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PREFACE

This project is written and designed by Allan Virenfeldt Hansen (stud. M.Sc. eng. Arc), Lennart Loth (stud. M.Sc. eng. Arc) and Marc Vestergård Kristiansen (stud. M.Sc. eng. Arc) at the 4th semester of the M.Sc. program in Architecture at Aalborg University. The main theme is sustainable architecture in coherence with architectural and technical quality. The project report is a part of the product of their master thesis project.

ABSTRACT

The master thesis outlines a design proposal for future social sustainable housing on an abandoned site in Skive. As a housing project, the aim is to fight the decline in population the city of Skive is suffering from. To do so the housing project seeks to further develop the concept of sustainability, especially social sustainability, by incorporating social communities and common functions on the project site. The aim is further strenghtened by the placement of the buildings in a cluster typology on the site and by implementing nature as a key element, which not only characterizes the site, but the whole city of Skive as a proof of understanding of the context and its identity.

0

PROLOGUE

OUR THANKS TO

Arkinord A/S
Danish Crown
Skive Kommune
Skive Folkeblad
Petersen Tegl
Kingspan Insulation
Cupa Danmark
Schöck Danmark
Frøslev Træ
Rockwool
Krone Vinduer
BM Byg A/S
Skyone

GUIDE OF READING

DEVIATION FROM TOPIC APPLICATION

The initial idea of the project was the transformation of the burnt down slaughterhouse site in Skive based on the masterplan Big Blue Skive for 2040 and an american competition called "Timber In The City". As the project developed, the competition brief shifted more and more away from the context of Skive and the theme of social housing. Thus the competition brief was replaced by a more relevant one to outline the project: FBAB - Fremtidens Bæredygtige Almene Bolig.

LAYOUT

This book is divided into chapters, each describing a part of the project, introduced with a short description of the content presented, thus serving as an ongoing reading guide throughout the book. The chapters are gathered in six segments of the book: the prologue, the program, the presentation, the process, the epilogue and the annex.

PROCESS

The project itself was created following the principles of the integrated design process as described in the chapter "Methodology", but for the purpose of simplicity and easier understanding for the reader, the process has been divided into two segments: the architectural design process and the technical design process. Through continuous cross-referencing, the reader will be notified whenever the processes overlap or complement each other.

PRESENTATION

The presentation material has been added to this book without scale to give an initial impression to the reader. The entire presentation material in scale is attached in an enclosed binder for the reader to use as sees fit.

SOURCES

Throughout the report, specific facts will be validated with references, while general references for the project in general are collected in a list of sources at the end of the report.

Furthermore, at the end of the report a list of sources is collected for all figures, that are not produced by us.

TABLE OF CONTENTS

METHODOLOGY

INTEGRATED DESIGN PROCESS

The development of the project is based on the Integrated Design Process guidelines, a method used for architectural projects at Aalborg University, defined by Mary-Ann Knudstrup [Knudstrup, 2005]. The idea is to combine the different aspects of the project in a controlled way from the beginning in order for them to be cohesive and above all to influence each other to achieve a stronger project in all its components.

It is particularly important since it proposes the integration of architecture, engineering and construction. This exact method also promotes the use and acquisition of several different tools that will test and allow study of different parameters and sides of the project, exploring the strengths of each team member. In fact, the articulation of design, functions, technology and construction aspects since the beginning is an advantage, not only because the project is more complete and realistic compared to the challenges of our professional life but also because some areas complement others to justify and clarify decisions. The phases of the project are the Problem Formulation, the Analysis, the Sketching phase, the Synthesis phase and the presentation of the material as shown in Fig.1

During the **problem phase** the focus lies on understanding the problem, getting familiar with it and what is required to solve the problem. It is necessary to create a base for the next phase, making sure of what is needed to proceed.

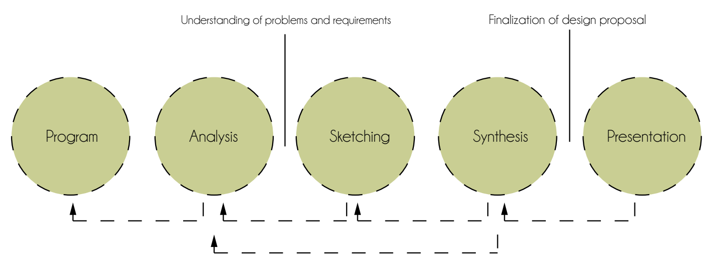


Fig.1: *Integrated Design Process*

The analysis phase involves getting a deeper knowledge of the site, its character and its relevant aspects, such as the climate, sun exposure, sound analysis and historic analysis, among others. The process of studying references and case studies for the several aspects of the proposal is initialized.

The sketching phase is the beginning of the studies in design, structure and space, with assistance of graphic and digital tools, sketches, physical and digital modelling. The main aspects are the relationship between the project and the site, the way the architecture and engineering are combined and several experiences on the volumetric aspects are made.

In **the synthesis phase**, the exploration of the parameters takes place as well as the refinement on the relationships between form, structure and space. The changes are made according to the information obtained by the analysis on the different aspects, ending up affecting each other and justify decisions that needed to be made. [Hansen, Knudstrup, 2005]

After this we are able to proceed to the details and **the presentation phase**, developing everything that is required to communicate the proposal.

USER INVOLVEMENT

For many, the dwelling today is an item, which they invest in for a period of time. Homes are part of our consumption pattern, which is becoming more and more unpredictable, punctuated by coincidences, moods.

The architects' current challenge is that changing habitants with different assumptions will provide different requirements for the same property in the lifespan of the dwelling. The design of the future home will be about the balance between the defined and undefined spaces, to create homes with open framework that can be adapted to new needs. Changeable, personalized housing that provides space for expression, diversity and choices. However, at the same time, homes that have a permanent, architectural quality that can last through all the changes, and be an anchor during a turbulent time. By involving the users in this way, it will give a certain feeling of ownership, and it will decrease the needs to promote the consumption pattern.

TOOLS

For the sketching phase, Sketch UP, Rhinoceros and hand sketching is used. For 2D modelling the Adobe package, will be used. The project will be prepared in Autodesk Revit 2016 before getting finished in 3Ds-MAX.

BSim and Be15, as well as spread sheets and Velux Visualizer are the tools used to calculate and simulate as well as document the process throughout the project. Also BSim is an important tool used for optimization of the architectural space during the later phases of the process. Velux Visualizer will be used as an integrated design tool to test daylight conditions throughout the entire process.

1
PROGRAM

SITE ANALYSIS

Fig. 2: *Map of Denmark (Site location)*

LOCATION

The building site is located in the central Jutland region in the town of Skive.

With 20.453 inhabitants, Skive is considered a medium sized city. It's the seat of the municipality of Skive and counted as "The capital of Salling". [da.wikipedia.org]

Fig.3: *Municipality of Skive*

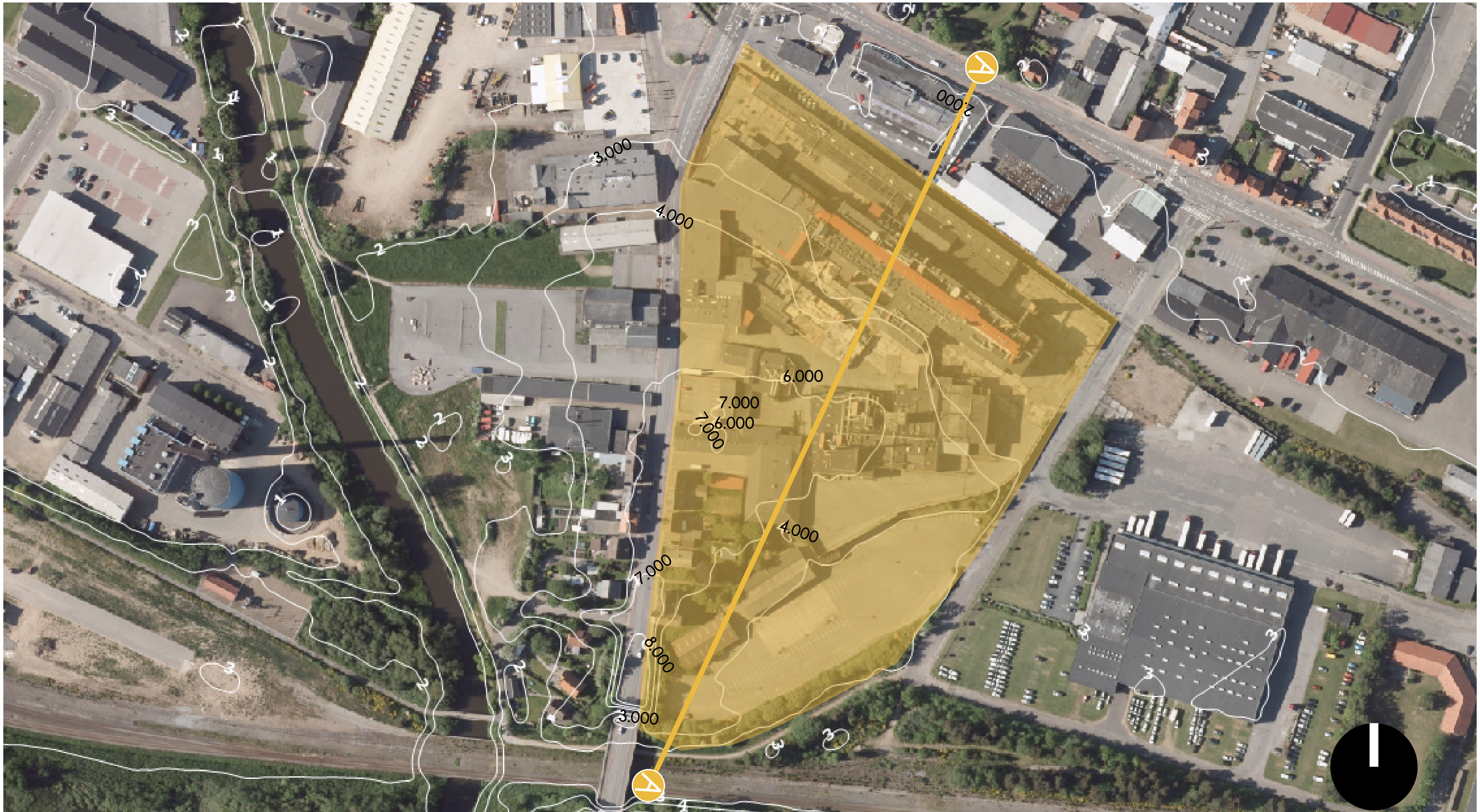


Fig. 4: *Site location in Skive*

THE SITE

The site of 43.000m^2, which is owned by Danish Crown is located in a fully fledged industrial area in the south east of Skive, near Karup Å. The slaughterhouse located on the site burned down in 2007, leaving it as an abandoned ghost town in the city. As the site is now, it elevates from North to South from 2m to 7m at the heighest and down to 4m. (see contourlines on Fig.4 / site section Fig.5)

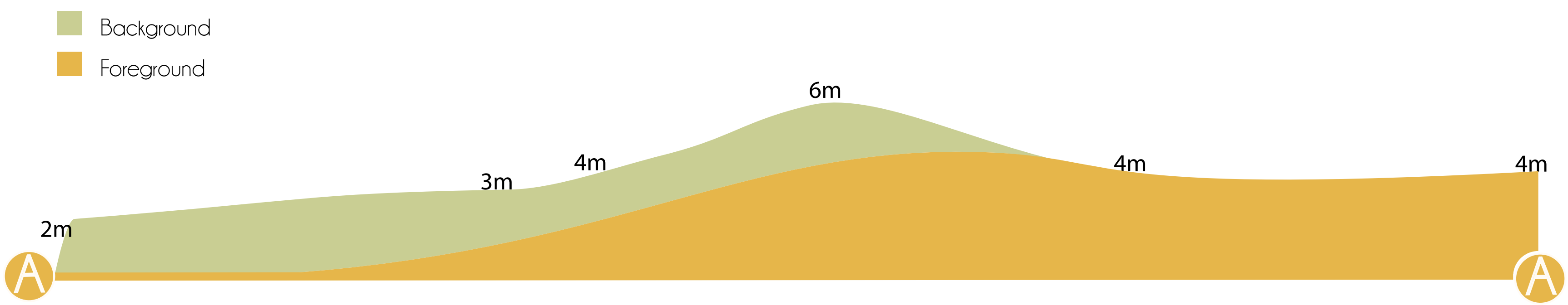


Fig.5: *Site section*

INFRASTRUCTURE

The site is defined by the congested Viborgvej to the North, which connects to the lesser busy Bråupgade and Engvej to the West. The site is accessed from Bråupvej and Færøvej, which was used for the former parking lot of the slaughterhouse.

As seen on Fig.6, four bus stops are close to the site, one at Bråupgade and three on Viborgvej.

The old railway tracks divide the site into two; the northern business area and the southern part with the burned down slaughterhouse. The southern part of the site consists of the new railway that encloses the area, creating a barrier to the Bråup area. Following the railway a nature path system leads to the station within 10-15 mintues of walking. The path also connects to a nature reserve and Karup Å.

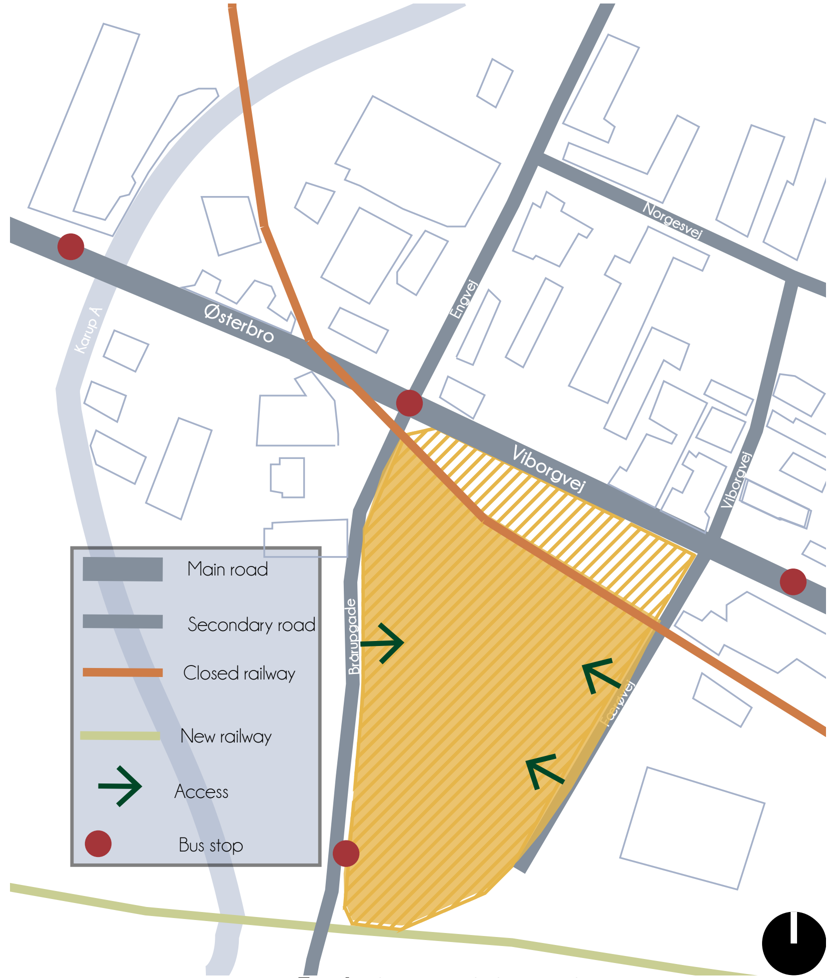


Fig.6: *Accessability to the site*

VEGETATION

Karup Å which runs into the fjord, divides Skive into North and South and with it a green wedge is implemented in the landscape surrounding the site. There are plantages of trees, focused on the areas which required noise reduction from their surroundings, as for instance is the case on the South end of the site where the new railroad is located, complementing the natural path following the East-West direction as shown on Fig.7.

Fig.7: *Vegetation around the site*

TYPOLOGY

The area surrounding the site is characterized by an industrial quarter. Moreover, most of the buildings are 2-3 storeys tall as can be seen on Fig.8.

The typology in this certain area can be characterized as small clusters of low-dense typology combined with the industrial typical typology.

Fig.8: *Typologies surrounding the site*

FUNCTIONS

The area surrounding our site is contains multiple functions: industry, service and living areas as shown on Fig.9.

The Industry covers factories and industrial work places, service covers shops, centers etc. and places for leisure time.

Fig.9: *Functions around the site*

HISTORY AND FUTURE OF SKIVE

HISTORY OF SKIVE

Skive was once a strategic node for trade and traffic, which roots is dated back to the year 1231. Skive was founded and built around Karup Å that was the important element for the city.

The oldest existing building is Gl. Skivehus, which cellar is dating back to the original castle in the same spot, which role was to house the King, other royals and nobles.

In 1825 Skive once again became relevant for the trading network. This time by ships, which had access from the North Sea through the Limfjord. This resulted in a resurgence in trade but also in part of the population, which had been subject to a declining era. The new trade traffic and the opening of the railway station at Brårupgade, made it now attractive for industry to build in Skive. Over time this trend has resulted in Karup Å being subject to a decline in value, since new construction had its focus on the industrial revolution. Thus the industry started blooming around Brårupgade by 1860 where the Skive Cooperative Slaughterhouse opened in 1902, which today is known as Danish Crown.

THE SKIVE SLAUGHTERHOUSE

The slaughterhouse in Skive, had great historic value to society. In addition to contributing with many jobs, they put Skive on the map by being evolutionary in the technological knowledge and new inventions to improve slaughterhouse approach for the daily work.

In 2007, a fire broke out at Skive slaughterhouse as tragically proved to have fatal consequences for Skive city as a whole. Despite some attempts to start temporary work and renovation of individual departments of the slaughterhouse, the fire had been too extensive, so Danish Crown had to close it entirely. Since the fire at the slaughterhouse the area has been like a ghost town, and from the outside you can still see the damage from the fire.

NEGATIVE TRENDS IN SKIVE

Skive is suffering from a decline in population for the past 5 years, because of the major societal tendencies on the increased urbanization, where many young people move from town to higher education in Aalborg, Aarhus and Copenhagen. Skive require in their settlement strategy that jobs are the most important prerequisite for increasing population, and thereby halt the decline. Skive municipality offers some youth appeal and secondary education and a limited degree of higher education. Therefore, they will focus on partnerships with other educa tional institutions, as well as increase jobs as widely as possible by offering highly skilled jobs after their high education type. Thus the municipality wants to offer high qualitive housing and attractive building plots, as the Master Plan BIG Blue Skive should be able to contribute up to 2040 as described later.

The slaughterhouse site has been untouched for nine years, which sends out a bad signal for both Danish Crown and Skive. The 29th of May 2015 Danish Crown sent an offer to Skive Municipality on the purchase of the land, which the economy Committee in the municipality of Skive turned down. The price was too high according to what the realtors had assessed and what is tolerable to spend on such a site when the state is the buyer. The municipality is still interested though, if the offer is changed accordingly.

Fig.10: *Historic Brårupgade, Skive, 19th century*

Fig.11: *Brårupgade, Skive, present*

BIG BLUE SKIVE 2040

Skive has created an Å-plan committee, obtained by the urban development committee, whose purpose is to focus on the development of the area around Karup Å. The Committee had taken the initiative to BIG Blue Skive 2040, when SparVest Fund had given Skive resources for the preparation, on their 25th anniversary as shown on Fig.12.

The purpose of BIG Blue Skive is to make the city attractive once again and unite the city with qualitys of the river. Skive municipality is very decisive on fighting the decline in population, thus the overall plan with Big Blue Skive is to gain a population increasement again. [Skive Kommune]

The plan is to use and improve the resources the city already has, and especially use what made Skive so popular in the past when the city was founded, namely the blue and green resources - nature.

The plan will open up for new developments along Karup Å and the fjord by utilizing the existing blue resources as a recreational element. The various development zones around the creek allow for a freedom of variation in terms of typology and function, thus creating a diversity of sustainable housing areas with a common connection to the recreational areas. [Skive Kommune]

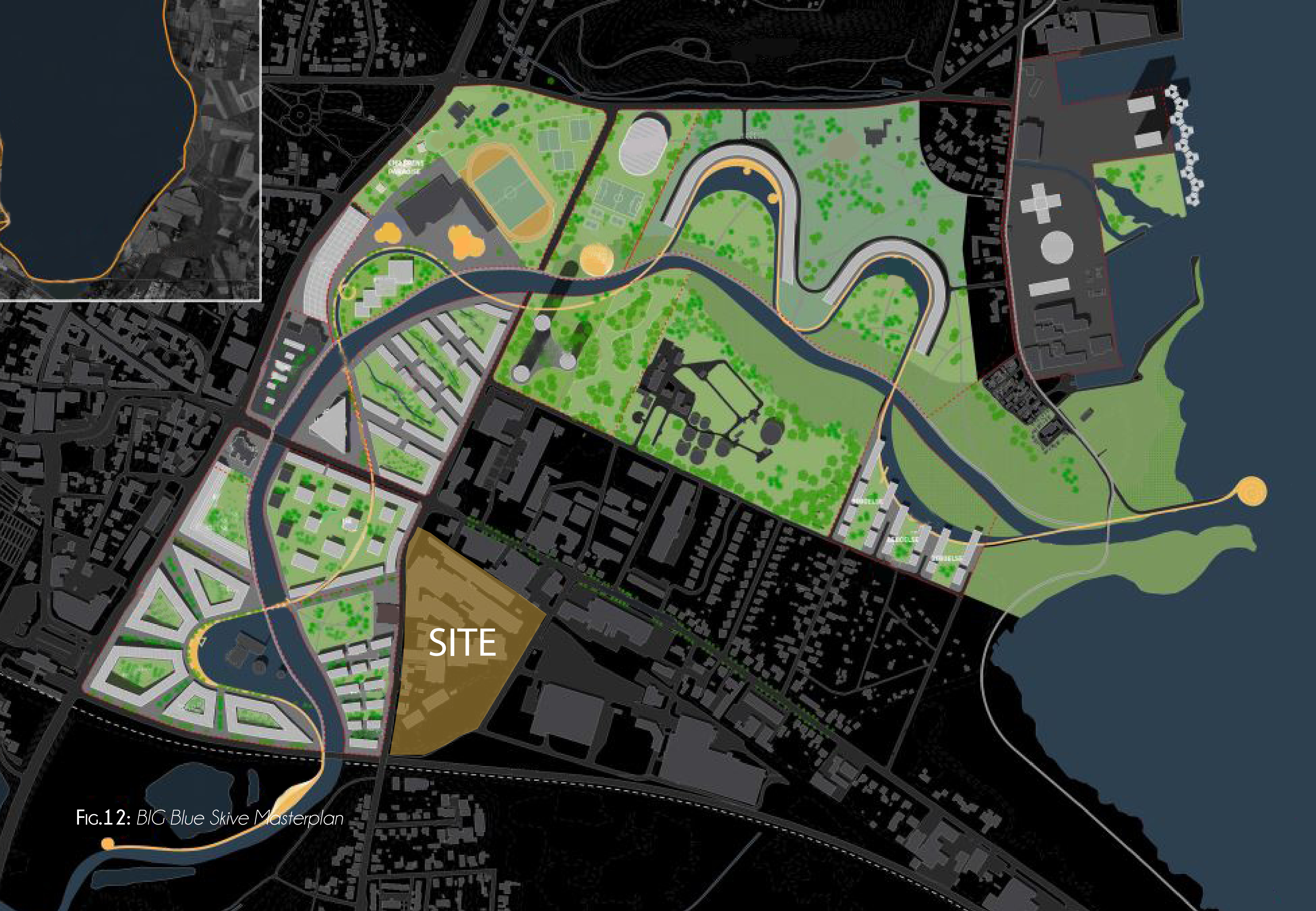


FIG.12: *BIG Blue Skive Masterplan*

TRAFFIC CONDITIONS

The municipality plan takes into account future opportunities for the slaughterhouse site, where the desire for a transformation from industrial to a new quarter becomes a high priority. During the work of the masterplan, Cowi have been involved in the planning, to counter the emerging traffic problems. The new road system must have a well-functioning system that should not load the primary network. Brårupgade is closed and instead Færøgade are to be used, which is connected with Brårupvej and Søndre Boulevard. Besides reducing traffic on the upcoming exposed areas in the city center, the new road are connecting the old part of the city, with the new area. [Skive kommuneplan 2013-2025]

Å-PLAN

The city council of Skive adopted in 2013 the new municipality plans for the city transformation at Karup Å. It must respond to the part of the city which is located at south of Karup Å, where the need to accommodate the linking of recreational areas in the city, and a starting point for the further development of the plan's structure. The plan is to create a new town with a modern, sustainable and varied expression of the quarter. In this plan, the slaughterhouse area is included and the closure of Brårupgade will remove the barrier of the site against Karup Å.

The municipality plan was reviewed in late 2015 to meet the vision from Big Blue Skive. The intention of the plan from 2013 was maintained where the wish for a quarter with attractive homes and large shared green spaces along a scenic green axis, and by using the benefits in Karup Å. The master plan for Big Blue Skive should be seen as an overall vision that connects areas on a much larger scale, and the Å-plan as a detailed plan for the development of small areas along the Karup Å. [Skive kommuneplan 2016-2028]

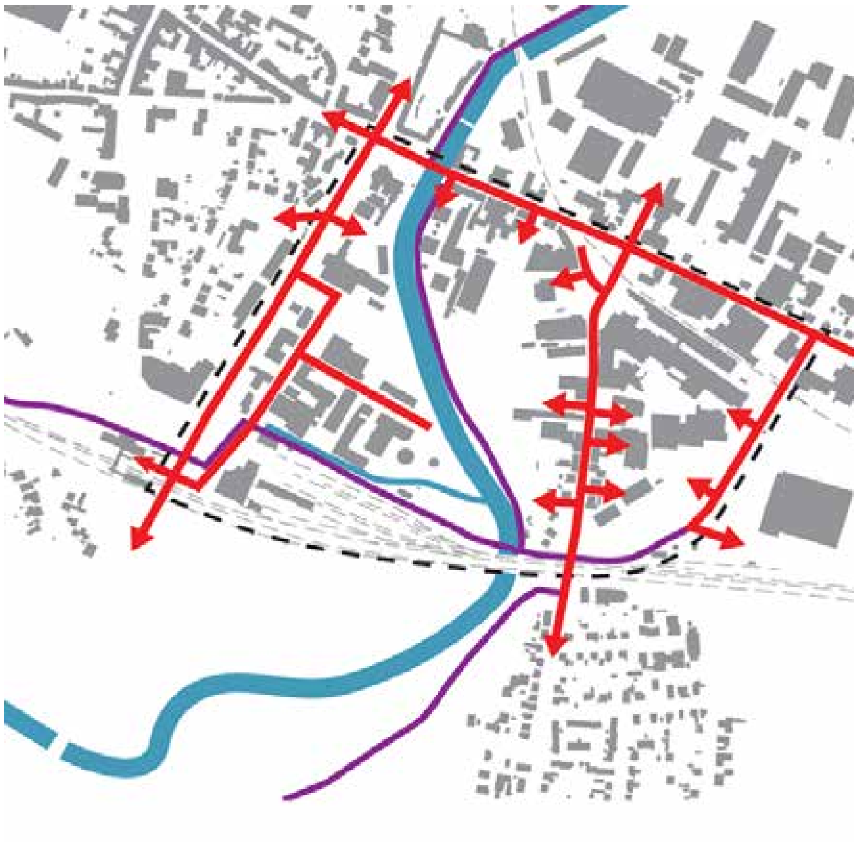


Fig.13: *Present infrastructure, Skive municipality*

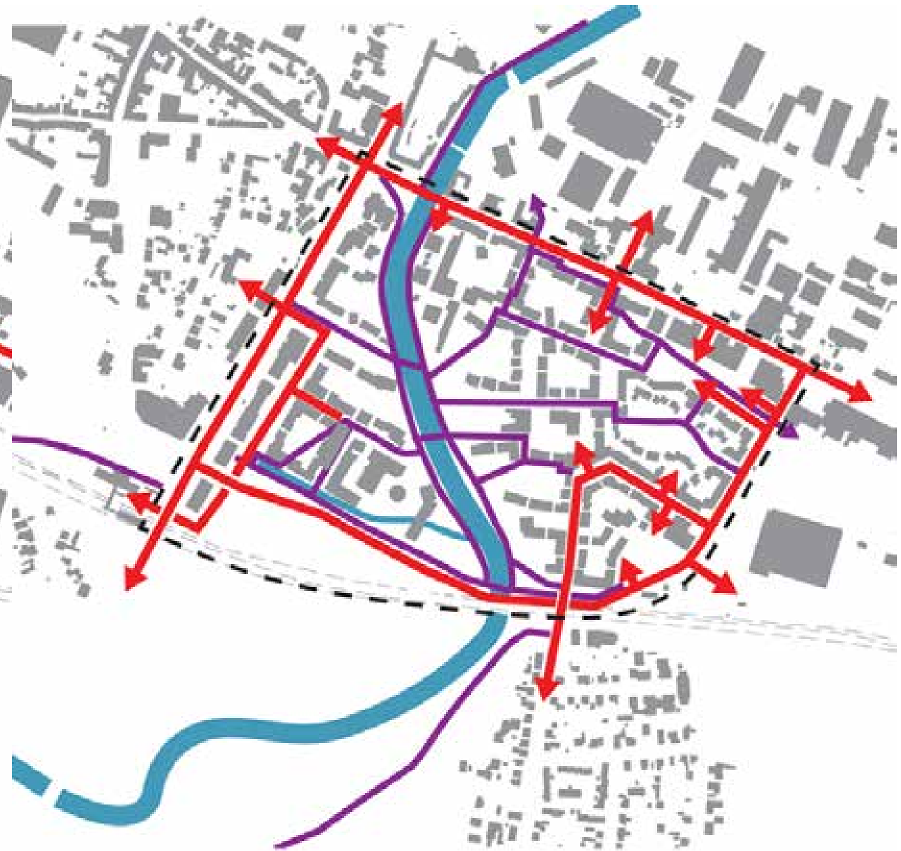


Fig.14: *Future infrastructure, Skive municipality*

USERS

The following section describes the user groups and behaviour as a focus during the project.

USER AGE

As shown on Fig.15 [Denmark's statisticsis] there is a lot of individuals moving out of the city in the earlier years, either to study or to explore. There is a peak from between the age groups 25-29 to 45-49 years which can give an indication, that some of the individuals who moved away from the city, went back after they have completed an education elsewhere, often to settle down with a family. The individuals moving back felt safe in their early life neighborhood, and probably want their children to grow up under the same safe environment. [Bosaetningsstrategi 2014-2018]

It also shows that there are a lot of elderly individuals in Skive, peaking at 60-64 years of age and again with the 67+. This is the generation, which had just left the labor market and started life of retirement. They have a wish to live where they originally came from – close to family, friends and nature. This type of population will increase during the next years as the birth number is falling, and the need for elderly care is getting bigger. [Ældresagen]

USER DEVELOPMENT

In recent years there has been a relatively powerful movement from rural to urban, particularly centered around the country's two largest cities, Copenhagen and Aarhus. When a municipality is geographical "far away" from these two metropolitan centres, one must look at the factors that come into play on this general trend, to be used to support a continued growth and development in the region.

There is no doubt that the occupations and jobs is one of the main prerequisites for settlement and retention of citizens. In addition to the new jobs could be education, pairing and divorce, some of the life events that are of particular importance to the settlement. If you look at what considerations the various demographic groups makes around the surroundings and locations of their residence, the urban life and the possibilities it holds, is the most determining factor in the choice of housing for families under 30 years, for families with children who weigh good social conditions, and for people aged 67+ who weigh the nature highly. In

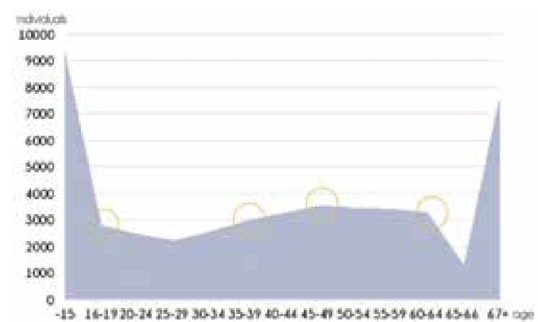


Fig.15: *User Age*

particular, young people have a relatively high mobility, and statistically the greatest mobility is for the ages 17-35years. [Skive Kommune]

In this Master Thesis, there is an intention to mix social groups and population, which would reflect the variety of the society in the different stages of their life. From here user groups originates and can be divided into three categories: young couples, families with children, and the elderly which is shown in numbers in Tab.1 below.

Mingling diverse user groups can be advantageous. Playing children brings life and essentialness to the environment, while the adults and elderly can provide safety and security for the community, the elderly appreciate seeing life happening through their windows. By creating a bridge between agegroups, live experience and values are traded.

If certain activities and the habitants are gathered it could get the individual events the ability to stimulate each other. And the participants in a situation will have the opportunity to experience and participate in other events. A self-reinforcing process will have the opportunity To get started. [Livet mellem husene]

Skive 2015	3 persons	4 persons	5+ persons
0 child	0	0	0
1 children	1632	0	0
2 children	398	2065	0
3 children	0	103	939
4 children	0	0	183
5 children or more	0	0	38

Tab.1: *User by numbers and number of children*

USER TYPOLOGIES

The young couples need a more private home, they need to be relatively close to the city and their social network. The space needed and the interior has to be flexible due to the possibility of family expansion.

The most young couples study or work most of the time, meaning that they often uses their weekend as a time to be together. These types of dwellings should contain at least a bedroom, restroom, and a kitchen / living room.

For the families it is very important to be close to kindergartens, schools and leisure activities. There is a need to have a private or semiprivate outdoor space for children to play in, this public or semi public area should be kept safe from traffic, and other threats. In Denmark the most common thing is that both parents work, so the family are gathered in the weekends mainly. These types of dwellings should contain at least on/two children's room with related restrooms, and a combined conversation kitchen, and a livingroom big enough for the entire family to be together.

The elderly can be satisfied if their environment are considered safe, their dwellings are a one level plan and they have access to green areas or balconies, either private or public. The elderly has a great need to be social in order for them to still function in the society, which makes it important to have some urban areas nearby, where it it possible to meet other people. These types of dwellings should contain at least a bedroom, restroom and a kitchen/livingroom.

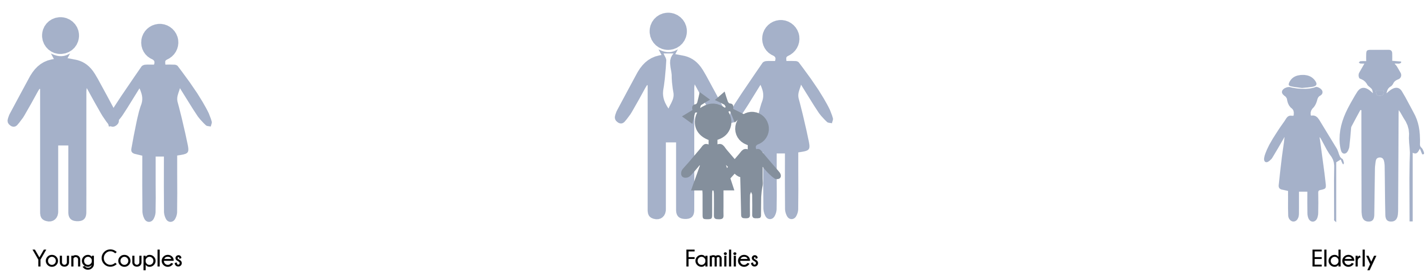


Fig.16: *User Groups*

CLIMATE

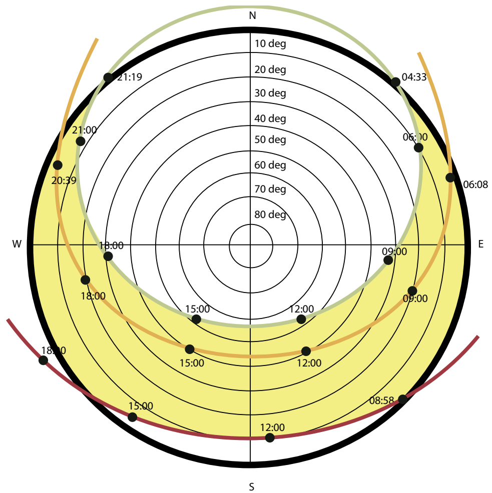


FIG.17: *Sun diagram*

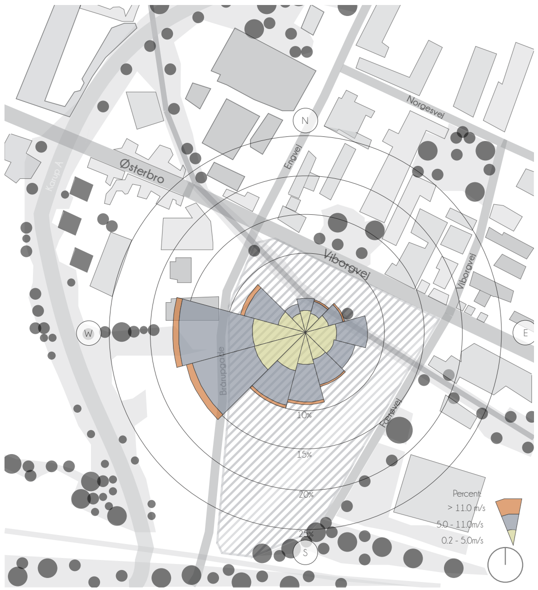


FIG.18: *Wind rose DMI (1989-98)*

As shown on Fig.17 the solar angle varies greatly throughout the year. Thus it should be taken into consideration during all stages of the design process how the different solar conditions affect the solar heat gains and the atmosphere in the interior and exterior.

As Fig.18 shows, the wind speed and decor averaged over a year measured from the windstation in Hald. The most dominant wind can be observed from the west and southwest with a speed of mostly 5-11m/s. Additionally it should be mentioned, that occasionally the southern and eastern direction are more dominant, especially during autumn.[dmi.dk 1989-98]

Thus shading from critical wind velocities as well as exploitation of wind and solar exposure for heating and cooling purposes is mandatory, moving onward in the process.

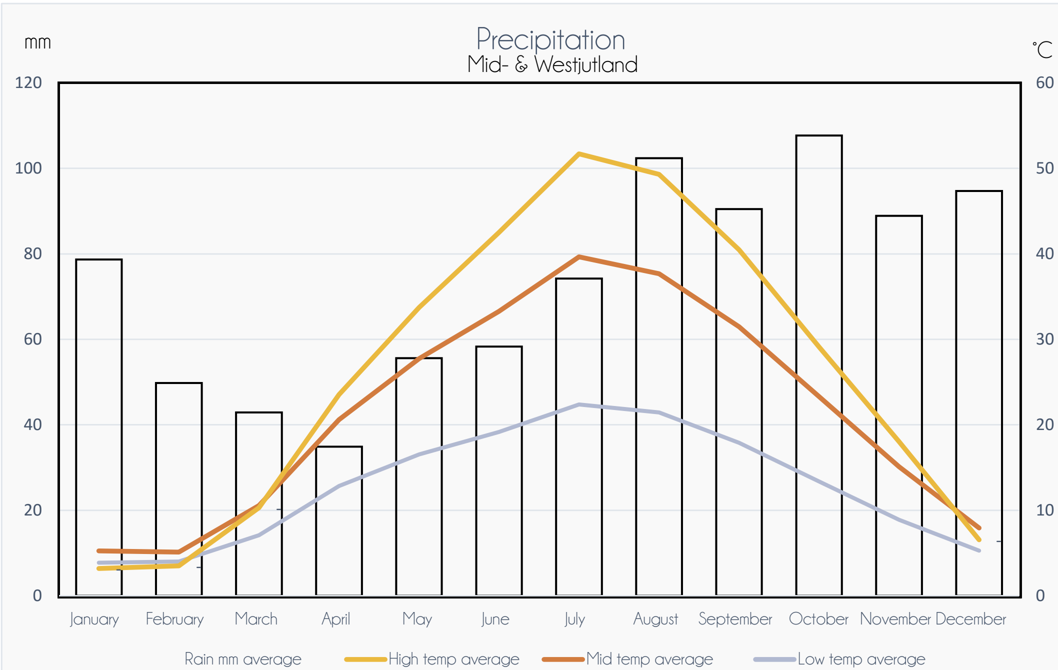


Fig.19: *Weather statistics [DMI 2005-16]*

Measurements from 2005-2016 in the Central Jutland region shows that the most precipitation fell during autumn and winter as shown on Fig.19.

Therefore cover and shelter from the precipitation as well as the possibility to take advantage of rain water should be part of the considerations moving forward in the project.

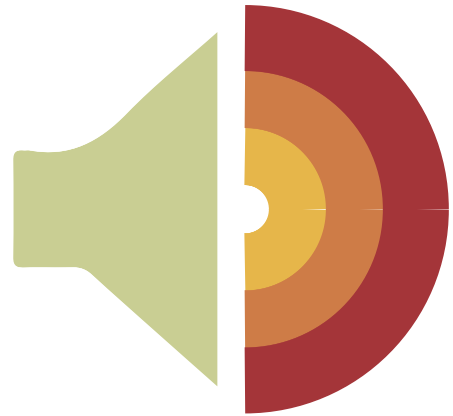


Fig.20: *Soundscape*

Unfortunately Skive municipality has not done any sound investigations in the city. Thus only anticipations can be made based on the measurements outside the city and common sense. Noise reduction should be part of the design process around Viborgvej and the new railway.

SUSTAINABILITY

In the following section the term sustainability is explained to give an understanding of its definition and its role during the design process as well as the approach taken to sustainability as a whole.

SUSTAINABIITY IN GENERAL

Sustainability originates from the latin “sustinere” which means “uphold” with various synonyms such as “support”, “endure” or “maintain”. The modern meaning of the term has its offspring from the UN document “Brundtland Report” also known as “Our Common Future” from 1987 which describes and defines the effort of a sustainable development to meet the needs of the present without compromising the ability of future generations to meet theirs.

For the building sector the most important points are as follows:

- Reduction of energy and resource consumption
- Recycling of waste materials
- Prevent and counteract loss and waste of resources (e.g. FSC for timber)
- Integration of economic and environmental aspects in the design process

[Brundtland Report, 1987]

Sustainability and its holistic approach together with the Integrated Design Process enables a well-balanced process involving all disciplines and an increased potential of the building design during the process. Although the broad spectrum of sustainable approaches and solutions requires a pre-filtering of the work load to achieve a manageable scope for the project.

In the building sector sustainability can be divided into three aspects that contain various subtopics as described further below:

- Social Sustainability – Healthy, suitable building design
- Environmental Sustainability – Low impact building design
- Economic Sustainability – long-range investments

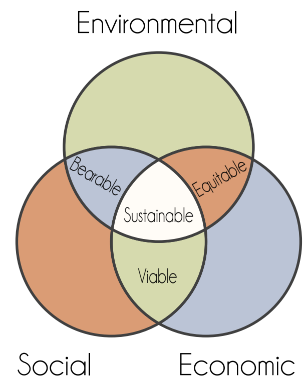


FIG.21: *The three aspects of sustainability*

SOCIAL SUSTAINABILITY

Social Sustainability mainly describes the conditions and circumstances for a healthy living inside a suitable building design which should be an accommodation to the user's needs in the present and the future for all users alike. In short: Equity

Social sustainability is hard to categorize in clear scales and numbers, therefore user surveys and information gathering by the government such as crime rates and economic compositions of residents are used to get a broader picture of the user groups in an urban context.

The main aspects of social sustainability are well-functioning, healthy, safe and secure spaces as stated and emphasized by the responsible governmental entity of Danmark, the Ministry of City, Housing and Rural Districts.
The approach taken towards social sustainability is mostly concentrated on the well-functioning of spaces in terms of spatial experience, functions and the experienced comfort in spaces.

Important aspects of social sustainability are:

- Create comfort spaces
- Create a variety of spaces
- Create desirable cities
- Support quality of life
- Support social diversity
- Support healthy living
- Support accessibility

[Hvidbog om Bæredygtighed, 2013]

ENVIRONMENTAL SUSTAINABILITY

Environmental sustainability describes mainly the low-energy building design as well as the perceived quality of the indoor space. The building regulations, legislations and certification systems mainly focus on environmental sustainability. During the early design stages environmental sustainability is a key aspect to ensure a low running costs during the life cycle of a building as well as a high quality space.

To ensure a high quality in terms of environmental sustainability different certification systems are used around the globe with BREEAM and LEED as the common systems internationally and DGNB in Germany and Denmark. Thus the involved parties in a building project can agree on a level of certification to be met for the building design which will be documented throughout the entire process.

The main focus during this project lies on the high quality indoor space as well as the use of local, renewable resources and materials. Additionally the technical aims will be discussed further in the report.

Important aspects of environmental sustainability:

- Utilize local, renewable materials
- Optimize indoor climate
- Optimize energy consumption
- Optimize land usage
- Minimize waste of materials

[Hvidbog om Bæredygtighed, 2013]

ECONOMIC SUSTAINABILITY

Economic sustainability describes the total value of a building design and the long-term interests of a project to ensure a profitable investment for the city and the owner. Furthermore material and construction costs are a big part of the economic perspective of a project as well as its maintenance. Thus the planning and design stage is very important for the economic sustainability of a project, since the decision-making and problem-solving in the early stages of a project can prevent costly corrections of building mistakes during the later stages.

Investing in sustainable aspects during the design process often times ensures a lower running cost and thus a cheaper building looking at the overall lifecycle costs.

Important aspects of economic sustainability are as follows:

- Optimize design and planning
- Optimize resource management
- Optimize maintenance
- Focus on lifespan and lifecycle costs
- Secure long-term economic interests and investments

[Hvidbog om Bæredygtighed, 2013]

In order to achieve a good building design, a consciousness about all three aspects of sustainability and their impact on each other is important. Thus the integrated design process works as a great tool to constantly involve sustainability in all design stages and in the different scales of the project.

HEALTHY CITIES

HEALTH AND SOCIAL VALUE

One of the key points to create a sustainable living in the cities is a prerequisite of health. The urban environment includes physical, social and environmental aspects, where the promotion of a healthy lifestyle is important, and the choice for a healthy lifestyle should be easy.

WHO signifies health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. [WHO] It is therefore not only important to minimize adverse health factors such as pollution and social problems, but to create conditions that promote health, safety and well-being for the human in the city.

During the planning of the city, it should be an aim to encourage people to become more active. It should be an easy choice to leave the car and take other active initiatives such as walking or cycling which improves the mental surplus and social welfare. [dac.dk – bæredygtige byer]

HEALTH IN THE LOCAL COMMUNITY

Cities and their management have a collective responsibility and brings an obligation to include, inspire and invite for movement and physical activity in the urban space. This movement creates healthier citizens and life between the dwellings.

Throughout the ages, people living in the city have evolved a pattern to move less. During the day, more people are sitting down. Looking at the trends from work where you are sitting in front of a computer or the transportation or on the domestic activities. Movement was a necessity before the car was invented, and that is what the city of tomorrow's innovations is to repent so that more active movement and healthier habits are achieved in the city. [dac.dk – sundhed i lokalsamfundet]

HEALTHY CITIES

Jan Gehl elaborates on how the 21st century cities should develop themselves and he expresses great importance to the need to be lively and healthy and to ensure sustainability. He explains how the qualities can be achieved through new laws, which would make increase the popularity of cycling and walking.

Jan Gehl explains that a sustainable city is a city, which is very people-friendly. The city must invite people to walk and cycle as much as possible and to have well-designed public spaces nearby. Good pedestrian and bycycle pathes are important. It is also important to focus on enhancing the public transport, so it is possible to achieve a reduction in the dependence on private cars, so the city can become more people-friendly.

He also points out the importance of the bike culture in certain countries as a common form of transportation. He refers to the

Netherlands and Denmark, where they have achieved an attractive bike environment, which has helped to increase the bicycle transportation.

It is important that cities are becoming more ecofriendly and contain sufficient green areas, which can purify the air. In Jan Gehls view, a sustainable city will be green, but also contains many green buildings, but emphasizes that it's not only greens buildings that create sustainability in itself. [Jan Gehl]

Fig.22: *Cycling in green areas*

TECHNICAL AIMS

The following section will give insight on the technical aims for the project in terms of indoor climate spcifically.

THERMAL INDOOR CLIMATE

During summer time a mean operative temperature of 24,5°C±1,5°C should be upheld during user time. During winter a mean operative temperature of 22,0°C±2,0°C should be kept during user time. [CR1752] Furthermore, the excessive heat in a given room should not exceed 100 hours above 27°C or 25 hours above 28°C during user time. [BR10, 2020 req.]

VISUAL INDOOR CLIMATE

A sufficient daylight factor for living zones is achieved with an average of 5% in at least half of the rooms and in other zones that require daylight 3% in at least half of the room. Furthermore the glazing area should at least equalize 15% of the floor area. [BR10, 2020 req.

