HIGH RISE...

RETHINKING MIX USE HIGH RISE ARCHITECTURE

MA4-ARK7 NIELS THUESEN JULY 2010

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Technical Supervisor: Poul Henning Kirkegaard

Architectural Supervisor: Adrian Carter

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Niels Thuesen

Synopsis | The paper deals with the problematic of designing mix use high rise architecture in a Danish context.

Functionally and high architecture quality are incorporated to achieve contemporary design solution. A solution that takes the advantages of building high and having a mix use of function. The design thereby creates a new type of high rise.

The final design is more that impressing icon of glass and steel. The design contains multiple layers many of which only become visible in a deeper analysis of the composition of the building.

TABLE OF CONTENT

INTRODUCTION

A short introduction to the motivation and the ma main themes of the paper

MOTIVATION

The motivation for writing this paper is to push the boundaries of architecture in Denmark and look upon the possibility to design a tall building in a danish context. The scope of the paper is framed by a competition written by the municipality of Rødovre, a suburb of Copenhagen.

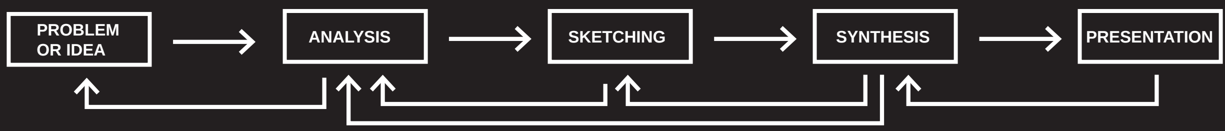
Building high is not common in the danish society and is therefore often look upon with skepticism, but tall buildings has a long history in other big dense cities. The design of the building therefore have to challenges the Nordic building traditions but still be an integrated part of the city fabric.

A decisive factor is challenges the performance of the building concerning daylight condition and energy consumption. To design a sustainable building with low energy use and thereby not only create high quality architecture but also performative design in terms of energy use.

It is desirable that the design will reflect the process and the performance of the building begin a result of different investigation and tools, which speak the language of both the architect and the engineer. The main focus of the paper is therefore not to create a dramatic high icon but to create spaces for real people for real living.

Ill 01.

THE INTEGRATED DESIGN PROC



Ill 02. The stages in the integrated design process from problem or idea to presentation. [Hansen, Knudstrup; 2005]

The design of the building in this paper will be based on the integrated design process. The integrated design process is a hybrid approach of interaction between architect and engineers. An approach that otherwise can be problematic because of difference in the language and design criteria. The integrated design process ensures interaction between the skills of the architect and the engineer thought-out the design process and can make the design take skill from all the involved actors into consideration.

The integrated design process is an iterative process, which means that work flow between the phases not necessarily is linear. This means that the process can take multiple iterations, and each different phase can be repeated several times for optimizing the design, before the process is completed. The phases of the integrated design process are showed in ill. 2.

The process is based on a problem or an idea, which is addressed in the first phase of the process. The next analysis phase is concentrating on analyzing the context and the site and its conditions. The investigations in the analysis phase give the designers an understanding of the passive design parameter that can be incorporated into the design.

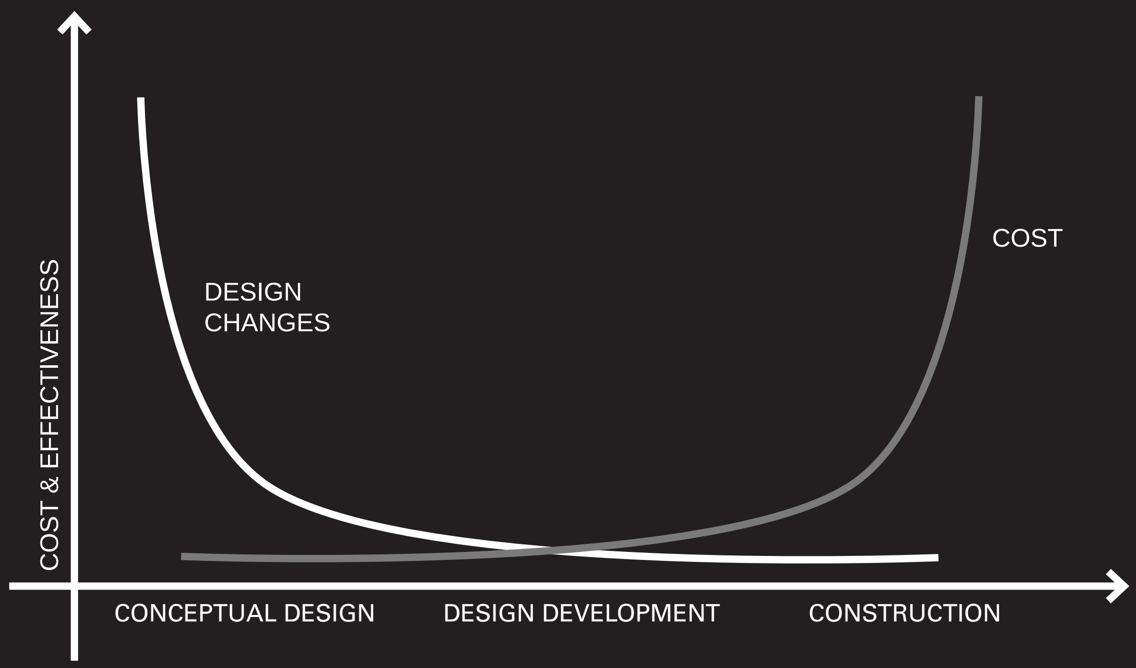
In the sketching phase the designers evaluate the design proposal regarding issue as, the program, the construction, and the buildings energy consumption. This phase is therefore very important and include skills both the architects and the engineers.

The next phase is the synthesis phase, which starts when the overall design is determinate and is concentrating on optimizing and detailing. The overall design is therefore decided when this phase starts. The last phase is the presentation phase, which deals with presenting the final design proposal. [Knudstrup; 2006]

Building high rise challenges both the architects and the engineers. These challenges are confronted in the integrated design process that has an involvement by the engineer at the early concept stage. The process thereby becomes multi-disciplinary though out the whole process. The structural as well as the aesthetic parameters become important and are evaluated from the beginning of the design process. The multi-disciplinary process is important when building tall buildings because of the fact that the expression of the building is greatly affected by the structural system and vice versa.

The integrated design process is therefore a hybrid practitioner- or architect-engineer ap-

CESS



ill. 03. The graph show how that building cost and design alterations are connected regrading the phases of the design [kilde]

proach, where an architect-engineer or hybrid practitioner works simultaneously with both aesthetic and technical design requirements. The performance and aesthetics of the building are thereby ensured integrated from the early stages of the design process. [Klitgaard, Kirkegaard]

The integrated design process implements parameters regarding the architect and the engineer early in the design process. This insure that all of the aspects of architecture are part of the early phases of the design minimized the cost. Ill 03 shows the benefits of the integrating solutions in the early stages of the sketching and thereby make the overall changes of the design in the early phases instead of late in the design process.

DENSITY

High density has negative and positive effects on the city and the urban fabric and high dense building often have larges energy consumption for heating and cooling. Building high is therefore not necessary an environmental sustainable solution, but having high density in cities can have positive effect on the energy and the quality of spaces.

Copenhagen is mostly consisting of 3-5 stories building because of historical reasons and is one of the European capitals, where the inhabitants drivers most kilometer, which is a result of a relative low dense city fabric. The higher need for transportation triggers also a higher energy use per inhabitant, which makes the structures of the city less sustainable.

If you compare Copenhagen with the city of Wien that in many ways looks a lot like Copenhagen, the copenhageners could save both time and energy on transportation by having a higher density. [www.berlingske.dk] In high-income countries, residents of denser settlements are likely to have lower CO_2 emissions per capita than residents of surrounding areas as a result of smaller housing units and greater use of public transportation systems.

Ill. 04. The enviromental and social sustaniable negative and positive effect by increasing the density of the city. The illustration shows that higher density can have positive effect in both areas but also have some social negative consequences. When designing high density this nagative elements have to be taken into consideration. [36]

S OF DENSITY

- BETTER ACCESS TO FACILITIES
- BETTER PUBLIC TRANPORTATION
- BETTER WORK ACCESSIBILITY
- SMALLER HOUSING UNITS
- GREATER WARKING/CYCLING OPPOTUNITIES
- LOWER LEVELS OF SOCIAL SEGREGATION (ALSO MIX USER)

S OF DENSITY

- POORER ACCESS TO GREEN SPACE
- LESS AFFORABLE HOUSES
- REDUCED DOMETRIS LIVING SPACE
- POORER HEALTH (GENERAL, MENTAL AND RESPIRATORY)

High density strategies without assessing the factors of distribution job opportunities and the public transportation systems are not likely to provide lasting environmental or social sustainability. The benefits of higher density are only arising with the awareness of urban form and process, well-planned, effectively-managed, and densely-settled cities. These cities can help to limit greenhouse gas emissions and be more social sustainable. [Dodman; 2009]

Ill 04. shows some of the positive and negative elements that are the output of a high dense city fabric. The elements are split up into social and environmental sustainability. The negative elements of the higher density are mainly concerning the social sustainability, which therefore also needs to be taken into consideration when designing high rises and therefore important elements in the designing of the building and the areas around it.

SUSTAINABILITY

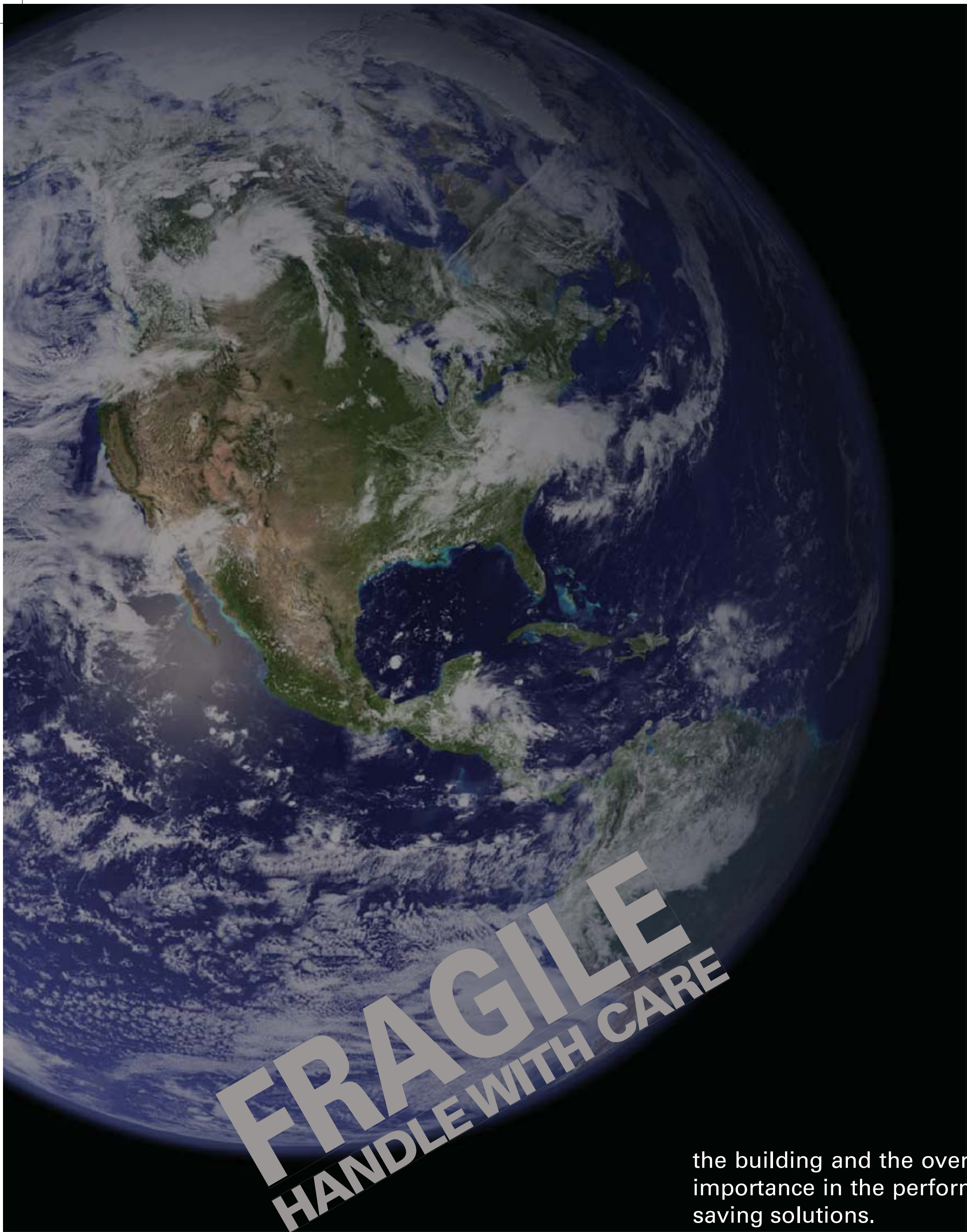
The build environment stands for up to 40% for all CO2 emissions in EU. The energy performance of new building therefore plays an important role in the plans of reducing the CO2 emission. The building regulation in Denmark requires that new buildings in 2020 reduce the energy consumption with minimum 75% compared to the energy use of buildings to day [1 gammel rapport]. Therefore low energy use has to be integrated in the building design in contemporary building if the reduction of CO2 emission is going to be a reality.

The modernistic glass and steel high rises known from all over the world can be massive consumers of energy. There is therefore a need of rethinking the design of tall building so that the design takes energy efficiency into consideration during the process and thereby relating energy performance and design.

"The design of energy-efficient enclosures has the potential to transform architecture design from begin an uncertain, seemingly whimsical craft, into a confident science." [Fasoulaki; 2008]

For high performance buildings, the full integration of architecture and engineering is crucial. The complexity of the design process and the multi-disciplinary approach requires the designer to understand the consequences the design alteration have on the energy performance of the building. The integrated design process therefore is evident to use in design of high rise with the aim of low energy use. [Ali, Armstrong; 2008]

An important factor in building sustainable is the incorporation of sustainable solutions early in the desig process, because the layout of



the building and the overall design has great importance in the performance of the energy saving solutions.

The process of designing and the tools used to optimize the design of the building has therefore great influence on the final result and the performance of the building. Low ratio façade to volume can reduce the energy use for heating and cooling.

The design of energy-efficient enclosures has the potential to transform architectural design into more than a matter of aesthetics. The design becomes a result of the interaction between the architecture and the engineering. Investigations that can underlay this unity between the different fields of architecture and engineering are therefore important for the evolvement of the design of this paper.

AN

The analysis phase of the paper. In this section be analyzed and evaluated, together with the fu ing tall buildings in Denmark

NALYSIS

on the characteristic of the site will
fundamental problematics of build-

GOING HIGH

Building tall buildings is not a strong tradition in Denmark because of historical reasons. The central Copenhagen consist of a city fabric that are between 3 and 5 stories high with church spires as the dominating silhouette of the skyline.

The highest building in central Copenhagen is Christiansborg. The building stand as a symbol of the power of the democratic (106,5 m), and the tower of Copenhagen city hall is only 1 meter lower. To strengthen this symbolism it has therefore not been allowed to build tall buildings that exceed this height. These historical factors have been important in the discussion of placing high rises in Copenhagen, which has been going on for many years.

Tall buildings has therefore only been allowed to be build in the outskirts of Copenhagen away for the old center, but because of the great visibility building tall is still a sensible topic. [Teknik- og Miljøforvaltningen; 2007] Some of the tall buildings place in Copenhagen can be seen in ill. 06.

Building tall in the outskirts can produce positive results for the city, but has to be handled carefully in order not to dominate the city in a negative way. Tall buildings can be a generator in developing new areas and a focus point that symbolizes modernity that can reflect the new spirit of architecture and urban planning and improve the identity for the urban area.

The coherence between the existing city fabric and the new high rise is also important hence the building even though its scale do not become alienated and a negative element. The existing profile of Copenhagen is therefore looked upon. It is important for the designers to be aware about these factors when designing high rises and designing the building. The placements of functions in the building are also important in concern of experience of the city. Placing public functions in the lower floors to counteract the interpretation of the building as begin closed and private. [Teknik- og Miljøforvaltningen; 2007]

Thinking the city and the design of the tall building as a whole is therefore essential to focus on so that an unique and modern skyline is created; a design that are underlying the character of the city and the area and the exiting city profile.

ill 05. Skyline of Copenhagen. The skyline is mark by few tall buildings and with many church spires

ill 06. Tall buildings in Copenhagen. 1: Ferring 2: Cobbertower 3: Copengahen Tower 4: Balla Hotel 5: H.C. Ørstedspower station 6: Charlsberg old silo

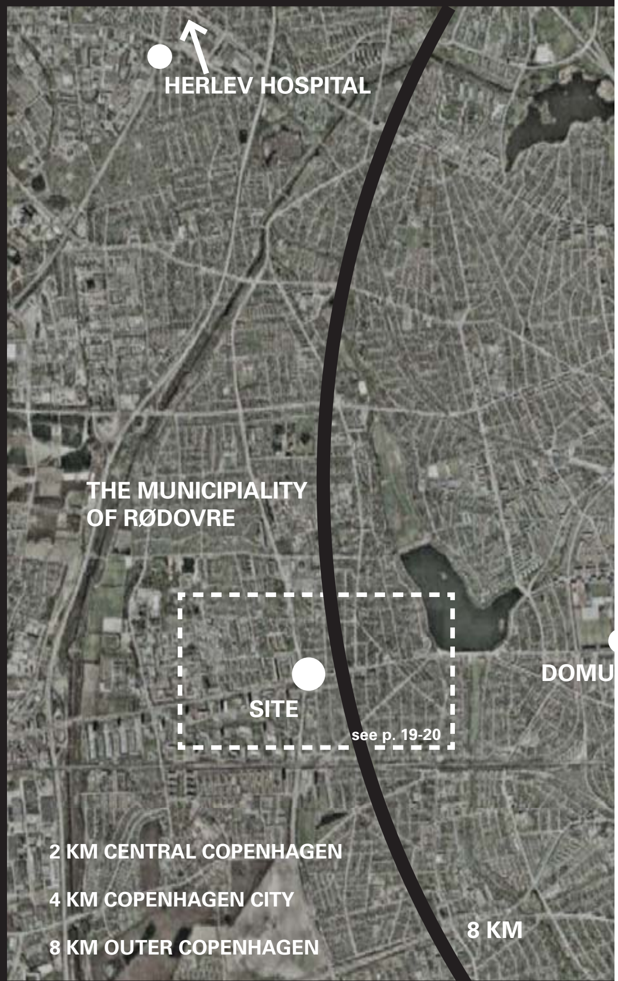
GOING HIGH

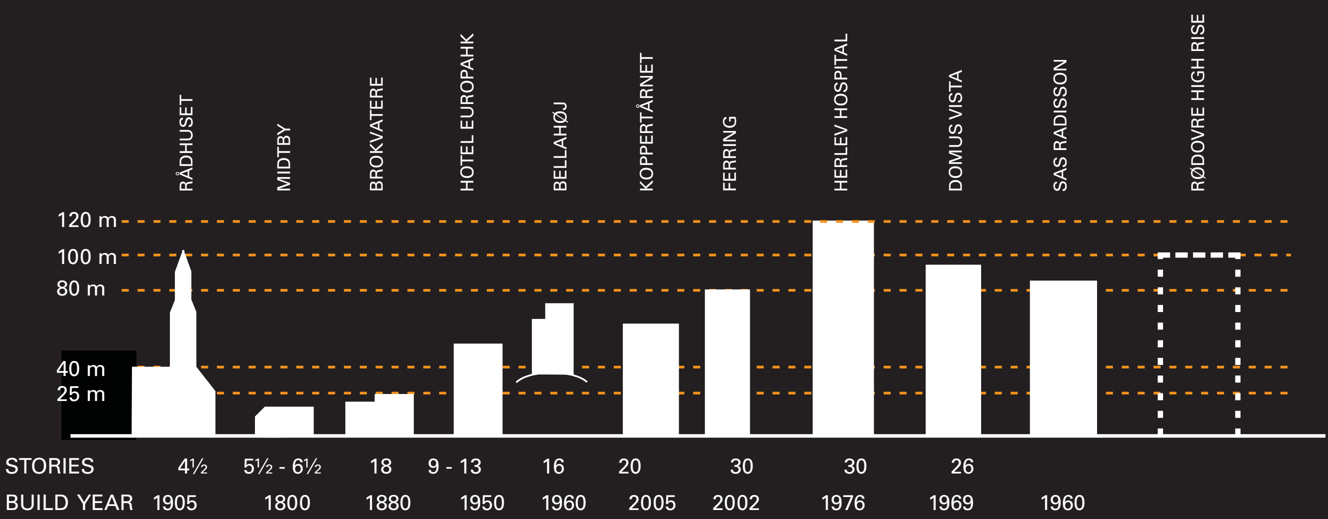
The inherent monumentality of tall building as a result from their scale makes their architectural expression very significant in any urban context. In spite of this, high rise can still become a positive element in the urban composition and thereby relate to its surroundings and not be an alien element. Site and environment therefore plays an important role in the development of high rise in any given site. [Fasoulaki; 2008]

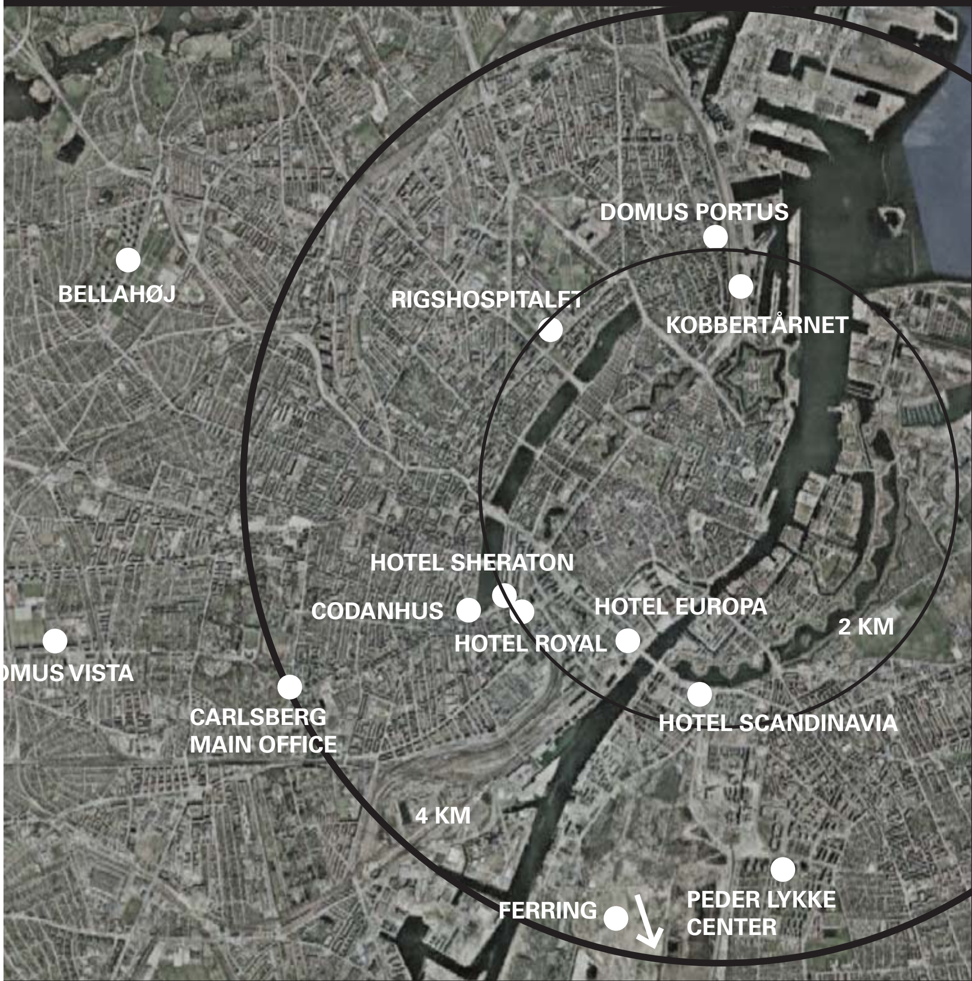
An indication of the significant high-rises in the region can be seen in ill. 07 and an outline of some of the significant buildings in Copenhagen can be seen in ill. 08. The two illustrations indicated the impact placing a tall building in Rødovre will have on the skyline of Copenhagen.

A tall building erected at the site will mark in the hub in Rødovre. The building will therefore no matter what become a landmark in Rødovre but also be a tall building in a row of others such as the Domus Vista. Domus Vista that, when erected in 1977-79, was the tallest residential building in Europe. These high-rise buildings set a rhythm that the new building should fit into wail at the same time emphasize and enhance it.

The building can therefore be a generator for a new and positive development as well as a lightower for the areas potentials.







Ill 07. The exiting tall buildings in Copenhagen mapped to indicate their placement and concentrating. In the inner city there are no high rises because of the historical reasons mentioned. The majority of the tall buildings in Copenhagen are therefore concentrated in between Copenhagen City (4 km from center) and outer Copenhagen (8 km from center).

The site of this project is placed in Rødovre just outside the outer Copenhagen. The site is located in a continuer's string of tall building that is located among the same road towards the central city. The distance from the site to the old central city ensures that the building will not be dominating the skyline of the old city.

The building is going to be marking the new development of Rødovre municipality and be a part of a skyline that the municipality wants to develop. This means that the building will be a marker of the area, which will give the building a special status. It is therefore important to be aware of the signal the design of the building is sending and how the building is interpreted both from distance and nearby.

III. 08. The illustration shows a skyline investigation of dominating building in Copenhagen. The tallest building is Herlev Hospital that reaches a high of 120m. The tallest buildings in Denmark are in general hospitals and hotels build in the 70ties. The illustration also shows that all of the buildings (except Herlev hospital that are placed outside outer Copenhagen) are lower than the city hall to respect the tradition.

The majority of the tall building are build in the late 60 – early 70 which illustrates the resistance of building high in present times. The project in Rødovre (max 25 floors) will therefore be one of the tallest mixed use buildings in Copenhagen.

THE SITE

The site is analyzed in regards to the location in Rødovre. Themes that can have an impact on the design of the building is investigated to ensure that condition of the site are taken into consideration the in sketching phase of the design process.

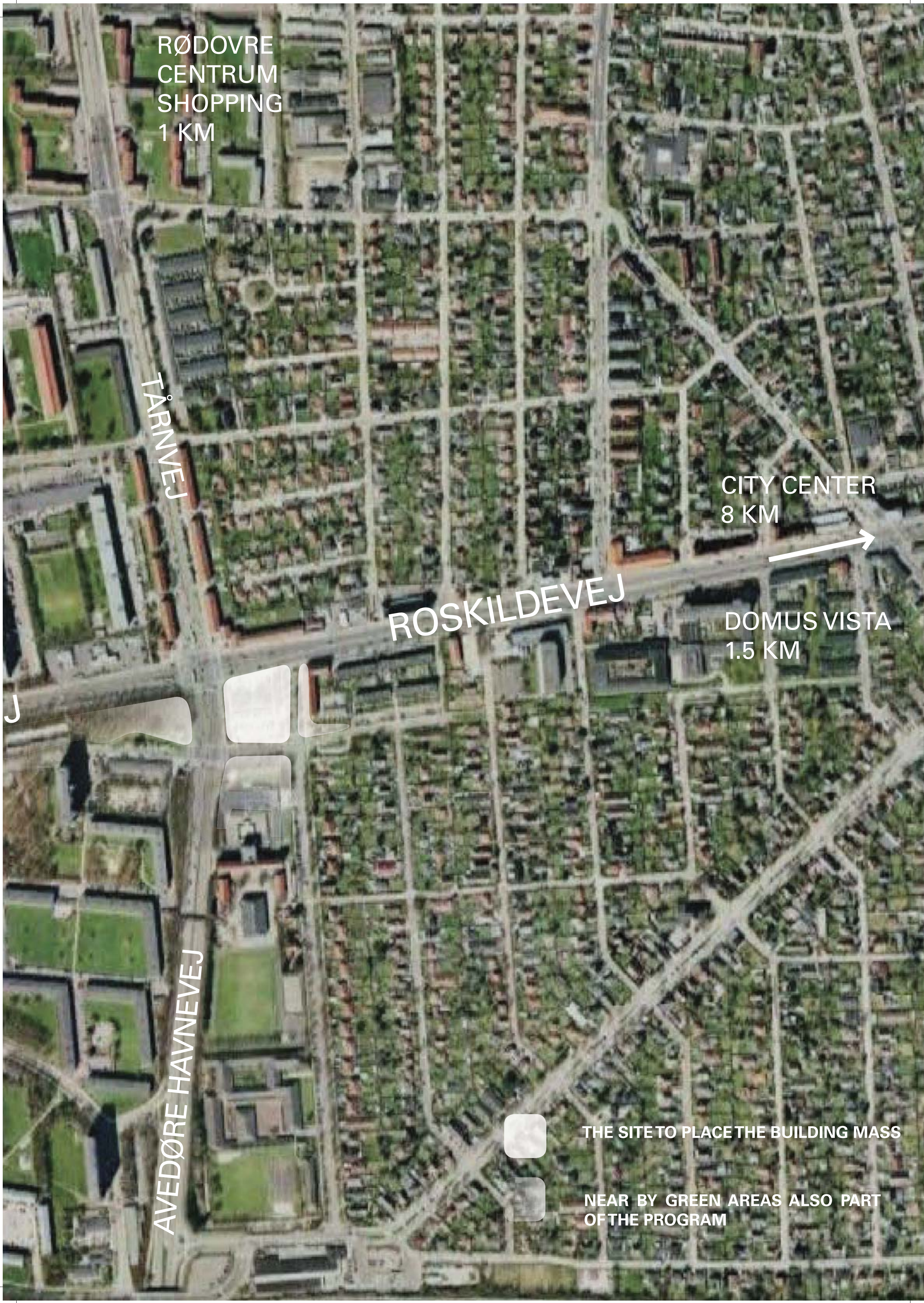
Tall buildings can have a great impact on the balance of an urban environment in which it is placed, and therefore many factors have to be taken into consideration to maintain the quality of the city. These factors are responsiveness to the quality of the surroundings and the urban and environmental impact as well as the building's functional program. The building therefore has to create an image that has positive values not only to the owners but also to the people using the city. The building also has to fit the site with proper approaches and an inviting environment.

Tall buildings have to respond to the users of the building and the larger urban environment because of its size and visual impact. The building therefore has to be gauged relative to its purpose and its function as an element in the immediate urban setting. The degree to which tall building add to or detract from the quality of their urban surroundings is dramatic affecting not only the immediate users but also the context of the urban fabric in which it is placed. [Competition brief]

It is therefore crucial that the design fit elegantly into the urban landscape both aesthetically and functionally and thereby insuring good architectural quality.

In the next pages the context of the site is analyzed. The analysis will be the background for the design of the building that have to take the context into consideration.

Ill 09. The ste and the near context. The site is located at the junction of thre main road being, Roskildevej, Tårnvej and Avedøre Havnevej. The program also have some of the green areas near the site as a part of the program that thereby can be a part of the master plan


RØDOVRE
CENTRUM
SHOPPING
1 KM
TÅRNVEJ
CITY CENTER
8 KM
ROSKILDEVEJ
DOMUS VISTA
1.5 KM
J
AVEDØRE HAVNEVEJ
THE SITE TO PLACE THE BUILDING MASS
NEAR BY GREEN AREAS ALSO PART OF THE PROGRAM


SITE
ROSKILDEVEJ

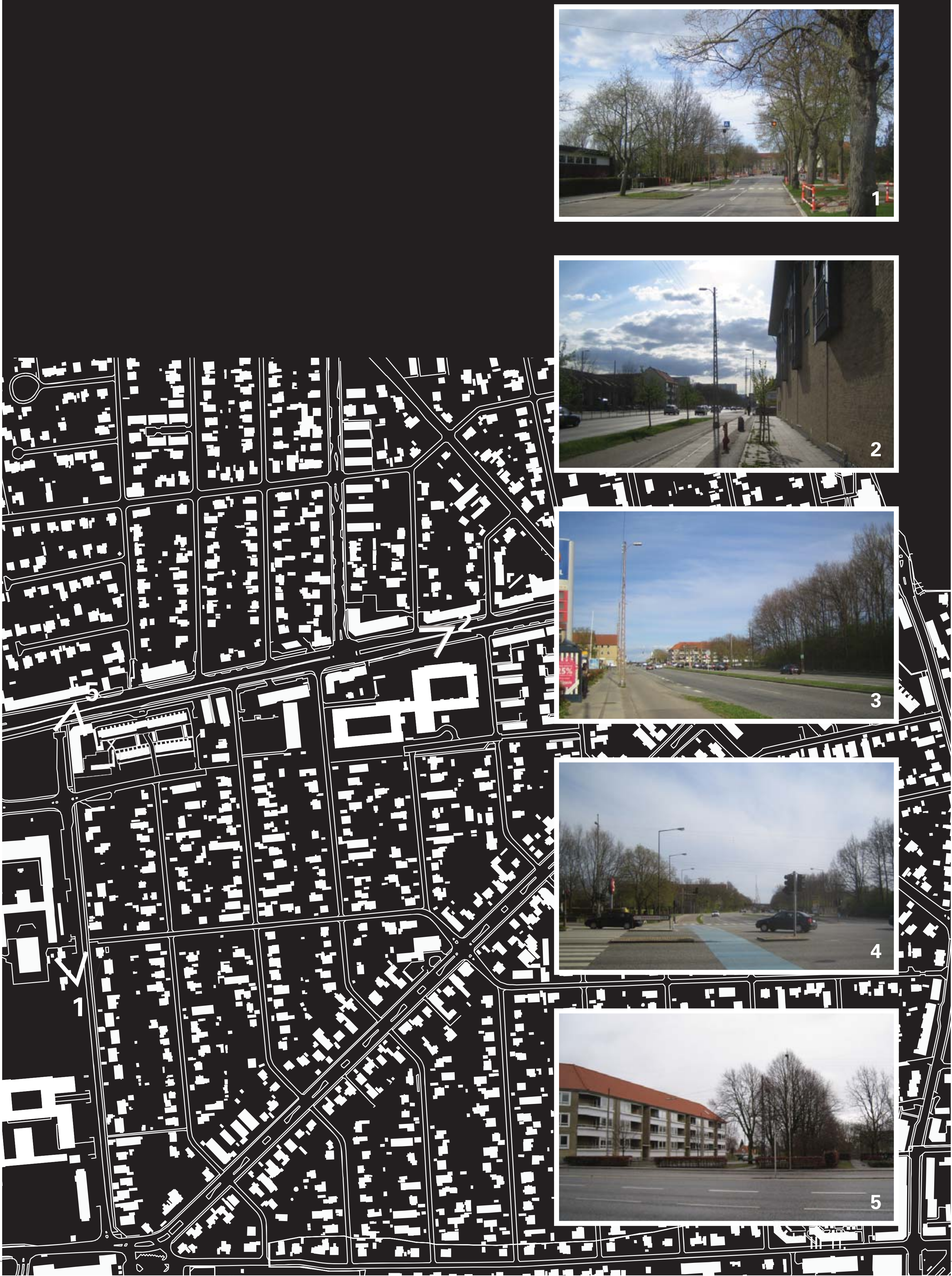
Ill 10.

THE SITE AND THE PERIMETER

The illustration on this page shows pictures from the site to illustrate the atmosphere of the city around the site.

Many of the buildings are concrete block building or traditional brick houses and the site and the nearby building are mark by the fact of begin a suburb to Copenhagen. The main roads are dominating the townscape that lack changes that can bring more life into the public space.

The design of the building therefore has to be a generator of life both in the building and in the areas around the site. The building has to provide useful urban space that can bring quality into the city.


1
2
3
4
5

MAPPING

The site and the surroundings are registered and analyzed to give an overview of the site and how it is related to green areas, zones, infrastructure and edges. These terms are evaluated to be the main elements that can and should be an integrated part of the design process so that the design ensures a god urban environment. The site itself is a parking lot with a small area of trees with it not considered to have any valued of the site.

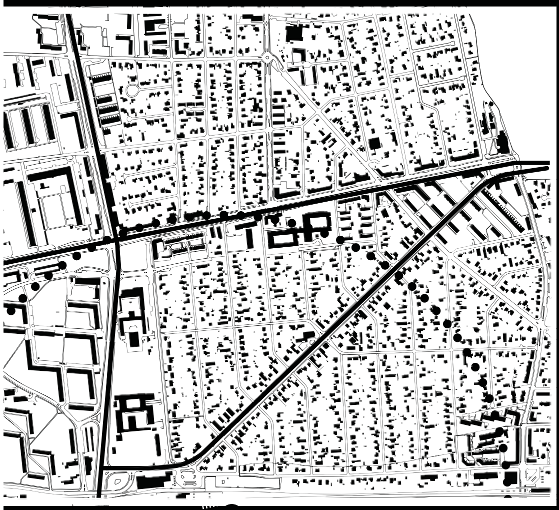
The investigated infrastructure, green areas and city fabric can be seen in ill 11 – 13. The investigation shows the main theme for the site; begin the urban fabric, the traffic and the green leisure areas around the site. The site is located in an area of one to two stories residential housing with higher buildings facing the main road. Two main roads are forming two edges of the site, which also have some connection to nearby green spaces. The site is well connected to public transportation and has high visibility because of the location at the corner at a junction between the main roads.

In dense cities it is important to preserve and emphasize the green areas because they improve the quality of the urban city therefore green spaces are therefore important factors of the design.

TRAFFIC ENVIROMENT

URBAN TRABRIC

GREEN AREAS



Ill. 11. The project site is surrounded by two main roads and one smaller road. Roskildevej's function as a traffic corridor, which implies heavy traffic loads, and therefore has a great impact on the site. Noise from the roads can act as a negative barrier to both indoor and outdoor spaces on the site. Regarding the air pollution the roads also have to be taken into consideration when thinking ventilation both natural and mechanical. Roskildevej mainly serves as a traffic corridor and has no real street environment for predestines. The site is serviced by efficient public transportation and is located within a 500m radius of Rødovre Train Station.

Ill. 12. The site is mainly surrounded by buildings that are between 4-6 stories high. The buildings near the main road are the tallest in the area with smaller residential area located behind. To the south west of the site there are tall building blocks with spread green areas in between. The blocks are between 10 and 15 stories high. West of the site bigger building volumes are placed with a height of 3 – 5 stories.

HIGHER BLOCK BUILDINGS

LOW BUILDINGS

RESIDENTIAL BUILDINGS

Ill. 13 A green recreational area is located west of the site, but the area need programming to become an attractive recreational area and is separated from the site by Avedøre Havnevej. A smaller green area is located to the north of the site. This area is more connected to the site because the separating road is smaller. Diffuse green areas are also located around the block housing south west of the site.

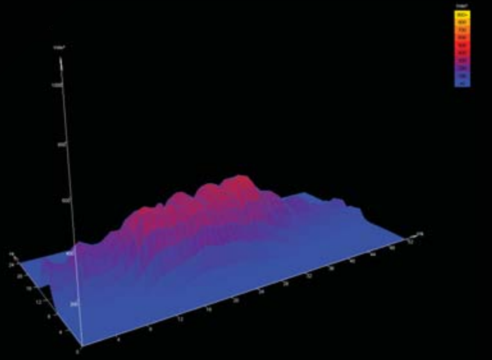
MICROCLIMATE

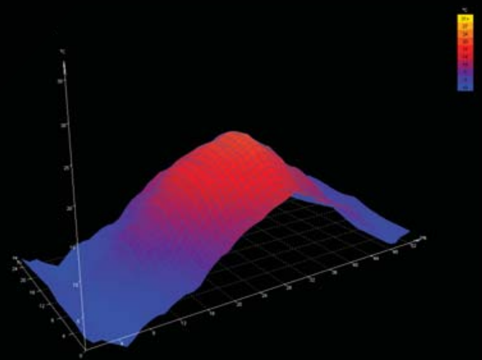
The microclimate is important in giving quality to the architecture when optimizing the performance of the building concerning energy use. The thermal condition is therefore investigated and visualized. The investigation indicated some of the parameters the designer need to be aware of when designing an energy efficient tall building.

The psychometric chart in ill. 15 shows the temperature in Copenhagen. The temperature is below the comfort zone main part of the year and is only in a small time span in or above the comfort zone. The main energy for thermal comfort will therefore be on heating, but cooling can also be an issue in periods in the summer.

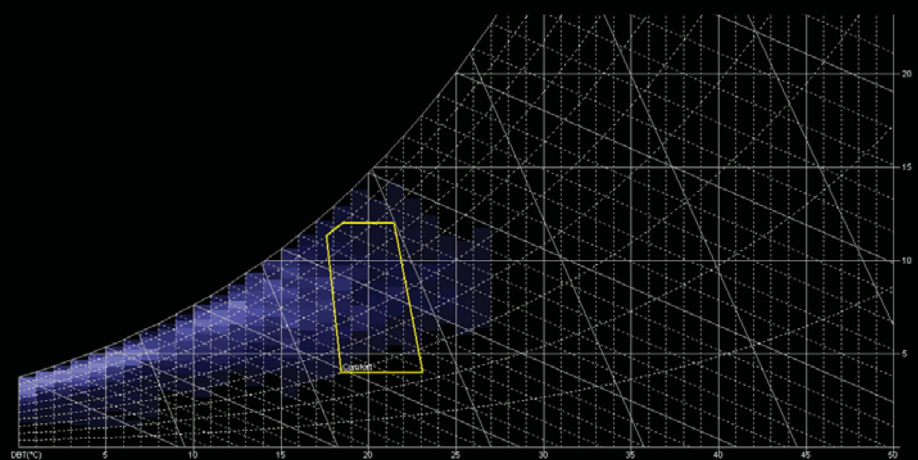
The solar radiation diagram in ill 16 indicates the solar radiation and the angle of the sun. The angle and intensity of the sun is important when direct and indirect sunlight is wanted or have to be avoided.

THERMAL CONDITIONS



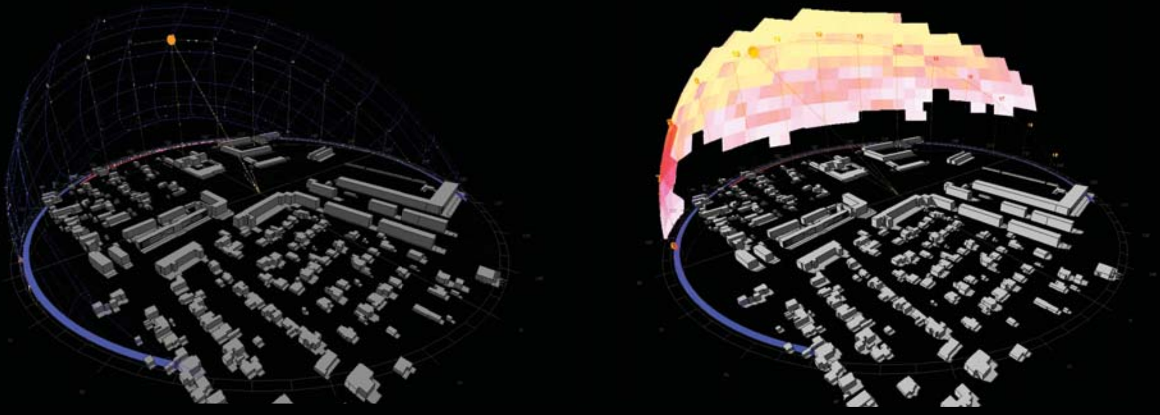


Ill. 14. Diagrams showing the temperatures and the intensity of the sun according to time and date of the year.



Ill. 15. The psychometric chart shows how the temperatures in Copenhagen are distributed according to the comfort zone that is marked with a yellow line. The blue areas shows that the temperature most of the year are lower that the comfort zone.

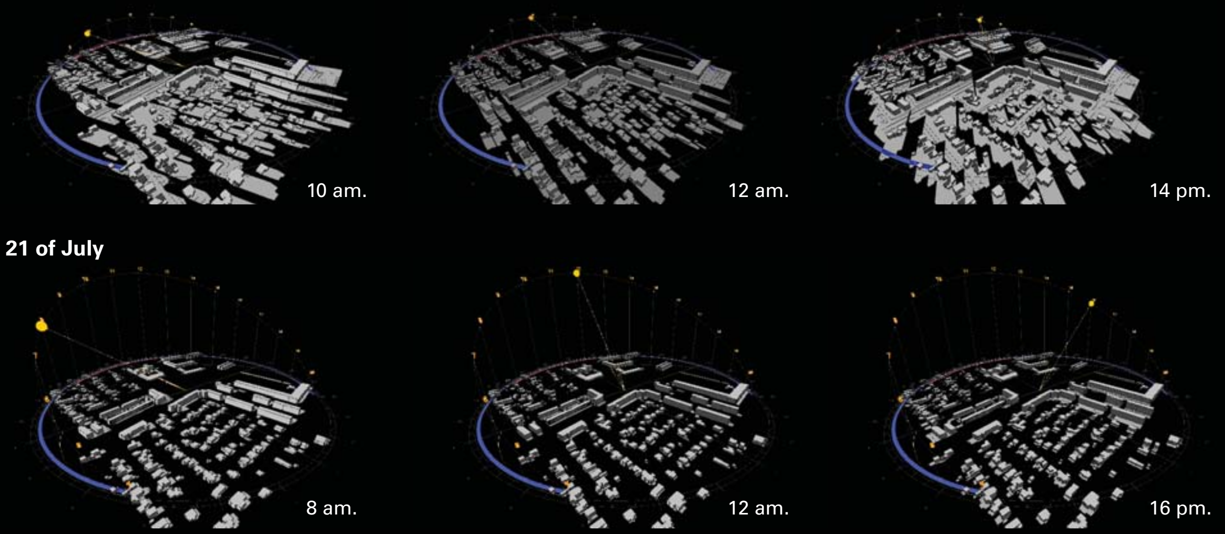
DAYLIGHT CONDITIONS



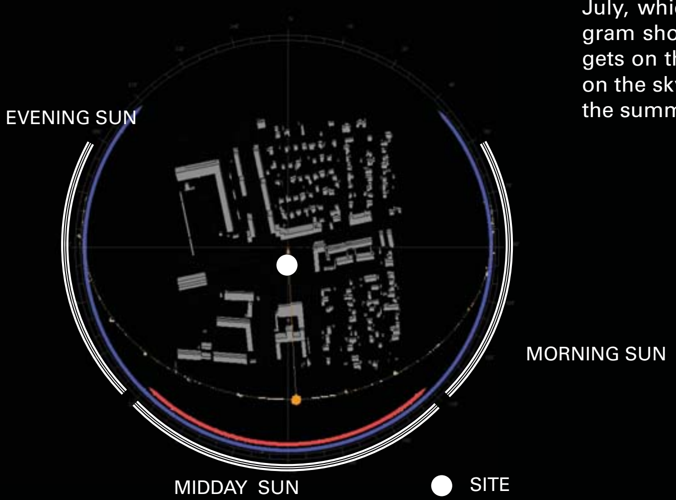
Ill 16. The path of the sun for a whole year is illustrated in the diagram to the left. This illustrates the angle of the sun at the site in Copenhagen. The intensity of the sun are illustrated together with the path on the sky in the diagram to the right.

21 of December

21 of July



Ill 17. The path of the sun and shadows on the 21 of December and July, which are the longest and shortest days of the year. The diagram shows the position of the sun and how high and low the sun gets on the sky. The diagram also shows that the sun only is visible on the sky for a short period of time in the winter and a long time in the summer.



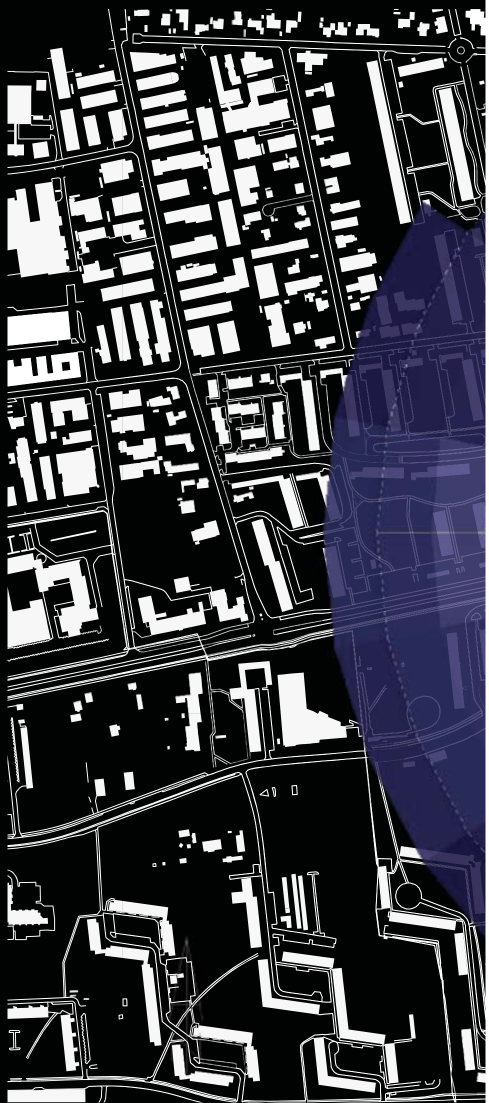
Ill 18. The position of the evening-, morning- and midday-sun. The position can be important when wanting to ensure good daylight condition in the apartments and in the offices. The blue and red lines illustrate the radius of the position of the sun in the shortest and longest day of the year.

MICROCLIMATE

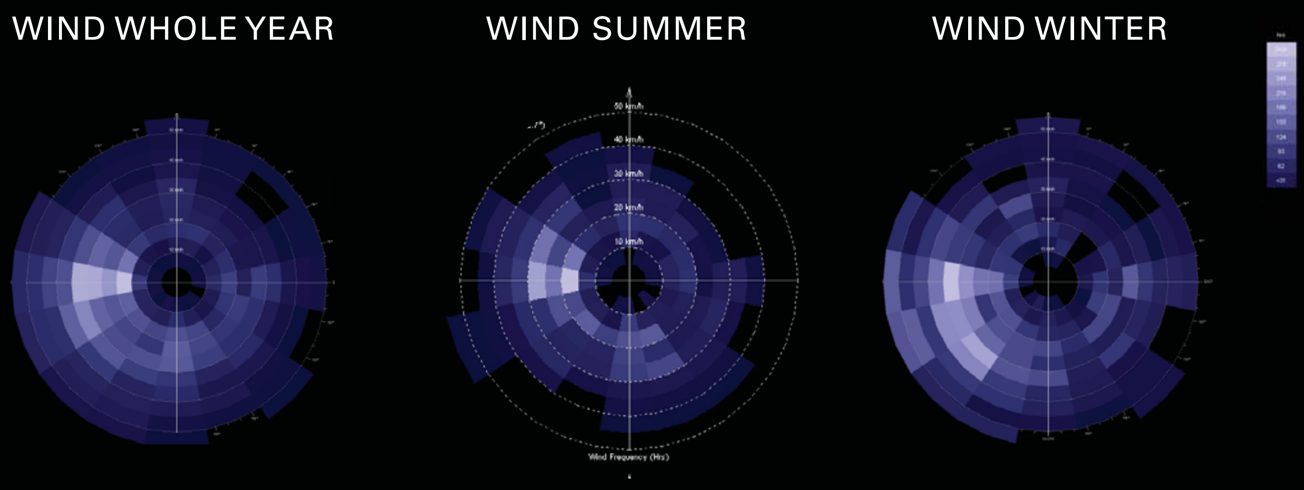
Wind can have a great influence on the conditions at the site because of possibility of wind turbulence created by a tall building which can be uncomfortable. The wind also has an influence in the integration of natural ventilation.

The wind rose shows that the prevailing wind is from the west both when looking at the intensity of the wind and the sequence of time. The wind rose in ill 20 indicates that there can be problems with uncomfortable wind from the west because Roskildevej makes it possible for the wind to flow undisturbed.

