (dB)	Rev time (s)	S/P
Equipment storage	1	25	25	8.75	0.48	850	-	-	0.8-0.4	P
Technical room	2	24	48	8.4	0.48	850	-	35-45	0.8-0.4	P
PATIENT										
Patient room	15	42.7	640.5	51.35	1.11	700	5	20-35 (night) 25-40 (day)	0.7-0.4	P
In-patient lounge	1	48	48	74	2.13	850	2	25-35	0.7-0.4	P
Family rooms	2	33	66	56.5	2.37	850	2	25-35	0.7-0.4	P
Dialogue room	2	21	42	30.5	2.01	850	2	25-35	0.6-0.4	P
Family bath-room	1	15	15	17.5	1.62	850	-	-	-	P

Table 5.3.1: Room Program

5.4 Functional diagram

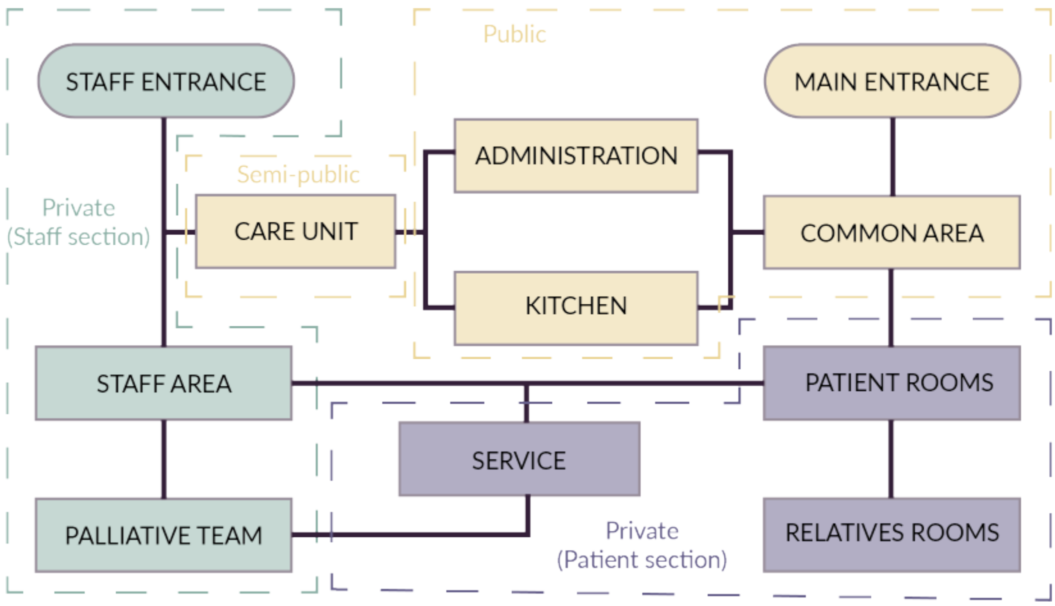

Figure 5.4.1: Functional diagram

The functional diagram is to show the relations between different zones. In-patients zone should be away from the common area to keep that area calming, quiet. Service zone should be near the patient zone because most of the activities of the service is provided for in-patients. The day-patients when arriving the hospice should get an easy access to the care unit. Therefore I placed the care unit next to the common area. However, this zone can be moved to be nearer the in-patients zone to make it easier for them to use the facilities daily. I try to shorten the travel distance for the staffs to reach the patients. But it might be re-thought in the case if the hospice is not too big.

6 | Design process

6.1 Volume study

From the information of the room program, it is estimated that the total area of the hospice is around 23000 m^2 not including the other service space such as corridor, stairs, veranda. The photo in figure 6.1.1 shows the size of the hospice in 1 floor and compares it with other houses in the context.

Figure 6.1.1: volume study in 1 floor compared with the size of the houses in the surroundings

The photo in figure 6.1.2 compares the space taken between 1 floor volume, 2 floors volume and the combination between 1 and 2 floors volume respectively.

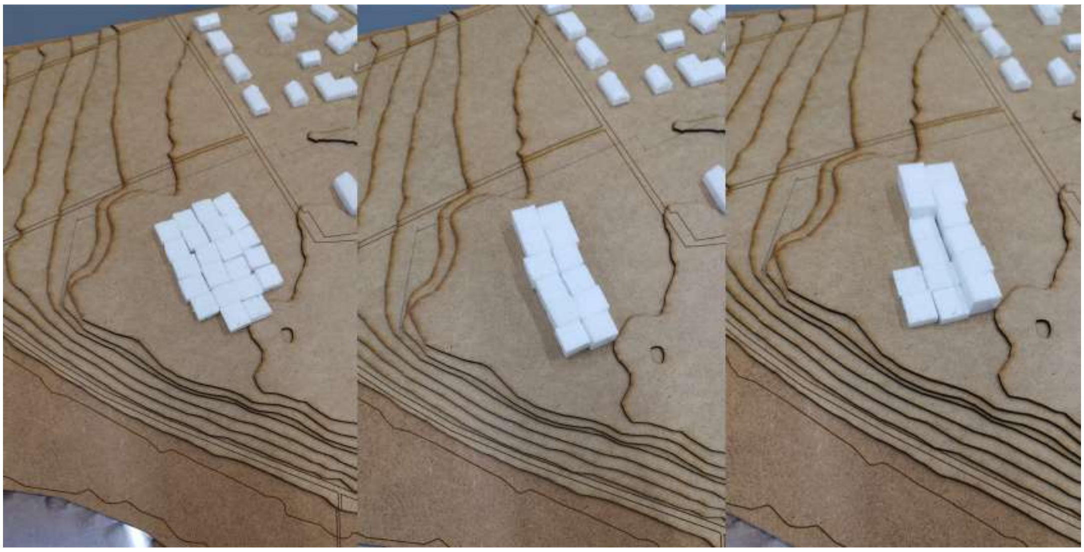

Figure 6.1.2: volume study in 1 floor

6.2 Conclusion from analysis phase

In the sketching phase, I have made conclusions based on studies from the analysis chapter to have a better overview before stepping into designing.

6.2.1 Weather condition

By building a Rhino model to prepare for climate simulation, I use it as a 3D model to explain the topography and the directions where the summer wind and winter wind comes from to have the solution of shielding the cold wind and taking advantage of summer wind for natural ventilation.

6.2.2 Topography

The 3D model combining with the section and the diagram of terrains help to find the best position to place the building.

6.2.3 Visual comfort conclusion

Figure 6.2.3 expresses the atmosphere and the beautiful location. View 1 towards Rye Mølle lake is considered for the common space and patient rooms where the users spend

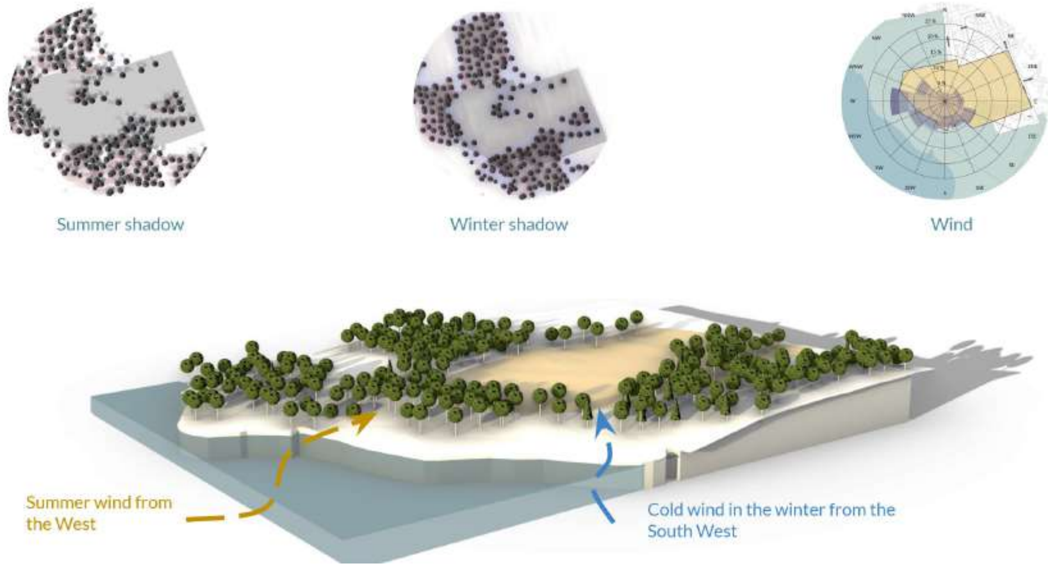

Figure 6.2.1: Weather conclusion

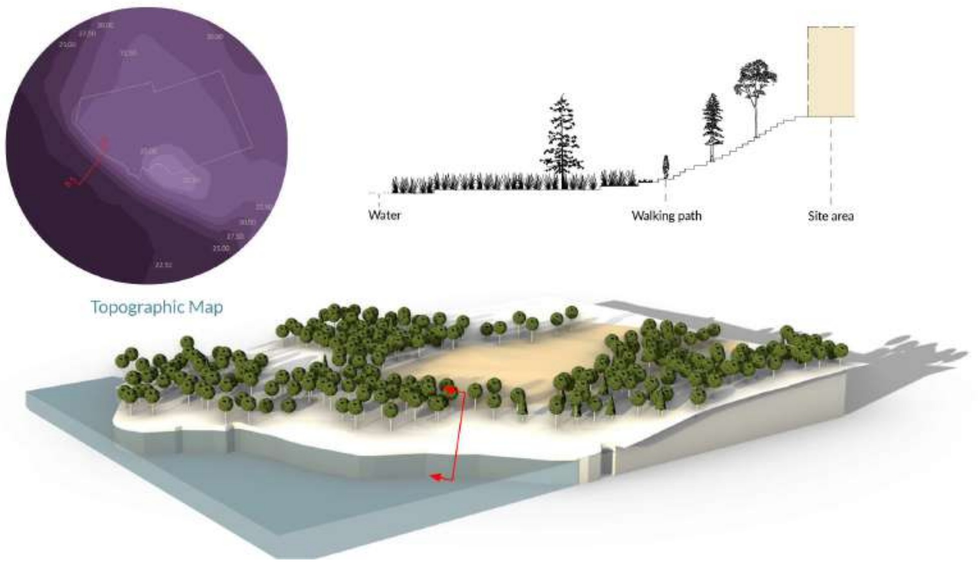

Figure 6.2.2: Topography conclusion

most of their time during the day.

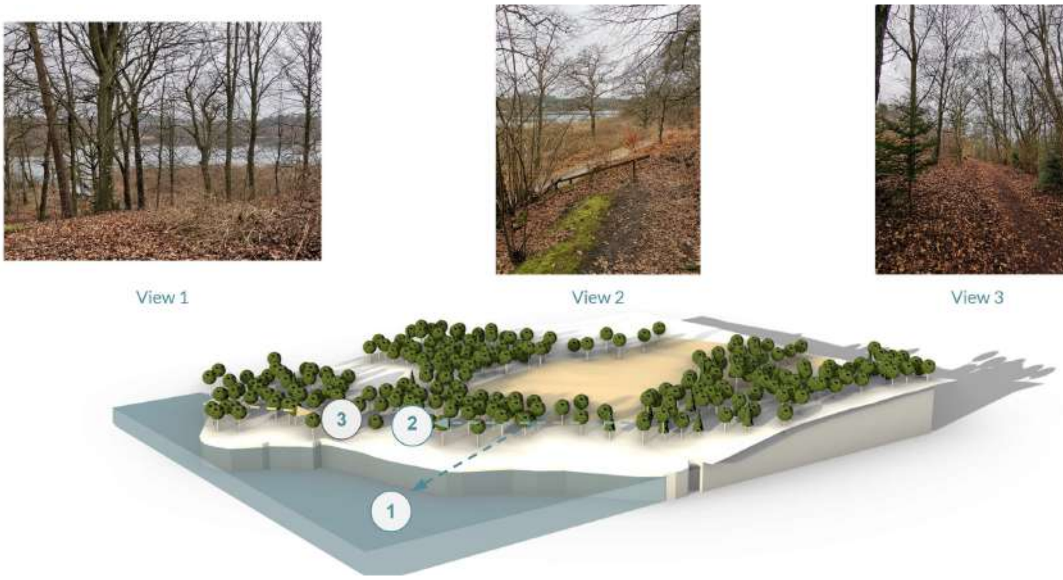

Figure 6.2.3: Visual comfort conclusion

6.3 Climate simulation for different studies

6.3.1 Sun radiation

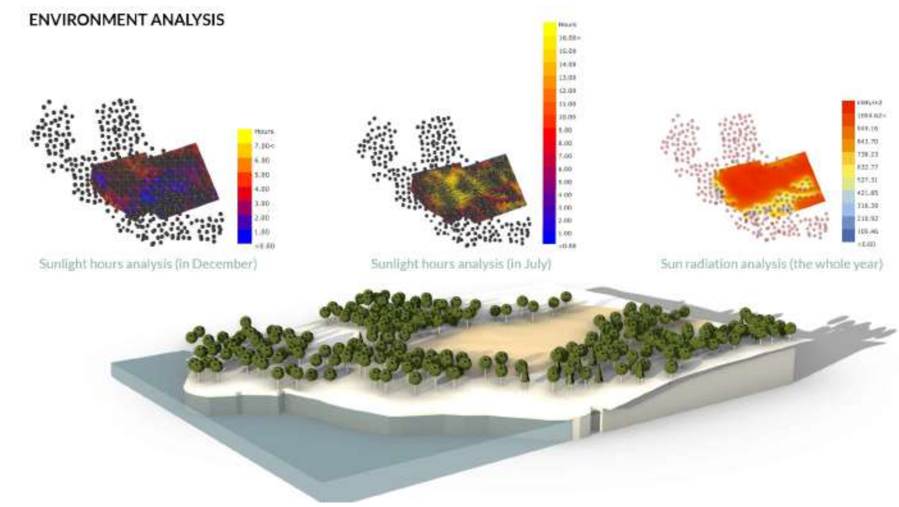

Figure 6.3.1: Testing sun radiation with Rhino simulation

The simulation of sun radiation is to check if solar cells can be an option for the renewable resource later in the phase where the zero energy need to meet.

6.3.2 Sunlight hour

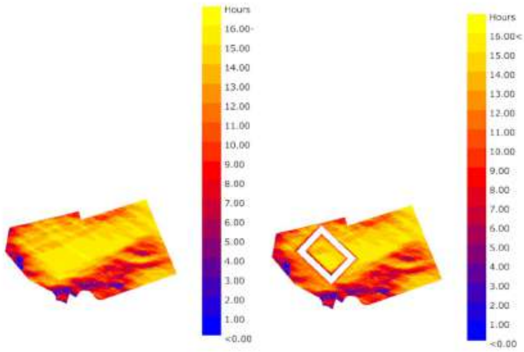

Figure 6.3.2: Testing sunlight hour with and without a courtyard

6.3.3 Shape study

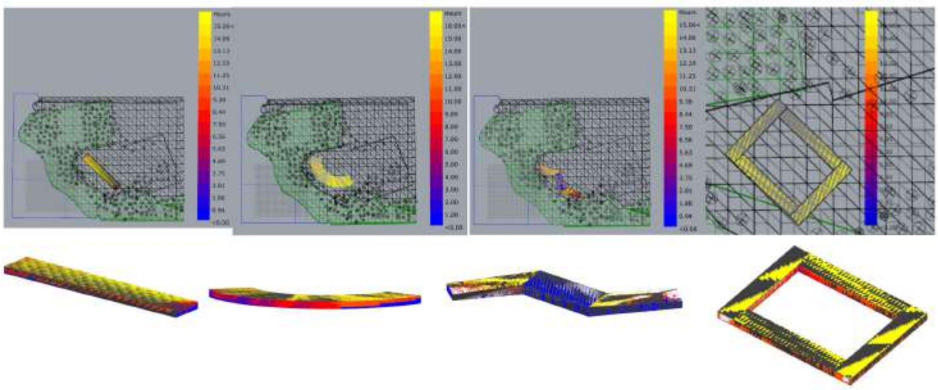

Figure 6.3.3: Testing shape studies to compare the amount of sunlight hour on the façade

Figure 6.3.3 is simulations on different basic shapes. In this study, the amount of sun radiation, expressed in colours on the façade facing south is important and the key for the decision. The study shows that the basic long rectangle has the most sun radiation. However, the technical aspect should not dominate the aesthetic aspect. The final design starts from the basic shape of rectangle and then changes slowly to satisfied shape.

6.4 Sketching concept

6.4.1 Inspiration of the architecture of mindfulness

Using Japanese architecture philosophy as the inspiration, the project concept has the goal of creating an architecture of mindfulness. The Hospice is hoped to create a space where art, landscape, and architecture come together.

Figure 6.4.1: Our mind is a part of our body, and our body is a part of the physical environment

Figure 6.4.1 reflect the theme that: Our mind is a part of our body, and our body is a part of the physical environment.

Figure 6.4.2: Hand sketching of a day of the patient at the hospice concept

Even though a hospice is where patients spend the period of the end of life, it still plays a role to make a happy life. Following that idea I try to imagine how a happy day for the patient is like. Figure 6.4.2 is quick hand sketching during the design process and later becomes the main theme of the design concept.

Figure 6.4.3: Hand sketching of garden - building integration

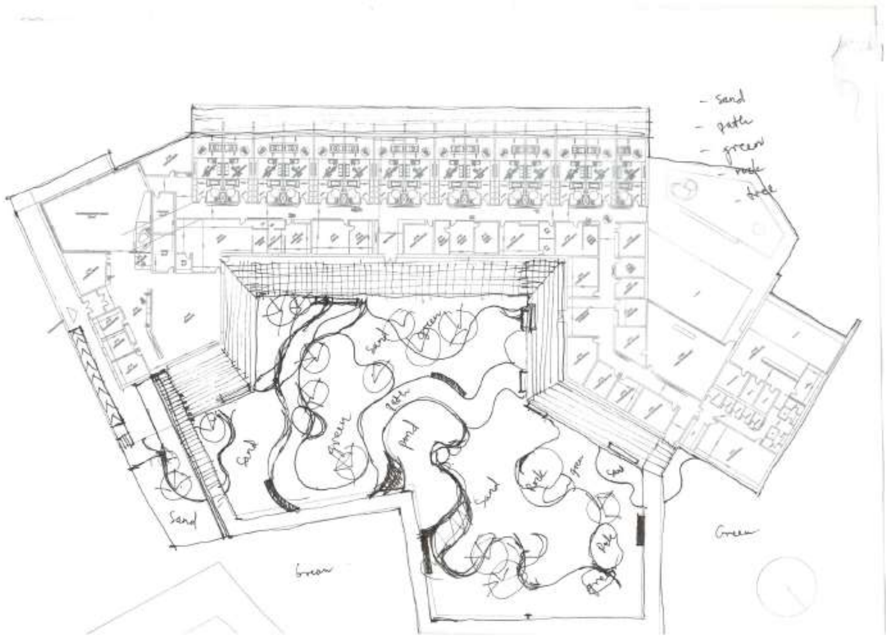

Figure 6.4.4: Hand sketching of garden

7 | Presentation

7.1 Concept

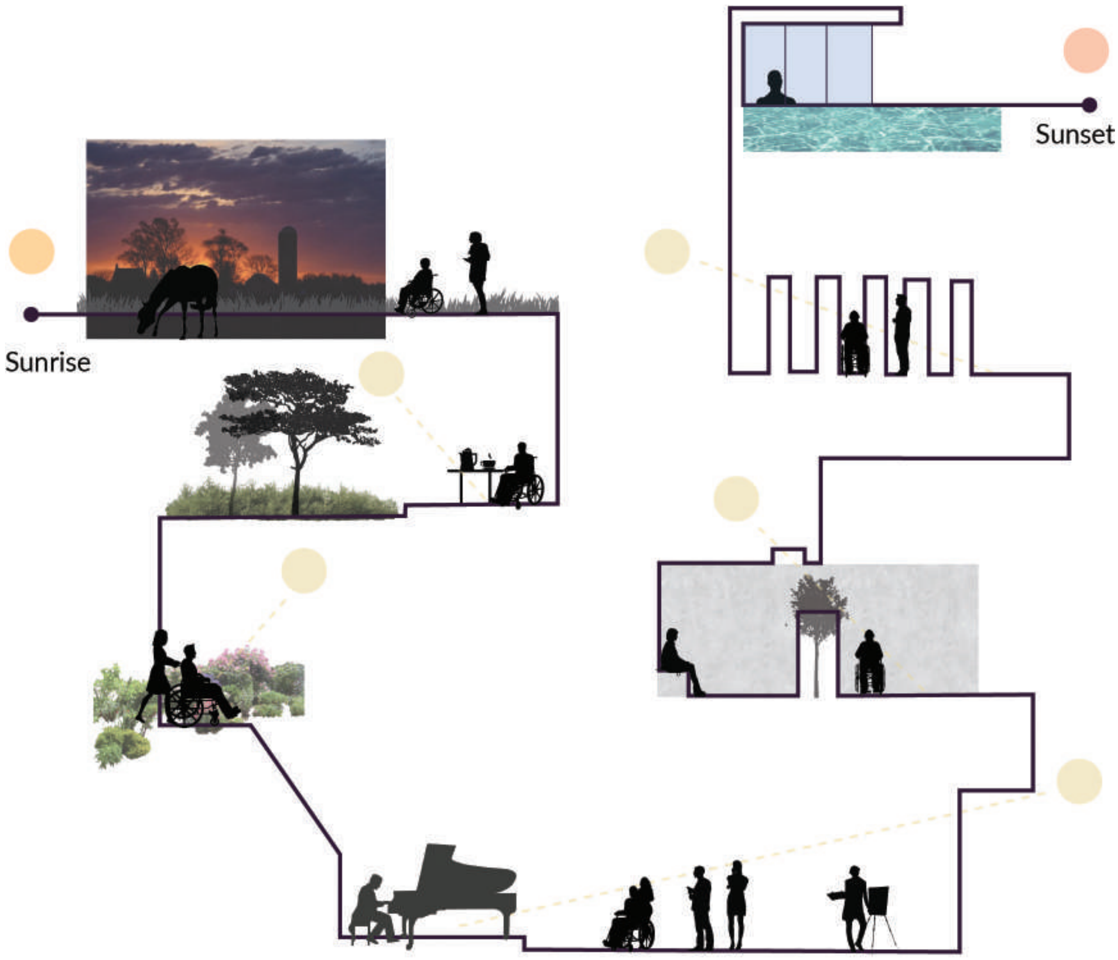

Figure 7.1.1: The concept of "a day with the sun"

The concept of this project was inspired by the concept of Can Lis - Utzon's house in Mallorca. The idea is that the sun, which is known as the symbol of life and happiness, will always follow the patients during their daily activities from early in the morning when the sun rises and until the end of the day or when the sun goes down.