ATMOSPHERIC INDOOR CLIMATE

The aim is to keep the CO_2 concentration in the air below 500ppm above the outdoor concentration during user time according to category II. [DS/EN15251].

Furthermore the perceived air quality should not exceed 1,4 decipol during user time according to category B. [CR1752]

All of the above aims are collected in Tab.2.

Category	I	II	III
Indoor Temperature, summer [°C]	24,5±1,0	24,5±1,5	24,5±2,5
Indoor Temperature, winter [°C]	22,0±1,0	22,0±2,0	22,0±3,0
CO_2 level over outdoor [ppm]	350	500	800
Exhaust Air flow kit/bath/wc [l/s]	28/20/14	20/15/10	14/10/7
Hours Above 27°C/28°C	100/25		

Tab.2: *Technical requirements*

CASE STUDY: ETERNITTEN

URBAN TRANSFORMATION

The transformation from "wasteland" to the city of tomorrow. The Eternit plot in Aalborg has been subject to industry through the centuries. The last fiber cement sheet was packed in 2004, and the historic industrial period was closed and moved abroad. It left an area in Aalborg with much potential, which is currently still under a process of transformation from an industrial area to a diverse district, in a unique landscape.

A quality program provides the specific guidelines and design principles, and acts as a supplement to the localplan for the area. The quality program is divided into three chapters:

- The area's character and coherence with the city.
- Concept for infrastructure, typology, green areas and urban architectural principles.
- Design catalog, which describes lighting, pavement and vegatation in relation to roads, paths, squares and green areas.

Eternitten is a unique area, in which Aalborg municipality desires a transformation that preserves and cultivates the special qualities in the area. [Aalborg kommune]

There is a strong emphasis on existing slopes and plateaus, sight lines and boundaries. The character of the area is formed by the industrial history, identity and flora. There are two main concepts for the site, which is the City architectural concept, landscape and green concept.

CITY ARCHITECTURAL CONCEPT

The historical value must be ensured by expansion, which is referred to the chalk landscape that acts as a sculptural element and must characterize the new district. They are working with a theme throughout the whole area, which is a contrast with open and closed. The essential values of the area, is the slope, large plateaus and culture-historical value to create the identity of the new city. The relation to the theme of the surrounding context and the hjstoric value is an interesting element that could be part of the design process as well.

LANDSCAPE AND GREEN CONCEPT

The green wedge from the golf park must be extended through the area, where each dwelling via common recreational areas have access to this green wedge. Path connections must provide access to the slopes, new landscape spaces and adjacent parks. The slopes are used for recreational landscape areas where large shrubs and trees will be removed to facilitate the area characteristic chalk landscape. Similarily, the natural characteristics Skive is defined by should play an important role during the design process.

Fig.23: *Eternitten, before transformation*
Fig.24: *Eternitten, after transformation*

Fig.25: *Eternitten, after transformation*

CASE STUDY: PEAR GARDEN

When working with flexible living, there are actually two elements to work with, when you want to create flexibility in the dwelling: space and structure.

If the spaces are flexibly created by the architects, it allows the habitants to choose which function they want to have. Moreover, if the architect organizes an open structure – a framework of interpretation – it can allow the habitants to organize and transform their interior on an ongoing basis.

The Pear Garden is a three storey tall housing complex, by Juul & Frost architects, located south of Ølby Station in Køge. The Pear Garden is a compact residential house in three floors with divided ownership between the owner-, holding- and the lease-dwellings.

The building includes a total of 220 dwellings assembled on smaller courtyards. The complex is the result of a competition with the focus to keep a low construction price.

The Pear Garden is a basic one-plan dwelling at around 6.5 x 12 meters; the dwellings are built of modules of 2.80 x 2.80 meters and each units is 90 m^2. They are built of wooden elements with exterior cladding of pre-patinated sinus plates in zinc and are linked by exterior access galleries. It is an open plan with a freely positioned bathroom core with connectivity option for a kitchen.

Most of the habitants have opted out of a removable mini kitchen and installed a larger, more expensive kitchen. The space is 2.8 meters high, all dwellings are basic decorated and prepared in an opt-in catalog, which gives the individual habitant access to permeate the spaces, which gives the feeling of ownership. The basic type can be separated with walls in smaller spaces, which can be redefined and reconstructed in line with the habitants ‘ changing needs. The walls are moveable and changeable; the habitants can switch out a wall, its painting or decorate it with mirrors and pictures. Kitchen and bathroom are located in a core, around which access and furnishings can take place freely, giving a wide frame for an individual interior design as seen on Fig.26, Fig.27 and Fig.28.

Another strength of the Pear Garden is the social network that occurs because the habitants are living together in the culture, which is the energy of their individual construction projects. [http://boligforskning.dk]

Fig.26: *Exterior of the Pear Garden*

Fig.27: *Example of the interior*

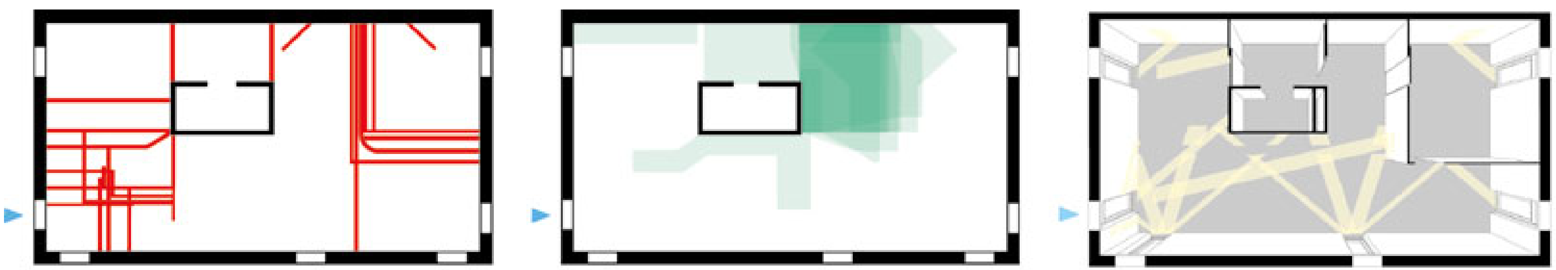


Fig.28: *Possible placement of walls, kitchens and lighting*

CASE STUDY: Bo01

Malmö is the third biggest city in Sweden, located in the West of Sweden and 45 minutes away from Copenhagen. The 140ha big Western Harbour of Malmö, Västra Hamnen, is now under transformation from coastal industry land to urban dwelling. Bo01 represents the first stage of the development of the area with its 9ha area and 60 dwellings. The general aim of the transformation is an urban development, reclaiming unused areas of the city for new purposes, ecological building and to set an example for sustainable architectural engineering. As the name suggests, the planning began in 2001 and is now approximately 50% finished including 600 homes, shops, offices and other services. [Malmo.se]

Part of the sustainable strategy for Bo01 are an active approach towards 100% renewable energy, biodiversity, rainwater collection, diverse architecture as well as a low car and high public transportation prioritization. To achieve a low energy use and a high energy production, different means were taken for the project area as listed below: [energy-cities.eu]

- High density architecture (43 people/acre in Bo01, 16 in Malmö, 27 in CPH)
- 1400m^2 solar collectors placed on top of ten buildings to complement the heat pump in the area
- 2MW wind station in the northern harbor area
- 120m^2 solar cells produce electricity for homes, heat pumps, fans and other pumps
- Long life-span materials with recyclability
- 0,7 parking spaces per household
- Max. 300m to a bus stop from any home
- Green roofs and a high level of vegetation and water installations
- Set goal of 105kWh/m^2/year per unit including applications etc. (city averages at 175kWh/m^2/year and the achieved energy use for Bo01 was 132kWh/m^2/year)

As the planning of Bo01 was using rather new methods and not previously used assumptions, the energy use calculations failed, especially for heating, caused by a big window area towards the harbor pier to the West and South.

Throughout the process, not only the technical sustainable solutions were integrated during the drawing stages, but a holistic approach was taken to create emotions and atmosphere in the area. Thus small details, such as built-in nesting boxes for birds are a natural part of Bo01.

The general approach to passive strategies as well as a high density, green architecture is highly relevant for this project. The methods used have greatly improved since the early stages of the Bo01 development, thus creating a good foundation for the Master Thesis.

Fig.29: *Bo01 bird's view*
Fig.30: *Integration of blue and green elements*

Fig.31: *Bo01 Masterplan*

CASE STUDY: COMPETITION BRIEF

FUTURE SOCIAL SUSTAINABLE HOUSING

FSSH is a compeition focusing on the future sustainable social housing for the average citizen in two different surroundings. The competition is divided into two areas, where one task is a low-dense district surrounded by existing urban architecture, whereas the other task is to design town houses in a new urban development district.

The key terms for the competition are sustainability, flexibility, innovation, architectonics, the community and quality. Aspects to include into the design should be the history of social housing, the contextual conditions, the current legislation as well the economic boundaries by the competition.

DGNB is used as a certification method for the sustainable measures taken through the projects.

SOCIO-ECONOMIC SUSTAINABILITY

The competition brief revolves around the term of social sustainability and how healthy living and living in a community are connected and contribute each other. How a community pushes the happiness of the individual, gives a sense of security and safety around the dwellings and how a community gives a sense of identy, recognition and a sense of belonging. All of these are key terms to a lifestyle of welfare and wellbeing. Additionally, living in a community can provide benefits, such as a shared economy and an improved ressource utilization.

A design revolving around a community provides problems that are to be handled with care together with the boundaries between private and public spaces and the limits of individual influence on the community. If the user is pushed too little, the community won't exist in the first place, but on the other side, the user has to be able to choose which and what offer or responsibility to take in the community. Thus the community is divided into 4 different scales: The individual dwelling, the social infrastructure of the dwelling, the organization of the community, the social life in the district.

COMPETITION PROGRAM

In the first area 60% of the housing units should be 4+ room dwellings and 40% 3+ room dwellings. Additionally a community center can be implemented to the project.

In the second area the distribution of dwellings is 62.5% 4+ rooms, 25% 3+ rooms and 12.5% youth housing. The town houses should decline towards the greenery to the North-East of the site. A community center can be implemented in the project as well.

COMMUNITY
QUALITY
INNOVATION
ARCHITECTONICS
FLEXIBILITY

FIG.32: *competition brief focal points*

ROOM PROGRAM

Based on the aforementioned analytical results, a base for an initial room program has been forged.

As mentioned before, the younger generation moves away from Skive possibly for education puposes and the general decline of population stops at around the late 20's and early 30's. At that point many are in a relationship and have children or are at the brink of becoming a family. Therefore the distribution of apartments should follow this trend, which requires a dominance in 3 room and 4 room apartments.

According to Denmarks Statistics, the average 3-room apartment in the municipality of Skive are between 75-100m^2 net area and a 4-room apartment between 75-125m^2 net area. Taking into account the common areas and a sustainable approach to the area efficiency inside the dwellings, a fitting size of apartments should be as shown in Tab.4. [www.dst.dk]

Thus, an initial room program can take shape with focus on 3-room and 4-room housing units for families of different sizes and couples with an average income as can be seen in Tab.3.

Furthermore a general idea of the distribution of functions is created as well as shown on Fig.33. The living fucntions and the private rooms should be clearly divided, to ensure appropiate levels of privacy and a rational flow between the functions.

Type	Net area [m^2]	Units [%]
3 rooms	50-74	40
4 rooms	100-124	60

Tab.3: *Initial room program*

Apartment type	2 rooms	3 rooms	4 rooms
-50 sqm	1460	384	6
50-74 sqm	322	1193	348
100-124 sqm	23	278	252

Tab.4: *Area per apartment size [dst.dk]*

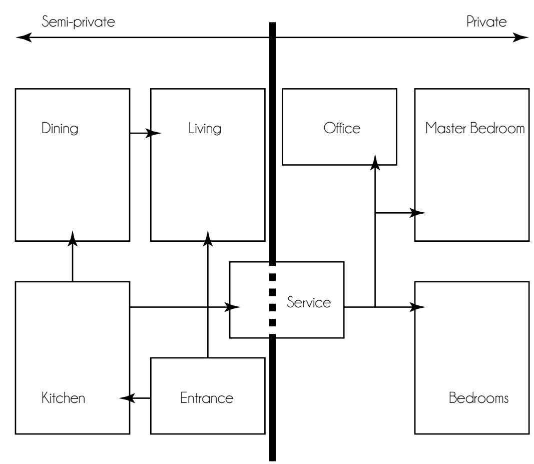


Fig.33: *Diagram of functions*

VISION

The project's aim is to transform the abandoned industrial site in Skive into a sustainable housing area with focus on social communities, functional as well as flexible building layouts and passive solutions in coherence with the natural elements Skive is characterized by.

2

PRESENTATION

CONCEPT: CLUSTER

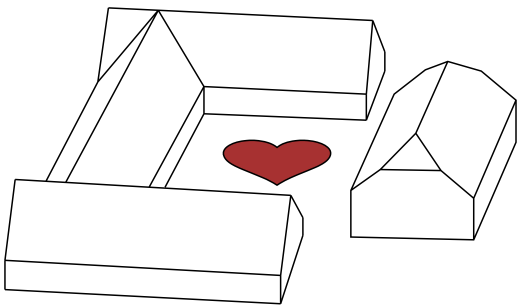


Fig.34: *The classic farm house as starting point.*

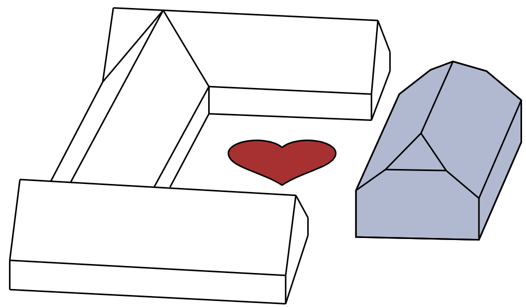


Fig.35: *Main house isolated for common house*

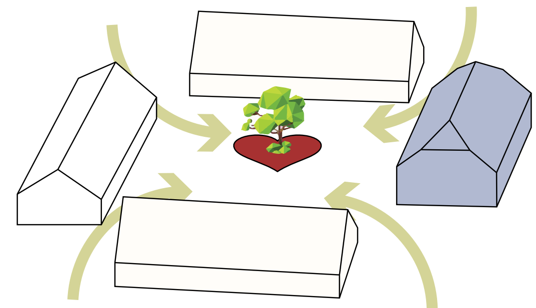


Fig.36: *The buildings are drawn apart, allowing nature to enter the courtyard*

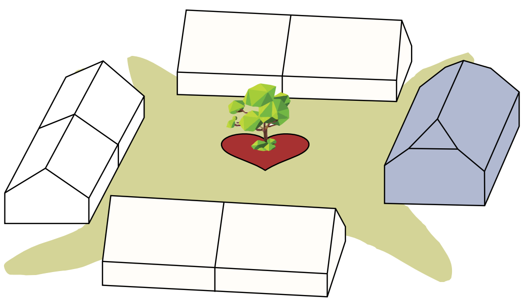


Fig.37: *The buildings are fragmented into smaller houses.*

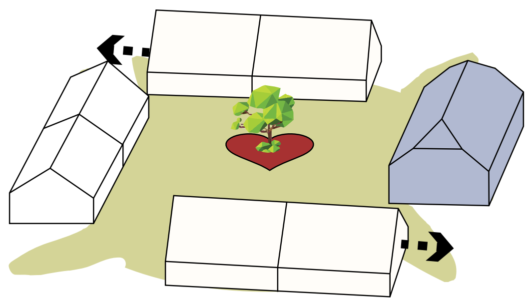


Fig.38: *These are displaced in order to allow more solar exposure and to create a more dynamic expression.*

CONCEPT: TYPOLOGY

Fig.39: *Existing buildings are demolished.*

Fig.40: *Terrain is raised in East for better view and sound barrier*

Fig.41: *Inspiration from city block typology is drawn from BIG Blue Skive*

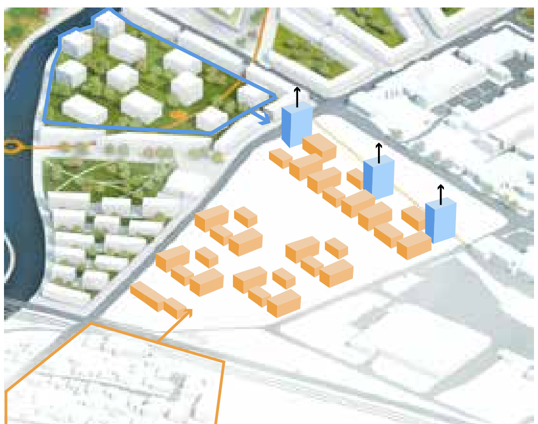


Fig.42: *Inspiration from low dense typology is drawn from the South*

Fig.43: *The green wedge is drawn onto the site, making nature a central element.*

Fig.44: *Masterplan*

MASTERPLAN

The Social sustainable housing masterplans distinctive cluster layout surrounding a green wedge is marked by its approach to social connectivity in multiple scales. The seven clusters consists of three housing types adjusted to climate and surrounding conditions. Three housing towers in the northern part of the site distinguish the Social sustainable housing from its surroundings, creating a unique living experience with views over the Ådalen, Skive fjord and the city of Skive.

The green wedge coming in from west gripping into the center of the site contains a a multipurpose field for soccer / basketball, a regular playground and a sensory playground with equipment made from natural elements. On the west of the site, theres a park like athmosphere with small rainwater ponds and a picnic area which invites to stay and enjoy the nature.

Fig.45: *Site section A-A*

Fig.46: *Site section B-B*


Fig.47: *Exterior - Housing Tower*

FIG.48: *Exterior - Cluster*

FIG.49: *Exterior - Cluster*

POSITIONING OF THE HOUSES

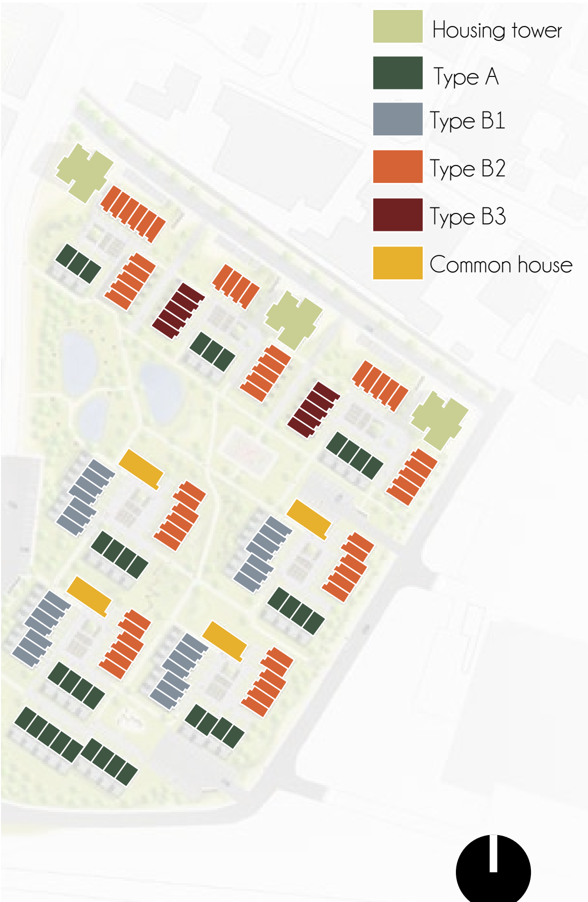


Fig.50: *Positioning of the houses*

Based on the design parameters set for the project, the orientation and placement of buildings has been greatly affected throughout the design phase. Thus, the buildings were turned according to the abandoned railway to the North and the adjacent road to the East. The buildings to the South and West in each cluster are placed perpendicular to the ones to the North and East. The orientation of the buildings and the conceptual solar studies then helped to create the general shape of the cluster which, when placed on the site, created a grid on which the clusters and the green wedge found their place.

The different building types are equally placed according to the design parameters. Therefore, the A type is placed on the North-South axis with a garden towards the South and the B1 Type on the East-West axis with a garden towards the West. Wherever a garden could not be placed, the B2 and B3 types have been placed, which includes a roof terrace to accommodate for the lack of a private outdoor space. These two types are placed on the North-South axis and East-West axis with the entrance located towards the courtyard and the outdoor area towards the South and West.

CLUSTER A

All seven clusters are defined by a court-yard and common facilities to strengthen the social connectivity. Furthermore, each cluster contains different façade materials, giving a sense of ownership to the habitants and creating a diversity on the higher scale.

A multitude of functions in the courtyard enables the users to meet, to stay, to play and to work in a common garden, creating a social space linked to the nature of the green wedge coming in from the west.

Cluster A is 1 of 2 cluster formations which make up the design, the cluster contains a housing tower with commonhouse on the groundfloor and 17 terraced houses, the 17 terraced houses are divided into 3 types, which are all designed by how they are situated in the cluster.

Fig.51: *Cluster formation A*

CLUSTER B

Cluster B are much similar to cluster A, the only difference are that the housing tower are replaced with a commonhouse.

Cluster B contains a commonhouse and 17 clusters, also divided into 3 types.

In both courtyards, you are invited to stay and socialize, and if the desire comes, it is possible to sit on one of the benches and watch life arising in the small cluster communities.

The commonhouse offers a banqueting room with kitchen and a terrace in warm materials, which invite you to stay, furthermore the commonhouse has room for a workshop that can be used by all habitants of each cluster.

Fig.52: *Cluster formation B*

TYPE A

The A type is a two-storey housing unit with up to three bedrooms, living room, dining area, kitchen, office, bathroom and toilet. From the living and dining area a garden can be directly accessed. This housing type is shaped wide and short, oriented on the North-South axis to accommodate for the solar conditions. The entrance area is pushed slightly back , while there is a shed placed in the garden to create private spaces. The users can rearrange the housing unit with multiple alternatives, such as an open space on the first floor or linking master bedroom and office space together.

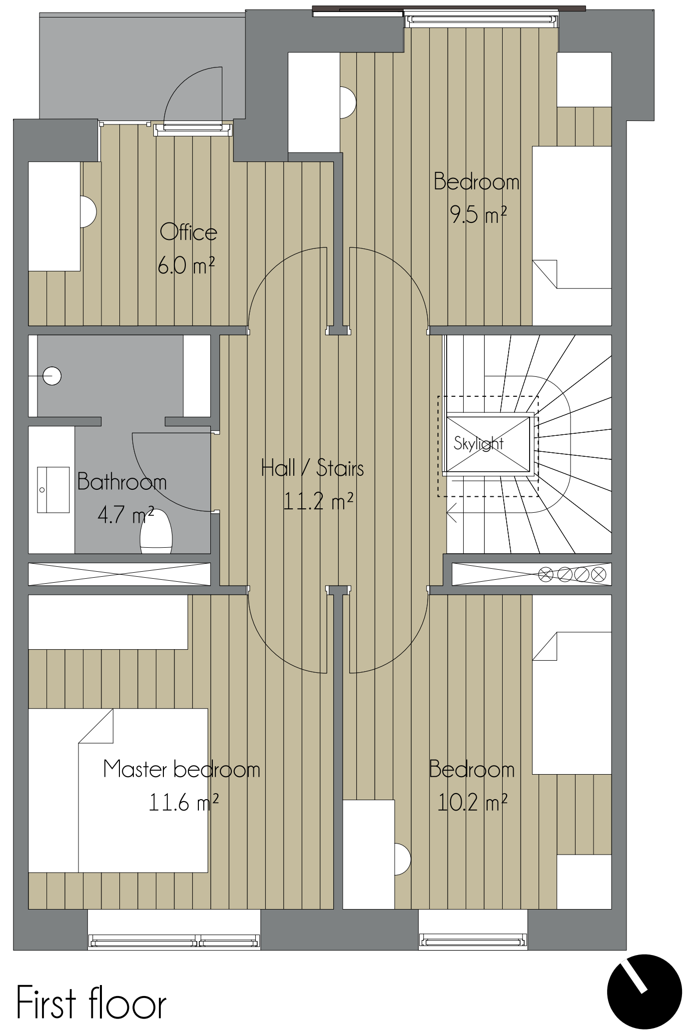
Facts	
Gross area	116.7m^2
Net area	98.6m^2

Tab.5: *Type A facts*

Fig.53: *Type A front facade*

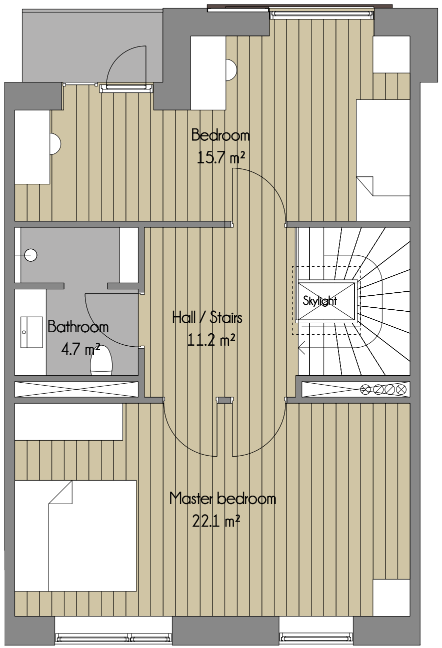
Fig.54: *Type A back facade*

Ground floor

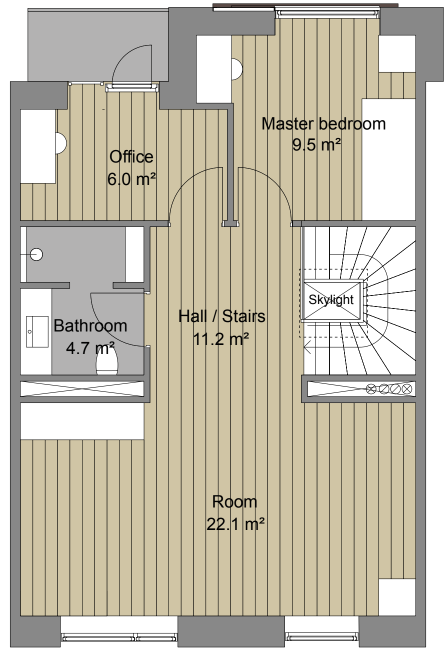


First floor

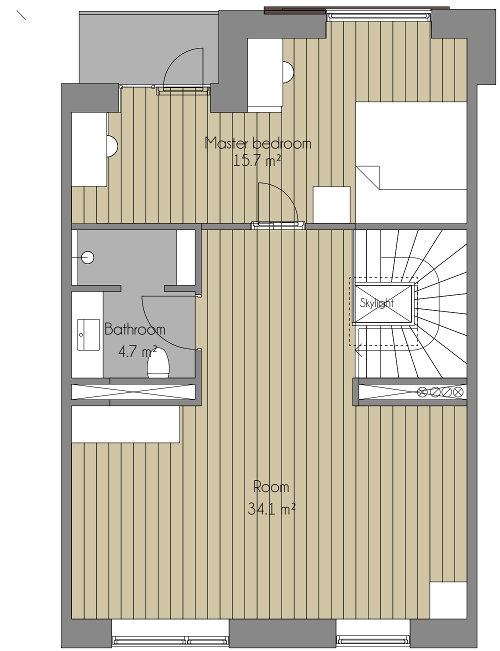
FIG.55: *Type A plan solutions*



Alternative 1



Alternative 2



Alternative 3

Fig.56: *Type A first floor alternatives*

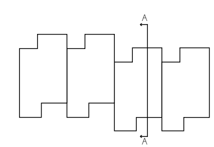


Fig.57: *Type A - section A-A*

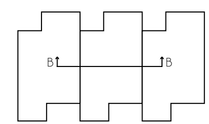


Fig.58: *Type A - section B-B*

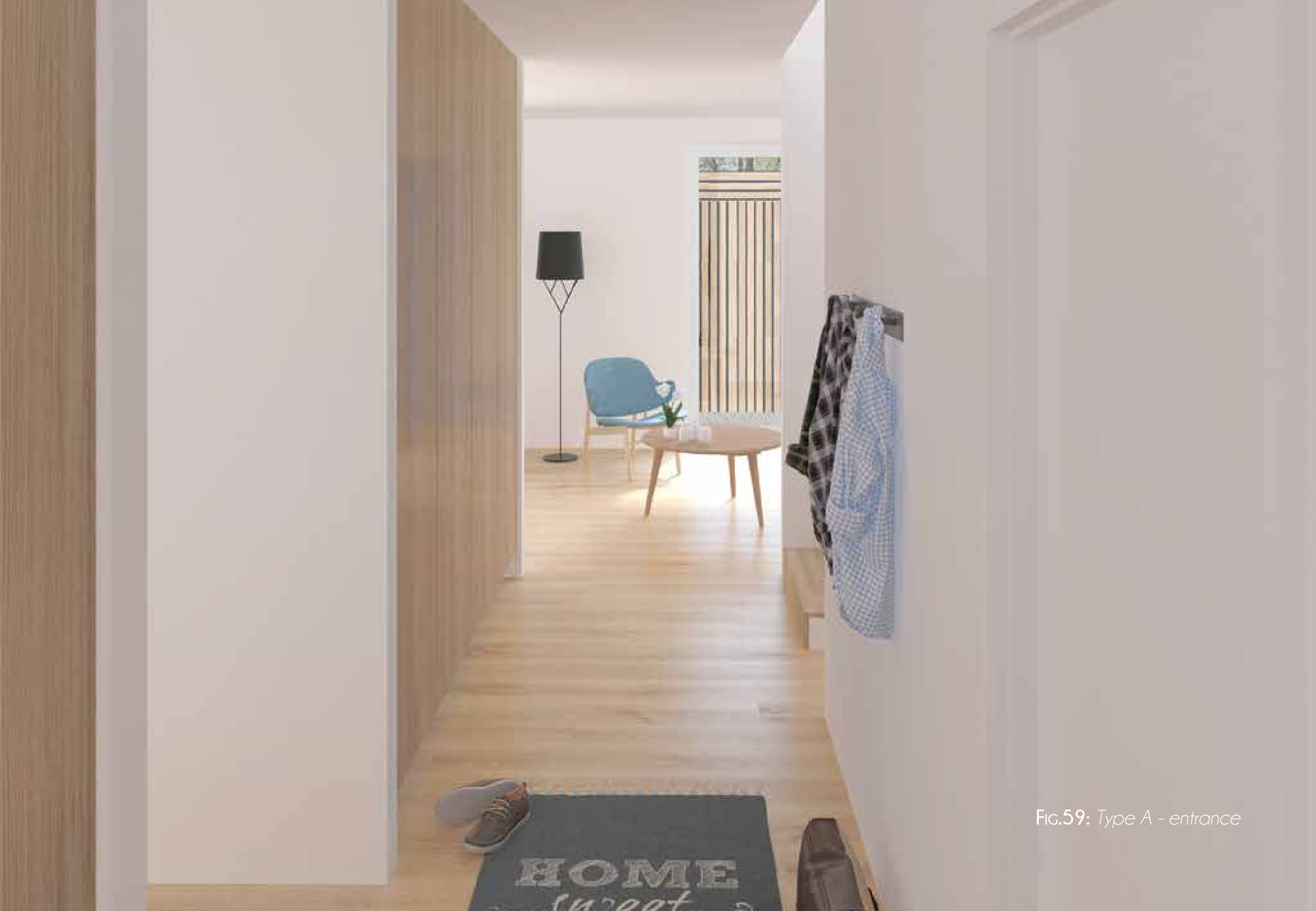


FIG.59: *Type A - entrance*

Fig.60: *Type A - Dining area*

Fig.61: *Type A - Livingroom*

FIG.62: *Type A - Bedroom*

TYPE B1

Type B1 is a similar housing type to Type A with a smaller, but deeper plan solution to accommodate for the East-West orientation's solar conditions. Equally this type consists of three bedrooms, a living room, dining area, kitchen, office, bathroom and toilet, as well as a garden on the back and a shed on the front side. The first floor can be rearranged in multiple ways, such as two instead of three bedrooms or an open office space and one master bedroom.

Facts	
Gross area	119.2m^2
Net area	92.7m^2

Tab.6: *Type B1 facts*

Fig.63: *Type B1 front facade*

Fig.64: *Type B1 back facade*

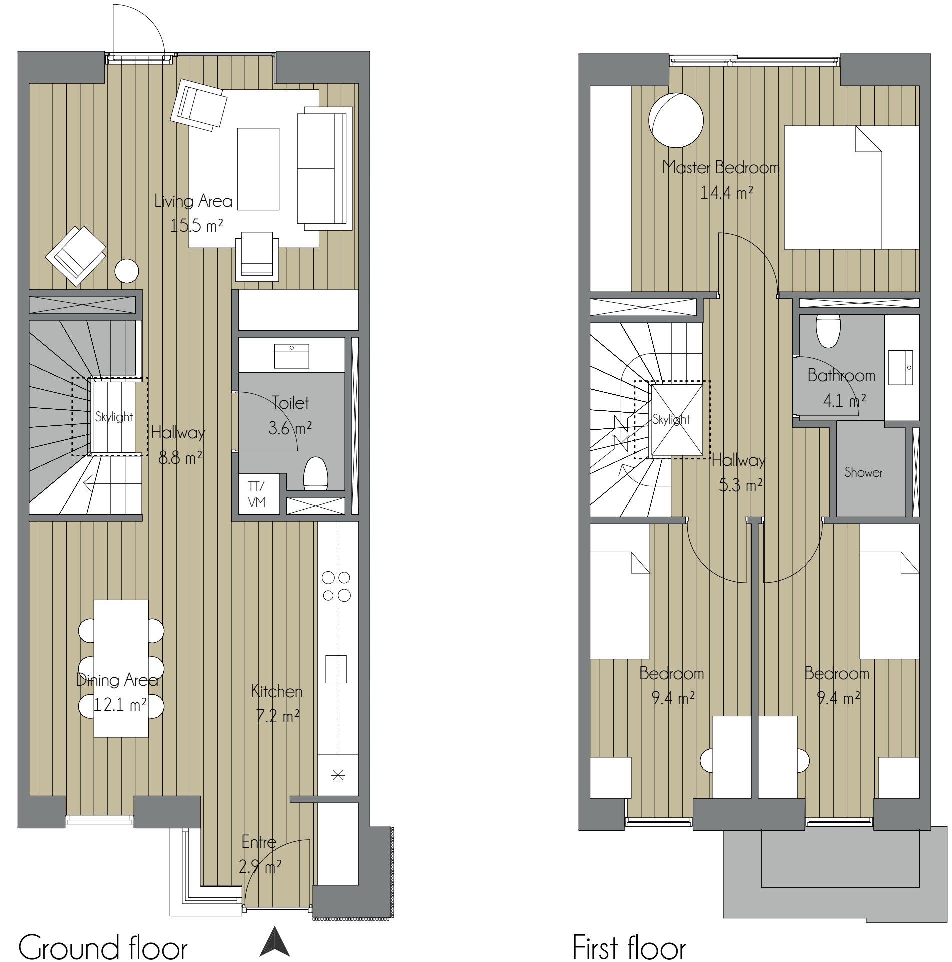


Fig.65: *Type B1 plan solution*

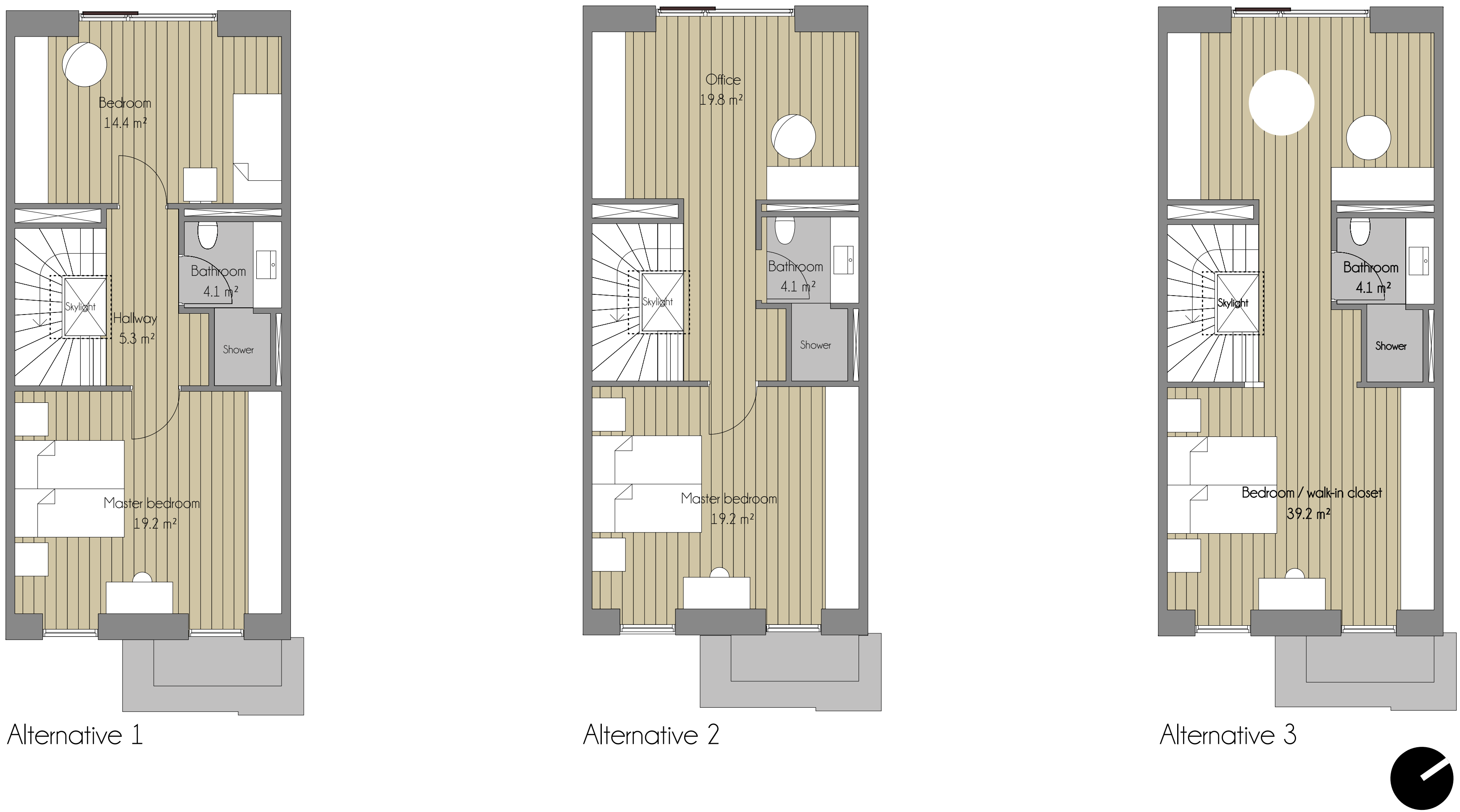


Fig.66: *Type B1 first floor alternatives*

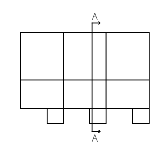


Fig.67: *Type B1 - section A-A*

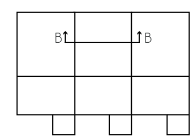


Fig.68: *Type B1 - section B-B*

TYPE B2

Type B2 is similar to the B1 Type with a second floor and a roof terrace to accommodate for the lack of a garden. This housing type is used both in East-West and North-South direction wherever a unit cannot be combined with a garden as an outdoor space. Similarly the first floor can be rearranged like type B1, while the second floor can consist of another bedroom and an office space or an open space.

Facts	
Gross area	154.9m^2
Net area	121.6m^2

Tab.7: *Type B2 facts*

Fig.71: *Type B2 - Facade*

Fig.69: *Type B2 front facade*

Fig.70: *Type B2 back facade*

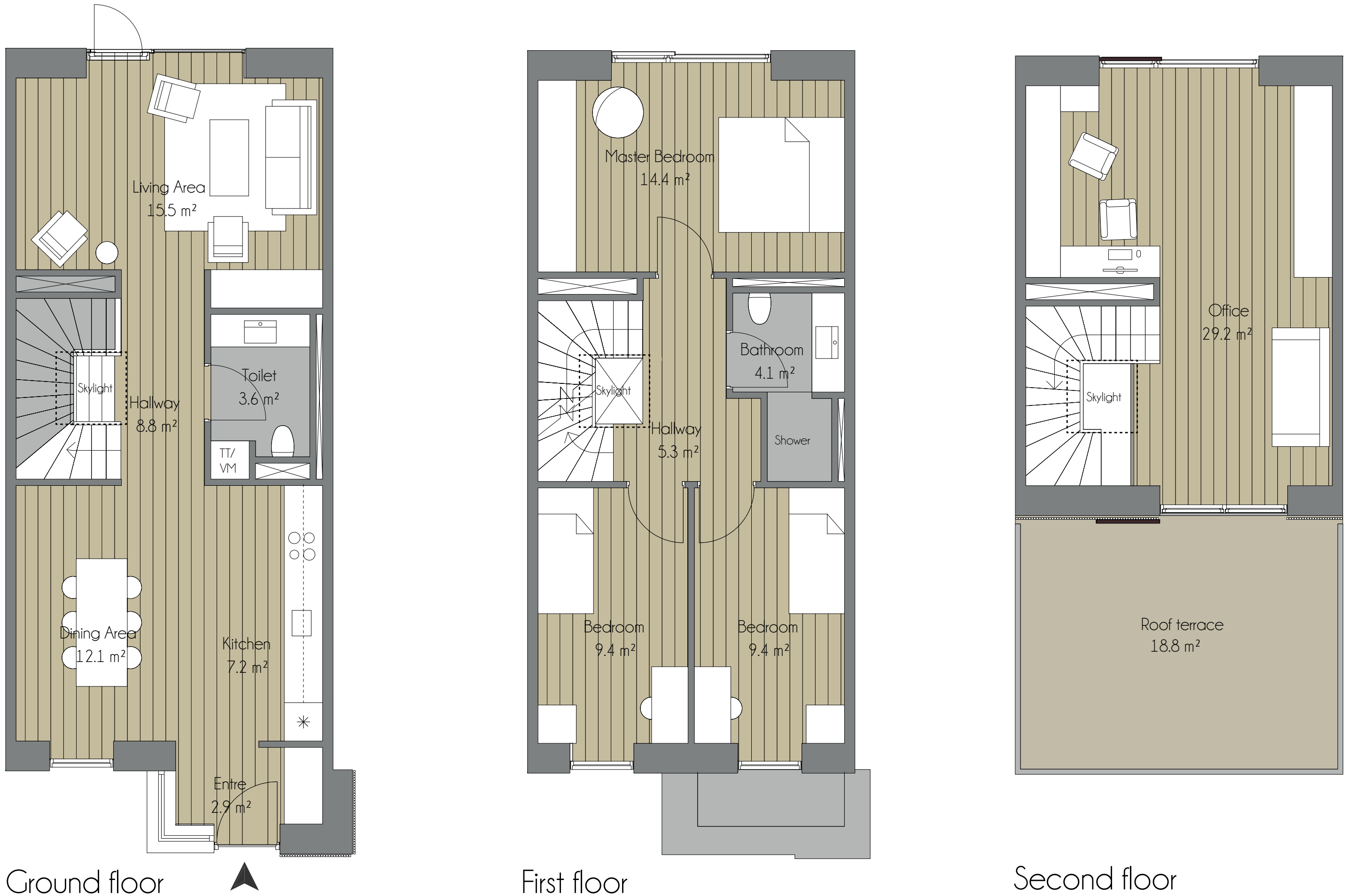
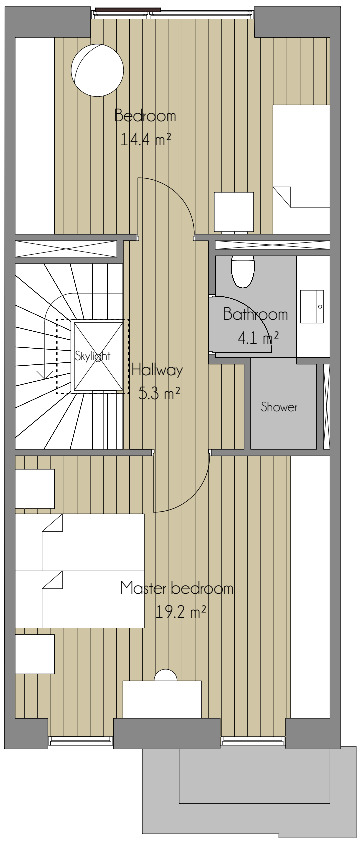
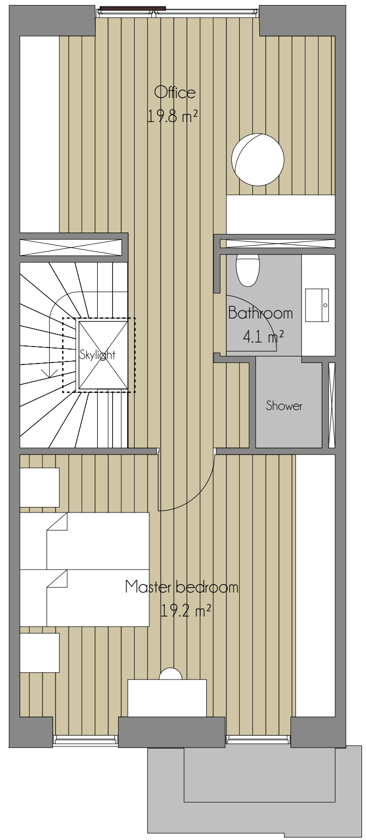


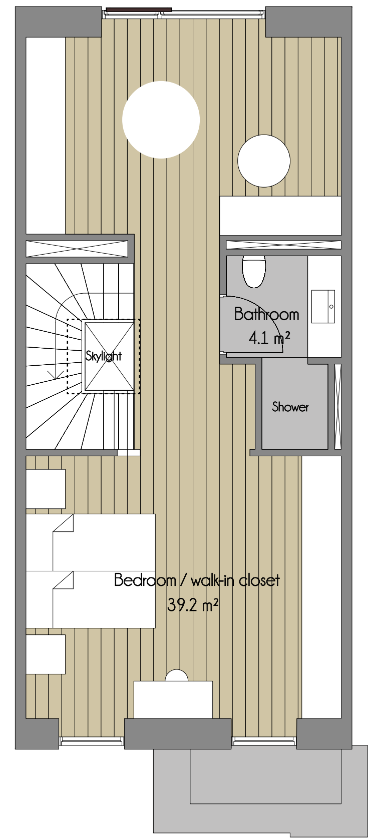
Fig.72: *Type B2 plan solution*



Alternative 1



Alternative 2



Alternative 3

FIG.73: *Type B2 first floor alternatives*

Alternative 1

FIG.74: *Type B2 second floor alternative*

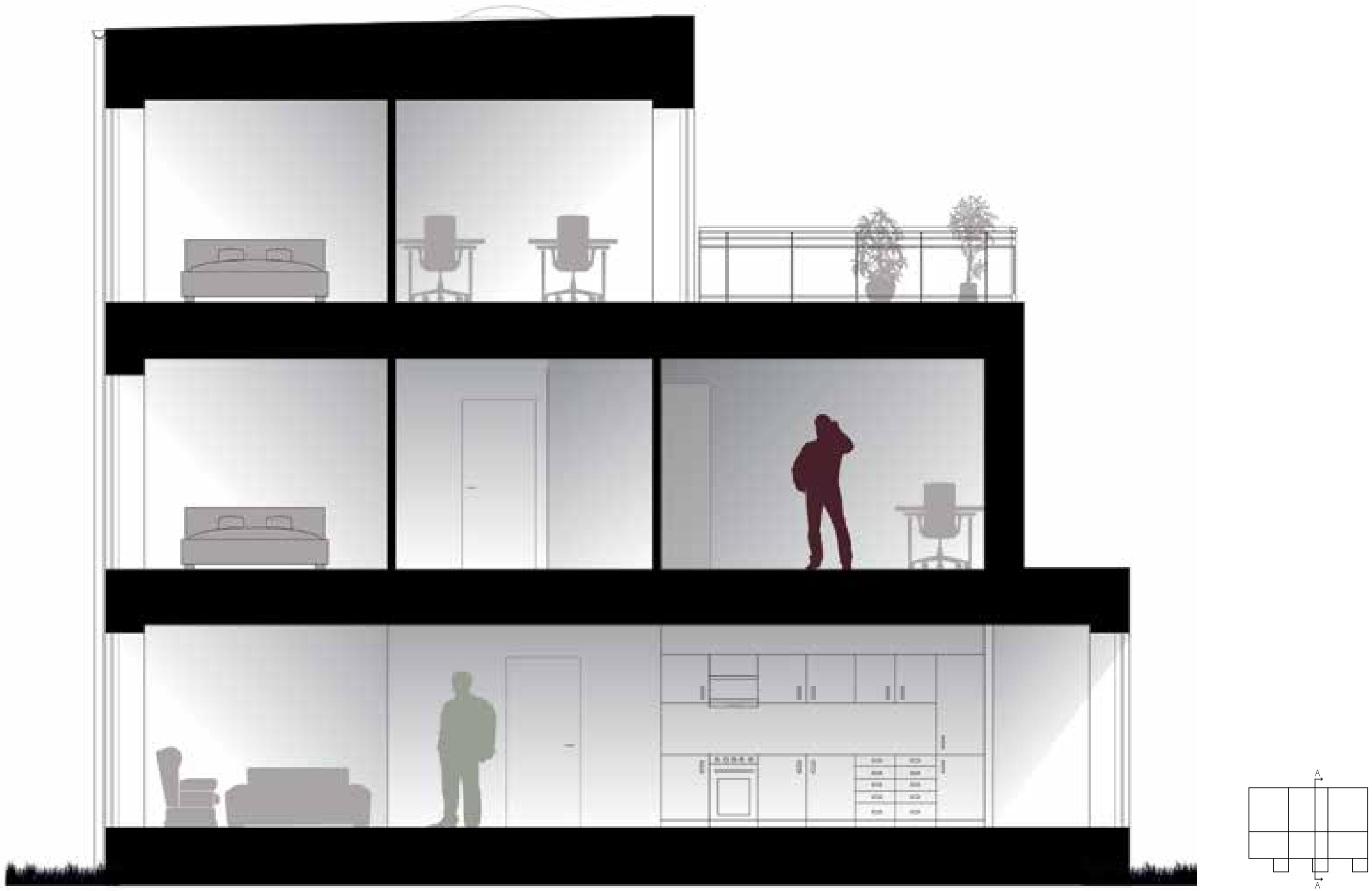
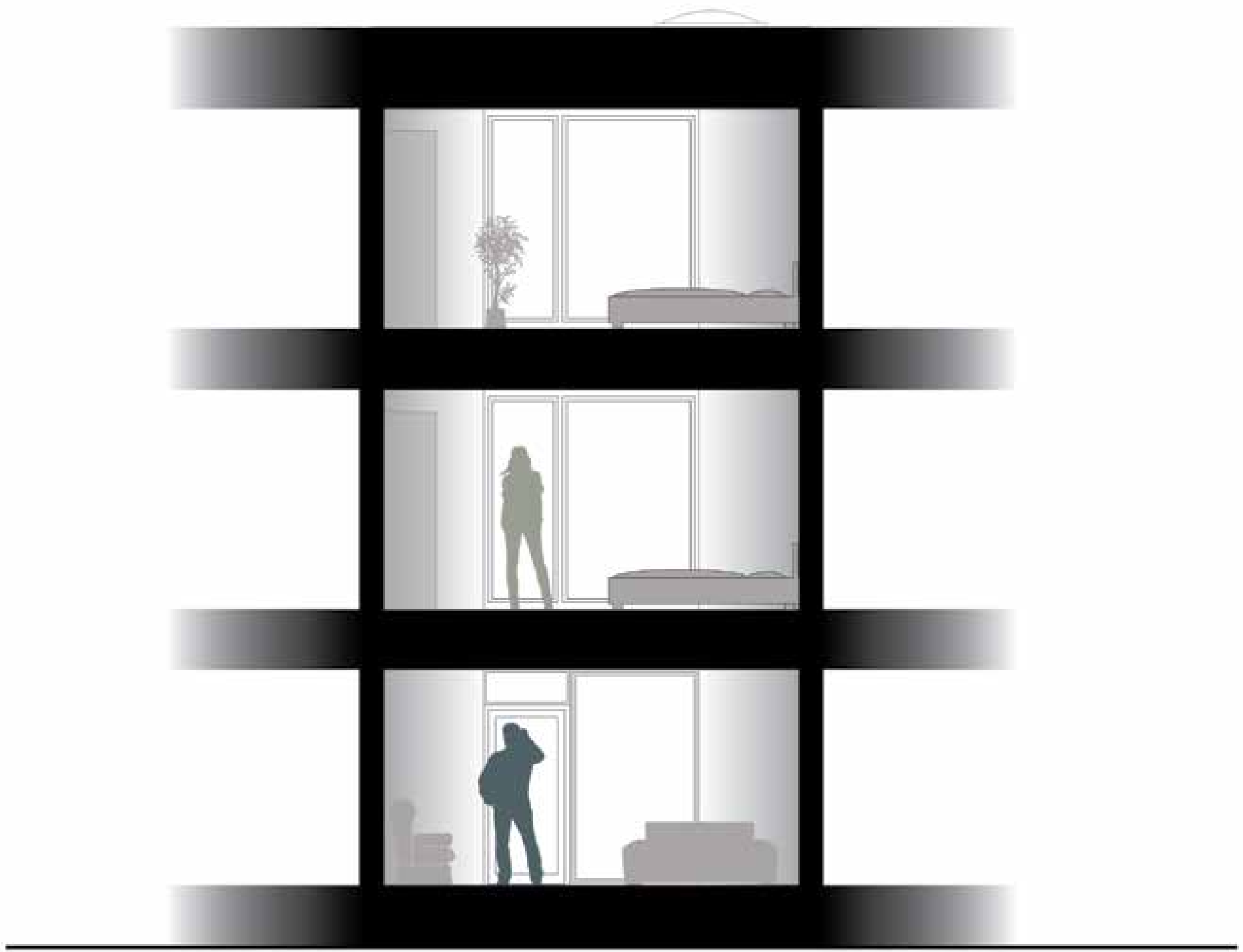


Fig.75: *Type B2 - section A-A*



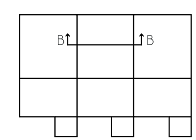


Fig.76: *Type B2 - section B-B*

Fig.77: *Type B2 - Kitchen*

Fig.79: *Type B2 - Living Room*

Fig.80: *Type B2 - Office*

Fig.81: *Type B2 - Master Bedrom*

TYPE B3

Type B3 has the same framework on the ground- and first- floor as the B2 type, with roof terrace to accommodate for the lack of a garden. In order to preserve the privacy for the inhabitants, the second floor is mirrored compared to Type B2 to prevent a direct vie between the roof terraces of the two types.

