MASTER

# Hospice the lighthouse
natural ventilation a home for end-of-life-care

Hofstra, F.F.

*Award date:*
2014

# HOSPICE THE LIGHTHOUSE

natural ventilation in a home for end-of-life-care

Folkert Hofstra
Master program Architecture Building and Planning
Specialisations Architecture & Building Technology
2013 — 2014

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# GRADUATION REPORT

Hospice The lighthouse: natural ventilation in a home for end-of-life care.

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August 2014
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# PREFACE

This master thesis is the result of my graduation project in the master Architecture Building and planning at Eindhoven University of Technology.

The combination between architecture and building technology has always appealed to me throughout my study. I choose this graduation studio for its focus on both the atmosphere and the practicalities in healthcare architecture.

I would like to thank some people that helped me at various stages in my graduation project. First of all, thanks to my tutors Jeanne Dekkers, Maarten Willems and Chris Geurts, for their insights, tips, comments, critiques and compliments.

Thanks to the staff at Cadenza hospice in Rotterdam, who are doing a great job in helping their patients, and who helped me in understanding the daily life in a hospice.

Thanks to the people that helped me with their various specialisations. Marcel Loomans with ventilation in the building, Ben Bronsema with the solar facade, Leo Gielen with the detailing.

Finally, I am thankfull to those who supported me during my graduation project and the rest of my study. My friends and fellow students, my roomie Fabian. And my family for their support and my girlfriend Maureen who was always there for me.

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# ABSTRACT

Due to the ageing population and budget cuts on elderly care, an increasing amount of people are staying at home as long as possible. This is usially the prefferable option for both patient and family. However, when their conditions worsens sometimes the family cannot provide the necessary care anymore. In these cases palliative care can relieve stress from the patient and their relatives. In a facility for palliative care, a hospice, everything is focussed on providing maximum comfort for the patients in the last months of their lives.

These hospice buildings are often hidden in rural environments or on the outskirts of cities, to provide quietness and peacefulness for their residents. This way the hospice remains unknown and often scary to many potential patients and their family. By building a hospice on a prime location on the seaside in Scheveningen, the process of dying and grieving is given the place it deserves. Because of its location of the dyke, raised over the boulevard, the building offers privacy whilst being in the middle of the city.

An existing office building is stripped and transformed into a soothing and comforting environment for this vulnerable target group. The building is organised to facilitate different levels of privacy and publicness. The individual rooms are the most private spaces, furthest from the entrance. Through the common spaces and a transition cloister overlooking the garden people reach the separated entrance volume which is also used by out-patients and other visitors.

The building is focussed on the sea, to the north west. All patient rooms can boast of a panoramic view over the beach and the sea. Each room is fitted with an operable louvre that can be used to control the amount of daylight in the room. When closed, the louvres blend in with the facade to provide a sheltered environment. The building is clad with Corten panels in an interlocking pattern.

In order to take advantage of the solar radiation on the closed south east facade, a solar facade is applied to power the ventilation of the building. In the solar facade, air is heated by the radiation through the glass, This generates thermal draft which draws air from the building through the atrium. On the top of the solar facade a heat recovery unit extracts heat from the air to be used immediately or stored for use in the cold season. Fresh air is brought into the rooms through the facade, eliminating the need for ventilation ducts and ensuring abundant fresh air.

# SAMENVATTING

Door bezuinigingen op ouderenzorg gecombineerd met de vergrijzing blijven steeds meer mensen tot het einde van hun leven thuis wonen. Meestal is dit inderdaad het beste voor zowel de patiënt als de familie. Maar soms kan de familie niet de zorg bieden die hun geliefde nodig heeft. In deze gevallen is palliatieve zorg, zorg voor stervenden, een oplossing om de familie te ontlasten. In een instelling voor palliatieve zorg, een hospice, is alles erop gericht oom het de patiënt zo comfortabel mogelijk maken in zijn of haar laatste maanden.

Vaak liggen deze hospices enigszins verscholen in landelijk gebied of aan de rand van de stad. Hierdoor ontstaat geborgenheid en privacy voor de patiënt, maar het hospice blijft ook onzichtbaar en onbekend voor het grote publiek. Door het hospice te bouwen op een zichtbare plek aan de zee in Scheveningen krijgt het stervensproces een prominentere plek, die meer recht doet aan het belang ervan. Door de locatie op de dijk, boven de boulevard, beidt het gebouw privacy terwijl het midden in de stad ligt.

Een bestaand kantoorgebouw wordt gestript en getransformeerd tot een geruststelend en comfortabele omgeving voor deze kwetsbare doelgroep. Het gebouw biedt verschillende niveaus van openbaarheid. De persoonlijke kamers zijn de meest private ruimtes, gelegen aan het eind van de route door het gebouw. Door de gemeenschappelijke ruimtes en een kloostergang met zicht op de tuin komt men bij het entree gebouw. Dit wordt ook gebruikt door dagpatiënten andere bezoekers.

Het gebouw is gericht op de zee in het noordwesten. Alle patiënten kamers hebben een panoramisch uitzicht over het strand en de zee. Elke kamer is uitgerust met beweegbare luiken waarmee het daglichtniveau kan worden geregeld. Wanneer de luiken worden gesloten vallen ze weg in het patroon van Corten casettes op de gevel.

Om te kunnen profiteren van de zoninstraling op de gesloten zuidoost gevel wordt een zonnegevel toegepast o het gebouw te ventileren. In de zonnegevel wordt lucht opgewarmd door zoninstraling op de gevel, wardoor de lucht stijgt. Hierdoor ontstaat thermische trek waarmee het gebouw wordt afgezogen. Bovenaan de zonnegevel wordt de warmte uit de lucht gehaald door een warmteterugwinningsinstallatie. Deze warmte kan worden gebruikt voor tapwater, of opgeslagen door middel van een WKO installatie voor gebruik in het stookseizoen. Verse lucht wordt in de kamers gebracht door roosters in de gevel Hierdoor zijn geen aanvoerkanelen nodig en beschikt elke ruimte over een overvloed aan frisse lucht.

# 1

# INTRODUCTION

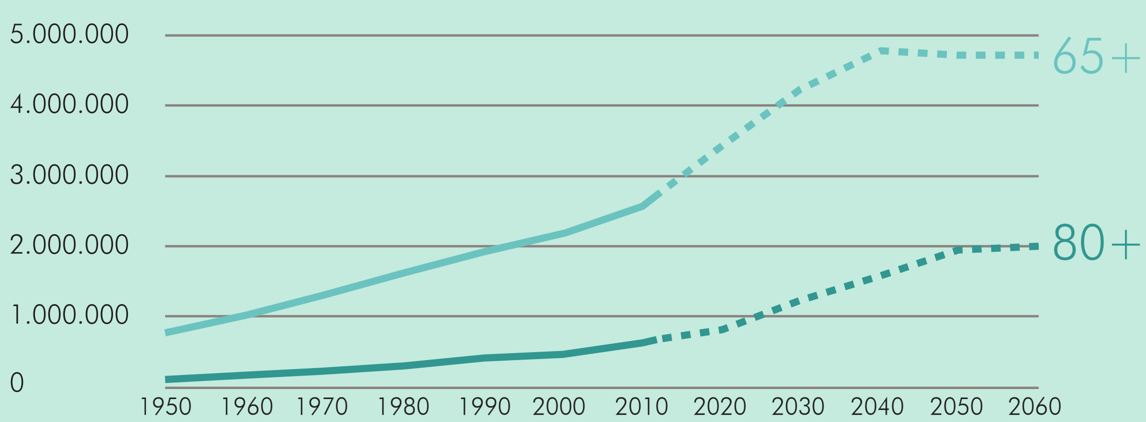



fig 1 *Percentage of elderly in the Dutch population, from 1950 till 2060.*

## 1.1 SENSE AND CARE RESEARCH

The graduation process which led to this report started with a three month group research in the graduation studio Sense and Care at Eindhoven University of Technology. In this studio, led by Professor Jeanne Dekkers and Maarten Willems, a team of 14 students studied healthcare architecture in the Netherlands, with a special focus on the sensory experience of healthcare architecture. The results of this research were bundled in a book which can be used for further reference on this topic.
The research consisted of two parts: a theoretical study on the history of health care architecture in the Netherlands as well as current developments, and a case study of recent healthcare architecture compiled in a practical handbook for designers. Both studies were used for the theoretical background in this graduation report.
This preliminary research was meant to get firm understanding of the topic before every student defined an individual design task in the field of health care architecture.

## 1.2 AGING POPULATION

A main observation in the research was the strong change in elderly care we are currently witnessing. After the Second World War, a baby boom caused a massive population increase in the Netherlands. Strong economic growth combined and a large workforce allowed for a system of social security to be installed. Housing for elderly was a major part of this transformation. For the first time, all elderly were able to get a decent pension and housing, funded by the government.
However, the last decades the population growth is declining. With the baby boom generation now approaching their pensions, the amount of elderly is increasing. The number of people over the age of 65 is expected to double in the next 25 years.[1] Next to this, the present day elderly are different from the elderly 50 years ago. They have had a good job most of their life, and they have gotten used to a certain level of luxury and comfort. They don't want to go to a traditional retirement home. These elderly people are more assertive and anti-hierarchic. They want to determine their own lifestyles. They are self-conscious and individualistic, but also involved with society and internationally orientated. Furthermore, recent research by medical delta shows that the elderly do not want to leave their house. 95% of them are satisfied with their current house.[2]
These two developments mean that a drastic change in elderly housing is already happening. More and more elderly are staying in their own house as long as possible. In 2000, 80% of people over 80 still lived in their own house; in 2010 this had already increased to 86%.
With a few modifications to the house, people with minor issues can continue to live at home. However, for some people there will come a time when even this is no longer feasible.
When people living in a retirement home get ill, they can have medical care in the complex.

1. CBS Bevolkingsprognose 2012-2060
2. College Bouw Zorginstellingen, De hitte de baas, p. 9

People living at home need to stay in a hospital, or temporarily move to a nursing home during their treatment. The big question for these people is what to do when treatment is no longer possible. The majority of people can spend their last days in the protective environment of their own house. This is the ideal situation, both for patients and family. However, sometimes it is just not possible to stay at home, or to go home from the hospital when treatment is over. People probably need 24 hour medical attention, or specialist care that family and other volunteers cannot give. They either lack the capability, the time or the energy to completely dedicate their life to their dying relative. Staying in a hospital or large scale facility is not an option for these patients. With more people staying at home longer, the size of this problem will increase in the coming years. This type of care is called hospice care.

## 1.3 CASE STUDIES

The second part of the Sense and Care research focused on the sensory experience of healthcare architecture. Six recent examples of health care buildings were visited and analysed regarding the design of five main spaces. For each of these spaces, a number of recommendations was given regarding the sensory design of the space. Each space was analysed separately for each of the four senses. The results were combined into a sensory diagram for the space, revealing the impact each sense has on the experience of that particular room. It is striking to see that the experience you get from one sense can be so different from another sense. The research also confirms the visual dominance in our everyday life. Seeing is a sense you simply cannot ignore, so the visual experience of a room will have a strong influence on the overall experience.
The spaces that were analysed are the entrance, the corridor, the individual space, the common space and the common outdoor space. These functions were chosen because they are always used in a care center, no matter what size. This means the recommendations can be used for any health care building. The recommendations are represented using a number of diagrams.

## 1.4 INDOOR CLIMATE

The preliminary research has defined a very specialist target group for this design challenge. One important aspect is designing for such a vulnerable group is the indoor climate. Each summer when temperatures are rising, we hear alarming reports on rising numbers of deaths among elderly and in nursing homes. Elderly are more sensitive to extreme temperatures. These have to be avoided.

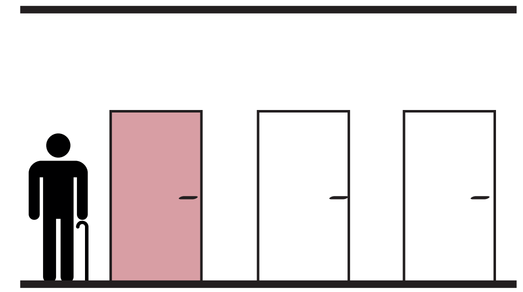


fig 2a *Clearly marking of doors used by patients*

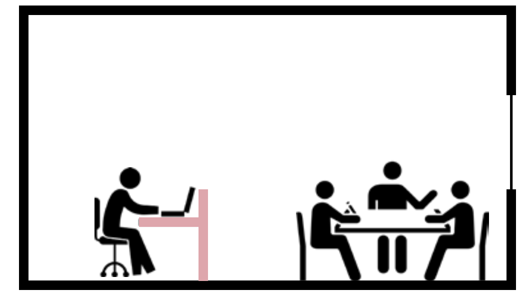


fig 2b *Having multiple zones in the common spaces*

fig 2c *Buffer zone between corridor and private rooms.*

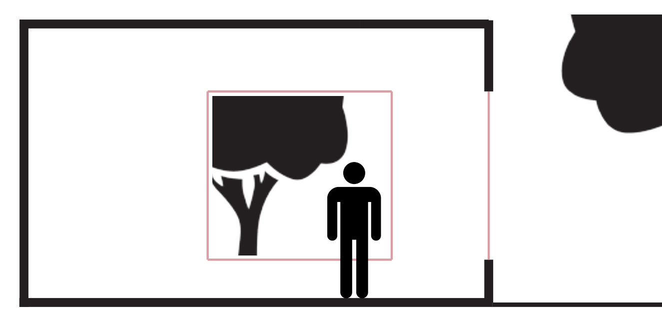


fig 2d *Create a strong relation with the outdoors*

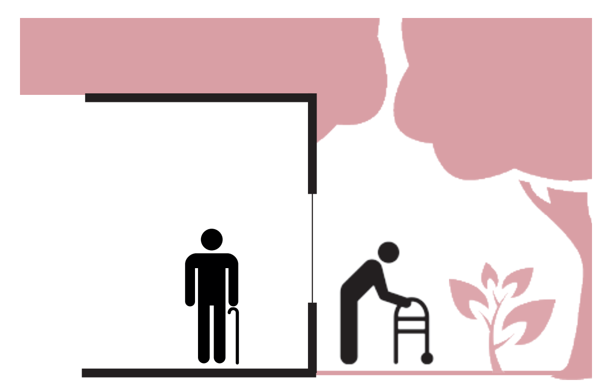


fig 2e *Easy access to outdoor areas*

The usual method of preventing extreme temperatures is by using an air conditioning system to heat or cool the indoor climate and provide ventilation. However, users of the building often do not appreciate this indoor climate, even though it meets all regulations. People associate air conditioning with large public buildings and offices. It certainly does not match with the home-like atmosphere in a hospice. In their home, people want a connection with the outside, and the feeling of being in control. Research shows that users are more prone to accepting higher indoor temperatures in non-climatised buildings. In these buildings the indoor temperature fluctuates with the outdoor temperature. Users expect and accept this.[3]
This means the building should accommodate this individual control and connection with the outside, while maintaining a comfortable indoor climate. Rather than cooling the hot interior, the focus should be on preventing overheating and using the local climate. This is why the indoor comfort has been selected as a third key point in this design study.

## 1.5 RESEARCH QUESTION

The preliminary result on healthcare architecture and sensory experience, as well as a literature study on climatic design led to the following research question:

How can the design of a facility for palliative care provide a protected and comfortable environment for people in the last stage of their lives?

To help answering this question, a number of sub-questions have been formulated:

In what ways can various sensory experiences be used to create a protected, comforting environment in a hospice?

How can this hospice be designed to fully utilize the local climatic conditions to create a comfortable indoor climate, while minimizing energy consumption?

3. College Bouw Zorginstellingen, De hitte de baas, p. 9

# 2

# THEORETICAL DISCOURSE

## 2.1 HOSPITIUM

The word hospice originates from the Latin Hospitium, which was a building where travellers could get food and shelter for the night. These were built along the major roads in the Roman Empire to provide a home away from home for everybody. In the Middle Ages, this task was taken over by the church, which ordered that all monasteries should offer help to people in need. This broadened the target group, also aiming at the ill and homeless. This evolved into the modern independent care facilities we know today. With each technological development, hospitals grew in size and scale. The modern hospice movement is a reaction to this, in a desire to go back to the original function of the hospitium: taking care for people in need. It became clear that there was a need for specialist care for people nearing the end of their life. This care is not meant for curing the patient, or even elongating the life of the patient. What is needed is space where people can come to terms with what is happening to them, where they can spend time with their family without worrying about practicalities.[4, 5]

## 2.2 PRESENT

The goal of hospice care is taking away all the noise of daily life, to focus on what is really important. Hospice care is not just about physical care. It is just as important to help patients with their mental well-being.

Psychiatrist and pioneer in palliative care Elizabeth Kübler-Ross identified five stages that all patients have to go through after hearing they cannot be cured, as explained on the next page. These stages can intertwine or succeed each other. Some people take longer for specific stages, some people might not even manage to go through all phases. One of the goals of the hospice staff is to help everyone to accept what is inevitable.[6,7]

Development of hospice care in the Netherlands has been slower compared to other western countries. But since late 1990's the number of palliative care institutions is rapidly growing. Today we make the distinction between high-care and low-care hospices. A low care hospice, also called bijna-thuis-huis (nearly home house) is a small scale facility, with usually 4-8 beds, where people receive only minor care. Mainly staffed by volunteers, these are truly a home away from home, often located in old villas. They focus on providing a comforting, homely environment for the patients, but they cannot accommodate patients with special needs.

The second category is the high-care hospice, which is usually larger, with up to 20 beds. These have more opportunities in care for patients with severe conditions. There are in-house therapists, nurses and a doctor.

Despite these different approaches, the goal of the hospice remains the same. By eliminating all the noise of everyday life, patients and family can spend their last moments together in a comforting environment which closely resembles a private house.

4. Meertens, 2011. De meeste mensen gaan hier dood, p.71
5. Verderber & Refurzo, 2006. Innovation in hospice architecture p.27
6. Meertens, 2011. De meeste mensen gaan hier dood, p.36
7. Van Vliet, Five stages of loss and grief

*fig 3* *Friedenheim hospice in London was set up in 1885 by Frances Davidson. Initially with eight beds, it later expanded to 35 beds, focussing on giving end-of-life care to tuberculosis patients in particular. Admission was free, but there were private rooms for people that could afford it.*

**"Dying is nothing to fear. It can be the most wonderful experience of your life. It all depends on how you have lived."**

*Elisabeth Kubler-Ross*



# FIVE STAGES OF GRIEF

**1. Denial**
*The first reaction when learning of terminal illness or death is to deny the reality of the situation. It is a normal reaction to rationalize overwhelming emotions. We block out the words and hide from the facts.*

**2. Anger**
"Why me? It's not fair!"; "How can this happen to me?"; "Why would God let this happen?"
*Once in the second stage, the individual recognizes that denial cannot continue. Because of anger, the person is very difficult to care for due to misplaced feelings of rage and envy. Anger can manifest itself in different ways. People can be angry with themselves, or with others, or at a higher power, and especially those who are close to them.*

**3. Bargaining**
"I'll do anything for a few more years."; "I will give my life savings if…"
*The third stage involves the hope that the individual can somehow undo or avoid a cause of grief. Usually, the negotiation for an extended life is made with a higher power in exchange for a reformed lifestyle.*

**4. Depression**
"I'm so sad, why bother with anything?"; "I'm going to die soon so what's the point?"
*During the fourth stage, the grieving person begins to understand the certainty of death. The idea of living becomes pointless. Things begin to lose meaning to the griever. Because of this, the individual may become silent, refuse visitors and spend much of the time crying and sullen. This process allows the grieving person to disconnect from things of love and affection, possibly in an attempt to avoid further trauma. Depression could be referred to as the dress rehearsal for the 'aftermath'. It is a kind of acceptance with emotional attachment. It is natural to feel sadness, regret, fear, and uncertainty when going through this stage. Feeling those emotions shows that the person has begun to accept the situation.*

**5. Acceptance**
"It's going to be okay."; "I can't fight it, I may as well prepare for it."
*In this last stage, individuals begin to come to terms with their mortality or inevitable future, or that of a loved one, or other tragic event. This stage varies according to the person's situation. People dying can enter this stage a long time before the people they leave behind, who must pass through their own individual stages of dealing with the grief. This typically comes with a calm, retrospective view for the individual, and a stable mindset. This phase is marked by withdrawal and calm.*

## 2.3 CHILDREN AND YOUTH

Most patients in a traditional hospice are elderly. These are the largest target group, so traditional hospices are most fit to their needs. For other ages, there are only a few alternatives. Several children's hospices exist. These are a little different in their intention. They are not necessarily meant as a place to pass away, but more as a refuge, where children with a terminal disease can stay to take some stress away from the parents. It is quite common for children to stay in a children's hospice for a couple of short periods rather than the last months. These hospices are aimed at young children, until the age of 12.
There are currently no facilities for older children and youngsters. Adolescents need a place for themselves, and ill adolescents are no exception. They want more freedom, to hang out with friends. They are ready for a bit more distance to their relatives. This group is currently not served by hospice care. They are too old for a children's hospice, but they would not be happy amongst only adults and elderly. A specialist youth hospice seems like a missing link.
By combining both elderly and youth in a hospice while maintaining a level of separation, both user groups can benefit from each other. The youth can use common facilities like treatment rooms. The elderly meanwhile will benefit from having something else than just elderly in their vicinity. Visitors from both groups might overlap, with youngsters visiting their grandparents spending some time with the younger patients.

## 2.4 FUTURE

Given the fact that modern day hospice care originated in the US and UK, it makes sense to look at state of the art hospice care in those countries in order to see the future of hospices. Both the public opinion and the professional care in those countries are more used to palliative care. A stunning fact is that in The Netherlands, over 60% of the people do not know what palliative care is. [8] Of the people that do know, quite a lot still have negative connotations with the term, identifying it with death and sadness. It turns out that the best way to change the public opinion is to let the public get in touch with palliative care. A vast majority of people that do have experience with hospice care greatly appreciate it. Improving the image of palliative care is important in improving the care itself. Hospice staff indicates that sometimes patients delay their intake as long as possible, whereas if they had come earlier, the quality of life in the hospice could have been a lot better.
A number of other trends can be observed in new hospice design.



### Palliative daycare

In the UK it is quite common for patients that live at home to come to a hospice for treatment. This way they can use the facilities and speciality of the hospice, for example in physiotherapy and hydrotherapy. In the largest hospice in The Netherlands, Cadenza in Rotterdam, this was also tried when the hospice was built in 2008. But after a few years the therapy rooms where transformed into patient rooms. It turned out that coming to a hospice was still one bridge too far for most patients. However, with the aging population and the budget cuts on nursing homes, it seems that palliative day care in hospices is inevitable.
According to British health care think-tank The Kings Fund, 'The role of day care in hospices is to provide advice, support and care when and where needed for the referred patient and their family or carer.'[8]

### Complementary Care centers

Modern care centers go one step further than just giving physical care to their patients. Complementary care centers, especially in the UK, also provide, information sessions for family members of patients and bereavement counselling for people who lost a relative. This can be family members of former patients, but the counselling is also meant for people that lost a relative elsewhere. The expertise of staff in the hospice is used for trainings and seminars for other care workers and volunteers as well.[9]

### Expressions of remembrance

The acceptance of hospice care always had to deal with denial and evasion of death. As the process of dying is less and less hidden, remembering past patients is becoming more and more important is hospices. People are acknowledging that even though the patient's life is over, the hospice can still offer help with letting go and accepting.[10] The times where the patient's body would be quickly and anonymously taken out are over.

8. The Kings Fund, Principles of Hospice Design, p. 8
9. Verderber & Refurzo, 2006. Innovation in hospice architecture p.140
10. Verderber & Refurzo, 2006. Innovation in hospice architecture p.138

fig 4 *Grand cafe at hospice Cadenza, Rotterdam*



## A DAY IN THE LIFE

Everything in the hospice is aimed at making the patients feel comfortable and at home for the short time they live in the hospice. People can come when their life expectancy is less than three months. Some people pass away within hours after they arrived, and very occasionally someone makes a miraculous recovery and goes home again, but on average people stay for 30 days.

The patients are free to decide whether to join any activities. Often this correlates with their stage of grief acceptance. Some people come to the hospice being fully aware of their nearing end, and they want to make the most of their last days. For these people there are music sessions, arts therapy and bingo evenings: the type of activities you would find in any nursing home. Patients that are physically capable can participate, sometimes with their family.
There are also patients that have more difficulties with accepting their fate. They might want to stay in their room, alone or with family members. It even happens that people come to the hospice unaware of their oncoming death, because their relatives were scared of telling them.
The beauty of a larger high care hospice is that you are likely to have multiple types of patients. The ones that want to socialize can do so, and there is plenty of space for them not to bother the people that want to be left alone.

Many people want to get out of bed every day, as long as they can. Getting dressed and eating at the table are simple rituals but they give the patients so much more dignity. Meals are prepared in the living room, by staff, volunteers or family members. The simple notion of being in a living room, where food is prepared which the patients can see and smell is so much more appealing than getting a pre-made meal form an anonymous cook in the basement.
In the beauty salon and hair dressers, the patients can completely escape the idea of being sick for a while. It truly feels like going for a day out for most of them.

The fact that death is so common in a hospice can also help the patients in accepting their own death. Patients say that the sight of a hearse at the entrance can be disturbing at first, but it also helps if you know what will happen to you after you die. In hospice Cadenza, deceased patients are not taken through the back door but escorted to the hearse through the main entrance, with the staff forming a guard of honour. Death is not hidden, it is treated as it is: a part of life.