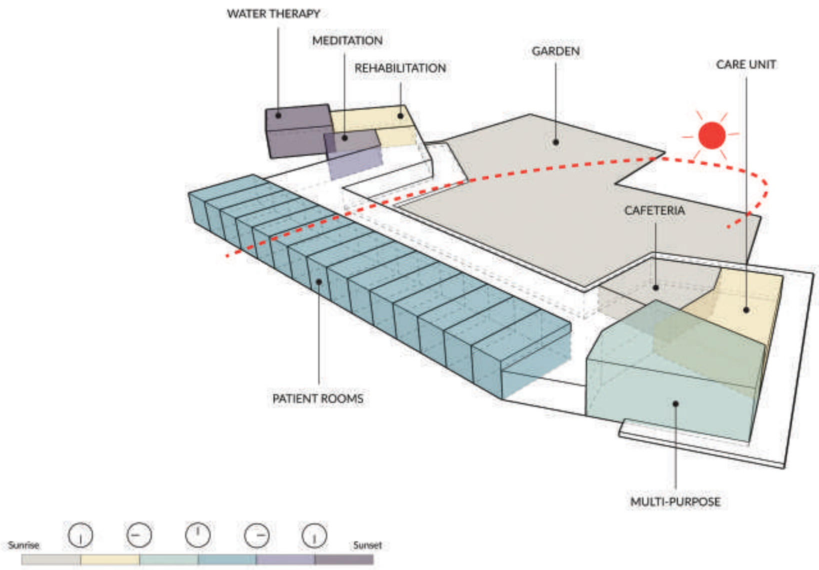

Figure 7.1.2: The functions are distributed following the sun trace

In the existing context, on the east of the site is the horse farm and on the west side is the lake. Since the nature on the west is attractive with the view to the water. To keep the east side lively, a garden with the retreat quality is designed. The garden provides a better atmosphere for the functions or the rooms towards to east. The space is distributed along the sun trace, see figure 7.1.2.

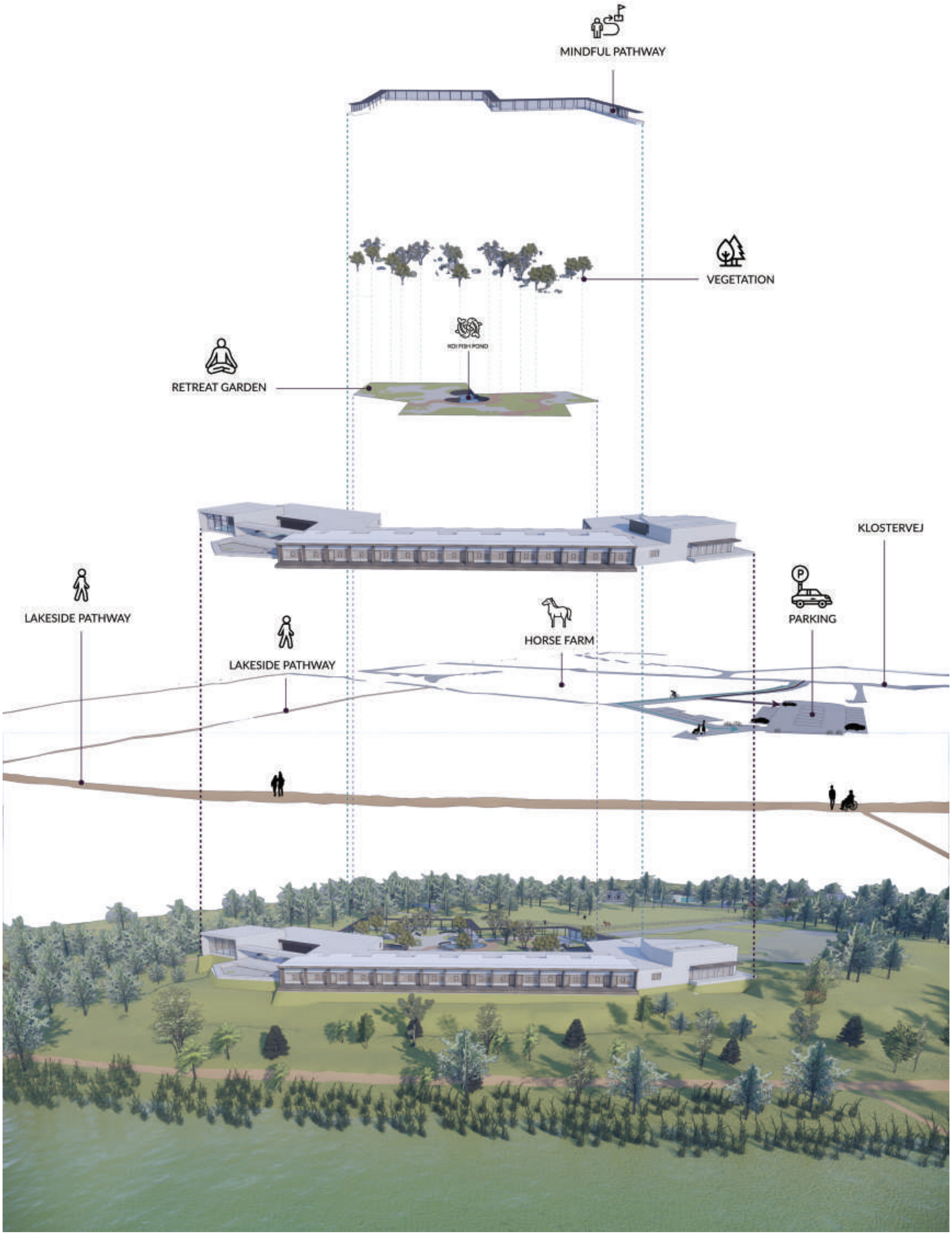

Figure 7.1.3: Function distributions

7.2 Technical drawings

Figure 7.2.1: Southern façade, scale 1-850

Figure 7.2.2: Northern façade, scale 1-850

Figure 7.2.3: Western façade, scale 1-850

Figure 7.2.4: Eastern façade, scale 1-850

The hospice is situated in between the forest, Rye Mølle lake and the horse farm. The access to the site is from Klostervej on the east side. Towards north-east is the residential area where the residents have the right to get to their house through the entering pathway of the hospice. However, this is not their main access which is further north.

The lake on the west side offers special atmosphere and experiences for the users of the hospice. It opens for public as well.

The building volume is 33000 m^2 with 1 floor to adapt to the forest. The parking lot is hidden between trees on the south-east of the building. It has in total 48 lots for bikes, 52 lots for normal cars, 5 lots for 3.5 x 5.0 m handicap cars and 4 lots for 4.5 x 8.0 m handicap cars. Details shown in appendix A.8.

The roof is covered with PV panels in the term of reaching zero energy. It is however illustrated without PV panels in figure 7.2.5 to make the drawing more clear.

Figure 7.2.5: Master plan, scale 1-1200

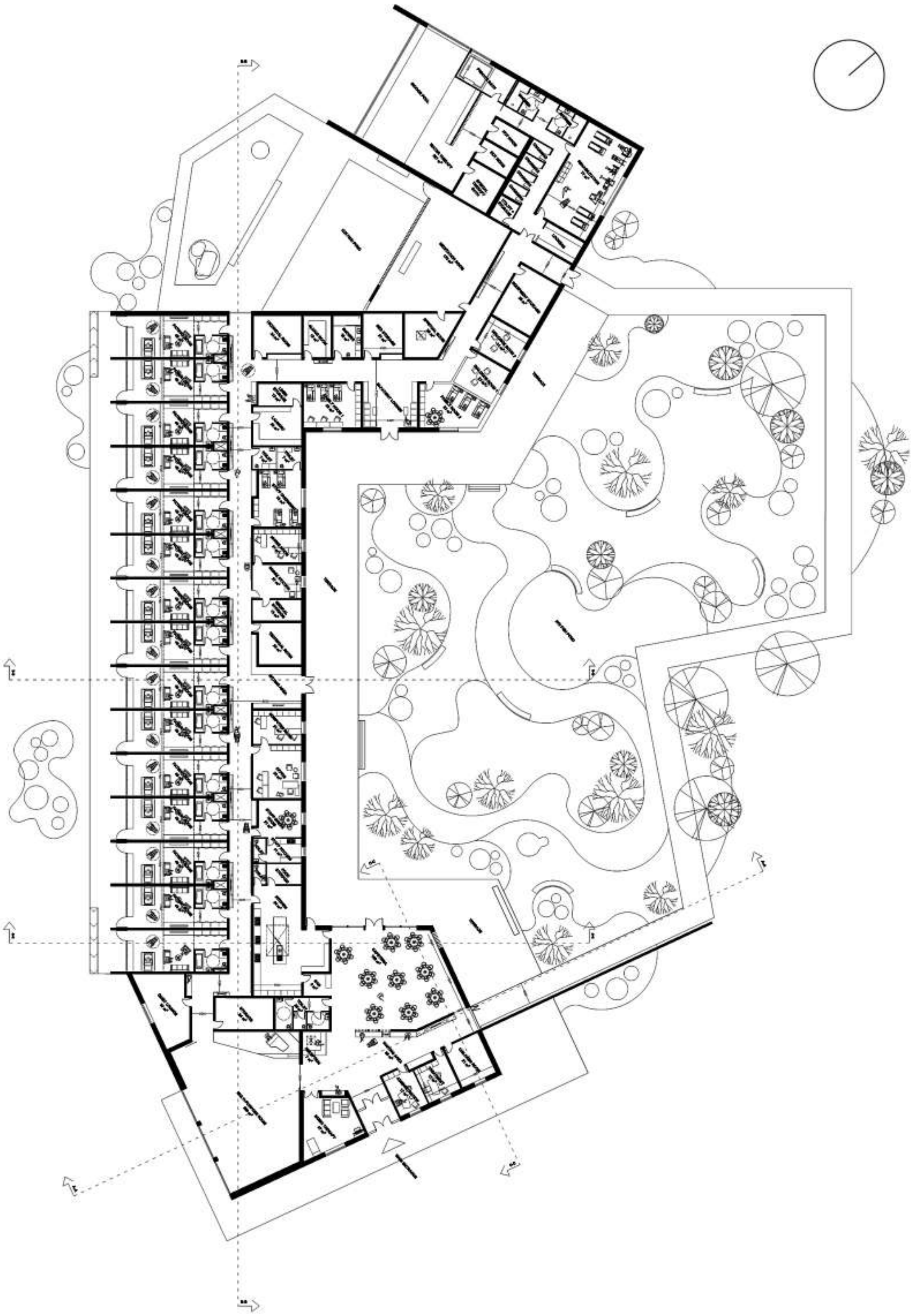

Figure 7.2.6: Floor plan, scale 1-800

The beginning and the end part of the building are for care unit function, served for both day-patients and in-patients.

The beginning of the building on the south-east consists of waiting area, cafeteria, multi-purpose room, quiet lounge and treatment services such as administration, treatment room and music therapy room. The other part on the north is the special therapy area such as water therapy, rehabilitation, mediation and spiritual room. To get to this part, the day-patients can use the pathway with roof in the garden connected the both parts of care unit or get through the hallway between patient rooms and the staff area.

Closet to the entrance is the common space, used for all types of user like patients, relatives and staffs. The functions in the common space are arranged for the best convenience of use, described more in the sub section 7.3.3.

The patient rooms are arranged at the best part of the building where the view is opened towards nature: forest and the water. The storage served to the multi-purpose room separates this area from the common space by stopping the long straight hallway with a turn in a subtle way. Each patient room has their own small terrace. Walls on two side provide privacy for them when sitting on their terrace.

The patient unit has also 2 family rooms to allow the family members of the patient to stay overnight. They are on the north-east of the building, next to the dialogue rooms where holds some private conversations for the patients, relatives and staffs.

The staff area is placed on the opposite side of the patient rooms to shorten the travel distance for the staffs. The rooms are on the north-east, opened towards the garden. The project manages to bring green access to all users.

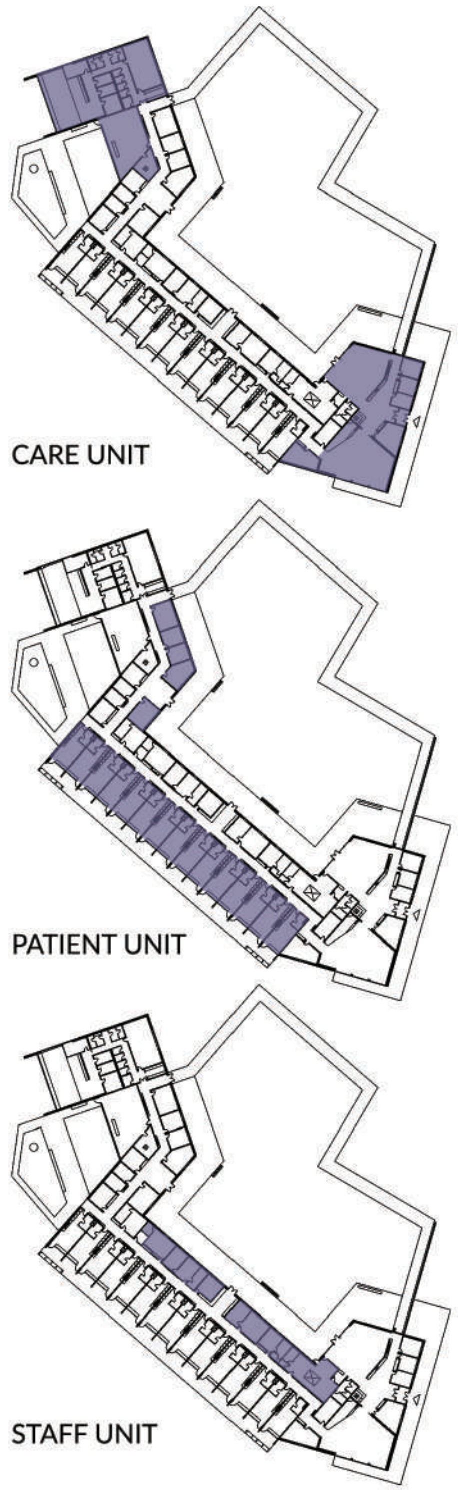

Figure 7.2.7: Functions distribution

7.3 User experience

7.3.1 Arrival

"It is a Sunday morning and Philip is on the way to visit his father who was diagnosed with cancer at the final stage and has moved into a hospice in Ry. The path through the horse farm and trees is so pleasant. In a moment, Philip has forgotten things bothering him for a while"

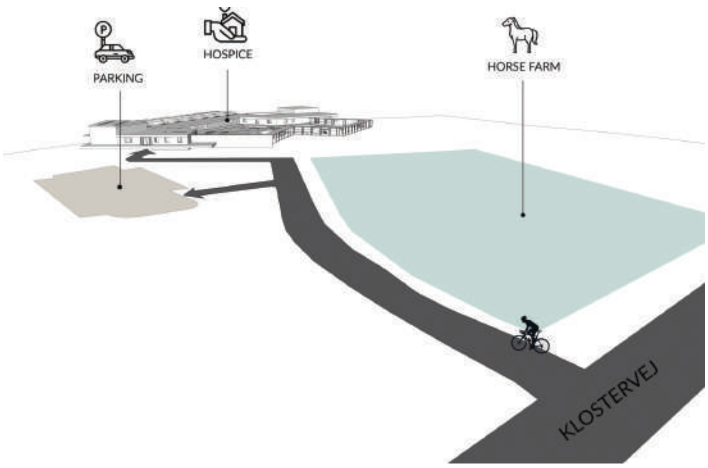

Figure 7.3.1: The pathway before arrival

The path from Klostervej to parking area is about 100 meters long. This "small trip" has the intention to clear people's mind or calm them down in their difficult period in life. It has also the function as the transition before entering the hospice.

Figure 7.3.2: The path through the horse farm and trees from Klostervej before reaching the entrance

7.3.2 Entrance

"Now he is at the entrance. It is right next to the parking. The building modestly strands alone in nature. It doesn't look very impressive but easy to navigate as there is only one door. Philip did not think much. He walks towards the door..."

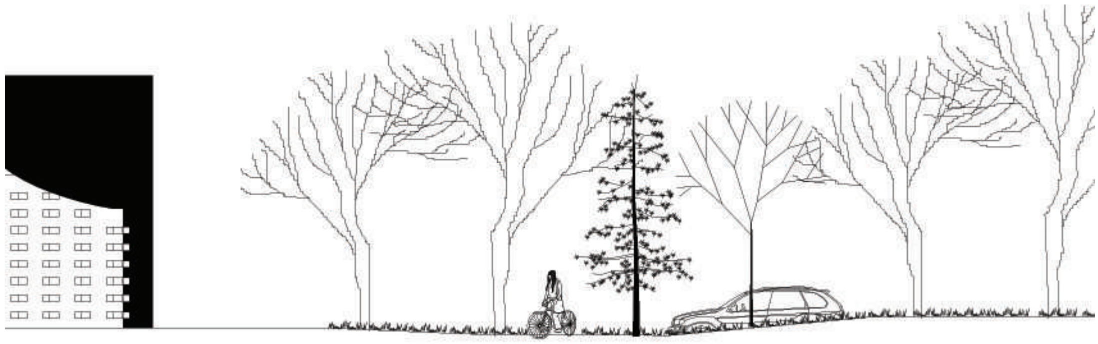

Figure 7.3.3: Terrain condition at the entrance, scale 1-200

The terrain at the entrain is quite flat to make it friendly for people with wheelchair. A long connected concrete wall is added on the right side of the entrance to hide the "world" inside, not exposed to outside.

The look of the building at the entrance is intentionally designed to be modest and simple. The first reason is to mark the entrance doors visible, easily to navigate for the users, especially for vulnerable people who are the patients and relatives. The other reason is to increase the contrast between the indoor and the outdoor space.

Figure 7.3.4: The visualisation of the entrance in the morning

7.3.3 Waiting area

"Philip steps into the building, now he is standing at the waiting area. The sunlight is shining through the glass door of the entrance. The atmosphere is so warm and the whole space is so beautiful that it surprises him. People are chatting while waiting for their turn, some young children are running between the children room and the garden. Now he looks to the right and see a pathway leading to outdoor. He has heard about this "mindful pathway" that his dad has named it and talked about it before. On the left hand is the view straight to the water. Philip feels quite relaxed in this moment. He decides to walk to the cafeteria behind the waiting area to get a cup of coffee before seeing his father."

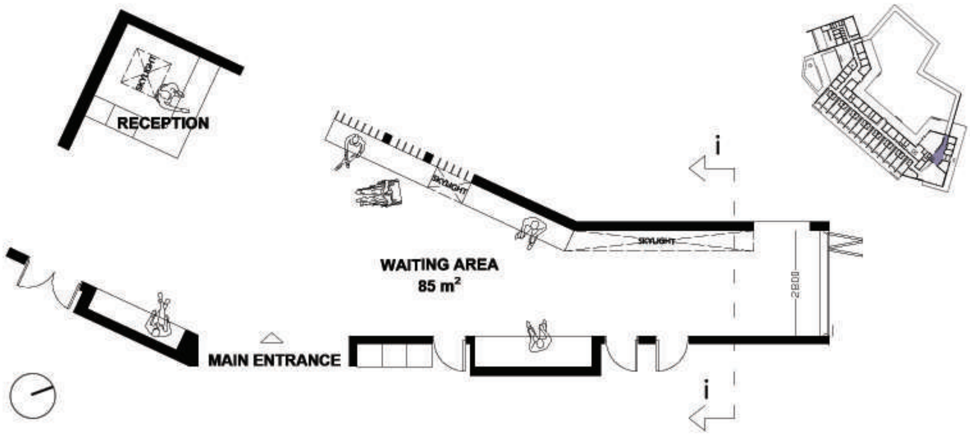

Figure 7.3.5: Waiting area, scale 1-200

Figure 7.3.6: The visualisation of the waiting area when entering the building

Figure 7.3.7: View to the water outside when standing at the waiting area

The waiting area is placed in the center of the common area. From this space, the users has the views throughout to other spaces such as cafeteria, multi-purpose room and towards the mindful pathway leading to outside space. The waiting space and cafeteria are divided by the wooden strips and a concrete wall. In this way, the two spaces become both connected but still giving the private feeling for people sitting in each space.

Figure 7.3.8 explains the connections between the functions: cafeteria, waiting area, and the children room. These three spaces are placed next to each other to provide the practical needs of the users. The children can be difficult to keep being patient for a long time and they need space to be active while their parents are waiting for their turn. The children room is also right next to the outdoor space where they can run back and forth between the garden and the indoor space.

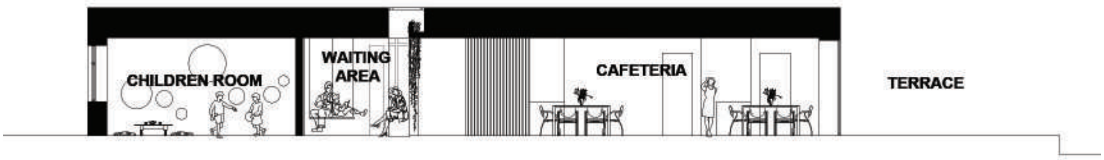

Figure 7.3.8: Section i-i, scale 1-200

Figure 7.3.9 shows the daylight condition of the waiting area at 8 a.m in the summer. The space receives both view and daylight from the connected spaces while also being provided with daylight from the skylights. The distribution of daylight from different type of windows provide differences in brightness and the contrast of the shadow gives the space a nice atmosphere.

The combination between the materials: concrete and wood together with other natural elements: daylight, vegetation, small white stone are mixed to create the calm feeling.

