Kløvkærhuse - Accessible Dwellings in Seest

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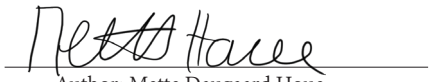

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Preface

This project is made as a Master Thesis project with specialization in Architecture at Aalborg University, at the Department of Architecture and Design. The overall subject in this thesis is 'Accessible Dwellings', with the sub-themes 'Universal Design' and 'Sustainability'.

The base and overall frame for the design development is the competition 'Fremtidens Bæredygtige Almene Bolig', which is an open architectural competition started in September 2013. It is aiming to generate new ways of developing social housing within the context of Lisbjerg, Aarhus and Seest, Kolding,where this project is unfolding.

The Integrated Design Process (IDP) is applied as guidance for the whole project and a holistic approach to architecture and sustainability is applied within as calculations will be performed along with sensuous experiments to obtain good architecture.

This project aims to obtain the 2020 energy requirements of on a yearly basis along with strong focus on indoor climatic factors.

Abstract

'Accessible Dwellings' is addressing the physical living environment for intellectually disabled adults. Working with the aspects of promoting inclusion in the surrounding society and to foster a high degree of self-determination, the dwellings are perceived as a foundation of 'the good life'. Within a broad emphasis on sustainability the social and environmental aspects are main focus in this project.

Mentally disabled are often requiring clear boundaries and a structured everyday. This will be facilitated by enhancing the zoning of the housing with a distinction between private areas and social spaces. This will contribute to an increased wellbeing of the inhabitants. Physically disabled require accessible dwellings with optimized solutions regarding to access routes and stationary solutions. On the basis of an analysis of the user's needs design guides will be determined.

Environmental sustainability is to be adapted to this specific project. Active and passive means shall be balanced on the behalf of a good and healthy indoor climate and an energy reduced building. Passive means as the shape and construction of the building envelope, its position and orientation will be dealt with along with considerations of active means as energy-producing devices.

Readers guidance

This project can be read in more levels;

All chapters are initiated with a short introduction and overview of the forthcoming.
The whole report is presented chronological with the overall structure following the Integrated Design Process. Thus the IDP is performed in iterations, the presentation of the chapter is linear to facilitate an easier understanding.

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INITIAL IDEA
ANALYSIS PHASE
SKETCHING PHASE
SYNTHESIS PHASE
PRESENTATION

INTRODUCTION

NEXT CHAPTER INCLUDES FOLLOWING:

PROJECT INTRODUCTION
USER GROUP FACTS; intellectually disabled
METHOD; integrated design process and Vitruvius

This initial chapter has the function to outline the working process of this project. The user group, which this whole project evolves around, will shortly be introduced and the integrated design process will be presented as an overall working method and approach.

Introduction

A higher focus on the rights and inclusion of people with disabilities began in the late 1980s, making a historical and very important change. The so-called 'Servicelov' in 1998 and the de-institutionalization was a shift of paradigm leading away from the former tendency to install people with disabilities in large institutions. (Socialstyrelsen, n.d.)

A physical or mental handicap was before considered permanent, and people would live their entire adulthood at large institutions. A new attention came to the matter of handicapped and their rights as humans. In continuation of this the range of housing opportunities increased. (Socialstyrelsen, n.d.)

In 2009 Denmark joined the convention of FN securing people with disabilities the rights of independence and self-determination in the question of where, how and whom to live with. (Tænketank om fremtidens boliger til mennesker med handicap, 2010)

Working with dwellings for people with disabilities demands a high level of understanding of both physical and psychological requirements. The dwellings must not only provide healthy and good environment as 'regular' housing architecture, but they do also have to incorporate thoughtful solutions according to space layout, flow patterns and interior detailing.

There is currently a strong need for accessible housing in Denmark designed with the qualities of Universal Design. As the demography changes and with a still higher focus on the rights of humans with different difficulties, equal access and opportunities are in focus. (Møller and Knudstrup, 2008)

There is a tendency that the percentage of persons above 60 years of age is increasing compared with the percentage of the part of the population working. Increase in the dependency ratio calls for better solutions regarding to letting elderly or persons with disabilities stay in own home as long as possible. (Dansk Statestik, n.d.)

This fact leads to a natural need of more dwellings flexible to changes in lifestyle and ability throughout a lifespan. Implementing accessibility and equal rights in a design process allows a broader range of users without compromising with quality or functionalism.

Too many bad examples show how accessibility becomes an add-on and instead of implementing it through integration. In this project the dwelling is perceived as the point of departure of a barrier-free and independent every day. A handicap can be defined as one's lack of ability to navigate (both mentally and physically) in a given situation and space. The handicap is thus an expression of the surrounding's failure to include.

This project is partly originated in the architectural competition 'Fremtidens Bæredygtige Almene Bolig'; building site and social strategy are implemented in this project. The competition has been done in order to reinterpret and restart the discussion about how to develop sustainable dwellings, both regarding to the environmental, social and economic factors.

One of the aims is to secure social diversity in the sector of social housing by attracting inhabitants from all ranges of society and ages. By incorporating dwellings for people with disabilities into a larger context of housing a better understanding between the groups can be fostered.

During my half year working as an assistant for people with special needs, my interest has arisen upon equal rights and the built environment as a mean to obtain this. My personal understanding of the everyday challenges, one with disabilities might meet, is rooted in a qualitative first-hand experience.

Definition of essential terms

Universal Design
An ideology that includes *everybody* as user on equal basis regardless of physical/mental handicap or not. Universal Design is implying that all users are potentially handicapped, if the surroundings are restricting them. (Ryel, 2009)

Accessibility
Refers to the built environment as a potential barrier between the individual and its abilities to move freely. A term also included in Universal Design. (Ryel, 2009)

Intellectually disabled
An administrative diagnose that describes people who are developing slower than others and are developing to a lower state. User group in this thesis project.

User
The future inhabitant of the housing. All users are intellectual disabled but are having very different needs.

Sustainability
Defined as in the Brundtland Report written in 1987; sustainability is to be understood as the subdivision into social-, economic- and environmental sustainability. This definition will be unfold later in the programme. (Brundtland-commission, 1987)

Social Inclusion
A part of the definition of social sustainability, resulting in everybody being allowed to participate in the society no matter of precondition or impairment.

There are around

36.000

INTELLECTUALLY DISABLED

people living in Denmark.

'Intellectually disable' is no disorder but a

ADMINISTRATIVE DIAGNOSIS

INTELLECTUAL DISABILITIES

Often caused by:

- A genetic error, brain injury, chromosomal defects, low weight or lack of oxygen during birth

Might cause following:

- Motor skills and verbal challenges, challenges with social interaction, physical disabilities, Downs Syndrome (chromosomal defects), autism or autistic symptoms, ADHD

SEQUELS,

as visual and hearing impairments are known side effects from being intellectually disabled.

FACTS

(Landsforeningen LEV, n.d.)

All families with disabled kids and adults are having the right to receive

GUIDANCE AND SUPPORT

from the municipal, in which they live in.

Around

1/3

of all people with intellectual disabilities

are developing

EPILEPSY.

As an essential factor for a positive development kids with intellectual disabilities must experience

STIMULATION

- Socially
- Verbal
- Motoric

INTELLECTUAL DISABLED

- Does <u>not</u> mean 'not fully developed'
- Means 'developed slower than others' and 'developed to a lower state than the average'

Around

2 TIMES

as many boys are affected by intellectual disabilities as girls.

WHAT IS A *HANDICAP*?

WHAT IS *NORMAL*?

Ill. 1: Facts about intellectual disabilities

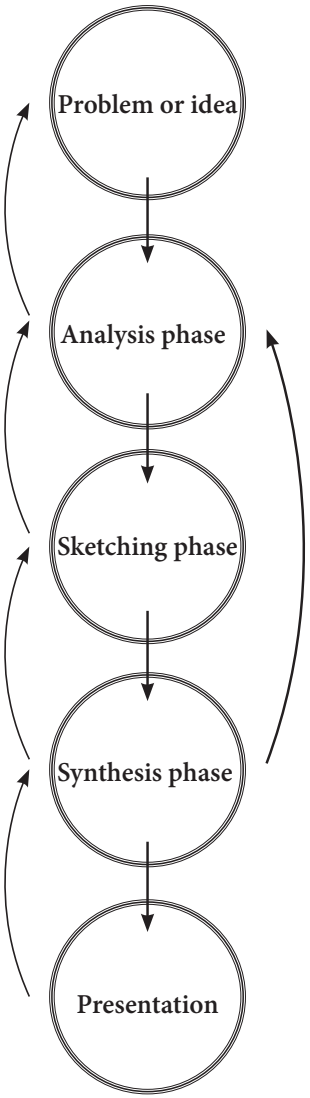
Methods

The following section deals with the methods utilized to control the process from first initial idea to the finished project. The Integrated Design Process (IDP) is structuring the overall flow of this project, while the principles of the ancient Architect and Engineer Vitruvius is securing a balanced, holistic and sustainable design. To assess the tools for investigations the hermeneutic and positivistic approaches are applied.

In order to obtain a logical order and an iterative flow, the IDP has been used. (Knudstrup, 2004) When working in the field of sustainability, the key factor is to be able to combine the specific competences of an Engineer with the sensuous and aesthetic approach. In this tension field design iterations are essential to ensure that both approaches are optimized. The fields are mutually dependent which means that measurable and immeasurable values must contribute to enhance another. Designing through iterations secures a flexible project, where sudden discoveries in a later phase might illuminate potentials overlooked in an earlier stage. The method is also reflecting the fact, that holistic architecture is only reachable when processes are worked through simultaneously and with an open mind.

In this project the hermeneutic and positivistic approach to knowledge and truth are both represented. They are used interdisciplinary along with IDP.
Hermeneutic origins from Greek and is meaning 'understand' and 'interpret'. This approach represents the *qualitative* studies especially important around the architectural qualities that cannot be measured. The positivistic approach searches the truth via mathematical or logical research. These studies are *quantitative* and represent the technical calculations done along with the architectural investigations. (Thurén, 2008)

On this page the IDP phases are listed, and their working tools / methods specified.



Ill. 2: Process model inspired by Knudstrup, 2004

IDP phases

Phase 01 - Project idea:
The first and initial phase is the idea or problem phase, where the project issue has to be stated.

Phase 02 - Analysis phase:
The analysis phase must contain the fundamental information to build the project from. This can include project site, user group, theoretical approach, architectural vision and technical requirements. This phase is summed up by a vision stating the aims for the sketching phase.

Phase 03 - Sketching phase
The sketching phase is taking departure in the potentials / problems stated in the analysis phase. The sketching phase shall reflect both the architectural and engineering skills with iterations between calculative investigations and aesthetic considerations. Every decision taken must be documented thoroughly and be assessed on the basis of the vision.

Phase 04 - Synthesis phase
In the synthesis phase all decisions are collected. This is where a final consistent product has to merge together in one building that solves all requirements.

Phase 05 - Presentation
The presentation phase must demonstrate all aspects of the final project and present it in the best way possible. The presentation is where the documentation of the final building(s) is presented and it must demonstrate that it meets the aims from the vision. This can be done through graphic material and models and technical results must be documented as equal design parameters.

Tools:

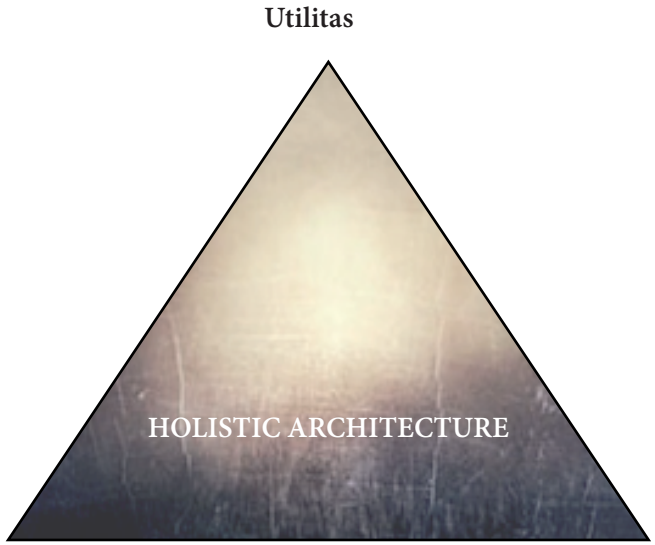
Qualitative investigations:

- Reference images
- Sketching
- 3D digital modelling
- Physical model making
- User needs
- Sensuous investigations
- Theory

Quantitative investigations:

- Spreadsheets
- Be10
- BSim
- Velux Daylight Visualizer
- Building regulations

Vitruvius



Ill. 3: Pollio, V., Morgan, M.H., 1960

The design principles of the ancient Architect and Engineer Vitruvius separate holistic architecture into three mutually dependent elements: **Utilitas, Firmitas and Venustas**.
Considering all three elements as equally important, the elements must serve as guidance during the design iterations. Each element has its own parameters, which must be assessed either qualitative or quantitative, but never isolated from the other elements. With the overall themes of this project in mind, the three elements must consider Universal Design and Sustainability as assessment basis.

Utilitas – architectural functionality according to user's needs: The parameters of Universal Design is to be assessed through qualitative and quantitative tests.
Firmitas – building and construction's durability: In this project assessed on the basis of environmental sustainability, which is done through quantitative calculations.
Venustas – aesthetics and sensuous aspects: These investigations are both qualities and qualitative in their natures and must be carried out through representative studies.

INITIAL IDEA
ANALYSIS PHASE
SKETCHING PHASE
SYNTHESIS PHASE
PRESENTATION

PROGRAMME

NEXT CHAPTER INCLUDES FOLLOWING:

USERS: Intellectual disabled
APPROACH: Universal Design and Healing Architecture
TOOLS: Design parameters
LOCATION: Site analysis
BACKGROUND: Sustainability, energy frame 2020
CASES: Typologies and pedagogy
FUNCTIONAL BUILDING REQUIREMENTS:
Function diagram and Room program

The following chapter searches to outline the user group and its needs, both physical and physiological.
This will be done through an analysis of the difficulties, that people with mental disabilities are struggling with, what their rhythm of day is like and how the good life is perceived.
After this the approaches to the task of developing good living conditions are presented; Universal Design and Healing Architecture. The site will be presented as well, and the approach and demands to sustainability will be listed. After this the technical requirements are presented followed by case studies on typologies. Finally the function diagram and room programme is presented leading to the vision for the design phase.

User group, intellectually disabled

Intellectually disabled are suffering from various impairments and often a combination of more. All impairments are varying depending on the person and the development stage of the individual. Some people with intellectual disabilities are capable of managing their own life with only very little help while others rely solely on help from the surroundings.

Intellectual disabled (ID) are a group of people with very different needs. They vary as everybody else and not two with intellectual disabilities are alike, either by their needs or abilities.
Many are capable of managing many daily functions by them self (shopping, social contact and cultural excursions) or by guidance of staff. They are often affected by cognitive impairments.
These impairments are causing difficulties when approaching the surrounding society where understanding is not always met.

This reflects in the fact that people with ID are having troubles communicating, both regarding messages and emotions.

Social contexts and interactions can be challenging as they require an adaptation to the society that is often missed by people with ID. The impairment is also resulting in an anticipation of the consequences of own / others actions. People with ID are benefiting from having a guidance helping them planning for their everyday and future, as this is often a quite hard task to fulfil by themselves.

Some physical / emotional / behavioural problems are normally following ID, complicating an fully independent everyday further depending on the level of the complications.

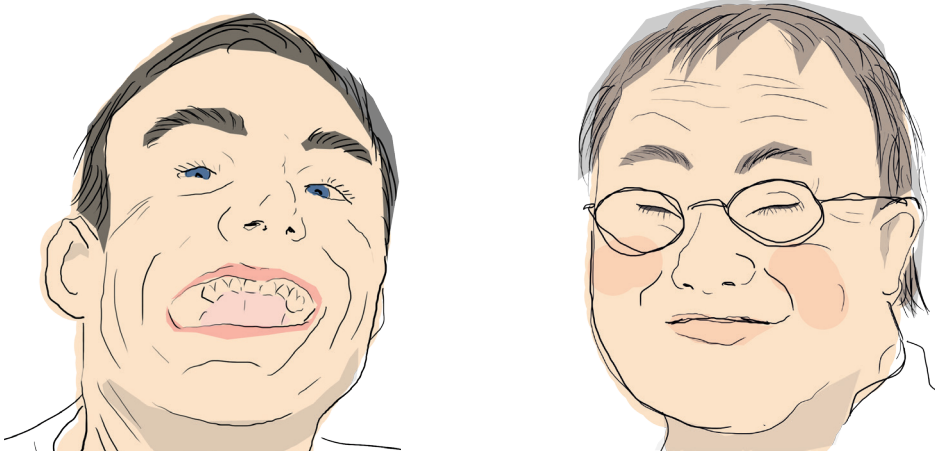
This can be physical problems which attach them to wheelchairs or walking frames or require them to accept help from other when travelling. Epilepsy in different stages is seen in 1/3 of people with ID. Some are deeply affected and are relying on helpers, who can overcome the situations of attacks. (Socialstyrelsen, n.d.)

All inhabitants are within category one; 'mild' and two; 'moderate' of the 'Development stages' diagram. This enables all the inhabitants to live a life with a high degree of freedom, as long as they have guidance and support from their built facilities as well as their surroundings and staff. The 'Development Stages' illustration 4 is made on basis of the IC-10 index. (Center for Oligofrenipsykiatri, n.d.)

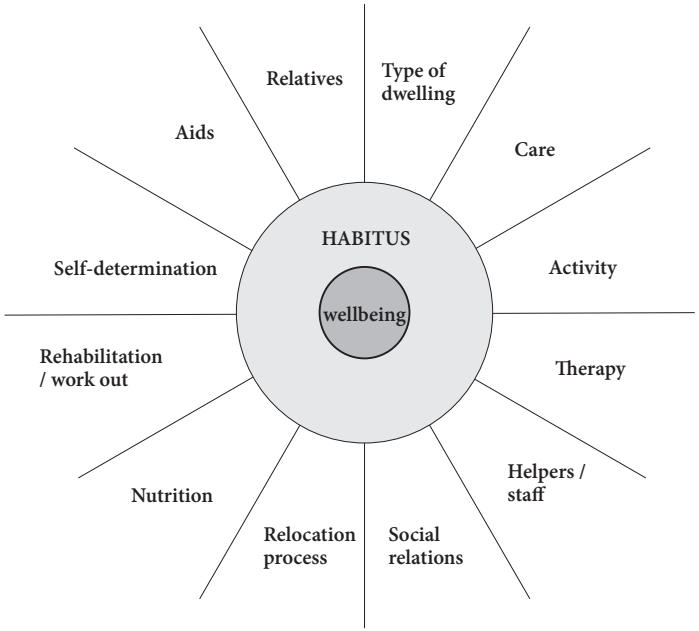
Development stages

IC-10 stage	Description
Mild	"A mild degree of intellectual disability is often causing learning difficulties when attending school. Most adults are capable of having regular jobs, engaging in social contact and are contributing to the society."
Moderate	"Results in distinct developmental disorder in childhood, but most can to some extent learn to cope with personal necessities. Adults need support to cope in society."
Moderately severe	"Needing constant support and help."
Severe	"Can not cope own necessities, continence or communication."

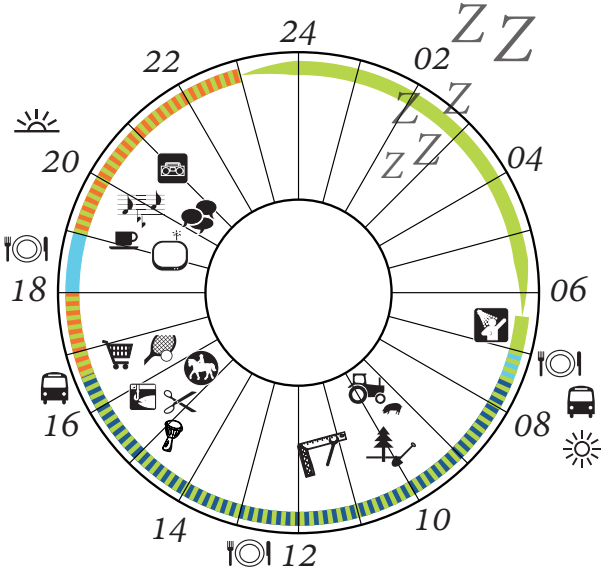
Ill. 4: Development stages of people with intellectual disabilities



Ill. 5: Portraits of people with ID



Ill. 6: Møller and Knudstrup, 2008



Ill. 7: Inspired by Team Juul l Frost Arkitekter

Habitus - perception of life quality

Wellbeing is an essential word when describing quality of life, but there is no formula to reach the aim of a 'good life'. Instead wellbeing can be defining as a combination of inner/personal and outer/environmental factors (Møller and Knudstrup, 2008).

Putting the individual in centre for the aim of creating an ideal living situation, self-determination is of great importance. The individual is perfectly entitled to choose between housing services and locations. All institutions have their set of values and ideological principles, which must appeal to the individual.
The good life is hereafter perceived as the experienced wellbeing given by the surroundings but understood of the habitus, which is the 'filter'.

As 'habitus' is a matter of personalized understanding one living conditions can be perfect for one while all wrong for another.

All inhabitants of a housing complex are individual persons with different needs and abilities and the external factors must therefore affect each individual differently. (Møller and Knudstrup, 2008)

Loss of senses / abilities results in a limited / changed sensory system. By making stimulating independently through the built environment the habitus of the inhabitants is respected.

A regular day

The users everyday varies from person to person, but most are considering attending day care services or other kinds of jobs. As seen in the diagram the dwellings are the everyday base of the individual.
The community and common areas are offers of togetherness and common facilities must be provided as an optional proposition.

Some might take the bus on their own to work and others will be picked up by common transportation for day care services.

Hobbies and recreational activities can be attended in the afternoon or what suits the timetable of the individual.
Dinner in the common areas is optional and must be arranged within the living units. In the evening different arrangements are taking place initiated by the inhabitants themselves or by staff / helpers.

These activities ties the inhabitants together and creates a stronger bond between them. All inhabitants are having a day off during week, which must be used for cleaning, washing and other practical work within the apartment or optional hobbies / activities.

Location

Job / day care services
Own apartment
Common dining facilities
Common living room

Approach: Universal Design and inclusion

Universal design is a design ideology based upon equal rights for everybody and treats everybody as users, as a handicap is considered a state that all people might end up through their lifetime. (Ryhl, 2009)

When designing by the principles of Universal Design society is setting the physical scene for whom to include. Considering children, families with strollers, pregnant, elderly and disabled people as one big user group no one are excluded.

The principles of Universal Design:

> **1.** *The objective is the provision of environments which are convenient, safe and enjoyable to use by everyone, including people with disabilities.*
> **2.** *The universal design principles reject the division of the human population into able-bodied and disabled people.*
> **3.** *Universal design includes supplementary provisions where appropriate.*
> (Ryhl, 2009)

The question of whether to implement Universal Design or not, can be put down in a simple differentiation; Does one disability only call for a single fixed solution which is specially optimized to solve this individual task? When integrating solutions throughout a process and continuously assess proposals, combined solutions accessible to everybody occurs. Universal Design is through its definition including the 'built environment' and 'programs and services', which is securing a holistic approach that includes aids.
(Ryhl, 2009)

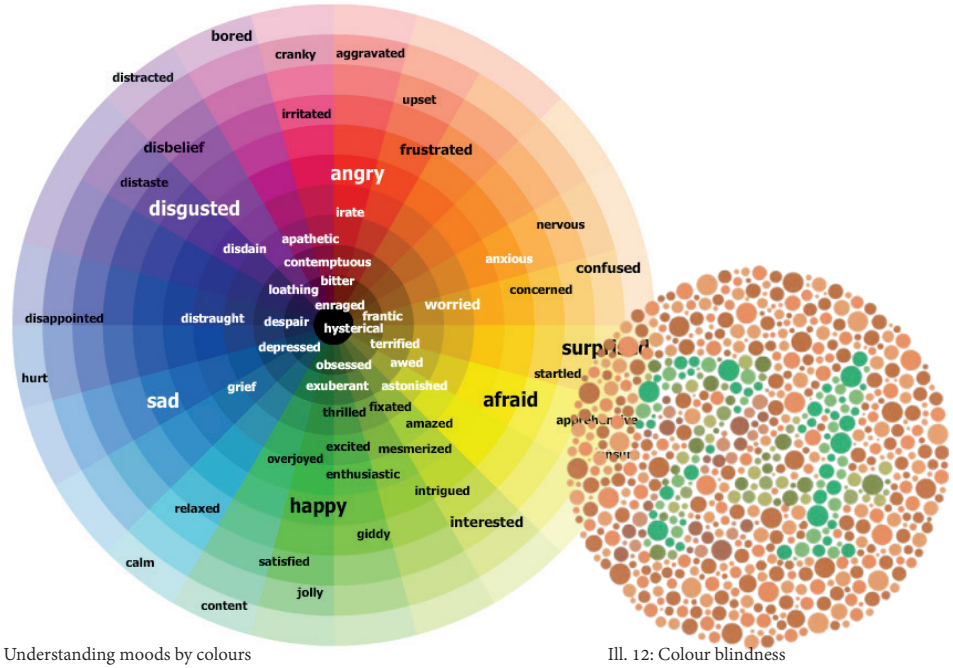
In this project Universal Design is utilized as a mean to include all users with various disabilities according to their intellectual impairment.

Ill. 8: Mental barriers

Ill. 9: Mental barriers

Ill. 10: Example of physical barrier

Everyday barriers



Ill. 1: Understanding moods by colours

Ill. 12: Colour blindness

Many everyday situations and tasks represents huge barriers to people with various disabilities. The pictures on this site and the previous illustrate some of the situations, that might cause exclusion; Too much and complex information, inadvertent use of colour combinations, a physical barrier as stairs and the ability to read other people are tasks, that 'normal' people take for granted. Designing our society by the principles of Universal Design is securing an inclusion, which is beneficial for everybody.

Universal design, case: Handicaporganisationernes Hus

To get an understanding of how to work with universal design, a studytrip was made to Handicaporganisationes Hus.

When the Danish handicap organizations in Denmark were to expand and be unified in a new office building, it was with the aim of designing a building of a high standard according to accessibility but with the costs and techniques corresponding to regular building practice.

The outcome is an extremely successful building, letting people with different kinds of handicaps navigate unobstructed and individually on all plans. The domicile has utilized the Universal Design solutions contributing to a high standard of the cross field between requirements and architectural quality. (Handicaporganisationernes Hus, 2013) This case study summarizes some of its features, that are transformable to a housing project.

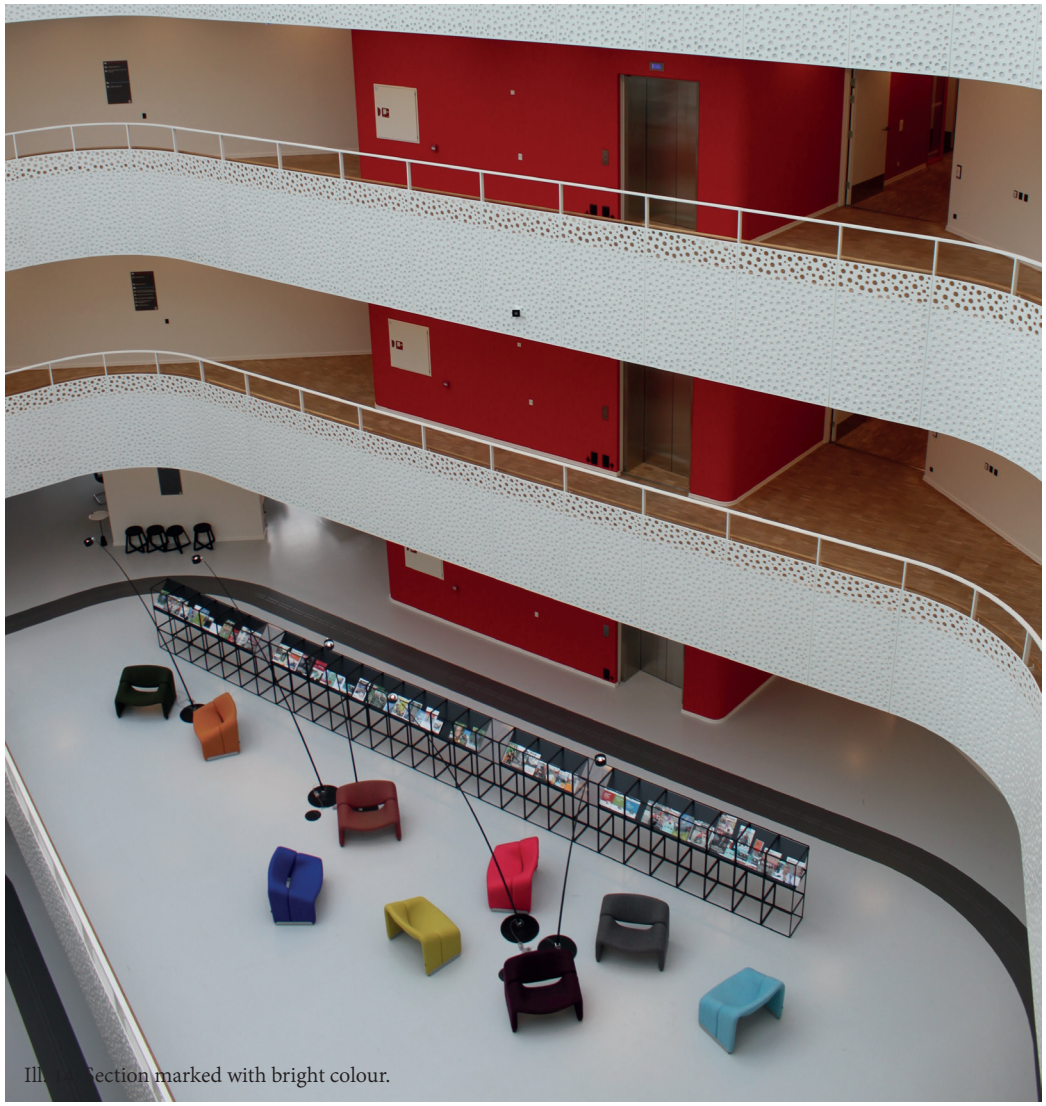
Architecture: The domicile consists of a large open atrium space embedded by with four arms / sections containing the offices of the organizations. Every sections is marked by a distinct colour, contributing to an easier reorganization and navigation across the building. The domicile has a clear division of functions; -1. floor and ground level consists of public functions, whereas the remaining floors are reserved for offices. All floors are having level access and are tied together with both an elevator and a spiral staircase.