The strong appreciation of hospice care in general is illustrated by the low amount of euthanasia in hospices. Despite the fact that dome patients arrive with a death wish, the excellent care and personal attention in hospice Cadenza made that only two patients where euthanized between 2007 and 2012.[11]

11. Meertens, 2011. De meeste mensen gaan hier dood, p.50

## 2.5 HOSPICE ARCHITECTURE

A literature review on end of life care shows that the vast majority focusses on the care itself, and only little attention has been paid to the design of the surrounding for people who are dying. Nevertheless a number of publications could be found to provide design recommendations and help formulate programmatic demands.
'Innovations in Hospice Architecture', by S. Verderber and B. Refuerzo in 2006 is the most elaborate piece on architecture for palliative care. The book describes the growth of palliative care, gives design recommendations and studies a number of international case studies.
'Improving Environments for Care at the End of Life', published by The Kings Fund in 2008 focusses on themes from general healthcare architecture and uses this to distil information on hospice architecture.
'Principles of Hospice Design', published by The Kings Fund and The Prince's Foundation for the Built Environment in 2012 is the report on a design competition and workshops regarding the design of a new hospice. Using input by professionals from both healthcare and architecture they formulate a number of design recommendations for a hospice design.
All publications indicate the importance of a home-like environment with individual rooms. This is the main distinction between a hospice and many other types of health care architecture. The home-like atmosphere is in fact the very reason hospices exist.

## 2.6 ATMOSPHERE

A number of recommendations regarding the layout and atmosphere in the building can be taken from these publications. In addition, a visit to Cadenza hospice in Rotterdam helped shaping ideas for the new hospice design.

### Natural environment

Every room in the building should have close relation to the natural environment. And even within the building, natural elements like plants or a water feature enforce the relation with outside. It has been shown that natural materials have a profound effect on patients. Research shows 'Patients who were exposed to pictures of nature in the hospital suffered fewer signs of stress: patients who could look through a window at trees rather than at a brick wall were able to leave the hospital faster and suffered fewer complications.'[12] The natural environment should continue inside the building, with simple, robust, natural materials.

12. Dorris (1993), Health Trends, Architecture, 82, p.93



fig 5 *Axlagarden hospice in Sweden (1989) is a fine example of a hospice in natural setting. Located on a hilltop, it offers both beautiful views and easy access to the garden.*

### The elements

Wherever possible, rooms should be naturally lit and ventilated. This has influence on the size and positioning of windows and the HVAC-system. This will be further elaborated in a subsequent chapter. It also means that the indoor climate should be adjustable by the patient.

### Arts and crafts

Art takes an important place in any healthcare building. It is often used as therapy and day-time activity. Works of art, whether made by residents or professional artists can enlighten a room and create a certain atmosphere.

### Legibility

An important issue is the organisation of public, semi-public, semi-private and private spaces. The personal room is the most private room in the hospice. It is followed by a series of increasingly public spaces. The architecture should guide this process, and help people identifying when they are entering (semi-)private spaces.

### Company and solitude

Emotions in a hospice are often more intense. There is intense grief, but also happiness, anger or relief. These emotions might exist very close to each other. Therefore the architecture should facilitate these different emotions without being obtrusive. There are times where people want to meet each other and times when they don't, and both should be accommodated.

# 2.7 SPATIAL RELATIONS

The hospice is completely patient-focussed. Everything is done to make the patient feel as comfortable as possible, and to support them in every possible way. The wishes of the patients should therefore be defining, not only in the day to day operation but also in the architecture and organisation of the building.

An important characteristic of the hospice is the small scale, anti-hospitalist approach. This matches with the sought after homely atmosphere, but it can conflict with the desired facilities and therapy spaces. Therefore the rooms are divided over multiple living groups with 6-8 rooms. In these groups one can get the personal attention and small scale of a low care hospice, but with the facilities of a high care hospice. The same principle is used in the youth department, which is separated from the adults groups but still uses the common facilities. There will be in total three groups for adults and one for youngsters.

The most important room in each group is the personal room of the patient. This is where they spend most of their time, where they can retreat to and get family visits. The room is in fact a small home, with all the comfort the patient would have at home. There is a bed, a sitting area and a personal bath room.

An important starting point in the layout of the hospice is the relation between private and public spaces. The personal room is the most private space in the hospice. Starting from the personal room there are a number of rings with increasing publicity.

From the personal room, one can go to the common living room. This is where patients can stay when they are strong enough, and in the mood for company. The staff and volunteers organise activities, there is a sitting area with TV, a ding area and a kitchen. The living room is also a meeting space for large families. The living room should have a direct relation with the outdoors. It acts as the heart if the group, centrally located between the personal room and the other functions.

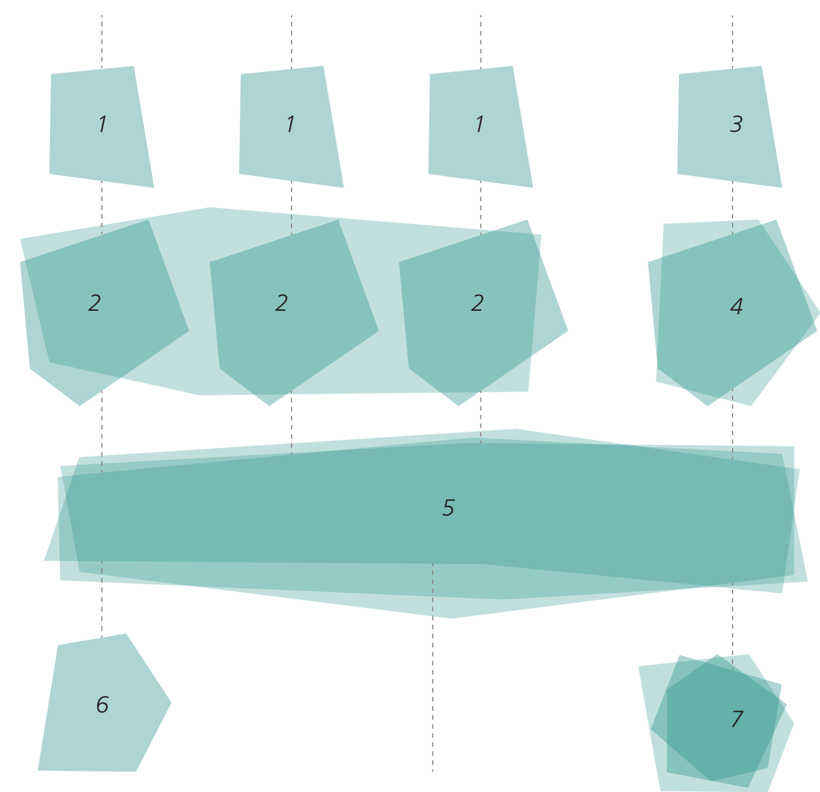
In addition to the living room, there are a number of other relaxation spaces in the living area, like a library, a meditation space and chapel and a multifunctional rooms. These are likely to be used on a irregular basis, but should still be easily accessible for all patients, any time at all.

Each group also has a number of supporting functions, like a nurse station, a bedroom for family members and a number of storage spaces.

The different groups get together in the centrally located 'grand cafe'. Located near the entrance, this serves as waiting area and informal meeting space. The cafe leads to the treatment rooms also used by outpatients. It also leads to the staff area which is separated from the patient areas. In the staff area, there are office spaces, meeting rooms, training rooms and a staff canteen.



A very unique function in the hospice is the grieving room. This is where deceased residents can be laid out for visitation until cremation or funeral. Including this function in the hospice can ease the grieving process for their relatives. People that pass away at home are often laid out in their own house, so why should this be different for people that lived in the hospice. It also allows the family members to say goodbye to the staff with whom they might have connected strongly. Staff can also help them with the grieving process. Nonetheless the grieving rooms should be somewhat separated from the living areas, to avoid all to confronting situations. The goal is to facilitate encounters, but not force them. Therefore the two grieving rooms get a separate entrance and a private gathering space.




*1 — private rooms*
*2 — common room*
*3 — youth private rooms*
*4 — youth common room*
*5 — shared entrance and facilities*
*6 — grieving rooms*
*7 — treatment spaces*

fig. 6 *Spatial relations between the different areas in the hospice, also showing the level of publicity in each area.*

## 2.8 LOCATION

The design of a new hospice starts with the selection of a location. Many hospices are found in rural areas, or on quiet peripheral locations in a city. This makes sense from a patients point of view. As mentioned before, a natural environment offers quietness and place for relaxations. It does not however contribute to the recognizability of hospices in general. Because of this secluded location, many people will never get familiar with a hospice. Only when they themselves or a relative are taken in will they be confronted with the hospice. This is during a time awash with emotions. It would be better to introduce the hospice as a normal element of the built environment, just like death is an essential part of life. Patients will feel more included in society, rather than being tucked away on a hospital site or in an anonymous building.
This has a number of consequences for the location of the new hospice. It should be a place in the city, in the middle of life but surrounded by nature.

This location was found on the seaside in The Hague, in the old fisherman's village of Scheveningen. A few hundred meters west of the old village centre and one kilometer from the main tourist center, the site is easily accessible and very visible. Residents in good shape can visit the beach or even the old village.
The location is dominated by the beautiful view over the North Sea to the north-west. The location has an unrestricted view over the beach and the sea. The flood line is around 250 m from the building. To the southeast the site is bordered by a large nursing home, blocking any views in this direction. It means the site is very much mono-directional. When visiting the site, everyone's view gets pulled towards the sea. Because of the location on the dyke and the design of the boulevard, the site is raised over the boulevard and the beach. This means that even during busy summer days, the location offers relative quietness. The location on the end of the boulevard also contributes to this.
Despite the busy surroundings, the proximity of the building is very quiet. It is located at the end of the Vuurtorenweg, a small residential street on the dyke. To the northeast, a small square houses the characteristic red lighthouse, dating back from 1875. This square is lined with six one story houses which were built to accommodate lighthouse staff. The square and the houses also act as a boundary, separating the site from the rest of the dyke. The lighthouse is currently not in use, though there are plans to reinstate it, as an element of the history of Scheveningen. The site includes a small park to the southwest with views to the lively fishing harbour. This park is also raised over the boulevard, and hidden for passers-by. Only a little-used footpath runs along the building.


fig. 7 *Map showing the location of The Hague in The Netherlands and the location of the site in The Hague, 1:5000*

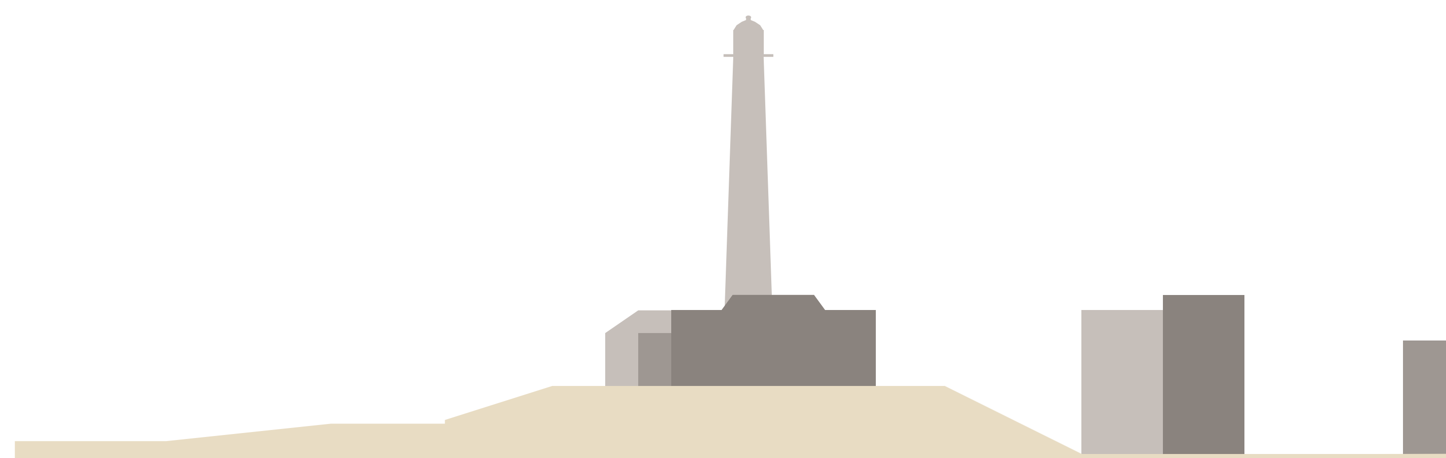


fig. 8 *Section NW-SE, showing the relation with the sea, 1:1000*

fig. 8 *View over the sea in Scheveningen, showing the coastline to the south and the piers of the harbour*

# 2.9 TRANSFORMATION

*Parts of this paragraph are based on research done with Fabian Vos for the masters course Methodology in architectural history and theory.*

The selected site is currently occupied by a former office building. This complex was built between 1972 and 1975 to house the State Lighthouse office and the State Pilotage office. The building is made in a typical 1970's functional architecture, clad with concrete gravel panels and reflecting gold glass. It is not a beautiful building, resembling a bunker, closed and uninviting. The office building is just one of many empty government buildings. The government is currently trying to rent or sell over 50 disused buildings, ranging from monumental villas to old bunkers to massive office towers.[13] The Dutch government is not the only party with too much office space. Vacancy of office buildings is an increasing problem in the Netherlands. Until recently, the market for office buildings in The Netherlands was based high demands. Investors and developers could afford to build large office blocks without a lot of attention for renters, because they would rent it anyway. Large office parks were constructed at prime locations near motorways. Everybody in the market benefited from this situation. Investing in real estate was seen as a solid investment. Investors were rewarded with high returns, developers received rent, local governments sold building lots and renters got a shiny new office building. This meant that it was not the true demand for new buildings that drove this construction cycle, but the financial stimulus for the parties involved.

In the current financial crisis, many companies have had to let people go, and the demand for office space has plummeted. Research by Twente University, VU University and StedenbaanPlus shows that the national office vacancy reached a record-high of 15%, locally up to 30%.[14] This is 7 million square meters of office space that is not being used. And it does not look like this is about to change, for a number of reasons. Firstly, a lot of companies are still occupying buildings that are too big for them, because of long term rental agreements. This free space can be filled before the company needs a new building. Secondly, the way we work is changing. 'The modern worker doesn't want to spend his time on an industrial estate. Workers want to travel by train, have a good lunch outside and go to the gym after work.' This observation was made by cultural historian Leon van Meijel in NRC.[15] This means that a lot of vacant office buildings will not be rented again. And the longer the vacancy, the less likely it is that the building will be rented again. This calls for solutions to deal with these disused buildings.

13. Rijks Vastgoed- en Ontwikkelingsbedrijf. Aanbod
14. Geurs, K., Koster, H., Visser, G., 2013. Kantorenleegstand en OV-knooppuntontwikkeling in de Zuidelijke Randstad
15. Eigenraam, A., 2013. Leegstand van Nederlandse kantoren is hoogste van Europa.



fig. 9 *The former office building of the State Lighthouse office and the State Pilotage office is located on the coastal dyke at Vuurtorenweg, Scheveningen, The Hague.*

fig. 10 *The building is clad in concrete facade panels with gold coloured glass.*

The building in The Hague is a prime example of an office that totally unsuitable for office functions. However, its unique location means that the building could be transformed into a new function. Studying the building more closely can reveal its potential for redevelopment, and the problems that need to be solved to make this work.
A number of studies have been done to help distinguish the potential for transformation of office buildings. The ministry for Housing, Planning and Environment (VROM) conducted the study 'living at work' in 2006 to investigate the potential for apartments in office buildings. A study in 2011 by the Royal Institute of Dutch Architects BNA with Delft University focussed on transformation of office buildings into care buildings. Both studies developed tools to determine whether an office building is suitable for transformation. They also give valuable points of interest to keep into account during the transformation process. The checklist provided by BNA was used to evaluate the strengths and weaknesses of the building in The Hague.
This 'transformatiemeter zorg' defines the main problems of the building as the bad state of installations, the poor sound and heat insulation, the complicated layout and the poor entrance area. See the appendix for the full specification of the strength and weaknesses analysis.
The building was constructed in three phases from north to south, replacing a former office from the 1930's. The building was meant as an office building with storage space for two independent government agencies. This has lead to the cluttered layout with many different sized rooms and various technical spaces. The main entrance is very small and inconspicuous.
The building is shaped around a courtyard which was used for storage of vehicles and equipment. The building is characterized by the slanted corners and many edges, making for a very complicated interior.
The building is made of poured concrete slabs with columns in the facades and some interior points. The southern part has a concrete core containing vertical transportation, services and storage spaces. The corridor surrounding this core is narrow and dark, without any daylight.
All facades are identical, clad with slightly insulated concrete panels by Durisol. These panels have 6 cm of insulation material in them. However, each joint between panels is a thermal bridge. The good thing is that these panels were prefabricated, and hung to the construction using bolts. This means they can easily be removed to strip the building of its facade.
The building appearance is not suitable for any representive function. The overall impression is that of a bunker, due tot the grey concrete facade, the relatively small windows and the slanted edges. It does not fit in with the rest of the area.

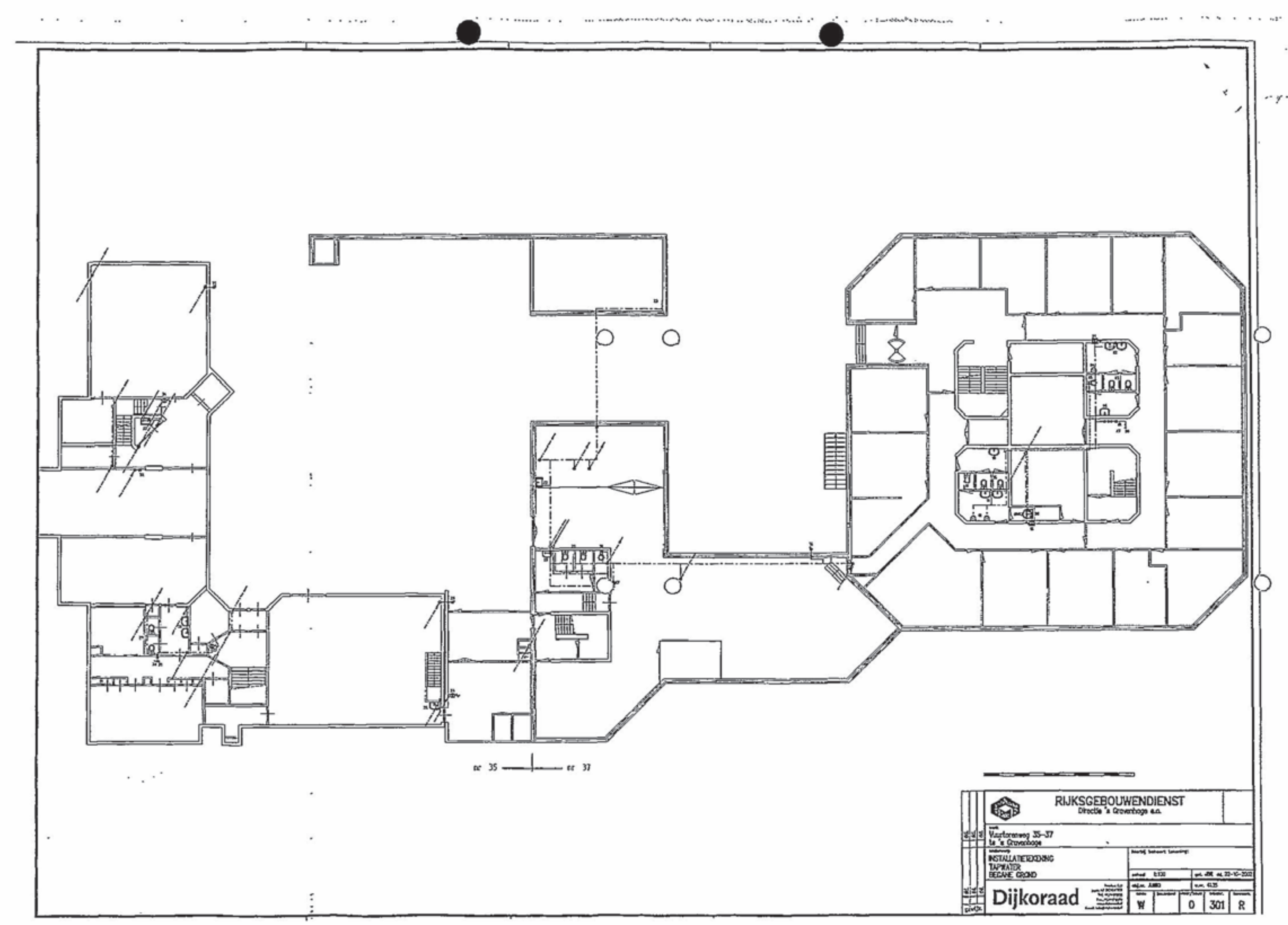



fig. 11 *Existing building, original floor plan of ground floor. Southeast is facing up.*

fig. 12 *The interior is dark, with no daylight and unclear routing.*

fig. 13 *The seaside location is by far the strongest element of the existing building. The only pleas space in the current building is not actually in th building, it is the roof terrace overlooking the se*

# 3

# LOCAL CLIMATE

## 3.1 LOCAL CLIMATE

The local climate has always dictated the way we live, our rhythm of life. Humans sought protection for the environment, first using clothing but soon using structures and buildings.
In hot climates, buildings were designed to block the heat and maintain a cool building. In colder climates, building design focused on compact structures that were easy to heat. In areas prone to strong winds the buildings were directed away from the wind and integrated in the landscape.[16]
It is only since the 20th century that we have collectively abandoned this age old knowledge in favour for a generic worldwide architecture. Due to technological innovations, we could now control the indoor climate no matter the outdoor situation. However, this caused a dramatic increase of energy consumption. It is time to go back to a situation where designing for a specific location also means designing for the local climate. Especially when building for a unique location like this seaside location.
The Netherlands has a maritime climate, strongly influenced by the sea. The climate requires winter heating and modest summer cooling, as well as varying responses in spring and autumn that require either heating or cooling. The Dutch seaside is known to receive the most sunlight in the country throughout the year. However, outdoor temperatures are generally lower in summer and higher in winter than in most of the country. Also, being on the seaside, the site is prone to strong winds. The presence of the sea also has consequences for the geology of the site and the soil conditions.
To identify these consequences, and help using them in the design of the hospice, the local climatic conditions were studied using data from the Royal Dutch Institute of Meteorology (KNMI). To know how these conditions can be used in the building design, a literature study was performed on climatic design. The study focused on on-site energy harvesting and design for solar architecture.

16. May, J. 2010. Building without architects, p.25

fig. 14 *Building for cold climates: iglu in northern Canada.*

fig. 15 *Building for hot climates: wind towers in Yazd, Iran*

fig. 16 *Building for strong winds: black house in Hebrides, Scotland*

## 3.2 SUN

Solar design is one of the most important factors in sustainable architecture. The amount of solar energy which reaches the earth is enormous. Every two minutes the sun gives the earth more power than is used worldwide in a year.[17] It is our main source of renewable energy, and the only source that can truly provide all the energy we need.
There are three ways currently used for harvesting some of the suns massive energy output: solar electricity, solar thermal and solar fuels. As solar fuel is based on using biomass, either fresh or fossilized, to transform solar energy, this research focusses only on solar electricity and solar thermal energy.

### Solar electric

The most well-known form of solar energy is solar electricity, harvested using photovoltaic panels. The energy can be used to power HVAC installations or for household use. The most current building element to place photovoltaic panels is the roof. A quick calculation shows that the 1600 $m^2$ roof of the existing building can generate electricity for 50 households when fully fitted for photovoltaic panels. This is a simple measure to harvest energy, but it lacks a connection with the architecture.
In recent years, the financial investment needed to include pv-panels has dropped dramatically. Standard pv-panels on a flat roof should be included in the building whenever possible, so they are hardly an expression of sustainability anymore. They are invisible, and merely a way of using otherwise empty space. The next challenge is truly integrating pv-systems in the design, for example in facades or glass roofs. This needs to be balanced against other solar energy harvesting methods, since sunlight can only be used once. Using pv-cells for sunshading is a good example, which combines the need for shade with the presence of sunlight.

### Solar thermal

Rather then transforming solar radiation into electricity, the sun can also be used to generate heat in the building. The use of thermal solar energy in buildings can be defined as either passive or active. Passive systems use only the solar energy, without additional energy input. Examples are greenhouses, which are heated by the solar radiation entering the glass box. It is very hard to quantify the use of passive solar energy. Essentially, all surfaces exposed to the sun absorb some of its energy. Even a closed surface like a flat roof absorbs sunlight, and will transmit some energy depending on insulation.
Active systems rely on additional energy-consuming components like circulation pumps, air blowers, optical concentrators and trackers.

17. Guzowski, M. 2010. Towards Zero-Energy Architecture: New Solar Design, p.15



**DATA**

***Sun hours: 1700 h/year***
***NL average: 1620 h/year***
***Average sum of global irradiation: 1055 kWh/m²***
***NL average: 1000 kWh/m²***

*[KNMI Klimaatatlas]*

### Passive thermal

Until the 20th century, solar design was a major factor in building design. A good orientation to the sun was the main way to realize a comfortable indoor climate. The facade, including the roof, was the boundary between inside and outside, the only protection against the harsh outdoor climate. This had of course consequences for the architectural expression of the building. With the development of air-conditioning, the importance of good thermal passive design decreased. However, the use of extensive HVAC installations has a negative impact on the indoor climate and electricity use. The building industry reacted in developing insulating, reflective glazing. This was just seen as an encouragement to use even more glass in the design. This lead to a separation between architecture and climatic design. With a more sensitive approach to passive solar design, we can once more utilize the free solar energy that reaches the building, turning solar irradiation into a good thing. Various methods use the principle of capturing solar rays for passive energy gain.

fig.17 *Active house in Lystrup, Denmark. The south facade features many windows to get daylight and warmth. Overhangs provide shade from the high summer sun. The remaining closed surfaces are used to generate solar electricity. The north facade is very closed, with only small roof lights were daylight is required. This shows that orientation is key when designing for solar architecture.*

## Heating in winter

This is the basis of solar thermal design. Allowing sunlight to enter the rooms when the warmth is needed, usually in winter months, and occasionally in other seasons. In periods when the internal heat production is sufficient, sunlight should be blocked to prevent overheating. This requires a good level of control over the sunlight. In summer, the sunlight should be blocked with blinds or screens, which conflicts with having a panoramic view.
Orientation is key to achieving optimal thermal benefits. To harvest as much heat from the sun as possible, the building should be open to the south to allow heating in winter time, while blocking sunlight in warmer seasons. The northern facade, which does not get any sunlight, should be closed to minimise energy loss through windows and openings. However, in the case of Scheveningen, the orientation will be dominated by the presence of the sea in the north west. Spaces facing this direction will see sunlight only in summer afternoons, so they cannot rely on solar heat alone to warm the space.