Figure 7.3.9: The daylight condition in lux of the waiting area at 8 a.m in the morning

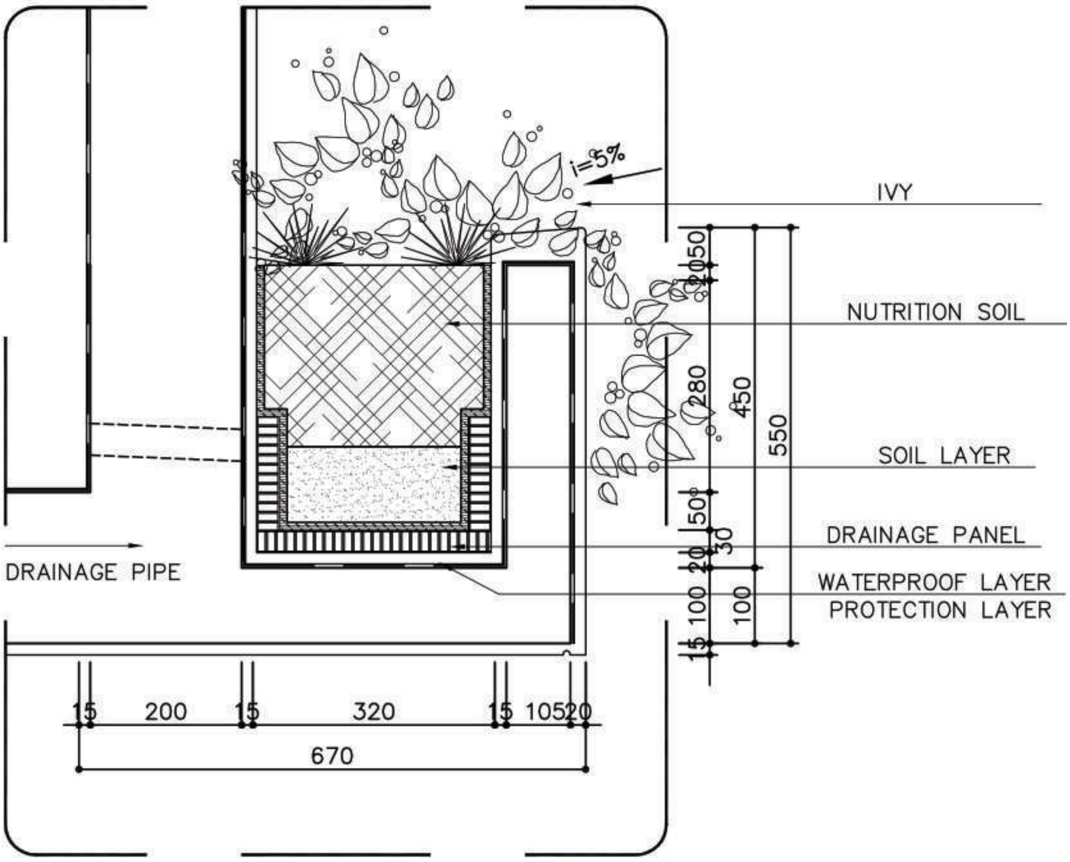

Figure 7.3.10: Detail of ivy plant box, scale 1-10

7.3.4 Patients rooms

"Meanwhile, Philip's father - Peter has just woken up. He sits quietly on his bed and looks out to the lake through the window. Since he and the family received the news about his health condition, it has been tough. Peter has a happy family and he has nothing to regret in his life. But the idea of leaving this world is still somehow difficult. This place is the transition for him between life and death."

Figure 7.3.11: Peter in his room in the early morning

Daylight condition

The patients rooms have the best view which is towards Rye Mølle lake for the reason of patients' well-being. With the orientation of south-west, the room will benefit from receiving a lot of the sunlight during the day. In the afternoon, the patient rooms receive the most sunlight to compare with the whole day. See figure 7.3.19 for the visulaisation of the room in the afternoon.

The goal is that the daylight condition should reach at least 3% of average of daylight factor because of its significant impact on patients' well-being. Therefore, a very big glass window is implemented both for the light condition and also for a good view to nature. The room becomes well-lit and reaches the average daylight factor of 5% measured from the window to a half of the room (see figure A.1.3 in appendix A). The figure 7.3.12 shows in details how the daylight is distributed along the depth of the room. To check the average daylight factor of the room refer to the section A.1 in appendix A.

To prevent overheating problem, an overhang of 2.4 meter depth is added above the glass window shown in the figure 7.3.13. It shades the inside space from the direct summer sun rays but allows the winter sun rays to enter and heat up the room. This way the room is lit up with the diffuse light.

The heavyweight construction creates the ability to soak up excess heat on warm days and help the room to stay cooler during summer. This daily cycle of absorbing and releasing heat continues on a year-round basis and contribute to reduce the energy needed to keep buildings warm during the heating seasons thanks to the high thermal mass.

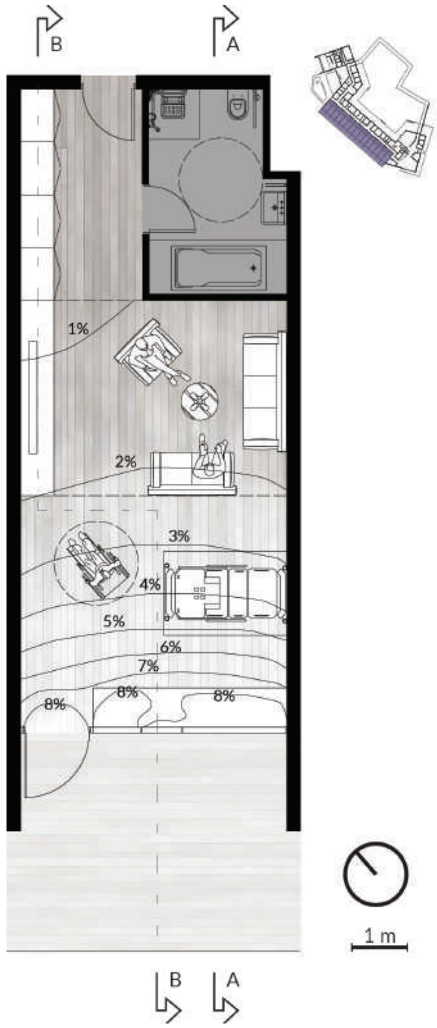

Figure 7.3.12: Daylight factor distribution in patient rooms, scale 1-135

Section A.2.3 explains the calculation for the average temperature in the hottest month - July.

The diffuse light comes from the skylight together with the convex ceiling to create a calming atmosphere for the patient room. See figure 7.3.14.

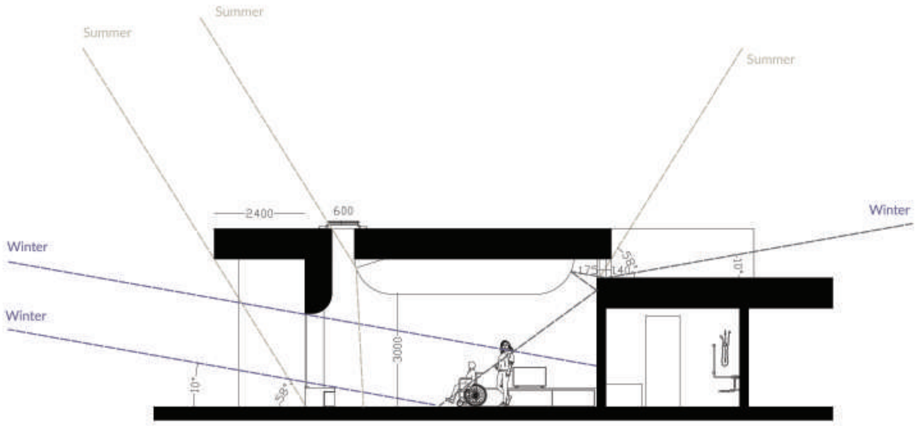

Figure 7.3.13: Section A-A: Summer and winter sun rays, scale 1-200

Natural ventilation

Hybrid ventilation which combines both natural ventilation and mechanical ventilation is designed to achieve thermal comfort.

Figure 7.3.14: The diffuse light comes from the skylight and the convex ceiling create a calming atmosphere for the patient room

In patient rooms, natural ventilation is driven by wind-pressure through the window on the south-western façade and by thermal buoyancy where warm air is exhausted from the two higher windows on the north-eastern walls, shown in the figure 7.3.15. In winter when the windows are shut most of the time, mechanical ventilation is activated to supply fresh air and extract the used air to ensure a good indoor air quality. The section A.2.3 of appendix A is the calculation of the necessary air change per hour and how the openings' dimension are calculated.

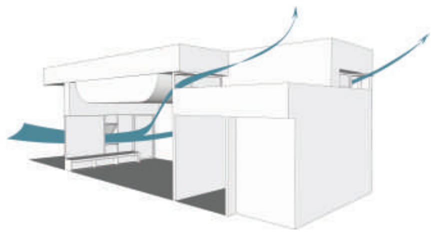

Figure 7.3.15: the path of the air flow in patient room

Figure 7.3.18 explains the cold air coming from outside, entering the room and then be being heated up before leaving.

The result of temperature from BSim shown in figure 7.3.16 in the patient rooms ranges from 22 °C to 25 °C, matched with the expectation and the calculation from 24 hour average sheet. Details of the calculation and the BSim result, check A.2.3 in appendix A.

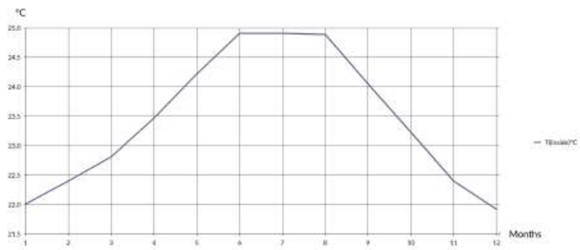

Figure 7.3.16: BSim, temperature in the patient room

The ideal temperature for patient from references is at 24 °C. In fact, people have different preferences regarding to comfortable temperature. It can be also be adjusted with the heating system and mechanical ventilation.

Overheating problem however should be controlled to be at 20°C < t_{op} < 24°C for general condition and at 23°C < t_{op} < 26°C in the summer regarding to DS 474. Thanks to the big overhang above the big glass window, the low people and equipment load, the indoor temperature is maximum at 25 °C, shown both in BSim result and in the calculation in the appendix.

The CO_2 levels in the same time are not challenging in the rooms because of the low person load, shown in figure 7.3.17.

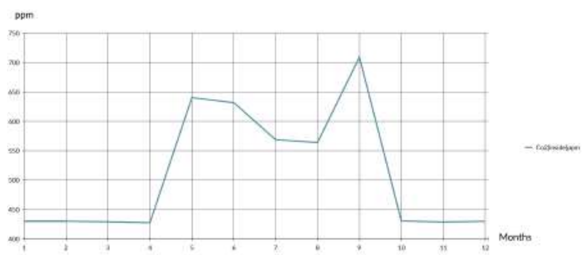

Figure 7.3.17: BSim, CO_2 level in the patient rooms

Mechanical ventilation runs from October to April. From May to September, the room is ventilated with natural ventilation. In September the CO_2 level increases because the cold seasons start around there.

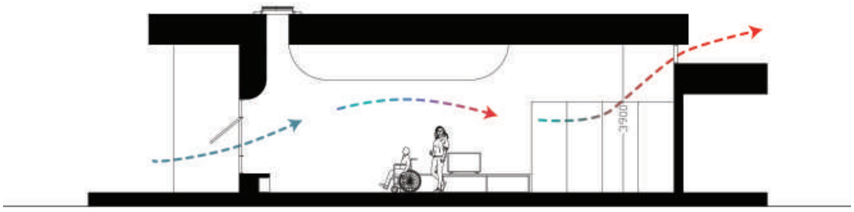

Figure 7.3.18: Section B-B: Natural ventilation, scale 1 - 200

From May to September when natural ventilation is applied, the window is opened and the the CO_2 level in the room is affected by the amount of the outdoor the CO_2. In the summer months, the CO_2 typically decreases because photosynthesis removes CO_2 from the air. In the winter months, the CO_2 levels increase as the plants lose the leaves and become less active with the cycle of absorbing and releasing CO_2. The other reason to explain for the rise in the CO_2 levels in winter is because of cars and home heating. To see more in details, see appendix A.2.3.

Figure 7.3.19: The visualisation of patient room in the afternoon

7.3.5 Garden

"A day of Peter sometimes starts with watching sunrise together with his son over the horse farm whenever he feels well. When he was young, his family had a farm in a small village and he has always been grateful to grow up with nature and the animals. He enjoyed the nostalgia brought from this site so much."

Figure 7.3.20: Peter starts his day with watching sunrise over the horse farm with his son

The garden is a mix of different elements inspired from the Japanese garden including: white stone garden, rocks, koi fish pond and variety of different type of vegetation. The aim of the garden is creating retreat quality for the users with mindful quality. See figure 7.3.21.

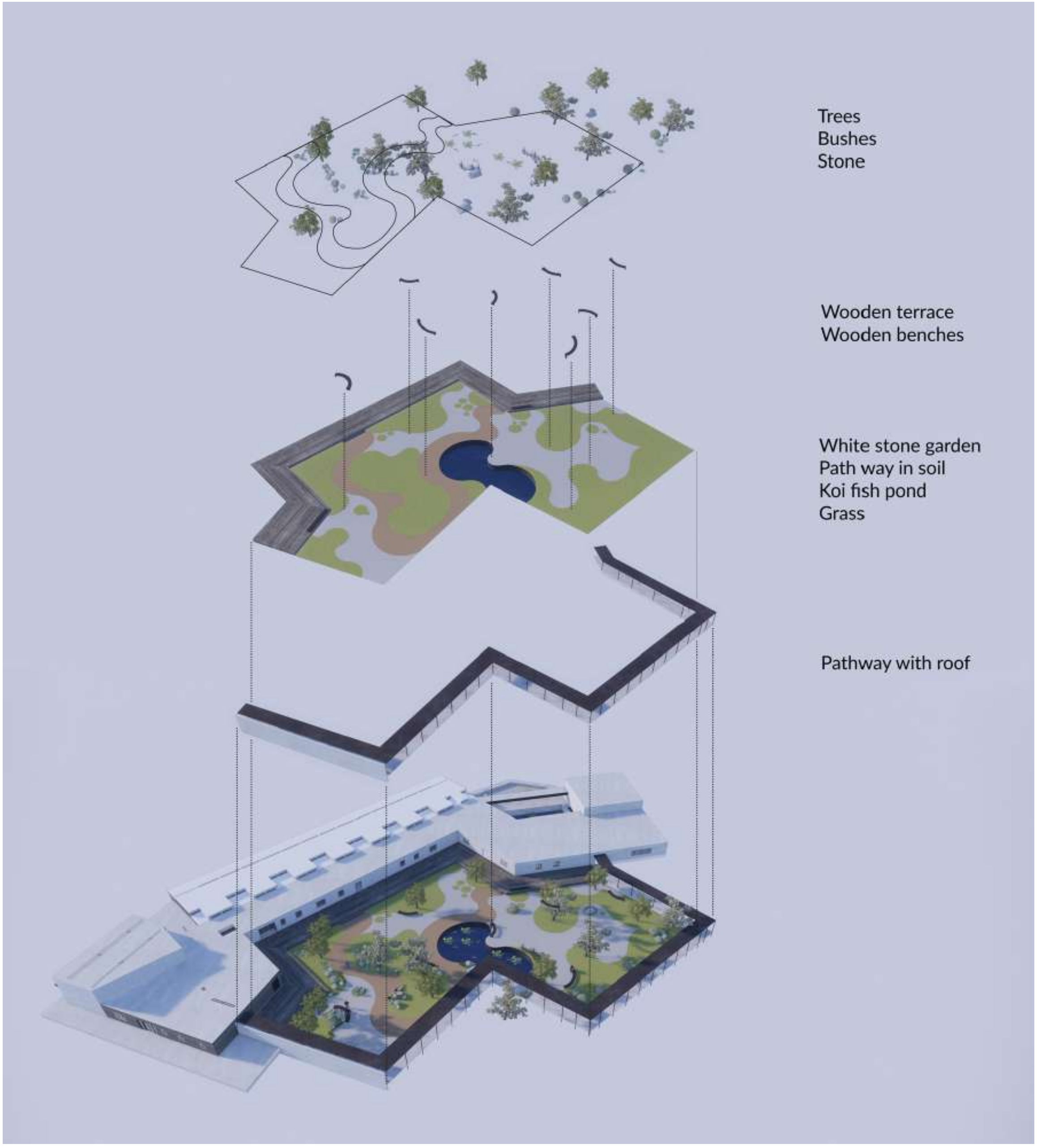

Figure 7.3.21: Different layers in the garden

The water, rock and vegetation in Asian culture are the symbol of natural element respectively ocean, mountain and forest. The sun, the water and the air are viewed as moving material that keep moving around the building and people. With the shape of the building, it is intended to embrace the garden, shield it from unpleasant strong wind from the west. The garden receives most sun light in the morning with the soft intensity from the rays.

The transition between the building and the "outside world" gradually changes from the building to the garden then the horse farm and finally to the road - Klostervej. It can be seen in figure 7.2.5.

"When Katrine has woken up, Peter will have breakfast with her. They are like many other Danish that love to eat in the garden and enjoin the sun. In the morning, they often spend time in the garden and when the sun moves to the west in the afternoon, they prefer to eat lunch on their private terrace of Peter's room. Sometimes, they have meals inside at the cafeteria. "

Katrine always talks much, but she is a great company for Peter's life. He is happy that the hospice offers the opportunity for his wife to stay over during his stay. Sometimes she sleeps in the sofa that can be transformed into a bed in Peter's room. Sometimes she prefers to sleep in the family room in tough days.

People are here and there in the garden. The laughter and low voice spreading through the garden together with the kind of silent sound of the trees. Peter can feel the fresh air and the pleasant smells from the grass and flowers."

Figure 7.3.22: The atmosphere in the garden in the morning

Figure 7.3.23: The garden is a mix of different natural elements creating the relaxing atmosphere

Figure 7.3.24: The garden is a mix of different natural elements creating the relaxing atmosphere

"A pathway with roof connecting the beginning and the end part of the building is Peter's favourite trip. During the day when he has to move between the two places, the nurse, and also himself, like to take this trip instead of the hallway inside the building. They enjoy looking at the surrounding view and chat together."

The pathway in the garden is named as "the mindful pathway" because it is designed to encourage people to walk and explore. Many turns happen on this path to force people to look in several directions and recognize the beauty of the surrounding views. The roof has the function to protect people from the weather condition and in the same time it creates a boundary for the garden as well as the whole space of the hospice. While standing at the terrace looking to the east, the roof and columns of the pathway become the frame for the "photo" of the outside world, shown in figure 7.3.23 and 7.3.24.

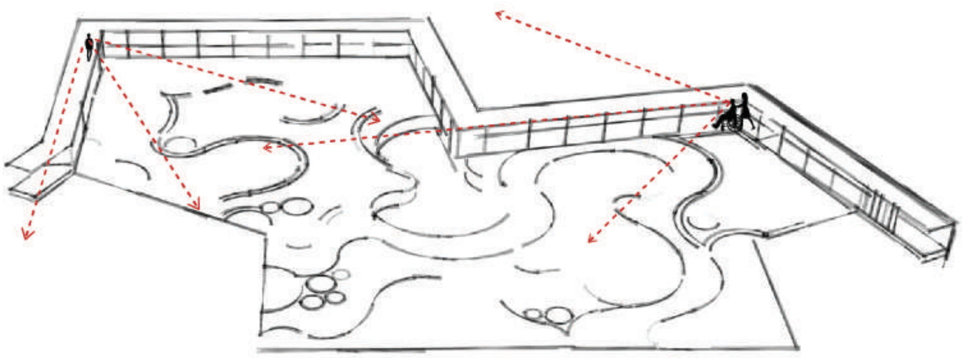

Figure 7.3.25: The mindful pathway encourages people to walk more and explore more

Figure 7.3.26: Peter is moving on his favourite path - the mindful pathway with a nurse

7.3.6 Multi-purpose room

"Everyday is a new day, Peter knows that and he tries to enjoy every last days of his life with a positive mindset. The whole hospice also has this spirit. The lovable musical therapist - Asger likes to hold some small concert sometimes. He is everyone's favourite person and also the one to lighten up people's mood with his beautiful melody.

When the sun shines into the interior, the mood of the room suddenly becomes so deep. The diffuse light comes from the skylight through the convex wooden roof makes the whole space even more special. In an instant, Peter can read his mind and feeling. He feel the existence of his body, the space, and the air. Over there at the corner, he sees a young man silently standing alone looking out to the water. They both must have the same thought about life right now."

Daylight condition and natural ventilation

The multi-purpose room functions as a small concert room or cultural facility. Music concerts and art galleries will occur in this center space of the building sometimes. So light and acoustic are considered and is taken well care of in the design of the room.

As the main material of the building is concrete. The goal is controlling the 3 factors: indoor climate, daylight condition and acoustic environment. To keep the interior from overheating in summer, overhang is added over the large window. By this way, the direct summer sun ray at the angle of 58 degree is stopped before reaching the interior while the low angle winter sun ray at 10 degree still can get in deeply into the space.

Figure 7.3.27: The design of convex roof has the purpose to diffuse the sound of music to the audience

Figure 7.3.28: The atmosphere in the multi-purpose room around noon

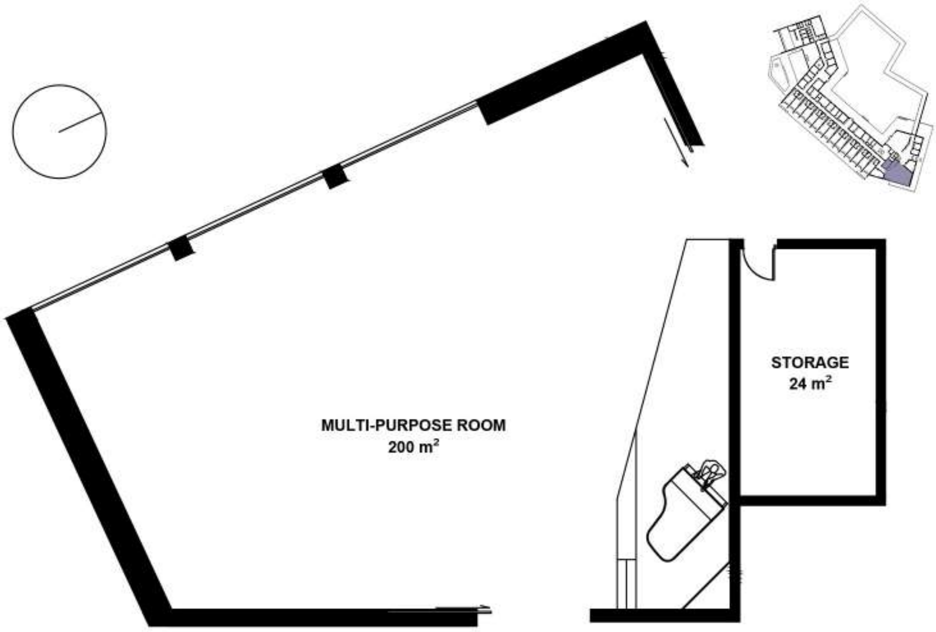

Figure 7.3.29: Multi-purpose room, scale 1-200

Diffuse light comes from the skylight and brings a special atmosphere to the room and pathways are created for heat to escape, see figure 7.3.30 and 7.3.31. Low-emissivity glass is used in the skylights.