Acoustics and daylight: Good acoustics improves the interpretation and sense of space and eases the amount of disturbance from a high number of people for users, who requires peaceful surroundings to thrive.
The solution is perforated acoustic panels on railings at the central staircase and at the railings in the atrium.

A high quality of daylight is secured by the atrium which distributes the light from within as well as the narrow arms let in the light from two sides in the office sections.

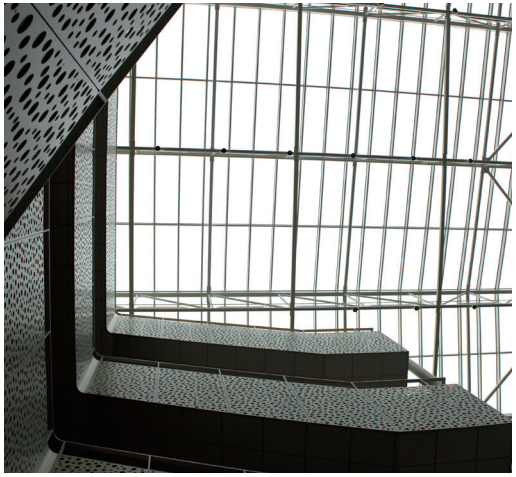
Tactility and orientation: To secure an easy and independent navigation in and around the building are several means integrated in surfaces. This ensures visually, as well as mentally, impaired a higher sense of direction and recognizability. Pictogram, tactile signs and changing colours ensures users with for instance physically handicaps to an easier understanding and increased familiarity with areas.

Ill. 13: Plants are creating life within the building.



Ill. [illegible] section marked with bright colour.

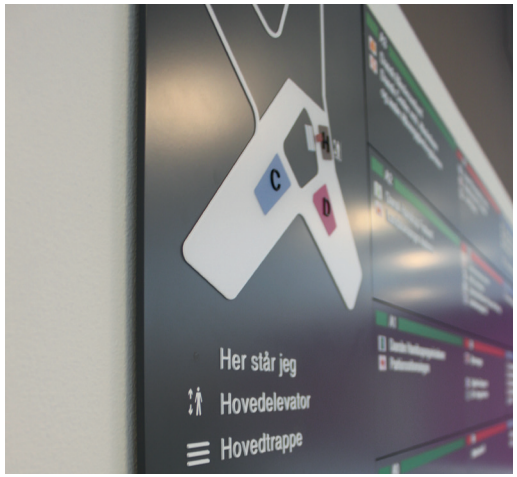
Ill. 15: Architectural detailing, central staircase



Ill. 16: Skylight ensures a natural and soft light within the atrium.

Ill. 17: Pictograms are helping persons with cognitive disabilities easing the task of reading signs.

Ill. 18: Shift in flooring helps navigation for mentally restrained and people with visually impairment.



Ill. 19: Information understandable in more ways; tactile, audible and readable.

Ill. 20: Tactile detail telling the visually impaired that an important function is located here.

Conclusion

Good architecture and a high level of accessibility does not have to conflict, but can be beautifully merged during an integrated design process with the principles of Universal Design. Considering various user needs while designing for both mind and body can results in a building with great durability for a broad diversity of users.

Healing Architecture and a way of gaining more happiness

In order to enhance life quality, architecture must be 'nurturing, responsive and alive'. (Coates, G. J. 2000) By incorporating Healing Architecture with Universal Design, a building reaching for all is based.

Healing architecture has a holistic approach to body and mind and is a design concept that evolves around the build environment as a positive factor for healing and human wellbeing. It takes departure in an evidence-based positivistic approach, and is originally based on hospitals as case, but the principles are applicable for other kinds of built environments in the health sector. The design concept is both applicable for inhabitants (users), the staff and relatives / visitors. (Frandsen, A. K., et al. 2009)

The seven principles of healing architecture, that are presented here, are somehow overlapping with the demands to a good, healthy indoor environment given by the building regulations, and these demands will be described further at page 29.

Healing architecture must be included in the IDP as a way of linking a healthy mental state with the built environment and especially its link to its surrounding natural elements.

Quality of light
Daylight is of great importance for wellbeing, and is known for its ability to reduce stress and depression and an adequate amount of daylight improves the sleeping pattern of the individual. (Frandsen, A. K., et al. 2009) Light is not only a question of reaching a certain daylight factor but is also a question of colour, light/shadows and contrasts. These factors are affected by the time of year, orientation of the room and obstructions as trees or shades. Placement of windows is as well of great importance, and views towards nature / green and life is preferable.

Sounds / acoustics
By securing a low level of noise from both other inhabitants and installations, a higher level of comfort is reached. For people with sensory impairments the sounds of nature are highly relaxing, for example water trickling, birds singing or the sound of the leaves rustling in the treetops. (Frandsen, A. K., et al. 2009)

Air / scents
Fresh clean air and a good temperature comfort level reduces the physical stress of inhabitants. Air quality goes beyond CO_2 concentration, as different scents are known for their ability to have an psychological impact on humans. Many emotions are closely related with scents and being able to sense the scents from nature will bring the nature closer to the living environment. (Frandsen, A. K., et al. 2009)
Other scents as fresh laundry, freshly brewed coffee and home cooked food are other factors that will make the inhabitants feel home, while unwanted smell from constructions and pollution will disturb.

Private space / social spaces
Differentiating between the characteristic of spaces helps inhabitants to approach social life in their own pace. Having the possibility to retreat to a private sphere is important and a basic right for all inhabitants, and the private areas must be respected as personal domains.
Having the possibility to get visitors and let them stay will ensure more social contact with relatives. (Frandsen, A. K., et al. 2009)

Outdoor space / proximity to nature
Being able to see nature and being closely linked to it is stress reducing and increases the wellbeing of both inhabitants, staff and visitors. The use of outdoor activities is also increased when they are within visual distance. To encourage the use of outdoor spaces, there must be a variety of offers, and there must be possibilities for both users, who wish to be private / social and active / passive.
Variation in vegetation and elements as water and furnishing is also essential for the use. (Frandsen, A. K., et al. 2009)

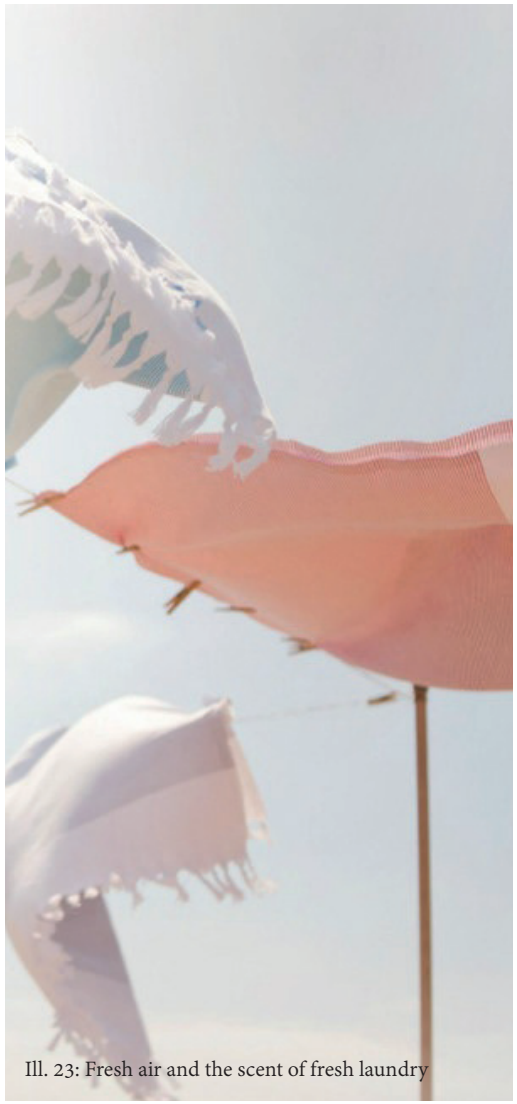
Art / architectural details
Aesthetic elements as art, colours, and tactility distracts aggression and stimulates the senses. Working with art and installations must be done carefully to make it as an integration and not as a distraction.
Art simulating nature is calming and auditive art / sounds of nature reduces stress as well. (Frandsen, A. K., et al. 2009)

Movability / navigation
Being mobile and able to navigate without help from others improves the feeling of being self-reliant. Making a logic floor plan with transparency and good sight lines is essential for a self sufficient life.
(Frandsen, A. K., et al. 2009)

Examples of calming elements

Ill. 21: Light

Ill. 22: Nature



Ill. 23: Fresh air and the scent of fresh laundry

Ill. 24: Rain on window

Ill. 25: Natural elements

Design parameters for barrier free housing

On the basis of the user analysis a set of design parameters are set op. These parameters are taking the difficulties, that people with ID might suffer from, into account, in this chapter are four main difficulties dealt with. While designing to people with ID the principles of Universal Design is applied, and design solutions must contribute to the advantage of a broad range of users.

As seen in the scheme, several different solutions solves more that ones need, and by incorporating smart design from the overall building layout down to the detail a unity accessible to everybody is available.

Groups

- Walking restrained
- Visually impaired
- Mentally impaired
- Hearing restrained

Measures	Target group				Description
Logical building layout	♿	●●●	🧠		Distributing functions in a clear, logical way ensures everybody to feel safe navigation on their own. This helps the self esteem and reduces the dependency of others.
Clear boundaries, structures and zoning			🧠		By dividing facilities into zones a clear distinction between private and public functions is made. This relieves the stress that might follow with the stimulation of living close with more people and is also preventing conflicts.
Recognizability and familiarity		●●●	🧠		Moving away from home the first time can result in anxiety. By creating homely frames the inhabitants are able to feel safe. Also applicable to people with a visual impairment, who are having troubles navigating in unfamiliar settings.
Tactile signs / pictogram / pictures / audio		●●●	🧠	🦻	By making important information clear and understandable in several ways everybody are included and self-reliant.
Good handrails by stairs and ramps	♿	●●●	🧠		Setting up handrails clears the sense of direction for mentally impaired and helps walking restrained people keeping balance.
Use of contrasts colours / shifting materials		●●●	🧠		Shifting materials and colour contrasts marks different zones and eases the sense of direction. Tactility in materials is further serving as guidance.
Wide doors and a spacious layout	♿				Wide doors allow wheelchair-users and others, who need walking aids, to move freely.
Parking near entrance and short distances	♿	●●●	🧠		Walking and visually impaired are having trouble when moving over longer distances and are benefiting from proximity of important
Anti-slip flooring	♿	●●●	🧠		Places where the floor gets wet are risky for people with walking issues. It is as well dangerous for mentally impaired, who are at greater risk of stumbling.
Conscious use of colours		●●●	🧠		To many colours might confuse people, who are intellectually disabled, as they might supper from colour-blindness. Many colours can cause confusion due to over stimulation as well.
Enough and even light		●●●		🦻	Evenly distributed light helps people with visual impairments to navigate better. Hearing restrained are very dependent of their sight and visual communication and navigation. Good colour rendering necessary.
Good acoustics		●●●	🧠	🦻	A reduction of noise while controlling the reverb satisfies hearing restrained, who are vulnerable to background noises and visually restrained, who rely on their hearing. Also calming for mentally impaired who are easily stressed.
Stimulating surroundings	♿	●●●	🧠	🦻	When being impaired in one way or another, stimulating surroundings enriches the life quality if the stimulation is controlled and aimed the different handicaps.
Kitchen and bath facilities with high accessibility	♿	●●●	🧠		Basic functions making the individual independent of staff / helpers and heightens the self esteem.
Flexible, transformable dwellings	♿	●●●	🧠	🦻	Being able to adapt the dwellings to a given life situation is crucial for everybody. Making arrangements after needs and the possibility to move together with a partner creates a strong feeling of self determination.

Ill. 26: Design parameter scheme (DS 3028, 2001)

Requirements

To assess the built initiatives three categories of accessibility levels are defined; Category A, Category B and Category C. The building regulation requires a basic level of Category C, however this is not sufficient to comply with a complete accessible building. (Sbi 222, 2008) Category B is therefore chosen as a minimum level of accessibility based upon the abilities of the user group. Some functions may yet comply with Category A, but only if it makes sense in the given situation.

Surfaces

Reflection

Must not be reflective when wet.

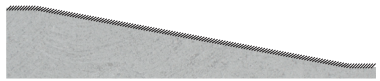
Ill. 27.0 (Sigbrand & Jensen 2008)

Inclination

Must not slope more than 1:20.

Ill. 27.1 (Sigbrand & Jensen 2008)

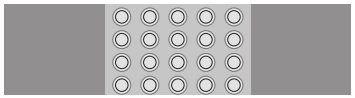
Roughness



Must provide non slippery surface

Ill. 27.2 (Sigbrand & Jensen 2008)

Guidelines

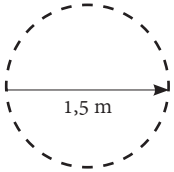


Use of contrast colours + tactile marking

Ill. 27.3 (Sigbrand & Jensen 2008)

Space requirements

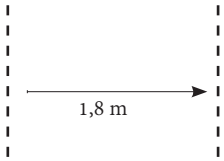
Turning radius for wheelchair users



All rooms shall allow a manoeuvring area of minimum 1,5 meters permitting a wheelchair user to turn 180° unobstructed by furnishing.

Ill. 28 (Sigbrand & Jensen 2008)

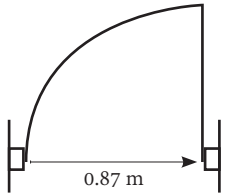
Minimum with of walkways



Walkways shall be minimum 1,8 meters wide to allow two wheelchair users to pass each other obstructively.

Ill. 28.1 (Sigbrand & Jensen 2008)

Door widths



Entrance doors must have a minimum width of 0.87 meters in order to let wheelchair users pass unobstructed.

Ill. 28.2 (Sigbrand & Jensen 2008)

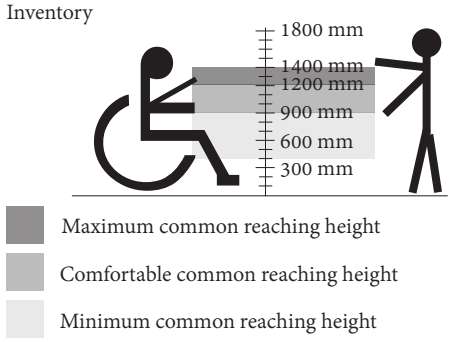
Heights

Windows

All rooms must have maximum sill height of 0,7 meters to allow wheelchair users to look out of the windows.

Ill. 29 (Sigbrand & Jensen 2008)

Inventory



Ill. 29.1 (Fisher & Meuser, 2009)

Inventory shall be designed and dimensioned so that inhabitants in wheelchair can access them without help from others. This is partly done by placing everything within range. The illustration shows the minimum, comfortable and maximum heights for inventory, and reaching height must not exceed these limits.

Ill. 30: Map showing the location of Kolding

"For at fremme social bæredygtighed skal fremtidens bæredygtige almene boligbebyggelse indrettes med henblik på mangfoldighed og fleksibilitet, så bebyggelsen appellerer til en bred kreds af boligsøgende, og rummer boliger der kan indrettes efter skiftende livssituationer og familiemønstre – situationer og mønstre, som medfører behov for mere eller mindre plads."

(Ministeriet for By, Bolig og Landdistrikter, 2013)

Kolding, Seest, Kløvkær

As a part of the open architectural competition 'Fremtidens Bæredygtige Almene Bolig' is the small suburb Seest in Kolding setting the scene for a new, experimental neighbourhood. The following chapter is containing a delimitation from the competition's outline to the outlines of this specific project. It will as well contain an analysis on the chosen building area and its contextual setting.

The 9,2 ha Kløvkær site is currently a large, open field. It is terraced from its former use as building sites for factories. The whole area is sloping from south towards north with around 6 meters. Kløvkær is situated in the outskirts of Kolding surrounded by a well-established residential neighbourhood, Seest, which were highly affected by the firework explosion catastrophe in 2004. It is closely linked to woods and other green areas, which are favoured for walking and runs by the current residents of the area.

In the southern part of Kløvkær is a closed factory located at the moment. The building grounds in close relation to this are chosen as the settings for the new housing complex for the handicapped. The old factory building has to be torn down as a part of the planning of the new area.

The city centre of Kolding, which is located about 2 km from the site, is easy reachable with public transport or by foot / bike. The nearest bus stop is located only 100 metres from the entrance point to the site. This is convenient for the new inhabitants of the dwellings, who may have difficulties travelling with shifting means of transport, leading to a higher level of independence of the individual.

The exploding at the firework factory

The site is former known for an explosion that happend on a fireworks factory in 2004. One fire worker died, 760 household and 2000 people were evacuated. The material damage was one of the largest ever seen in Denmark. Pictures of a burned-down neighbourhood were dominating the reputation of Seest in many years; however this might change with the forward-looking plan for a whole new and modern identity for the inhabitants of Seest.

Design criteria

The following are design criteria given in the competition programme and apply to the whole Kløvkær site.
Points relating to this specific project have been drawn out to narrow down the amount of information:

Technical regulations:
- Building heights up to 8,5 meters or two storeys.
- The floor to area ratio (FAR) must not exceed a maximum of 40 % for dense-low dwellings and dwellings in more than one story.
- The dwellings must satisfy a high standard of indoor climate.
- A building technology focusing on good materials, constructions and installations is important for the success of the dwellings.

Architectural values:
- Kløvkær has to stand out as a neighbourhood in itself.
- The architecture must be innovative and characteristic
- The site shall foster social sustainability by its planning and layout of buildings
- The dwellings on the site shall vary in size and ownership leading to diversity in the composition of inhabitants (Families, singles, elderly, young and people with and without handicaps)

(Ministeriet for By, Bolig og Landdistrikter 2013)

Views

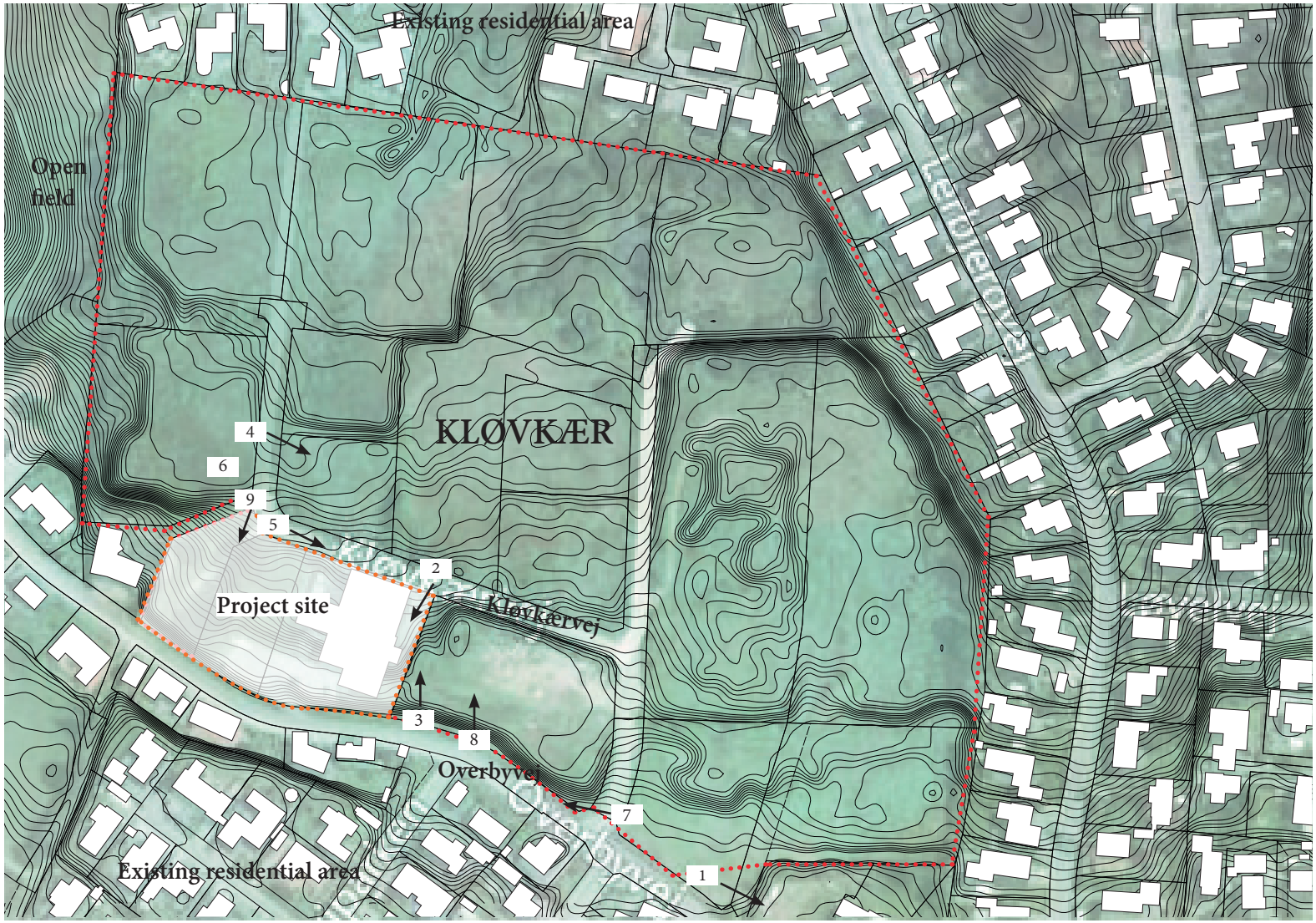
To get a better perception of the area pictures showing different viewpoints are presented along with some comments on particular observations on the site.

1. Road sign to Overbyvej.
2. View from Kløvkærvej to the main site, where the current factory is seen. The slightly sloping site is surrounded by bushes and smaller trees.
3. View from Overbyvej across the project site. Note the building height compared to the road and how the roof represents the 5th facade to the building.
4. Morning sun.
5. View along Kløvkærvej, which connects Kløvkær to Overbyvej and the rest of Seest.
6. Marsh area closely located to the project site. Area ideal for collection of rainwater due to its low lying position.
7. View from the entrance point to the competition area at Overbyvej. This entrance is currently only used by the locals for walking or by the factory.
8. Overview of Kolding from Overbyvej.
9. Western site of project site. Currently characterized by many years of decay.

Conclusion:
The project area has to undergo major changes from its present state. Firstly due to the factory and secondly the surrounding hilly terrain which has to be adapted through the design phase.

Competition site boundary

Project site boundary



Ill. 31: Project site

Ill. 32

Ill. 33

Ill. 34

Ill. 35

Ill. 36

Ill. 37

Ill. 38


Ill. 39

Ill. 40

Ill. 41

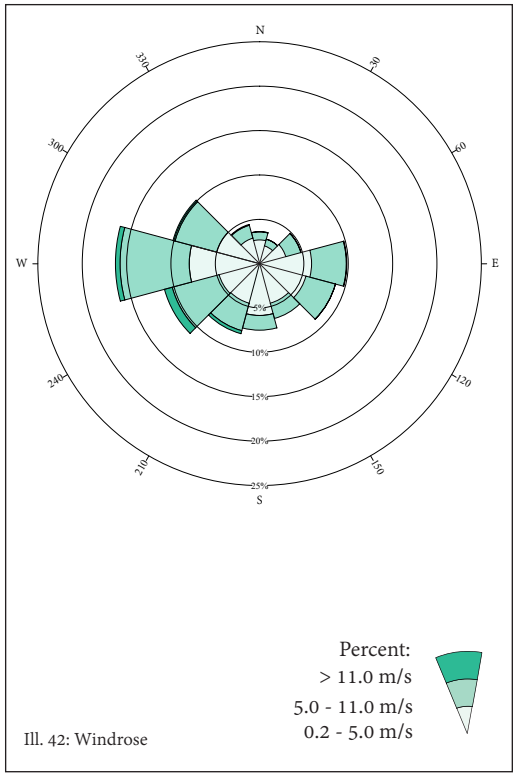
Ill. 41: Kløvkær's topography is highly characterized by its former industrial use and several plateaus are made in the terrain.

Micro climate

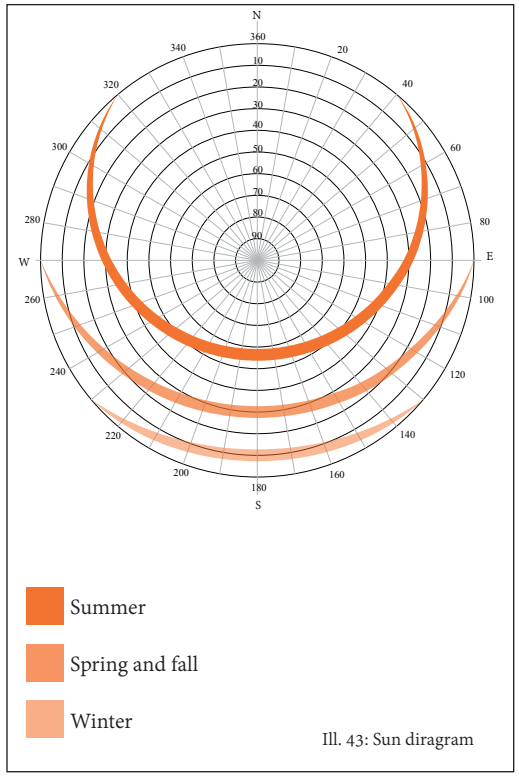
Microclimate is in this context to be understood as weather data for the site. Being able to interpret and control the microclimatic must result in highly comfortable spaces; Windless, peaceful courtyards with sun, dwellings with an appropriate amount of sun without overheating and exploitation of both sun and wind for active and passive energy producing / saving solutions.

Sun:
Denmark is located on the northern Hemisphere and summer Solstice occurs around 21th of June. This is the day where the sun is located precisely vertically on the Tropic of Cancer resulting in a day with the most sunlit hours. The opposite occurs 21th of December, which is the shortest day of the year in Denmark. The site is partly shielded by the sun towards south, which must be integrated in the room programme and throughout the design phase.

Wind:
As seen on the wind rose from Region Kolding Airbase the predominant wind direction is coming from west / west-northwest / west-southwest. The area has a hilly topography and with a diverse vegetation blocking some of the wind. In this project the wind must be utilized passively for natural ventilation and buildings must shield off towards west to enhance outdoor stay.



Ill. 42: Windrose



Ill. 43: Sun diragram

Sustainability in the broad perspective

'Sustainability' is in these days an inevitable term within the building sector. Since the first oil crisis in 1973-74 the world society became aware of the limitation of resources calling for a more conscious way of consuming. Keeping up with architectural quality has led to a greater need for practical tools leading the iterative design process resulting in holistic solutions.

To reach the energy frame of 2020 quantitative and qualitative design parameters must cooperate, as the building is solely dependent of its users to remain energy efficient. By giving the users an understanding of the system, as a highly sustainable building is, cooperation becomes natural.

Defined by the Brundtland report 'sustainability' refers beyond the climatic aspects and is therefore not only focusing on technical aspects, but also the micro environmental and personal consequences hereof. The three definitions derived from the term are mutually dependent and must be dealt with care and respect. In this project the definitions are to be treated in relation to the functions of the dwellings for the intellectually disabled.

Social sustainability
According to the competition of 'Fremtidens Bæredygtige Almene Bolig' diversity must be met in Kløvkær to secure social sustainability. This can be obtained through the built environment by incorporation different ownership and user groups by providing varying housing types. The individual habitus of the inhabitants perceives the surrounding social settings, and whilst inclusion might heighten ones feeling of being a part of society another might feel anxious being close with too many. Being intellectually disabled challenges the social infrastructure that other might take for granted.

Environmental sustainability;
Building to reach the 2020 energy frame requires a lot of knowledge, calculations and conscious planning.
Though, it can be obtained through different design strategies, that each contributes to a reduced need of energy: Building envelope, passive solar gain, passive cooling, natural cooling, natural ventilation, optimizing daylight, conscious use of thermal mass and a thorough planned indoor environment.

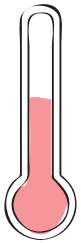
Economic;
Economic factors include the cost of constructing of the building but also to secure low maintenance in the future. Social housing must consider flexibility to promote ownership and to allow its users to achieve self-determination. Flexibility can be defined both at an interior layout level but also flexibility to change living arrangement when life situations changes.

Indoor comfort

These guidelines are requirements concerning indoor comfort. They are made from the demands of DS/EN 15251, Cr1752 which are stated by the Danish Building Regulations. The housing, that is in Category B, is set as a parameter for the indoor environment. The following are the regulations from BR2020, which the indoor climate must be evaluated by.

The technical indoor requirements seen to the right secure a comfortable environment within the dwellings and common areas. To comply with a high level of satisfaction of the inhabitants all comfort parameters must be met.

THERMAL COMFORT



Winter: 22 °C ± 2 °C

Summer: 24,5 °C ± 1,5 °C

26 °C < 100 hours
27 °C < 25 hours

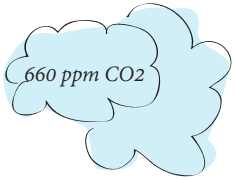
Ill. 43

REQUIREMENTS:

During winter months a pleasant indoor temperature is 22°C ±2°C
During summer months a pleasant indoor temperature is 24,5°C ± 1,5°C
(BR10, part 7.2.1)

- In housing there is a limit for overheating requiring an annually maximum of 100 hours with 26°C and 25 hours with temperatures of 27°C or more. This is specially applicable during summer months, where the heat might build up inside, as the standard of modern low energy housing results in very tight building envelopes. (Marsh, R. 2011)
- Overheating can be evaluated by the simulation programme BSim.
-The perceived value of an indoor thermal climate varies from person to person, but a low PDD (Predicted Percentage of Dissatisfied) index secure an overall satisfaction level on the basis of PMV (Predicted Mean Vote) interpreting the balance between activity level, clothing and parameters for the air quality. (DS/EN ISO 7730)

AIR QUALITY AND VENTILATION RATE

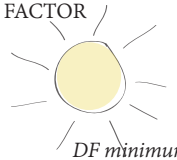


Ill. 44

REQUIREMENTS:

- To enhance a good indoor air quality the CO_2 concentration must not exceed 900 ppm (BR10, part 6.3.1.1).
- All rooms must be ventilated at min. 7 l/s per person to achieve a decent air quality.
- Kitchens and bathrooms must be ventilated at minimum rate at 20 l/s for kitchens and 15 l/s for bathrooms as the air has a higher humidity and pollution level, and air shall be ventilated from less to more polluted rooms.
- All apartments and common areas must have a satisfactory perceived air quality meaning that a balanced humidity, CO_2 level, (SBi 230-3)
- A higher ventilation rate is necessary when the CO_2 level excesses the permitted value. Ventilation systems must during winter exploit heat recovery with 75%. Mechanical ventilation shall be supplemented by natural ventilation during summer half giving a hybrid system.