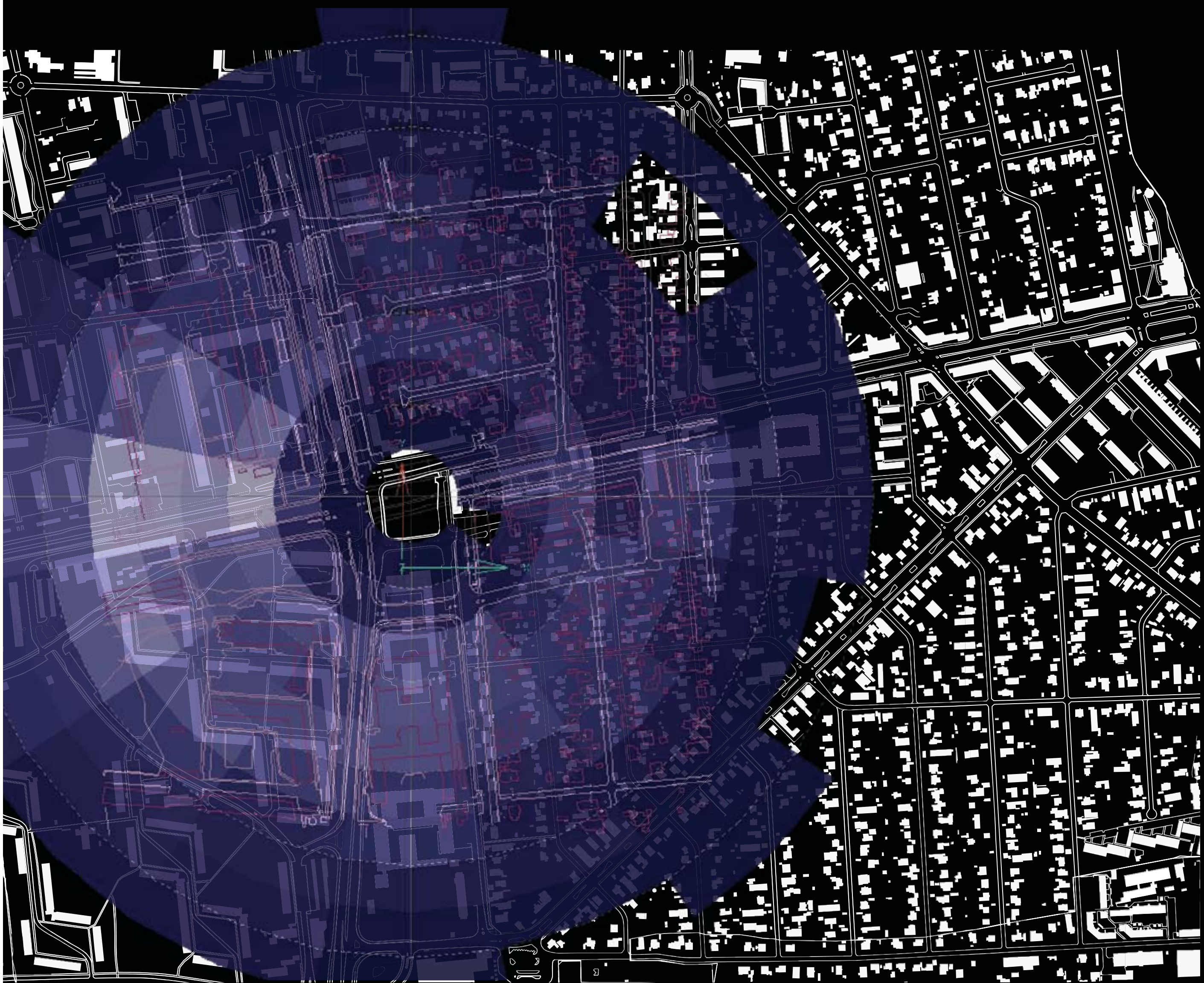
It also have to be taken into consideration that the site is located in a relative dense city and therefore the wind conditions can changes a lot depending on the buildings situated around the site, and therefore is the wind rose not necessarily representing the complete state of wind.



Ill 20. The wind rose compared with the urban environment at the site. The illustration indicates that there could be some uncomfortable wind coming blowing from the west at the road of Roskildevej. Otherwise the site is protected from strong wind from other directions by nearby buildings.



Ill 19. The wind conditions in for a whole years are compared with the wind condition for the summer and winter period. To investigate if there are any significant differences is important if natural ventilation should be implemented in the building. The wind condition in the summer and winter periods are not that different from the condition in the whole years. The prevailing wind is still from west but the wind is stronger in the winter period.



PROGRAM

The program is based on the design brief of “Co
Building” but also subjective interpretations of
fice and apartments and the expression of the b
gram is compiled in a vision that will be a guide

Competition for the Design of a High-rise
of for example internal spaces of the of-
e building. The main element of the pro-
ide line thought out the design phases.

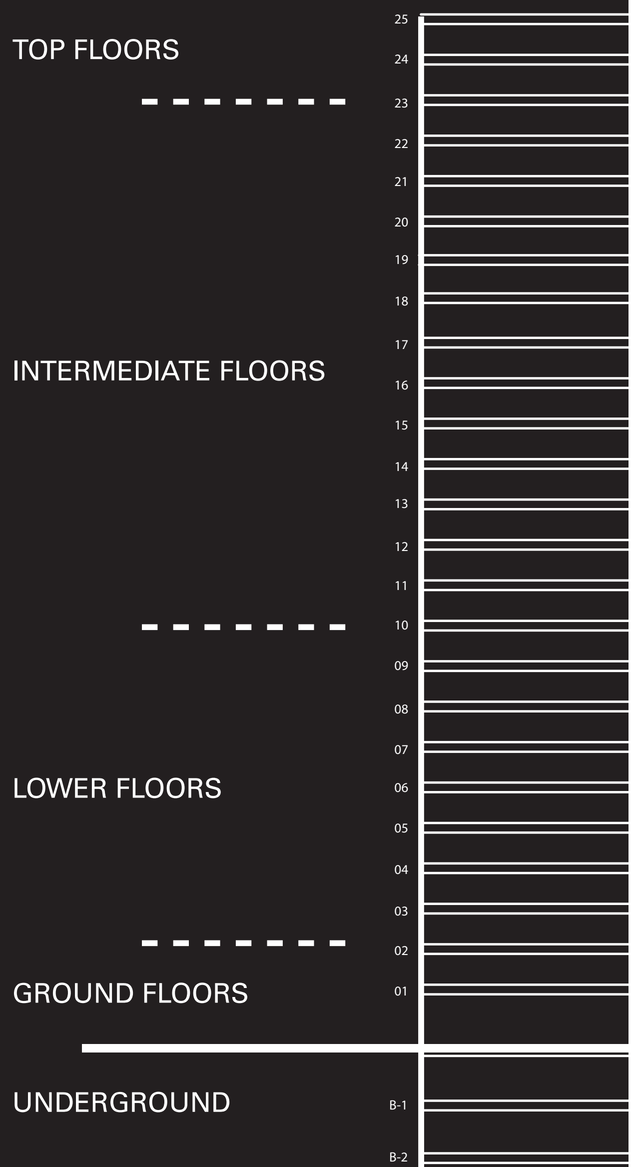
PLACEMENT OF FUNCTIONS

The program for the site is based on the competition "Competition for the Design of a High-Rise Building" The main facts concerning the building design will be paraphrased in the following section. The facts are both specific demands from the competition but also spin from more abstract wishes.

The program for the building is split into five sections dividing the building vertically. The sections begin with the underground floors, ground floors, lower floors, intermediate floors and top floors. The activities requested to be placed in the sections can be seen in ill. 21 and a diagram with the placement of the functions can be seen in ill 22.

The high rise building has to contain a mix of housing units, office and commercial facilities. The commercial area can be used for shops and supermarkets but thereis also a wish to incorporate other programs such as hotel activities or cultural activities. It is a demand that the lowest floors must "*foster and promote activities and outwards oriented functions*" [competition brief p. 17].

The maximum height of the building is 25 floors high because of the city regulations. The volume of the building may not exceed 625 % of the site area. [Municipal Plan 2006-2018]



Ill. 22. An interpretation of the placement of the different activities inside the building volume. The interpretation is made from the program which not specifies the different sections and therefore the distribution is only estimations.

PROGRAM

UNDERGROUND FLOORS:
parking areas
storages rooms for housing units
plant rooms

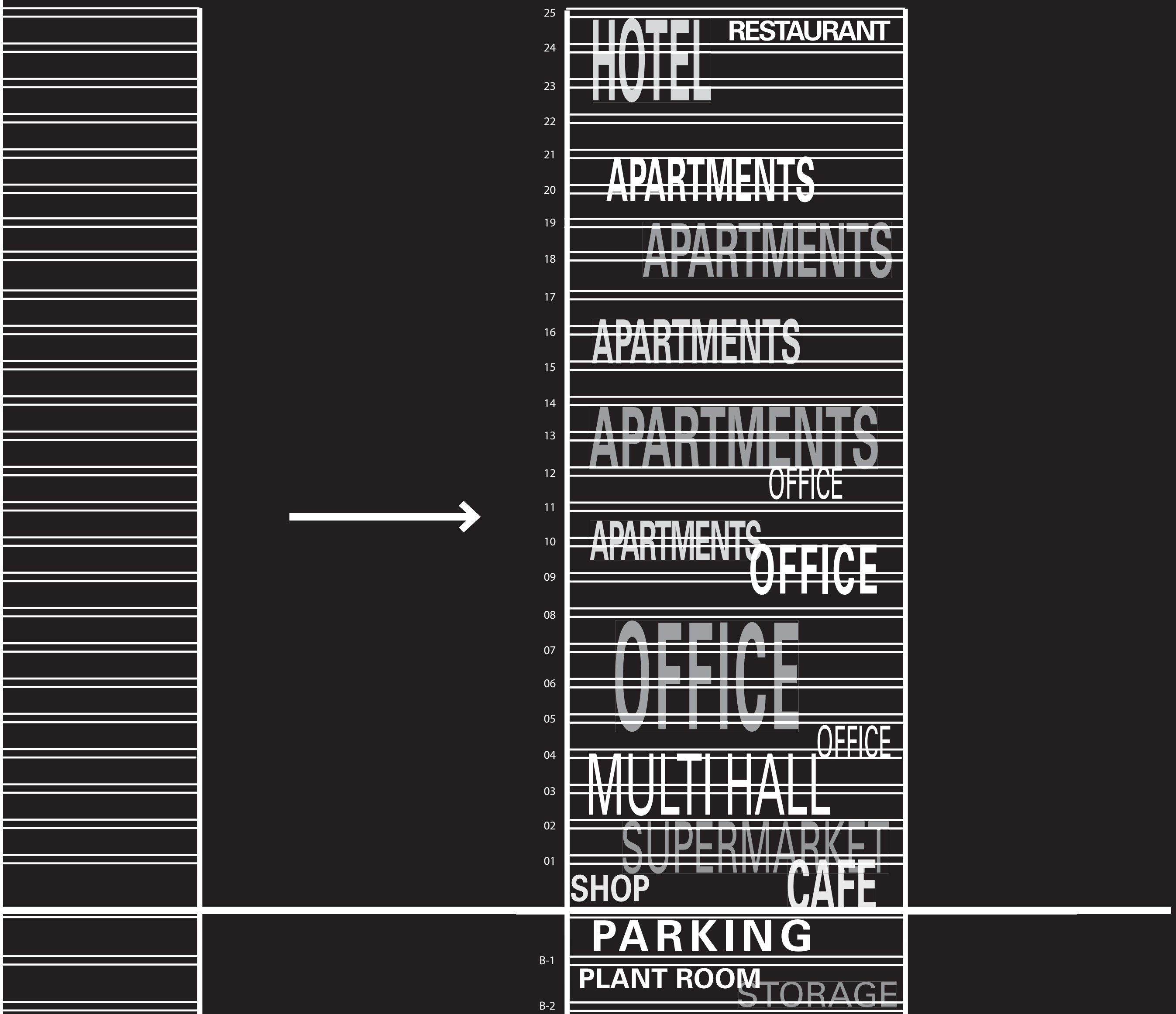
GROUND FLOORS:
commercial function, e.g. facilities such as small supermakets and cafes

LOWER FLOORS:
areas for cultural functions, e.g. multi purpose hall offices or similar facilities

INTERMEDIATE FLOORS:
housing units

TOP FLOORS
hotel with restaurant or similar facility

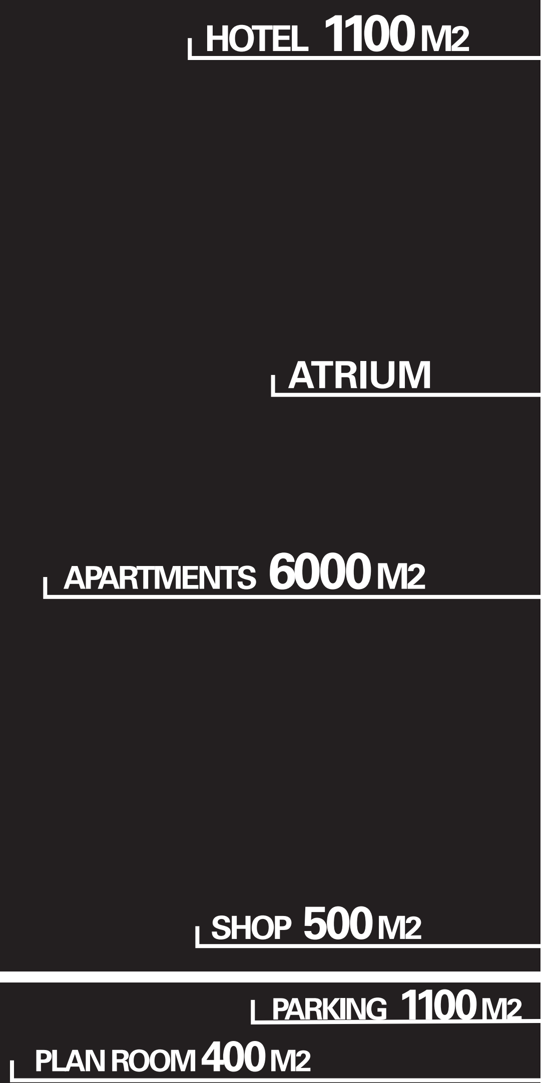
Ill. 21. The different activities placed in the five sections the building is divided up into according the program.



PROGRAM

There are no specifications on square meters on the different activities in the program but from the maximum building volume, square meters of the different activities are estimated. The square meters of the activities can be seen in ill. 25.

The competition brief and the site analysis consider outdoor spaces, exterior appearance and the greenery of the building and are all formulated in parameters which can be seen in ill. 23.



KEY WORDS:

OUTDOOR SPACES

It is a wish that outdoors spaces are incorporated into the layout of the apartment's plans. This could be a designet as a shared gardens integrated with the building or individual balconies.

EXTERIOR APPEARANCE

The ambition is to create a distinct exterior appearance of the building. The appearance of the building should also display a contemporary architectural design.

GREEN BUILDING

The municipality also emphasize the importance of a green profile in the building design, which means that both construction and maintenance must be based on well concidered environmentally friendly approaches and measures.

Ill.23. Some of the parameters conserving the expression and interpretation the building made from the site analysis and the building program.

FACTS:

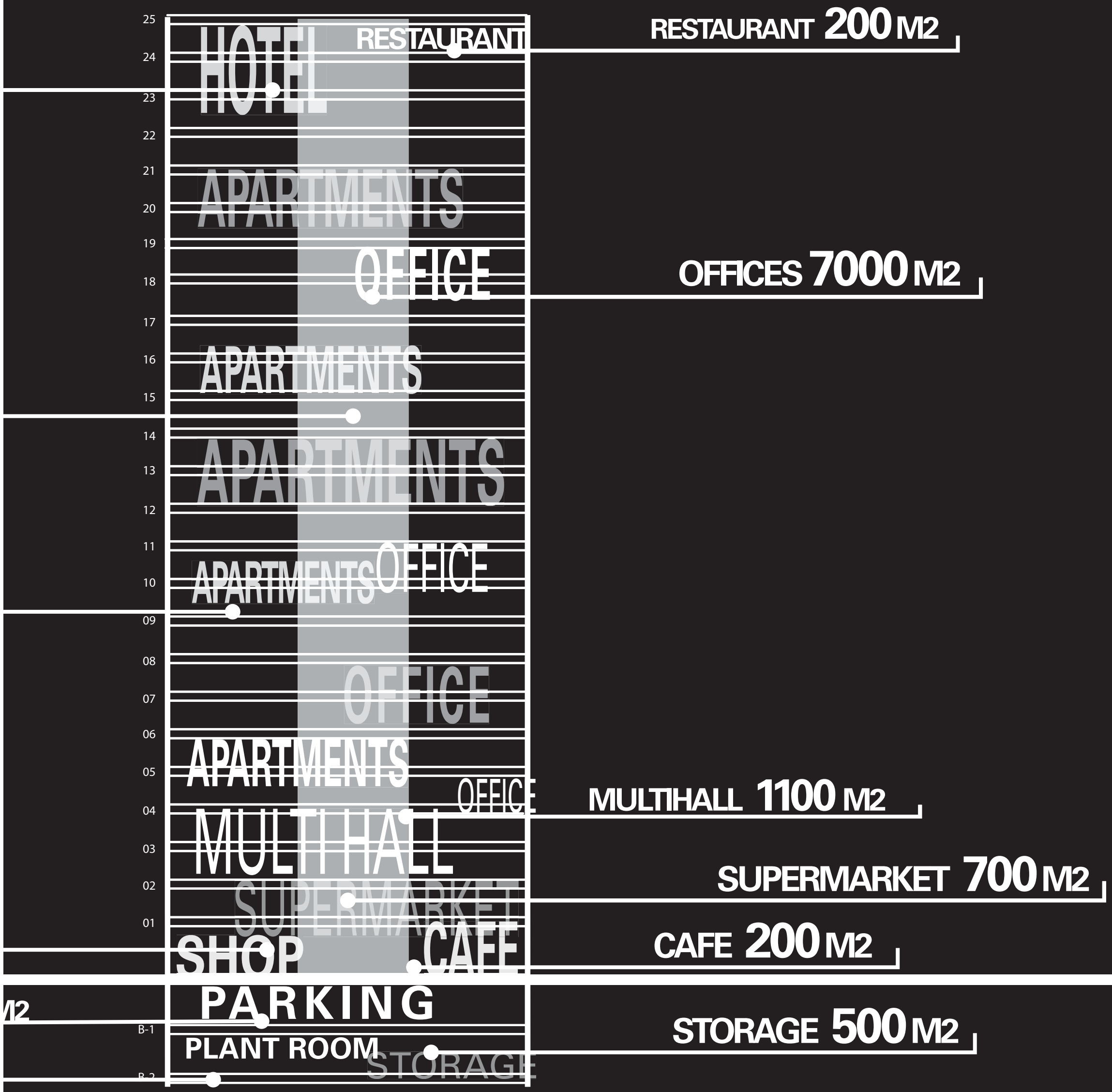
SITE SIZE = 4387 M2

MAXIMUM PLOT RATIO = 626 %

MAXIMUM VOLUME = 27400 M2

MAXIMUM HEIGHT = 25 STORIES APP. 100 M

Ill. 24. The site area and the maximum restrictions on the building height and volume



Ill. 25. The estimated size and distrubution of the different functions.

PROGRAM

The office and the housing units are two important functions that have a great influence in on the design of the building. The programs for these activities are therefore specified in ill 26 and 27.

The dwellings should attract a broad mix of users and therefore three different types of dwelling are used in the program. The three types of dwellings are divided up into a A, B and C with different volumes and different percentages. The internal program of the dwellings and of the offices as well as the different office types is are not mentioneds in the brief.

The brief also states that "It is assumed that the housing units will appeal to the modern city dwellers who appreciate living close to the activities of a big city. Families with young children are likely to prefer other types of housing...." [competition brief p. 13] It is a wish to break this statement and to create a building complex and environment that also attacks families with younger children by the treatment of the common spaces.

The office spaces are not meantion in the brife. The space program of the office are therefore made form estimations.

SPACE PROGRAM OFFICE

OFFICE TYPE
OPEN SPACE OFFICE
CLOSE SPACE OFFICE

SPACE PROGRAM DWELLINGS

DWELLING TYPE	SPACES INSIDE THE DWELLING				
	LIVING	LEISURE	WORKING	KITCHEN/ DINNING	ENTRANCE
10 % TYPE A 50 - 100 M2	10-20 m2	10-15 m2	5-10 m2	15-20 m2	2-5 m2
80 % TYPE B 100 -150 M2	10-20 m2	10-15 m2	5-10 m2	15-20 m2	2-5 m2
10 % TYPE C 150 - 200 M2	20-30 m2	15-30 m2	15-20 m2	20-30 m2	2-5 m2

Ill. 27. The three types of dwellings that are going to be incorporated in the building design. The percentages indicate the distribution of the different building types. The diagram also shows an estimations of the inside functions in the dwelling and there sizes.

SPACES INSIDE THE OFFICE

WORKING	LUNCH AREA	MEETING ROOMS	ENTRANCE	REST ROOM	OUTDOOR AREA
200-1.000 m2	30-50 m2	20-30 m2	10-20 m2	20-40 m2	--- m2
100-500 m2	15-30 m2	--- m2	5-10 m2	15-20 m2	--- m2

Ill. 26. The two types of office space implemented in the building design and the distribution of space inside the office.

MASTER BETHROOM	ROOM (S)	BATHROOM (S)	OUTDOOR AREA
10-20 m2	--- m2	5-15 m2	--- m2
10-20 m2	5-15 m2	10-20 m2*	--- m2
15-25 m2	20-30 m2*	15-25 m2*	--- m2

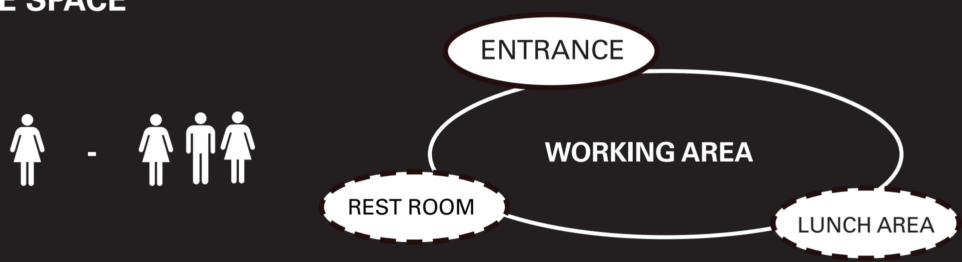
PROGRAM

Diagrams of the functions for the office and housing units are madke to indicate the relationship between the spaces in the different functions. The diagrams can be seen in ill. 29 - 30.
The challenge of the design of the building and dwellings is to attract all types of occupants both and without small children. This will create a more diverse building complex which will have a positive influence on the life inside.

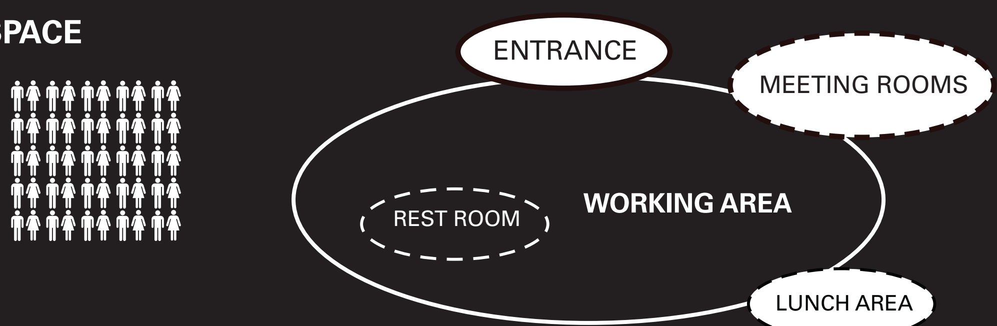
The spaces of the office are arranged like a traditional open and closed office space. The closed and small offices having shared spaces to optimized the more limited space.

SPACE DISTRIBUTION OFFICE

CLOSE OFFICE SPACE



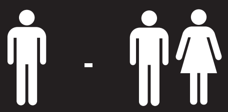
OPEN OFFICE SPACE



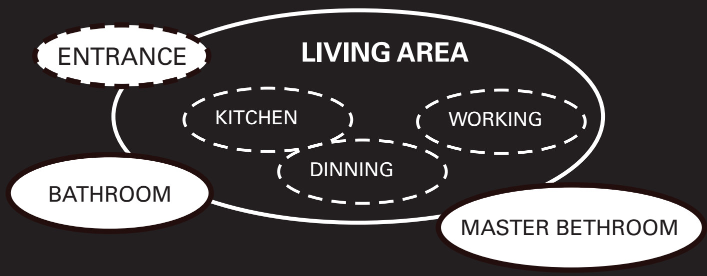
Ill. 28. The diagrams show the offices types and connections between the different spaces inside the unit. The numbers of people in the small and close office spaces are estimated to be between one and three whereas in the open office space the number of people can be higher.

SPACE DISTRIBUTION DWELLING

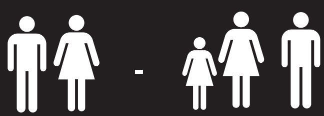
DWELLING TYPE A



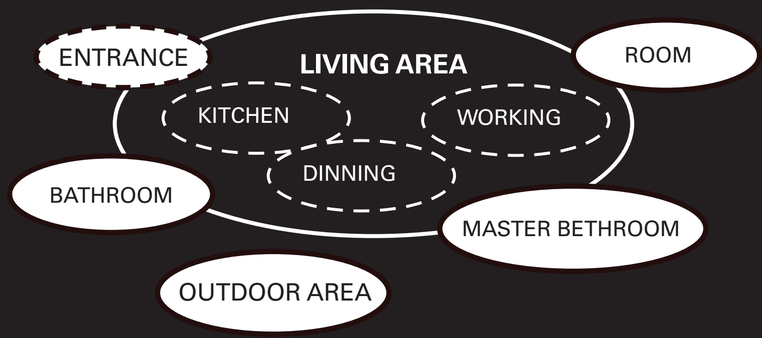
50 -100 m2, 10%



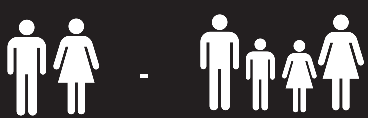
DWELLING TYPE B



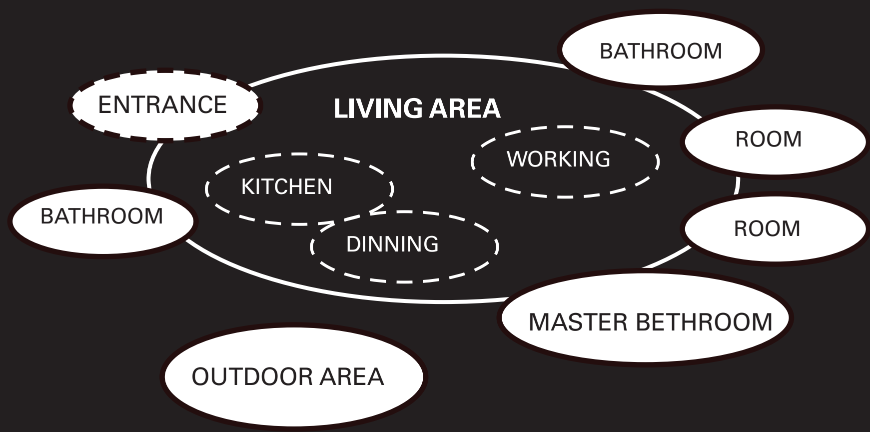
100 -150 m2, 80%



DWELLING TYPE C



150 -200 m2, 10%



Ill. 29. The diagrams show the three building types and connections between the different spaces inside the housing unit. The diagram also shows the number of people tha are estimated to live in the unit.

PROGRAM

The functions in the spaces of the dwellings and the offices are listed to give an overview of the different quantitative and qualitative parameters that affect the different rooms in ill 30 and 31.

Quantitative parameters are estimations about the view, flow and atmosphere which more describe the feeling of the room.

The quantitative parameters are values given mainly from the Danish Building Regulations. The building regulation states the daylight factor, room height, reverberation time and air change requirements of the rooms of office. These requirements are passed on to some of the rooms of the dwellings. The demands of daylight conditions are from DS 700.

ROOM REQUIREMENT DWELLINGS

	LIVING	LEISURE	WORKING	KITCHEN/ DINNING	ENTRANCE
FLOW AROUND	+	+	-	+	+
DAYLIGHT	> 200 LUX	> 500 LUX	> 500 LUX	> 500 LUX	> 50 LUX
DAYLIGHT FACTOR	~ 5 %	> 5 %	> 2 %	> 5 %	> 2 %
VIEW IN/OUT	OUT/IN	OUT/IN	OUT	OUT/IN	---
MIN AIR CHANGE	0,5 H^{-1}	0,5 H^{-1}	0,5 H^{-1}	0,5 H^{-1}	0,5 H^{-1}
TEMP SUMMER/ WINTER	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0
REVB. TIME	MAX 0,5 S	MAX 0,5 S	MAX 0,5 S	MAX 0,5 S	MAX 0,5 S

Ill. 31 requirements for the room of the ofice. The requirements are important factors that need to be taken into consideration when design the spaces of the building. The working hours of the apartment space is asumet to be from 18 - 8 in weekday and 00 - 24 in weekends in weekday.

ROOM REQUIREMENT OFFICES

	WORKING	LUNCH AREA	MEETING ROOMS	ENTRANCE	REST ROOM	OUTDOOR AREA
FLOW AROUND	(-)	+	-	+	-	+
DAYLIGHT	> 500 LUX	>200 LUX	>500 LUX	>50 LUX	>100 LUX	----
DAYLIGHT FACTOR	> 2 %*	> 2 %*	> 2 %*	----	----	----
VIEW IN/OUT	OUT/IN	OUT/IN	OUT	----	---	---
MIN AIR CHANGE	20 L/S PR. PERSON	20 L/S PR. PERSON	20 L/S PR. PERSON	20 L/S PR. PERSON	10 L/S PR. PERSON	---
TEMP SUMMER/ WINTER	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	---
REVB. TIME	MAX 0,5 S	MAX 0,5 S	MAX 0,5 S	MAX 0,5 S	MAX 0,5 S	----

Ill. 30 requirements for the room of the ofice. The requirements are important factors that need to be taken into consideration when design the spaces of the building. The working hours of the ofice space is asumet to be from 8 - 17 in weekday.

MASTER BETHROOM	ROOM (S)	BATHROOM (S)	OUTDOOR AREA
-	(-)	-	---
> 200 LUX	> 300 LUX	> 200 LUX	---
> 2 %	> 5 %	> 2 %	---
OUT	OUT	OUT	---
0,5 H^{-1}	0,5 H^{-1}	0,5 H^{-1}	---
21^0-24^0 19^0-22^0	23^0-26^0 20^0-24^0	23^0-26^0 20^0-24^0	---
MAX 0,5 S	MAX 0,5 S	MAX 0,5 S	---

FLOW

Vertical transportation in any tall building is dependent upon its elevator system. The elevators and the flow of the building are therefore important to have in mind from the beginning of the design phases. The flow is important because the vertical circulation is dominating and more intense than in low buildings and it affect the design opportunities of the building. The capacity of the elevator system is a critical issue in tall buildings together with the space occupied by the elevators. Ill 32 shows a selction of elevators and their properties.

The flow of the building is often situated inside the core of the building to optimize the space. In this way the construction needed for stabilizing the building also can be containing the elevators. Fire regulations also demands two escape routes from the building see app. 5. This means that two fire safe stair cases needs to be placed in the building which makes it possible to escape the building in case of a fire. See ill. 33.

A circulation between the different stories is also wanted in the building to create a more living environment and attractive spaces. This will make flow possible between interconnected stories without use of elevators and thereby make the connection between stories stronger.

To calculate the need for elevators in the building it is necessary to know the capacity of the elevators and the numbers of occupants the building. From the room program it is estimated that following numbers of people from the main function that demands elevator for transportation:

Apartments:	170 people
Office:	350 people
Hotel:	50 people

The total number of people is therefore estimated to be around 570 people.

Efficiency of the passenger elevator service in a building is usually measured by the “5-minute handling capacity”. To obtain the needed “5-minute handling capacity” in a mix use building the capacity of the elevators is estimated minimum to be between 9 to 13% of the occupants in the building. [04.02.10 www.hku.hk/bse]

The elevator capacity therefore has to be between 51 and 68 people. The biggest load on the elevators will be in the rush hours of the office.

PROPERTY OF ELEVATORS

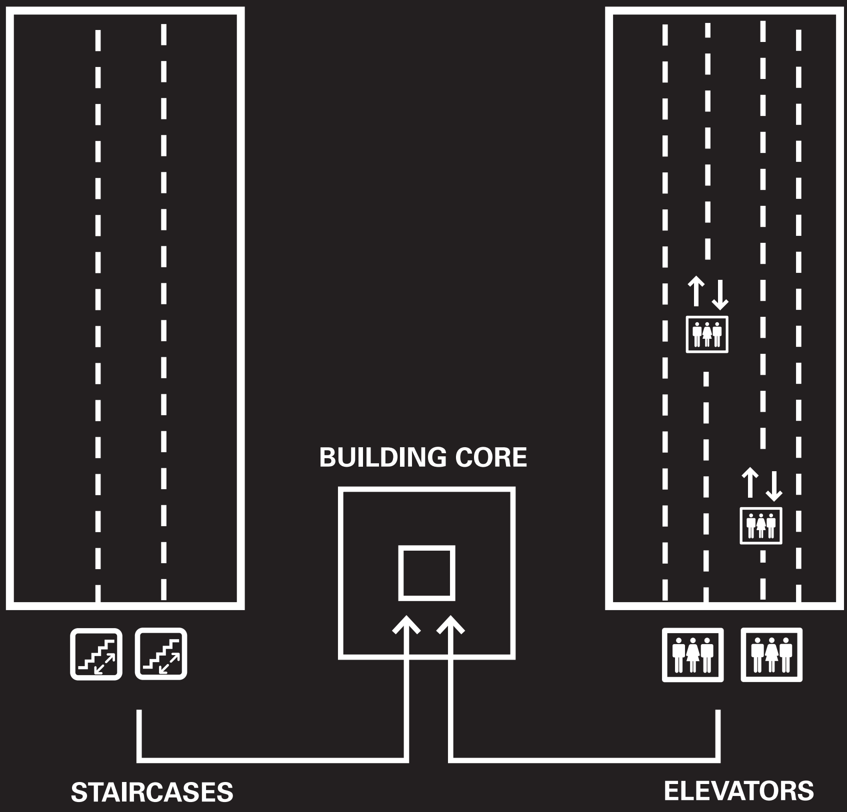
Size: 2600 x 2600 mm
Capasity: 1600 kg
People: 16-17

Size: 2600 x 1800 mm
Capasity: 1000 kg
People: 10-11

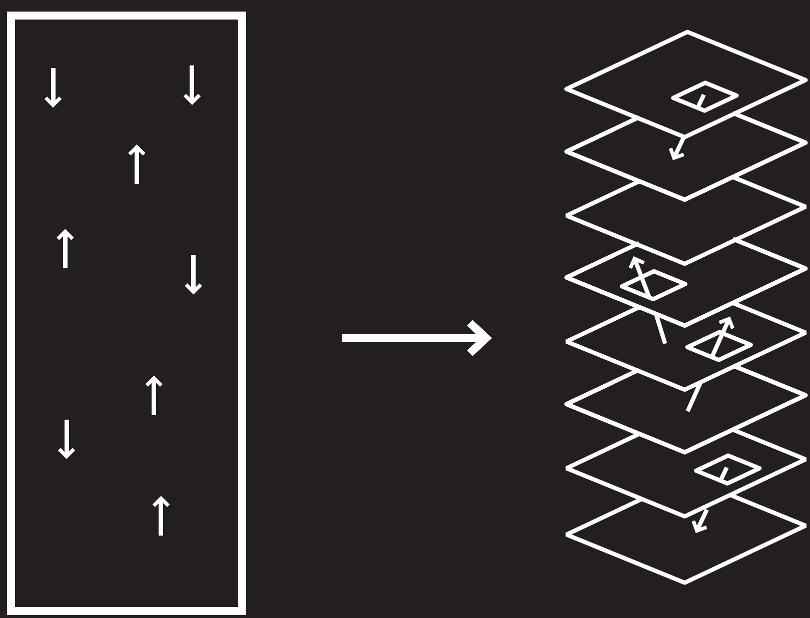
Size: 2100 x 1800 mm
Capasity: 630 kg
People: 6-7

Ill. 32. The capacity of the elevators can be achieved by placing a number of the same or different type of elevators. The minimum size of an elevator that needs to be accessible from the apartments is 2600 x 1800 mm for transportation of bigger items. Some of the most relevant types of elevators and there capacity and size can be seen in this illustration.

FLOW INSIDE THE BUILDING



Ill. 33. The main flow of the building will be though approximately 6 elevators which can be a combination of the types in ill 32. The escape routes in case of fire will be though 2 staircases see app. 5. Both the staircases and the elevators can be placed in the core of the building to optimize the space and the construction.



Ill. 34. The internal flow between the different stories can be though internal staircases or ramps that can provide access between the stories and create a stronger connection between the stories.

SUMMARY

To sum up the demands and the assumptions made in the program ill 35 is made. The illustration sums up the main parameters and design principles that are driven by the program and the site investigations.

The illustration shows the five main areas of interest that needs to play an important part of the design process. The five areas are picked because they are estimated to have great importance in fulfilling the vision of the building.

The subjects are the connection to the context, the energy performance of the building, the construction, the functionality according to the program, and the aesthetics of the building.

The summary outlines the parameters that will be the main focus in the vision and the following phases of the integrated design process.

PROGRAM OF SITE

- SITE PLAN 4387 M2

- BUILDING DENSITY MAX 625 %

- BUILDING HIGH MAX 25 FLOORS

- MIX USE PROGRAM

MAIN AREAS FOR INTEREST

DESIGN PRINCIPLES

THE SITE

- NOISE FROM TRAFFIC
- MINIMIZE CAST SHADOW
- CONNECTION TO GREEN AREAS
- MINIMIZE WIND TURBULENCE

ENERGY EFFICIENCE

- IMPROVE BIODIVERSITY
- THERMAL MASS
- INSULATION OF BUILDING ENVELOPE
- SURFACE TO FLOOR AREA RATION
- ZONING
- OPTIMIZING SPACE
- VENTILATION (NATURAL AND/OR MECHANICAL)
- UTILIZATION OF DAYLIGHT

CONSTRUCTION

- OPTIMIZING THE USE OF MATERIALS
- THE CHOICE OF CONSTRUCTIVE ELEMENTS
- INTEGRATING CONSTRUCTION AND EXPRESSION
- FIRE REGULATIONS

FUNTIONALITY

- MIX USE OF FUNCTIONS
- HIGH QUALITY DWELLING/OFFICES
- HOUSING FOR DIFFERENT USER GROUPS
- DIFFERENT TYPE OF OFFICE SPACES

AESTHETICS

- EXUDE OF GREEN ARCHITECTURE
- CONTEMPORARY ARCHITECTURE
- HUMAN SCALE I DESIGN

Ill. 35

VISION

The aim of the project is to create a tall building that in spite of the size embrace and relate to the surroundings and thereby makes it a positive element in the urban fabric. The building design will be focusing on the performance of the building in terms in energy use and in optimizing the construction which also should be an integrated element of the design solution.

It is also a wish that the elements in focus generate a form that reflect on the performance and perception of the building and thereby explore new aesthetics the high rise architecture.

This can be consolidated in the vision for this project that is made clear on the basis of the introduction, the site investigations and the program.

Ill. 35 The conecpt of the building program

How can high rise architecture be intergrated into a Danish context, and where the structural and energy performance are emphasized in the layout and design of the building?

The task is not to make a icon for the city even though the high rise is going to be a highly visible and dominating building but to make a building that is specific to the time and place in which it is placed and express human scale in it appearence, rather than just another part of the global high rise mono-culture.

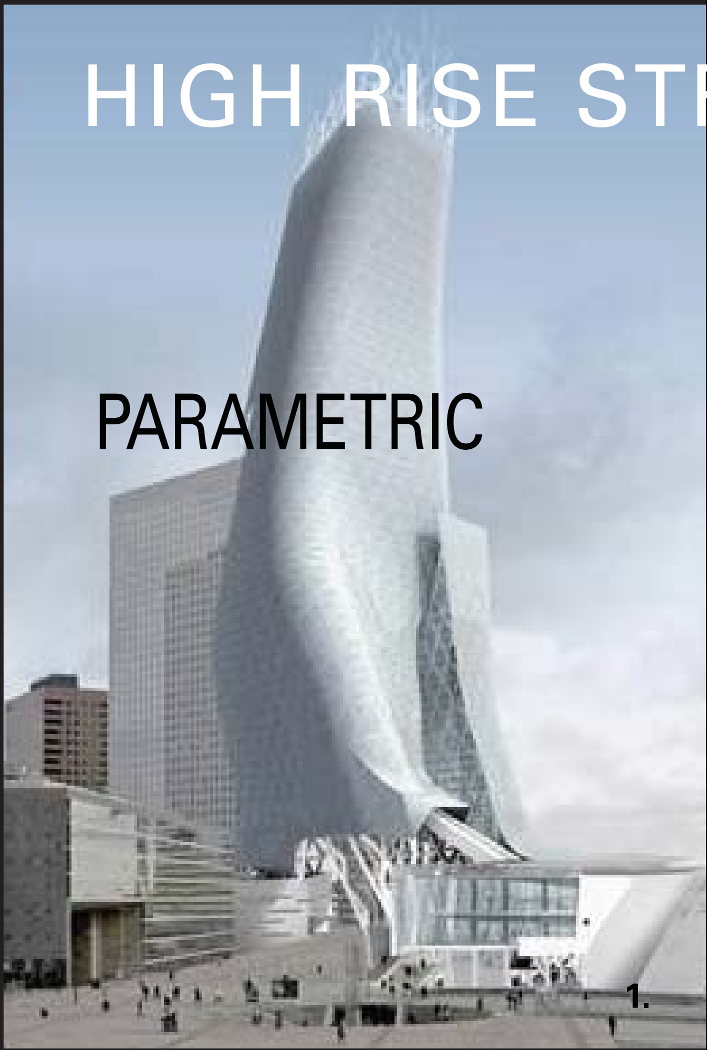
INITIAL IN

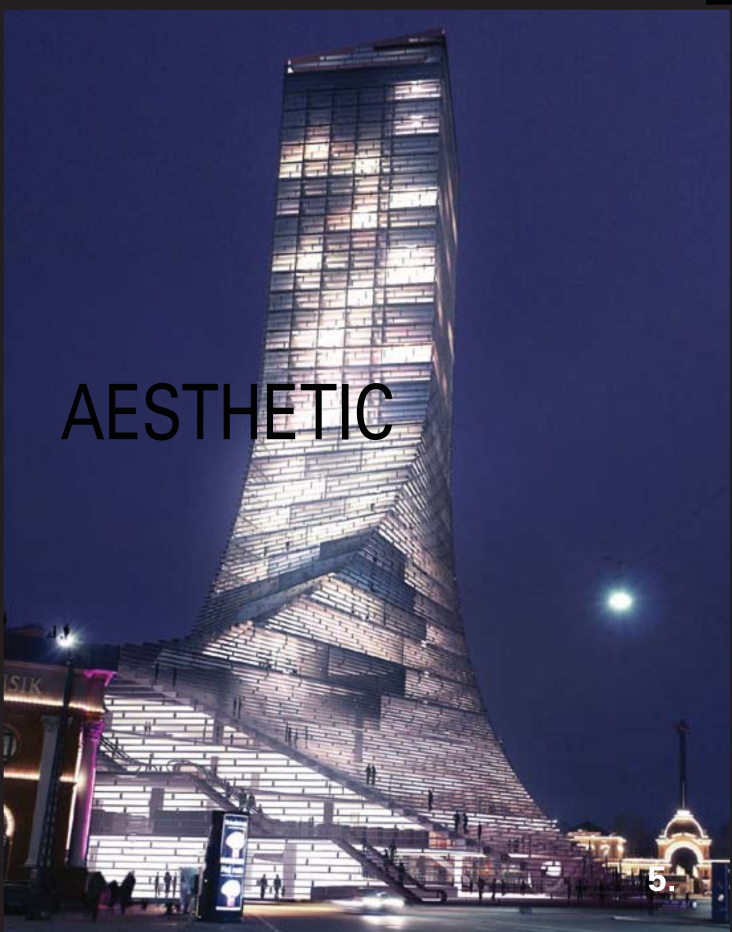
In this chapter some of the main characteristics approaches are explored. Main topics for high- ments, wind turbulent, optimizing of space and r to create a solid foundation to start up the sketch

INVESTIGATIONS

cs in high-rise buildings and their
jh-rises such as the structural ele-
d natural ventilation are evaluated
tching phase.

HIGH RISE STRATEGIES





Ill. 37 The illustration shows some of the clear design strategies in high rise buildings. The picture are collected to give an inspiration on how a clear design strategy can be converted into a high rise design.

1: One Madison Park by Rem Koolhaas and Shohei Shigematsu. 2: Vuitton's Tokyo flagship store Tokyo by UNstudio 3: Bishopsgate Tower London by Kohn Pederson Fox and Arup 4: JURYS BERKELEY COURT by Henning larsen architects 5: Scale Tower by BIG 6: enviro tower by ken yang 7: 23 East 22nd Street by Rem Koolhaas

STRUCTURE

The primary function of the structural system is to carry loads acting on the building, and transmit them to the foundation. Historically high rises are provided with heavy masonry cladding to required stability. The structural system where therefore rarely exposed because it were concealed beneath the masonry.

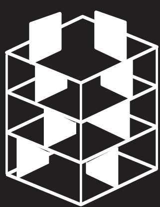
In present times buildings are becoming more slender and lighter because of new technologies and new aesthetics. This development increases the important role of the structural engineers that need to be implemented early in the concept stage. [Hira; 2007] The main structural systems that can be used in tall buildings are described in ill 39.

The different structural systems also have different limitations when looking at weight and hight of the building. The bearing wall system, which usually is made up of concrete, becomes due to the self weight of the material and the amount of material needed inefficient above 15-30 stories. The core system of concrete has some of the same disadvantage as the bearing wall system and maximum height of the construction is limited to between 15-30 stories because the weight of the construction.

The frame system can be more efficient than the core and bearing wall system, but the efficiency depends upon the stiffness of the system. Incorporating stiffness into the frame system increases the upper limit of approximately 60 stories of this system. As the building height increases the space between the steel frames has to become smaller and the grid between the frames thereby obtain more space.

The tube system is like a spatial frame with the vertical elements positioned at the exterior. This type of system also requires some kind of bracing employed for stabilizing the system. The tube system is the most efficient system when wanting to build high and is mostly used in buildings that are above 60 stories in height, see ill 38 [Hira; 2007]

MAIN STRUCTURAL SYSTEMS

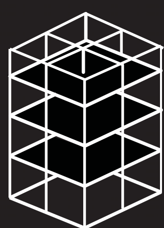


BEARING WALL

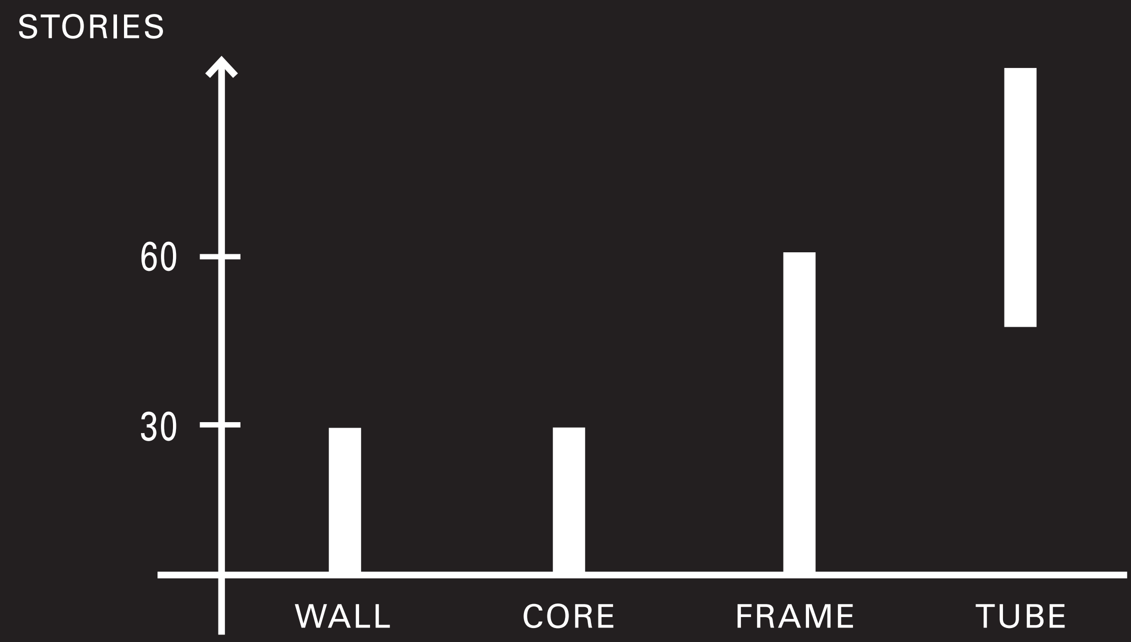
The loads are distributed down the building through the walls. The walls shall have the strength and stiffness to resist the horizontal and vertical forces in the building.

STEEL FRAME

Steel frames represent a simple and low cost structural system that in a 3D grid system displaces the weight of the building. A frame structure is usually made of columns, beams and floor slabs arranged to resist both horizontal and vertical loads.



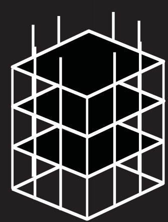
STRUCTURAL SYSTEMS AND HIGHT



III 38. The structural systems and the maximum and minimum stories in which the structures in generally are used.

TUBE FRAME

This structural system relays on close aligned supporting columns, so that the loads are distributed down in the façade of the building. This takes space in the façade and leaves smaller space for placing windows in the façade. On the other hand the system allows a maximum use of the floors space that can have a column and core free layout.



CONCRETE CORE

The concrete core is the most common structural system for high rises. The core provides the design a strong centre and allows the service installation (elevators, stairs, utilities in general) to be centralized in the building.

III 39

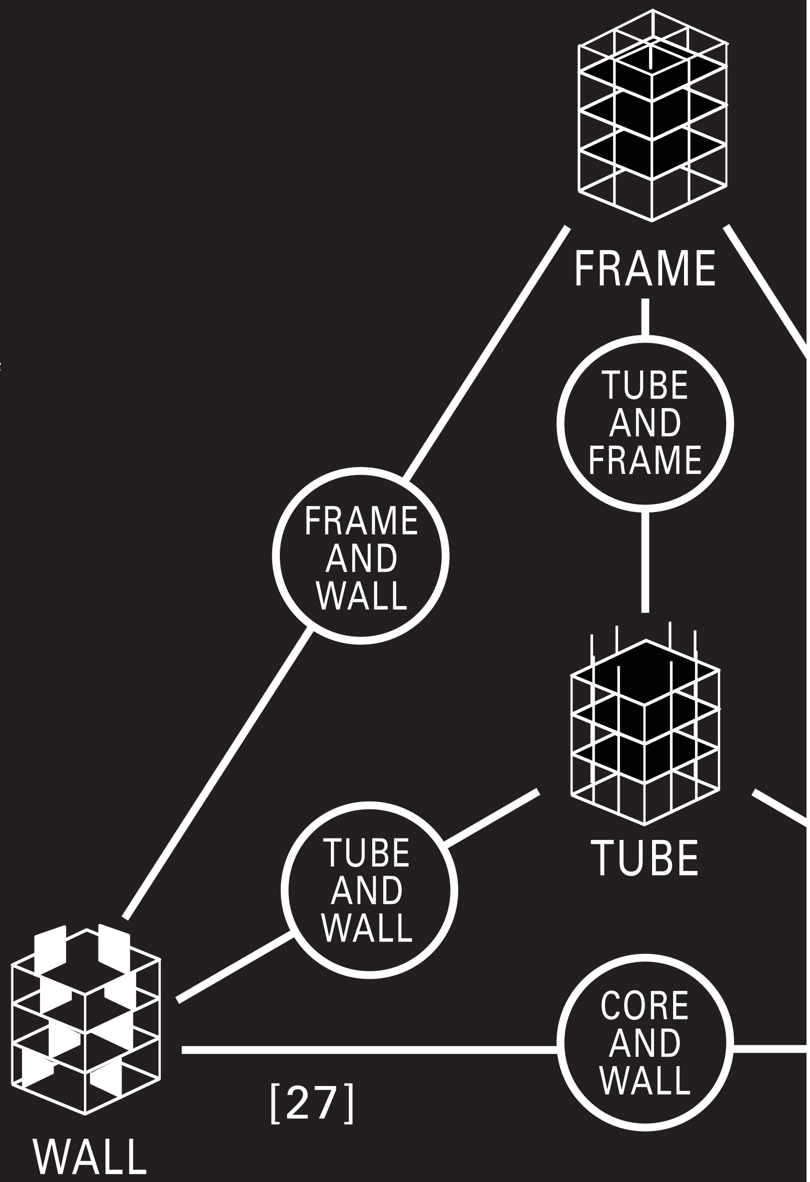
STRUCTURE

In the integrated design process the construction have great influence on the design, especially when designing tall buildings. Therefore building high rises demands a multi-disciplinary design process where the architects and engineers understand each other and are working together. An integrated design process is evident when designing high rises.