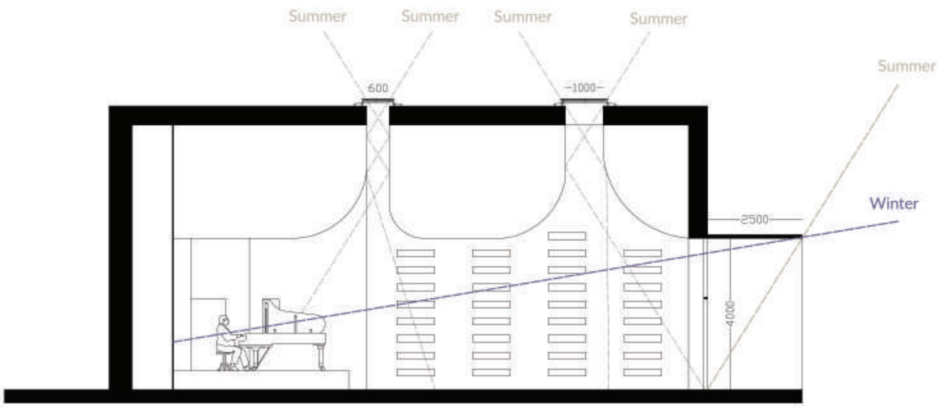

Figure 7.3.30: Overhang is added above the big glass windows to stop the direct summer ray while enable the winter ray to shine into the interior, 1-200

Thanks to the big glass windows and the skylights, the average daylight factor of the space results at 5% measured from the window to a half of the room (see figure A.1.1 in appendix A).

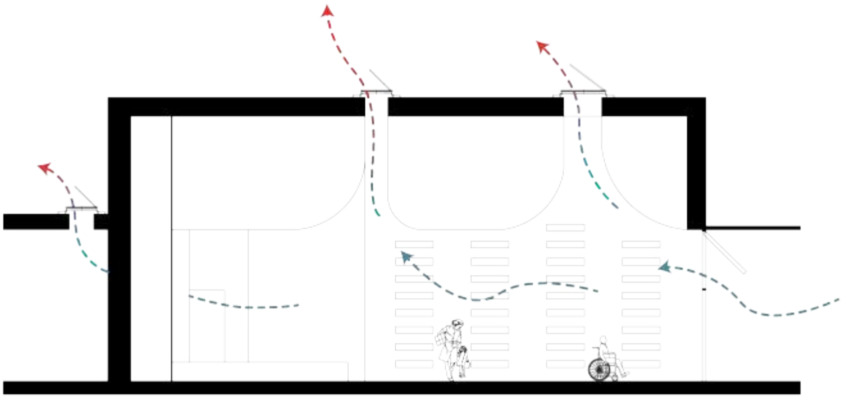

Figure 7.3.31: Natural ventilation in the common room is the combination of the wind and thermal buoyancy, scale 1-200

Acoustic environment

In order to ensure acoustic performance which is primarily for classical music, the objects of the acoustical design for the room are: sound absorbent, sound insulation, sound diffusion and reverberation time.

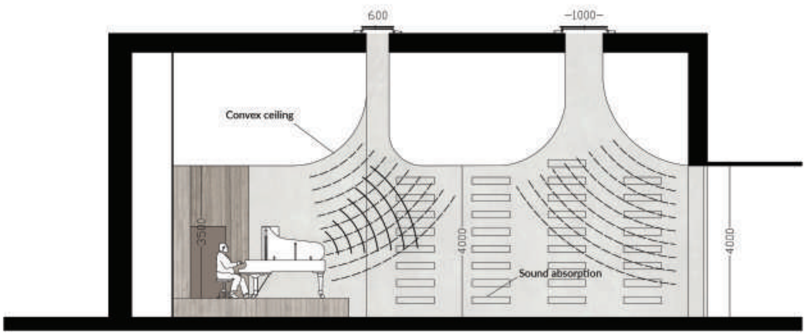

Figure 7.3.32: Convex roof diffuse the the sound to the audience, scale 1-200

The stage is place on the opposite side of the big glass so that the sound energy will not be transmitted. The convex ceiling is designed to diffuse the sound properly. To control reverberation time, numerous holes are opened in the surface of the concrete walls with acoustic absorbent material inserted when needed. The wooden stage floor is raised above the concrete floor, on top of the insulation layer and leave an empty space between the insulation layer and the concrete floor to reduce the sound reflection.

When the concert is going on, the two doors towards the waiting area and the patient rooms area are closed to keep other space not being influenced too much. In general, these two doors are hidden in the walls and only be used in some certain occasions. Depends on the type of instruments and the size of audience, the acoustic environment can be adjusted to a certain degree by using the rolling curtains hidden inside the convex ceiling above the windows or inserting acoustic material into the holes on the concrete walls. A big storage is placed next to the common space for chairs, acoustics equipment, instruments and other purposes.

Figure 7.3.33: The multi-purpose room in a wider angle perspective

7.3.7 Hallway

"Sometimes during the day the pain occurs. It comes suddenly any time without any forewarning. Peter is on the way back to his room. He stops in silence and looks straight to the outside. There, a tree has always stood in the end of the hallway. He suffers from the pain. But in his mind, there is always hope."

Figure 7.3.34: That tree in the end of the hallway is the symbol of the hope

The hallway is designed in the thought of supporting disabled people. The width of the hallway is 2.5 meters wide in total but only 2.3 meters are counted because there are long rectangle holes on the floor along the wall - 0.4 meter wide.

The hallway is wide enough for people with wheelchair, people with walking sticks and people with the walking supporter to get through, shown in figure 7.3.35.

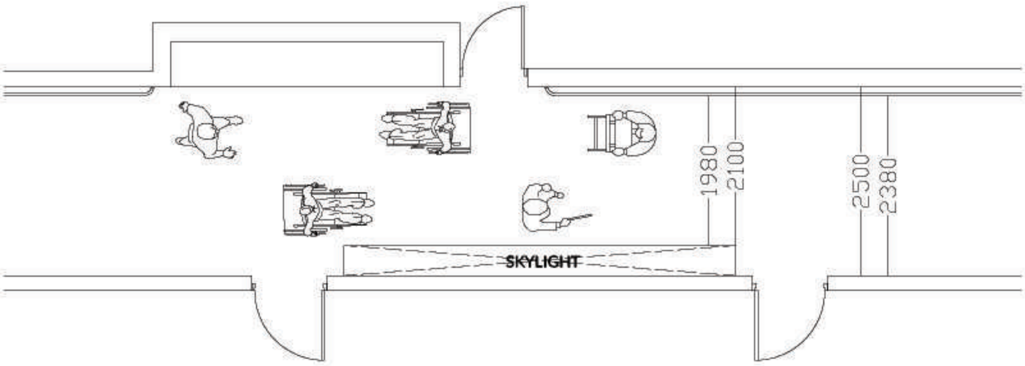

Figure 7.3.35: The hallway is wide enough for supporting people with wheelchair, people with walking sticks and people with the walking supporter to get through

On the west side, several long skylights are added along the hallway to enable the sunlight to lighten up the space. Parallel with the skylight vertically are rectangle holes filled with white stones to help diffuse the light and also to help blind people to navigate their movement.

There are seats along the hallway for people with walking difficulty to take a break and to allow people to sit down for small conversation though out the building. Handles are available on the eastern walls for handicapped people to lean on while walking. See figure 7.3.36.

The surface is in concrete material, smooth, non-slippery, easy to move with wheelchair.

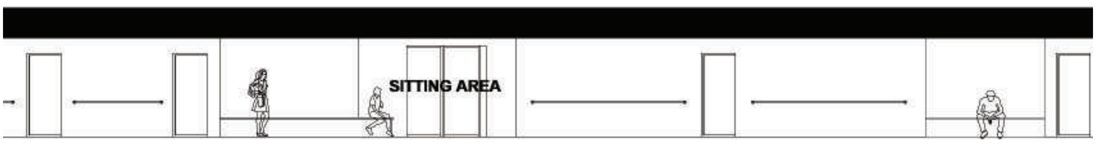

Figure 7.3.36: Hallway section, scale 1-200

7.3.8 Meditation room

"Later in the afternoon, Peter's best friend - Jepper comes to visit him. Jeppe lately has had problem with walking, he is getting old but still managing to visit his friend quite often. They are sitting in the mediation room. The sun at 2 p.m shines into the space through the wooden strips. The two men are having a conversation about life. Jeppe tries to make it easy for his friend to accept the coming death and feel peace in his mind. "What a beautiful place!" - Jeppe thinks in his head. The tree standing out there looks like a symbol of life and hope. They can hear the relaxing sound of the fishes in the pond moving. Or is that the sound of time passing?"

The meditation room is situated in the end part of the building on the west side. It consists of the mediation room connected with the spiritual room and its own garden right outside. This space is pushed deeper towards the east to provide a private feeling.

The daylight distribution in the mediation was designed to create different amount of day light and the level of the contrast of shadow by implement different size of the glass areas that allow afternoon direct sunlight to get in. It aims to provide different level of the brightness, changing gradually along the glass area. The idea is based on human's insecurity, for example vulnerable people prefer to stay in or near darkness while healthy and secured people like to be exposed to the light. In this way, the room provide different "room" for people with different mental state.

Figure 7.3.39 shows more more in detail the contrast of light and shadow, also the different amount of light along the glass area.

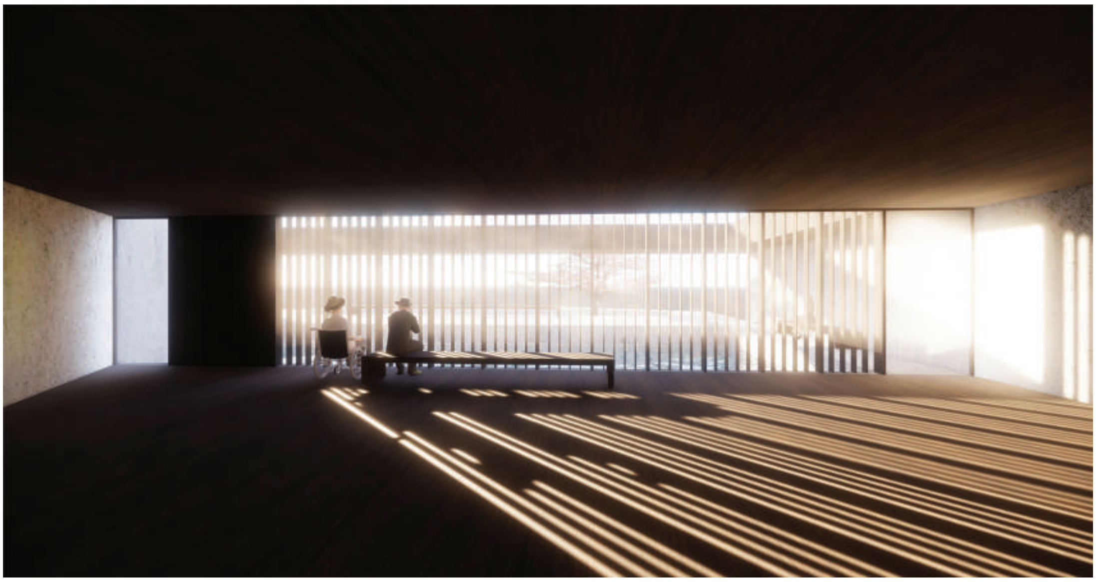

Figure 7.3.37: The conversation about life between Peter and his best friend - Jeppe in the meditation room

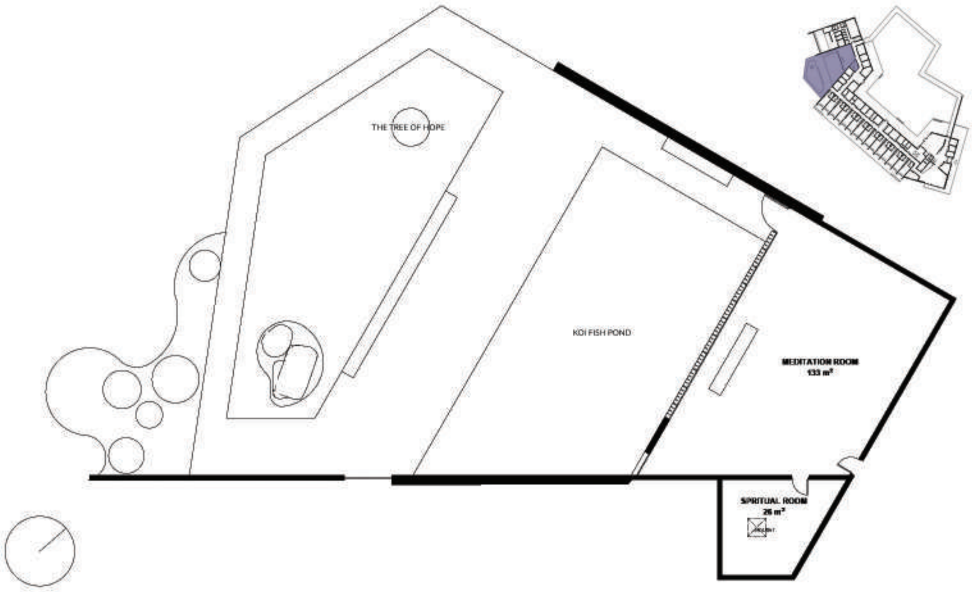

Figure 7.3.38: Meditation room, scale 1-400

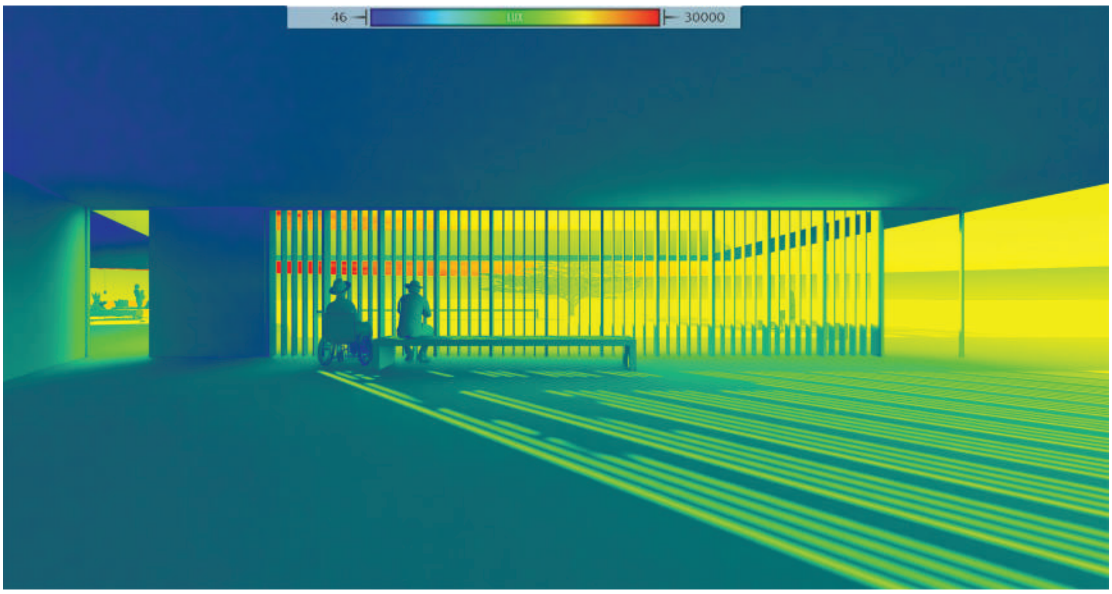

Figure 7.3.39: Day light distribution illustrated in lux

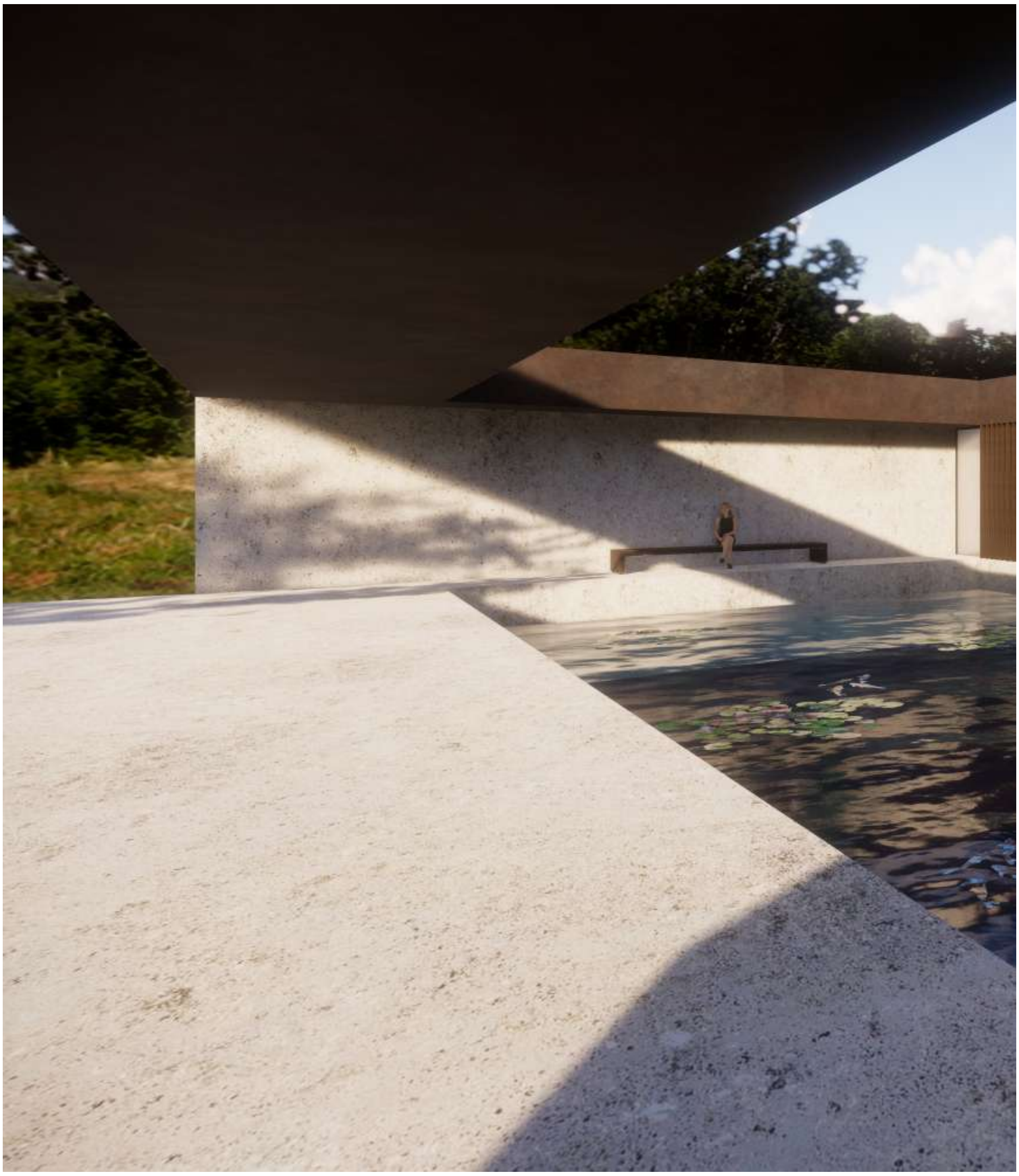

Figure 7.3.40: The outdoor space outside the meditation room

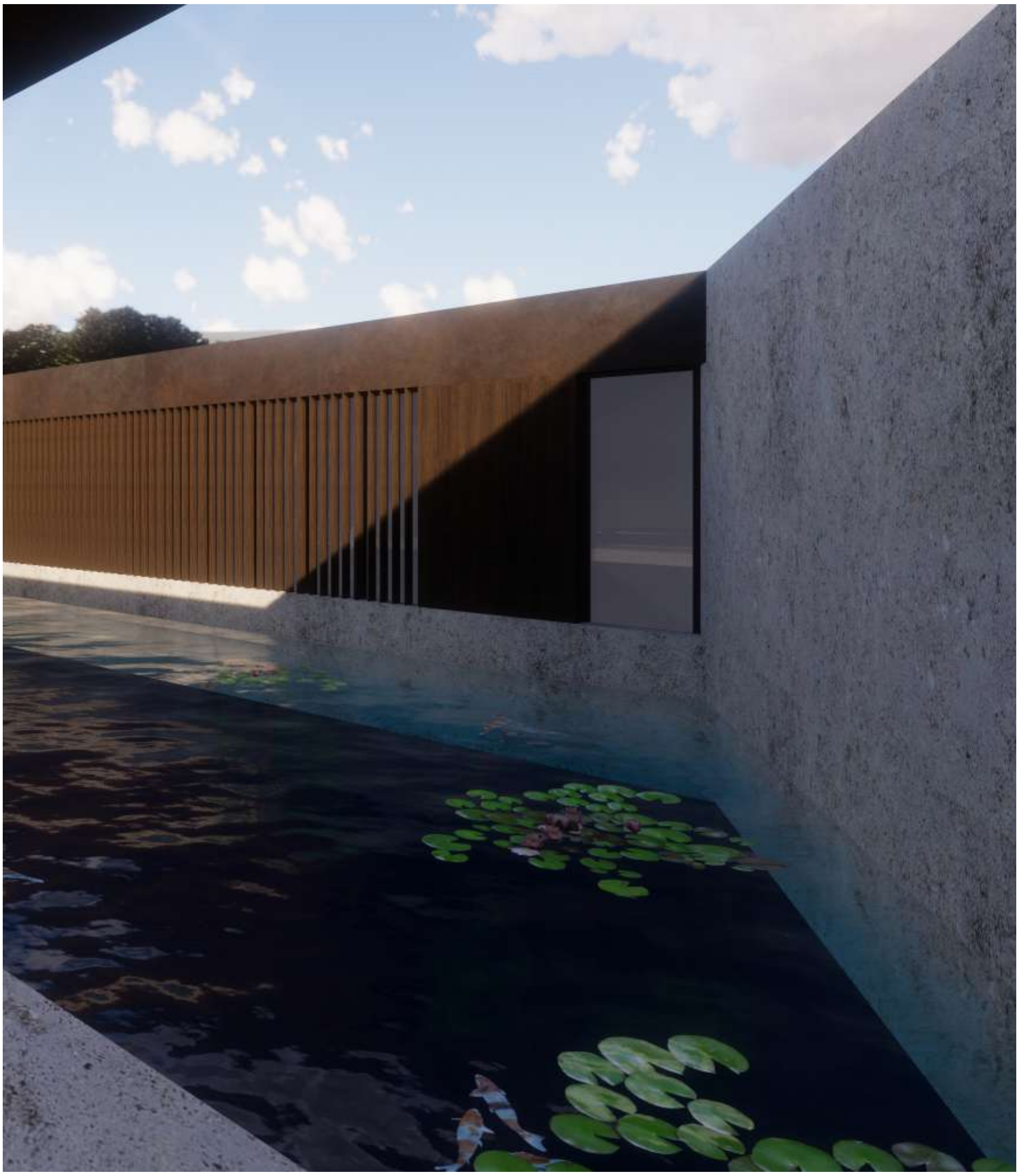

Figure 7.3.41: The outdoor space outside the meditation room

7.3.9 Connection with nature

"When Jeppe is left, Peter has so much thought in his head and Philip can feels it. He asks his father for a trip to the lake to get some fresh air. The sun is going down soon, the ends their walking trip on the wooden bridge. From here, they can see the building standing behind the trees. The ducks swim around the lake and make a lot of noise. It is so good that they have the opportunity to enjoy the nature within walking distance"