DAYLIGHT FACTOR



Ill. 45

REQUIREMENTS:

- In order to achieve a satisfactory amount of daylight BR2020 requires, that the window to floor ratio is at least 15% if the light transmittance is larger than 0,75.
- A minimum daylight factor of 2% is sufficient in kitchens and living rooms. Must be demonstrated through calculations as with Velux Daylight Visualizer.
(BR10, part 6.5.2)

ACOUSTICS

Ill. 46

REQUIREMENTS:

When designing to Class B more than 90% of the inhabitants must find the acoustics satisfying. This is a difficult aim to reach, thus is it possible in newer row houses (SBi 230-3) A good acoustic environment is of great importance to reduce stress and minimizing conflicts between inhabitants.
- Noise from technical installations: ≤ 25 dB
- Acoustic requirements between dwellings and common areas with a typical higher sound level:
Impact sound between dwellings or common areas from other dwellings or common areas ≤ 48 dB
Airborne sound insulation between dwellings and noisy facilities, for example workshops / common areas ≥ 58 dB (SBi 237, 2011)
- The reverberation time shall be calculated for the specific functions and be balanced due to the use. (BR10, part 6.4.2)

2020 demands and building strategy

To comply with the requirements of Building Energy Class 2020 the total energy consumption must not exceed 20 kWh per heated m² per year, including energy for heating, ventilation, cooling and domestic hot water. (March, 2011)

When reducing the total energy consumption with 75% from 2006 up to 2020, different strategies must be combined in order to succeed. The following section describes the strategies from the first initial planning of the building with the aim of reaching a 2020 energy frame to the strategies of building form, materials and technology.

The strategy flow is presented in illustration 47 and a clarification of the steps and their methods will be described in the section 'Strategy flow'.

Strategy flow

1. Understanding

Firstly all expectations must be balanced, as the energy frame of 2020 is demanding, and the users must contribute to succeed. Guiding the users towards an understanding of the new building is crucial to reduce the final energy use.

2. Building mass

Before adding any energy producing / reducing strategies, the building envelope must be optimized to secure the best conditional options regarding to sun, wind, shape and orientation. The local micro climate is here of great importance and must be carefully registered.
Distribute glass areas evenly and away from the sun reduces the need of cooling and the use of slim buildings will result in good daylight conditions and improve natural ventilation.

3. Materials - passive solutions

Passive solutions are in the following presented in order to get an understanding of means to obtain low energy buildings. The final strategies used will be presented in the synthesis phase.

3. Materials - Building envelope

Ill. 48

Building envelope
- Must be airtight.
- Low U-values of walls, windows and roof.
- Reducing thermal bridges.
- Avoid too large temperature fluctuations by exploiting building materials with a high thermal mass.

Strategy flow

1. Understanding
Balancing the expectations of the implemented parts of a building case; both users, builder and counsellor. Defining the energy frame 2020.

2. Building mass
Exploit potentials of building form regarding passive solutions and room qualities.

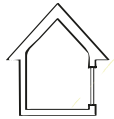
3. Materials
Exploit the potentials of the building materials with use of passive solutions. Use of passive means for lowering the energy consumption.

4. Technology
By implementing active energy producing technologies electricity supplies can be minimized or avoided and a zero-energy building can be obtained.

Ill. 47: March, 2011

3. Materials - solar gain

Exploiting the sun as renewable energy source secures an eternal supply of energy. The use must be balanced with calculations on daylight, indoor temperatures and energy consumption.

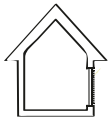


Ill. 49

Direct solar gain
- Carefully placed windows provides heat during winter
- Secures an sufficient amount of daylight within the dwellings

Ill. 50

Thermal mass
- Thermal mass will be heated up by the sun and releases the heat when the temperature drops
- Reduces high changes in temperature



Ill. 51

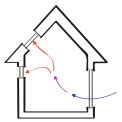
Passive cooling
- Solar shading prevents overheating during summer season and minimizes the need for mechanical cooling.

Ill. 52

Sunspaces
- An individual thermal zone provides an alternative use for winter gardens and transitions between areas.

3. Materials - natural ventilation

The principles of natural ventilation must be adapted to the given building type. Natural ventilation during summer season must be combined with mechanical ventilation, when the outside temperature is too low. This is called hybrid ventilation and secures the most beneficial method to the given situation. Weather, site conditions and building form and height are affecting the efficiency of the ventilation.

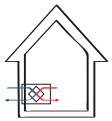


Ill. 53

- Stack ventilation and single sided ventilation are working with thermal buoyancy and cross ventilation is utilizing the difference in air pressure of the two sides of a building.
- Natural ventilation must secures a sufficient air change to prevent too high CO^2 concentration, moist in air and overheating.
- Combining natural ventilation with mechanical ventilation with heat recovery decreases the use of energy.

4. Technology - active solutions

Minimizes the need for user related energy consumptions.



Ill. 54

Heat recovery
- Heat recovery is saving energy, as the hot outbound air heats up the air intake from outside.
- When using mechanical ventilation 75% heat recovery is necessary during winter months.

Ill. 55

PV panels
- Photovoltaic panels are generating renewable energy.
- After applying all passive means photovoltaic panels can be installed if needed to reach the final aim of 2020.

Typologies and pedagogy

In this section three different typologies are analysed due to their abilities and approaches to the living conditions for handicapped people living in own apartments. Their individual planning is different which affects the social life and togetherness and reflects the specific needs of its target group.

The three typologies are:

- Row houses consisting of independent apartments and centralized common areas.

- Circular building with apartments on the outside and common areas in the inner circle.

- Clusters of apartments facing common areas connected by hallway.

The typologies are assessed by the needs of young people with mental disabilities, which is the user group of this project. A main parameter is the task of building a social network while still accommodating the essential needs of the individual.

Building a social network will for many inhabitants represent a difficult task, and the built surroundings are having a high impact on how and when the inhabitants are interacting. By differentiating the inhabitants in groups by interests, age and social abilities many conflicts are avoided, and by planning the meetings correct a meaningful network is possible.

Independent row houses - Kamelia Huset, Kolding, Hansson og Knudsen

Ill. 56: Kamelia-Huset, arrival. Light installation by Astrid Krogh

Ill. 58: Kamelia-Huset, arrival

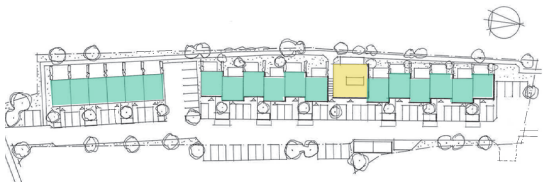
Ill. 59: Kamelia-Huset, common living room

Information

Inhabitants: 14 adults from the age of 24 to 32.
Size of apartments: 54 m^2.
Common facilities: 'Kulturhuset', where dinner is usually eaten, is located on the other side of the road. The common house is located centralized between the houses and is including common facilities as laundry service, common kitchen and staff area. All apartments are Wheelchair friendly.

'Kamelia Huset' is situated in the centre of Kolding in close relation with parks and bus connections allowing the inhabitants to travel freely to jobs and daycare services. All apartments contain a bedroom, a living room, kitchen and bathroom. (Kolding Kommune, n.d.)

The row houses allow a high degree of freedom, as the inhabitants can come and go as they please.
Arriving to the apartments without any interference with the common areas may lead to solitude, which is not desirable. These parameters have to be balanced to maintain a good cohesion between inhabitants without restricting the individual.



Ill. 57: Kamelia-Huset, Plan. Green; apartments, yellow; common house

Circular housing - Enghuset Gistrup, NORD a/s

Ill. 60: Enghuset. Entrances, private terraces and gallery.

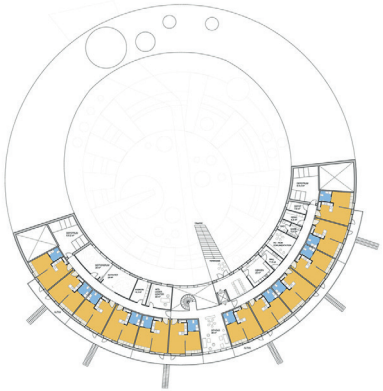
Information

Inhabitants: 36 people with mental disorders.
Size of apartments: 72 m² brutto including walkways and common areas.
Common facilities: Laundry service, workshop, gym facilities, common living room areas.
The apartments are wheelchair friendly.

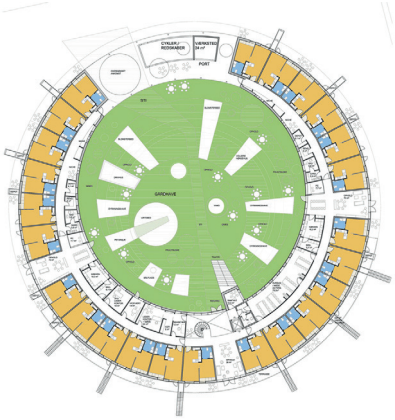
Enghuset is arranged in a way that permits self reliant inhabitants to manage their lives without too much interference from staff or other inhabitants.
Those who need more guidance and support are offered a community and will be able to seek the common facilities to built up a social network and self esteem.

This division cultivates a dynamic interaction between the inhabitants and meets the need for differentiation regarding to personal abilities.

The circular building form is dividing the functions into three zones; the apartments, the walkways, including common areas, and the inner courtyard as seen on the illustrations. The circular building form is furthermore energy optimizing making Enghuset a passive house. (Nord-as, n.d.)



Ill. 61: Enghuset. First floor



Ill. 62: Enghuset. Ground floor

Clusters - Astrupparken, NORD a/s

Ill. 63: Astrupparken, arrival.

Information

Inhabitants: 30 adults from the age of 20 to 80
Size of apartments: Five clusters with six apartments. Each about 45-50 m².
Common areas: Each cluster includes common areas as laundry facilities, common kitchen and living room. A daycare service is located in close relation and the main building is facilitating a larger common room which is used for meetings, church service and parties. (Nord-as, n.d.)

Arranging the apartments in clusters secure a cohesion between inhabitants and staff, as each cluster works as a housing unit on its own.

The apartments are embracing the common facilities which gives a clear structure and a good overview for both inhabitants and staff.

The inhabitants in this type of building are on the other hand 'forced' through the common areas, which may seem overwhelming for some.

Ill. 64: Astrupparken, sketch.

Ill. 65: Astrupparken, floor plan. Blue; apartments, orange; common areas, yellow; unheated walkways, hatched; service areas.

Conclusion on typologies

When assessing the three different typologies and their impact on the inhabitants, the principles of the circular building form have to be incorporated in the forthcoming design process. By letting the inhabitants observe the social life in a distance, the community becomes a choice that can be taken at the inhabitants own pace.

Having more options of how to arrive to the dwellings provides a self-determination, that is important. The arrival can be done either through the main entrance where the staff is situated, through the hallways or through own garden door as in Enghuset Gistrup. The building form is essential and provides two sections; one as the base with service functions and administration and an apartment section with apartments more separated from the rest.

The way of organizing the dwellings are shielding them, so that privacy can be obtained if wanted. In the same time, social gatherings must be offered and visually present to encourage the inhabitants to participate. Common areas shall provide transparency and a good overview to ensure, that both inhabitants and staff are able to navigate easy and on their own premises. Separating the apartments in two groups accommodates the different need of privacy. One apartment area is placed near the entrance area, which is closer to the flow of persons coming to and from the building. This area is livelier and less private where the other part is placed away from the entrance area, which is providing more privacy and peace.

Architecture as pedagogical methodology

The building form and programme organization is in itself not sufficient, but working with zoning and different types of spaces and their relation to another is crucial to succeed with a good living environment.

All areas and functions must be easy readable and by making the transition clear, inhabitants will know what to expect from the given situation and space.

The delimiting space

Shielding off spaces either visually or / and acoustically reduces stress and enhances the feeling of being safe and in control.

This can be done with build walls, either full height or half-walls, removable walls as screens, seen on illustration 66, room dividers made of plants, as seen on illustration 67 or transparent walls as glass walls with for example frosted parts or different print as seen on illustration 68. (Holm & Barfod 2005)

The foreseeable room

Overview and predictability are two main issues when dealing with mental disabilities. To improve these matters, hallways and common areas must be easy to navigate around, and it must be clear for the inhabitant what to expect from the different functions.

Hallways do also have to be divided into smaller passages and there must be an adequate amount of light. (Holm & Barfod 2005)

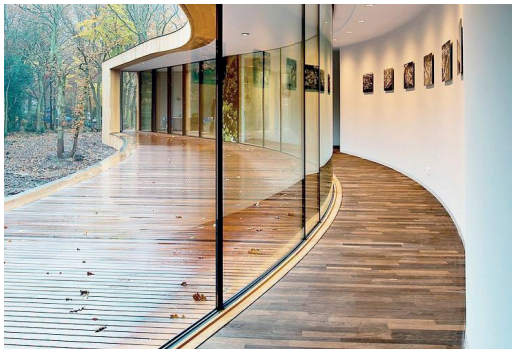
Illustration 69 shows a transparent hallway, where the inhabitants always are prepared for the meeting with other due to the clear overview.

Illustration 70 shows how to make privacy in areas while still allowing others to observe in a distance. This will at the same time serve as a passive invitation where the inhabitant is allowed to prepare for the upcoming event.

Clarification of functions

By combining more senses functions are easier readable. Seen on illustration 71 colour and pictograms are used for marking a specific function, that is clearly readable for everybody.

Ill. 66: screen wall



Ill. 69: Transparent hallway

Ill. 67: green room divider

Ill. 70: Clearance and readable functions

Ill. 68: frosted glass

Ill. 71: Pictograms and colours

Function program

On the basis of the social housing regulations (seen below) a room programme is to be made, which facilitates all the functions of the housing.

On this page, the functions and their specific needs are listed to get an overview before the function diagram.
On the opposite page illustration 72 is showing the wanted relations between functions. The illustration describes how the functions are related to another, and the hallway is working as a distribution path. This means that there must be put an effort and an extra experience into this area to make it successful. This can be good daylight, views to garden areas and art / features stimulating the senses.

Social housing regulations

The following regulations are specified by LAB (Lov om Almene Boliger) and applies to social housing communities for handicapped or elderly. The paragraphs are selected from a range, as they have relevance for this specific project.

Apartments including:
LAB § 5 part 3: Own toilet and bath
LAB § 110 part 2: Own kitchen
LAB § 110 part 2: Common facilities

"*Dwellings must be suitable for disabled including wheelchair users (LAB* § 110 part 1), *it shall be possible to call for help quickly all day (LAB* § 110 part 3) *and access roads must be suitable for persons with mobility impairment (LAB* § 110 part 3)."

"Each dwelling must not exceed ***110 square meters*** *including the permitted percentage share of the common areas* (LAB § 110 part 1 according to § 109 part 1)" (Videnscenter for Hjerneskade, 2003)

Functions

Apartments
Orientation: East or west.
Relation to other functions: Direct access to terrace.
Degree of privacy: Private.
Atmosphere: Homely, independence.

Terraces
Orientation: East or west.
Relation to other functions: Indirect relation to access paths and outdoor area.
Degree of privacy: Semiprivate.
Other functions: Space enough for a smaller herb garden, flowerpots, bench and table set etc.
Atmosphere: Protected but also included.

Common kitchen / dining / living room
Orientation: East or west.
Relation to other functions: Direct relation with access ways and openness to outdoor / terrace
Degree of privacy: Semi private
Atmosphere: Homely, safe, cohesion, inviting

Administration
Orientation: East or west.
Relation to other functions: Close relation to main entrance and staff area.
Degree of privacy: Semi private.
Atmosphere: It shall be possible to work in peace.

Staff area
Orientation: East or west.
Relation to other functions: Close relation to main entrance.
Degree of privacy: Semiprivate
Atmosphere: Good overview and relaxed.

Workshop + music therapy
Orientation: No specific needs, but adequate amount of light.
Relation to other functions: Must provide openness, so that potentially interested will be invited in.
Degree of privacy: Semi public.
Other functions: Possibilities for different activities as; painting, woodwork, playing instruments.
Atmosphere: Openness, active, flexibility.

Meeting facilities
Orientation: No specific needs.
Relation to other functions: Indirect relation to entrance area and direct relation to staff area.
Degree of privacy: Semiprivate.
Other functions: Possibilities to create private room.
Atmosphere: Privacy, confidence.

Main entrance
Orientation: No specific needs.
Relation to other functions: Close relation with information + staff area.
Degree of privacy: Semi public.
Other functions: Information area and mailboxes.
Atmosphere: Welcoming, openness, overview, homely.

Hallway
Orientation: No specific needs.
Relation to other functions: Provides access and connects all functions.
Degree of privacy: Semi public.
Other functions: The hallway shall incorporate good views to garden areas and other sense stimulating aspects.

Depot / food storage
Orientation: No specific needs.
Relation to other functions: Integrated in common areas and common kitchen room.
Degree of privacy: Semi private

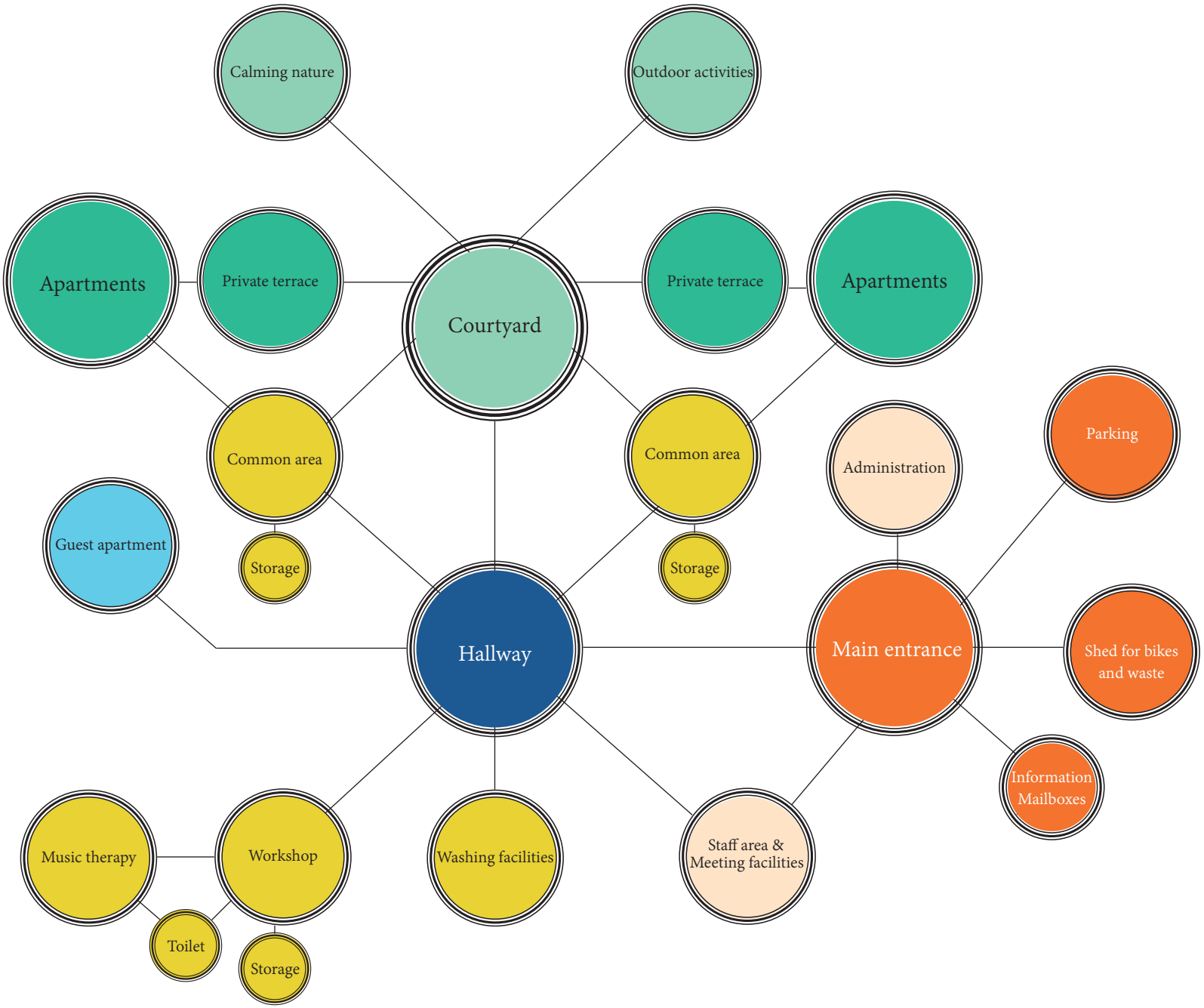
Technical rooms + cleaning facilities
Orientation: No specific needs.
Relation to other functions: Accessible for cleaning staff and other.
Degree of privacy: Semi private.
Other functions: Contains technical equipments as ventilation aggregate and cleaning equipment.

Courtyard / parking
Orientation: East / west
Relation to other functions: Direct relation to main entrance and good access from Kløvkær.
Other functions: Parking facilities and delivery of goods.
Degree of privacy: Semi-public / public.

Bike + waste shed
Orientation: No specific needs.
Relation to other functions: In direct relation to main entrance, easy accessible for staff and from kitchens.
Degree of privacy: Semi public.

Function diagram

North



Ill. 72: Function diagram

Room programme

The room programme describes the different needs for the functions regarding space and number. The total built area must not exceed 40% of the total site, which is 6471 m².

As seen, the total supported area for the 19 inhabitants is 2090 m² which can not be exceeded as well.

The distribution and balance between apartments and common areas is around 50 / 50 meaning that the apartments must be approximately 55 m² leaving the same amount of space for common areas per person.

Function	m²	Number	Total, m²
Site information			
Site area	6471		
Maximum built (40%)	2588		
Minimum area left for recreation (60%)	3883		
Users			
Inhabitants		19	
Staff		6	
Supported area, per person	110	19	2090
Parking			
Parking, ordinary	12,5	7	87,5
Parking, handicap	17,5	2	35
Parking, bus	36	1	36

Ill. 73: Room program

Function	Netto m²	Number	Netto total, m²
Private areas			**964,6**
Apartment	*52 / 62,6*	*18 / 1*	*964,6*
Toilet	*7,8*	-	-
Kitchen + living room	*25,3*	-	-
Bedroom	*18*	-	-
Common area			347 + 510
Common area + kitchen	*68,5*	*2*	*137*
Common washing facilities	*14,9*	*1*	*15*
Music therapy	*45*	*1*	*45*
Workshop + toilet and storage	*60*	*1*	*30*
Guest apartment	*41*	*1*	*45*
Hallway	*510*	*1*	*510*
Main entrance area	*75*	*1*	*75*
Staff areas			73,5
Administration	*16*	*1*	*16*
Staff area + meeting facilities	*57,5*	*1*	*57,5*
Technical functions			134
Technical room, aggregate	*100*	*1*	*100*
Depot	*6*	*1*	*6*
Cleaning room + stairs to technical room	*28*	*1*	*28*
Outdoor areas			*397*
Bike + waste shed	*25*	*1*	*25*
Parking area	*12,5 / 17,5 / 36*	*10*	*176*
Private terrace	*6*	*18*	*108*
Terrace, common area	*44*	*2*	*88*
		Green areas: 4381	Building total, netto: 1519
		FAR, total: 31%	Building total, brutto: 2015

Ill. 74: Room program

Vision

The vision with this project is to create a housing complex that benefits from Universal Design, and that is fulfilling the goals of an relatively independent life for intellectually disabled grown ups.
The complex shall demonstrate a high architectural standard with detailing ensuring implementation by integration. The housing shall take advantage from its surrounding neighbourhood and foster a social inclusion in the future community of Kløvkær in Seest.
The housing must demonstrate the aim of a 2020 building regulation - complying to a healthy indoor environment, a low energy consumption and thoughtful solutions regarding architectural details.

Delimitation

Economic parameters are not considered during this project besides the parameters derived from the environmental and energy saving entities.

SKETCHING PHASE

NEXT CHAPTER INCLUDES FOLLOWING:

INITIAL SITE DEVELOPMENT
ARCHITECTURAL CONCEPT
INITIAL BUILDING FORM
INITIAL APARTMENT PLAN
DISPLACEMENT STUDIES
INITIAL SUN STUDIES

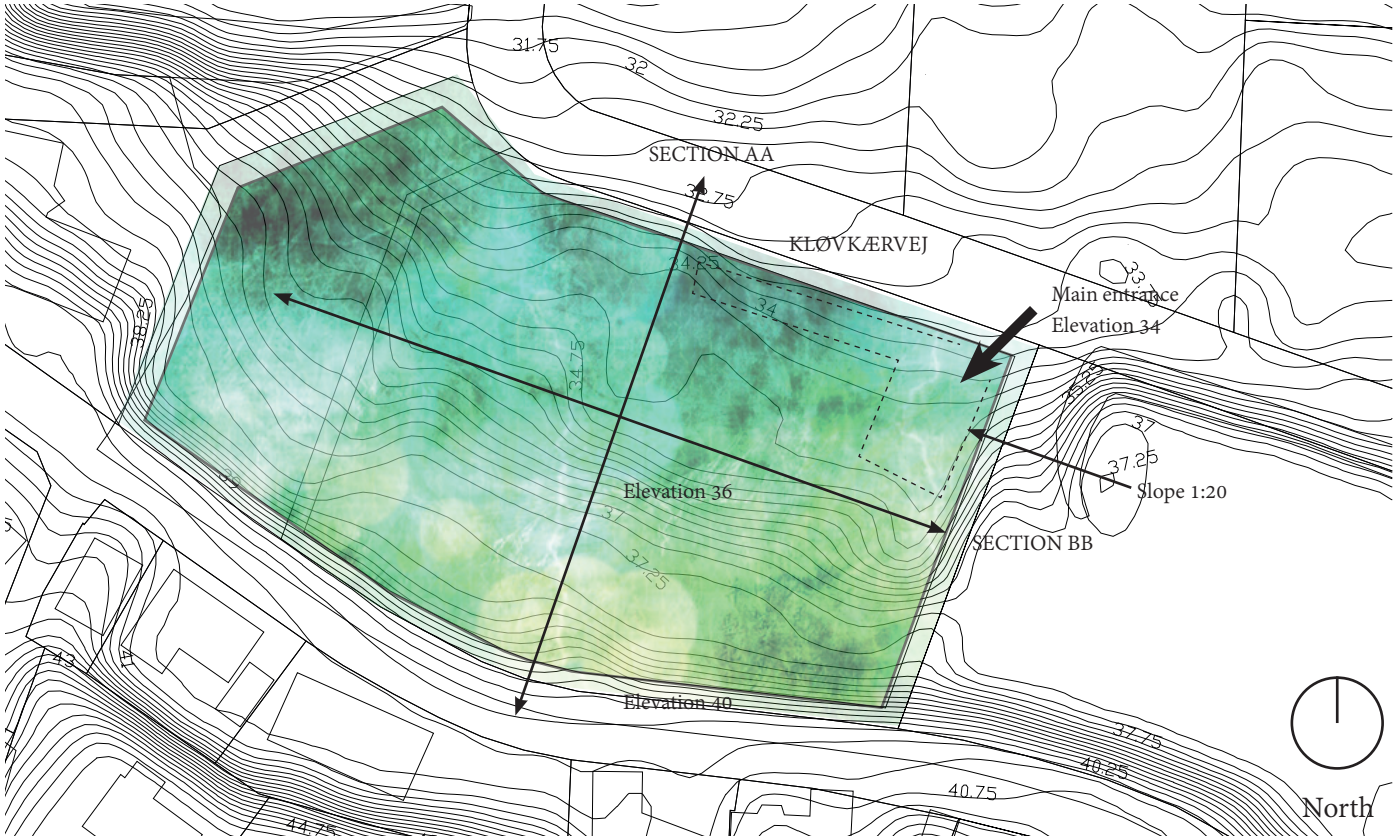
Based on the analysis the sketching phase is now carried out. In the previous chapter several design parameters were stated, and they are now to be translated into a whole building and a site plan. The sketching phase is initiated with an analysis on the actual building site, which will inform the forthcoming rough building shape.

Initial site development, terrain adjustments

According to BR10 part 2.2.3 the minimum building distance to the boundaries of a site is 2,5 meters (Building Regulations, 2010). Seen on illustration 76 is the actual building site that is available to be built.
The terrain is adjusted so that the main entrance point is located in the north eastern part of the site.
This is where all traffic by vehicles is arriving whereas people walking will be able to arrive from other points.

Section AA shows the site adjustments from south to north. As the site is to be accessed from Kløvkærvej in north, the site is adjusted to its align with its neighbour site to the east, which is flattened in illustration 75.

Section BB shows that the site is adjusted to the same level in east / west direction. This is done to adapt to the neighbour site towards east and to equalize the site to make it wheelchair friendly without too many ramps and slopes.



Ill. 75: the actual building site

Ill. 75.1: Section AA

Ill. 75.2: Section BB

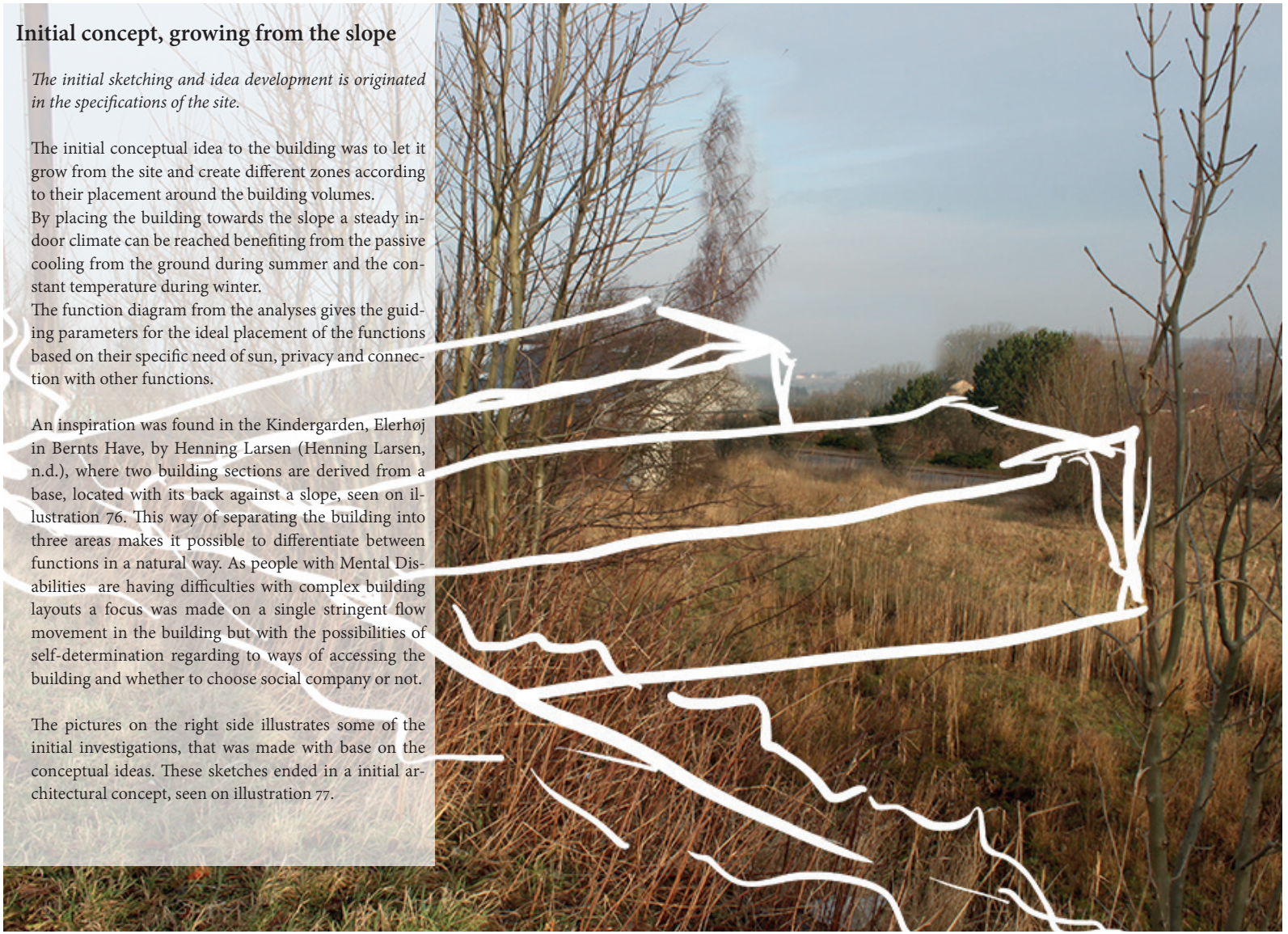
Initial concept, growing from the slope

The initial sketching and idea development is originated in the specifications of the site.