In structural performance, the basic objective is the minimization of weight of the structural system and to ensure the stiffness of the structure. Combining the basis structures gives a wider range of structural opportunities and makes it possible to exploit the different advantages of the basis structures.

The basic structures can be combined into six secondary systems see ill 40, but the range of sub-combinations are bigger thant described in this diagram than only represent the main combinations. [www.steel-insdag.org]

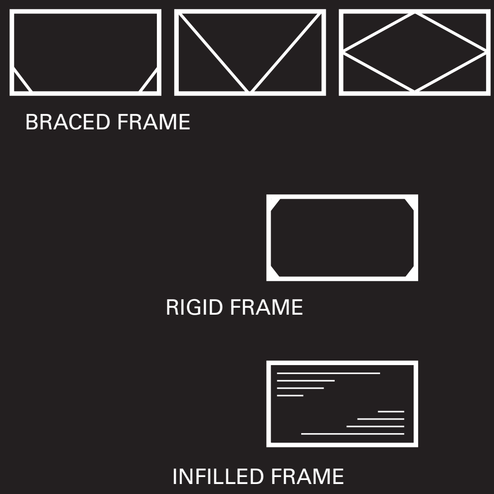
A combination integrating the core system is common because the core of the building can both obtain loads and contain the services elements. The placement of the core has a great impact in the overall design of the build-



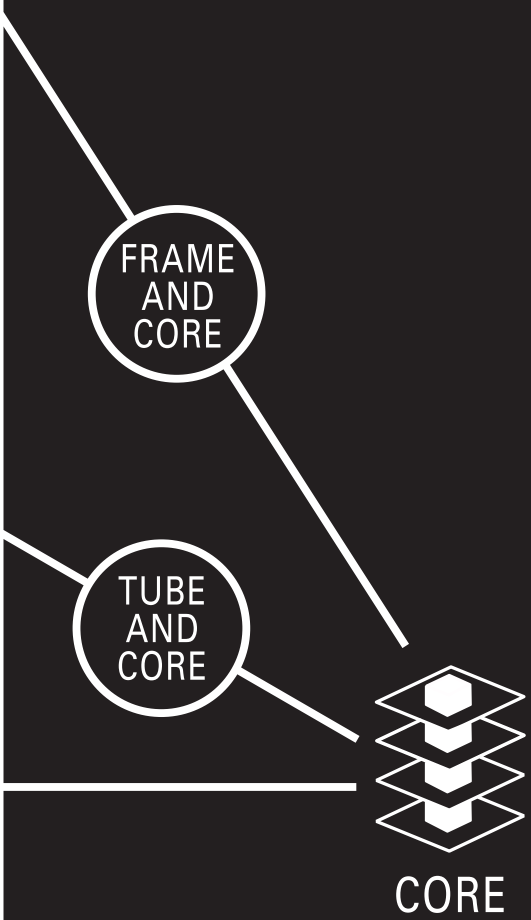
STRUCTURAL SYSTEMS AND COMBINTIONS

Ill 40 The main structural systems and there combinations possibilities.

FRAME OPPOTUNITIES



Ill 41 Different types of braced systems that can give stiffness to the structural system. The braced frame systems can have many other different looks, but some of them are showed in this illustration.



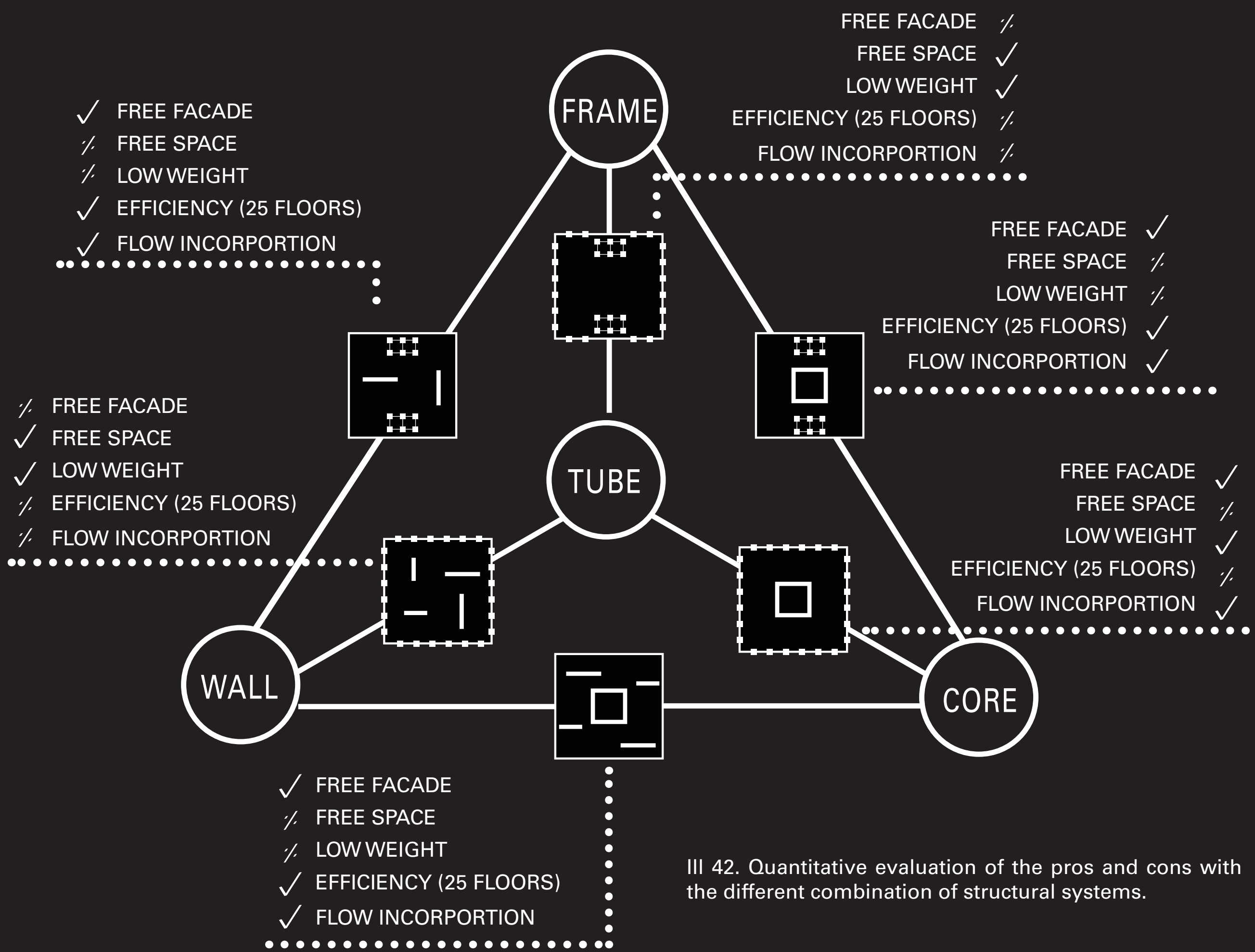
ing and therefore has to be integrated in the early design stages if used. The core can be designed to resist both vertical and horizontal loads and can therefore heighten the performance of the structural system if combined with other systems.

Baring walls system is in high rises mainly used with other structures to reduce the space obtained by the walls. The frame is an adaptable structural choice with regard to material and shape and other systems. Other systems are often added to give stiffness the frame structure. Stiffness can also be added though a combination the system of Braced-, Rigid- and in filled-Frame, see ill 41. [Coull, Smith 1991

Obtaining stiffness is also an issue in the tube system and like in the frame system the stiffness can be implemented by adding baring walls, frames or a core.

STRUCTURE

STRUCTURAL SYSTEMS EVALUATION



Ill 42. Quantitative evaluation of the pros and cons with the different combination of structural systems.

Combining the basis structures give a wider range of difference in structural properties and that makes it possible to exploit the different advantages of the different basis structures.

An evaluation on some of the pros and cons by combining the structural systems can be seen in ill 42. The evaluation shows that none of the combinations can be said to be the best solution. Never the less the designers have to be aware of the pros and cons when designing and choosing the structural system.

The evaluation also shows that the core system has many positive properties both alone and in combination with other systems in the scale that are relevant in this project. The tube system on the other hand is a more effective system to use in a scale bigger than this project.

Core positions can be classified into three types: central core, double side core and single side core. The placement of the core influences the functionality of the thermal mass, the solar radiation gains and the possibility of view from inside and out. [Hamzah & Yeang]

In tall buildings the service core can provide the principal structural elements for both the gravity load-resistant systems and lateral load-resisting systems. It provides the stiffness to deflections and accelerations to acceptable levels [Yeang; 2000].

The service core layout should also be geometrically efficient if it is to resist the structural loads, whilst fulfilling its architectural and service functions

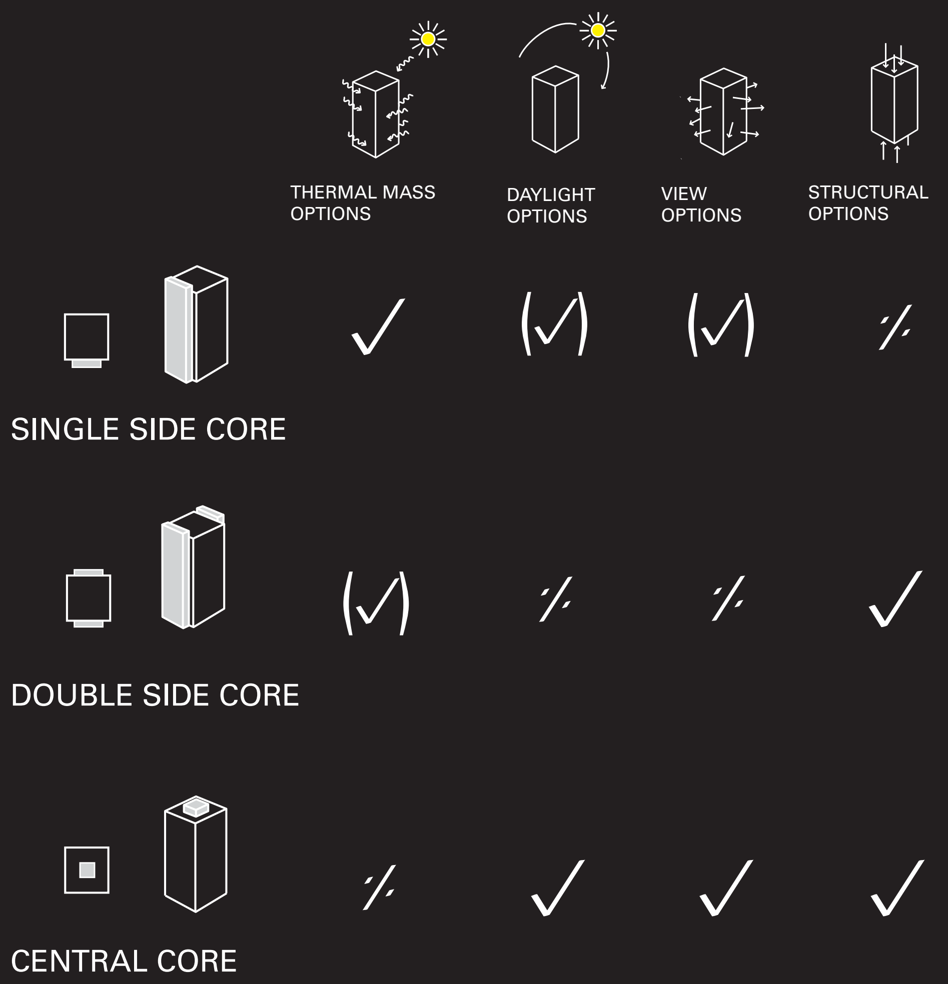
The initial design decisions of placing the service core system within the floor plate can significantly affect the mechanical and electrical systems distribution routes as well as the vertical circulation systems and the efficiently of use of the building. [Yeang; 2000]

A quantitative evaluation of the core placement is therefore investigated in ill 43. From this evaluation a central core structure is evaluated to be the placement which has to most benefits for this project.

The final selection of a constructive system cannot be made before the concept design of the building is picked, but because of the important role the structure play in building high rise, the different principles are important to have in mind.

Affecting the choice of structural system is also the function placed inside the building. An office building often calls for large open spaces where the space can be subdivided by light partitioning walls. In residential buildings and hotel accommodations the space is subdivided permanently. Therefore vertical columns and walls can be distributed dividing the space and contribute to separate the rooms and at the same time be the barring structural system. [Coull, Smith 1991]

CORE EVALUATION



Ill 43. Quantitative evaluation of the placement of the core.

WIND

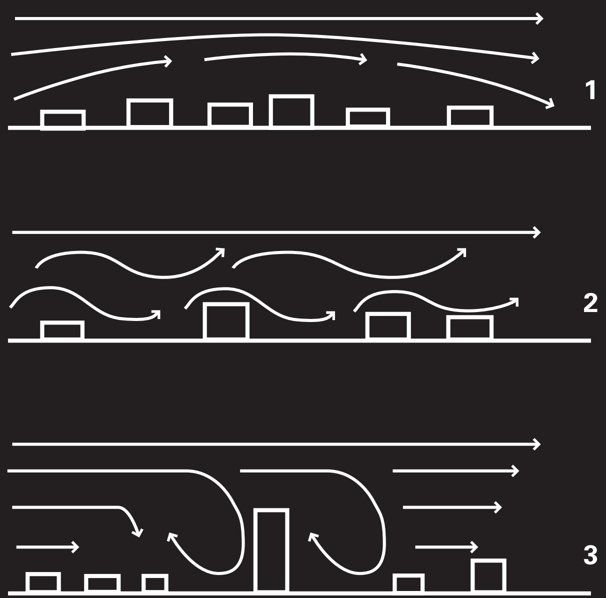
For building of up to 10 stories and of typical proportions, the design is rarely affected by wind load. Above this height the pressure from the wind will normally affect the construction. In terms of structural considerations a building is defined as tall, when its strength and behavior is governed by lateral loads where the main lateral loads being the wind. [Hira; 2007]

The loads on the structural system for high rises can be looked upon in two distinct categories. The gravity load resisting the structural system and the lateral load resisting the structural system. The forces from the wind are strong in high rises and can therefore act as a form-determining factor of the construction. [Hira; 2007]

A broad building has a relatively high resistant to wind loads whereas a high slender building develops higher forces in the structural members. The forces results in demanding a resistance of the turning moments that will be transferred to the foundation. The load from the wind is estimated to be 1 kN per m2. A diagram showing the forces acting on the building can be seen in ill 45.

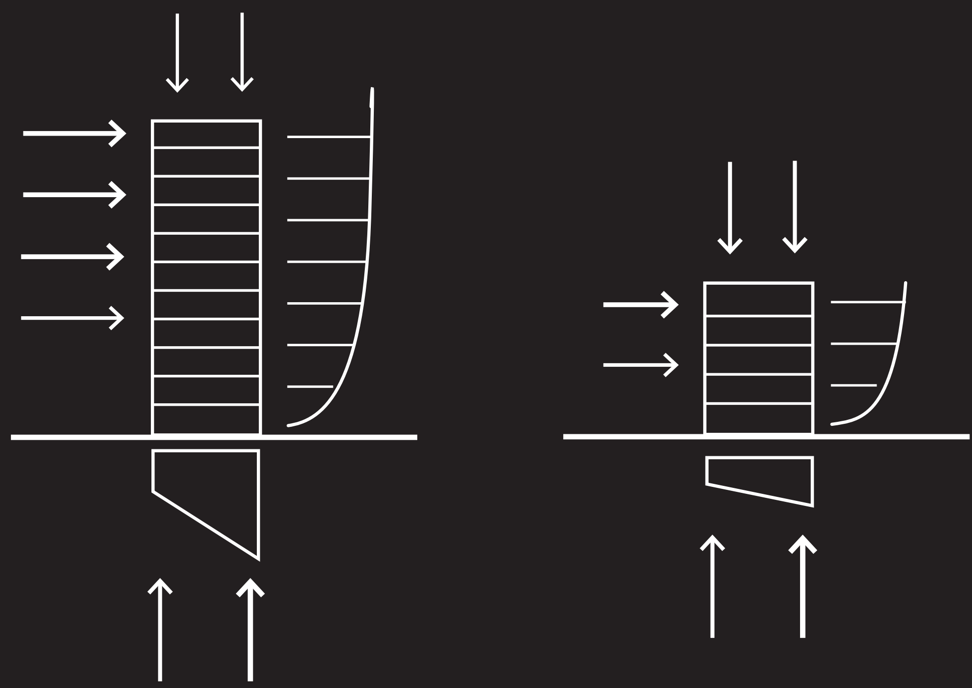
The building or will be causing turbulence of the wind and thereby be inconvenient at the street level. The shape of the building can help to break down the speed of the wind or allow the wind to flow more freely around the building and thereby avoiding wind going down to the street level. Different concepts of breaking the wind down and thereby avoiding heavy turbulence can be seen in ill. 46 and 44.

WIND AND CITY STRUCTURE



Ill. 44. Difference of the city fabric and wind conditions. The city structures in Denmark are often like diagram 1 and 2. The new high rise building will make the conditions around the site similar to diagram 3 which means that the wind conditions needs to be incorporated into the shape of the building and it surroundings. [kilde]

LOAD ON TALL BUILDINGS

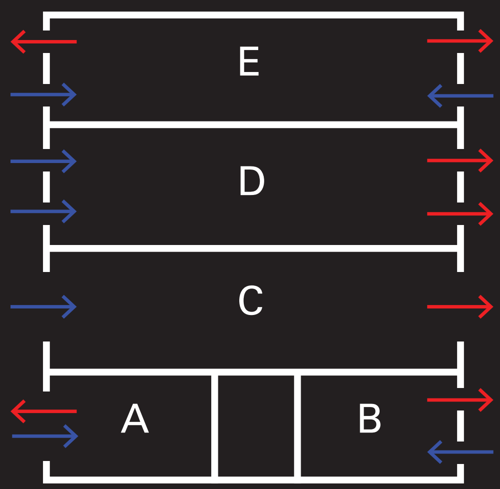


Ill 45. Forces acting on tall and small building structures. The diagram shows how the tall building is more affected by the wind load that the small building, which means that the lateral loads are stronger and can become higher that the gravity loads.

WIND TURBOLENCE AND DESIGN

Ill. 46. Building shapes and its effect on the wind condition near the ground. Making a base on the building can decrease the uncomfortable drag from the wind and the ground. The inconvenience of the wind can also be minimized by breaking the wind when it passes the building by adding staggering to the facade.

NATURAL VENTILATION



ill. 47. Different ventilation strategies. Double-sided ventilation (C-E) is more efficient that single-sided (A-B). Small openings (E-D) can help to control the floor of the ventilation but the natural ventilation strategy is also determent by the drive force being thermal difference or wind (E, thermal conditions D, wind)

Most tall buildings are designed such that the internal environment is completely enclosed and disengaged from the climatic conditions of the site. Thereby the building is 100% reliant on mechanical air conditioning for the comfort of their occupants. [Maunsell; 2002]

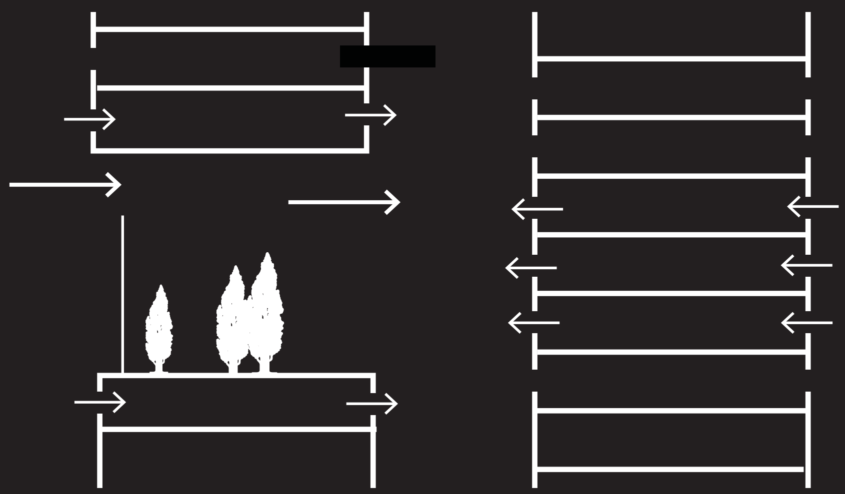
The possibility of integrating natural ventilation in the building is investigated to see if the use of natural ventilation can optimize the energy performance of the building. Incorporation natural ventilation has a great impact on the design and layout of the building and is therefore important to have in mind from the beginning of the design process.

By allowing air in and through the internal spaces of the building, natural air conditioning can be achieved. Natural ventilation can save energy and create a healthier internal environment. The comfort level of occupants can also get higher because the occupants get the opportunity to influence the internal environment and thereby have a higher tolerance of temperature differences and draft. [Maunsell; 2002]

The potential energy savings and other benefits of natural ventilation are valid for tall buildings as in low-rise. Until now there have been few tall buildings that have taken advantages of natural ventilation because of lack of ability to control the environment 100% when using this kind of ventilation. [39]

Most buildings with a natural ventilation system use a mixed-mode (or hybrid) design. This approach reduces the risks associated with a purely natural system. [Etheridge, Ford; 2008] When outside temperature and humidity conditions dictate a switch to mechanical air-conditioning, the building management system automatically locks the windows and heating or cooling can be provided.

Using natural ventilation the quality of the air and noise from open windows has to be taken into consideration. The incoming air cannot have a poor air quality and noise, for example generated by the city traffic, has to be taken into account. [Etheridge, Ford; 2008] This means that in this project the openings for the ventilation and the possibility to open win-



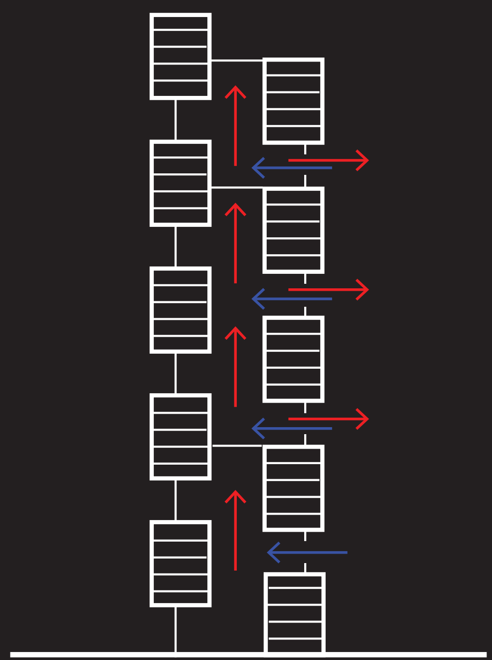
Ill. 48. Ventilation strategies achieved by having an atrium in the center of the building and green open space towards the outside.

dows have to be away from the ground level along the roads of Roskildevej and Tårnvej.

There are different ventilation strategies and wind flow patterns that can be implemented in the design, see ill. 47 and 48. The strategies show how the fresh air can enter and exit the building. In all cases the flow pattern is such that fresh (external) air enters each occupied space. The most efficient are double-sided ventilation which therefore is wanted in the building.

Thermal storage is particularly useful with natural ventilation to provide cooling during the day by means of cooling of the thermal mass during the night.

When designing tall buildings the designer needs to be aware of the risk of too high pressure difference in the building. The problem with too high pressure difference can be overcome by the use of internal resistances (small openings), or by the use of segmentation i.e. the building is divided into several segments that are isolated from one another by open space, see ill. 49



Ill. 49. Fragmentation of the ventilation strategy to avoid too high pressure difference inside the building

SPACE

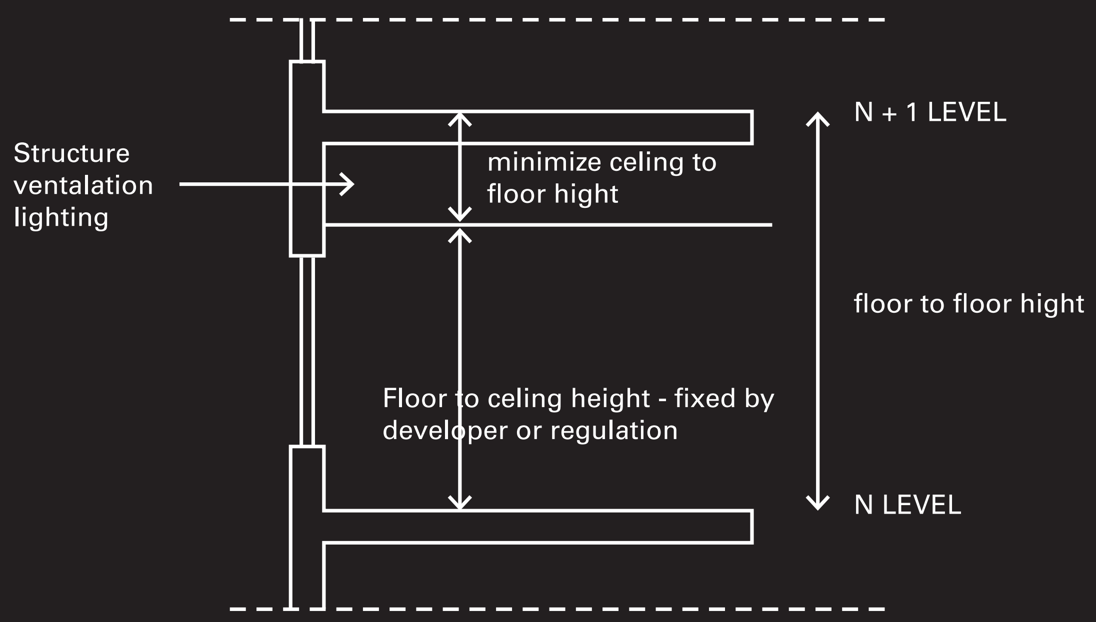
The optimizing of space is evident in high rise buildings. The changes of the floor-to-floor height might be minor for the single floors, but when designing a multi-storied building it can add up to a significant amount. Changes in the height thereby have a significant influence on the overall cost and the density of the building. [Hira; 2007]

The floor-to-floor height is determent by of the required ceiling height, the depth of the structural floor system and the depth of the space required for mechanical distribution. Saving height can be obtained by reducing the floor span and thereby minimizing the height of the structure. [Hira; 2007]

The ceiling heights of commercial functions can varieties between 2.7m and 3.7m. Ceiling heights in modern office buildings is often minimum 2.7m., whereas the height of a hotel and residential spaces can be as low as 2.5m. [BR08] The elements influence on the floor-to-floor height is illustrated in ill 50.

Another aim for the designer is to minimize the core area and maximize the rentable space within the building envelope. To appreciate the importance of minimizing the core area an investigation of different size, thinness and core are made in ill. 51.

FLOOR-TO-FLOOR HIGHT DEFINITION

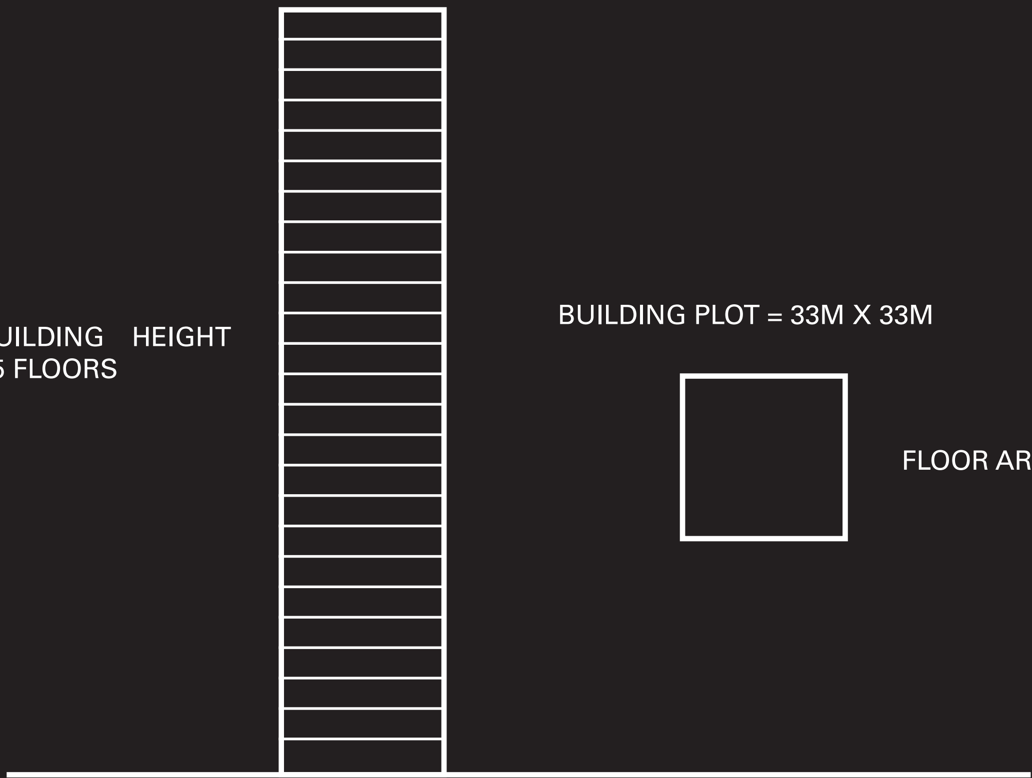


Ill 50. The definition of the floor-to-floor height and the elements that are influencing the height of the room.

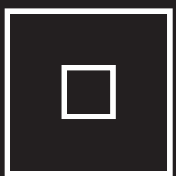
OPTIMIZING OF SPACE

BUILDING HEIGHT
25 FLOORS

BUILDING PLOT = 33M X 33M

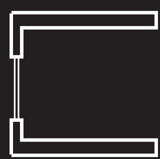


FLOOR AREA **27225** M2



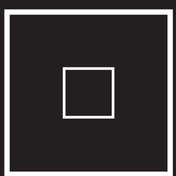
FLOOR AREA **26575** M2
CORE SPACE **651** M2

CORE: 10 X 10M
THIKNESS: 700MM



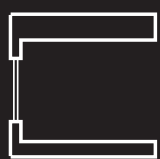
FLOOR VOLUME **667000** M3
CEILING SPACE **13621** M3

CEILING HEIGHT 0,5M
ROOM HEIGHT 3M



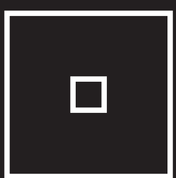
FLOOR AREA **26750** M2
CORE SPACE **475** M2

CORE: 10 X 10M
THIKNESS: 500MM



FLOOR VOLUME **661560** M3
CEILING SPACE **19060** M3

CEILING HEIGHT 0,7M
ROOM HEIGHT 2,8M



FLOOR AREA **26714** M2
CORE SPACE **551** M2

CORE: 8 X 8M
THIKNESS: 700MM

Ill 51. The areas and volumes are all calculated with reference to the same plot of a 25 storey building. The factor of reducing the construction and ceiling height plays different roles in optimizing the rentable areas. By adding parameters together they play an important role in optimizing the space.

DAYLIGHT AND SHADING

The integrated design focuses on the early design phase for improving the performance of the building. In this project the daylight strategy related to the geometric modulation of the building is therefore investigated.

Some of the main factors concerning daylight in the physical performance of the building are the minimization of solar gains during the summer, the maximization of solar gains during the winter and the efficient use of daylight. Making early design decisions based on these three aspects can have a significant impact, among others, on the reduction of energy consumption. [Fasoulaki; 2008]

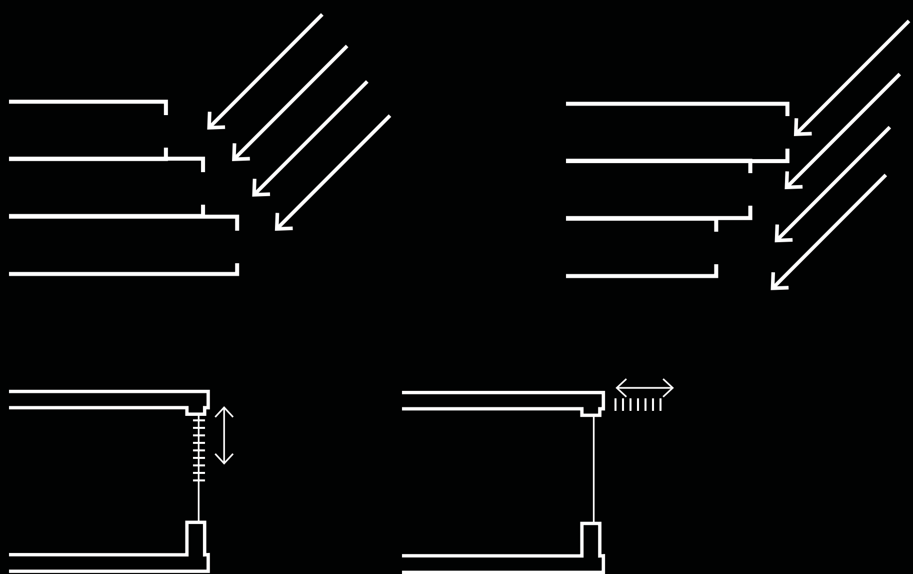
Daylight has a great impact on the indoor environment concerning the energy use for lightning and the feeling of the space. The daylight conditions can therefore influence the modulation of the shape of a building.

Narrower buildings can have a higher daylight factor than wide buildings, where the distance is long from the inner room to the facade. Some early investigations of the daylight factors compared with the geometry of the room are simulated to see how the geometry affects the daylight factor. The investigations can be seen in ill 53.

The use of an atrium is also a common element to increase the illuminance level of interior spaces in a low building. The use of an atrium is also deeply dependent on the functions of a building. Ill. 54 shows some investigations that indicate the efficiency of using an atrium with or without balconies for improving the daylight conditions in high rise buildings.

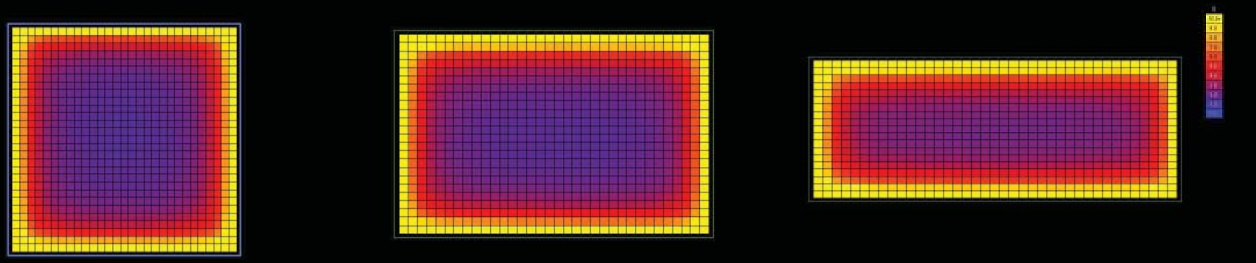
For optimizing the daylight conditions in terms of direct and indirect sunlight, fixed and movable shading devices can be added as well as using the building volume for shading. Some of the strategies of shading can be seen in ill. 52.

DAYLIGHT AND SHADING



Ill. 52. The illustration shows different ways of incorporating shading to the building volume. By pushing the building mass back or forward, it is possible to minimize or maximize the direct sunlight. Moveable shading if front of or above the windows is an option for controlling the direct sunlight.

DAYLIGHT AND GEOMETRY



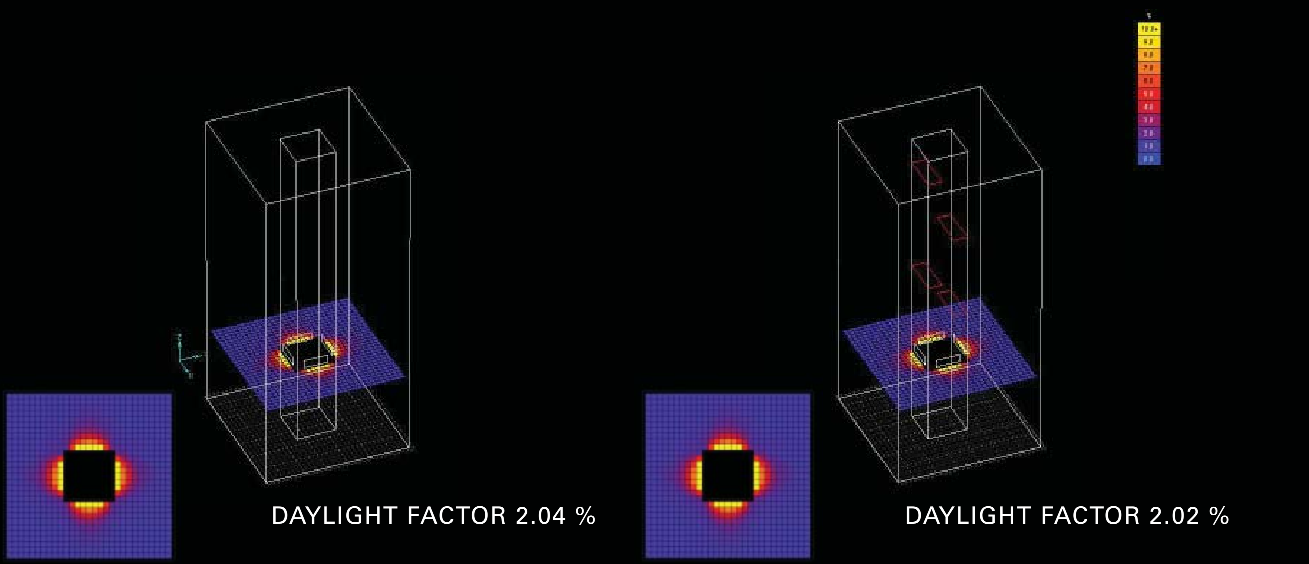
SIZE 33 X 33 M
DAYLIGHT FACTOR 5.32 %

SIZE 40 X 26 M
DAYLIGHT FACTOR 5.36 %

SIZE 49 X 19 M
DAYLIGHT FACTOR 6.35 %

Ill. 53. Daylight factor compared with the shape of the room. The investigation shows that the debt of the room should not become more that 9 meter from the facade to get better daylight factors.

DAYLIGHT AND ATRIUM



DAYLIGHT FACTOR 2.04 %

DAYLIGHT FACTOR 2.02 %

Ill. 54. Creating better daylight conditions inside the building volume can also be achieved by adding an atrium. Investigations are made to see if the daylight can reach down thought an atrium that is 80 m high. The investigation also shows that adding obstacles down though the atrium does not affect the daylight factor noticeable.

FUNCTION AND ORIENTATION

The mix program of the building creates different sections of activities on the different floors. To active a high performance of the building, in concern of low energy use, it is important that the shape of the building and the placement of functions take both direct and indirect daylight into consideration. Ill xx states some of the important parameters that are evident in the different functions.

Optimal shapes of the floor plans and the placement of the apartments and the offices are investigated in ill. 55. This is to study how the internal functions, that are stated in the program, influence the shape of the building.

FUNCTION AND NEEDS

HOTEL/RESTAURANT

ORIENTAION OF VIEW

HIGH HEATING NEED AND SMALL COOLING

DIRECT AND INDIRECT SUNLIGHT

OFFICE

NORTH-SOUTH ORIENTAION

HIGH COOLING AND SMALL HEATING NEED

INDIRECT - NO DIRECT SUNLIGHT

APARTMENT

EAST-WEST ORIENTAION

HIGH HEATING AND SMALL COOLING NEED

DIRECT AND INDIRECT SUNLIGHT

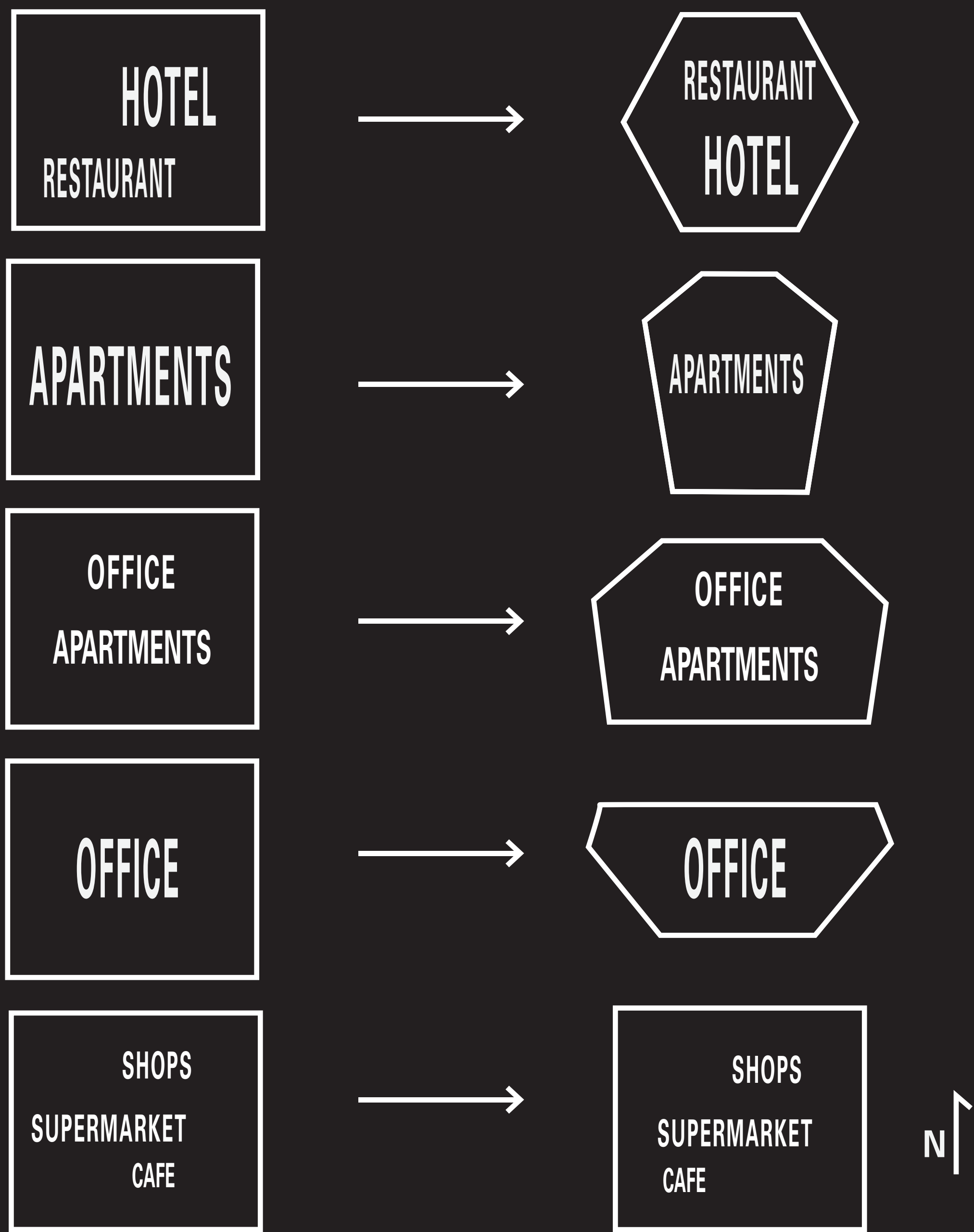
SHOP/CAFE/SUPERMARKET

NO SPECIFIC ORIENTATION

HEATING AND COOLING NEED

INDIRECT DAYLIGHT

OPTIMIZING SHAPE ACORDING TO FUNCTION



Ill 55. The diagram shows the different plans of the building according to the internal functions. The placement of the functions is made from estimations about the internal heat load and the need of daylight. The illustration shows how the plans can be shaped to optimize daylight condition according to the program of the plan and how the apartments and offices can be placed in the plan.

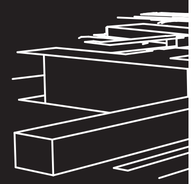
VOLUME AND PLACEMENT

When designing tall buildings it is very important to take the scale of the building into consideration. The perception of scale has great impact on the autonomous expression of the building on a low scale context. Also the vision declare that the building have to respect and relate itself to the context.

As explained in the program the maximum building volume is 625% of the site and the maximum building height is 25 floors. The maximum building volume can be arranged in different ways on the site. Some of the extreme placements of the building volume can be seen in ill. 56.

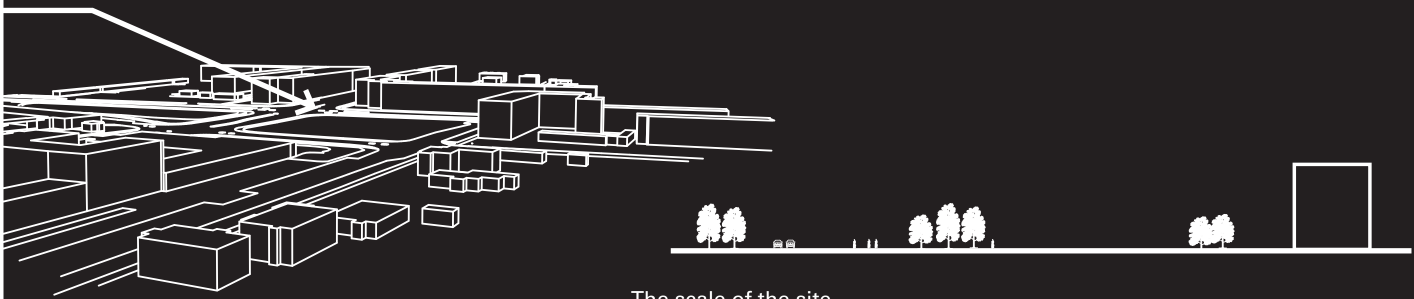
The illustration shows that building in the height makes the building stand out and visible from places far away from the site. Building low minimize the visibility far away but increase the solidness of the volume, which have a negative impact on the interpretation of openness and humanness human scale near the site. This means that the building design should be a compromise between the two extremes to take the human scale of the building into account. This challenge is going to be investigated in the sketching of the design process.

SITE 22400 m^2

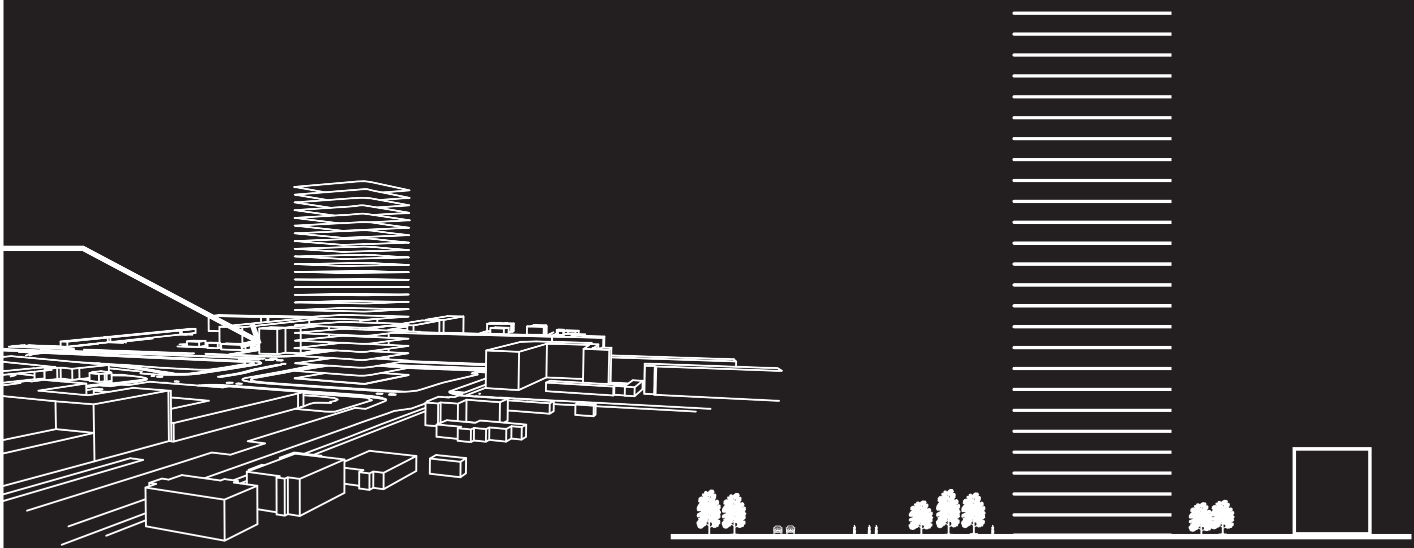


265 % BUILDING

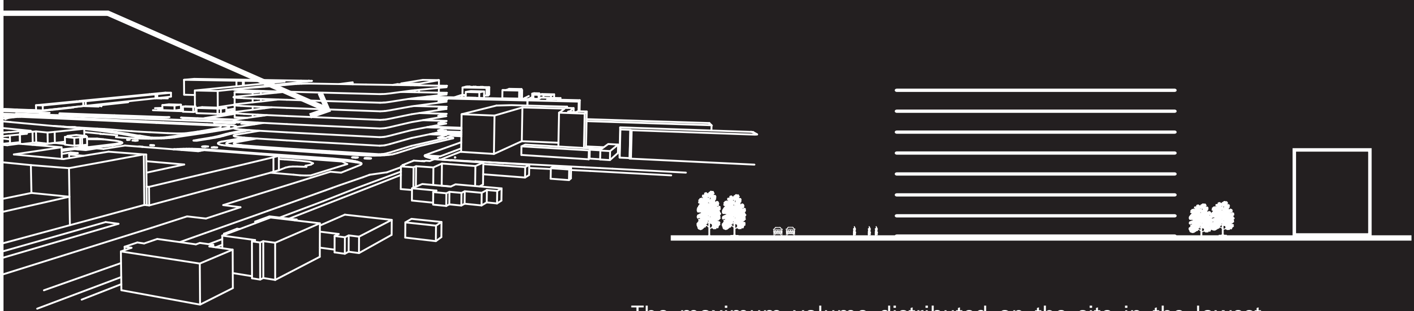
265 % BUILDING



The scale of the site



The maximum volume distributed on the site is 25 floors. The high of the building and the low footprint makes the impression vertical and not coherent with the human scale. The small footprint also leaves more open space free for public activities at the street level.



The maximum volume distributed on the site in the lowest height possible. The scale of the building is not remarkable higher than its surroundings, and leaves no open space at the site. The building becomes bombastic and not relating to the human scale because of the dense volume.

ill. 56

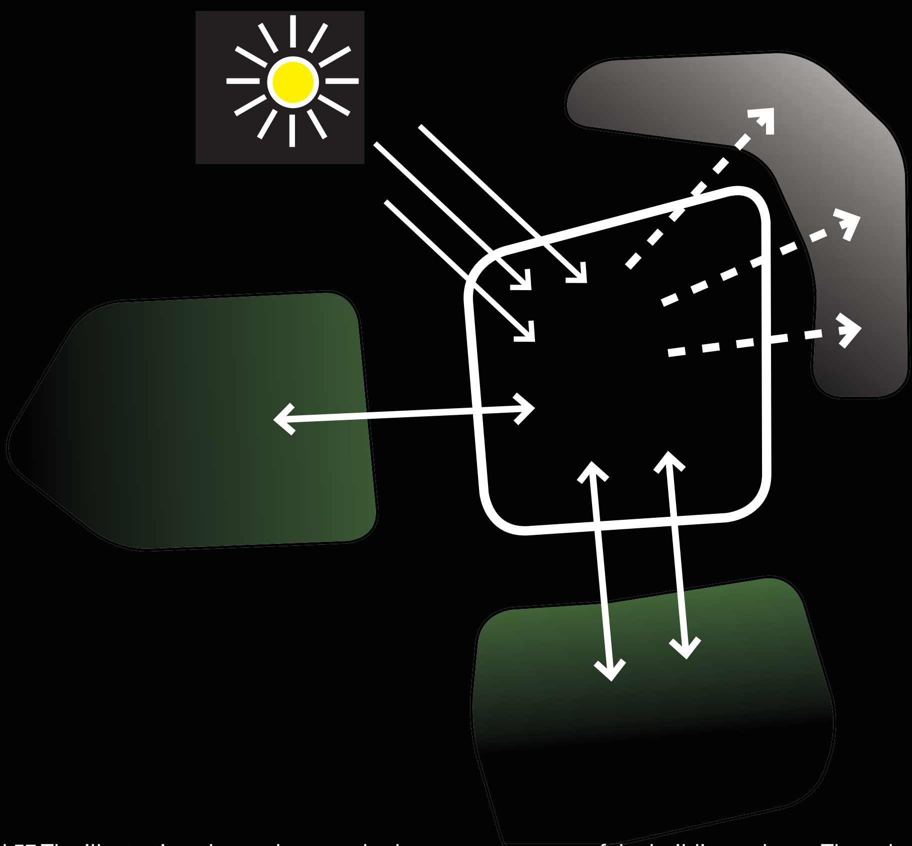
VOLUME AND PLACEMENT

The building site is relatively big and there are therefore many options for placing building mass and choosing the highest point of the building

An investigation is therefore made to clarify where the overall placement of the mass should be and also to study where the highest point of the building should be placed. The placement of mass and the highest point take different parameters into consideration which can be seen in ill 57.