## Atrium as a buffer

Solar radiation entering through the windows into a room is only heating the air currently in the room. Fresh air still needs to be acclimatized using additional methods. A way of combining temperature regulation and ventilation is by preheating the ventilation air using solar radiation. This has been done using a glazed buffer zone between in exterior and interior climate. Fresh air enters this buffer space, essentially a glass atrium, and is heated by in incoming sunlight. During warm times, the sun is blocked from the atrium. In summer nights, the atrium acts as a chimney, creating a pressure difference to allow natural ventilation to cool the building.[18] The function as a buffer zone means that the temperature in the atrium is far from constant. It can be an intermediate space between inside or outside, it can be warmer during summer and it can be colder in winter. This conflicts with the sensitive elderly of the target group. It would mean that the atrium cannot be used to the full extent the entire year.

## Solar chimney

Essentially a combination of the tradition solar heating and the atrium is the solar chimney. This has been used for centuries in hot climates, creating thermal draft to ventilate the building. The solar chimney is based on thermal draft, creating an upward air flow. But rather than just using the internal heat production, in a solar chimney the outgoing air is heated with sunlight to increase the air flow. This technique is being used by termites to cool their underground structures.[19]
This seems like a waste of solar heat, since the warm air is set to leave the building. However, the vast majority of solar thermal gain takes place in the summer months, when the heat is least needed. When the incoming air is exposed to sunlight, the light would need to be blocked in the summer months and the ventilation properties could not be used. Therefore, the solar chimney is positioned at the end of the ventilation system. Heat is recovered for use in the building or stored for later in the year.

18. J. Kristinsson 2002. Integraal Ontwerpen - Vitale Architectuur, p.62
19. B. Bronsema, 2013. Earth Wind and Fire p.130

fig. 18 *The 'greenhouse houses' (2009) by KSWA architects in Culemborg include a greenhouse-like atrium which creates a buffer between inside and outside. In cold seasons, the atrium is heated by the sun to provide a warm semi-outdoor space. In summer, sunshading protects the atrium from overheating.*

fig. 19 *Lycée Charles de Gaulle (2008), by Ateliers Lion and Transsolar in Damascus, Syria. Solar chimneys are used to ventilate the buildings.*

## 3.3 SEA AND SOIL

The most defining characteristic of the location is clearly the sea. It would be interesting to see whether the seawater can be used in the buildings energy system. Everyone who has been to the beach on a sunny day in spring knows that the temperature of the seawater can be very different from the air temperature. In summer the water is cooler, in winter the water is warmer. This means that it is a shear endless potential source of heat and cold.
Heat extraction from seawater has been done before. A pilot project in Duindorp, which coincidentally is also located in Scheveningen, was opened in 2009 by housing corporation Vestia. It offers warm water for heating and hot tap water to 800 households. The sea offers warmer water in winter and cooler water in summer. The source of this energy is virtually endless; the total power output depends on the scale of the installation. The installation at Duindorp has a power output of 3000kW.[20] The amount of installations required means that this technique is only feasible on medium to large scale projects. In the case of the hospice, the installation could be shared with the neighbouring elderly care centre and the fish market.
The installation extracts heat from the seawater. The heat is transferred to a local network which distributes water of 11°C through the neighbourhood. Each individual household is equipped with a heat pump which increases the temperature to the desired temperature for Low Temperature Heating and hot tap water. In summer, the system can be used for cooling using the same principle. The system at Duindorp is able to cool to 5°C below the outdoor temperature.
The fact that the sea is an endless body of thermal energy also has a downside. You cannot store heat in the sea, it will instantly mix and dilute. This means heat which is gained in summer cannot be used in winter.

### Geothermal heat storage

A geothermal heat pump captures heat in summer and stores it in the soil below or next to the building. This energy is regenerated in winter to heat up the building. It uses the same principle as the seawater plant, but the main difference is that heat in summer can be stored rather than wasted. This makes that it is a feasible system for projects that gain a lot of heat in summer. First applications of geothermal heat pump systems were used in green houses, which harvest a lot of heat in summer and need a lot of heat in winter. This matches the thermal properties of the solar chimney.

There are two types of geothermal heat storage. Closed systems use a closed circuit of pipes filled with a cooling liquid which exchanges heat with the soil. These are often quite small scale projects, which can be easily scaled by adjusting the number of pipes. However, it is not very suitable for heat storage because of the small scale. Any ground water flows dilute the stored heat.

20. Agentschap NL, 2012. Project uitgelicht: Zeemeeuw fase 1



**DATA**

***Average yearly seawater temperature: 05 – 18°C***
***High (end of August): 16 – 20°C***
***Low (end of February): 03 – 09°C***

*[surf-forecast.com]*

In an open system, ground water is pumped up to exchange heat. There are only two holes, at a depth of up to 200 meters, one cold source and one hot source. Because of the deep drilling required these systems are generally larger, 150 kW on average, which makes them suitable for large housing projects or commercial buildings.[21]
Open systems are best suitable for heat storage because of the larger scale. They are also more economic than closed systems. Therefore it is the better option for this project. The hospice itself will not need the full capacity of the system, but it can be combined with the adjacent nursing home to take full advantage of the system.

Initial concerns that using geothermal heat storage on a location close to the sea would be impossible due to underground water flows proved to be unjust. At the depth at which the system operates the ground water flows are very limited. The North Sea is very shallow, which means that at a depth of 200 meters its effects are only small.[22]

21. Lente akkoord, 2013. Wko 3x beter
22. Koude- en Warmteopslag en Geothermie Benelux LinkedIn group, 2014

## 3.4 WIND

### Free-standing wind turbines

Traditional free standing wind turbines have the largest efficiency. They are not impacted by the unevenness of the urban fabric. They benefit from the higher wind speed at altitude. However, in urban locations this type is not really feasible because of its great visual impact. There used to be a wind turbine in Scheveningen, but it was shut down in 2013, and the city council does not allow new turbines in the urban areas.[23]
Due to the large local resistance that usually arises when wind turbines are being proposed, the use of such an installation will not be beneficial in the acceptance of the sustainable transformation of the building.
The most efficient way of generating electricity from wind is sea-based wind turbines that benefit from high wind speed at sea. New plans for wind turbines at sea are being developed, but this goes beyond the scope of this project.

### Roof mounted turbines

Because of increasing resistance to large free-standing wind turbines, as well as their large cost and visual presence, it is worth looking at alternatives to harvest wind energy in urban area's. Rather than placing the turbine on a tower, we could use other structures to place wind turbines at a certain height.
Turbines on the roof take advantage of the increased wind speed near the edge of the roof. Two types of turbines can be used in this situation. Horizontal Axis Wind Turbines (HAWT's) are essentially scaled down versions of the large wind turbine. This is the most efficient technology of turning wind power into electrical power. However, HAWT's cannot really cope with varying wind directions in the urban environment, and they don't take advantage of the vertical component in the wind flow over the roof. That is why Vertical Axis Wind Turbines (VAWT's) are the better option.
The VAWT's can be placed either in the middle of the roof or on the side of the prevailing wind direction. To take full advantage of the wind flow, the turbine should be placed at approximately 1/3 of the building height above the roof.[24] This means that the turbine will always be very visible on a low-rise building. In most cases, the yield will be higher on a high building, because the effects of other buildings are less. On this specific location this will not be such a problem, because the dominant wind direction is from the sea and over the dunes, which are all lower and relatively smooth.  However, just like photovoltaic panels on the roof, a roof mounted wind turbine like described here is not an integral part of the design. It is merely a technical device stuck to the building.

23. Gemeente Den Haag, 2014. Sloop windmolen 'Duinvogel' Scheveningen. Report of council meeting
24. S. Mertens, 2006. Wind Energy in the Built Environment



**DATA**

***Average wind speed: 14 knts***
***Probability of wind speed > 4bft: 65%***
***Dominant wind direction: WSW-SSW***

*[surf-forecast.com]*

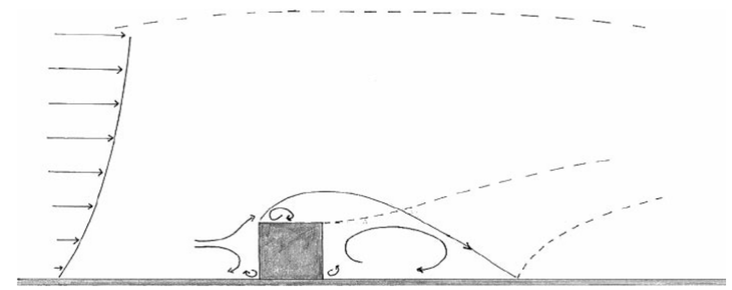


fig. 20 *Airflow around a building.*

### Building integrated wind turbines

Roof mounted turbines can never be fully integrated, because they need to be free standing. Integration of a wind turbine in the architectural design is very important, especially on such a prominent location. There have been some great examples, but success depends on the design language and context.
Building integrated wind turbines are an integral part of the building. Various techniques have been developed to make wind turbines less intrusive or even contributing to the architectural design. This can contribute to the acceptance of sustainable techniques.[25,26] However, integrating the wind turbine into the building usually limits its range. The design will be optimized for the most prevailing wind condition, but it will be less efficient in other conditions.

25. WINEUR, 2007. Urban Wind turbines
26. R. Dannecker and A. Grant, 2002.Investigations of a Building-Integrated Ducted Wind Turbine Module

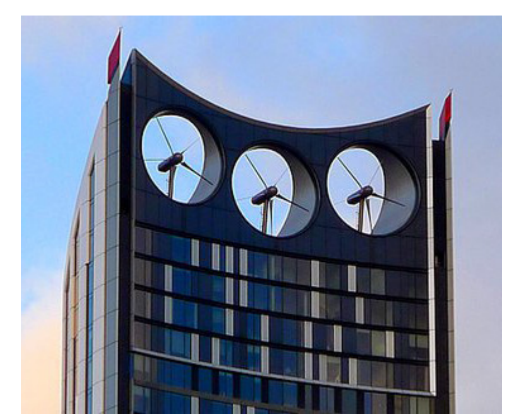


fig. 21 & 22 *Roof mounted VAWT's at Oklahoma Medical Research Foundation (2011) by Perkins+Will in Oklahoma, US, and HAWT's at Strata SE1 (2010) by BFLS in London, UK. Both systems are limited to a select wind direction.*

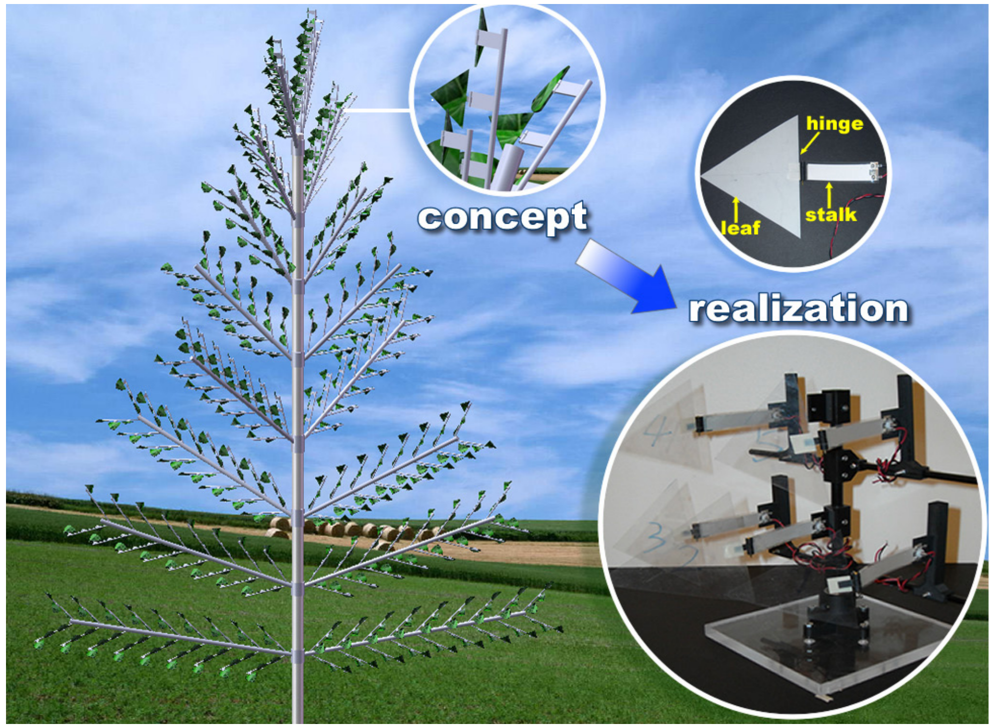



fig. 23 *Flapping leaf generator for wind energy harvesting, prototype by Cornell University*

**Piezoelectric energy harvesting**

A different technique that is currently being studied is piezoelectric energy harvesting. This method converts mechanical movement into electrical current. One study created a system of small plastic strips which, when moved by the wind, generate a small current. By using a large amount of these devices, for example covering a facade, you could potentially generate a substantial power output.[27] However, this technique has only been studied since the late 1990's, and it is not yet viable for real world application. It also has the same limitations as other building integrated techniques: the system needs to be designed to the most prevailing wind condition, and loses efficiency in other conditions.

In general, wind energy harvesting in the urban environment is hardly ever successful. The basic principle of wind turbines is that bigger is better. Higher turbines with bigger blades are most efficient in generating electricity. Urban wind turbines by default need to be small to limit forces on the building's structure, so the power-generation potential is limited. Secondly, wind turbines generate a lot of noise and vibration. That is fine in sea based wind parks. For land based wind turbines, resistance against the noise and vibrations is growing. In a dense urban environment, noise can be a real problem, and vibration endangers building mounted turbines.[28]

27. W. Hobbs & D. Hu, 2011. Tree-inspired piezoelectric energy harvesting
28. A. Wilson, 2013. Wind Power: Why it Doesn't Make Sense Everywhere



## 3.5 RECOMMENDATIONS

In the design of the new hospice, the indoor climate is paramount. The traditional solar passive house has glass facades to the south, to maximize gain of solar heat. However, blocking heat in summer to prevent overheating is most important. That is why openings need blinds, which would block the amazing view at the site. Openings to the north need no blinds and the view is never obstructed.

In order to fully utilize the sun that falls on the southern facades, a solar facade is proposed for the building. A solar facade is essentially a widened version of the solar chimney. This way the solar heat that cannot be used directly to heat the building can be used to create thermal draft and ventilate the building.

To make sure the energy harvested by the solar facade can also be used in summer, geothermal heat storage is applied to store the heat to be used in winter time.

Solar electricity generated by photovoltaic panels contributes to power needed for additional installations, as well as household use. Building integrate photovoltaics are an option, but the most rewarding façade is already occupied by the solar facade. Integration of the photovoltaic panels depends on the architectural design.

The advances in building integrated wind energy solutions are not yet ready to apply to this building. Even though the surroundings are pretty much ideal, with no wind blocking buildings in the prevailing wind direction, the relatively small size of the south western façade does not allow any substantial harvesting in the façade. Wind harvesting on the roof is possible, but the turbine on would be a very visible element in this three story building.

# 4

# ELABORATION OF THE DESIGN

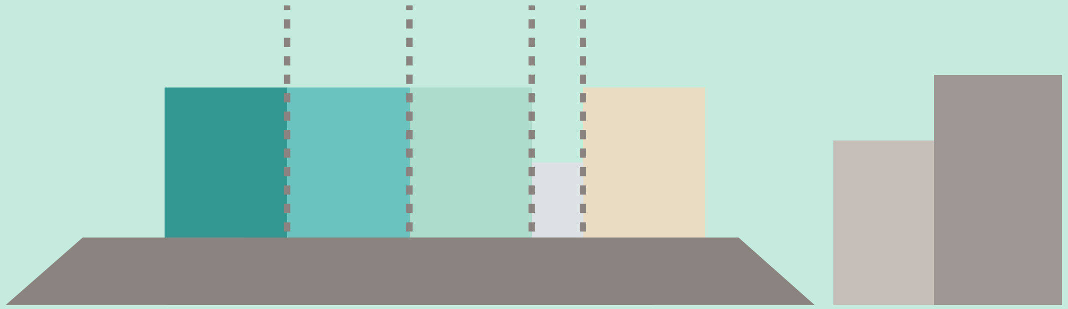


fig. 24 *Sequence of spaces ranging from the very private individual room, facing the sea, to the public entrance area with semi-public facilities*

## 4.1 CONCEPT

Just like the word hospice derives from the Latin hospitium, the design of this hospice is based upon the principles of a monastery. This is perfectly captured in the principle of the cloister, a long, rhythmic corridor facing nature. These walking spaces provide both privacy and meeting spaces. The distinction between meeting and retreating, between public and private, plays an important role. Therefore the hospice offers both place for meeting people and for casual encounters, but also for retreat and solitude.

The design will be based around the needs of the patient, and more specifically, the patients room. During the last phase of their life, the private room is the only place where the patients will go, so it must offer them what they need.

The unique location for this hospice dictates almost every aspect of its design. It is the main reason why people will choose this hospice, so it should be exploited in the best possible way. This means every private room should be aimed at the sea, providing an unlimited view of the horizon. Coming from the private room, the other functions are laid out in a sequence of spaces, each being a little more public than the previous.

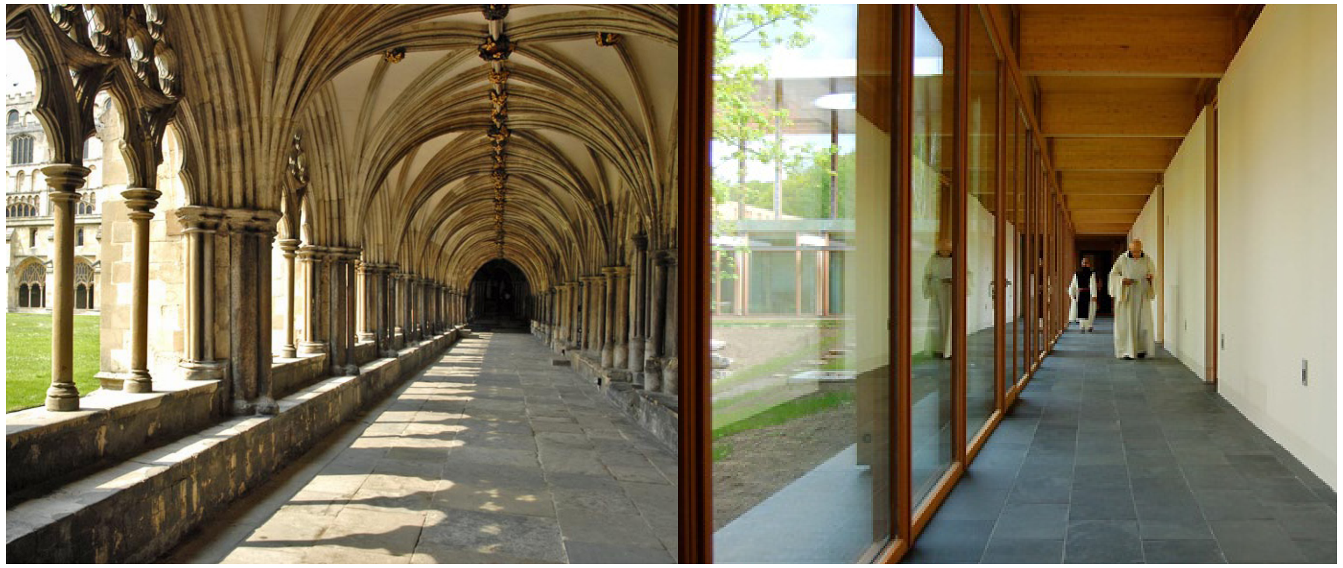


fig. 25 & 26 *Norwich Cathedral (1145) in Norwich, UK; Val Notre-Dame Abbey (2010) by Atelier Pierre Thibault in Saint-Jean-de-Matha, Quebec, Canada. Cloisters are characterized by a number of recurring elements. Orientation is one-sided, with one closed wall and one open, with a view to a garden. The open wall is very rhythmic, creating a rhythm in the corridor and a sequential view outside. The end of the cloister is often closed. The end can be dark or lighter, clearly visible as the end, but without it being clear what goes on beyond the corridor. This creates a notion of endlessness, the cloister always seems to continue around the corner.*

## 4.2 INTERVENTION

Analysing the existing building has already shown its weaknesses. Apart from the technical aspects, the main problem is the orientation of the building.

(I) The existing building faces inland. The U-shaped volume create a courtyard which has no access to the sea. It does not use its sublime location, the building has no connection with the sea. This makes that the building has no clear front or back side.

(II) By removing the middle part, the courtyard opens towards the sea. This also breaks the complicated internal layout into two distinct parts. The southern part is completely symmetrical, lacking any reference in the facade of where the sea is. The northern part can now be seen as two parts: one wing facing the sea and one wing facing the open courtyard.

(III) The two parts are connected again by a new third volume. This creates a sheltered court-yard, this time facing the sea. The new volume also has this great view.

(IV) By strategically positioning the entrance area in the connecting volume, the entrance becomes the transition between the seaside and landward side in two directions. This also clearly marks the entrance coming from the northeast. The main shape now shows the three parts described in the spatial relations program: the two living wings, separated and connected by the common entrance area.

(V) Removing excess building parts clears up the entrance area

(VI) The core of the southern volume is emptied to create an atrium. This both allows daylight to penetrate the building, and it creates a clearly structured interior, with multiple spaces all surrounding the atrium.



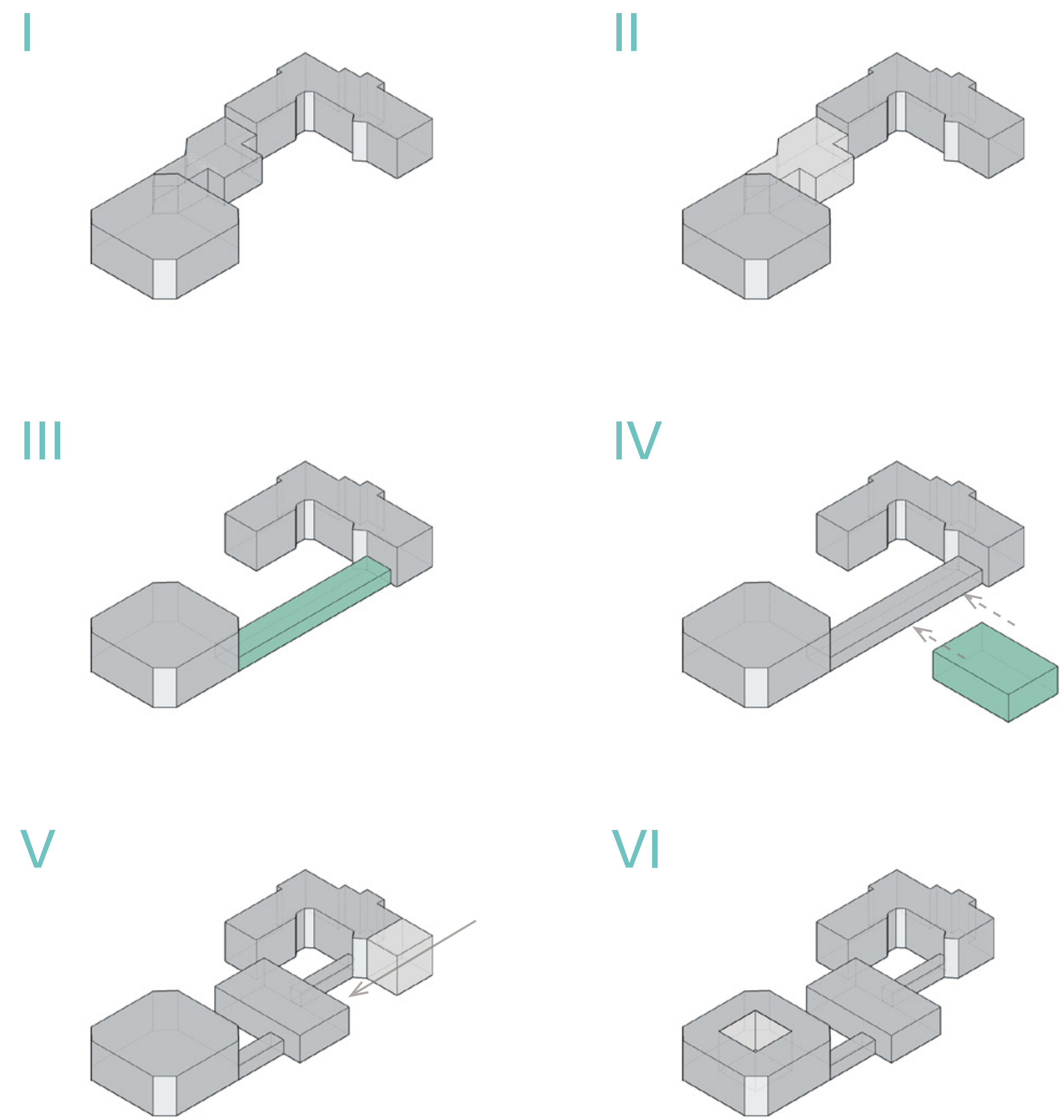



fig. 27 *Interventions*

# 4.3 ORGANISATION

The combination of using an existing building with a very specific program with many different spaces has the potential to create a confusing layout. Separating the building into three zones, each with a very specific function and specific users prevents this. The distinction between meeting and retreating, between public and private, plays an important role.
The building is organised according to the sequence of private and public spaces. The most private rooms are facing the sea, followed by the semi private common spaces and the supporting functions. The living groups for adults and youth are separated, each in a dedicated wing. They are organised around an atrium and courtyard respectively. The semi-public treatment rooms and public entrance area are all concentrated in the heart of the building. These are connected to the main wings through two transition zones: cloisters with a view to the garden, marking the transition between the public and private area of the hospice. The result is an open building which maintains privacy for the patients.