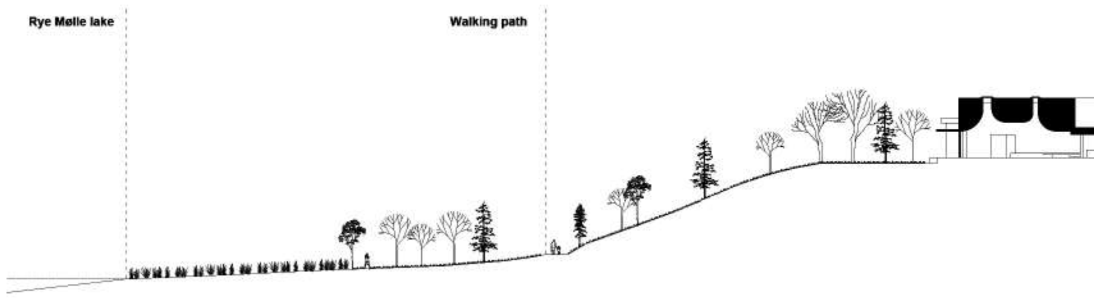

Figure 7.3.42: Terrain condition between the hospice and Rye Mølle lake, scale 1-850

The nature at the site benefits the building and the users with beautiful views and a nice atmosphere. The hospice is located on the top of the hill and in between the forest. See figure 7.3.42.

Figure 7.3.43: View to the hospice building from the wooden bridge

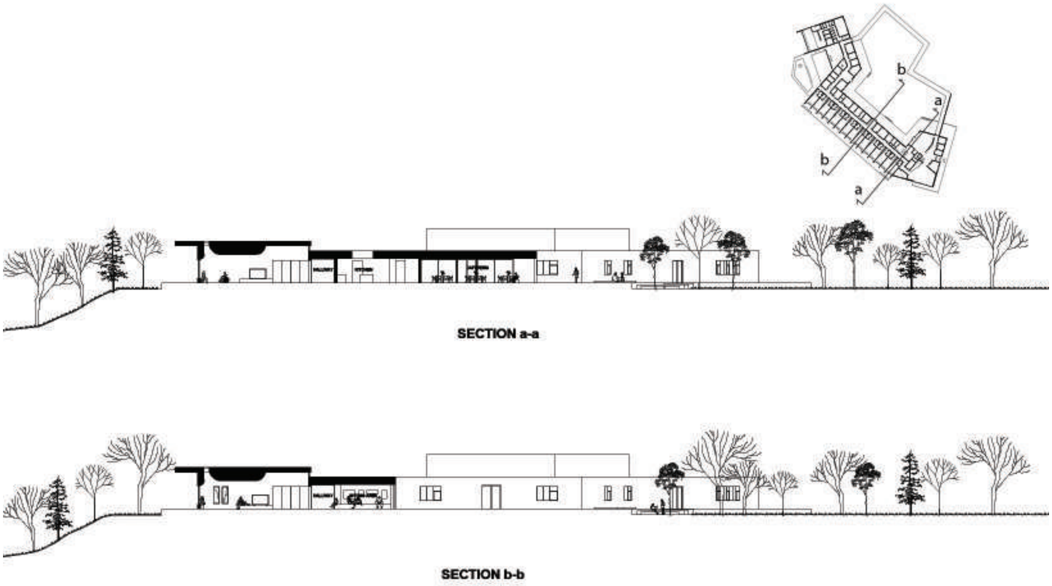

Figure 7.3.44: The connection of the building and the green, scale 1-800

With the existing nature at the site area and the designed garden, the users have the access to green on the both sides of the building as shown in figure 7.3.44

Figure 7.3.45: View to the hospice building from water

7.3.10 Water therapy

"End of the day, Philip and his sister - Karen help his father to enjoy the hot water in the water therapy room. The heat from the water helps to ease the pains. The sun is going down and the whole space blends into the beautiful red color of sunset. The children feel grateful that his father has this special place to spend his last days. He seems more relaxed since he moved into this hospice. They do not know if there is hope for their father. But they believe the path to the other side of life is now much easier for him."

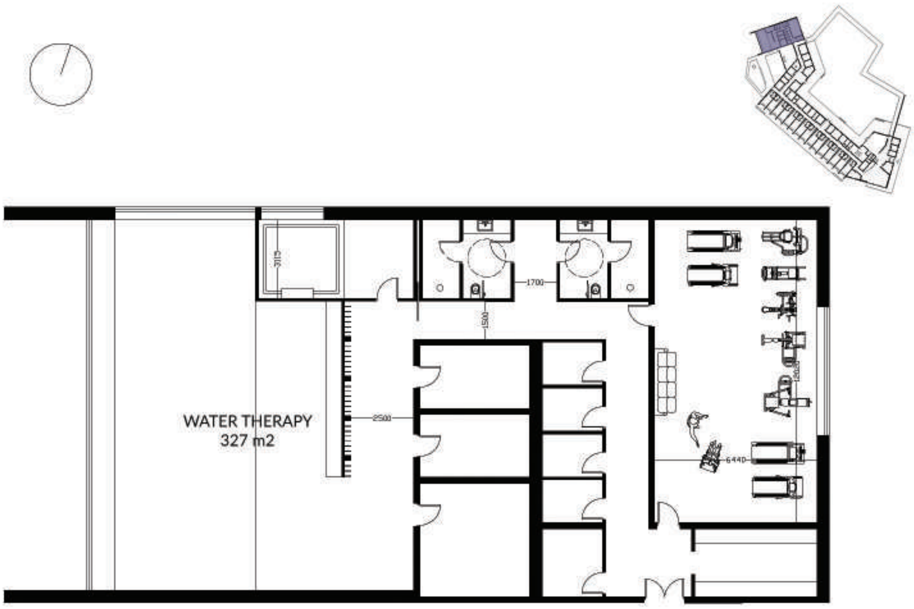

Figure 7.3.46: Water therapy and rehabilitation area, scale 1-300

Figure 7.3.47: The sun is going down and the whole space blends into the beautiful red color of sunset

The water therapy and rehabilitation room are placed in the end of the building. The two room share the same common function such as shower rooms, toilets, lockers and changing room.

In the water therapy treatment space, the patient has the choice to either use the common indoor pool with the view to forest and water or they can book to use the private bath. Other water therapy services are also available in this area.

This area is designed to level up the facility convenience and the high quality life or well-being for the patients. Because the argument is, hospice should be a great place for people in the transition between death and life. they should be offered both medical treatment and the best experience in the last days of their life.

7.4 Materiality

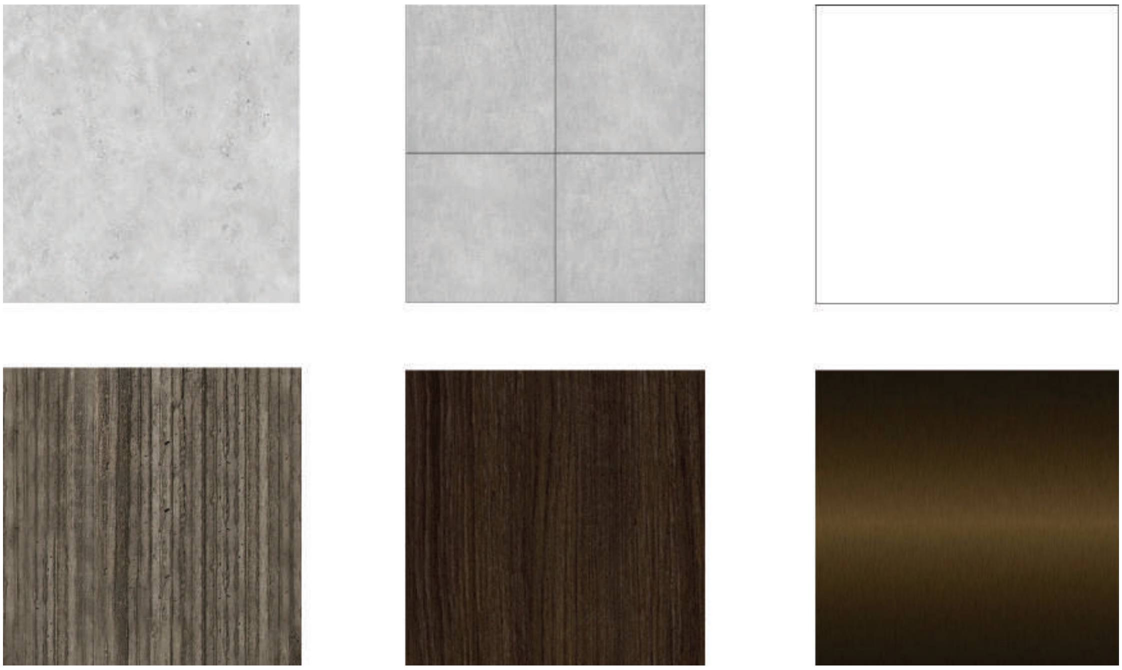

Figure 7.4.1: Materials used in the designed building

The overall materiality used in the building focuses on the aim to create a calming atmosphere, reflecting the relationship with nature and the patina look over time.

To obtain good daylight, spaces with normal ceiling height at 2.6 meters need good daylight condition and are painted in white. The other high ceiling rooms like the multi-purpose room, patient rooms and water therapy have wooden ceiling instead. The rest of the building use raw material without being painted to avoid the unhealthy emission for the users and reduce the cost as well as labouring of maintenance.

Concrete is the main material for construction including walls, floor, roof in this design. This type of material has the best heat store capacity to apply into the passive solar heat strategy. It is also a good choice to create the calming feeling. Throughout the building, the walls are in concrete material and have the pure look and texture of concrete. Beside that, pine strips of 3 centimetres width cover on top of concrete surface some of area to create a soft and warm feeling and tone down the cold feeling of concrete materials. This wooden material is also used for built-in seats along the hallway and waiting area.

Smooth tiles with the similar color with concrete is used for interior floor to avoid the glossy look of concrete while still can keep the atmosphere of meditation quality.

In the theme of dark colour, mainly with grey-brown colour, darker wood and deep bronze aluminium join the mix. Wooden strips in spaces like waiting area, meditation and water therapy use the darker color wood. The frame of door and window is wood but covered in the deep bronze aluminium material.

By using above mentioned materials, shown in figure 7.4.1, the building thus can reach the goal of using the space, structure and material to stimulate human perception, connect human and building in the charm of nature.

7.5 Zero energy

The design of hospice in Ry has fulfilled the energy requirement frame BR2020, which is described in details in appendix A.4.4. This has made it easier to reach the goal of zero energy building by adding PV panels on the roof with 0 degree horizontally. The calculation is shown in appendix A.5.

Figure 7.5.1: Illustration of PV integrated with the building roof

Conclusion

This master thesis presents an architectural solution for a sustainable hospice building in Ry. The two main elements of sustainability in the project is social sustainability and environmental sustainability.

The hospice in Ry is situated in a beautiful location with the view to Rye Mølle lake. The atmosphere at the site is very relaxing where during the day the sound of bird singing is dominant over the low traffic noise. From the building it is easy to get access to the lake walking path which can be seen in figure 7.2.5 in the chapter presentation.

Using the architecture of mindfulness together with my real experience as a patient's family member, I step into the user's feelings to design for their well-being. With a famous quote from Aalvar Aalto I have mentioned in the motivation that says:

> "Architecture should defend man at his weakest".

I have tried to create a space for terminally ill people to feel safe, home and calm in their days at the hospice.

The hospice should reflect human existence and provide a smooth transition between life and death for the patients. I have put more thought into it, where I give a subtle hope for those vulnerable people to see the beauty of life and to fight for it. The architecture also encourages the patients as well as other types of user to walk more, explore more, and connect the nature more - by taking advantage of the beautiful location, designing a sensory garden, expanding the travel distance between care unit facilities. While also supporting disabled people to walk by applying handles along the hallway, using smooth, non-slip floor material to ease the movement of wheelchair and adding seats randomly in the radius within 5 - 15 meters for breaks both in interior and exterior space.

On the contrary the staffs unit is placed in the center of the building to shorten their travel distance and reduce stress.

Privacy and social interaction happen in the same time in this hospice. Common space such as cafeteria, multi-purpose room and the garden provide the chance for people to connect with each other. On the other hand, privacy is also given to the users in small details, for example the built-in seats have two side-walls to give embracing feeling, wooden strips in waiting area, meditation and water therapy help to make the space seems like the entire area belong to one big space but also divide them into different areas.

Concrete and wood are in favour used mainly in this project because of their characteristic warm and calming feeling. The materials reflect the connection between human and nature: concrete has its pure look and wood as an organic material provide the natural feeling in the contact with human senses.

In the theme of healing architecture, daylight is taken care of in every space even where good daylight is not required like the hallway. Moreover, daylight is also used in a special way to support the user's feeling in the meditation room. More details is expressed in the subsection 7.3.8.

In the term of environmental sustainability, several strategies are applied to reduce the energy used such as passive solar, overhang to prevent overheating, natural ventilation and good daylight condition.

Natural ventilation is used in the summer while in the winter, mechanical ventilation helps to maintain the good indoor comfort. Both cross ventilation and one-side ventilation are considered. Patient rooms and the multi-purpose room use the combination of natural ventilation and thermal buoyancy. The other rooms are considered as living space have one-sided ventilation.

To reach zero energy, the building first manages to fulfil the building requirement of low energy consumption BR2020 and then using solar cell to cover the total energy consumption. Details are shown in appendix **??**

In the multi-purpose room acoustic is calculated carefully to ensure proper resonance, shown in appendix A.3

The design of hospice in Ry is a result of an integrated design where both the technical aspect and the architecture aspect support and synergize each other. More than that, this project has pushed the value of the architecture to another level where the architecture becomes a big part in supporting the human mental condition for its users.

Reflection

A building in my opinion will not complete the goal of being sustainable if it is not favoured by its users and do not fit in the context. Therefore, during the design process, my main focus is the user's well-being. My dream is that the architecture of the hospice will support patients both physically and emotionally. Because of that I have my own direction of choosing materials from beginning, which is concrete and wood. Concrete is an inorganic material and difficult to re-use in future if the building is demolished.

While designing a healing architecture project, architects are encouraged to use their knowledge and search from different sources of references to create persona profiles to have a better understanding. I personally have used my experience of a terminally ill patient's daughter which can be considered as a qualitative knowledge. However, my experience can not reflect all cases and what I think is necessary for the patients is not necessary true for everyone.

To finish this project I have read several references and looked into several projects. I did not have the chance to show all of them in the case studies section due to the limitation of the thesis length. And I did not have the chance to visit any hospice in reality.

Furthermore, I have my own expectations of how a good hospice is. Therefore the technical parts were chosen to support my idea. Those were done well and in details. It also means that all the knowledge of the technical aspect belonging to sustainable architecture I have learned from Aalborg university are not all mentioned or used in this thesis.

While designing the layout and calculating the daylight factor in each room, I managed to put the rooms and windows in similar measurements to reduce the cost, time, labour, and energy of producing the construction elements.

Finally, big glass windows are applied on the south-western side to maximize the view to nature for visual comfort reason. It benefits the passive solar strategy in the same time. Overhangs over big glass windows are added to help preventing overheating problem. Energy efficient windows are used to reduce the energy consumption. But a big amount of heat loss still happen during winter and this require a lot of energy to heat up the space.

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Appendices

A | Technical calculations

A.1 Daylight factor

Good daylight condition has a great impact on well-being of the patients as well as the staffs and relatives. Besides, while providing good daylight also means helping to reduce the energy consumption and heat load from artificial lighting. Larger windows gives better daylight. Conversely, larger glass area between south-east and south-west south obtains more sun radiation and increase the temperature of the space. Between north-west and north-east large glass area creates heat loss problem. Therefore, it is important to balance between the daylight condition and heat load by designing the adequate of glass area and using solar shading.

The goal is to give the patient rooms the best daylight condition which is estimated from 3 % up to 5 % of daylight factor in average. Other areas such as offices and common area should reach minimum 2 % of daylight factor. The table below shows the result of the daylight study in each room.

According to BR 18, applied to buildings which are not residential types that the glass area needs to be at least 10 % of the floor area for the façade windows or doors and 7% for the roof windows. The average daylight factor is minimum 2 % counted from the window to a half of the room.

To reach energy requirement BR2020, the glass area should not be too much. Therefore, the window should have the dimension which can provide enough daylight factor but in the same time should be as small as possible.

The method in this project is firstly checking the daylight condition with the glass area which is 10% of the floor area. If it does not reach 2% of average daylight factor, then the with of the window is increased until it reaches 2% in average of daylight factor.

To minimize the labouring and time because of the sustainable reason, the dimension of the windows and doors should be in some certain measurements. In order to do that, the floor area of the rooms should have similar sizes as the requirement of the glass area need to be at least 10 % of the floor area needs to fulfil.

Table A.1.1 shows in details the daylight condition in rooms belonged to the living area. The information includes the glass percentage to compare with the heated floor area, the dimension of glass frames and the average daylight factor measured from window to a half of the room. The last column- Velux result is the result of daylight factor simulated by the program Dayligh Visualizer. See figure A.1.1, A.1.2 and A.1.3 for more details.