Facts	
Gross area	153.9m^2
Net area	117.2m^2

Tab.8: *Type B3 facts*

Fig.82: *Type B3 front facade*

Fig.83: *Type B3 back facade*

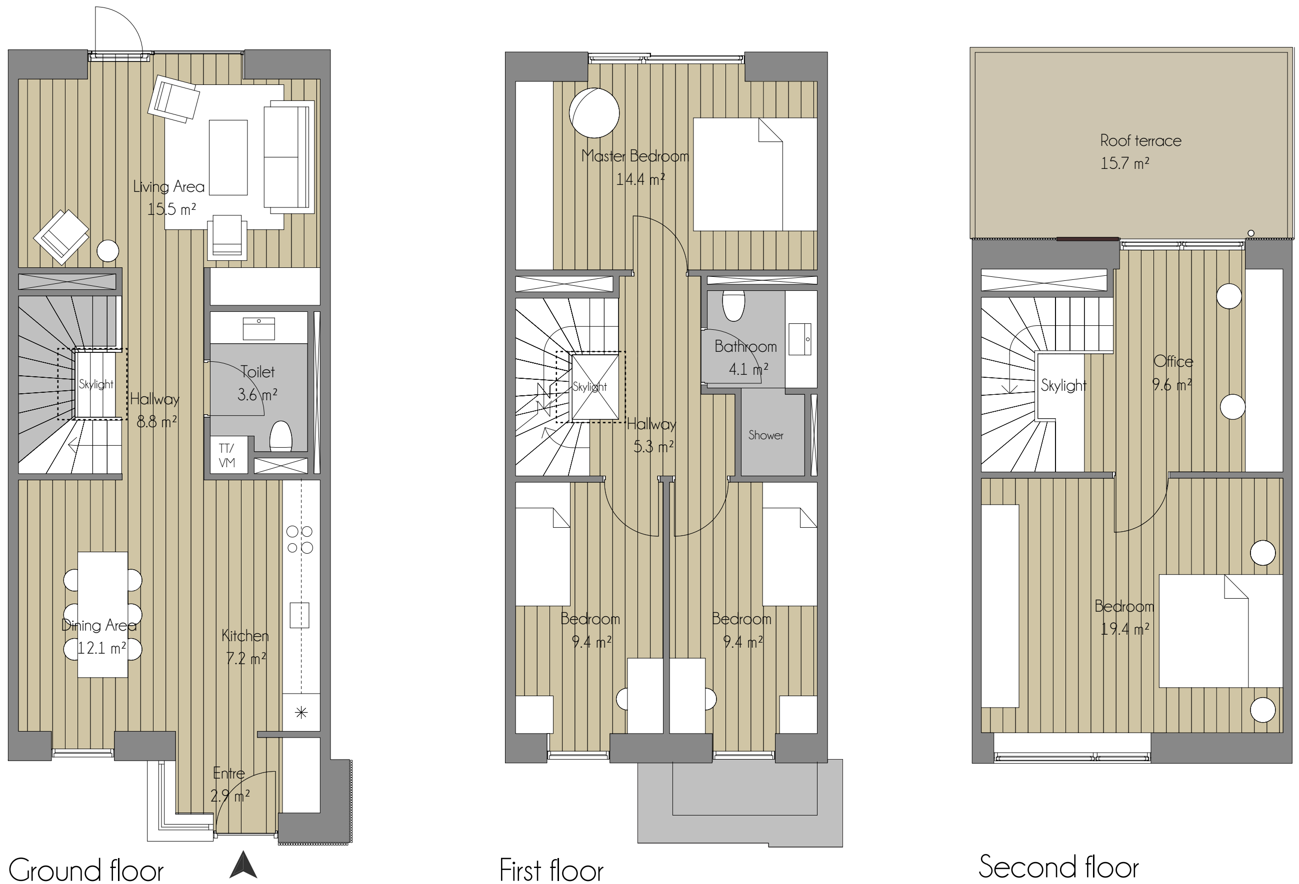
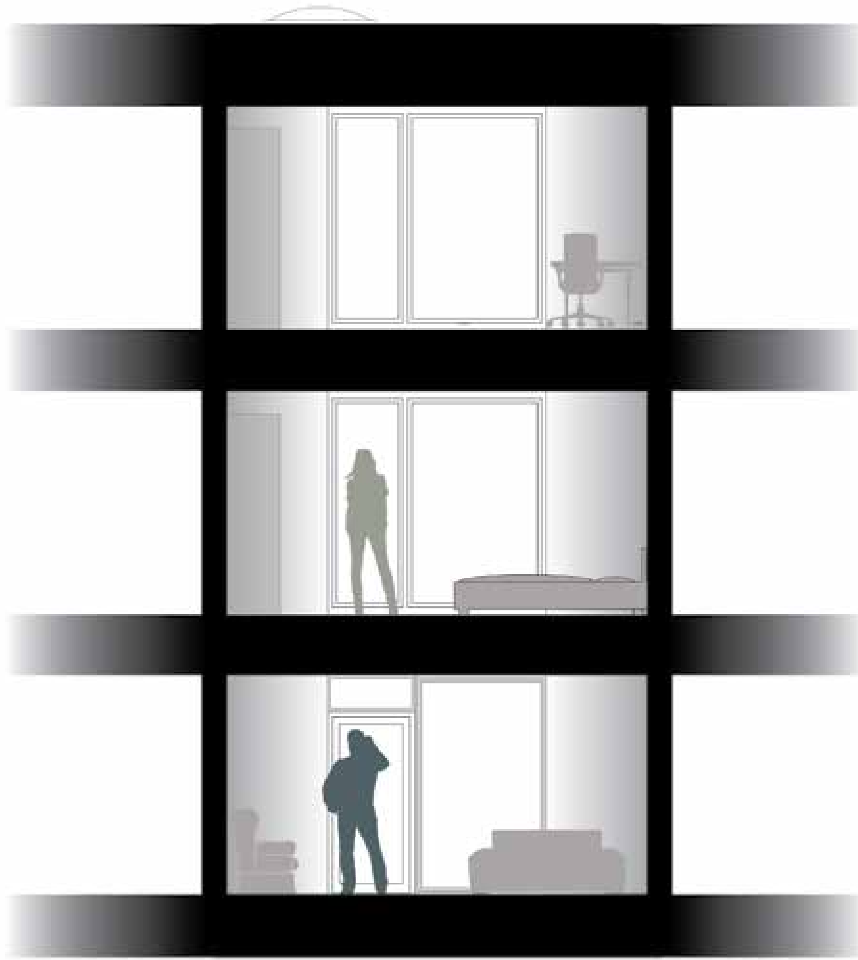


Fig.84: *Type B3 - plan solutions*

Fig.85: *Type B3 section A-A*



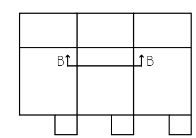


Fig.86: *Type B3 - section B-B*

TYPE C

The three housing towers are located in the North of the site, giving the three clusters in that area an urban expression, while creating a value of recognition of the project in general both for the inhabitants of the site and the residents of Skive

The displacement of the windows and the facades as a whole together with the shifting of the light brick tiles, create a dynamic and playful expression that works well together with the materiality of the remaining housing types. The dark window frames and the concrete base of the building together with the wooden shutters add a distinct contrast to the brick tiles as well.

Fig.87: *Type C North facade*

Fig.88: *Type C South facade*

Fig.89: *Type C SW facade*

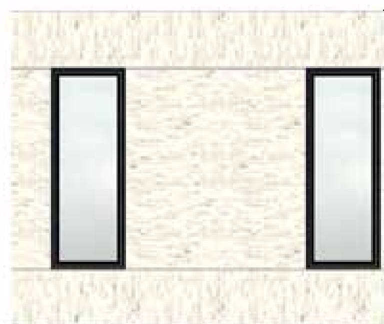


Fig.91: *Type C facade detail*

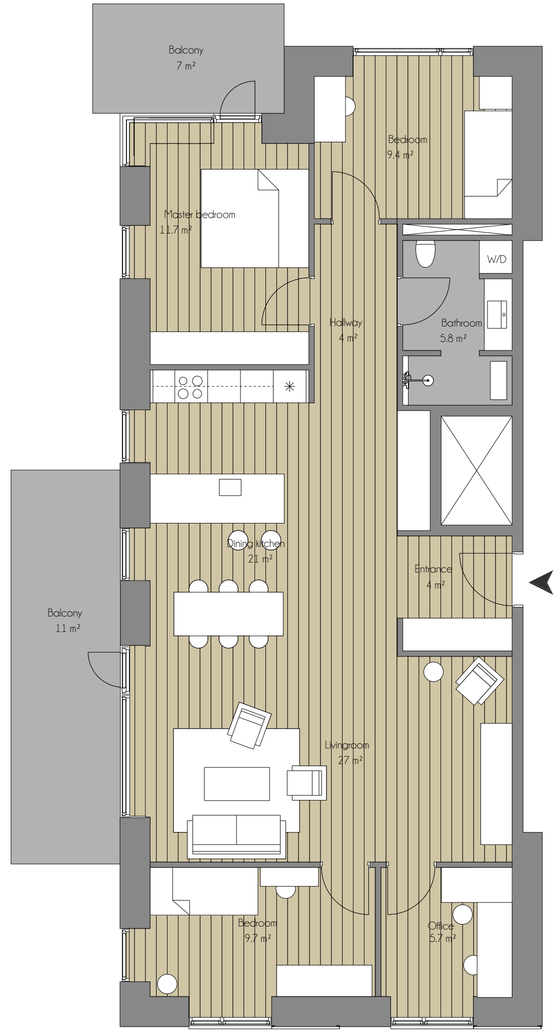
Fig.90: *Type C NW facade*

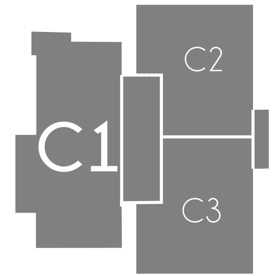
TYPE C1

Type C1, located on the west side of the housing towers, consists of three bedrooms, an open space with living and dining zones as well as a kitchen, a bathroom and an office. Alternatively the open space can be extended, removing a bedroom and the office walls or the office and the thirds bedroom can be linked together. Additionally, two balconies are attached to this housing type, one as part of the open living area and one as a private outdoor space accessed from the master bedroom.

Facts	
Gross area	142.8m^2
Net area	100.4m^2

Tab.9: *Type C1 facts*





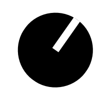


Fig.92: *Type C1 plan solution*

Fig.93: *Type C1 alternatives*

FIG.94: *Type C1 - Kitchen*

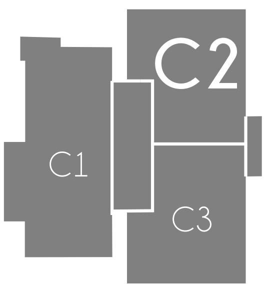
Fig.95: *Type C1 - Kitchen*

Fig.96: *Type C1 - Living Room*

Fig.97: *Type C1 - Master Bedroom*

TYPE C2

This unit is located on the east side of the housing towers. The two bedroom apartment contains an open living space as well as an open dining area in extension of the kitchen. Alternatively the living area and the bedrooms can switch places or one bedroom can be removed entirely to increase the size of the open space. Also, a balcony is attached to either the master bedroom or the living area. This one storey appartment is especially suitable for the elderly, because of a high level of accessibility.



Facts	
Gross area	116.4m^2
Net area	80.1m^2

Tab.10: *Type C2 facts*

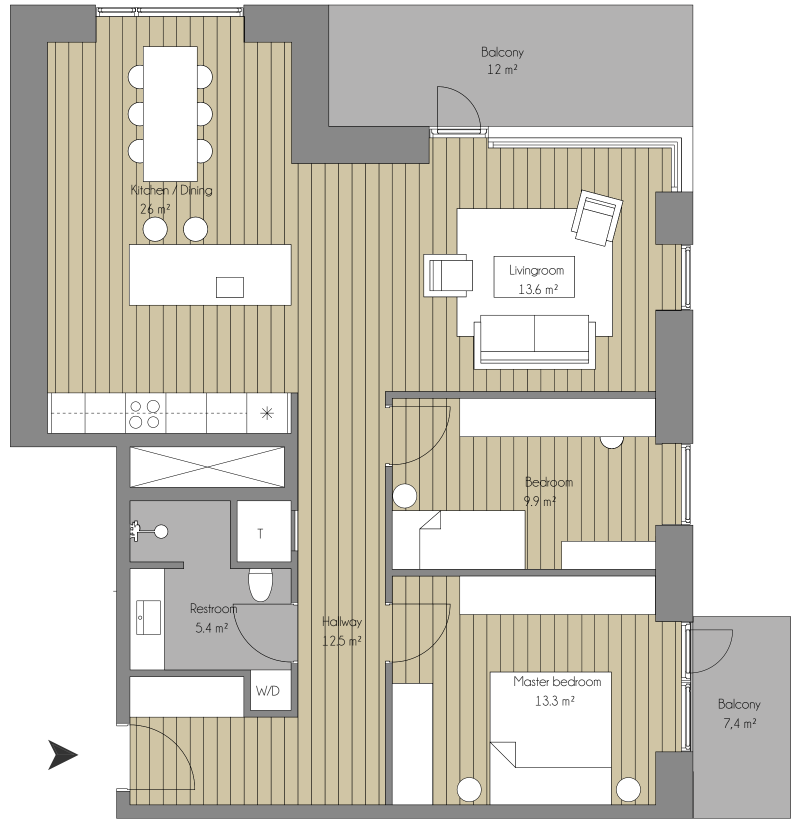
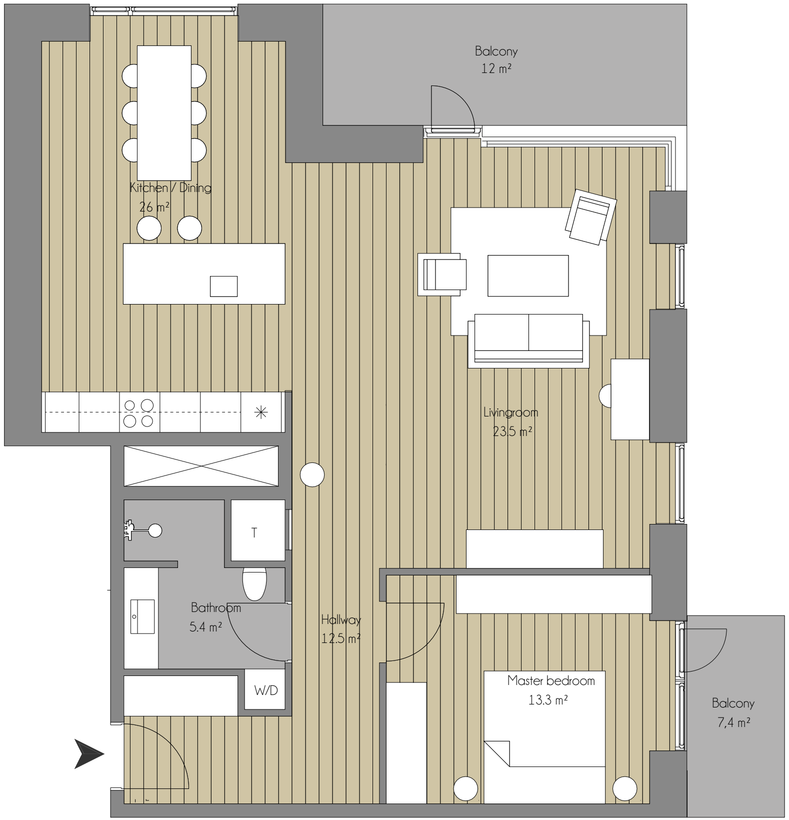
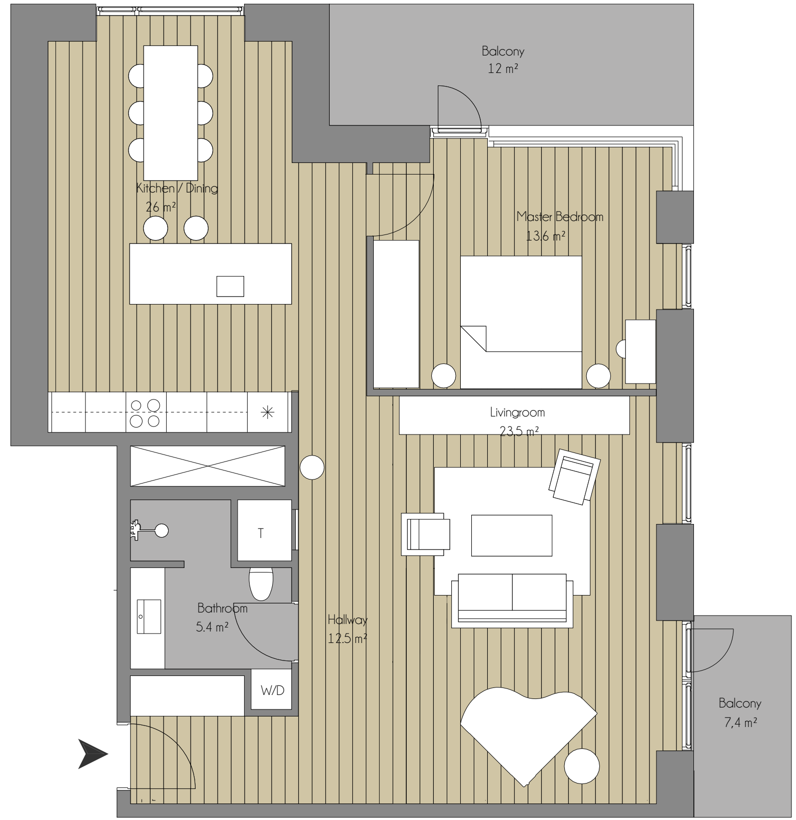


Fig.98: *Type C2 plan solution*



Alternative 1



Alternative 2

Fig.99: *Type C2 alternatives*

Fig.100: *Type C2 - Kitchen*

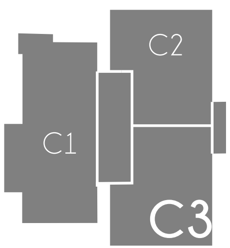
Fig.101: *Type C2 - Dining Area*

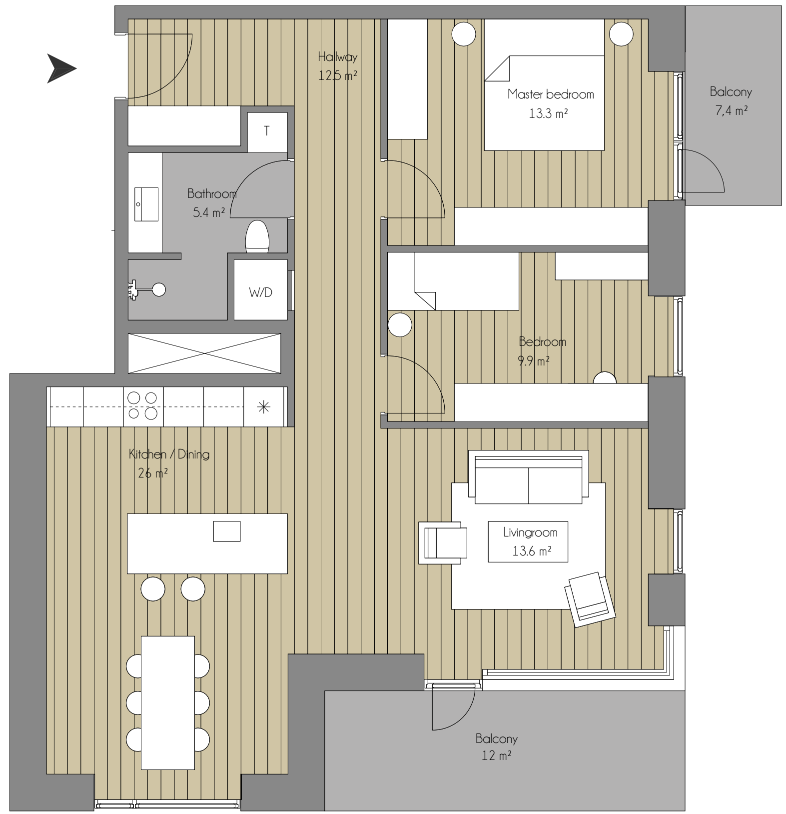
Fig.102: *Type C2 - Living Area*

Fig.103: *type C2 - Master Bedroom*

TYPE C3

Type C3 is similar to type C2 in its plan solution, but mirrored horizontally, locating the living areas towards the south-west. Equally, it is the two bedrooms, that define the flexible interior of this type, by either swapping them between each other or with the living area. Also one bedroom can be removed entirely. Similarily, type C3 is especially suitable for elderly people, as it is very accessible.

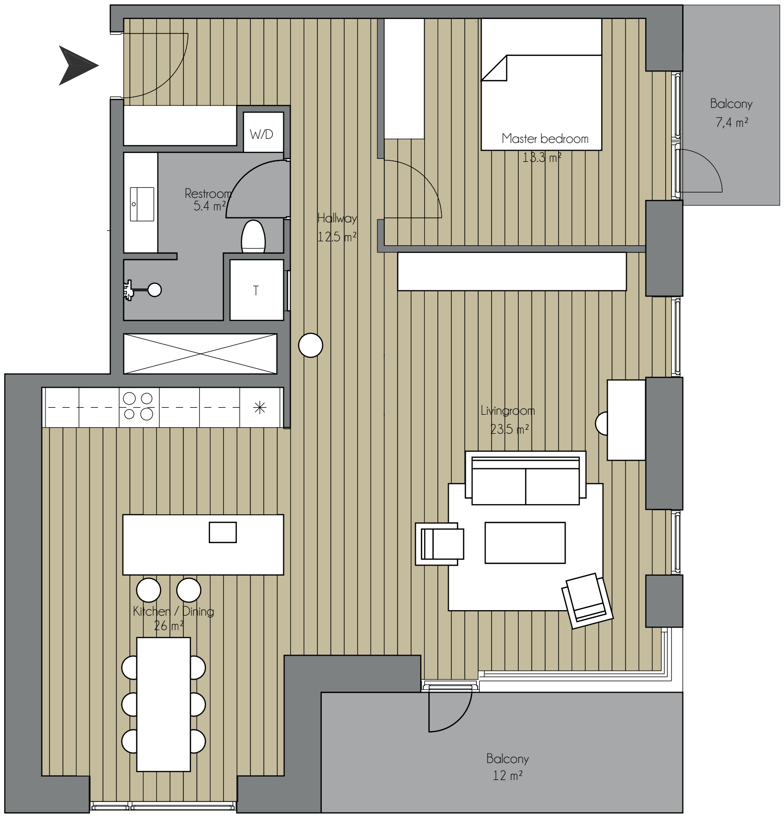




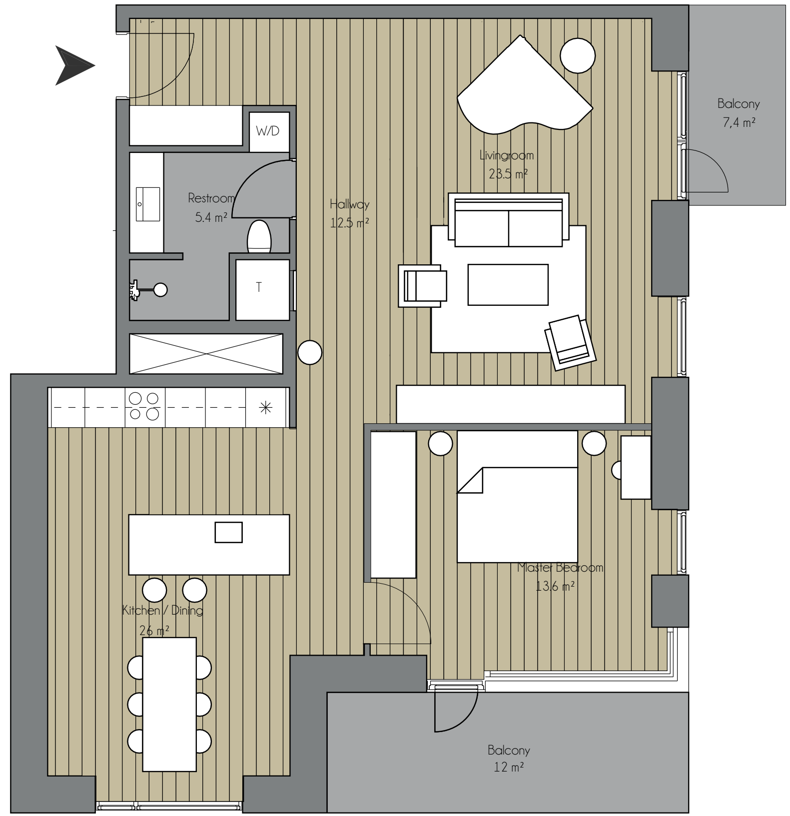
Facts	
Gross area	116.4m²
Net area	80.1m²

Tab.11: *Type C3 facts*

Fig.104: *Type C3 plan solution*



Alternative 1



Alternative 2

Fig.105: *Type C3 alternatives*

COMMON HOUSE

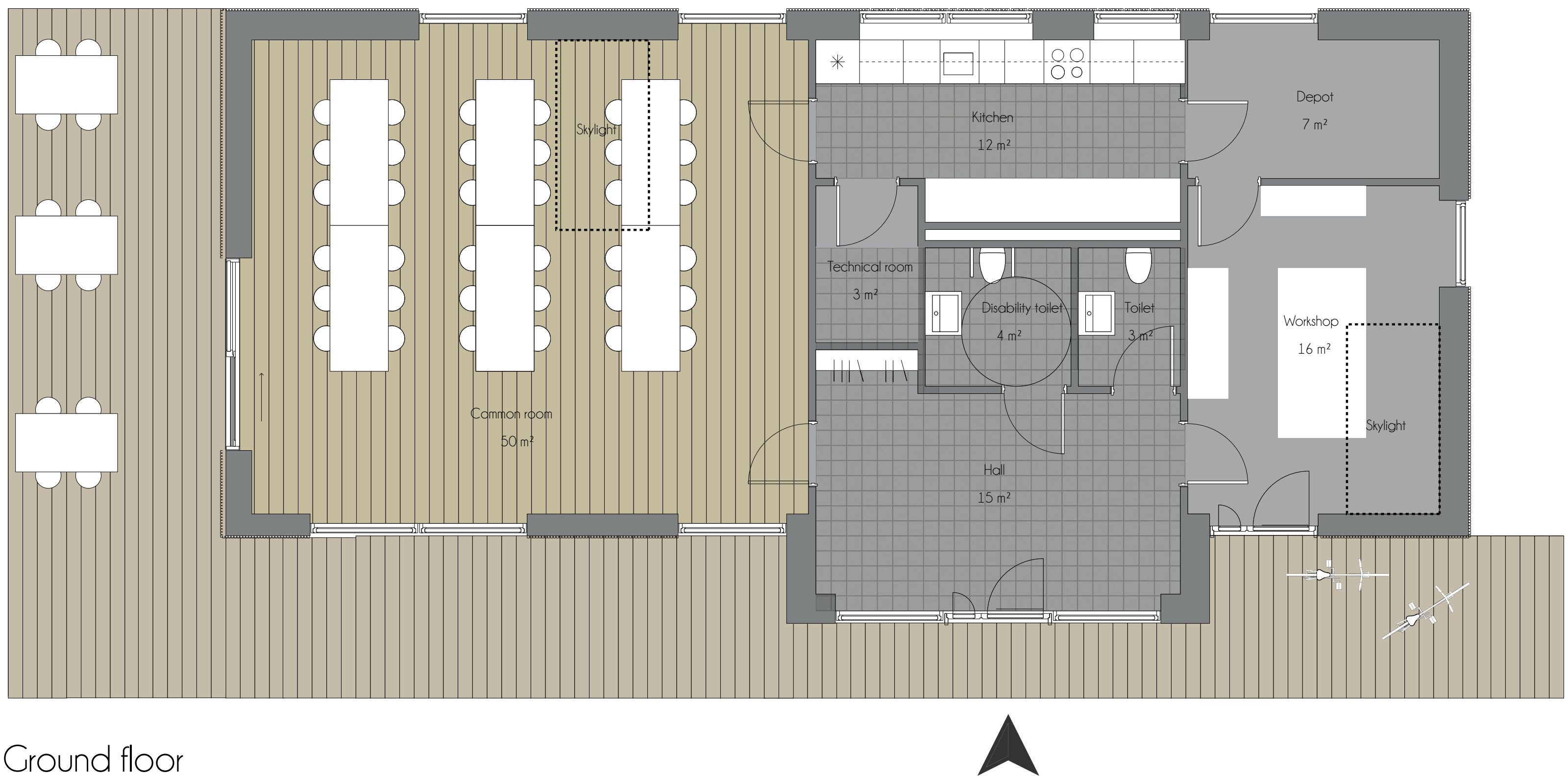
The common house is part of the social community, which forms the framework for different types of communal facilities and activities. The common house includes kitchen and dining facilities in which it is possible for the residents to cook together or to hold gatherings and festivities. Additionally, a workshop is integrated for the residents to be creative or to maintain their bicycles and motorbikes during their leisure time.

Fig.106: *Common house SE and NE facades*

Fig.107: *Common house NW and NW facades*

Facts	
Gross area	130m ^{2}
Net area	110m ^{2}

Tab.12: *Common House facts*

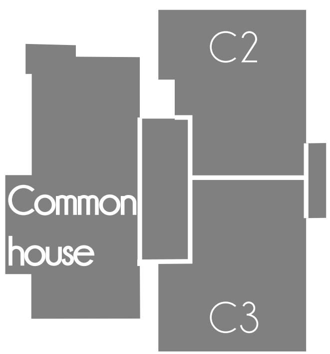


Ground floor

Fig.108: *Common house plan solution*

COMMON HOUSE - HOUSING TOWER

This common house is situated on the first floor of the housing tower, as an addition to the courtyard, the common house is the central framework for the activities that integrate the habitants of the community. Moreover, it can be used for opening the living community in relation to the surrounding society, for example to let friends, family and neighbours attend parties and communal gatherings.



Facts	
Gross area	128.3m^2
Net area	109.5m^2

Tab.13: *Type C common rooms facts*

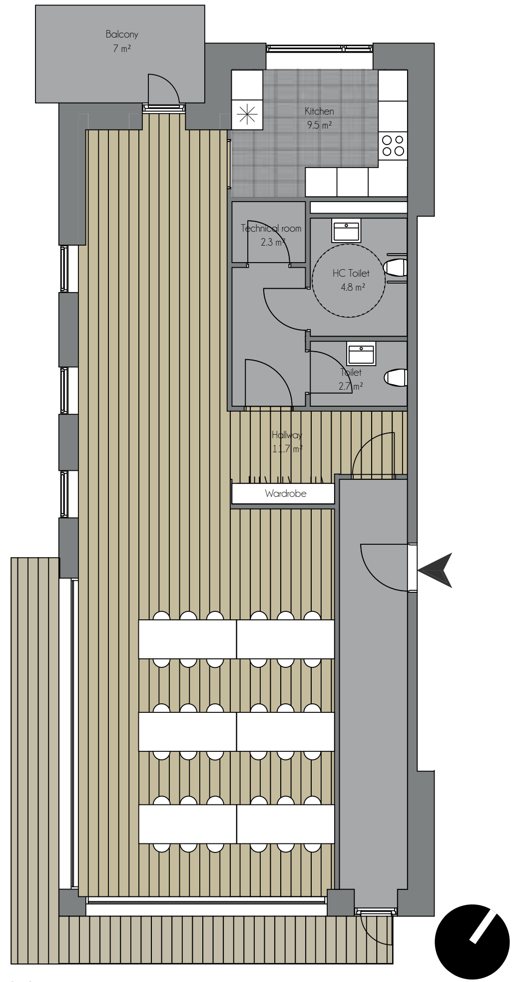


Fig.109: *Common house plan solution*

3

PROCESS

ARCHITECTURAL DESIGN PROCESS

FIG.110: *Nature*

FIG.111: *Sustainable Architecture*

FIG.112: *Social community*

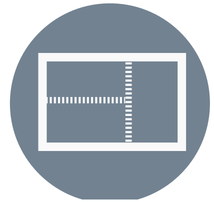


FIG.113: *Flexibility*

FIG.114: *Diversity*

FIG.115: *Realistic Approach*

DESIGN PARAMETERS

To summarize the key elements from the program and our own ambitions for the project, a number of design parameters has been collected in a list below.

Nature
The value of greenery as an integrated part of the masterplan is set to be very highly. The liveliness a well-designed green area gives, while creating a contrast and a connection to the buildings, its surrounding is an important parameter to take into account during all design stages.

Sustainability & Architecture
As described earlier, sustainability is an important factor during all design stages and should therefore be incorporated in the project in such a manner, that the architectural quality doesn't suffer but rather be improved by the sustainable solutions chosen throughout the process.

Social community
In terms of sustainability, social sustainability stands out to be of a very high priority. As such, it is to prefer choosing design solutions that offer the opportunity to create social community in the project.

Flexible Living
The possibility to rearrange and adjust the interior solutions of a dwelling according to long-term changes during a family life is an important key factor that is taken into consideration at all stages during the project.

Diversity
Not only should the interior design be defined by a diversity according to life choices, but the exterior as well. Therefore, design solutions that create diversity in materiality, spatiality and outdoor spaces in general are valued highly.

Realistic Conditions
The project shouldn't be a purely fictive one, but be designed in such a fashion, that it would be realistic to be built in the future, thus including the plot ratio, exterior and interior solutions as well as material and detail choices throughout the process.

INITIAL PROCESS

In the beginning of the design process it was important to have a free sketching phase, where ideas of interest could flourish.

There were some requirements which should be met, these were, using the nature as a core value, which meant that the typology couldnt be too dominant. Emphasis should be placed on the experiences of the term and the buildings, also the disused railway should be preserved as a path in the best way possible. By starting with a free design process, we had the possibility of aligning our expectations and at the same time distinguish the different group members' ideas, which served as inspiration.

The free design process consisted mostly of master plans with different varieties of building types and placement, but also the infrastructure, with paths, roads and parking

The design ideas were very different according to typology and the infrastructure. The typologies designed ranged from townhouses to detached houses, multi-storey buildings and outlying settlements. Parallel to this, quick sketches were drawn of the design of each house and the expression that it should give according to the materiality and the spatiality.

There were a great variety of ideas, but master plans and sketches did not give an idea of the plot ratio, and we began modelling with foamcubes in 1:500 of 7.5x7.5m and some at 10x10m according roughly to the initial room program created earlier. Initially we worked in a total of 4 workshops with different focal points:

- WS1: Density & Atmosphere
- WS2: Typology % Structure
- WS3: Wind and Sun
- WS4: Synopsis of the previous workshops

Fig.116: *Initial masterplan sketch*

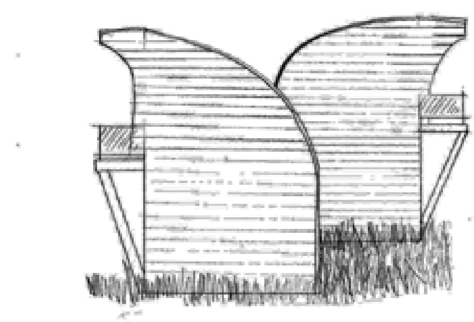


Fig.117: *Initial building sketch*

Fig.119: *initial masterplan sketches*

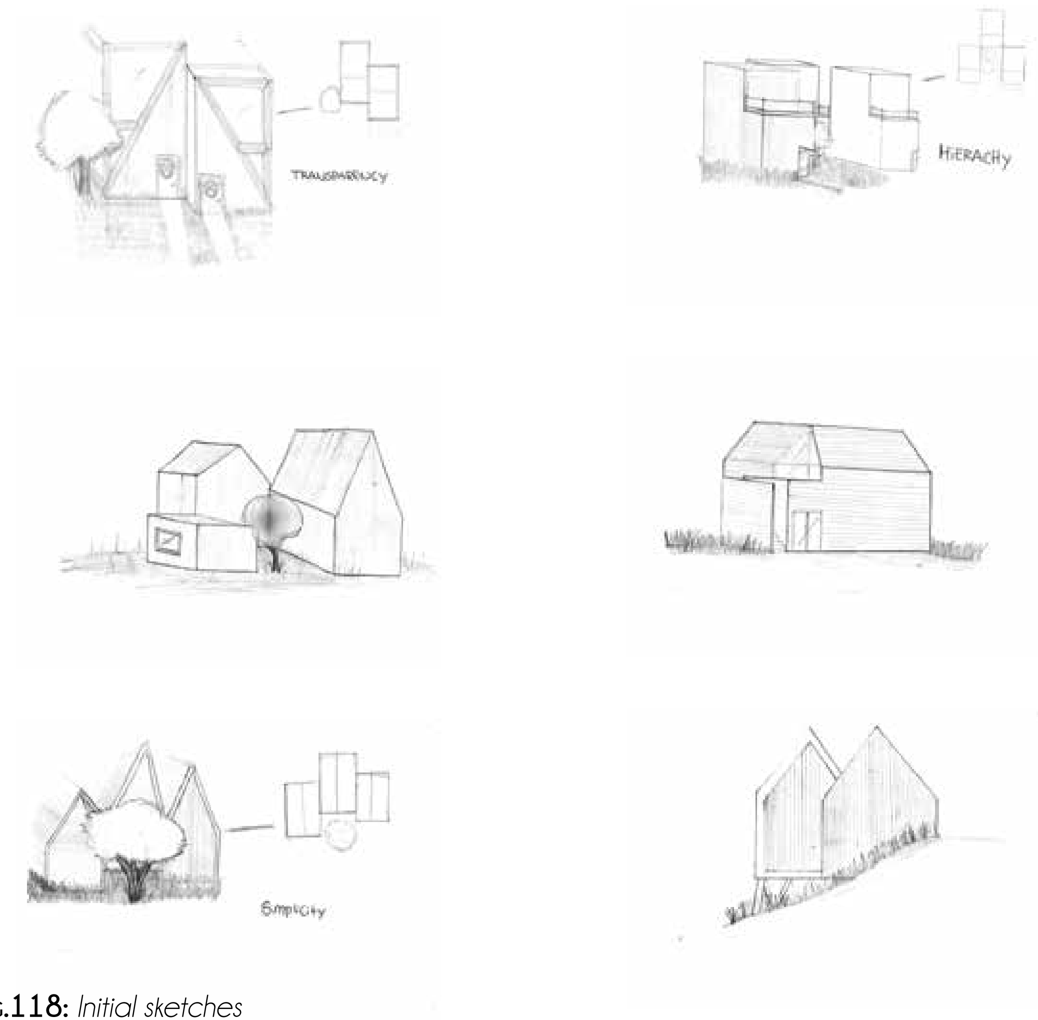


Fig.118: *Initial sketches*

WORKSHOP #1

In this phase, we started a volume study by listing some different typologies in relation to the plot ratio, we tried typologies with 100 and 80% to experience the spatial feeling of a higher plot ratio and 70% to work with what the municipality would suggest.

We started with mixed typologies to get the understanding of how much space it would consume. When placing the 100%, the intention were to see which type of expression it could give, distances between the blocks and if it could give an idea of the infrastructure.

The results of studies showed that a building percentage of 100% was too much because it gave a sense of an ideal block structure as you see in major cities, thereby exceeds the needs of Skive. Eventually 80% also became too much, creating unpleasant outdoor spaces. Therefore these type of plot ratio's were not considered to be developed further.