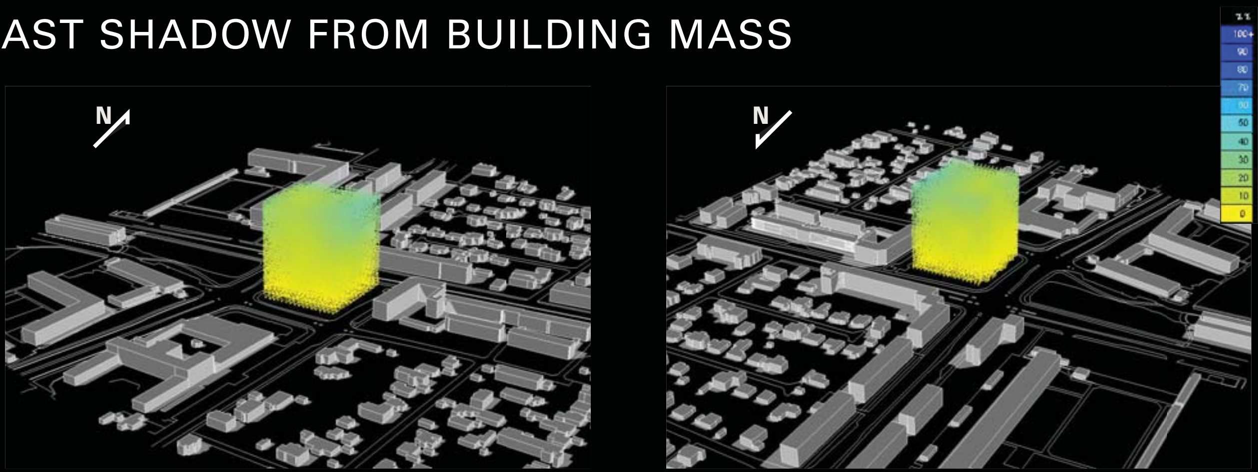
A cast shadow investigation is made in ill. 58 and 59. This is to show the consequences of placing an 80 meter high building near the perimeter of the site.

PARAMETERS FOR PLACEMENT



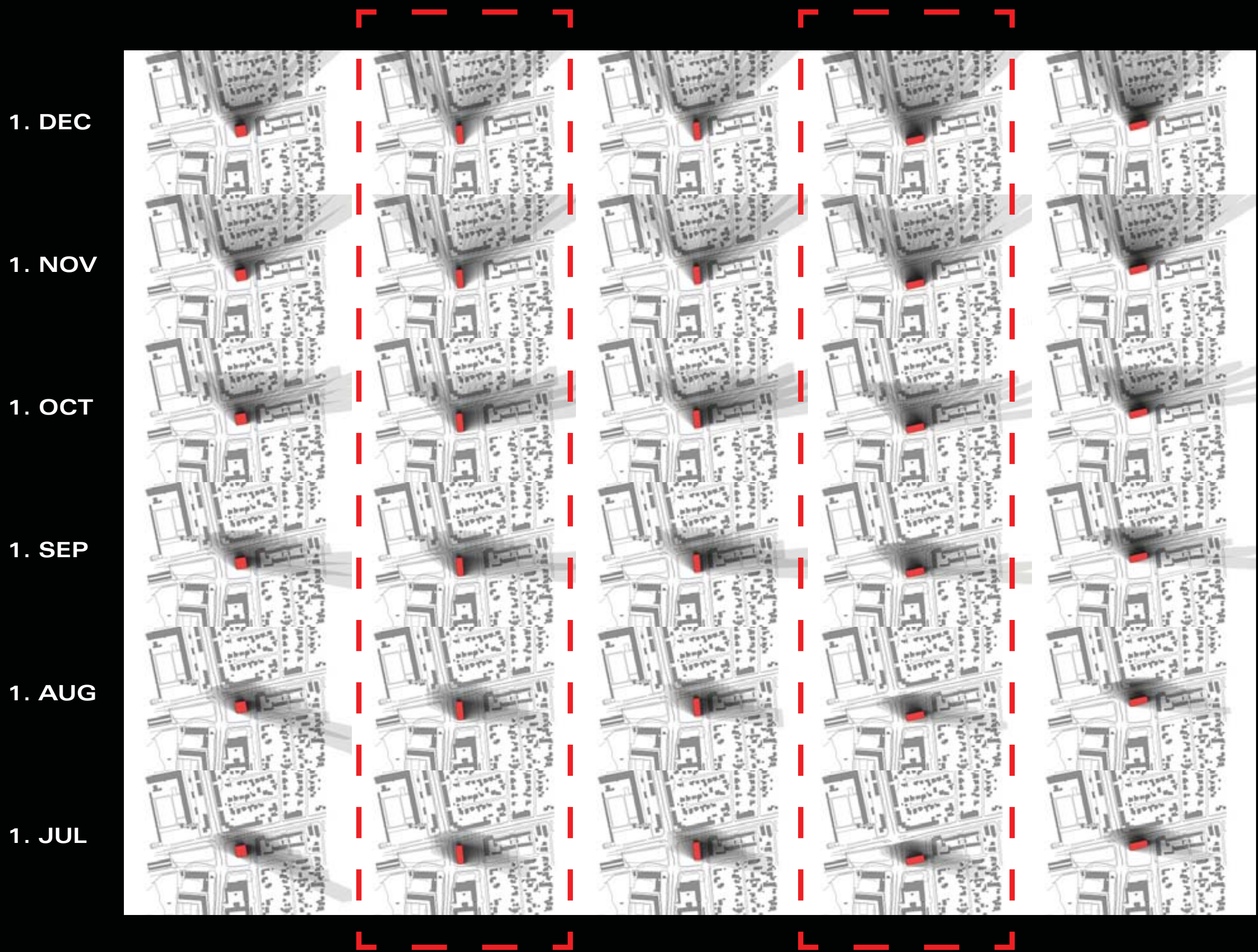
Ill 57. The illustration shows the cast shadow consequences of the building volume. The colors indicate the impact the volume has on the buildings near the site. Yellow colors being the lowest impact and blue color the height impact.

CAST SHADOW FROM BUILDING MASS



Ill 58. The illustration shows the parameters that can have an impact on the building volume and height. The parameters being connection to green areas illustrated in the context analysis, cast shadows and the access of daylight on the site.

CAST SHADOW ON CONTEXT



Ill 59. Cast shadows illustrated with different placement of the building volume at different times of the year. The red line marks the best solution when looking at the cast shadow consequences being on north or west of the site.

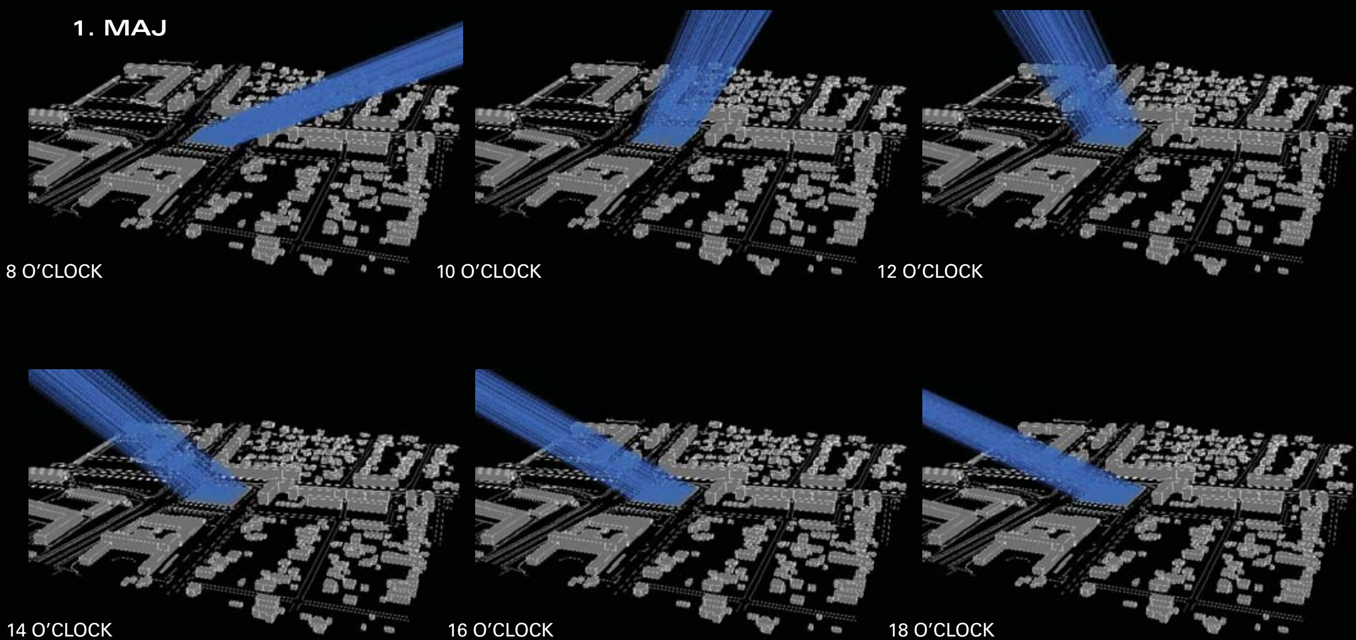
VOLUME AND PLACEMENT

The height of the building in relation to the context is investigated in ill 61. The illustration also takes the expression of the building into consideration when driving at the main road of Roskildevej towards central Copenhagen.

The connection to the greens areas near the site is evaluated in ill. 62. A good connection to the green areas is wanted even though the site and the green areas are separated by roads.

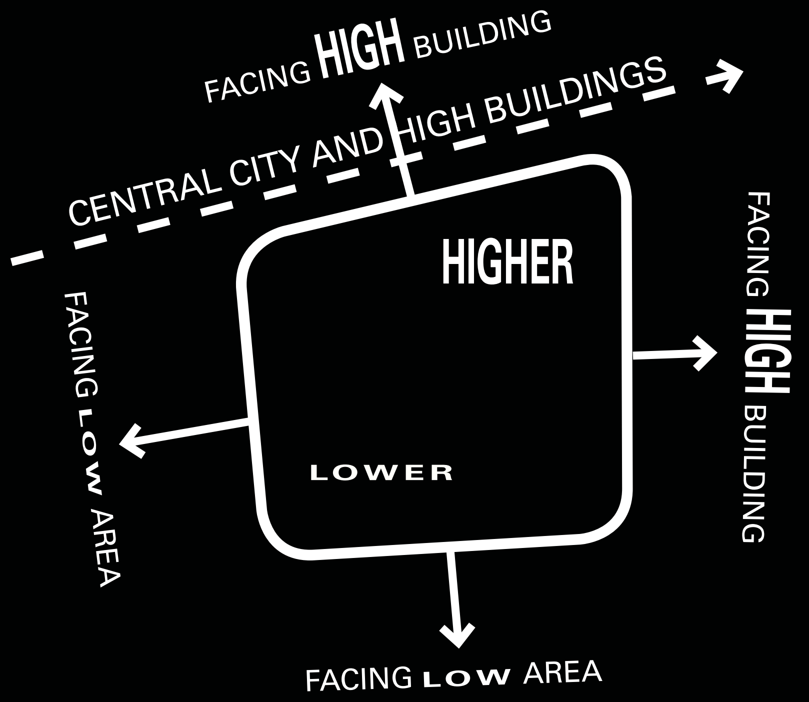
The site also has to contain outdoor public activities. It is therefore important that the building does not cast shadows on the site and allows daylight to reach the open space. The daylight access to the site compared with the placement of the building is therefore investigated in ill. 60.

DAYLIGHT ACCESS ON SITE



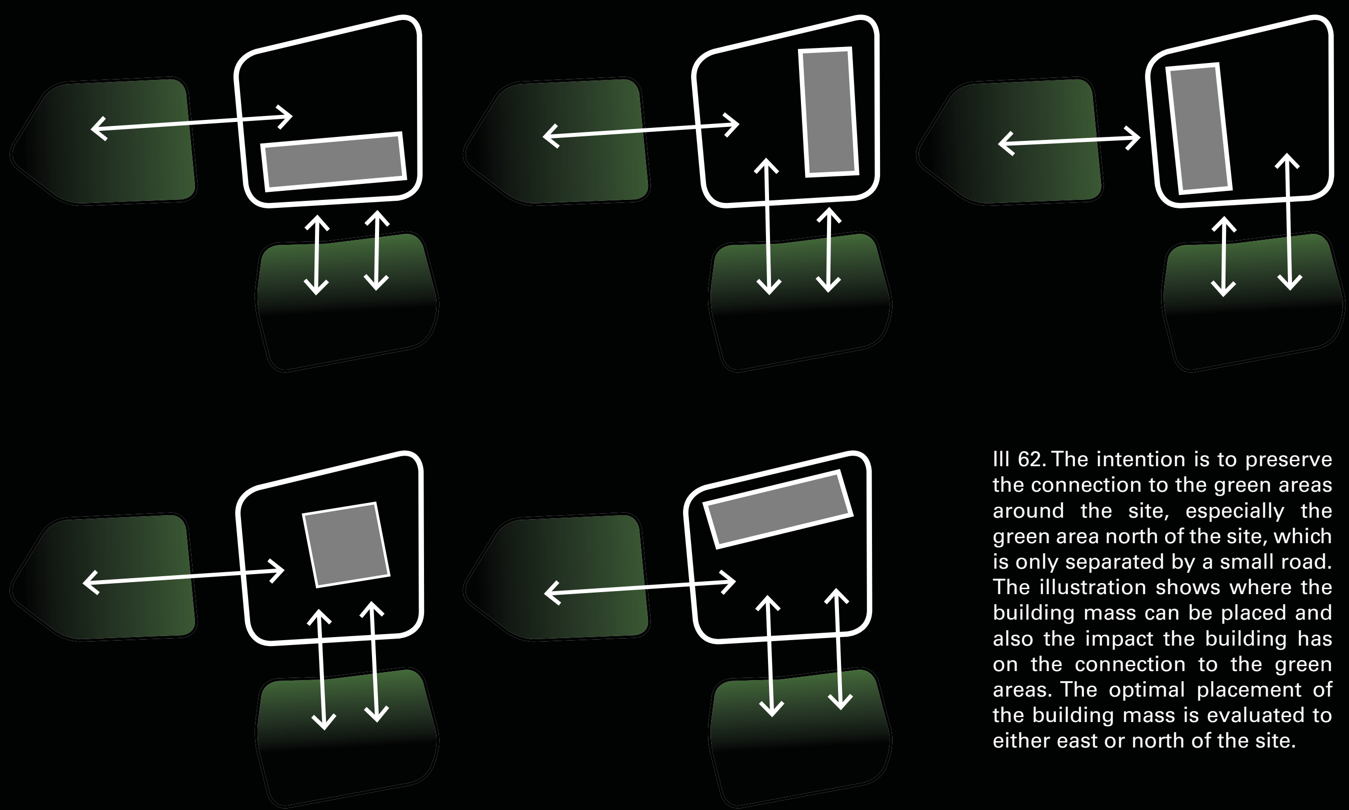
Ill 60. The access of sunlight to the site and the placement of the building are investigated to minimize the cast shadows onto the site. The investigation shows that the optimal placement is in the north east side of the site.

THE CONTEXT



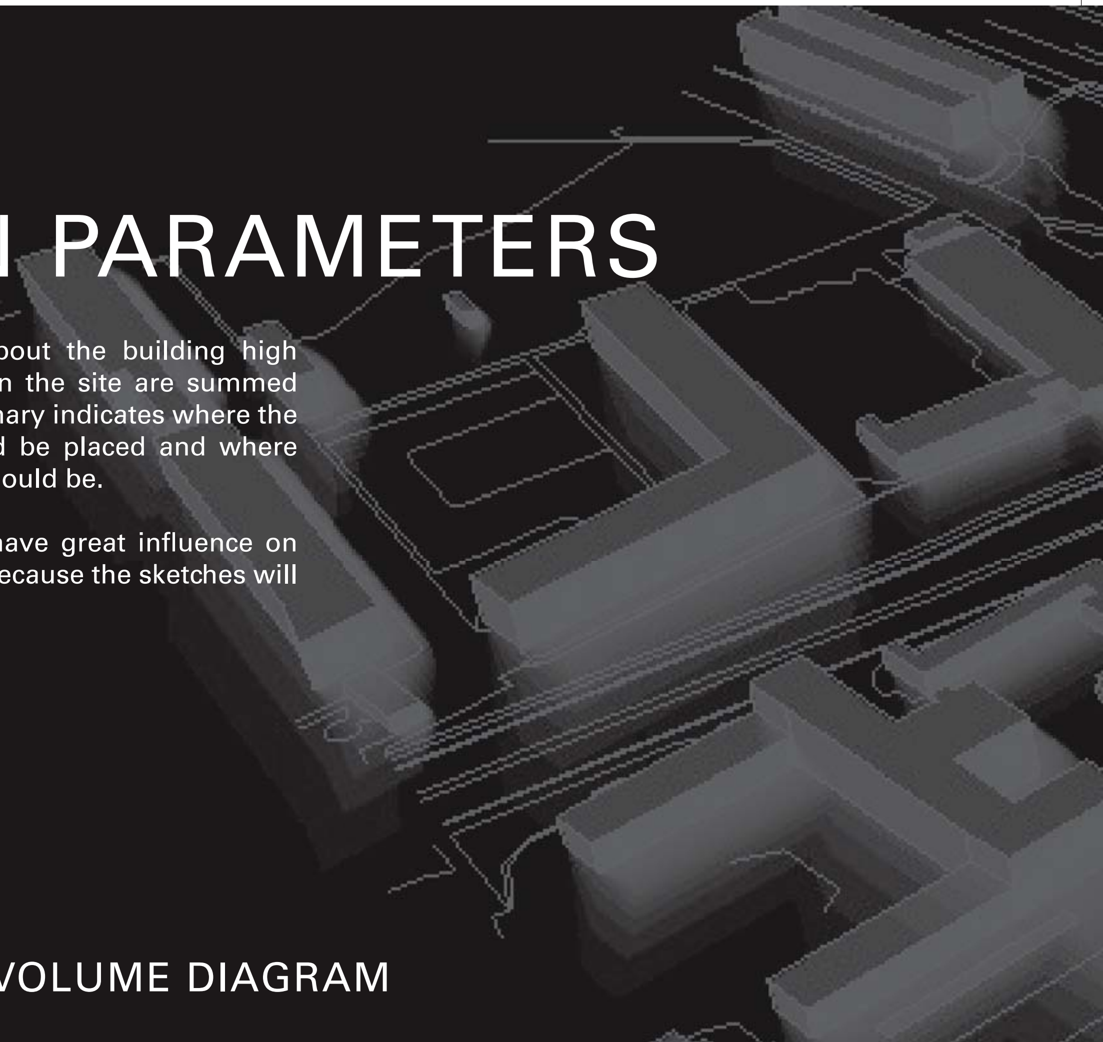
Ill 61. The experience of the exiting city fabric also plays a role in the placement of a high building volume. The height of the building should relate to the height of the surrounding context.. The building height should also relate to the view from the main road towards the central city of Copenhagen

CONNECTION TO GREEN AREAS



Ill 62. The intention is to preserve the connection to the green areas around the site, especially the green area north of the site, which is only separated by a small road. The illustration shows where the building mass can be placed and also the impact the building has on the connection to the green areas. The optimal placement of the building mass is evaluated to either east or north of the site.

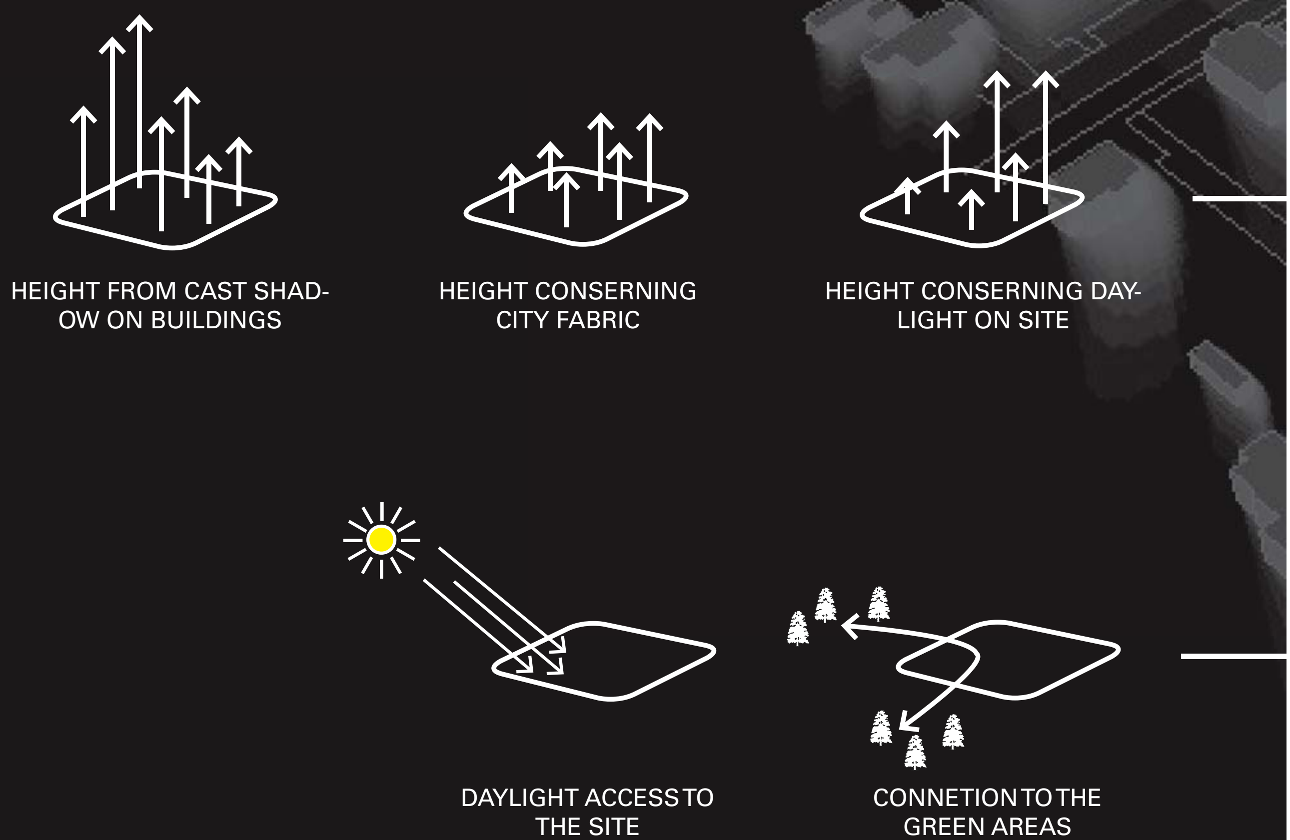
DESIGN PARAMETERS



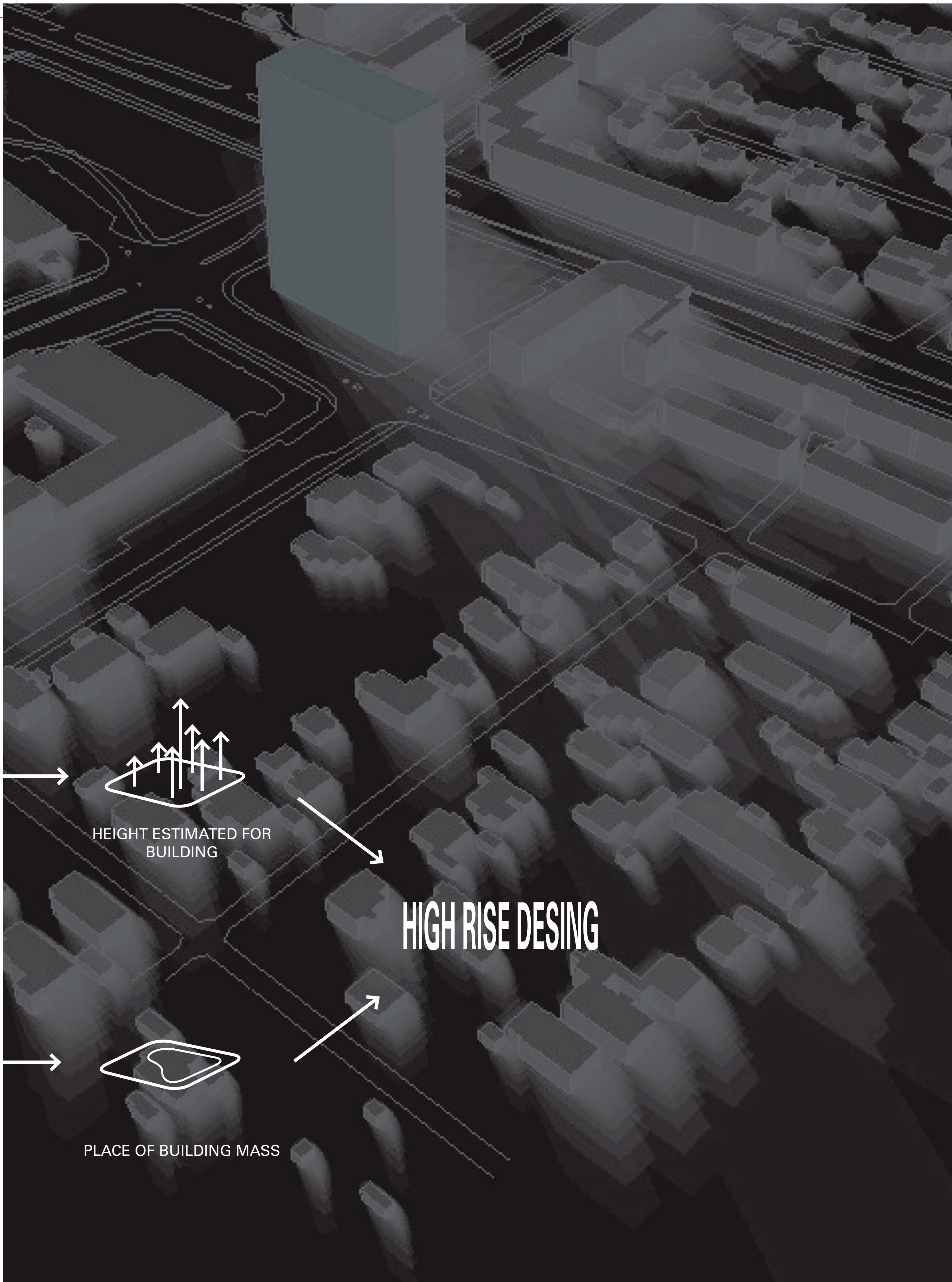
The investigations about the building high and the placement on the site are summed up in ill. 63. The summary indicates where the building mass should be placed and where the maximum high should be.

The conclusion will have great influence on the sketching phase because the sketches will be based on it.

HEIGHT AND VOLUME DIAGRAM



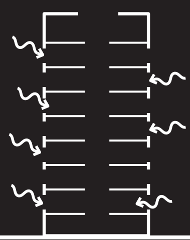
Ill 63. The diagram sums up the investigation made of the placement of the building, volume and height. The illustration also idisplays the results of the investigation and gives estimation on where the maximum high and the overall building mass should be placed on the site.


HEIGHT ESTIMATED FOR BUILDING
HIGH RISE DESING
PLACE OF BUILDING MASS

DESIGN PARAMETERS

Design parameters are made to sum the initial investigations and the analysis, which have been made in the early stages of the design process. The parameters describe the main elements that should be integrated into the building design to improve the performance and the perception of the building.

The parameters serve as guide lines for the sketching phase and all of them will therefore not be implemented into the design. The designers have to pick the parameters that are the most relevant for the design concept and the parameters that refine the aesthetics of the building design.

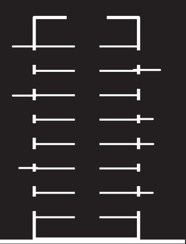


DAYLIGHT FACTOR

The openings of the façade as well as the building geometry should be corresponding to the need of daylight inside the building to minimize the use of artificial light. Given the earlier investigation the maximum width of the building should be approximately 20 meter.

WIND

Wind turbulence around the building is important to avoid. The shape of the design has to break down the wind to minimize uncomfortable wind at the street level

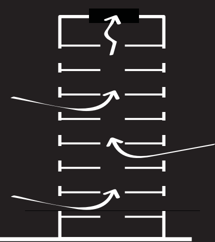


SHADING

To avoid overheating the shading of the windows have to be taken into consideration when designing the facade. The shading can prevent overheating in the summer and still allow daylight in the winter.

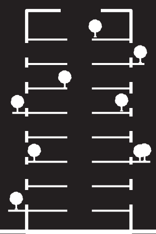
PLACEMENT OF FUNCTIONS

The placement of function should relate to the orientation of the building. Hence the functions different needs are corresponding with the performance of the building.



VENTILATION

Natural ventilation can be implemented as an active part of the design to minimize the energy use for obtaining good thermal conditions indoor.

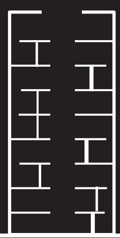


GREENERY

Greenery can be use for their ecological and aesthetic benefits of the building and also improve the performance of the building and the indoor environments.

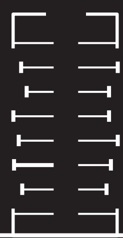
THE FACADE

The façade of the building should reflect the outdoor environmental as a membrane with adjustable openings. The facade has to respond to very cold winters and hot summers and therefore have to provide both insulation and openness.



CONSTRUCTION

Optimizing the construction is an important parameter to obtain the optimal use of space. The construction therefore need to be integrated into the design and long spans need to be avoided.



RECESSES

Deep recesses can provide shade on the building's hot side and thereby optimize the performance of the building in form of energy use. Windows can be totally recesses in from of balconies or similar.

III 64.

SKETCHING

In the sketching phase the main design of the building w
and volumes are investigated to find to most optimal shap
phase ends when the concept and the overall shape of th
ready to enter the synthesis phase.

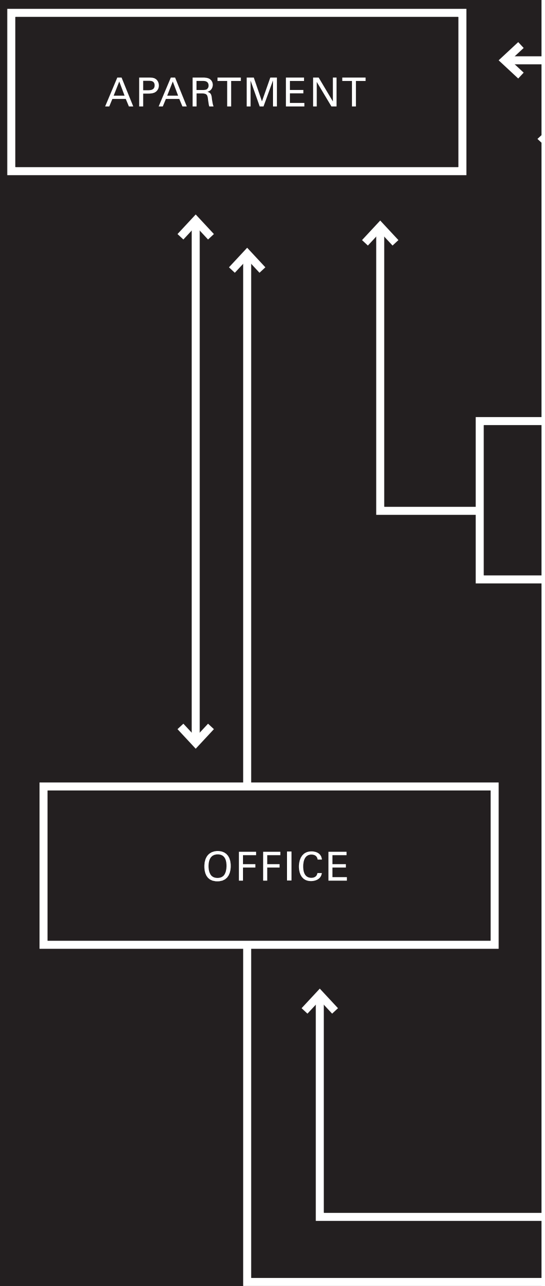
g will take place. Different shapes
hape and aesthetic expression. The
f the building is found and thereby

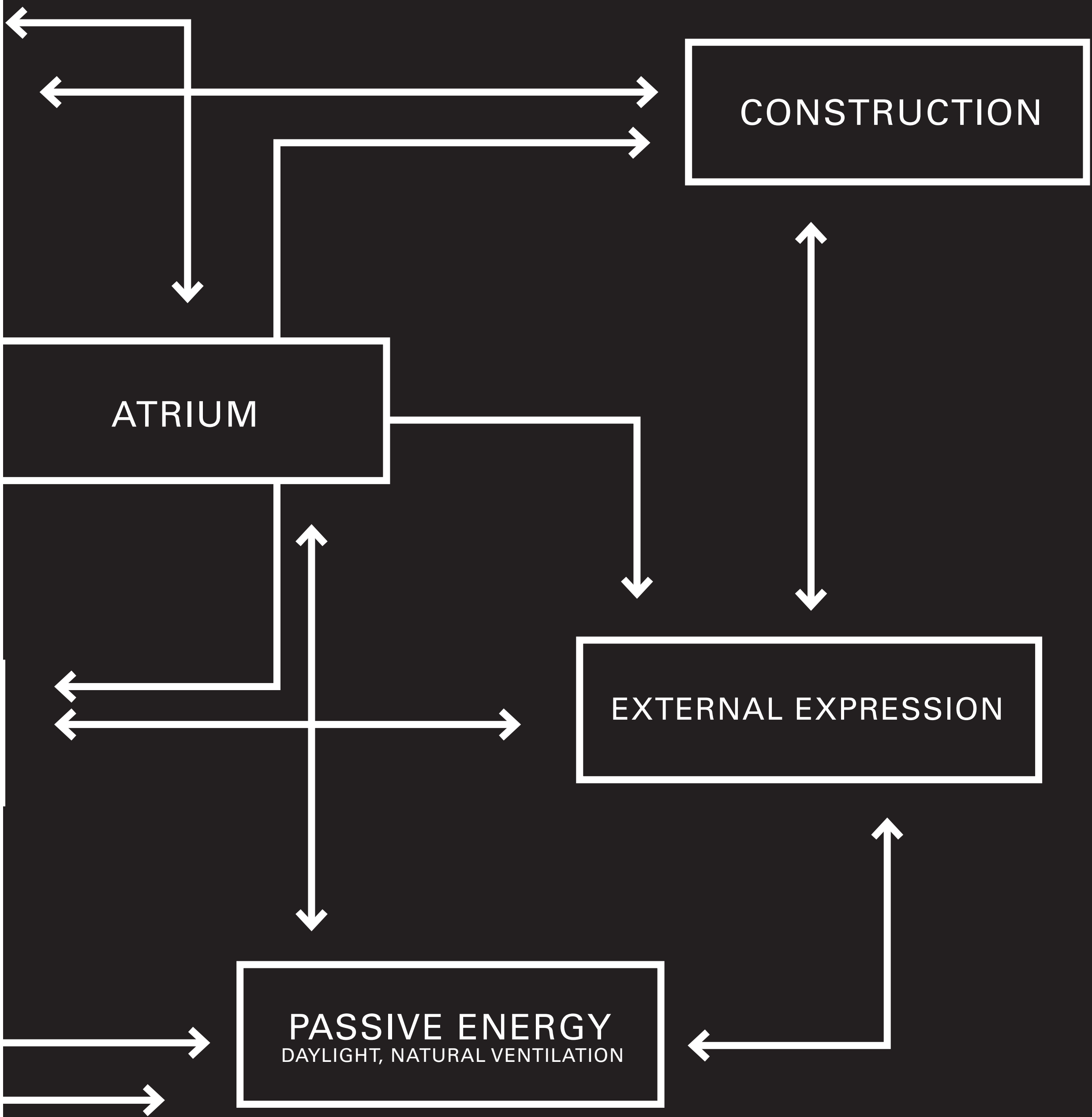
PROCESS

The next chapter describes the design process of the mix use high-rise building. The process goes through different phases and iterations and is therefore not a linier process as described in the integrated design process p. 09 – 10. The process therefore takes different elements into consideration from the early stages of designing which also is evident in the initial investigation. The process is split up into main elements even though they are all worked on simultaneously and connected in the design process. The elements in the design process can be seen in diagram 65.

The process in this paper has the goal to describe how the form has evolved through the integrated design process in the sketching phase. The process will therefore be described as a linear process to create a clearer overview for the reader although the process has been iterative and have had an inherent complexity of shapes and concepts interacting on each other.

The process is divided into iterations before and after the main concept is developed. The process before the main idea is chaotic and not stringent. The investigation in this stage is mainly investigating different shapes. Therefore are some of the iterations not relevant for the paper and have been neglected. After the development of the main concept the process moves into a different stage where the concept and ideas are developed even further. The progression through the process is made possible by the use of different tools and models which also will be discussed through the visualization of the process.





Ill. 65. Diagram of the main element that will be discussed in the process

EXTERNAL EXPRESSION

The first iteration is concentrated about the expression of the building and the idea about a high-rise rising placed into the context. This phase is also about testing the scale of the building and how the elements from the analysis and initial investigation be implemented into the building design.

The investigation is about rotation of the plans, stacking different floor slaps, scaling, and pixilation of the elements that joint the building together. Plans of the high rise are also a part of this early process, with a traditional horizontal separation of the different functions see ill 67 and 68.

The construction of the building is also tested at this stage and the possibility of having a core as the only barring element is calculated, see app. 1 and ill 66.

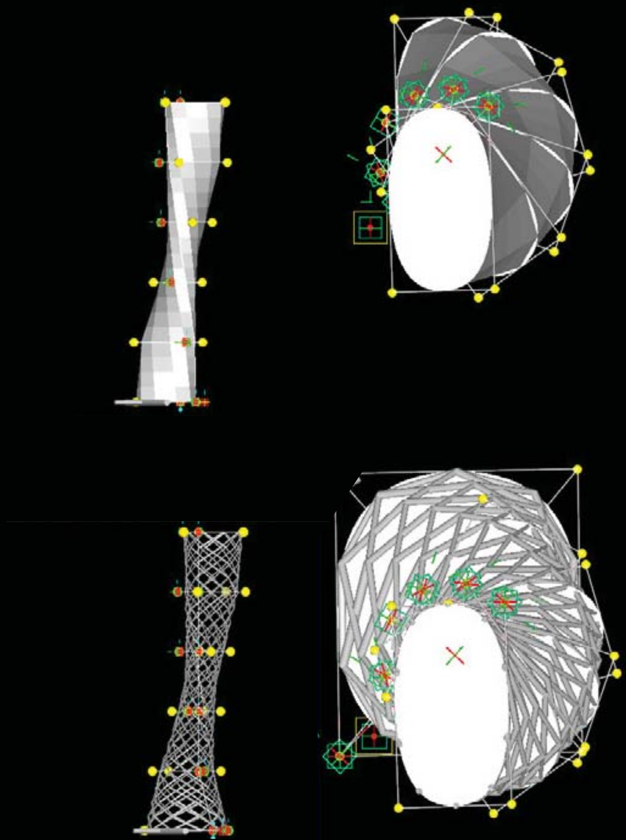
CORE 5 X 5m
THICKNESS 0,5m

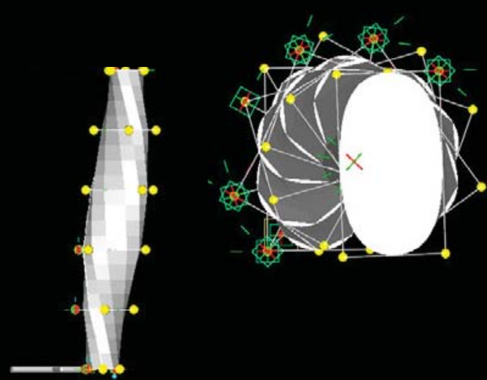
STORIES	15	20	25
N/A + M/W	15	25	37

CORE 5 X 5m
THICKNESS 1m

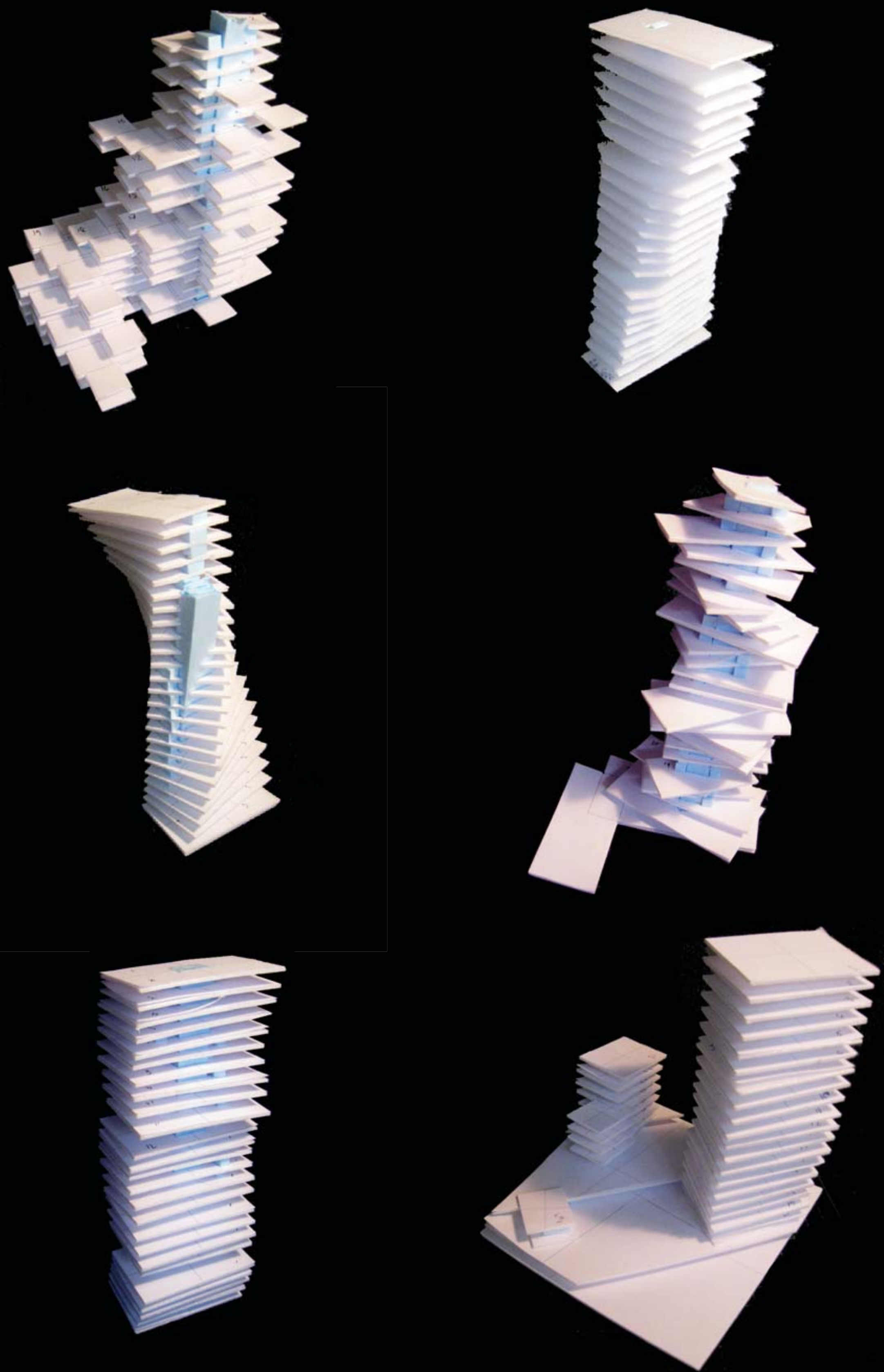
STORIES	15	20	25
N/A + M/W	15	25	37

Ill. 66. Calculations of the core dimensions and the stresses on the construction as a result of the lateral and vertical loads. If the stresses exceed 200 Mpa the construction becomes unstable.





Ill. 67. Investigation of GenerativeComponent where twisted and scaled shapes are visualized



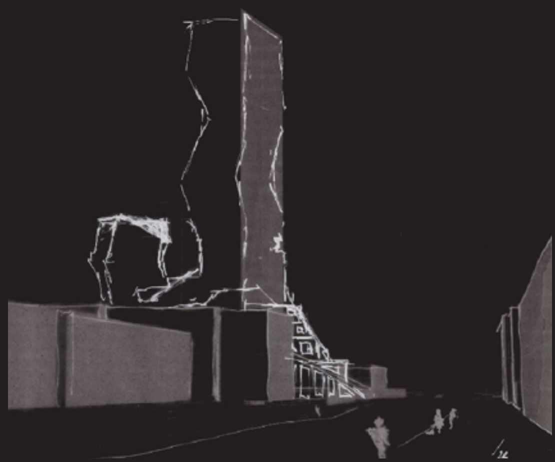
Ill. 68. Models showing some of the shapes investigation made in the early process and of the project.

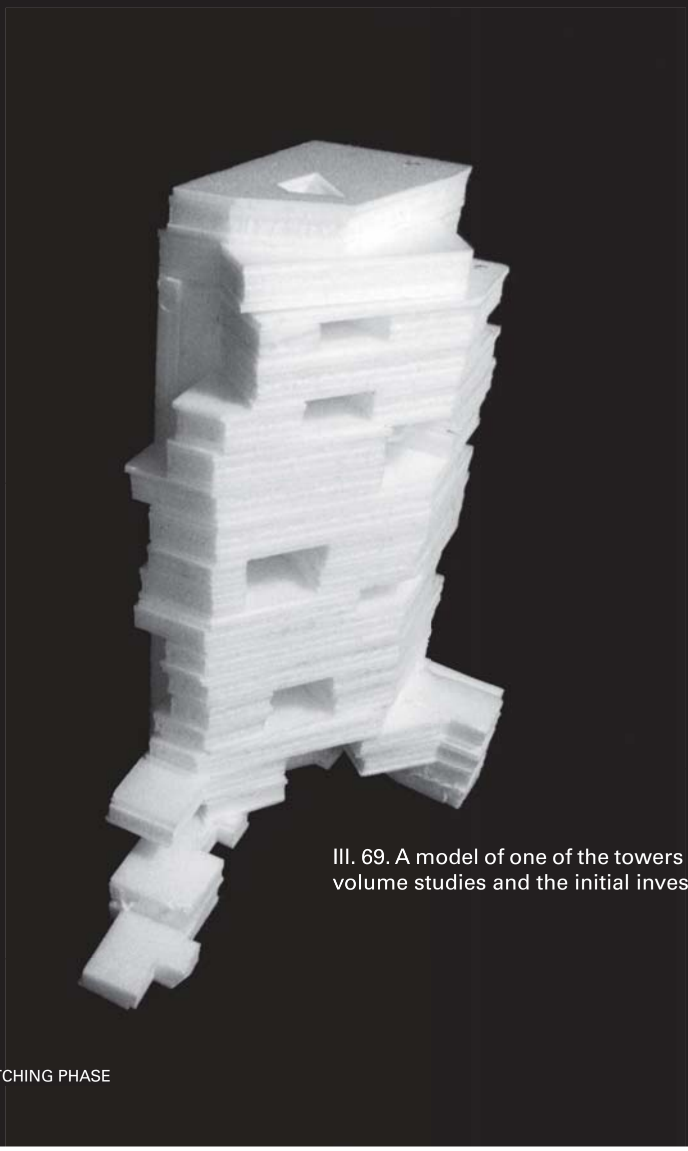
EXTERNAL EXPRESSION

The solidity of the building in the investigation showed that makes the building stand out as an alien element in the context. The concept is therefore changed from being one isolated element to towers rising on the site. The site is developed with different levels to emphasize the rise of the volumes. Each tower containing a different function having the same aesthetic expression.

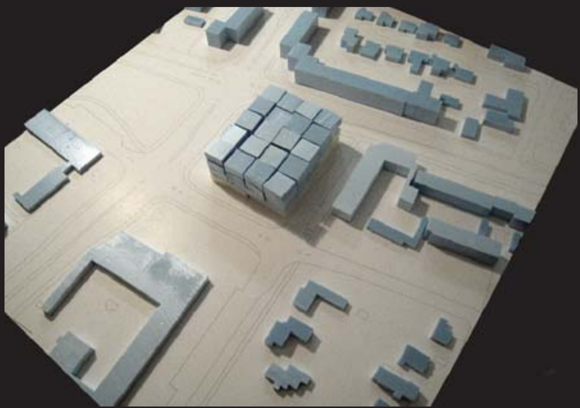
It is chosen not the develop any further on this concept, because the form do not contain the architectural quality that is wanted and the building is not well integrated in the context.

A new investigation is therefore made. The point of departure is in one main tower raised at the north side of the site.





Ill. 69. A model of one of the towers that is a result of the volume studies and the initial investigations



Ill. 70. Volume studies where the different functions are placed at the site. The volume is placed according to the placement analysis in p. 75 – 76.

Ill. 71. Perspective drawing of the building seen from the west.

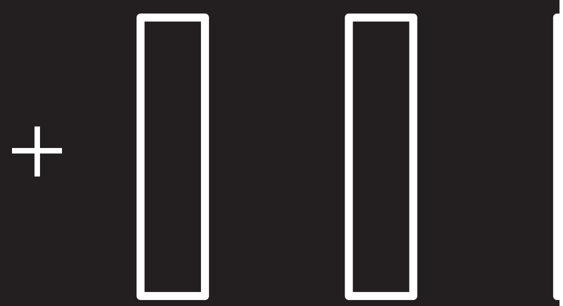
THE MAIN CONCEPT

The result from the initial investigation of the plans of the functions p. 67-68 and the daylight analyses gives a clear idea about how the optimal placement of the function could be according to energy saving and good daylight conditions.

