TOWARDS

A TECTONIC ACCESSIBILITY

- within Dwellings for Seniors

MA4-ARK9 :: AALBORG UNIVERSITY :: MSC04 ARC :: JUNE 2015

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SUNLIGHT AT SITE

COLOPHON

Title: *Towards a Tectonic Accessibility - within Dwellings for Seniors*
Group: ma4-ark9
Theme: Tectonics
Semester: A&D MSc04 ARC
Period: February 2015 untill June 2015
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Technical Supervisor: Lars Damkilde, professor at AAU
Number of pages: 131
Number of copies: 5

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SYNOPSIS

Accessibility often becomes a matter of practicality; the width of door openings, area of manoeuvre, ramps and handrails. But the theme actually has much more fundamental roots in the architectural field: it is about the senses. The field of accessibility looks for spatial interaction as sensuous compensation for an impairment, such as studs in the pavement for the blind. I see a potential for gaining an architectural knowledge from this field, which can inform a *tectonic* accessibility, one which explores the knowledge and creates a new level of sense-itivity in architecture, so that the boundary between architecture and accessibility is wiped out, and all of us are able to interact with the spaces at a level of inhabitation.

My master thesis evolves from this vision of re-joining the body and the space, taking its point of departure in the aged body, as this is a body stage we will all experience at some point. The project is self-defined based on this user group, an analysis of which has revealed a new tendency towards the residential solution of the co-house, in Danish terms denoted "bofællesskab". This is a typology offering a social level of accessibility, which is further enforced in this project by connecting the individual dwelling through a common atrium, which also becomes a joint between outside and inside, making the nature accessible independantly of the season.

The site chosen for the project offers accessibility at the landscape scale; offering the qualities of prospect and refuge of a sloping site near Randers in eastern Jutland, a site with characteristic featueres formed from a glacier during the previous ice age. This has inspired to a site-specific, tectonic accessibility; a horizontal concrete surface in the dwellings, gesturing a joining between the wall and the body, being a supportive handrail element, but also a material joint between wood and concrete as well as signifying a joint between the proportions of a wheelchair body and an erect body. It meanders through space, forming surfaces for seatings as well as table surfaces, for the direct spatial interaction through the furniture scale.

Hereby it becomes the joint between tectonic accessibility on the different scales of the project, from the contextual scale to the scale of detailing.

This approached has informed the techinncal forcus of the project, which has explored constructive solutions for the furnitures as well as the roof structure of the atrium, through which it has been the aim to construct not just a structure, but also a movement and a light experience by the pattern of beams and purlins. The contextual reference to the glacier has also arrived at a synthesis with the parameters of sustainability in this solution, as polycarbonate sheets are exploited to create a white, diffuse light in the atrium, while they ensure a comfortable climate throghout the year with their thermal properties.

Tectonic solutions for accessibility have thus been explored on all scales of the project, in order to advance towards a new approach of working with the senses throughout the design process.

PREFACE

This is a step towards my manifest.

Any architectural engineering project is a manifest of the architect's vision and societal ambitions. This project is my first individual, academic project, and thus it is my step towards a recognition of my own architectural engineering positioning. Throughout this education, I have continuously questioned myself regarding this position, and acknowledge that architectural engineering is a very sensitive matter to me. There is no universal answer to it, but somehow I find that the only truth to me is to question whatever things that we take as a matter of course. When something is different from our expectations, it triggers our thoughts and makes us ask questions, and this is the foundation of change and progression. Regardless of the theme of any project, this is what drives me in my work and causes me whatever challenges that I might face. In relation to this project, I am exploring a tectonic approach towards inhabitation of space. The choice of tectonics as a theme is rooted in my desire to understand the relation between the space and its constituents. As a future architect engineer, I want to be able to rethink how these constituents can become generators of bodily interaction with the space. The theories of Marie Frier Hvejsel, assistant professor AAU, propose that we can learn a lot about this interaction from the furniture scale. Though I am not, at least at this point, concerned with the furniture scale per se, I am very inspired by the ability to use the furniture scale as a spatial joint with the body, and it is the same action which I am seeking to master. This project is my first, humble step towards mastering this bodyspatial joint, where I am seeking elements for sensuous experience from architecture concerned with accessibility, as accessibility works with the different senses for guiding the body through space. Thus, I am challenging how we consider the spatial elements. Simultaneously, I am challenging myself by doing this project singularly. The architectural engineering process is a teamwork, but in order to be able to cooperate as a team, we first need to be aware of our own strengths and weeknesses. I believe that the architectural engineering process is also a personal process, at least to myself, and in order to develop and be aware of my personal architectural engineering language, I need to push myself past my comfort zone, past the "safe" design, past the 'fast food' architecture. This kind of action needs resistance in order to grow and reach a sort of destination, but I have been surprised to find this resistance within my very self, due to the new situation of doing the project alone. This challenge can start a personal battle. Someone once told me, that some people hurt more in the architectural process than others. I am one of those that get hurt, but I also believe that we grow from pain, and that it is needed in order to get progression.

I want to thank Marie Frier Hvejsel for having been not just a supervisor, but a mentor in this project, and an infinite source for inspiration and knowledge. I also want to thank my family for their tireless support and encouragement, and finally, I want to dedicate this project to Jacob Leonhard Nielsen, my beloved life companion, for standing by my side during the entire project.

TO JACOB

GUIDE OF READING

The report sets out with an introduction to the project and the related themes, followed by a presentation of the design proposal through drawings and visualizations, accompanied by explanatory texts. The presentation is followed by the analysis of the themes as well as the chosen site, a description of the design process and finishing with the epilogue of conclusion and reflection. Finally, at the end of the report, the appendices are placed together with the reference list and illustration list. All references are denoted by the Harvard System, in-text references as (authour, year:page number) (page number only if relevant). The report will denote the typlology using the Danish notion "bofællesskab", because of its ethymologic characterization of the building form, with its closest English denotion being "co-housing".

METHODOLOGY

Architectural designing is a complex process with a lot of influentive parameters. The choice of tectonics as an approach demands a consideration of the relation between body and space, as the structural joining of spatial elements has a high influence on the spatial experience and inhabitation.

In order to develop the project tectonically, the design process evolves as an Integrated Design Process, as defined by Mary-Ann Knudstrup (Knudstrup 2005), which is a method for linking knowledge of the architectural- and the engineering fields within the design process, ensuring a closer relation with the building processes. Thus, parameters of both fields have been catalyzers of the design development, in order to arrive at a synthesis between them.

Combined with the Problem Based Learning at Aalborg Univserity, the project evolves from the definition of a problem and works towards an integrated tectonic solution. Thus, this project has evolved from the problem of providing inhabitable dwellings for senior residents, concluding from the analysis that the ability to dwell is closely related to the level of accessibility, and more profoundly, to tthe tectonic level of accessibility. The analysis is thus a tool for unveiling issues and potentials within the assignment, and design parameters are defined based on these, encapsulated in the formation of a vision for the proejct, as the driving forces through the design process.

CONTENTS

1 :: INTRODUCTION

During my work with this project, I had the privilege of accommodating myself at the Klitgården Studio; a small building in the sand dunes, fifty meters from the ocean and with a view to Skagen city. The pleasure of working here is found in the silence. The spaces are stripped from any finery or style; they are kept as neutral as possible, like a white canvas, so that your mind is deliberated into its own pattern of thought. All equipment is off – not even the humming of a refrigerator can distract you. Only the sound of the wind blowing through the vegetation is present. This is silence, not noise nor dead silence. Just silence. My body is present through the same silence. I find myself in a desirable body state, where I relax as a body, and my body does not demand my attention, it just *is*. This silence fractures when our body becomes impaired. Suddenly we are dependent on tools for moving around; a walking stick, a rolling walker or a wheelchair. Because these do not connect to our muscular senses, we suddenly have to direct our attention towards them, in order to be able to move them around, and thereby move ourselves. Our mind hereby experiences an "attentional" and sensuous noise. The field of accessibility works with solutions for silencing this noise through stimulation of the senses, thus this is a field with a high level of knowledge about our body and our senses.

The architectural field has one central ever-present parameter: the body. And the means of interaction between body and space are the senses. Juhani Pallasmaa has elaborated his theory on sensuous architecture in his book "*The Eyes of the Skin*" (2012), and the mere title of the book wraps up my proposition: that we experience a building with our entire senuous organ, and we need to mould architecture as an extension of our senses, and not just as spaces that are 'accessible'. This is where tectonics becomes a central theme, as it is a field of poetic linking of body and space, and poetry is a sensuous experience. Understanding this body-space interaction is a key element of understanding architecture, which is why I find it a crucial knowledge as foundation for my future career as an architect engineer.

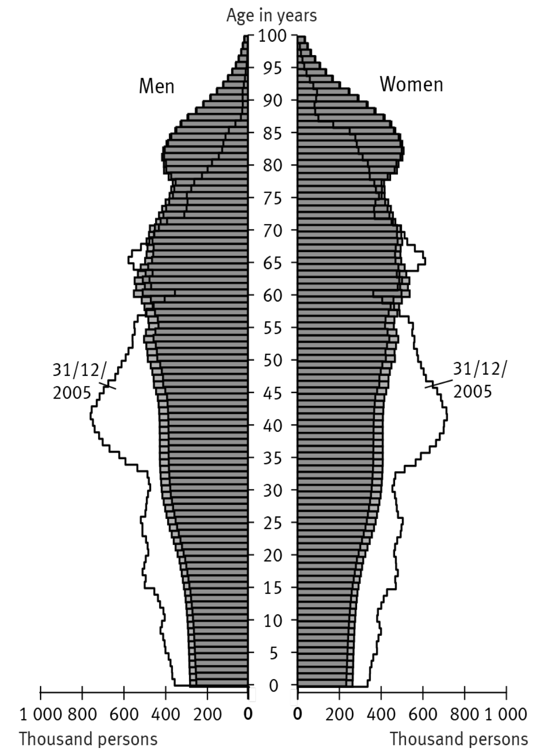
INITIAL PROBLEM :: THE DEMOGRAPHIC DIVIDE

The background for my choice of theme is a socially sustainable approach towards a demographic problem: the European society is undergoing change in the age structure. As other continents still have a high fertility rate and increase their population, Europe on the other hand see a decline in its population. As a result of the baby boom following in the late 20th century, we are facing an age structure resembling the graph of illustration 1.1. In Denmark specifically, the population of age above sixty will constitute about 1/3 of the total population in 2050 (Befolkningsfremskrivning 2014). As this age group is in a state of life of physical delapidation, they often experience that their home involve an increasing amount of obstacles, and therefore need assistance for doing their everyday activities. Alternatively they move into institutions that provide the physical surroundings that accommodate their needs, but this is both a reluctance for them and also a big economic expense for society. Therefore, there is a need to provide them with residencies that make them independendent for as long as possible. Hence, the initial problem is:

how do we ensure that seniors are able to remain self-reliant for as long as possible in their dwellings?

In Germany, as an example, research shows that out of 39 million dwellings, only 350.000 of them meet the needs of older people, and there is a need for an additional 800,000 by the year 2020 (Heiss, Degenhart & Ebe, 2010:33).

As a socially sustainable appraoch towards the demographic divide, it is my objective to explore new dwelling solutions for the senior residents which evolve architecturally from their physical body state, instead of being *adjusted* to these and thus just be "accessible". I will explore this archtiectural accessibility through the field of tectonics, as this provides exactly the poetic link between architecture and engineering to procreate, what I denote, *tectonic accessibility*.



ill. 1.1 :: The demographic divide (Eisenmenger, Pötzsch & Sommer 2006)

TECTONIC ACCESSIBILITY AS POETIC LINK BETWEEN ARCHITECTURE AND ENGINEERING

In order to be able to express my interpretation of working with the theme of tectonics, I will evaluate how I understand the historic evolution of the term, as I believe it is necessary to know the origins of it in order to understand the contemporary interpretations of the term, which are manifold. The architect and historian Kenneth Frampton is one of the most recent writers elaborating widely on this topic. In his Studies in Tectonic Culture, he connects its development ethymologically as the following:

"*Greek in origin, the term tectonic derives from the word tekton, signifying carpenter or builder. The corresponding verb is tektainomai. This in turn is related to the Sanskrit taksan, referring to the craft of carpentry and to the use of the axe. Remnants of a similar term can be found in Vedic poetry, where it again refers to carpentry. In Greek it appears in Homer, where it alludes to the art of construction in genereal. The poetic connotation of the term first appears in Sappho, where the tekton, the carpenter, assumes the role of the poet. In general, the term refers to an artisan working in all hard materials except metal. In the fifth century B.C. this meaning undergoes further evolution, from something specific and physical, such as carpentry, to a more generic notion of making, involving the idea of poesis. Needless to say, the role of the tekton leads eventually to the emergence of the master builder or architekton.*" (Frampton 1995:3-4)

This passage is to me the most important description of understanding the term, as it reveals that the term has evolved as a *poetic* connotation. Poetry is exactly what distinguishes the creation of architecture from the mere act of building, as architecture is a deliberate and sensitive act of procreation. Architecture involves each spatial element (such as light, context,

material, joint, structure, form) and parameter (aesthetics, function, durability cf. Vetruvius) as part of a symbiotic whole, because all of these affect us phenomenologically. A tectonic work is thus a work where all these parts - covering the field of architecture as well as engineering - arrive at a symbiotic relationship, and from here evolves the poetry. Thus, a tectonic approach cannot be secluded to architecture nor engineering. Most importantly, it takes a point of departure from the most important parameter: the human, and thus, the body. It is this fundamental parameter which I find that the tectonic discussion sometimes seem to forget. Instead, together with the digital tools and new approaches towards a re-integration of the disciplines of architecture and engineering, tectonics often become a solution, an optimization and economization of a structure and construction. This is evident in many of the contemporary projects built today, clearly revealing the digital tools used in the design process as generators of the – often geometrical - formal language, for example as seen in the Sendai Mediatheque by Toyo Ito. Arriving from the idea of organic plankton, the structural columns are formed as variants of warren trusses with different spacings creating the dynamic forms. As the digital tools are clearly an advantage in dimensioning these complex structures, they also entail the risc of the design process of the structure being secluded to this dimensioning, forgetting the next level of detailing of the structure; namely the direct interaction with the body.

This tectonic view of mine is partly inspired by the theories of Marco Frascari in his "The Tell-the-Tale Detail" (Frascari 1996), where he describes details as joints, primarily as material or constructional joints. He is referring to the works of Carlo Scarpa, generally known as the master of details. Carlo Scarpa had a unique way of expressing joints in spaces, be that the joint of interior-exterior (ex. the intertwining circles in his "Brion Cemetary"). I believe that there is a universal truth in *the tale of the detail*; that the detail is a joint between scales, and that the detail is closely related to the inhabitation of space through aesthetics; "*The art of detailing is really the joining of materials, elements, components, and building parts in a functional and aesthetic manner*" (Frascari 1981:p.2). The notion of aesthetics is really a matter of perception, as explained by Bloomer and Moore: "*From the beginning of academe in ancient Greece there has been inquiry into the laws and priorities which govern our sense of beauty. (...) This inquiry necessarily included attempts to describe the role of the body and its sensory apparatur. (The word "aesthetics" comes from the Greek* asthetikos *meaning "of sense perception"* (Bloomer & Moore 1979). I propose that the detail is a tale comprising all senses; including the haptic sense as adduced by Juhani Pallasmaa (cf. my introduction on p.10) . Sight and touch, as well as taste, odour and sound, are senses which we use to basically inhabit a space, thus we really need to join these and the spaces. The field of accessibility can teach us much about how to create this spatial joint with the senses. A tectonic space, in my interpretation, thus must construct a movement. This interpretation is closely linked to working with the aging body, as this is a body state that requires a distinct spatial layout because of a motoric impairment. Understanding the spatial relation to the impaired body can advance us in understanding the relation between space and the universal body. Hereby, the relation to the user is a careful tectonic consideration of constructing the movement within the space, which is the point of departure for the tectonic accessibility and can make us wipe out the boundaries between architecture and accessible architecture, a boundary revealed in many contemporary nursing homes, as in ill. 1.2.

Basically, it is my statement, that no architecture should be secluded to 'accessibility' – what is an accessible space, other than just a space which you can physically access? The discussion of accessibility really needs to rise to a discussion of sense-ibility; that all of us need to be able to experience the space through all of our senses. Thus, it is my ambition to construct a tectonic approach towards accessibility, which expands the field into a sensuous task.

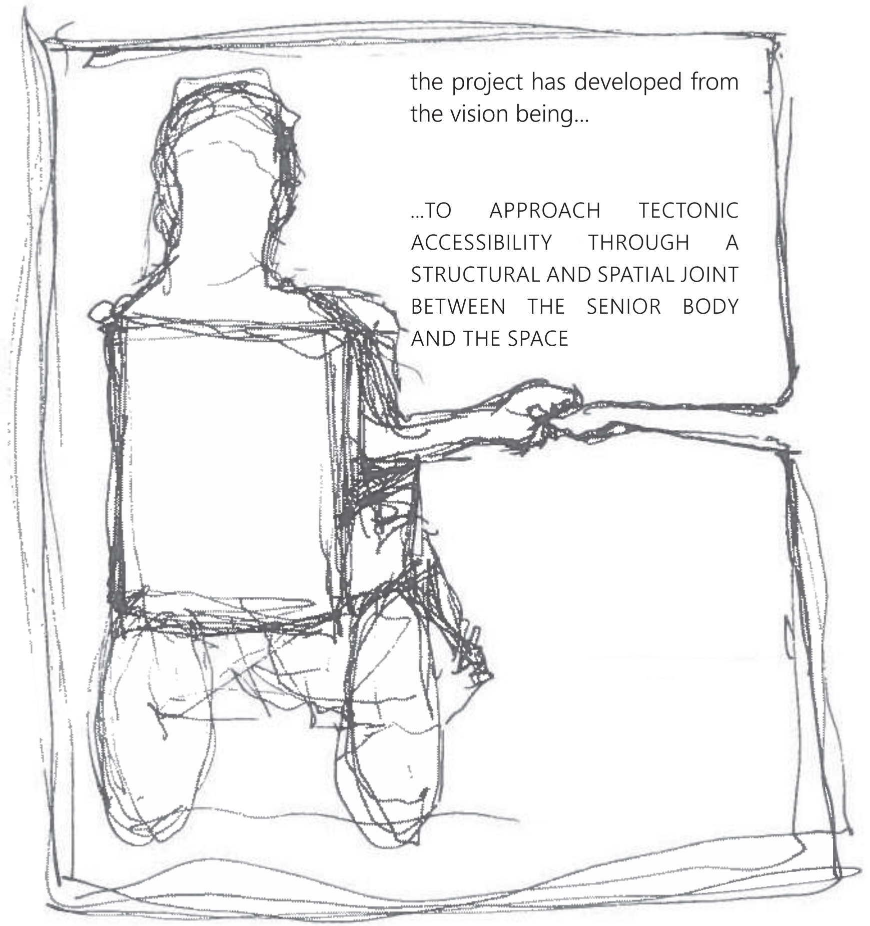

ill. 1.2 :: Handicap toilet at hotel, exemplifying how solutions of accessibility are approached in many contemporary relations (Weibel 2013)

2 :: PRESENTATION

The following pages will unfold to you my design proposal for an approach towards tectonic accessibility in the form of senior dwellings in a Danish version of the co-housing, a "bofællesskab". The tectonic accessibility is constructed within three scales; the building, the dwelling and the detailing, depicting three levels of spatial joining, and the project is presented according to these three scales; started from the building scale and zooming in.

INTRODUCTION

The design proposal is situated at a site in eastern Jutland, at a glacier plateau on the edge between townscape and landscape. The glaciological reference has inspired to a physical manifestation of the spatial and structural joining; a horizontal surface proportionalizes the wall as a joint between the proportions of the impaired, wheelchair body and the hale, erect body. The tectonic accessibility has evolved from this concept into an exploration of tectonic accessibility on all scales of the project.



VIEW 1 :: ACCESSIBILITY AT BUILDING SCALE :: THE ATRIUM

"*The most important place on the house facade is thefront door, to which, almost always, there is a special stepping up. On larger houses the entrance might be under a protective roofed porch, or below a fanlight or a dormer window projecting from the attic, all of which draw connotations of upness to the passage in*" (Bloomer & Moore 1979:2)

Though this passage mentions elements specially related to the American context, the vertical emphasizing of the front door is also a characteristic feature in the Danish context, and often depicts the protective roof. The dwelling entrances are all within a protective roof of the atrium, whereas they individually are thought to be under a green roof of plants, as ill. 2.1 depicts.

The hearth of the "bofællesskab" is this: the atrium. The atrium creates a base for the social community, but at non-formal circumstances. The atrium allows the residents to reside outside their dwelling at any season, hereby it becomes an social extension of the private dwelling. A horizontal surface evolves through the space as a growing element, gesturing a socially supporting joint; some places becoming a raised flower bed, combined with a wooden seating surface for resting.

ill. 2.1 :: visualization of the accessibility of the atrium; a climatic buffer zone for social interaction, transitions between private and social and the horizontal surface

ill. 2.2 :: master plan :: 1:250

ACCESSIBILITY AT BUILDING SCALE :: MASTER PLAN 1:250

From south the building is approached through the main entrance, from where the walls open up into the atrium. From here the space meanders in between the 'pocket spaces', with raised flowerbeds moulding the movement together with the horizontal concrete handrail surface, wooden seating surfaces and wooden flooring in front of the dwelling entrances to mark the transition between social and private spheres. Continuing along the space, you arrive at the central common area with a common house of dining hall with kitchen, technical room, wardrobe and disability friendly toilet. The common house is oriented towards west, with a big terrace for enjoying the evening sun. Within the atrium, a partly enclosed gathering area is oriented towards the east, where a public path passes right outside the window, for interaction with the neighbours. This gathering area is a green climax in the atrium, with common herbs and vegetables growing on the walls. Continuing further down, following the surface of the common house, you reach the northern end of the building complex where laundry room and workshop are placed.

A common laundry room releases some space in the dwellings, while being a functional space in which the residents can meet each other informally. The workshop ensures the residents a high level of self-helping, being able to repair and redecorate the building complex themselves. Through the northern exit, a path leads to the surrounding forest through which a path leads down to a golf course to the east, taking the accessibility into the landscape.