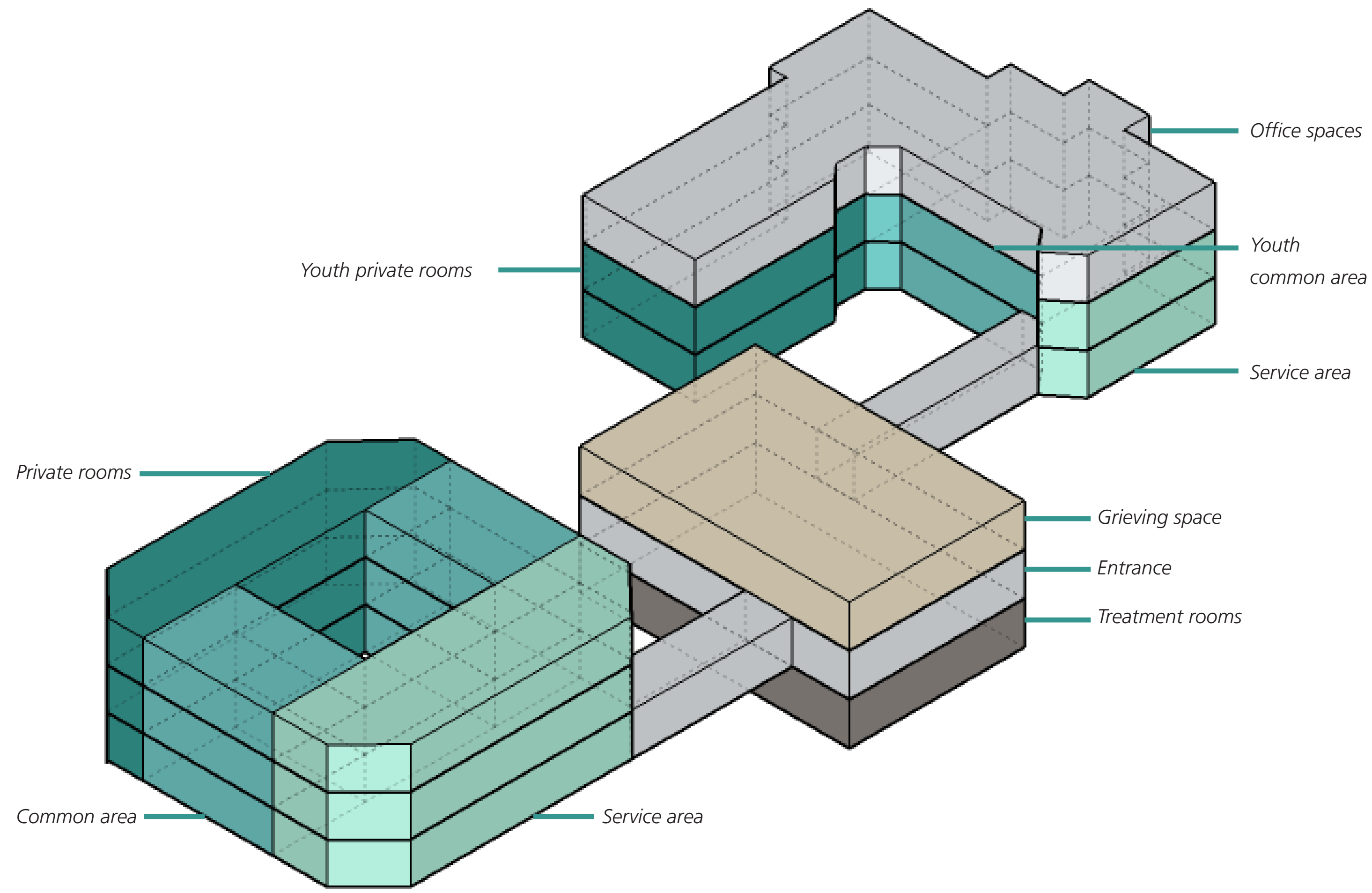



fig. 28 *Organisation of functions in the hospice*

01 — private room
02 — common room
03 — meeting room
04 — chapel / meditation room
05 — nurse station
06 — storage
07 — library
08 — family accommodation
09 — multi functional room
10 — elevator
11 — grand cafe
12 — reception / bar
13 — family room
14 — grieving space
15 — nurse station
16 — hydrotherapy
17 — hairdresser
18 — beauty salon
19 — therapy room
20 — meeting room
21 — private room youngsters
22 — common room youngsters
23 — nurse station
24 — games room
25 — staff canteen
26 — office
27 — training facility

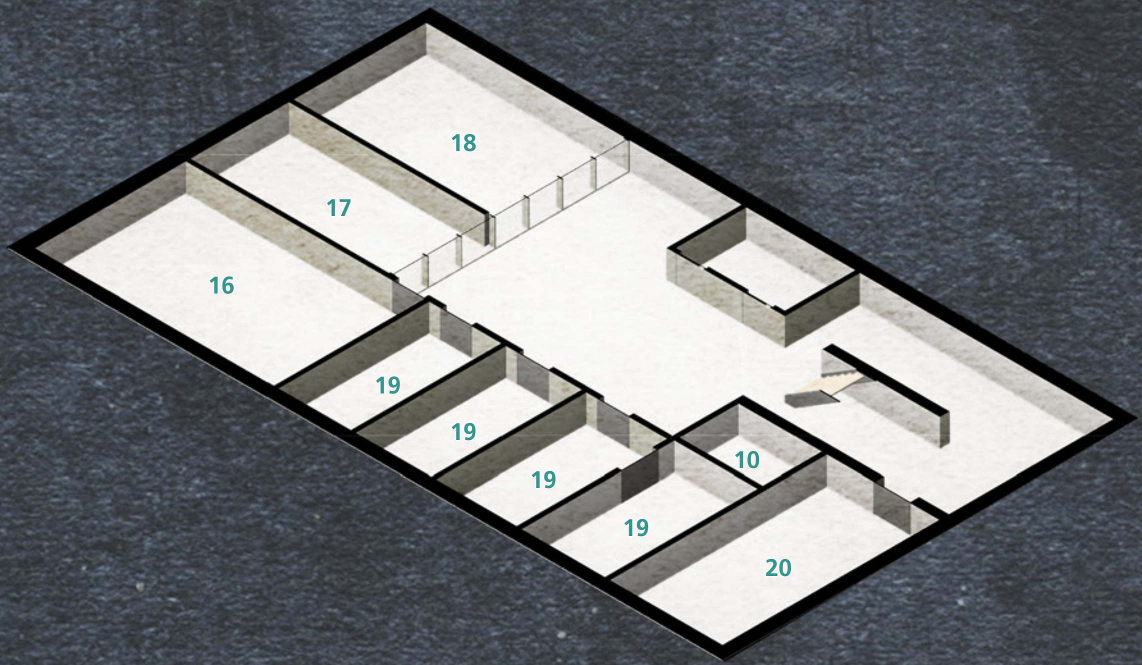



fig. 29 *Floorplan floor -1, 1:200*

01 — private room
02 — common room
03 — meeting room
04 — chapel / meditation room
05 — nurse station
06 — storage
07 — library
08 — family accommodation
09 — multi functional room
10 — elevator
11 — grand cafe
12 — reception / bar
13 — family room
14 — grieving space
15 — nurse station
16 — hydrotherapy
17 — hairdresser
18 — beauty salon
19 — therapy room
20 — meeting room
21 — private room youngsters
22 — common room youngsters
23 — nurse station
24 — games room
25 — staff canteen
26 — office
27 — training facility

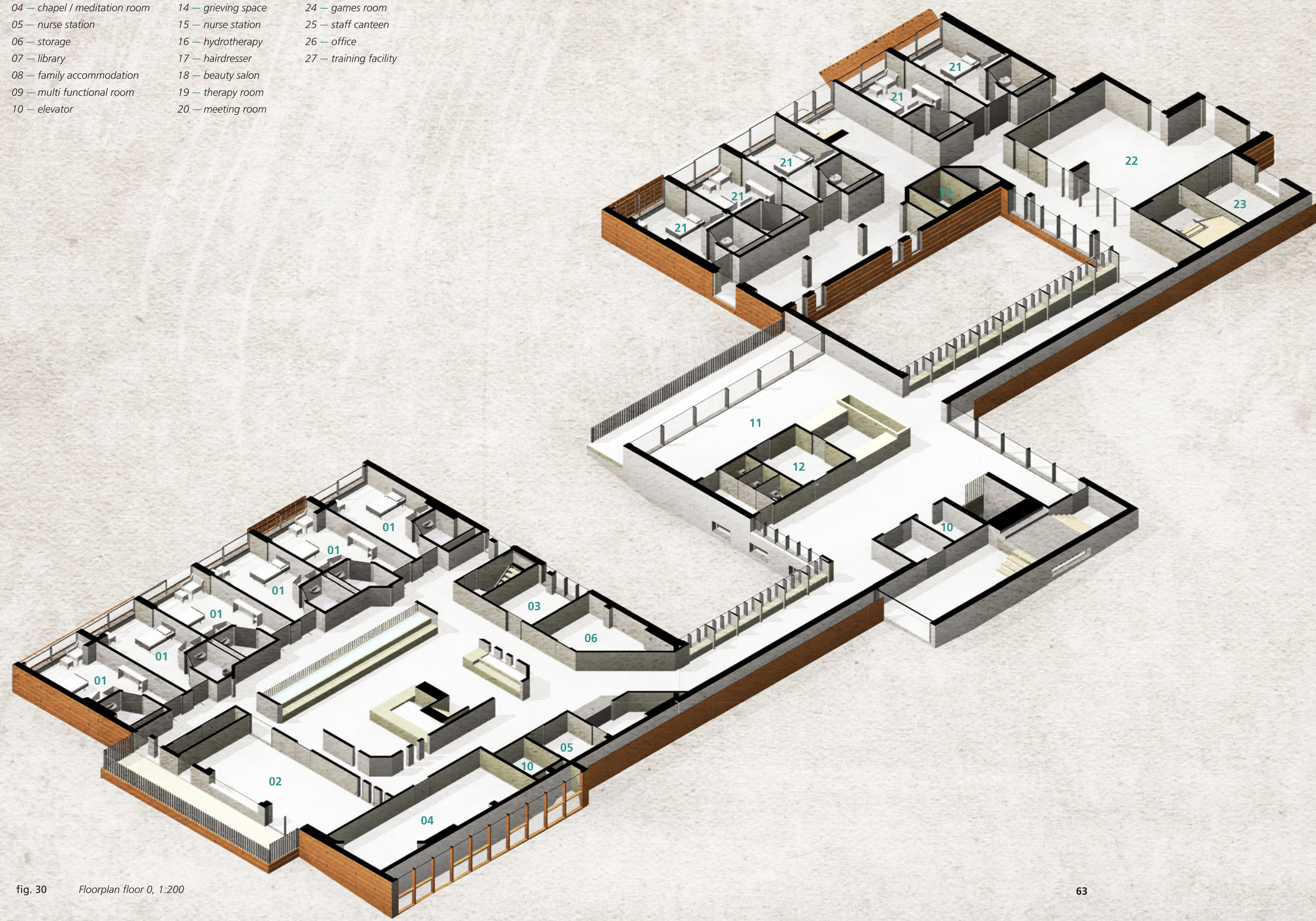



fig. 30 *Floorplan floor 0, 1:200*

01 — private room
02 — common room
03 — meeting room
04 — chapel / meditation room
05 — nurse station
06 — storage
07 — library
08 — family accommodation
09 — multi functional room
10 — elevator

11 — grand cafe
12 — reception / bar
13 — family room
14 — grieving space
15 — nurse station
16 — hydrotherapy
17 — hairdresser
18 — beauty salon
19 — therapy room
20 — meeting room

21 — private room youngsters
22 — common room youngsters
23 — nurse station
24 — games room
25 — staff canteen
26 — office
27 — training facility

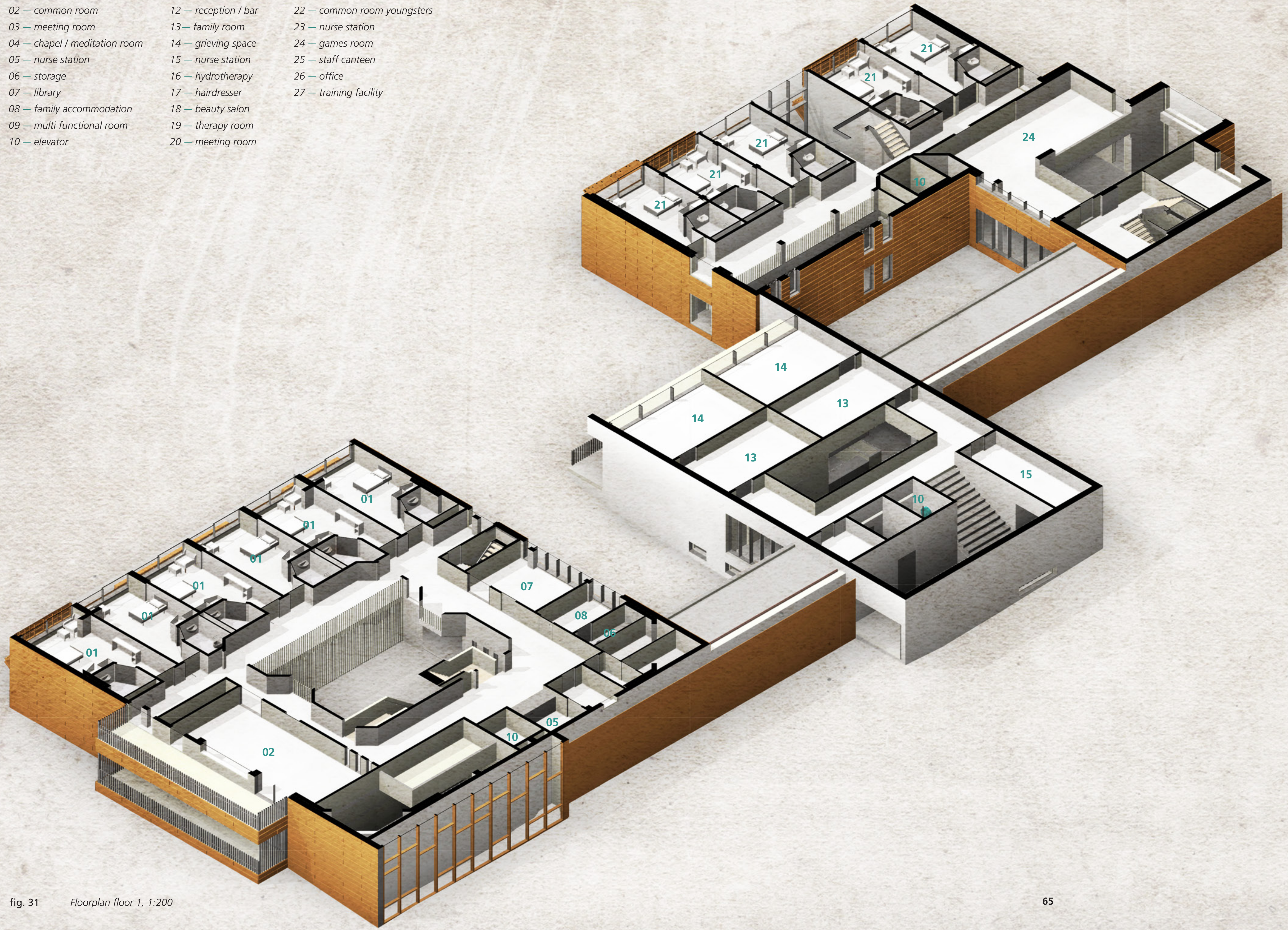



fig. 31 *Floorplan floor 1, 1:200*

*01 — private room*
*02 — common room*
*03 — meeting room*
*04 — chapel / meditation room*
*05 — nurse station*
*06 — storage*
*07 — library*
*08 — family accommodation*
*09 — multi functional room*
*10 — elevator*

*11 — grand cafe*
*12 — reception / bar*
*13 — family room*
*14 — grieving space*
*15 — nurse station*
*16 — hydrotherapy*
*17 — hairdresser*
*18 — beauty salon*
*19 — therapy room*
*20 — meeting room*

*21 — private room youngsters*
*22 — common room youngsters*
*23 — nurse station*
*24 — games room*
*25 — staff canteen*
*26 — office*
*27 — training facility*

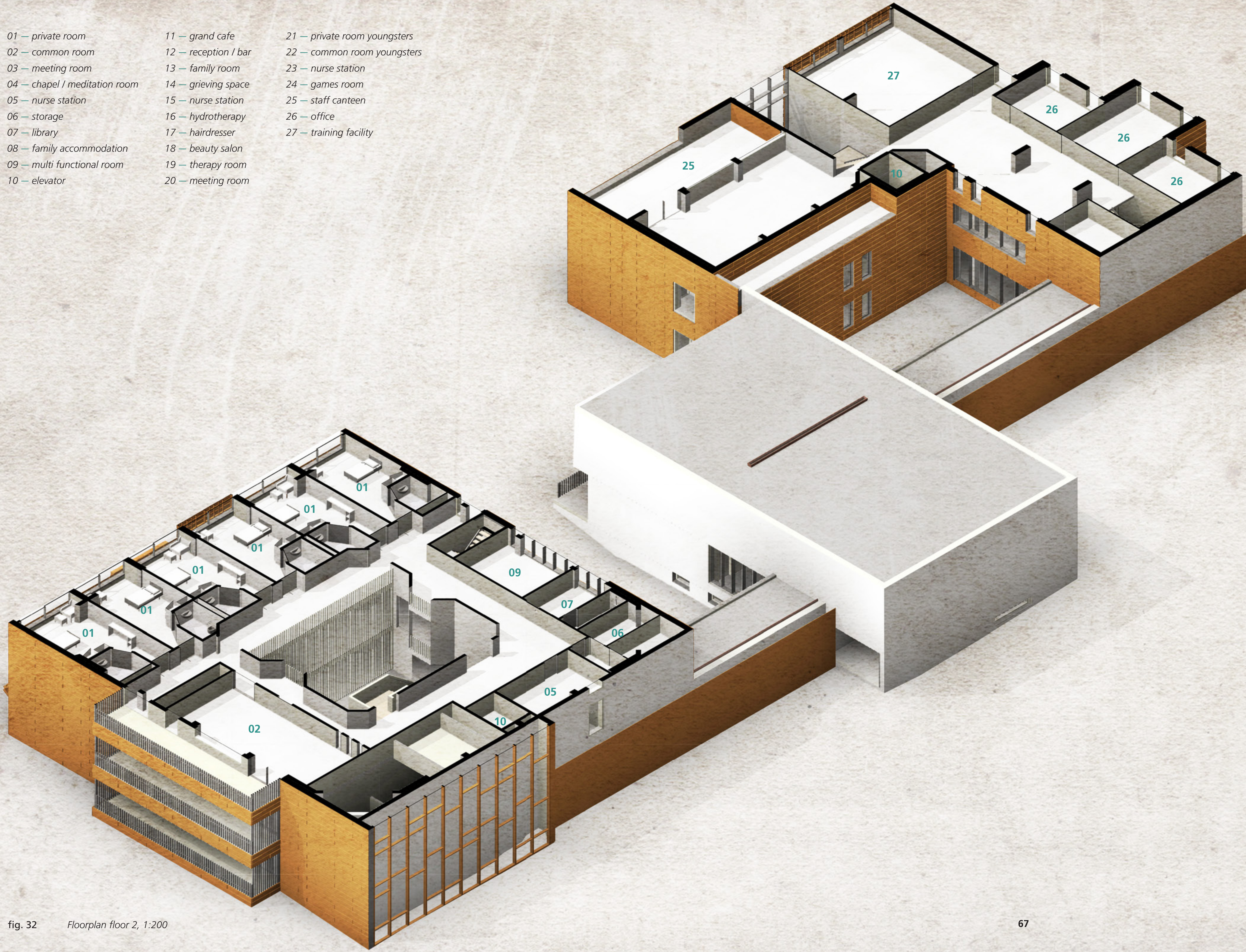



fig. 32 *Floorplan floor 2, 1:200*

fig. 33 *Section along the axis NW-SE, showing a private room, the atrium and the chapel*

fig. 34 *Section along the axis NW-SE, showing the entrance building with treatment rooms, cafe and grieving rooms.*

fig. 35 *Section along the axis SW-NE, showing the adults wing, the entrance area, a transition cloister and the youth wing.*

## 4.4 SEQUENCE

**Private room**

The distinction between meeting and retreating, between public and private, plays an important role. The individual rooms in either wing are the most private spaces. These are meant just for the patient and close relatives. The private room is the place where the patient probably spends most of the time. In order to take full advantage from the view, each room has a large sliding window with a low window sill, framing the view over the sea and the beach. The window is located in a little alcove which is visually separated from the rest of the room. The room is deliberately not equipped with a balcony. The local climate at the site can be quite harsh, and patients staying inside are most vulnerable. There will not be a lot of time that they can actually go outside.
In a normal home, people can look forward to the summer, knowing they can spend time outside, sit in their garden or on the balcony. Here, people can no longer look forward to anything more than a month ahead. Many people staying in the hospice will never experience summer here. Having a balcony would not only be quite useless, it would also partly block the view and hide daylight for the room below. Therefore, the room itself is designed as a balcony. The sliding window can open, leaving a 2 by 1,8 meter opening. The window zone, which is an extension to the existing structure, is fully clad in wood, to create a separate area within the room. The entire window area acts as a strong frame.

When people near the end of their life, they often feel the need to seclude themselves. They sleep a lot, or stay in bed all day. This asks for a slightly darker room. Therefore each window is equipped with operable louvres. Unlike curtains, these louvres open horizontally. Therefore the view of the horizon is never fully blocked. Closing the upper half of the louvres stops most daylight while maintaining the view of the entire horizon.

From the outside this also shows what is happening inside. The louvres mark each individual room. The opening and closing of the facade reveals the rhythm of life inside the building.



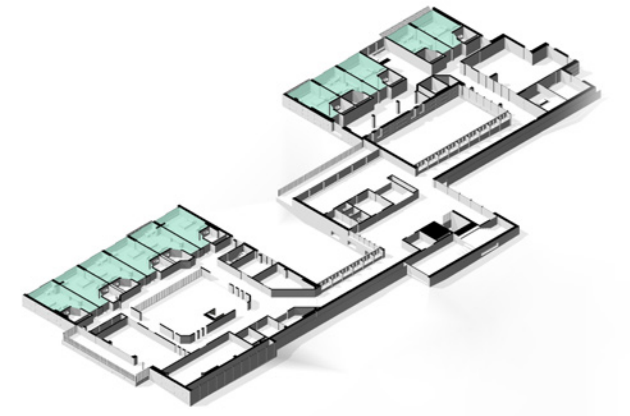


fig. 36 *Private room*

### Common area

The private room leads to an atrium which connects the common rooms and leisure spaces. The atrium is meant for relaxation, creating openness in the building. It offers wandering spaces, little private corners and viewpoints to the indoor garden. Having vegetation inside contributes to a pleasant atmosphere for the patients and visitors.[29]

The entrance to the individual rooms is marked with an alcove in the atrium wall, creating a firm boundary to the most private space. This alcove acts as a buffer space, preventing people from stepping right onto the corridor when leaving their room. The alcove is finished with the same materials as the room to emphasize the buffering function.

The atrium visually and aurally connects the three living groups. Standing on the balustrade, one can see onto all the levels. Still, because of the dual routing and the sheltered corridors, the feeling of privacy is high. People coming from the elevator can choose to walk to the rooms via the common room, or via the opposite side.

Apart from the common rooms on each floor, there are a number of shared functions. There are two family rooms, for family members wishing to stay overnight. There is a library and contemplation room overlooking the courtyard, and a big multifunctional space which can be used for large gatherings or big families.

The chapel is housed in its own little atrium, spreading over all three floors. There is a small gallery on each floor, so patients can visit the chapel in private on their own floor.

This is really the heart of the living area in each wing. A lot of spaces are connected to the atrium, not just the common rooms for the patients but also the storage rooms and meeting rooms. To ease orientation for the patients, there is a distinction between door that they can use and door they do not have to use. These service doors are mounted nearly invisible within the wall, while the doors for patients are recessed into the wall revealing the door frame. The walls themselves are clad with timber laths.