Room	Flr area (m^2)	Glass area (m^2)	Type of window (%)	Glass perc	Frame dimension	Average DF (%)	Velux result
Waiting	85	7.28	Façade	23.6	2.8x2.6	5	(1)
		8.73	Façade		4x2.6		
		5.69	Roof				
Administration	17	1.68	Façade	9.9	1.35x1.5	2	(2)
Treatment	17	1.68	Façade	9.9	1.35x1.5	2	(3)
Children room	21	2.10	Façade	10.0	1.4x1.5	2.4	(4)
Music therapy	37	3.75	Façade	10.1	3x1.5	2	(5)
Cafeteria	149	30.94	Façade	38.0	2x2.6	10	(6)
		25.74	Façade		9.9x2.6		
Kitchen	84	6.00	Roof	7.1	3.24x2.24	4.7	(7)
Quiet lounge	37	3.75	Façade	10.1	3x1.5	2	(8)
Common area	200	67.5	Façade	33.8	13.5x5	12.5	(9)
Staff break	21	2.10	Façade	10.0	1.4x1.5	3.8	(10)
Staff kitchen	11	1.56	Façade	14.2	1.04x1.5	2.9	(11)
Office	33	3.30	Façade	10.0	2.2x1.5	3	(12)
Computer	21	2.10	Façade	10.0	1.4x1.5	2.6	(13)
Sitting area	35	5.20	Façade	14.9	2x2.6	3	(14)
Nurse station	21	2.10	Façade	10.0	1.4x1.5	2.6	(15)
Nurse room	21	2.10	Façade	10.0	1.4x1.5	2.6	(16)
Staff overnight	33	3.30	Façade	10.0	2.2x1.5	2.8	(17)
Dialogue	21	2.10	Façade	10.0	1.4x1.5	2.6	(18)
Rehabilitation	77	7.65	Façade	9.9	5.1x1.5	3.5	(19)
Private bath	19	5.20	Façade	27.4	2x2.6	6.6	(20)
Indoor pool	173	21.70	Façade	45.7	5.5x3.9	7	(21)
		57.30	Façade		14.7x3.9		
Patient room	43	11.90	Façade	41.4	3.4x3.5	5	(22)
		5.92	Façade		1.8x3.29		
Family 1	33	3.30	Façade	10.0	2.2x1.5	3	(23)
Family 2	33	3.30	Façade	10.0	2.2x1.5	3	(24)
In-patient lounge	47.9	5.20	Façade	10.9	2x2.6	2.7	(25)

Table A.1.1: Daylight condition in living space

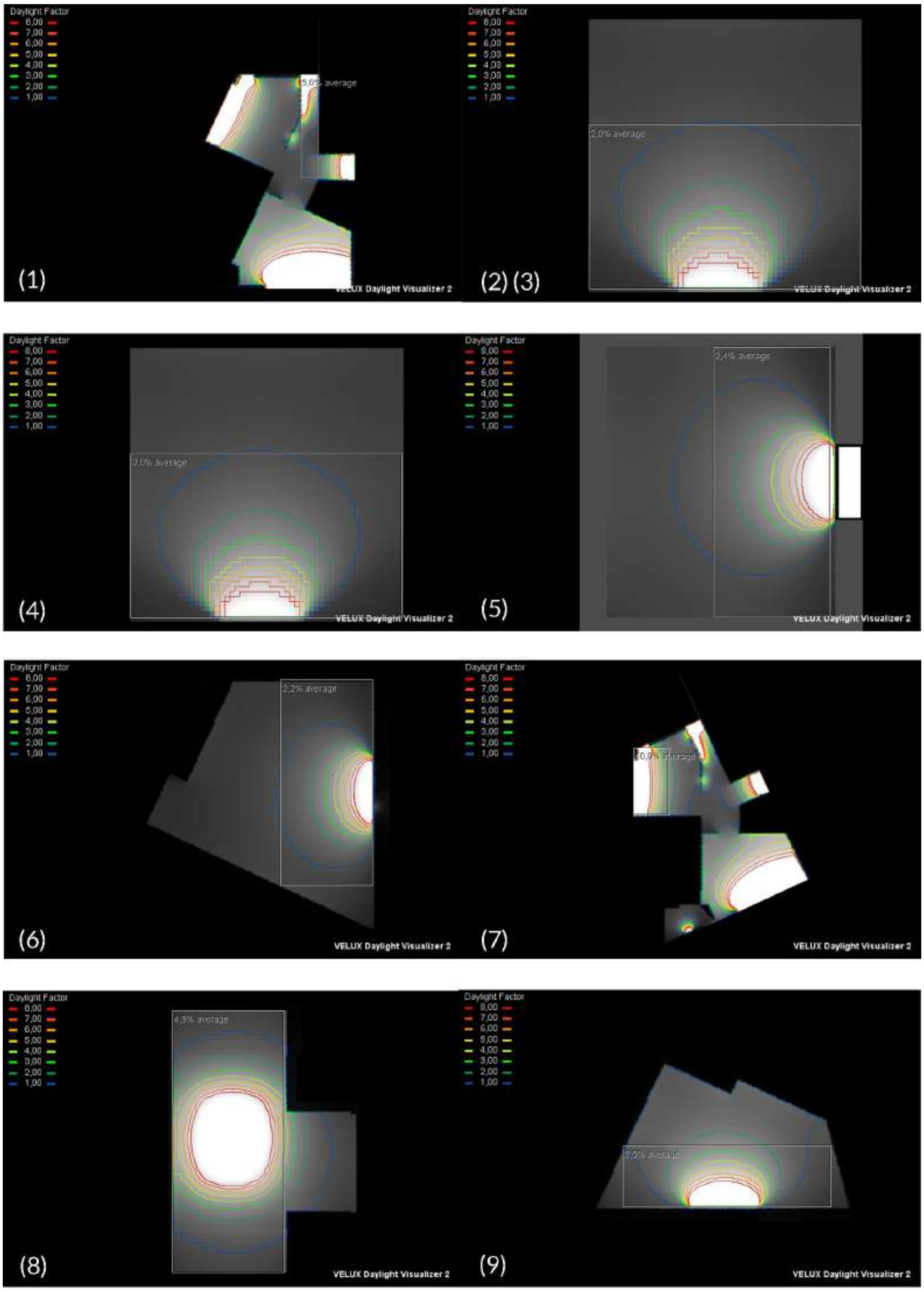

Figure A.1.1: Velux result

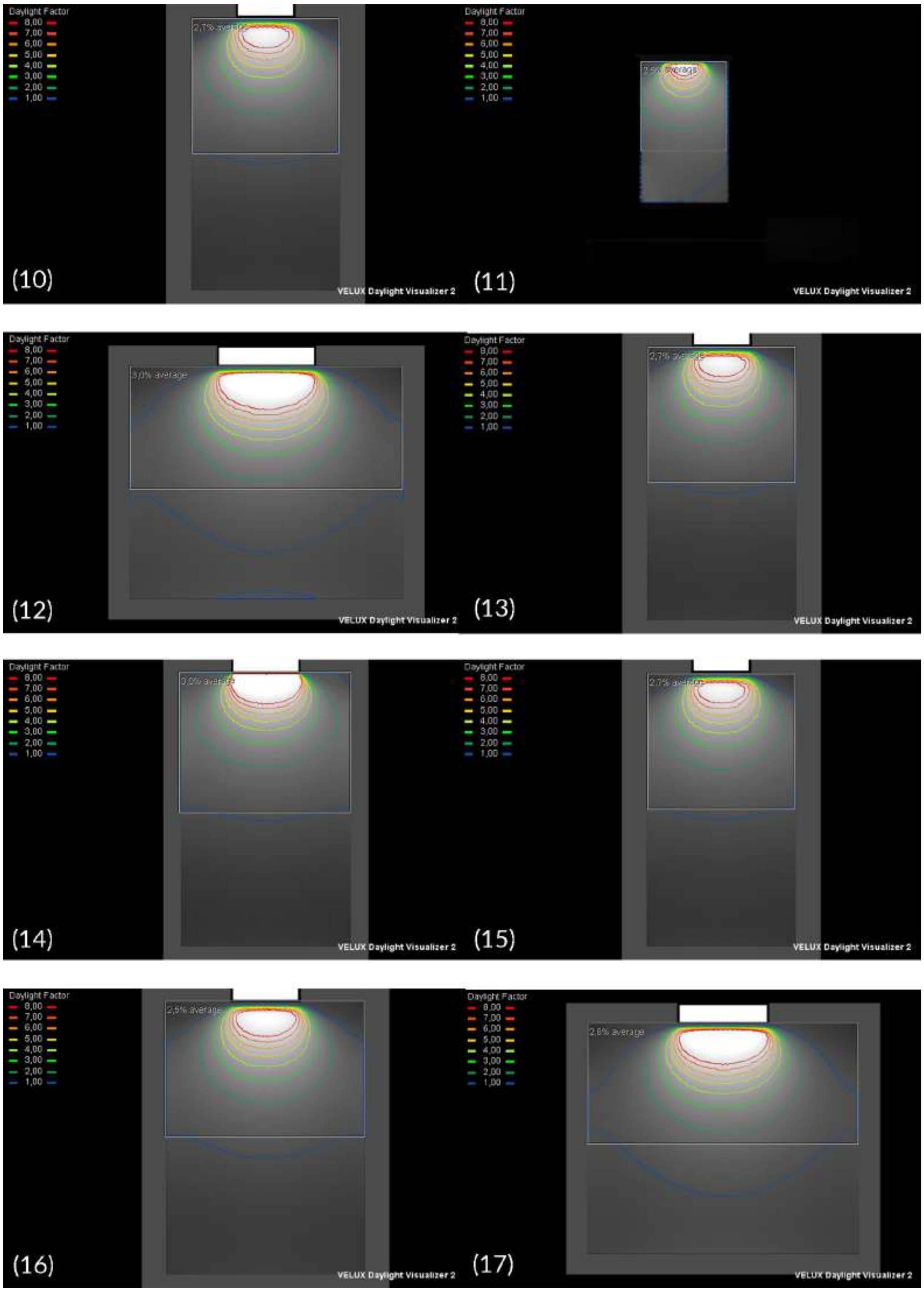

Figure A.1.2: Velux result

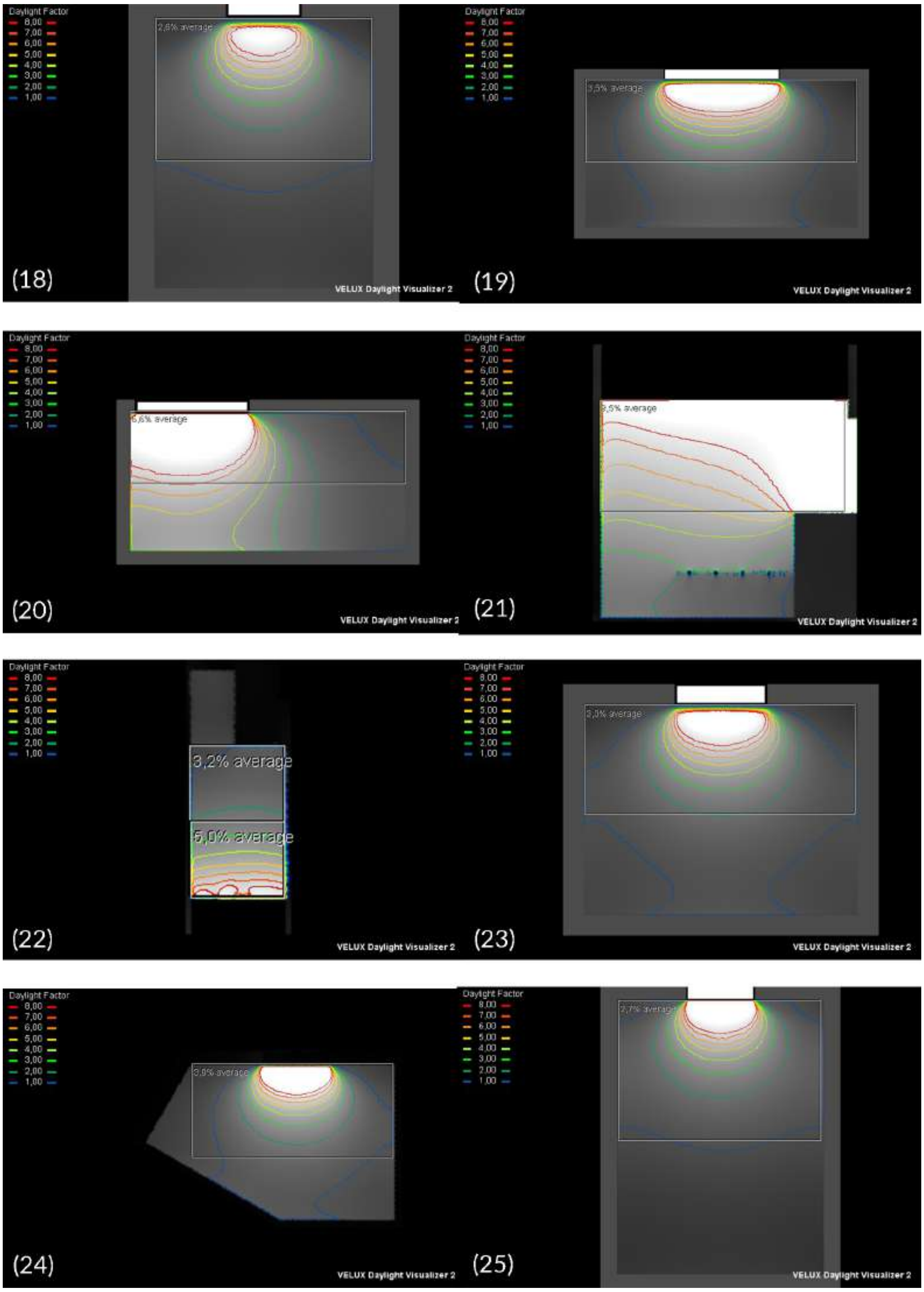

Figure A.1.3: Velux result

A.2 Natural ventilation

A.2.1 Wind velocity

The wind speed varies depends on the terrain condition and the height above ground level. From the meteorological medium speed, the mean velocity in a certain height and a certain terrain determined by:

$$v_h = v_{10} \cdot k \cdot h^{\alpha} \tag{1}$$

where:
v_h is the wind speed at the height h, m/s
v_{10} is the meteorological wind speed in open land at the height of 10 m, m/s
h is the actual height above the terrain, m
k is a factor, depends on the terrain (check the table A.2.1)
α is an exponent, depends on the terrain (check the table A.2.1)

Type of terrain	k	α
Open, flat country	0.68	0.17
Landscape with scattered vegetation	0.52	0.20
Suburban areas	0.35	0.25
Town center	0.21	0.33

Table A.2.1: Factors for the characterization of different terrain types (British Standard Institution, 1991)

In the area context, the type of terrain is landscape with scattered vegetation. So:

$$v_h = v_{10} \cdot 0.52 \cdot h^{0.2} \tag{2}$$

A.2.2 Required opening area

The required opening area of an opening no. j determined by the equation:

$$A_{required,j} = \frac{q_{v,j}}{C_{d,j}|\frac{2\Delta p_j}{\rho}|^{1/2}} \tag{3}$$

where $q_{v,j}$ is the desired volume flow through the opening. Δp_j is the pressure difference across the opening. In the case there is only thermal buoyancy is taken into account, the pressure difference is calculated with the equation:

$$\Delta p_j = \rho_u g(H_{0,ref} - H_j)\frac{\Delta T}{T_i}) = \rho_i g(H_{0,ref} - H_j)\frac{\Delta T}{T_i}) \tag{4}$$

In the case when both thermal buoyancy and the wind are taken into account, calculated with the equation:

$$\Delta p_j = p_j - p_i = (1/2\rho_u C_{p,j} v_{ref}^2 + \rho_u g(H_{0,ref} - H_j)\frac{\Delta T}{T_i}) - p_i \tag{5}$$

where:
Δp_j is the pressure difference at the time j, Pa
p_j is the external pressure, Pa
p_i is the internal pressure, Pa
ρ_u is the outdoor air densities, kg/m^3
ρ_i is the indoor air densities, kg/m^3
$C_{p,j}$ is the wind coefficient,
v_{ref}^2 is the wind speed at a reference altitude, m/s
g is the acceleration of gravity, m/s^2
$H_{0,ref}$ is the vertical distance from the lowest floor level up to the chosen reference level at the same time as the level at which the internal pressure is p_i, in the case where there is only 1 floor, assuming H=0, m
H_j is the vertical distance from $H_{0,ref}$ to the opening, m
ΔT is the temperature difference between indoor and outdoor, K
T_i is the internal temperature, K

In the simplest case, when the two opening areas and the two outdoor airflow coefficients are the same, then the obtained pressure differences across the two openings are same and can be determined by:

$$\Delta p_1 = \Delta p_2 = 1/2 \cdot (\pm 1/2\rho_u(C_{p,1} - C_{p,2})v_{ref}^2 + \rho_u g(H_2 - H_1)\frac{\Delta T}{T_i}) \tag{6}$$

A.2.3 Patient room

Building orientation and location

The patient rooms are oriented with south-west. The building is located in the slope landscape condition covered by trees. With the openings on the south-west façade and north-east façade, it provides the positive contribution to driving pressure for natural ventilation. In the summer, the wind mainly comes from the west. The wind direction creates a 49 degree angle.

Building design

The bathroom with high pollution load is placed in the end of the room, towards the north east and provided with mechanical exhaust. The rest of the room is naturally ventilated in the summer. Mechanical ventilation is considered to be used during cold seasons.

The room is 11 meters deep, 4.76 meters wide. The ceiling height is 3.7 meters counted from the actual ceiling and 2.8 meters counted from the wooden ceiling. The actual height is taken into account to calculate because the window on the leeward side if placed on the top of the wall, next to the ceiling. The ratio of the room depth and ceiling height is about 1:3 and is good for cross ventilation to be used. Ventilation buoyancy is also taken into account besides natural ventilation.

Building construction

The walls, roof and floor are heavy construction. To create the warm feeling in the room, both floor and ceiling have a layer of wooden layer on the top towards the inside space. For a better acoustic condition, the inner linings of our acoustic wood ceilings is installed.

Calculation of ventilation requirements

The floor area of the room is 42.7 m^2not including the bathroom. Assuming the number of users is 2 people most of the time: the patient and a care taker from family. To design the best environment for the users, the category I of the necessary air supply in DS 447 is used.

Volume: V_R = 124.78 m^3
Personal load: 3 persons, 21.25/m^2person
fresh air demand: 10 l/s/person + 0.5 l/s/m^2floor area
q_{tot}= 51.35 l/s , n= 1.48 h^{-1}

Basic air need

The desired CO^2 levels in the patient C_{op} is 700 ppm. The CO_2 levels outdoor C_{in} is approximately about 350 ppm. With the condition of constant ventilation and constant source of contamination, the basic air need to reach the CO_2 levels maximum 700 ppm can be calculated in the equation:

$$q_v = nV_R = \frac{G}{C_{op} - C_{in}} \tag{7}$$

where:
q_v is the basic air need, l/s

n is the air exchange rate, h^{-1}
V_R is the room volume, m^3
G is pollution emission, m^3/h
C_{op} is the pollutant concentration in the zone at the time τ = 0, m^3/m^3
C_{in} is the pollutant concentration in the supply air, m^3/m^3

When G is in l/h and the unit to achieved is in l/s:

$$q_v = nV_R = \frac{G}{350 \cdot 10^{-6} \cdot 3600} = 0.79G \tag{8}$$

Assuming the two persons occupied in the room are men. One person is sick and not active and another the one is normal active. The metabolism rate of them respectively are 1.0 met and 1.2 met. The pollution emission from them are calculated in the equation:

$$q_{v,CO_2} = 17M \tag{9}$$

where:
q_{v,CO_2} is CO_2 flow, l/h M is the metabolism, met

This this case, assuming the pollution emission is mainly from the people occupied in the room. Then G = q_{v,CO_2} :

G = 17 · (1.0 + 1.2 +1.2) = 57.8 l/h. Thus, q_v = 45.87 l/s

The result of the basic air need is smaller than the requirement ventilation, therefore the air change rate calculated from the requirement ventilation is used to test the indoor temperature.

Determination of cooling air requirement

According to DS 474, the indoor temperature should be 20°C < t_{op} < 24°C for general condition and 23°C < t_{op} < 26°C in the summer.

To calculate the indoor temperature and the temperature difference between the indoor temperature and outdoor temperature depends on the construction which can be understand as the building's heat storage capacity. The designed building's construction is known as the extra heavy type which several heavy structure, such as concrete slabs, concrete ceiling as well as partition wall of concrete. The accumulation conductivity of the building is ranged from 13-15 W/°C m^2.

The 24-hour average temperature is calculated with the 24HourAverage-English sheet provided from Aalborg university. Assuming the ventilation air has the same the temperature as the outdoor air. The chosen month is July to check the indoor temperature in the hottest days. The result of average temperature is t_i= 24.0 °C, the temperature variation is Δt_i = 2.3°C the maximum temperature in hottest hours is $t_{i,max}$ = 25.2°C.

This is a good result, firstly it satisfies the requirement indoor temperature in DS 474 for the cooling air requirement. Secondly, it is matched the goal of keeping the indoor temperature of the patient room at 24 °C. The temperature sometimes increases up to 25.2 °C in the hot period in July. Some people however prefer the temperature to be slightly lower or higher. Therefore, 24 °C is still the goal of the patient room temperature according to reference.

Chosen month: July	t_u=	21.0°C
24-hour average	t_i=	24.3°C
Temperature variation	Δt_i =	2.2°C
Max. Temperature	$t_{i,max}$ =	25.4°C

Table A.2.2: Result of 24-hour average indoor temperature in patient room

The result is achieved by giving these inputs:

Surface	A (m^2)	U (Wm^2K)
Outer walls	3.73	0.07
Roof	43.61	0.05

Table A.2.3: Construction towards outdoor

Surface	A (m^2)	U (Wm^2K)	tr (°C)
Inner walls	90.56	0.18	24.0
Floor	43.61	0.07	16.1

Table A.2.4: Construction towards ground and surrounding rooms

Detail of the U-value of the constructions are described in section Energy requirement - BR 2020 A.4

The main internal heat loads are from people, installations and equipments, and solar radiation through glass surfaces.

The heat load from people are calculated based on the gender, age and the level of activities. Generally, an adult man has a body surface of approximately 1.7 m^2. In the situation if he's sitting and relaxed most of the time, the heat load he contribute to the room is around 100 W. A woman and a child's heat contribution will be approximately 80% and 60% of a man's.

The loads were entered based on the schedule at the hospice. The room is occupied by 1 patient and his or her care taker most of the time. Some hours during the day, there will be also a nurse come by. During the day, sometimes the patient is not at the room for different activities, such as eating, training, treatment, doing hobbies and going out for fresh air.

Surface	A (m^2)	U (Wm^2K)	Orient	Incli	g	f (beta)	f (shade)	f (shadow)	f (glass)
South-west windows	13.45	0.65	319	90	0.60	0.90	0.60	0.20	0.83
North-east windows	1.04	0.65	41	90	0.60	0.90	0.60	0.10	0.50
North-east entrance windows	1.09	0.65	41	90	0.60	0.90	0.60	0.10	0.51

Table A.2.5: Windows towards outdoor

Type	Air change (h^{-1})	Room volume (m^3)	Air flow (m^3/s)
Ventilation	1.48	124.78	0.051
Infiltration	0.10	124.78	0.003
Total	1.58	124.78	0.055

Table A.2.6: Ventilation

Heat accumulation	thermal capacity	Floor area	Ba
	(W/K per m^2)	(m^2)	(W/K)
Extra heavy	14	42.61	596.54

Table A.2.7: Heat accumulation

The heat load from the installations and machines are mainly from lighting and equipment. According to BR 18 (applied same to BR 2020) that the light condition should be 300 lux. Assuming the power for the light is 6 W/m^2. In this appendix, I will not explain in details how much the heat load from the installations and equipments even though it will be taken into calculation of the total heat load in a room. However, the equipments I have entered into the sheets are television, computer and some of the healthcare machine to support the patient. It will not be explained into details for the details of solar radiation through glass surface either. But the input can be seen at the table A.2.5.