VIEW 2 :: ACCESSIBILITY AT BUILDING SCALE :: GATHERING AREA IN ATRIUM

As a common hearth, the center of the atrium is the social climax with a gathering area, where the residents can meet in the green surroundings of herbs, fruit trees and vegetables while looking outside upon the trees and the neighbours walking by on the public path.


ill. 2.3 :: gathering area in atrium

ill. 2.4 :: northern facade :: 1:250

ill. 2.5 :: southern facade :: 1:250

VIEW 3 :: ACCESSIBILITY AT LANDSCAPE SCALE :: ENTRANCE

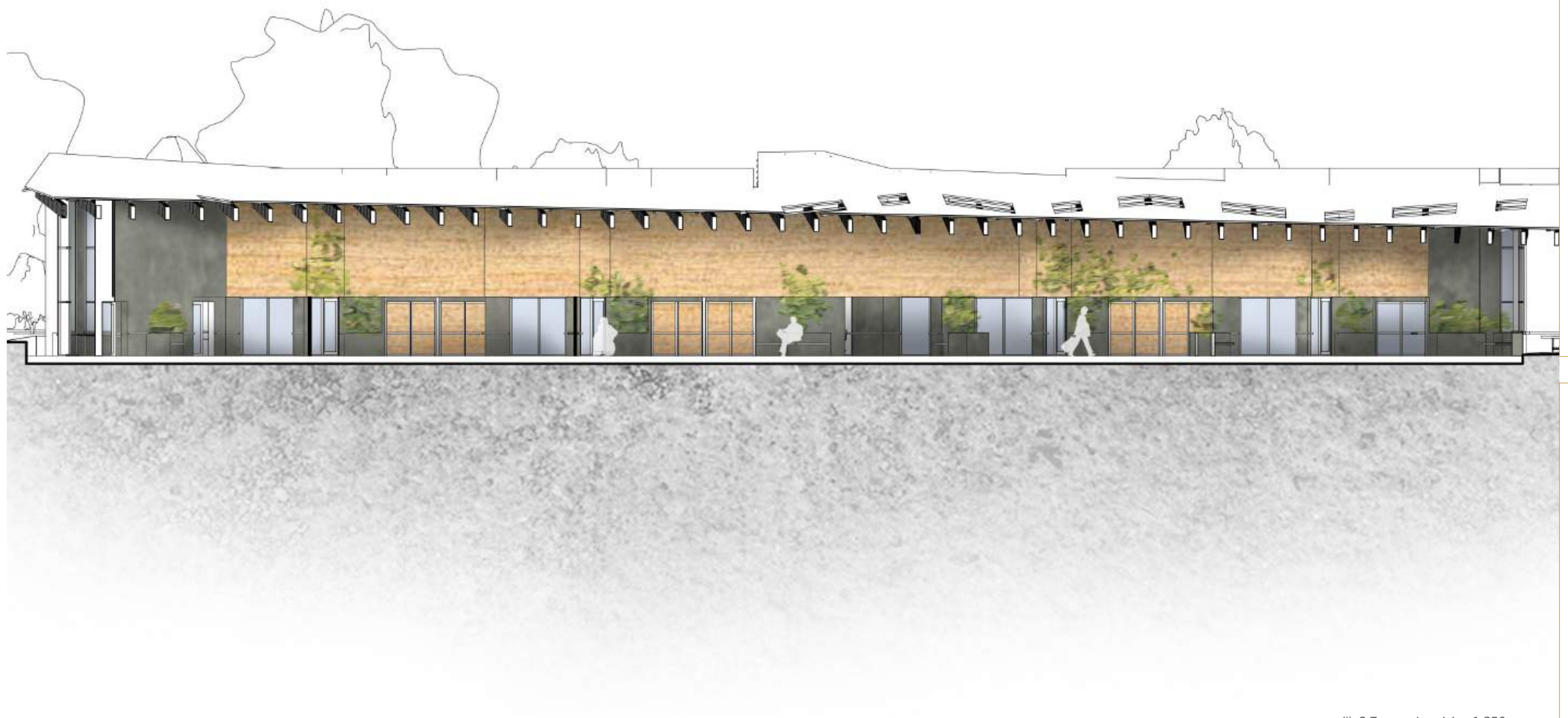
Along a wedge of a glacier plateau, the building situatues in between two belts of trees. Towards the east, the landscape slopes upwards, with a public path leading the neighbours right pass the building facade. Towards west, the landscape slopes downwards towards a big golf course with all its diverse paths. The building is thus right on the edge of urbanscape and landscaoe, with qualitites of prospect on one side, and refuge from the embracing landscape on the other.

ill. 2.6 :: visualization of the entrance area with the entrance doors reaching out, forming a roofed south-facing terrace area :: along the east of the building, a public path passes

2 :: PRESENTATION

ACCESSIBILITY AT BUILDING SCALE :: SECTION AA :: 1:250

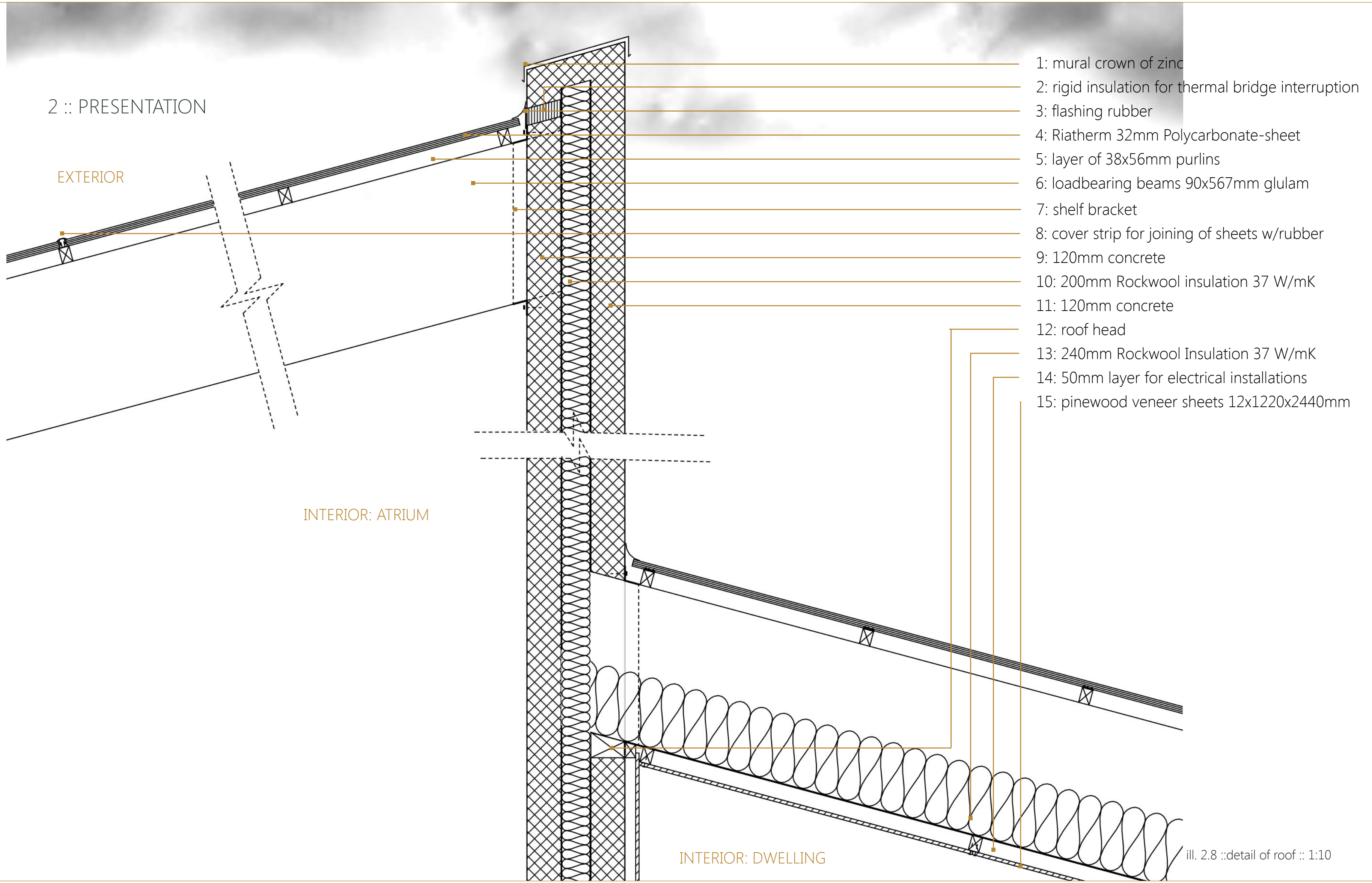
The interior of the atrium is joint between materials, spaces as well as light, as the section shows in ill. 2.7. The difference between the proportions of the human body and the building body is reflected in the joining of the materials; the stereotomic mass (cf. the theories of Gottfried Semper as discussed on p.71) of the concrete signifies a heavy base, while the tectonics of nordic related pine wood forms a lightweight top. The roof structure is composed of polycarbonate sheets on wooden purlins and beams, creating a diffuse white light in the atrium, as a reference to the nordic white light and the whiteness of a glacier. The purlins of the structure are placed in a pattern reflecting the meandering space udnerneath, and at the center of the roof are placed glazed windows creating a pattern of light beams along the pattern of movement at the floor, as visualized in view 1.



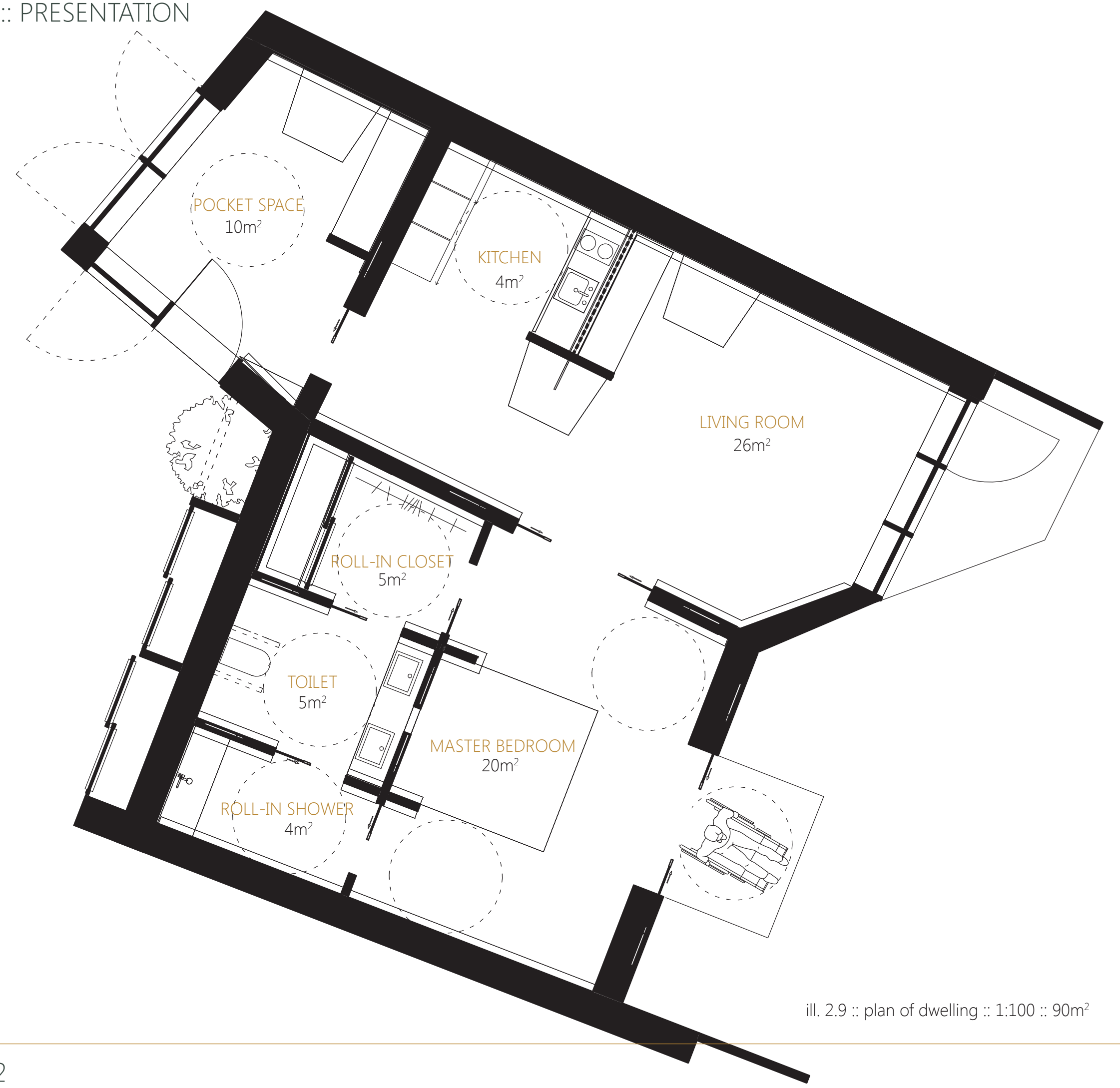
ill. 2.7 :: section AA :: 1:250

DETAIL 1 ::ACCESSIBILITY ON DETAIL LEVEL :: DETAIL DRAWING OF ROOF :: 1:10

Two concrete walls compose a structural spine through the site, and these are also the divisions between private and public in the building. The spaces are partly cladded with pinewood veneer in the dwellings, giving a soft ambience, wherease the atrium is more rough by revealing the cocnrete walls. The structural beams constructing the polycarbonate roof are joined with the walls by a shelf bracket, gesturing an underpinning of the beam; "I serve to you a structural beam". A beam may be simple, but effectful. Appendix 2 shows the dimensioning of the beam structure, appendix 3 calculation of U-value.



ill. 2.8 ::detail of roof :: 1:10

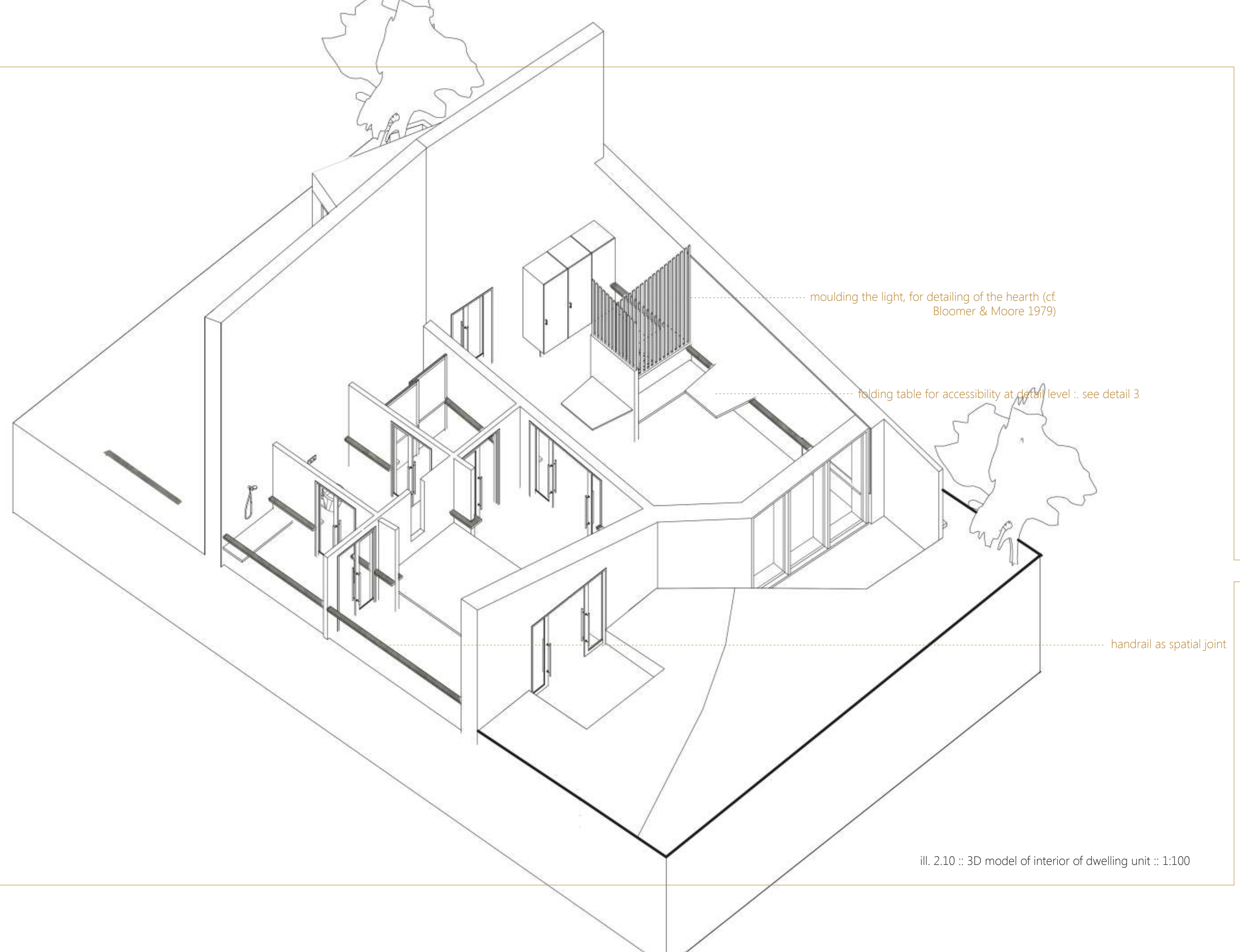


ill. 2.9 :: plan of dwelling :: 1:100 :: 90m²

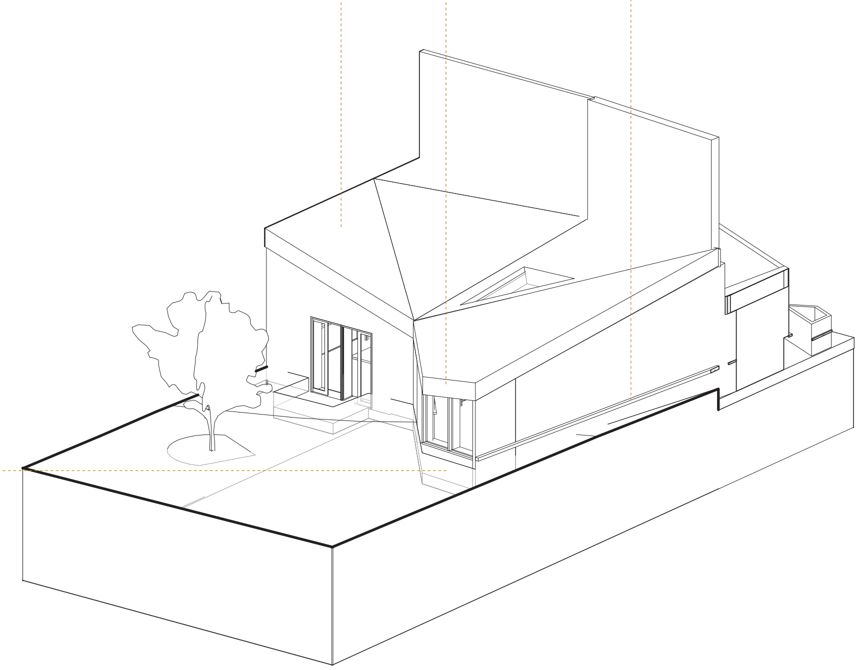
ACCESSIBILITY ON DWELLING SCALE

"*Inside, the areas of special importance receive special attention. The fireplace, for instance, framing the hearth (which qualifies still as the heart of the house), is honored even now, although the heat may be coming from a furnace located in the basement or even in a closet (...). The formal attention to detail is likely to be richer here than anywhere else in or on the house, except perhaps the front door, which opens the way to all this*" (Bloomer & Moore 1979:2).