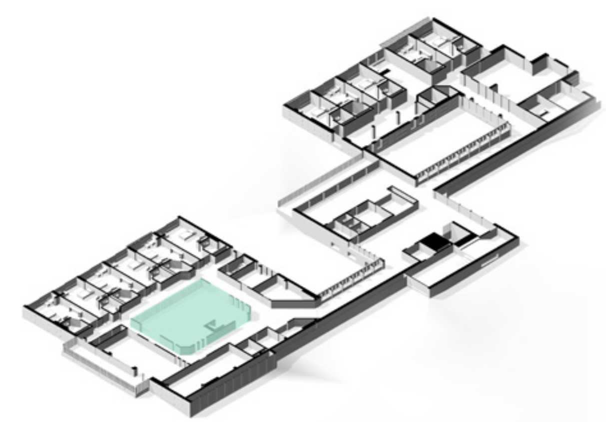
The roof of the atrium asks for special attention. Just like the private rooms, the atrium should not be too light. It should not be a glass covered semi outdoor space with a high tech roof. Instead the atrium should feel relaxing and quiet. Therefore the roof is closed. The roof grid consists of 100 mm thick and 1200 mm high wood trusses. The boxes in the roof emphasize the height of the atrium space. Daylight comes in through strips of windows on three sides of the roof. Because of these windows the roof feels lighter, disconnected from the rest of the building despite its strong presence. The structural frame becomes a design feature that creates an interesting pattern overhead.

Simulation shows that times when the direct sunlight reaches all the way down are very limited. Most direct light is blocked by the window frames or the trusses. To limit solar heat gain, the south-west window is fitted with glass with a low solar factor, minimising solar heat gain.

29. Verderber&Refurzo, Innovation in hospice architecture p.140



fig. 37 *Atrium*



In the northern wing, the rooms of the youngsters on two floors all meet into a central gallery, spanning the entire building. This corridor also leads into a common area. Because the youngsters wing is smaller, they share all facilities among ten rooms. There is a living room on the ground floor, with some couches and a dining area with kitchen. On the first floor there is a games room and a second sitting area, all joined with a large void. Adolescents can feel the strong need to be alone, or to be around a lot of people. Therefore there are multiple common spaces, allowing both separation and common activities. They can retreat into one of these rooms when friends are visiting, so they can have private time without having to stay in the bed room. The youngsters common rooms does not look out onto the sea. Instead, they faces both the courtyard and the lighthouse. These patients are less interested in staring out over the sea, their area is more introvert.



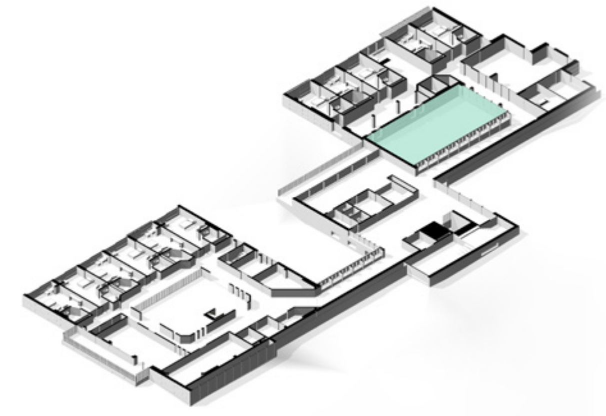


fig. 38 *View overlooking the courtyard into the youth living room.*

## Living room

On each floor, the southern living room creates a small community within the hospice. All patients have easy access to one of the living rooms. The living rooms are fitted with a small kitchen which is can be used by patients and their family. The patients can eat here together if they wish and can, but they can also choose to eat in their room. To create a homely atmosphere, the living room is furnished with comfortable sofas, and a warm wooden floor.

Each living room also has access to the outdoors, on a large southwest facing balcony. The balcony is large enough to take some beds outside, so even the very ill can enjoy the sun, feel the wind and hear the sea. The balcony is designed as an extension of the living room itself, continuing the wooden floor outside.

The balcony acts as a sun shading device for the room below, protecting it from the hot summer sun. In winter, the low afternoon sun enlightens the living room, shining through the building even into the atrium.

fig. 39 *View from the common balcony.*

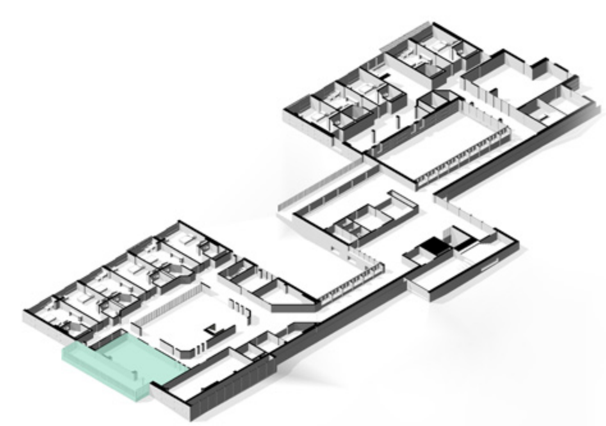
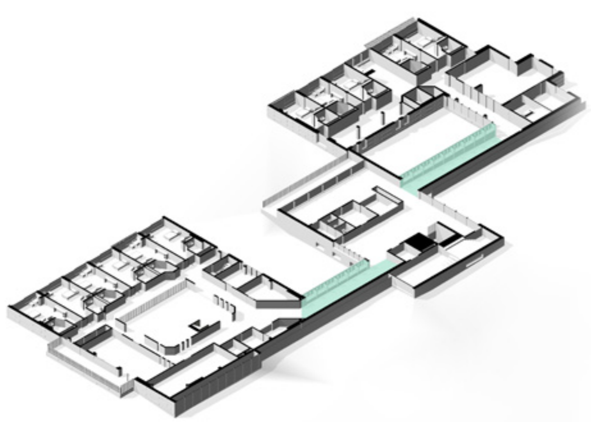


fig. 40 *View of the transition zone coming from the adults wing towards the entrance building, overlooking the garden.*





**Transition zone**

The transition from the two wings north and south to the central building is very important. It marks the transition between private/semiprivate and public areas. The wings are only meant for visiting relatives, whereas everybody can visit the entrance building. For the patient it also creates a way of ‘getting out’ without actually leaving the hospice. They can go to have a coffee in the grand cafe and really feel like leaving the building for a while

The transition is formed by a cloister. It is inspired on cloisters in monasteries and churches. The seaward side is very open, offering views to the garden and the sea. The columns and mullions create a strong rhythm, offering segmented views outside and emphasizing the length of the space. Often in care buildings, corridors should be avoided because they feel depressing and impersonal. This is very different. It almost feels like outside, and it is very light. The end of both transition zones are clearly marked, showing the end but hiding what is behind the corridor. This way the transition zones are very clean and clear.

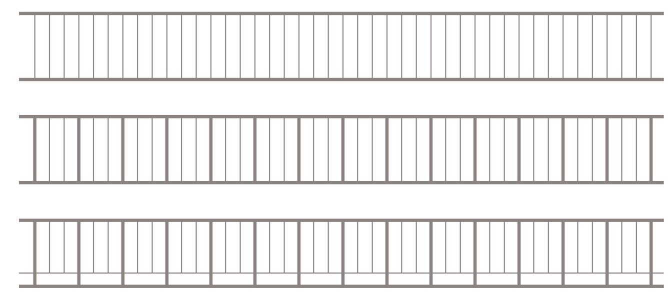


fig. 41 *The rythm is based on a pattern of 300x100 mm window mullions, 600 mm ctc. These are accentuated with wider columns every 1800 mm to further emphasize the length of the cloister. The window is raised 400 mm, creating sitting alcoves in the corridor.*

## Entrance area

The entrance space is the heart of the hospice, where patients can ‘go out’ and meet people in a different setting. The grand café is visible from the entrance area, but still somewhat separated. This way people are free to decide if they want to join or avoid the other guests. The grand cafe offers views over the sea and the garden.
In the middle of the entrance area is a bar combined with reception desk, to welcome visitors and overlook the entrance.
The entrance area allows access to the treatment rooms in the basement, which are also used by outpatients. There are a number of treatment rooms as well as a beauty salon and a hair, and a waiting area for outpatients. The basement is illuminated with daylight coming through the hair and beauty salon, and through a void connecting it with the ground floor.
On the first floor two grieving rooms enable the family to say their last farewell to a loved one in a familiar environment. The grieving rooms can be accessed from outside, and the route to the grieving rooms is hidden from patients and other visitors. It can be accessed independently by the family members 24/7. Relatives enter though a special door directly into the enclosed area. From here, a dedicated staircase leads to the first floor where to walking bridges cross the entrance area and lead to both grieving rooms. Each grieving room is preceded by a private gathering space where family members can come together. The grieving rooms offer a beautiful view over the sea.
The transition from the entrance area to the grieving area is through a passage in the concrete wall of the entrance area. It clearly marks the transition and prevents the mourners from accidentally encountering others. When the deceased are leaving for their burial or cremation they can be carried through a large dedicated door directly into the hearse.

fig. 42 *Entrance area.*

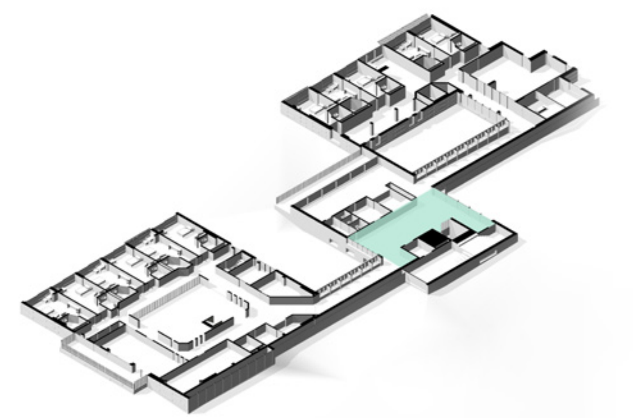


fig. 43 *Approaching the entrance*

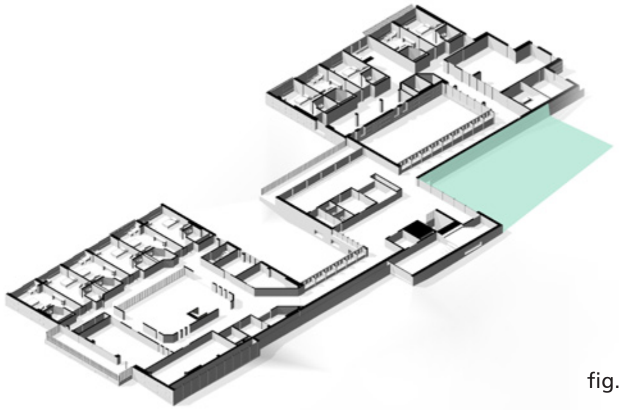


fig. 44 *South west elevation, 1:250*

## Approach

People approach the hospice from the northeast. They go up the dyke, past the old lighthouse and the small homes. That is when they see the hospice entrance awaiting them, at the end of the Vuurtorenweg. Still, they have not seen the sea, at is was hidden by the dyke and other buildings. The route towards the entrance leads the visitor past the exterior wall of the long transition zone. This concrete wall is covered with a wind veil, a interactive artwork based on the work of American artist Ned Kahn. It features an array of small copper strips which hang on steel cords, allowing them to move freely in the wind. This creates a mesmerizing, rippling effect in the facade. It strengthens the relation with the elements and brings dynamics to the rear of the building. The wind veil leads to a large opening in the concrete entrance building. As one gets nearer to the entrance, the view through the entrance widens, revealing the dunes behind it. With a wide glass facade it is open and inviting to the surroundings. The entrance shows it is a public building, it shows you can enter. The transparency allows visitors to see through the entrance, revealing the interior and making them feel more comfortable. At the same time, the residents in the grand cafe are hidden, creating a protected environment for them.

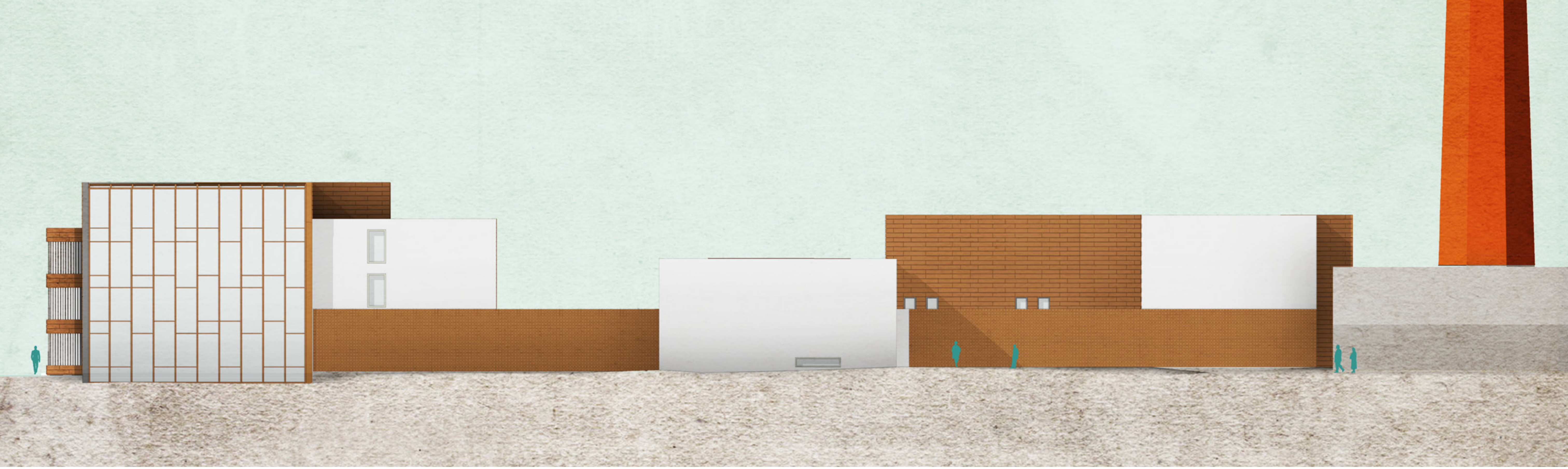


fig. 45 *South east elevation, 1:250*

fig. 46 *North west elevation, 1:250*

## Outdoor area

The hospice is located on a dyke which is part of the coastal defence of The Hague. Therefore no soil may be removed from the site, not even during the construction process. The soil excavated to facilitate the new entrance building is therefore used to reconstruct a dunes landscape on the dyke. This match the recent transformation of the boulevard from a high barrier into a sloping array on different levels. The slope of the dyke is made more gentle. The area surrounding the hospice is made more natural, with variations in elevation and sandy and grassy areas. The sloping garden also allows to adjust to the various ground floor levels, as well as the windows in the basement.

On the south side, the entrance building forms the end of the current street. It offers place for dropping off people, as well as some parking space on the side of the road. Once inside. all one can see is the dunes landscape



fig. 47 *Site plan*

# 4.5 MATERIALS

The materials used in the hospice have been carefully selected to match the delicate atmosphere inside. The materials have a warm appearance, using earthly colours and a strong texture. As mentioned earlier, the building should not hide itself, or pretend to be something different. Like the people that live inside, this building may show that it is aging.
The facades are clad in weathering steel or Corten steel. Under the influence of the weather conditions the steel gets a durable patina which gradually transforms from a bright orange to a warm brownish colour. It is a contrasting colour, which stands out even in dull weather.

Wood is used a lot on the interior to achieve a homely atmosphere in the common spaces. The walls are covered with wooden laths.
In the existing building parts the floor to floor height is limited. Therefore the ceilings are left as bare concrete, painted white. The floor is an epoxy resin floor on screed with underfloor heating. In the common rooms the floor is wood as well.

The rear facade of the building is made of fair faced concrete, emphasizing the barrier it creates between the hospice and the outside world.  The light colour of the concrete matches with the sandy colour of the dunes.

The fourth element is not really a building material, but it is important nevertheless. Natural elements are an essential part of the design. The building is set on the dunes, in the dunes, surrounded by dunes. The outdoor space is left very basic, with coastal vegetation like tall grasses being only interrupted by some paths and outdoor furniture. Nature is continued inside in the atrium and in the courtyard with the same marram grasses as well as bamboo, an even taller species of grass which can reach up to the top of the atrium.

fig. 48 *Material collage*

fig. 49 *Exterior of the adults building, overlooking the private rooms and common rooms.*

# 5

# VENTILATION IN THE HOSPICE

## 5.1 CLIMATIC CONCEPT

The architectonic concept of the design is based on fully using the characteristic beauty of the location: the view over the sea, the sunset, the fresh sea breeze. All of this is used for the benefit and comfort of the patients. The climatic concept follows this approach. This unique location offers a set of special characteristics that can be used in the building.
In addition to the location, the very specific function of the building also provides clues for the climatic design. This conflicts with an optimal passive solar design as described in the previous chapter. First of all, the orientation of the building is dominated by the sea. All personal rooms are aimed at the sea, and therefore facing the north-west. To minimise energy loss through windows, this side of the building should be as closed as possible. This is not an option, because of the desire for an unrestricted view. The long south-eastern facade on the other hand houses a lot of routing and supporting functions, which do not need windows. The south west facade does catch a lot of  sunlight. This houses the common rooms in both wings. They also offer a phenomenal view over the sea, so any sun shades should not limit this view.
The unique function demands that, should the climatic design and the experience of the patient conflict, the patients interest should always prevail. Patients come to this hospice specifically for this location, and they only stay for a short time. If there would be sunshades blocking their view half of the time they cannot fully benefit from the hospice. The end users are not interested in the energy bill. They do have an interest in an excellent indoor climate, and in an outstanding relation with the surroundings.
The building itself also sets limitations. The available floor-to-ceiling height is only 2750 mm. The new floor and insulation takes 60 mm, leaving just 2690 mm. Creating a false ceiling to place air canals would take at least 200 mm, which would lead to ceilings that are too low. This rules out ventilation canals in the rooms.

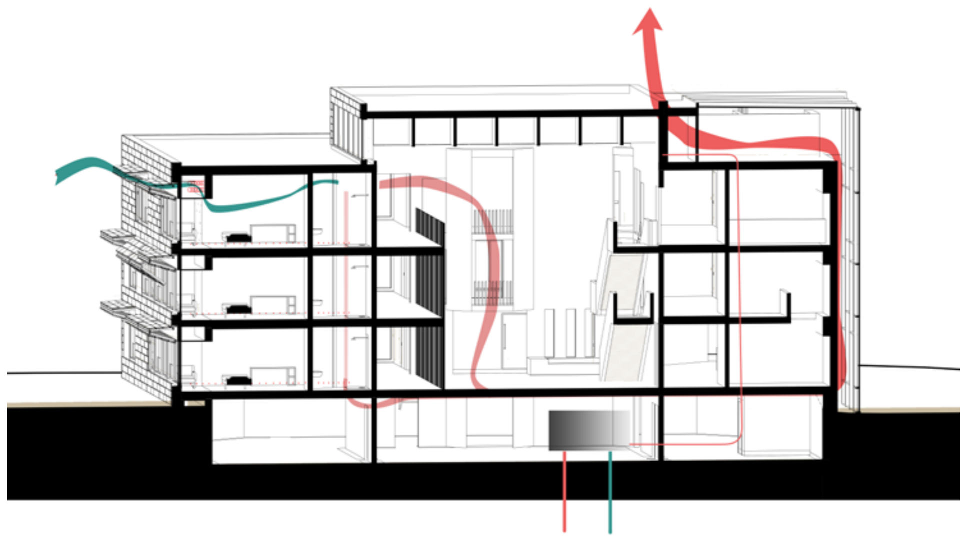


fig. 50 *The flow of air through the building. Fresh air enters the rooms through the facade. It is sucked through the atrium to a solar facade which creates pressure through thermal draft.*

# 5.2 VENTILATION INFLOW

The climatic concept for the building starts with the wish for a strong relation with the surrounding on one hand, and the desire to utilize the blind south east facade on the other hand. Multiple studies regarding the interior climate and comfort show that users rate the indoor climate better when they feel they can control the indoor climate, even when the parameters are actually the same. They really appreciate a direct relation with the outdoor climate. [33] This is done by ventilating all spaces directly through the facade.

Using fresh air directly through the facade lets the fresh sea air in. Contrary to centralized ventilation, there are no filters that need cleaning and no canals that can potentially pollute the air. Ventilating through the facade also asks for specific measures. In winter, the incoming air is cold. Directly allowing it into the room would create a cold draft which is highly uncomfortable. Therefore the air is preheated in the void above the window zone. This can be done using a Duco air grid with an integrated heating strip.
To minimise draft, the opening should be as large as possible, spanning the width of the facade. The ceiling of the window is perforated to create a maximum opening, thus minimising the air speed. This essentially creates a 4,4 by 1 $m^2$ big ventilation inlet. Due to the location of the ventilation inlet in the window zone, the relation with the exterior remains strong. The patient can also at all times decide to open the window entirely, at which point the fan coil is automatically switched off.

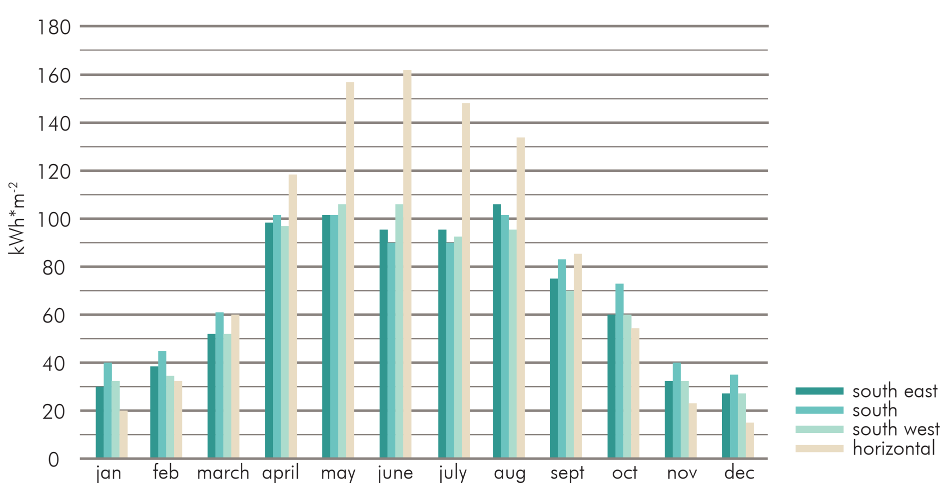



fig. 51 *Monthly sum of global irradiation on vertical and horizontal surfaces [Bronsema]*

30. College Bouw Zorginstellingen, De hitte de baas, p. 10



# 5.3 SOLAR FACADE

The air entering through the facade is subtracted on the other side of the room, to ensure a good mixing. The pressure needed for this extraction will be generated by a solar facade on the south east facade.
A solar facade is essentially a widened version of the solar chimney as described in chapter 3. Most literature regarding solar chimneys is about ventilation of small buildings or individual houses. Another study focussed on developing a kind of solar ventilator to be installed on the roof of a home.[31] A large study to the use of a solar chimney in a moderate climate was done in the PhD research by B. Bronsema. This study describes the process of designing a solar chimney in a building with natural air conditioning. The research paper Earth, Wind and Fire has been an important help in the design of a solar facade in the hospice.

### Orientation

Intuitively, orientating the solar facade towards the south gives the best possible yield. However, during summer days, the high altitude of the sun means that the irradiation of a vertical surface is less, whereas the southwest and southeast facade take full advantage from the lower altitude in morning and afternoon. There is a difference though between summer and winter. In winter the maximum altitude is lower, so the south facade is the most rewarding. This winter energy can be used directly in the building, heating other spaces. Energy harvested in summer needs to be stored in the geothermal heat storage system first, which is less efficient.
In addition to catching solar heat, the solar facade is also meant for ventilating the building. The performance in summer is critical for this, because in the cold season, the temperature difference between inside and outside already generates enough thermal draft to ventilate, even without sun. The southeast facade in summer is heated  from early in the morning, generating a stable thermal draft early on.

31. N. Bansal, R. Mathur & M. Bhandari, 1993. Solar Chimney for enhanced stack Ventilation

**standard conditions: summer day, 20°C 8:00-18:00 average hourly influx 430W*m²**

## Design

To design the optimal solar facade for this building, we should first study the principle that drive the solar facade. The solar facade is based on thermal draft, much like you would find in an ordinary chimney. Hot air rises in a vertical canal, creating a pressure difference which draws in new air. The air flow that is generated by thermal draft depends on the vertical temperature gradient, the diameter of the canal and the height difference, according to the following formula:

formula 1

$$Q = K*A*\{h*(T_i - T_o\}$$

With

| | |
|---|---|
| Q: | Air flow [$m^{-3}$*$hour^{-1}$] |
| K: | Canal resistance [-] |
| A: | Canal diameter [m2] |
| h: | Height solar facade [m] |
| $T_i$: | Temperature at height (h) [°C] |
| $T_o$: | Exterior temperature [°C] |

In a solar facade, this can be rewritten as follows, with the resistance being described with the Coefficient of Discharge Cd:

formula 2

$$Q_i = C_D*A_i*\{2*(\Delta T/T_i)*g*h\}^{1/2} * (1 + A_r^2)^{1/2}$$

With

| | |
|---|---|
| $C_D$: | Coefficient of discharge [-], between 0.5 and 0.8 |
| $A_i$: | Inlet area [m²] |
| $T_i$: | Temperature inlet air [°C] |
| g: | Gravitational constant [m*$s^{-2}$] |
| h: | Height solar facade [m] |
| $A_r$: | Ratio outlet/inlet area [-] |

$\Delta T = yT_{f,o} + (1 - y)T_{f,i}$ with y=0.74

This shows that the airflow depends on the height of the solar facade, the glass surface of the facade and the temperature gradient in the facade.

The size of the facade can be adjusted within the limits of the design, which means the missing variable is the temperature difference. This shows the big benefit of the system: it is self-controlling. When the temperature outside rises on a hot day, the airflow rises as well, so more warm interior air can be disposed of.