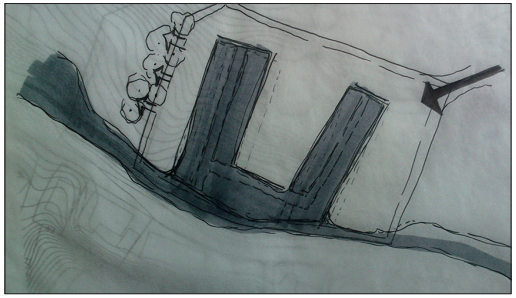
The initial conceptual idea to the building was to let it grow from the site and create different zones according to their placement around the building volumes.
By placing the building towards the slope a steady indoor climate can be reached benefiting from the passive cooling from the ground during summer and the constant temperature during winter.
The function diagram from the analyses gives the guiding parameters for the ideal placement of the functions based on their specific need of sun, privacy and connection with other functions.

An inspiration was found in the Kindergarden, Elerhøj in Bernts Have, by Henning Larsen (Henning Larsen, n.d.), where two building sections are derived from a base, located with its back against a slope, seen on illustration 76. This way of separating the building into three areas makes it possible to differentiate between functions in a natural way. As people with Mental Disabilities are having difficulties with complex building layouts a focus was made on a single stringent flow movement in the building but with the possibilities of self-determination regarding to ways of accessing the building and whether to choose social company or not.

The pictures on the right side illustrates some of the initial investigations, that was made with base on the conceptual ideas. These sketches ended in a initial architectural concept, seen on illustration 77.



Ill. 76: Inspiration, Bernts Have, by Henning Larsen



Ill. 77: Intitial architectural concept

Architectural concept

Based on the specific site and with the project vision in mind, an architectural concept has been developed. Taking departure in the sloping site and the initial sketching and inspiration the building concept was diving in the following functional areas:

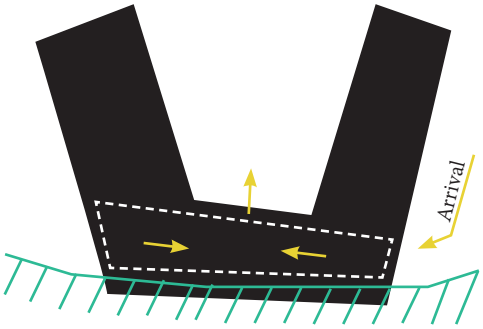
- One functional base (ill. 77)

- Two apartment sections (ill. 78)

-Three garden spaces (ill. 79);
Arrival area
Relaxing area
Active area

By having this clear division between functions, the building becomes more manageable and transparent for the inhabitants with intellectual disabilities, as they will know what to expect and when. They will also be able to know where to go, when they are seeking social activities or guidance / help from the staff.

This helps breaking down the psychological barriers, that might occur in a building complex, whereas the physical barriers are to be treated further in the planning. Here the initial decisions are about building in one plan helping wheelchair users and others, who are impaired on their mobility.

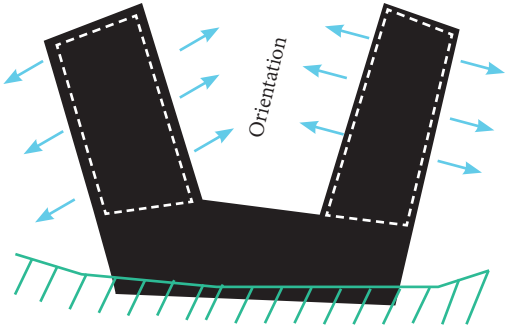


Ill. 77: The functional base

The functional base - from public to semi-private

The building is meeting its site's southern boundary towards the slope that lets the building grow from it. The functional base shall contain all service functions and provides a securing base for all inhabitants of the building. This is where the staff is found when needed and where day activities can be planned.

The functional base is also where people from outside meets the building and where the logistic about food delivery and handling of waste is proceeded through.
There must be access from the base to the outside, as seen on the illustration.



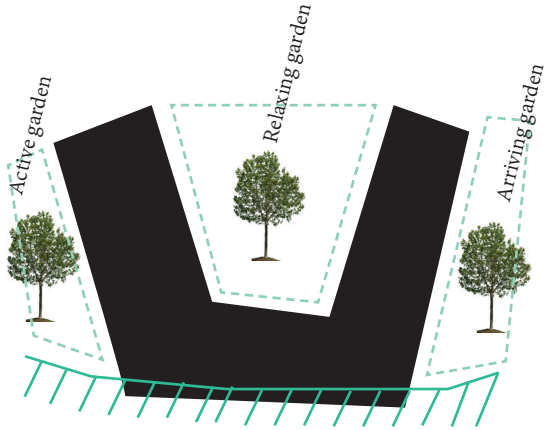
Ill. 78 : The apartment sections

Two apartment sections - From semiprivate to private

The two apartment sections are growing from the building and divides the inhabitants in two wings, Eastern and Western wing. Both wings contains apartments and common areas and both wings are having apartments facing the common courtyards in the middle.

The Eastern Wing is having apartments facing the arrival area in east and the Western Wing has apartments facing the garden area in the west. All apartments must be reachable from two ways; one through the common areas and one through own garden.

By dividing the inhabitants in two wings, smaller communities are created, and the inhabitants do not have to manage too many sensory input from others.



Ill. 79: The three gardens

Three garden spaces - semiprivate / semi public

Being close to recreational areas, as this building form allows, is a part of the evidence based design, that shows this as a healing factors for body and mind.

The three gardens are located around the building. One facing east, one in the courtyard between the two wings and one in the western part of the site.
The three spaces are having different qualities;

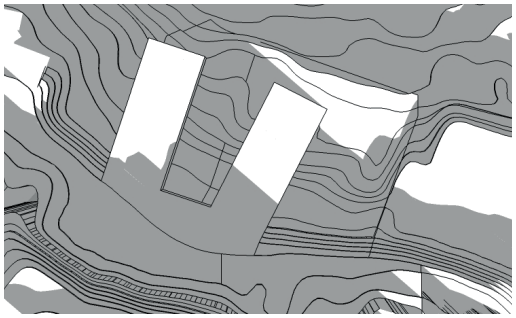
The arriving area is an active 'garden' with a flow of people arriving and departing. This is semi-public area which matches the outgoing and curious inhabitant.
The relaxing garden is situated between the two wings. In this garden small niches are found and activities as growing vegetables and herbs is possible in prolonging of the outdoor area from the Eastern Wing.
The active garden is far west and enclosed by a neighbour housing area. It contains activities as motoric playground and others as bonfire place.

The gardens will get described further in the synthesis phase.

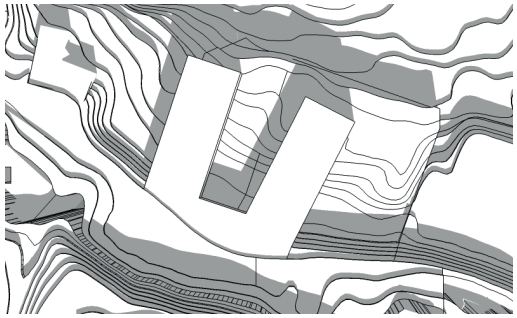
Investigations of sun at the site

Placing the building towards the slope might cause shading on the site. A sun study is therefore made, showing the shadows throughout the year.
By modelling the initial building form in Google SketchUp, an estimation of the shadowing on the site is made. This study gives a good indication on where to place functions, regarding to their need of direct sunlight.
The studies are made on winter solice, when the sun stands in equinox and the summer solice. Functions that are used in the afternoon or evening must be placed on the western side of the wings, as these gardens receives sun from around 12 o'clock. The wings of the building are placed with larger facades towards east and west, which leaves the apartments to be facing either east or west. The two orientations are having different qualities; morning or afternoon sun. The functional building base is facing north and is not receiving direct sunlight. This means that skylight needs to be added to secure a comfortable daylight factor.

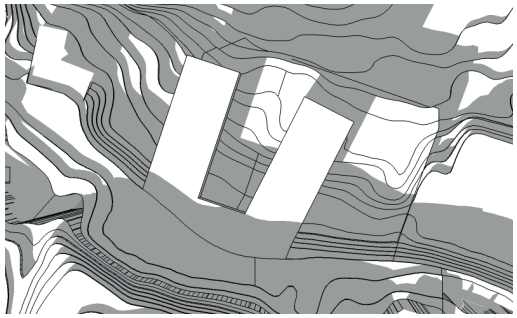
Initial sun paths studies



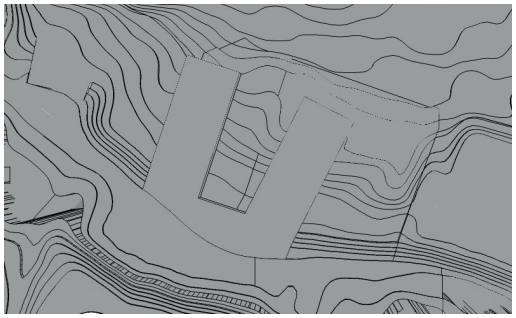
Winter solice, December 21th, 09:00



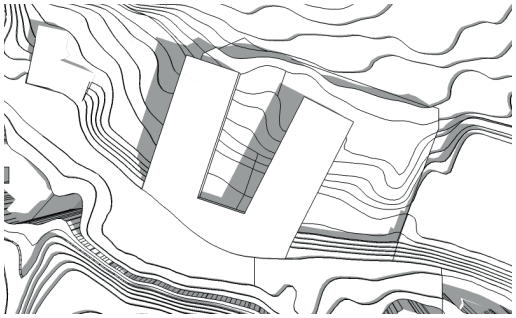
Winter solice, December 21th, 12:00



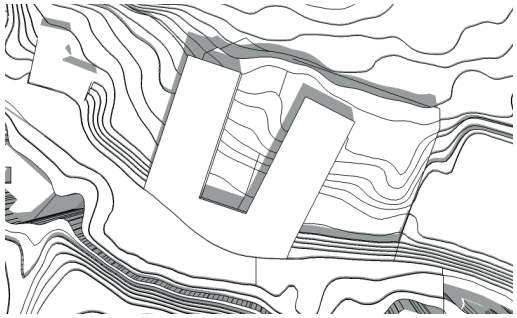
Winter solice, December 21th, 15:00



Winter solice, December 21th, 18:00



Equinox, March / September 21th, 09:00



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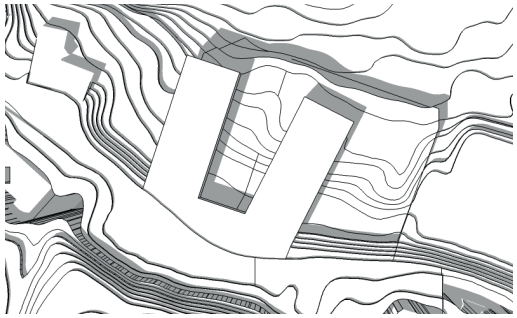

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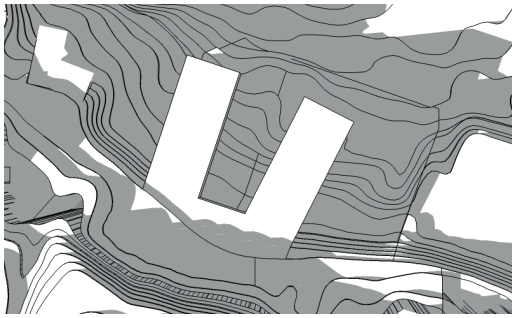
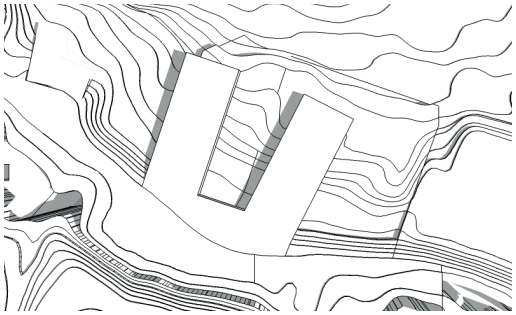
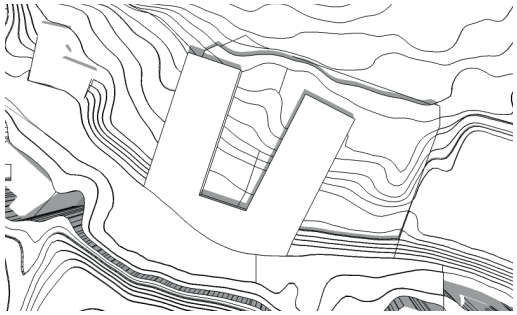


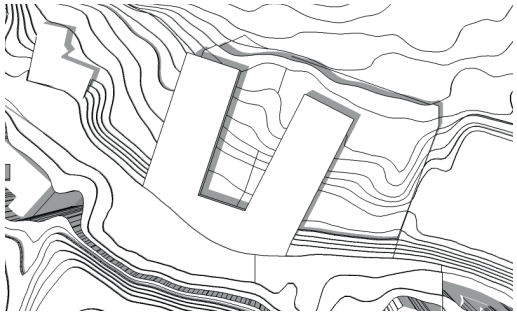
Equinox, March / September 21th, 18:00



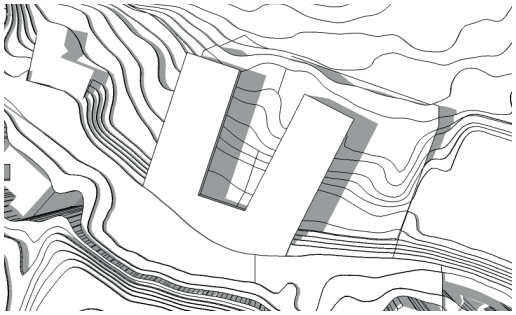
Summer solice, June 21th, 09:00



Summer solice, June 21th, 12:00



Summer solice, June 21th, 15:00



Summer solice, June 21th, 18:00

Ill. 80: Sunpath diagrams

Initial development of the apartment, qualities

The apartments are the most private spaces in the whole building and are where the inhabitants are approaching the surrounding world from. Developing the apartments is done with this privacy and curiosity in mind.

Based on the needs and abilities of the inhabitants, the apartments are evolved. All apartment must comply with the functional and technical demands and must at the same time provide architectural detailing that speaks to both body and mind.

The apartments must stand out as separate units in the building form but still comply with the whole. This has to be seen in both the arrival to the apartment from the hallways and in the facades from the outside as well.

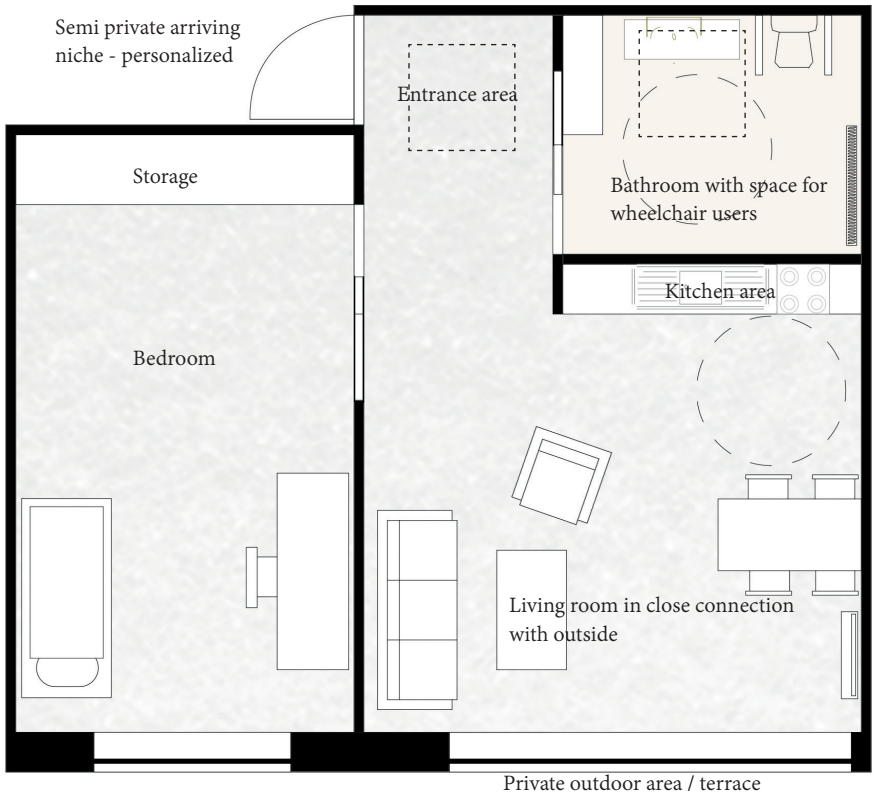
An example of the apartment as separate, but a part of a whole is seen at illustration 81. Here the apartments are similar but displaced from another, creating privacy in the half enclosed space, that is occurring.

Picture 82 shows how a smaller niche can be made, and how this niche will provide a breathing space both when entering the apartment but also before leaving the apartment and entering the hallway, where other inhabitants might be met.

Illustration 83 is an early version of the apartment. It shows the division into different zones, that allows the user to adapt the apartment to changing situations.
In this apartment some of the wanted functions are incorporated, as the semi-private niche in front of the apartment door. This will, when the apartments are put together, have the ability to create different kinds of rooms according to the displacement. The layout and materials will be dealt with later in the synopsis phases as well as the climatic issues.

Ill. 81: Apartments are perceived as individual but as a part of a whole

Ill. 82: Marking entrances with identification



Ill. 83: Initial apartment plan showing the zoning.

Displacement of apartment

The purpose with the displacement of the apartments is to make a variety in the facade, to mark the apartments as individual units and to get rid of the institutional uniform look of the building on the exterior while creating niches and smaller private pockets along the hallway on the inside.

These studies were made along with the development of the placement of windows and the tests of solar shading, that will get presented in the synthesis.

Development

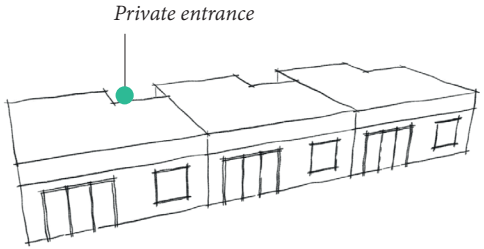
Iteration one:
The recesses in the apartments towards the hallway are making the wanted entrance area, but the facades are uniform and without any kind of privacy or identification.

Iteration two:
The apartments are displaced to make a better identification of each unit in the facade, while still keeping the recess around the entrance.

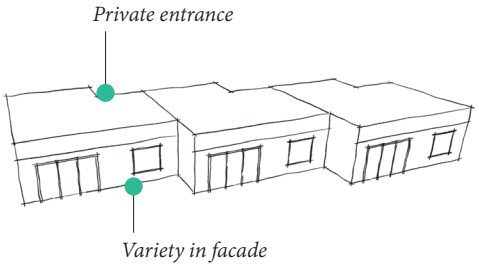
Iteration three:
By displacing the apartments further, an integrated terrace is made in front of the living room.
By putting the apartments together and aligning the living room of one apartment with the bedroom of the next, an overhang is created between the two.

Conclusion:
The apartments will be displaced in the pattern as 'iteration three'. This displacement will be incorporated in the further development of the final building plan.
Factors as the placement of other functions will get an influence on the final apartment composition.

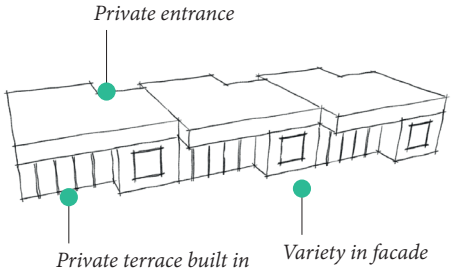
Iteration one



Iteration two



Iteration three, final composition



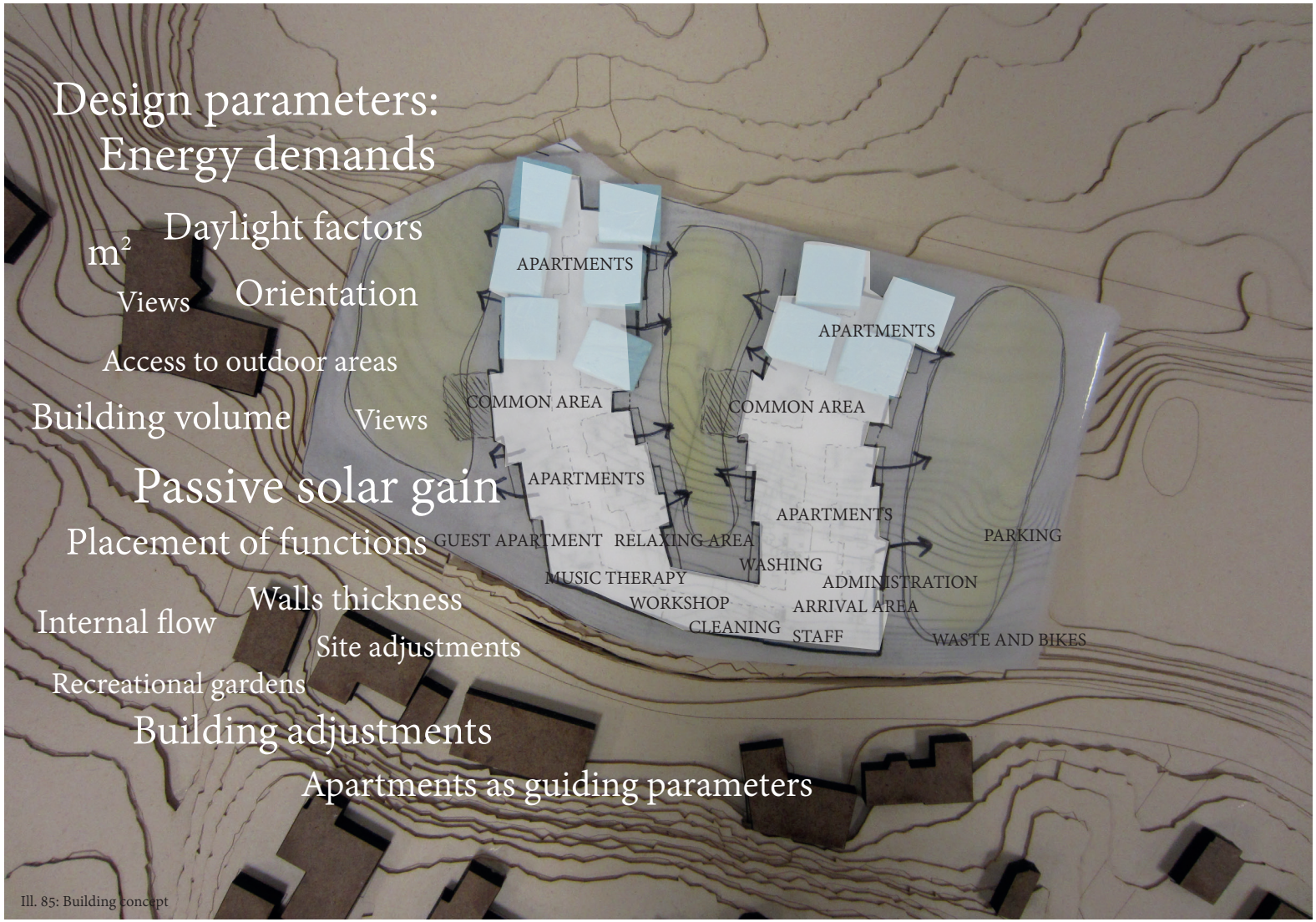
Ill. 84: Development of facade

Concept model

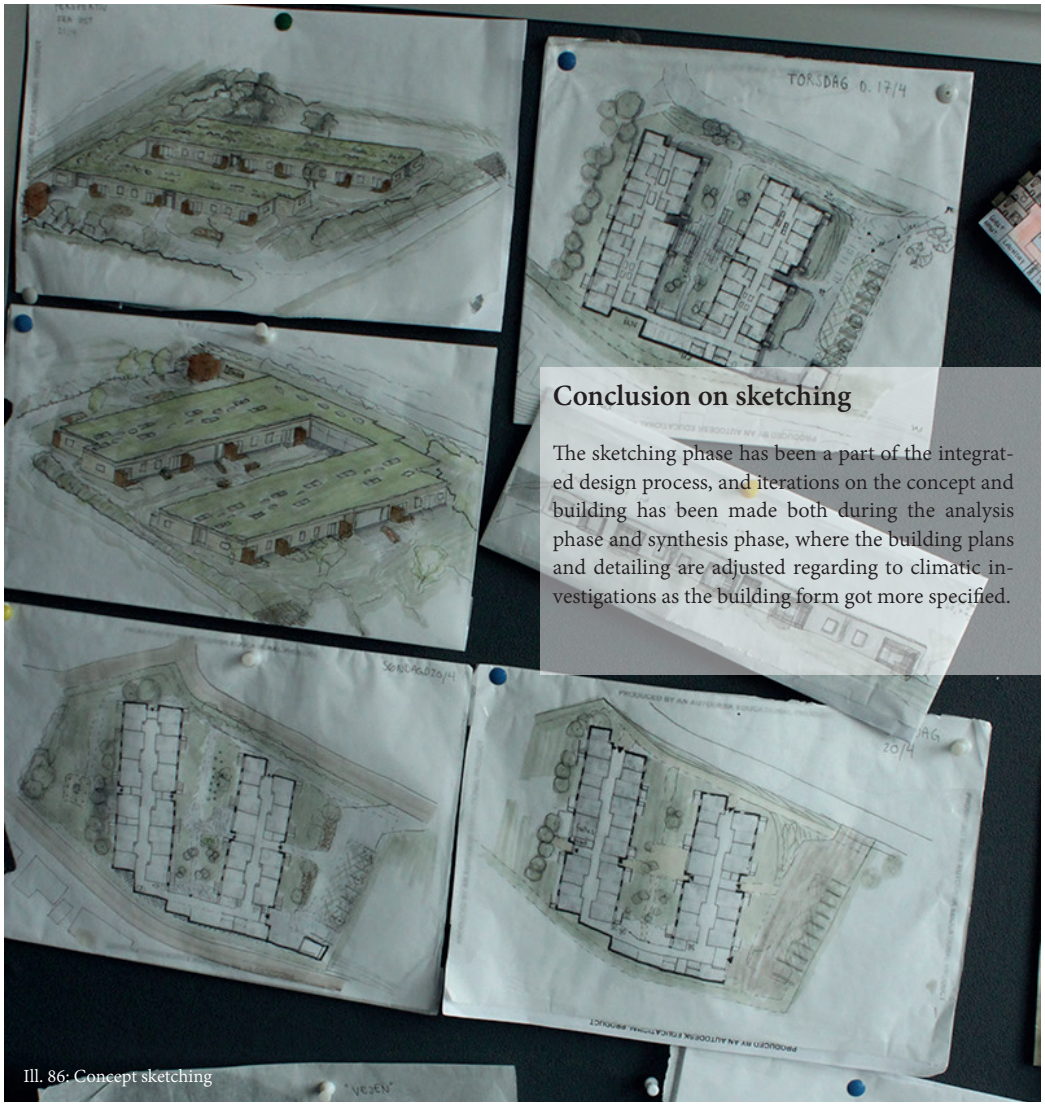
Developing the building from a conceptual form to the final building has been done through iterations and with various values in mind, as seen on illustration 85.

The functions given in the room programme are incorporated in the initial iterations, and the demands are sought satisfied. Combining functional needs with passive initiatives to achieve a sustainable building the internal planning has been preventing dead ends according to layout and technical demands. All the technical parameters and design criteria are seen on the illustration written with white. The placement of the functions are marked with black.

- From the initial to the final building concept the wings has been twisted in order to create internal visually shorter hallways, to shape the gardens and to ensure a varying facade. The apartments have been used as a guiding unit, as their internal relation and placement was shaping the wings.
- All hallways are having of with of a minimum of 2500 mm - Complying with regulation for fire and allows two wheelchairs passing another.
- Apartments are places in groups of 4-6 to ensure more private connection between groups
- Orientating common living rooms facing east
- Having different characters to the storm flaps, they shall all seem guiding and leading towards entrances.



Ill. 85: Building concept



Ill. 86: Concept sketching

Conclusion on sketching

The sketching phase has been a part of the integrated design process, and iterations on the concept and building has been made both during the analysis phase and synthesis phase, where the building plans and detailing are adjusted regarding to climatic investigations as the building form got more specified.

SYNTHESIS PHASE

NEXT CHAPTER INCLUDES FOLLOWING:

TECHNICAL DEMANDS: Daylight factor, energy demands and indoor thermal environment
MATERIALS: Diversifying functions and facilities
FIRE: Complying with Building Category 6
PARKING AT THE SITE: A green, functional parking area
VENTILATION PRINCIPLE: Hybrid ventilation
CONSTRUCTION DETAILS: Integrating low U-values with architectural detailing

The synthesis chapter is collecting all investigations from the analysis chapter, the specific technical knowledge gained and the ideas from the sketching phase and developing the data into a whole consistent building.
This is where the integrated design process is shown as a tool for balancing all inputs to an final output, that shall meet the parameters.