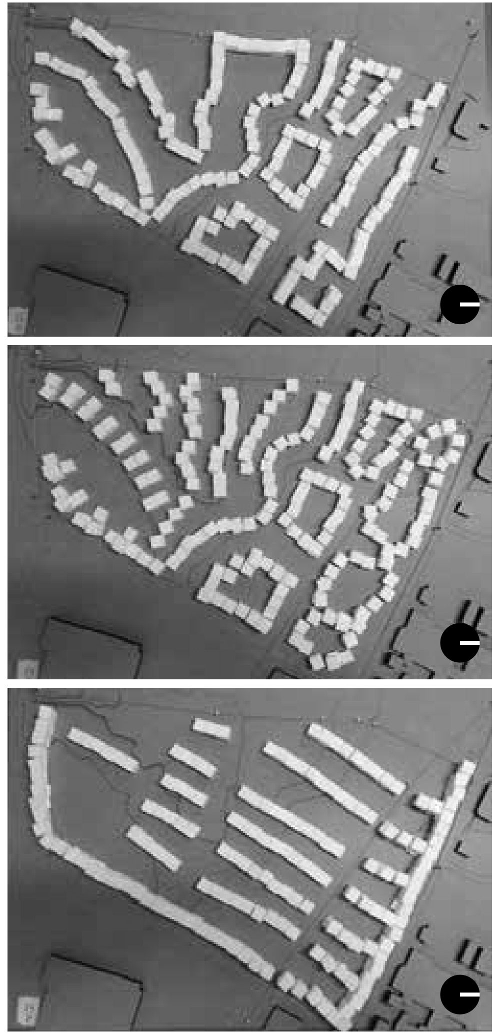


Fig.120: *Plot ratio of 100% volume study*

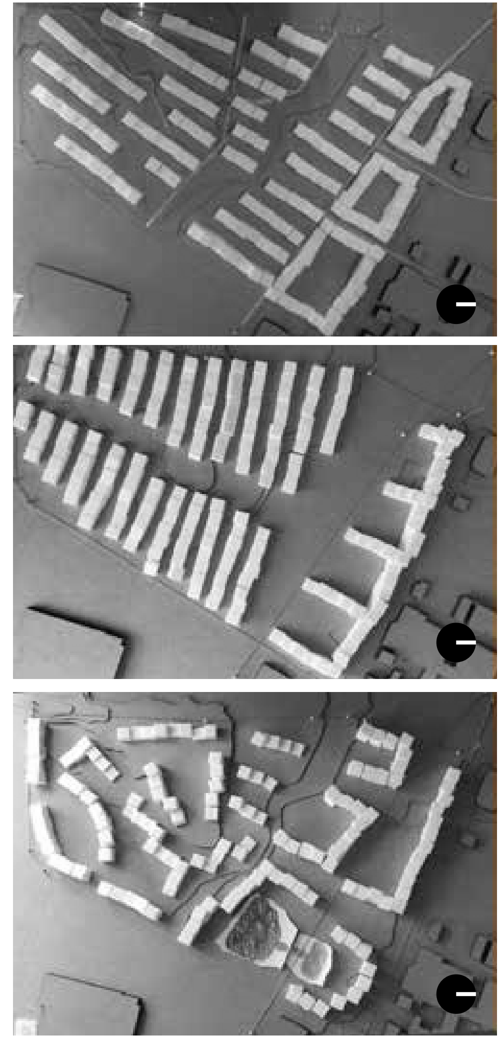


Fig.121: *Plot ratio of 80% volume study*

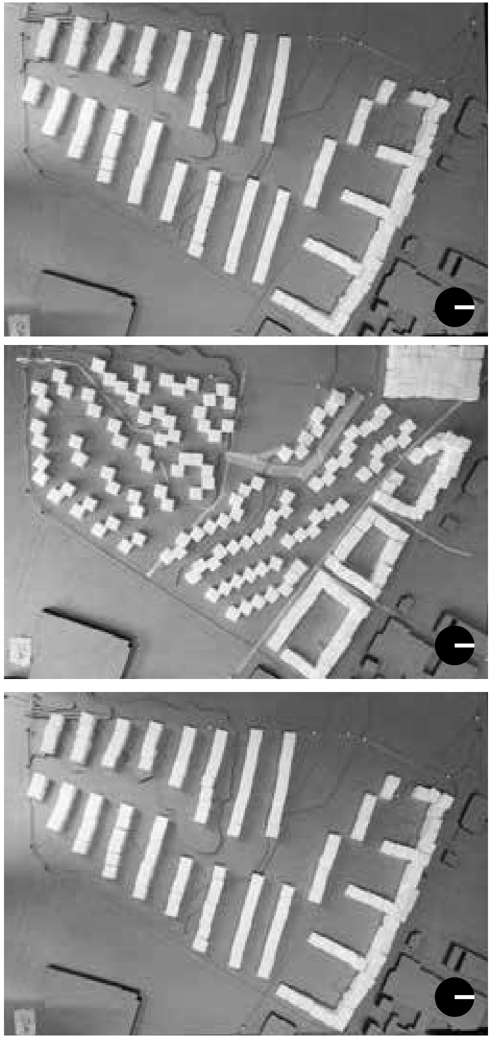


Fig.122: *Plot ratio of 70% volume study*

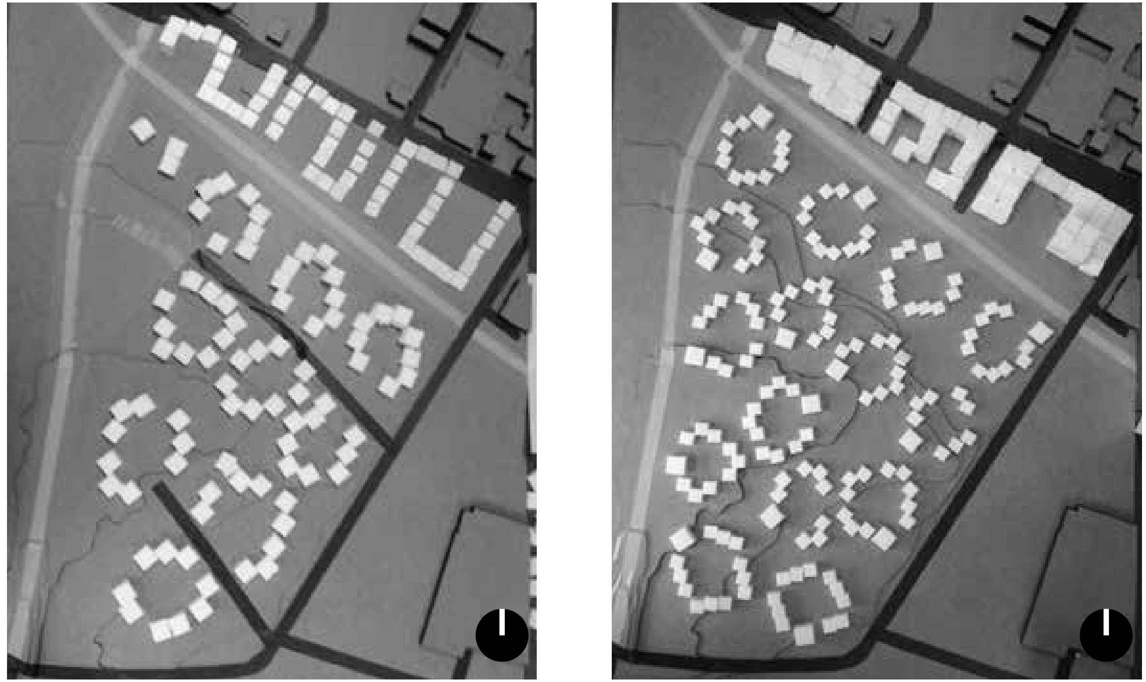


Fig.123: *Cluster housing formations volume study*

Through simoultanously researching, we began studiyng cluster houses, as the emphasis were on social sustainability. This typology were a better compliment to the masterplan of BIG "Big Blue Skive 2040" and can offer exciting courtyards full of life. Although, one of the downsides of this typology is a rather small plot ratio. This were considered as the typology we used for further development according to the qualities it gives to the social sustanability. and the fact that we were designing homes for families. Here we also began to see it in comparison with the context of Skive versus a bigger city, and the clusterhouse stood out to be stronger according to our design parameters.

WORKSHOP #2

In this workshop we went deeper into the design of the building, The methods used here was sketching and foam as a volume study but on a larger scale, which enabled us to expand our spacious understanding.

We had taken the idea of cluster houses further from workshop 1 and worked from an idea of a fragmented farm house that would provide momentum in the architectural expression. and create architecture where solar and wind, in relation to shelter and daylight were taken into account.

In addition to the above, we had ongoing studies on whether one could use prefabricated modular elements, and how the structural system should be as it has always been the idea to use wood as the main material.

Simoultaniously we started to look into the different plan solutions of the volume studies.

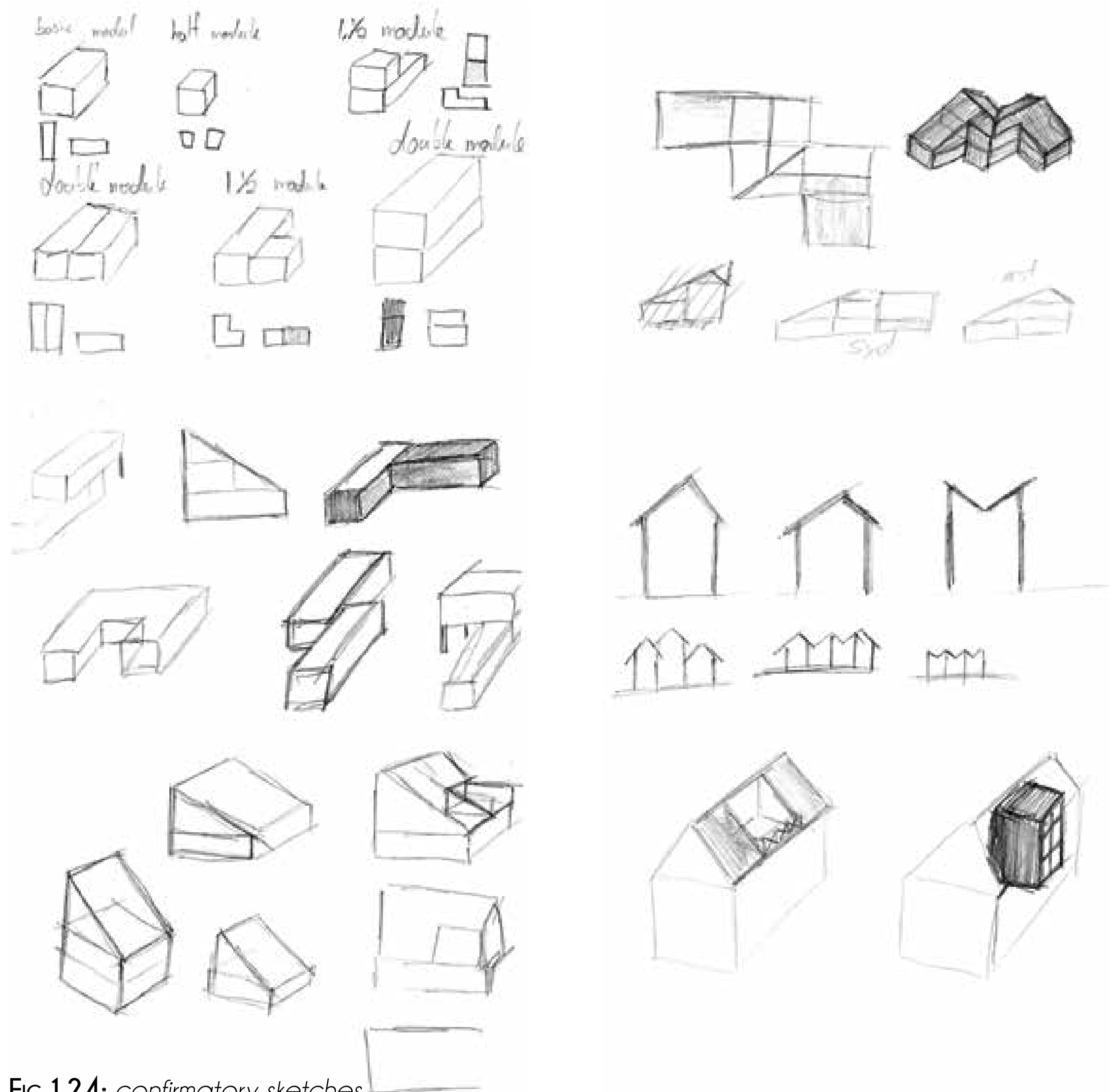


Fig.124: *confirmatory sketches*

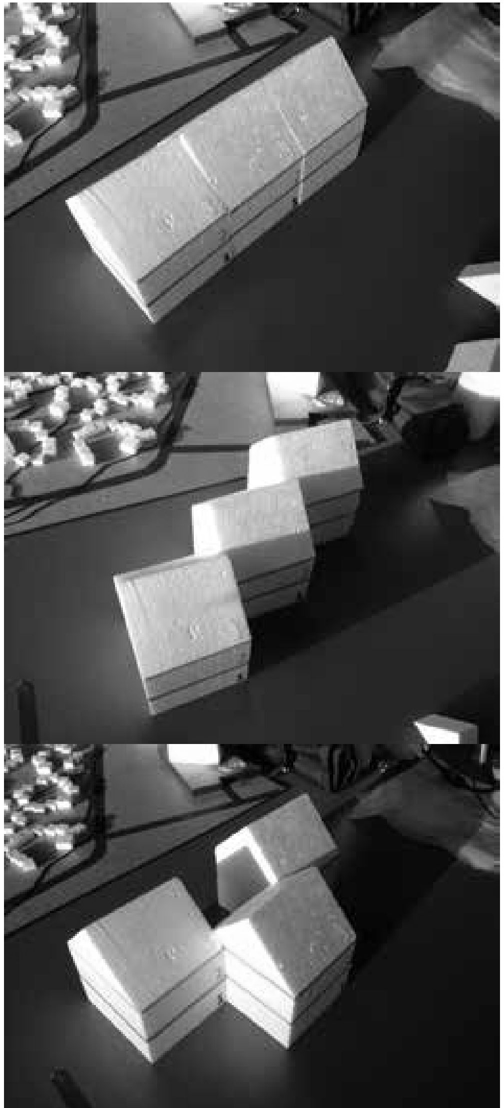


Fig.125: *Farmhouse study*

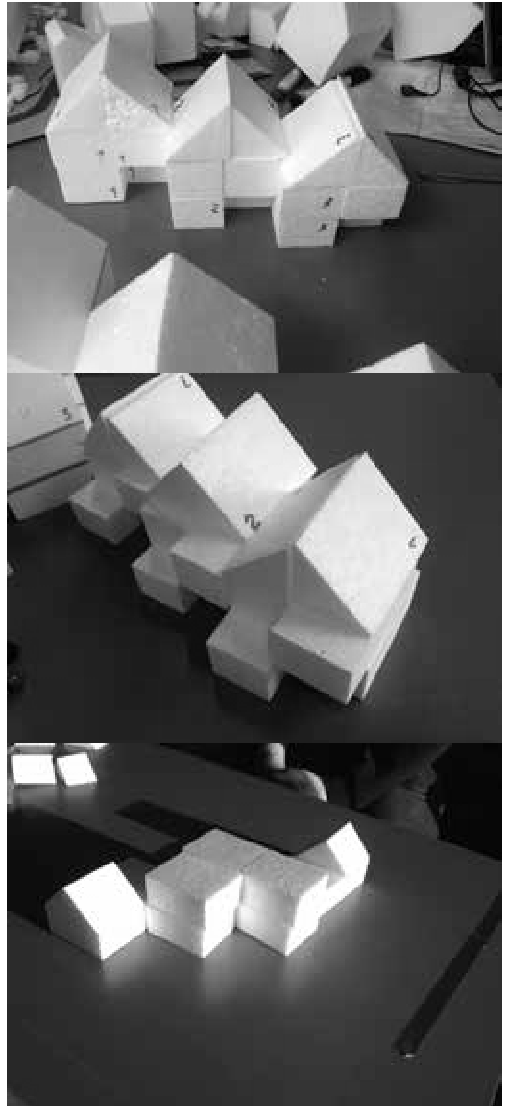


Fig.126: *Fragmented and mixed typology study*

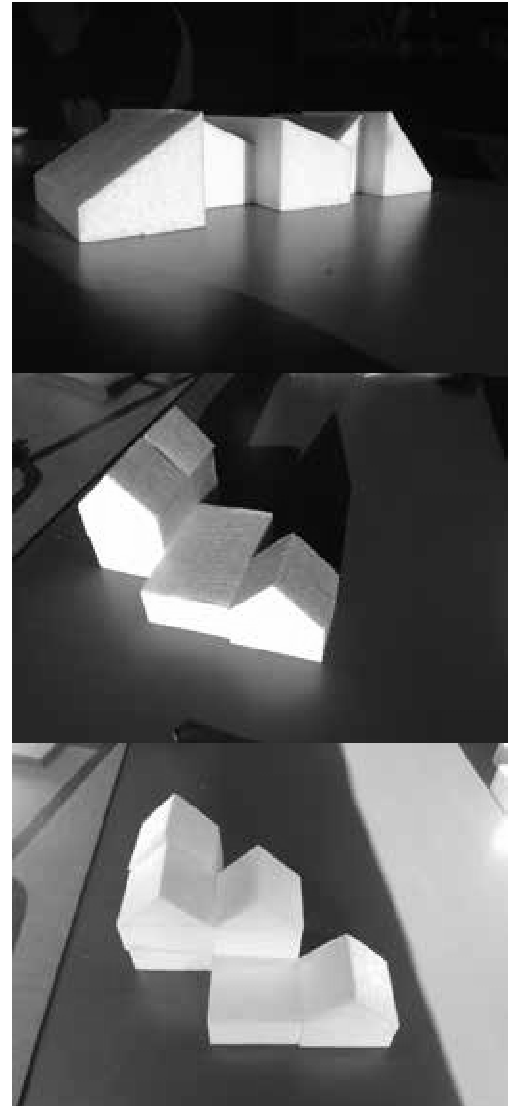


Fig.127: *Confirmatory volume studies*

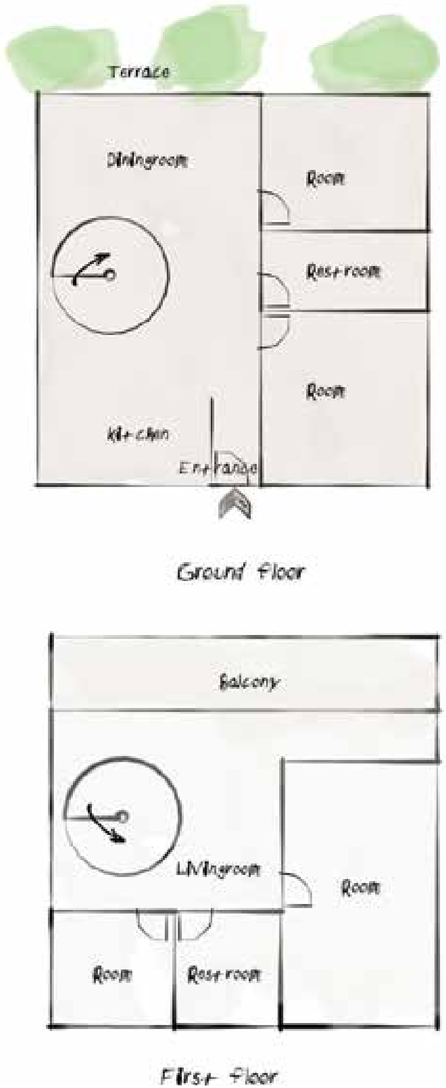


Fig.128: *Plan sketches from models*

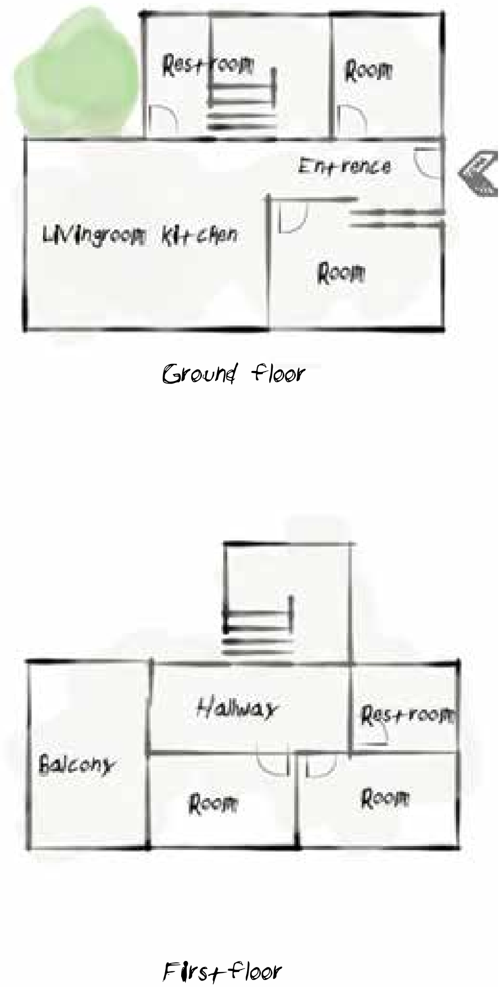


Fig.129: *Plan sketches from models*

PLAN SKETCHES

While sketching at the first plan solutions, we were very aware that the buildings should have the character of flexibility to adjust for vicissitudes of the everyday life over any period of time.

We wanted to drag parallels from the qualities of the single-family housing, according to the outdoor areas but also the size - where there is room for everyone - this was of great importance. A space for each and everyone in the household should be possible, both for gathering and to be alone.

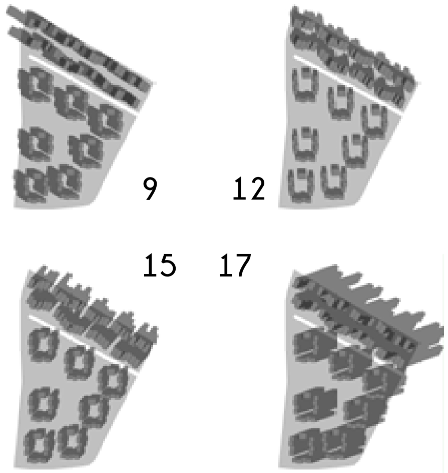


Fig.130: *Shadowstudy - March 21st*

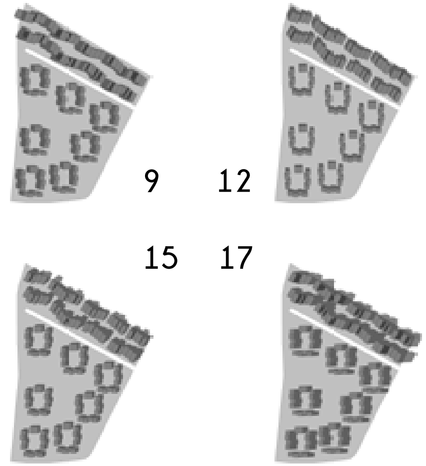


Fig.131: *Shadowstudy - June 21st*

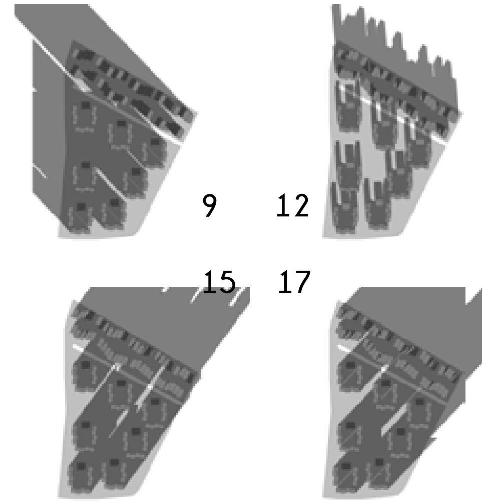


Fig.132: *Shadowstudy - December 21st*

WORKSHOP #3

In workshop 3, the focal points lied on the pleasant outdoor areas, courtyard and interior according to daylight exposure and excessive heating (basic studies). The intention with the solarstudy was to create an area that was comfortable to stay in, most of the year, compared to the sun and how the cluster buildings cast their shadows.
This was done, however, to give an indication of how far the individual houses should be placed from each other, so as to minimize the recreative areas being covered in shade. Alongside with the solarstudy, we examined some windowtypes and orientations as shown in the technical design process.

These studies have given us an indication of window placement, to get the most daylight benefit, and that the difference in the displacement of the glass area according to the facade is of big influence according to the architectural expression, which should be taken into consideration in the further progress.

WORKSHOP #4

In workshop 4, the focus lied on gathering the knowledge gained from the first three workshops and create an initial masterplan.

The initial thoughts behind the synthesis workshop were to make use of the historic buildings on the site and reproduce similar typologies on the site to maintain and retell the history of the slaughterhouse. The slaughterhouse was divided into a structured typology to the north and scattered buildings to the South which is shown with the clusters and the terraced houses. Furthermore, the land use is finally increased. The negative reputation surrounding the site might transmit with the new buildings, putting the design under a bad spotlight for the inhabitants. Additionally, the northern structure would rather create a barrier towards than a harmony with the cluster typology.

In order to maintain the dynamic approach and the increased plot ratio with the two typologies, a combination of scattering and row houses is chosen. Thus a relation to the surrounding typologies in the city is created with scattered city blocks to the north, relating to the north western surroundings and the clusters relating to the southern typologies as shown on Fig.133

From here another problem occured: there was still a barrier that divided the northern part and the southern part, and we started to angle the typolygies to make them coheasent to each other, simoultaniously with a fragmentation of the very strict order in the northern part, also the infrastructure were reorganised. shown on Fig.134.

Simoultanously we started looking into whether the formation of the cluster should be rectangular or circular. We figured out that the rectangular form has a better relation to the typologies in the North, and was better to maintain privacy, also the courtyard are exploited better according to space and gives a more semiprivate

Fig.133: *Workshop 4 masterplan proposal*

approach. see study on Fig.135. There was a high emphasis on the atmosphere in the courtyards, and how they appeared in their

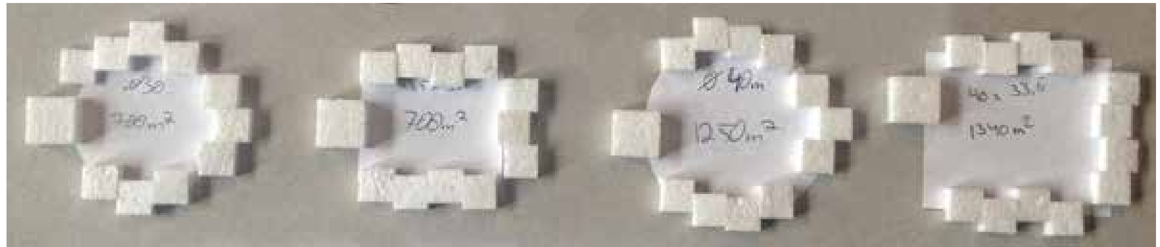


Fig.135: *Cluster formation proposals*

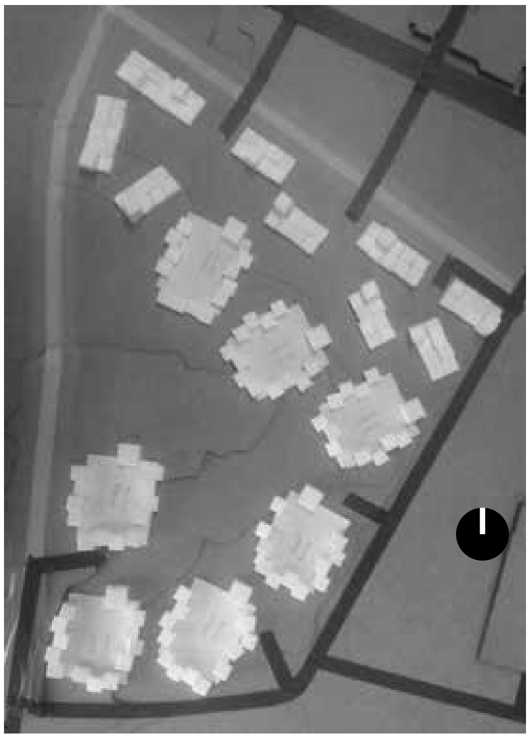


Fig.134: *Workshop 4 masterplan proposal*

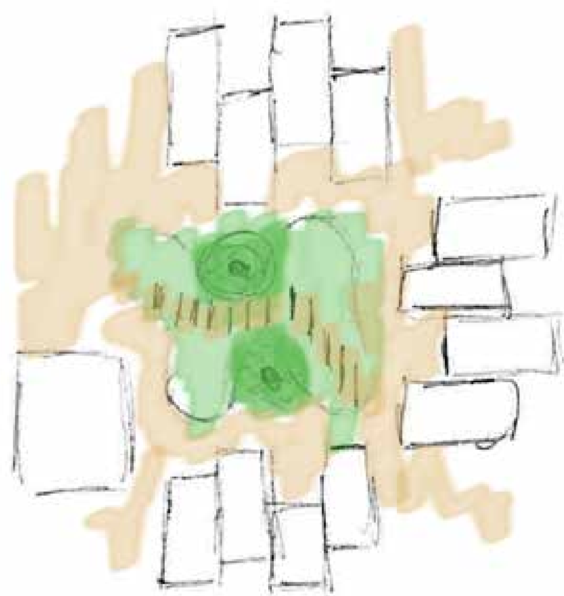


Fig.136: *Courtyard atmosphere*

formation in a more spatial way. The size of a cluster should not exceed 12 at this point as studies show that in a terraced house the best amount of homes to form a relationship to your neighbours lies between 12-16. [uderum udeliv]

Although the communication between the typologies was improved greatly, it was still lackluster, directed towards the surroundings rather than the project site which is the main focus moving onward in the process.
WS4 was the last step before midterm critique.

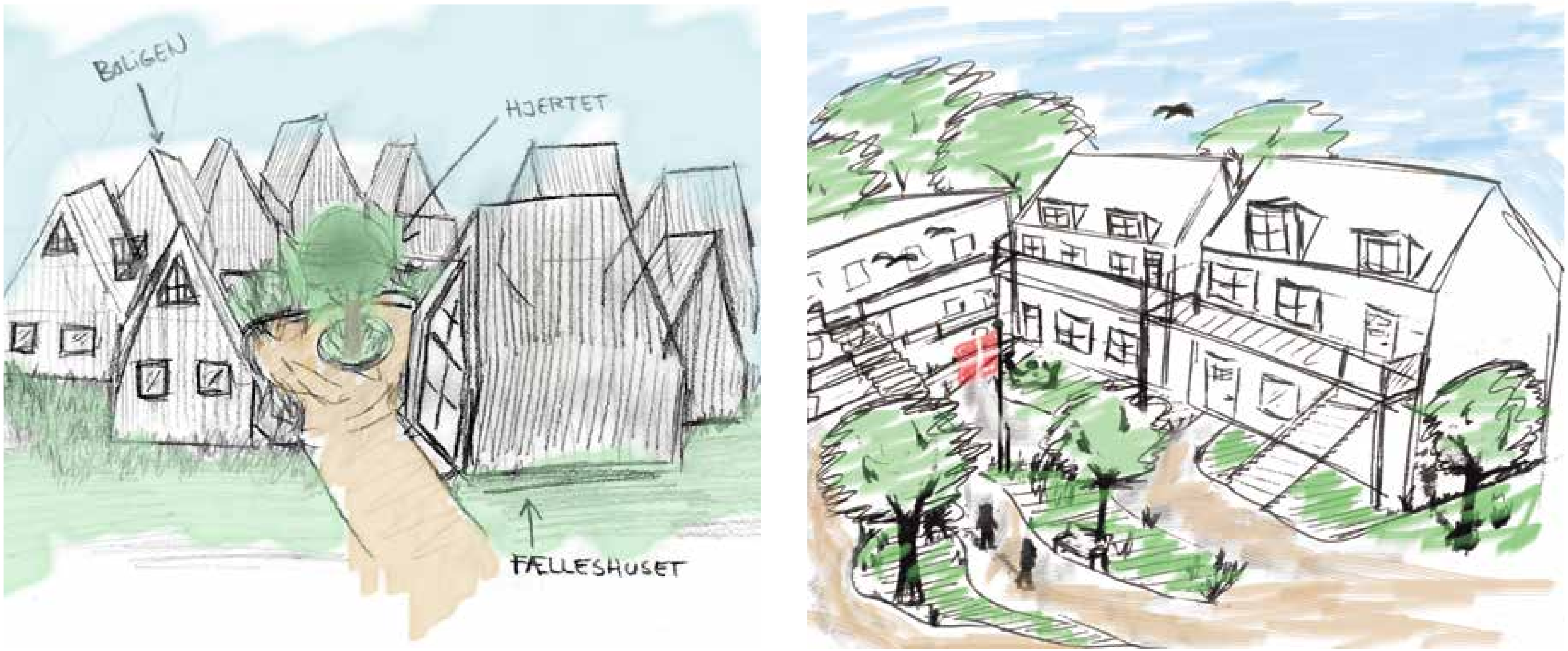


Fig.137: *Workshop 4 atmosphere sketch*

MIDTERM CRITIQUE

At the midterm critique we were made aware of some issues we have not realized or had not yet engaged upon. Among other things, a more strict approach to our masterplan was necessary as our typology gave the impression that too many things were going on. Thus a more in depth approach to the cluster typology would improve the overall coherence of the masterplan. This would reult in a very low plot ratio and we had to start to challenge the standard cluster typology, which was solved by increasing the floor number from 2 to 3 floors in some buildings.

We became more aware of what type of tenants who need to use the different types of typologies. The 2 storey clusters were addressed to residents who want to experience the qualities of the suburb, but still stay in the city. Whereas the 3 storey building would deliver a more urban impression.

Beside this, it was mentioned that the architectural element was missing, However, we did not, at this point have a solid design in relation to each house, instead we focused on a long-term decision-making in order to find the right design. Thus the coherence of interior and exterior qualities was still under process.

The greatest challenge, moving onward, was to maintain a high quality courtyard as one of the key elements in the design. Thus we concentrated on improving the city block structure towards that goal, making use of simple geometric solar studies, as described in the technical process. The cluster typology was adapted to the surroundings of each part of the building grid, using one side as a border towards the trafficed roads and the rest to open up towards the green wedge.

POST MIDTERM

After the midterm critique, we did some changes in the masperplan, where we began to focus more on the cluster formation and how we could achieve the dense and diverse urban structure, as in our casestudy with Bo01 Malmö.

The lack of connectivity between the cluster houses and the terraced houses became more of a contrast rather than creating the cohesion that we wanted to achieve.

Because we started to work exclusively with the cluster formations, we lost a great part of the plot ratio, which was too low according to our aim of a realistic project. Also we wanted the site to exude diversity and recognition according to the different typologies used in the design.

HOUSING TOWERS

Because of the aim of a more realistic project we had to compromise in terms of social sustainability, which we put high emphasis on, but we also wanted an area that bore evidence of being in the city and created diversity and served as landmarks.

We again took a step backward, zoomed out to look at the context surrounding the site, and we figured out that we could use the nature better, than we had done until now, by implementing housing towers with view over the green wedge, introducing the Karup Å, and Skive fjord while maintaining the key values of the terraced housing.

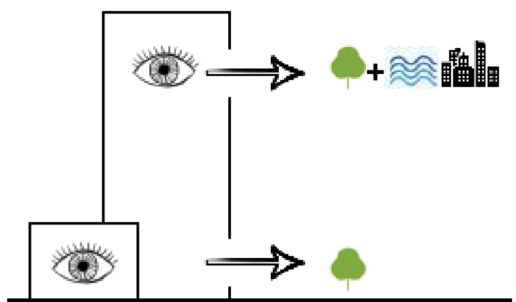


Fig.139: *Difference in view sights*

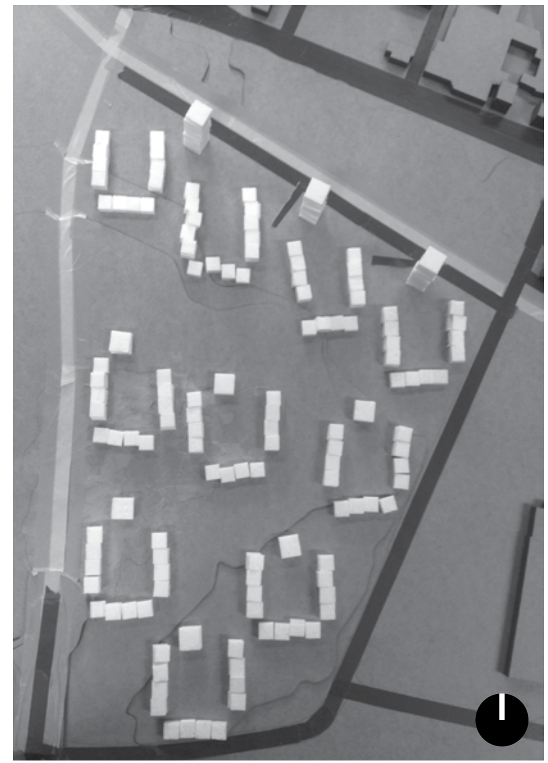


Fig.138: *Workshop 4 masterplan proposal with housing towers.*

The main purpose of the housing tower was to increase the plot ratio of the site, and to create this landmark which takes advantage of the surrounding nature.

The idea was to design a single apartment and then rotate it around a core containing the staircase, to create a floor with 4 apartments, the apartments should have the same open space qualities as the terraced houses, which allowed the flexible living, which was one of our design paramteres.

Simoultanously we began modelling the architectural expression, to give an impression about the human scale according to the building scale.

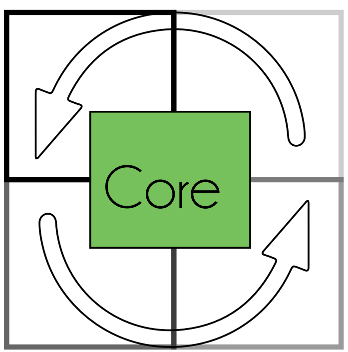


Fig.140: *Diagram of apartments in the housing towers.*

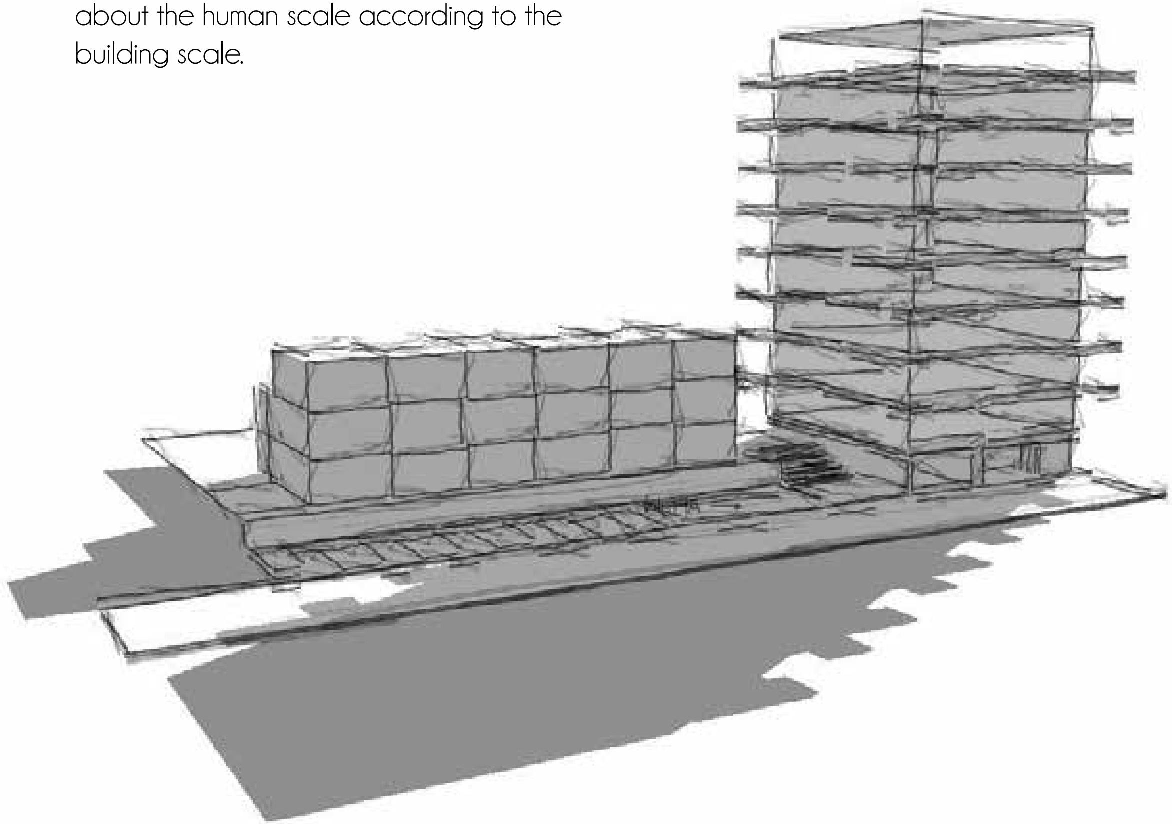


Fig.141: *Sketch of housing tower expression*

As we went further in the progress, we started to work with a more different approach on how the apartments should be arranged and how the footprint.

In order to maintain diversity as a leading parameter, we concluded that different plans were needed for the housing towers, which would appeal more potential buyers and tenants.

This resulted in four completely different apartments, as shown on Fig.142. With the plan drawings settled, we worked further with the architectural expression.

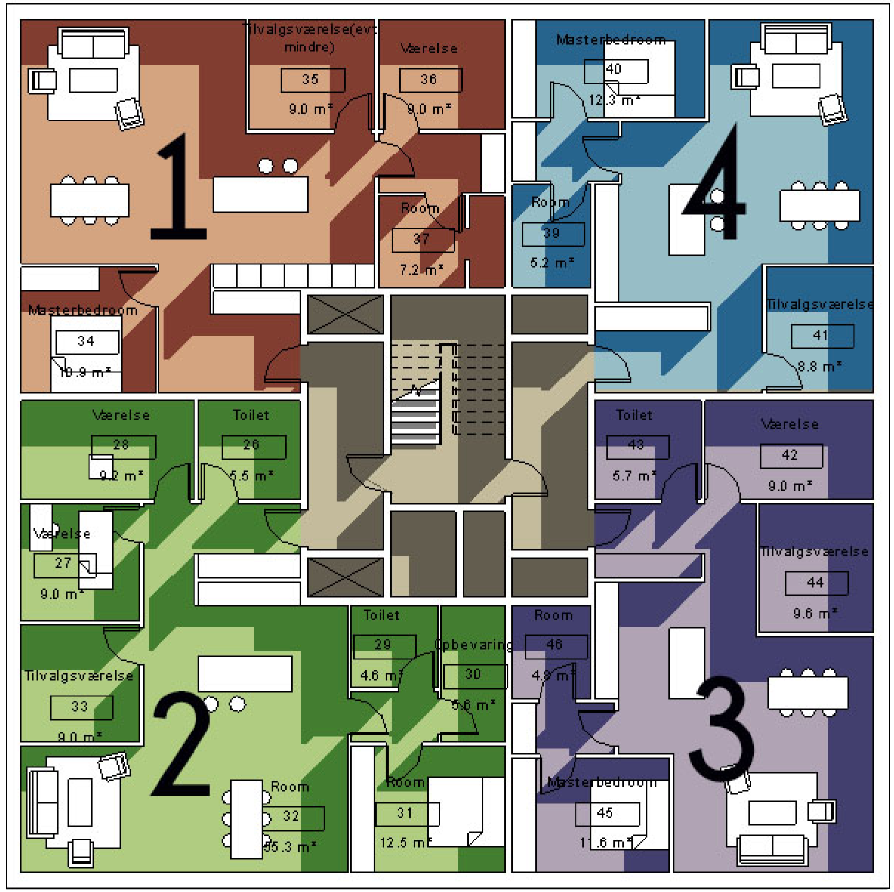


Fig.142: *Further progress of housing tower plan*

It was important for us that the housing tower would not appear as a large heavy block in the landscape, but that the architectural expression should help to create a whole and serve as guidance both for the habitants, but also the city of Skive, so we broke down the facades to develop a lighter perception and a more playful facade instead. This was achieved by dividing the plan in two, pull them apart, where the main core is located, minimize the footprint on the left side by pushing it in from North and South, to create a diversity in the facades, which helped minimize the expression as a heavy block structure as shown on Fig.143. As a consequence we lost one of four apartments on each floor though.

From this came three apartments, which we named C1, C2 and C3. see Fig.144. The lack of space for a common house was compensated with by placing common rooms on the ground floor of the housing towers.

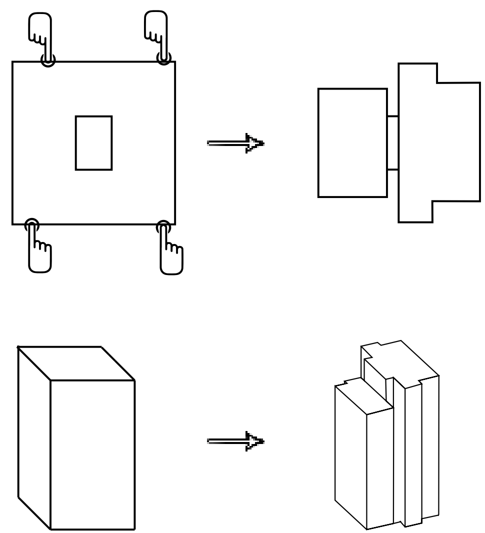


Fig.143: *Concept of final housing tower*

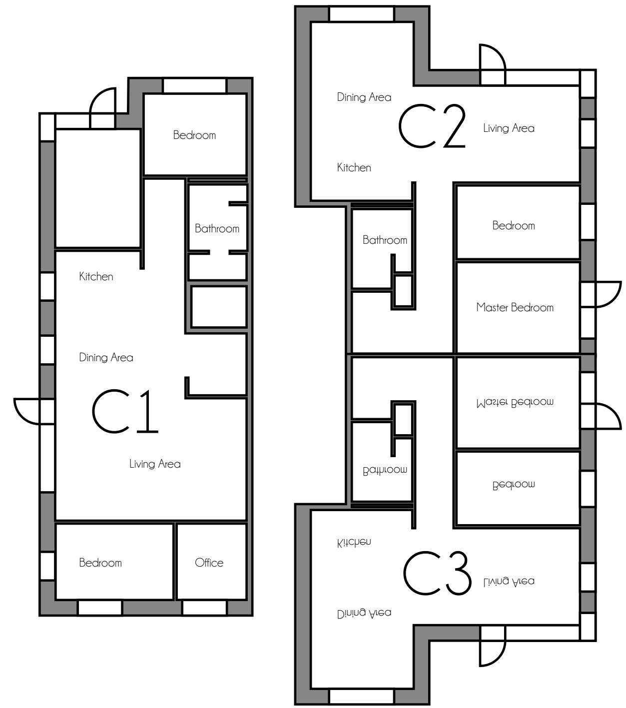


Fig.144: *plan solution for C.*

TERRACED HOUSING A AND B1

From the initial plan sketches from one of the earlier workshops, we developed some plan solutions for the terraced housing. We figured out that we wanted oblonged buildings instead of quadratic, also according to the technical research which was examined simoultaniously, more of this later on.

The plans of the terraced housing were based on multiple prerequisites we set for ourselves based on research. Thus a flexible environment is strengthened by creating spaces of 12-16m^2 to cover most of the functions in a dwelling. [Row Houses] Furthermore due to the solar conditions, a building depth of 7-9m is recommended in a North-South orientation and 12-14m in an East-West orientation. [Town Houses] Based on the above information and an approach to functional building design, the plan solutions for Type A and B were created. The A Type is oriented on the North-South axis, the B Type on the East-West axis.

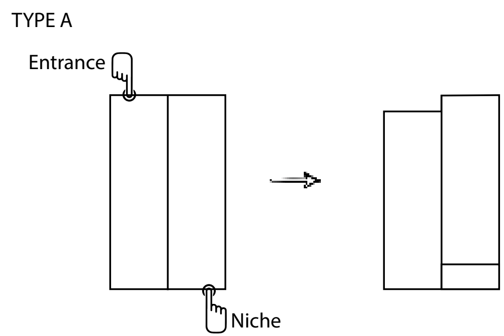


Fig.145: *Type A niche creation*

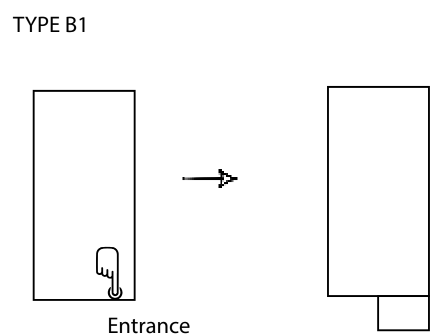


Fig.146: *Type B creation of dominant entrance*

In order to avoid a rather trivial facade expression, we made use of niches by pushing some of the building volume back on both ground and first floor, thus creating a niche for a private balcony and entrance area. This would further contribute to a greater diversity, when the buildings are put together in a row. see Fig.145 and Fig.147.

Equally, Type B was displaced by pulling out the entrance, adding a corner window, in order to create diversity in the facade and an attractive entrance with plenty of daylight. See also Fig.146.

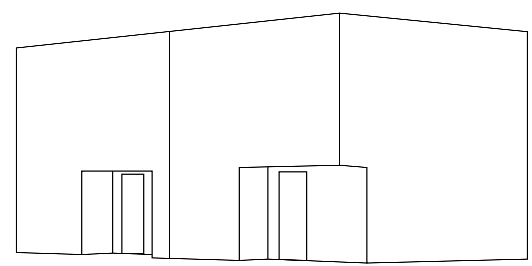


Fig.147: *Type A entrance, conceptual*

TYPE A

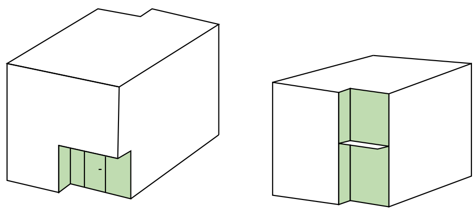


Fig.148: *Type A expressional diagram*

TYPE B1

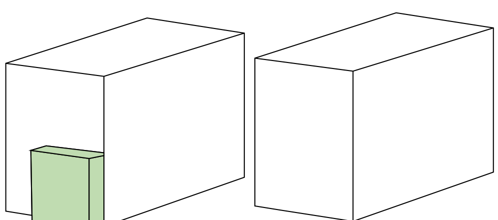


Fig.149: *Type B1 expressional diagram*

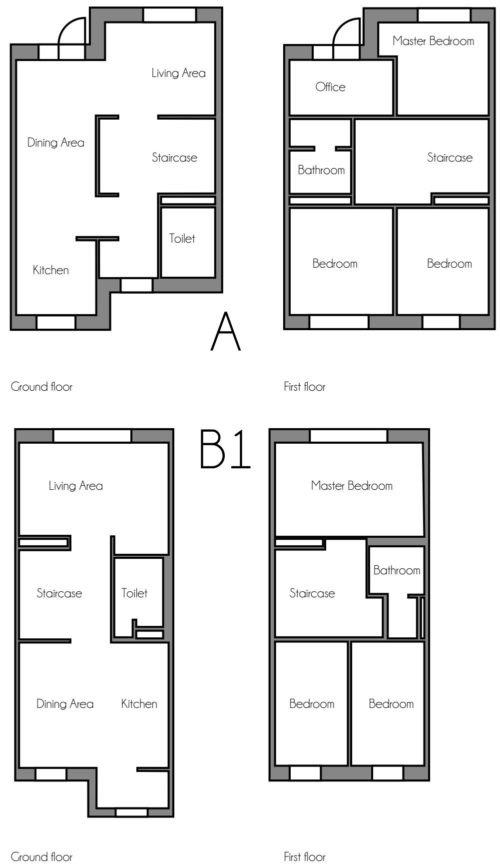


Fig.150: *Type A/B1 plan diagram*

While displacing the two building volumes, the plan solutions for each of them became clearer. Revolving around the service core in the center of the buildings, the functions could be placed clearly according to the preferable orientation of each of them as well as how the natural flow through the building should look. The rather public functions and living areas located on the ground floor were linked together in an open space with few, but clear divisions. Meanwhile on the upper floor, the private functions were clearly divided, thus creating a private space for each household member. Addidtionally, a service core was placed in the center of the building, where the daylight conditions are worst.

B2 and B3

When we first began sketching the plan solutions, our first thoughts were to create diversity through flexibility in the interior rather than through a quantity of housing types. Because of the fact that we also wanted to design a pleasant and comfortable area, where as many habitants as possible felt good about living. We needed to optimize according to how we wanted to orientate the buildings on the site.