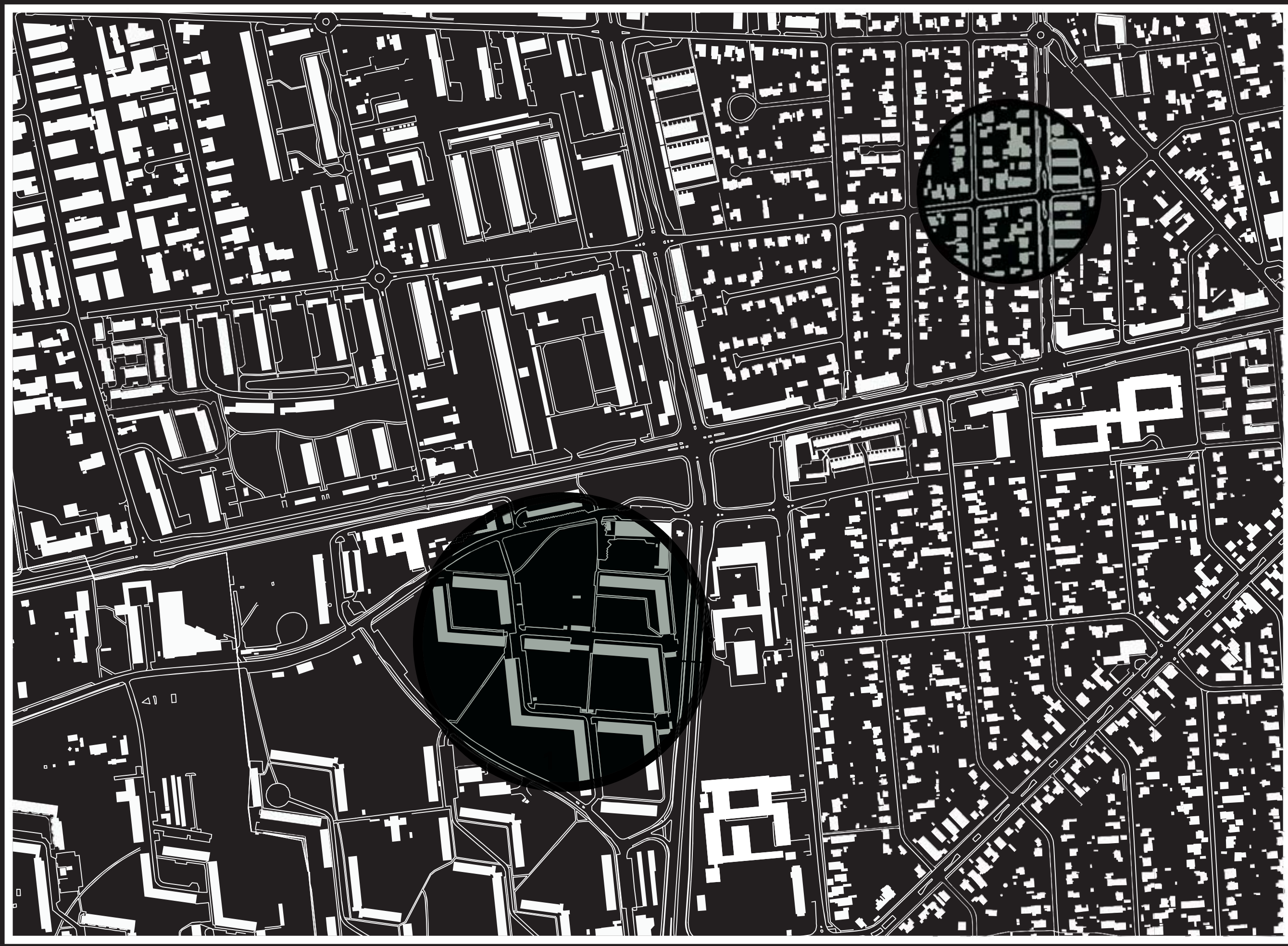
This leads to a new breakpoint and to rethink the mix use of a high-rise where the functions are separated horizontal like a pancake stable. The most natural thing would therefore be to separate the function of the apartments and the office vertically and thereby breaking some of the statements in the program.

A new concept is therefore developed with inspiration from the context analysis and the layout of the exiting urban fabric of the municipality of Rødovre. The two shapes that give inspiration the new concept can be seen in ill. 72.The main inspiration from the context is the single houses and the monolithic blocks give Rødovre its character. The new concept can be seen in ill. 73

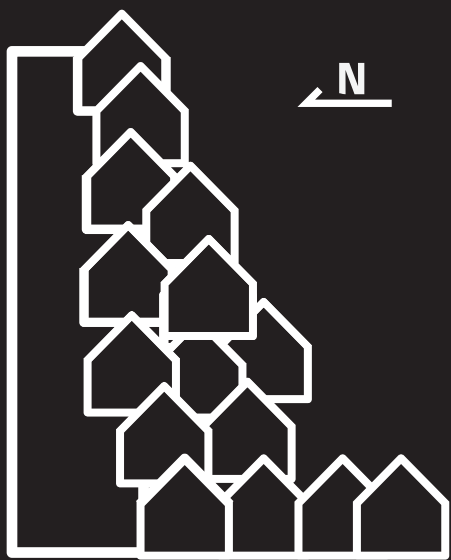
Typical urban sprawl for Rødovre



Typical monolithic high blocks in Rødovre



Ill. 72. The two types of urban layout that are chosen as inspiration for the design of the high-rise. The high and straight block building (1) and the single house sprawl (2).



yre

The concept of the high rise building with a straight block placed to the north side of the site and single units floating down on the south side.

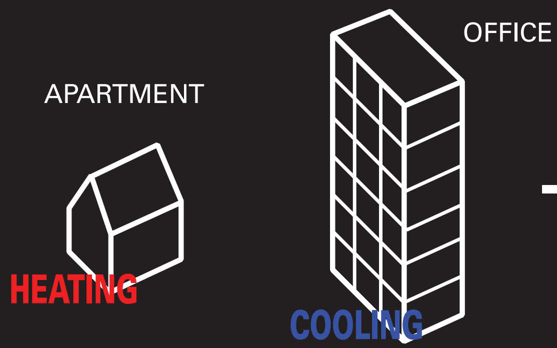
Ill. 73.

THE MAIN CONCEPT

The concept of mixing the two typologies together in one building is based on the stainability approach that is described in the introduction.

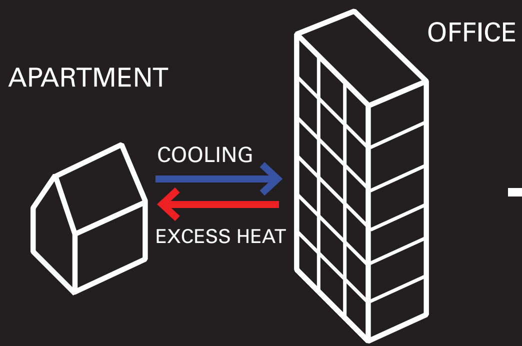
The possibility of joining the functions of the apartments and the office is a symbiosis also creates a new type of building where it is possible to use the advantages of their differences, see ill 74.

The new concept changes the layout of the functions stated in the program, but because of the advantages of rearranging the distribution, this is not seen as a problem but more as a natural opportunity. The new layout of the functions can be seen in ill. 75.

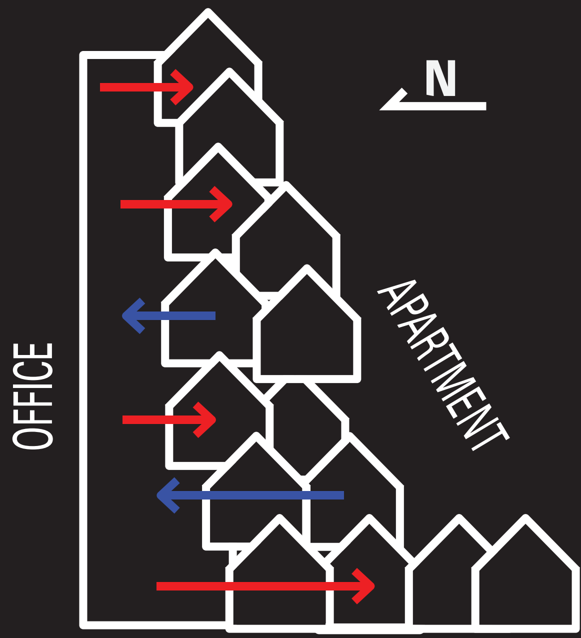


The main use of the energy use, for keeping a good indoor climate, is heating in the apartments and cooling in the offices.

The arrangement of the functions stated in the program.



The variation in the thermal environments makes it possible to save energy by exchanging the heating and cooling needs of the two functions.



The concept of energy savings is implemented into the main concept of the building.

Ill. 74.

The new arrangement of the functions as a consequence of the main concept with an atrium in the middle when joining the functions together.

Ill. 75.

THE MAIN CONCEPT

Architectural the concept is expressed in the drawings on this page. The concept contains two different expressions. Towards the high traffic road to the north, see context analysis p. 27 – 28 the building creates a straight edge. The straight edge also creates a more stringent expression for the offices.

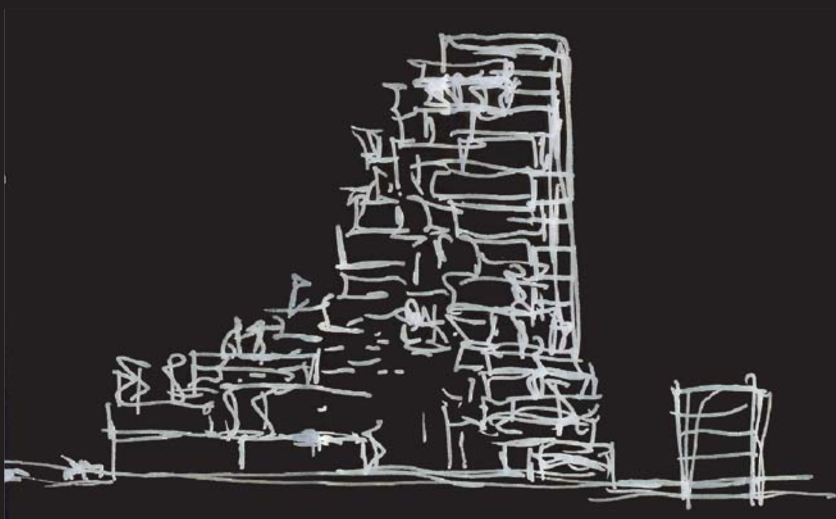
On the other side of the building the façade of the apartments creates a more organic expression with concern to the human scale. The southern façade have a more dynamic expression because it is separated into smaller individual units. The facade in contrast to the straight surface of the office façade at the northern side of the building.

Greenery also plays an important part of the building. The green areas towards the west and the south are continued up along the side of the building.

The building will have three main facades from where the building is exposed; the south, where the people comes from the train station, the west where people drives by, and from the north where the biggest flow of people drives by the building.

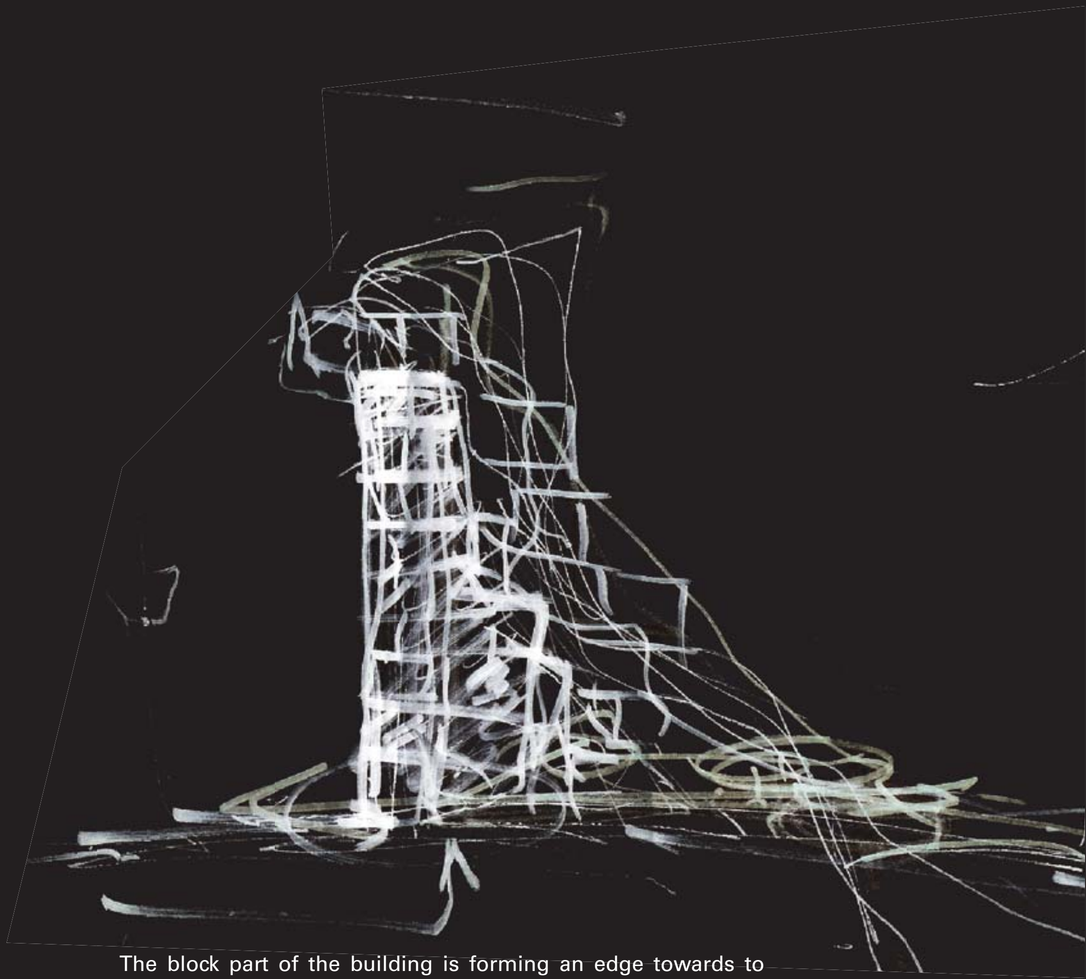
From this point of the sketching phase, the design focus on generating a form that is true to the main concept and have the qualities that are stated the vision of project. The process starts to focus on the internal functions to make them influence the external shape and expression of the building.

Site plan of the concept. The building is placed in the north east corner of the site, as suggested in the initial investigations.

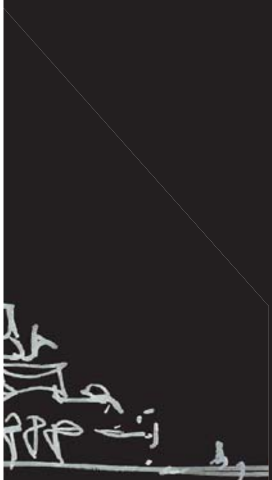


Conpectual view of the building looking at the site from the sough west

Conpectual view of the building looking at the s



The block part of the building is forming an edge towards to north with the apartments and the greenery floating down the side of the building. Thereby the design minimize the scale of the building and drags the green areas from the perimeter of the site into the site and on up along the building.



the site from the west

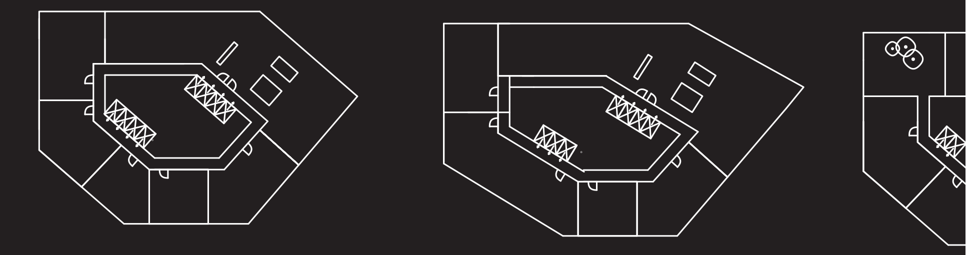
Conpectual view of the building looking at the site from the north   Ill. 76.

PLAN DEVELOPMENT

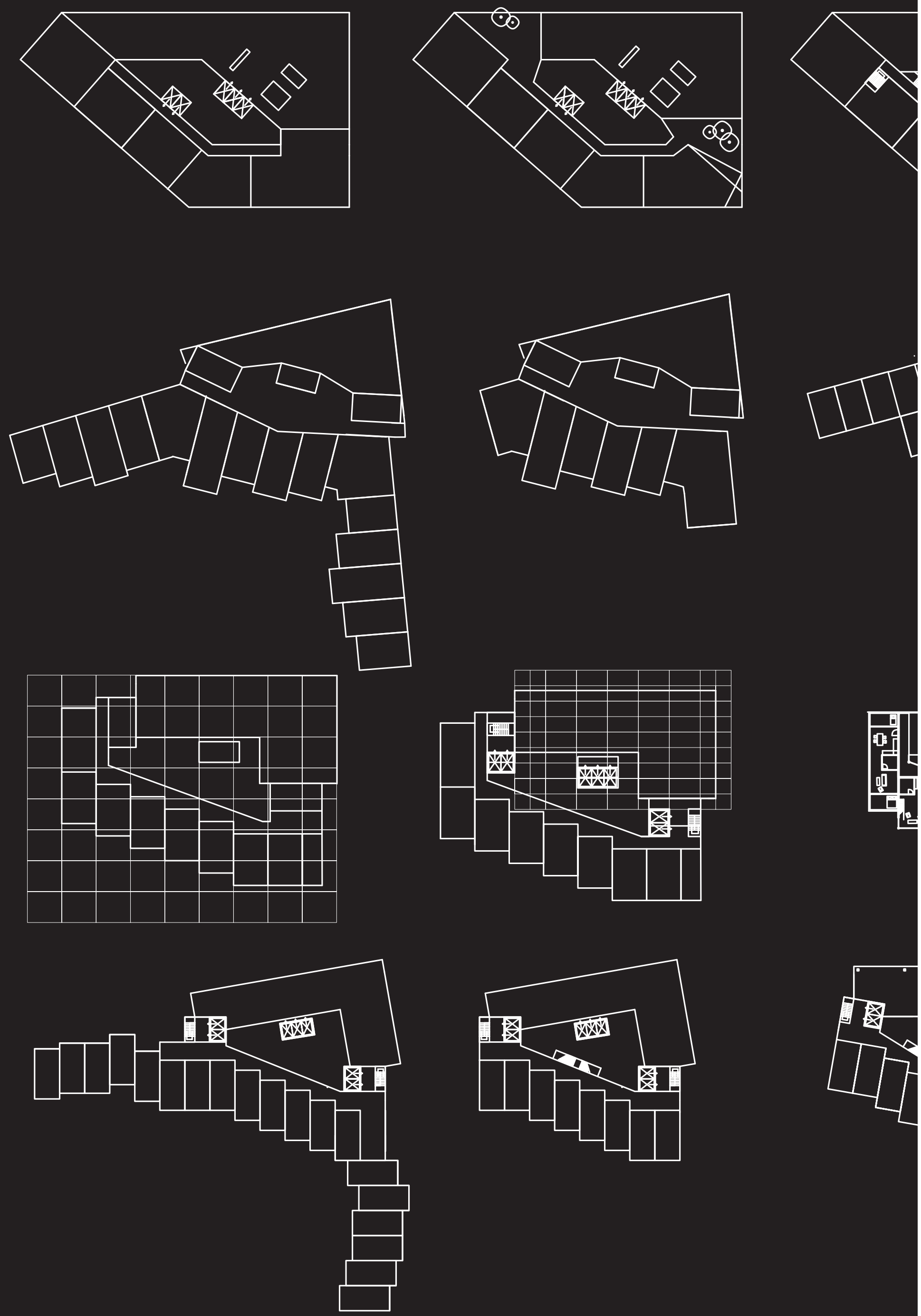
This section describes the progression of the plans through the design process. The drawings reflect the iterations through the process and how the space of the atrium, the offices and the apartments have changed and thereby generate new expressions of the building.

The plans are not going to be explained separately but are going to be explained in the process together with the other elements of the building.

The plans of the building are therefore not going to be explained in chronological order from this point but are showed as the result of different iteration in the process.



START



END

Ill. 7.7

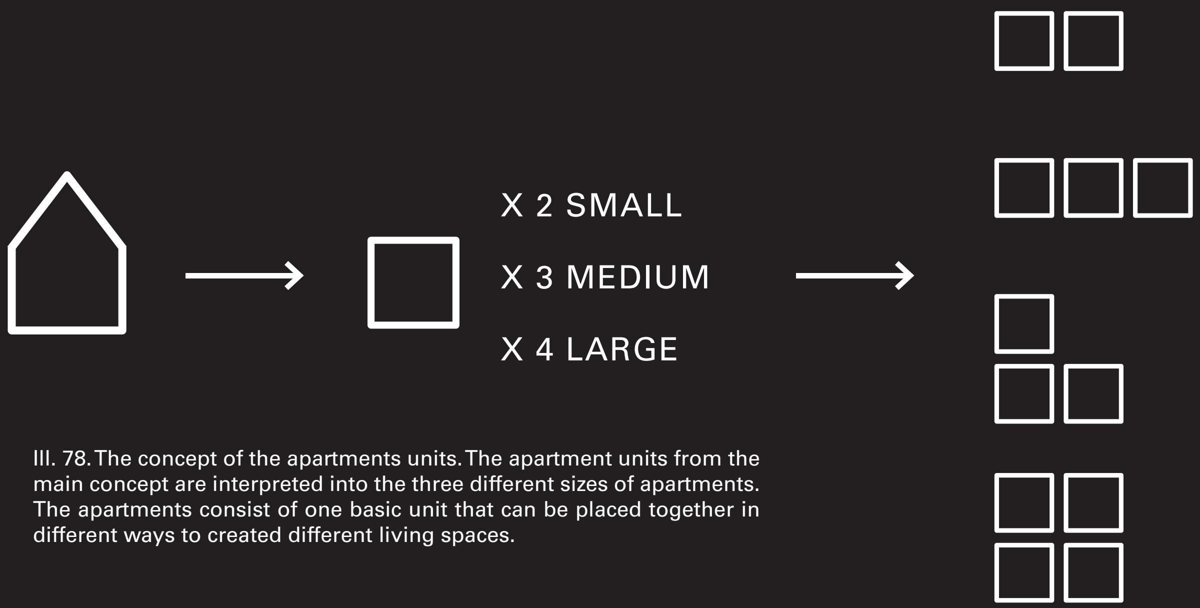
THE APARTMENT

The apartments are one of the most important functions in the building, because of the vision of creating a living building suited for different user. Apartments have low degrees of flexibility it the orientation and the programming of the space which makes it important to think of the functions outside in as well as inside out.

The program states the different size of apartments and the arrangement of rooms that is wanted to be integrated. The concept of the apartments units, viewed as individual units, can be seen in ill. 78.

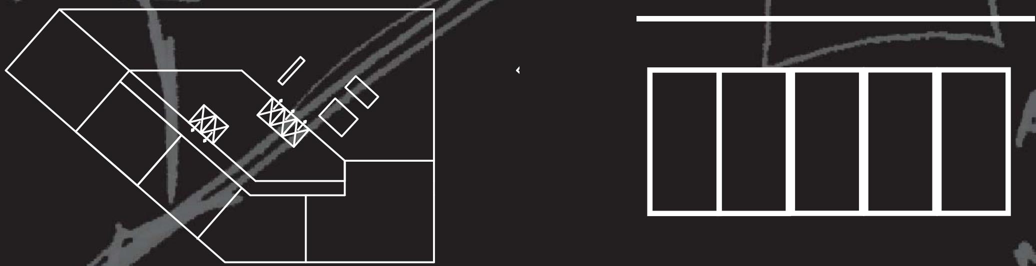
The initial analysis shows that the apartments should be south or south/west orientated to give optimize daylight and passive heating. The parameter is therefore implemented into the plan of the building and into main concept. The main iterations of the apartment plan can be seen in ill. 80. The process goes through three main iterations where the placement of the apartments units is changed.

The changes are caused by an internal investigation of the daylight conditions of the apartment and the perception of space and daylight together with the wish of privacy both in terms of view and outdoor space. The changes are interconnected with the development of the rest of the building but are here showed as an isolated development.

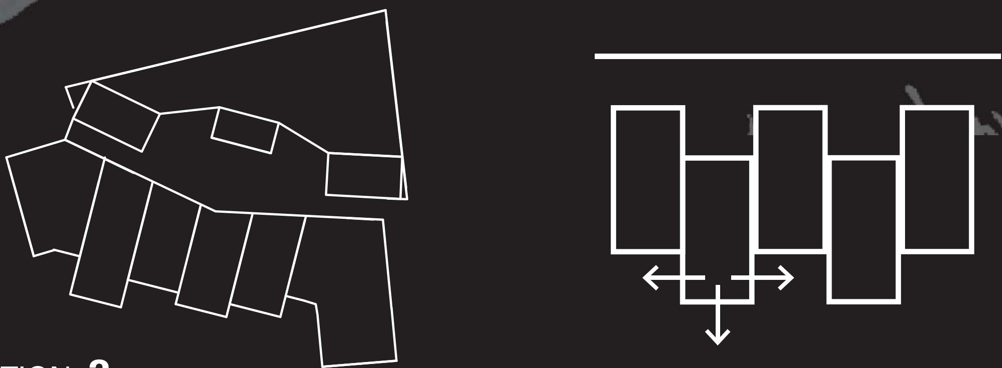


Ill. 78. The concept of the apartments units. The apartment units from the main concept are interpreted into the three different sizes of apartments. The apartments consist of one basic unit that can be placed together in different ways to created different living spaces.

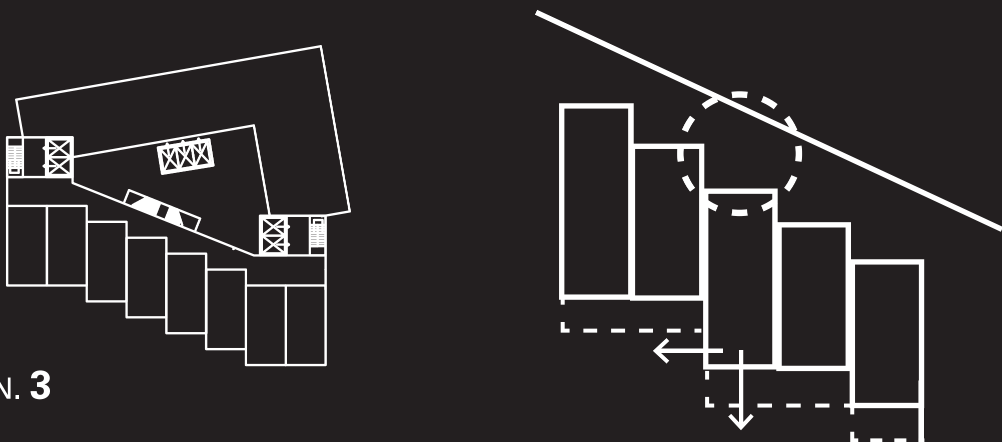
Ill. 79. Inspiration picture for the sketching phase.



ITERATION. **1**



ITERATION. **2**



ITERATION. **3**

Ill. 80. The three main iterations of the apartment plan through the process. The iterations are based on the expression of the room in terms of daylight. The iterations are also based on the need of overhang, private view and outdoor spaces which will be explained in the following pages.

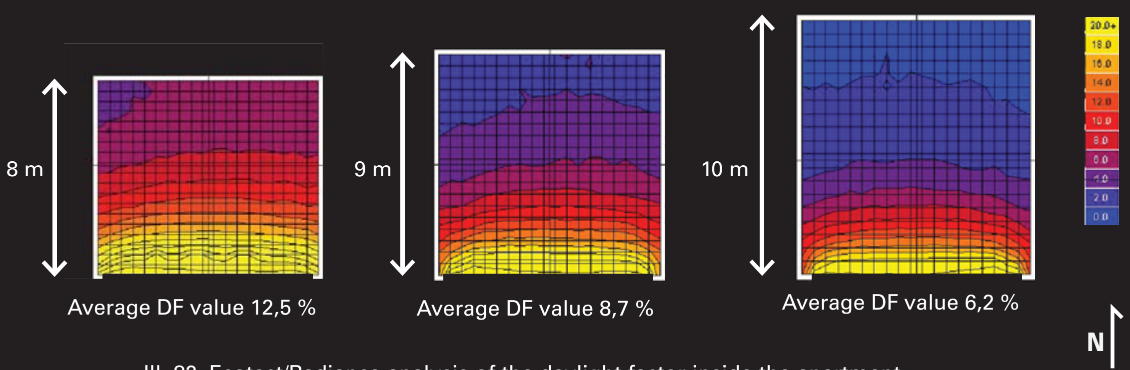
THE APARTMENT

The daylight in the apartments is an important factor for sketching the space and the internal experience of the room. The zoning of the room is also guided to the needed daylight factors that are stated in the program, see ill 81. The three iterations are describes in the following pages.

The maximum depth of the apartment is investigated in ill 82. as an extension of the initial investigations in p. 67 - 68. The daylight and the distribution of it is evident in sketching the plan solution of the apartments that are illustrated in ill. 84. The layout of the apartments in the first iteration can be seen in ill. 83.

The atrium is added to the plan which makes it possible to have daylight entering the room from two sides. Simulation made in Ecotect/Radiance is to analyze the amount of the daylight coming from the atrium. The investigation can be seen in ill 84. The thermal benefits of the atrium can be seen in ill 88.

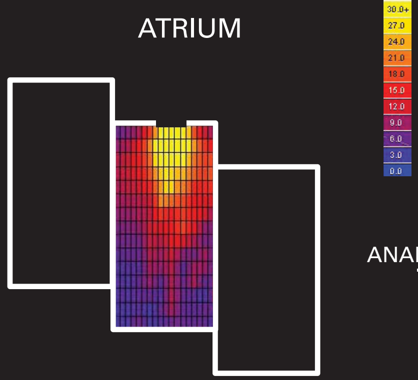
Ill. 81. Zoning of the apartments according to the amount of daylight. The different functions are placed with reference to the need of daylight.

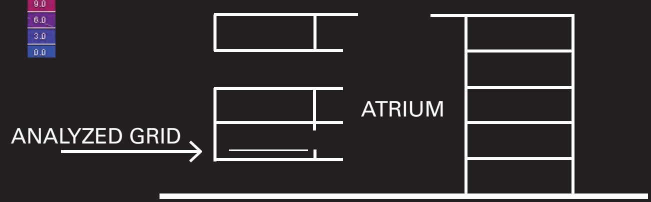


Ill. 82. Ecotect/Radiance analysis of the daylight factor inside the apartment. The investigations are made to see how deep the apartment can get and still have acceptable daylight conditions. The investigation is made of worst case scenario with daylight from only one side. The result shows that the rectangular shape of the apartment should have a maximum depth of 9 to preserve good daylight conditions of the space.

ITERATION. 1

Ill. 83. Initial plan drawings of the apartments. From the beginning all of the plans are facing south, where the main openings are placed. Openings to other side are limited or avoided because of the main concept of only having the apartments facing one side of the building.





Ill 84. Daylight investigation of the daylight entering the room from the atrium. The window is 1 x 1 meter and the illustration shows that the daylight factor in the rooms is suitable for functions that have a low need for daylight.

THE APARTMENT

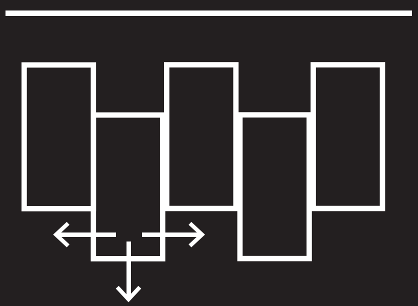
It is evident that daylight from two sides is needed to be able to make functional plans and have the opportunity to place rooms at the north side of the apartment.

A new iteration of the plans of the apartment is made with the possibility of placing the rooms at the in both end of the apartment. In the 2. iteration the arrangement of the apartment units is push and pull to create a more dynamic façade, see ill. 86 and to optimize the daylight entering the space, see ill. 87.

Thermal calculation made in BSim shows a need for shading the windows to avoid overheating. An overhang of 1.5 meter is simulated in the model and the result can be seen in ill. 88.

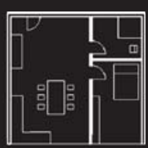
The possibility of the having daylight entering the space form both the north and the south side of the building also opens the opportunity to create deeper spaces and this lead to a more flexible apartment plan. It also makes it possible to have the apartments themselves creating overhang by pushing and pulling them in the section of the building.

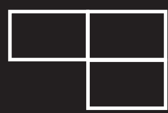
The need of overhang and the wish to create outdoor private spaces leads to the 3. iteration which can be seen in ill 86. To create better daylight conditions double high rooms are also added to the plans which are analyzed in ill. 87. The new iteration creates small and more private spaces inside the building and in front of the entrance to the apartment.



ITERATION. **2**

AREA = 72 m^2



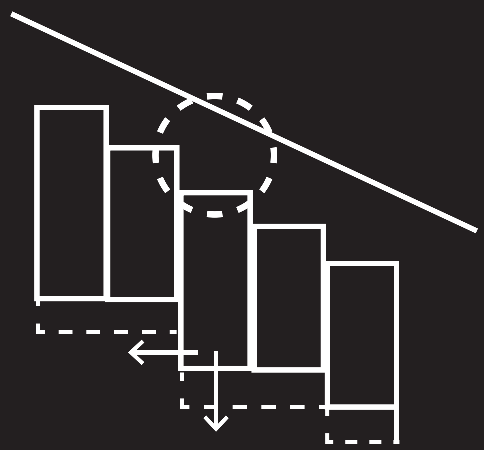


AREA = 108 m^2

AREA = 144 m^2

AREA = 72 m^2

Ill. 85. The units of the apartments are put together in 4 different formations and with the possibility of pushing and pulling the units in relation to each other. The dimensions of the units are 9 x 4 meters. The daylight factor and the perception of the daylight are simulated in Ecotect in ill 87, which shows shifts between strong daylight and dark areas which can cause glare.



ITERATION. 3

Ill. 86. The new iteration of the apartment plans. Putting the units together with an angle creates small private spaces in front of the apartment.
The arrangement also makes it possible to create outdoor private spaces because the view is blocked by a barring wall that continues out from the apartment.

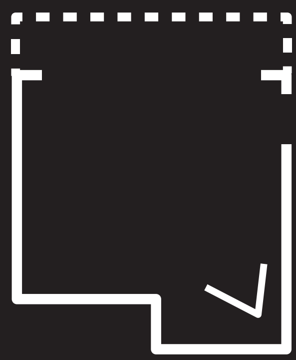
THE APARTMENT

The iteration of the apartment is guided by many different improvements. One of the very important parameters is the daylight factor and the distribution of the daylight which therefore becomes better for each iteration.

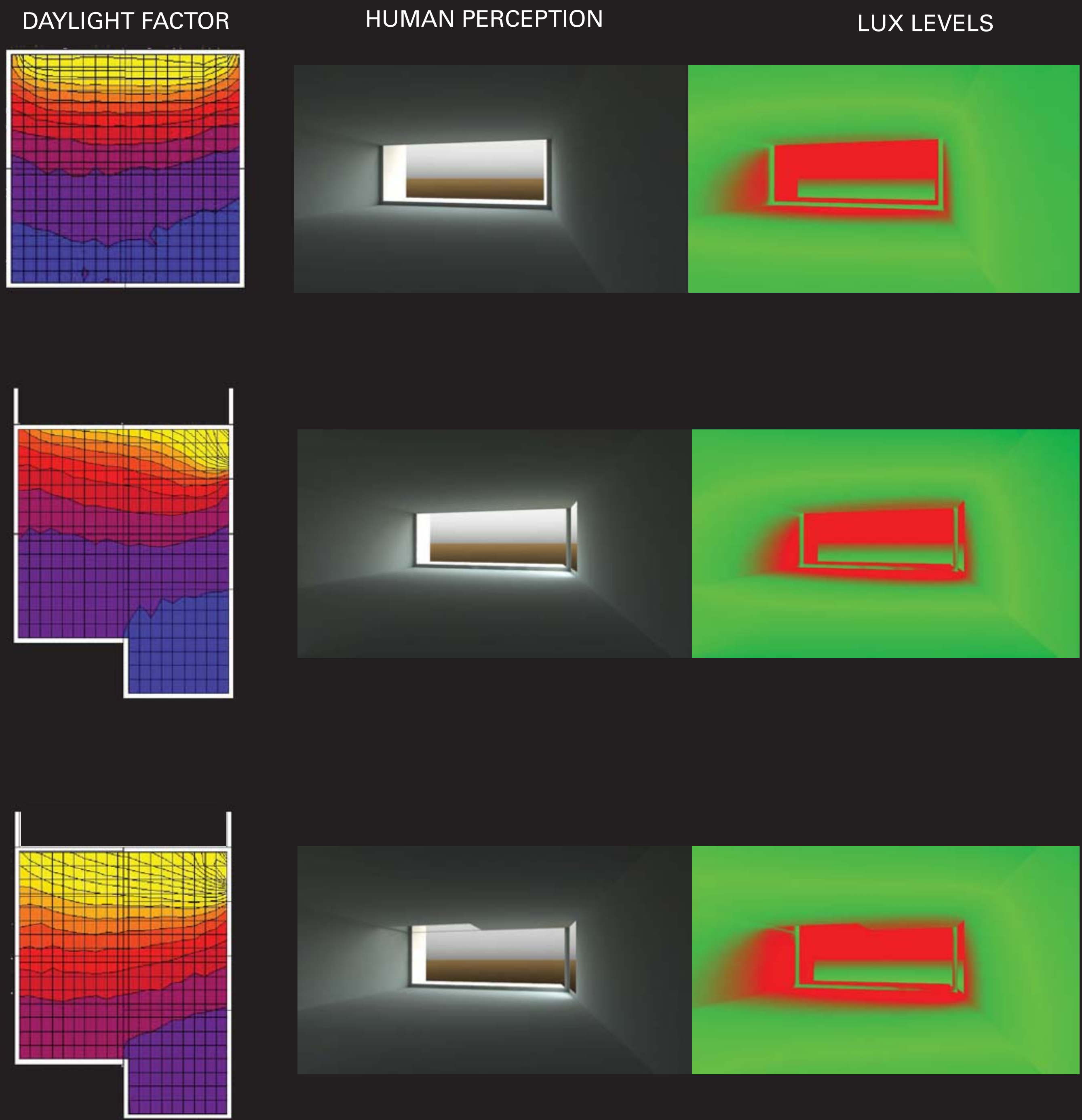
The iteration and the improvement of the daylight conditions are simulated in Ecotect and can be seen in ill. 91.

ITERATION. **1**

ITERATION. **2**



ITERATION. **3**



Ill 87. Daylight investigations of the apartment in the three iterations. The iterations shows that the daylight factor becomes higher after each iteration. The distribution and the perception also becomes better because of a more even distribution of the daylight which minimise big contrast in the daylight which can cause glare.

THE APARTMENT

The table in ill. 89 show the different consequences that the alterations have on the apartments. Adding the atrium improves the heating need for the apartment. Adding the overhang and external shading improves the hours of overheating to be maximum 40 hours per year which is an acceptable level. The need for cooling is thereby eliminated. The higher need for heating when adding the external shading is also estimated to high as it in real life would be very small. See app. 3. for further information about the BSim model.

The total energy consumption in the final iteration in terms of heating is also simulated in BSim. The result shows that the apartment because of the iteration and the optimizing is highly performative and has a very low energy use for heating. The energy used for heating can be 0 if the apartment has a heat recovery on 80% see app. 3

The apartments that are designed are only of two different sizes. The program stated three different sizes. The bigger size apartment which is lacking according to the program will not be designed but can easily be achieved by adding more apartments units together.

APARTMENT

	SUM	MONTH OF THE YEAR 1	2	3	4	5	6	7	8	9	10	11	12
HOURS > 28	931	0	0	1	4	62	178	225	398	43	18	2	0
HOURS < 20	1361	487	222	25	0	0	0	0	0	0	0	79	548

APARTMENT WITH ATRIUM

	SUM	MONTH OF THE YEAR 1	2	3	4	5	6	7	8	9	10	11	12
HOURS > 28	1026	0	0	3	8	65	192	251	437	49	18	3	0
HOURS < 20	1107	387	144	16	0	0	0	0	0	0	0	61	499

APARTMENT WITH ATRIUM AND OVERHANG

	SUM	MONTH OF THE YEAR 1	2	3	4	5	6	7	8	9	10	11	12
HOURS > 28	314	0	0	0	0	0	45	79	168	13	9	0	0
HOURS < 20	1165	409	172	23	0	0	0	0	0	0	0	58	503

APARTMENT WITH ATRIUM , OVERHANG AND SHADING

	SUM	MONTH OF THE YEAR 1	2	3	4	5	6	7	8	9	10	11	12
HOURS > 28	40	0	0	0	0	0	20	2	18	0	0	0	0
HOURS < 20	1732	635	407	50	0	0	0	0	0	0	0	60	580

Ill. 88. Thermal simulation of the apartment made in BSim through the process to optimize the thermal condition of the apartments.

ENERGY FRAME

70 +2200/104 M2 = **91 kW/m²** PER YEAR

ENERGY CLASS 1

35 +1100/104 M2 = **46 kW/m²** PER YEAR

Ill 89. Different energy frames.

APARTMENT WITH ATRIUM AND CANTILEVER AND SHADING ($104m^2$)

NORMAL VENTILATION	34 KW/M2 PER YEAR
VENTILATION AND HEAT RECOVERY 80%	0 KW/M2 PER YEAR

Ill 90. The Energy consumption of the building simulated in BSim. The energy use for heating is very low compared to the energy frame for a normal apartment. The energy class of the apartment cannot be stated because the energy use for hot water, lighting, etc. is not estimated but it is likely that the apartments are near energy class 1.

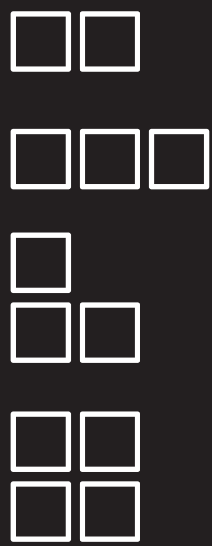
Ill 91. Models of the final design of the different apartments.

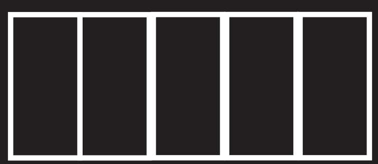
THE APARTMENT FACADE

The expression of the apartment facade is a consequence of the development of the plan of the apartments and the way they are connected. The need for shading as calculated in the BSim simulation ill. 88 is also evident in many of the iterations of the façade.

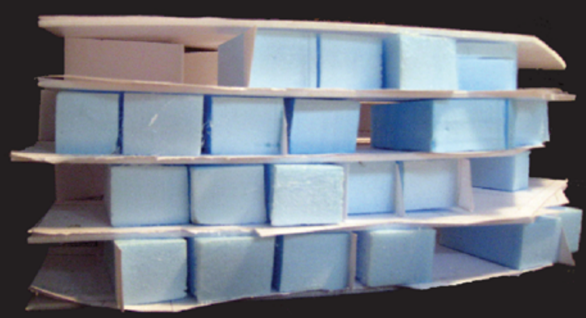
The main concept of giving an individual character to the façade by making each apartment visible, see ill 94, also play an important role and is thereby a contrast to the straight rigid office façade. The way the green areas are distributed and emphasized gives character to the facade which will be further discussed later in the paper.

The three iterations of the facade can be seen in ill. 95 - 99.

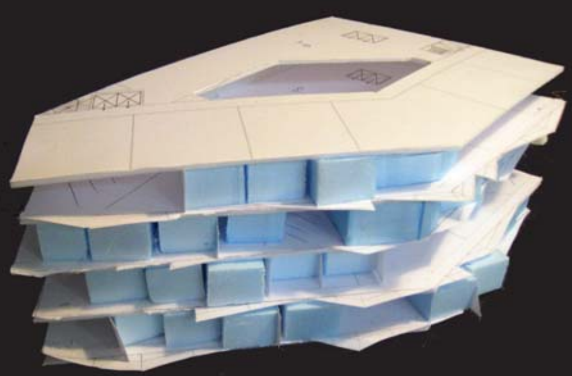


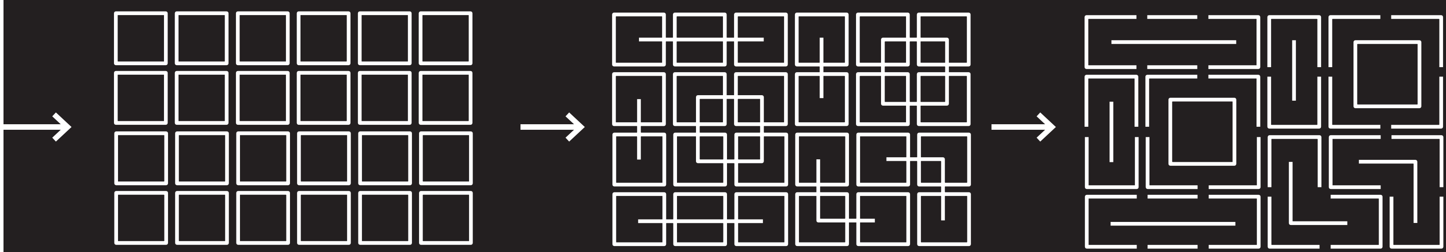


ITERATION. **1**



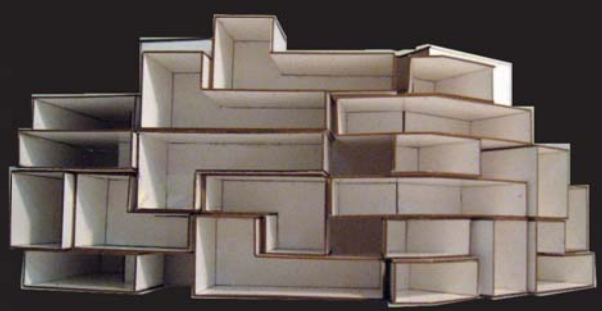
Ill. 95. The first iteration of the façade. The unit grid of the facade is flat with only balconies to emphasize the individual apartments.

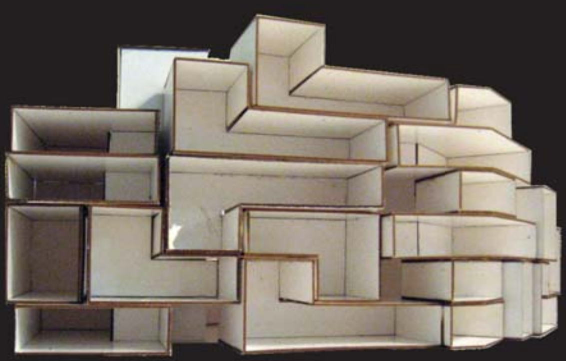


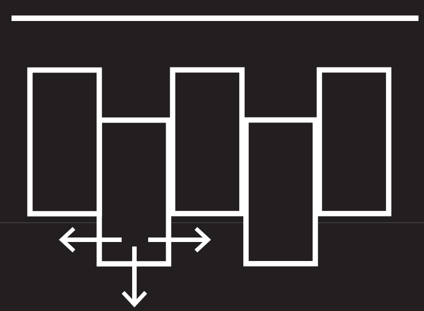


Ill. 94. The concept of the apartment facade. The individual apartments are placed into the grid of the façade but emphasized separately which makes it possible to see the individual apartment.

Ill. 96. The apartments are pushed or pulled in the facade which gives a more dynamic expression and also creates the possibility of the apartments shading for each other and thereby avoiding the need for overhangs.

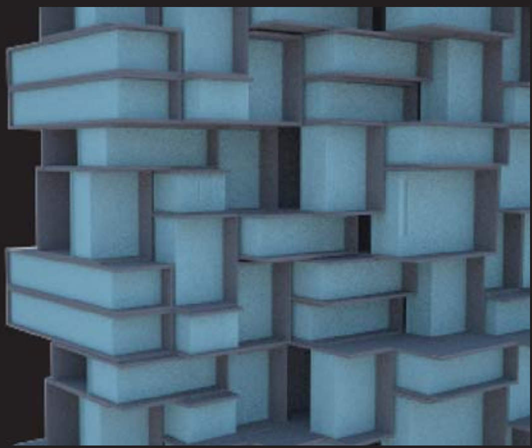


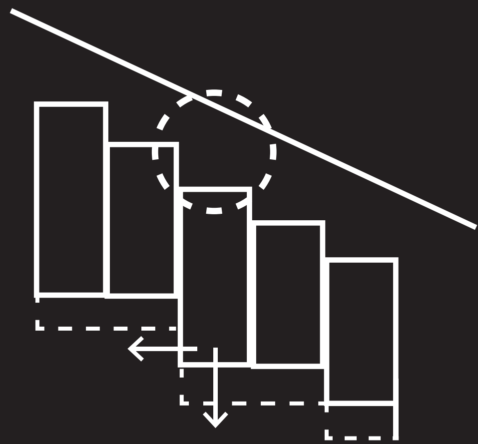




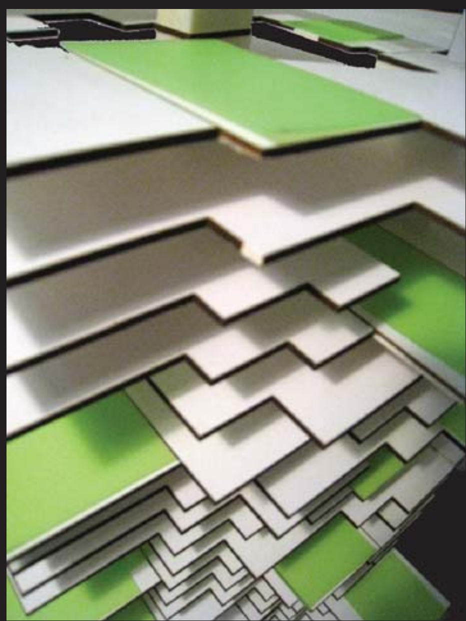
ITERATION. **2**

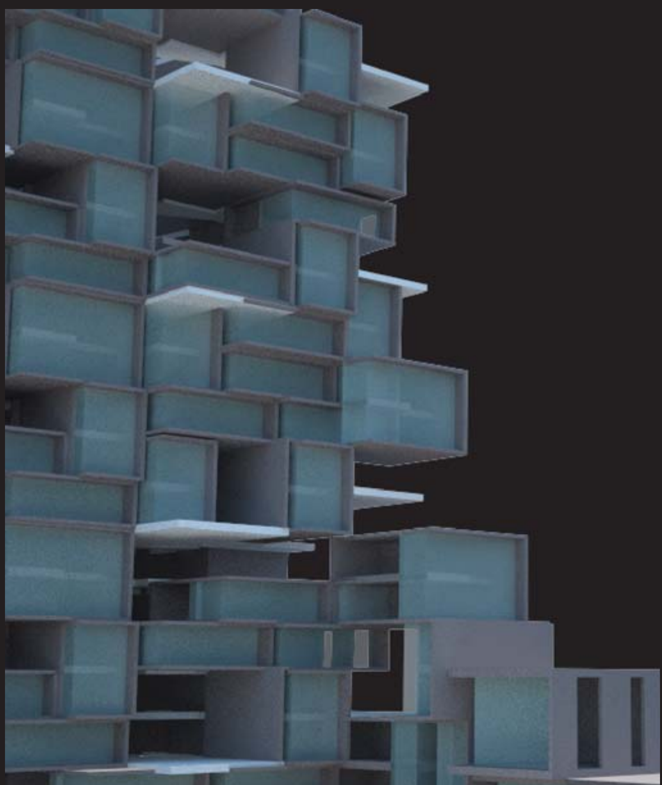
THE APARTMENT FACADE



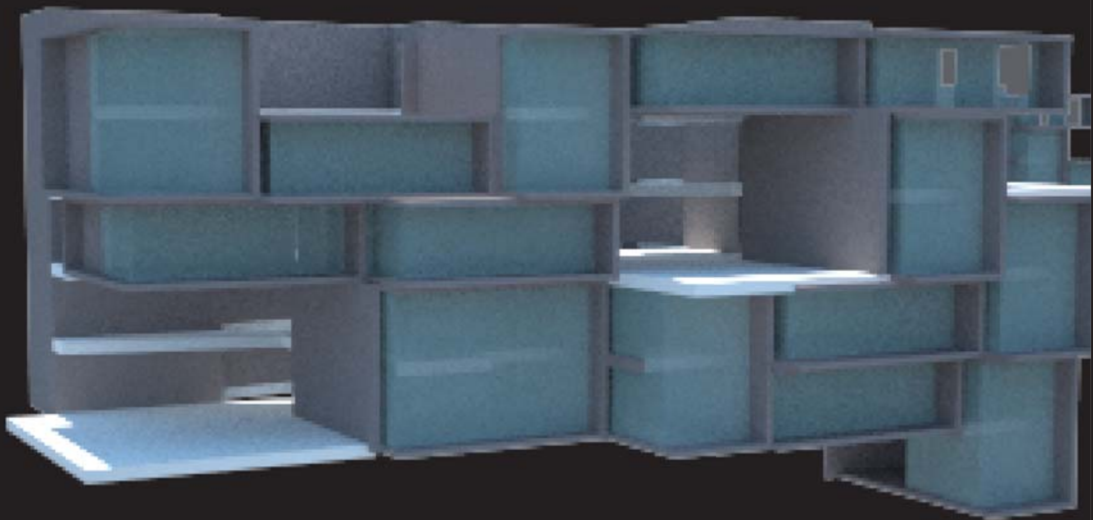


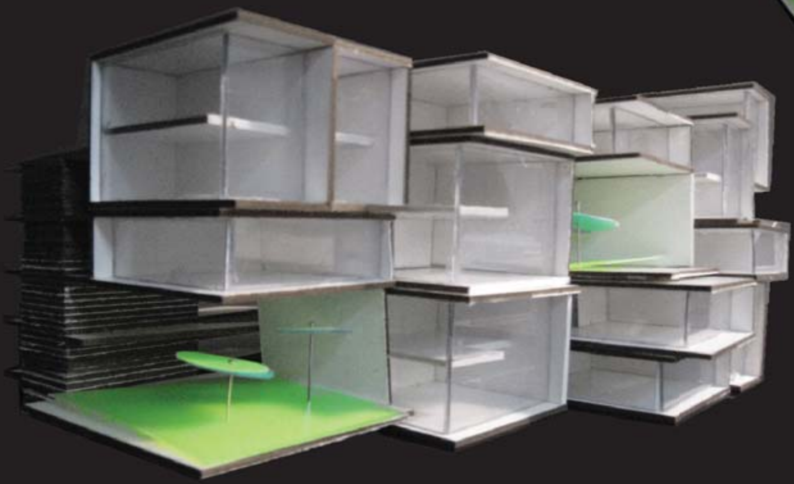
Ill. 97. The apartments are arranged together according to the 3. iteration of the apartment plan. The apartments have private individual balconies, not visible for each other. The apartments to the left are irregular because of the plan and the way the apartments are put together. The arrangement of the facade is therefore changed.