Though the fireplace is not typical hearth in contemporary dwellings, expecially due to sustainability of fossil fuels, all dwellings need a central place to *dwell*; in the design proposal, two kinds of hearths are proposed; the hearth of nature, looking from the living room and out upon the nature, or the hearth of the social sphere of the "bofællesskab", enjoyed from the 'pocket space'.



ill. 2.10 :: 3D model of interior of dwelling unit :: 1:100



ill. 2.11a :: 3D model of dwelling unit :: 1:200

VIEW 4 :: ACCESSIBILITY AT DWELLING SCALE :: THE DWELLING

The hearth of the living room, a space of tectonic accessibility at different levels; sensous differentiation of the daylight ranging from thw white, diffuse light of the polycarbonate skylight, direct sunlight through the curtain wall and the exterior forest, and through the vertical panels between the kitchen and the living room area. Haptic differentiation between the cold, gravelly concrete and the warm, fibrous wood. The kitchen area makes it possible for both rolling walkers and the wheelchair to roll into space underneath it, see detail 2. At the end of the kitchen, a dining area can fold out as a folding table, which folds out by the use of a pulley system, which bisects the load of the table counter top, see detail 3. Meandering its way alont the walls is a small surface of concrete, at some walls marking the joint between the wood and the concrete, phenomenologically signifying the direction from the social sphere of the atrium and the nature, while practically being a handrail gesturing a supporting reaching out of the wall.

ill. 2.11b :: visualization of dwelling

ACCESSIBILITY AT BUILDING SCALE :: SECTION BB :: 1:250

The approach to the distinctive site is inspired by Sverre Fehn's approach to a sloping site for his Villa Busk:

"*The first element is the site with its potential for a place on top of the rocks. The introduction of the wall changes the site fundamentally; it defines the habitable place on top of the rocks and protects it from the danger of the edge. This is an ancient way of making a place. To make the place more easilty habitable the ground is levelled into a platform, using the wall as a retainer, holding in the earth*" (Unwin 2015:190)

As the wall has been a central element for this project, being the basic element for the spatial joint, this passage of Simon Unwin about Villa Busk has inspired to the initial approach to the site; creating the spines of walls along the curvature of the topography, as defining the difference between the upwards slope and the downward slope. Section BB depicts the two spinal walls defining the separation between dwelling and atrium. The section cuts through two dwellings and the atrium in between them, as well as the ventilation shafts as explained in appendix 4.. Towards east, the landscape slopes slightly upwards, creating a refuge-spatial cave of the terrace for the dwelling oriented this way. Towards west, the landscape is on the other hand sloping downwards, giving prospect of the surroundings. The sloping landscape is often characterized as a non-accessible one, but these spatial qualities of both prospoect and refuge are made accessible in this design proposal, as these qualities should not be secluded to the hale body only.

ill. 2.13 :: section BB :: 1:250

ill. 2.14 :: detail 2 of counter top for tectonic accessibility at the kitchen function :: 1:10

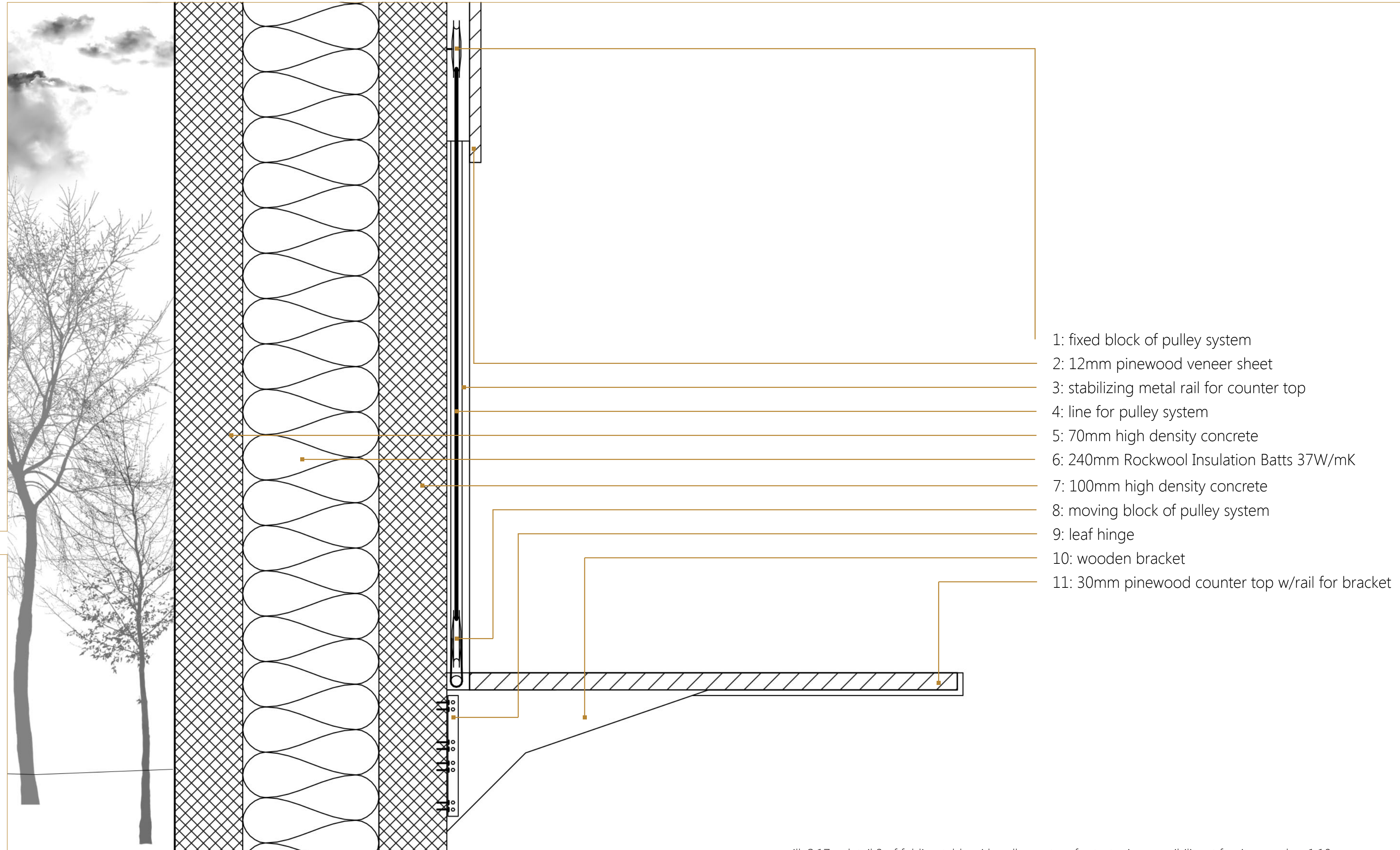
DETAIL 2 :: DETAIL OF KITCHEN COUNTER TOP :: 1:10

The kitchen is an important space in contemporary dwellings, and the tectonic accessiblity needs to be thought into the solutions for it, even though the kitchen is only a kitchenette, as the residents will spend most days eating together in the common house. As a wheelchair user, an ordinary kitchen with floor cabinets is very dificult yo use, therefore the design offers a solution with a cantilevering counter top, making it possible for the wheelchair to use the space udnerneath for the legs.

Appendix 1 shows calculations for the concrete frame, as the critical parameter of the design of this is to avoid deflection of it.

ill. 2.15 :: eastern facade :: 1:250

ill. 2.16 :: western facade :: 1:250



ill. 2.17 :: detail 3 of folding table with pulley system for tectonic accessibility at furniture scale :: 1:10

DETAIL 3 :: DETAIL OF FOLDING TABLE - 1:10

As part of the tectonic accessibility on a detail level, a folding table is developed to ensure the ability of the wheelchair to be able to drive into the table without any obstacles for the legs. The experience of transforming a part of the wall into a table extends the feeling of joining body and dwelling, extending the interaction and thereby breaking any hierarchy between the two. This is a spatial joint.

The table is developed with a *block and tackle* pulley system solution, which ensures a bisection of the load of the counter plate from approximately 9kg to 4.5kg. The reduction of the load is related to the amount of blocks in the pulley;

$$F_z = F_l + \frac{n}{20} * \frac{F_l}{n}$$

n = number of blocks
F_l = load
F_z = pulling force

The table folds up along the wall by pulling a string. It is chosen to pull the table up instead of folding it down, to avoid the risk of the table to fall down in the process. It should be noted that the pulling distance is doubled for a pulley system of two blocks.

Compared to a mechanical solution, this is a tectonic approach because you are able to experience the transforming process of wall to table.

3 ::
THE SENIOR AND THE DWELLING

This chapter uncovers the aspects related to the senior resident and the dwelling. In order to do so, I wil specify the group of age, the obstacles that they primarily experience within their dwelling, so that these can catalyze the tectonic accessible explorations. The chapter further reveals state-of-the-art of senior dwellings to inform a typlogical perspective of the project,.

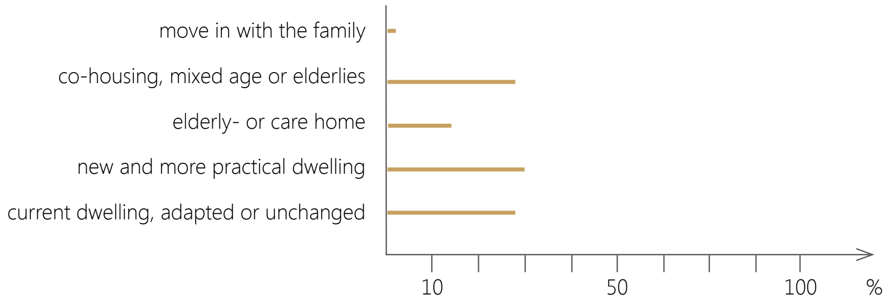
THE SENIOR RESIDENT

THE GENERATION

As elaborated in the introduction, there is a need for dwellings that accommodate the requirements of the senior residents. This is an economic as well as a socially sustainable approach, as senior-friendly dwellings can avoid the expense of society having to provide care facilities for them, as well as it addresses their life quality by making them self-sufficient for as long as possible. In order to be able to provide the physical environments for this third age of life, we first need to understand the challenges that they meet within their dwellings. This project takes its point of departure from the generation at the age of sixty-five and above, namely the seniors who have just retired from the labour market, and seek a dwelling which meets their new economic situation, new daily life and developing body state. The current year being 2015, the generation in focus is born in the fifties, and according to a study conducted by the Danish *Ældre Sagen*, called Ældre Sagens Fremtidsstudie, the majority of this generation, 30%, prefers to find a new and more practical dwelling, and as an alternative to remaining in their current home, they prefer to live in a co-housing manner, ill. 3.1. The co-housing residential manner provides a social environment, where close social relations between the neighbors creates a sub-community, where the residents look out for each other and help with daily activities.

OBSTACLES IN THE DWELLING

The senior is a residential group in search for a place to enjoy their retreat. Those fortunate enough to only experience the physical restrictions of aging and avoid mental deterioration, have the best premises for avoiding the nursing home, therefore it is the physical circumstances we need to address first, so that hands and finances can be released for assistance of the ones in highest need of it. The physical restriction causes some challenges in the everyday life of the senior. A questionnaire reveals the hierachy between these obstacles, visualised in ill. 3.2. Not surprisingly, the biggest problem they face in their dwelling is to climb stairs. After practical daily activities, a primary obstacle is the simple act of walking around the dwelling; the one problem which affects all the other problems. Therefore, it is chosen to evolve the project around a senior couple, one of which has a motoric impairment making him/her dependant on using a wheelchair; the most challenging tool regarding the spatial layout of the dwelling, thus if we can solve the



ill. 3.1 Answers by seniors (born in the fifties) to the question: "if you at some point are unable to take care of yourself, which residential solution would you then prefer?" (Lyhne 2006:87)

1 climbing stairs
2 taking a bath
3 preparing meals
4 showering/washing
5 heating the dwelling
6 walking around
7 going to bed/getting up
8 sitting down/getting up
9 using the toilet

ill. 3.2 Problems faced by older people within their home, listed hierachically (Heiss, Degenhart & Ebe 2010:29)

layout according to this, we will come a long way in assuring a higher wellbeing within the dwelling.

The future dwellings for senior will be a hybrid between a regular dwelling and a traditional elderly dwelling, as concluded by Ældre Sagens Fremtidsstudie: "*Samlet viser Fremtidsstudiet, at der blandt nuværende og kommende ældre er et stort ønske om at blive boende i sin bolig som ældre. Et ønske, der er steget i gennem de sidste 15 år. Det kan tyde på, at fremtidens ældrebolig bliver en almindelig bolig for mange. Det er derfor vigtigt, at boliger (...) og udemiljøer indrettes fremtidssikret, fleksibelt og med god fysisk tilgængelighed således, at enhver bolig, dens adgangsforhold og udemiljø egner sig for alle aldersgrupper - også mennesker med funktionstab.*" (Lyhne 2006:87). Thus, there is a continuously higher need to integrate the accessible solutions in our dwellings, but in a way where they become a part of the architectural expression - the accessibility becomes teconic.

SENIOR DWELLING TYPOLOGIES

The history of dwellings for seniors is relatively young, as it is born out of the dwellings intended for elderly. Housing for elderly is also a relatively young notion, as it is no more than a century ago that they were left to live at, what we ind Danish relations call "fattigmandsgårde" (Fich, Mortensen & Zahle 1995). Today there are several options for dwellings for seniors and elderly, and much research has been conducted on the wellbeing of elderlies in their dwelling. Møller and Knudstrup have developed a model on this, ill. 3.3, but whereas this model distinguishes between 'accessibility' and

ill. 3.3 The model of wellbeing of elderly in nursing home (Møller & Knudstrup 2008:10)

'sensoric stimulation', it is my proposition that these two parameters need to be considered as one, in order to avoid the accessible solutions becoming being detached from the dwelling. A search on senior dwellings at housing accommodation websites reveal that most of the options for senior dwellings are apartments in high-rise buildings in urban areas or varieties of the row house-typology in less dense areas. Both options offer rental or multi-ownership, and both options also offer co-housing dwellings, but only a very few of them are listed as wheelchair-friendly, just as it is the case in Germany as mentioned in the introduction. The low-rise typology provides a higher level of flow between interior and exterior, compared to a high-rise typology, and thus also an easier access to the social sphere of being exterior, therefore this typology has a bigger relation to the co-housing dwellings. I will therefore explore tectonic accessibility within the co-housing low rise-typology of the row house.

The following two case studies show contemporary senior dwellings in two very different co-housing manners, and with very different qualitites arriving from these. None of them pays a special attention to accessibility, as seems to be the general case in Danish relations. Instead, I find solutions for this in a Japanese nursing home. The first case study on senior dwellings, *Ådalen 85* in Randers, is to some extend the extremum of sociality in the co-housing, whereas the second, *Lærkehaven I* in Lystrup, practises the extremum of privacy in co-housing, thus the differentiation between social and private spheres within co-housing is sought to be found as a merge between these two.

ill. 3.4 :: Ådalen 85 in Randers

"ÅDALEN 85" BY DANSK ARKITEKT- OG INGENIØRKONTOR

Ådalen 85 is a co-housing community in the North-Western part of Randers, designed by Dansk Arkitekt- og Ingeniørkontor, which was a local Randers-based office at the time.

Ådalen 85 is interesting because of its solutions for common facilities: the units are organized as a stock-typology surrounding a common, semi-exterior corridor, as a buffer-zone between interior and exterior, making it easier for the residents to spend time outside their dwelling in a social sphere. This atrium-like corridor is actually an extra hallway for all of them, an extension of their dwelling, with the possibility of applying their personal touch to their unit with plants and furniture, which is easier because these are sheltered for the Danish weather. Each apartment has its kitchen facilities towards the atrium; a function which is today a somewhat social function and a space in which we spend more and more time. The more private bedrooms are placed away from the corridor, and the living room stretches all the way through the apartment thus differentiating in privacy according to the desires of the residents. I interpret this common atrium as a manifestation of the social sphere, a tectonic accessibility within the building scale, making the social interaction accessible for the seniors as part of their daily life, and this is how it is explored my design proposal.


ill. 3.4 :: accessibility at building scale :: the atrium

ill. 3.6 :: Lærkehaven i Lystrup by Herzog + Partner

"LÆRKEHAVEN I" BY HERZOG + PARTNER

Lærkehaven I from 2008 in Lystrup, designed by the German office Herzog + Partner, is a row-house typology listed in aarhusbolig.dk as a "bofællesskab" for seniors. It has a central, but physically detached, common house, surrounded by the dwellings, and this appears to be the contemporary solution to co-housing in Denmark, though there is not really much community-feeling about it. Each dwelling unit consists of two equally dimensioned squares connected by a corridor, and these three elements surround an fully enclosed courtyard together with the neighbouring house. It is this surrounding of a courtyard which makes this project interesting, as this courtyard becomes a contemporary version of a *'hearth'.* Because of the high level of sheltering of the space, it becomes an interior/exterior buffer zone, or a semi-exterior space. In combination with the common atrium, this kind of 'pocket space' can provide a transition between private/social, inside/outside, as a transition space which can shut out the social sphere, or open up and invite it into the dwelling. The units do not address accessibility particularly, but the volumetric differentiation between a living area and a sleeping area has inspired to the dwelling solutions of this project.

In the following I will elaborate on accessibility as a theme, from which I will explore how architectural solutions can arrive from accessibility.


ill. 3.7 :: courtyard of Lærkehaven I in Lystrup by Herzog + Partner

COMPILING THE SENIOR USER AND THE DWELLING

Even though the last century has improved the accommodation possibilities of elderlies, there is still a need for attention to their physical circumstances if we take a social sustainable take on their wellbeing within their dwelling.

As a step towards this, I will explore how accessibility can become architectural through a tectonic approach, within the desires and needs of the senior user. As the study of Ældre Sagen depicts, there is an increasing interest to live within a social co-housing sphere, where the neighbors provide surveillance and help each other. As the co-housing complex demands a high differentiation between social and private spheres, two contemporary projects depicting these extrema are used as inspiration. These case studies also reveal a state-of-the-art of the dwellings for seniors, as these both lack a special attention to the physical challenges that this heterogenous group of age experience. Therefore, state-of-the-art of senior dwelings has to be merged with state-of-the-art of accessibility, and through a tectonic exploration of these two elements, I see a potential to arrive at a new tectonic accessibility, which can hopefully take both senior dwellings and accessibility to a new level.

3 :: THE SENIOR AND THE DWELLING

4 :: TECTONIC ACCESSIBILITY

This chapter seeks to uncover state-of-the-art of accessibility and relate it to the senior resident, in order to make the architecture evolve tectonically from this specific parameter. Accessibility is a wide and varied field, primarily focusing on disability, but is related to the senior user by the motoric impairment. In order to understand the physiological processes related to a motoric impairment, the study takes its point of departure from phenomenology, which informs the link between the impaired body and space. Accessibility is currently balancing on two levels: practical, physical accessibility and physiological accessibility, and phenomenology will prove the common ground of these two levels. Based on these analyses, a case study of a tectonic approach towards tectonic accessibility reveals how these fields informs a symbiosis between the spatial elements, from which the design process has evolved.

THE EVOLUTION OF ACCESSIBILITY

As depicted in the user analysis, accessibility is one of the factors affecting the wellbeing of senior residents in the dwelling. Most of us take it for granted that we are able to move around and fully interact with our surroundings, both vertically and horizontally. We move from a firm chair into a soft sofa, get up and move into an enlightened window frame to take in the view of the surroundings. We make these movements without any special attention to our body, except from the perceptions that we achieve from it. All of us, though, will at some point experience how our body can become a point of focus instead of the center of perception when we face illness, pregnancy or the changes following the aging process. Thus, when our built surroundings improve for the impaired, it improves for all of us.

State-of-the-art of accessibility today is primarily a result of different societal, political and medical developments, and the focus on the theme as a society-related problem is a quite recent acceptance, as late as the nineteen-seventies (Heiss, Degenhart & Ebe, 2010:15).

The development from this paradigmatic shift has had a quite slow impact on the creative fields, thus most material related to this subject has a technical or political character to it. The tectonic *poiesis* within barrier-free designing is much less present, but is slowly beginning to make its sporadic entrance, and this is where my intention of shifting from accessible architecture towards a tectonic accessibility is taking its point of departure. Accessibility is related to many themes, e.g. barrier-free design, disability, healing architecture, but regardless of the notion, I draw the inference that it has evolved from a mere practical, physical level, and today is evolving into a physiological, evidence-based level as a means to approach a phenomenological discussion of accessibility. As phenomenology practises the relation between the physical - the surrounding world - and the metaphysical - how we perceive it, I propose that it is through this field we are able to link the practical and the physiological levels of accessibility.

Therefore, I will take my point of departure in the phenomenological study of the impaired body - or as phenomenology denotes it, the *dys-appearing* body, a theory developed by the philosopher Drew Leder.

PHENOMENOLOGY OF THE AGEING BODY

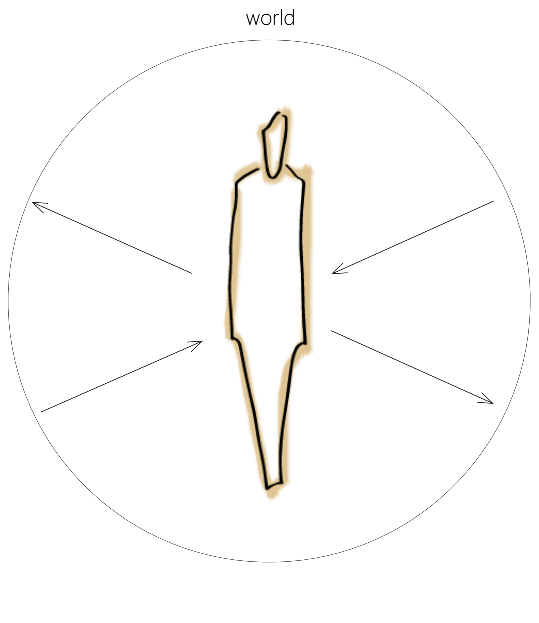
The physical body has always been a central architectural parameter, but the bodily state, and how this affects the interaction with the surroundings, has been a more sporadic attention. Dr. Drew Leder, philosopher at Loyola College in Maryland and the author of many writings on the subject, elaborates a phenomenological link between the weakened body and phenomenology.

The senior generation as user is phenomenologically a sub-category to the sick and/or disabled body, as the aging body is in a process towards a dis-abled state. This body differentiates from the hale body in the relation between the "I" and the surrounding world. Drew Leder has elaborated a theory of these two bodily states, where the healthy body is characterized as an absent one, ill. 4.1, whereas in sickness or bodily impairment, the body becomes instead a blurry filter, through which "I" am not able to wholly interact with the surrounding world, ill. 4.2. The body becomes the center of attention, the attention is directed *to*-wards the body because of the pain or lack of mobility. With a healthy, non-impaired body, the attention is instead directed *from* the body *towards* the world.

"*In case of health, the body is alien by virtue of its disappearance, as attention is primarily directed toward the world. With the onset of illness, this gives way to dys-appearance. The body is no longer alien-as-forgotten, but precisely as-remembered, a sharp and searing presence threatening the self. One is a mode of silence, the other a manner of speech, yet they are complementary and correlative phenomena.*" (Leder 1990:91)

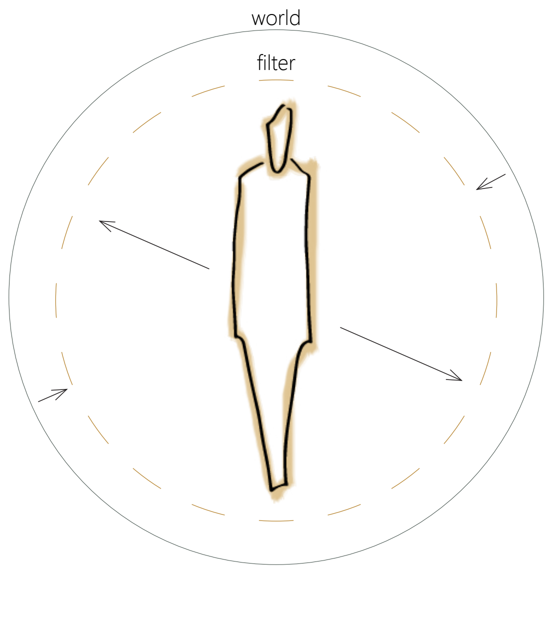
This dichotomy is the very reason for working with accessibility, as it edifies us that an awarenes of the surroundings and the ability to physically inhabit these can help the individual forget the impairment, and hereby we can permeate the "filter", as visualized in ill. 4.3. We have to silence the body, by making the surroundings inhabitable disregarding the bodily state. In order to do so, we have to initiate from the impaired body. When sitting in a wheelchair, the body is constantly perceiving the wheelchair, and is thus reminded about the impairment. The wheelchair is a physical manifestation of the filter. The wheelchair is at the same time the tool compensating for the impairment, making it possible to move the body. This dichotomy implies that we have to work with inhabitation

THE HALE INDIVIDUAL



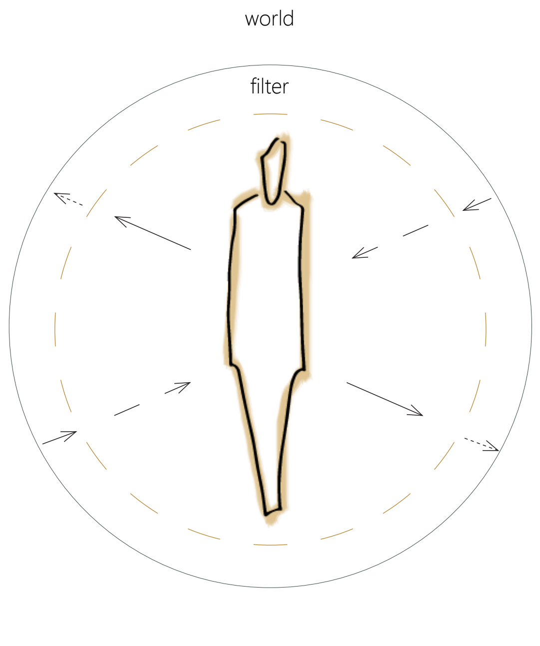
ill. 4.1 :: The hale individual interacts with the world without specific attention to the body

THE IMPAIRED INDIVIDUAL



ill. 4.2 :: The impaired individual only experiences limited interaction with the world, because the body impairment acts as a filter

SENSORICAL ACTIVATION



ill. 4.3 :: The task of architectural accessibility is to break the filter

of the space on two levels: with and without the wheelchair. With the wheelchair, making it possible to 'wheel' into the spatial elements. Without the wheelchair, making it possible to transfer the body from the wheelchair and into a spatial element, thus perceiving and inhabiting the space directly with the body. Thus these are two different explorations of pervading the filter. These two levels relate to the two levels of accessibility, the practical barrier-free level and the physiological level.