We created a B2 type out of the B1 framework, adding a third floor, making room for a roof terrace, because some of the B-types didn't have room for a small garden facing West or South. At the same time it was neccesary for us to provide the habitants with the same possibilities for privacy everywhere. With the new roof terrace on the top floor, we encountered some problems: The new roof terrace, gave an oddly looking shape, see Fig.151. We then discussed whether we should use the extra space for another outdoor spaces or place an extra

TYPE B2

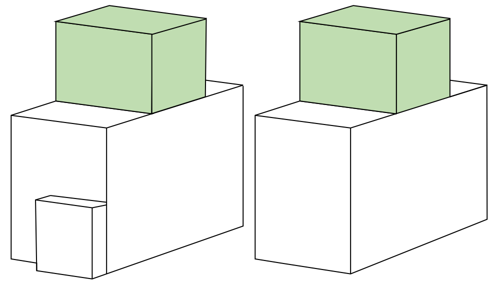


Fig.151: *Type B2 expressional diagram*

TYPE B2

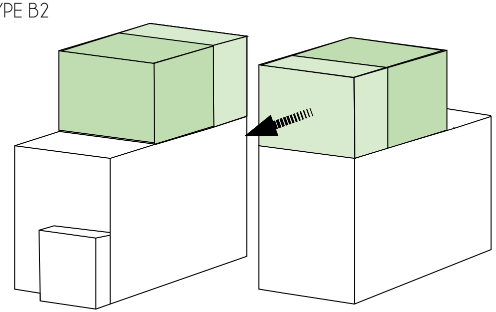


Fig.152: *Type B2 expressional diagram*

room. It didn't make sense to place another roof terrace, because it would be facing North. Also two roof terraces interrupted by a building volume wouldn't be very functional. An extra room on the other side would increase the housing type's size to 150m^2, gross area which is a compromise we had to accept according to the design parameters. The changes to the building volume are shown on Fig.152.

However, we figured out that some of the terraced houses would suffer from a direct look beyond the privacy of the residents according to the placement of the roof terraces, therefore we had to rotate the third floor a 180 degrees on the B2 type to create a B3 type so that the privacy could be preserved and the outdoor area would gain advantage of the solar exposure from the west orientation.

The roof terrace is then located on the opposite side of the entrance, which also made some changes to the plan solution in the B3 type. The roof terrace became smaller, because of the staircase while the office and bedroom got a little bigger. In the exterior the architectural expression remained the same as the B2 type as can be seen on Fig.153.

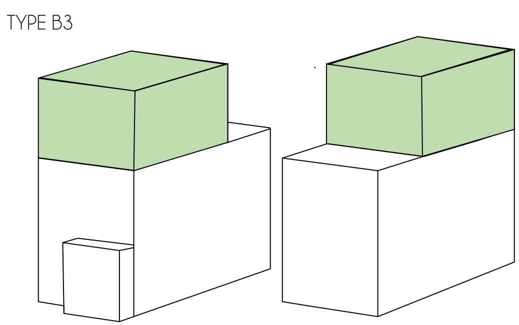


Fig.153: *Type B3 expressional diagram*

Fig.154: *Type B2/B3 plan diagrams*

FACADES

With the plan solutions worked out, we began the work on the facades and their expression and according to our design paramters a clear view towards the natural elements combined with a lot of daylight should be preferred over small windows for excessive heat prevention. Therefore shutters are introduced and worked with to give an architectural quality and diversity in the expression, when the building is situated in a way that does not require shading, the shutters are replaced with slats that instead are vertical. The technical part of this process is shown in depth during the technical process.

We also started to visualize our thoughts about the materiality of the facades, and that we wanted to create an area which exudes a similar diversity in the townscape in relation to the facade expressions as seen in, Bo01 Malmo.

This diversity has been important for us from the beginning, because we wanted to design a residential area with a high focus on social sustainability, but also give the tenants the sense of ownership.

Such sense of ownership comes to life also in the choice of materials, and contributes to the detection value of each cluster and also each single housing unit. On the terraced houses we wanted to use Petersen Cover of different colors, plaster in white and slate in black. The intention was to create different expressions in each cluster, to contribute to a diversity in the architectural expression, as a delicate harmony with the typical materiality of the city, but also to serve as a contrast to the surrounding nature. Four colors of the Petersen cover are chosen from an iteration with different facade expressions on how we thought they complimented each other in order to provide the diversity we aimed for. Furthermore, we thought the color influences our perception of the building and its impact on the context.

Fig.155: *Facade iterations*

Fig.156: *Facade iterations*

Fig.158: *Facade iterations*

See Fig.156 and Fig.155 for a small part of the iteration of the facade expressions, while the rest can be found in Annex 14. The final materials chosen, based on the design parameters and our own architectural vision, are shown on Fig.158.

Together with slate and plaster combined with light brown wood in order to highlight the entrance on each building, while contributing to a warmer atmosphere on the terraces as a contrast to the rustic and exclusive look.

On the housing towers we used brick shells in such a manner that they underline the fact that it is a sheathing, material rather than traditional masonry. This was done by emphasizing the horizontal bands with a vertical direction , and the vertical to a horizontal, also to bring in the diversity on the facades of the housing towers. see Fig.157.

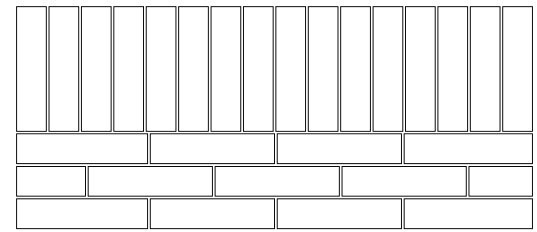


Fig.157: *Type C facade expression*

Because we wanted the materials to be maintainance free it was clear for us that we should use brick shells, because other than giving a rustique and exclusive look which last for decades, brick shells are also maintainance free, Traditional masonry is maintenance-free to a certain degree, but not the joints that after a certain number of years should be looked into and possible repaired, brick shells are without joints and therefore 100% maintenance free.

MASTERPLAN

Following the plan solutions for both the housing towers and the terraced houses, we began to arrange the types more precisely according to solar exposure, views on the surrounding nature and outdoor spaces. The data can be seen in the following technical process.

- Type A in a North-South orientation
- B1 in an East-West orientation on the west side
- B2and B3 in a North-South or East-West orientation where there's no space for a garden towards South or West.

When we placed the terraced houses, we wanted to ensure that the tenants had the opportunity to be private, even though, it is a project that focuses much on being social. The privacy part allowed the tenants to retire and either relax in the small garden, or on the roof terrace. The roof terraced are located in such way that ther is no direct look from roof terrace to roof terrace. which

Fig.159: *Initial detailed masterplan for further progress*

is something that has been in our mind the entire proces, when designing.

From the initial masterplan, which we used to elaborate on the detailing, for example where to place the parking areas and the recreational spaces according to functions, the small sheds for the terraced houses, the ponds for collecting rainwater and so on, we began working on the final masterplan.

The paths which permeates the site, connecting it to the surrounding context, had to be thought through, because we wanted the citizens of Skive to use the recreational facilities on the site, but we didn't want the paths to lead through the green wedge directly into the small courtyards, so we had to think of a way to avoid that. Thus, we worked with two kinds of paths: one primary and one secondary. The primary path was the infrastructure connecting the different zones on the site, the secondary would be the path from the green wedge leading into the site and around the courtyards, allowing the citizens to visit, but without leading them directly into the courtyards. It was important for us to meet the requirements with regard to the roads leading to the site, to the north, east and west in connection with the parking lots are large enough for fire vehicles to pass and enter the site in case of emergency.

When working on the courtyards we began focusing on what the courtyard should contain. In order to meet the aim of a social community, it needed to have something the habitants could be social about.

In our earlier research, we figured out that we wanted to place kitchen gardens allowing the tenants to have a piece of land and to grow their own vegetables or flowers. Also we wanted the parents to be able to bring their children outside, tend to their garden, while their children are playing on the hilly landscapes or the playgrounds, or the nature, surrounding the courtyard as shown in Annex 13.

It has also been our priority to bring in the green wedge coming in from the west and into our site like a hook that grabs onto the site and holds it, in relation to the upcoming master plan for Big Blue Skive 2040.

TECHNICAL DESIGN PROCESS

EXTERIOR PROCESS

Following the aforementioned dilemmas surrounding the masterplan during the mid-term critique, we took a rational approach in order to create a high quality courtyard space in terms of solar exposure and views.

Thus we investigated the shading of a two and three storey building, that is rotated 35 degrees according to the initial masterplan. The times chosen for the investigation are when the sun is positioned perpendicular to the building, around 15:00 and at 18:00, to simulate the afternoon hours in which the probability is highest for a longer stay in the courtyard. Additionally, the investigation is executed for the summer half year between the two equinox dates 21st March and 21st September, the time in which the probability for people staying outside in the afternoon is higher.

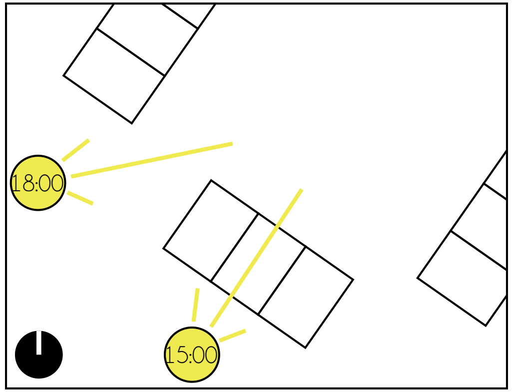


FIG.160: *Solar angles studied*

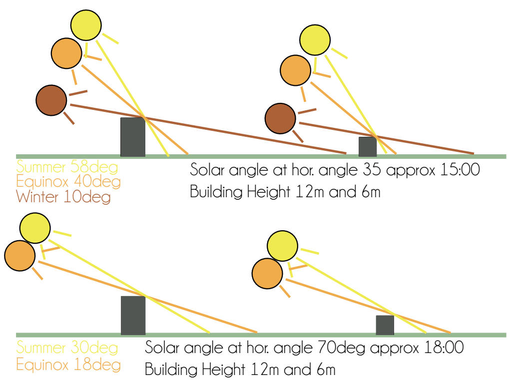


FIG.161: *Solar angles and building heights studied*

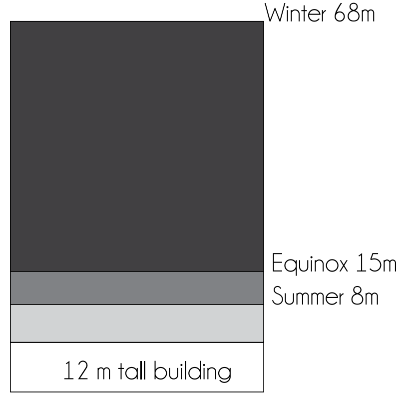


FIG.163: *Shadow length 15:00*

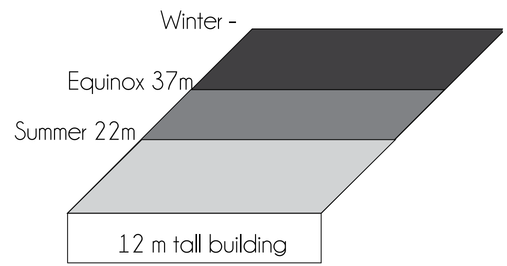


FIG.162: *Shadow length 18:00*

Based on the results shown on Fig.162 and Fig.163, we created a building grid in which building heights and distances were accounted for to ensure a courtyard and an outdoor space of high quality, as shown to the right.

Later on, with the architectural solutions chosen throughout the process, the buildings and thus the grid became more detailed, but the parameters to create a well-lightened courtyard has been important at all points, which the solar study of the final courtyard show on Fig.165. The solar peak hours lies at 627 kWh/m^2 while the average around Skive lies at 1014 kWh/m^2.

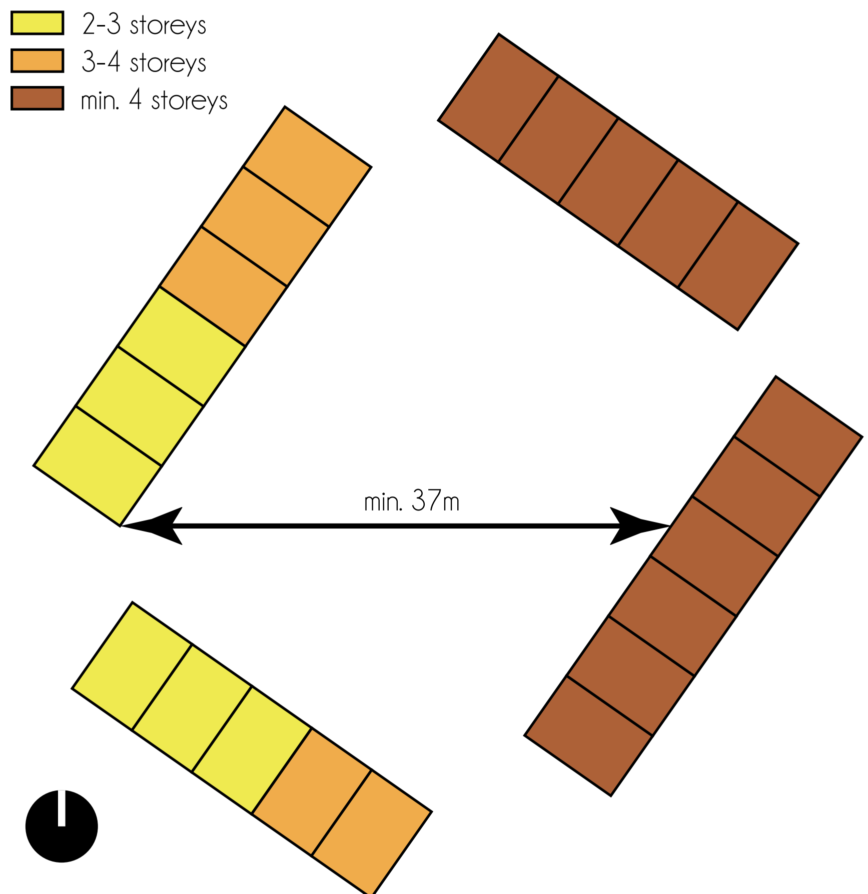
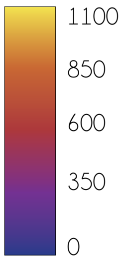


FIG.164: *Courtyard dimensioning*

Area	2974m^2
Solar irradiance avg.	627kWh/m^2
Solar irradiance Skive	1014kWh/m^2



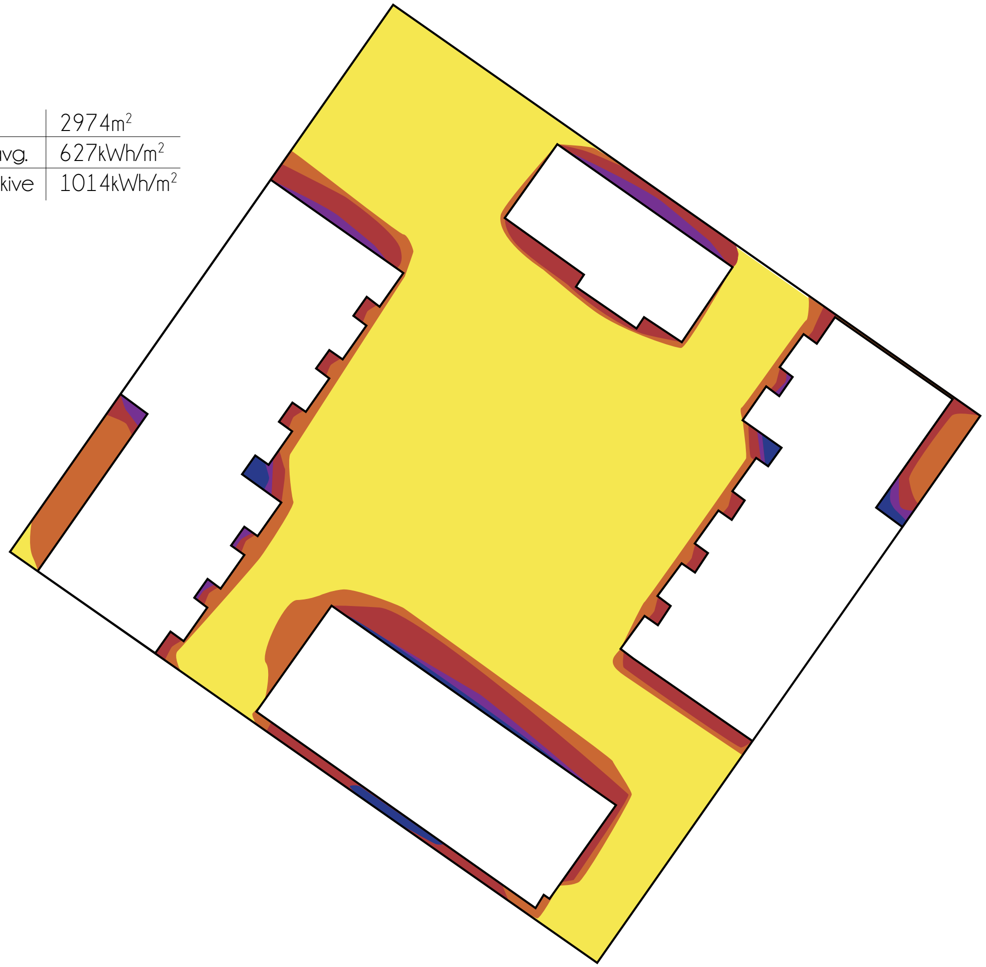


Fig.165: *Courtyard solar exposure*

Part of the exterior planning from the early stages has been the term local rain water accommodation. Thus many solutions have been discussed throughout the process, using a spreadsheet to calculate the necessary space requirements for each of the methods listed below:

- Rain water bassins
- Lawn areas
- Fascine
- Ditches
- Rain water beds
- Artificial water areas
- Bassins for delay of subsiding

Based on general rquirements, such as the reduction of volume and max flow of rain water, the removal of dirt and the level of maintenance and costs, multiple solutions have been chosen for the masterplan in cohrence with their contribution to the archtiecture of the masterplan. Tab.14

Thus, the rain water beds and rain water bassins were chosen to contribute to the architectural coherence, while lawn areas and ditches were the apparent choice for the green spaces surrounding paths and roads.

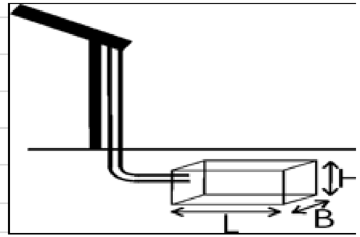
Based on the evaluation spread sheet for rain water accommodation, a total of 500m^2 of rain water beds would be necessary to cover for the amount of roof area on the site, as shown on Fig.166. [LARiDanmark.dk]

The Danish spread sheet is attached on the USB key for further inspection.

	Red. of Max Flow	**Red. of Volume**	**Removal of dirt**	**Maintenance**	**Cost**
Rain water bassins	High	Low	high	High	High
Lawn areas	Medium	Medium	High	High	Low
Fascine	High	High	Low	Medium	Medium
Ditches	High	Medium	High	Medium	Low
Rain water beds	Medium	High	Medium	Medium	Medium
Artificial water areas	High	Low	High	High	High
Bassins for delay of subsiding	High	Low	Medium	High	High

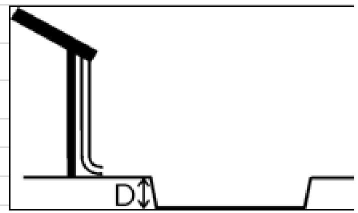
Tab.14: *Evaluation of rain water accommodation methods*

Faskine		
Bredde (B)	1	m
Højde (H)	1,3	m
Hulrums andel i faskine [Plast: 0,95, sten: 0,25]	0,95	0-1
Længde faskine (L)	**230,9 m**	

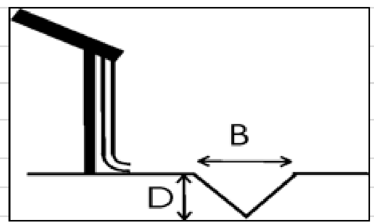


Version 1.1		
Vandsynketest		
Vandet er sunket antal cm	5	cm
på antal minutter	100	mi
Indsæt tal		
Årsmiddelnedbør (mm) - se figur nederst	750	mm
Gentagelsesperiode (år mellem oversvømmelser)	5	år
Befæstet areal (tilsluttet tag, terrasse osv) (m²)	7403	m²
Ud fra vandsynketesten er jorden:	Ledningsevne K:	
Ler med sand	**8,333E-06**	m/

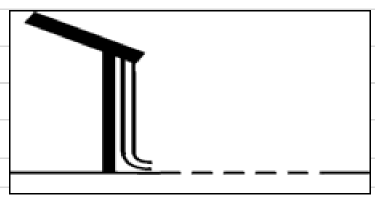
Regnbed		
Dybde (D)	0,5	m
Areal regnbed	**499,9 m²**	



V-formet nedsivningsgrøft - ikke transport grøft		
Bredde (kronekant) (B)	2	m
Dybde (D)	0,5	m
Længde grøft	**515,6 m**	



Permeabel belægning		
Areal af permeabel belægning	5000	m²
Areal af tilstødende afvandingsareal (tag, vej, etc)	7403	m²
Opstuv. vol under og i belægning *	**34 l/m²**	



* 1 l/m² svarer til 1 mm vand under og i belægningen

FIG.166: *Spreadsheet for rain water accommodation*

INTERIOR PROCESS

As the general idea of the terraced house kept on developing and the functionally and spatially qualitative plans were finished, the technical calculations were meant as a tool to support the process up to this point.

Thus BSim and Velux were used to test and validate different window solutions in order to strengthen the architectonic appearance as well as to investigate whether the thermal and visual indoor climate were within the allowed values according to DS/EN:15251 category II and the building regulations 2020 requirements as shown below in Tab.15.

In this stage BSim was used to verify whether there was excessive heating in the dwellings according to the windows chosen during the initial Velux studies. Moving onward the process became iterative, adjusting window sizes according to potential excessive heating problems, testing them in Velux and so on.

Afterwards the two levels were combined to discuss the architectonic impression of the facades, after which the iterations continued until a symbiosis of architectonics, thermal and visual indoor climate was achieved.

Category	I	II	III
Indoor Temperature, summer [°C]	24,5±1,0	24,5±1,5	24,5±2,5
Indoor Temperature, winter [°C]	22,0±1,0	22,0±2,0	22,0±3,0
CO_2 level over outdoor [ppm]	350	500	800
Exhaust Air flow kit/bath/wc [l/s]	28/20/14	20/15/10	14/10/7
Hours Above 27°C/28°C	100/25		

Tab.15: *Technical requirements*

WORKSHOP #3

During Workshop #3 Velux has been used as a tool to gain general knowledge about the corelation between window width, height, depth and room depth, width and orientation. The light reflectance values were chosen as shown in Tab.16 according to Velux standard settings. The general setup of the workshop is shown as an example to the right on Fig.167. The remaining results for different window sizes are attached in Annex 3. Additionally a BSim model has been created to test for excessive heating conditions with the different parameters. The general knowledge gained by this study would benefit us later during the process.

Surface	Material	Reflectance
Floor	Wood	0,842
Ceiling	Paint, matte	0,840
Wall	Paint, matte	0,840
Frame	Polyurethane	0,920
Lining	Paint, matte	0,840
Pane	Std. Glass	0,780

Tab.16: *Velux Light Reflectance Values*

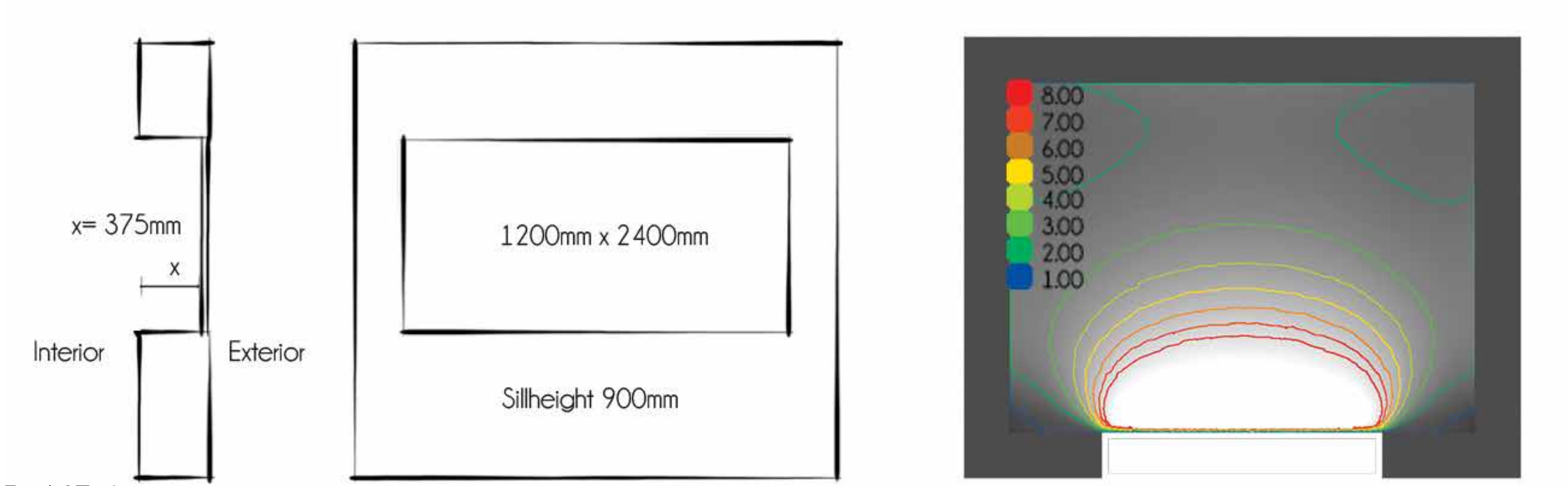


Fig.167: *Setup of the initial Velux studies*

Room dimension 3000mm x 4000mm		Window dimension 1200mm x 2400mm		
Room height 2800mm		Displacement (X) X = 25mm	Displacement (X) X = 200mm	Displacement (X) X = 375mm
Sill height 900mm		Daylight factor Avg. %	Daylight factor Avg. %	Daylight factor Avg. %
North	Long	3.30	3.40	2.90
	Short	3.20	3.20	2.80
West	Long	3.40	3.40	2.90
	Short	3.20	3.20	2.80
South	Long	3.30	3.40	2.90
	Short	3.20	3.20	2.80
East	Long	3.40	3.40	2.90
	Short	3.20	3.20	2.80

Tab.17: *Result of initial Velux studies*

POST-MIDTERM

Simultaniously a BSim simulation has been executed to get an understanding of potential excessive heat problems due to the window sizes as shown below in Tab.18. Thus, moving onward, we gained a general understanding we could use later in the process.

Moving forward, we were about to finish the functional and flexible interior plans. Thus, we could move on to a series of tests using Velux and BSim to begin with and Be15 later on. The systems chosen according to a regular family life of 5 people are shown to the right on Fig.168 and Tab.19.

A simplified version of the plans and models used for Type A are shown on Fig.169 and Fig.170. For the Velux simulation, the window sizes from workshop #3 were used to begin with, then moving on to different sizes as shown in Fig.171.

		N		V		S		Ø	
Excessive heat (hr)		>26	>27	>26	>27	>26	>27	>26	>27
1,2m x 1,2m	Short	0	0	0	0	0	0	0	0
	Long	0	0	0	0	0	0	0	0
2,4m x 1,2m	Short	0	0	498	126	802	112	711	26
	Long	0	0	600	137	923	146	850	113
1,2m x 2,4m	Short	0	0	546	157	939	171	797	113
	Long	0	0	697	212	1067	222	918	176

Tab.18: *Results of the initial BSim study*

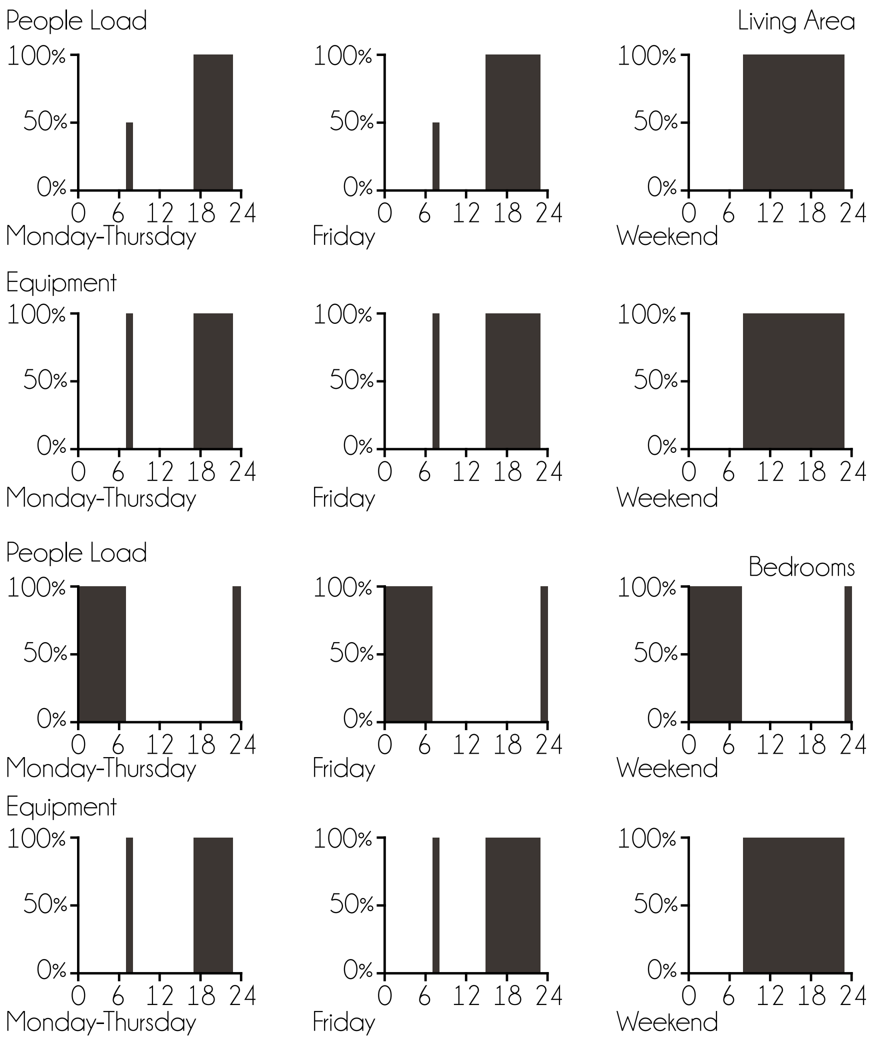


Fig.168: *System values for the initial BSim studies*

System	Description	Control
Human Load (1-5 persons)	1-5 persons, standard 100% present	People Mon-Thurs, People Fri, People we
Equipment (TV, Light, Household, PCs etc.) Infiltration	0,1kW, air proportion 70% 100% turned on Basic air change rate 0,1 TmpFactor 0, TmpPower 0 WindFactor 0	Equip Mon-Thurs, Equip Fri, Equip we All Time
Venting	Basic air change rate 0,4 TmpFactor 0, TmpPower 0, WindFactor 0 Max AirChange 1	Venting Mon-Thurs, Venting Fri, Venting we SetPoint 22,0 SetP CO_2 850ppm Factor 1
Heating	MaxPow 5 kW Fixed Part 0 Part to Air 0,6	Heating Factor 1 Set Point 22,0 Design Temp -12,0 MinPow 0,5kW Te min 17,0
Ventilation	<u>Input</u> Supply 0,015m³/s Pressure Rise 600 Pa Total Eff 0,7 Part to Air 0,5 <u>Output</u> Supply 0,05m³/s Pressure Rise 600 Pa Total Eff 0,75 Part to Air 0,5 <u>Recovery Unit</u> Max Heat Rec 0,85 Min Heat Rec 0 Max Cool Rec 0 Min Cool Rec 0 <u>Heating Coil</u> Max Power 2kW	Inlet Control All Time Part of nom. flow 1 Point 1 Te1 -12 Tinl1 on line 24 Point 2 Te2 8 Tinl2 on line 19 Slope before 0 Slope after 0 Air humidity irrelevant

Tab.19: *System values for BSim models*

Fig.169: *Simplified plans of Type A*

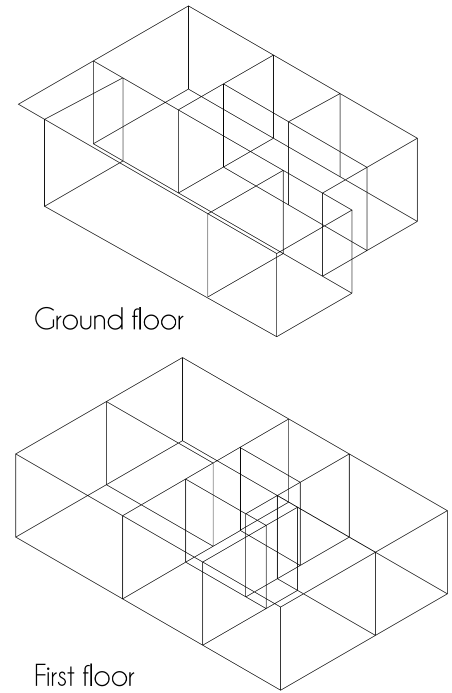


Fig.170: *BSim model of Type A*

Starting with the ground level, the simulation clearly shows a strong overheating during the summer months from may-september. The simplified model was therefore revised to include the overhangs (Step 2). The result showed only small improvements. The following process included multiple window sizes, decreasing the glazing area step by step. The architectonic impression and exterior view lost their value, because of the decreased size, thus another solution was needed to maintain the qualities of daylight and outside view. The different sizes are shown on Fig.171 (Step 3).

The discussion then went on, whether to continue working with the window sizes or how to improve on both aspects: the architectural impression and the situation of the indoor climate. As the views and the direct connection to the courtyard of the cluster and the natural element are of high importance, the solution for the problems had to be of other nature than the window sizes (Step 4).

Therefore shading devices are the next step to approach. As bigger overhangs and fixed shading devices come with drawbacks, such as heat storage, view obstruction and daylight obstruction, non-permanent solutions were to prefer (Step 5).

The choice then stood between automated and manual solutions. There are only few users to satisfy which makes it rather important, that these have control of the shading solution, thus automatic solutions with user overrule are the better solution.

In terms of material, wooden devices fit the general architectonic vision of the project better and give a rather warm atmosphere as opposed to metallic or plastic devices.

The following simulations validate the solution and the idea of a comfortable, lightened place with the possibility to be kept cool during summer.

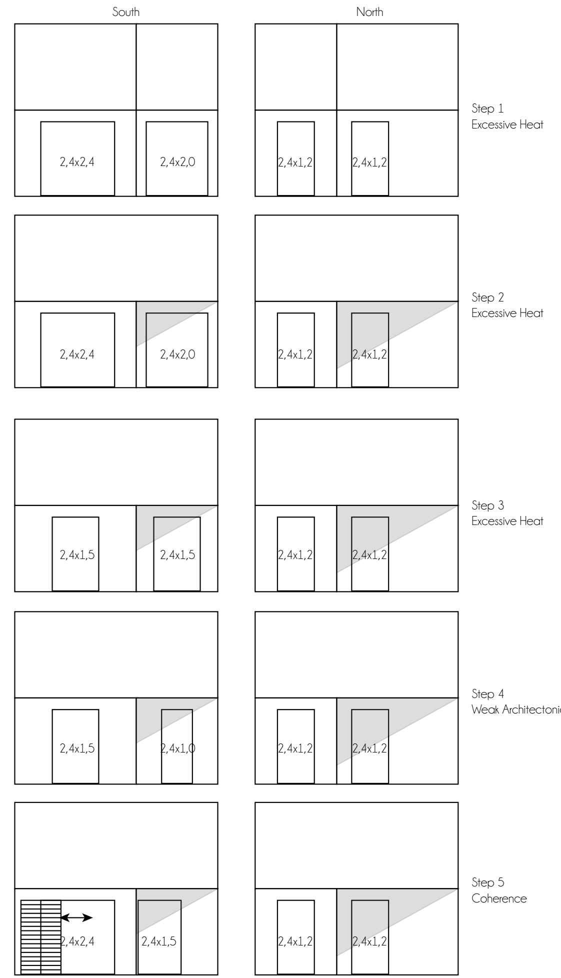


Fig.171: *Process of the facade*

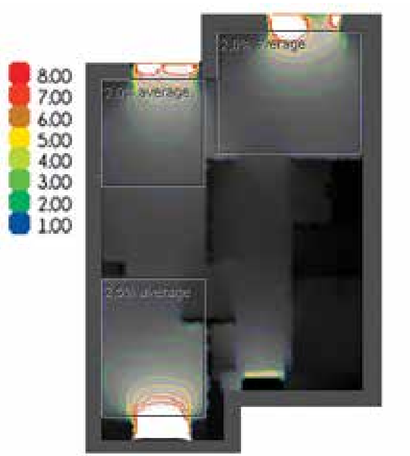


FIG.172: *Daylighting according to step 4*

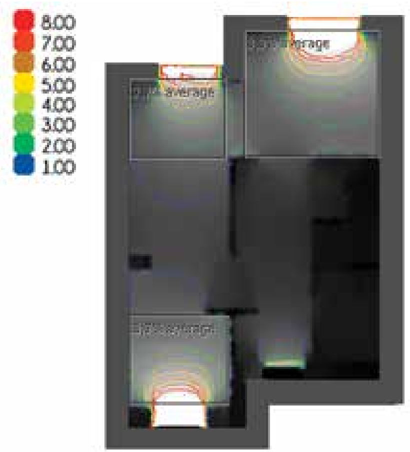


FIG.173: *Daylighting according to step 5*

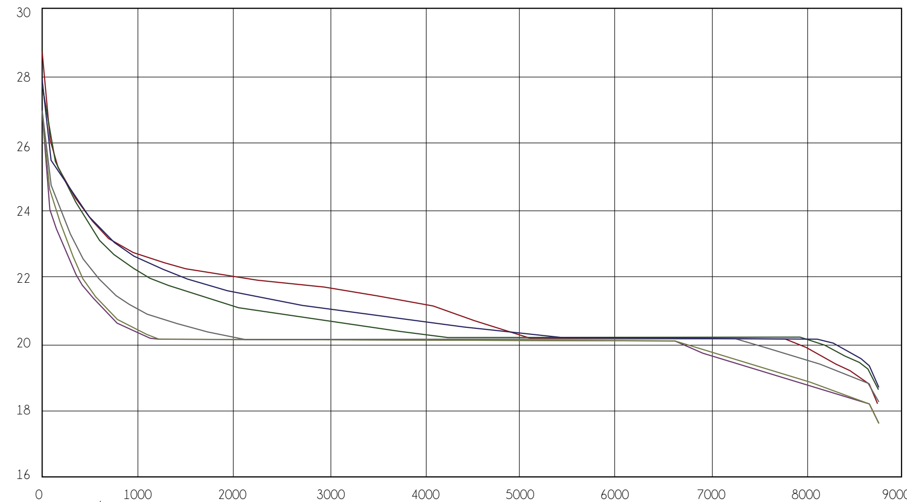


FIG.174: *BSim simulation according to step 4*

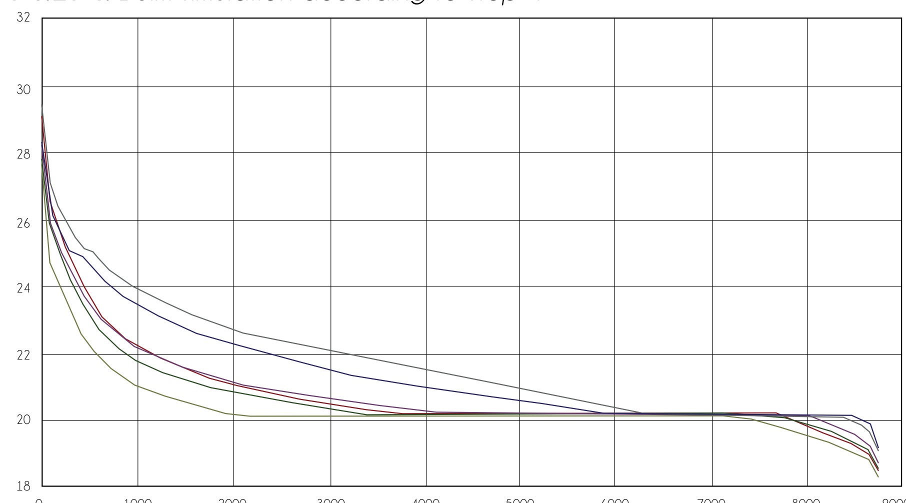


FIG.175: *BSim simulation according to step 5*

Hours >26	78
Hours >27	30

TAB.21: *Excessive heat in the most critical room*

As shown above the excessive heat in the living area is in the acceptable range according to building regulations. Thus the automated shutter system is a satisfying tool to maintain the qualities of daylight and exterior view, while working as a passive strategy for excessive heat prevention. Lastly the shutter system works as an architectural feature for the facade, complementing a variety of facade materials.

On the second floor the process was more linear and straight forward. Starting with 2400mm x 1200mm the daylighting conditions were very satisfying, but BSim showed large excessive heat problems. Decreasing the size of the windows to 1500mm x 1000mm in BSim was sufficient, reducing the excessive heat to acceptable values. A Velux simulation then validated the solution.

Lastly a Be15 model was created for a row of three rowhouses as shown on the masterplan below. To support the model, simple Excel sheets were used to calculate the ventilation rates needed in the building. Using standard solutions for the building envelope and systems was sufficient to follow the 2020 requirements of the building regulations, making the technical calculations for the row house complete.

As seen below, the results are satisfactory, but the facades are lacking architectural value. The next step was therefore, to improve on that problem and to incooperate the technical solutions, namely the shutters and window sizes, with the materials of the facades to create an architectonic cohesion as can be read in the architectural process above.

Hours >26	38
Hours >27	17

TAB.20: *Excessive heat in the most critical room*

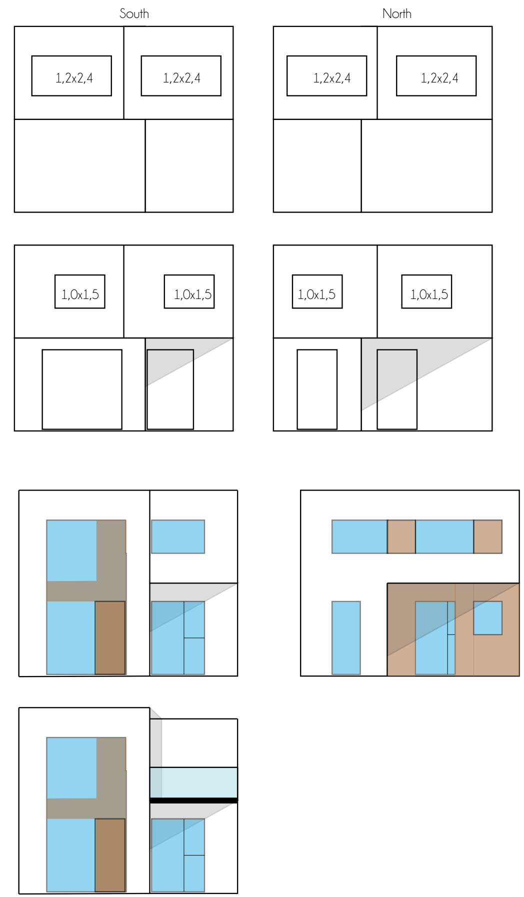


FIG.176: *Process of the facade*

Following up on the design decisions for the facades we had to go further into detail with the technical aspects as well. Thus calculations for natural ventilation and opening areas of the windows were the next step to be able to place mullions, which affects the overall architectural idea of the facade as well.

The calculations were done for the entire building, making use of both the principle of buoyancy and wind induced ventilation, thus creating a combined cross and stack ventilation through the building. See Tab.22

Furthermore, the calculations were done for the ground floor only, which makes use of wind induced cross ventilation only, since all windows are of the same height. See Tab.23

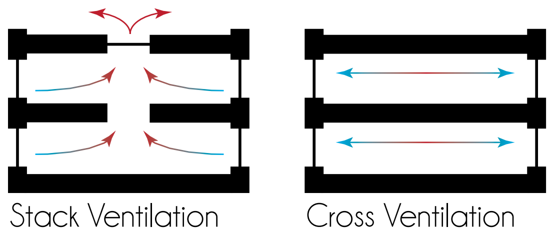


Fig.177: *Ventilation principles*

Location of neutral plan	3,3 m	Windward -0,65	
Outdoor temperature	12°C	Leeward -0,13	
Zone temperature	22°C	Roof -0,7	
Discharge coefficient	0,75	Vmeteo 6,4 m/s	Pmin -5,6 pa
Air density	1,205 kg/m³	Vref 3,642 m/s	Pmax -5,2 pa

	Area [m²]	Eff. Area [m²]	Height [m]	Thermal Buoyancy [pa]	AFR (thermal) [m³/s]	Pres Coefficient	Wind pressure [pa]	AFR Wind) [m³/s]	Wind pressure [pa]	AFR total [m³/s]
Kitchen	3	2,250	1,2	0,856	2,68	-0,65	-3,115	-5,116	-3,184	-4,422
Dining	3,6	2,700	1,2	0,856	3,22	-0,13	1,040	3,547	0,971	4,702
Living	4,08	3,060	1,2	0,856	3,65	-0,13	1,040	4,020	0,971	5,329
Room 1	2,04	1,530	4,9	-0,628	-1,56	-0,65	-3,115	-3,479	-3,184	-3,848
Room 2	2,04	1,530	4,9	-0,628	-1,56	-0,65	-3,115	-3,479	-3,184	-3,848
MB	4,08	3,060	4,3	-0,387	-2,45	-0,13	1,040	4,020	0,971	3,012
Office	3,6	2,700	4,3	-0,387	-2,16	-0,13	1,040	3,547	0,971	2,658
Skylight	1,69	1,268	6,4	-1,229	-1,81	-0,7	-3,514	-3,061	-3,583	-3,582

Tab.22: *Combined ventilation through the entire building*

Location of neutral plan	1,2 m	Windward -0,65	
Outdoor temperature	12°C	Leeward -0,13	
Zone temperature	22°C	Roof -0,7	
Discharge coefficient	0,75	Vmeteo 6,4 m/s	Pmin -5,6 pa
Air density	1,205 kg/m³	Vref 3,642 m/s	Pmax -5,2 pa

	Area [m²]	Eff. Area [m²]	Height [m]	Thermal Buoyancy [pa]	AFR (thermal) [m³/s]	Pres Coefficient	Wind pressure [pa]	AFR Wind) [m³/s]	Wind pressure [pa]	AFR total [m³/s]
Kitchen	3	2,100	1,2	0,000	0,00	-0,65	-3,605	-5,137	-3,605	-5,137
Dining	3,6	2,520	1,2	0,000	0,00	-0,13	0,550	2,408	0,550	2,408
Living	4,08	2,856	1,2	0,000	0,00	-0,13	0,550	2,729	0,550	2,729

Tab.23: *Crossventilation on the ground floor*

Furthermore, Be15 models have been created for all building types, which have been adjusted according to the design changes during the process. The results for Type A are shown in Tab.24, while the rest is in annex 7.

		Energy frame 2020 19,9 kWh/m^2	
Contribution to energy frame:		Net requirements:	
Heat	24,4	Room heating	4,8
Electricity for building op.	2,9	Domnestic hot water .	13,1
Excessive Heat	0,0	Cooling	0,0
Chosen electricity requirements:		Installation heat loss:	
Lighting	0,0	Room heating	1,7
Room heating	0,9	Domnestic hot water	0,0
VBV heating	0,7		
Heatpump	0,0	Output by special sources	
Ventilation	1,2	Solar heat	0,0
Pumps	0,7	Heat pump	0,0
Cooling	0,0	Photovoltaics	0,0
Total elecricity consumption	24,8	Windmills	0,0

Tab.24: *Be15 results of type A*

VENTILATION SYSTEM

Regarding mechanical ventilation, the general thoughts during the earlier stages have been the use of a decentralized ventilation system for small user groups, as is the case with a terraced house, and a centralized system for bigger user groups, which is the case in the housing towers.

A decentralized system gives the users great freedom in terms of controlling the indoor climate, but also the responsibility of maintenance, for instance cleaning a filter once or twice a year. In order for this system to work, inlet and outlet of the ventilation air have to be placed for each housing unit separately, which could have great effect on the architectural expression of the facades. Therefore inlet and outlet are placed on the roof, while the system can be maintained from udner the staircase.

A centralized system does not allow for individual control of the indoor climate, but also frees the users from maintenance service of the system. However, only one inlet and outlet has to placed, which allows for greater architectural freedom as well, since no ventilation components are necessarily visible on the facades. The central unit is placed on the roof as it barely affects the archtiectural expression of the building and to reduce the number of ducts in the building.