Ill. 98. The arrangement of apartment is duplicated to the side of the building where the apartments are placed. This gives the wanted expression of individuality and a organic facade with small private balconies with view to the south and west.





Ill. 99. The plans of the apartments are refined which gives the right character to the façade. The apartments are pushed and pulled according to each other which create shading and thereby avoid overheating. The placement of greenery is also emphasized which also creates possibility of shading. The arrangement of the green areas can be seen in p. 113 – 114.

THE APARTMENT FACADE

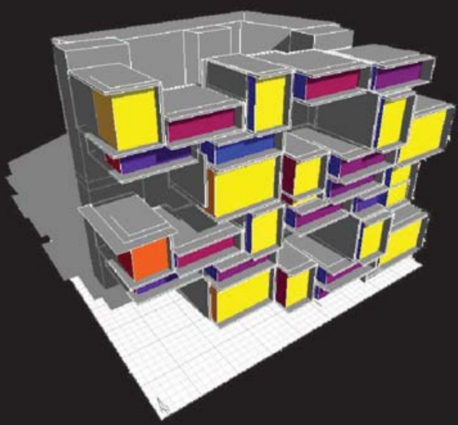
The BSim analysis in ill. 89. of the apartment showed that overheating in the summer as evident problem. The goal is therefore that all of the apartments not obtain more solar radiation that the one story high reference apartment.

The progress of the plans of the apartments showed that the apartment because of the daylight from the atrium have the flexibility small extensions of approximately 0.5 meter which out having compromising the daylight conditions or the plan of the room. The length of the balconies is also flexible and can therefore be adjusted.

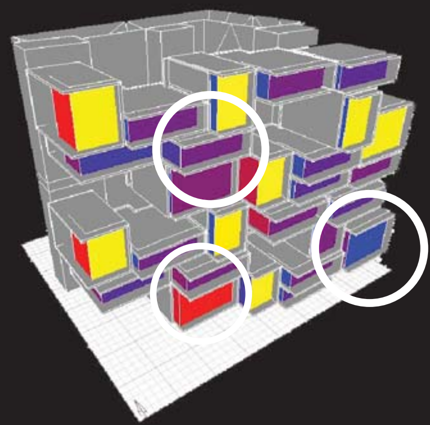
The solar exposures for the windows of the apartments are therefore investigated in Ecotect, see ill 101. which resulted in a new iteration of the south façade.

ITERATION. **3**

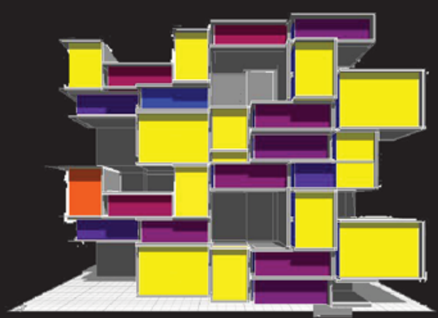
Investigation 1



Investigation 2



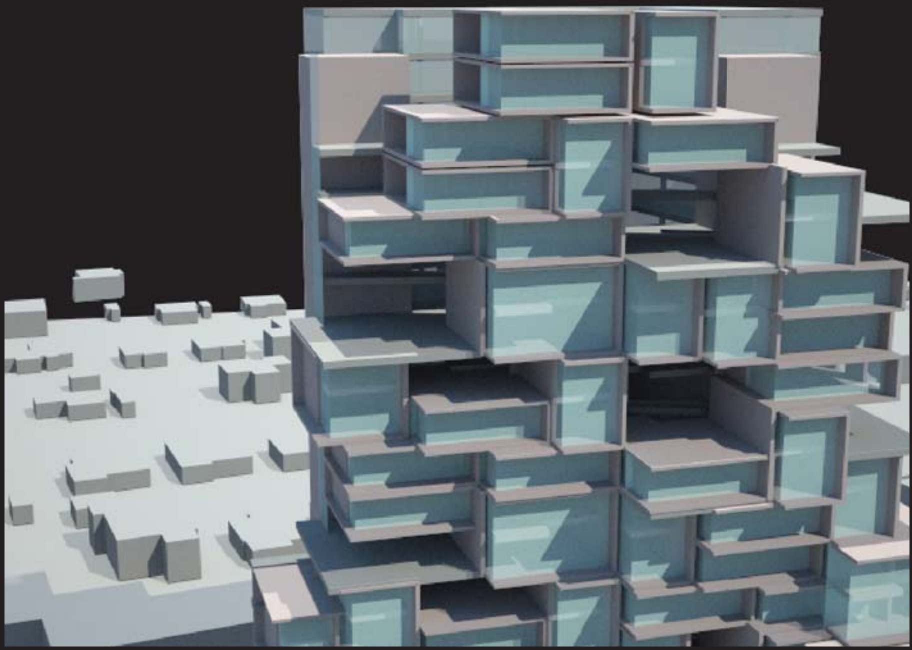
= puss and pull of the apartments and balconies



The arrangement of the apartments in ill 99 duplicated on top of each other.

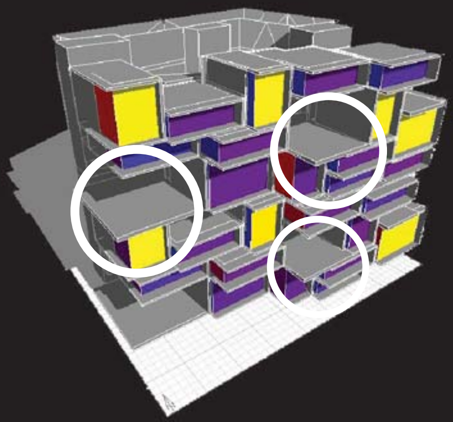
Puss and pull of the apartments and balconies to avoid high solar exposure.

Ill. 101. The solar exposure of the windows of the apartments. The reference model in BSim is made by a one story high apartment which there acts as a reference solar radiation in the mid summer (being the blue or purple color tone). The the yellow and oranges colors in the investigation therefore need to be avoided. The investigation shows that solar exposure is especially a problem for the double high apartments because of the smaller effect of the cantilevers. These problems that are solved though the investigation in this illustration.



Ill. 100. The concept of the apartment facade after the solar radiation investigations in Ecotect.

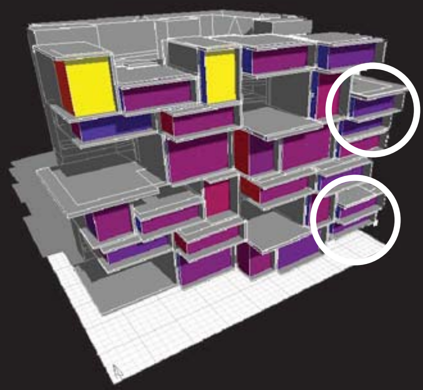
Investigation 3



◯ = small extensions of green balconies

Small extensions the green balconies to create a more even distribution of shading

Investigation 4



◯ = re-arrangement of apartments

Re-arrangement of the apartments, moving some of the double high apartments into the middle of the facade where more shade are provided

THE ATRIUM

The atrium is situated between the office and the apartment and thereby joining the two functions together. The atrium is therefore central for the building and serves various functions. Some of the architectural experience of the atrium can be seen in sketchers in ill 102 - 105. The various thermal benefits of having the atrium are illustrated in ill. 106.

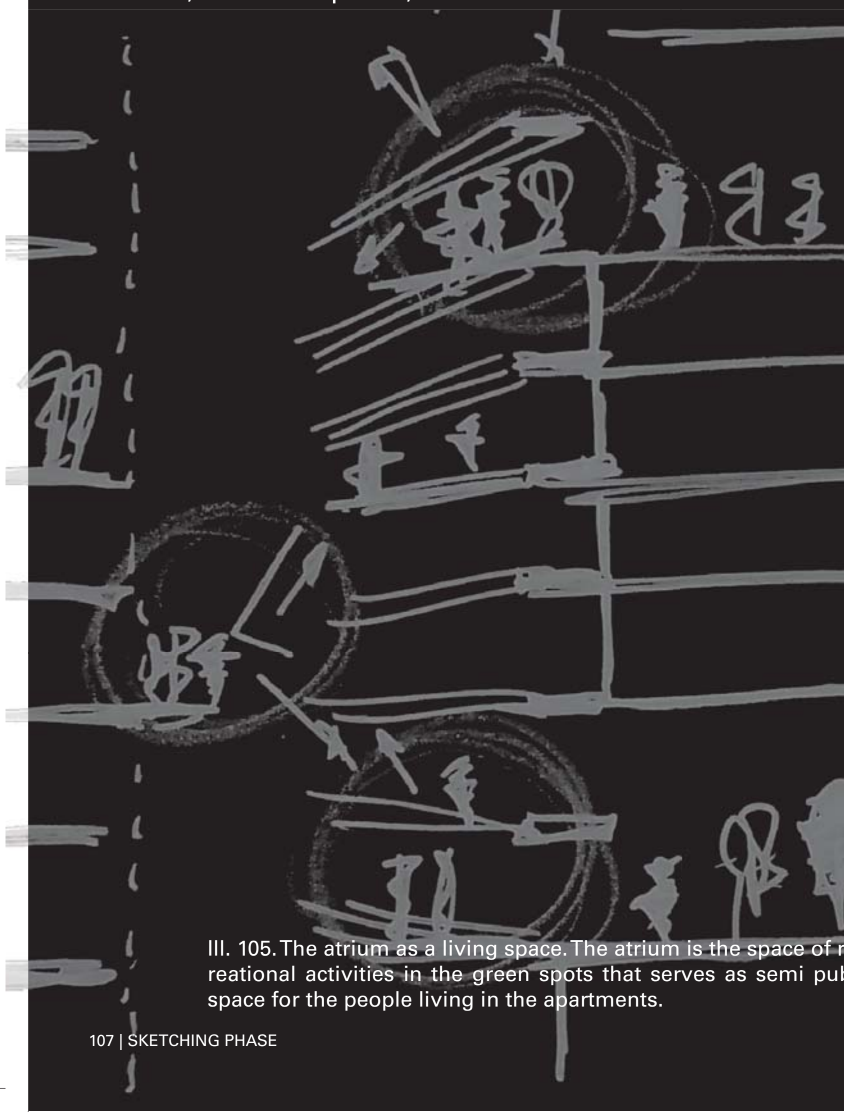
The atrium is like a buffer between the office and the apartments that in spite of their difference are join together in the space of the atrium. The atrium is therefore important in the perception of the building and in the performance of the building in tens of energy use.

The atrium is a non heated area only heated by solar energy and the excess heat from the offices. The thermal benefits for the atrium are simulated in BSim and explained in the apartment and office section of the process, see p. 101, ill. 88 and p. 124, ill. 121.

Ill. 102. The atrium as the space of connection. The interconnection between the apartment across stories and the ground floor as described in the initial investigations.

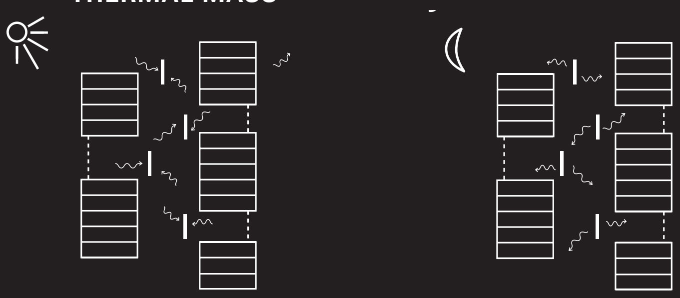
Ill. 103. The atrium as the buffer between the apartments and the offices. The atrium is the space that makes it possible to bring the two different functions together and eliminates the problem of having them joined in a vertical section.

Ill. 104. The atrium as the barring element of the building.



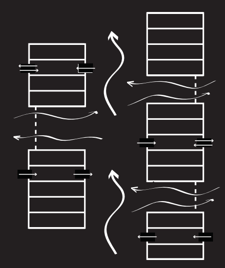
Ill. 105. The atrium as a living space. The atrium is the space of recreational activities in the green spots that serves as semi public space for the people living in the apartments.

THERMAL MASS



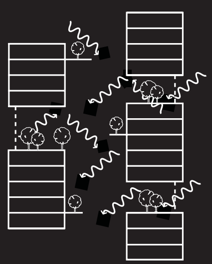
Thermal mass in the atrium makes it possible to store heat and cold when needed and thereby save energy.

NATURAL VENTILATION



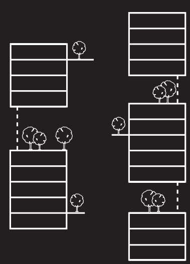
The atrium makes it possible to have a double side natural ventilation in both the offices and the apartments.

DAYLIGHT CONDITIONS



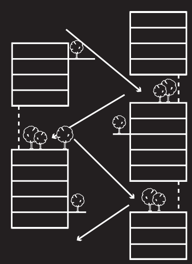
Better daylight conditions because of daylight from two side of the building

SEMI PUBLIC GREEN SPACES



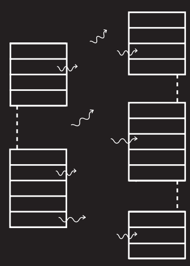
Semi public green spaces cuts through the facade and into the atrium.

VISIBLE CONNECTION BETWEEN FLOORS



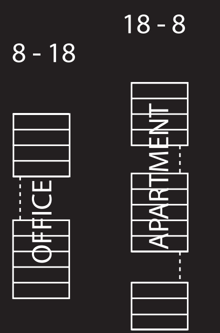
Flow and view between the green areas.

HEAT TRANSFERRED



Excess heat transferred from the office thought the atrium to the apartments.

DOUBLE PROGRAMMING



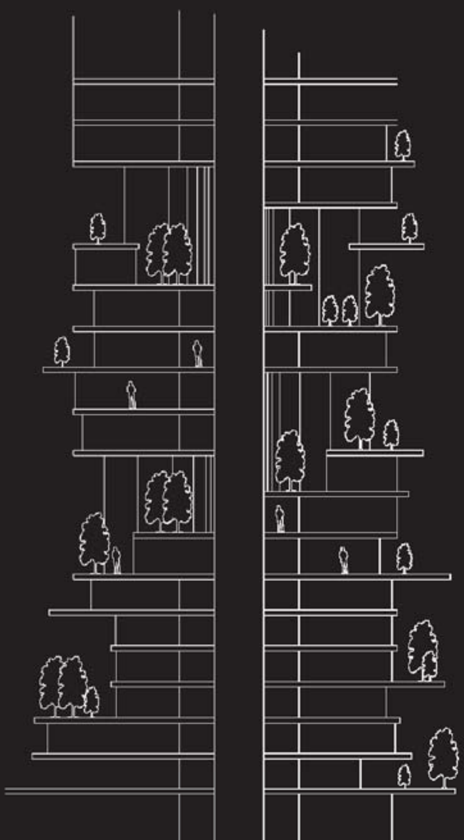
Active spaces in the building all day because of the different programs.

Ill. 106. The concepts that is wished to be implemented into the design of the atrium. The concepts are developed from the initial investigation p. 63- 68. The process of integrating the concept into the design is described in the following pages.

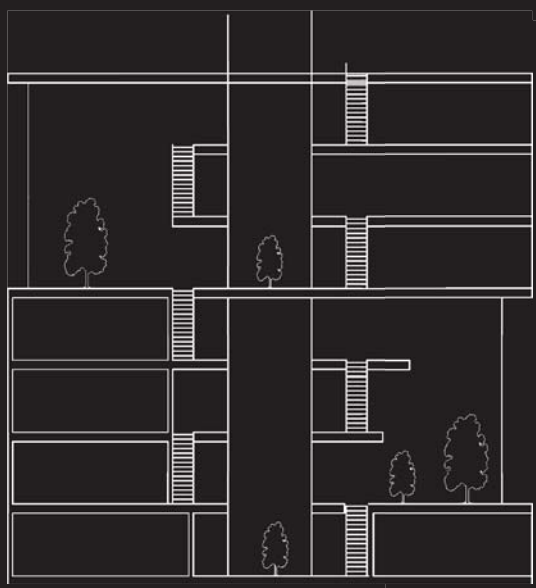
THE ATRIUM

The shape of the atrium and its appearance are depending on the plan of the offices and the apartments. The two types of spaces therefore have great influence on the development of the atrium. The different stages of the shapes of the atrium are illustrated in the plan drawings in ill. 107. The illustration shows the main iterations of the space through the sketching phase.

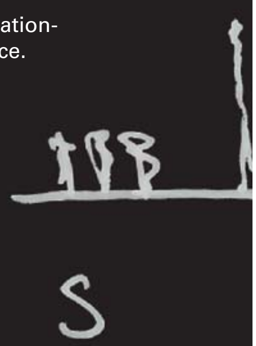
Thought depending of the office and apartment space the atrium is also optimized through the integrated design process to have good daylight conditions inside the atrium. The first drawing the atrium can be seen in ill. 107 - 108.

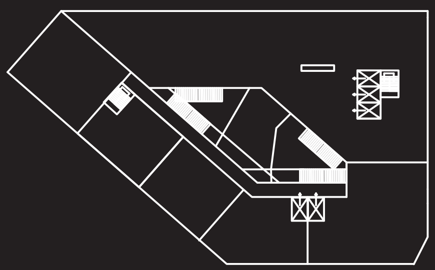


Ill. 107. Early sketching of sections thought the building showing the space of the atrium and the green areas

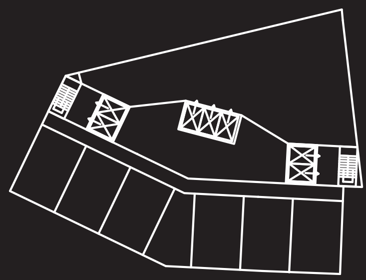


Ill. 108. Sketch of the atrium and the relationship between the apartments and the office.

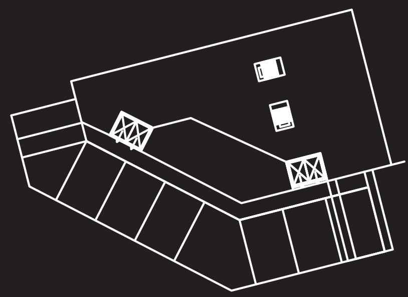




ITERATION. **1**

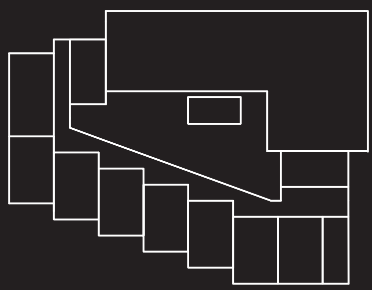


ITERATION. **2**

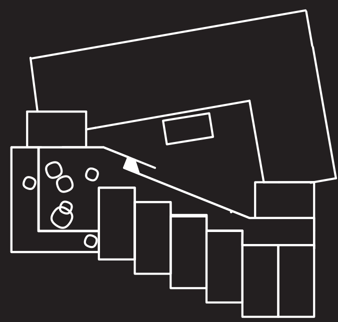


ITERATION. **3**

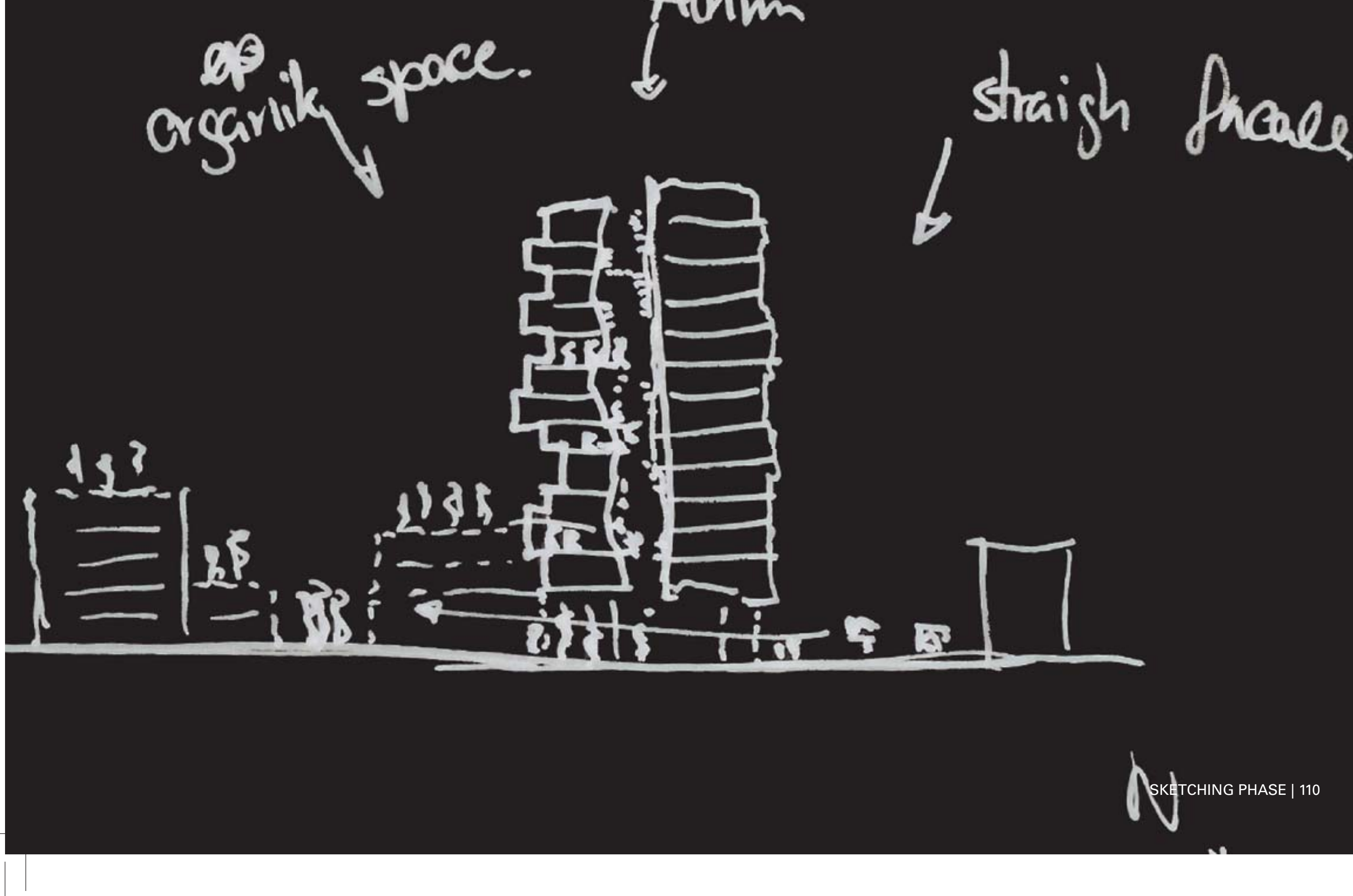
Ill. 107. The process of the atrium illustrated by the process of the plans drawings of the building. The connection between the cores and the atrium changes from being placed outside the atrium to being place inside. This means that a higher thermal mass is place in the atrium and thereby fulfilling some of the criteria in ill 106. p. 108.



ITERATION. **4**



ITERATION. **5**



THE ATRIUM

The daylight conditions depend on the light coming into the space from the openings in the façade. The openings are created by the green semi public areas that connect the outdoors space with the space of the atrium.

The optimization of the daylight conditions are visualized in ill. 109 where the progress of the different plans and the daylight condition inside the atrium are simulated.

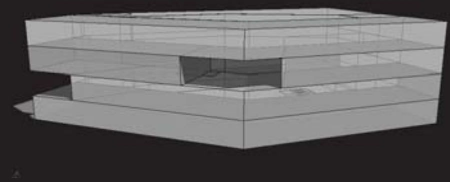
The incorporation of semi public green areas is a parallel investigation with optimizing the daylight. The green spaces inside and outside the building are an important element giving the building its aesthetic quality. The green leisure spaces will counterbalance some of the negative sides of living in a high rise compared with living in a villa. The green spaces make it more attractive for people with children to live in the building, a wish that is formulated in the program for the building in p. 113 - 114.

Conceptual investigations on how the green spaces can be distributed can be seen in ill 110.

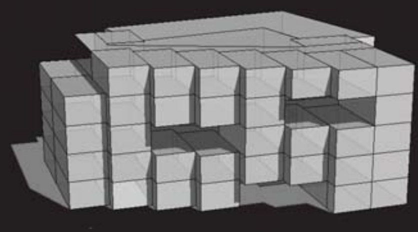
The thermal bouncy of the atrium can cause troubles because of the high difference between top and bottom, see app. 6. The openings of the atrium therefore need to be controlled to prevent too high pressure deferens.

DAYLIGHT INVESTIGATION OF TH

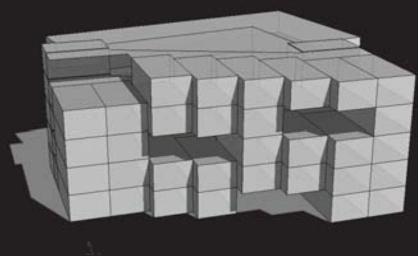
ITERATION. **1**



ITERATION. **4**



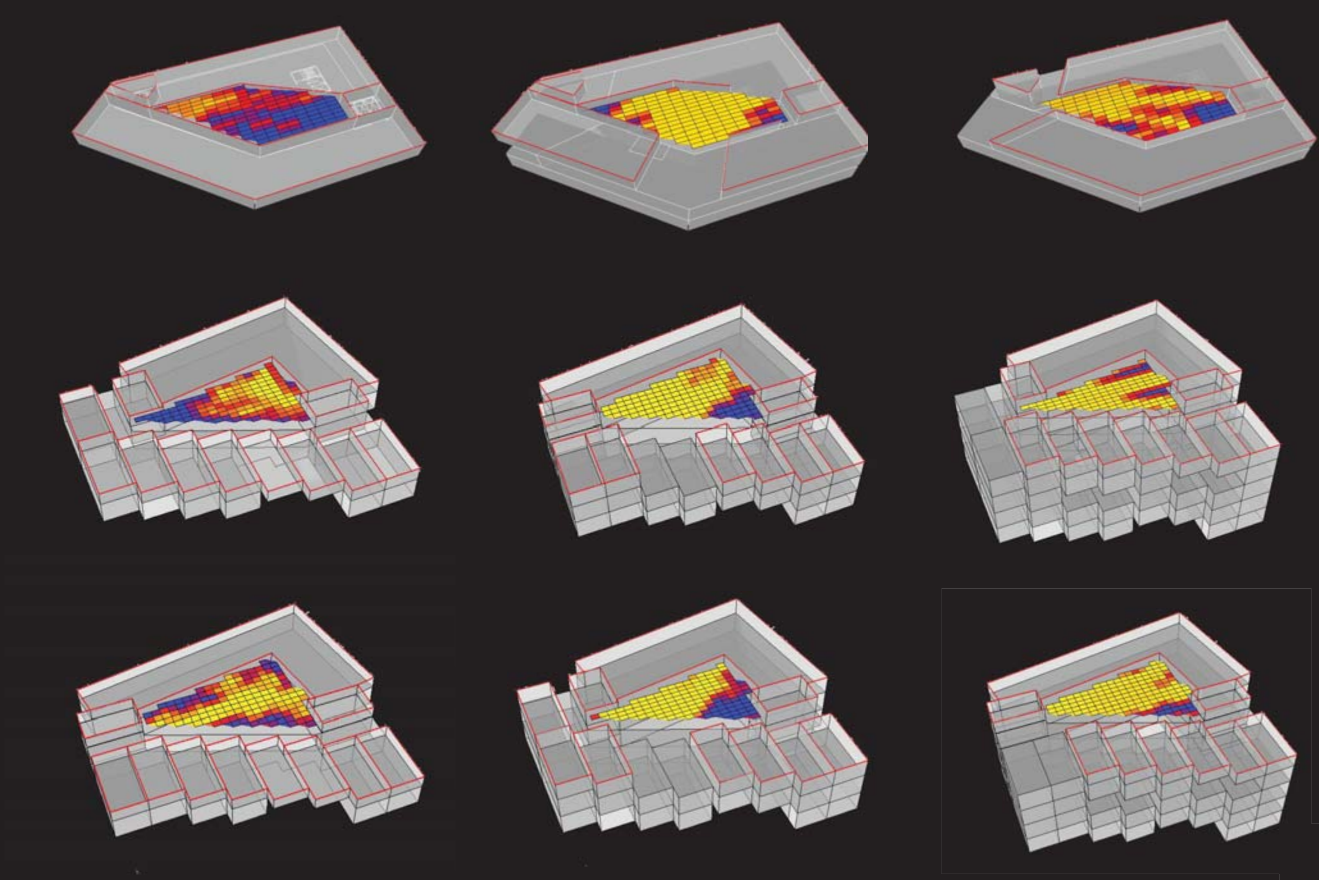
ITERATION. **5**

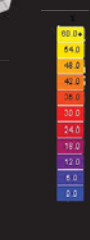


Ill. 110. Investigations of the green wedges and the façade. All of them have the qualities of being pulled out of the facade and thereby shading the apartments. The arrangement of number 3 is picked because of the expression which underlines the rest of the facade expression.

THE ATRIUM

NO OPENINGS | OPENING IN THE MIDDLE | OPENING IN THE SIDE





Ill. 109. Daylight simulations of the atrium in Ecotect/Radiance of different iterations of the process. The daylight conditions inside the atrium are improved by changing the composition of the apartments units. The amount of daylight is improved and the dead spots not containing daylight are minimized. The calculations are made from the worst case scenario with no daylight coming from above and thereby solely dependent on light coming through the southern façade. The investigation also shows that there in all of the cases are a high daylight levels in the atrium. This is also proven by the daylight factor entering apartment from the atrium in p. 97 – 98.

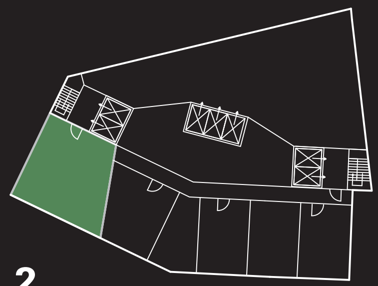
THE ATRIUM

The green spaces that grab into the atrium from outside and thereby take in greenery to the atrium that becomes a vertical garden. The atrium becomes a living vertical garden both used by the people living in the apartments and the people working in the space of the offices. The different possibilities of green space in two of the iterations are illustrated in ill. 111 and 112.

The green areas have different programs and qualities because of the orientation towards the sun. The programs of the green space will be containing leisure and sports activities but will not be detailed any further. Access between the floors is therefore important which are illustrated in p 117 - 118.

The openings of the green space also play an important role in the natural ventilation strategy of the building which can be seen in p. 147 in the synthesis section. Adding the green areas inside the atrium will minimize the daylight conditions in the atrium, but the consequences will be minimal according the initial daylight investigation in p. 68.

The atrium ends in the sky garden that is a semi public space for leisure activities. The concept can be seen in ill 113.

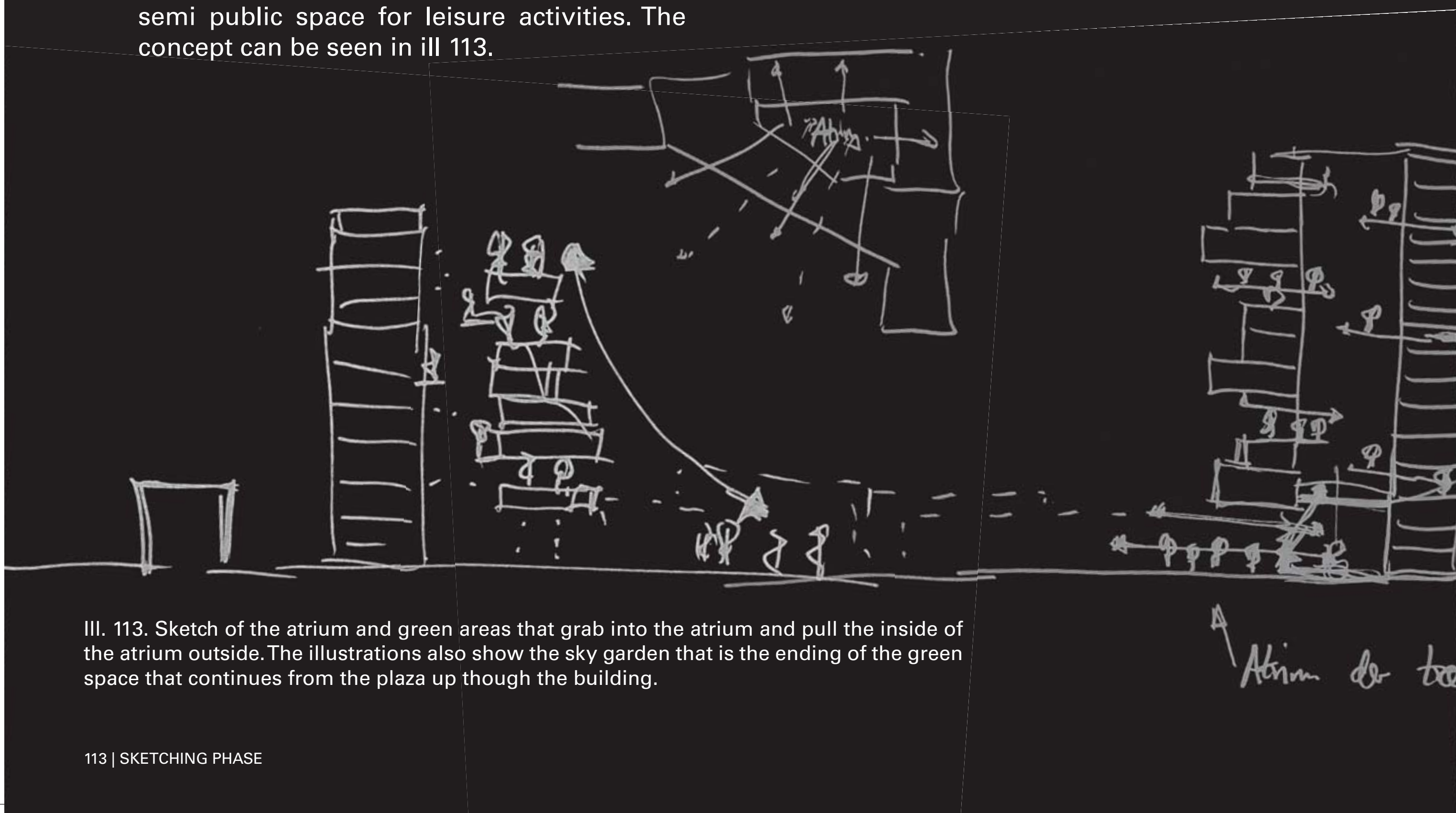


ITERATION. **2**

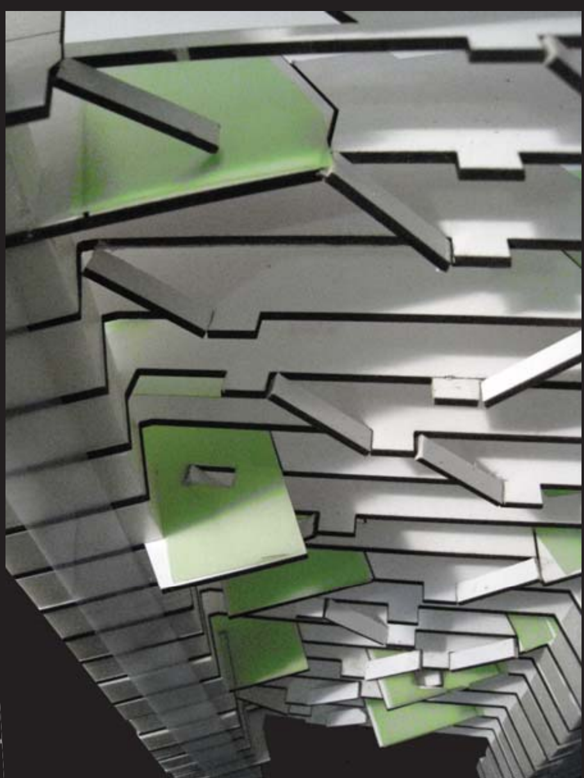
Ill. 111. The green wedges of the 2. iteration. The green areas are implemented in both the plan of the apartments and the offices. The wedges only partly penetrate the atrium because of the limited space in the atrium.

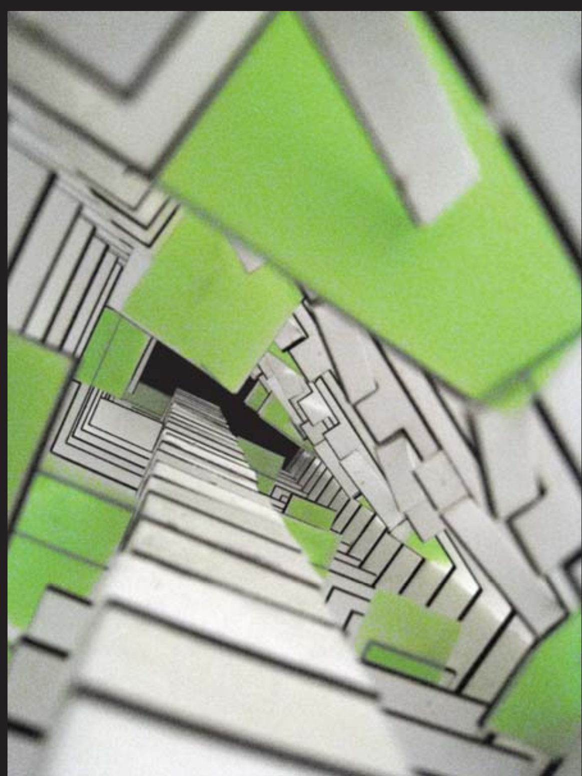
ITERATION. **5**

Ill. 112. Proposals for the green areas incorporated in iteration 5 of the plan solution. The space flow into the atrium and thereby creates the feeling of the vertical garden. The flow of the atrium is also incorporated in the green areas.



Ill. 113. Sketch of the atrium and green areas that grab into the atrium and pull the inside of the atrium outside. The illustrations also show the sky garden that is the ending of the green space that continues from the plaza up though the building.





Ill. 114. Model pictures of the atrium and the green spaces that grabs into the space and created the illustration of a green vertical garden.

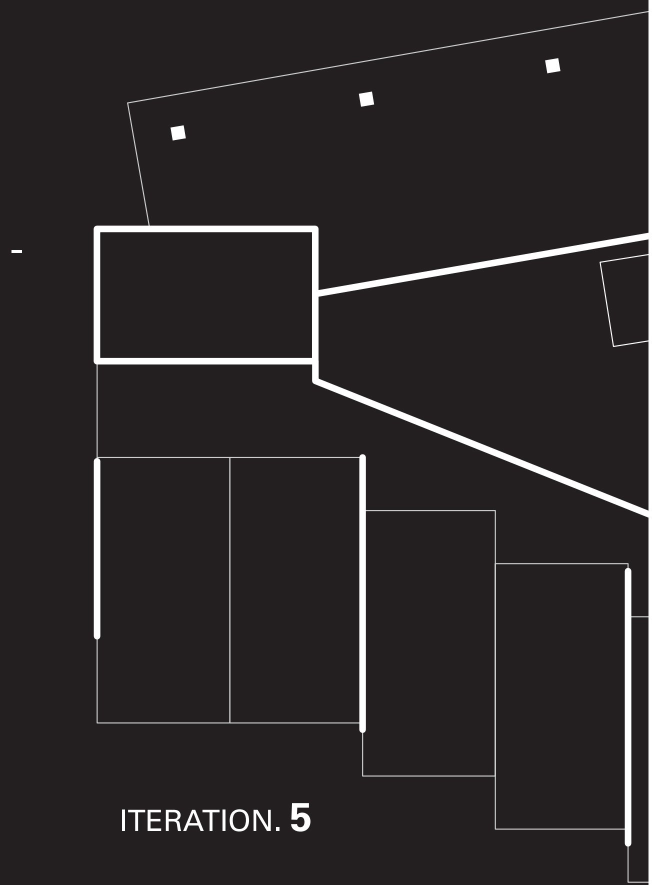
THE ATRIUM STRUCTURE

The atrium is part of the barring structure of the building. The structure of the atrium is thought of as rigid tube construction described in the initial investigation in p. 53 - 60. The atrium is load barring together with the columns in the office space and load barring walls in the apartments, see ill. 116.

There are different loads acting the construction and because of the height of the building the wind load plays a more significant role in the load combinations. See ill 118 for loads. The moment load which is the biggest load is absorbed in the construction of the cores and the office construction and the wind load is estimated to be a constant load after getting up app above 20 meters.

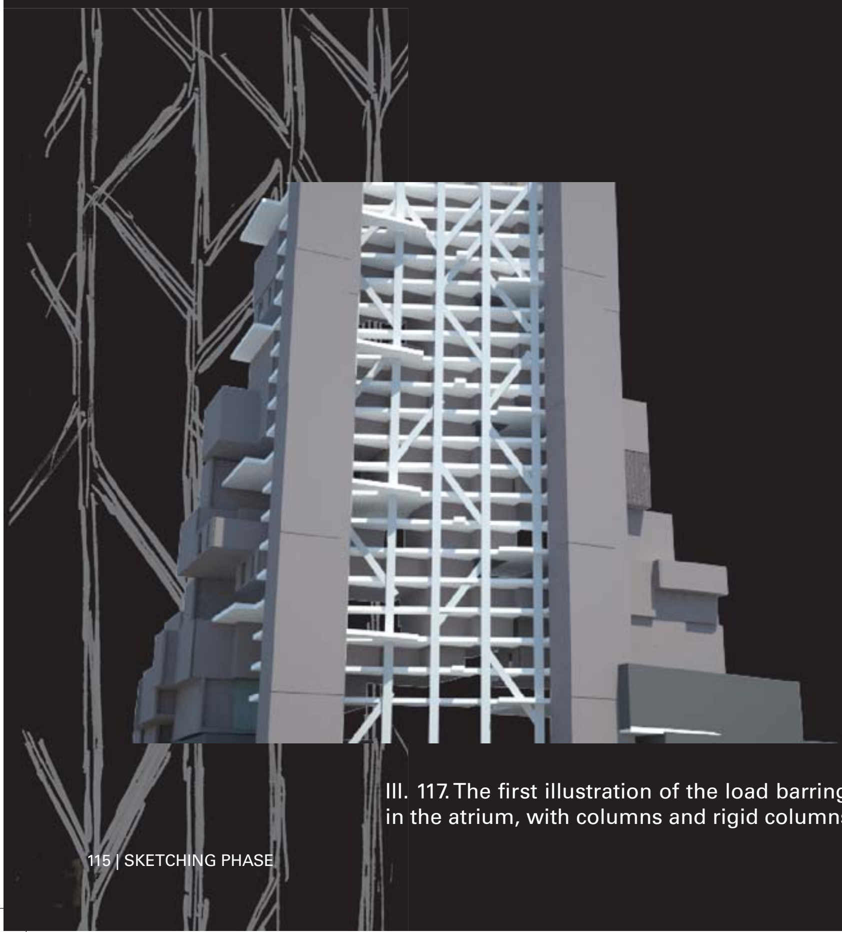
The rigid tube construction of the atrium needs to be able to obtain the dead- and the wind load. The rigid tube needs a cross structure to be able to obtain the horizontal load from the wind.

The process of shaping the constructive elements of the atrium will be investigated the following pages

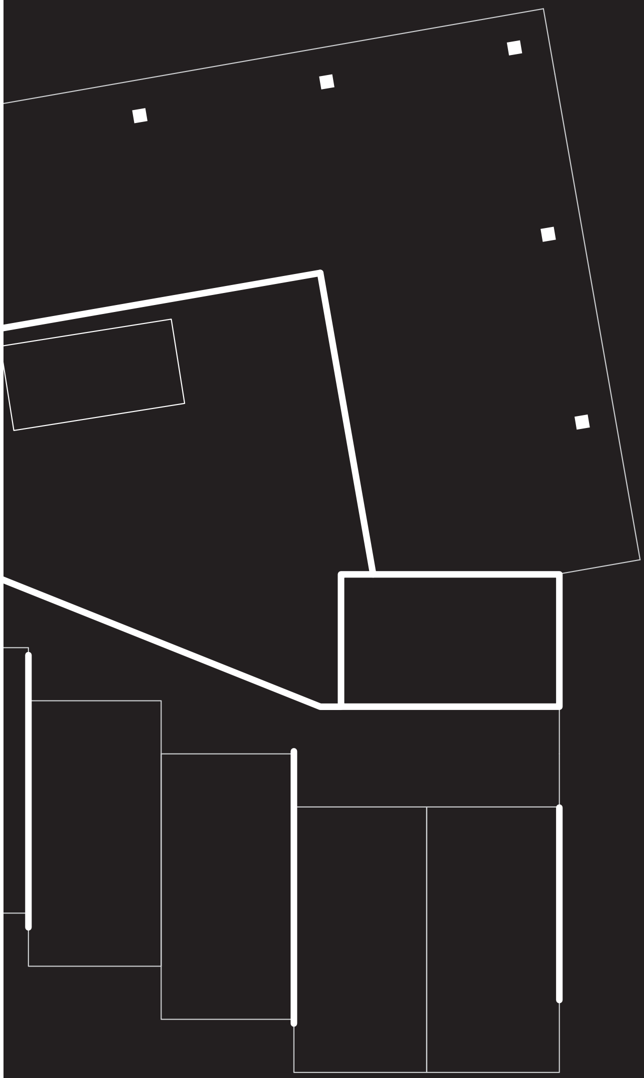


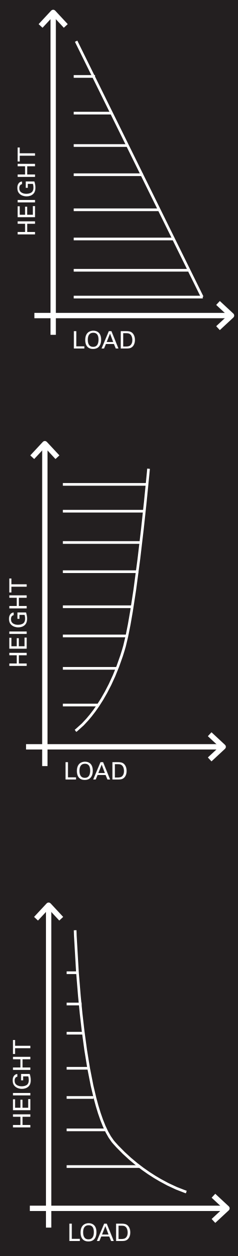
ITERATION. **5**

Ill. 116. The constructive elements of the building. The columns of the office space, the baring walls of the apartments and the tube structure of the atrium.



Ill. 117. The first illustration of the load barring structure in the atrium, with columns and rigid columns.





Ill. 118. The loads acting on the construction of the building. The diagrams are quantitative illustrations and are therefore not showing their actual size compared to each other

THE ATRIUM STRUCTURE

The iteration of the columns of the atrium is made with the tool of GenerativeComponent.

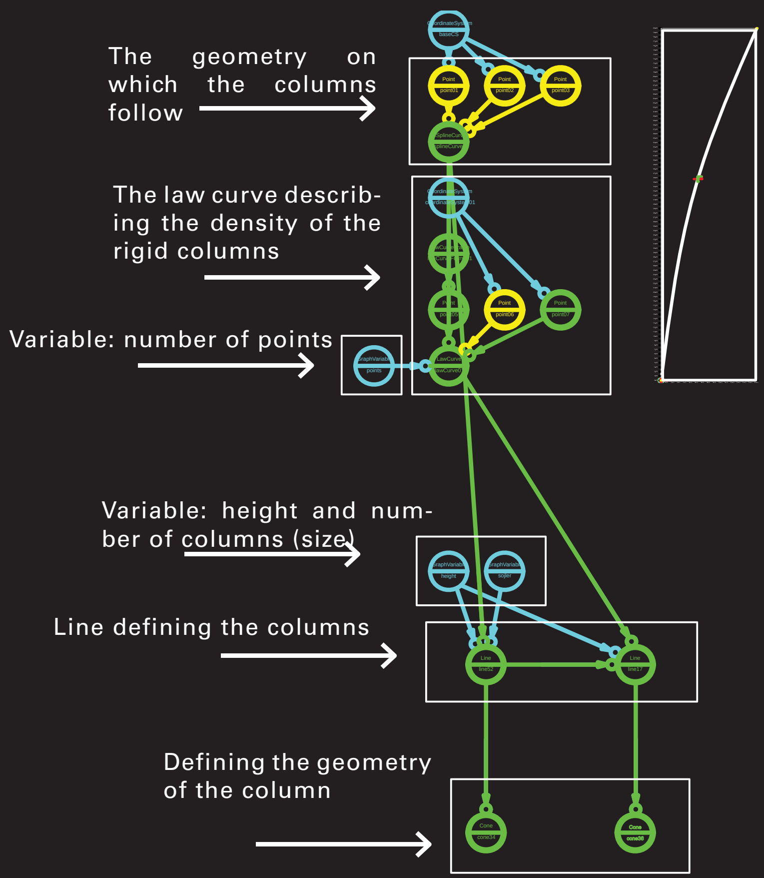
The needed size of the columns in the atrium is calculated in app. 2 where the line load on the columns also is estimated.

The moment load is not a active load on the columns because it is counteracted by the cores. The play load and the wind is implemented into the design of the columns by using GenerativeComponent.

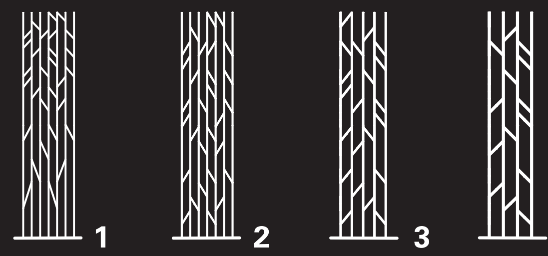
The parameter of the size of the column is therefore a function of the numbers of columns and the cross barring structure, which is live generated in the GenerativeComponent model, can be seen in ill 119.

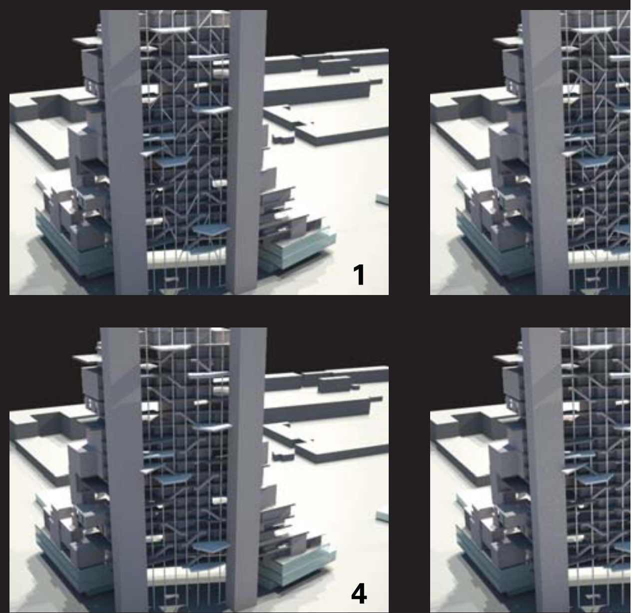
The result of the generations of forms in GenerativeComponent can be seen in ill. 120 as 3D visualizations. The 3D visualizations of the columns are placed into the model of the building to test how the form interacts with the rest of the building.