First, I will evaluate on the physiological level; a contemporary approach towards healing architecture.

THE CONTEMPORARY APPROACH: HEALING ARCHITECTURE

Besides the architecture being "accessible", there is a new tendency growing that the architecture should be able to do more than just providing mobile surroundings, namely that the surroundings should also address the physiological state of the individual, where we are able to measure a healing effect. Though, in relation to the aging body, instead of healing architecture, we would instead focus on the architecture being palliative. To some extend it is a theme which architecture has always been aware of - as architecture has always to some extend striven to make comfortable, beautiful surroundings which we enjoy inhabiting, but the new focus includes a measurable evidence-based approach. The 20th century showed an increasing interest in how architecture can affect health; from Alvar Aalto's *Paimio Sanatorium* in the 1930s, focusing on elements of daylight and air (Griffiths, n.d.), towards the paper of Roger Ulrich in 1984 (Fich et.al. 2014), demonstrating that view to nature influence recovery from surgery. The experiences and knowledge gained throughout these projects have now developed into research studies, one of the recent being *Can architectural design alter physiological reaction to psychosocial stress? A virtual TSST* (Fich et.al. 2014), demonstrating a relation between stress and the openness of a space, suggesting that this relation is due to *how freely the subject can potentially move*. This is largely a relation that architects have always been aware of intuitively, but through studies as this one we can appraoch a deeper understanding of how these are related. Through evidence-based design we can substantiate the knowledge which we have gained from experience and intuition, and arrive at new conclusions and an understanding of how these relations exist. As with any quantifiable data, we need to treat this data according to our intuition and experience. Though the relation between stress response and the ability to potentially move freely is only validated for healthy young men, and only through the induction of acute stress, it is my hypothesis that this relation can be applied to the case of a motoric impaired body in a wheelchair. As this is a person who is constantly subject to limitations of movement, the person must also experience some level of prolonged stress, which proves to be a health problem, causing e.g. a higher risk of infections due to immunosuppression (Fich et.al. 2014). As previosuly mentioned, the wheelchair itself acts as a tool for spatial mobility, but as this tool is also a physical manifestation of the impairment, it also reminds the individual of his impairment and becomes a part of the phenomenological "filter". As I conclude from the phenomenologic theories of Drew Leder on pp. 56-58, it is important for the individual to make his bodily state dis-appear and turn his awareness away from it, thus I propose that we must re-join body and space, by making him able to *inhabit* it with his wheelchair-body. I hereby propose that there is a positive relation between the level of movement and level of inhabitation, and this is the relation which I will explore with point of departure in the "Long House" case study, in order to approach a tectonic accessiblity on the level of palliative architecture. Architecture for the hale body, shows different approaches to tectonic inhabitation, for example in the case of Le Corbusier's Villa Savoye from 1929, ill. 4 .4, where he moulds a wall in the bathroom

4 :: TECTONIC ACCESSIBILITY

according to the sprawled lying body. The form of the surface narrates the contours of this body position. At the same time, the wall is a spatial boundary, a boundary between the formal part of the bathroom; the bathtub, and the more informal surroundings to the bathtub. The wall balances exactly between formality and informality; it makes the transition formal by emphazising it, but as it contours the body as sprawling, as in the most relaxing body state, it simultaneously de-formalizes the transition. A contemporary example of a tectonic inhabitation is the Final Wooden House from 2006 by Sou Fujimoto, ill. 4.5. In this case there is no obvious boundary between structure, space, furniture, floor or wall, and as opposed to the case in Villa Savoye, it is not pre-defined how you position your body within this space. These two cases are abstractions of tectonic inhabitation through the use of structural elements. In order to be able to relate these cases to my project, I will first elaborate on the practical level of accessibility in senior dwellings, after which I will present a case which merges the practical and the physiological.

ill. 4.4 :: Villa Savoye :: tectonic inhabitation of wall detail in bathroom

ill. 4.5 :: Final Wooden House :: the tectonic principle providing inhabitation of the structure

ACCESSIBILITY IN THE SENIOR DWELLING

Accessible architecture today is primarily a result of different societal, political and medical developments, and the focus on barrier-free designing as a society-related problem is a quite recent acceptance, as late as the nineteen-seventies (Heiss, Degenhart & Ebe, 2010:15). It focuses on a barrier-free design, and is thus a practical solution. Based on the Danish *Bygningsreglement* as well as the *Danish Standard 3028 - Tilgængelighed for Alle,* this involves for example

- the width of doors min. 870mm
- avoding thresholds
- ensuring an area of maneuvre of 1500mm in each space (and also in relation to certain functions)
- windowsills below eye-level of a sitting person, max. 700mm from floor

These demands primarily ensures an *accessible* architecture, and these are solutions which are often implemented at a rather late stage of the design process. Tectonic accessibility, where the features of accessibility are implemented from the beginning of the design process, is much less widespread. The new *Handicaporganisationernes Hus* in Høje Tåstrup is a showcase of examples of how to work with the different elements of accessibility and making them become a part of the spatial experience, as exemplified in ill. 4.6, where the handrails become a tactile experience informing the spatial layout (Handicaporganisationernes Hus 2012).

The Danish urban scene is also reacting on accessible experiential solutions by integrating studs in the ground surface, informing level changes or restrictions in the space, ill.3.7 These

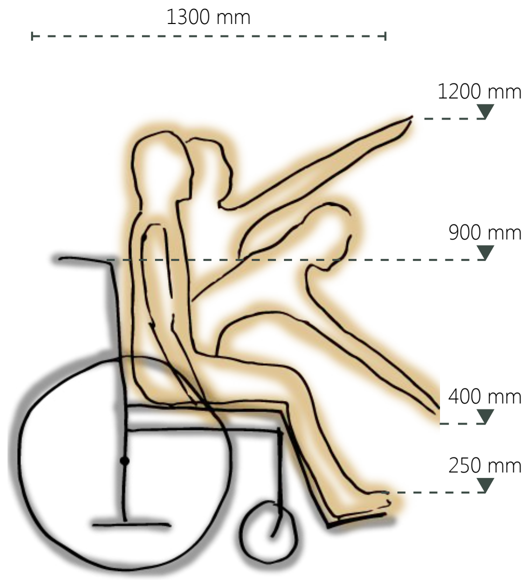
ill. 4.6 :: tactile marking of railing :: Handicaporganisationernes Hus :: Tåstrup

ill. 4.7:: tactile markers in pavement

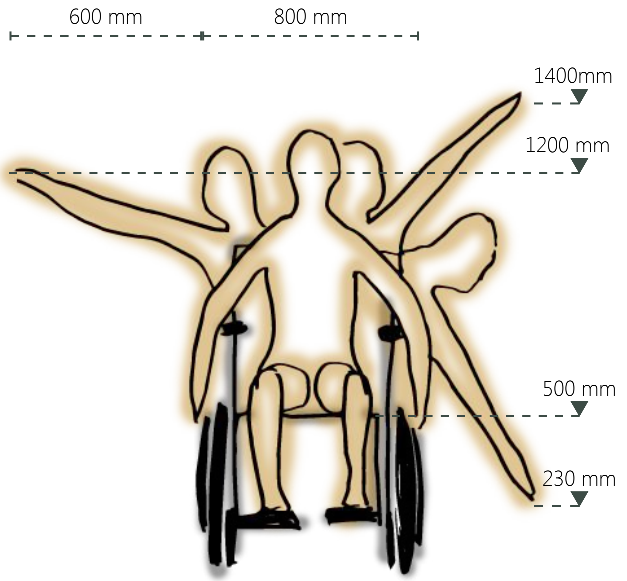
are examples of how the tools become part of the spatial experience for all users of the space - not just for the disabled or impaired, and hereby they enrich the universal architecture, giving everyone sensoric experiences. These are specific manifestations of approaching an tectonic accessiblilty. Relating accessibility to the wheelchair user specifically, the most important thing to take into account is the proportions. The wheelchair-bound body has another field of proportions than the erected body, affecting the level of the visual field as well as the motoric level of the arms. Illustrations 4.8-4.9 show the area of maneuvre from the wheelchair as well

as the overall proportions. These proportions are based on generalized measurements conducted by the American industrial designer Henry Dreyfuss, denoted in his book *The Measure of Man and Woman: Human Factors in Design* (Dreyfuss Associates 1993), and they have informed the basic spatial layouts of the project.

As a case study of how these proportions can inform the spatial layout at a tectonic level, I will now present to you the nursing home "Long House" by Kawai Architects on the following pages.



ill. 4.8 :: Profile view of person in wheelchair with main proportions



ill. 4.9 :: Front view of person in wheelchair with main proportions

CASE STUDY OF TECTONIC ACCESSIBILITY: LONG HOUSE BY KAWAI ARCHITECTS

Long House is a care facility for both ambulant and permanent aged residents in need of care (Schittich 2007:90-93), situated on the Japanese Henza Island and designed by Kawai Architects.

It is an example of how the spatial proportions arrive from the proportions of the wheelchair body. The porportions actually affect the structural principle, ill. 4.10, making the beams and columns evolve an inhabitable rectangular; the height of the horizontal, wood surface is leveled for the sitting body, letting the wheelchair inhabit the structure and turning the beam into a function of a table which the wheelchair can roll into. Hereby the body become a part of the building envelope.

The corridor also practices accessibility within

ill. 4.10 :: Long House :: the tectonic principle of beam and column create inhabitable space for the wheelchair

ill. 4.11 :: Long House :: entrances to the apartment units from the corridor

ill. 4.12 :: Long House :: the supportive gesture of the beam

ill. 4.13 :: Long House :: the tectonic, modular principle affects the facacde

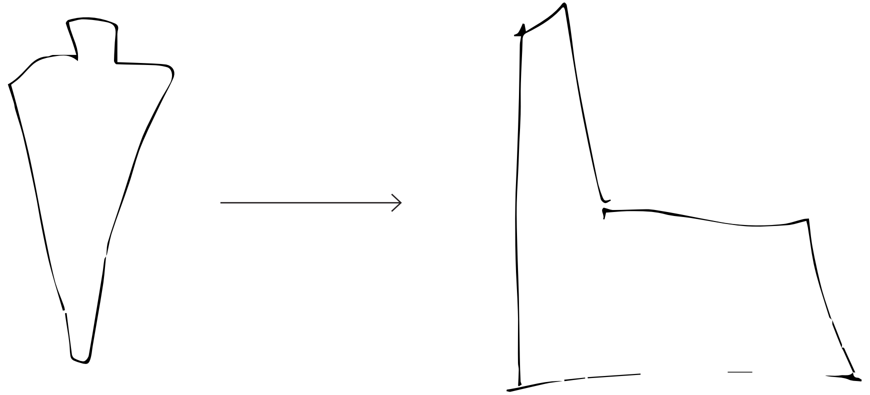
the structural solution, providing a horizontal surface that the residents can use as support when they walk along the corridor, ill. 4.12 or they can again roll into this beam and enjoy the view outside. Outside, the tectonic principle also informs the expression of the facade, narrating the interior experience, ill.4.13.

This is an example of how architecture can arrive from a focus upon accessibility - the space, as well as the structure, is *accessible* at a whole new level, namely a level of symbiosis, between function, structure, material and the body.

As the accessibility actually arrives from the structural principle, it becomes also a tectonic accessibility.

COMPILING TECTONIC ACCESSIBILITY

The theme of accessibility is currently evolving into a new level; from a practical, barrier-free focus, it is evolving under the notion of Healing Architecture as an evidence-based physiological approach. Even though evidence-based architectural theory might support and even alter our intuitive and experience-based knowledge, it cannot teach us good architecture. I believe that we need the philosophy of phenomenology to interpret the measured results, just as I am trying to evaluate the practical solutions to accessiblility through phenomenology. Thus, I am trying to use both the phenomenological and the evidence-based knowledge to break the filter of the dys-appearing body. The most important thing to acknowledge when working with tectonic accessibility is that the proportions of the wheelchair-bound body are much different compared to the hale body, proportioned as Leonardo da Vinci's Vetruvian Man. These tectonic accessible solutions have evolved in a symbiosis with the conclusions of the following site analysis, and compiled in the later spatial programme.



5 :: SITE ANALYSIS

The site analysis will evaluate on the Nordic context, as a macroscale, zooming in on the site and the elements which make it special for the project, informing the context-related tectonic development.

CHOICE OF SITE

The site for this project is chosen for its proximity to both city and nature; a site in Over Hornbæk, a suburb to the city Randers not far from Aarhus, Denmark. It is a site with some very specific characteristics relating it to both the Nordic context and to the senior as resident, as the location geologically is part of the valley of Gudenå, a big valley formed by the melt water from the glacier reciding at the ridge during the previous ice age (Houmark-Nielsen, Krüger & Kjær 2005). The glacier residing along this ridge has formed a plateau upon which a newly defined local plan has specified a residential area.

As the site is on the verge of the city and the nature, it offers residents the choice of enjoying the social activies of the city or the recreational qualities of the moor.

ill. 5.1 :: glacier front with melt water forming the ladscape

NORDIC CONTEXT

It is important in any project to be aware of the architectural identity of the context. Though the last decades of increasing globalization has to some extend blurred the lines between cultural differences, affecting also the architectural differences between cultures, I still believe that it is a quality to have cultural differences and identities according to the physical place, as it is the fundamental approach for the human means of identification. According to recent debate, there is a tendency towards a New Nordic architecture, which seeks to establish Nordic Architecture within a frame of the existing roots, but reinterpreted through the global perspective (Kjeldsen et.al. 2012:11).

Through his discussion on the senses in his "The Eyes of the Skin", Juhani Pallasmaa (2012) verifies the role of the senses in Finnish and Nordic architecture. Within this context, the senses have always played an important role in defining the spatial layout. This is much related to the reknown minimalistic style of Nordic architecture. The style is regarded as a non-decorated one, but instead of ornamental decoration, spaces are decorated through the sensoric activation. Using the senses as aesthetic catalysts is what I seek to explore as a spatial haptic joint, specifically through the joining of materials. As a part of the Nordic context, known for its vast dark forests as a contrast to the cold, white light, the wooden material has undergone a Nordic revolution of establishing the New Nordic, and as a physical manifestation of this, I will use this material for its haptic qualitis as an inhabitable material. To emphasize the haptic qualities of it, I will justapose it with another contemporary material; the massive, industrial, cold concrete. The choice of material informs a tectonic relation, which I will elaborate further in the following.

THE AESTHETIC QUALITIES OF WOOD AND CONCRETE

The wooden material is one of the first materials that mankind has ever used for the creation of shelter, and as such the use of it has a long history of evolution and has itself influenced the evolution of architecture. The aesthetic as well as the haptic qualities of the material has made it evolve into the field of furniture as well, and it has made Nordic wooden furniture internationally reknowned on this behalf. As pointed out in the quoted passage by Kenneth Frampton on p.10, the tectonic term also has fundamental relation to wood, as it originally signified the act of carpentry. This material is thus explored extensibly, but still keeps evolving together with the implementation of new engineering tools, such as for example the digital parametric or algorithmic tools. The extensive varieties of processing the material is a result of its heterogenous proporties as an organic material. As it is able to adjust to the natural climate and context in which it grows, each wooden piece is unique, and many different species have evolved, each with distinct properties. These variations include e.g. structural ability, acoustics, hue, hardness, fibrousity or insulation (Deplazes 2008); all parameters which affect the spatial perception. Though traditionally processed as lumber pieces, relatively massive elements, it has evolved as an engineering material into a lightweight structure by the manufacturing of using adhesives in different ways to make it exceed its natural properties. Because of its strength regarding both tensile and compression forces, it qualifies a both beam and column and is often formulated as a lightweight structure. Contradictory to the often filigree structures of wood, which is prossesed through cutting, the concrete material is on the other hand a mass material, prossesed as a moulding, cf. the theories of Gottfried Semper in his *Die Vier Elemente der Baukunst* (Semper 2010), where he defines the material according to the prossessing of it; the *tectonics* of the frame, which creates a spatial matrix, and the *strereotomics* of the earthwork, the mass. As signifiers of the spatial joint, these two materials are exploited as material joints, approaching tectonic accessibility within the Nordic context.

From the scale of the Nordic context, I will now zoom to the extends of the actual plot and its closer context, after which I am able to arrive at an elaboration on the spatial programme.

ill. 5.2 :: lines of the glacier in previous ice age (denstoredanske.dk 2014)

MACRO SCALE

The site is located in the outskirts of the eastern Jutland city Randers, a suburb of the name Over Hornbæk. This small town is located within an area of great natural features, ill. 5.2, as this is an area much affected by the geological events during the Pleistocene Ice Age. Towards the end of this period, the streams in front of the glacier eroded the landscape, and this event is still evident in the undulating contours of the site, as depicted in ill. 5.7 p. 75.

CONTEXT

The site is an extension of the dense-low residential area of Over Hornbæk, and forms the graduation from town to nature, ill. 5.3. The near-by "nature" of the Golf Course is dominated by human activity all year round, adding a certain level of activity to the area. On the other site of the golf course, is a camping site, ill.5.4, providing more intense activity during the summer months, and towards southeast is a big natural park surrounding the Gudenå. These surroundings relate to the senior user while emphasizing the seasonal shifts.

ill. 5.3 :: Zoom-out of site

THE PLOT

The plot is at the northern end of the hill, and a steep slope cuts through it, making it a possible to build out from it, ill. 5.4.

If the slope is considered part of the plot it covers an area of approximately 10000 m^2.

The forest to the west of the site is preserved, and the vegetation primarily consists of deciduous and coniferous trees. The area is approached from Mosevænget to the southeast.

LOCAL DEVELOPMENT PLAN

VISIONS
The area is expected to remain as the boundary between town and nature, thus the municipality does not expect further building towards west.

APPROVALS
According to the local development plan, only two building plots are approved within the plot area, with an individual size of 27x27m. This project wll interfere with this intention, but the intention is to prove the potentials of this site as regarding the user group, which can also in turn add surplus value to the area. A common house is already intended in the center of the area.

NOISE
No traffical noise is detected in the area.

HISTORY
Two small burial mounds have been detected to the southwest of the area, which are preserved.

ill. 5.4 :: Plot :: 1:2000

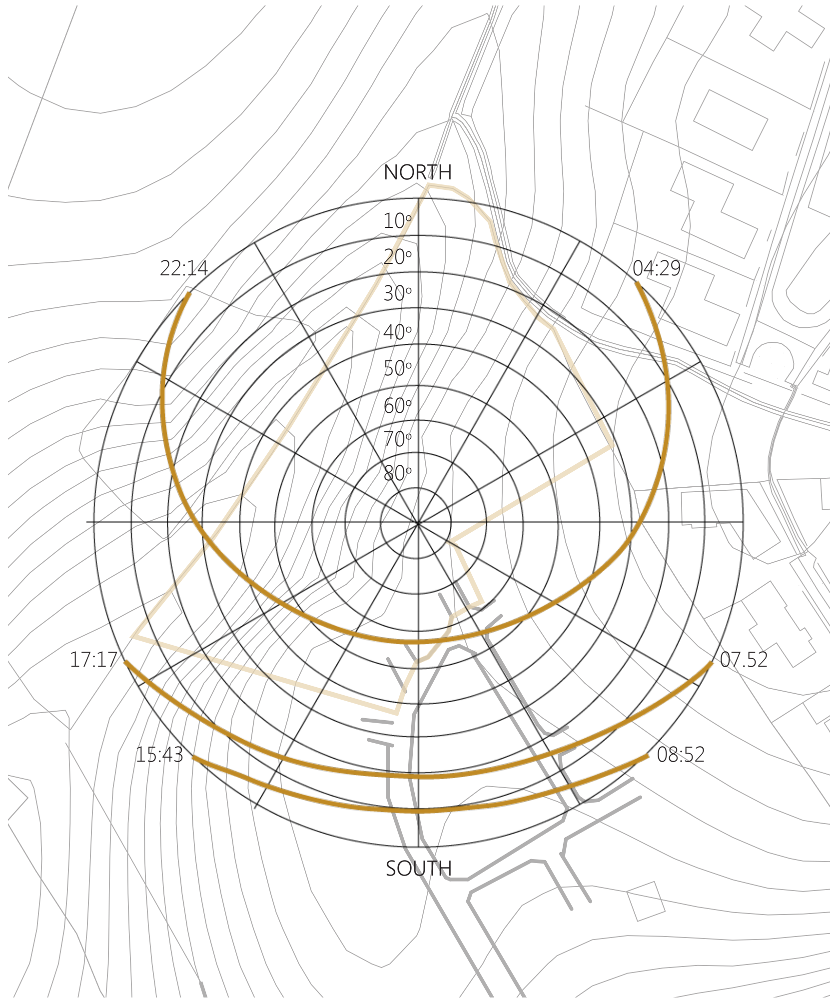
VIEW

The site is approached from the road to southeast, ill. 5.5, and hereby one arrives from the high part of the plateau and descent a little into the site along the contours. The site depicts two very different orientations; one towards east, into the neighbouring buildings and a path, path 1, from the road and down to the golf course. The other one towards west, overlooking the hilly golf course through a narrow strip of trees, through which the sun flicker in the late summer evenings, see video clip on p.2. A golf course path, path 2, carries runners, dog walkers and mountain bikers along the site.