Moving forward, we incorporated the space for service facilities during all planning stages, as can be seen on the earlier plans during the design process. Therefore, a common problem was solved already in the beginning of the process: Space for installations, ventilation ducts, etc. Thus, the ventilation plans shown on Fig.178 could be shaped according to the calculations for mechanical ventilation. The calculations were executed for the atmospheric indoor climate according to the requirements for the CO2 concentration in the air and the sensoric air quality and validated in BSim for thermal indoor climate which resulted in the following ventilation duct dimensions as shown in Tab.25. The calculations for atmospheric indoor climate are attached in Annex 5.

Room	Area [m^2]	Air Volume [m^3/s]	Air Volume [l/s]	Air Change Rate [h^{-1}]	Diameter [mm]
Living/Dining Area	22,3	0,041	-	3,4	160
Kitchen	10,4	0,020	20	2,4	100
Bedroom 1	9,5	0,018	-	2,7	100
Bedroom 2	10,2	0,020	-	2,7	100
Master Bedroom	11,6	0,026	-	2,9	125
Office	6,0	0,013	-	3,1	80
Bathroom	6,7	0,015	15	2,2	80
Toilet	3,9	0,010	10	2,2	80

Tab.25: *Duct sizes for Type A*

Fig.178: *Conceptual Ventilation Plans Type A*

CONSTRUCTION PLANS

Lastly we worked with construction details to finalize the design even in the smallest scale. Additionally, estimate calculations for the constrution were done using Finnwood, an application created by Metsä to ensure safe and realistic construction solutions as shown on Fig.179. The software is updated according to the lates Eurocodes. The calcualtions are documented in Annex 10.

Furthermore construction plans have been created for each of the building types. On Fig.180 the construction plans for Type A are shown.

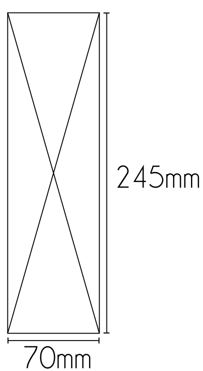


Fig.179: *Crosssection of timber beam*

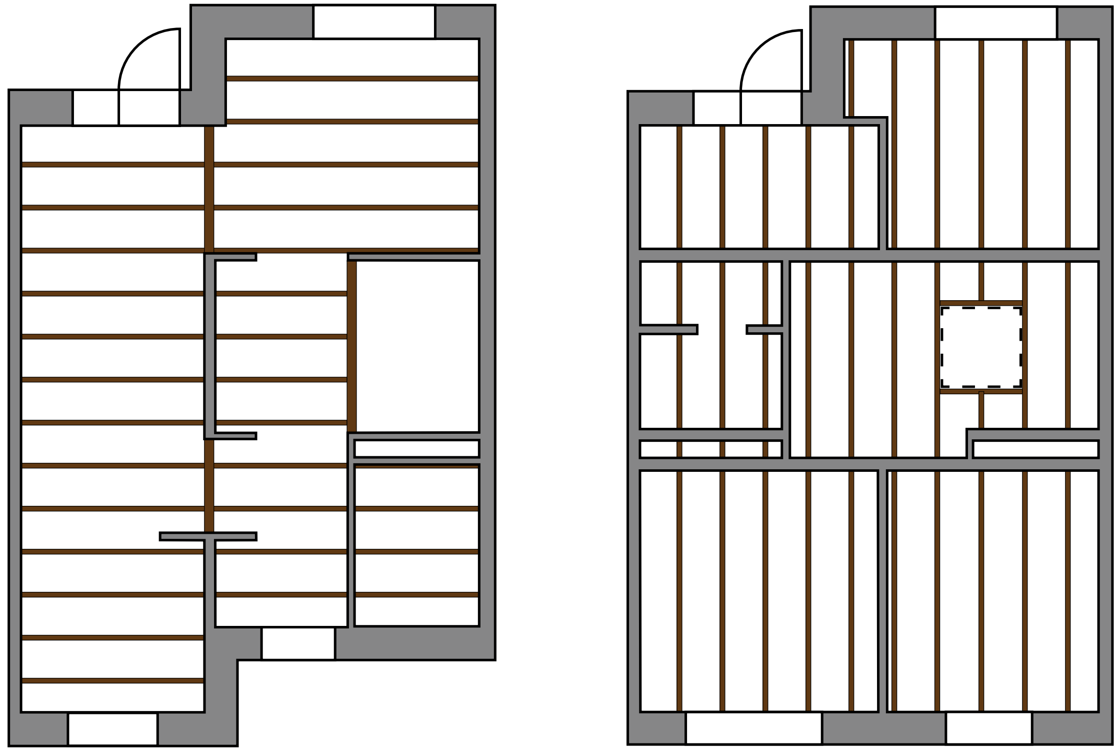


Fig.180: *Construction plans*

Type C has been designed using concrete as the structural material, as it is the safer choice in terms of construction and fire safety.

On Fig.181 the structural plans for type C are shown with standard sized slabs with few exceptions where necessary, but all according to Spæncom's data for the Xtrumax type.

The standard width of an element is 1200mm with all elements placed according to wall placements. The minimum width of any element is 350mm which has resulted in the lowest module width in the project at 400mm. With a module thickness of 270mm the span of the modules lies at up to 13m.

Spændvidde			5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6
M_{Rd}	152.74 kNm	q_{Rd}	-	24.6	19.7	15.9	13.0	10.7	8.9	7.3
V_{Rd}	100.77 kN	q_{vRd}	-	24.3	21.7	19.6	17.8	16.3	15.0	13.8
MmREI60	127.72 kNm	qmREI60	-	19.9	15.8	12.7	10.3	8.4	6.8	5.5
MmÅbnFak0,02	90.18 kNm	[illegible]	-	13.0	10.1	7.9	6.2	4.8	3.7	2.8
MmÅbnFak0,04	109.01 kNm	[illegible]	-	16.5	13.0	10.3	8.2	6.6	5.3	4.2
MmÅbnFak0,06	124.08 kNm	[illegible]	-	19.3	15.3	12.2	9.9	8.0	6.5	5.3
Vvbrand	67.69 kN	q_{vbrand}	-	15.1	13.4	12.0	10.8	9.7	8.8	8.0
MmREI120	49.80 kNm	qmREI120	-	5.5	3.9	2.7	1.7	-	-	-
MmREI120*	119.20 kNm	qmREI120	-	18.4	14.5	11.6	9.4	7.6	6.1	4.9
Mrev	138.40 kNm	q,rev	-	21.9	17.5	14.1	11.5	9.4	7.7	6.3
Mbal	51.80 kNm	q,bal	-	5.9	4.2	3.0	2.0	1.2	0.6	0.0
flev i mm		f_{lev}	-	6.1	6.5	6.6	6.2	5.4	3.9	1.6
fe1 i mm		f_{e1}	-	0.4	0.6	0.9	1.3	1.7	2.2	2.9
Egensvingning	Hz	f_{1}	-	16	14	13	11	10	9	9

Tab.26: *Load capacity EX27 [spæncom]*

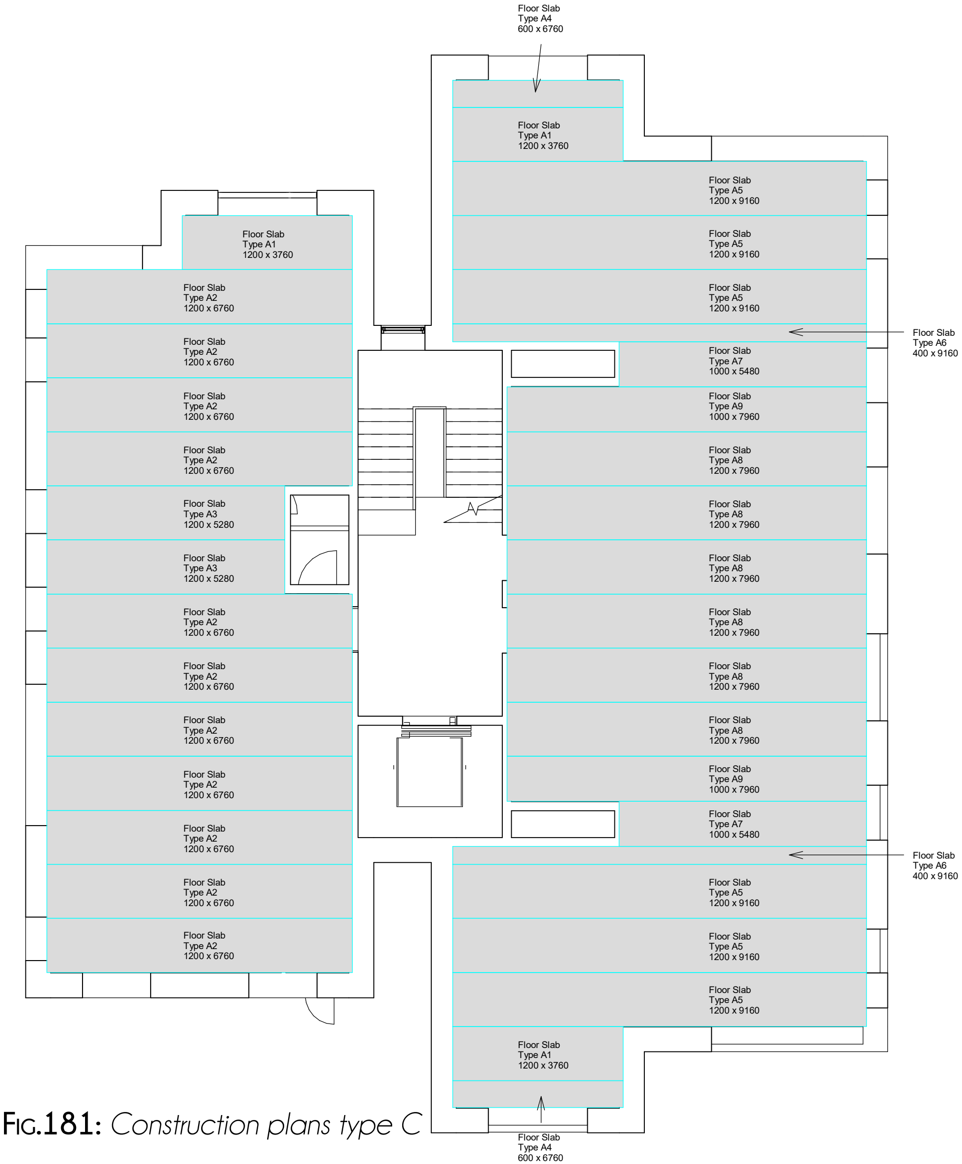


Fig.181: *Construction plans type C*

4

EPILOGUE

CONCLUSION

Initially the project were meant to create a dialogue between the municipality of Skive and the owners of the project site by designing a sustainable housing project that would replace the ruins of the burnt down slaughterhouse on the project site. In order to fulfill this assignment, the project needed to be a rather realistic one, which was achieved by making use of interdisciplinary methods and an iterative process, working with both aesthetics, function, technique and sustainability all at once, thus strengthening the overall outcome of the project.

Furthermore, flexible living has been a great part of the project, to maintain the possibility of rearranging the interior plans at all times according to certain life choices. The general idea to answer this question was the removal or linking of one or more bedrooms to create alternative spaces. Meanwhile the living area has been designed as open spaces at all times to maintain a certain flexibility with the furnishing.

Additionally, nature and its liveliness were important parts from the very beginning of the project, as greenery and the creek are characterizing elements of the city of Skive. The integration of a green wedge into the project site and creating a diverse exterior creates many opportunities for occupants of the site as well as people from outside the site to visit the area and stroll around to experience the natural elements. Furthermore, the courtyards were meant to be an integrated part of the natural element on the site which was achieved by implementing small common gardens, initiating a relation between the inhabitants and the surrounding site.

The common gardens were not only used as a link to the surrounding nature, but to engage into a social community as well. The cluster typology together with the courtyards creates the opportunity to form a social relationship with the other inhabitants, which has been of high priority from the beginning of the project.

Lastly, it has been very important to keep the project realistic in terms of plot ratio according to the municipality plans as well as being rational during the design process and the decision-making, in order to create the aforementioned dialogue between the involved stakeholders. With a plot ratio of 68,95% and a sustainable approach during all stages of the design process to ensure realistic decision-making, the project is fulfilling the assignment.

REFLECTION

During the process a lot of challenges occurred, of which some haven't been solved as well as others. The gable facades are one of these challenges, that has not been engaged properly. By actively including the gable facades in the early planning stages, multiple facade elements and windows could have been an integrated solution to this challenge instead of the now empty facade.

The housing towers have been engaged on well during most of the process. However, it can be up for discussion whether the vertical displacement in the amount of storeys is a mediocre solution. One of the facades suffers from a monotonous expression on the top levels, which could been solved better. From a technical perspective, DGNB could have been an integrated part of the project from the beginning, by examining and filtering the different criteria to create a fitting scope of work for the project. However, DGNB has been a topic, which we actively engaged on thorughout the entire project and which was of great assistance during many of the design stages on a conceptual level.

At the same time prefabrication methods could have been a relevant topic during the early stages of the process already. Especially prefabricated modules would have been a highly relevant topic in terms of economic sustainabilit and a realistic approach to the project. Though, we have worked actively with the production and manufacturing of the individual housing units.

On the masterplan, the integration of rain water accomodation solutions such as whaddies and small creeks has a high potential that reflects the characteristics of the city of Skive.

Lastly, in terms of functions and flexibility, an improvement to the housing type B2 along Færøgade could be a rearrangement of functions, to ensure high quality living spaces towards the West instead of East as it is now.

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https://issuu.com/aa_udstillinger/docs/140611102159-d109227dd4cd4871a3d629b5e4438384/1?e=2800514/8216933 [6/5-2016]
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http://www.skive.dk/media/9118/150525-poster_small.pdf [10/5-2016]
http://www.skive.dk/kommune-politik/politikker-kort-og-planer/planer/big-blue-skive-2040/ [10/5-2016]

LIST OF FIGURES

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ANNEX 1: FIRE STRATEGY

FIRE STRATEGY

According to the Danish building regulations, the fire strategy needs to be considered, where accessibility of fire resue vehicles has to be clear.

The path system that permeates the landscape must have a minimum width of 1.3 meters. By increasing availability, for example. By cyclists, it is a good idea to increase the width to be above 1.8m so cyclists and / or pedestrians can cross each other without coming too close to each other. [Aalborg Universitet, 2011]

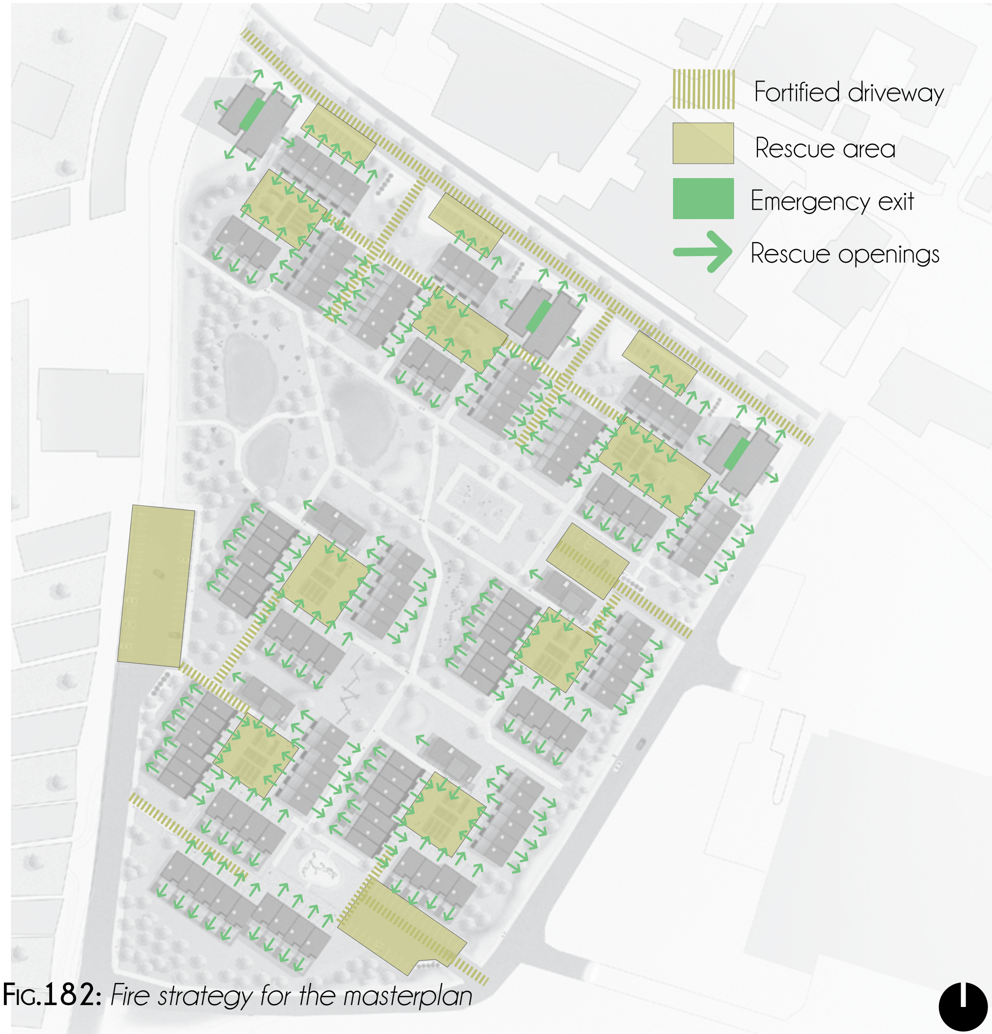


Fig.182: *Fire strategy for the masterplan*

In relation to fire safety, there are some important parameters which have to be met.

- Fire-fighting equipment must be carried forward to any door to the outside.
- No more than 40 meters from the doors of the building in terms of walk path, to a sufficiently broad paved carriage road (fire lanes) see Fig.182
- Driving path must have a minimum width of 2.8 m, with the increase or decrease of max. 1:10.
- There must be an exempt minimum width of 0.3 m on each side of the fire road. see Fig.184
- Fire The road must be brought up to a maximum distance of 10 m from the hydrants.
- Fluctuating access roads for fire roads, should be selected for fire appliances, built with an outer turning radius of 12 m. see Fig.184

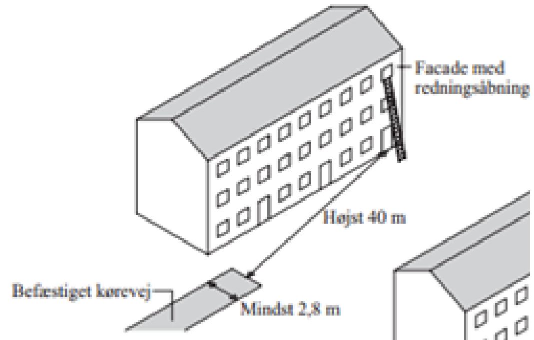


Fig.183: *Requirements distances*

Under the 2010 Building Sec. 2.6.3 paragraph. 4 and Sec. 5.6, it must be ensured that the fire brigade portable ladders must be fed to the rescue openings (windows). And if the lower edge of the rescue openings in the upper floor are more than 10.8 m above ground level (usually corresponding to the 3rd floor), the fire service executable. rise / lift could be brought to the required emergency exits. [Byggecentrum 2012]

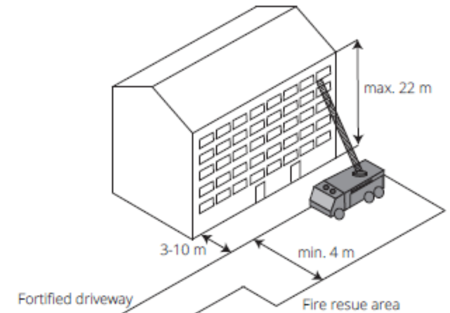


Fig.185: *Requirements fire resque area*

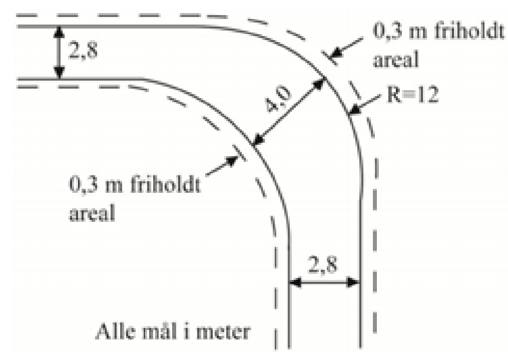


Fig.184: *Fluctuating access roads for fire roads Byggecentrum, 2012*

ANNEX 2: PARKING STRATEGY

PARKING

The parking areas on the site has been designed following the demands from the danish standards and the municipality of Skive, see Fig.186. the parking lots has been spread over the site to serve the different clusters , to minimize the distance from parking lot to the apartment.

When designing parking lots it is a requirement to make space for disabled people, and according to the Fig.190 each outdoor parking are equipped with 1-2 because the number of parking spots doesnt exceed 25 nowhere on the site.

Residential areas

Normal parking demands (DK)
1-2 parking lot pr. apartment
Demands for Skive city
1/2 parking lot pr. apartment.

Fig.187: *DK demands vs Skive, Trafikplan 2012.*

Fig.186: *Parking on the site*

BASEMENT PARKING

The Clusters situated in the north , has parking basements, with entrance from the road crossing, Bicycle parking are located in the basement of the housing towers.

Each basement parking has 37 parking lots for vehicles, and 41 for cyclists.

The sheds that are located by the terraced houses contain the bicycle parking which are required for each apartment.

Residential areas

Normal parking demands (DK)
2 parking lots pr. apartment

Fig.190: *DK requirements, Trafikplan 2016.*

Parkeringsanlæggets størrelse	Handicappladser til alm. biler (3,5 × 5,0 m)	Handicappladser til kassebiler (4,5 × 8,0 m)
1-9		1

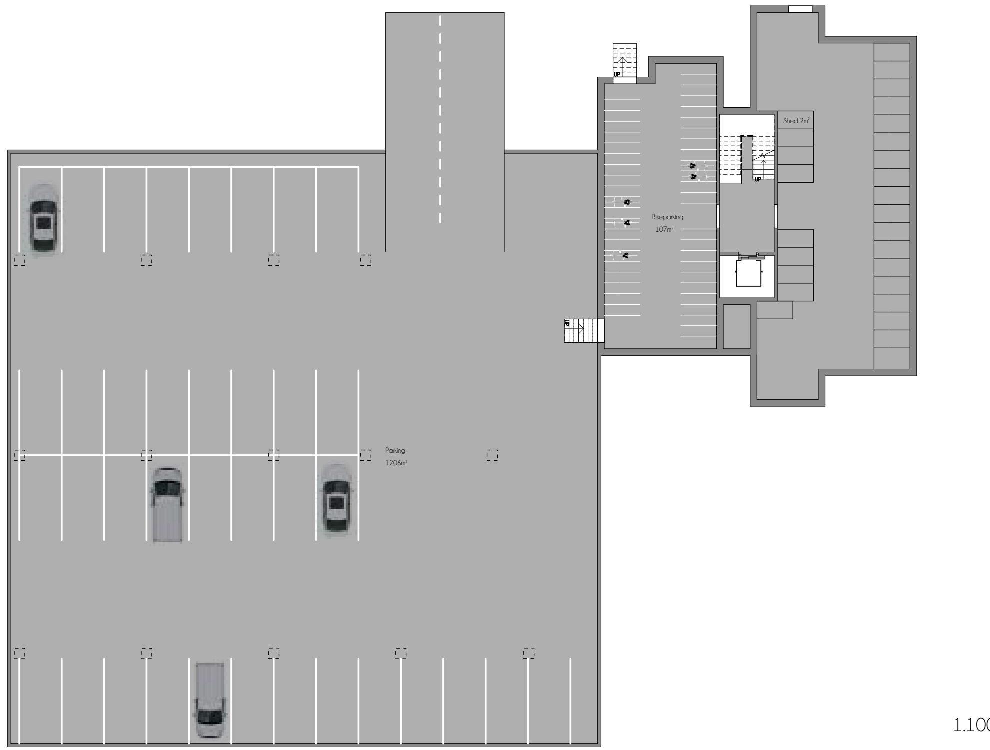


Fig.188:*Number of parking spaces for people with disabilities (4.2 Parkeringsarealer - BR15. 2016)*
Fig.189:*.Basement parking plan solution*

ANNEX 3: VELUX WORKSHOP #3

Room dimension 3000mm x 4000mm		Window dimension 1200mm x 1200mm		
Room height 2800mm		Displacement (X) X = 25mm	Displacement (X) X = 200mm	Displacement (X) X = 375mm
Sill height 900mm		Daylight factor Avg. %	Daylight factor Avg. %	Daylight factor Avg. %
North	Long	1.90	2.00	1.60
	Short	1.90	1.90	1.60
West	Long	1.90	1.90	1.60
	Short	1.90	2.00	1.60
South	Long	1.90	2.00	1.60
	Short	1.80	1.90	1.60
East	Long	1.90	1.90	1.60
	Short	1.90	1.90	1.60

Room dimension 3000mm x 4000mm		Window dimension 2400mm x 1200mm		
Room height 2800mm		Displacement (X) X = 25mm	Displacement (X) X = 200mm	Displacement (X) X = 375mm
Sill height 900mm		Daylight factor Avg. %	Daylight factor Avg. %	Daylight factor Avg. %
North	Long	4.40	4.60	4.00
	Short	4.20	4.40	3.70
West	Long	4.40	4.60	4.00
	Short	4.20	4.40	3.70
South	Long	4.40	4.60	4.00
	Short	4.20	4.40	3.70
East	Long	4.40	4.60	4.00
	Short	4.20	4.40	3.70

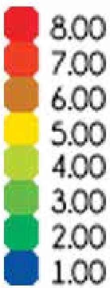
Tab.27: *Velux Study Workshop #3 part 2*

ANNEX 4: VELUX PROCESS

Type A

Groundfloor

First floor



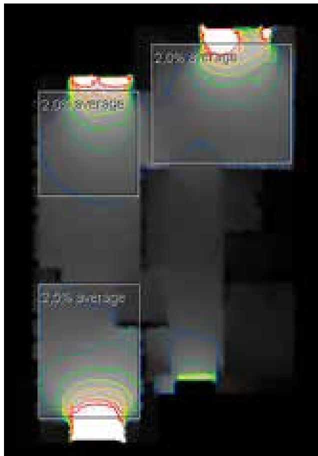


Fig.191: *Type A ground floor first plan*

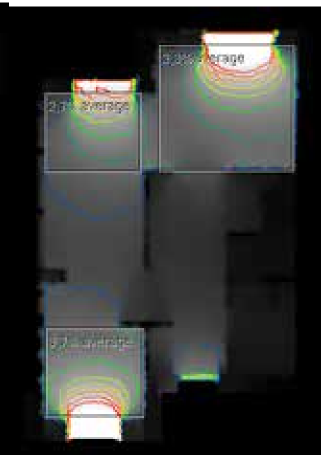


Fig.192: *Type A ground floor optimized*

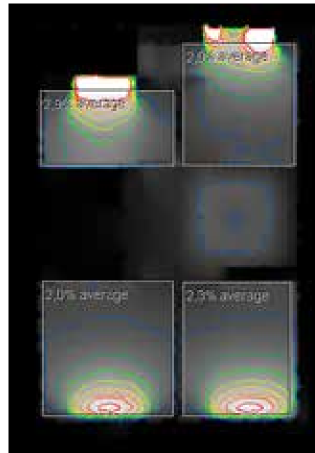


Fig.193: *Type A first floor first plan*

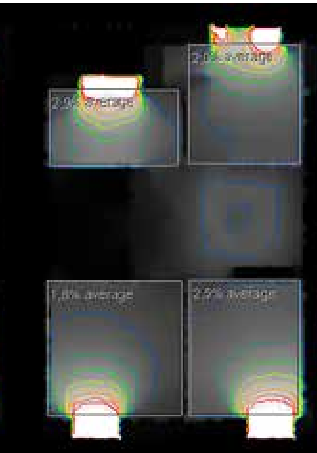


Fig.194: *Type A first floor, smaller windows*

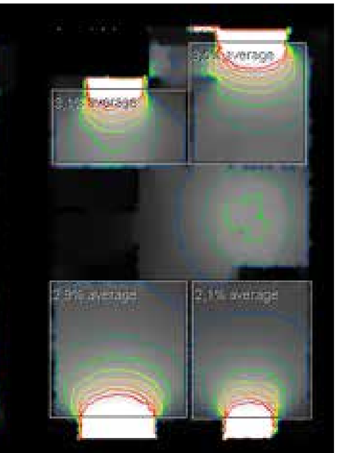


Fig.195: *Type A first floor, optimized*

Type B

Groundfloor

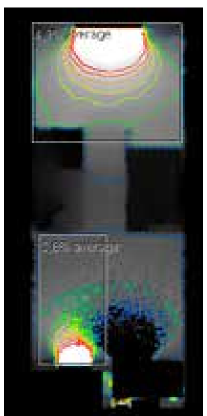


Fig.196: *Type B ground floor, first plan*

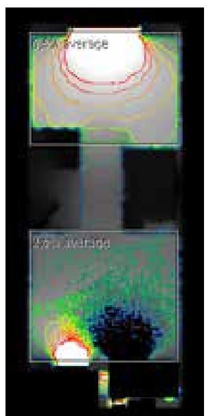


Fig.197: *Type B ground floor, increased window sizes*

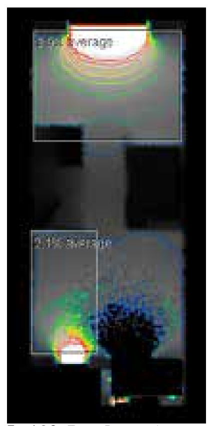


Fig.198: *Type B fround floor, optimized*

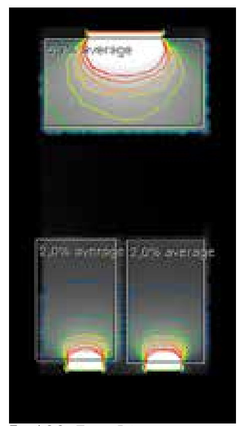


Fig.199: *Type B1 first floor, first plan*

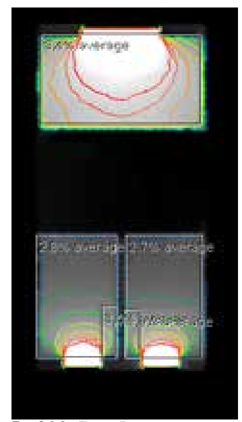


Fig.200: *Type B first floor, increased window sizes*

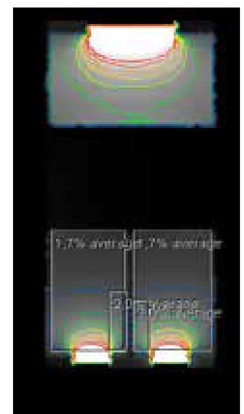


Fig.201: *Type B first floor, changed positioning of windows*

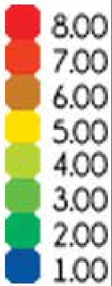


Fig.202: *Type B1 first floor, first plan*

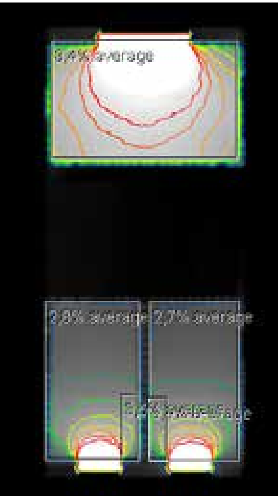


Fig.203: *Type B1 first floor, increased window sizes*

Fig.204: *Type B1 first floor, changed positioning of windows*

Fig.205: *Type B first floor, increased window height*

Fig.207: *Type B first floor, optimized*

Fig.208: *Type B second floor, first plan*

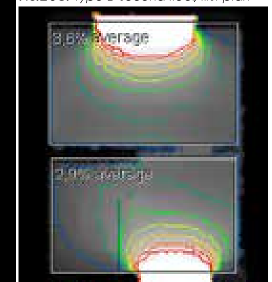


Fig.206: *Type B second floor, increased floor and glazing area*

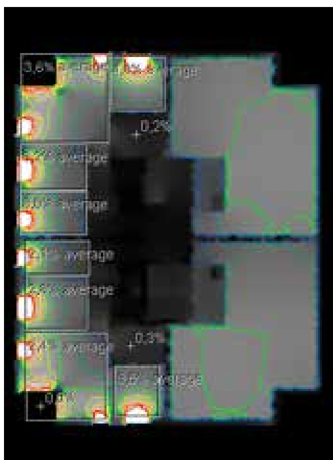


Fig.209: *Type C first plan*

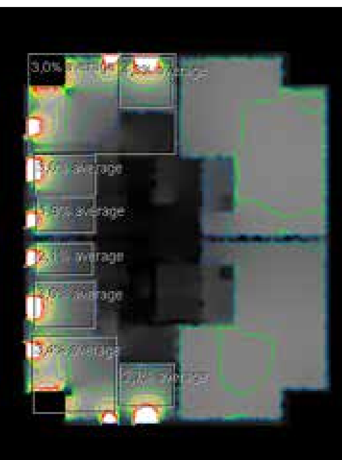


Fig.210: *Type C first plan, improved window placement and sizes*

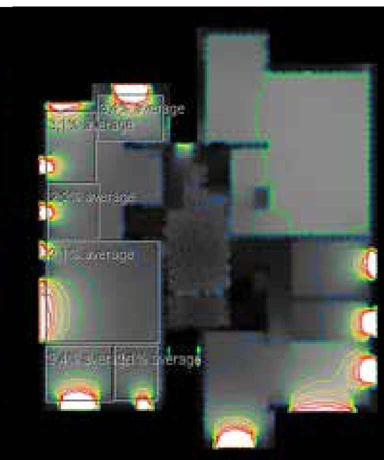


Fig.211: *Improved C type, first plan*

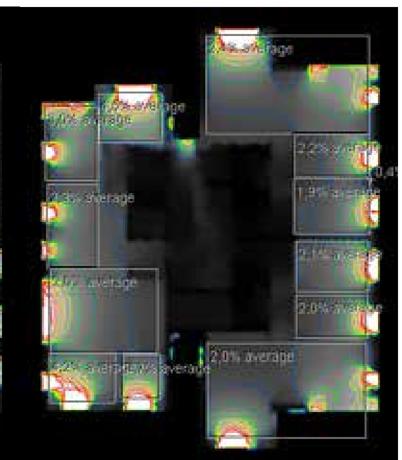


Fig.212: *Improved C type, optimized*

ANNEX 5: ATMOSPHERIC INDOOR CLIMATE

CO2		Gulv-areal	Højde	Volu-men	Pers.	Pers.	Akti-vitet	Foru-rening	Foru-rening	Foru-rening	Udeluft	Indeluft(II)	Luftskifte	Volumen-strøm	Volumen-strøm
Rum	Antal	m2	m	m3	N/m2		met	l/h CO2	l/h CO2	m3/h	ppm	ppm	h^-1	m3/h	l/s
Living Room	1	16,7	2,572	42,95	0,15	1,0	1,2	19	22,8	0,023	0,00035	0,00085	3,4	146	41
Kitchen	1	10,6	2,572	27,26	0,24	0,2	1,2	19	4,6	0,005	0,00035	0,00085	0,3	72	20
WC	1	3,9	2,572	10,03	0,64	0,0	1,2	19	0,0	0,000	0,00035	0,00085	0,0	36	10
Room 1	1	9,5	2,572	24,43	0,26	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,9	23	6
Room 2	1	10,2	2,572	26,23	0,25	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,9	23	6
Bathroom	1	6,7	2,572	17,23	0,37	0,0	1,2	19	0,0	0,000	0,00035	0,00085	4,4	54	15
Kontor	1	6	2,572	15,43	0,42	0,5	1,2	19	11,4	0,011	0,00035	0,00085	1,5	23	6
Master Bed	1	11,79	2,572	30,32	0,21	1,0	1,2	19	22,8	0,023	0,00035	0,00085	1,5	46	13
		75,39													

OLF	Antal	Gulv-areal	Højde	Volu-men	Pers.	Pers.	Foru-rening	Foru-rening	Foru-rening	Foru-rening	Forurening samlet	Luftkvalitet ønsket	Luftkvalitet ude	Ventilations-effektivitet	Ventilations-mængde	Luftskifte	Volumen-strøm
Rum		m2	m	m3	N/m2		olf/pers.	olf	olf/m2	olf	olf	dp	dp		l/s	h^-1	m3/h
Living Room	1	16,7	2,572	42,95	0,15	1,0	1	1	0,2	3,3	4,3	1,4	0,1	1	33,4	2,8	120,2
Kitchen	1	10,6	2,572	27,26	0,24	0,2	1	0	0,2	2,1	2,3	1,4	0,1	1	20,0	2,6	72,0
WC	1	3,9	2,572	10,03	0,64	0,0	1	0	0,2	0,8	0,8	1,4	0,1	1	10,0	3,6	36,0
Room 1	1	9,5	2,572	24,43	0,26	0,5	1	1	0,2	1,9	2,4	1,4	0,1	1	18,5	2,7	66,5
Room 2	1	10,2	2,572	26,23	0,25	0,5	1	1	0,2	2,0	2,5	1,4	0,1	1	19,5	2,7	70,3
Bathroom	1	6,7	2,572	17,23	0,37	0,0	1	0	0,2	1,3	1,3	1,4	0,1	1	15,0	3,1	54,0
Kontor	1	6	2,572	15,43	0,42	0,5	1	1	0,2	1,2	1,7	1,4	0,1	1	13,1	3,1	47,1
Master Bed	1	11,79	2,572	30,32	0,21	1,0	1	1	0,2	2,4	3,4	1,4	0,1	1	25,8	3,1	93,0

TAB.28: *Mechanical ventilation, Type A*

CO2		Gulv-areal	Højde	Volu-men	Pers.	Pers.	Akti-vitet	Foru-rening	Foru-rening	Foru-rening	Udeluft	Indeluft(II)	Luftskifte	Volumen-strøm	Volumen-strøm
Rum	Antal	m2	m	m3	N/m2		met	l/h CO2	l/h CO2	m3/h	ppm	ppm	h^-1	m3/h	l/s
Living Room	1	15,5	2,572	39,87	0,16	1,0	1,2	19	22,8	0,023	0,00035	0,00085	3,4	136	38
Dining	1	10	2,572	25,72	0,25	0,2	1,2	19	4,6	0,005	0,00035	0,00085	3,4	87	24
Kitchen	1	9,2	2,572	23,66	0,27	0,2	1,2	19	4,6	0,005	0,00035	0,00085	0,4	72	20
WC	1	3,6	2,572	9,26	0,69	0,0	1,2	19	0,0	0,000	0,00035	0,00085	0,0	36	10
Room 1	1	9,4	2,572	24,18	0,27	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,9	23	6
Room 2	1	9,4	2,572	24,18	0,27	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,9	23	6
Room 3	1	14,4	2,572	37,04	0,17	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,6	23	6
Bathroom	1	4,1	2,572	10,55	0,61	0,0	1,2	19	0,0	0,000	0,00035	0,00085	4,4	54	15
Kontor	1	14,5	2,572	37,29	0,17	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,6	23	6
Master Bed	1	14,4	2,572	37,04	0,17	1,0	1,2	19	22,8	0,023	0,00035	0,00085	1,2	46	13

OLF	Antal	Gulv-areal	Højde	Volu-men	Pers.	Pers.	Foru-rening	Foru-rening	Foru-rening	Foru-rening	Forurening samlet	Luftkvalite t ømsket	Luftkvalitet ude	Ventilations-effektivitet	Ventilations-mængde	Luftskifte	Volumen-strøm
Rum		m2	m	m3	N/m2		olf/pers.	olf	olf/m2	olf	olf	dp	dp		l/s	h^-1	m3/h
Living Room	1	15,5	2,572	39,87	0,16	1,0	1	1	0,2	3,1	4,1	1,4	0,1	1	31,5	2,8	113,5
Dining Area	1	10	2,572	25,72	0,25	0,2	1	0	0,2	2,0	2,2	1,4	0,1	1	16,9	2,4	60,9
Kitchen	1	9,2	2,572	23,66	0,27	0,2	1	0	0,2	1,8	2,0	1,4	0,1	1	20,0	3,0	72,0
WC	1	3,6	2,572	9,26	0,69	0,0	1	0	0,2	0,7	0,7	1,4	0,1	1	10,0	3,9	36,0
Room 1	1	9,4	2,572	24,18	0,27	0,5	1	1	0,2	1,9	2,4	1,4	0,1	1	18,3	2,7	65,9
Room 2	1	9,4	2,572	24,18	0,27	0,5	1	1	0,2	1,9	2,4	1,4	0,1	1	18,3	2,7	65,9
Room 3	1	14,4	2,572	37,04	0,17	0,5	1	1	0,2	2,9	3,4	1,4	0,1	1	26,0	2,5	93,6
Bathroom	1	4,1	2,572	10,55	0,61	0,0	1	0	0,2	0,8	0,8	1,4	0,1	1	15,0	5,1	54,0
Kontor	1	14,5	2,572	37,29	0,17	0,5	1	1	0,2	2,9	3,4	1,4	0,1	1	26,2	2,5	94,2
Master Bed	1	14,4	2,572	37,04	0,17	1,0	1	1	0,2	2,9	3,9	1,4	0,1	1	29,8	2,9	107,4

Tab.29: *Mechanical ventilation, Type B*

CO2		Gulv-areal	Højde	Volu-men	Pers.	Pers.	Akti-vitet	Foru-rening	Foru-rening	Foru-rening	Udeluft	Indeluft(II)	Luftskifte	Volumen-strøm	Volumen-strøm
Rum	Antal	m2	m	m3	N/m2		met	l/h CO2	l/h CO2	m3/h	ppm	ppm	h^-1	m3/h	l/s
Living Room	1	15	2,572	38,58	0,17	1,0	1,2	19	22,8	0,023	0,00035	0,00085	3,4	131	36
Dining	1	9,9	2,572	25,46	0,25	0,2	1,2	19	4,6	0,005	0,00035	0,00085	3,4	87	24
Kitchen	1	10,2	2,572	26,23	0,25	0,2	1,2	19	4,6	0,005	0,00035	0,00085	0,3	72	20
Room 1	1	9,7	2,572	24,95	0,26	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,9	23	6
Room 2	1	10,4	2,572	26,75	0,24	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,9	23	6
Bathroom	1	6,2	2,572	15,95	0,40	0,0	1,2	19	0,0	0,000	0,00035	0,00085	4,4	54	15
Kontor	1	6,1	2,572	15,69	0,41	0,5	1,2	19	11,4	0,011	0,00035	0,00085	1,5	23	6
Master Bed	1	11,7	2,572	30,09	0,21	1,0	1,2	19	22,8	0,023	0,00035	0,00085	1,5	46	13

OLF	Antal	Gulv-areal	Højde	Volu-men	Pers.	Pers.	Foru-rening	Foru-rening	Foru-rening	Foru-rening	Forurening samlet	Luftkvalitet ønsket	Luftkvalitet ude	Ventilations-effektivitet	Ventilations-mængde	Luftskifte	Volumen-strøm
Rum		m2	m	m3	N/m2		olf/pers.	olf	olf/m2	olf	olf	dp	dp		l/s	h^-1	m3/h
Living Room	1	15	2,572	38,58	0,17	1,0	1	1	0,2	3,0	4,0	1,4	0,1	1	30,8	2,9	110,8
Dining Area	1	9,9	2,572	25,46	0,25	0,2	1	0	0,2	2,0	2,2	1,4	0,1	1	16,8	2,4	60,4
Kitchen	1	10,2	2,572	26,23	0,25	0,2	1	0	0,2	2,0	2,2	1,4	0,1	1	20,0	2,7	72,0
Room 1	1	9,7	2,572	24,95	0,26	0,5	1	1	0,2	1,9	2,4	1,4	0,1	1	18,8	2,7	67,6
Room 2	1	10,4	2,572	26,75	0,24	0,5	1	1	0,2	2,1	2,6	1,4	0,1	1	19,8	2,7	71,4
Bathroom	1	6,2	2,572	15,95	0,40	0,0	1	0	0,2	1,2	1,2	1,4	0,1	1	15,0	3,4	54,0
Kontor	1	6,1	2,572	15,69	0,41	0,5	1	1	0,2	1,2	1,7	1,4	0,1	1	13,2	3,0	47,6
Master Bed	1	11,7	2,572	30,09	0,21	1,0	1	1	0,2	2,3	3,3	1,4	0,1	1	25,7	3,1	92,5

TAB.30: *Mechanical ventilation, Type C1*

CO2		Gulv-areal	Højde	Volu-men	Pers.	Pers.	Akti-vitet	Foru-rening	Foru-rening	Foru-rening	Udeluft	Indeluft(II)	Luftskifte	Volumen-strøm	Volumen-strøm
Rum	**Antal**	**m2**	**m**	**m3**	**N/m2**		**met**	**l/h CO2**	**l/h CO2**	**m3/h**	**ppm**	**ppm**	**h^-1**	**m3/h**	**l/s**
Living Room	1	18,5	2,572	47,58	0,14	1,0	1,2	19	22,8	0,023	0,00035	0,00085	3,4	162	45
Dining	1	9,3	2,572	23,92	0,27	0,2	1,2	19	4,6	0,005	0,00035	0,00085	3,4	81	23
Kitchen	1	11,9	2,572	30,61	0,21	0,2	1,2	19	4,6	0,005	0,00035	0,00085	0,3	72	20
Room 1	1	10,5	2,572	27,01	0,24	0,5	1,2	19	11,4	0,011	0,00035	0,00085	0,8	23	6
Bathroom	1	5	2,572	12,86	0,50	0,0	1,2	19	0,0	0,000	0,00035	0,00085	4,4	54	15
Master Bed	1	13	2,572	33,44	0,19	1,0	1,2	19	22,8	0,023	0,00035	0,00085	1,4	46	13

OLF	Antal	Gulv-areal	Højde	Volu-men	Pers.	Pers.	Foru-rening	Foru-rening	Foru-rening	Foru-rening	Forurening samlet	Luftkvalitet ømsket	Luftkvalitet ude	Ventilations-effektivitet	Ventilations-mængde	Luftskifte	Volumen-strøm
Rum		**m2**	**m**	**m3**	**N/m2**		**olf/pers.**	**olf**	**olf/m2**	**olf**	**olf**	**dp**	**dp**		**l/s**	**h^-1**	**m3/h**
Living Room	1	18,5	2,572	47,58	0,14	1,0	1	1	0,2	3,7	4,7	1,4	0,1	1	36,2	2,7	130,2
Dining Area	1	9,3	2,572	23,92	0,27	0,2	1	0	0,2	1,9	2,1	1,4	0,1	1	15,8	2,4	57,0
Kitchen	1	11,9	2,572	30,61	0,21	0,2	1	0	0,2	2,4	2,6	1,4	0,1	1	20,0	2,4	72,0
Room 1	1	10,5	2,572	27,01	0,24	0,5	1	1	0,2	2,1	2,6	1,4	0,1	1	20,0	2,7	72,0
Bathroom	1	5	2,572	12,86	0,50	0,0	1	0	0,2	1,0	1,0	1,4	0,1	1	15,0	4,2	54,0
Master Bed	1	13	2,572	33,44	0,19	1,0	1	1	0,2	2,6	3,6	1,4	0,1	1	27,7	3,0	99,7

TAB.31: *Mechanical ventilation, Type C2*

ANNEX 6: BSIM MODELS

Room	Hours >27	Hours >28	Shutters
Office	39	12	x
Master Bedroom	30	7	x
Living Area	53	21	x
Bedroom 1	15	1	
Bedroom 2	7	0	