The test makes it evident that adding cross columns into the atrium is an element that does not fit the rest of the building. The investigation also shows that the stairs in the



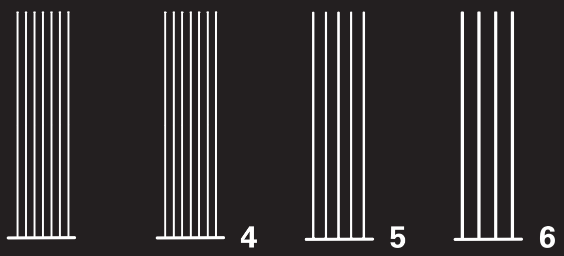
Ill. 119. The first illustration of the load barring structure in the atrium, with columns and rigid columns.

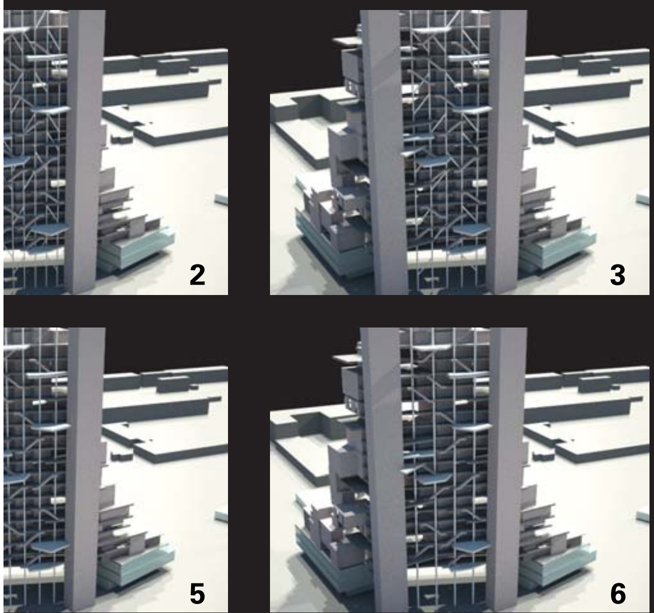


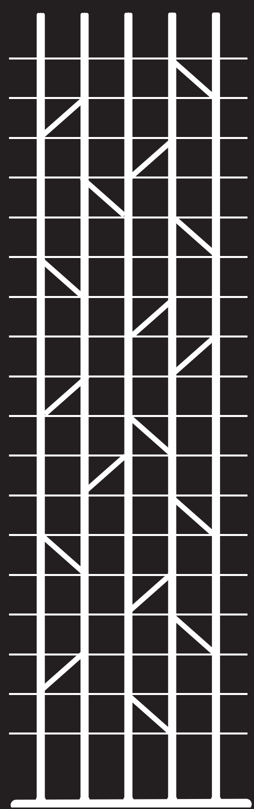


atrium gives the needed rigidity to the structure.

The final choice of columns is therefore the straight standing columns with a distance of 5 meters. Choosing more columns would make the columns create a wall closing of the atrium and choosing less columns would make the size of each column to big and dominant.







Ill. 120. The picked concept of the atrium with the columns and the stairs connecting the different floors and acting as rigid columns giving the needed stiffness to the construction.

THE OFFICE

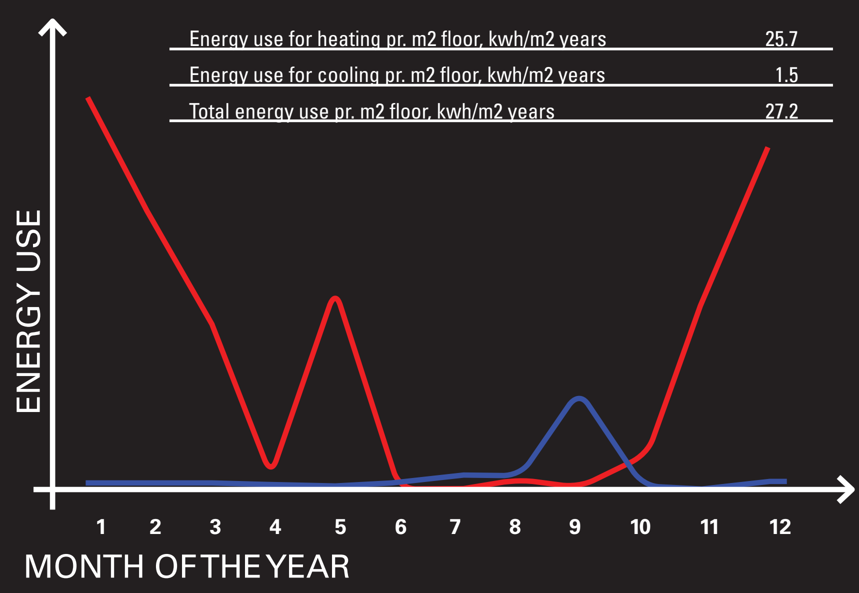
The process of designing the office space plays an important part for the overall expression of the building. The main iterations of the office space can be seen in ill. 122. The office façade is facing north and is considered as a glass facade. The thermal consequences of having a pure glass façade can have a great impact on the indoor environment, but the great internal heat load and the need of diffuse daylight in office spaces makes the consequences of the façade beneficial. These thermal assumptions are tested in spreadsheets, see ill. 121

The expression of the facade is plain and straight and thereby in contrast to the more organic and complex facade of the apartments on the south side of the building. Thereby the office space express functionality and durability, which are important attribute for companies possible to make use of the space.

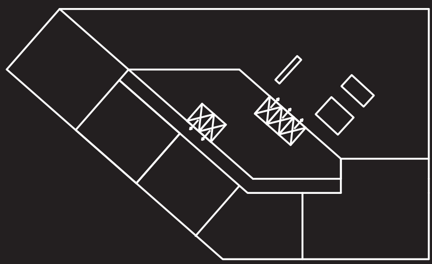
Placing apartments and offices next to each other create concerns about noise and unwanted exposure for the workspaces. These concerns are treated in the atrium and the transition from the atrium to the office where a wall separating the office and the atrium is placed. The wall is transparent or translucent to let in daylight and still allow privacy in the office space and to block out noise.

The form of the plan is free and not as restricted as in the apartments but the functionality of the space is still important. The construction of the office space it is a grid structure of columns placed in a span of 8 meters. The columns stabilize the construction of the building and create a natural separation of workspaces units. The columns makes it possible to have a free open space and still have a stable rigid frame, as described in the structure section.

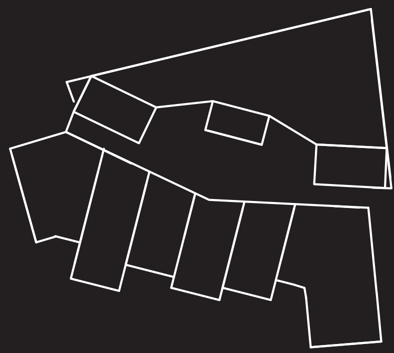
ITERATION. **1**



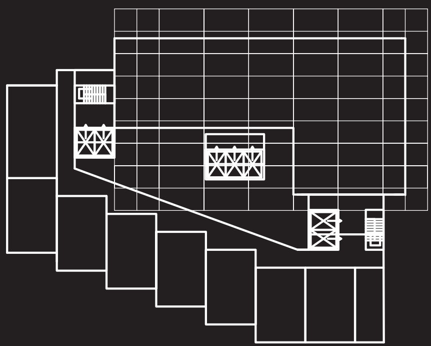
Ill. 121. Initial investigation of the thermal condition of the office. The investigation show that even though the office has a glass facade to the north the energy use for heating and cooling the space are small which makes it acceptable to implement the glass facade.



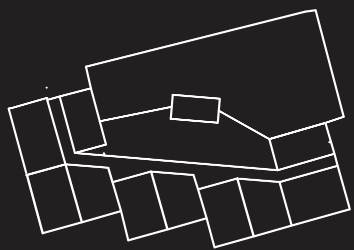
ITERATION. **1**



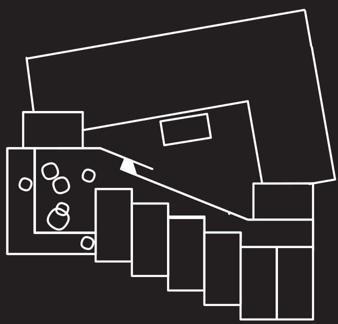
ITERATION. **2**



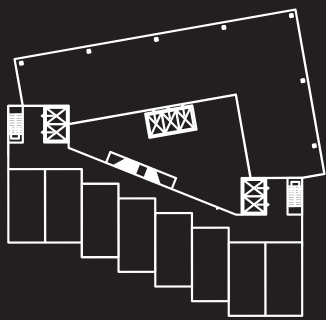
ITERATION. **4**



ITERATION. **3**



ITERATION. **5**



ITERATION. **6**

Ill. 122. The functionality of the office space is important and therefore a parameter that is incorporated thought the iterations of the office space. The flexibility of the space is also important because of the wish to create different sizes of workspaces. Aesthetical and visual separation of the offices and the apartments in the facade is also important for the expression. The progress shows how the cores become the separating element between the two functions. Making the facade follow the road is also important for the overall expression of the building and the placement on the site.

THE OFFICE

The space of the office is simulated in BSim to give a more accurate picture of the thermal condition, see ill. 124 and app. 4.

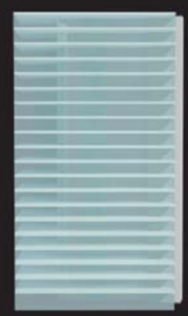
The first simulation shows that the internal heat load is much higher compared with the apartment as assumed. The benefits of adding the atrium and avoiding south orientated windows can be seen in ill. 124.

The design process of the office has been concentrating about the façade expression and the functionality of the plans. Many different proposals on the façade have been evaluated thought the process, which can be seen in ill. 123.

The facades are evaluated in concern to the main concept and the connection to the rest of the building. It is therefore also important that the office façade has a reference to the apartment façade. This reference is made by an abstraction of the visibility of different office units and the adding and subtracting in the floor slabs.

The overheating that still are evident in the space but improved by adding internal shading, The working regulation allows temperatures above 26 degrees in 100 hours a years which means that the space has a need for cooling but the energy for cooling have been minimized even further.

Ill. 124. Thermal investigation of the office shows the need for cooling and heating in the different months of the year. Comparing the result of the reference office space with the reference apartment it becomes evident that even though the office is north orientated the heating need is low. Adding the atrium and thereby avoiding heat gain. The south windows improve the need for cooling significantly.



- A straight facade only slabs visible
- Strong expression
- Monotone and lacking life

- Introvert boxes repeated in the facade
- Forming green spaces inside and balconies outside
- A more uninterrupted facade needed

Ill. 123. The iteration of the facade expression. The facade is a glass facade with a high U-value and factor. This eliminates problems with glare and draught from windows, which can be a problem in rooms where windows are more than one story high. The facade marked with a white square are the façade that have the most appealing expression in concern of the design parameters.

OFFICE

	SUM	1	2	3	4	5	6	7	8	9	10	11	12
		MONTH OF THE YEAR											
HOURS > 28	2885	0	6	24	71	313	667	728	734	320	16	6	0
HOURS < 20	177	299	11	0	0	0	0	0	0	0	0	3	81

OFFICE WITH ATRIUM

	SUM	1	2	3	4	5	6	7	8	9	10	11	12
		MONTH OF THE YEAR											
HOURS > 28	374	0	0	0	0	1	89	157	127	0	0	0	0
HOURS < 20	1645	706	602	24	0	0	0	0	0	0	0	41	272

OFFICE WITH ATRIUM

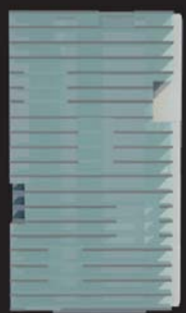
	SUM	1	2	3	4	5	6	7	8	9	10	11	12
		MONTH OF THE YEAR											
HOURS > 28	374	0	0	0	0	1	89	157	127	0	0	0	0
HOURS < 20	1645	706	602	24	0	0	0	0	0	0	0	41	272

- C shape added on the facade
- Balconies outside the offices
- Facade to chaotic

- C shape added like boxes
- Forming green spaces in- or outside
- Looks mounted on the facade
- Need more clean expression

- Abstract interpretation of the box pulled in and out of the facade
- Clean expression but still chaotic
- No reference to the plans of the facade

- Straight glass facade
- Abstract reference of the box subtracted in plans inside
- Clean expression
- Possibility of balconies



- A straight glass facade
- Inverted spaces inside forming green spaces
- Interconnection between stories
- Strong and clean expression

- Straight glass facade
- Inverted spaces inside forming green space
- Interconnection between stories
- The walls separating spaces inside
- Expression of different units.

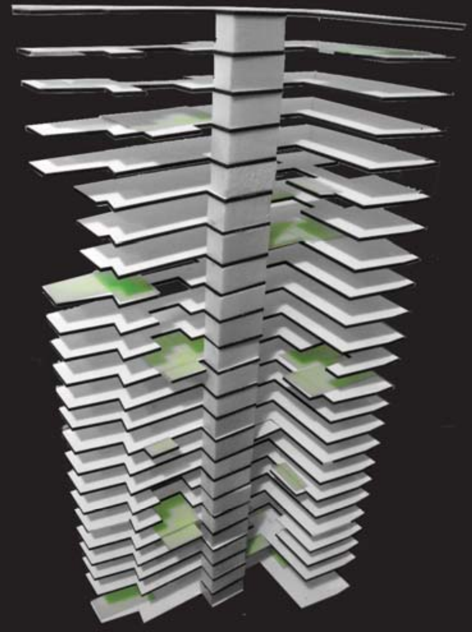
Ill. 125.

THE OFFICE

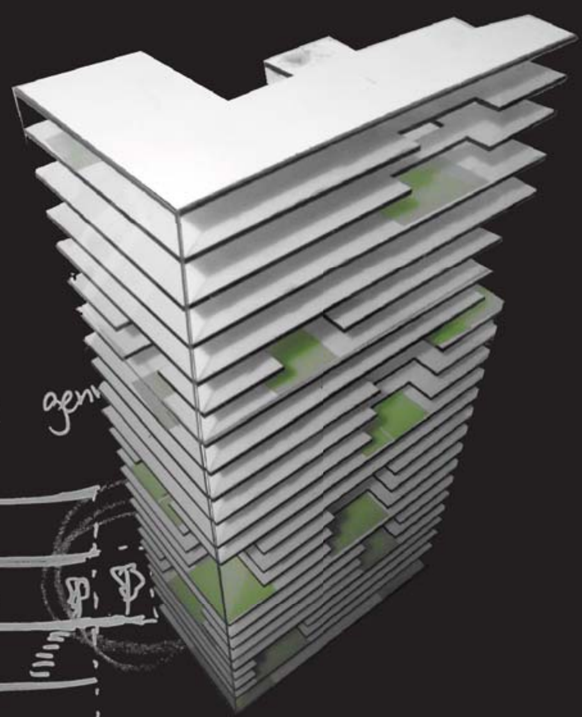
The office space has been optimized towards getting useful and flexible plans, which fulfill the demands of the program and creates the possibility to separate the space up into smaller units.

The main entrance for the office is the lobby at the ground floor. The ground floor is connected to the office space though an elevator placed in the atrium. Each office plan has in front of the elevator the possibility to have: one more formal meeting point if necessary, space to place for cloakroom and a small reception. The office elevator is not a stabilizing core in the constructive layout of the building. The walls of the elevator can therefore be transparent and thereby emphasize the experience of moving up though the green spaces of the atrium.

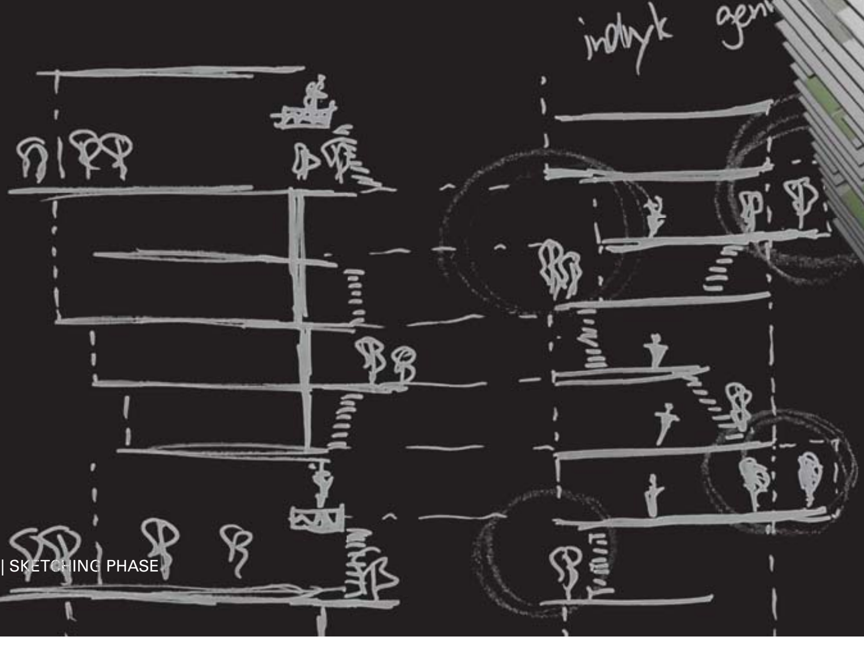
The final proposals for the floor plans of the office space can be seen in ill. 129. where different proposals of layouts are illustrated. The quality of the office space is improved by adding balconies to some of the floors plans as can be seen in 126-127. The balconies make it possible for the occupants to enter the atrium and dragging the green space of the atrium into the offices.

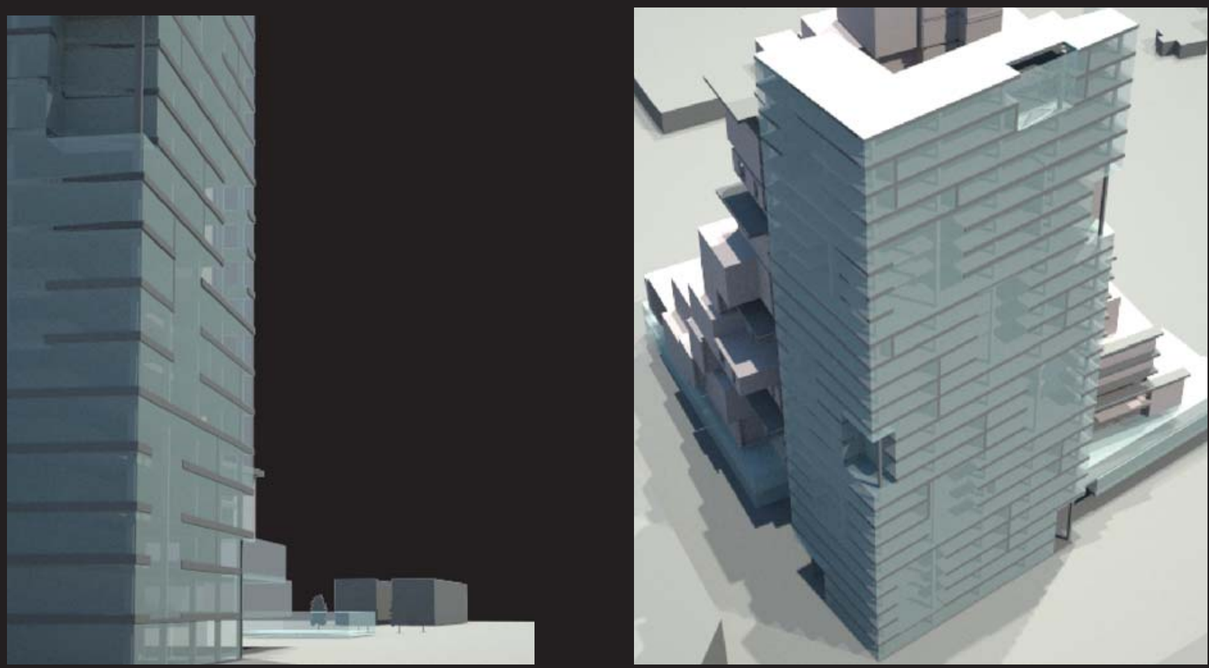


Ill. 126. Model shows the inner space of the atrium and the office façade facing the atrium. The balconies are interacting with the atrium and thereby pull the space of the atrium into the offices.

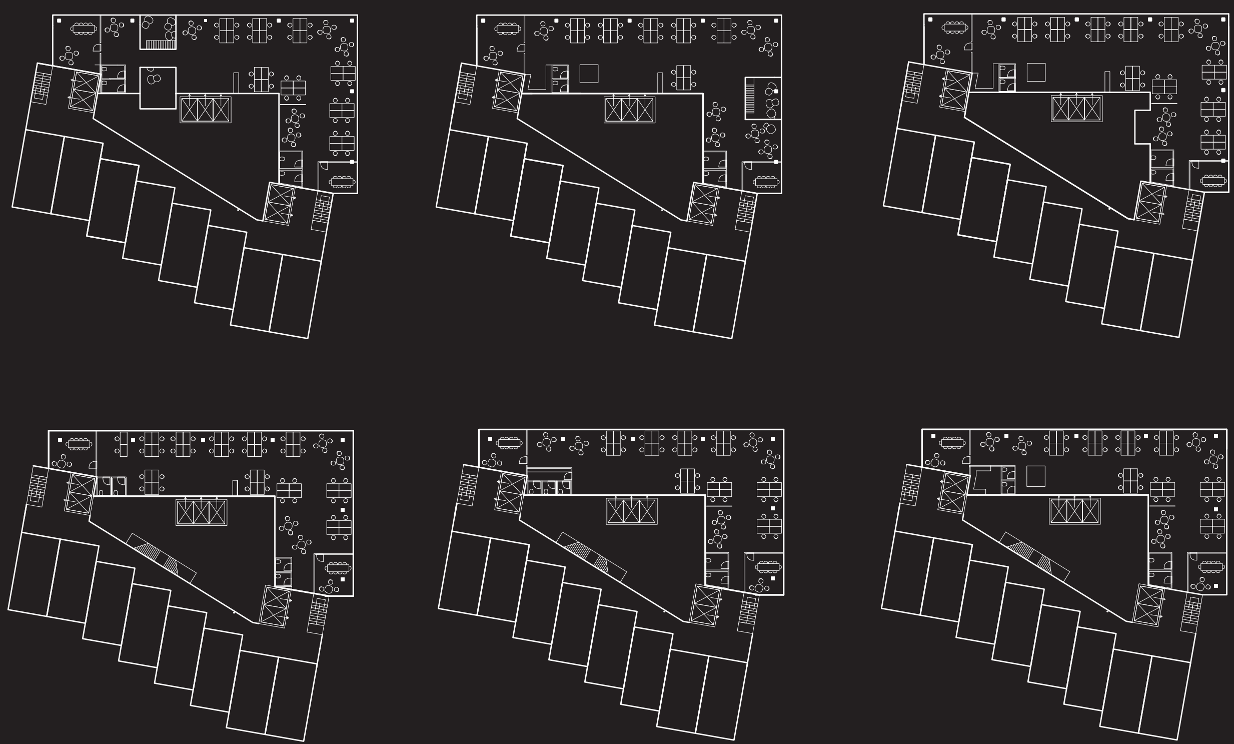


Ill. 127. Model shows the north and east façade of the offices. The green inverted spaces, which are referencing to the greenery in the atrium, are connecting to the floors and become a visible element in the façade.





Ill 128. The final facade expression of the office



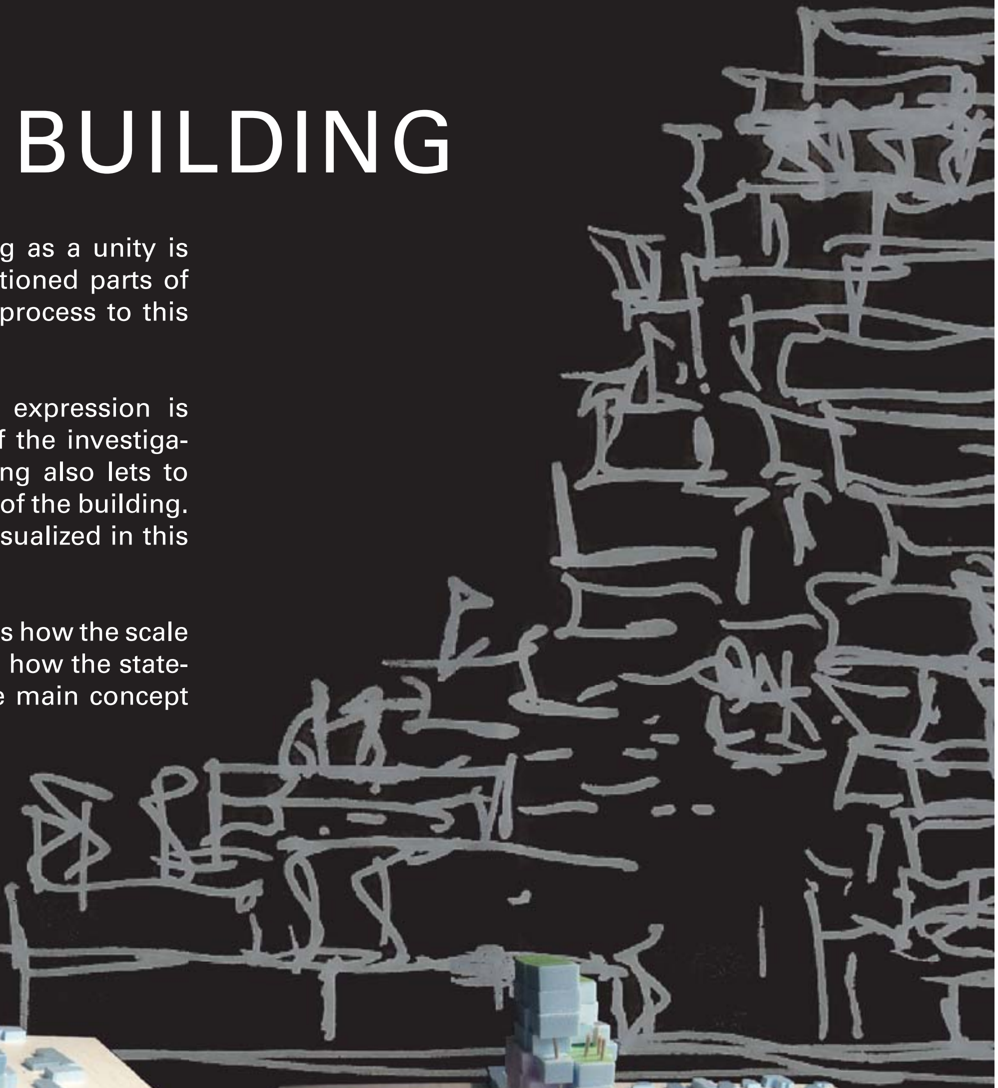
Ill.129. Different proposals of arrangements of the spaces in the office. The functionalistic layout of the plans makes it possible to have flexibility and thereby possible to have a layout that fits the need of the office.

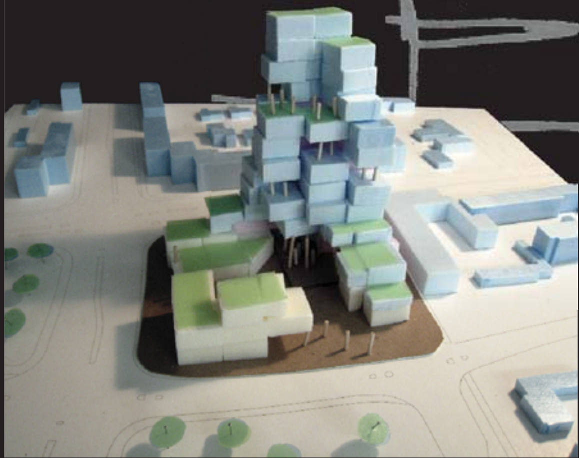
OVERALL BUILDING

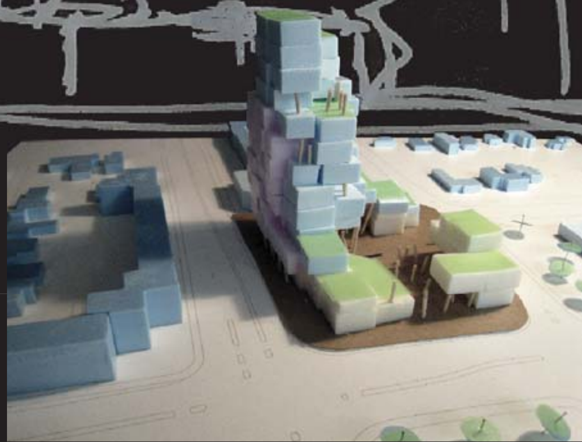
The expression of the building as a unity is an interplay of all of the mentioned parts of the building described in the process to this point.

The process of the building expression is therefore a reflection on all of the investigation but visualizing the building also lets to iteration of the inner functions of the building. The main iterations that are visualized in this section can be seen in ill 130.

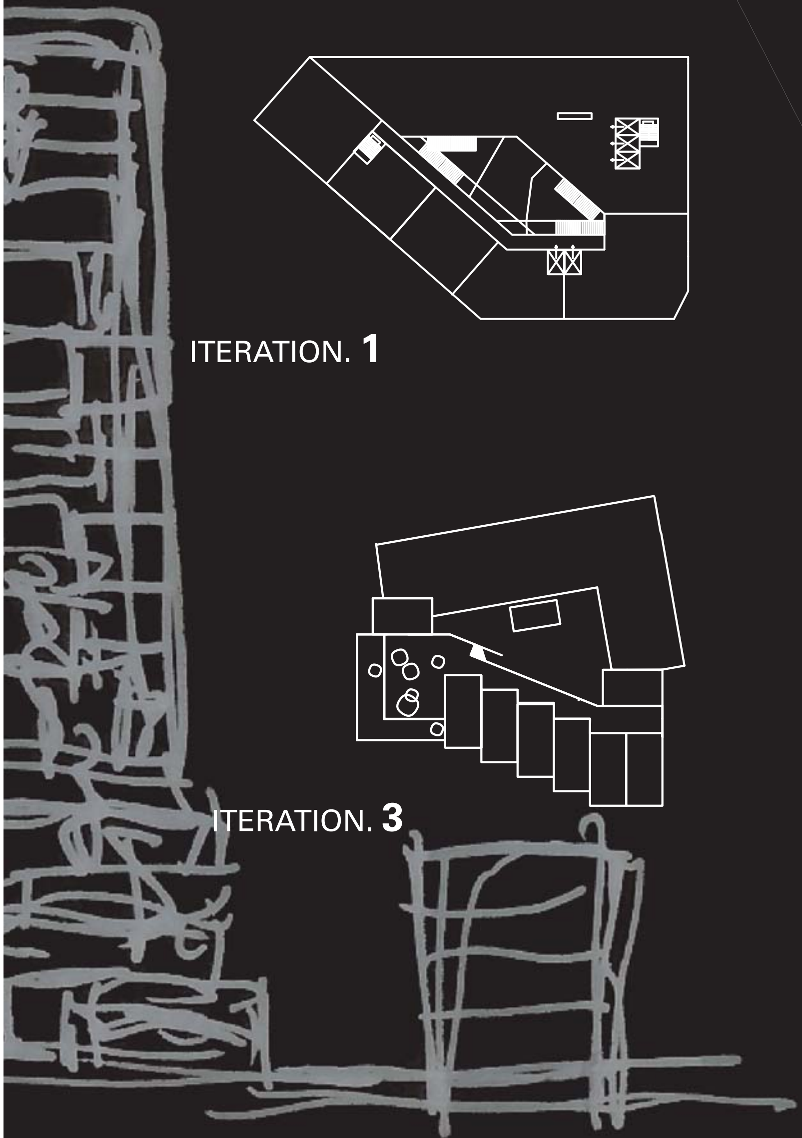
The model of the iterations tests how the scale of the building fits the site and how the statements in the vision and in the main concept are evident in the building.



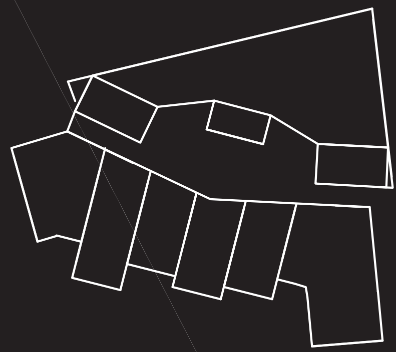




Ill. 131. One of first models made from the main concept and therefore not related to any specific plans drawings. The different colors of the model represent the different functions in the building. The model is reflecting on the expression stated in the concept and the room program. The model shows the straight office facade to the north and the more complex apartment facade to the sought of the apartments. The ground floors contain public facilities such as shops and cafes.



ITERATION. **1**

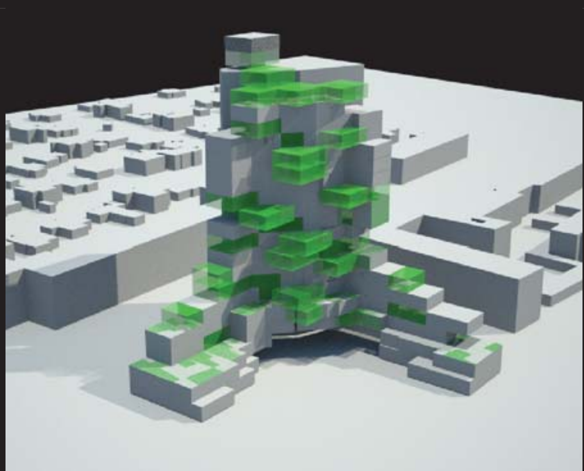


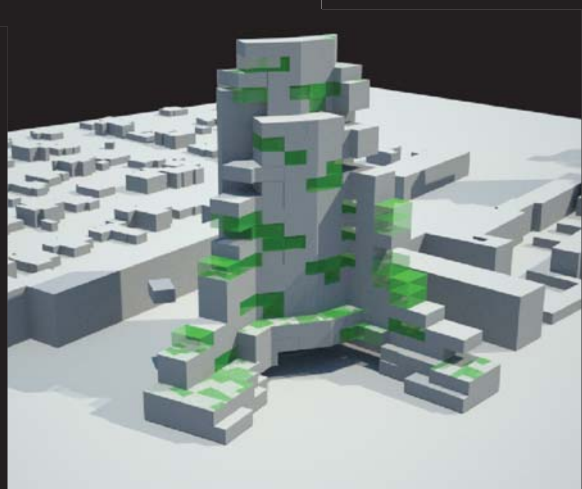
ITERATION. **2**

ITERATION. **3**

Ill. 130. The three main iterations of which the overall expression of the building are investigated. The three iterations are represented in the following pages.

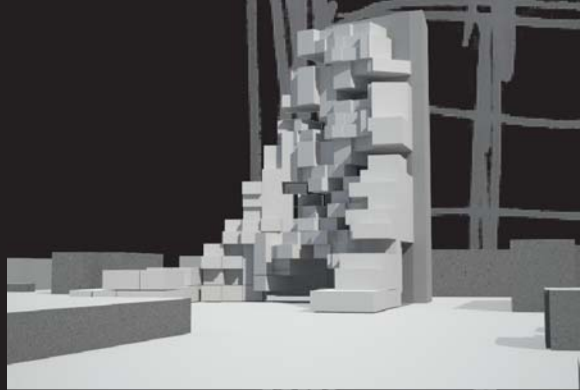
ITERATION. **1**



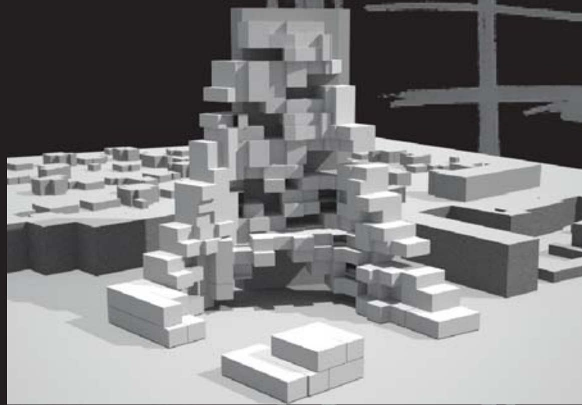


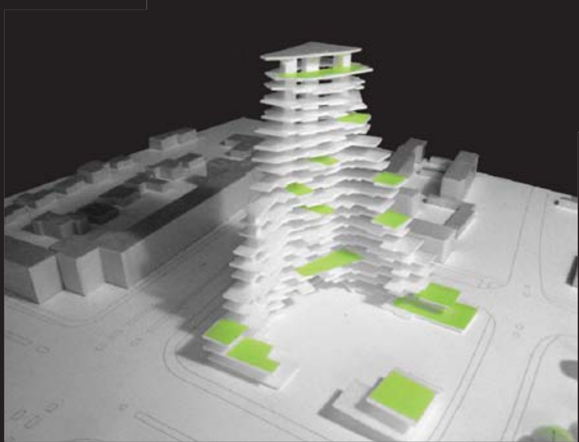
Ill. 132. The building layout in iteration 1. The south façade is straight and monotone and only broken up by the green spaces. The functionality of the plans and the expression is more flat than illustrated in the concept therefore changes.

OVERALL BUILDING



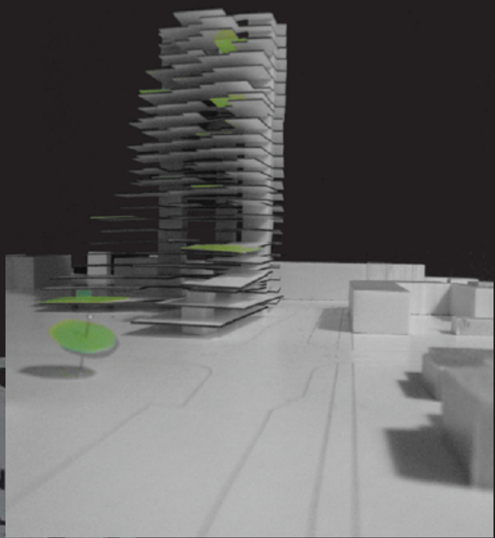
ITERATION. **2**

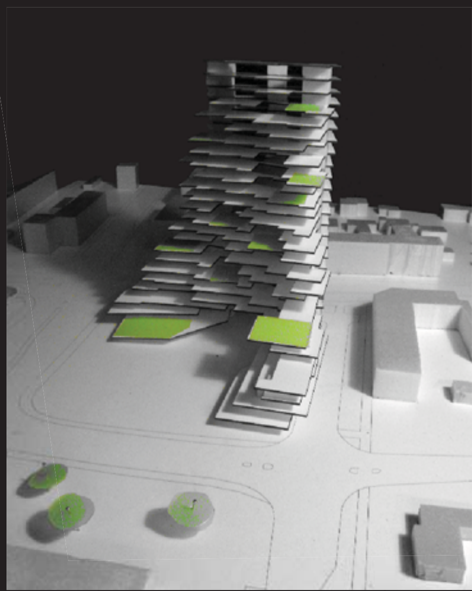


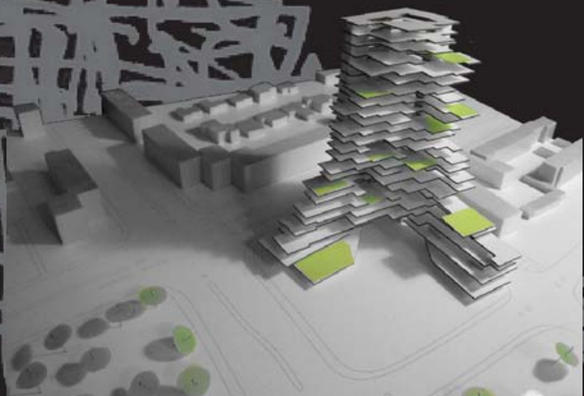


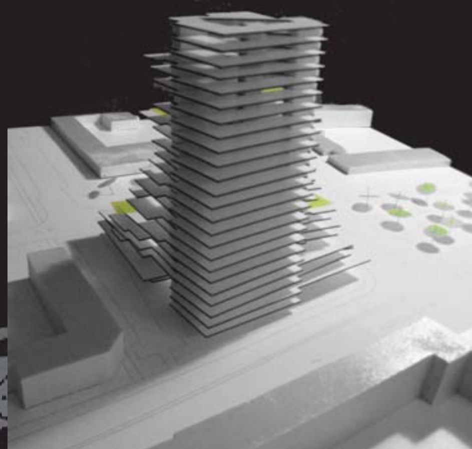
Ill. 133. The second iteration of the building expression. The apartment units are pushed and pulled in the layout. The expression is disorganized and lacks functionality.

ITERATION. **3**

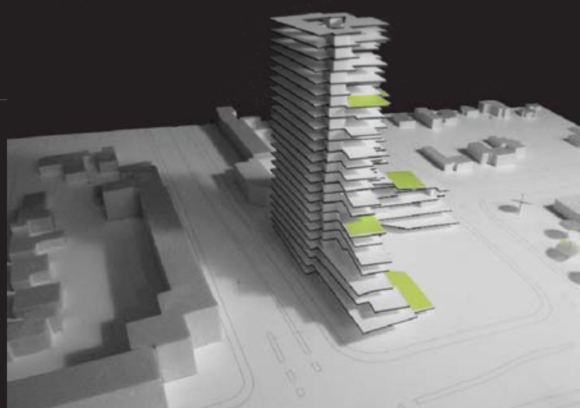




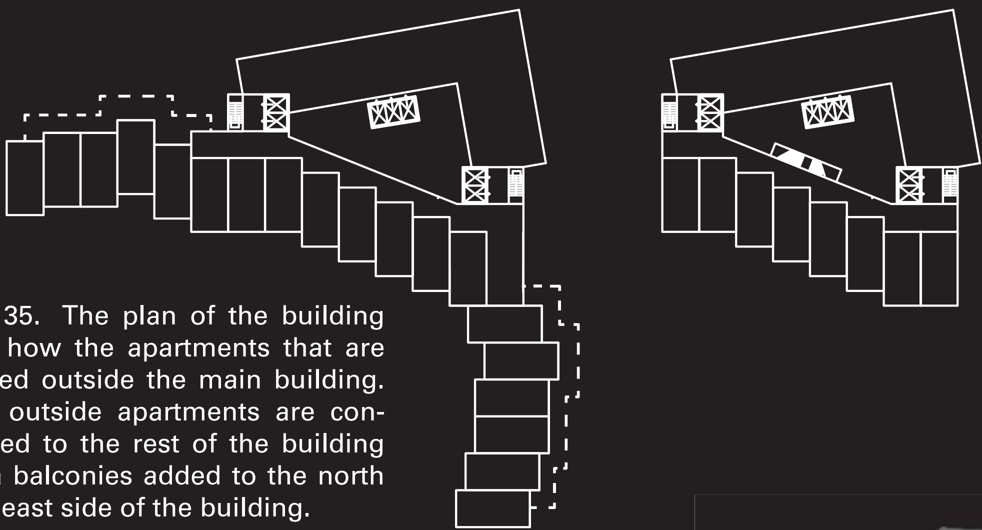




Ill. 134. The next iteration of the building expression shows the green leisure areas in the building that is organized. The unit of the apartment is regulated in terms of thermal conditions and daylight. The daylight condition in the atrium is also optimized as described in ill. 109 p. 112 as well as the office space becomes more flexible and functionalistic see p. 121.



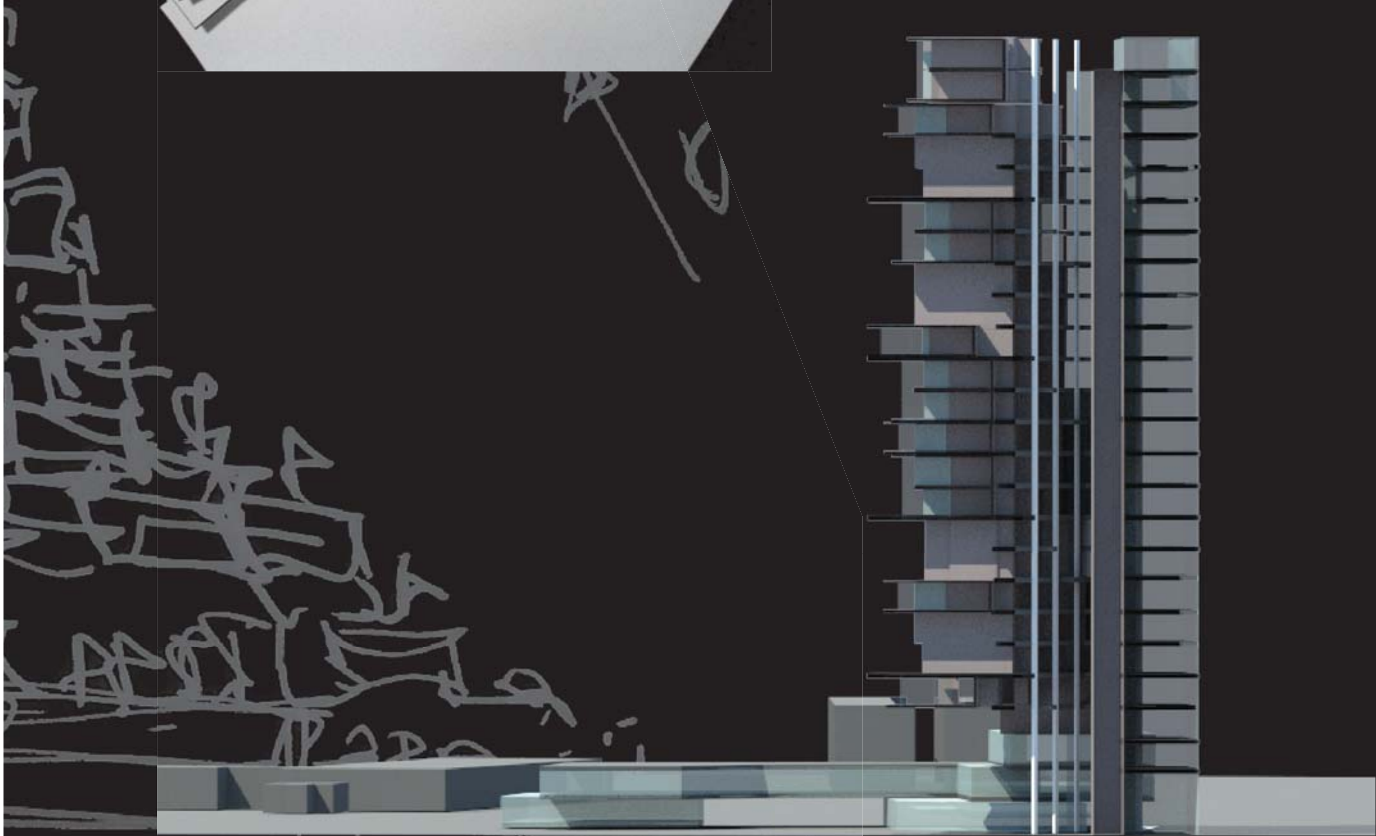
OVERALL BUILDING



Ill. 135. The plan of the building and how the apartments that are placed outside the main building. The outside apartments are connected to the rest of the building by a balconies added to the north and east side of the building.

Ill. 136. The building seen from west. The picture illustrates the separation of the apartments and the offices by the core the contrast of the façade that still preserve the same references to each other. The illustration also shows the elevation of the site with public functions in the facade.

Ill. 137. Larger scale model shows the green leisure areas ranging though the facade from the atrium



Ill. 138. Section though the building shows the connections between the apartments, the atrium and the office. The section expresses the difference in the space and its reference to the function inside.

BUILDING HEIGHT

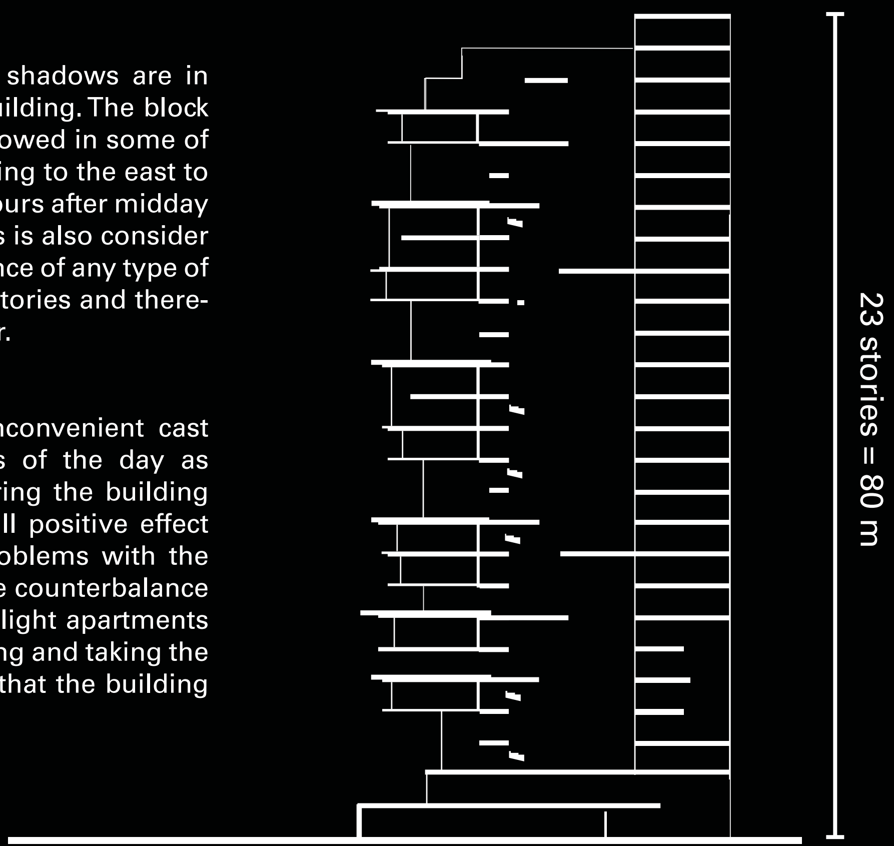
The height of the building have a great effect on the micro environment in terms of cast shadows on the existing urban fabric.

Inconvenient cast shadows is unavoidable when building high, but still a factor that need to be avoided if possible. The height of the building is therefore a function of the density of the building, the need of daylight in the building and the orientation and placement of the mass.