Building plan development, access ways

Different ways of entering the building enables all inhabitants to choose between more ways of arriving to their apartment and the common areas. If one wants to visit the common areas or simply to see, what activities are taking place, one can use the central entrance on each wing. This entrance leads towards the common areas, that are semitransparent towards the entrances, so that possible events are revealing themselves as one walks by.

The main entrance is primarily utilized by the staff and other persons, who has an errand in the building as for example visitors, food delivery or technical assistance.

Inhabitants can enter their apartment through their terrace doors, or via the hallways within.

Illustration 87 shows how the functions can be accessed, where the solid line shows expected primary route and the dotted line show an alternative.

By diversifying the flow the individuals will experience more freedom to choose on basis of their moods and needs.

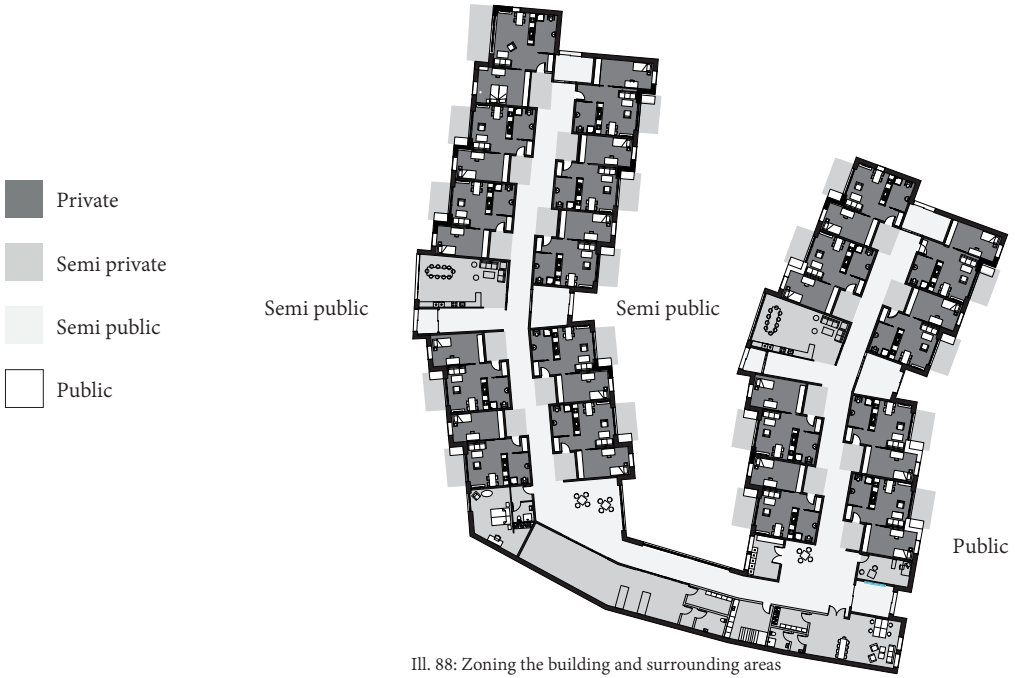
Ill. 87: Flow in building

Building plan development, zoning

One of the main parameters has been the zoning of spacing and making a clear distinction between degrees of privacy. Living with Intellectual Disabilities may result in a difficult social life, but by securing the inhabitants private spaces as 'safe zones' the approaching to social areas might seem easier. Illustration 88 shows how the different zones are planned;

All apartments are private zones and are only accessed by permission of the inhabitant.
The terraces are semiprivate as they are a part of both the apartments and the surrounding green areas.

They are functioning as a buffer zone for the inhabitant, who can observe the activities in the gardens at a distant without participating actively.
The walkways are semi public and are mainly accessed by staff and inhabitants that lives connected to them.
They contain small private niches, where skylights put focus on each. Further personalization gives character and makes the niches a semiprivate area.
The common functions are semiprivate as well and are only for inhabitants and staff.
The surrounding gardens are semi public and are accessible for inhabitants of the whole building and the staff.



Ill. 88: Zoning the building and surrounding areas

Green areas

Planning the green areas surrounding the building has a huge impact in the future use. By making a clear distinction between the areas an easier navigation is secured, and the inhabitants know where to search the activities wanted.

The active garden to the west shall host activities as the motorical playground seen on illustration 89. The calming garden shall incorporate elements as water and stones, that are both visual and auditive calming, as seen in illustration 90. The arrival area shall be perceived active and green, and parking areas shall not seem as empty spaces, when there are no cars. Illustration 91 shows a way of making greenery a part of an area like this. Changing materials helps a visual expression of the area as a planned garden.

Ill. 89: Active garden: motorical playground

Ill. 90: Relaxing garding: audiative elements

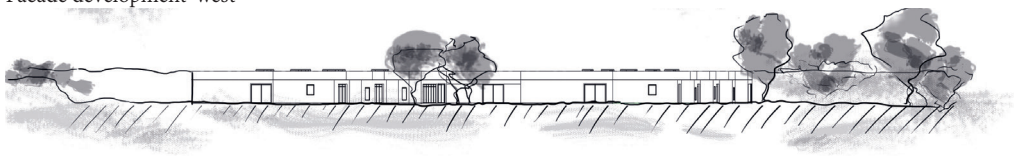
Ill. 91: Arrival area: materials

Developing the facade

The facades are the first thing that is experienced of the building. Developing the facades has been done in iterations between interior and exterior considerations.

The main parameter when perceiving the building is to be able to locate the apartments while still perceiving the building as a whole. The facades shall mimic the individualism of town-houses and communicate self-dependence and pride.
Making 3D models of the buildings, the expression of the facades have been evaluated along with the development of each apartment.
Illustration 92 shows a study in the final proposal where the combination of windows / doors and recesses are creating a diverse expression.

Facade development west



Facade development east

Facade development north

Ill. 92: Study on facades

Daylight and evaluation of solar shading

Daylight is not only about obtaining a certain amount of natural light but also about the perceived quality of the light, the placement of windows and the shadowing hereof.

This sections searches to evaluate the dimensioning of the windows and how this affects the access to views towards garden areas and the expression in the facade as a consequence hereof. The architectural investigations has to be balanced simultaneously with technical calculations as energy demands and daylight factor to find the best solutions.

Illustration 93 shows inspiration to the exterior expression wanted in the facades, and with this as a starting point different varieties are carried out to be assessed on following parameters:

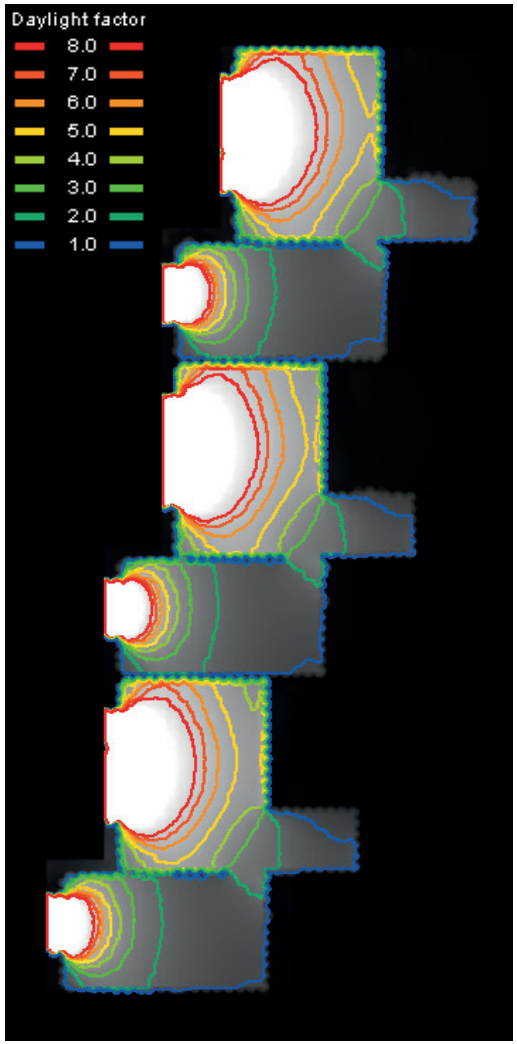
Guiding parameters
- All rooms must have daylight access and a minimum of 2% in minimum half of the living area
- All windows shall provide view from a wheelchair (maximum 0,7 meters above floor)
- At least one window opening must serve as a windoor with access to a small, private terrace
- Skylight has to illuminate rooms with no facade towards outside
- It must be possible to adjust the amount of light individually within the apartments as the same apartment type is placed facing either east and west and might therefore have different needs throughout the day / year.

Velux has been used as a tool for rendering images of the solutions while it is also used for the calculations of the daylight factor. BE10 calculations are done simultaneously to follow the outcome of the decisions made. The tested apartment type is facing west north-west and is probably the apartment with least sun.

inspiration

Ill.93: Inspiration picture, recesses marks private terraces

Proposals

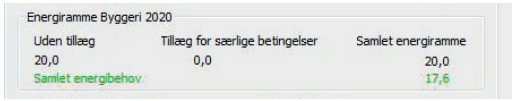


Ill. 94: Daylight factor in the apartment shows a satisfying amount of daylight in living area, but no light in the bathroom

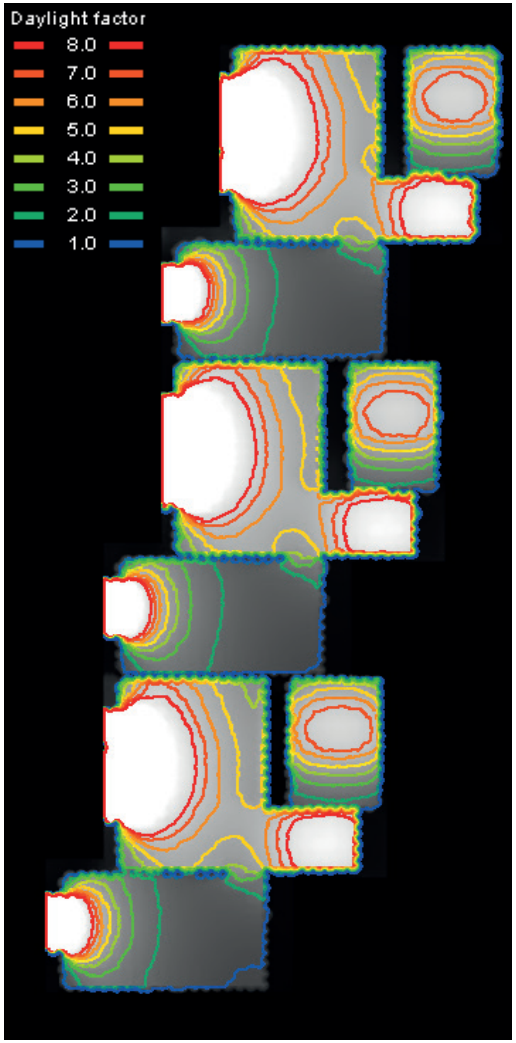
Ill. 95: velux render from apartment with three glass sections, where one is a door, in the living room, one window in the bedroom and no solar shading.

Apartment with basic windows
Iteration one - Three larger windows in the living room, one window in the bedroom.

Assessment: As seen on illustration 94 the apartment does gain enough light during the day in the living room area and in the bedroom. The bathroom is, however, without any light which might be solved through skylight windows. The apartment is also exposed for views of by-passing people and might need more privacy in terms of shading devices and a private outdoor area. As seen in the BE10 evaluation below the total housing unit meets the energy demand of 2020 with this type of windows and shading.



Ill. 96: Energy demands from BE10



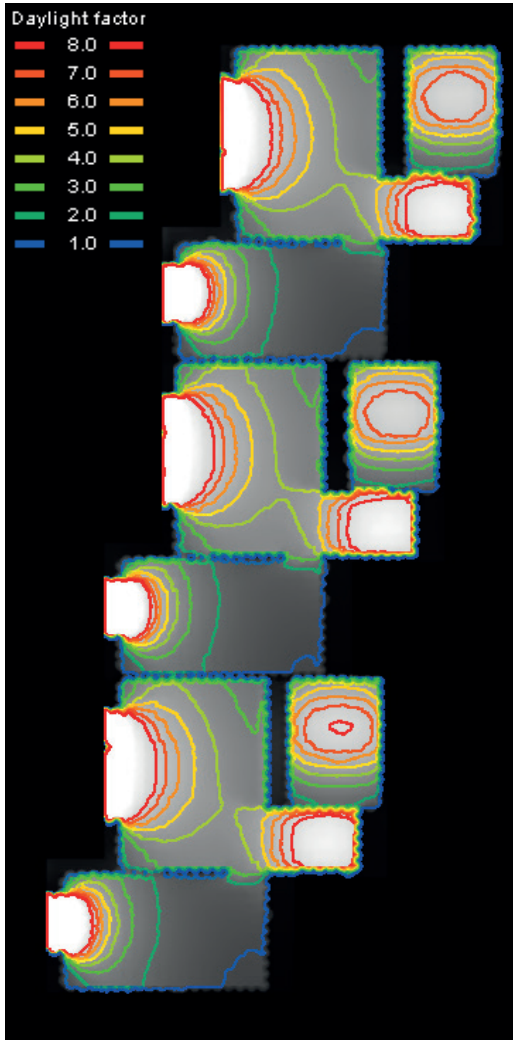
Ill. 97: By equipping the entrance and bathroom with skylight, all rooms are having access to daylight.

Ill. 98: The additional skylight has no impact on the facade and view

Apartment with additional skylight
Iteration two - Skylights in bathroom and entrance area are added.

Assessment:
As seen on illustration 97 the added skylights makes a huge different in the bathroom and entrance area. These are assumed as sufficient concerning daylight.
Even though more window area is added and therefore a larger line loss and energy loss the needed energy is lowered. This might be caused by the increased amount of passive solar gain through these windows, resulting in a lowered need for heating.

Ill. 99: Energy demands from BE10



Ill. 100: By equipping the entrance and bathroom with skylight, all rooms are having access to daylight.

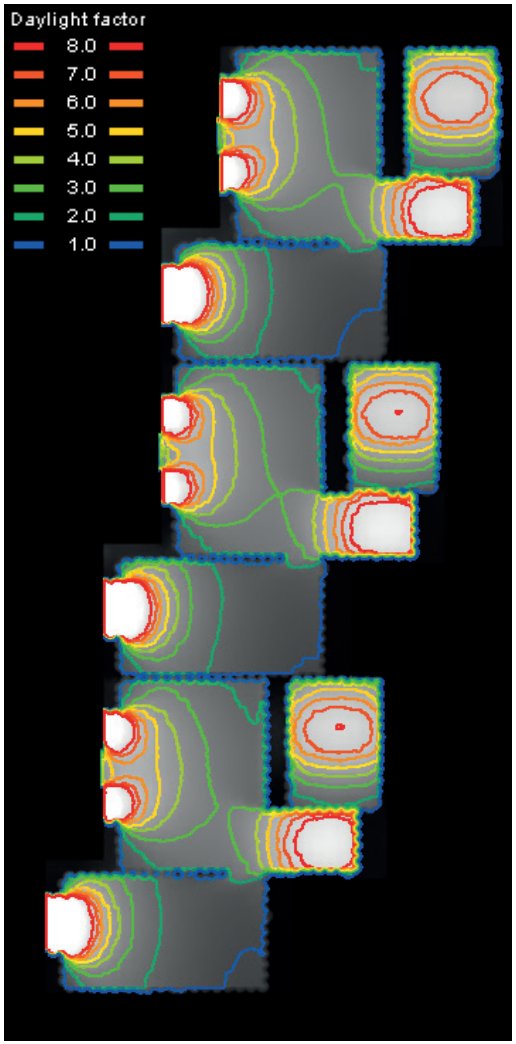
Ill. 101: The added overhang creates a room boundary for the outside terrace of each apartment

Apartment with additional skylight and overhang
Iteration three - overhang added in the front of the living room.

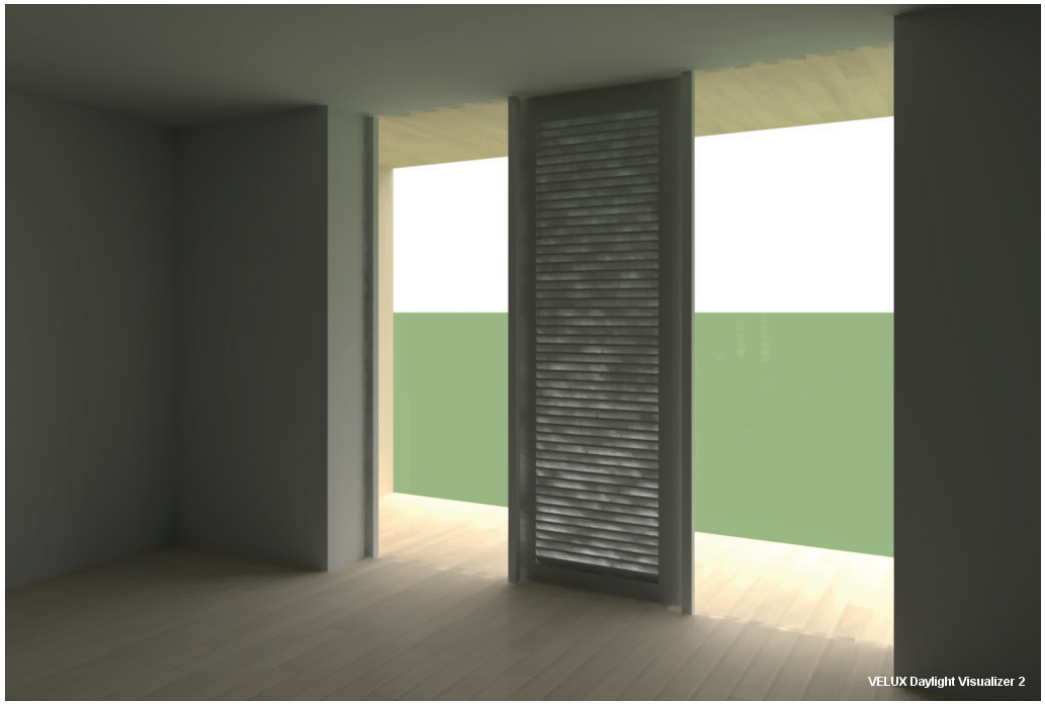
Assessment:
As seen on illustration 100 the daylight factor is slightly lowered in the living room, while the bedroom is unchanged, as the overhang is only covering in front of the living room. Thus the daylight factor is still sufficient in the activity areas. The increased energy consumption reflects the expected increase of heating demands because of the loss of passive solar heat gain through the windows. The apartment might still need sliding solar shading panels, as the apartments facing south east are likely to receive more direct sunlight throughout the day, and can therefore be overheated as a consequence hereof.

Ill. 102: Energy demands from BE10

Final proposal



Ill. 103: By equipping the entrance and bathroom with skylight, all rooms are having access to daylight.



Ill. 104: Final proposal for solarshading

Apartment with sliding solar shading panels
Iteration three - adding solar shading panels

Assessment:
By adding sliding panels, the inhabitants are having the option of letting more or less sun in the apartments, which heightens the climatic participation for each inhabitants. This is also increasing the privacy within the apartments, as the solar panel is movable and it can therefore be placed on the basic of ones specific needs.

The lack of direct sun might affect the passive solar gain, resulting in a higher energy use, but as the solar shading is only used during summer periods, this will have no effect.

The needed energy amount is though still within the energy frame for 2020, and the applied solutions are considered valuable enough to justify this increase.

Ill. 105: Final energy use

Conclusion on windows and shading

The final solution allows adequate views towards garden areas while the apartment remains private for views from by-passing people. The solution is though still letting enough daylight within the apartments.

The windows are to be more detailed, than the illustration shows, as a subdivision of the windows allowing automatic natural ventilation is to be placed in the top part of the windows.

Arriving to a bright entrance area secures a positive feeling from the very beginning of the apartment. The bathroom is likewise bright and the skylight lets the inhabitant get a glimpse of the sky.

Adapting the architectural expression to energy demands and indoor comfort is an essential parameter of working holistic with low-energy buildings.
The energy demands are being fulfilled with the window placement showed, and as this setting is complying with the energy demands it will be chosen for the further design development of the apartment.

Reaching the 2020 demands, BE10

The following sections will describe the initiatives that have been done to secure a low energy consumption in the building.

In the section '*2020 demands and building strategy*' the strategic way to reaching the demands was described. After the initial planning of the building volume the materiality had to secure a low energy consumption with passive solutions. This has been done be using constructive elements with low U-values, as seen on illustration 106. This is resulting in a very compact building with a heigh thickness of constructions, as seen on illustration 106.

To demonstrate the energy consumption the calculation programme BE10 has been used.
Ongoing tests have been done to keep track of the energy consumption, and has been assessed through results from BSim and Velux, as the mechanical ventilation and window areas are having a large impact on the final use of energy.

The total energy consumption has to fulfil the goal of maximum use of 20 kWh/m2 where the actual consumption in the building is 18,9 kWh/m2, seen on illustration 107, which means that the building complies with the energy demands.

The total energy use for heating is located in Appendix 02.

Face	U-value	Unit	Thickness	Unit
Roof	0,09	W/m² K	1002	mm
Ground slab	0,11	W/m² K	492	mm
Outer wall	0,9	W/m² K	510	mm
Windows	1,1	W/m² K	-	-

Ill. 106: U-values for the construction

Nøgletal, kWh/m² år

Energiramme BR 2010

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
53,3	0,0	53,3
Samlet energibehov		29,0

Energiramme Lavenergibyggeri 2015

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
30,5	0,0	30,5
Samlet energibehov		25,7

Energiramme Byggeri 2020

Uden tillæg	Tillæg for særlige betingelser	Samlet energiramme
20,0	0,0	20,0
Samlet energibehov		18,9

Bidrag til energibehovet

Varme	16,7
El til bygningsdrift	4,9
Overtemp. i rum	0,0

Netto behov

Rumopvarmning	16,7
Varmt brugsvand	13,1
Køling	0,0

Udvalgte elbehov

Belysning	92,0
Opvarmning af rum	0,0
Opvarmning af vbv	0,0
Varmepumpe	0,0
Ventilatorer	4,9
Pumper	0,0
Køling	0,0
Totalt elforbrug	35,6

Varmetab fra installationer

Rumopvarmning	0,0
Varmt brugsvand	0,0

Ydelse fra særlige kilder

Solvarme	0,0
Varmepumpe	0,0
Solceller	0,0
Vindmøller	0,0

Ill. 107: The table shows the total energy consumption of the building and that it complies with the 2020 energy demands.

Calculating on the indoor environment

As a part of the integrated design process calculations of overheating are done in order to obtain a good thermal environment.

Month average spreadsheet

The first initiatives towards a good indoor climate consists of the overall planning of the building. An adequate amount of daylight has to be reached within the building, and the apartments are therefore placed facing east or west as described.

The first calculation done to investigate the state of the building is a simple spreadsheet, that has the purpose to examine the thermal indoor environment on the basis of the apartment layout, its orientation, building frame and energy gains, both solar and internal heat gains from people and equipments and losses through the building envelope.

Illustration 110 shows the scenarios of two apartments, that are similar according to layout but has to different orientations. It is seen, that the west facing apartment is slightly warmer than the east facing, but none of the apartments are alarmingly overheated.

After checking the 'worst case scenario' for overheating through the spreadsheets, the BSim model is carried out as a more specific and precise calculation.

Ventilation principle

Ventilating the apartments has a huge impact on the thermal environment and on the energy use of the building.

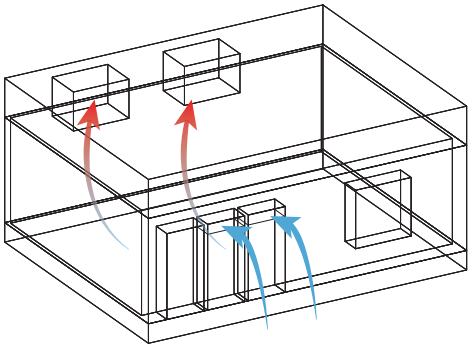
The ventilation principle used for the whole building is hybrid ventilation. This means natural ventilation during summer (April-October) and mechanical ventilation with heat recovery during heating season (October-April).

The principle for natural ventilation is seen on illustration 108. The system for mechanical ventilation has to keep the CO2 level down below 1010 ppm and the olf level down as well.

The key numbers for the needed ventilation rates are seen on illustration 109, where it is seen, that olf requires the highest ventilation rate and is therefore setting the level of mechanical ventilation during heating season.

The apartments are oriented east / west and are equipped with theft-proofed top-windows in the facade and skylight windows that are automatic opening. This securing cross ventilation through the apartment with thermal buoyancy and a sufficient venting during the summer half. The final diagram showing the piping through the building will be presented later in the synthesis.

Natural ventilation principle



Ill. 108: Principle of natural ventilation; automatic opening theft proof windows and thermal buoyancy

Ventilation key numbers

Demands	Rate	Unit
BR10	0,225	h^{-1}
Olf	1,23	h^{-1}
CO_2	0,64	h^{-1}

Ill. 109 Requirements to the ventilation rates, the calculations can be seen in Appendix 03.

Month average spreadsheet, results

Apartment type	Day average temperature (tu)	Variation in temperature (Δti)	Maximum temperature (timax)	Temperature control
Apartment facing 275 ° west	23,9 ° C	3,6 ° C	25,7 ° C	*OK*
Apartment facing 110 ° east	23,8° C	3,5 ° C	25,6 ° C	*OK*

Ill. 110: Spreadsheet calculations showing the maximum temperature in apartment

BSim model

The BSim model examines the indoor environment on an hourly basis and displays, among other factors, the fluctuations in temperature and CO_2 levels. The BSim calculations are done in order to check the indoor environment, and are not taking parameters as energy consumption into consideration. These aspects were calculated through BE10 in the previous chapter.

Construction and systems

Thermal zones
Thermal zones is describing a series of room with the same thermal conditions, as for example an apartment unit.

Time schedule and internal loads
In the analysis phase a time schedule was presented described the inhabitants use of the apartment. The specific use is of course impossible to predict, but an estimation shows the expected use and thereby loads of persons and equipments. These informations are used to set up a time schedule within BSim.

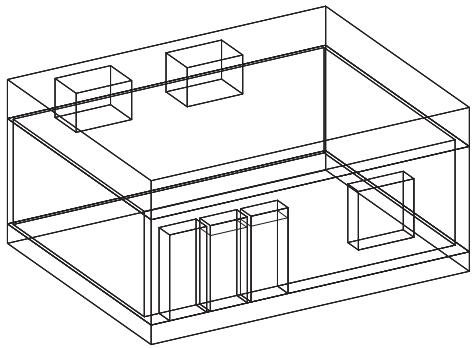
Venting / summer half
Venting is applied as natural ventilation, that works as intake of the outdoor air without heat recovery.

The possible air change through windows is calculated to ensure an adequate amount of fresh air for natural ventilation through summer half.

Mechanical ventilation / winter half
BR10 Class B demands a minimum ventilation rate on 0,3 l/s m^2 during heating season. However, calculations on CO_2 and olf show that a higher ventilation rate is needed to keep the olf level down.
See illustration 109 on previous side or Appendix 01 for more information.

Approximation of apartment unit
Firstly the apartment is approximated in order to simplify the simulation as seen on illustration 112. In this case the apartment is seen as one thermal zone with same conditions, and is therefore modelled as one unit as the air flows freely between the rooms. Overhang and solar shading panels are defined in the window properties within the programme.

Approximation of apartment unit



Ill. 112: Approximation of apartment unit. Thermal zones, building frame, windows and orientation are specified.

Temperature	Hours	Allowed	Temperature control
> 26 ° C	53	100	OK
> 27 ° C	13	25	OK

Ill. 113: The hours of overheating is complying with the requirements from BE10.

Conclusion

Illustration 113 shows the hours with overheating in an apartment facing west north-west, as this was the apartment with the highest temperature according to the 'month average spreadsheet' on the previous side. The thermal requirements are specified in the chapter '*Indoor comfort*' on page 29.
After testing the apartment unit it is concluded, that the calculated apartment is complying with the demands. The computed amount of natural ventilation needed to keep the CO_2 and olf levels down during summer is given in Appendix 01.

Hours with overheating within apartments

Month	Sum	Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hours > 21 ° C												
Hours > 26 ° C	53		5	3		*18*	*13*	*14*				
Hours > 27 ° C	13					*7*	*2*	*4*				
Hours < 20 ° C												

Ill. 111: BSim calculations on apartment unit showing the amount of hours with overheating in apartments.

Exterior materials

The exterior materials shall underline the shape of the building and put focus on details. It is crucial that the materials help breaking down the scale of the building and marks important areas as the entrances and apartments.

Materials chosen:

Facades: White concrete plaster
The building shape must be underlined by its facade material, and a white concrete plaster is chosen.
The white colour secures a light appearance and lets details stand out. The white plaster is covering the facade up to the roof and makes the building stand as a solid whole with cut outs.

Recesses: Larch wood slats
The slats appears more warm and tactile against the white concrete and marks important areas as terraces, entrances and the underside of the overhangs.

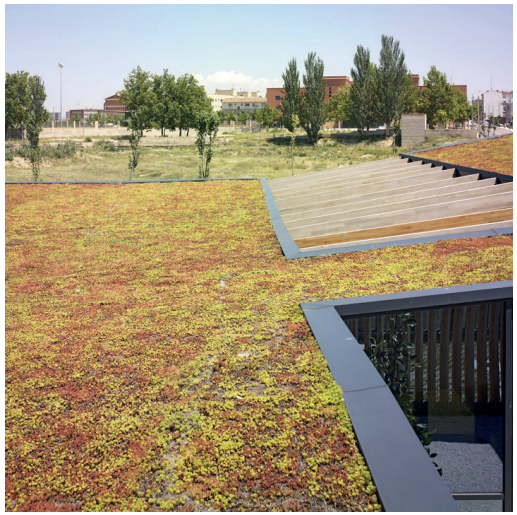
Windows frames and shading panels: Larch wood
The window frames are kept in the same material as the slats to make a connection between the two.

Roof: Green sedum roof
The roof is constructed as a green sedum surface and becomes a fifth facade, that will blend in with its function as growing from the slope. The roof will change in colours according to the amount of water that it receives, and can vary from green to red tones as seen on illustration 116.


Ill. 113: Wood slats in recesses


Ill. 115: Solar shading panel


Ill. 114: White concrete plaster


Ill. 116: Sedum roof

Interior materials, common areas

Working visually with the interior helps creating a strong architectural identity for the inhabitants and staff. With base in the evidence based method, Healing Architecture, interior can make a huge different with colours and materials as calming elements.