TAB.32: *Excessive heat and shutter placement Type A*

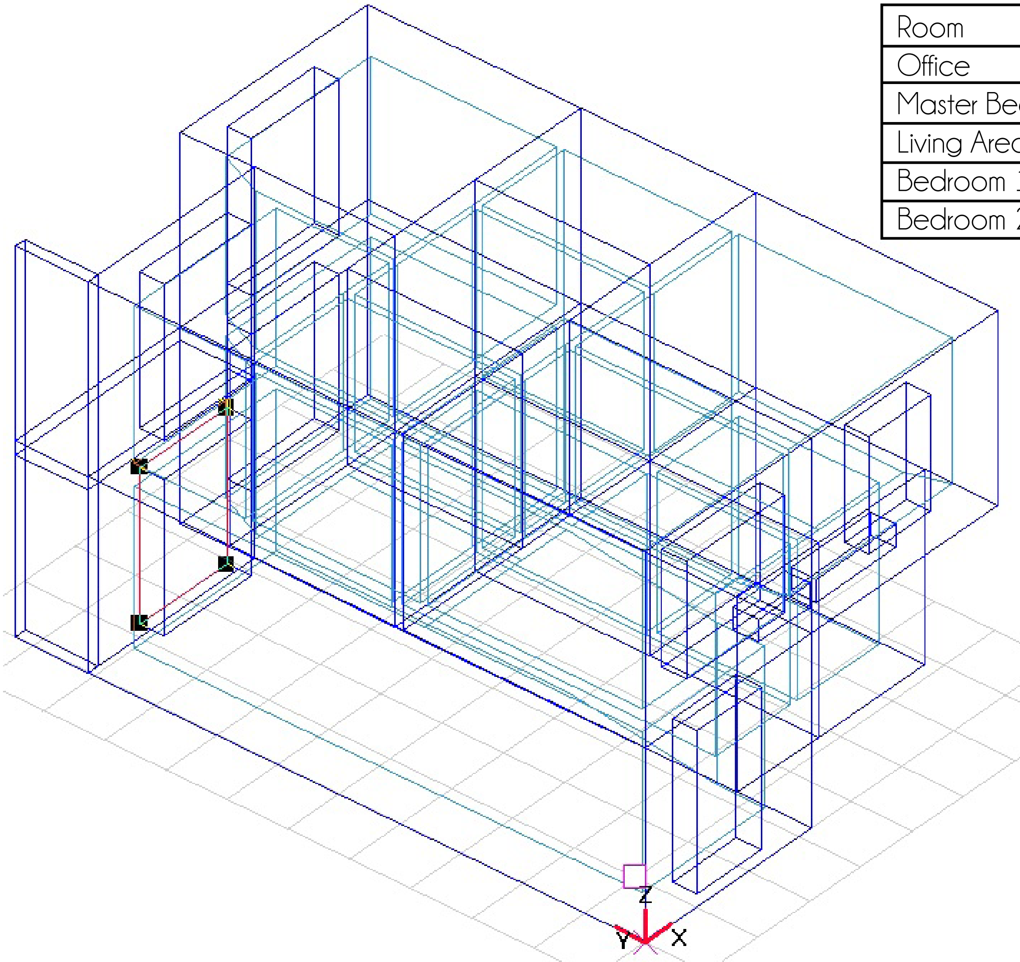


FIG.213: *BSim model A type*

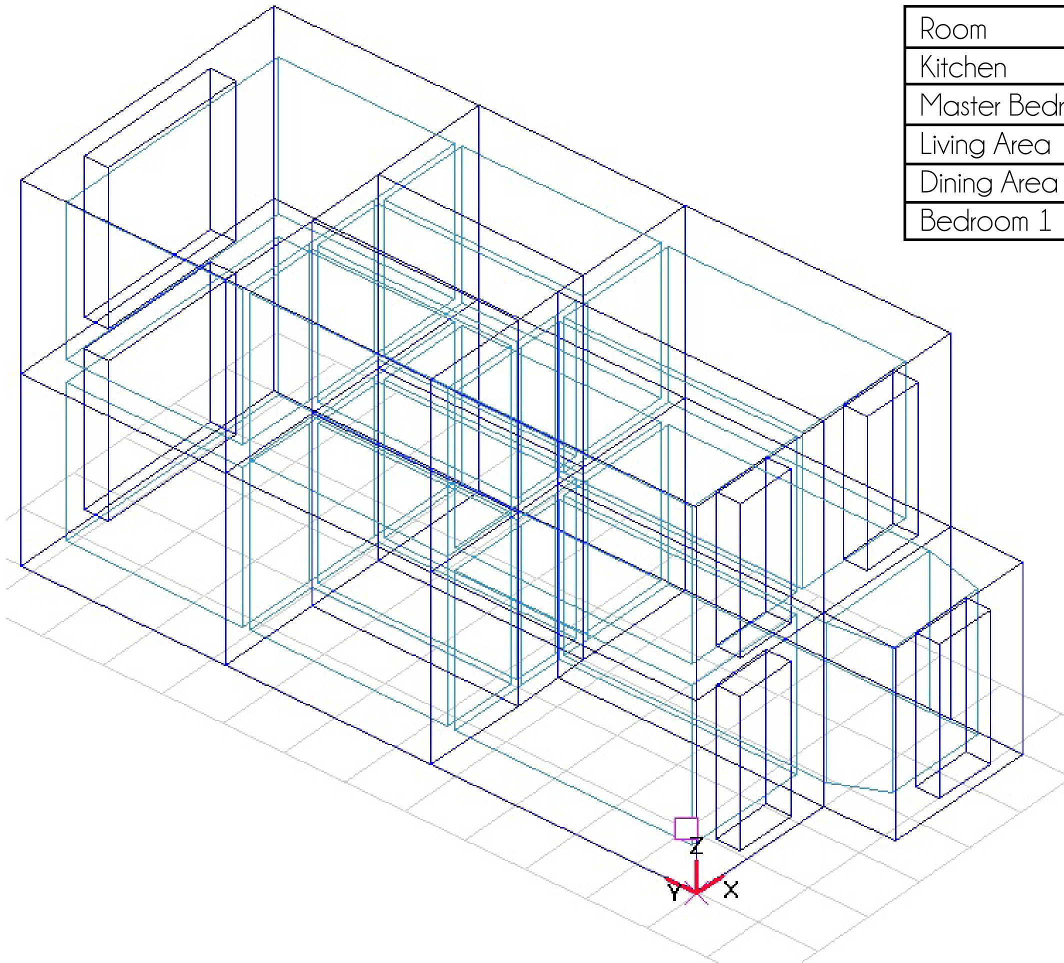


Fig.214: *BSim model B1 type*

Room	Hours >27	Hours >28	Shutters
Kitchen	56	16	
Master Bedroom	16	0	x
Living Area	11	0	x
Dining Area	5	0	
Bedroom 1	0	0	

Tab.33: *Excessive heat and shutter placement Type B1*

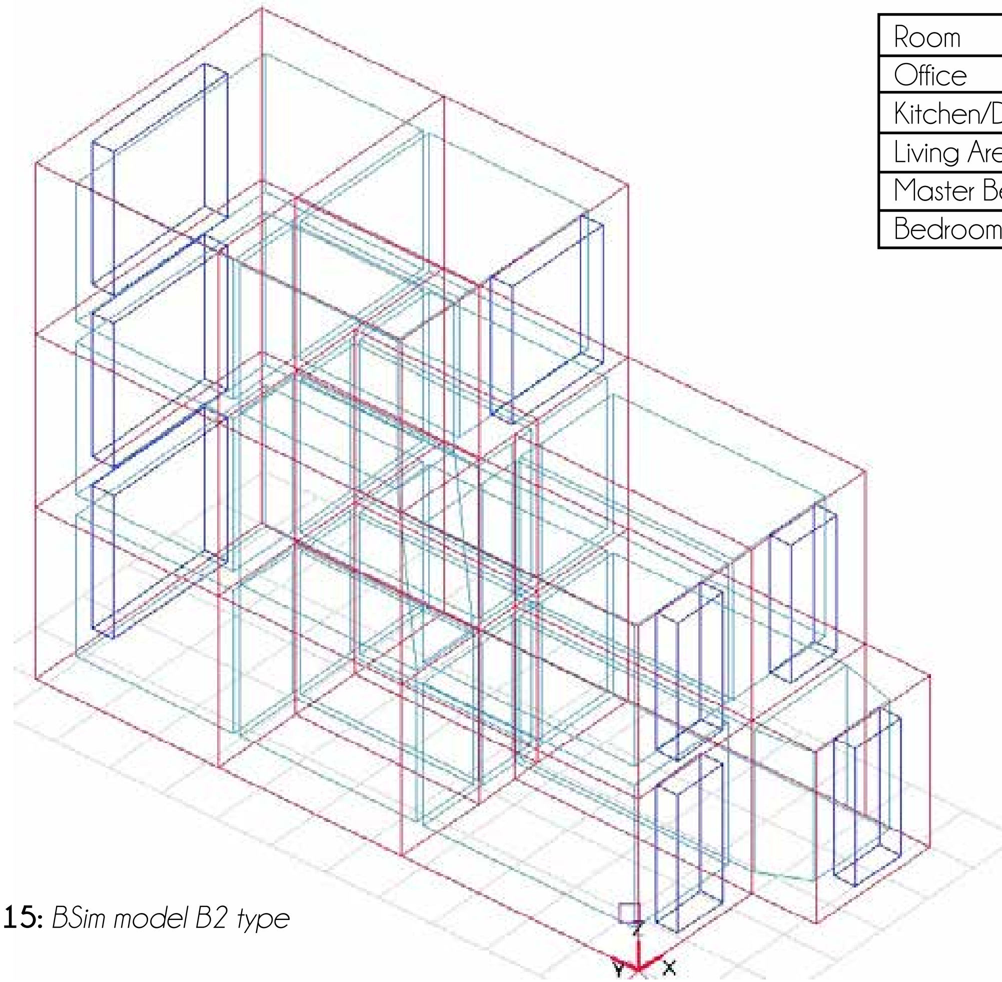


Fig.215: *BSim model B2 type*

Room	Hours >27	Hours >28	Shutters
Office	63	13	x
Kitchen/Dining	14	5	
Living Area	0	0	x
Master Bedroom	25	2	x
Bedroom 1	14	1	

Tab.34: *Excessive heat and shutter placement Type B2*

Room	Hours >27	Hours >28	Shutters*
Optional Room	0	0	x
Living Area	2	0	x
Master Bedroom	0	0	x
Bedroom 1	0	0	x

*if facing South

Tab.35: *Excessive heat and shutter placement old Type C*

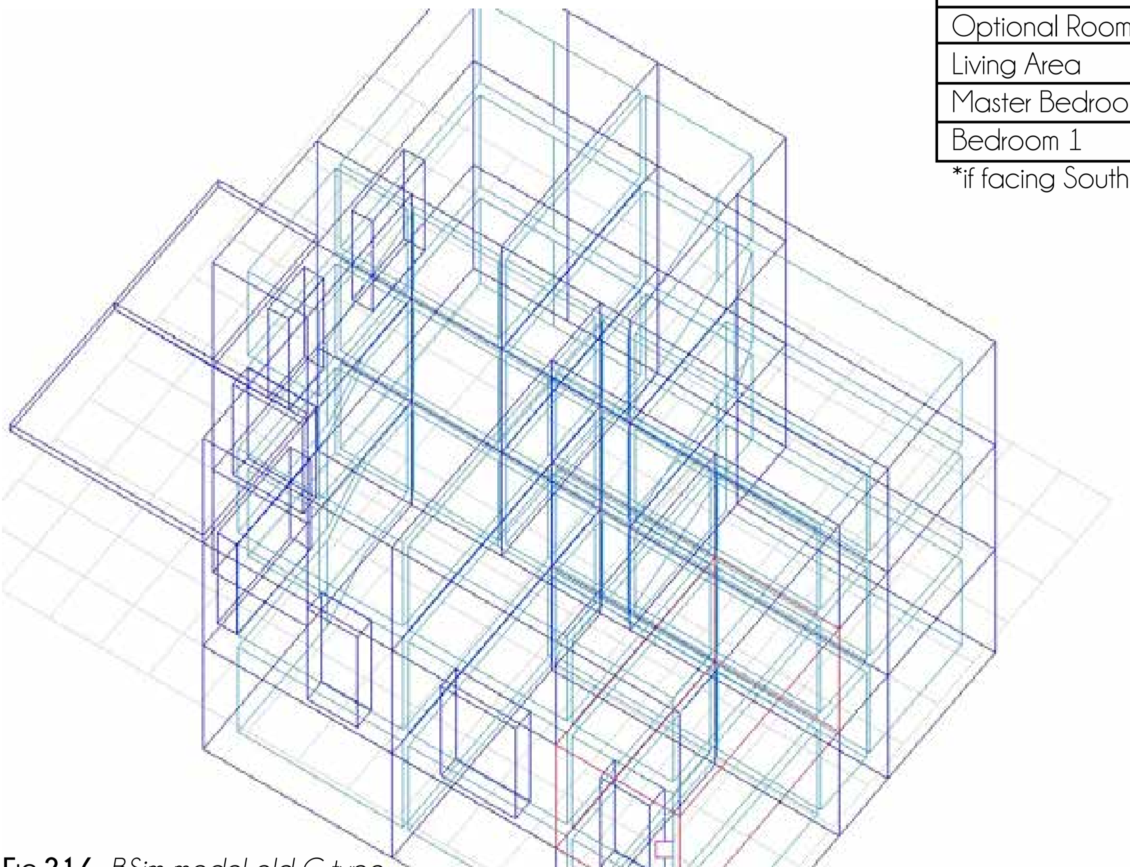


Fig.216: *BSim model old C type*

Room	Hours >27	Hours >28	Shutters*
Office	26	2	x
Master Bedroom	76	24	x
Living Area	47	20	x
Bedroom 1	0	0	x
Bedroom 2	47	15	x

*for windows facing South or West

Tab.36: *Excessive heat and shutter placement Type C1*

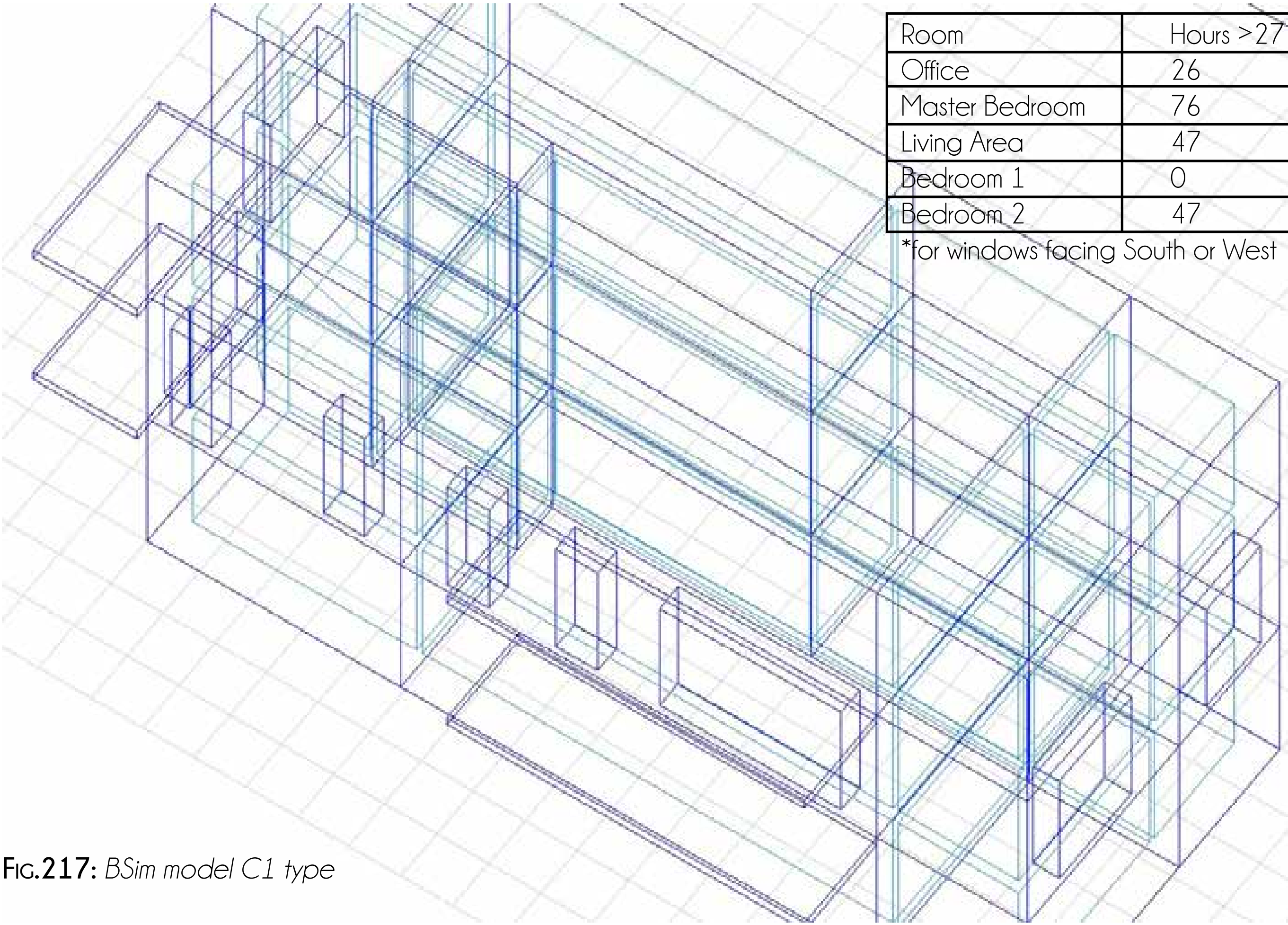


Fig.217: *BSim model C1 type*

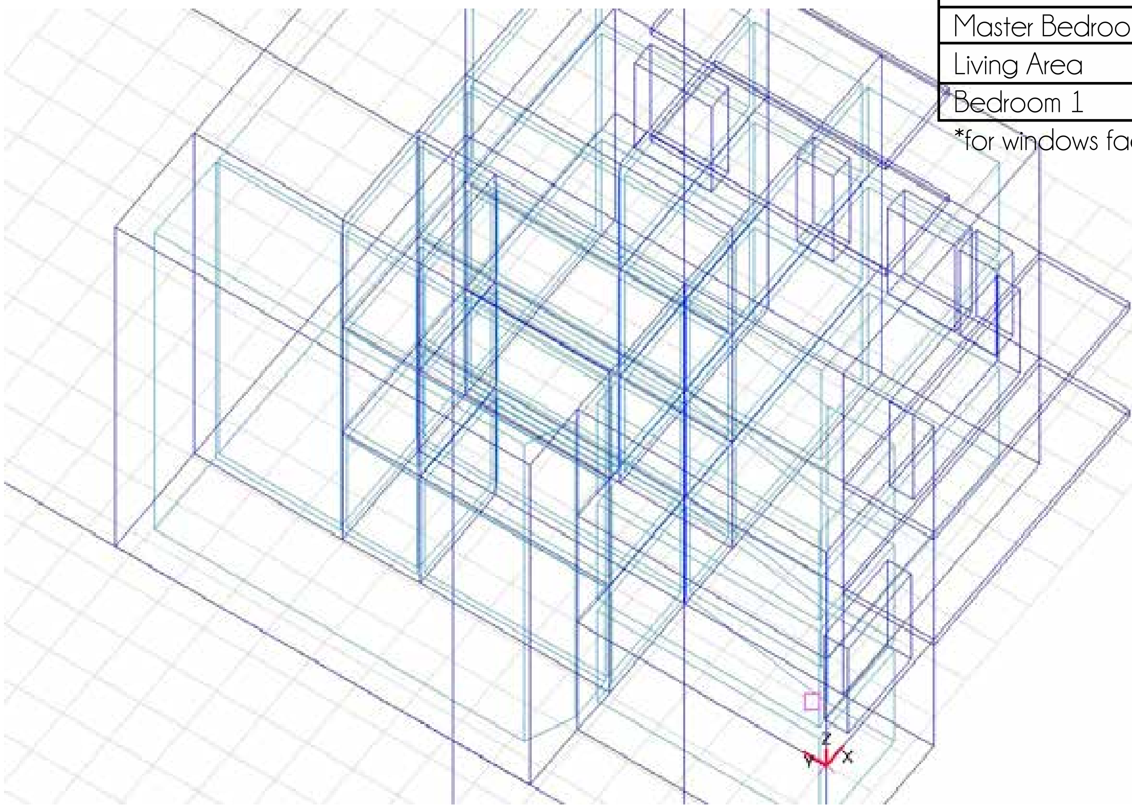


Fig.218: *BSim model C2/3 type*

Room	Hours >27	Hours >28	Shutters*
Master Bedroom	67	17	x
Living Area	16	0	x
Bedroom 1	7	0	x

*for windows facing South or West

Tab.37: *Excessive heat and shutter placement Type C2*

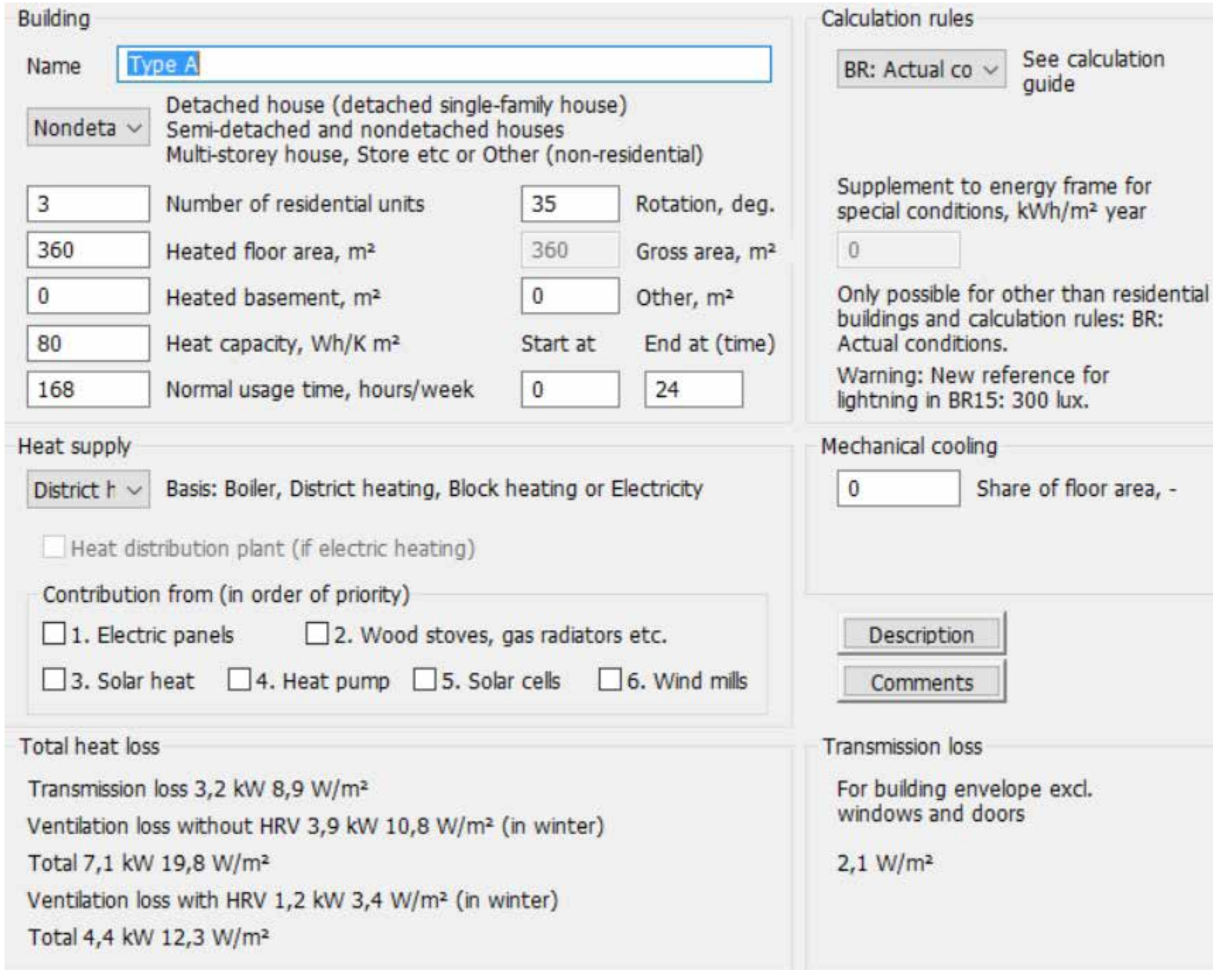


Fig.219: *Be15 project data A type*

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
136,7	0,0	136,7
Total energy requirement		31,7

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
66,3	0,0	66,3
Total energy requirement		31,7

Energy frame BR 2015

Without supplement	Supplement for special conditions	Total energy frame
38,3	0,0	38,3
Total energy requirement		26,8

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		19,9

Contribution to energy requirement

Heat	24,4
El. for operation of bulding	2,9
Excessive in rooms	0,0

Net requirement

Room heating	4,8
Domestic hot water	13,1
Cooling	0,0

Selected electricity requirements

Lighting	0,0
Heating of rooms	0,9
Heating of DHW	0,7
Heat pump	0,0
Ventilators	1,2
Pumps	0,7
Cooling	0,0
Total el. consumption	24,8

Heat loss from installations

Room heating	1,7
Domestic hot water	0,0

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

Fig.220: *Be15 results A type*

	MWh	January	February	March	April	May	June	July	August	September	October	November	December	Total
	Heating requirement													
+1	Trans.- and vent.loss	2,13	1,94	2,28	1,37	0,93	0,61	0,24	0,23	0,58	1,12	1,77	2,13	15,35
2	Vent. VF (total)	0.07	0,06	0.08	0,00	0,00	0,00	0.00	0,00	0.00	0,00	0,04	0,07	0,31
3	Vent. VGV down reg.	0,00	0,00	0,00	-0,00	-0,05	-0,08	-0,12	-0,12	-0,08	-0,03	0,00	0,00	-0,50
4	Heat loss	2.06	1,88	2.20	1.38	0.99	0,69	0.37	0,36	0.66	1,16	1,73	2.06	15,54
5	Incident solar radiation	0,29	0,60	1,34	2,05	2,47	2,34	2,59	2,25	1,60	0,96	0,38	0,23	17,10
6	Internal supply	1,07	0,97	1,07	1,04	1,07	1,04	1,07	1,07	1,04	1,07	1,04	1,07	12,61
7	From pipe and VVB const.	0.10	0.09	0.10	0.10	0.10	0.09	0.10	0.10	0,09	0,10	0,10	0,10	1,16
8	Total supplement	1,46	1,66	2,52	3,18	3,64	3,47	3,76	3,41	2,73	2,13	1,51	1,40	30,88
9	Rel. supplement, -	0,71	0,88	1,14	2,31	3,69	5,00	10,26	9,57	4,11	1,84	0,87	0,68	
10	Part of room heating	1,00	1,00	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,71	1,00	
11	Variable heat supplement	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Toal supplement	1,46	1,66	2,52	3,18	3,64	3,47	3,76	3,41	2,73	2,13	1,51	1,40	30,88
13	Rel. supplement, -	0,71	0,88	1,14	2,31	3,69	5,00	10,26	9,57	4,11	1,84	0,87	0,68	
14	Utilization factor	1,00	0,98	0,85	0,43	0,27	0,20	0,10	0,10	0,24	0,54	0,98	1,00	
15	Heat requirement	0,60	0,26	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,66	1,72
16	Vent. VF (central heating)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
17	Total	0,60	0,26	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,66	1,72

Fig.221: *Be15 requirements A type*

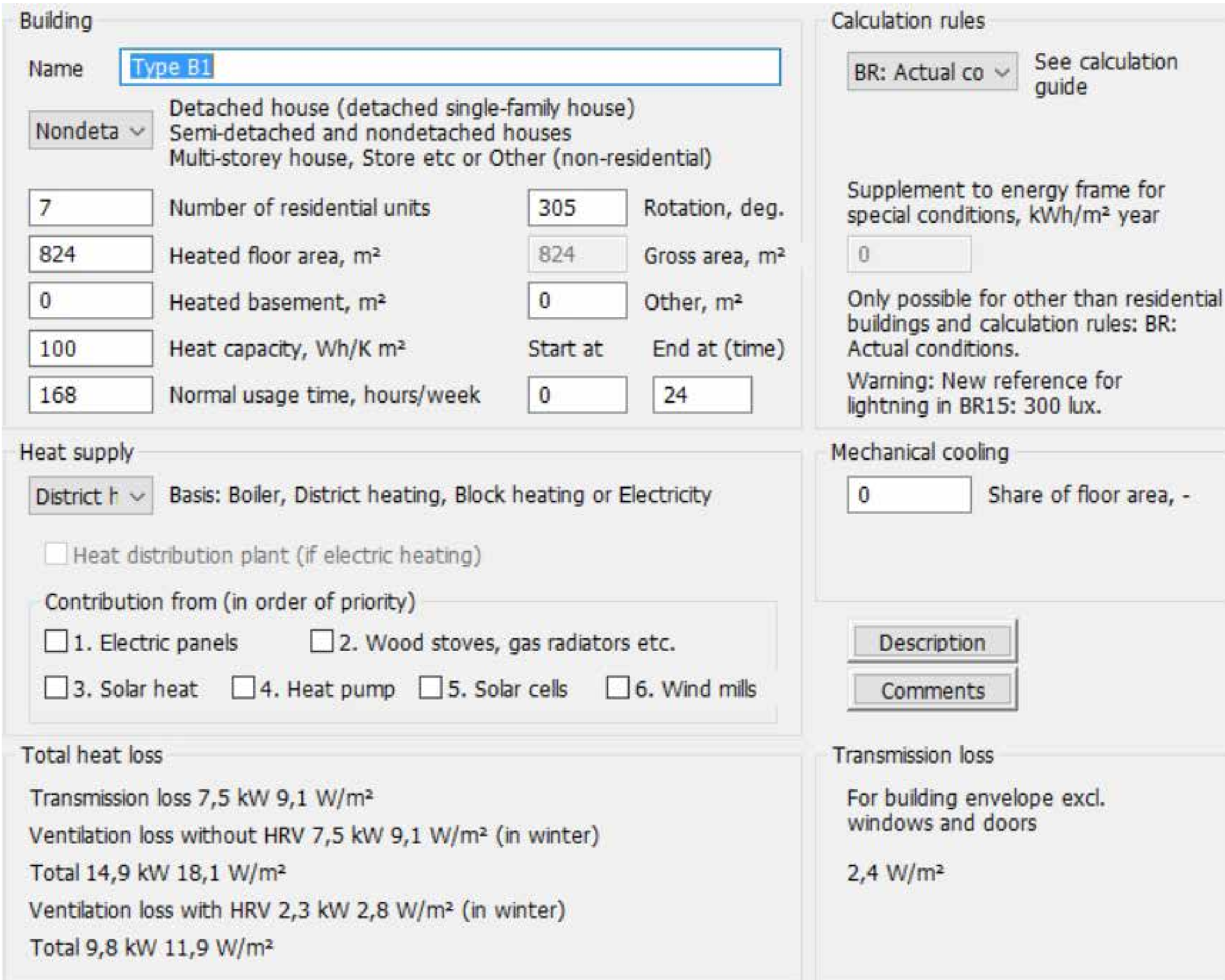


Fig.222: *Be15 project data B1 type*

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
137,2	0,0	137,2
Total energy requirement		28,5

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
66,5	0,0	66,5
Total energy requirement		28,5

Energy frame BR 2015

Without supplement	Supplement for special conditions	Total energy frame
38,5	0,0	38,5
Total energy requirement		23,9

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		17,7

Contribution to energy requirement

Heat	23,3
El. for operation of bulding	2,1
Excessive in rooms	0,0

Net requirement

Room heating	5,2
Domestic hot water	13,1
Cooling	0,0

Selected electricity requirements

Lighting	22,9
Heating of rooms	0,7
Heating of DHW	0,3
Heat pump	0,0
Ventilators	1,0
Pumps	0,3
Cooling	0,0
Total el. consumption	24,0

Heat loss from installations

Room heating	3,4
Domestic hot water	0,0

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

FIG.223: *Be15 results B1 type*

	MWh	January	February	March	April	May	June	July	August	September	October	November	December
	Heating requirement												
+1	Trans.- and vent.loss	4,73	4,32	5,07	3,05	2,08	1,37	0,54	0,52	1,29	2,50	3,93	4,73
2	Vent. VF (total)	0,13	0,12	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,13
3	Vent. VGV down reg.	0.00	0.00	0.00	-0.01	-0.10	-0.15	-0.24	-0.24	-0.16	-0.07	0.00	0.00
4	Heat loss	4,60	4,20	4,92	3,06	2,18	1,52	0,78	0,76	1,45	2,57	3,87	4,60
5	Incident solar radiation	0,54	1,13	2,54	3,88	4,69	4,45	4,95	4,22	2,99	1,80	0,71	0,42
6	Internal supply	2,45	2,21	2,45	2,37	2,45	2,37	2,45	2,45	2,37	2,45	2,37	2,45
7	From pipe and VVB const.	0,17	0,15	0,17	0,16	0,16	0,15	0,15	0,15	0,15	0,16	0,16	0,17
8	Total supplement	3,16	3,50	5,16	6,41	7,30	6,97	7,56	6,82	5,51	4,41	3,24	3,05
9	Rel. supplement, -	0,69	0,83	1,05	2,09	3,35	4,58	9,71	9,03	3,79	1,72	0,84	0,66
10	Part of room heating	1,00	1,00	0,51	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,75	1,00
11	Variable heat supplement	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Toal supplement	3,16	3,50	5,16	6,41	7,30	6,97	7,56	6,82	5,51	4,41	3,24	3,05
13	Rel. supplement, -	0,69	0,83	1,05	2,09	3,35	4,58	9,71	9,03	3,79	1,72	0,84	0,66
14	Utilization factor	1,00	0,99	0,92	0,48	0,30	0,22	0,10	0,11	0,26	0,58	0,99	1,00
15	Heat requirement	1,44	0,73	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,48	1,56
16	Vent. VF (central heating)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fig.224: *Be15 requirements B1 type*

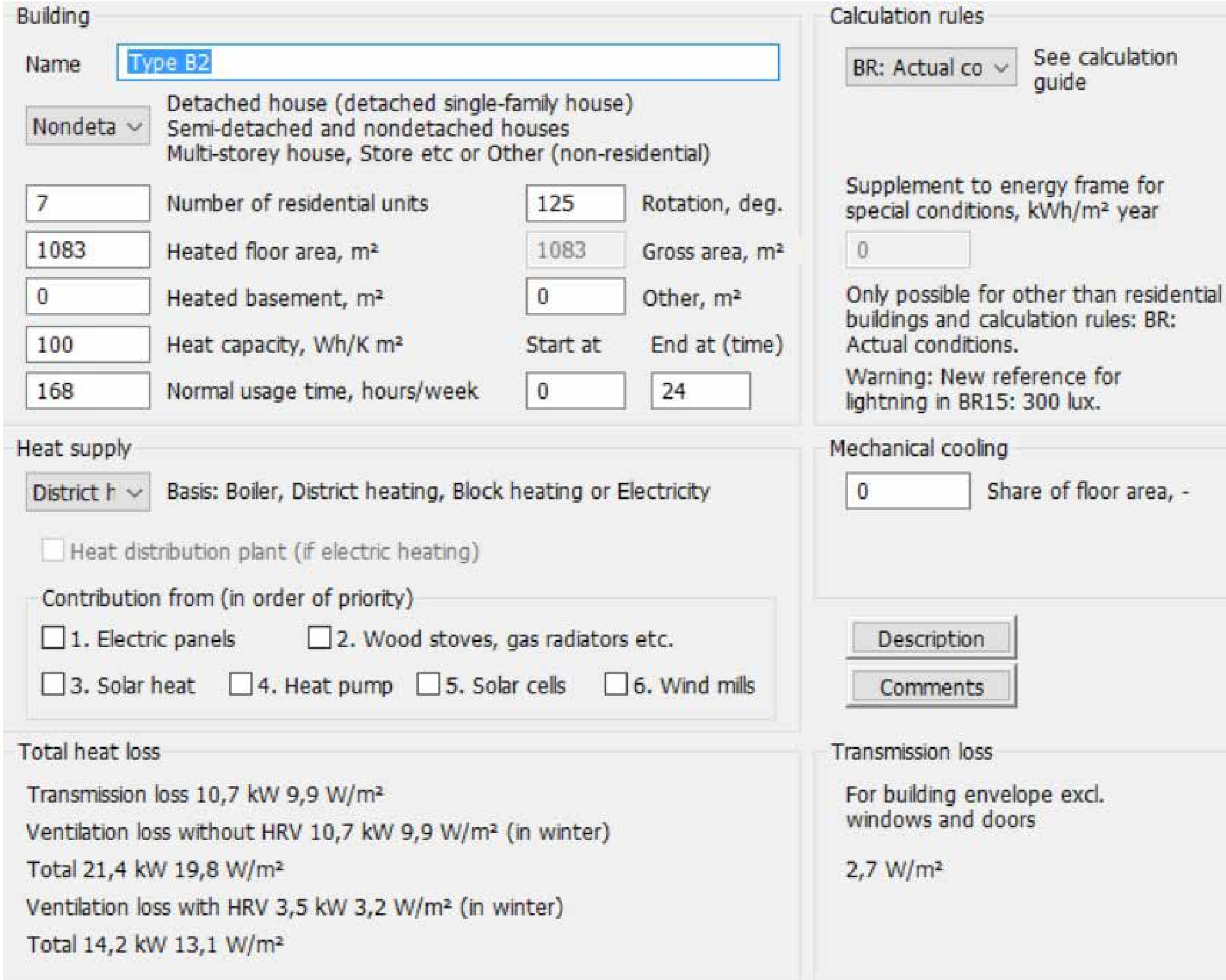


Fig.225: *Be15 project data B2 type*

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
130,7	0,0	130,7
Total energy requirement		28,5

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
63,2	0,0	63,2
Total energy requirement		28,5

Energy frame BR 2015

Without supplement	Supplement for special conditions	Total energy frame
36,5	0,0	36,5
Total energy requirement		23,9

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		17,7

Contribution to energy requirement

Heat	23,2
El. for operation of bulding	2,1
Excessive in rooms	0,0

Net requirement

Room heating	6,4
Domestic hot water	13,1
Cooling	0,0

Selected electricity requirements

Lighting	34,6
Heating of rooms	0,8
Heating of DHW	0,2
Heat pump	0,0
Ventilators	1,1
Pumps	0,2
Cooling	0,0
Total el. consumption	20,8

Heat loss from installations

Room heating	2,6
Domestic hot water	0,0

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

Fig.226: *Be15 results B2 type*

	MWh	January	February	March	April	May	June	July	August	September	October	November	December
	Heating requirement												
+1	Trans.- and vent.loss	6,61	6,05	7,10	4,27	2,91	1,91	0,76	0,73	1,81	3,50	5,50	6,61
2	Vent. VF (total)	0,18	0,17	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,18
3	Vent. VGV down reg.	0,00	0,00	0,00	-0,01	-0,14	-0,22	-0,33	-0,33	-0,23	-0,09	0,00	0,00
4	Heat loss	6,44	5,88	6,88	4,28	3,05	2,13	1,09	1,06	2,03	3,59	5,41	6,44
5	Incident solar radiation	1,13	2,27	4,94	7,27	8,63	8,10	9,01	7,91	5,80	3,64	1,48	0,90
6	Internal supply	2,75	2,48	2,75	2,66	2,75	2,66	2,75	2,75	2,66	2,75	2,66	2,75
7	From pipe and VVB const.	0,17	0,15	0,17	0,16	0,16	0,15	0,15	0,15	0,15	0,16	0,16	0,17
8	Total supplement	4,05	4,90	7,86	10,09	11,54	10,91	11,92	10,81	8,61	6,55	4,30	3,82
9	Rel. supplement. -	0,63	0,83	1,14	2,36	3,78	5,13	10,94	10,22	4,24	1,83	0,80	0,59
10	Part of room heating	1,00	1,00	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,76	1,00
11	Variable heat supplement	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Toal supplement	4,05	4,90	7,86	10,09	11,54	10,91	11,92	10,81	8,61	6,55	4,30	3,82
13	Rel. supplement. -	0,63	0,83	1,14	2,36	3,78	5,13	10,94	10,22	4,24	1,83	0,80	0,59
14	Utilization factor	1,00	0,99	0,86	0,42	0,26	0,20	0,09	0,10	0,24	0,55	1,00	1,00
15	Heat requirement	2,39	1,02	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,85	2,62
16	Vent. VF (central heating)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Fig.227: *Be15 requirements B2 type*

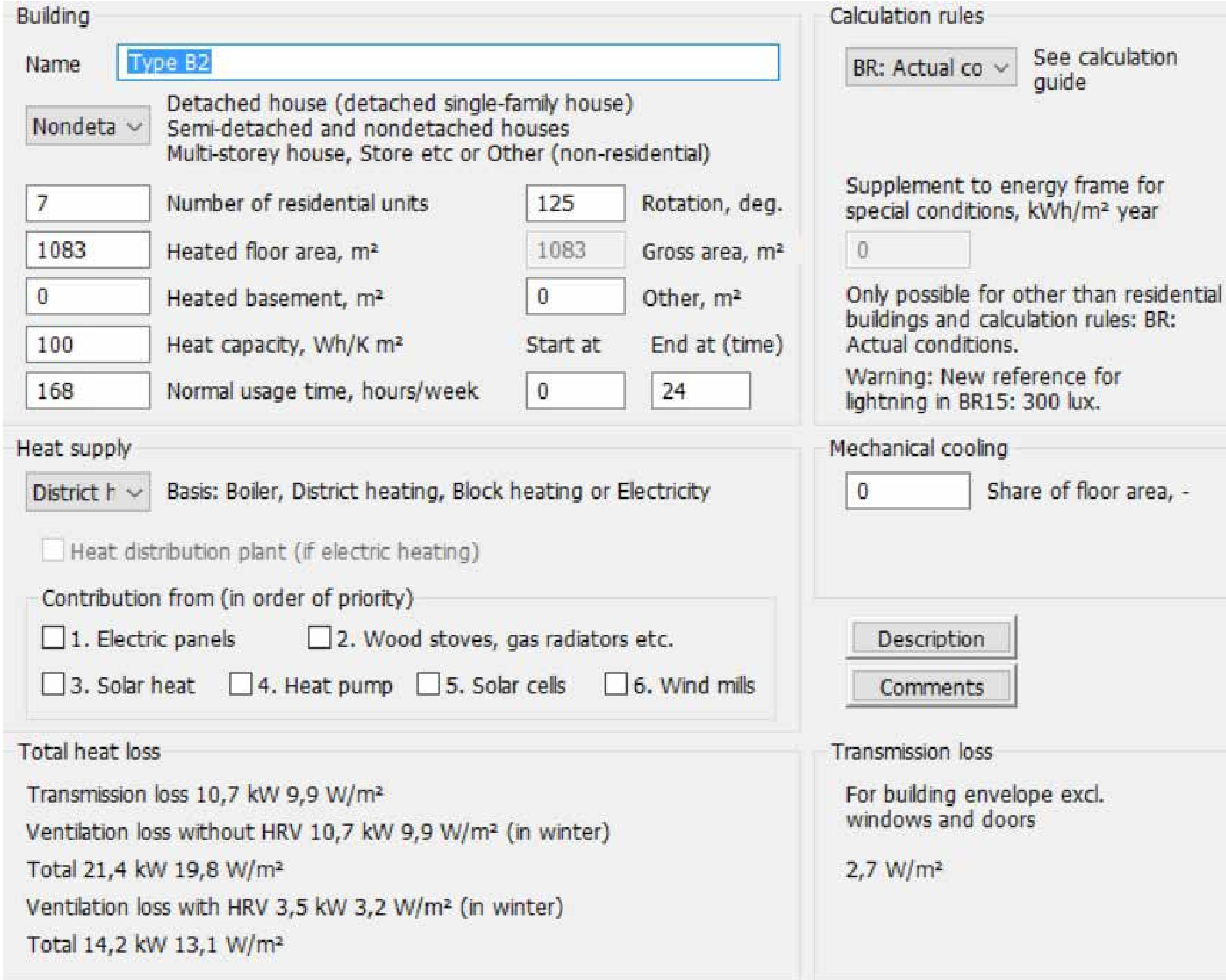


FIG.228: *Be15 project data B3 type*

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
130,7	0,0	130,7
Total energy requirement		28,5

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
63,2	0,0	63,2
Total energy requirement		28,5

Energy frame BR 2015

Without supplement	Supplement for special conditions	Total energy frame
36,5	0,0	36,5
Total energy requirement		23,9

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		17,7

Contribution to energy requirement

Heat	23,2
El. for operation of bulding	2,1
Excessive in rooms	0,0

Net requirement

Room heating	6,4
Domestic hot water	13,1
Cooling	0,0

Selected electricity requirements

Lighting	34,6
Heating of rooms	0,8
Heating of DHW	0,2
Heat pump	0,0
Ventilators	1,1
Pumps	0,2
Cooling	0,0
Total el. consumption	20,8

Heat loss from installations

Room heating	2,6
Domestic hot water	0,0

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

FIG.229: *Be15 results B3 type*

	MWh	January	February	March	April	May	June	July	August	September	October	November	December
	Heating requirement												
+1	Trans.- and vent.loss	6,61	6,05	7,10	4,27	2,91	1,91	0,76	0,73	1,81	3,50	5,50	6,61
2	Vent. VF (total)	0,18	0,17	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,18
3	Vent. VGV down reg.	0,00	0,00	0,00	-0,01	-0,14	-0,22	-0,33	-0,33	-0,23	-0,09	0,00	0,00
4	Heat loss	6,44	5,88	6,88	4,28	3,05	2,13	1,09	1,06	2,03	3,59	5,41	6,44
5	Incident solar radiation	1,13	2,27	4,94	7,27	8,63	8,10	9,01	7,91	5,80	3,64	1,48	0,90
6	Internal supply	2,75	2,48	2,75	2,66	2,75	2,66	2,75	2,75	2,66	2,75	2,66	2,75
7	From pipe and VVB const.	0,17	0,15	0,17	0,16	0,16	0,15	0,15	0,15	0,15	0,16	0,16	0,17
8	Total supplement	4,05	4,90	7,86	10,09	11,54	10,91	11,92	10,81	8,61	6,55	4,30	3,82
9	Rel. supplement. -	0,63	0,83	1,14	2,36	3,78	5,13	10,94	10,22	4,24	1,83	0,80	0,59
10	Part of room heating	1,00	1,00	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,76	1,00
11	Variable heat supplement	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Toal supplement	4,05	4,90	7,86	10,09	11,54	10,91	11,92	10,81	8,61	6,55	4,30	3,82
13	Rel. supplement. -	0,63	0,83	1,14	2,36	3,78	5,13	10,94	10,22	4,24	1,83	0,80	0,59
14	Utilization factor	1,00	0,99	0,86	0,42	0,26	0,20	0,09	0,10	0,24	0,55	1,00	1,00
15	Heat requirement	2,39	1,02	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,85	2,62
16	Vent. VF (central heating)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Fig.230: *Be15 requirements B3 type*

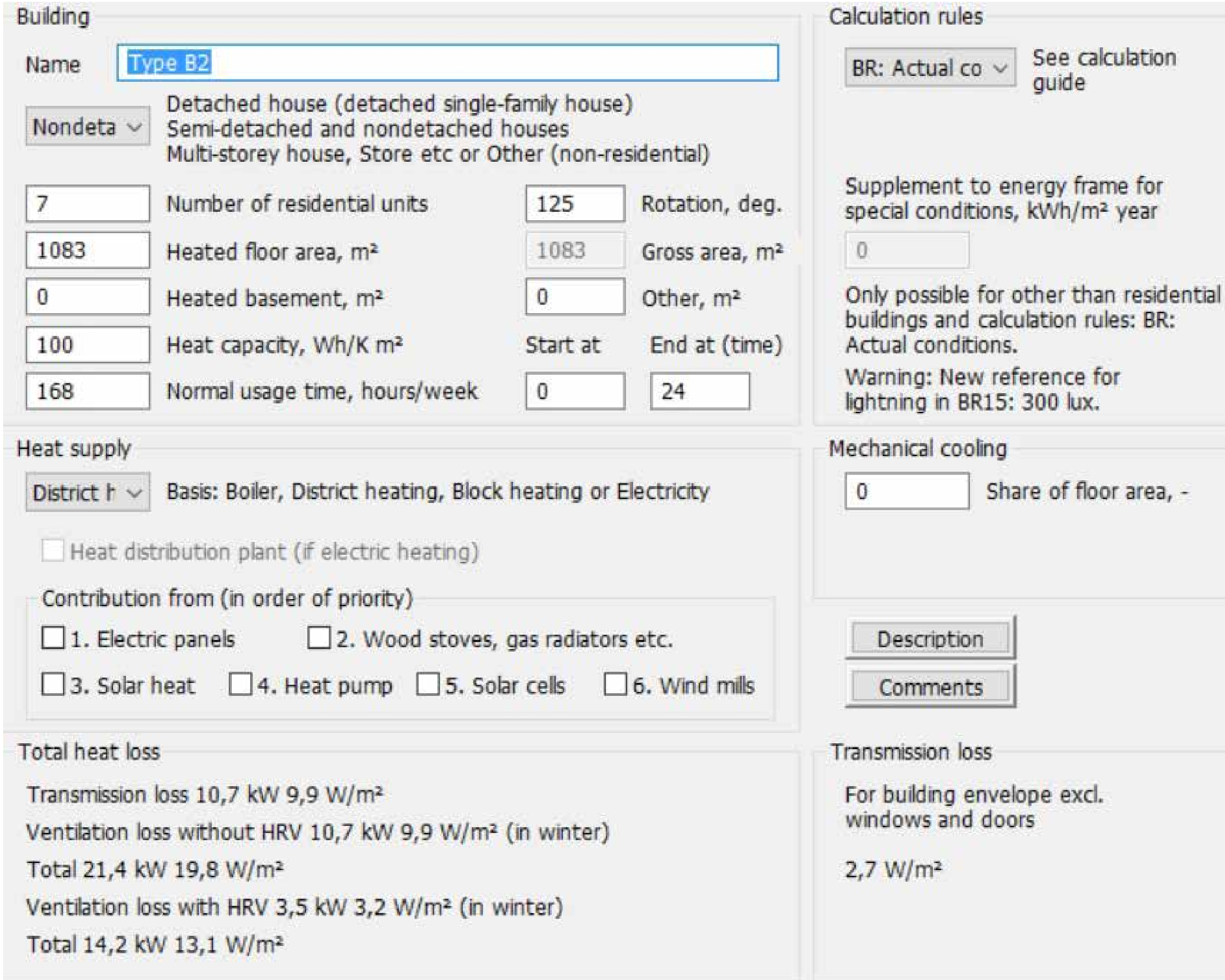


Fig.231: *Be15 project data C type*

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
130,7	0,0	130,7
Total energy requirement		28,5