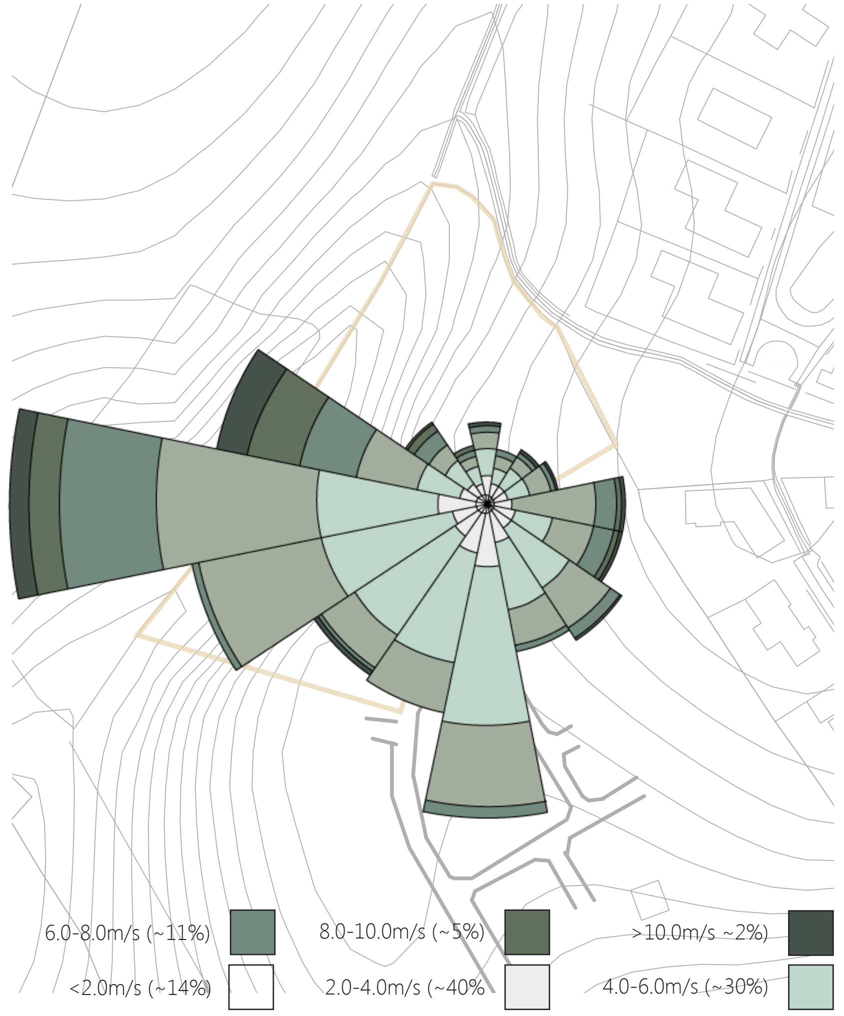
ill. 5.5 :: Plot :: 1:2000

CLIMATE CONDITIONS

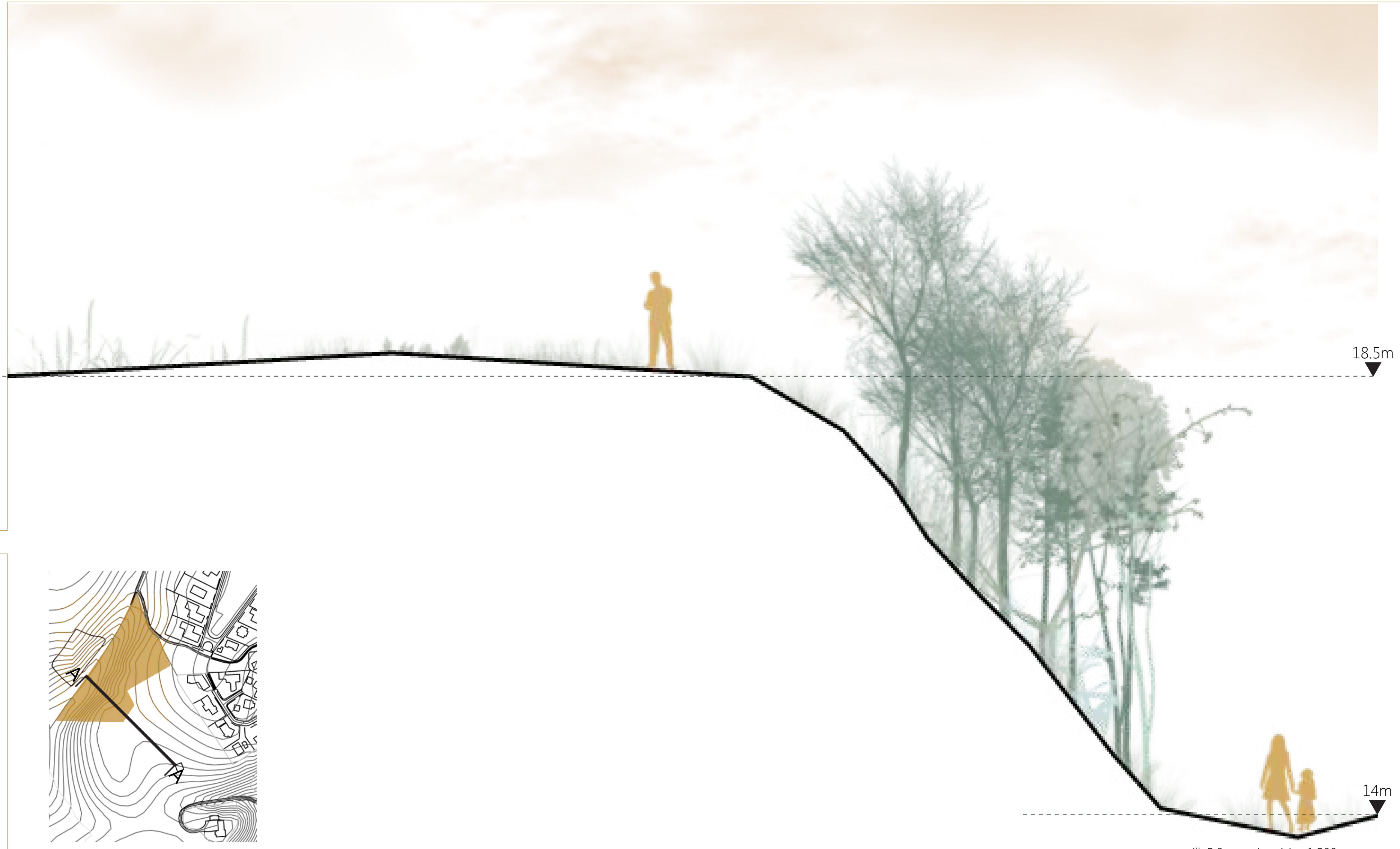
The choices of building materials, technical details, thermal envelope and overall form have to be in accordance with the microclimate conditions of the building site. As the site is located in Denmark, the building will be exposed to radical weather changes due to the Boreas influence in the north and the Atlantic to the west (Weatheronline.com 2015). Thus the mean monthly temperatures varies between 0ºC in January and 18ºC in July, while the average annual precipitation is approximately 600mm per year (Gaisma 2015) - in other areas of Denmark this number can reach a level of 900mm per year, but the location being a relative distance to the west coast decreases this number. These weather conditions calls for a building layout that provides covered outdoor areas in order to make it possible for the senior residents to spend time outside throughout the course of the year regardless of the weather. These areas should also shield from the wind, the majority of which arrives from the southwest, ill. 5.7, informing some exterior spaces with a high level of sheltering. Sun position varying between 10º (winter solstice) and 58º (summer solstice), ill. 5.6 informs an atrium solution which explores materials with low U-values, to prevent heat loss during winter, as well as low g-values, to prevent excessive heat gain during summer. The orientation of the building combined with the sun- and wind conditions causes some challenges. The desired view is towards northwest, and fortunately the late summer evenings, where the sun stays up until 10.00 pm, provides a lot of evening sunlight from this angle as well, but as the strong wind also comes from the west, there is a need to both shield and open up towards this direction.



ill. 5.6 :: Sun (Gaisma 2015)



ill. 5.7 :: Wind Rose Diagram measured at Aarhus Airport (enviroware 2012)



ill. 5,8 :: section AA :: 1:500

ill.5.9 :: context

SITE ANALYSIS: ATMOSPHERE

A varied tundra and dramatic relief of the site impose changes in both light, openness and foci. It is the aim to transmit these dramatic elements into the body of the building and the spatial atmospheres.

ill. 5.10 :: Panoramic view of site

COMPILING THE SITE ANALYSIS

The chosen site is situated in a Nordic context, in over Hornbæk near Randers, implying a certain material attention, tectonic style through a redefinition of the roots. The Nordic identity is partially defined through the use of the wooden material, which will be explored according to the architectural accessibility for its tactile qualities. The site has a historic value relating it to the Nordic context, as it depicts the remnants of the ice age through its characteristic contours, creating a plateau from which a spectacular view can be enjoyed. But the view towards the northwest is challenged by the chilling western wind, so there is a need for both shielding off and opening up towards this direction, as the northwestern direction is also the angle of the evening summer sun.

The local development plan suggests an area with a common house facility as the center of the plateau, signifying a gradient between a social sphere in this center and privacy towards the periphery. This will be further established in the layout of the co-housing senior dwellings.

6 :: PROGRAMME

The following chapter constitutes the programme for the project, and as such it is the link between the theoretical part of the project and the design part. The programme will sum up the knowledge gained from the analysis and specify the field of focus, the vision and methods for structuring the design process. This will conclude in a programming of the building, which evaluates the sizes and qualities of the spaces.

CYNOSURE

The demographic problem is approached in this project through the aim of providing dwellings for seniors which does not just make them self-reliant for as long as possible, but also applies a high level of inhabitation. Such a dwelling demands a certain level of accessibility according to the physical declination that age conveys. I propose that we can seek a new approach towards this accessibility, where the spaces are not just accessible, but make us able to interact with them through our senses.

Statistics show that there *is* a future need for more accessible dwellings, and these also have to address the residential desires of the user group, which reveals an increasing interest in living in co-housing solutions, *"bofællesskaber"*, where the neighbors develop a close relationship to each other and are able to provide surveillance, a social network and help in everyday activities. Co-housing dwellings, though being fundamentally a social residential solution, can still practise the social sphere on very different levels, as exemplified by the two senior co-housing case studies, which have inspired to the exploration of different social and private spheres relating to the dwellings. As these case studies reveal, there is a lack of attention to the accessible solutions in contemporary senior dwellings, therefore it has been my task to establish such a focus, and joining this problem to the tectonic theme, accessibility is explored as an element which evolves architecturally. I state that accessibility can be addressed on two level: a practical level, where the architecture becomes barrier-free (the spaces are accessible for all people), and a physiological level, where focus is on the influence of the tectonic solution upon the bodily state. I propose that we need to arrive at an tectonic accessibility, where both levels are practised, and that these can be linked through a phenomenological consideration. The levels are formulated into the project through inspiration from the Long House by Kawai Architects, where the tectonic principle becomes an extension of the wheelchair, and as a spatial joint with the body, inspired by the Villa Savoye by Le Corbusier and Final Wooden house by Sou Fujimoto.These ambitions of the project are formulated in the following vision:

the vision is...

...TO APPROACH TECTONIC ACCESSIBILITY THROUGH A STRUCTURAL AND SPATIAL JOINT BETWEEN THE SENIOR BODY AND THE SPACE

DEPLOYING THE SPATIAL PROGRAMME

As a means to unfold the spatial programme of the senior dwelling, the size of the dwelling is evaluated according to the expected economic circumstances of this generation. Statistics show that the majority of seniors receiving pension are able to spend aprroximately 70.000DKr (Danmarks Statistik 2014) on their dwelling per year, corresponding roughly to 5800DKr per month. A contemporary senior dwelling in Randers, in a similar context as the chosen site, shows a size of 90m^2 corresponds to this price (randersbolig.dk 2015). Co-housing for elderly being a typological hybrid between a row-house and a nursing home, it will entail qualities from both of these; the close neughbouring relationships as well as some practical, accessible solutions. Regarding the functions, the point of departure has been:

DWELLING

ENTRANCE
The entrance is the transition between the semi-public co-housing facilities and the private dwelling, and has the potential to become a central tectonic element for accessibility between these. The size has to provide space for the wheelchair to rotate 180º, approx. 2m^2, general storage and storage of the wheelchair.

KITCHEN
As the common house will facilitate a big kitchen area, there is a possibility to minimize the kitchen area in the dwellings to the function of a kitchenette. The most important tectonic relation to the wheelchair is the ability to neglect the cabinets underneath the table in order to make it possible for the wheelchair to maneuvre underneath it.

BATHROOM
The bathroom is the most critical space regarding the ability of the senior to be self-reliant, as ill 2.2 reveals that the second biggest obstacle in the dwelling for the senior is showering. Therefore, this room has to be spatious and practical. It is also the most private space in the dwelling, but because of the many practical tools for accessibility, it often gets an institutionalized character. Therefore the tectonic explorations for this space seek a new spatial solution for the shower.

MASTER BEDROOM
The master bedroom needs to be proportioned according to a master bed, and 1500mm on the one side to make it possible for the wheelchair user to access the bed from the wheelchair. 1200mm is needed on the other side of the bed in case the wheelchair user has to somehow support the partner (Heiss, Degenhart & Ebe 2010:65). This is a tectonic accessible parameter, but also the ability to make the bedridden enjoy the surrounding nature as well take part in the living room activities is part of the tectonic ambition.

POCKET SPACE

SPACE	SIZE (NETTO)	QUALITY OF LIGHT	TECTONIC ACCESSIBILITY
ENTRANCE	4 m^2 (partial integration into other space)	natural	easy access, storage space for wheelchair
KITCHEN	4 m^2 (partial integration into other space)	combination	cantilevered counter top for wheelchair access underneath
BATHROOM	7,5	inclusion of natural	cantilevered counter top for wheelchair access underneath, hand rails for toilet
MASTER BEDROOM	20 m^2	mainly natural	bed accessible from wheelchair from both sides, easy access to bathroom and closet
POCKET SPACE	10 m^2 (possible integration into other space)	combination of natural and artificial	cantilevered counter top for wheelchair access underneath, ability to open to social atrium
LIVING ROOM	26 m^2	mainly natural, very light	folding dining table, cantilevered seating, ac-cess to terrace, handrail feature
TOTAL	90 m^2		
PRIVATE CLOSETS	6 m^2	artificial	
COMMON HOUSE	100 m^2	natural and artificial	cantilevered kitchen counter top for wheelchair access underneath, view to both nature and gathering area in atrium, include a terrace

ill. 5.1 :: spatial programme

The additional bedroom is for use as a link between the dwelling and the atrium, the private and the social sphere. This space can have functions such as an extra living room, a hall, a hobby space or the like.

LIVING ROOM
The living room will be the space in which the residents spend most time, and therefore it will be the space focusing on inhabitation of the structure. On a practical level, it needs to be spacious enough for the wheelchair to move around the furniture.

COMMON FUNCTIONS

COMMON HOUSE
As inspired by the Ådalen 85-case study, the common house will provide the durroundings for a daily gathering around the dinner meal monday to friday every week. Therefore this house has to entail an industrial-like kitchen, with a cantilevered counter top as the tectonic accessible parameter, wardrobe facility and a spatious toilet. This facility will also be used for family parties for the residents, and can possibly be a rental facility for the surrounding neighbours.

ATRIUM
As a central space for the social life of the "bofællesskab", the atrium is the tectonic accessible element of the building scale. It should be a space for greenhouse-like, landscape space with possible interaction from dwelling to dwelling, niches for conversations and a central space for gathering with a view to the surrounding nature and neighbours. As the local development plan does not allow private gardens, this atrium is proposed as a semi-public 'garden' for the residents as well as for the neighbours, as a part of a path in the

landscape

WASHHOUSE
As a place for informal meetings in the daily life, again inspired by Ådalen 85, a common washhouse is a supplemental function for the programme.

WORKSHOP
"The joy is not in owning, but in creating" - was the philosophy of Jørn Utzon, and as a gesture of supporting joined creation, reparation and self-help of running the physical surroundings of the "bofællesskab", a workshop facility is incorporated to the building complex. This is a facility which surrounding neighbours can possibly make use of, hereby strengthening the community feeling into a bigger coherence.

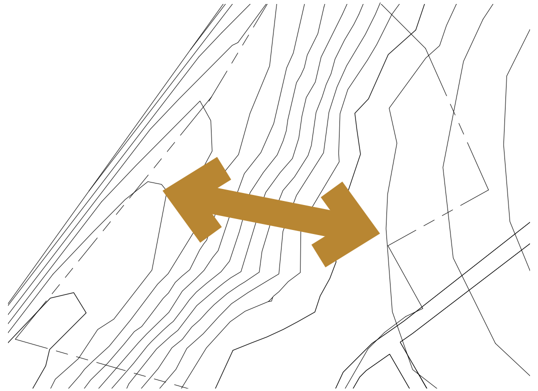
TYPOLOGICAL CONSIDERATIONS

Through the ambition of approaching tectonic accessibility, I cannot neglect that I am also creating a new typology, as I am proposing a rethinking of the relation between wall and floor as t architectural elements. The relation between wall and floor forms the means for tectonic accessibility, as I see the potential of the wall to undertake some of the tasks that are continuously assigned to the floor. This new typology is really a typology of perception, of a re-joining of the universal body and the space, hereby becoming universal, but rooted in the Nordic, cf. the theories of Pallasmaa (2012).

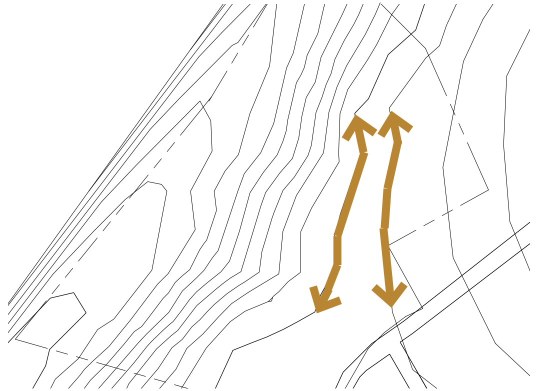
7 :: DESIGN PROCESS

INTRODUCTION

As a master thesis student, I believe that the design process is just as important and informative as the actual design proposal, as this is the part of the project upon which we are actually able to reflect and improve from. The processes leading towards a design process can teach us a lot about creativity, how we help it to thrive and how we sometimes risk killing it. The following pages will therefore depict some of the main processes that have led to the design proposal, in a simplified, presentable manner, not able to fully reflect the complex balance between order and chaos of any design process.

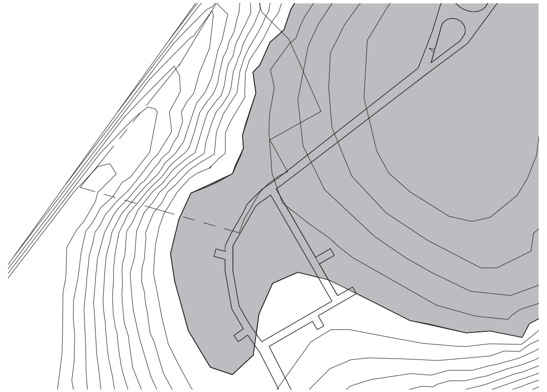

ill. 7.1a :: 1:1500 :: building organization along slope

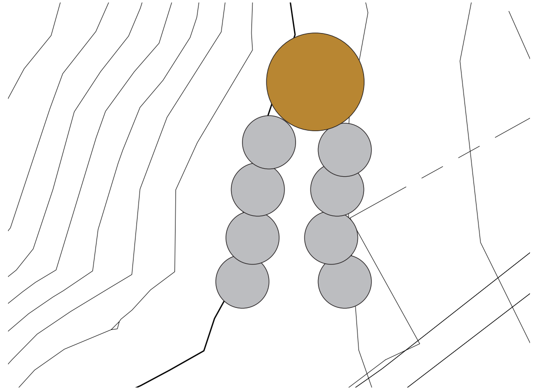

ill. 7.1b :: 1:1500 :: building organization on a line along wedge

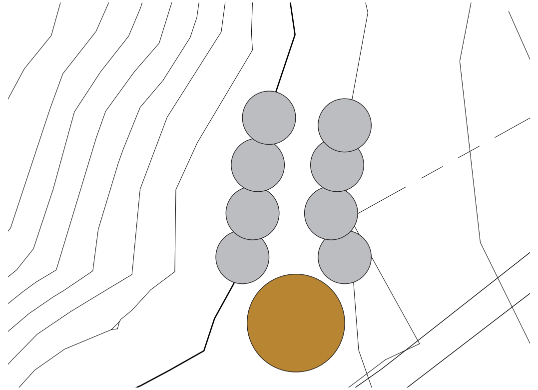

ill. 7.1c :: 1:1500 :: building organization defined by wedge

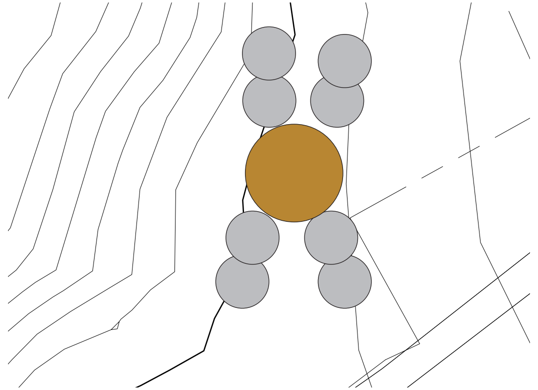
1 :: TECTONIC ACCESSIBILITY ON SITE LEVEL :: BUILDING ORGANIZATION

From the site analysis it was revealed that the site is defined by the previous ice age by a glacier, which has moulded the site into its current topography with a plateau, ill. 7.1d. I explored three approaches to the site; ill. 7.1a where the building descends down along the slope, but which creates some obvious challenges regarding accessibility, needing a lot of ramps and stairs. Ill. 7.1b explores a building which is oprganized along the edge of the wedge, a row house-variant depicting the curvature of the wedge. This let to the third and final approach, where the building is defined by the form of the wedge. This idea was informed by the case study of "Ådalen 85", where the dwelling units are organized as two stocks, makng room for an atrium in between them as common area. Two structural walls along the wedge form the spine of the building, defining both landscape, building form and the trasition between private and public in the building as inspired by Svere Fehns *Villa Busk*.