Materials chosen:
The interior materials shall reflect a modern expression of homeliness.

Acoustic ceilings; Troldtekt suspended ceilings
Troldtekt ceilings are having good acoustic abilities and it is possible to integrate solutions as skylights and spotlights as seen on illustration 118 and 120.

Flooring; Different coloured linoleum
Linoleum flooring is a sustainable flooring, as it consists of recyclable materials. It is easy to clean and is durable for many years of use. (forbo-flooring.dk) Linoleum comes in a variety of colours and is flexible according to shifts between functions. Changing colours in flooring is giving direction and gives affiliation for inhabitants.

Walls: White plasterboard painted concrete
Shifting between neutral, calm surfaces, as plasterboard and concrete, and more vibrant surfaces as coloured / tactile areas creates a stronger focus on each material.

Niches: Wood / coloured wood
Wood panels / slats are tactile and can be used as a combination with plasterboard walls as marking of special areas / functions.

Generally:
The colours can be used as flooring but also on acoustic panels and details as mailboxes and other furnitures.

Ill. 117: Colours on floors are giving affiliation

Ill. 119: Colours on floors are giving affiliation

Ill. 118: Round skylights are giving character to the ceiling

Ill. 120: Nørrebro Park Skole, colours and materials

Interior materials, apartments

Moving from the common semiprivate areas to the private apartments a shift in materials shall mark this transition. The materials within the private areas must be more homely and calm and allow the individual inhabitant to decorate the apartment according to preferences and temper.

Materials chosen:

Floors: wood
The floors shall mark the transition between functions and is one of the first things noticed when entering an apartment. Wooden floors are having a more homely look and appears more warm than the linoleum in the common areas.

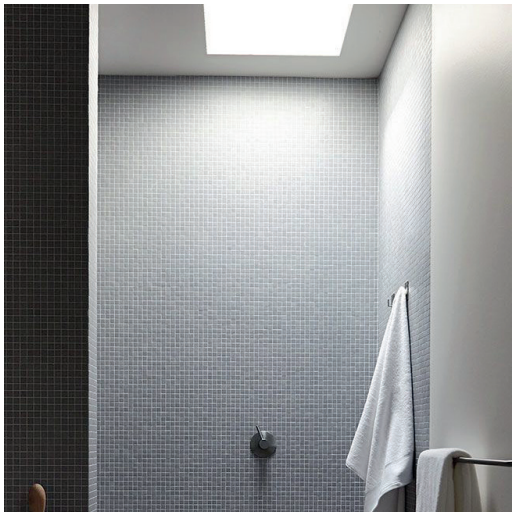
Walls: White plaster
White plaster walls reflects the lights from outside and acts as a neutral frame for various furnishing.

Windows frames and shading panels: Larch wood
Relating to the floors and outside, larch wood creates a connection between exterior and interior.

Ceiling: White plasterboard
The ceilings are covered with white plasterboard and differs from the ceilings in the common areas. This shift is also marking the difference between common and private areas.

Bathrooms: white plasterboard and tiles
The bathrooms shall work as breathing spaces, where the day starts and ends. Smaller tiles on the walls are giving tactility to the shower niche and makes the bathroom seem bigger because of the zoning made by these.

Ill. 121: Simple materials at wall and floors



Ill. 122: Tiles and skylight

Acoustic

Keeping the reverberation time low is crucial in areas, where many people are gathered at the same time to prevent an unwanted high level of noise.
As described in the chapter of indoor climate, the allowed reverberation time differs according to use. In this section the music therapy room is studied, as it is at risk for being too noisy due to its use.

A good acoustic climate is not only beneficial for people with hearing impairments but also for others, as noise is both stressing and disturbing for the concentration.
To improve the acoustic comfort working with room shapes and materials is crucial as hard materials reflects sound more than soft, absorbing materials.

Absorption is described as a coefficient, where 0 represents a total reflection and 1 represents a total absorption of sound. The materials chosen for the given room is represented in illustration 123 where it can be seen, that the Troldtekt ceiling is quite absorbing. Troldtekt ceilings are being used both for their noise absorbing abilities but also, as they have a high architectural quality as an element in itself as seen on the reference pictures 126 and 127.

The reverberation time is calculated for the music therapy, which is specified as a room for teaching for music and song, which is smaller than 230 m^3. The total reverberation time must not exceed 1,1 s according to the regulations. (bygningsreglementet.dk)

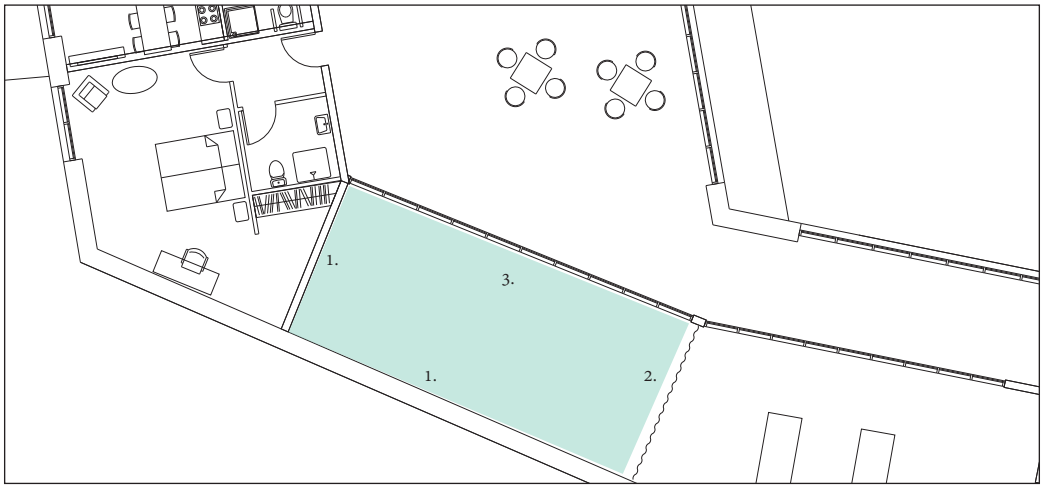
Illustration 124 shows the calculated reverberation time, which does not exceed the allowed value for its given type of use.

Surface	Material	Area	Absorption at 125 Hz
Floor	Wood, soft	48 m^2	0,02
Ceiling	Troldtekt panels	43 m^2	0,65
Wall (1.)	Plasterboard	16,2 + 27 m^2	0,3
Wall, removable (2.)	Folding wall	12,15 m^2	0,14
Wall, glass area (3.)	Glass	10,8 m^2	0,08
Wall, plasterboard (3.)	Plasterboard	16,2 m^2	0,3
Windows, skylight	Glass	5 m^2	0,08

Ill. 123: Absorption of materials

Hertz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Reverberation time	0,5 s	0,3 s	0,3 s	0,3 s	0,3 s	0,3 s

Ill. 124: Reverberation time for the different frequency



Ill. 125: Placement and shape of music therapy.

Ill. 126: Acoustic ceiling, Troldtekt

Ill. 127: Acoustic ceiling Troldtekt

Construction

The structural system of the building is consisting of load bearing exterior walls and some of the interior walls. The interior walls must not only serve as separation between apartments but are also functioning as division between fire sections and withstand the regulations hereof. They must also provide satisfying sound absorption between units to secure privacy within each apartment.

Illustration 128 shows the placement and types of load bearing walls and the structural elements are detailed at the next page (page 64).

Ill. 128: Plan of load bearing walls

Exterior wall construction, 1:20

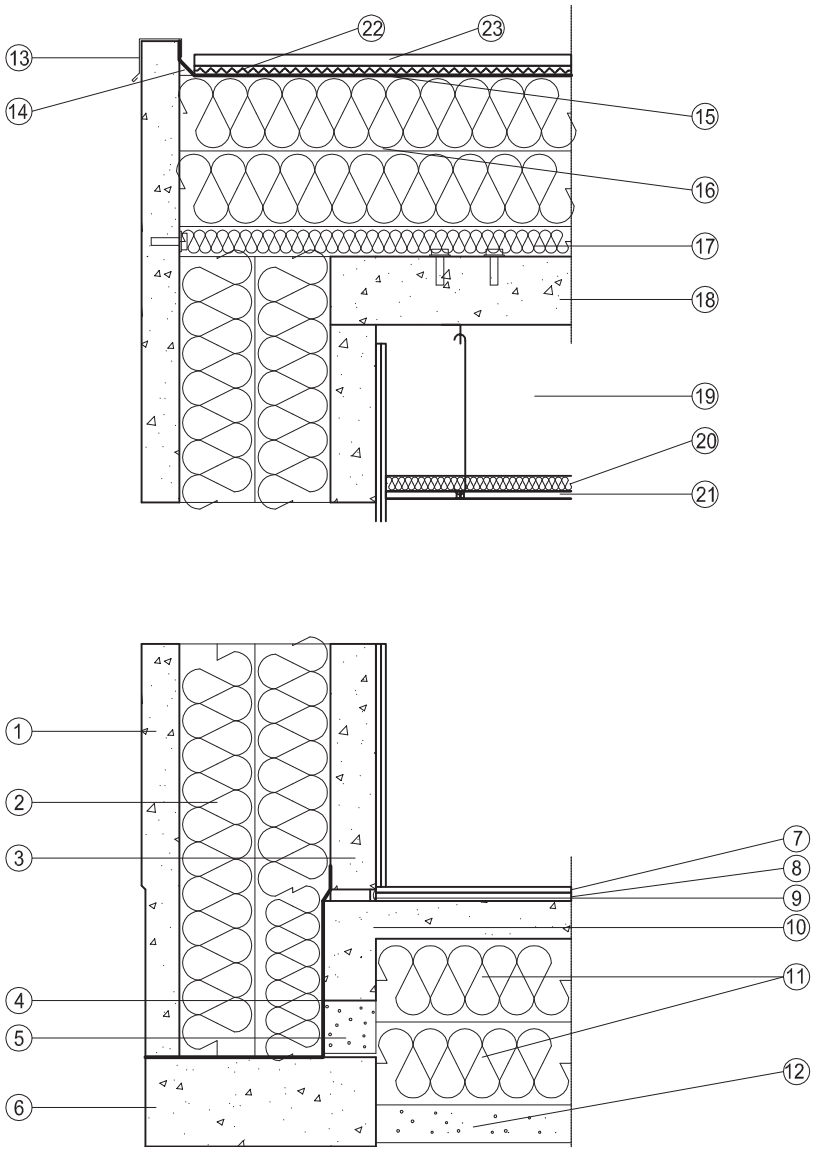
The construction is build up as load bearing outer walls with stabilizing inner walls. The principles for the construction are made with construction solutions from different manufacturers home pages. (vegtech.dk, rockwool.dk, and troldtekt.dk)

The construction must comply to the standards of U-values, acoustics, aesthetics, the functional aspects of having a green roof, while still allowing suspended ceilings for ventilation gap.

Exterior finish: White plastered concrete.

Interior finish: Plasterboard, painted.

Exterior wall construction:
U-value: 0,09
Thickness: 600 mm



Ill. 129: Detail, exterior wall (Vegtech, n.d., Rockwool, 2014 and Troldtekt, n.d.)

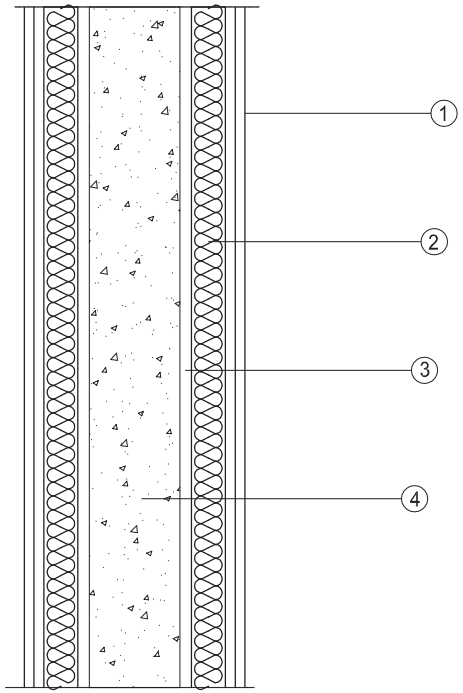
Layers

1. 100 mm lightweight concrete
2. 2 x 200 mm ISOVER insulation
3. 120 mm lightweight concrete element
4. Radon- and moisture barrier
5. 140 + 190 mm FoamGlass building blocks
6. 120 mm lightweight concrete element
7. 15 mm linoleum floor
8. 22 mm MDF
9. Rubber joint
10. 100 mm concrete slab
11. 2 x 200 mm polystyrene
12. Sandbed
13. Zinc covering
14. Triangle list
15. 2 layers asphalt roofing
16. 400 mm ISOVER Taurus
17. Standoff
18. 180 mm lightweight concrete
19. 400 mm suspended ceiling
20. 40 mm mineral wool
21. 20 mm Troldtekt
22. 25 mm Nophadrain ND 5+1 draining system
23. 30 mm mos Sedum mat

Interior walls

Some of the interior walls are functioning as load bearing walls different places within the building and other places placed as non-load bearing walls.

Load bearing interior wall, 1:10



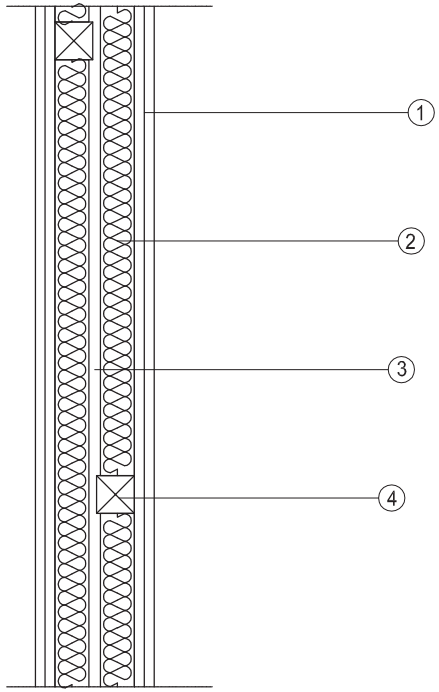
Ill. 130: Detail, interior wall, load bearing (Rockwool,2014)

Layers: 1. *2 x 13 mm plasterboard, painted* **2.** *45 mm rockwool Flexibat* **3.** *15 mm cavity* **4.** *120 mm lightweight concrete*

Load bearing walls are places strategically to stabilize the construction of the building. The walls are built with a stabilizing concrete core and cavities securing double walls with insulation on each side to secure sound reduction between apartments.

Thickness: 292 mm

Non-load bearing interior wall, 1:10



Ill. 131: Detail, interior wall, non-load bearing (Rockwool, 2014)

Layers: 1. *2 x 13 mm plasterboard, painted* **2.** *45 mm rockwool Flexibat* **3.** *15 mm cavity* **4.** *50 x 50 mm tree construction 600 mm displaced*

Non-load bearing walls must be insulated with a non combustible material, in this case Rockwool Flexibats, that can withstand temperatures up to 1.000 °C without melting (Rockwool, n.d.).

Thickness: 157 mm

Fire regulations

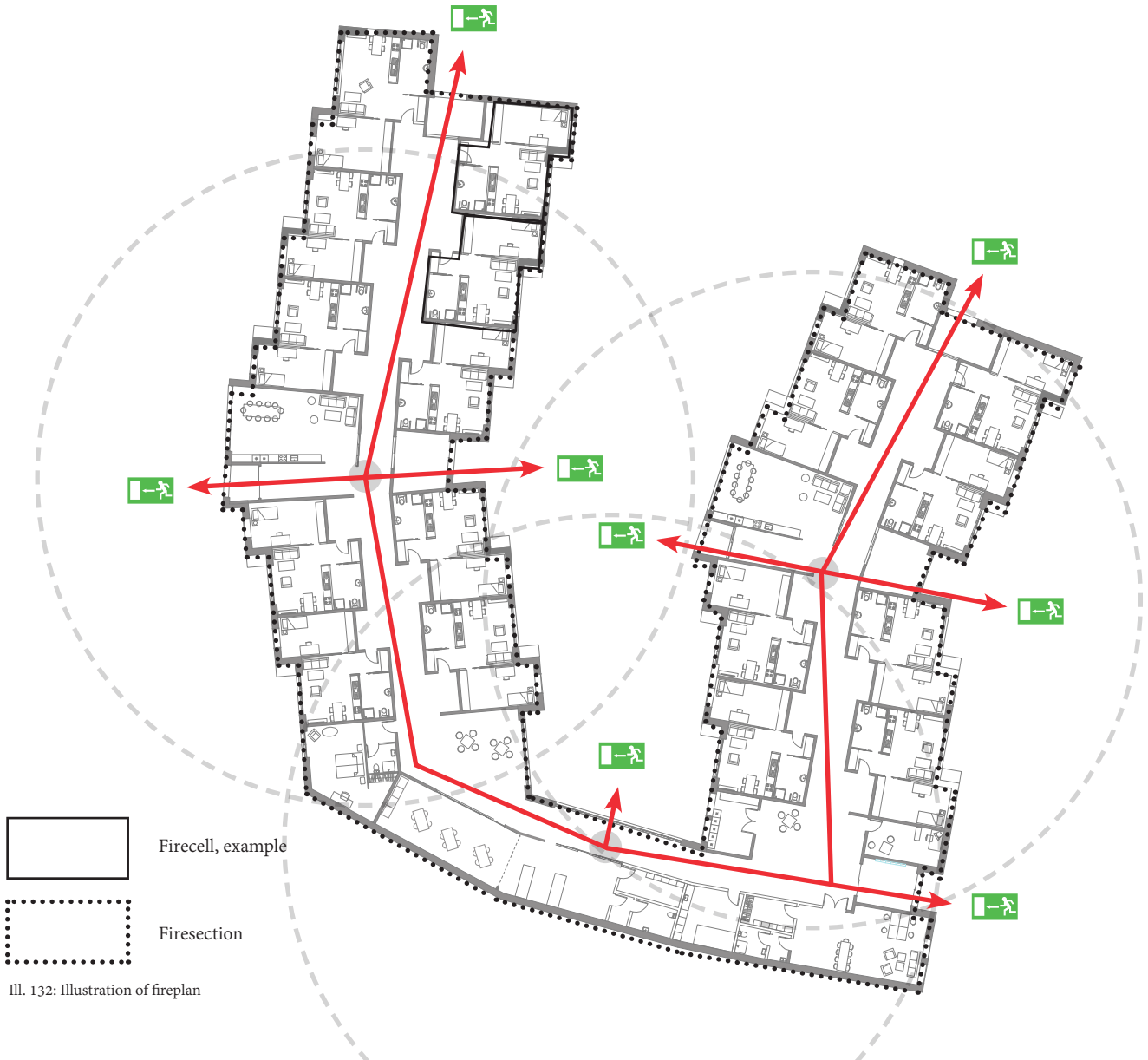
According to the Building Regulations, this building is covered by Category 6 which includes buildings for people with permanently reduced physical or / and mental function. (SBi, n.d.)

The building is equipped with automatic fire alarms and has escape the routes marked. All walkways are 2,5 meters wide, which allows two hospitals beds to pass each other unobstructed.
All doors used for fire escape shall be able to automatically open in the case of fire, and escape routes must be visually easy to locate for inhabitants, who are visually impaired. This is generally done by contrasting colours and materials throughout the building.
(SBi, n.d.)

For people with hearing restraints the visually guidance for escape is extremely important.
On illustration 132 fire routes are marked and all places in the building are equipped with minimum two separate entries to the outside within a distance of 25 meters.

Illustration 132 shows fire sections and fire cells. Each apartment is a fire cell and the whole building is a fire section. The fire cells must withstand fire from its adjacent cell in the period of time it takes to evacuate the whole building, which in this case is 60 minutes. The construction of the walls separating the apartments are fireproof and are described in the details on page 65. (BR 5.2 stk. 6)

All escape routes are marked with red arrows on the illustration, and firedoors are marked with a sign.



Ill. 132: Illustration of fireplan

Parking at the site, arriving area

Parking has to be done on the site and is planned in the eastern part of the side close to the entrance and the staff area. The parking spaces have to comply with the regulations given by the building regulations.

At least one parking lot, marked as '3' on illustration 132, is dimensioned to facilitate a minibus which is 4,5 x 8 meters. This parking space is thought as a part of the turning area, as mini buses are only used for loading and unloading.
The spaces are calculated as 1 car per staff member and 3 spaces for visitors. This number is an assumption, as some of the staff members will come by bike or by bus, and in that case not occupy a space.
Some of the parking spaces are broader than others and serve as buffer area for manoeuvring a wheelchair out of a car. These spaces are marked as '1' on the illustration 132, while regular spaces are marked as '2'.

Number of spaces:
One car per staff member: 6
Guest parking: 3
Parking for one minibus: 1

Dimensions for turning area, hammerhead:
Type of vehicle: Smaller truck (Example: garbage truck or food delivery) Speed: 5 km/h, Lengths: B: 5,0 meters, R: 4,5 meters and L: 12,5 meters.

Green parking:
The parking spaces are partly paved with permeable surfaces, that allows rain to infiltrate on the site. This gives both a green surface at strategic plances and a sustainable way of infiltrate rain. Smaller trees are furthermore planted between the spaces.

Manoeuvring area: 6.9 meters.
(HFB, 2008)

Ill. 132: Principle for parking area

Paving

Firetrucks requires roads that are minimum of 2,8 meters wide and that are having hard foundations, which is seen on illustration 132. (Aalborg Kommune, n.d.)
Wheelchairs require an even foundation and illustration 133 shows a permable paving with an even surface, that furthermore can withstand the weight of a firetruck (TTE, n.d.).

Ill. 133: Inspiration, even permable paving

Ill. 134: Inspiration, leading water away from parking area

Mechanical ventilation and piping

Being able to ventilate properly is essential for the indoor climate, both regarding to smell, temperature and level of CO_2.

The ventilation rate needed is calculated on the basis of two factors;

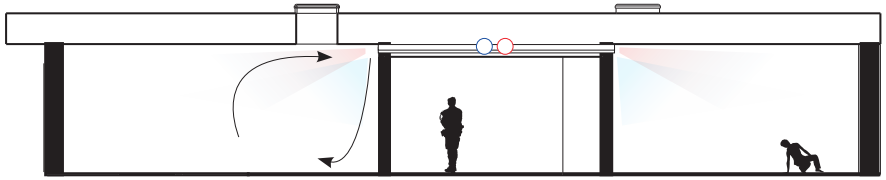
- The CO_2 level
- The olf level.

The two parameters are calculated individually and the factors that requires the higher rate is determine the dimensions, see appendix 01.

A combination of natural ventilation during summer and mechanical ventilation with heat recovery during winter months secures a economical way of keeping the indoor climate at a good level.
The technical room containing the aggregate is placed centred in the building close to the entrance and in direct connection with the cleaning room. From the technical room the intake and outlet air is distributed throughout the building. Each apartment is receiving one pipe with supply air creating a overpressure.

To get rid of polluted air, two return pipes are placed respectively on the bathroom and in the kitchen. These are causing underpressure, that ensures an airflow from the living room to these pipes.

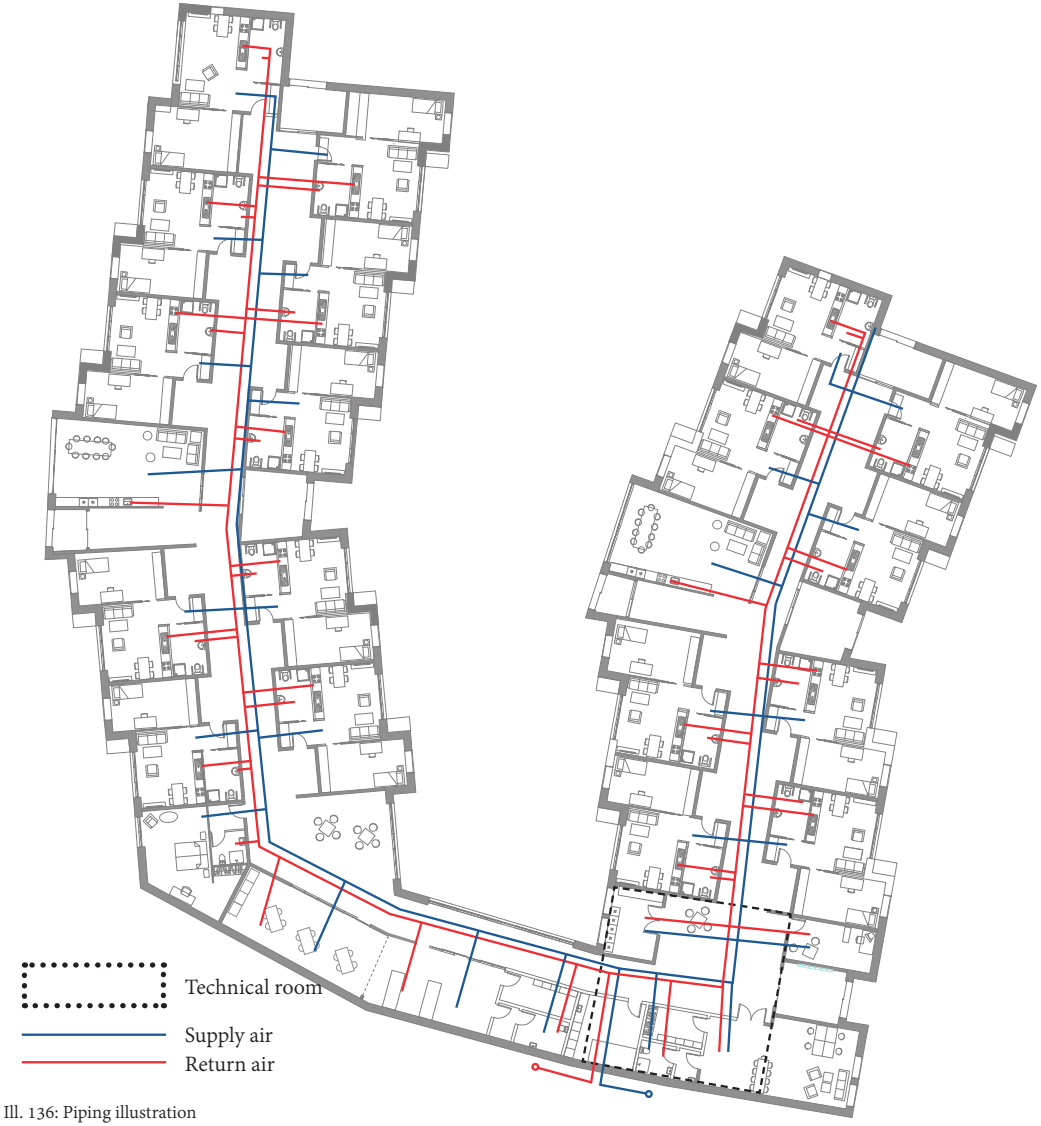
By blowing in fresh air the principles of mixing ventilation is achieved.



Ill. 135: Section, suspended ceilings and placement of pipes

Mixing ventilation utilizes thermal buoyancy and distributes heat and pollution evenly throughout a room. This ensures a stable indoor climate without too high differences in temperatures from floor to ceiling. It is likewise possible use mixing ventilation for heating. (Hvenegaard 2002)

Illustration 136 shows the placement of the technical room and the pipework, which is placed under the roof construction, seen in the section on illustration 135.



Ill. 136: Piping illustration

Conclusion

The synthesis phase has now verified the final building regarding to technical and functional solutions. The architectural expression and detailing has been outlined, but the final understanding of spaces is to be presented in the lase phase, the 'Presentation'.

PRESENTATION

NEXT CHAPTER INCLUDES FOLLOWING:

MASTER PLAN, OUTDOOR AREAS, 1:500
BUILDING PLAN, 1:500
APARTMENT PLAN, 1:100
SECTIONS, 1:200
DETAIL SECTIONS, 1:75
ELEVATIONS, 1:200
VISUALIZATIONS:
- ARRIVAL
- APARTMENT
- HALLWAY
- OUTDOOR AREAS

In the following chapter is the whole project presented through visualisations and all architectural and technical solutions shall be presented in the best way to understand the project.

Masterplan 1:500

The masterplan shows the building in its relation to the context. The green sedum roof blends in with the greenery when seen from above and from the road.

The main entrance to the site is located in the northwest, and leads to the parking area. The parking spaces for wheelchair users are located closest to the main entrances, and next to the shed for bikes and waste a larger parking space is located.

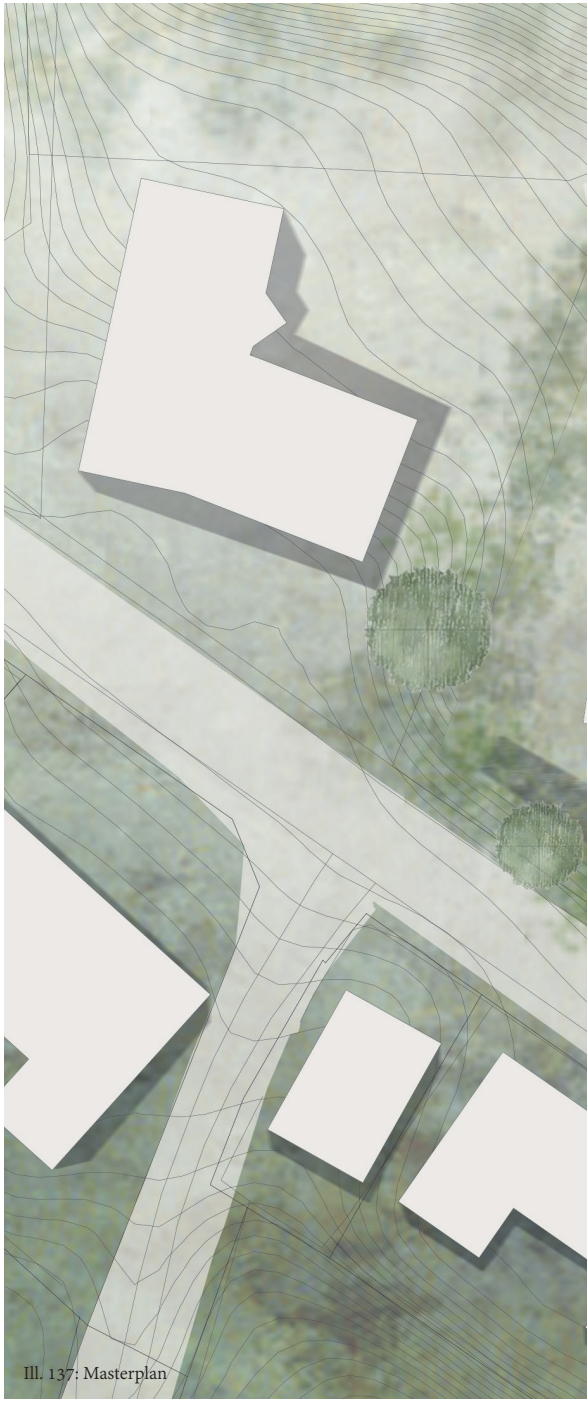
When arriving to the site by foot two different stairways leading to the paths can be chosen. One stairway steps down from Overbyvej in south an additional stairway is leading up to the site from Kløvkærvej in the north.