The temperature gradient is caused by the heating of the air which is sucked in from inside the building. The starting temperature is set to 24°C, the maximum acceptable interior temperature. This air is heated by the sun falling through the glass of the solar facade. This temperature increase can be determined using the following formula:

formula 3

$$\Delta T = (h*R*\Phi_{zon}*\eta_z)/(\rho*c*w*D)$$

With

| | |
|---|---|
| h: | Height solar facade [m] |
| R: | Reduction net/gross glass area [-] |
| $\Phi_{zon}$: | Radiant flux sun zon [W*$m^{-2}$] |
| $\eta_z$: | Efficiency glass [-] |
| ρ: | Density air at 24°C [g*$m^{-3}$] |
| c: | Specific heat capacity air [J*$g^{-1}$*$K^{-1}$] |
| w: | Air speed [m*$s^{-1}$] |
| D: | Depth solar facade [m] |

This shows that the temperature increase during set conditions depends only on the height and depth of the facade. The width of the solar facade has no impact on the temperature increase. The width does have an influence on the total air flow as shown in formula 1. It shows that the depth of the facade should be kept at a minimum: the higher the depth, the lower the temperature increase. To ensure maintenance in the facade is still possible, the depth is set to 0.65 m.

The remaining unknown in this equation is the air speed. It shows that the lower the air speed, the bigger the temperature increase. This makes sense: the lower the air speed, the more time the air can be heated before reaching the top of the facade. The frictional resistance of the air in the facade is quadratic proportional to the air speed in the facade. This means that the lower the air speed in the system, the lower the resistance in the system, so less pressure is needed to ventilate the building. A low air speed of course also means a lower air flow. This is the main advantage of the solar facade over a narrower solar chimney: the width can be set to maintain a large enough air flow with a minimal air speed. Therefore a solar facade can even ventilate buildings of low height like this one. For this system, the air speed is set at 0.5 m/s.

## Materialization

The materialization of the solar facade is also an important aspect in optimizing the performance. The amount of glass is important, as well as the quality of the glass. To ensure maximum irradiation, the light transmittance of the glass should be maximised, defined by a high g-value. Meanwhile the thermal insulation should be high to prevent heat from escaping through the glass, defined by a low U-value. With a g-value of 0.75 and a U-value of 1.1, SGG Planitherm Solar glass 4/15/4 with argon filling is the best option.
The other important element of the facade are the window frames. To allow maximum heat penetration, the frames need to be narrow. Leaving more room for glass. The frame should also be well insulated, just like the glass itself. In order to fit in with the rest of the facades, an aluminium curtain wall system is used, with 100 mm wide mullions and a U-value of just 0.82.
The rear wall of the solar facade needs special attention as well. This wall will be made in dark concrete which can store heat and slowly release it during the day. This means that the temperature gradient will be more even during the day, especially on days when the sun is not constantly shining. The rear wall acts like a buffer to prevent a sudden loss of pressure in such a case. The wall should of course also be insulated, to prevent heat leaking into the building.

## Dimensions

Using the formulas described in this chapter, we can define the exact geometry of the solar facade. The system should generate enough pressure and have a large enough capacity to ventilate the building. As far as the pressure is concerned, it shows that all parameters need to be optimized in order to generate sufficient pressure. Using formula 3 we can calculate that the temperature increase in the solar facade will be over 8°C during standard conditions. With the inflowing air at 24°C, the maximum temperature in the top of the solar facade will be 12°C during standard conditions.
Using Gay-Lussac's law, the pressure differences can be calculated

*formula 4*

$$\Delta p = p_0 * (T_0/T_1 - T_0/T_2) * g * h$$

With

$p_0$: Density air at 0°C [kg*m-3]
$T_0$: Air temperature at 0°C [K]
$T_1$: Air temperature outside [K]
$T_2$: Air temperature in top [K]
g: Gravitational constant [m*s-2]
h: Height solar facade [m]

32. B. Bronsema, 2013. Earth, Wind and Fire, p.230



With a solar facade of 12.8 m and a maximum temperature of 32°C, this shows that a pressure of 5,5 Pa will be generated.
Because of the limited height of the facade, the temperature gradient will not always be enough to generate sufficient thermal draft. There is however an easy way of increasing the effective height of the facade without actually increasing the height. Figure 49 shows that especially in summer, most radiation on horizontal surfaces is larger than on any vertical surface. Therefore the solar facade is extended onto the roof, creating a sort of green house roof top. This connects to the top of the atrium, the installations room and the elevator control room to blend into the roofscape. It covers a total of over 100 $m^2$. It is estimated that with an air flow of 7 $m^3$ per hour, this could generate an additional 2 Pa of pressure in the system. [32]
On very difficult days, when the outdoor temperature is high but without sunlight, for example during a thunderstorm, additional fans are needed to provide the necessary ventilation. These are only used as backup, during the seldom times that the solar facade cannot generate sufficient pressure.

To determine the necessary width of the facade, the total ventilation capacity of the building is calculated using Dutch ventilation regulations. The calculation is shown in the appendix. It amounts to a total ventilation capacity of 7 $m^3$ per hour. This means with a facade depth of 0.65 m and an airspeed of 0.5 m/s, a 6.3 m wide solar facade can ventilate the entire complex. There was also the option to build two dedicated solar facades, one for each wing. However, the facade of the south wing is large enough to ventilate the entire building. Because of all the glass and framing, the solar facade is quite expensive, so building two while one is sufficient would be a waste of money and resources. Therefore the air is taken below the corridors towards the solar facade.

fig. 52 *Drawing of the solar facade seen from the south east.*

## 5.4 ATRIUM

In order to collect all used air into the solar facade, the air is drawn in from each room into the atrium or corridor. Only spaces that need direct extraction such as the kitchens and bathrooms are ventilated via dedicated canals. Using humidity sensors and $CO^2$ sensors, the need for ventilation in the various spaces is observed. The bathrooms are only ventilated when needed. This saves dramatically in installation space because many rooms do not need extraction canals. It also means that the air speed can be kept low: the air speed is proportional to the diameter of the canals, so to minimize air speed, the canals should be as large as possible. Using the atrium means having a shear infinite canal diameter.

Because of the low air speed, the air flow through the atrium will not be disruptive. It does have consequences for the design of the atrium though. In order to prevent the air from raising in the atrium and bypassing the solar facade, the temperature increase in the atrium should be kept at a minimum. This means preventing sunlight from entering. During extreme situations, where the temperature in the atrium is too high, valves in the roof can allow the air to escape, turning the atrium in a solar chimney. This air cannot be use for heat recovery, but since this will only happen during very hot days, it is not a problem. During the night, when patients are in their rooms, extra ventilation through the common rooms and offices into the atrium ensures a cool atrium every morning. The increased airflow in this situation is not a problem because all patients are sleeping.

# 6

# TECHNICAL ELABORATION

# 6.1 STRUCTURE

The design is characterized by the three different building volumes: two existing and one new. The existing building is made of a concrete poured in place structure with columns and beams in the facades. In the northern wing there are also concrete beams and columns in the interior. The existing concrete is in good condition. However, the rest of the building is deteriorated. Therefore it is stripped to the bare concrete, leaving a strong frame to work with.
The new facades are connected to the existing structure using a light frame of cold formed steel. The steel frames are mostly prefabricated, and hung to the concrete on site. They are less suspect to imperfections in the existing building because they are attached to the outside instead of between the columns. Using large panels, the building can be made weather-tight in a very short time span. This creates a lightweight substructure which can be easily connected to existing concrete structure.
The facades of the private rooms are extended to create the protected window zone. Consoles of heavy steel profiles are bolted to the concrete columns. The lightweight frame is hung to these steel consoles.

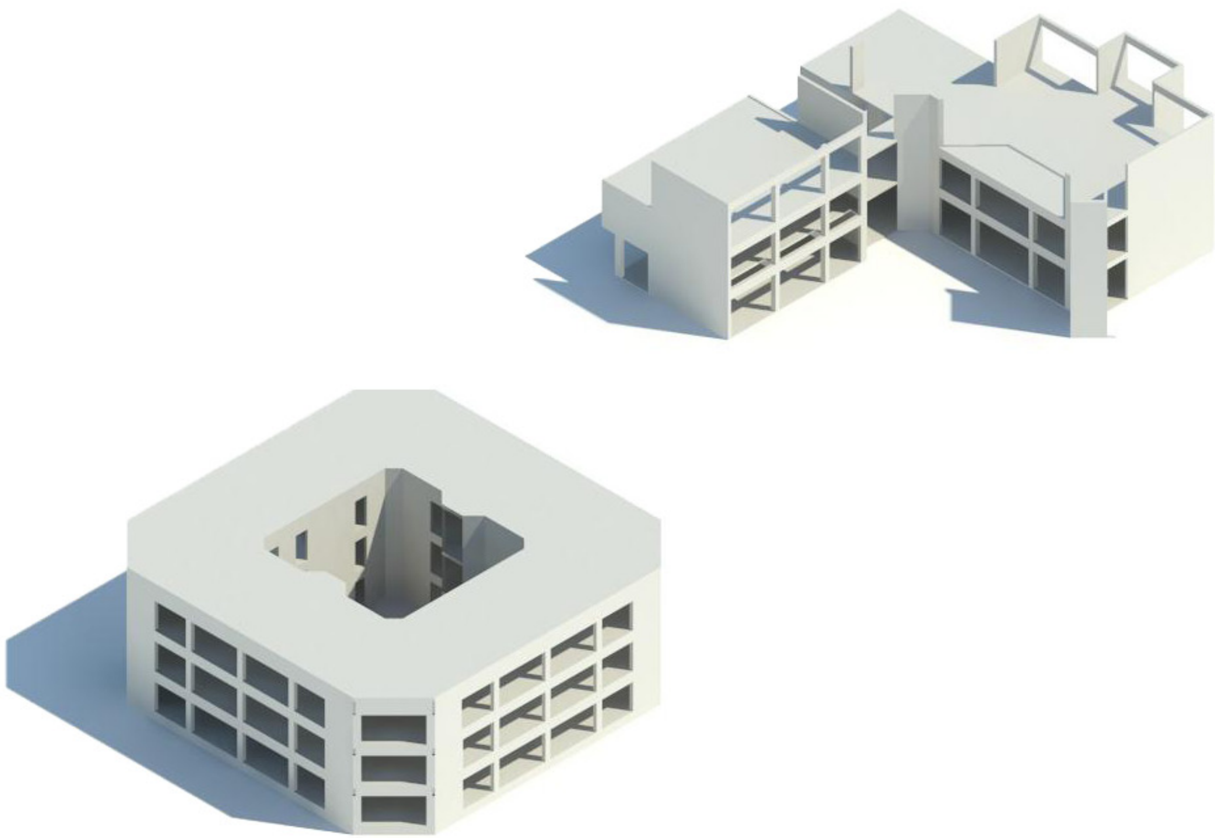
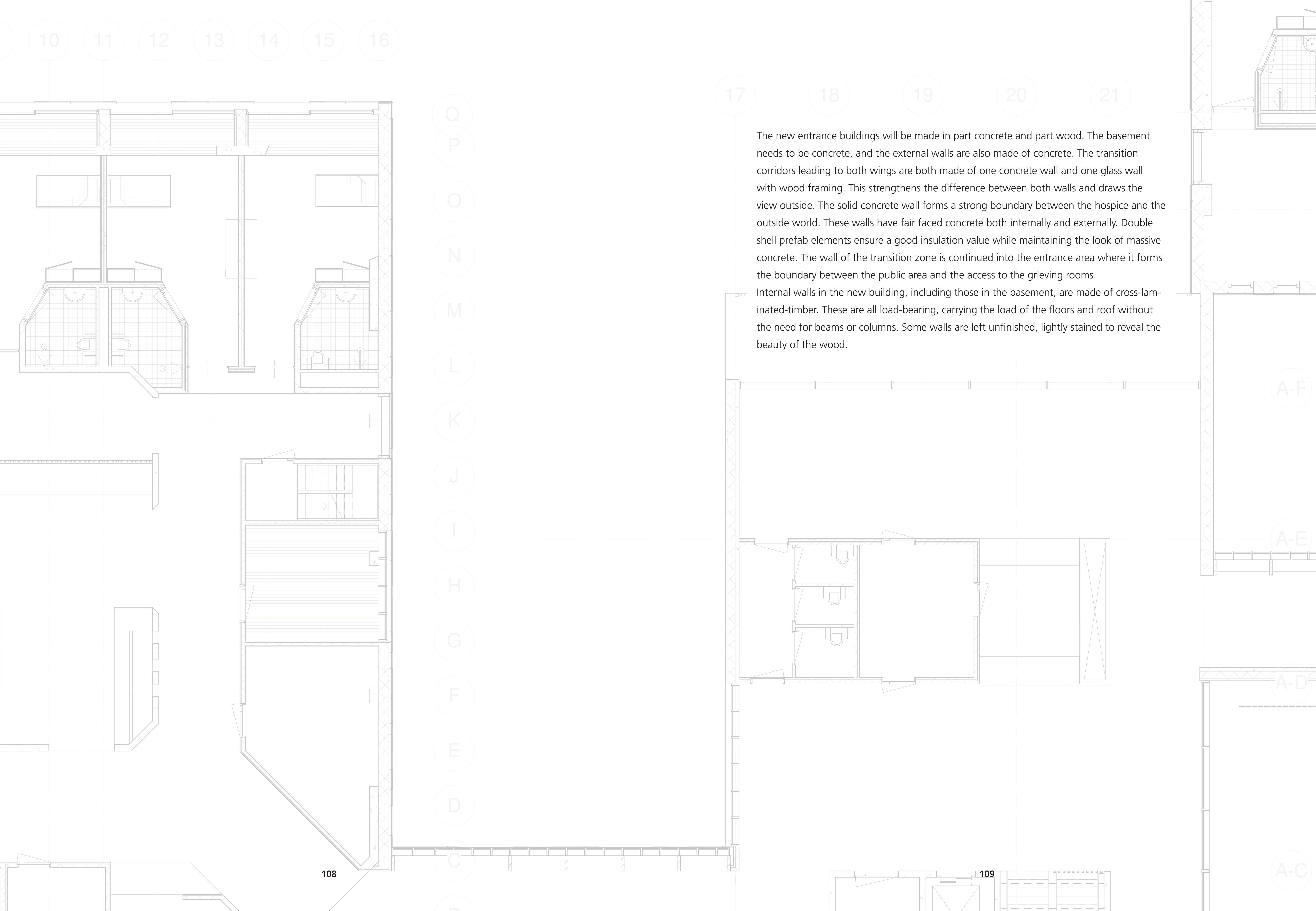


**fig. 53** *The existing building is stripped to the concrete frame, which leaves only these elements*

The new entrance buildings will be made in part concrete and part wood. The basement needs to be concrete, and the external walls are also made of concrete. The transition corridors leading to both wings are both made of one concrete wall and one glass wall with wood framing. This strengthens the difference between both walls and draws the view outside. The solid concrete wall forms a strong boundary between the hospice and the outside world. These walls have fair faced concrete both internally and externally. Double shell prefab elements ensure a good insulation value while maintaining the look of massive concrete. The wall of the transition zone is continued into the entrance area where it forms the boundary between the public area and the access to the grieving rooms.
Internal walls in the new building, including those in the basement, are made of cross-laminated-timber. These are all load-bearing, carrying the load of the floors and roof without the need for beams or columns. Some walls are left unfinished, lightly stained to reveal the beauty of the wood.



## 6.2 DETAILS

The most dominant facade in the design, both visually and technically, is the Northwest facade facing the sea. On the following pages, the facade will be explained using details of all important connections. The facade cladding in Corten steel is the defining element in the facade.
The weathering aspect of Corten, which was one of the main reasons for the selection of the material, also brings a potential problem.
The weathering of Corten is caused by rust particles forming on the surface of the steel. With 'normal' carbon steel this would destroy the sheet. In Corten steel, the addition of copper to the alloy leads to the formation of a thin but very dense layer of rust, which seals of the core of the steel preventing further corrosion.[33]
This process depends on the conditions in environment. The rust forms when the steel gets wet and dry repeatedly. This means the detailing should not allow water to remain on the facade. Atmospheric conditions can also influence the rusting process. Sulphur dioxide and sulphur trioxide, commonly found in industrial and urban areas, speeds up the corrosion process, but it also means critical points are more prone to excessive rusting. The same goes for chlorides in the air, found in coastal areas like The Hague. It is therefore not recommended to use Corten for structural applications in a marine climate.
A special type of Corten alloy with nickel has been developed to deal with this problem. It was specifically developed for structural use in bridges which are subject to de-icing salt. The nickel binds with the chloride in the air, preventing it from disturbing the rust layer. [34,35]
In order to be better able to withstand the marine climate, the façade uses 2 mm Corten panels, while 1,5 mm is standard more small panels like these. This provides extra security in the weathering process.

33. Rautaruuki Oyi, 2001. COR-TEN facades
34. J. Gross et al, 2010. Improved corrosion resistant steel for highway bridge construction
35. Nippon steel, 2010. Providing improved salt-corrosion resistance

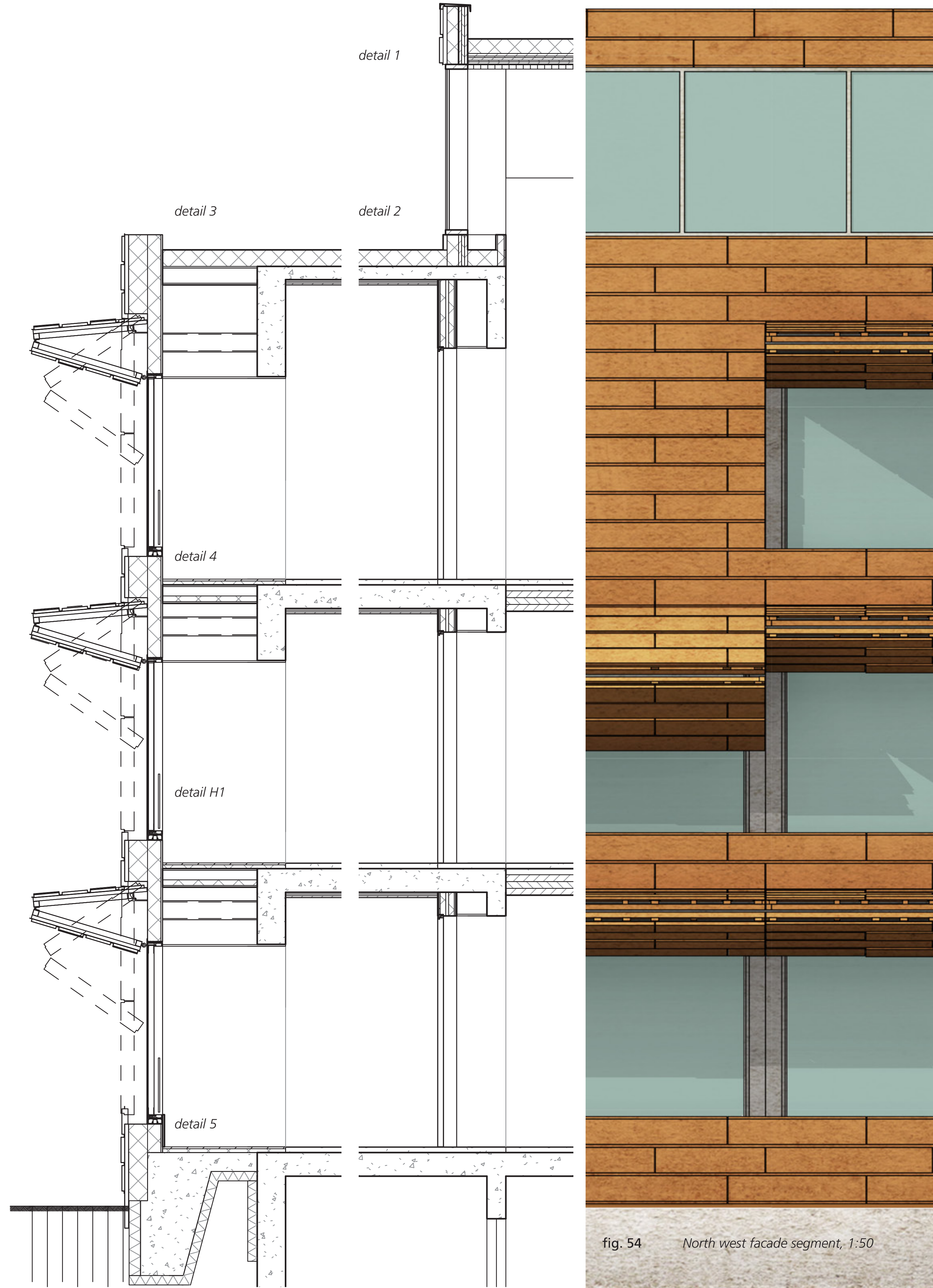
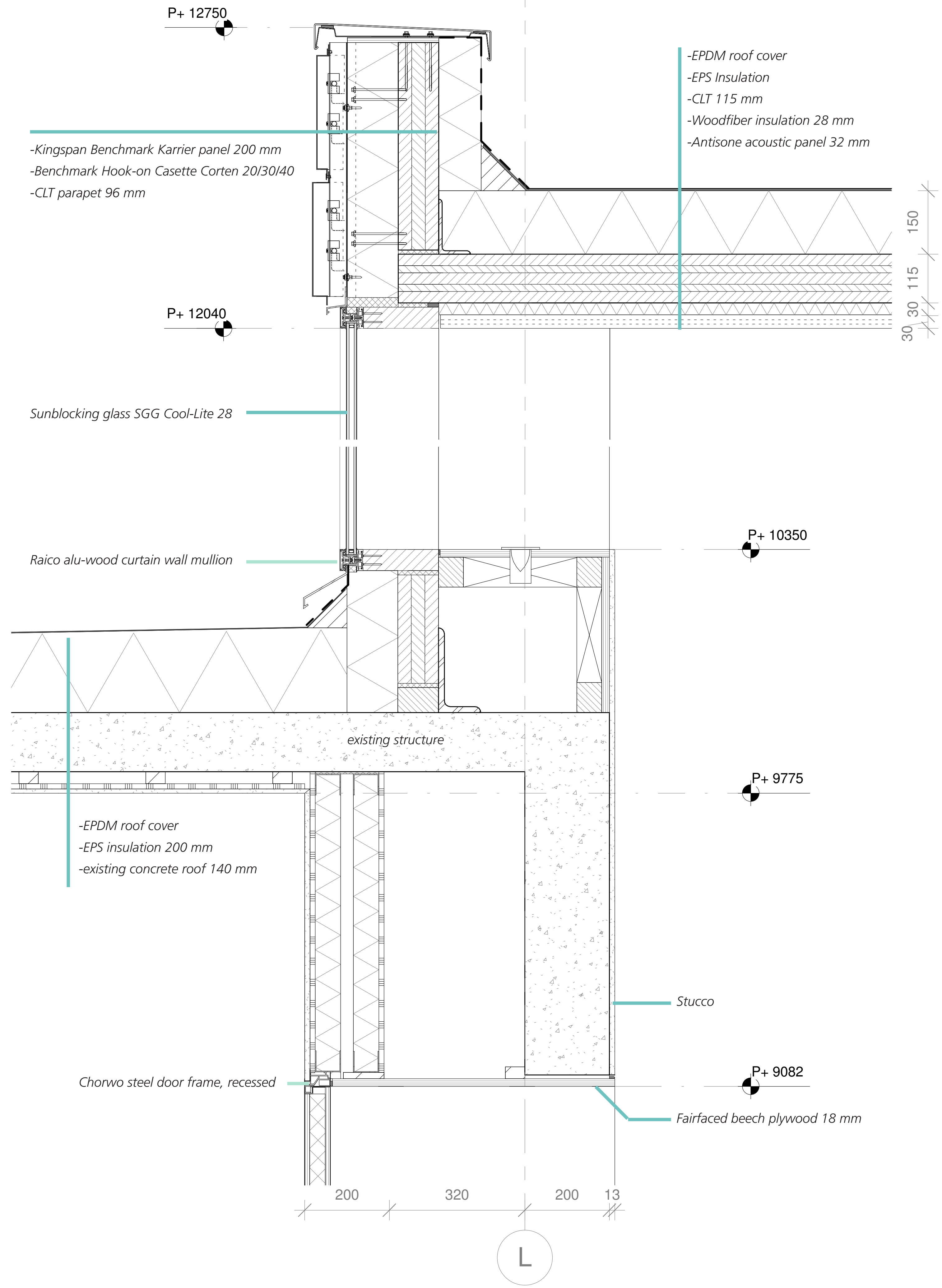



fig. 54 North west facade segment, 1:50

**Detail 1&2,** 1:10

The roof of the atrium is an important element in this central space. The timber frame draws attention, emphasises the height of the atrium. The strip of windows below the roof gives the roof lightness, and it brings light into the atrium.
The roof itself is made of Cross-laminated timber (CLT), supported by laminated beams. Because of the small spans between the beams, only 1760 mm, the beams and the roof can be made in slender panels. The beams are connected with recessed steel connection elements. At 1200 mm, the height of the beams provides strength in the longitudinal direction. The perpendicular beams prevent buckling.
In between the beams, the roof is covered with acoustic timber panels. These are perforated panels with beech plywood finishing. These contribute to acoustic comfort in the tall atrium space. Lighting fixtures provide a gentle illumination of the beams.
A strip of windows beneath the roof brings in daylight and emphasizes the roof. The windows are made of aluminium and wood curtain wall elements which are mounted to the roof structure. To prevent overheating in summer the glass is sunblocking glass with a very low solar factor of 28%.

The entrance to the individual rooms is positioned in an alcove in the existing concrete wall. This creates a buffer zone between the atrium and the rooms. The alcove is finished with beech plywood panels. The door frame is recessed into the wall, turning the entire alcove into a frame around the door.