ill. 7.1d :: 1:3000 :: plateau level defining building plot


ill.7.2a :: 1:750 :: building organization along slope


ill. 7.2b :: 1:1500 :: building organization along slope

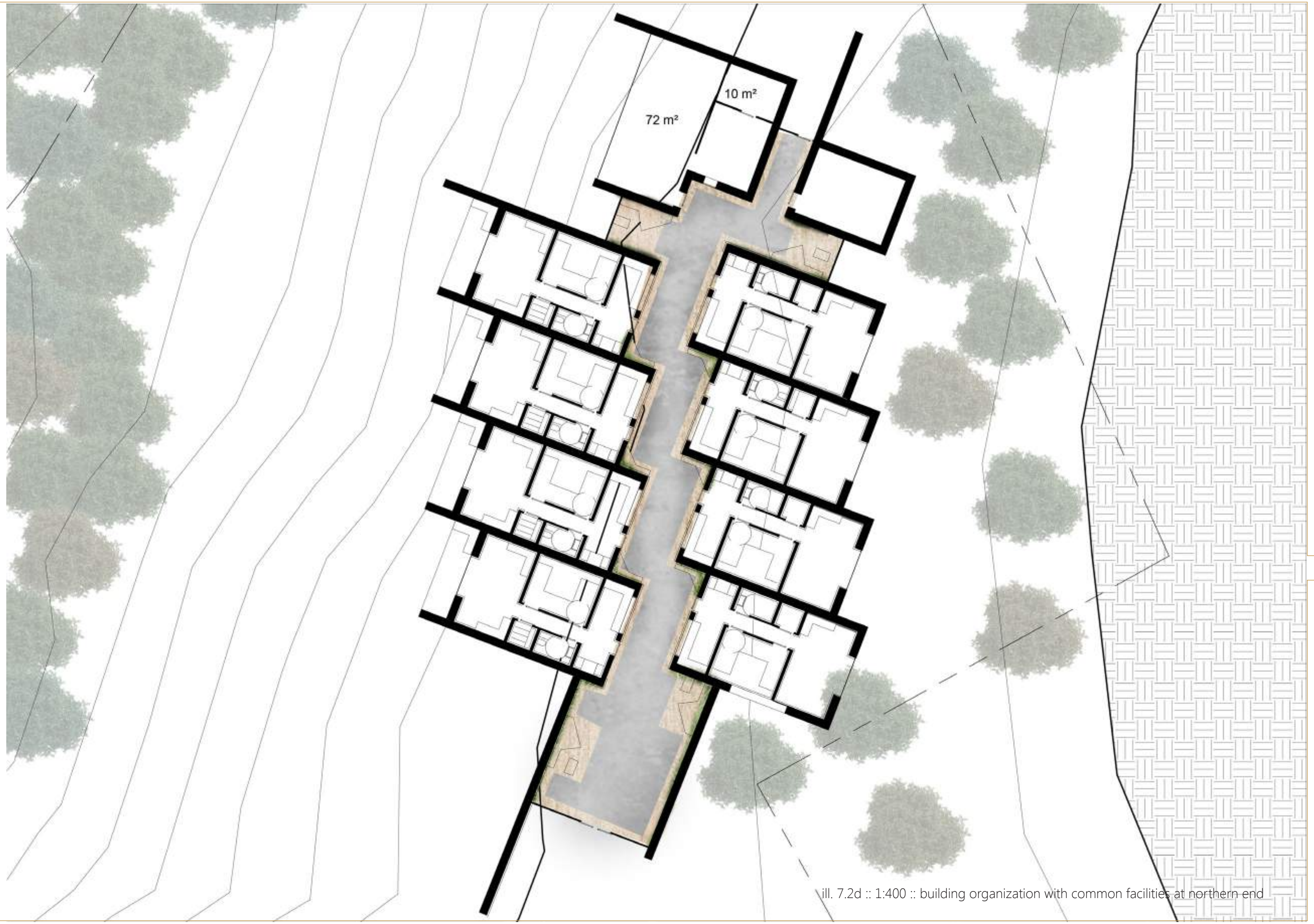

ill. 7.2c :: 1:1500 :: building organization along slope

2 :: TECTONIC ACCESSIBILITY ON BUILDING LEVEL :: CO-FUNCTIONS

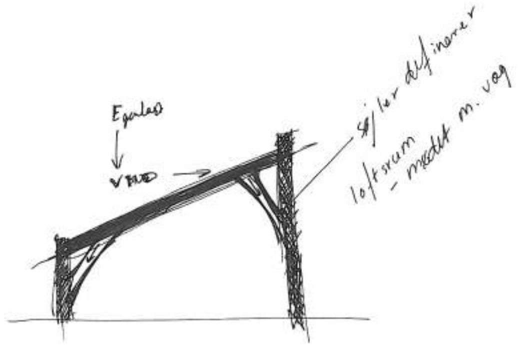
The common functions of common house and gathering area in the atrium have been explored in three positions; at the northern end of the site, ill.7.2a, where they act as a climax of the building, but may feel detached. Placed at the southern end of the site, ill.7.2b, they state an unwanted hierarchy between private and public, whereas they pose a more humble social gathering in the middle of the building, while differentiating the flow through the building, ill.7.2c.

2 :: ILLUSTRATING COMMON FUNCTIONS AT NORTH END

During part of the process, it was chosen to place the common facilities at the northern end of the building, as a variant of 7.2a. This plan solution, as depicted in ill.7.2d, was relatively strict and rigid, though, with little opportunity for "kiss-&-go"-spaces; spaces where the residents can meet casually and sit down for a small-talk. The placement of the common spaces at one end also makes this end a "dead end"; an area which is dead, dark and silent when not in use. Therefore, the design process took a new iteration from this point.



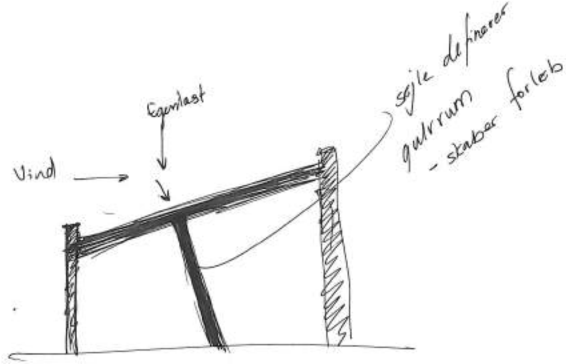
ill. 7.2d :: 1:400 :: building organization with common facilities at northern end



3 :: TECTONIC ACCESSIBILITY ON BUILDING LEVEL :: STRUCTURE

As a central part of the tectonic accessibility on building level, the roof structure of the atrium has been explored in relation to the spatial experience. Originally arriving from the idea of using frames as spatial dividers, as evaluated in appendix 2, concrete walls with wooden beams on top was instead chosen for the higher fire resistance of the concrete as well as better air sound insulation. As the roof material is chosen to be a partial light transmitting one (the polycarbonate sheets), the structure has the potential to mould the light reflected into the space underneath, hereby becoming a guiding gesture of the flow. As the space is a

ill. 7.3a :: structure 1 :: three-dimensional beam defining glass element

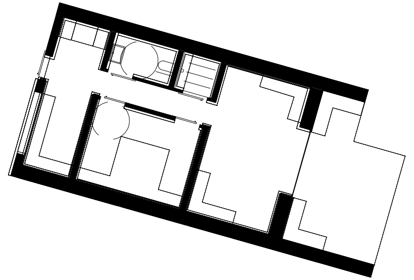


very differentiating, almost landscape-like, the structure should on the contrary be relatively calm. A structure composed of beams and purlins was chosen, and different variations of it has been explored; two of these variants are depicted in ill. 7.3a-b, one which explores the structure reaching down into the atrium, but emphasizes the wall more the than the actual space, and the other which creates an enlightening emphasizing of the flow.

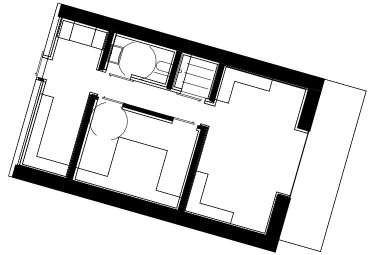
The idea of the structure constructing the light, the light which constructs a flow, has inspired the final structural expression.

ill. 7.3b :: structure 2 :: the purlins of the structure creating a herringbone pattern which defines glass partitions that simulate the flow on the ground

ill. 7.2a :: plan 1



ill. 7.2b :: plan 2

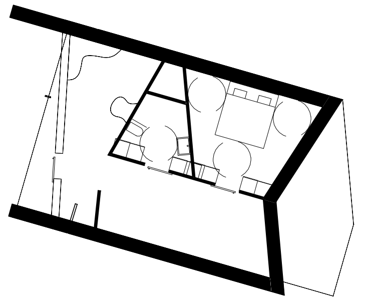


ill. 7.2c :: plan 3

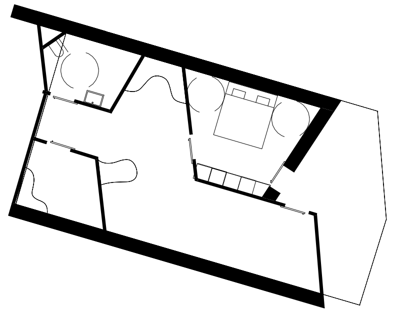
4 :: TECTONIC ACCESSIBILITY ON DWELLING LEVEL :: PLAN IDEATION

The analysis of the site and the analysis of the theme of accessiblity arrived at a synthesis of developing a dwelling where the furniture are formed from the walls; a spatial joint making it possible to inhabit the spaces with a whhelchair. The plan development has evolved from this point of departure, seeking to make the furniture space defining.

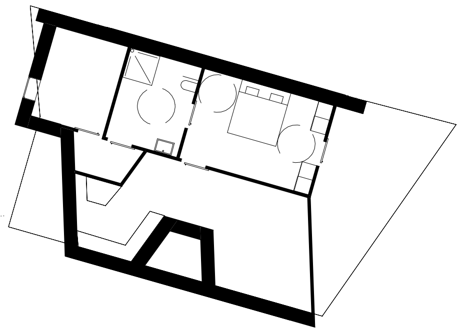
The first plan proposals struggled to define this formation, ill. 7.2a-c, until a more organic formal language was explored, ill. 7d-f, and the



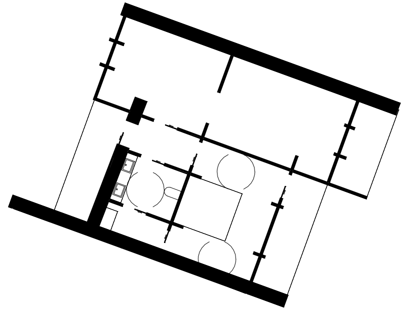
ill. 7.2d :: plan 4



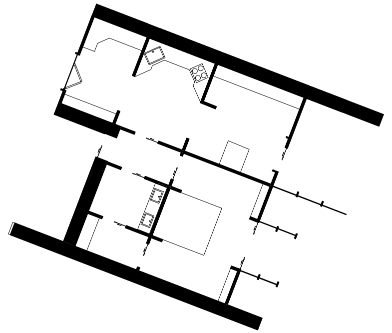
ill. 7.2e :: plan 5



ill. 7.2f :: plan 6

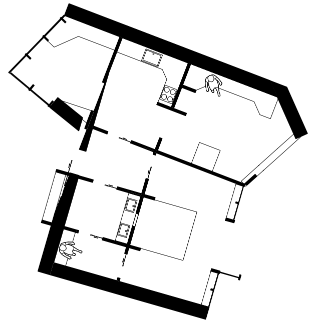


ill. 7.2g:: plan 7

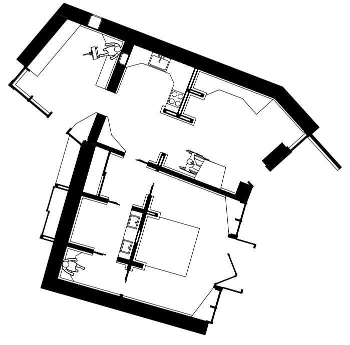


ill. 7.2h:: plan 8

idea of using the walls as embracing elements for the furniture surfaces, ill. 7.2g. This approach gave identity to the plan, defined the spaces, as well as it continued the formal language of the section, which also is defined by a horizontal element reaching out from the wall to reach the inhabitant. The dwelling is further moulded together with the overall building, to make the dwelling define the space of the common atrium through the 'pocket space'; a new spatial typology introduced as a transfer between the dwelling and the atrium, ill. 7.2h-j.



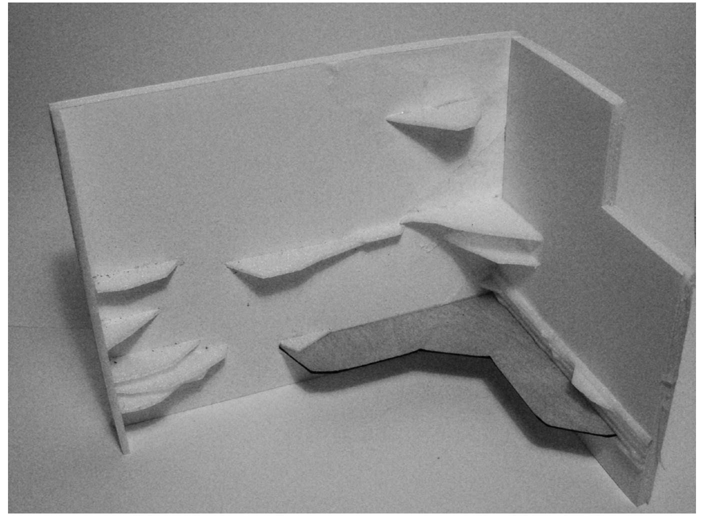
ill. 7.2i:: plan 9



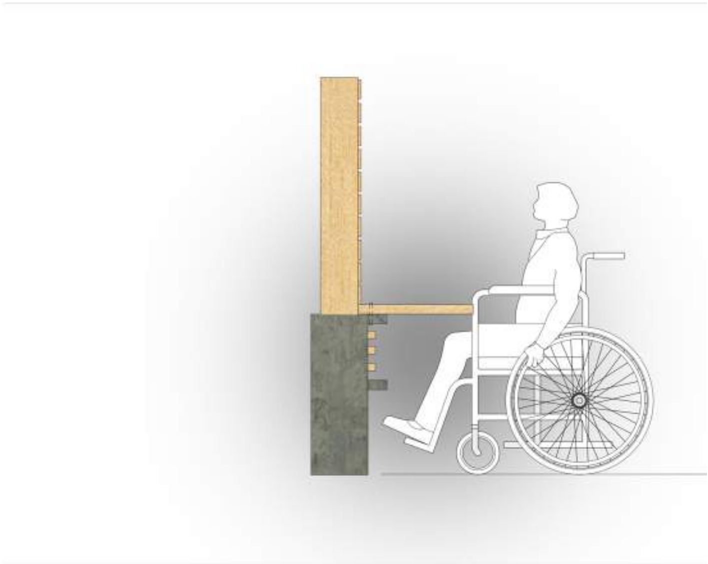
ill. 7.2j:: plan 10

5 :: TECTONIC ACCESSIBILITY ON DETAIL LEVEL :: THE SPATIAL JOINT

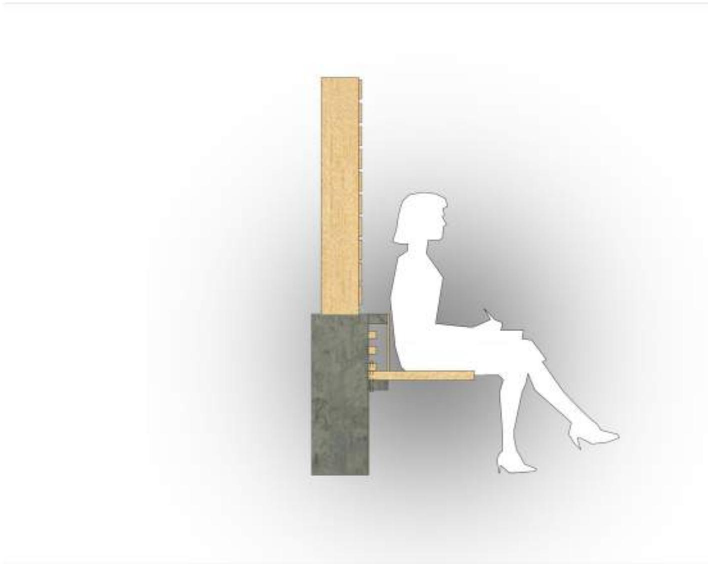
Departuring from the idea of concrete irregular surfaces growing from the wall, ill. 7.5a, as references to the glaciological amalgamation of the site, the spatial joint developed into a less literate one, where two concrete ribbons along the wall defines the body-spatial zone, ill. 7.5b-c. This spatial joint is emphasized by a material joint; the meeting between wood and concrete, with concrete as the earthbound mass and wood as the leightweight filigree. The spatial joint developed from this into the simpler, more clarified single ribbon.



ill. 7.5a :: model of glacier-inspired spatial joint

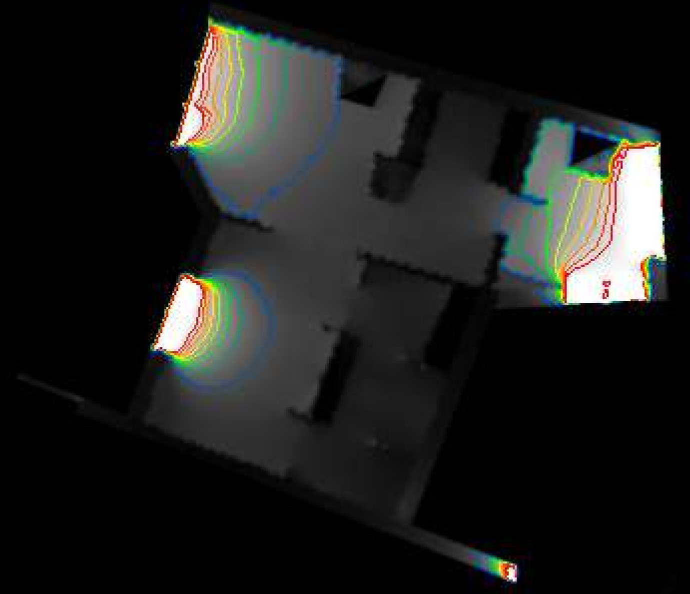


ill. 7.5b :: counter top surface of spatial joint



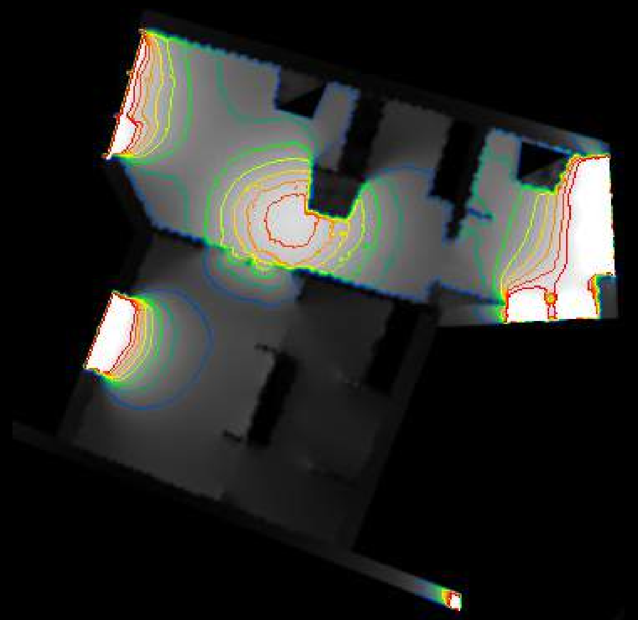
ill. 7.5c :: seating surface of spatial joint

DAYLIGHT STUDY 1



ill. 7.6a :: daylight brough in only through facades

DAYLIGHT STUDY 2



ill. 7.6b :: daylight introduced through skylight

7 :: DESIGN PROCESS

6 :: DAYLIGHT IDEATION

As I propose that tectonic accessibility is about sensuous activation as a spatial joint, the use of daylight is an important parameter for the spatial interaction. Initially, the daylight was introduced to the dwellings only through the walls; in the 'pocket' bringing in daylight from the atrium, and in the living room and master bedroom bringing in the daylight from exterior, ill. 7.6a. Causing a relatively dark central area near the kitchen, a skylight is introduced in this area, ill. 7.6b, emphasizing this area as the joint between the sojourning section and the sleeping section of the dwelling, as well as the joint between a social and a private section of the dwelling.

7 :: COMPILING THE DESIGN PROCESS

Though any design process is a matter of both order and chaos, the chapter has presented to you a simplification of some of the main design elements of this project of tectonic accessibility. Though my point of departure was a detailing spatial joint, I propose that tectonic accessibility is a theme affecting all scales of an architectural engineering project, and through this design process I have therefore sought to explore the potential of it in all scales. As this chapter was the final step of explaining the outcome of this project, it is now my intention to conclude and reflect upon both the process as well as the design proposal in the following epilogue.

8 :: EPILOGUE

CONCLUSION

With the impaired body as a tectonic catalyst, this project proposes a new approach towards a universal accessibility; an accessibility which arrives from the structural and spatial joining, generating a principle which triggers a sensoric activation within the impaired as well as the hale body.

Situated in the hilly, glaciological landscape of eastern Jutland, the project proposes that accessibility is not a matter of a planar site; but that we make all kinds of landscapes universally accessible, providing the experience of ascending and descending and changing of the perspective. This is a tectonic accessibility on a master plan level.

On building level, tectonic accessibility deals with the choice of interacting socially or to recede from the social sphere. Inspired by the Ådalen II-case study, this is physically manifested in this project through the atrium - a climatic buffer zone physically extending the dwelling, and thereby also the mental body space. This space has been the structural focus as well, developing a structure which constructs the social sphere, but also constucts a light experience and a pattern of movement.

The dwelling continues this idea with a pocket space as link between dwelling and atrium; through this space, it is possible to invite the social sphere into the dweling. Depending on the residents' inhabitation of this space, it can vary between characterstics of a patio, a hall, an outdoor kitchen, an atelier, a workshopspace, a dining room, living room etc.

On detailing level, the project explores spatial joining in both furnitures as well as the wall as structural element. The glaciology of the site has inspired to a horizontal surface along the walls with a supportive gesture as a handrail, but also as a joint between bodily proportions and tactility of materials. This element was explored as solution for the furnitures as well, and hereby it became the tectonic solution for the coutner tops in i.e. kitchen and bathroom and seating surfaces. A high level of joining the body and the space is thus achieved from the ability of the wheelchair to move around the space freely, cf. the theories of Fich. et.al. about relation between stress and freedom of movement, but also to interact with the dwelling through the sensoric experience of structure, material, surface and light, through which it has been the attempt to permeate the dys-appearing filter of the impaired body., cf. the phenomenological theories of philosopher Drew Leder.