The common areas are easy to locate from the roof construction, which is lifted towards west and the two courtyards, active garden and relaxation garden.

The shed for waste is in convenient distance to the main entrance, and this is where the staff and inhabitants will leave garbage and sorting for recycling. This shed has sedum roof as the main building which links the two buildings together.

Sedum roof, abilities:
Weigh by full water absorption, about 50 kg/m²
Thickness of material about 55 mm
Absorption of annual rainfall, about 50 %
Maximum water absorption, about 15 litre/m²
(byggros.com)

Built area at the site:
Site area: 6.471 m²
Building footprint: 2.015 m²
Floor to area ratio, FAR: 31 %



Ill. 137: Masterplan

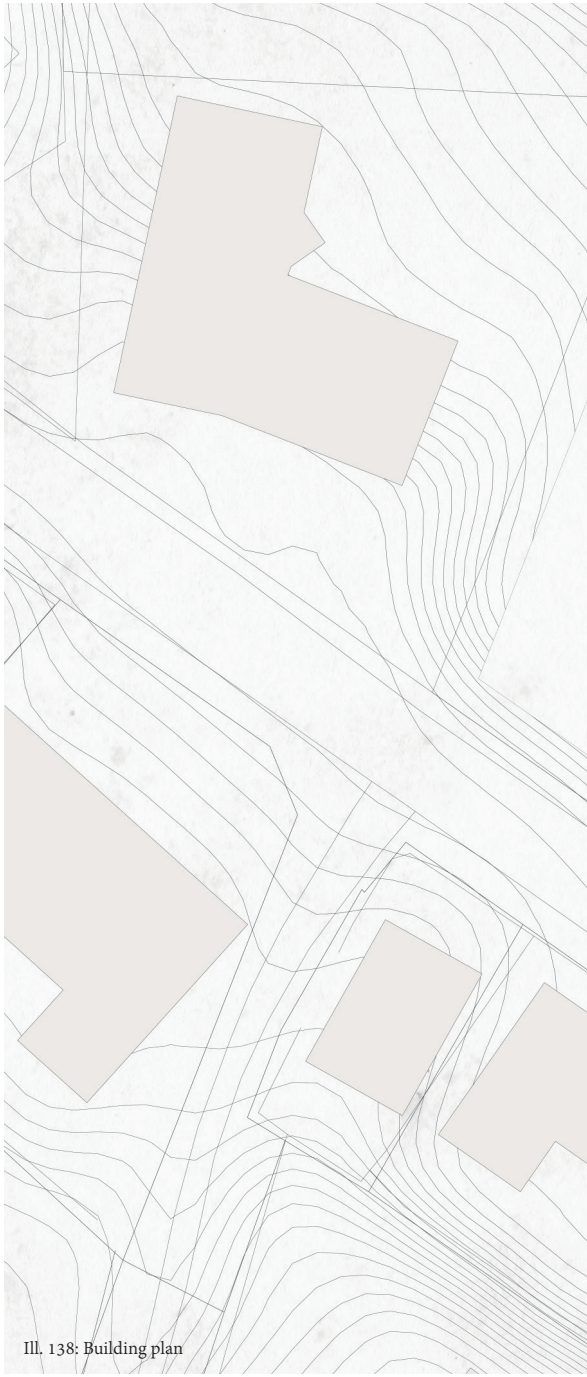

North

Building plan 1:500

The building is planned with a service base towards the slope and has its back against the remaining housing area in seest. In this way Kløvkærhuse is starting the new chapter for the Kløvkær area where the fireworks factory exploded in 2004.

The two building wings are facing east and west and secures either morning or afternoon sun in the apartments and in the common areas.

The building contains 17 regular apartments and one 'springboard' apartment for couples or inhabitants, that are more self-dependent and who might consider moving to own apartment.
This secures a flexibility as moving can be quite a change and may require some time for habituation.



Ill. 138: Building plan


North

Arriving to kløvkærhuse

When arriving to Kløvkærhuse one shall have the option whether to enter by the main entrance or by one of the other entrances either by the middle entrance of the entrance at the endpoints of the wings.

The main entrance is connected with practical functions as mailboxes and staff's area, and when arriving to the house for the first time will be through this area.

The paving leading from the parking to the entrance shall serve as guidance for direction by tactility and colour change. This secures equal access for everybody, disabled or not.

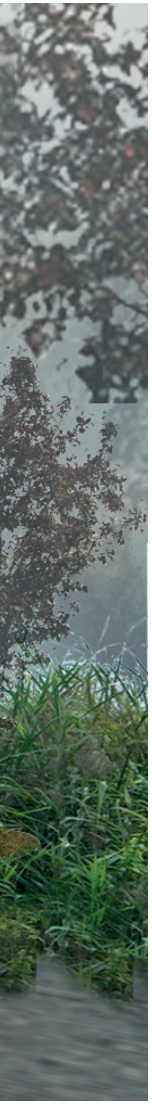
The entrance area appears welcoming and bright and the wooden recess in the facade shows, that an important function is located here.

The wall towards the road is thought as a living wall where plants, that does not require direct sun, as honeysuckle and ivy, can grow.

Ill. 139: Ivy

Ill. 140: Honeysuckle

Ill. 141: Arriving area, perspective



Ill. 142: Main entrance, perspective

Mailboxes and information

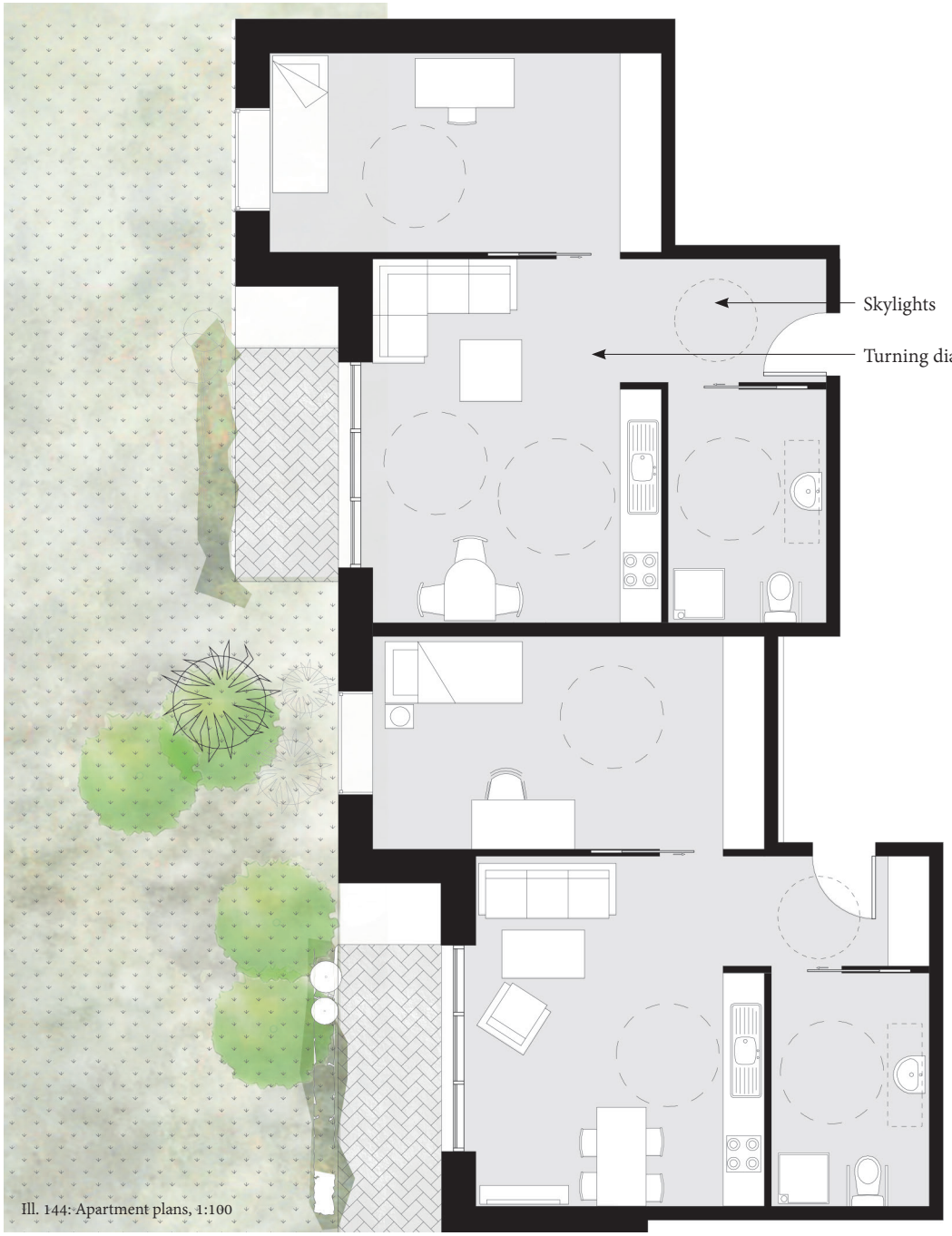
The main entrance shall provide clairity and welcome both guests, staff and inhabitants. A large informaion board is placed here, and a tactile map shows where all inhabitants live and where the common functions are placed.

Mailboxes in blue and green colour combinations indicates the two different wings and stands as a visual element.

The flooring is working as a leading line, that leads to the hallways and the staff area, which is located as the first thing after the entrance room.

Apartment, facts:
- Size, netto: 59,5
- Daylight factor:
- Window sills: 700 mm above floor
- Turning diameter for wheelchairs: 1500 mm
- Skylights for bright apartments and a daylight factor on 2% in the active zones

Ill. 143: Perspective from apartment



Ill. 144: Apartment plans, 1:100

Apartments

The plan shows a standard apartment and an apartment towards north, that has a different entrance. These two apartments together with the 'springboard' apartment, constitute the range of types available.

All apartments are accessible for wheelchair users, as they allow a turning diameter of 1,5 m in all rooms and there will be no changes in levels or high door frames restraining inhabitants with walking difficulties.

Entrances
Each entrance has a unique slatted panel in the colour scheme of the wing. Giving the entrances unique looks will result in a higher affiliation for the inhabitants, who might have difficulties of reading. The panels shall be visually clear with strong colours and are seen on the detailing on the next page.

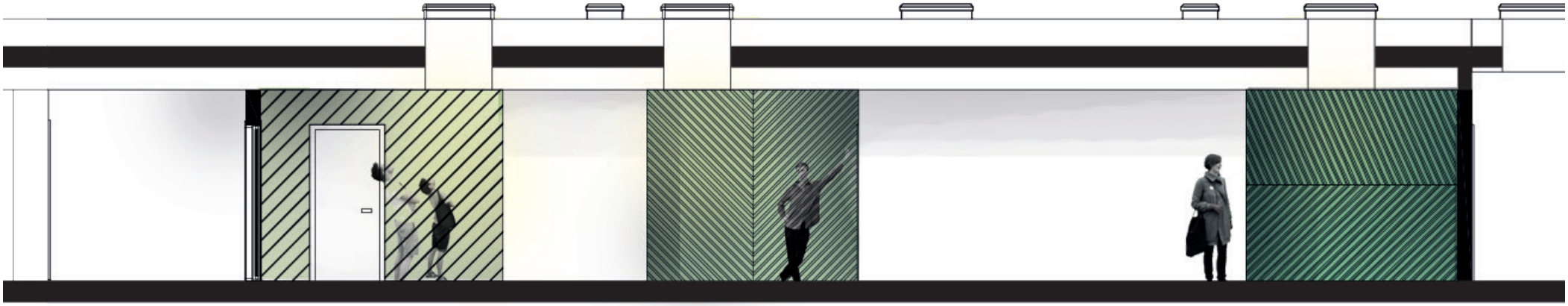
Living room
The living room is combined with a kitchen and dining area, which optimizes the use of space. The Living room is in direct visual connection with the outdoor terrace, which brings in the nature and allows the inhabitants to sit outside their own apartments during summertime.
The kitchen facilities are build in a wall and an integrated part of the living area.

Bedroom
The bedroom is separated from the remaining area by a sliding door, and the construction of the internal wall allows it to be removed when needed / wished for by the inhabitant. The makes the apartment flexible for different requirements and situations through life. The bedroom has a large build in closed.

Bathroom
The bathroom is equipped for wheelchair users and the plans show how armrests can be installed if needed. A skylight illuminates the room with daylight and allows glimpse of the sky.

Kitchen
The kitchen is set up as a single sided kitchen due to the minimal space. An angle kitchen is more ideal for wheelchair users, at the angle allows the user to have a larger range from the corner.
The kitchen in this apartment allows a wheelchair to turn in 1,7 m, which is required for Category B (Sigbrand & Jensen 2008). The kitchen is further described later.

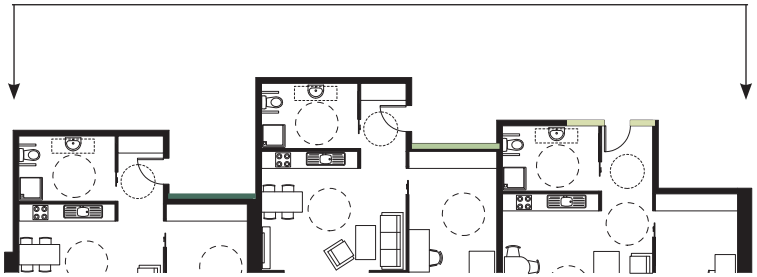
Detailing



Ill. 145: Section in 1:100 is showing personalization of personal spaces in front of doors

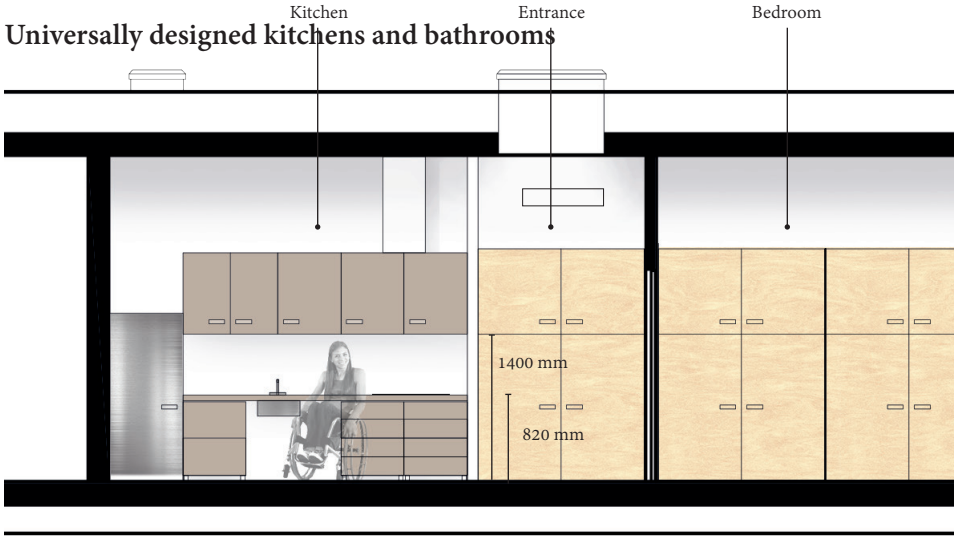
Personalization on entrances

This section shows how coloured panels can be placed in the niches around the entrance doors to create affiliation and recognition for the inhabitants. All niches are having their own expression and combination of colours and patterns. Blue wing will have blue patterns and green wing will have green patterns.

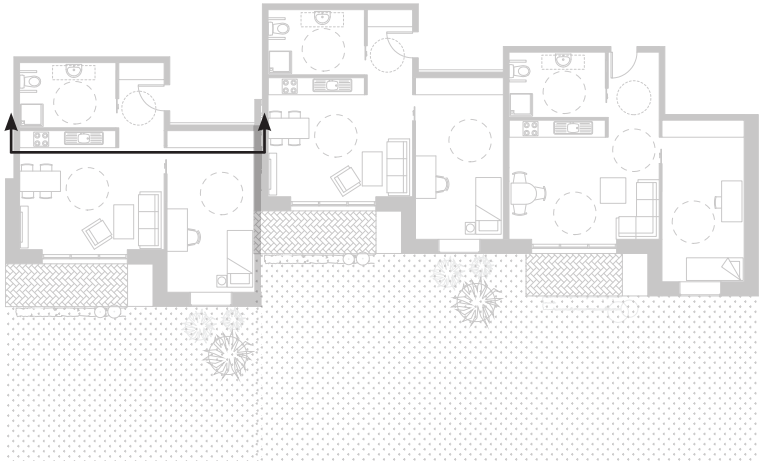


Ill. 146: The section shows where the coloured wooden panels are placed.

Universally designed kitchens and bathrooms



Ill. 147: Section in 1:75 showing kitchens and storage in the apartments



Ill. 148: Section showing the kitchen view.

Being self-dependent requires that the everyday functions can be performed without, or with only little, help from others. A part of the daily routine is cooking in own kitchen and being able to manage own apartment facilities.

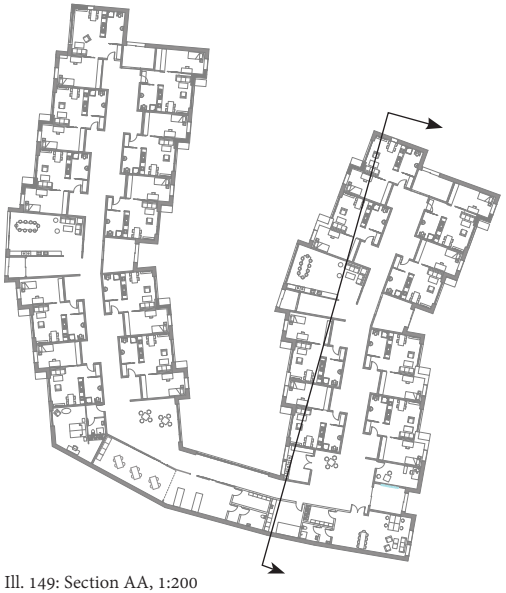
This is helped along by furnishing the kitchen and bathrooms with appropriate heights and inventory. By designing these facilities for the whole user group everybody will have the same basis for managing their own apartments.

The section shows the kitchen of the apartment, which is dimensioned for wheelchair users.

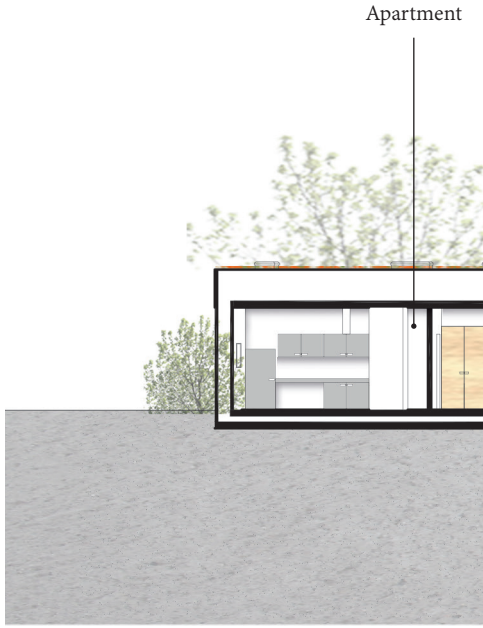
- The kitchens are equipped as kitchenette with mobile storage modules.
- There is a clear space for manoeuvring underneath the kitchen table.
- The tall cupboards are placed so that the lower shelf is reachable within 1400 mm, which is the maximal reaching height for a person sitting down.
(Fisher & Meuser, 2009)

Section AA

Section AA is a north-south going section that shows the relation between the functions in the eastern wing of the building.
The technical room that, among others contains the ventilation aggregate, is placed under ground in relation to the cleaning facilities. It is placed here in order to save space in ground level for other functions, as it is about 100 m^2. The apartments are put together two and two separated by the common living room. The section shows the kitchens of the apartments and the build in closets in the bedrooms.



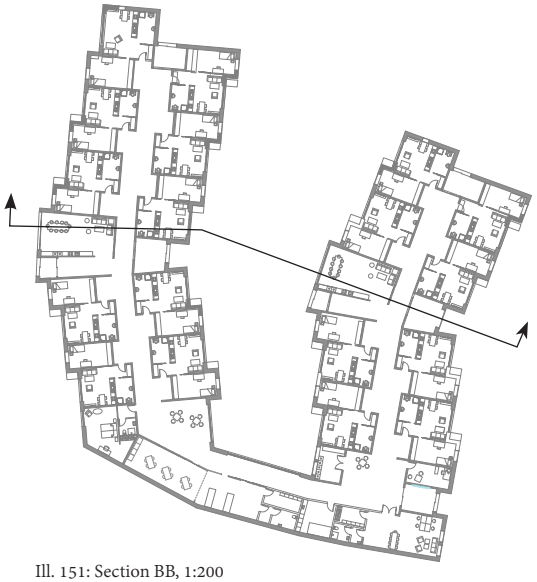
Ill. 149: Section AA, 1:200



Ill. 150: Section AA, 1:200

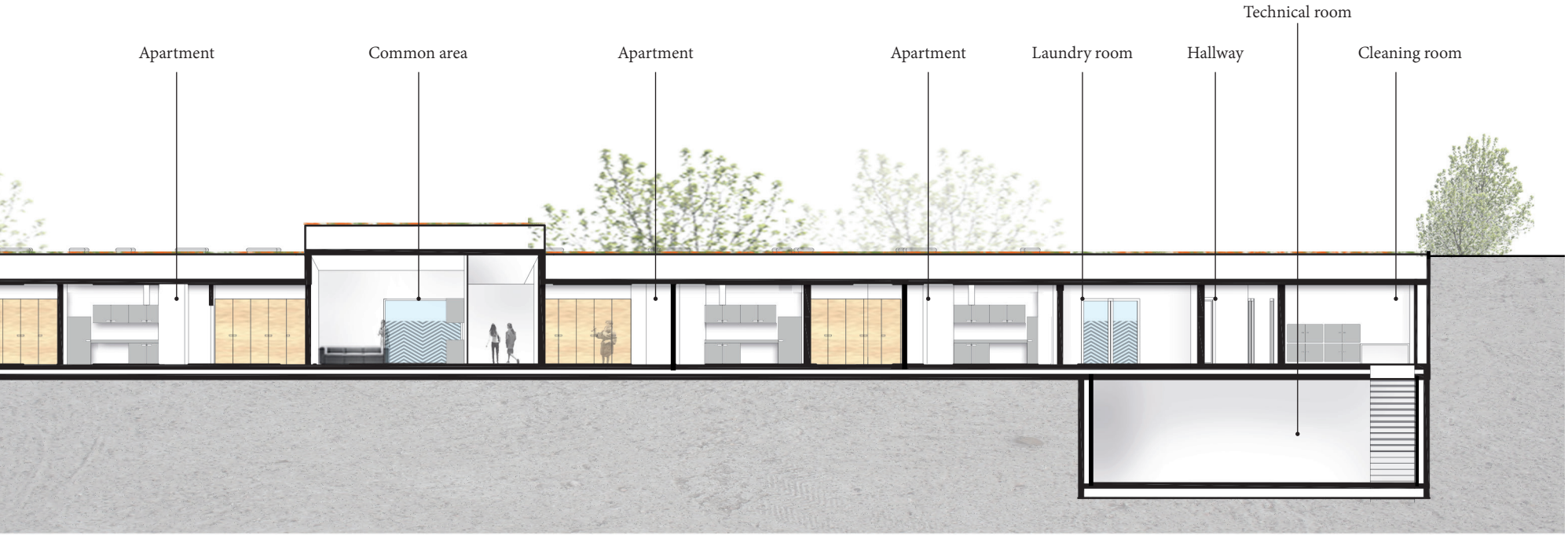
Section BB

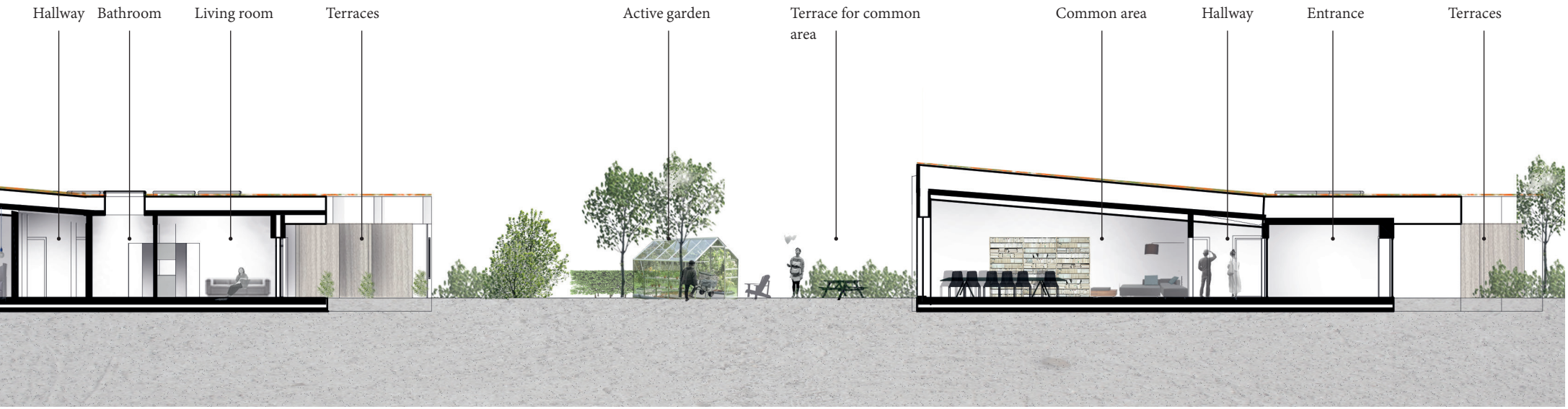
Section BB is a east-west going section through the entrance door in the east, the hallway and the common area in the eastern wing, the active garden in the middle and an apartment, the hallway and the common area in the western wing. The differences in heights of rooms are also visible in this section.
The common area has a decreased ceiling height to open up to the courtyards and to let in the afternoon sun.



Ill. 151: Section BB, 1:200

Ill. 152: Section BB, 1:200


Technical room
Apartment
Common area
Apartment
Apartment
Laundry room
Hallway
Cleaning room


Hallway
Bathroom
Living room
Terraces
Active garden
Terrace for common area
Common area
Hallway
Entrance
Terraces

Facades, 1:200

The facades of the building are kept simple in white concrete plaster and wooden slats window frames and recesses. Each apartments shall stand out as individual but as a part of a whole. The recesses secures a more privacy for the inhabitants, and greenery will make a small niche in front of the apartments.
The common areas for each wing has a sloped roofs with extra room height to make them stand out visually from the outside and to create a more spacious room inside.

Ill. 153: West facade

Ill. 154: North facade

Ill. 155: East facade

Hallways

The hallways are connecting all functions and are setting the frame for casual social meetings.
When passing the common functions, one shall be able to observe social events, that are eventually taking place.

Guidelines in the floor are leading both visually impaired through the building to important functions. They are as well serving as help for inhabitants with mental challenges, that might have troubles finding way. The common area are marked on the hallway and lamps in the ceilings are serving as guiding lights.

Some of the common area are marked with pictograms on their doors to help inhabitants know the functions as seen on illustration 156.

Illustration 157 shows the hallway in front of a common area. Transparency helps inhabitants meet the function in a slow pace and allows them to deside whether to participate or not before entering the room. This helps intellectually disabled who might find it challanging to seek out social interaction on their own hand.

The sliding door from the storm flap leads directly to the common area, and inhabitants are in this way encuraged to meet others on their way to the apartments.

Ill. 156: Entrance area

Ill. 157: Hallway

Common facilities

A common area is shown on illustration 58. Each wing has a common area, where the inhabitants meet for social gathering, meals and other activities. The kitchens are equipped to allow inhabitants to help prepare the dinner while guided by the staff.

The common areas are having increased ceiling heights to open up towards the gardens and to indicate the change in function. The window has a great view towards the green and is in direct contact with the large terrace outside. This shall be possible to accessed directly from the common area.

Relaxing garden

Placed in between the two wings, relaxing garden is found. This is a place with calming natural elements as water, herbs and vegetables in a greenhouse and small niches surrounded by greenery. Relaxing garden is surrounding the outdoor area of the eastern wing and a large terrace allows inhabitants to sit outside during summer months.
The paving shall be solid to ease the access of walking restrained and flowerbeds should be lifted in the height to allow wheelchair users to touch and interact with the natural elements.
The terraces adjacent to the gardens are kept semi-private with bushes, that provides covers for the activities within the apartments.

Ill. 158: Perspective common facilities

Ill. 159: Perspective towards relaxation garden

Conclusion

This master thesis project addresses the lack of sustainable housing for young people with intellectual disabilities in Seest, Kolding.

The project is developed through the integrated design process, where technical aspects have set the frame for attaining high architectural quality for the whole building. This has been done through iterations where architectural values have been tested against technical demands and thereby been optimized for both aspects.

By working determined with Universal Design and Healing Architecture a calm, accessible environment has been created for the inhabitants. Making an accessible building inhabitants with a wide range of disabilities are secured an unobstructed everyday and staff will experience a good working environment. This leads to a high degree of both physical and physiological wellbeing beneficial for everybody.