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
63,2	0,0	63,2
Total energy requirement		28,5

Energy frame BR 2015

Without supplement	Supplement for special conditions	Total energy frame
36,5	0,0	36,5
Total energy requirement		23,9

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
20,0	0,0	20,0
Total energy requirement		17,7

Contribution to energy requirement

Heat	23,2
El. for operation of bulding	2,1
Excessive in rooms	0,0

Net requirement

Room heating	6,4
Domestic hot water	13,1
Cooling	0,0

Selected electricity requirements

Lighting	34,6
Heating of rooms	0,8
Heating of DHW	0,2
Heat pump	0,0
Ventilators	1,1
Pumps	0,2
Cooling	0,0
Total el. consumption	20,8

Heat loss from installations

Room heating	2,6
Domestic hot water	0,0

Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

Fig.232: *Be15 results C type*

	MWh	January	February	March	April	May	June	July	August	September	October	November	December
	Heating requirement												
+1	Trans.- and vent.loss	6,61	6,05	7,10	4,27	2,91	1,91	0,76	0,73	1,81	3,50	5,50	6,61
2	Vent. VF (total)	0,18	0,17	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,18
3	Vent. VGV down reg.	0,00	0,00	0,00	-0,01	-0,14	-0,22	-0,33	-0,33	-0,23	-0,09	0,00	0,00
4	Heat loss	6,44	5,88	6,88	4,28	3,05	2,13	1,09	1,06	2,03	3,59	5,41	6,44
5	Incident solar radiation	1,13	2,27	4,94	7,27	8,63	8,10	9,01	7,91	5,80	3,64	1,48	0,90
6	Internal supply	2,75	2,48	2,75	2,66	2,75	2,66	2,75	2,75	2,66	2,75	2,66	2,75
7	From pipe and VVB const.	0,17	0,15	0,17	0,16	0,16	0,15	0,15	0,15	0,15	0,16	0,16	0,17
8	Total supplement	4,05	4,90	7,86	10,09	11,54	10,91	11,92	10,81	8,61	6,55	4,30	3,82
9	Rel. supplement. -	0,63	0,83	1,14	2,36	3,78	5,13	10,94	10,22	4,24	1,83	0,80	0,59
10	Part of room heating	1,00	1,00	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,76	1,00
11	Variable heat supplement	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Toal supplement	4,05	4,90	7,86	10,09	11,54	10,91	11,92	10,81	8,61	6,55	4,30	3,82
13	Rel. supplement. -	0,63	0,83	1,14	2,36	3,78	5,13	10,94	10,22	4,24	1,83	0,80	0,59
14	Utilization factor	1,00	0,99	0,86	0,42	0,26	0,20	0,09	0,10	0,24	0,55	1,00	1,00
15	Heat requirement	2,39	1,02	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,85	2,62
16	Vent. VF (central heating)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

FIG.233: *Be15 requirements C type*

ANNEX 8: NATURAL VENTILATION SPREADSHEETS

Pressure Coefficient		**Windfactor**	0,569	**Pwind**	8,0	pa
Windward	-0,65	**Vmeteo**	6,4 m/s	**Pmin**	-5,6	pa
Leeward	-0,13	**Vref**	3,642 m/s	**Pmax**	-5,2	pa
roof	-0,7					

Location of neut	3,3 m	**Buildingvol.**		m3		
Outdoor tempera	12 C	**Volume**		m3/section/floor		
Zone temperatur	22 C					
Discharge coeffi	0,75	**Internal pressure**	pa	-2,08		-2,01
Air density	1,205 kg/m3					

	Area m2	**Eff. Area m2**	**Height m**	**Thermal B pa**	**AFR (thermal) m3/s**	**Pres Coefficient**	**Wind pressure pa**	**AFR Wind) m3/s**	**Wind pressure pa**	**AFR total m3/s**
Kitchen	3	2,250	1,2	0,856	2,68	-0,65	-3,115	-5,116	-3,184	-4,422
Dining	3,6	2,700	1,2	0,856	3,22	-0,13	1,040	3,547	0,971	4,702
Living	4,08	3,060	1,2	0,856	3,65	-0,13	1,040	4,020	0,971	5,329
Room 1	2,04	1,530	4,9	-0,628	-1,56	-0,65	-3,115	-3,479	-3,184	-3,848
Room 2	2,04	1,530	4,9	-0,628	-1,56	-0,65	-3,115	-3,479	-3,184	-3,848
MB	4,08	3,060	4,3	-0,387	-2,45	-0,13	1,040	4,020	0,971	3,012
Office	3,6	2,700	4,3	-0,387	-2,16	-0,13	1,040	3,547	0,971	2,658
Skylight	1,69	1,268	6,4	-1,229	-1,81	-0,7	-3,514	-3,061	-3,583	-3,582
				Massebalanc	0,00		Massebalance	0,00		0,00

Tab.38: *Natural ventialtion, combined, Type A*

Pressure Coefficient		**Windfactor**	0,569		**Pwind**	8,0	pa	
Windward	-0,65	**Vmeteo**	6,4	m/s	**Pmin**	-5,6	pa	
Leeward	-0,13	**Vref**	3,642	m/s	**Pmax**	-5,2	pa	
roof	-0,7							

Location of neut	1,2	m	**Buildingvol.**		m3	
Outdoor tempera	12	C	**Volume**		m3/section/floor	
Zone temperatur	22	C				
Discharge coeffi	0,7		**Internal pressure**	pa	-1,59	-1,59
Air density	1,205	kg/m3				

	Area	**Eff. Area**	**Height**	**Thermal B**	**AFR (thermal)**	**Pres Coefficient**	**Wind pressure**	**AFR Wind)**	**Wind pressure**	**AFR total**
	m2	**m2**	**m**	**pa**	**m3/s**		**pa**	**m3/s**	**pa**	**m3/s**
Kitchen	3	2,100	1,2	0,000	0,00	-0,65	-3,605	-5,137	-3,605	-5,137
Dining	3,6	2,520	1,2	0,000	0,00	-0,13	0,550	2,408	0,550	2,408
Living	4,08	2,856	1,2	0,000	0,00	-0,13	0,550	2,729	0,550	2,729
Room 1	0	0,000	4,9	-1,484	0,00	-0,65	-3,605	0,000	-3,605	0,000
Room 2	0	0,000	4,9	-1,484	0,00	-0,65	-3,605	0,000	-3,605	0,000
MB	0	0,000	4,3	-1,243	0,00	-0,13	0,550	0,000	0,550	0,000
Office	0	0,000	4,3	-1,243	0,00	-0,13	0,550	0,000	0,550	0,000
Skylight	0	0,000	6,4	-2,086	0,00	-0,7	-4,004	0,000	-4,004	0,000
	0,000	0,000		Massebalanc	0,00		Massebalance	0,00		0,00

TAB.39: *Natural ventialtion, cross ventilation ground floor, Type A*

Pressure Coefficient		**Windfactor**	0,569		**Pwind**	8,0	pa
Windward	-0,38	**Vmeteo**	6,4	m/s	**Pmin**	-1,4	pa
Leeward	-0,12	**Vref**	3,642	m/s	**Pmax**	-3,0	pa
roof	-0,18						

Location of neut	3,1	m	**Buildingvol.**		m3		
Outdoor tempera	12	C	**Volume**		m3/section/floor		
Zone temperatur	22	C					
Discharge coeffi	0,7		**Internal pressure**	pa	-2,34		-2,24
Air density	1,205	kg/m3					

	Area m2	**Eff. Area m2**	**Height m**	**Thermal I pa**	**AFR (thermal) m3/s**	**Pres Coefficient**	**Wind pressure pa**	**AFR Wind) m3/s**	**Wind pressure pa**	**AFR total m3/s**
Kitchen	2,4	1,500	1,25	0,725	1,65	-0,12	1,384	2,273	1,279	2,735
Living	3,75	2,625	1,25	0,725	2,88	-0,38	-0,693	-2,816	-0,799	-0,920
Door	2,1	2,100	1,05	0,805	2,43	-0,38	-0,693	-2,253	-0,799	0,214
Door top	0,1	0,100	2,3	0,304	0,07	-0,38	-0,693	-0,107	-0,799	-0,091
MB	6,25	2,500	4,4	-0,539	-2,36	-0,38	-0,693	-2,682	-0,799	-3,725
BR1	2,4	1,500	4,4	-0,539	-1,42	-0,12	1,384	2,273	1,279	1,662
BR2	2,4	1,500	4,4	-0,539	-1,42	-0,12	1,384	2,273	1,279	1,662
Skylight	1,21	0,847	10	-2,785	-1,82	-0,18	0,905	1,038	0,799	-1,538
	0,000	0,000		Massebalan	0,00		Massebalance	0,00		0,00

Tab.40: *Natural ventialtion, cross ventilation ground floor, Type B1*

Pressure Coefficient		**Windfactor**	0,569		**Pwind**	8,0	pa
Windwa	-0,38	**Vmeteo**	6,4	m/s	**Pmin**	-1,4	pa
Leewar	-0,12	**Vref**	3,642	m/s	**Pmax**	-3,0	pa
roof	-0,18						

Location of ne	1,2	m	**Buildingvol.**		m3		
Outdoor temp	12	C	**Volume**		m3/section/floor		
Zone tempera	22	C					
Discharge coe	0,7		**Internal pressure**	pa	-2,85		-2,84
Air density	1,205	kg/m3					

	Area m2	**Eff. Area m2**	**Height m**	**Thermal pa**	**AFR (thermal) m3/s**	**Pres Coefficient**	**Wind pressure pa**	**AFR Wind) m3/s**	**Wind pressure pa**	**AFR total m3/s**
Kitchen	2,4	1,500	1,25	-0,013	-0,22	-0,12	1,894	2,660	1,879	2,640
Living	3,75	2,625	1,25	-0,013	-0,39	-0,38	-0,183	-1,447	-0,198	-1,556
Door	2,1	2,100	1,05	0,067	0,70	-0,38	-0,183	-1,157	-0,198	-0,981
Door to	0,1	0,100	2,3	-0,435	-0,08	-0,38	-0,183	-0,055	-0,198	-0,102
	0,000	0,000		Massebalan	0,00		Massebalance	0,00		0,00

Tab.41: *Natural ventialtion, cross ventilation ground floor, Type B1*

Pressure Coefficient			**Windfactor**	0,569		**Pwind**	8,0	pa
Windwa	-0,38		**Vmeteo**	6,4	m/s	**Pmin**	-1,4	pa
Leewarc	-0,12		**Vref**	3,642	m/s	**Pmax**	-3,0	pa
roof	-0,18							

Location of ne	4,0	m	**Buildingvol.**		m3		
Outdoor tempe	12	C	**Volume**		m3/section/floor		
Zone temperat	22	C					
Discharge coe	0,7		**Internal pressure**	pa	-1,35		-1,62
Air density	1,205	kg/m3					

	Area m2	**Eff. Area m2**	**Height m**	**Thermal pa**	**AFR (thermal) m3/s**	**Pres Coefficient**	**Wind pressure pa**	**AFR Wind) m3/s**	**Wind pressure pa**	**AFR total m3/s**
Kitchen	2,4	1,500	1,25	1,091	2,02	-0,38	-1,691	-2,513	-1,415	-1,100
Living	3,75	2,625	1,25	1,091	3,53	-0,12	0,387	2,103	0,663	4,478
Door	2,1	2,100	1,05	1,171	2,93	-0,12	0,387	1,682	0,663	3,663
Door top	0,1	0,100	2,3	0,669	0,11	-0,12	0,387	0,080	0,663	0,149
MB	6,25	2,500	4,4	-0,173	-1,34	-0,12	0,387	2,003	0,663	2,254
BR1	2,4	1,500	4,4	-0,173	-0,80	-0,38	-1,691	-2,513	-1,415	-2,435
BR2	2,4	1,500	4,4	-0,173	-0,80	-0,38	-1,691	-2,513	-1,415	-2,435
BR3	5	2,500	7,7	-1,497	-3,94	-0,12	0,387	2,003	0,663	-2,941
Skylight	1,21	0,847	10	-2,419	-1,70	-0,18	-0,093	-0,332	0,183	-1,632
	0,000	0,000		Massebalan	0,00		Massebalance	0,00		0,00

Tab.42: *Natural ventialtion, cross ventilation ground floor, Type B2*

Pressure Coefficient				**Windfactor**	0,569		**Pwind**	8,0 pa		
Windwa	-0,38			**Vmeteo**	6,4 m/s		**Pmin**	-1,4 pa		
Leeward	-0,12			**Vref**	3,642 m/s		**Pmax**	-3,0 pa		
roof	-0,18									
Location of neu		4,0 m			**Buildingvol.**			m3		
Outdoor tempe		12 C			**Volume**			m3/section/floor		
Zone temperat		22 C								
Discharge coef		0,7			**Internal pressure,**		pa	-1,35		-1,62
Air density		1,205 kg/m3								

	Area m2	**Eff. Area m2**	**Height m**	**Thermal pa**	**AFR (thermal) m3/s**	**Pres Coefficient**	**Wind pressure pa**	**AFR Wind) m3/s**	**Wind pressure pa**	**AFR total m3/s**
Kitchen	2,4	1,500	1,25	1,091	2,02	-0,38	-1,691	-2,513	-1,415	-1,100
Living	3,75	2,625	1,25	1,091	3,53	-0,12	0,387	2,103	0,663	4,478
Door	2,1	2,100	1,05	1,171	2,93	-0,12	0,387	1,682	0,663	3,663
Door top	0,1	0,100	2,3	0,669	0,11	-0,12	0,387	0,080	0,663	0,149
MB	6,25	2,500	4,4	-0,173	-1,34	-0,12	0,387	2,003	0,663	2,254
BR1	2,4	1,500	4,4	-0,173	-0,80	-0,38	-1,691	-2,513	-1,415	-2,435
BR2	2,4	1,500	4,4	-0,173	-0,80	-0,38	-1,691	-2,513	-1,415	-2,435
BR3	5	2,500	7,7	-1,497	-3,94	-0,12	0,387	2,003	0,663	-2,941
Skylight	1,21	0,847	10	-2,419	-1,70	-0,18	-0,093	-0,332	0,183	-1,632
				Massebalan	0,00		Massebalance	0,00		0,00

TAB.43: *Natural ventialtion, combined, Type B3*

Pressure Coefficient			**Windfactor**	0,569		**Pwind**	8,0	pa	
Windward	-0,38		**Vmeteo**	6,4	m/s	**Pmin**	-1,4	pa	
Leeward	-0,12		**Vref**	3,642	m/s	**Pmax**	-3,0	pa	
roof	-0,18								
Location of neutral	1,2	m	**Buildingvol.**			m3			
Outdoor temperatu	12	C	**Volume**			m3/section/floor			
Zone temperature	22	C							
Discharge coefficie	0,7		**Internal pressur**			pa	-1,14		-1,14
Air density	1,205	kg/m3							

	Area m2	**Eff. Area** m2	**Height** m	**Thermal** pa	**AFR (thermal)** m3/s	**Pres Coefficient**	**Wind pressure** pa	**AFR Wind)** m3/s	**Wind pressure** pa	**AFR total** m3/s
Kitchen	2,4	1,500	1,25	-0,013	-0,22	-0,38	-1,894	-2,660	-1,896	-2,670
Living	3,75	2,625	1,25	-0,013	-0,39	-0,12	0,183	1,447	0,182	1,387
Living Door	2,1	2,100	1,05	0,067	0,70	-0,12	0,183	1,158	0,182	1,349
Door top	0,1	0,100	2,3	-0,435	-0,08	-0,12	0,183	0,055	0,182	-0,065
	0,000	0,000		Massebalar	0,00		Massebalance	0,00		0,00

Tab.44: *Natural ventialtion, cross ventilation ground floor, Type B3*

Pressure Coefficient				**Windfactor**	0,569		**Pwind**	8,0 pa		
Windward	0,2			**Vmeteo**	6,4 m/s		**Pmin**	0,0 pa		
Leeward	0,25			**Vref**	3,642 m/s		**Pmax**	1,6 pa		
roof	0									
Location of neut	1,4 m				**Buildingvol.**		m3			
Outdoor tempera	12 C				**Volume**		m3/section/floor			
Zone temperatur	22 C									
Discharge coeffi	0,7				**Internal pressure**		pa	1,79		1,79
Air density	1,205 kg/m3									

	Area m2	Eff. Area m2	Height m	Thermal pa	AFR (thermal) m3/s	Pres Coefficient	Wind pressure pa	AFR Wind) m3/s	Wind pressure pa	AFR total m3/s
MB	2,57	1,799	1,375	-0,002	-0,09	0,2	-0,189	-1,009	-0,190	-1,015
Kitchen	2,57	1,799	1,375	-0,002	-0,09	0,2	-0,189	-1,009	-0,190	-1,015
Dining	2,57	1,799	1,375	-0,002	-0,09	0,2	-0,189	-1,009	-0,190	-1,015
Living Do	1,89	1,323	1,05	0,129	0,61	0,2	-0,189	-0,742	-0,190	-0,423
Door Top	0,45	0,315	2,3	-0,373	-0,25	0,2	-0,189	-0,177	-0,190	-0,304
Room 1	2,57	1,799	1,375	-0,002	-0,09	0,2	-0,189	-1,009	-0,190	-1,015
Room 1	2,65	1,855	1,375	-0,002	-0,10	0,25	0,210	1,096	0,209	1,089
Room 1	1,375	0,963	1,375	-0,002	-0,05	0,25	0,210	0,568	0,209	0,565
Room 2	2,65	1,855	1,375	-0,002	-0,10	0,25	0,210	1,096	0,209	1,089
Room 2	1,375	0,963	1,375	-0,002	-0,05	0,25	0,210	0,568	0,209	0,565
MB Door	1,89	1,323	1,05	0,129	0,61	0,25	0,210	0,781	0,209	0,991
Door Top	0,45	0,315	2,3	-0,373	-0,25	0,25	0,210	0,186	0,209	-0,164
Room 3	1,59	1,113	1,375	-0,002	-0,06	0,25	0,210	0,657	0,209	0,653
				Massebalan	0,00		Massebalance	0,00		0,00

TAB.45: *Natural ventialtion, cross ventilation, Type C1*

Pressure Coefficient		**Windfactor**	0,569		**Pwind**	8,0 pa
Windwar	0,2	**Vmeteo**	6,4 m/s		**Pmin**	0,0 pa
Leeward	-0,6	**Vref**	3,642 m/s		**Pmax**	1,6 pa
roof	0					

Location of ne	1,4 m	**Buildingvol.**		m3		
Outdoor tempe	12 C	**Volume**		m3/section/floor		
Zone temperat	22 C					
Discharge coe	0,7	**Internal pressure**	pa	-4,03		-4,02
Air density	1,205 kg/m3					

	Area m2	Eff. Area m2	Height m	Thermal pa	AFR (thermal) m3/s	Pres Coefficient	Wind pressure pa	AFR Wind) m3/s	Wind pressure pa	AFR total m3/s
Living	2,57	1,799	1,375	-0,006	-0,18	-0,6	-0,765	-2,027	-0,770	-2,042
Optional	3,18	2,226	1,375	-0,006	-0,23	-0,6	-0,765	-2,508	-0,770	-2,526
MB Door	1,89	1,323	1,05	0,124	0,60	-0,6	-0,765	-1,491	-0,770	-1,369
Door Top	0,45	0,315	2,3	-0,377	-0,25	-0,6	-0,765	-0,355	-0,770	-0,435
MB	2,57	1,799	1,375	-0,006	-0,18	-0,6	-0,765	-2,027	-0,770	-2,042
Dining	1,59	1,113	1,375	-0,006	-0,11	0,2	5,627	3,401	5,622	3,398
Living Do	1,89	1,323	1,05	0,124	0,60	0,2	5,627	4,043	5,622	4,086
Door Top	0,45	0,315	2,3	-0,377	-0,25	0,2	5,627	0,963	5,622	0,929
				Massebalar	0,00		Massebalance	0,00		0,00

Tab.46: *Natural ventialtion, cross ventilation, Type C2*

ANNEX 9: MECHANICAL VENTILATION DUCTS & PLANS

Room	Area [m^2]	Air Volume [m^3/s]	Air Volume [l/s]	Air Change Rate [h^{-1}]	Diameter [mm]
Living Area	15,5	0,038	-	3,4	125
Dining Area	10,0	0,024	-	3,4	125
Kitchen	9,2	0,020	20	2,4	100
Bedroom 1	9,4	0,018	-	2,7	100
Bedroom 2	9,4	0,018	-	2,7	100
Bedroom 3	14,4	0,026	-	2,5	125
Master Bedroom	14,4	0,030	-	2,9	125
Office	14,5	0,026	-	2,5	125
Bathroom	4,1	0,015	15	2,2	80
Toilet	3,6	0,010	10	2,2	80

Tab.47: *Ventilation ducts type B*

Fig.234: *Ventilation Plans B type*

Room	Area [m^2]	Air Volume [m^3/s]	Air Volume [l/s]	Air Change Rate [h^{-1}]	Diameter [mm]
Living Area	15,0	0,036	-	3,4	125
Dining Area	9,9	0,024	-	3,4	125
Kitchen	10,2	0,020	20	2,4	100
Bedroom 1	9,7	0,019	-	2,7	100
Bedroom 2	10,4	0,020	-	2,7	100
Master Bedroom	11,7	0,026	-	3,1	125
Office	6,1	0,013	-	3,0	80
Bathroom	6,2	0,015	15	2,2	80

Tab.48: *Ventilation ducts type C1*

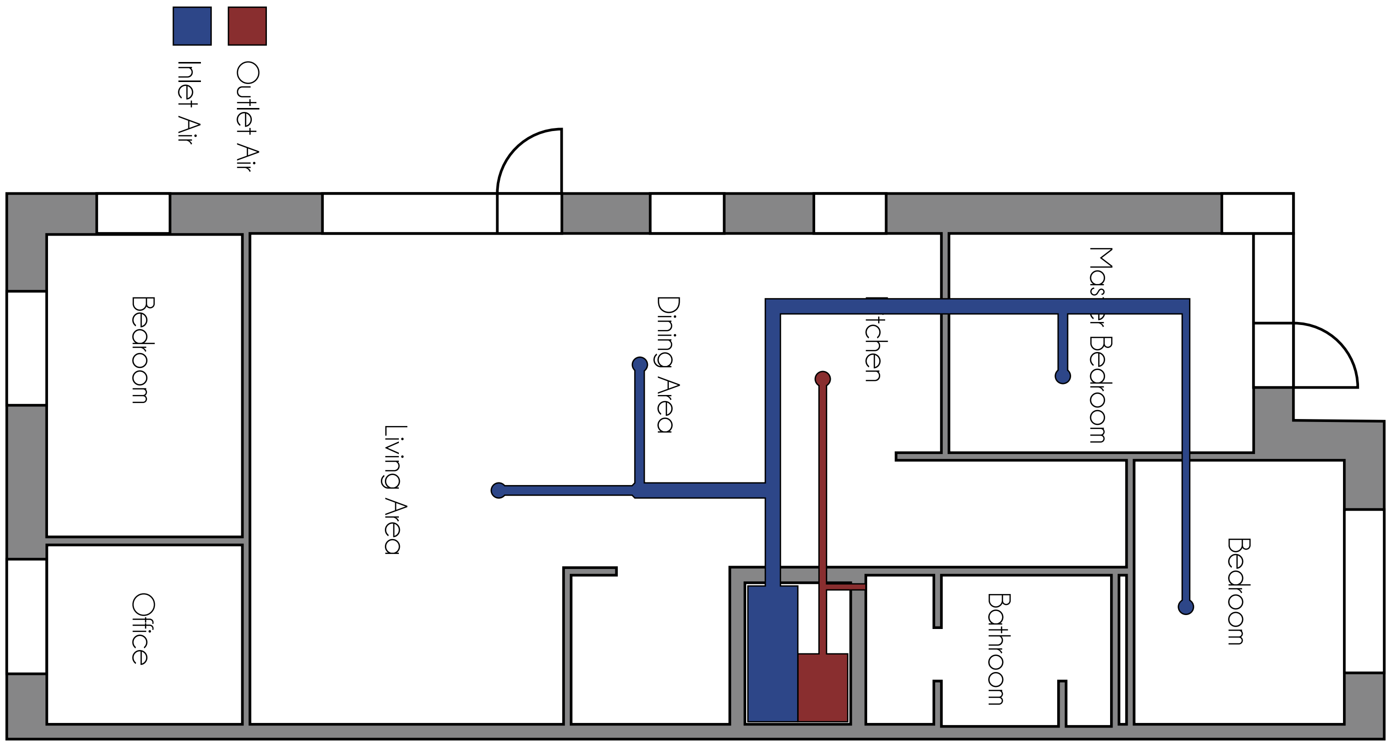


Fig.235: *Ventilation Plans C1 type*

Room	Area [m^2]	Air Volume [m^3/s]	Air Volume [l/s]	Air Change Rate [h^{-1}]	Diameter [mm]
Living Area	18,5	0,045	-	3,4	160
Dining Area	9,3	0,023	-	3,4	100
Kitchen	11,9	0,020	20	2,3	100
Bedroom	10,5	0,020	-	2,7	100
Master Bedroom	13,0	0,028	-	3,0	125
Bathroom	5,0	0,015	15	2,2	100

Tab.49: *Ventilation ducts type C2*

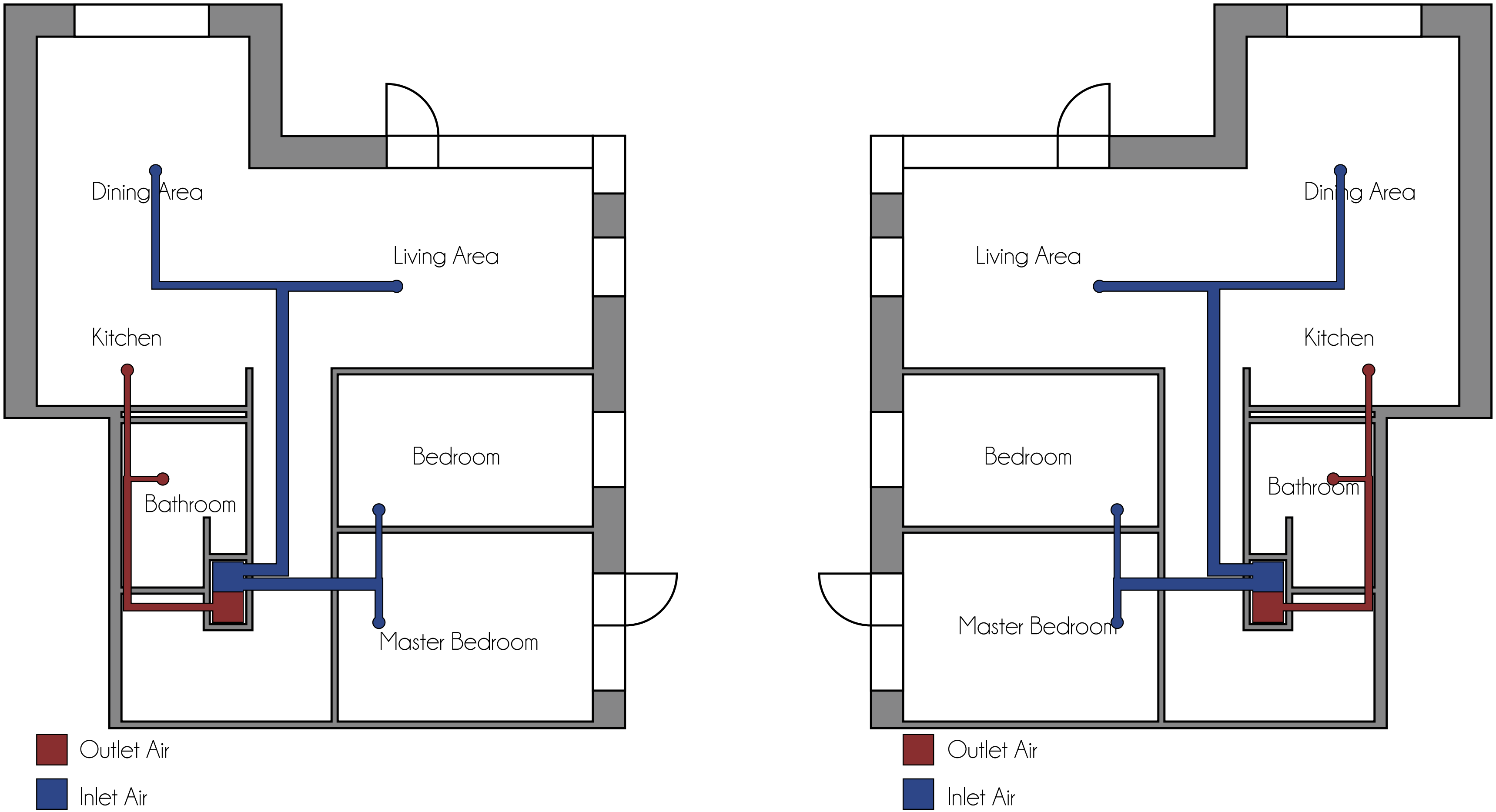


Fig.236: *Ventilation Plans C2 type*

ANNEX 10: FINNWOOD DOCUMENTATION

Finnwood 2.3 SR2 (2.4.009)
Danmark (02.07.2013)

PROJEKT INFORMATION

Beregner:	?
Firma:	?

Konstruktionsdel:

D:\...\bjælke Type-A.s01

KONSTRUKTIONSBESKRIVELSE

Konstruktionstype	Tagbjælke
Materiale:	C18
Dimension:	70x245 (B=70 mm, H=245 mm)
Anvendelsesklasse:	2
Konsekvensklasse:	CC2 (KFI=1.0)
Belastningsbredde:	610 mm (for fladelaster)

Udkragning/spæn længder:	
Udkragning/Spænd:	Horisontal [mm]:
spændvidde 1	5000.0
Total:	5000.0

UNDERSTØTNING	POS. x [mm]	Vederlag [mm]	TYPE
1:	0	95	Simpel (Z)
2:	5000	95	Simpel (X,Z)

---

fm,k (My):	18.00 N/mm2
fm,k (Mz):	20.96 N/mm2
fc,0,k:	18.00 N/mm2
fc,90,k:	2.20 N/mm2
ft,0,k:	11.00 N/mm2
fv,k (Vz):	3.40 N/mm2
fv,k (Vy):	3.40 N/mm2
E,mid:	9000 N/mm2
G,mid:	560 N/mm2
E 0.05:	6000 N/mm2
G 0.05:	375 N/mm2

Materialefaktor gamma,m: 1.35

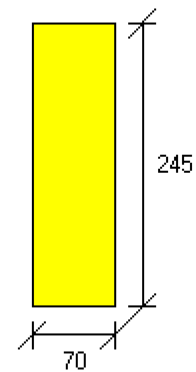


FIG.237: *Finnwood beam documentation*

LASTER

Egenlast (Egenlast, Permanent last):

Bjælkens vægt:	QZ = 0.065 kN/m	x = 0 - 5000 mm
Fladelast: 1:	QZ = 0.600 kN/m2	x = 0 - 5000 mm

Snelast (Snelast, Korttidslast):

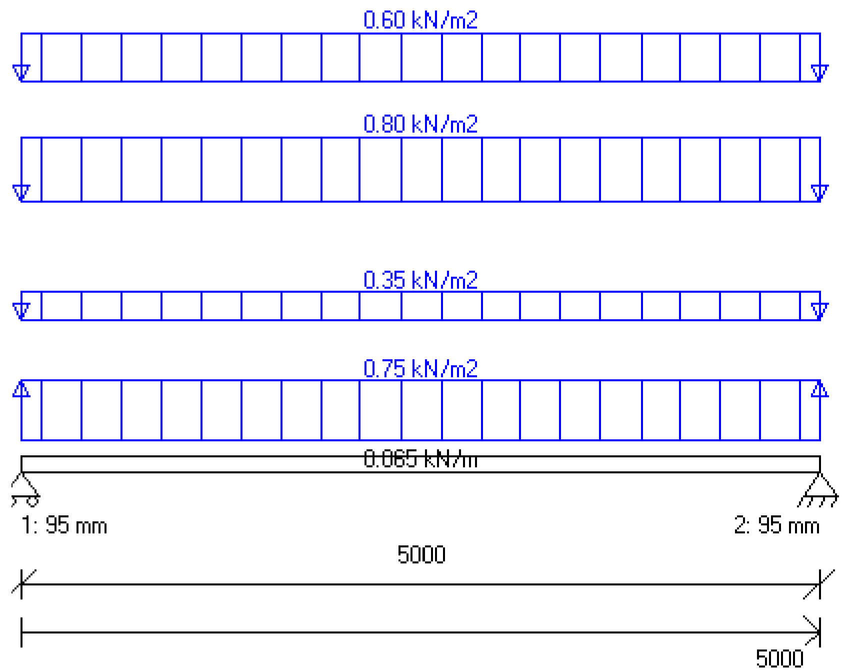
Fladelast: 1:	QZ = 0.800 kN/m2	x = 0 - 5000 mm

Vindlast (nedad) (Vindlast, Øjeblikkelig last):

Fladelast: 1:	Qz = 0.350 kN/m2	x = 0 - 5000 mm

Vindlast (opad) (Vindlast, Øjeblikkelig last):

Fladelast: 1:	Qz = -0.750 kN/m2	x = 0 - 5000 mm



LASTGRUPPE	kmod
Permanent last:	0.600
Langtidslast:	0.700
Mellemlang last:	0.800
Korttidslast:	0.900
Øjeblikkelig last:	1.100

---

kdef	0.800

FIG. 238: *Finnwood beam documentation*

Kombination 1 (ULS, Permanent last)
1.00*1.20*Egenlast

Kombination 2 (ULS, Korttidslast)
1.00*1.00*Egenlast + 1.00*1.50*Snelast

Kombination 3 (ULS, Øjeblikkelig last)
1.00*1.00*Egenlast + 1.00*1.50*Snelast + 1.00*1.50*0.30*Vindlast (nedad)

Kombination 4 (ULS, Øjeblikkelig last)
1.00*1.00*Egenlast + 1.00*1.50*Vindlast (nedad)

Kombination 5 (ULS, Øjeblikkelig last)
1.00*1.00*Egenlast + 1.00*1.50*Snelast + 1.00*1.50*0.30*Vindlast (opad)

Kombination 6 (ULS, Øjeblikkelig last)
1.00*1.00*Egenlast + 1.00*1.50*Vindlast (opad)

Kombination 7 (ULS, Øjeblikkelig last)
0.90*Egenlast + 1.00*1.50*Vindlast (opad)

Kombination 8 (ULS, Permanent last)
1.00*1.00*Egenlast

Kombination 9 (ULS, Permanent last)
0.90*Egenlast

Kombination 10 (Stivhedseftervisning, kombinationer)
1.00*Egenlast

Kombination 11 (Stivhedseftervisning, kombinationer)
1.00*Egenlast + 1.00*Snelast

Kombination 12 (Stivhedseftervisning, kombinationer)
1.00*Egenlast + 1.00*Snelast + 1.00*0.30*Vindlast (nedad)

Kombination 13 (Stivhedseftervisning, kombinationer)
1.00*Egenlast + 1.00*Vindlast (nedad)

Kombination 14 (Stivhedseftervisning, kombinationer)
1.00*Egenlast + 1.00*Snelast + 1.00*0.30*Vindlast (opad)

Kombination 15 (Stivhedseftervisning, kombinationer)
1.00*Egenlast + 1.00*Vindlast (opad)

Kombination 17 (Stivhedseftervisning, snelast)
1.00*Snelast

Kombination 18 (Stivhedseftervisning, vindlast)
1.00*Vindlast (nedad)

Kombination 19 (Stivhedseftervisning, vindlast)
1.00*Vindlast (opad)

FIG.239: *Finnwood beam documentation*

BEREGNINGSRESULTATER

Norm/Standard:	DS/EN 1995-1-1+AC:2007+A1:2008
Total udnyttelsesgrad:	67.9 %

BEREGNINGSFORUDSÆTNINGER

Deformationskriterium Wg,fin:	L/400	(SLS, kombinationer)	
Deformationskriterium Wq,inst:	L/400	(SLS, snelast)	
Deformationskriterium Wq,inst:	L/250	(SLS, vindlast)	
Faktor for venstre udkragning:			2.00
Faktor for højre udkragning:			2.00

Der er sikret for søjlestabilitet i begge retninger (y og z)

Kipning for bøjning My omkring y-aksen:

Afstand mellem tværafstivning i overside: Lk1 = 375.00 mm

Afstand mellem tværafstivning i underside: Lk2 = 300.00 mm

Lasten angriber ved konstruktionens overside (Lef1=Lk1+2xH og Lef2=Lk2)

BEMÆRK! Lk1 anvendes når My>0 og Lk2 når My<0

DIM. LASTKOMB.

Kombination 2/1 (Korttidslast):

1.00*Egenlast + 1.50*Snelast

Kombination 10/1 (SLS, kombinationer):

1.00*Egenlast

Kombination 17/1 (SLS, snelast):

DIMENSIONERENDE BEREGNINGSRESULTATER

ANALYSE	AKTUEL	KAPACITET	UDNYT.-GRAD	POS. x [mm]	
Forskydning (z):	2.57 kN	25.92 kN	9.9 %	4708 mm	Komb. 2/1, Korttidslast
Bøjning (My):	3.63 kNm	8.40 kNm	43.3 %	2500 mm	Komb. 2/1, Korttidslast
(uden kcrit):	3.63 kNm	8.40 kNm	43.3 %	2500 mm	Komb. 2/1, Korttidslast
Bæring, understøtning 1:	2.91 kN	16.04 kN	18.1 %	0 mm	Komb. 2/1, Korttidslast
lastfaktor for tryk mod sidetræ =1.64 (=kc,90*A,ef/A,understøtning)					
Bæring, understøtning 2:	2.91 kN	16.04 kN	18.1 %	5000 mm	Komb. 2/1, Korttidslast
lastfaktor for tryk mod sidetræ =1.64 (=kc,90*A,ef/A,understøtning)					
Spændvidde 1, Wg,fin:	8.5 mm	12.5 mm	67.9 %	2500 mm	Komb. 10/1 (SLS, kombinationer)
Spændvidde 1, Wq,inst:	5.3 mm	12.5 mm	42.7 %	2500 mm	Komb. 17/1 (SLS, snelast)
Spændvidde 1, Wq,inst:	-5.0 mm	20.0 mm	25.0 %	2500 mm	Komb. 19/1 (SLS, vindlast)

FIG. 240: *Finnwood beam documentation*

1.00*Snelast

Kombination 19/1 (SLS, vindlast):

1.00*Vindlast (opad)

DIMENSIONERENDE SNITKRÆFTER

Vz,max	3.15 kN	5000 mm
My,max	3.94 kNm	2500 mm

REAKTIONER

Understøtning	maks, styrke	min, styrke	maks, stivhed	min, stivhed	Vederlagstryk
1:	3.15 kN	-0.75 kN	2.46 kN	-1.14 kN	0.47 N/mm2
2:	3.15 kN	-0.75 kN	2.46 kN	-1.14 kN	0.47 N/mm2

- Negativ reaktion (sug) forekommer, vær opmærksom på forankring eller del konstruktionen
- Reaktioner fra stivhedsanalyse, kun til orientering

REAKTIONER, LASTGRUPPER:

Lastgruppe:	Egenlast
Understøtning:	FZ [kN]:
1:	1.08
2:	1.08

Lastgruppe:	Snelast
Understøtning:	FZ [kN]:
1:	1.22
2:	1.22

Lastgruppe:	Vindlast (nedad)
Understøtning:	FZ [kN]:
1:	0.53
2:	0.53

Lastgruppe:	Vindlast (opad)
Understøtning:	FZ [kN]:
1:	-1.14
2:	-1.14

FIG.241: *Finnwood beam documentation*

- Eftervisning er udført iht. EN 1995-1-1:2004, EN 1995 DK NA:2007 inkl. Tillæg 1:15-12-2008 samt A1:2008
- ULS = Brudgrænsetilstand, SLS = Anvendelsesgrænsetilstand
- Anden ordens analyse/laster er ikke taget i regning
- *) procent værdien ved kontrol af kombinerede belastninger står for forholdet mellem regningsmæssig belastning og regningsmæssig bæreevne, ikke den egentlige udnyttelsesgrad
- Bæreevnen af den underliggende konstruktion skal kontrolleres separat.
- Kontrol af udbøjning bliver ikke udført ved udkragning under 200 mm.
- Beregninger tager ikke hensyn til opadgående udbøjninger på udkragninger der er mindre end 10 mm
- Der kan være behov forankring ved mellemunderstøtning (for at undgå yderligere svingning) skal kontrolleres
- Faktor kcr er 1.0 for alle træmaterialer
- ved lastkategori E er det nødvendigt at definere faktorerne psii0, psii1 og psii2 separat for sne og vindlast (med fri konstruktion)
- Det antages at gamma3 er 1.0 for alle materialer og alle konstruktioner
- Forskydning blev medtaget i stivhedsanalyse
- Forskydning blev ikke medtaget i beregning af snitkræfter
- Reduktion af forskydningskræfter er taget i anvendelse tæt på understøtninger, og laster antages at angribe på modsat side af konstruktionen i forhold til understøtningsområdet.
- Forskydningskraft reduktion sker på forskydningskraft kurven på lastkombinationer, i afstanden H fra kanten af understøtningen.
- Tværsnitsstørrelsens indflydelse på elementets styrke bliver indregnet via faktoren kh, der er inkluderet i den karakteristiske styrke
- Kerto, limtræ eller konstruktionstræ bør ikke bruges i anvendelsesklasse 3 uden yderligere træ beskyttelse
- Den projekterende skal være opmærksom på detaljerne i konstruktionen, og sikre sig at der ikke kan opstå vandlommer.
- Der er taget hensyn styrkens afhængighed af konstruktionsdelens størrelse ved faktoren kh og er inkluderet i de karakteristiske styrkeværdier

FIG.242: *Finnwood beam documentation*

ANNEX 11: CONSTRUCTION PLANS

Fig.243: *Construction plans Type B1*

Fig.244: *Construction plans Type B2*

ANNEX 12: ROOF INSULATION PLANS

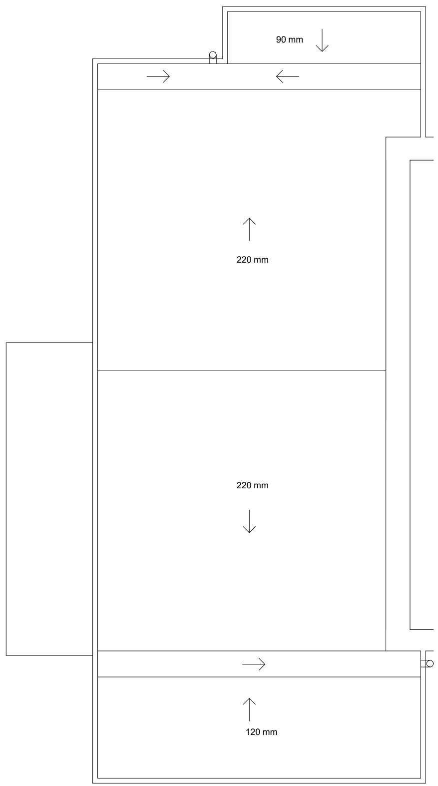
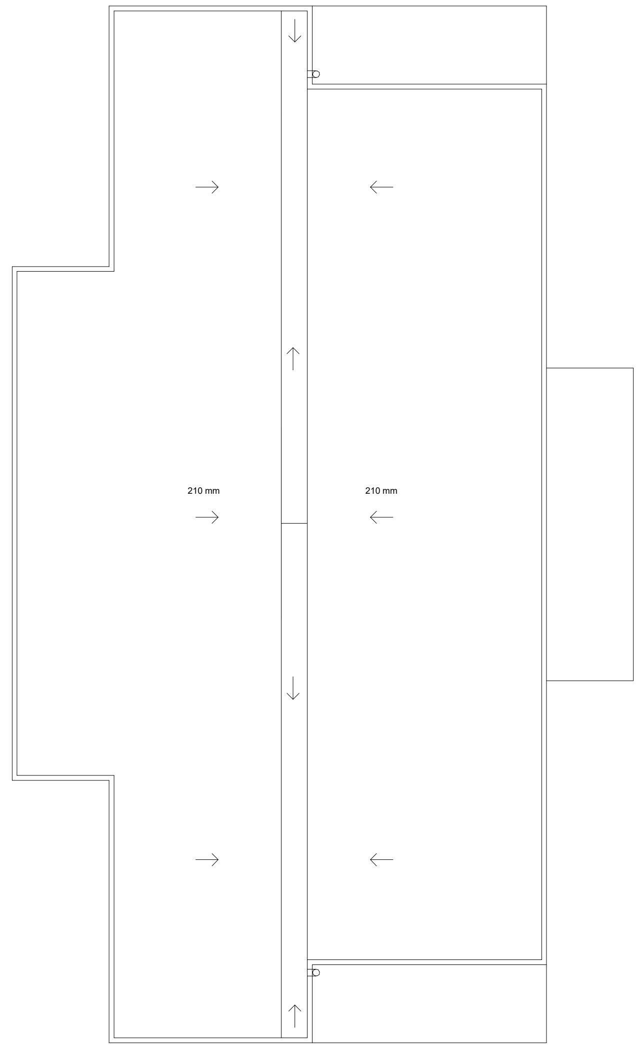


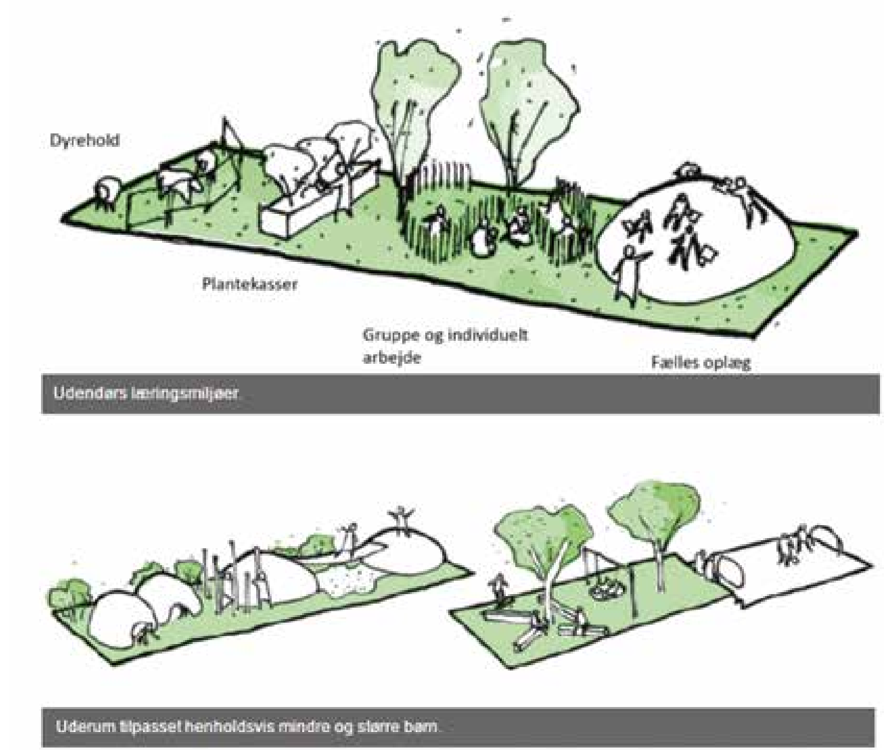
Fig.245: *Insulation angling on roof construction of Type C*



ANNEX 13: COURTYARD INSPIRATION

COURTYARD INSPIRATION

There are many ways to design recreational fascilities, for example, you can raise / lower the terrain, creating a soft, hilly landscape that invites both the urge to stay and the movement. A variation between the green surface and asphalt allows for both ball games and other types of games. Younger children need manageable units that are both comfortable and accommodating that they can play hide or seek. Older children and adults can better relate to larger, unprogrammed areas, but thrives best in outdoor environment, if there are places to hang out, benches, and the like. to contribute to the outdoor space ownership need not only be for play. Action-related activities can also take place during breaks such as vegetable gardens.



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Add to My References

Fig.246: *diagrams showing inspiration to courtyards. [Modelprogram.dk,2016]*

ANNEX 14: FACADES

Fig.247: *Facade iteration part 2*