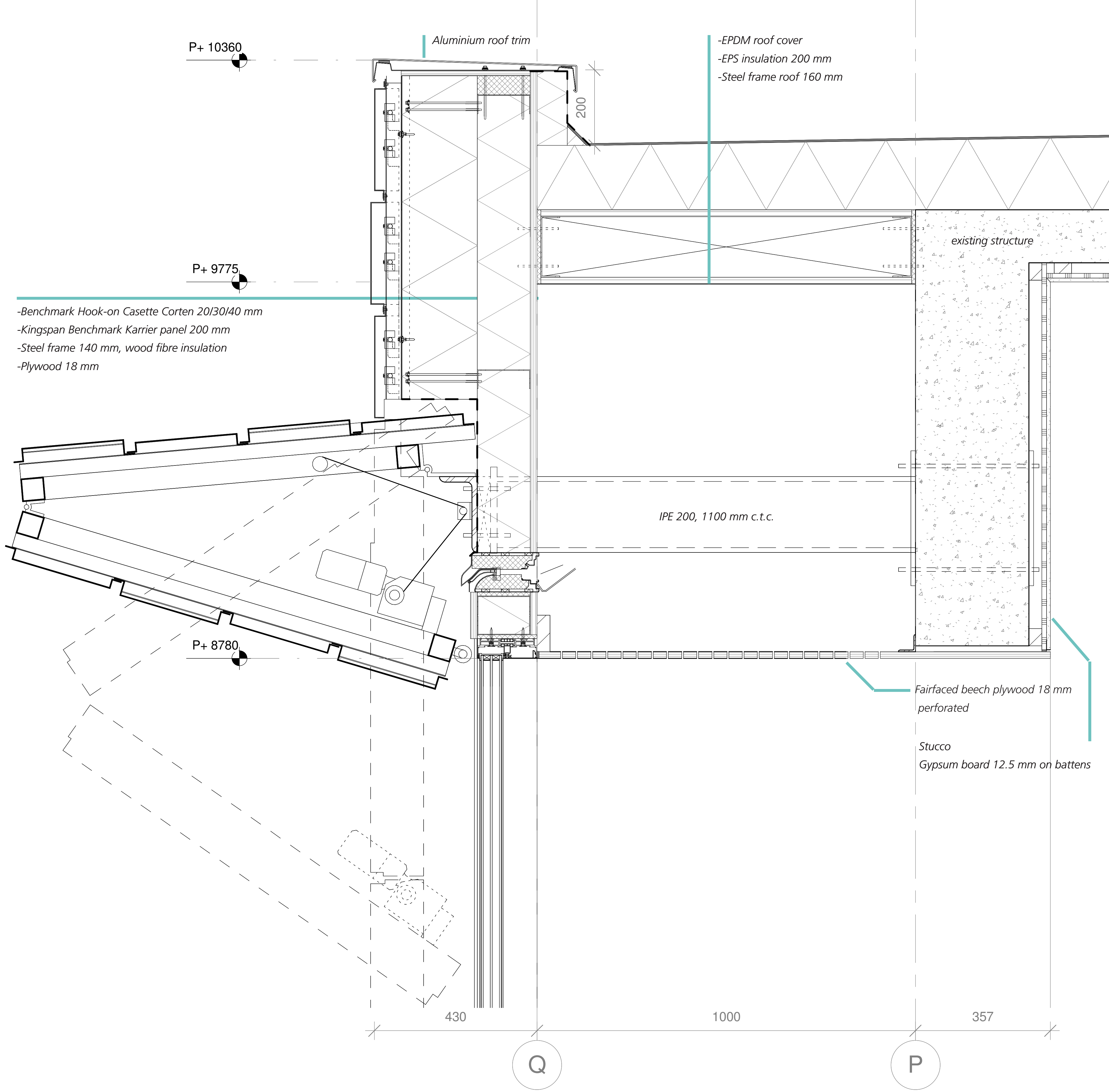
**Detail 3,** 1:10

The facade is built up of Corten panels. The panels are made in three different standard lengths, in a thickness of 20, 30 and 40 mm. This creates the desired dynamic facade. The pattern of the panels is inspired by the planks of wooden ships.

In order to create the facade with this variation in depth, the Corten is applied as cassettes. The cassettes can be made in varying thickness's, all using the same substructure. This substructure is a sandwich panel based facade system by Kingspan called Benchmark Karrier. It is based on insulating panels of rigid insulation material with a dense exterior finish. The vertical steel mullions can be fastened directly to this sandwich panel.

The Corten cassettes are hung to the mullions using a bed hook system, and fixed on the top of the panel. By pre-drilling the holes for the bed hook pins, the system ensures a correct alignment and quick fastening of the cassettes.

Above the window, Duco ventilation unit lets in fresh air. The unit has an integrated heating element to preheat the incoming air. This is capable of heating the air when the outdoor air is below 12°C, to prevent thermal draft in the room. The air is infiltrated through the plywood ceiling.



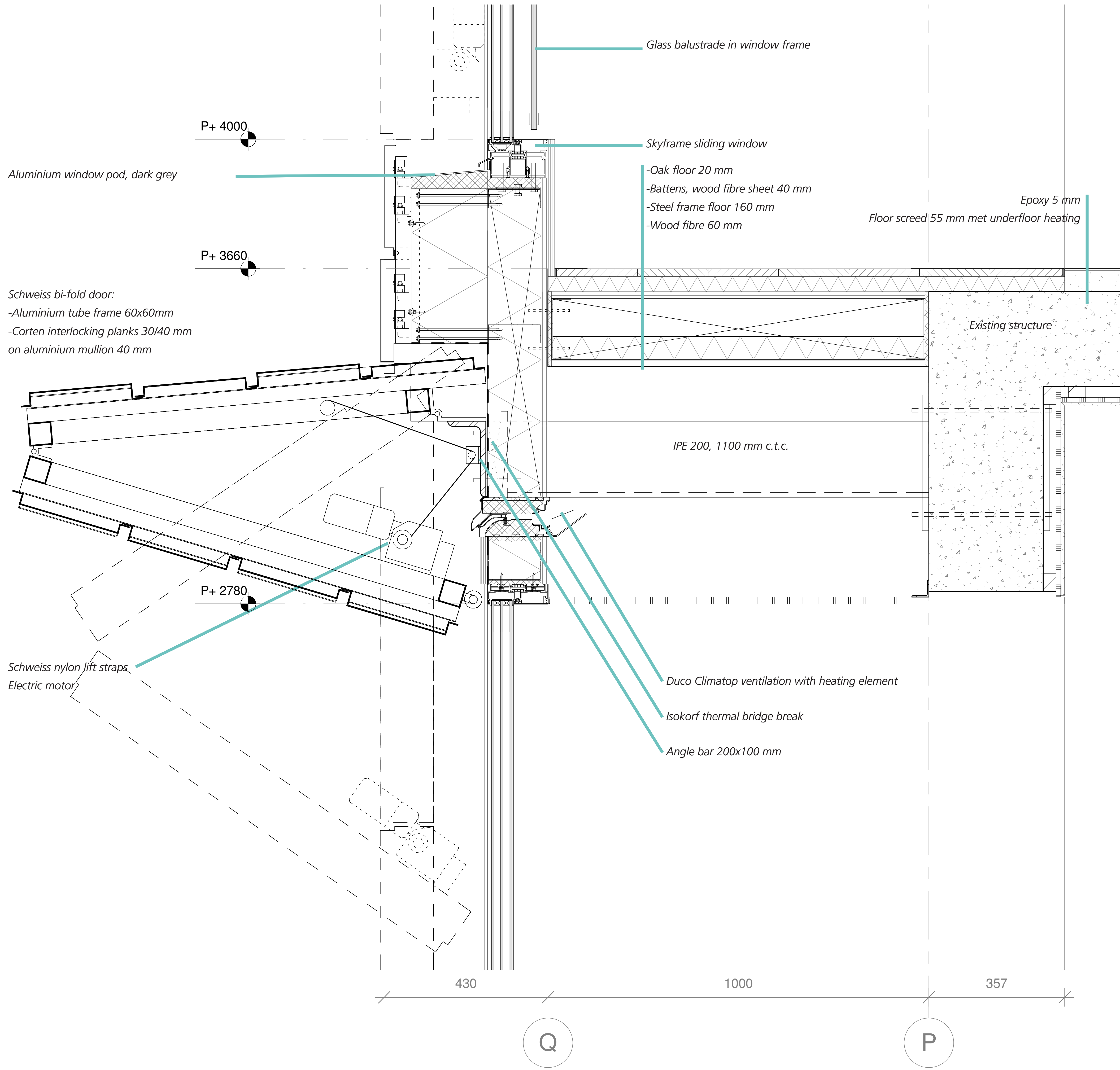
**Detail 4,** 1:10

Each room is equipped with a large sliding window of 4 m by 1.8 m, which can open to 2m by 1.8 m. The entire window zone acts as a frame to frame the view through this window. The window frame itself is recessed in the wall, leaving only glass and wood. The sliding window is actually a sliding door by Skyframe, designed to have an invisible frame.

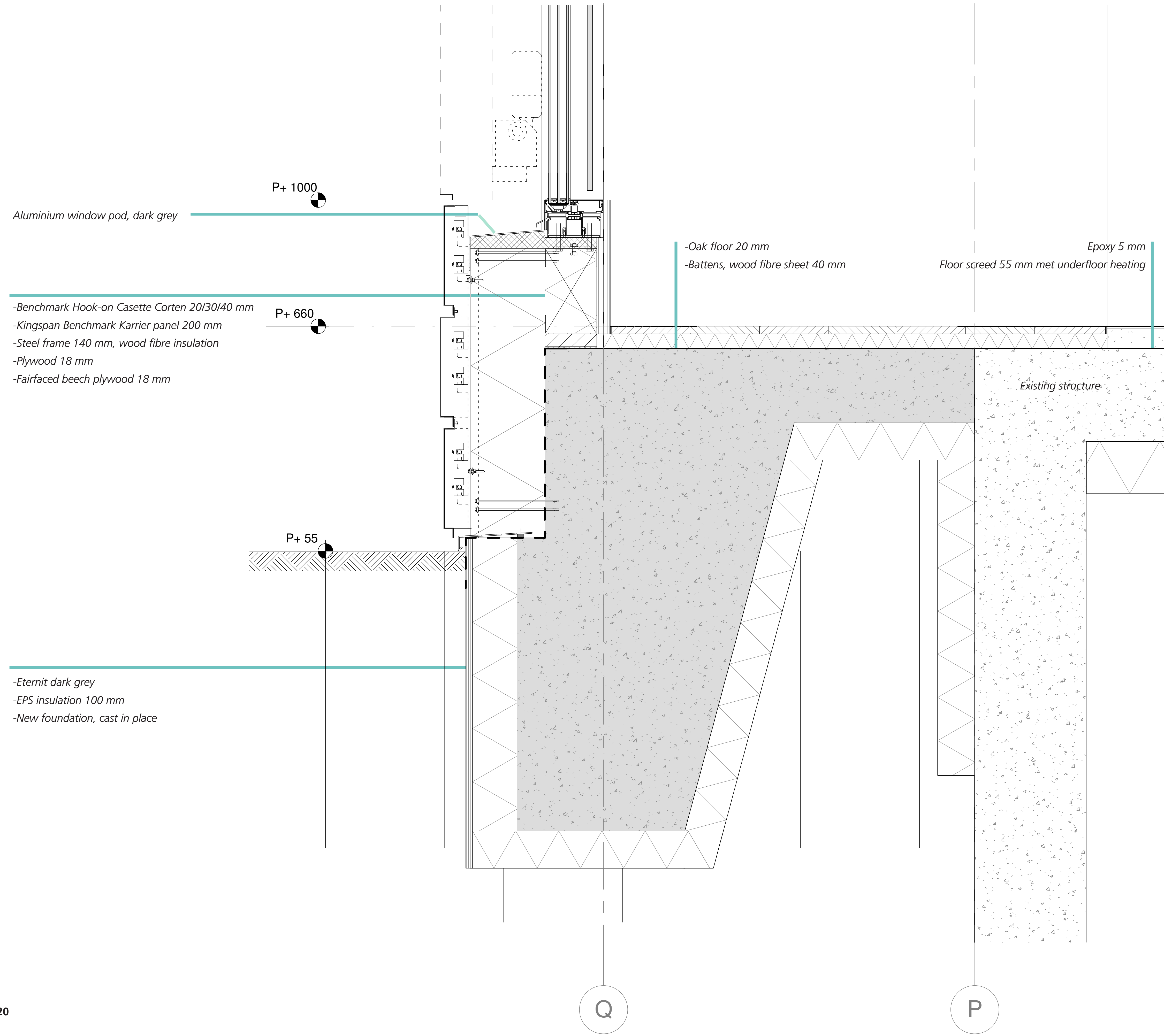
The unique function of the building means that sometimes the rooms needs to be (partly) darkened. Normal curtains or louvres would narrow the horizon. Vertically opening louvres always keep a panoramic view of the horizon.

When closed, the louvres should blend in with the rest of the facade, clad with Corten. This asks for strong, sturdy louvres. The Corten sheets, 13 m2 at 16 kg/m2, have a weight of 212 kg. The bi-fold louvre was developed as a door for large hangars, which can be up to 5 meters high. It consists of a aluminium framework, connected to the building using heavy duty hinges on the top. The louvre is lifted using nylon straps, powered by an electric motor. Both the straps and the strap roll and the electric motor are mounted to frame of the louvre itself, to minimise installation space in the wall. The bottom of the louvre is guided by wheels on the side of the window. This way, the louvre hoists itself up. The door opens slightly inward on the top, which allows the close fitting of the louvre when closed.

This aluminium frame can be clad with any material, in this case Corten cassettes. To save weight, the cassettes on the doors are made as interlocking planks which need less material. These are fixed on top and bottom to an aluminium omega mullion.

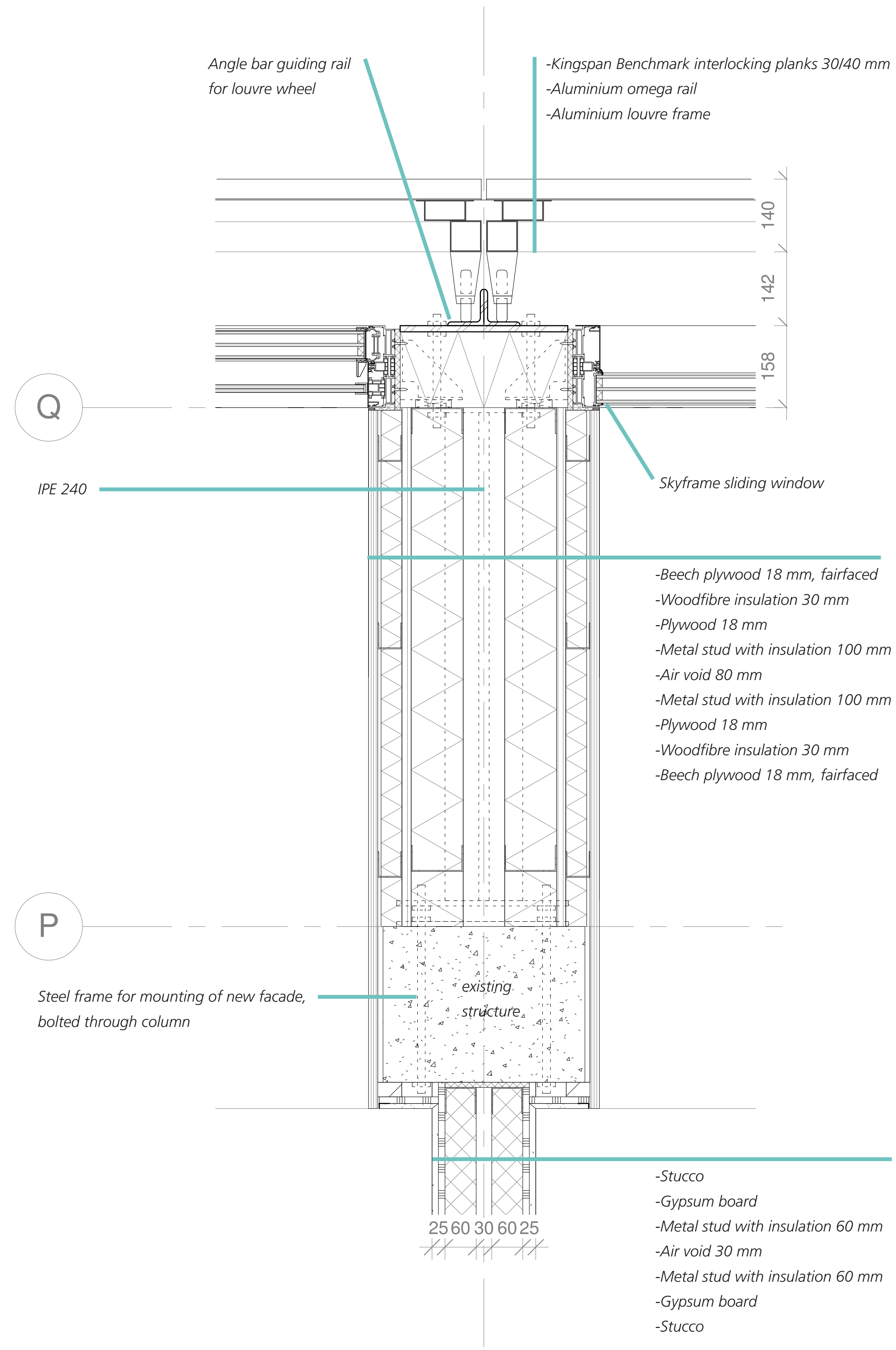


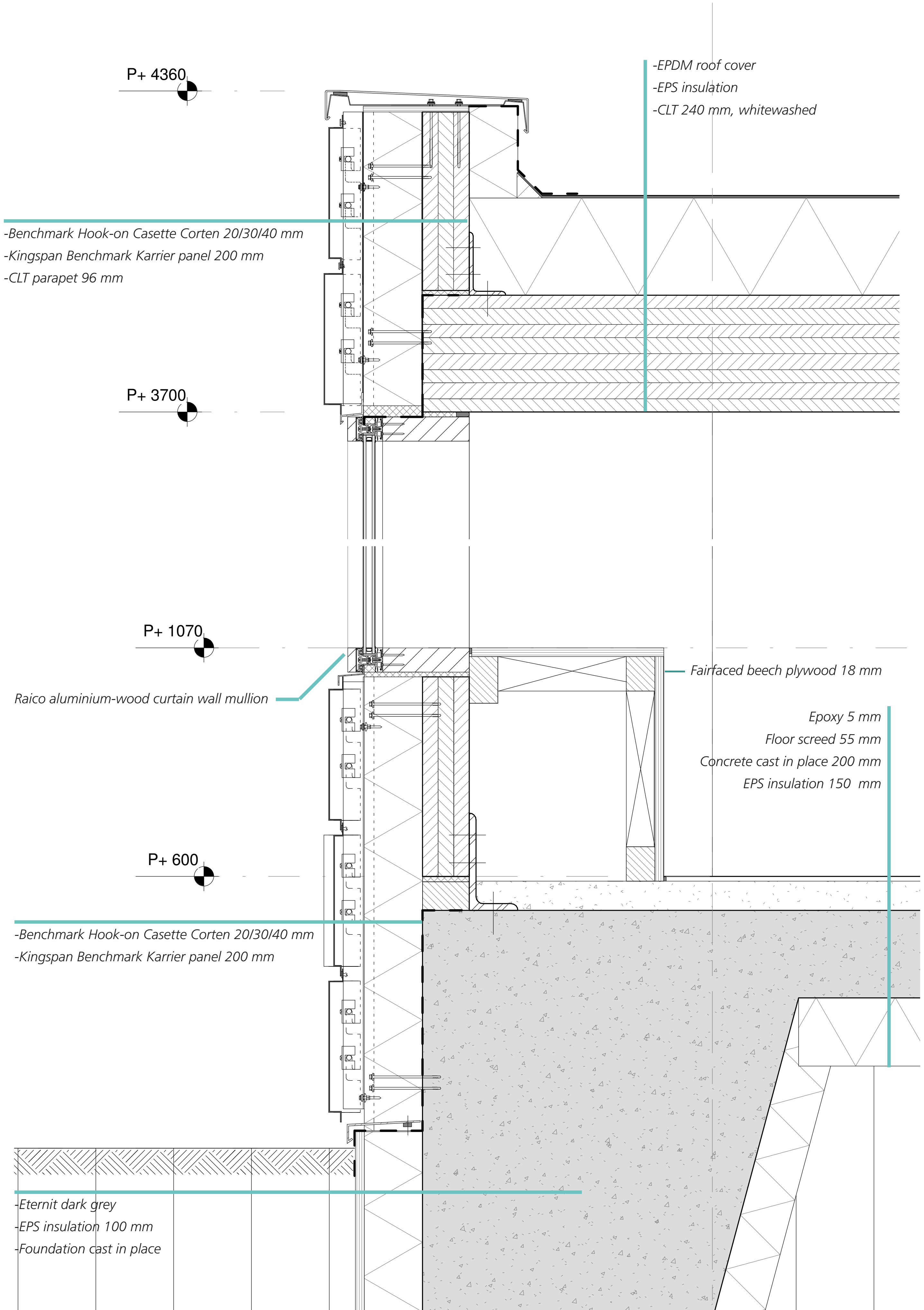
**Detail 5,** 1:10

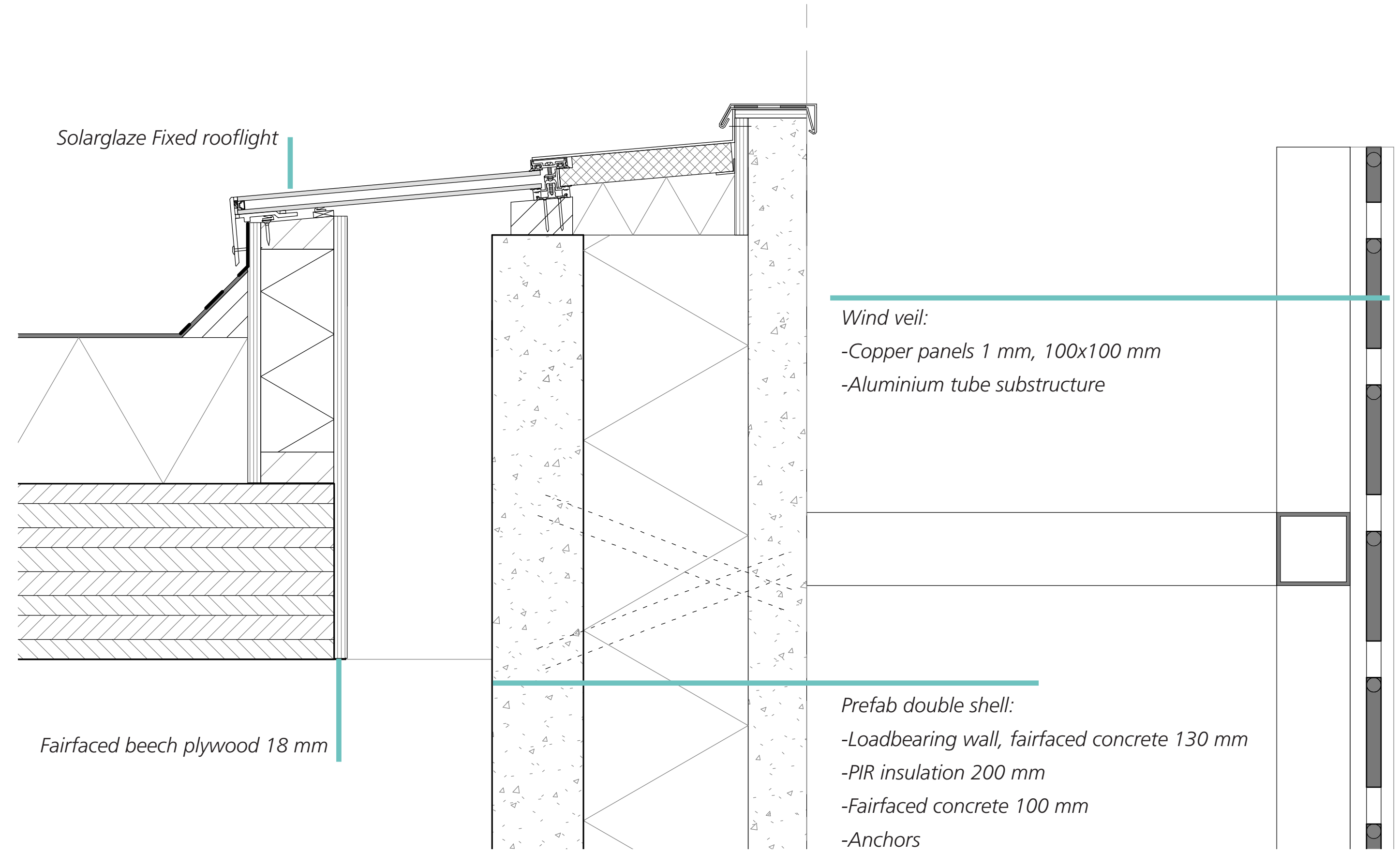

P+ 1000
Aluminium window pod, dark grey
-Oak floor 20 mm
-Battens, wood fibre sheet 40 mm
Epoxy 5 mm
Floor screed 55 mm met underfloor heating
-Benchmark Hook-on Casette Corten 20/30/40 mm
-Kingspan Benchmark Karrier panel 200 mm
-Steel frame 140 mm, wood fibre insulation
-Plywood 18 mm
-Fairfaced beech plywood 18 mm
P+ 660
Existing structure
P+ 55
-Eternit dark grey
-EPS insulation 100 mm
-New foundation, cast in place
Q
P

**Horizontal detail H1,** 1:10

This facade extends 1000 mm out of the existing concrete structure. The new facade is connected to the exiting structure using steel consoles attached to the existing columns.
This steel frame also supports the guiding wheels of the louvres. The Skyframe window frame is recessed into the wall to create the frameless view..