Opening area calculation in general

According to the data from DRY and the wind pressure coefficients from (Orme et al., 1998), I have built up these data:

(1) Wind direction
(2) Wind pressure coefficients

time	Personal load (W)	Lighting (W)	Other (W)	Sum (W)
1	113	0	0	113
2	113	0	0	113
3	113	0	0	113
4	113	0	0	113
5	113	0	0	113
6	113	0	0	113
7	113	0	0	113
8	218	0	35	253
9	0	0	0	113
10	0	0	50	50
11	0	0	50	50
12	142	0	50	192
13	0	0	0	0
14	0	0	0	0
15	142	0	35	253
16	142	0	0	218
17	0	0	0	0
18	0	256	50	306
19	142	256	50	448
20	142	256	50	448
21	132	256	50	438
22	113	0	0	113
23	113	0	0	113
24	113	0	0	113
Sum	2342	1024	420	3786
Average	98	43	18	158
Max. hour value	218	256	50	306
Min. hour value	0	0	0	0

Table A.2.8: Internal heat loads

Let's say $\rho_u \approx \rho_i \approx \rho$ = 1.25 kg/m^3. The highest rate of error in this case is 2%-3%. The top of the roof of the patient room is at 4.7 meter over the floor. The found basic air requirements and the ventilation for the air cooling requirement mean that in general,

Month	Outdoor temp (°C)		Wind speed (m/s)				WD(1)	WPC(2)	
	Aver	Max	The whole year	days with t_{max}> 20°C	days with t_{max}> 25°C	hours with t> 25		SW façade	NE façade
January									
Average	-1.0								
July									
Average	16.1			1.0			W	0.6	-0.35
Hot days	21.0				1.3		W	0.6	-0.35
Max temp		26.0				4.6	W	0.6	-0.35
October									
Average	8.9		2.0				SW	0.2	-0.6
Max temp	13.7	2.0					SW	0.2	-0.6

Table A.2.9: Dimensioned outdoor climate data and wind pressure coefficients for the calculation of opening area in the patient room

the air should have a continuous air change rate n = 1.48 h^{-1} (or q_v = 0.05135 m^3/s) through the window. In the hot season, there is supplied outdoor air estimated at n = 10h^{-1} (or q_v = 0.35 m^3/s).

$$v_{ref} = 0.52 \cdot 4.7^{0.2} \cdot v_{10} = 0.7v_{10} \tag{10}$$

Opening area is determined by the equation 3, and the input pressure difference may be generally determined by the equation 5. Ventilation requirements are q_v = 0.05 m^3/s.

In January, average hour:

The driving force in this situation is only thermal buoyancy. Assuming t_u = -1°C (T_u = 272K) and t_i = 22°C (T_i = 295K). So, ΔT = 23K. In this situation, v_{ref}=0 (Orme et al., 1998). There are 3 openings in the room: 1 inlet and 2 outlets. The height of the inlet windows are H_1 = 1.45 m, H_2 = H_3 = 3.65 m. The height of neutral plane is H_0 = 2.55 m.

The pressure difference across the outlet opening is:

$$\Delta p_2 = \Delta p_3 = 1.25 \cdot 9.82 \cdot (3.65 - 2.55) \cdot \frac{23}{295}] = 1.05Pa \tag{11}$$

And from the equation 3:

$$A_{required,2} = A_{required,3} = \frac{0.05135}{0.7 \cdot (\frac{2 \cdot 1.04}{1.25})^{1/2}} = 0.057m^2 \tag{12}$$

The pressure difference across the inlet opening is:

$$\Delta p_1 = 1.25 \cdot 9.82 \cdot (2.55 - 1.45) \cdot \frac{23}{295}] = 1.05Pa \tag{13}$$

And from the equation 3:

$$A_{required,1} = \frac{0.35}{0.7(\frac{2 \cdot 1.05}{1.25})^{1/2}} = 0.38m^2 \tag{14}$$

In July, hot days:

In the hot days of July, the natural ventilation is the combination of thermal buoyancy and the wind. From the data of the table A.2.9, v_{10} = 1.3 m/s, t_u = 21.0°C (T_u = 294K) and t_i = 26°C (T_i = 299K). From equation 2: v_{ref} = 0.52 · 1.3 = 0.676 m/s and ΔT = 5K. From equation 6 and 3, we have:

Pressure difference across the outlet window, consider thermal buoyancy:

$$\Delta p_{T,2} = \Delta p_{T,3} = 1.25 \cdot 9.82 \cdot (3.65 - 2.55) \cdot \frac{5}{299}] = 0.23Pa \tag{15}$$

And from the equation 3:

$$A_{required,2} = A_{required,3} = \frac{0.05135}{0.7 \cdot (\frac{2 \cdot 0.23}{1.25})^{1/2}} = 0.122m^2 \tag{16}$$

Pressure difference across the inlet window, consider only thermal buoyancy:

$$\Delta p_{T,1} = 1.25 \cdot 9.82 \cdot (2.55 - 1.45) \cdot \frac{5}{299}] = 0.23Pa \tag{17}$$

And from the equation 3:

$$A_{required,1} = \frac{0.05135}{0.7 \cdot |\frac{2 \cdot 0.23}{1.25}|^{1/2}} = 0.12m^2 \tag{18}$$

When the wind is included, a modest change of the found opening areas is obtained, but not too much and the internal pressure with an approximation can be determined by:

$$p_i = 1/2\rho_u v_{ref}^2 \frac{C_{p,1}(C_{d,1}A_1)^2 + C_{p,2}(C_{d,2}A_2)^2}{(C_{d,1}A_1)^2 + (C_{d,2}A_2)^2}$$

$$= 1/2 \cdot 1.25 \cdot 0.676^2 \cdot \frac{0.6(0.7(2 \cdot 0.184))^2 + (-0.35)(0.7 \cdot 0.12)^2}{(0.7(2 \cdot 0.184))^2 + (0.7 \cdot 0.12)^2}$$

$$= 0.029 Pa$$

The outlet window gets when following pressure difference from the wind (inward):

$$\Delta p_{v,2} = \Delta p_{v,3} = 0.029 - 1/2 \cdot (-0.35) \cdot 1.25 \cdot 0.676^2 = 0.129 Pa \quad (19)$$

Therefore:

$$A_{required,2} = A_{required,3} = \frac{0.05135}{0.7 \cdot (\frac{2(0.23+0.129)}{1.25})^{1/2}} = 0.097 m^2 \quad (20)$$

This room has more than 2 windows, thus we have the mass balance form, with $\rho_u \approx \rho_i \approx \rho$ and the pressure difference determined by the equation 5:

$$\sum_{n}^{j=1} C_{d,j} Aj (\frac{|2\Delta p_j|}{\rho})^{1/2} \frac{\Delta p_j}{|\Delta p_j|} = 0 \quad (21)$$

When accessing only the wind, the wind pressure difference over the outlet opening is determined by:

$$\Delta p_{v,2} = \Delta p_{v,3} \approx 1/2 \cdot 1.25 \cdot (0.6 + 0.35) \cdot 0.676^2 = 0.271 Pa \quad (22)$$

The following volume air flow is found with A = $A_{required,2}$ = $A_{required,3}$ = 0.125m^2:

$$q_{V,v,2} = q_{V,v,3} \approx C_d \cdot A(\frac{2|\Delta p|}{\rho})^{1/2} = 0.7 \cdot 0.125 \cdot (\frac{2 \cdot 0.271}{1.25})^{1/2} = 0.058 m^3/s \quad (23)$$

or nearly 1/6 of the required air flow at 0.35 m^3/s. Thermal buoyancy therefore is highly dominant in this case. We already have $\Delta p_{v,2}$ = 0.23 Pa from the equation 15.

$$q_{V,T,2} = q_{V,T,3} = 0.7 \cdot 0.125 \cdot (\frac{2 \cdot 0.23}{1.25})^{1/2} = 0.053 m^3/s \quad (24)$$

$$q_{V,1} = 0.35 - 0.053 = 0.294 m^3/s \quad (25)$$

We already have $\Delta p_{T,1}$ = 0.23 Pa from the equation 17.

$$A_{required,1} = \frac{0.294}{0.7 \cdot (\frac{2 \cdot 0.23}{1.25})^{1/2}} = 0.7 m^2 \quad (26)$$

So, to ventilate the room and keep the CO_2 level to be at 700 ppm, the inlet window should be 0,7 $m^2$and the two outlet windows should be 0.12 m^2.

In the worse case, when the room is occupied by 10 people. The calculation is done with the process like above. The result is that the inlet window should be still 0.7 m^2but the outlet windows should be 0,29 m^2. To make this to be simple, the outlet windows are designed that each window has 2 openings: one is 0.12 $m^2$and another one is 0.29 m^2like how it is show in figure 7.3.15. In general, the small window is opened during summer for natural ventilation. But when for example when the patient is passed away, the family estimated with 10 people (including wife or husband, 2 children with their partners, 2 grandchildren, a nurse and 2 good friends) will come and be in the room. Then, the bigger window is used.

When all the outlet windows are opened, the room is able to ventilate for 15 people in the room. If the case is even worse, the mechanical ventilation is turned on with the ventilation control based on the CO_2 level which should be at 700 ppm.

BSim

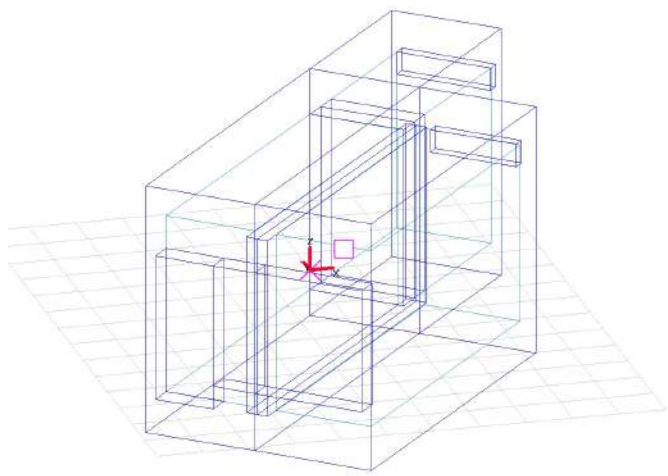

Figure A.2.1: BSim model

	Min	Mean	Max	1	2	3	4	5	6	7	8	9	10	11	12
CO_2	350	509	846	430	430	429	427	638	629	561	561	707	430	428	429
T_i	20.9	23.4	30.7	22.0	22.4	22.8	23.5	24.2	24.9	24.9	25.0	24.0	23.2	22.4	21.9

Table A.2.10: BSim result in details of indoor temperature and CO_2 levels

A.3 Acoustic in the multi-purpose room

Acoustic environment

The room is designed to hold a small music concert sometimes for the patients, mainly classical music or only piano. Therefore, the acoustic environment is designed based on the characteristics of the piano notes. When a piano is played, the strings vibrate at specific frequencies, which depend on their length, mass, and tension. The lowest note has a fundamental frequency of about 27 Hz and the highest fundamental is 4186 Hz (Long, 2005). Figure A.3.1 shows the fundamental frequencies associated with each note.

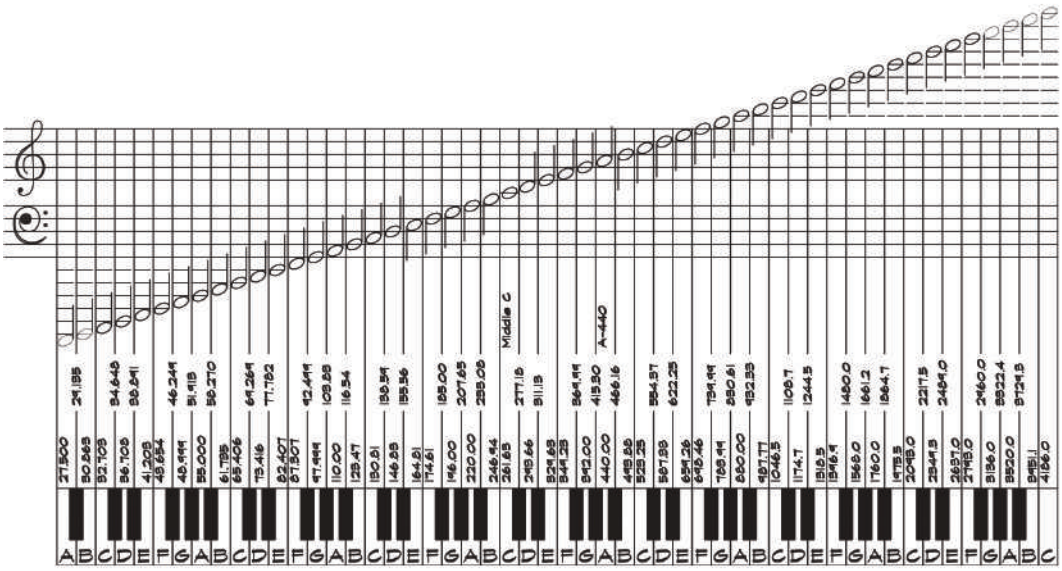

Figure A.3.1: Frequency Range of a Piano (Pierce, 1992)

The wavelength is calculated by the equation:

$$\lambda = \frac{c}{f} \tag{27}$$

Where:

λ is wavelength, m
c is velocity of wave propagation, m/s
f is frequency, Hz

Under normal conditions of temperature (around 20 °C) and atmospheric pressure, the velocity of wave propagation is about 344 m/s (Long, 2005). From equation 27, the wavelength of the lowest tone and highest tone are found found respectively $\lambda \approx$ 12,7 m and $\lambda \approx$ 0.08 m.

While the longest wall in the room is 17,5 meter and is longer than the wavelength of the lowest tone. It means that the sonic quality in the room is clear enough.

Room volume

	Volume per Seat cu ft (cu m)		
Type of Auditorium	Min	Mid	Max
Rooms for Speech	80 (2.3)	110 (3.1)	150 (4.3)
Concert Halls	220 (6.2)	275 (7.8)	380 (10.8)
Opera Houses	160 (4.5)	200 (5.7)	260 (7.4)x
Churches/Synagogues	180 (5.1)	255 (7.2)	320 (9.1)
Multi-purpose Auditoriums	180 (5.1)	250 (7.1)	300 (8.5)
Motion-picture Theaters	100 (2.8)	125 (3.5)	180 (5.1)

Table A.3.1: Range of Volume per Seat by Type of Auditorium (Doelle, 1972)

Consider the multi-purpose room belongs to the type of multi-purpose auditorium in a small scale, the room volume per seat thus ranging from 5.1 $m^3$to 8.5 m^3. Table A.3.1 shows typical ranges by room use. The known volume of the common space is 785 m^3, so the estimated seats for audience is 110 seats.

Reverberation Time

Classical musical concert need a "live" space and the preferred reverberation time ranging between 1.2 s an 1.6 s. From figure A.3.2, the room volume for the symphonic music with the desired reverberation is from 600 $m^3$to 3000 m^3. As the room volume is 785 m^3, it belong to the ranged volume.

In general, the size of a concert halls and piano showrooms should be big enough to allow the sound to properly resonate, small rooms can not absorb so much sound, and will easily overload when the instrument is played full out. On another the hand, the room has big windows which created the transmission of sound. Therefore, to achieve the reverberation time between 1.2 second to 1.6 second the materials in the room should be able to keep the sound "live". The floor thus is chosen to be in concrete material instead of wooden floor. After trying different material, the desired reverberation time is

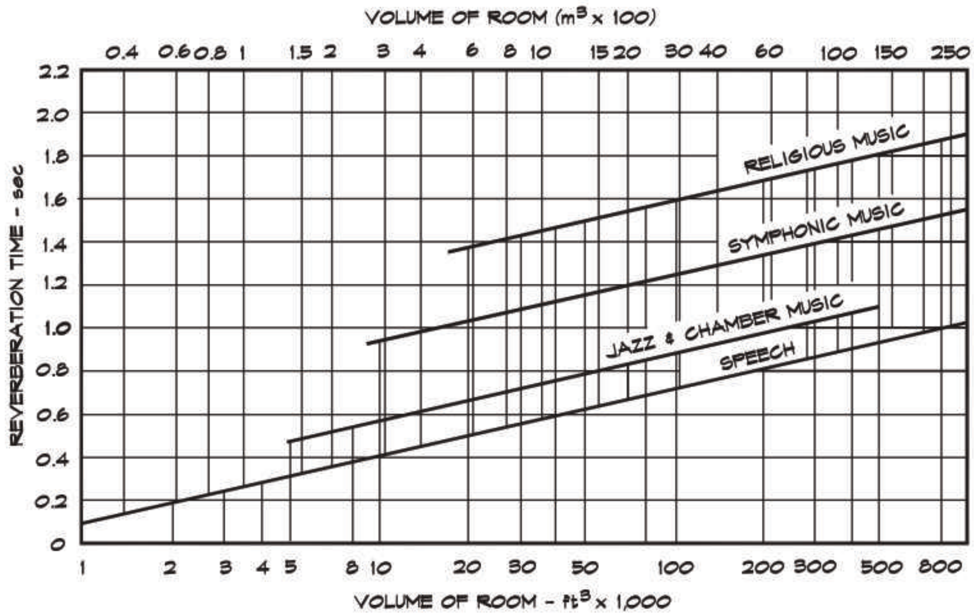

Figure A.3.2: Reverberation Times for Studios in the 500–1000 Hz Range (Doelle, 1972)

reached, shown in table A.3.2.

Sound absorption

Since when the concert is held, there should be chairs taken from the storage for the audience. The ability of sound absorption from the seats should be taken into account. To maintain a consistent acoustical environment, the total absorption should not calculated with a certain number of people but the space itself including the seats. The reverberation calculations of the seats should be based on an absorption coefficient per unit area of seating (Beranek and Martin, 1996).

The two walls played as the rear walls in the room have several holes to increase the sound absorption while still be able to reflect the sound energy. In the case when other activities such as speech happen, sound absorption material like acoustic foam can be inserted in these holes to increase the total absorption.

The stage floor where piano or other instrument is laid on is wood, raised above the concrete floor, on top of the insulation layer and leave an empty space between the insulation layer and the concrete floor to reduce the sound reflection.

Sound diffusion

Side wall and ceilings should provide useful reflections to the musician seating while angling outward to accommodate audience seating layout (Long, 2005). Convex ceiling shape was chosen to diffuses the sound and aids in the sense of envelopment, or feeling

Equivalent absorption area	Area S m^2	125Hz α	Sa	250Hz α	Sa	500Hz α	Sa	1000Hz α	Sa	2000Hz α	Sa	4000Hz α	Sa
Floor	180	0.01	1.80	0.01	1.80	0.02	2.70	0.02	3.60	0.02	3.60	0.02	3.60
Stage flr	20	0.15	3.00	0.11	2.20	0.10	2.00	0.07	1.40	0.60	1.02	0.07	1.40
Ceiling	270	0.24	64.7	0.19	51.2	0.14	37.8	0.08	21.6	0.13	35.0	0.08	21.6
Rear wall	58	0.01	0.58	0.01	0.58	0.02	1.16	0.02	1.16	0.02	1.16	0.02	1.16
Stage RW	38	0.10	3.84	0.05	1.92	0.06	2.30	0.07	2.69	0.09	3.46	0.08	3.07
Side wall	590	0.01	5.90	0.01	5.90	0.02	11.8	0.02	11.8	0.02	11.8	0.02	11.8
Window	52	0.18	9.36	0.06	3.12	0.04	2.08	0.05	2.60	0.02	1.04	0.02	1.04
Holes	9	0.01	0.09	0.01	0.09	0.02	0.17	0.02	0.17	0.02	0.17	0.02	0.17
Absorption from persons	Nr	Sa /stk	Sa Sa	Sa /stk	Sa Sa	Sa /stk	Sa Sa	Sa /stk	Sa Sa	Sa /stk	Sa Sa	Sa /stk	Sa Sa
Musicians	1	4.00	4.00	8.50	8.50	11.5	11.5	14.0	14.0	15.0	15.0	12.0	12.0
Chairs	110	0.15	16.5	0.19	20.9	0.22	24.2	0.39	42.9	0.38	41.8	0.30	33.0
Absorption in air v/ 50 % RF	V m^3	125Hz m	mV	250Hz m	mV	500Hz 4mv /1Km^3	4mV	1000Hz 4mv /1Km^3	4mV	2000Hz 4mv /1Km^3	4mV	4000Hz 4mv /1Km^3	4mV
	785					1.60	1.26	4.00	3.14	9.60	7.54	24.4	19.2
Total absor			110		96.2		96.9		105		122		108
RT			1.1		1.3		1.3		1.2		1.0		1.2

Table A.3.2: Reverberation time in common space

surrounded by the sound.

Ceiling design

Convex ceiling was chosen to diffuses the sound and aids in the sense of envelopment, or feeling surrounded by the sound. The ceiling is designed with different angles to distribute and reflect the sound over the audience.

A.4 Energy requirement - BR 20

A.4.1 BR20 overview

The Building's primary energy requirements for new buildings in future in the energy context, supplemented by a limitation of the design heat loss through the building envelope exclusive windows and doors (Aggerholm, 2011).

For construction 2020 is proposed to the energy frame:

Housing: 20 kWh / m^{2}per year Others building: 25 kWh / m^{2}per year

The requirement for maximum designed heat loss through the building envelope exclusive windows and doors are shown in Table A.4.1 (Aggerholm, 2011):

Number of floors	2008	2010	2015	2020*
One floor	6.0	5.0	4.0	3.7
Two floors	7.0	6.0	5.0	4.7
Three or more floors	8.0	7.0	6.0	5.7

Table A.4.1: Maximum designed heat loss through the building envelope exclusive windows and doors in W/ m^2

(*) Suggestion

A.4.2 Details of U-value

	U-value (W/m^{2}K)	R-value (m^{2}K/W)	Thickness (m)		
			Outer Concrete	Insulation	Inner concrete
Concrete outer walls	0.77	12.94	0.2	0.23	0.07

Table A.4.2: Outer wall construction

A.4.3 Construction description

	U-value	R-value	Thickness (m)							
			cement mortar	Rein-forced concre-te	Li-ght concre-te	Water proof	Insu-lation	As-phalts	Cement mortar	cement slab
Roof	0.04	23.39	0.013	0.2	0.1	0.015	0.419	0.01	0.02	0.023

Table A.4.3: Roof construction

	U-value	R-value	Thickness (m)						
			Tiles	Cement mortar	Concre sub-flr	Insu-lation	Sand biding	Block workn	Earth
Foundation	0.06	17.49	0.015	0.05	0.2	0.3	0.05	0.15	-

Table A.4.4: Foundation construction

Heated floor area: 3300 m^2

Heat capacity: 160 Wh/K m^2(extra heavy construction)

heat supply: District heating

Construction u-values

Outer walls: 0.77 W/m^2K

Roof: 0.04 W/m^2K

Floor: 0.06 W/m^2K

Window/door values

U-value: 0.65 W/m^2K
G-value: 0.52

Figure A.4.1: Building description

A.4.4 Be18 calculation

The total requirement frame the building has to reach is 25 kWh / m^{2}per year. And the result is 24.6 kWh / m^{2}per year.

From figure A.4.2, it shows that the building does not have overheating problem thanks to good ventilation and deep overhang over the glass windows towards the south.