From the established theories related to the theme of this project, a new theory has been developed from which an approach towards a tectonic accessibility evolved.

THE AIM OF THE THESIS
Through the choice of theme for this thesis, it has been the aim for me to advance my knowledge about the relation between the body and the space. This knowledge has been investigated through a point of departure in the impaired body and the theme of accessibility, as this field has the potential to teach us a lot about spatial acitvation of the senses.

REFLECTION

I would like to take a different approach to reflecting upon this project. During the finalization of the project, I discovered a project by Frank Lloyd Wright which in many ways incorporates my thoughts upon the theme of tectonic accessibility, the Kenneth Laurent House from 1952. Therefore, I would like to conduct a spatial analysis on this project, from which I will reflect upon my own design proposal. The aim of doing this analysis is not to praise the Laurent House as a sort of 'correct' solution to tectonic accessibility, but rather as a point of departure for discussing how tectonic accessibility can inform an architectural engineering thinking.

As it is my hypothesis that the architectural expression should arrive from the tectonics of accessibility as a sensoric triggering, I have been lacking an method for analyzing how this can be approached. This has caused my struggle in finding a suitable work as case study for the project, and I have now realized that I should have constructed my own method for analyzing in relation to my theme. Instead, I

ill. 8.1 :: wheelchair-inhabitable table counter top

8 :: EPILOGUE

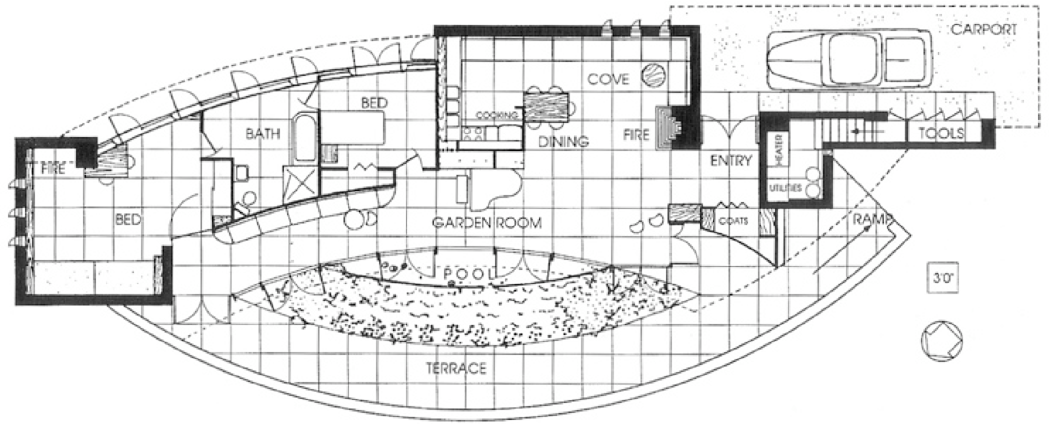
will conduct this analysis as a reflection upon my project, and as analytical theory, I will construct a method as a hybrid between the method developed by Marie Frier Hvejsel in her "*Interiority - a critical theory of domestic architecture*" (Hvejsel 2011). I will use her notion of 'gesture', the emotional gesticulation that a detail evokes, and 'principle', the structural build up of the detail, combined with the fifth aspect of Lise Bek's "Arkitektur som rum og ramme" (Bek 2000); the visual-experiential and aesthetic aspect. This aspect discusses which elements are utilized as artistic-aesthetic effects and how the experiencing subject receives an expression of- and inhabits the space. The combination of these constructs a discussion of the relation between scales, as I am not analysing the project as a whole, but instead analysing how the horizontal ribbons constitute a spatial joint.

The Kenneth Laurent House was designed for a wheelchair-bound resident; Kenenth Laurent was paralyzed during his service in the World War II, and they contacted Frank Lloyd Wright for his thoughtful designs and open floor plans (laurenthouse.com)

The wall as architectural engineering element basically signifies a vertical boundary. Though

ill. 8.2 :: principle of horizontal ribbons arriving from the wheelchair movement

it is born from the drawing as horizontal line, dividing spaces horizontally, the human body interacts with it as a vertical element, moving along and around it, whereby it constructs a horizontal movement. Depending on the proportions of it, the wall as element can be perceived as both a vertical and a horizontal element, but the movement it generates will always be a horizontal one. The ribbons of the Kenneth Laurent House 'gestures' a both guiding and following element in the movement according to it. The 'principle' of it being a layering of the wooden cladding, it substantiates the layering of the space, proportionalizes the walls into furnituring zones, or zones for different kind of inhabitation. Some of the ribbons create seatings, ill. 8.2, others create table surfaces, ill. 8.1, and others again create shelves. Thus, a hierarchy of the wall is engraved by the ribbons. When bound to a wheelchair, the movement is even more restricted to horizontality, and the horizontal ribbons dissolves the verticality of the wall into an element on the premises of the wheelchair



ill. 8.3 :: plan drawing of Kenneth Laurent House

ill. 8.4 :: detailing arriving from the ribbon principle of layering

proportions. When looking at the layered wall of ill. 8.2, you can quite clearly imagine the change of perspective emphasized by the lines of the ribbons, and they give you a higher awareness of your bodily height, while your eyes will move along one of the ribbons as you move along the wall. Thus, the detail also affects the furnituring and the building scale, and the sensoric experience, the tectonic accessibility, becomes the architectural expression, thereby enclosing all the senses into aesthetics.

The house practices two primary materials; the wood and the masonry, and clearly distinguishes the different interaction with the walls according to these materials. The masonry walls are stripped from the ribbons, whereby Wright identifies these as 'background' walls, not for direct interaction and inhabitation, whereas other walls are cladded with the wooden material together with the ribbons, identifying these as the phenomenologically interacting, inhbaitable walls, ill. 8.3-4. Frank Lloyd Wright was clearly ahead of his time with this project regarding a new approach towards accessibility. Many of his thoughts in this project is developing today as an awareness of the phenomenological consequences of being bound to a wheelchair. What this analysis proves about tectonic accessibility,and what my master thesis has proved to me, is that tectonic accessibility is really about a rethinking of the relation between the two most fundamental elements of architecture: the wall surface and the floor surface, the very basic two elements that Sverre Fehn also used for the creation of a place at his Villa Busk.

I believe that a new awareness of sensous architectural activation can evolve if we become able to understand the processes the Frank Lloyd Wright seems to have explored in this project. This architectural expressivity and phenomenological effect has been the scope which I have attempted to explore through this project. Though it was really my intention to make it evolve as a principle within all scales of the project; detail as well as structure, the final proposal does not wholly depict this vision. One of the reasons for this should probably be found in the fact that I worked from the smallest scale, the detail, and sought to arrive at a principle on the larger scales, plan and structure. Though I managed to mould the plan according to the 'embracing' gesture of the detail, it was initially my intention to arrive at a more spatial structural principle.

This master thesis has taught me lot about humbleness towards the archtiectural scales; I have critisized the new structuralism for its lack of attention towards details, but I also acknowledge that the grand scales are the means for existence of the detailing scale, and that our phenomenological experience of a space encapsulates all the scales, and as such, as spatial joint is more than a physical manifestation of the space reaching out; a spatial joint is has to involves all the elements composing an architectural piece, and this is where tectonic accessibility can become architecturally generating.

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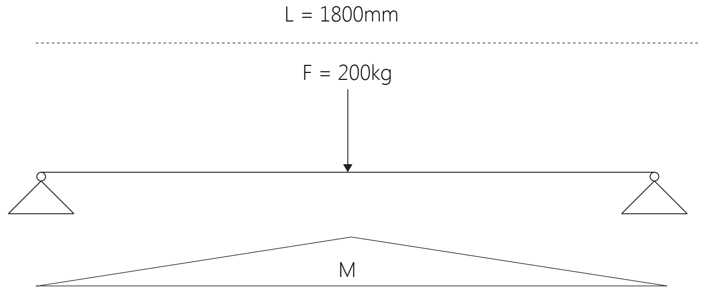
8 :: EPILOGUE

9 :: APPENDIX



ill. 9.1 :: Diagram of load and moment

APPENDIX 1 :: CALCULATION FOR COUNTER TOP

The following calculations are for a simple deflection from a quasi-permanent load, taking into account an increased stiffness from a non-cracked rectangular cross section with tension reinforcement. The non-cracked condition corresponds to the tension stress of the concrete reaches the average tension strength, fctm. . Ill. 8.1 shows the load and moment diagram. For deflections, the height of the beam has to be at least 1/20 of the length. As the length is three kitchen cabinets = 1800mm (ill. 9.1), the height has to be at least 90mm. With beam dimensions of 0.09mx0.04m, the minimum and maximum areas of reinforcement becomes (Jensen 2011, formula 3.21):

Self load of beam, dimensions 40mm X 90mm X 1800mm: g =2400kg/m³*0.04m*0.09m*1.8m*9.82m/s² = 0.15kN/m

Checking for degree of reinforcement:

$$A_{s,min} = \frac{f_{ctm} * A_c}{f_{yk}} = \frac{2.9MPa * (0.09m * 0.04m)}{550MPa} = 19mm^2$$

$$A_{s,max} = 0.04 * A_c = 0.04*(0.09m*0.04m) = 144mm^2$$

As the area of reinforcement is $2*\pi*r^2 = 2*\pi*4^2 = 100.5mm^2$, it is concluded that the cross section is normally reinforced.

With a point load in the middle of the 1.8m beam of 200kg, q is 1.0kN/m. c/c of the reinforcement is 20mm, and the height of it is also 20mm.

Concrete C30: $f_{ck} = 30MPa$

$$f_{cd} = \frac{f_{ck}}{\gamma_c}$$

$$\gamma_c = 1.45 * \gamma_3$$

$$\gamma_3 = \text{control class} = 1.0$$

$$f_{cd} = \frac{30MPa}{1.45} = 20.6MPa$$

$$\lambda = 0.8$$

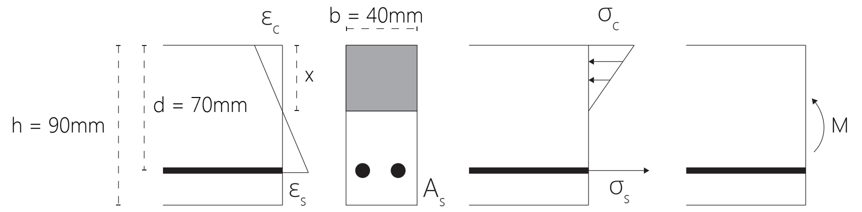
$$\eta = 1.0$$

$$\varepsilon_{cu3} = 0.35\%$$

Steel Ø8: $f_{yk} = 550MPa$

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{550MPa}{1.2} = 458.3MPa$$

$$E_s = 0.21*10^6 MPa$$



ill. 9.2a-c :: a) diagram of strains b) cross section c) diagram of stresses d) diagram of section forces

SERVICE LIMIT STATE
The use of the construction defines the allowable deflection, which for quasi-permanent (long-term) load is defined for dwellings to be **l/250 = 560mm/250 = 1.12mm** (Jensen 2008:89) **The quasi-permanent load is** given by (Jensen 2008:93):

$p_1 = g + \psi_2 * q$

$\psi_2 = 0.2$

$q = 1kN/m$

$p_1 = 0.15kN/m + 0.2*1kNm = 0.35kN/m$

Wehereas the characteristic load is:

$p_2 = p + q = 0.15kN/m + 1kN/m = 1.15kN/m$

And the short-term load is the difference:

$p_0 = p_2 - p_1 = 1.15kNm - 0.35kNm = 0.8kN/m$

We need to find the maximum stresses of both concrete and reinforcement. For concrete, this is at the edge of the force induction, as shown in ill. 9.2a-c (Jensen 2001, formula 5.65-66):

$$\sigma_{c,max} = \frac{M}{\varphi_b * b * d^2}$$

$$\sigma_{s,max} = \alpha\gamma\sigma_{c,max}$$

$$\alpha\rho_{long\text{-}term} = \alpha\frac{A_s}{b*d} = 34 * \frac{100.5mm^2}{40mm*70mm} = 1.22$$

$$\alpha\rho_{short\text{-}term} = \alpha\frac{A_s}{b*d} = 8.5 * \frac{100.5mm^2}{40mm*70mm} = 0.04$$

$$\alpha_{long\text{-}term} = 34$$

$$\alpha_{short\text{-}term} = 8.5$$

Long-term load:

$$M_\infty = p_1{*}L = 0.15kNm{*}1.8m = 0.27kNm$$

$$\sigma_{c,max} = \frac{0.36 * 10^6}{1.25 * 40 * 70^2} = 1.46MPa$$

$$\sigma_{s,max} = 34 * 0.306 * 1.46MPa = 15.2MPa$$

Short-term load:

$$M_0 = p_0{*}L = 0.8kNm{*}1.8m = 1.44kNm$$

$$\sigma_{c,max} = \frac{1.44 * 10^6}{0.133 * 40 * 70^2} = 0.8MPa$$

$$\sigma_{s,max} = 8.5 * 1.32 * 0.8MPa = 55.2MPa$$

Total stress of reinforcement:

15.2MPa+55.2MPa = 70.4MPa

- as this is considerably lower than $0.8{*}f_{yk}$ = 0.8*550MPa = 440MPa, it is reasonable to assume that there will not be any unacceptable deformation or cracks (Jensen 2008:88). In case the tension stress of the reinforcement exceeds $0.8{*}f_{yk}$, unelastic strains, too big cracks or deformations might be present.

In order to verify an acceptable deformation, I will calculate the deflection, which for a simply supported beam is found by (Jensen 2008,

formula 4.82):

$$u_{max} = \frac{1}{10} * \alpha\frac{\sigma_c}{E_s * x}l^2$$

For long-term load:

$$x_\infty = \beta * d = 0.766 * 70 = 53.6mm$$

$$u_{max,long\text{-}term} = \frac{1}{10} * 34\frac{1.46MPa}{0.21*10^6*53.6mm}1800mm^2 = 1.43mm$$

For short-term load:

$$x_0 = \beta * d = 0.246 * 70 = 17.22mm$$

$$u_{max,long\text{-}term} = \frac{1}{10} * 8.5\frac{0.8MPa}{0.21*10^6*17.22mm}(1800mm)^2 = 0.6mm$$

As none of these exceed the allowed 7.2mm, we can conclude that the counter top is sufficiently reinforced - in fact we can conclude, that it is possible to reduce the amount of reinforcement, or to change it to another class of strength. On the other hand, the counter top is a very visual element in the dwelling and close to eye level in height, even a small deflection will be visible, thus it would be wise to remain at the deflection of 1.43mm.

APPENDIX 2 :: STRUCTURAL CALCULATIONS

As part of the tectonic vision for the atrium, the design process of the structure is an integration of the digital design tools for a remodeling of the structure towards a synthesis between optimizing the structure and evaluating daylight and the spatial gesture of the structure.

CALCULATING THE ACTIONS

The structure is dimensioned according to the local conditions of the climate and the terrain, as specified in the site analysis pp. 80-84. The Danish context is subdued to the Eurocodes, which specifies the dimensioning according to the safety of the people using the building. The actions and loads on the structure are chosen to be combined in relation the Ultimate Limit State, for failure and deformation of the structural member (STR) with permanent and temporary design situations.

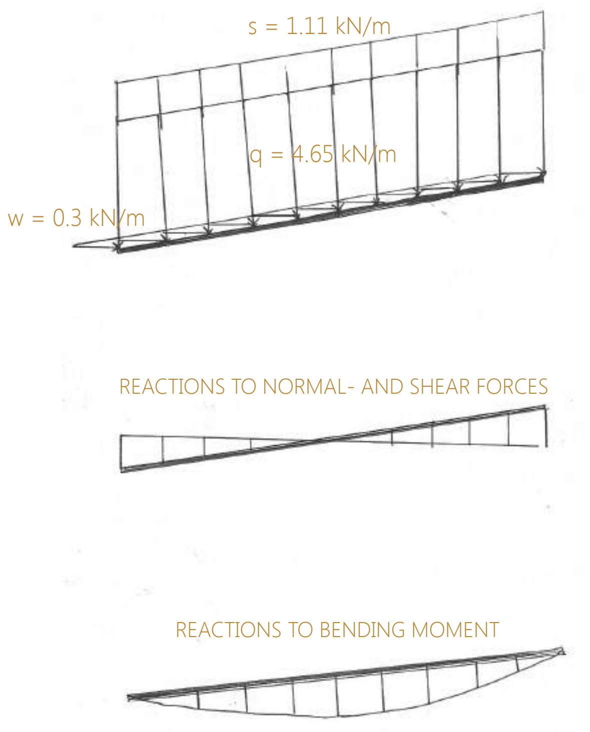
Permanent actions, self-load:

The self-load is constituted by the load of the roof construction and the load of the structure itself. For the creation of the snow-white, soft light, a skin of Riatherm polycarbonate plates with a weight of 0.3kN/m² is chosen for its low U-value of 1.1 W/mK, reducing the heat loss during wintertime, combined with a low g-value of 0.3, reducing the heat gain during summer.

Variable load, wind:

The wind load affects the structure with both pressure and suction, according to the direction of the wind and the building form. The following wind calculations are conducted based on Eurocode 1.1-4 and the relating annex. The calculations of the wind load includes

- Mean wind velocity, $v_m(z)$
- Wind turbulence, σ_v
- Peak velocity pressure, $q_p(z)$



ill. 9.3 :: actions on beam and reactions

- Wind forces on roof, F_w

The wind rose diagram on p. 81 shows that the wind primarily comes from west, and the wind load is therefore calculated based on this direction.

MEAN WIND VELOCITY:

In the following calculations, the following specifications are used:

- Terrain category III
  -> $z_0 = 0.3m \wedge z_{min} = 5m$

$v_m(z) = c_r(z) \cdot c_0(z) \cdot v_b$
(formula 4.3 in Eurocode 1.1-4)

where:

z = height of structure = 6m
vb = 24m/s (National annex p.2)
z_{min} = 5m (Table 4.1 Eurocode 1.1-4)
z_{max} = 200m (p.20)
$z_{0,II}$ = 0.05 (Table 4.1)

$c_r(z)$ = roughness factor, which accounts for the variability of the mean wind velocity at the site of the structure due to I) height above ground level and II) ground roughness of the terrain upwind of the structure in the wind direction considered. As the structure is higher than the 5m defined according to the terrain category, the roughness factor is defined by;

$c_r(z) = k_r * \ln\left(\frac{z}{z_0}\right)$ for $z_{min} \le z \le z_{max}$

z_0 = roughness length = 0.3m (Table 4.1)

$k_r = 0{,}19 * \left(\frac{z_0}{z_{0,III}}\right)^{0.07} = 0{,}19 * \left(\frac{0.3}{0.05}\right)^{0.07} = 0.22$

$c_r(z) = 0.22 * \ln\left(\frac{6}{0.3m}\right) = 0.65$

$c_0(z)$ = orography factor: is determined based on annex A by:

$\Phi = \frac{H}{L_u} = \frac{6.5m}{166.9m} = 0.03$

Φ = is the upwind slope in the wind direction
H = effective height of feature
L_u = actual length of the upwind slope

$C_0(z) = 1+2 \cdot s \cdot \Phi$ for $0.05 < \Phi < 0.3$

$= 1+2 \cdot 0 \cdot 0.086 = 1.0$

s = determined from figure A.2 = 0

$v_{m(z)} = c_r(z) \cdot c_0(z) \cdot v_b = 0.65 \cdot 1.0 \cdot 24m/s = 15.8m/s$

WIND TURBULENCE:

Standard deviation of the wind turbulence is:

$\sigma_v = k_r * v_b * k_I$ (formula 4.6)

$k_I = 1.0$ (p. 21)

$= 0.22*24m/s*1.0 = 5.2\ m/s$

$l_v(z) = \frac{\sigma_v}{v_m(z)}$ for $z_{min} \leq z \leq z_{max}$ (formula 4.7)

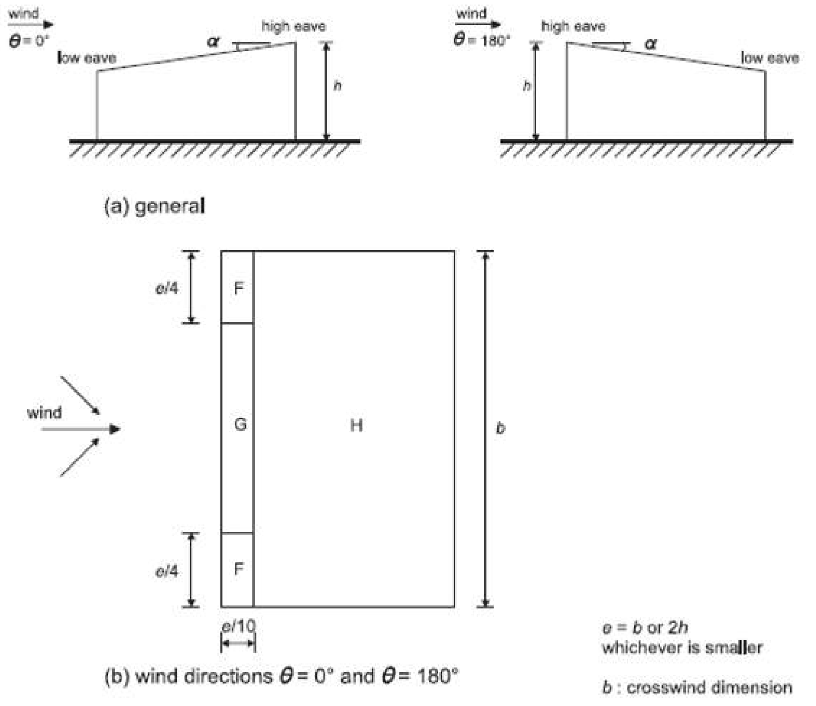
$l_v(z) = \frac{5.2m/s}{15.8m/s} = \underline{\underline{0.33}}$

Turbulence intensity:
PEAK VELOCITY PRESSURE:

$$q_{p(z)} = [1 + 7 * l_v(z)] * \frac{1}{2} * \rho * v_m^2(z)$$

The peak velocity pressure depends on the mean- and short-term fluctuations:

$l_v(z)$ =turbulence intensity = 0.33 from



ill.9.4 :: division of roof form into zones

previous calculation

ρ = air density = 1.25kg/m³

$v^2_m(z)$ = mean wind velocity = 15.8m/s from previous calculation

WIND FORCES:

$F_w = c_s c d_, \Sigma w_e A_{ref}$ (formula 5.5)

The wind forces are calculated based on the external wind pressure on the structure:

$c_s c_d$ = the structure factor = 1.0 (for buildings lower than 15m)

A_{ref} = reference area of the individual surface

W_e = external pressure on the

$w_e = q_p(z_e) * c_{pe}$ (formula 5.1)

Z_e = reference height for external pressure

individual surface at height z_0,
and depends on the form of the surface

z_e = reference height for external pressure

C_{pe} = pressure coefficient for external pressure

The structure is monopitch, thus it is divided into zones as given in ill. 9.4:

Zone F:

Area: (1.2m*6) = 7.2m²

$C_{pe,1}$=-0.9 $C_{pe,2}$= +2.0 (Table7.3a)

1: $w_e * A_{ref} = \left(\frac{0.46kN}{m^2} * -0.9\right) * 7.2m^2 = -2.9kN$

2: $w_e * A_{ref} = \left(\frac{0.46kN}{m^2} * 2.0\right) * 7.2m^2 = 6.6kN$

Zone G:

Area: (57m*1.2m) = 68.4m2

$C_{pe,1}$=-0.8 $C_{pe,2}$= +0.2 (Table7.3a)

1: $w_e * A_{ref} = \left(\frac{0.46kN}{m^2} * -0.8\right) * 68.4m^2 = -25.2kN$

2: $w_e * A_{ref} = \left(\frac{0.46kN}{m^2} * 0.2\right) * 68.4m^2 = 6.3kN$

Zone H:

Area: 869m2

$C_{pe,1}$=-0.3 $C_{pe,2}$=0.2 (Table7.3a)

1: $w_e * A_{ref} = \left(\frac{0.46kN}{m^2} * -0.3\right) * 869m^2 = -119.9kN$

2: $w_e * A_{ref} = \left(\frac{0.46kN}{m^2} * 0.2\right) * 869m^2 = 79.9kN$

As the angle is between $5° < \alpha < 45°$, the external pressure coefficient, Cpe, has to be calculated for both positive and negative values:

For negative values of Cpe:

-2.9kN-25.2kN-119.9kN = -267.9kN

For positive values of Cpe:

6.6kN+6.3kN+79.9kN = 92.8kN

As the value is numerically highest using the negative pressure coefficient, these are the ones assigned to the structure in Robot.