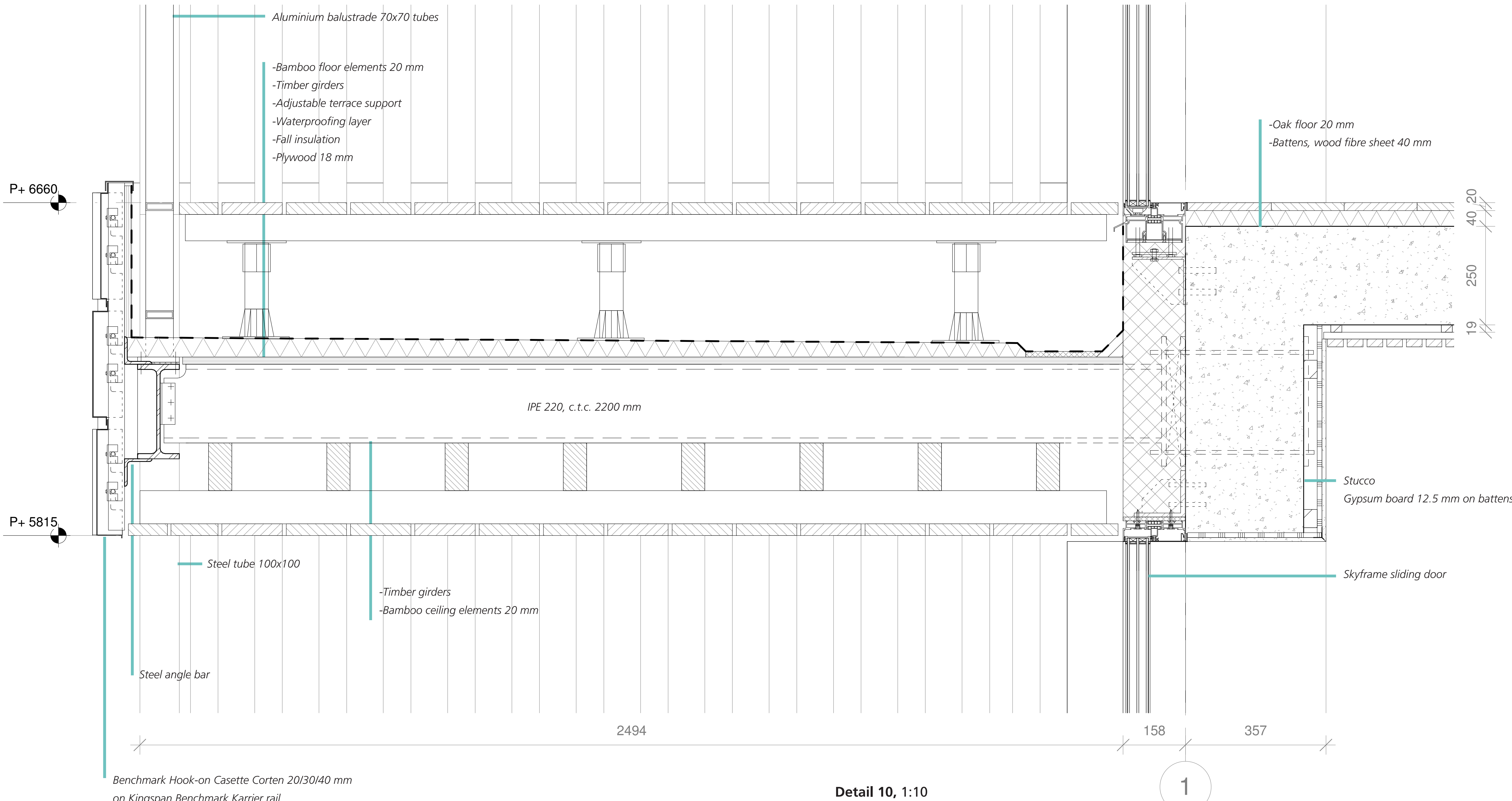



**Details 6, 7, 8,** 1:10

The transition corridor is characterised by the timber frame curtain wall on one side, and the fair-faced concrete on the other side. The curtain wall and timber columns create a strong rhythm in the corridor. On the outside the corridor is clad with the same Corten cassettes as the rest of the building, using the same mounting system.

The concrete wall is illuminated with floodlight coming through the roof light. On the exterior side this wall is covered with a wind veil, an array of copper sheets which can move in the wind. The copper sheets can be thinner than Corten because the protective patina is thinner. The wind veil is located on the Southeast facade. On a facade, especially a facade which is not perpendicular to the prevailing wind direction, the copper forms a brownish patina of copper-oxide matching the patina of Corten.




**Detail 10,** 1:10

The balcony of the common room acts as a sun shading device for the room below. The floor cover continues from inside the room, uninteruped by the hidden door frame. The balcony edge is clad with Corten panels like the other facades. The railing is made of vertical aluminium tubes in elements of 1,6 m wide. On the sides of the balcony, the full height tubes also act as a supporting frame.

fig. 55 *3D facade section*

# 7

# SCALE MODEL IMPRESSION

fig. 56 *Entrance to private rooms*

fig. 57 *Looking through the entrance.*

fig. 58 *Patient rooms facade*

fig. 59 *West perspective*

fig. 60 *South perspective*

fig. 61 *South west facade*

# REFLECTION

In the introduction, a number of research questions have been defined, setting the goals for the design of the hospice in The Hague.

*How can the design of a facility for palliative care provide a protected and comfortable environment for people in the last stage of their lives?*

*In what ways can various sensory experiences be used to create a protected, comforting environment in a hospice?*

*How can this hospice be designed to fully utilize the local climatic conditions to create a comfortable indoor climate, while minimizing energy consumption?*

### Atmosphere

The atmosphere in the hospice has been very important in the design process. The function demands a comfortable, protecting environment. With the transition zones and routing around the patio and courtyard, the routing creates corridors to meet people, spots to retreat, little viewpoints throughout the building and space for contemplation.
The strict set of materials creates a calm environment. The materials used each have strong character. Corten steel creates a beautiful weathered look, changing over time. Concrete, both new and existing, brings security both inside and outside. The use of wood in the interior creates warmth, and a truly homely atmosphere.

### Solar facade

Studying the solar facade has been an interesting research. Based on the available information through existing literature, the solar facade should work on this building. To get a complete picture of the airflow in the building, a computational fluid dynamics (CFD) simulation would be needed. This was too detailed for the scope of this master thesis. It became apparent that this was not the ideal building for a solar chimney or solar facade. In a higher building the temperature increase could be significantly bigger. Though albeit these reservations, the solar facade is a good solution to a very specific problem. The program and layout created a closed south facade. Using the solar facade, this facade seems not so closed anymore, and solar heat is being used. Like a good climatic design, it did not impose any boundaries on the architectural design. Instead, the climatic design uses characteristics of the architectural design.



### Using the elements

One of the goals was to make use of the elements wind, sun and sea, not only for the experience and atmosphere, nut also for the energy balance and climatic design. The solar facade uses sun light of course, but the other two elements could not be used in the design. Using energy in the seawater is a good concept, with great potential for heating coastal areas. However, the lack of heat storage makes it not suitable for this building.
Using wind power seems like the right thing to do at this location. The wind is always available. However, the true potential of building based wind power is not very big. A roof mounted system would have generated electricity, but an integrated system would limit itself to only a small section of wind directions.
It shows a desire for sustainability, but when the system is actually not that efficient, is it really fair to make it such a big deal? The wind veil integrated in the south east wall uses the wind solely for spherical and aesthetic reasons, without pretending anything else.

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# APPENDIX

# APPENDIX 1: SOLAR ENERGY POTENTIAL

power output pv panels: 150 Wp/m2
PVGIS radiation database: 799 kWh/kWp

| Name | Available area ($m^2$) | Power ($kW_p$) | Loss factor | Yearly Yield (kWh) |
|---|---|---|---|---|
| south wing | 570 | 85,5 | 0,87 | 68.315 |
| atrium roof | 144 | 21,6 | 0,87 | 17.258 |
| entrance building | 325 | 48,8 | 0,87 | 38.951 |
| north wing | 450 | 67,5 | 0,87 | 53.933 |
| cloister | 94 | 14,1 | 0,87 | 11.266 |

\+

189.713

# APPENDIX 2: VENTILATION CAPACITY

## FLOOR -1

| Number | Name | Area ($m^2$) | Persons | Per $m^2$ ($dm^3/s$) | Per Person ($dm^3/s$) | Minimum ($dm^3/s$) | Ventilation ($dm^3/s$) | Ventilation per room ($dm^3/s$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Beauty salon | 28 | 3 | | 6,5 | 7 | 19,5 | 19,5 |
| 2 | Hair salon | 38 | 3 | | 6,5 | 7 | 19,5 | 19,5 |
| 3 | Complementary Therapy | 15 | 2 | | 6,5 | 7 | 13 | 13 |
| 4 | Lymphoedema clinic | 15 | 2 | | 6,5 | 7 | 13 | 13 |
| 5 | Physiotherapy clinic | 15 | 2 | | 6,5 | 7 | 13 | 13 |
| 6 | Occupational therapy | 15 | 2 | | 6,5 | 7 | 13 | 13 |
| 7 | Meeting room | 35 | 10 | | 6,5 | 7 | 65 | 65 |
| 8 | Hydrotherapy | 50 | 5 | | 6,5 | 7 | 32,5 | 32,5 |

## FLOOR 0

| Number | Name | Area ($m^2$) | Persons | Per $m^2$ ($dm^3/s$) | Per Person ($dm^3/s$) | Minimum ($dm^3/s$) | Ventilation ($dm^3/s$) | Ventilation per room ($dm^3/s$) |
|---|---|---|---|---|---|---|---|---|
| 9 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 15 |
| 10 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 16 |
| 11 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 17 |
| 12 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 18 |
| 13 | Room | 27 | | 0,9 | | 7 | 24,3 | overflow into 19 |
| 14 | Room | 27 | | 0,9 | | 7 | 24,3 | overflow into 20 |
| 15 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 16 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 17 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 18 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 19 | Bathroom | 5 | | | | 14 | 14 | 24,3 |
| 20 | Bathroom | 5 | | | | 14 | 14 | 24,3 |
| 21 | Common room | 57 | | 0,9 | | 21 | 51,3 | 51,3 |
| 22 | Chapel | 50 | 8 | | 4 | 7 | 32 | 32 |
| 23 | Meeting room | 21 | 5 | | 6,5 | 7 | 32,5 | 32,5 |
| 24 | Nurse | 24 | 5 | | 6,5 | 7 | 32,5 | 32,5 |
| 25 | Café | 70 | 20 | | 4 | 7 | 80 | overflow into 26, 27 |
| 26 | Kitchen / Reception | 31 | | 0,9 | | 21 | 27,9 | 59 |
| 27 | Toilet | 15 | 3 | | 7 | 7 | 21 | 21 |
| 28 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 33 |
| 29 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 34 |
| 30 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 35 |
| 31 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 36 |
| 32 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 37 |
| 33 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 34 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 35 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 36 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 37 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 38 | Common room kids | 81 | | 0,9 | | 21 | 72,9 | 72,9 |

## FLOOR 1

| Number | Name | Area (m²) | Persons | Per m² (dm³/s) | Per Person (dm³/s) | Minimum (dm³/s) | Ventilation (dm³/s) | Ventilation per room (dm³/s) |
|---|---|---|---|---|---|---|---|---|
| 39 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 45 |
| 40 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 46 |
| 41 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 47 |
| 42 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 48 |
| 43 | Room | 27 | | 0,9 | | 7 | 24,3 | overflow into 49 |
| 44 | Room | 27 | | 0,9 | | 7 | 24,3 | overflow into 50 |
| 45 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 46 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 47 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 48 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 49 | Bathroom | 5 | | | | 14 | 14 | 24,3 |
| 50 | Bathroom | 5 | | | | 14 | 14 | 24,3 |
| 51 | Family | 12 | | 0,9 | | 7 | 10,8 | |
| 52 | Bathroom Family | 6 | | | | 14 | 14 | 14 |
| 53 | Common room | 57 | | 0,9 | | 21 | 51,3 | 51,3 |
| 54 | Library | 32 | 6 | | 6,5 | 7 | 39 | 39 |
| 55 | Nurse | 20 | 5 | | 6,5 | 7 | 32,5 | 32,5 |
| 56 | Family room | 31 | 10 | | 4 | 7 | 40 | 40 |
| 57 | Family room | 31 | 10 | | 4 | 7 | 40 | 40 |
| 58 | Grieving room | 35 | 10 | | 4 | 7 | 40 | 40 |
| 59 | Grieving room | 35 | 10 | | 4 | 7 | 40 | 40 |
| 60 | Preparation room | 20 | 3 | | 6,5 | 7 | 19,5 | 19,5 |
| 61 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 66 |
| 62 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 67 |
| 63 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 68 |
| 64 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 69 |
| 65 | Room | 24 | | 0,9 | | 7 | 21,6 | overflow into 70 |
| 66 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 67 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 68 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 69 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 70 | Bathroom | 6 | | | | 14 | 14 | 21,6 |
| 71 | Common room kids | 40 | | 0,9 | | 21 | 36 | 36 |

## FLOOR 2

| Number | Name | Area (m²) | Persons | Per m² (dm³/s) | Per Person (dm³/s) | Minimum (dm³/s) | Ventilation (dm³/s) | Ventilation per room (dm³/s) |
|---|---|---|---|---|---|---|---|---|
| 72 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 78 |
| 73 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 79 |
| 74 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 80 |
| 75 | Room | 26 | | 0,9 | | 7 | 23,4 | overflow into 81 |
| 76 | Room | 27 | | 0,9 | | 7 | 24,3 | overflow into 82 |
| 77 | Room | 27 | | 0,9 | | 7 | 24,3 | overflow into 83 |
| 78 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 79 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 80 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 81 | Bathroom | 5 | | | | 14 | 14 | 23,4 |
| 82 | Bathroom | 5 | | | | 14 | 14 | 24,3 |
| 83 | Bathroom | 5 | | | | 14 | 14 | 24,3 |
| 84 | Family | 12 | | 0,9 | | 7 | 10,8 | overflow into 85 |
| 85 | Bathroom Family | 6 | | | | 14 | 14 | 14 |
| 86 | Multi-funcional room | 32 | 20 | | 4 | 7 | 80 | 80 |
| 87 | Nurse | 29 | 5 | | 6,5 | 7 | 32,5 | 32,5 |
| 88 | Common room | 57 | | 0,9 | | 21 | 51,3 | 51,3 |
| 89 | Office | 20 | 3 | | 6,5 | 7 | 19,5 | 19,5 |
| 90 | Office | 20 | 3 | | 6,5 | 7 | 19,5 | 19,5 |
| 91 | Office | 29 | 4 | | 6,5 | 7 | 26 | 26 |
| 92 | Office | 20 | 3 | | 6,5 | 7 | 19,5 | 19,5 |
| 93 | Training room | 67 | 15 | | 8,5 | 7 | 127,5 | 127,5 |
| 94 | Canteen | 80 | 15 | | 4 | 7 | 60 | 60 |
| 95 | Meeting room | 30 | 8 | | 6,5 | 7 | 52 | 52 |
| 96 | Meeting room | 24 | 8 | | 6,5 | 7 | 52 | 52 |
| 97 | Toilets | 15 | 3 | | 7 | 7 | 21 | 21 |

Total ventilation capacity: 2059,40 dm³/s
Depth: 0,65 m/s
Air speed: 0,5 m/s
With solar facade: 6,34 m

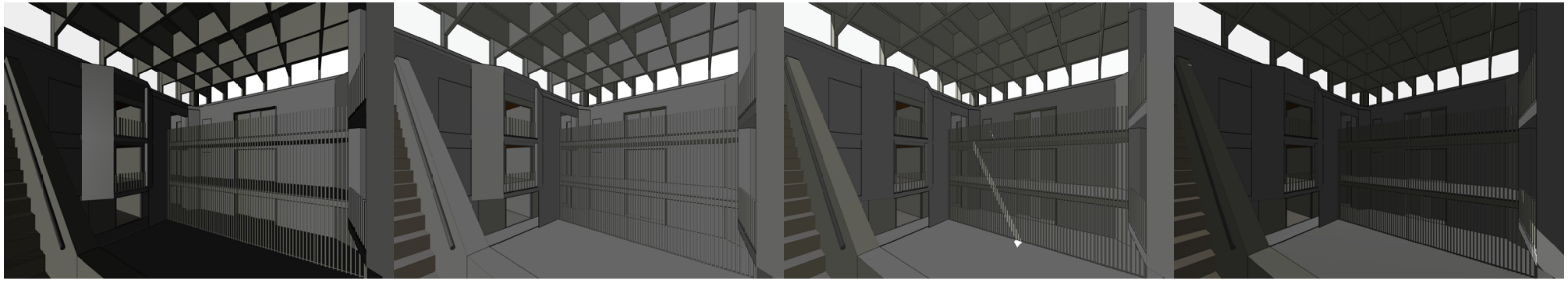
# APPENDIX 3: TRANSFORMATION CHECKLIST

| | Aspect | Criteria | Remark | Result | |
|---|---|---|---|---|---|
| MARKET | Target group and supply | Potential demand for care+living | For developer | | |
| | | Availability of empty office building | For care provider | + | |
| LOCATION | Minimal area quality | Noise hindrance below norm | <=50dB on facade | + | |
| | | Fine dust below norm (roads, industry, livestock) | <50μg/$m^3$ is exceeded max. 35 days per year | + | |
| BUILDING | Dimensions casco | Sufficient storey height after transformation | >= 2,6 m | + | 2,7m |

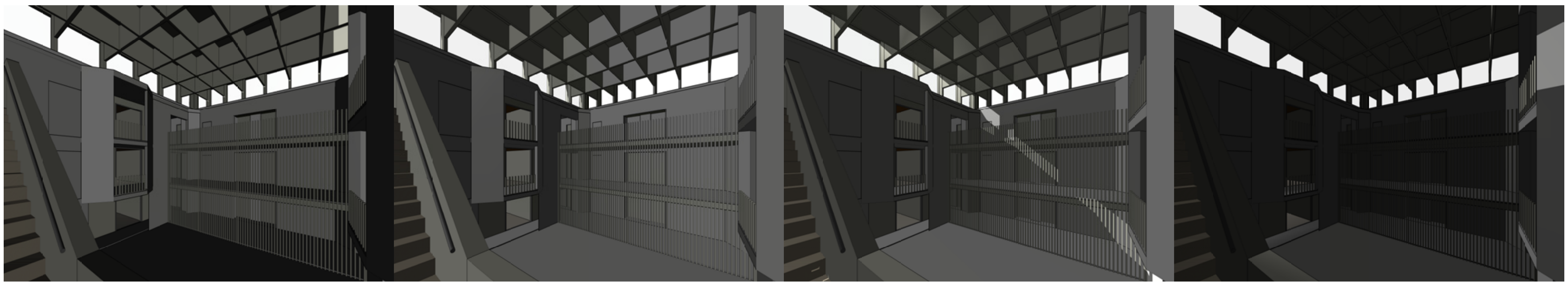
| | Aspect | Criteria | Remark | Result | |
|---|---|---|---|---|---|
| MARKET | Supply | Building is older than 3 years | | + | |
| | | Building is totally empty | | 0 | Current renters are temporary |
| LOCATION | Bestemmingsplan | Bestemmingsplan allows living function | | | |
| | | Bestemmingsplan allows densification | | | |
| | | Ground in ownership | Ground lease is bad for value | + | |
| | | Ground unpolluted | Especially when ground works are necessary | | |
| | Area quality | Neighbourhood suitable for care+living | No industrial estate | + | |
| | | Presence of other residents | Quality of living for semi independent residents | + | |
| | | Good solar radiation | South facade not in shade of other buildings | + | |
| | | Presence of park/green/water | Within 500 m | + | |
| | | Good social security | Street visible from apartments, activities on street level | + | |
| | | Low garbage and graffiti | Deprivation | + | |
| | Services | Services groceries | Within 500 m | + | |
| | | Services banking | Within 500 m | + | Not applicable for hospice |
| | | Library, theatre, church etc | Within 500 m | + | Not applicable for hospice |
| | | Sports centre, community centre | Within 500 m | + | Not applicable for hospice |
| | | Care provider/nursery home | Within 500 m | + | |
| | | General practitioner, pharmacy | Within 500 m | + | Not applicable for hospice |
| | | Physiotherapy, Occupational therapy, dentist | Within 500 m | + | Not applicable for hospice |
| | Accessibility | Accessibility public transport | Within 200 m | + | Mainly for visitors |
| | | Accessibility by car | No traffic problems | + | Mainly for visitors |
| | | Sufficient parking | 2% disabled parking <=25m from main entrance | 0 | Sufficient free space, plenty public parking on boulevard |
| | | Possibility for resting place on pedestrian access routes | | | |

| | Aspect | Criteria | Remark | Result | |
|---|---|---|---|---|---|
| BUILDING | Dimensions Casco | Sufficient space for care unit and services | Dependant on target group | + | Plenty floor space, total and per floor |
| | | Grid suitable for care+living | Short spans can be tricky | + | |
| | | Basement (parking, storage units, installations) | | + | Storage units not applicable |
| | | Possible to connect new interior walls to facade | | + | Non-load-bearing facade |
| | | Floor height >=2,6 m, <3,6 m, or >5,5 m | High costs for unused space | + | |
| | Maintenance | Load-bearing structure in good condition | | + | |
| | | No leakages | | + | |
| | | No asbestos | Pay attention to buildings built before 1985 | ? | |
| | Load-bearing structure | Robust construction with possibility for extra floor | | + | |
| | | Openings in the floor possible | | 0 | |
| | | Sufficient sound insulation, or space for insulation measures | Sound through air +5dB, Sound through contact +10dB | ? | Present insulation probably too low |
| | | Sufficient fire resistance | Floor <7 m: 60min., 7-13 m: 90min., >13 m: 120min | ? | Present insulation probably too low |
| | Fire safety | Two independent escape routes | Distance to front door apartment <= 30 m | + | |
| | | Fire elevator present | When floors >12.5 m | - | |
| | | Possibility for fire compartments | Max 500 m² | 0 | |
| | | Sufficient fire resistance | 30 min within unit, 60 min between apartments and units | - | Present insulation probably too low |
| | Functionality | Possibility for horizontal extension | | + | |
| | | Presence of courtyard, patio, garden | | + | Plenty open space |
| | | Accessible storage units | Target group dependant | 0 | Not applicable for hospice |
| | | Floor plan allows feasible group units | Operating costs, organisation | + | Good layout for centralised units without corridors |
| | Facade | Sufficient sound insulation | Variable | ? | |
| | | Sufficient thermal insulation | 2,5 m² x K/W | - | 1.6 m² x K/W |
| | | Windows can be opened | | + | |
| | | Recognisable building, with character | | + | |
| | | Recognisable entrance | | - | |
| | Installations | Usable shafts | | + | |
| | | Presence of cooling and heating system | Max. 10 years old, sufficient capacity | - | |
| | | Presence of ventilation system | Sufficient capacity | - | |
| | | Space available for new installations | New ducts and openings | + | |
| | Accessibility | Main entrance visible and accessible | Free space on both sides >=2,1 x 2,1 m | - | |
| | | Accessibility for physically disabled | Ramp when height difference >20 mm | - | |
| | | Elevator and main stair case accessible from main entrance | | + | |
| | | Beds elevator present, or space available | Shaft 1.8 x 2.6 m | 0 | Space available |
| | | Comfortable stairs | Straight stairs, with landing every 1,8m. Riser <=18,5 cm, tread 60-65 cm – 2 x riser | - | |
| | | No height difference in floors | Thresholds max. 20 mm, otherwise use a ramp | - | |
| | Comfort | View from private spaces and common spaces | Parapet max. 700 mm | - | |
| | | Good view | Target group dependant | + | View over the sea on three sides |
| | | Private or common outdoor space | Target group dependant | 0 | |
| | | Private outdoor space possible for independent apartments | | + | |
| | | Sufficient daylight penetration | 10% of floor area | + | |

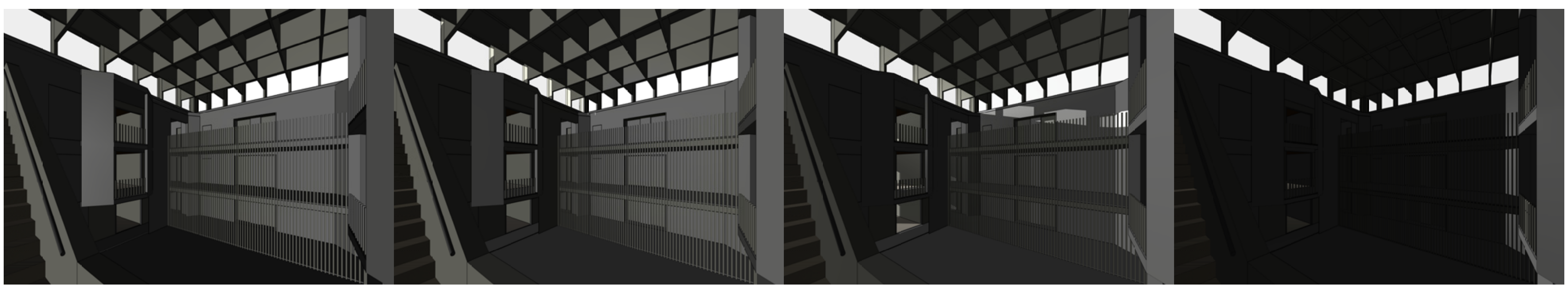
# APPENDIX 4: SOLAR STUDY ATRIUM



*Sun study - 21 june: 7 AM, 12 AM, 3 PM, 6 PM*



*Sun study - 21 march: 7 AM, 12 AM, 3 PM, 6 PM*



*Sun study - 21 december: 7 AM, 12 AM, 3 PM, 6 PM*