The energy to heat up the building however is quite high. It is probably because of the big glass window in the water therapy, large glass area in total of roof windows

Figure A.4.2: Be18 result

A.5 Zero energy

Total energy according to Be18 result:

24.6 kWh / m^{2}per year.

$$Energy\ demand = 24.6 \cdot 3300 = 81180\ kWhperyear \qquad (28)$$

To estimate the electricity consumed by appliance, the document "ECG72 Energy Consumption in Hospital - CIBSE) is used:

Categories	Electricity consumption per m^{2}per year (kW/ m^2)
Medical equipment	17
IT equipment	6.7
Personal small power	14
Cooking and food storage per person	1.2

Table A.5.1: Electricity consumption estimation

There are 15 in-patient rooms in the hospice. Let's say in average, a patient will have 1 care taker with. Assuming there are 6 nurses, 2 doctor, 10 volunteer and 50 out-patient using the facility at the hospice. So, the total electricity for cooking and food storage is 117.6 kWh

The total electricity used for the hospice is:

$$Total\ electricity = (17 + 6.7 + 14) \cdot 3300 + 117.6 = 124527.6\ kWh\ per\ year \tag{29}$$

Thus, each year the total energy needed to run the hospice is: 81180 + 124527.6 = 205707.6 kWh per year

calculation of the amount of PV's that is needed based on the calculation sheet "Skema til overslagsberegning af nettilsluttede solcelleanlaeg i Danmark":

$$Energy\ generated = C \cdot D \cdot E \tag{30}$$

Where:

C is area efficiency / 100, C = $A \cdot B$ with A is the area of PV (m^2), B is the module efficiency assessment (%)
D is system factor
E is solar radiation

For the economy reason, polycrystalline is the type of PV chosen. To keep the look clean from human perspective, PV should be install on the roof with 0 degree horizontally. Then the necessary area for PV to reach the required energy is:

$$A = \frac{Energy\ generated \cdot 100}{12 \cdot 0.7 \cdot 999} = 2451.35 m^2. \tag{31}$$

The total roof area is 3300 m^2, from the result, about 74 % area of the roof should be used to install PV and reach zero energy.

A.6 Construction structure

This project uses the book "Dimensionering med diagrammer" to design the construction structure. Concrete outer walls and inner walls are the load-bearing element. Table A.6.1 is the different thickness of the walls which can be used to check their ability of bearing the load in figure A.6.1.

In general, the thickness of the load-bearing walls in this hospice is 120 mm, 2.6 m tall. It means that every 1 meter of the length, it can bear the load of 25 m^2 or 12.5 meter wide on each side. Thus, it is more than good enough to bear the whole construction of the building.

	1	2	3	4	5	6	7
Thickness (m)	100	120	150	175	200	240	300

Table A.6.1: Wall thickness (mm)

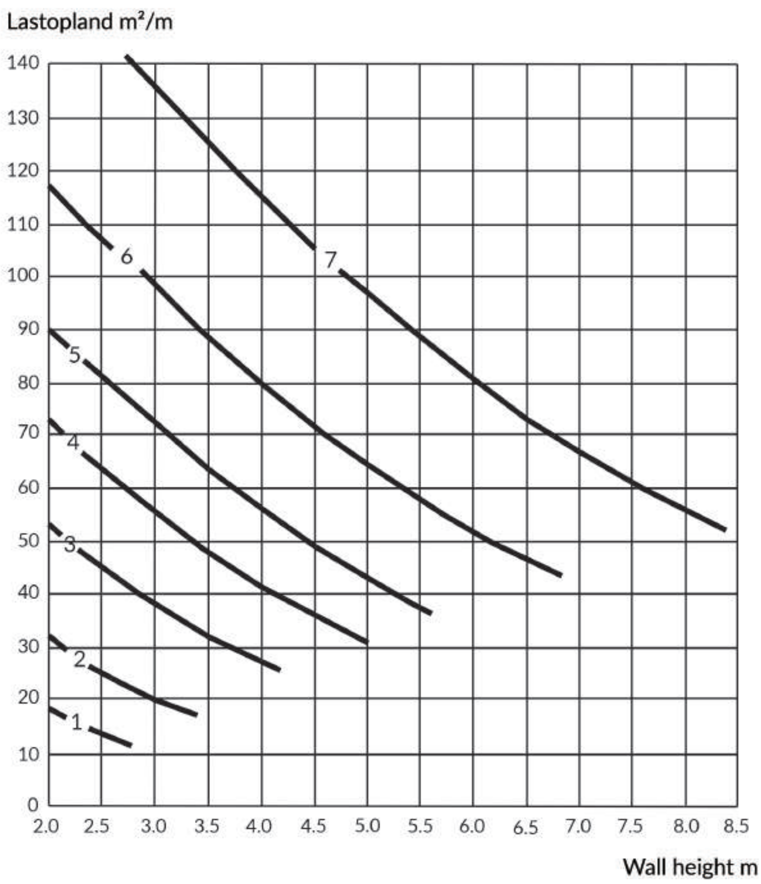

Figure A.6.1: Load-bearing walls graph, (Ahler, 2013)

A.7 Fire safety

In the case when the fire occurs, people can reach to the escape door within 25 meters radius. Figure A.7.1 show more in detail. The overlap parts means there are more choices or direction that people can choose to escape.

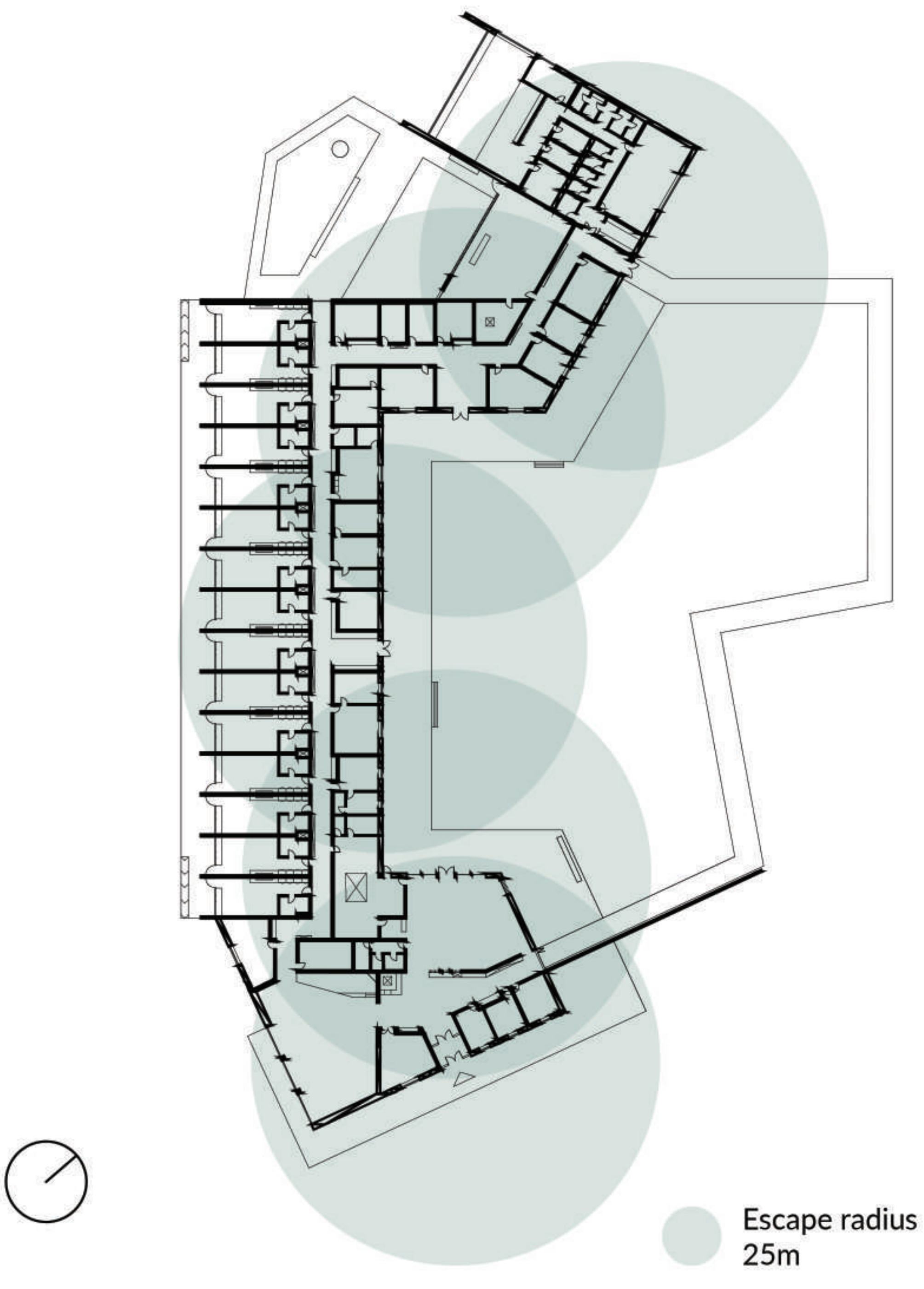

Figure A.7.1: Escape door in the radius of 25 meters in the case of fire

A.8 Parking for cars and bikes

The design of parking in this project follow the parking norm for Skanderborg municipality, both for car parking (Teknik og Miljø, 2015) and bike parking (Teknik og Miljø, 2016).

Hospice belongs to the building type of institutions. According to the plan of Skanderborg municipality:

Institutions	Bike parking requirement	Car parking requirement
Nursing homes of residential homes, possibly with associated day centres	1 parking lot per residence, plus 50 m^2service area	1.5 parking lot per residence, plus 50 m^2service area
Elderly homes without affiliated staffs	no requirement	1 parking lot per residence
Office/administration	1 parking lot per 100 m^2floor area	1 parking lot per residence, plus 50 m^2floor area
Primary school	7 per 10 staffs	1 parking lot per residence, plus 50 m^2floor area
"Voksenskole"	5 per 10 staffs	1 parking lot per residence, plus 25 m^2floor area
Daycare (60 children)	1 per 5 standardized lots	Minimum 1 parking lot per standardized employees plus 1 parking lot per 3 children
Other public institutions	Requirement is set individually according to the municipality's assessment	Parking requirement is set individually according to the municipality's assessment

Table A.8.1: Parking requirement for institutions in Skanderborg

From the table A.8.1, the hospice belongs to the type of "nursing homes of residential homes, possibly with associated day centres". It has 15 patient rooms which is counted as residence units. Thus, it requires to have 15 bike parking lots and 23 car parking lots plus the extra lots for each 50 m^2service area. The service area of the hospice is 1638 m^2which means 33 bike parking lots and 33 car parking lots extra are needed.

In total the hospice is required to have room for 48 bikes and 56 cars to park. Since it is an institution for patients, it is important to keep in mind that people will come with handicap cars. According to BR15, the number of parking lots for handicap cars is shown in the table A.8.2

As the required number of car parking for the hospice is 56. It means that among those 56 parking lots, there should be at least 2 lots with the size of 3.5 x 5.0 m and 2 with the size of 4.5 x 8.0 m.

The final designed parking has 48 lots for bikes, 52 lots for normal cars, 5 lots for 3.5 x 5.0 m handicap cars and 4 lots for 4.5 x 8.0 m handicap cars.

Parking lots size	3.5 x 5.0 m size	4.5 x 8.0 m size
1 - 9		1
10 - 25	1	1
26 - 50	1	2
51 - 75	2	2
76 - 100	2	3
101 - 150	3	3
151 - 200	3	4
201 - 500	4	4
501 - 1000	4	5

Table A.8.2: Numbers of parking lots for handicap cars

B | Technical detail drawings

B.1 Construction details

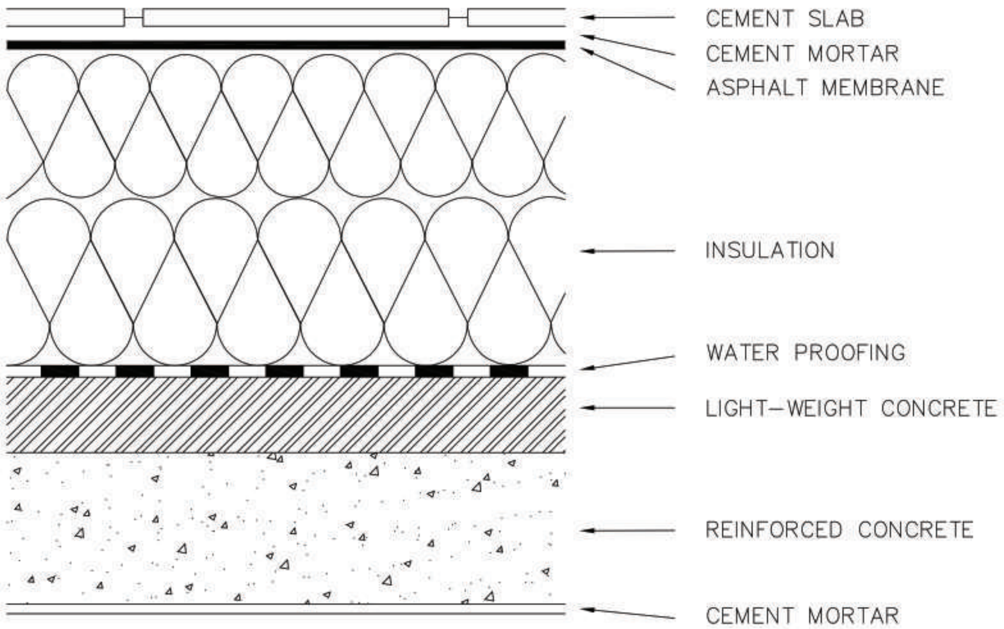

Figure B.1.1: Detail of roof construction, scale 1-10

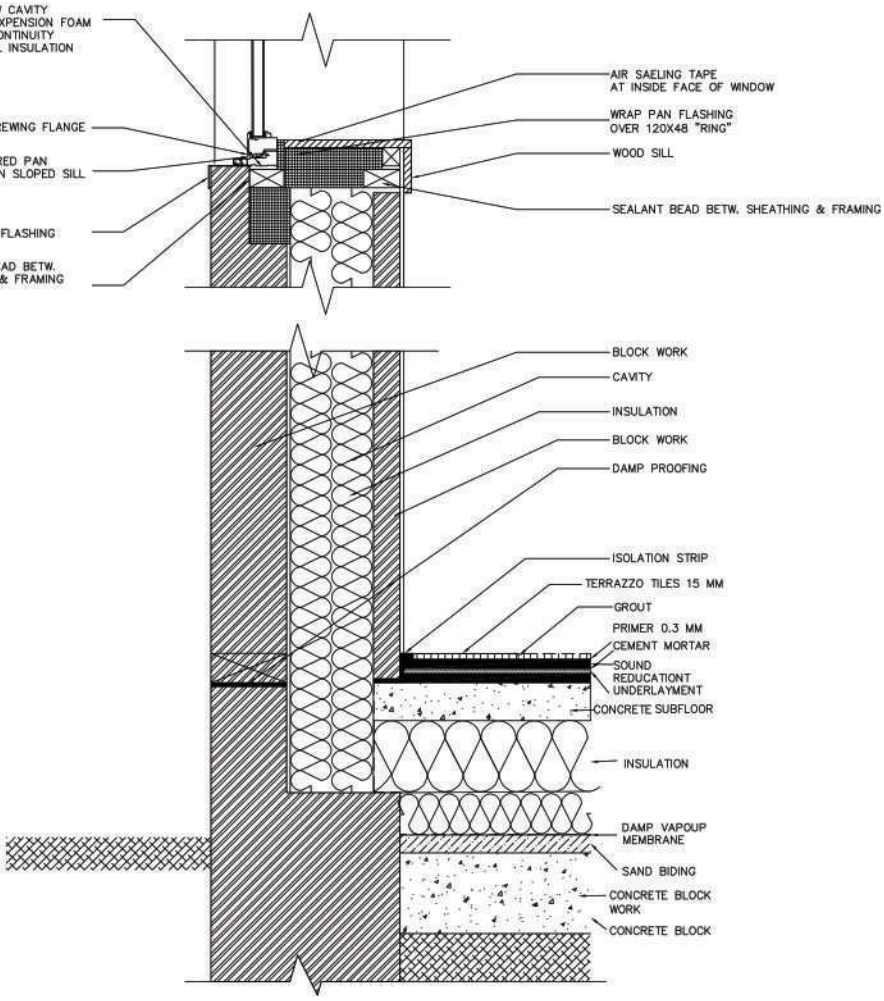

Figure B.1.2: Detail of window installation, outer wall and foundation construction, scale 1-20

B.2 Koi fish pond in meditation area

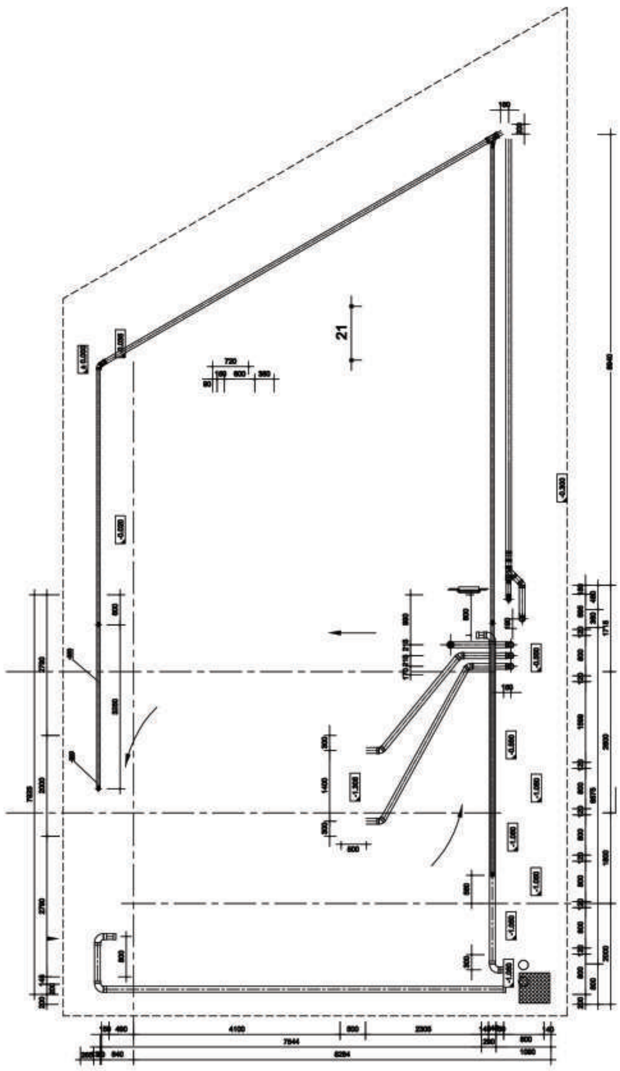

Figure B.2.1: Pipes installation in koi fish pond, scale 1-150

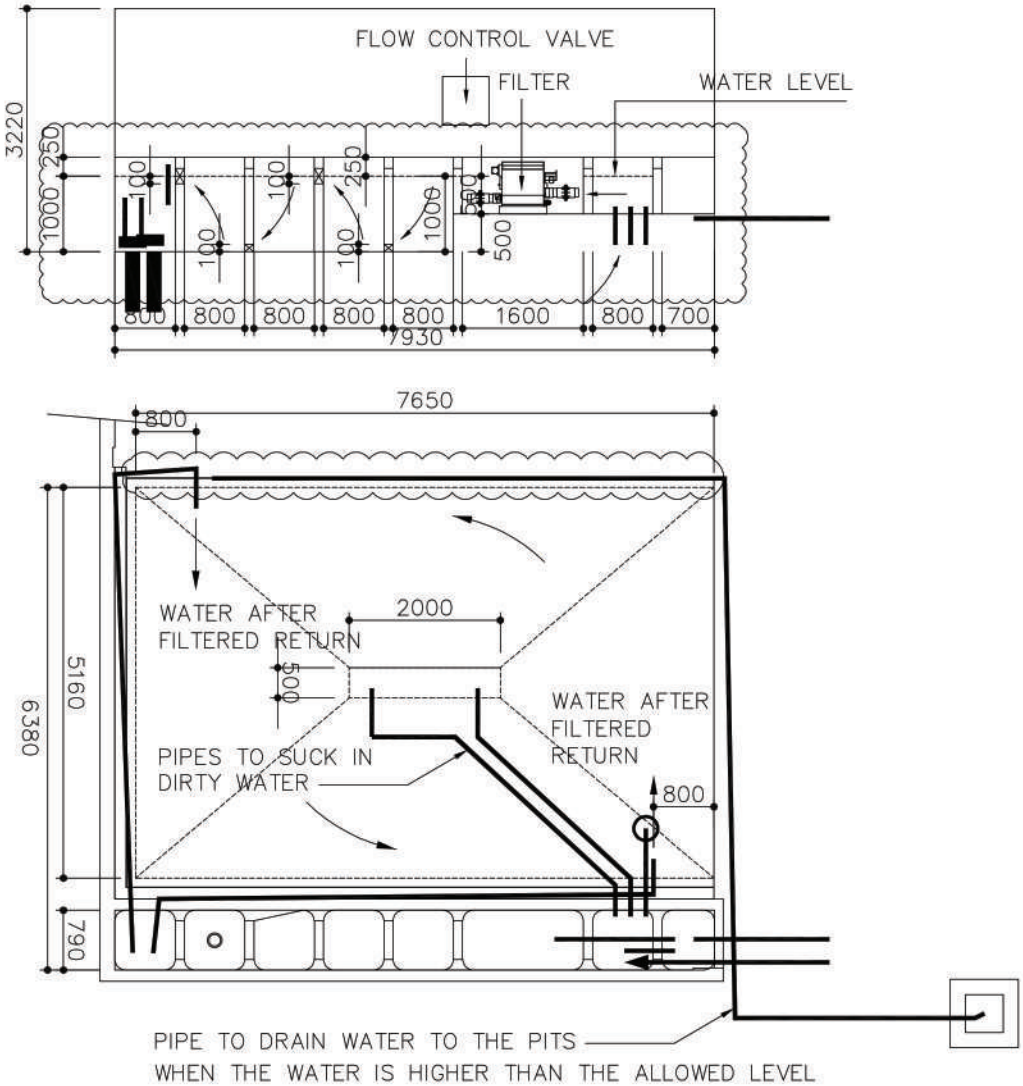

Figure B.2.2: Principle of filtering water in the fish pond, scale 1-200