The total force on the roof is **-0.24kN/m²**, thus there is a primary suction on the roof.

VARIABLE LOAD, SNOW:

The following calculations are based on the procedures defined in Eurocode 1.1-3 and the related annex. The snow load depends on the shape and roughness of the roof, thermal properties, amount of heated area under the roof, surrounding buildings and terrain and the meteorological climate. As the roof is monopitched, we use figure 5.3, Eurocode 1.1-3 to calculate the three load arrangement cases. The thermal coefficient is used to account for reduction of the snow load on roofs with high heat transmittance, as is the case for glass roofs as the atrium, but because the glass type is a low energy one, it is chosen not to reduce the load according to this.

$s = \mu_i * C_e * C_t * s_k$ (Formula 5.1)

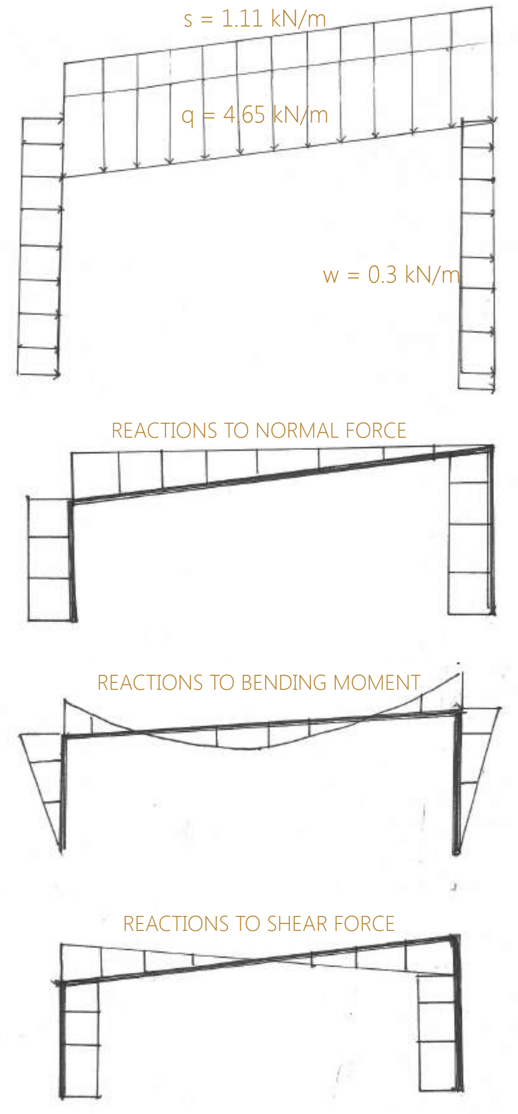
μ_i = snow load shape coefficient = 0.8 (Table 5.2, for 0°<α<30°)

C_e = exposure coefficient = 1.2 (Table 5.1)

C_t = thermal coefficient = 1.0 (p. 20)

S_k = characteristic value of snow load on the ground = 0.9 kN/m² (Annex p.2)

$s = 0.8 * 1.2 * 1.0 * 0.9 kN/m^2$ = 0.86kN/m²



ill. 9.5 :: actions on frame and reactions

LOAD COMBINATIONS

$E_d = \sum_{j\geq1}\gamma_{G,j}G_{k,j}$ "+" $\gamma_{Q,1}Q_{k,1}$ "+" $\sum_{i>1}\gamma_{Q,i}\varphi_{0,i}Q_{k,i}$

$\sum_{j\geq1}\gamma_{G,j}G_{k,j}$ = design value of sum of permanent action

$\gamma_{Q,1}Q_{k,1}$ = design value of dominant variable action

$\sum_{i>1}\gamma_{Q,i}\varphi_{0,i}Q_{k,i}$ = design value of sum of accompanying

Eurocode 0 defines the combination as:
For snow load as dominating variable load:

E_d = 1.0* 1.0 * (self load) + 1,5 * 1.0 (K_{FI})) * (snow load) + 1.5*0.3*1.0 (K_{FI})*(wind load)

The partial coefficient method is used to over dimension the structure slightly by transforming the characteristic values to design values. The partial factors are applied to the structure in Robot.

PURLINS:

The purlins between the beams are dimensioned firstly, with the length defined by the center distance of the beams being 1250mm, as this is the maximum width of the polycarbonate sheets:

$$u_{max} = \frac{L}{400} = \frac{1.25m}{400} = 3.1mm$$

E_0 = 7000MPa for Construction wood C14

$$I = \frac{5 * (\frac{0.3kN}{m} + 1.5 * \frac{0.89kN}{m} + 0.45 * \frac{0.24kN}{m}) * 1250mm^4}{3.1mm * 384 * 7000MPa} = 0.556 * 10^6 mm^4$$

This moment of inertia corresponds to a cross section of 38mmX56mm as listed in table 7.3 in Teknisk Ståbi (Jensen 2011).

BEAMS:

The actions and reactions of the beam are visualized in ill. 9.3. The moment of inertia is calculated to find the initial dimensions of the beams. The load on these includes the load of the purlins: 17 purlins of

$$I = \frac{5*p*L^4}{u_{max}*384*E_0} \qquad \text{(Madsen 2010:343)}$$

$$u_{max} = \frac{L}{400} = \frac{14.1m}{400} = 35mm$$

E_0 = 13700MPa for Glulam C32

$$I = \frac{5*(0.009kN/m + \frac{0.3kN}{m^2}*1.25\frac{m^2}{m} + 1.5*\frac{0.89kN}{m^2}*1.25\frac{m^2}{m} + 0.45*\frac{0.24kN}{m^2}*1.25\frac{m}{}}{35mm*384*13700MPa}$$

$$= 2348*10^6 mm^4$$

0.038m*0.056m*1.25m*290kg/m^3 = 13.1kg = 0.128kN/14.1m = 0.009kN/m

This moment of inertia corresponds to a cross section of **90mmX700mm** as listed in table 7.6 in Teknisk Ståbi (Jensen 2011).

VERIFYING CALCULATION THROUGH ROBOT STRUCTURAL ANALYSIS

Applying the load combinations to the beam in Robot, together with the self load of it, proves that these dimensions are acutally not sufficient, which is due to tilting around the strong axis, y:

$$\frac{\sigma_{m,y,d}}{k_{crit}*f_{m,y,d}} = \frac{8.69MPa}{0.25*23.04MPa} = 1.57$$

Dimensioning with this tool results in a cross section of **115mmX767mm**, with a moment of inertia of 4320mm^4.

FRAME CALCULATIONS

In the beginning of the design process, it was the idea to use frames as spatially defining elements for the atrium, as the sketch in ill. 9.6 depicts. The dimensioning of these is visualized here for the comparison to the beam calculation. The actions and reactions are visualized in ill. 9.5. Besides the beam calculation as listed above, the dimensioning of the frame includes a calculation for the columns. For aesthetic

$$\frac{F}{A} \leq k_c * k_d * f_{c,0,k} \qquad \text{(Madsen 2010:282)}$$

k_c is read from table 7.15 from λ_{rel}

$$\lambda_{rel} = \frac{k_{rel}*l_{s,y}}{h} = \frac{0.054*6000mm}{667mm} = 0.48 =$$

$k_{rel,GL32c}$ = 0.054 (Jensen 2011:table 7.13)

- this gives a k_c of 0.977

$$k_{d,variable\ load} = \frac{k_{mod}}{\gamma_m} = \frac{0.692}{1.3} = 0.53$$

$f_{c,o,k}$ = 26.5MPa

$$k_c * k_d * f_{c,0,k} = 0.977*0.53*26.5MPa = 13.76MPa$$

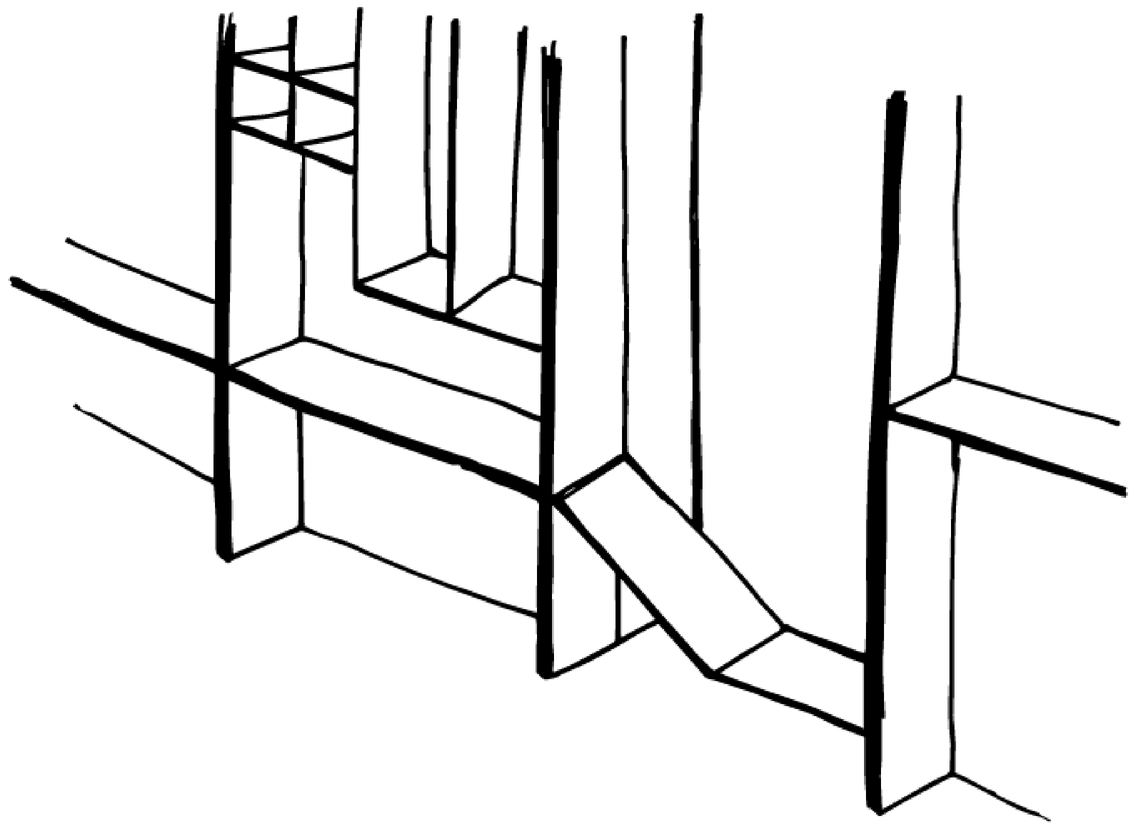
$$\frac{F}{A} = \frac{30.66kN}{(667mm*90mm)} = \frac{0.0005kN}{mm^2} = 0.5MPa$$

reasons, the same dimensions as for the beam is initially tried out - 115x667mm:

We see that the column is highly overdimensioned, but due to the lateral wind force, the utilization ratio in Robot is due to bending moment

$$\frac{\sigma_{m,y,d}}{k_{crit}*f_{m,y,d}} = \frac{8.97MPa}{0.75*20.48MPa} = 0.59$$

Thus it is possible to apply a smaller cross section to the column, but it is also reasonable to retain these dimensions.



ill.9.6 :: division of roof form into zones

APPENDIX 3 :: U-VALUES

The U-values for three primary elements of the building are calculated; the exterior walls, the roof of the dwellings and the separational walls between the dwelling and the atrium. As a tool for doing the calculations, the Rockwool Energy Design calculater is used becuase of its material library and visualization. The U-value calculations are done according to the formula

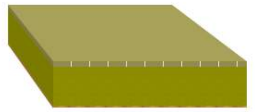
$$U = d/\lambda + R_{SI} + R_{SE}$$

where d = thickness of the material layer
λ = the thermal conduction properties of the material
R_{si} = interior surface transition insulation
R_{se} = exterior surface transition insulation

DWELLING ROOF CONSTRUCTION

Note that the polycarbonate material was not part of the material library of the Rockwool Energy Design tool, so instead is used a material with the same thermal properties.

UDE



INDE

	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rse (ude)					0,04
1	Generisk materiale	Kalksandsten 1800 kg/m3	0,032	1,090	A	0,03
2	Generisk materiale	Mineraluld 33	0,200	0,033	A	6,06
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
3	Generisk materiale	Diffusionsåben membran (tør)	0,000	0,170	A	0,00
4	Generisk materiale	Træ 450kg/m3	0,014	0,120	A	0,12
	Rsi (inde)					0,10
			0,246			**6,35**

Begrundelse for ændring af overgangsisolanser:

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

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

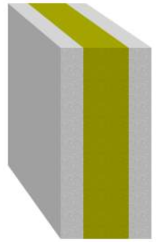
U = 1 / 6,35 + 0,000 + 0,000 = 0,16 W/(m²K)

U_{max} = 0,20 W/(m²K) U = 0,16 W/(m²K)

9 :: APPENDIX :: 3

PARTITION WALLS BETWEEN DWELLING AND ATRIUM

UDE INDE



	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rse (ude)					0,04
1	Generisk materiale	Beton, høj densitet 2400 kg/m3	0,120	2,100	A	0,06
2	ROCKWOOL A/S	A-Murbatts	0,240	0,037	A	6,49
	Murbindere / Fastgørelse	Rustfast stål ø 4 mm	4,000	17,000		-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
3	Generisk materiale	Beton, høj densitet 2400 kg/m3	0,120	2,100	A	0,06
	Rsi (inde)					0,13
			0,480			**6,77**

Begrundelse for ændring af overgangsisolanser:

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

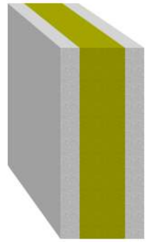
U-værdikorrektion i henhold til DS 418
Korrektion for mekanisk fastgørelse dUf = 0,000 W/(m²K)
Korrektion for luftspalter dUg = 0,000 W/(m²K)

U = 1 / 6,77 + 0,000 + 0,000 = 0,15 W/(m²K)

U_{max} = 0,30 W/(m²K) U = 0,15 W/(m²K)

EXTERIOR WALLS

UDE INDE



	Producent	Navn	Tykkelse [m], antal	Lambda [W/(mK)]	Q	R [m²K/W]
	Rse (ude)					0,04
1	Generisk materiale	Beton, høj densitet 2400 kg/m3	0,100	2,100	A	0,05
2	ROCKWOOL A/S	A-Murbatts	0,240	0,037	A	6,49
	Murbindere / Fastgørelse	Rustfast stål ø 4 mm	4,000	17,000		-
	Luftspalte	Niveau 0: ΔU" = 0,00 W/(m²K)				
3	Generisk materiale	Beton, høj densitet 2400 kg/m3	0,100	2,100	A	0,05
	Rsi (inde)					0,13
			0,440			**6,75**

Begrundelse for ændring af overgangsisolanser:

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

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

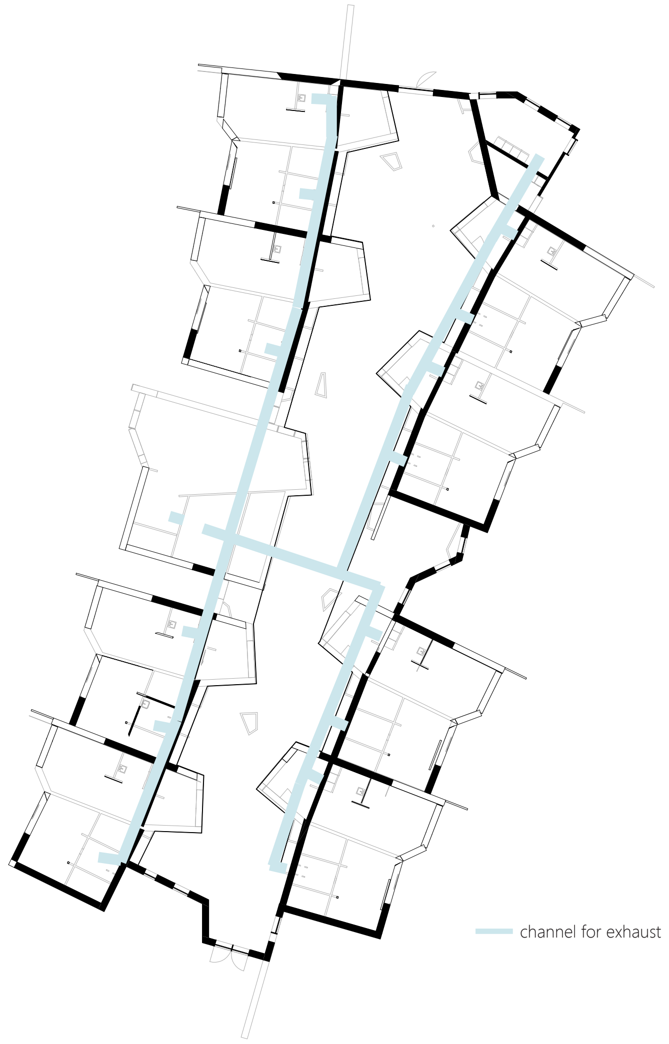
U = 1 / 6,75 + 0,000 + 0,000 = 0,15 W/(m²K)

U_{max} = 0,30 W/(m²K) U = 0,15 W/(m²K)

9 :: APPENDIX :: 4

APPENDIX 4 :: VENTILATION

As the building consists of relatively few zones, ie. the people load is relatively similary in the different spaces, the most economic solution regarding the ventilation system will be a CAV-system of Constant Air Volume, which is cheaper to install than a VAV-system because it does not need gussets. The exhaustion happens from the critical spaces, kitchens and bathrooms, which are all organized along the two structural spines of the building, whereby unnecessary bendings of the channels are avoided. The channels will run along the spines inside the atrium, but above the pocket spaces and the closets, whereby they will not be visible, but will be hidden by exploiting the tectonic material layerings. The ventilation principle is thus a hybrid one, combining the mechanical ventilation with natural ventilation, as the atrium can function as a ventilational buffer zone; a zone from which the dwellings can get fresh air without loosing too much heat. Furthermore, the height difference between the roof of the atrium and the curtain walls in the dwellings adds a positive ventilation effect through thermal boyancy. Heating of the building is done from floor heating.



ill. 8.7 :: ventilation plan :: 1:500

9 :: APPENDIX :: 5

APPENDIX 5 :: MATERIAL CHARACTERISTICS OF POLYCARBONATE SHEETS

RIATHERM®
32 MM 5-LAGS M-STRUKTUR
HEATSTOP

RIATHERM® 32 mm 5-lag M-struktur Heatstop

Fordele

- Laveste U-værdi
- Fremragende isolering
- Varmedæmpende effekt
- Slagfast
- Stor stivhed

RIATHERM® 32 mm 5-lags Heatstop ribbeplade består af vejrbestandig polycarbonat.

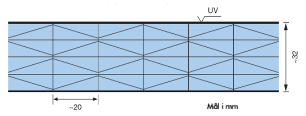
Læs mere om RIATHERM® på www.rias.dk

Anvendelser:

RIATHERM® 32 mm 5-lags Heatstop er markedets bedst isolerende ribbeplade. Hvis der benyttes lavenergiglas i dine lodrette partier, bør du vælge denne plade.
RIATHERM® UV Heatstop er velegnet til anvendelser, hvor der både ønskes den højeste varmeisolering om vinteren samt en varmedæmpende effekt om sommeren. Grundet pladens specielle udvendige overflade, viser tests en forskel på helt op til 13°C på den indvendige temperatur, sammenlignet med alm. opale RIATHERM® UV plader.

UV-beskyttelse

Siden, med det co-exstruderede UV-beskyttende lag, monteres så den vender opad/udad. Det giver RIATHERM® pladen en yderst effektiv beskyttelse mod vejrpåvirkninger, en beskyttelse der garanteres i 15 år.



RIATHERM® 32 mm 5-lags M-struktur	Tekniske data
Pladetykkelse, mm	32
Materiale	Polycarbonat
Farve	Opal
Vægt g/m^2	3700
Pladelængde, mm (bredde 980 mm)	3000, 3500, 4000, 4500, 5000,6000
Pladelængde, mm (bredde 1230 mm)	3500, 4000, 4500, 5000
Ribbeafstand, mm	20
Afstand midte til midte spær, mm	1005/1255
U-værdi W/m^2 °K	1,1
Lysgennemgang %	30
Termisk udvidelseskoefficient, mm/m°C	0,065
Min./max. Brugstemperatur – uden belastning	-40/+120

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