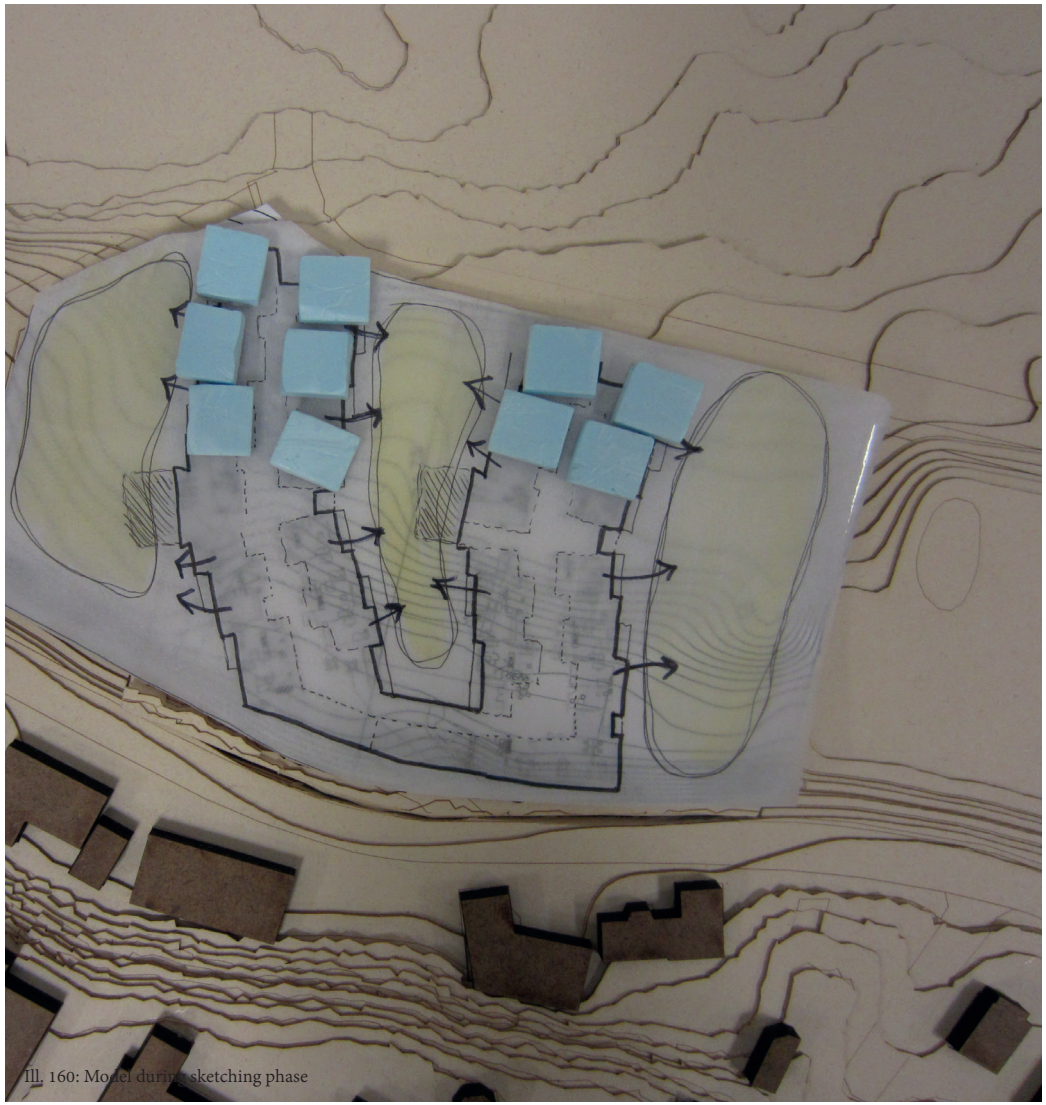
The competition 'Fremtidens Bæredygtige Almene Boliger' has raised the question of how sustainable housing shall improve towards the future. This has set the frame for Kløvkærhuse, which is developed further towards environmental initiatives by complying with the energy demands of year 2020 as well as indoor climatic and wellbeing factors.

Though people affected by intellectual disabilities perceive the built environment in a different way than others, a universally sustainable and accessible building is attained. The apartments and common functions are intended to support a relatively self-sufficient life for the individual, where physical barriers are replaced by endless possibilities.

These facilities are detailed in a way that supports different disabilities but encounters everybody in their intuitive way of being informed and guided through a building. Dividing the complex in different zones has created a socially safe environment that is adjusted to the specific need of each individual.

The apartments are also intended to support individualization as the design is kept relatively neutral and flexible regardless of personal requirements and needs. Living in Kløvkærhuse is both intentional for young people, who are moving from home for the first time but also for inhabitants from other housing services.

According to the evident based concept of Healing Architecture, all apartments and common areas have a close relation to the surrounding nature. The building divides the site into three areas with different themes, and it shall be possible to explore each one in one's own pace.



Ill. 160: Model during sketching phase

Reflection

Social sustainability can be a relatively misused term and is presented interchangeably in many contexts. It does not have a strict definition and can therefore be used as one wish. In this project living together regardless of abilities and disabilities is the link to social sustainability. Kløvkærhuse shall be incorporated as a part of a larger new housing area, where mixing the user group shall heighten the understanding and collaboration between ages, occupations and physical or psychological abilities.
The remaining housing of the competition is thus under development, and the final proposal is still unknown at the moment of writing.

When creating a project like this, the timeframe has had limiting impact on the iterations possible on the different parameters. Each parameter is interlock with others, and every decision has to comply with the overall vision for the project, both architectural and environmental.

An aspect, that has been left out is the incorporation of active energy producing solutions, as for example solar cells. An integration of these could have been encompassed in the roof construction as a part of the green roof. This would have led to a self-sufficient building energy wise and further visual attention of the building as being 'green'.

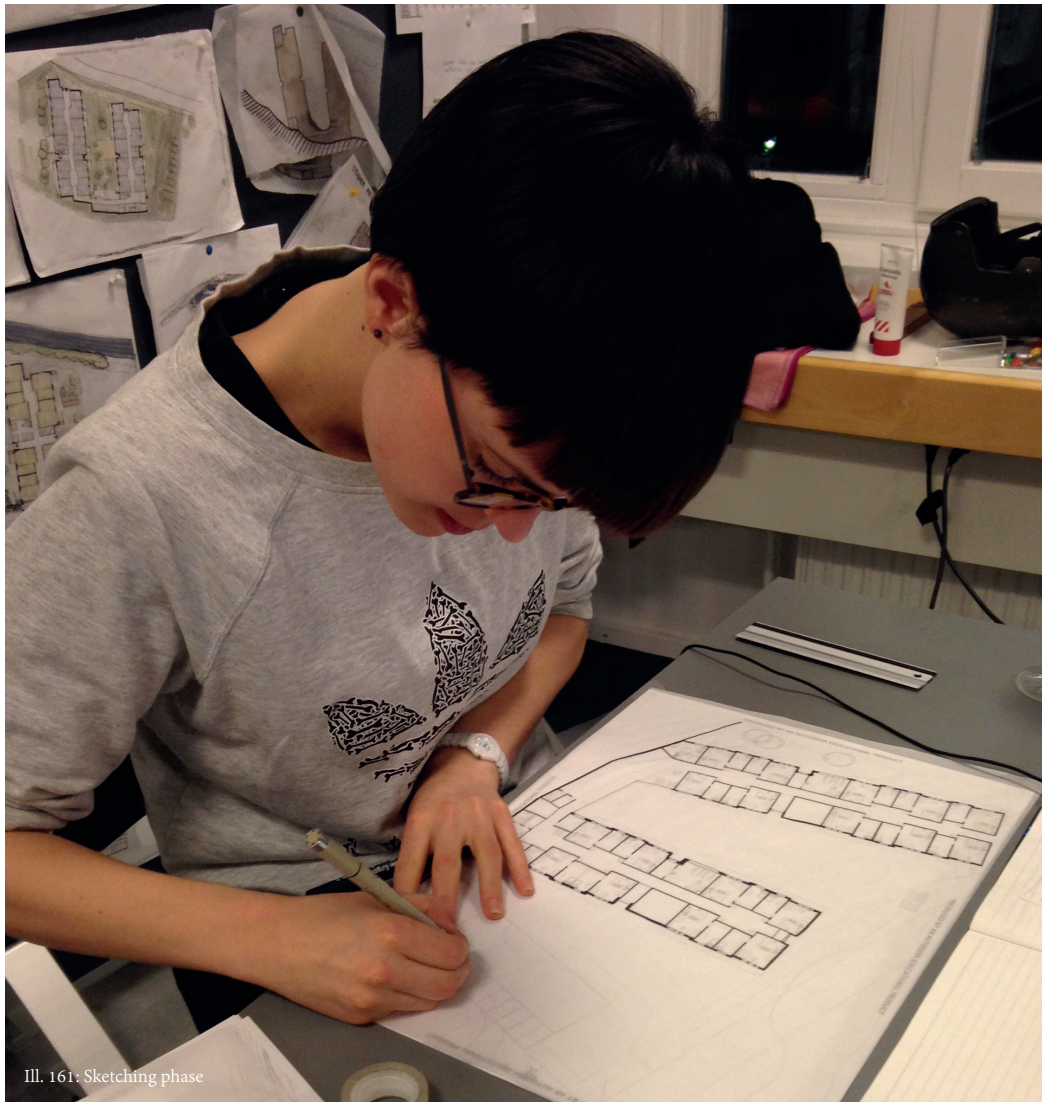
With the high demands that follow a low energy consumption a great responsibility rests on each household. When low-energy building, in some cases fails to fulfil their ambitious aims, a large impact is placed on the user.

This requires a throughout knowledge of the system, and as the users of this project are people with various mental disabilities, automatically controlled systems become of great importance. This has been conducted within the ventilation system that secures automatic venting through summertime and mechanical ventilation during summer and reduces the responsibility of the individual.

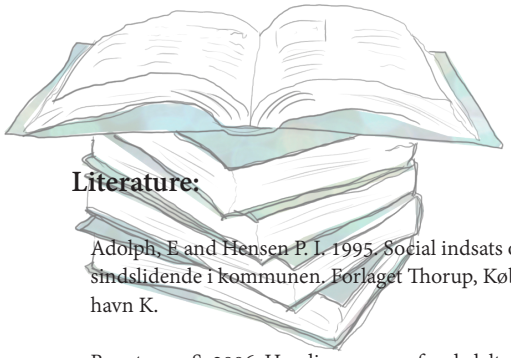
Building on a sloped site has led to difficulties, as minimizing the use of ramps within the building has been a preference from the start. The outcome is a building that is derived from its physical boundaries and a site that has been adjusted to the new use. Choosing another site would have led to a completely different building, which in many ways would have opened other doors and ways of arranging apartments and common facilities.

This project has in many ways opened my eyes to the necessities of the methodology by working integrated when a building has to comply with such a wide range of demands, restrictions and strategies as this project has. With the society's increasing focus on inclusion, socially and physically, the built environment has a huge impact on the degree of success. It requires that the influential institutions will work together and secure the optimal universally designed society.

Working alone has been instructive, as managing all aspects of a design development had forced me to keep up with all details, both aesthetic and technical throughout the whole project. This has to some extend been challenging when working in groups, where handing over knowledge has occasionally led to misunderstandings and mistakes.



Ill. 161: Sketching phase



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APPENDIX

NEXT CHAPTER INCLUDES FOLLOWING:

01: VENTILATION, CALCULATIONS
02: BE10, RESULTS
03: NATURLIG VENTILATION
04: BSIM, RESULTS
05: U-VALUES, CALCULATIONS FROM ROCKWOOL
06: ACOUSTIC CALCULATIONS, SPREADSHEET

APPENDIX 01: Ventilation calculations

Ventilation, CO^2:
The necessary air change according to CO^2 is given by the equation:
$\mathbf{n = q / V(c-c_i)}$

Where:

q is the pollution load given by four persons:	0,08 m^3/h
V is the room volume:	160,5 m^3
C_i is outdoor concentration:	0,00035 m^3/m^3 (350 ppm)
C is max concentration:	0,00101 m^3/m^3 (350 ppm + 660 ppm)

Air change needed in the apartment, $\mathbf{n = 0,64\ h^{-1}}$

Ventilation, Olf:
The necessary air change according to Olf is given by the equation:

$\mathbf{n = V_L / V_R}$
$\mathbf{V_L=(10*q)/(c-c_i)}$

Where:

c_i is:	0,1 decipol
c is:	1,4 decipol
q_{person} is the personload:	1,2 olf
$q_{building}$ is the buildingload:	5,95 olf
A_{floor} is the floor area:	59,5 m^2
V_R is the room volume:	160,65 m^3
V_L is:	55 l/s

Air change needed in the apartment, $\mathbf{n = 1,23\ h^{-1}}$

Ventilation rate according to BR10

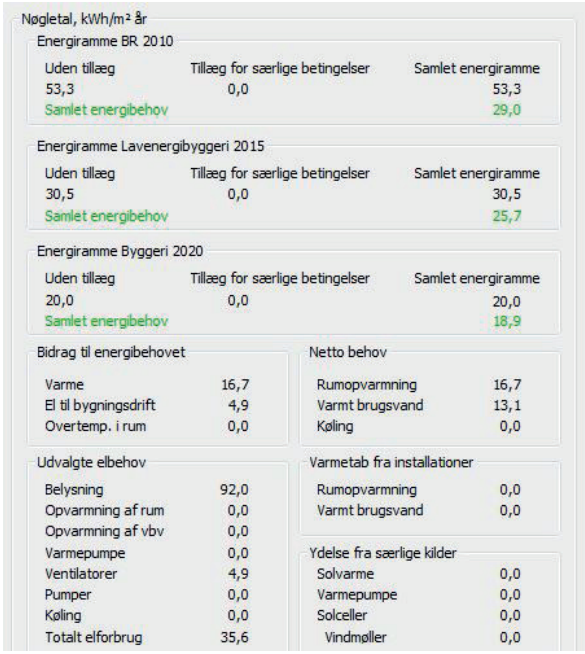
To obtain BR10 indoor climate class b the minimum ventilation rate must be 0,3 l/s.
The apartment has an area of 59,5 m^2 which requires a ventilation rate at 18 l/s.
Minimum air change according to BR10: n = 0,225 h^{-1}

The ventilation rate for CO_2 exceeds the need for category b requirements of BR10, and an air change of 0,225 h^{-1} is not enough to keep the CO2 level down.

APPENDIX 02: BE10 calculations

	MWh	Januar	Februar	Marts	April	Maj	Juni	Juli	August	September	Oktober	November	December	I alt
	Varmebehov													
+1	Trans.- og vent.tab	20,03	18,53	17,88	13,62	8,50	4,73	3,52	3,71	7,09	10,65	14,37	18,08	140,71
2	Vent. VF (total)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	Vent. VGV nedreg.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	Varmetab	20,03	18,53	17,88	13,62	8,50	4,73	3,52	3,71	7,09	10,65	14,37	18,08	140,71
5	Solindfald	2,42	3,92	6,41	5,68	10,11	10,25	10,01	8,80	4,51	4,70	2,62	1,61	71,03
6	Internt tilskud	7,77	7,02	7,77	7,52	7,77	7,52	7,77	7,77	7,52	7,77	7,52	7,77	91,54
7	Fra rør og VVB konst.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
8	Samlet tilskud	10,19	10,94	14,18	13,21	17,89	17,77	17,78	16,57	12,04	12,47	10,14	9,39	162,58
9	Rel. tilskud, -	0,51	0,59	0,79	0,97	2,10	3,76	5,06	4,46	1,70	1,17	0,71	0,52	
10	Del af rumopv.	1,00	1,00	1,00	0,59	0,00	0,00	0,00	0,00	0,00	0,29	1,00	1,00	
11	Variabl. varmetilsk.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Tot. tilskud	10,19	10,94	14,18	13,21	17,89	17,77	17,78	16,57	12,04	12,47	10,14	9,39	162,58
13	Rel. tilskud, -	0,51	0,59	0,79	0,97	2,10	3,76	5,06	4,46	1,70	1,17	0,71	0,52	
14	Udnyt. faktor	1,00	1,00	0,99	0,95	0,48	0,27	0,20	0,22	0,59	0,84	1,00	1,00	
15	Varmebehov	9,84	7,59	3,82	0,67	0,00	0,00	0,00	0,00	0,00	0,06	4,25	8,69	34,92
16	Vent. VF (centralvarme)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
17	I alt	9,84	7,59	3,82	0,67	0,00	0,00	0,00	0,00	0,00	0,06	4,25	8,69	34,92

Ill. 162: Scheme for heat gains and losses



Ill. 163: Complying with the 2020 demands

The scheme shows the final results from BE10, that has been an incorporated part of developing the building, its form, orientation and frame concerning U-values, windows and their orientation.

APPENDIX 03: Natural ventilation and thermal buoyancy

The apartments are ventilated through natural ventilation in summer periods, and the amount of air, that can be ventilated through the apartments shall be calculated.

Determination of height of neutral plane.
The neutral plane describes the point where the pressure difference between outside and inside is 0,

Neutral plane: ΔP= 0

$$H0 = \frac{A1^2 \cdot H1 + A2^2 \cdot H2}{A1^2 + A2^2}$$

if pu=pu, Ti=Tu, Cd1=Cd2

H0 = 2,86 m

The pressure difference between openings is given by:

$$\Delta Pt1 = pu\, g\, (H0 - H1)\, \frac{Ti - Tu}{Ti}$$

pu is air density, 1,205 kg/m^3
g is gravitational acceleration, 9,82 m/s^2
Ti is indoor temperature, 22°C
Tu is outdoor temperature, 17,5 °C

ΔPt1 = 2
ΔPt2 = -0,18

Ventilation by wind:
The internal pressure, pi is calculated by the equation:

$$Pi = \tfrac{1}{2} pu \cdot v^2 ref\, \frac{A1^2 \cdot cp1 + A2^2 \cdot cp2}{A1^2 + A2^2}$$

V ref is dependent of the speed of the wind and the site specific wind factor, here given to: 3,1 m/s

Cp describes the pressure coefficient, which is 0,7 for an exposed building with length to width ratio 2:1 and a wind angel of 0.

Cp1, Leeward side, -0,7
Cp2, Windward side, 0,5
Pi = -0,58 Pa

Winds pressure equation:
$P_w = C_p * \tfrac{1}{2}$ pu * v^{2}ref

The winds pressure across an opening is:
ΔPw1 = Cp1* ½ pu * v^{2}ref - Pi
ΔPw2 = Cp2* ½ pu * v^{2}ref - Pi

ΔPw1 = - 3,47 Pa
ΔPw2 = 3,48 Pa

The total pressure is the sum of the wind and the thermal pressure : ΔP = ΔPt + ΔPw

ΔPt = 2 + (-0,18) = 1,82 Pa
ΔPw = -3,47 +3,48 = 0,01 Pa

ΔP = 1,82 Pa + 0,01 Pa = **1,83 Pa**

The thermal buoyancy secures a wind flow from the windows in the facade to the skylight in the openings.

Air flow rate from opening 1 to opening 2:

The air flow rate is given by following equation:

$$Q = Cd \cdot A \cdot \sqrt{\frac{2 \cdot |\Delta P|}{pu}}$$

Cd is the discharge coefficient, which is 0,7 for windows.

Q1 = 0,37 m^3/s = 1317 m^3/h
Q2 = 0,09 m^3/s = 334 m^3/h

Air change possible in an apartment:

Apartment size: 194,7 m^3
Total air change possible = 8,48 h^{-1}

Facade windows:
Opening area A1: 0,3 m^2
Height, H1: 2,2 m

Skylight:
Opening area A2: 0,85 m^2
Height, H2: 3,1 m

APPENDIX 04: BSim calculations

This scheme shows all the results from the indoor simulation programme BSim.

2014 | Month | Hours | ThermalZone132

ThermalZon	Sum/Mean	1 (31 days)	2 (28 days)	3 (31 days)	4 (30 days)	5 (31 days)	6 (30 days)	7 (31 days)	8 (31 days)	9 (30 days)	10 (31 days)	11 (30 days)	12 (31 days)
qHeating	1123,43	249,93	185,78	125,56	88,26	0,00	0,00	0,00	0,00	0,00	68,69	149,05	256,15
qCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qInfiltration	-552,15	-73,30	-68,96	-67,38	-51,37	-35,74	-23,59	-20,02	-20,58	-30,45	-41,55	-53,11	-66,09
qVenting	-1565,53	0,00	0,00	0,00	-88,11	-276,23	-330,25	-345,75	-316,96	-208,22	0,00	0,00	0,00
qSunRad	2626,59	120,02	187,30	257,31	259,87	309,63	311,58	308,41	276,49	221,39	155,84	135,81	82,95
qPeople	115,63	9,82	8,87	9,82	9,50	9,82	9,50	9,82	9,82	9,50	9,82	9,50	9,82
qEquipment	481,80	40,92	36,96	40,92	39,60	40,92	39,60	40,92	40,92	39,60	40,92	39,60	40,92
qLighting	652,70	62,00	56,00	59,90	52,10	45,80	43,30	44,80	50,10	55,60	61,10	60,00	62,00
qTransmissic	-1768,22	-255,20	-243,38	-232,77	-166,81	-94,20	-50,15	-38,18	-39,79	-87,42	-136,14	-184,72	-239,47
qMixing	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qVentilation	-1114,25	-154,19	-162,57	-193,36	-143,04	0,00	0,00	0,00	0,00	0,00	-158,69	-156,13	-146,27
Sum	-0,00	-0,00	-0,00	0,00	-0,00	-0,00	0,00	0,00	0,00	0,00	-0,00	-0,00	0,00
tOutdoor me	7,7	-0,5	-1,0	1,7	5,6	11,3	15,0	16,4	16,2	12,5	9,1	4,8	1,5
tOp mean	21,7	21,2	21,4	21,6	21,3	22,0	22,4	22,5	22,4	21,9	21,5	21,3	21,1
AirChange/h	1,7	1,5	1,5	1,6	1,7	1,5	2,2	2,6	2,4	1,1	1,4	1,5	1,5
Rel. Moistur	35,7	22,4	20,2	22,8	28,5	37,8	49,4	54,5	51,9	48,9	37,3	31,6	23,4
Co2(ppm)	368,6	363,6	363,4	363,1	362,3	387,0	369,2	364,5	367,4	391,9	363,7	363,3	363,6
PAQ	0,5	0,7	0,7	0,6	0,6	0,4	0,2	0,1	0,2	0,3	0,5	0,5	0,7
Hours > 21	5326	97	181	320	382	742	720	744	744	719	402	200	75
Hours > 26	53	0	5	3	0	0	18	13	14	0	0	0	0
Hours > 27	13	0	0	0	0	0	7	2	4	0	0	0	0
Hours < 20	0	0	0	0	0	0	0	0	0	0	0	0	0
FanPow	554,40	80,42	76,14	85,91	75,09	0,00	0,00	0,00	0,00	0,00	78,70	79,02	79,12
HtRec	4610,74	834,00	811,19	772,12	518,63	0,00	0,00	0,00	0,00	0,00	378,40	569,70	726,71
ClRec	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HtCoil	14,73	6,10	4,51	1,74	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,20	2,17
ClCoil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Humidif	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FloorHeat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FloorCool	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HeatPump	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HeatPumpE	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Ill. 164: Complying with the 2020 demands

APPENDIX 01: U-values

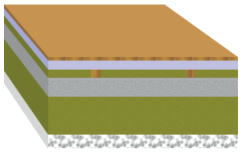
The programme Rockwool Energy Design has been used as a part of testing different construction types.

Rockwool Energy Design 4.1

Dato: 25-04-2014

U-værdiberegning i henhold til DS 418
Konstruktion: **Gulv på strøer, isol. 200/45, U=0,11**
Konstruktionstype: Gulv mod jord (0.5m over - 0.5m under terræn)

INDE



UDE

	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rsi (inde)					0,17
☑ 1	Generisk materiale	Spånplade, 600 kg/m3	0,022	0,140	A	0,16
☑ 2	DS 418	Ikke ventileret, vandret varmestrøm	0,050	-	A	0,18
☑ 3	Inhomogent materialelag	bestående af:	0,045	0,045		0,99
	Rockwool A/S	FlexiBatts	90,00%	0,037	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Generisk materiale	Træ 450 kg/m3	10,00%	0,120	A	-
☑ 4	Generisk materiale	PE-folie (hæftet fast) 0,15 mm	0,000	0,170	A	0,00
☑ 5	Generisk materiale	Beton, medium densitet 1800 kg/m3	0,100	1,200	A	0,08
☑ 6	Kapillarbrydende lag	indeholder:	-	-		5,26
	Rockwool A/S	Terrænbatts Erhverv	0,200	0,038	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
☑ 7	Generisk materiale	Letklinker 85	0,075	0,085	A	0,88
	Rj (jord)					1,50
			0,492			**9,23**

Begrundelse for ændring af overgangsisolanser:

Byggematerialerne er grupperet i 3 klasser. Disse klasser er:
A Data er indtastet og verificeret af Rockwool A/S.
B Data er indtastet og verificeret af andre producenter eller leverandører.
C Egen indtastning af data.

U-værdikorrektion i henhold til DS 418
Korrektion for mekanisk fastgørelse dUf = 0,000 W/(m²K)
Korrektion for luftspalter dUg = 0,000 W/(m²K)

U = 1 / 9,23 + 0,000 + 0,000 = 0,11 W/(m²K)

U_{max} = 0.20 W/(m²K) U = 0.11 W/(m²K)

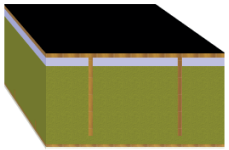
Ill. 165: Rockwool detail

Rockwool Energy Design 4.1

Dato: 25-04-2014

U-værdiberegning i henhold til DS 418
Konstruktion: **Built-up 37, 5% træ, U=0,09**
Konstruktionstype: Tag med hældning <= 60

UDE



INDE

	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rse (ude)					0,10
☑ 1	Generisk materiale	Tagpap	0,008	0,230	A	~~0,03~~
☑ 2	Generisk materiale	Træ 450 kg/m3	0,025	0,120	A	~~0,21~~
☑ 3	Inhomogent materialelag	bestående af:	0,050	0,956		0,05
	Generisk materiale	Ventileret lag	95,00%	1,000	A	-
	Generisk materiale	Træ 450 kg/m3	5,00%	0,120	A	-
☑ 4	Inhomogent materialelag	bestående af:	0,395	0,041		9,60
	Generisk materiale	Mineraluld 37	95,00%	0,037	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Generisk materiale	Træ 450 kg/m3	5,00%	0,120	A	-
☑ 5	Inhomogent materialelag	bestående af:	0,050	0,041		1,22
	Generisk materiale	Mineraluld 37	95,00%	0,037	A	-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
	Generisk materiale	Træ 450 kg/m3	5,00%	0,120	A	-
☑ 6	Generisk materiale	Polyethylen film 0,15 mm	0,000	0,170	A	0,00
☑ 7	Generisk materiale	Træ 450 kg/m3	0,019	0,120	A	0,16
☑ 8	Generisk materiale	Gips 13 mm	0,013	0,250	A	0,05
	Rsi (inde)					0,10
			0,560			**11,28**

Begrundelse for ændring af overgangsisolanser:

Byggematerialerne er grupperet i 3 klasser. Disse klasser er:
A Data er indtastet og verificeret af Rockwool A/S.
B Data er indtastet og verificeret af andre producenter eller leverandører.
C Egen indtastning af data.

U-værdikorrektion i henhold til DS 418
Korrektion for mekanisk fastgørelse dUf = 0,000 W/(m²K)
Korrektion for luftspalter dUg = 0,000 W/(m²K)

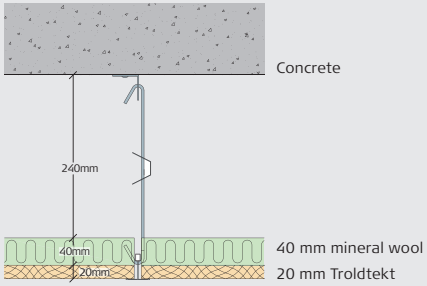
U = 1 / 11,28 + 0,000 + 0,000 = 0,09 W/(m²K)

U_{max} = 0,20 W/(m²K) U = 0,09 W/(m²K)

Ill. 166: Rockwool detail

APPENDIX 05: Acoustics

VERTICAL SCHEMATIC DIAGRAM



SOUND ABSORPTION MEASUREMENTS

Hz	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
α	0,46	0,65	0,72	0,83	0,86	0,94	1,00	0,91	0,88	0,98	1,00	0,94	0,93	0,91	0,86	0,86	0,90	0,95

α_w = 0,95 – NRC = 0,90 - Absorptionsklasse A.

Ill. 168: Troldtekt, Sound absorption

To lower the reverberation time in the music therapy room Troldtekt suspended ceilings have been applied. They will be a part of an integrated solution that has both space for ventilation, reduce the noise level within the room and has high architectural qualities due to its many ways of appearing (e.g. colours).

The illustration shows the construction and attachment to the ceiling / roof construction.

Reveberation time

Equivalent absorption area	Material	Areal S(m^2)	125 Hz α	125 Hz Sα	250 Hz α	250 Hz Sα	500Hz α	500Hz Sα	1000Hz α	1000Hz Sα	2000Hz α	2000Hz Sα	4000 Hz α	4000 Hz Sα
Floor	Linoleum on concrete	48	0,02	0,96	0,02	0,96	0,03	1,44	0,04	1,92	0,04	1,92	0,05	2,4
Ceiling	Troldtekt	43	0,65	27,95	0,86	36,98	0,91	39,13	1	43	0,91	39,13	0,9	38,7
Front wall	Partly plasterboard	16,2	0,3	4,86	0,3	4,86	0,2	3,24	0,15	2,43	0,5	8,1	0,5	8,1
Front wall	Partly glass walls	10,8	0,18	1,944	0,06	0,648	0,04	0,432	0,03	0,324	0,02	0,216	0,02	0,216
Wall, removable	Folding wall	12,15	0,14	1,701	0,35	4,2525	0,53	6,4395	0,75	9,1125	0,7	8,505	0,6	7,29
Side wall, left	Plasterboard	11,34	0,14	1,5876	0,3	3,402	0,2	2,268	0,15	1,701	0,5	5,67	0,5	5,67
Windows, ceiling	Window with termoglas wich has 3-4 mm glas	5	0,18	0,9	0,06	0,3	0,04	0,2	0,03	0,15	0,02	0,1	0,02	0,1
Wall against slope	Plasterboard	27	0,15	4,05	0,3	8,1	0,2	5,4	0,15	4,05	0,5	13,5	0,5	13,5

Absorption from persons		Antal	Sα/stk	Sα	Sα/stk	Sα	Sα/stk	Sα	Sα/stk	Sα	Sα/stk	Sα	Sa/stk	Sα
Persons		8	0,22	1,76	0,3	2,4	0,38	3,04	0,42	3,36	0,45	3,6	0,45	3,6
chairs		8	0,01	0,08	0,01	0,08	0,01	0,08	0,01	0,08	0,04	0,32	0,05	0,4

Absorption in air v/ 50% RF		Volumen [m3]	125 Hz m	125 Hz mV	250 Hz m	250 Hz mV	500Hz 4m-vær	500Hz mV	1000Hz m	1000Hz mV	2000Hz m	2000Hz mV	4000 Hz m	4000 Hz mV
		129,6					4E-04	0,0518	0,001	0,1296	0,0024	0,311	0,0061	0,7906
Total absorption				45,8	2,6	62,0	2,5	61,7	2,7	66,1	3,7	81,1	3,6	80,0
Efterklangstid	T=(0,16*V)/((Σα*s)+(Σn*A)+(4*m*V))	Results		0,5		0,3		0,3		0,3		0,3		0,3

Ill. 167: Spreadsheet, Reverberation time

This illustration shows the spreadsheet that is used for calculation reverberation time in the music therapy room for different frequencies.