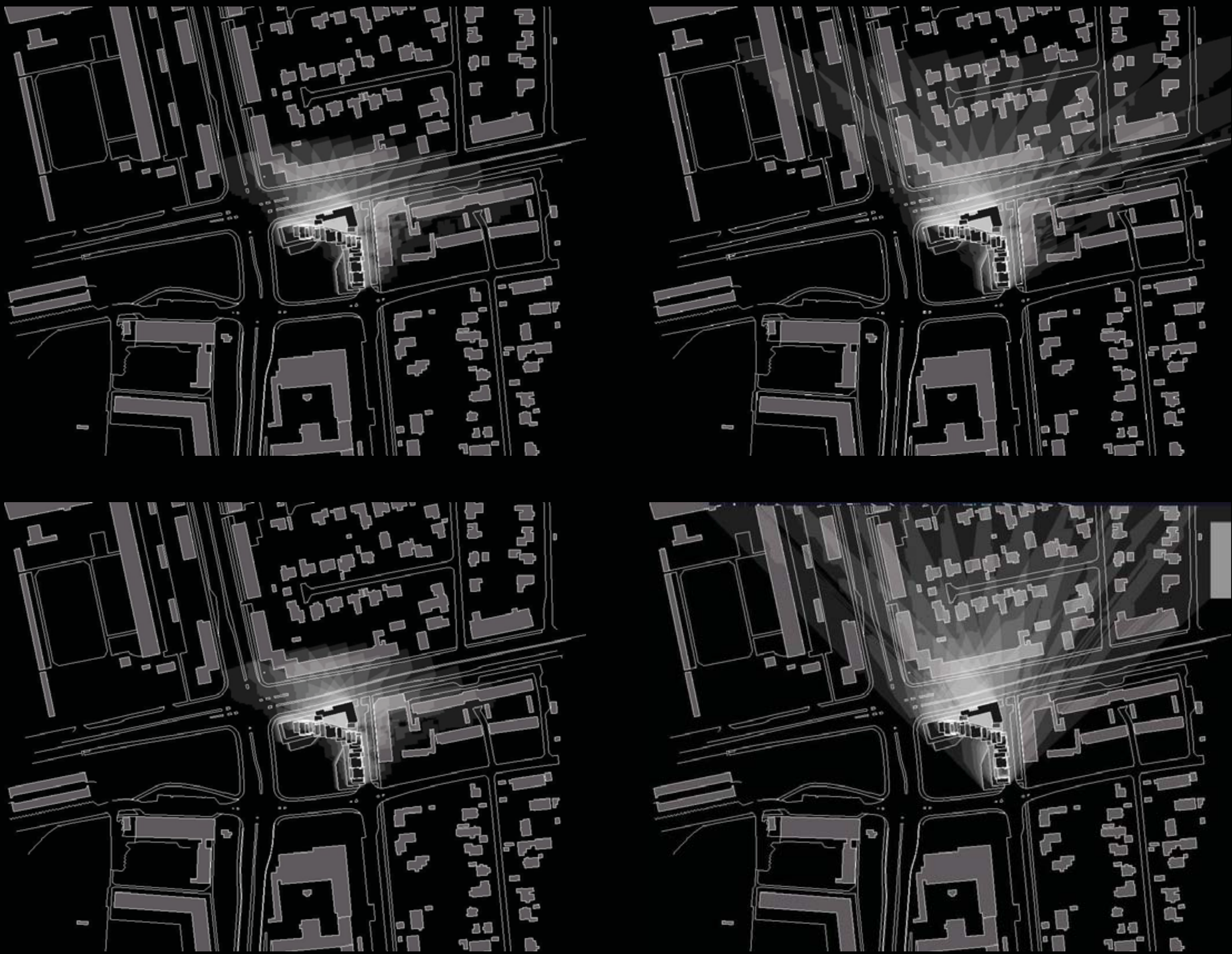
In the initial investigation of the placement of volume and height where qualitative evaluations that stated the mass and maximum height of the building to be in the north east corner of the site, see p 75-76. The overall building investigation showed that the building should be around 23 stories high, both in terms of placement of the functions and the expression of the building. The cast shadows of the building being 23 stories high can be seen in ill 139 and 140.

The main problems of cast shadows are in the south and west of the building. The block building to the south is shadowed in some of the winter months. The building to the east to the site is shadowed in the hours after midday large periods of the year. This is also consider as an unavoidable consequence of any type of building at the site above 4 stories and therefore also an acceptable factor.

In most of the cases the inconvenient cast shadows is only few hours of the day as evident in ill. 140 and lowering the building height will only have a small positive effect on the cast shadow. The problems with the cast shadows also need to be counterbalance to the high numbers of well light apartments that are situated in the building and taking the factor in mind it is consider that the building height is reasonable.



Ill. 139. The approx height of the building being 23 stories high.



Ill. 140. Cast shadows investigation in Ecotect. The investigation shows that the cast shadows from the building will have some effect on the building in the perimeter of the site. The building situated to the south and the east of the site begin the most affected.

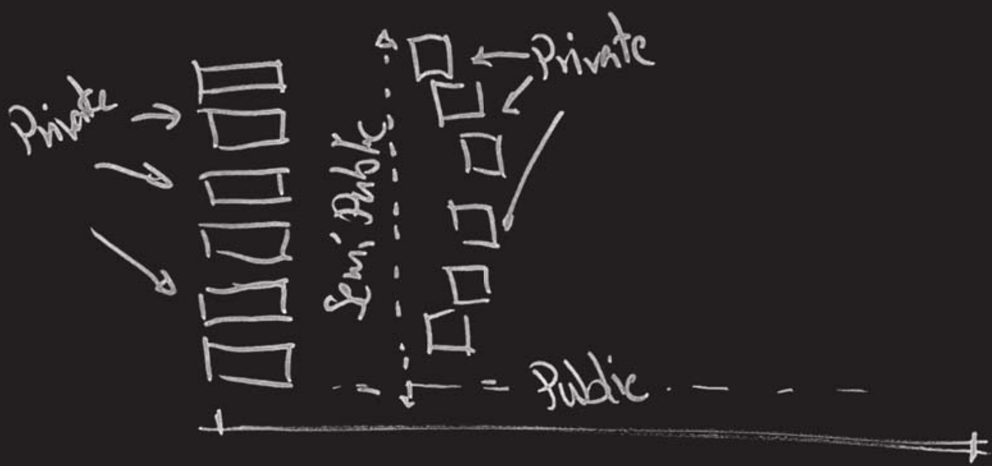
The cast shadow will also have an effect in a large part of the city in the winter most but as that investigation shows the individual space will only be affected a few hours of the day.

THE SITE

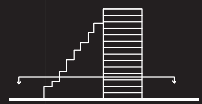
The meeting between the building and the site has great importance for the perception of the building and the way the site is used. The site is as a public space for both for people living in the city and the people living in the building see ill. 141.

The use of the site is affected by the main roads west and north from the site, which can cause inconvenience by noise and pollution as evident in the site analysis. For the site to become attractive a barrier that protects the site from the road is therefore integrated. Some of the first iterations of the site plan can be seen in ill 142 -145.

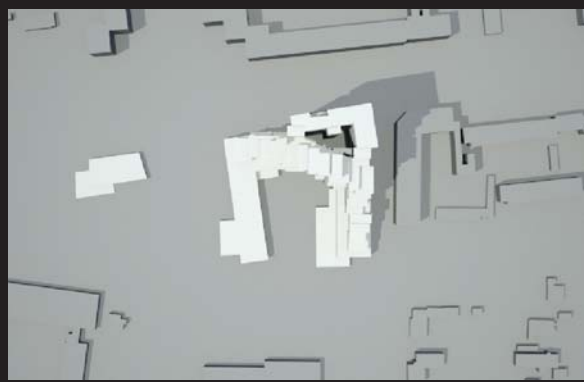
The site is a reinterpretation of a block building with an inner courtyard; a courtyard area that is protected from the roads but still has some connection to the green areas around the site and the city.

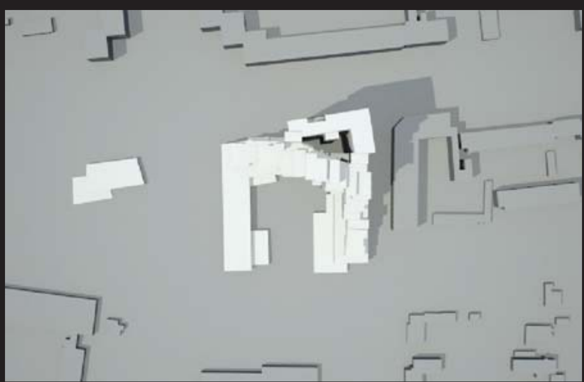


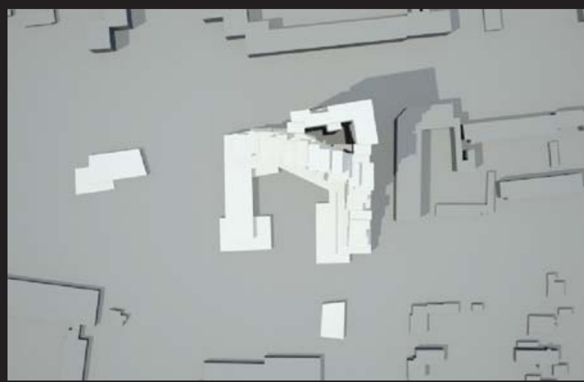
Ill. 141. The concept of the public and semi public spaces on the site and in the building. The ground floors are public space and extrovert functions give life to the perimeter of the site. Inside the building, in the atrium, are semi private spaces and in the individual apartment private outdoor spaces in the balconies.



Ill. 142. Illustration of the first interpretation of the site plan and the flow around it. The three lower floors have layers of public green spaces. In this case the site becomes an arcade. The design was therefore changed to create a space that relates to the courtyard, which connects to the green space in the atrium and the apartment façade.

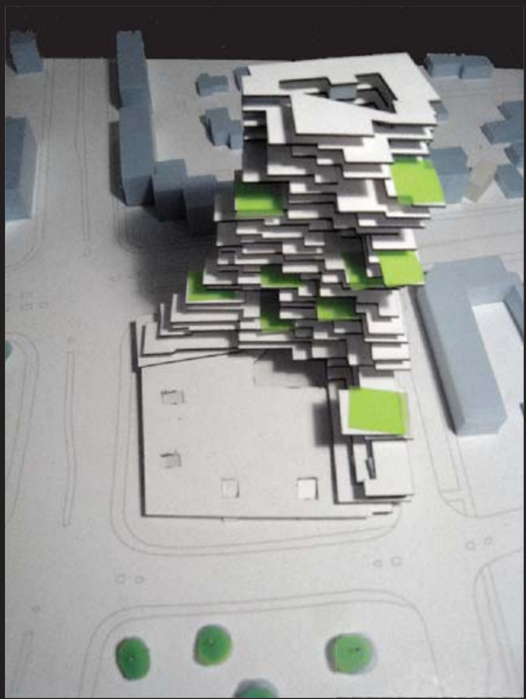


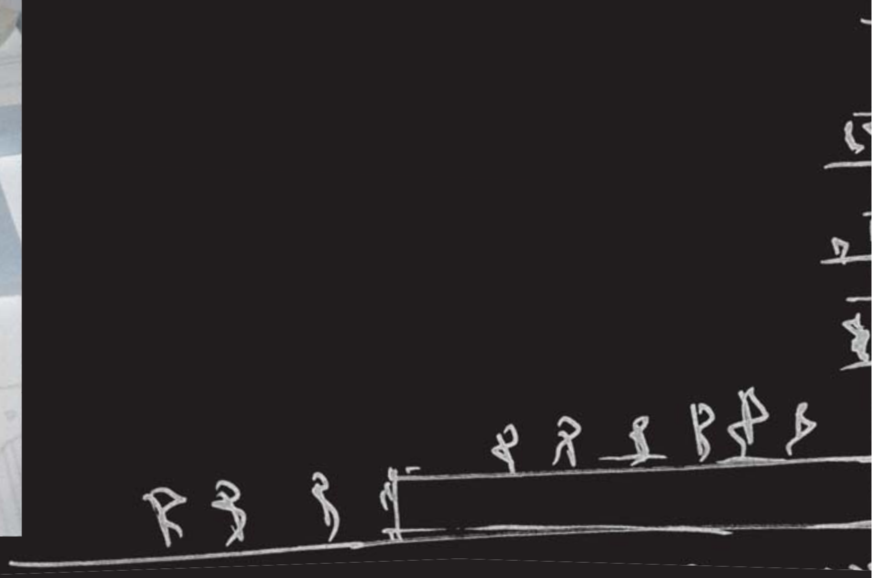




Ill. 143. Investigates space of the building and the relationship to the site. In the initial concept an extra extension of the building to the west or pavilion in the south west corner side is added to the building, but the expression did not fit the concept or the expression of the building. The solution of elevating the site thereby solved the problems in relation to separating the site form the traffic but still having a visual connection to the nearby areas.

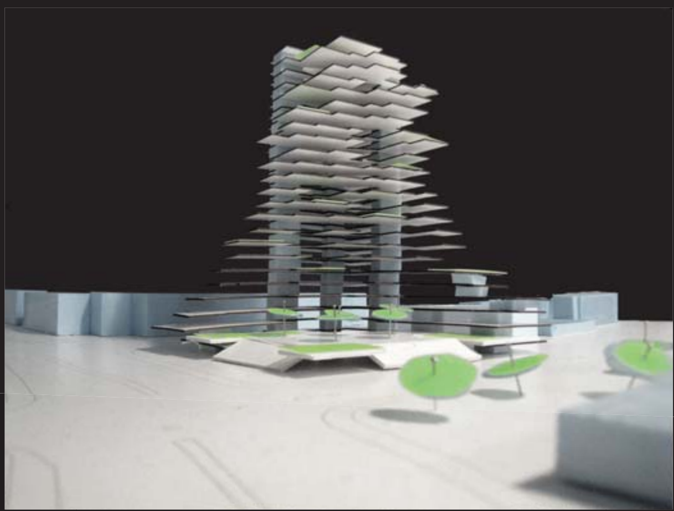
THE SITE

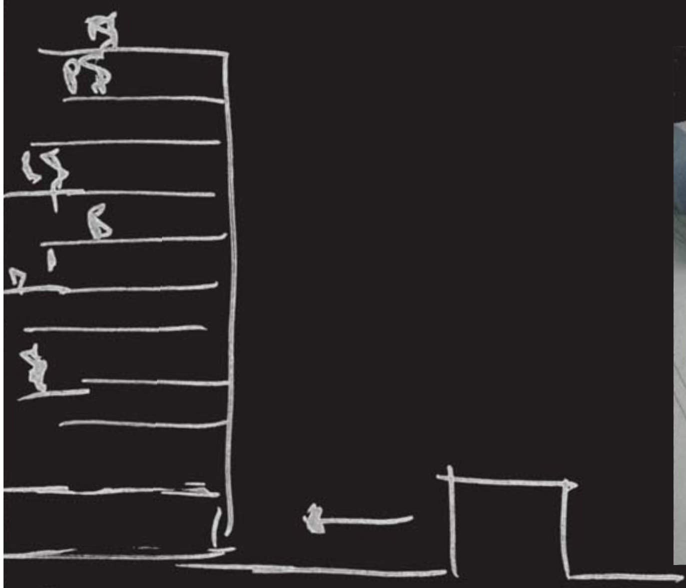


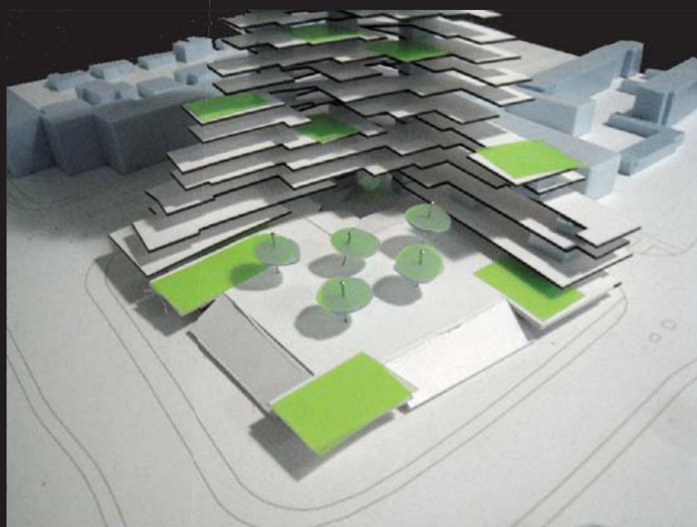


Ill. 144. Investigation of the site elevation and the contact between the site and the nearby areas to the north and west of the site. The model and the drawing show that the elevation of the plaza stresses the main concept and the greenery as a continuing element grabbing the green areas around the site.

Ill. 145. The picked solution of the site with stairs connected to the green areas. The façade of the site becomes extrovert with functions such as shops and cafés that attracts people waking by and those using the site.







SYNTHESIS

The synthesis phase begins with the main concepts ing determinate. The phase is treating details in the b the lobby and the programming of the green areas.

IS

ots and the overall layout of the build-
he building concept such as materials,
as.

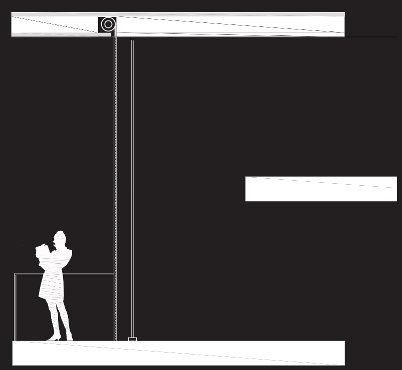
DETAILING - THE APARTMENT

Emphasizing the individual apartment is an important factor in the concept of the south façade and therefore important to articulate in the architectural expression. The apartments are all joined and have one vertical common wall. To make the apartment look like one unit inside the U that is formed by the balcony the glass façade are pulled to the side. see ill. 149

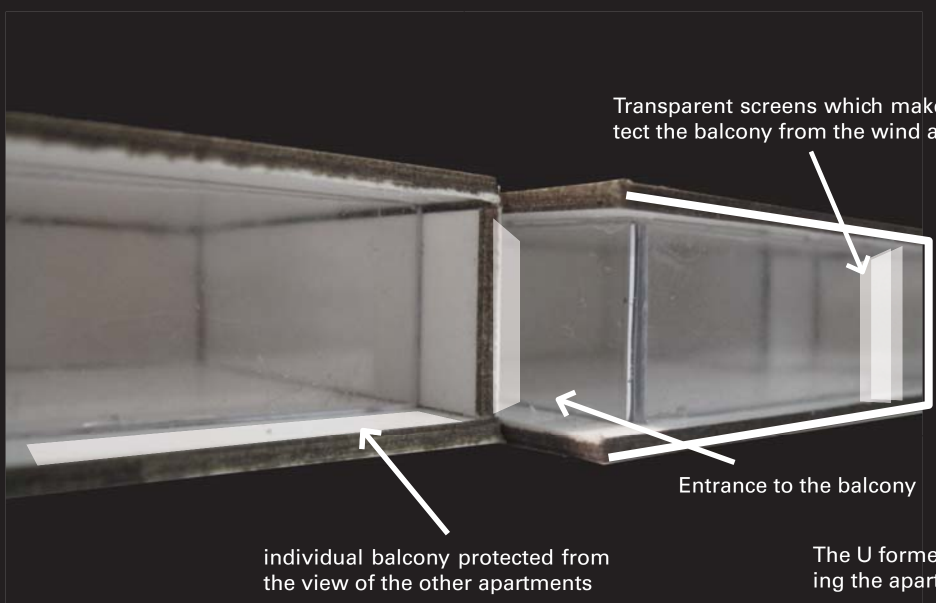
The balcony is a private outdoor space shield from the view of the other apartments by the barring wall. The wall also that side becomes an element that extends the room from inside to the outside.

The wind is a dominating most of the year because of the height of the building and the outdoor balcony, which can interfere with the use of the space. To protect the outdoor space from the wind a glass wall can be unfolded shielding the space from the wind. See drawing ill. 148 and ill 149.

The external shading that is requisite to avoid overheating in the summertime, which was evident in the Bsim analysis see ill. 146.

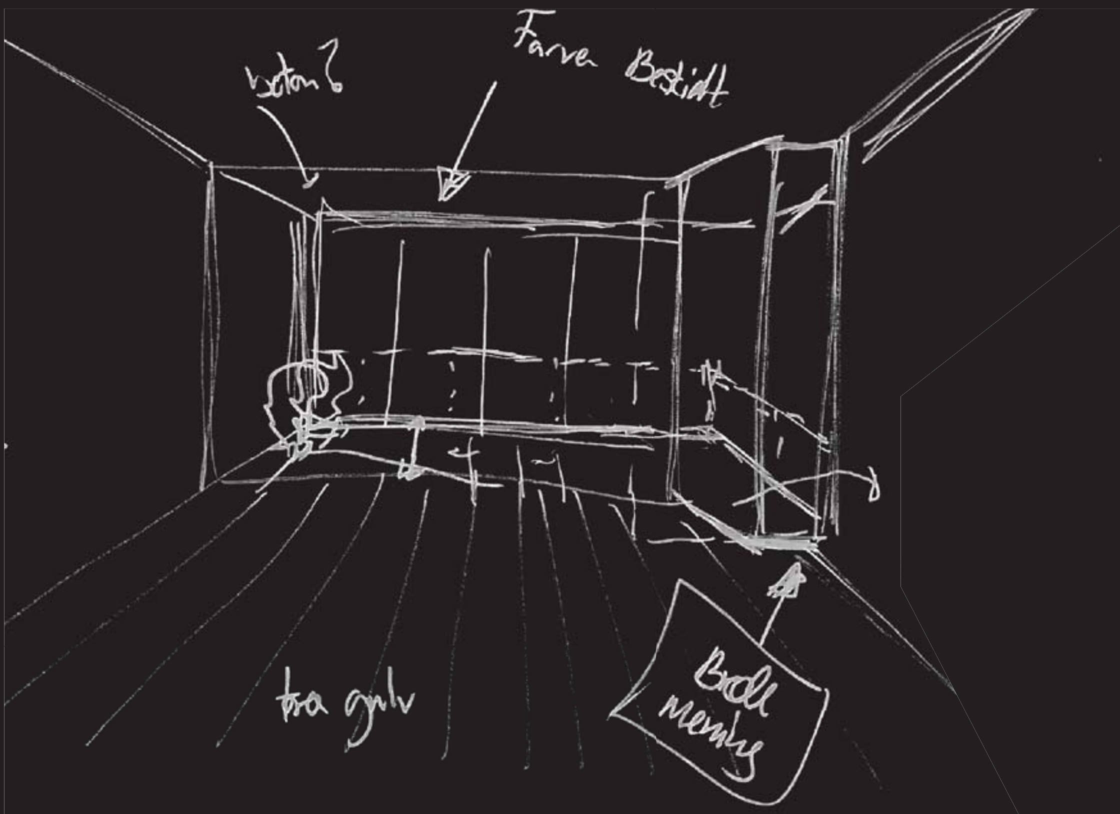


Ill. 146. The shading devise that is needed to avoid overheating of the apartments as calculated in BSim in p. 101 ill. 88.



ill. 149.

Ill. 147. The concrete and wood materials that are used in the building. The concrete are visible at the main elements such as the floor slabs and the cores and the wood is used in the apartment floors and in the semi public green spaces.



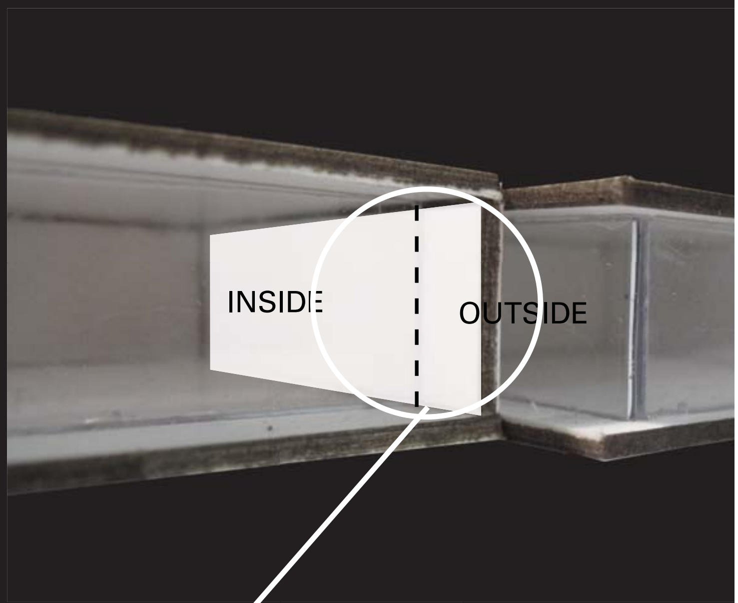
Ill. 148. Drawing showing the inside of the apartments. The illustration shows the common wall as continuing elements connecting the balcony to the inside of the apartment.

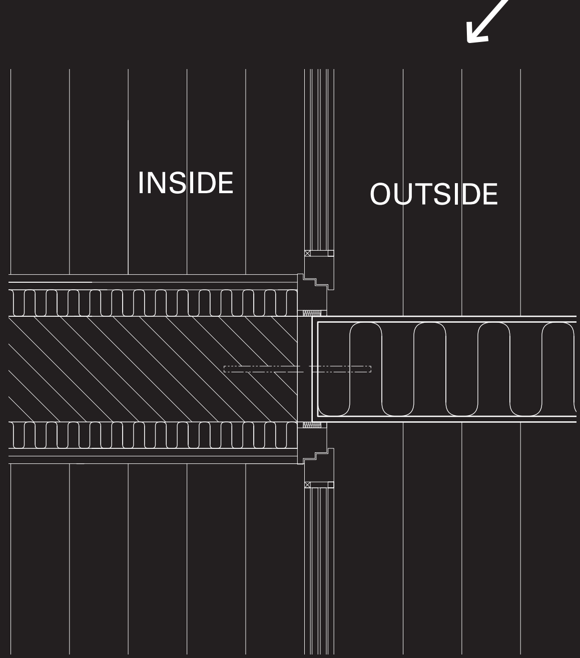
DETAILING - THE CONSTRUCTIO

Some of the constructive details that are important for the architectural expression are designed. The details are the carrying wall that separates the apartments that is situated both inside and outside the building envelope, see ill. 150.

Another detail separation between the apartments in the vertical section, see ill. 152. The detail of emphasizing the U in the balcony enhancer the perception of the individuality of the apartments units.

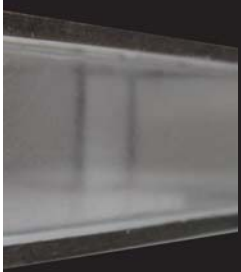
The connection between the office facade and the glass wall can be seen in ill. 151. The office facade should be perceived as one big ongoing facade and the meeting between the floor slabs and the facade is therefore important to detail.

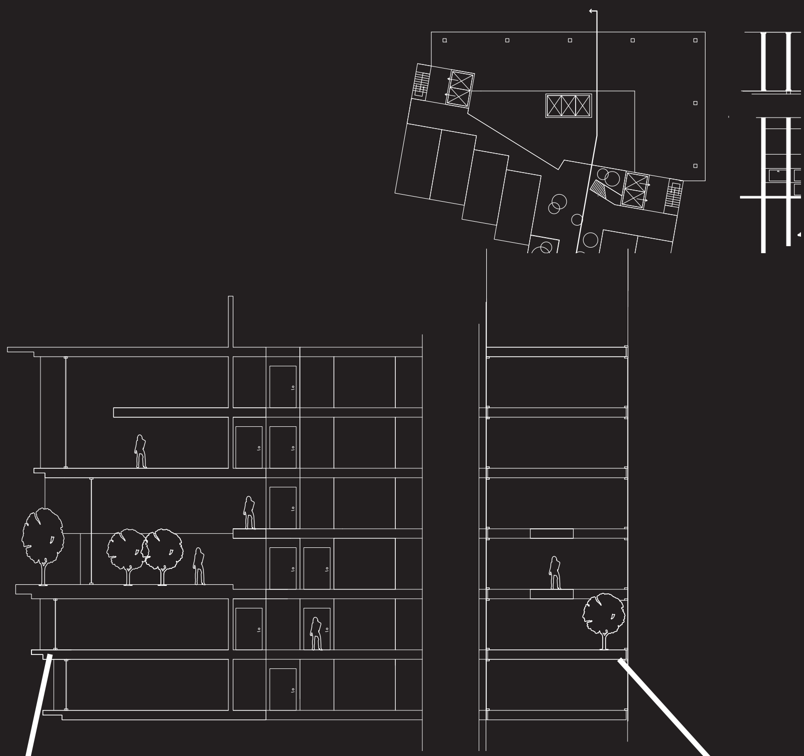


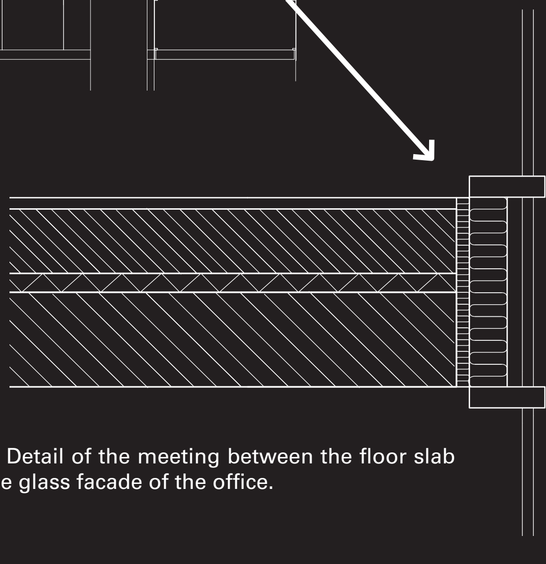


Ill. 150. Detail showing the wall that change composition going from inside to outside

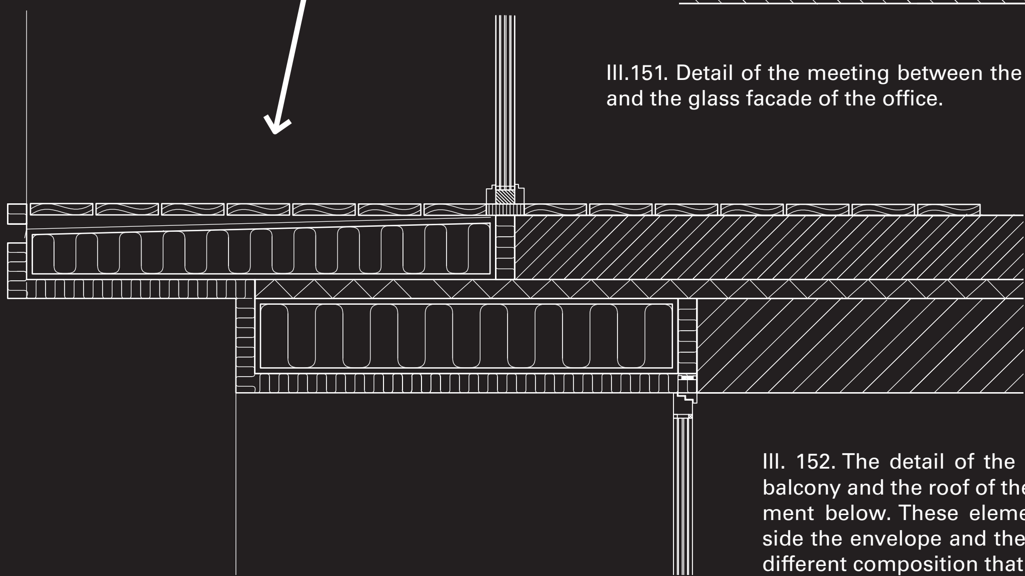
ON







Ill.151. Detail of the meeting between the floor slab and the glass facade of the office.



Ill. 152. The detail of the meeting between the balcony and the roof of the balcony of the apartment below. These elements are situated outside the envelope and therefore need to have a different composition that the floor slabs inside.

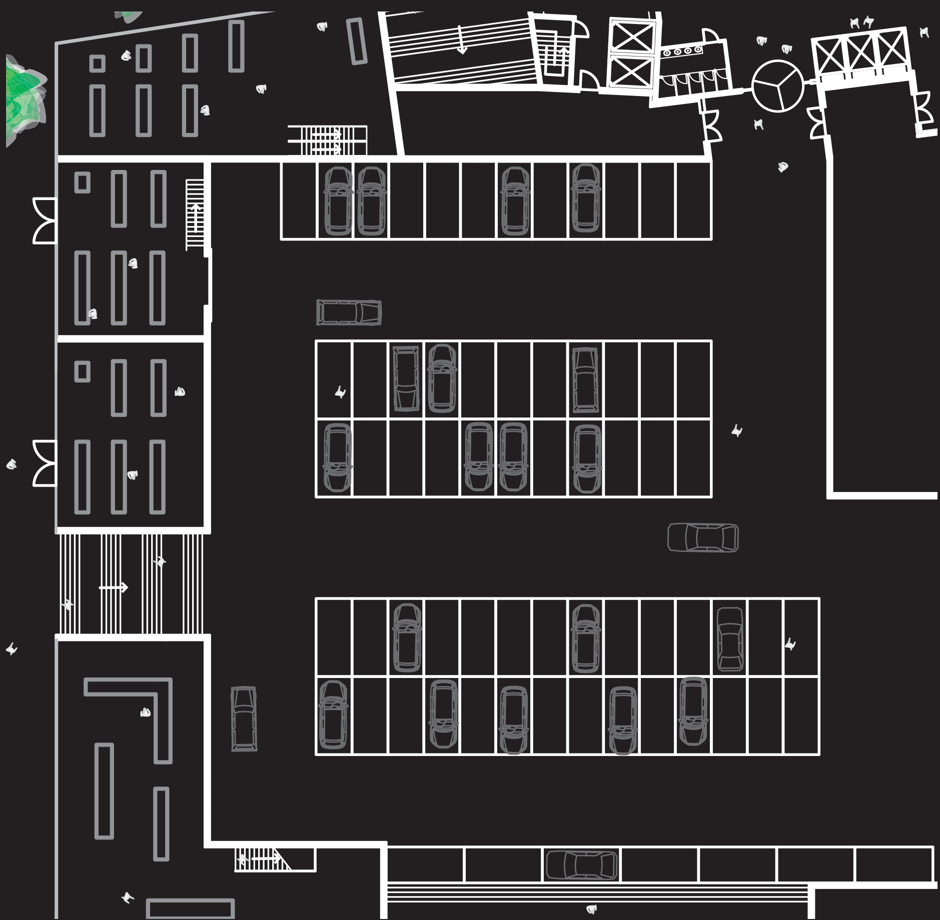
DETAILING - 1. FLOOR

The entrance to the office and the site is also important to articulate. The office section of the building continues to the ground level where the lobby, meeting and dinning spaces are placed see ill. 154. The three lowers floors in the office section therefore have a different layout and arrangements than the rest of the office space.

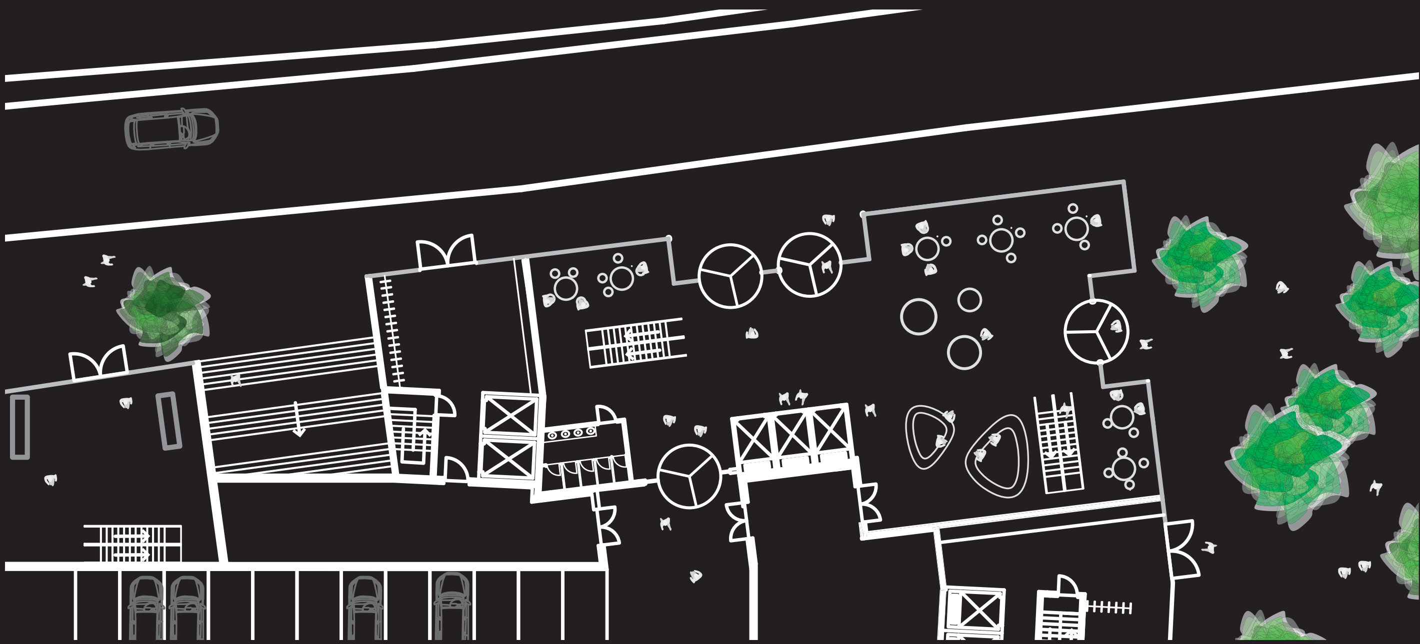
The ground level has because of the elevation of the side the possibility to contain some of the necessary parking space needed, see ill 153. The ground level also contains service space such as the kitchen for the offices dining areas. The entrance to the parking space is in the east side of the site because it is possible to have the cars entering directly from the main roads.

The façade of the site contains extrovert functions such as shop and cafe's which have their entrance for supplies though the parking space see ill 156.

The entrance to the elevator of the apartments is also detailed. The entrance is a closed space only accessible by the people living in the building and it contains space for bike parking and mail boxes, see ill. 155. The bike parking is limited and it will therefore also be possible to bring the bike into the elevator and park it in front of the apartment.



Ill. 153. Some of the parking spaces are placed at the ground which is made possible because of the elevation of the site plaza. The need for two underground stories is thereby not necessary and one can be sufficient.



Ill. 154. The office lobby and the entry plaza. The lobby contains reception and meeting places and is connected to the 2. floor by escalators where the food court is situated. This is also the entrance to the hotel that is situated at the top floors.

Ill. 155. The entrance to the apartment elevators which connects the ground level to the different apartment levels. The entrance constrains mails boxes and bike parking spaces.

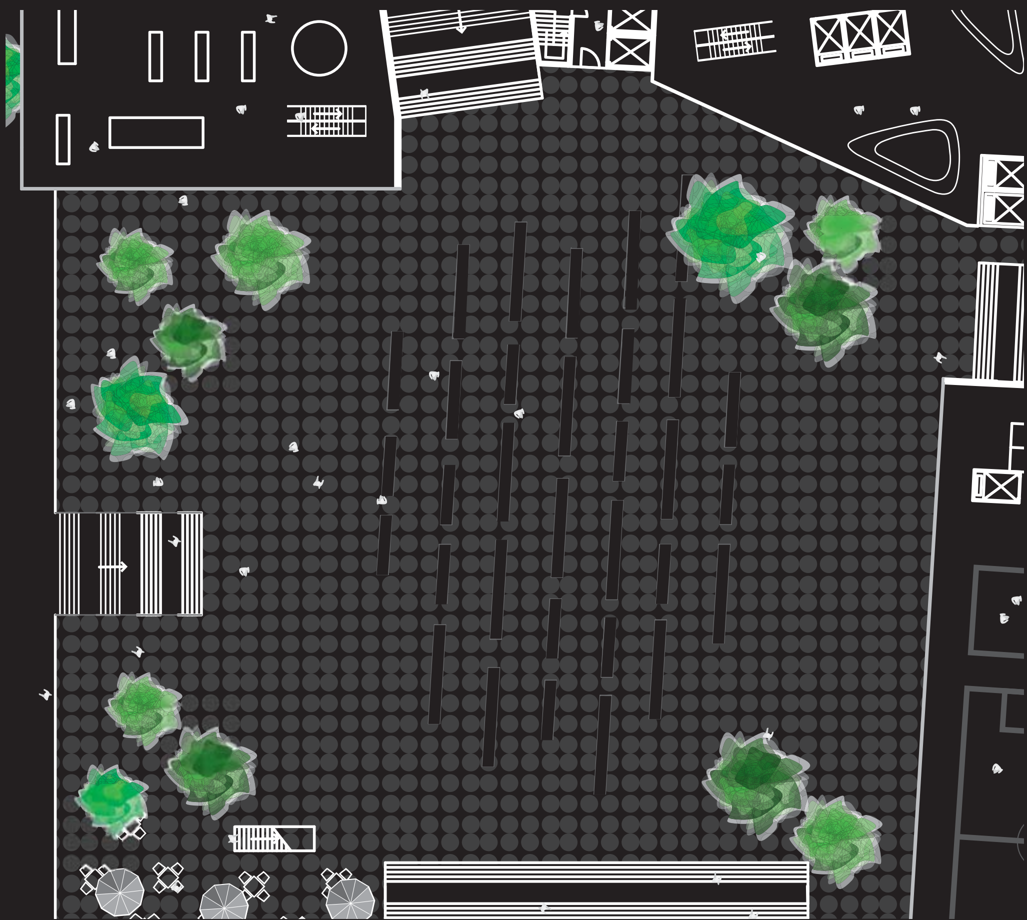
Ill. 156. Shop and other extrovert function are placed are placed in the façade of the elevated site. This creates a living environment and makes the site appear open and inviting to people passing by.

DETAILING - 2. FLOOR

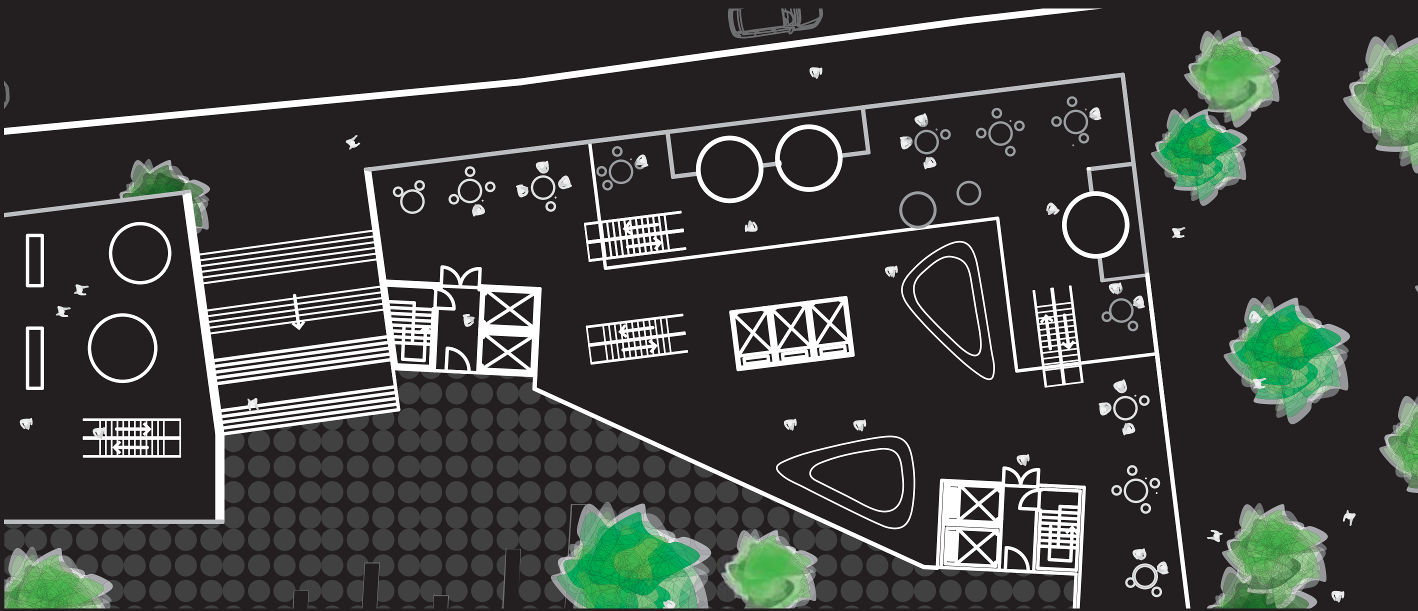
The big public plaza is located in the center of the site at the 2. floor. The plaza is a green space which leisure activities for both the people living in the building and the people passing by.

Big staircases connect the ground floor to the public space which thereby becomes urban furniture and active elements in the town-scape. In the plaza light shaft are place to drag down light to the parking space and thereby connecting the life at the plaza the parking space, see ill 157. The food court and the mul-tihall can be see in ill, 158 -159.

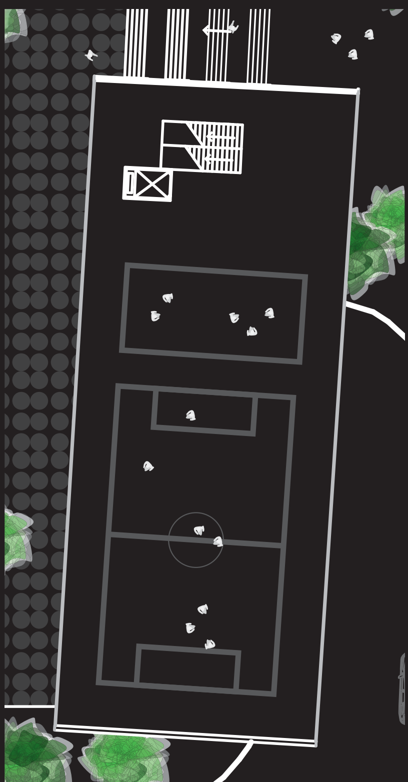
The plaza also contains terrace with cafes where it is possible to enjoy the view to the green areas and be elevated above the noise from the traffic passing by.



ill. 157. The public plaza and the light shafts that bring down light to the parking spaces below. The plaza is a green space for leisure which cafe and terraces and the view to the green space in the perimeter of the site. To avoid inconvenience from the wester wind trees are planted at the west side of the plaza to protect from the wind.



ill. 158. The food court for the people working in the offices. The food court is connected to the plaza which and to the floor above. This makes is possible to have space and dining both inside and outside and with the view over the site.



ill. 159. The multihall is placed in the east side of the building complex. The multihall is situated in three level and is thereby connected visual and physical to both the ground level and the plaza.

DETAILING - GREEN AREAS

The program of the green space in the building and the plaza is a crucial element of the building. The green areas in the building have different functions and different daylight condition during the daylight which makes the connection between them important.

The green areas in the building contain space for activities such as ball game and more isolated quiet spaces. To make these spaces more soft and private the floor and some of the wall materials in this space are made of wood. The used wood also reference to the wood used in the private space of the apartments.

The greenery in the building and in the plaza is planted on concrete slabs and therefore also need special treatment. Some of the big trees and plans are therefore placed in boxes like in ill. 106 - 162.

Ill. 160. Different way to integrate the trees and greenery in the public spaces, which is situated over ground level.

Ill.161. Grass incorporated into the pavement

Ill.162 Green plant boxes and tress incorporated into the pavement

DETAILING - VENTILATION

A good ventilation strategy is imperative in order to create a building, which is both energy efficient and provides a good indoor climate. Regarding natural ventilation of the building, there are issues that need to be considered as also mentioned in the initial investigation such as noise and pollution. The opening of the ventilation therefore need to be taken away from the roads of Roskildevej and Avedøre Havnevej at the ground level and because of the function of the office, which is mostly mechanical ventilated and facing the roads the problem is minimized.

The main ventilation system of the building is illustrated in ill 164. The different ventilation strategies based on the seasons of the year can be seen in the illustration in ill. 165

The ventilation strategy for the building is a mix of natural ventilation and mechanical ventilation. The different needs for cooling and heating for the office and the apartments also require different strategies together with the different needs in the summer and winter period.

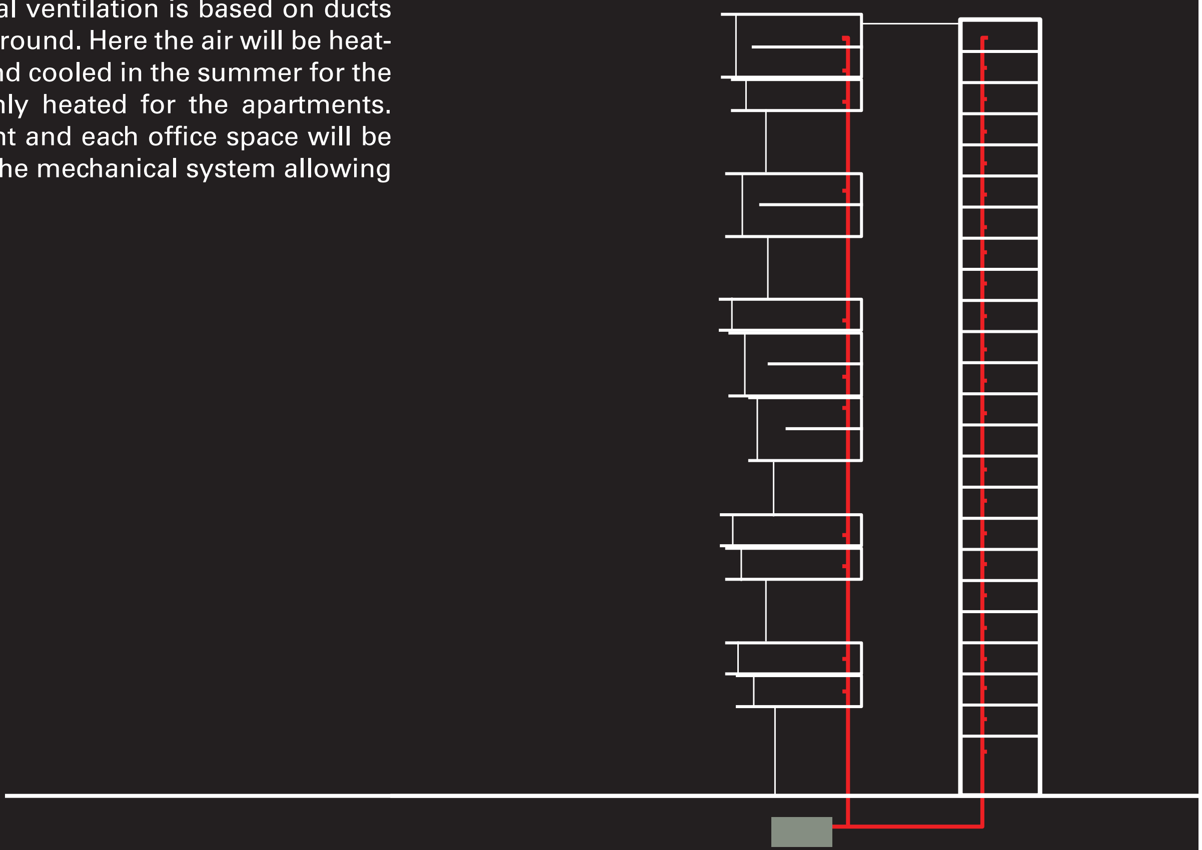
The mechanical ventilation is based on ducts buried in the ground. Here the air will be heated in winter and cooled in the summer for the offices and only heated for the apartments. Each apartment and each office space will be connected to the mechanical system allowing individual thermal settings and because of the mix use of function the ducts and the size of the mechanical systems can be minimized.

During summer time the ventilation in the apartment is only natural because no mechanical cooling is need. The driven factor being the stack effect is generated by thermal buoyancy, or cross ventilation driven by the wind. The wind is present most of the year because of the height of the building. In the office mechanical cooling will be needed.

In the spring and autumn the excess heat from the office is transferred to the apartment when needed with the atrium as a buffer. The atrium is thereby heated and is able to accumulate the heat when needed. In this period of the year cooling is still needed in some periods for the office space and heating for the apartments.

In the winter heating is needed in the apartments and to some degree in the office space.

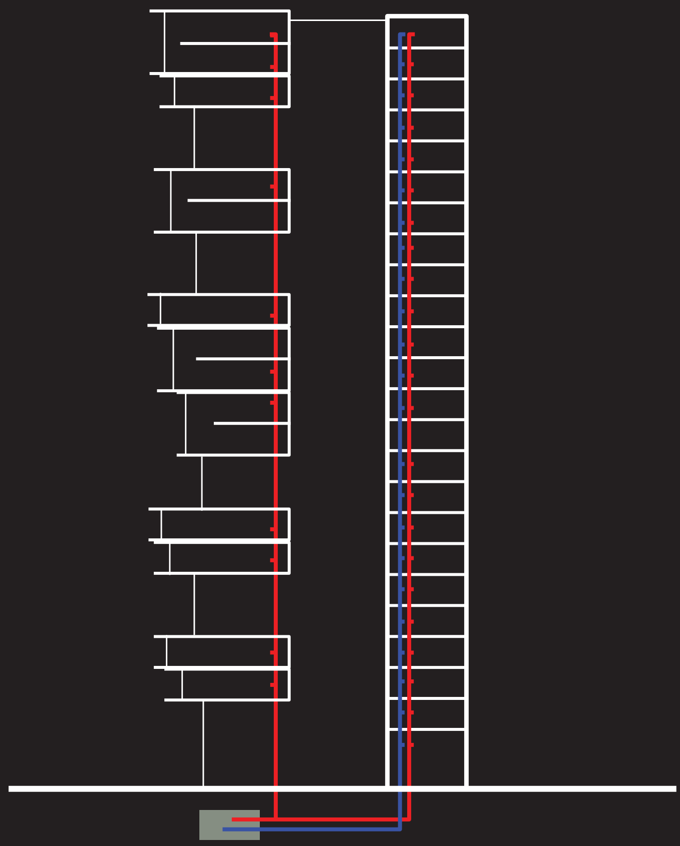
WINTER



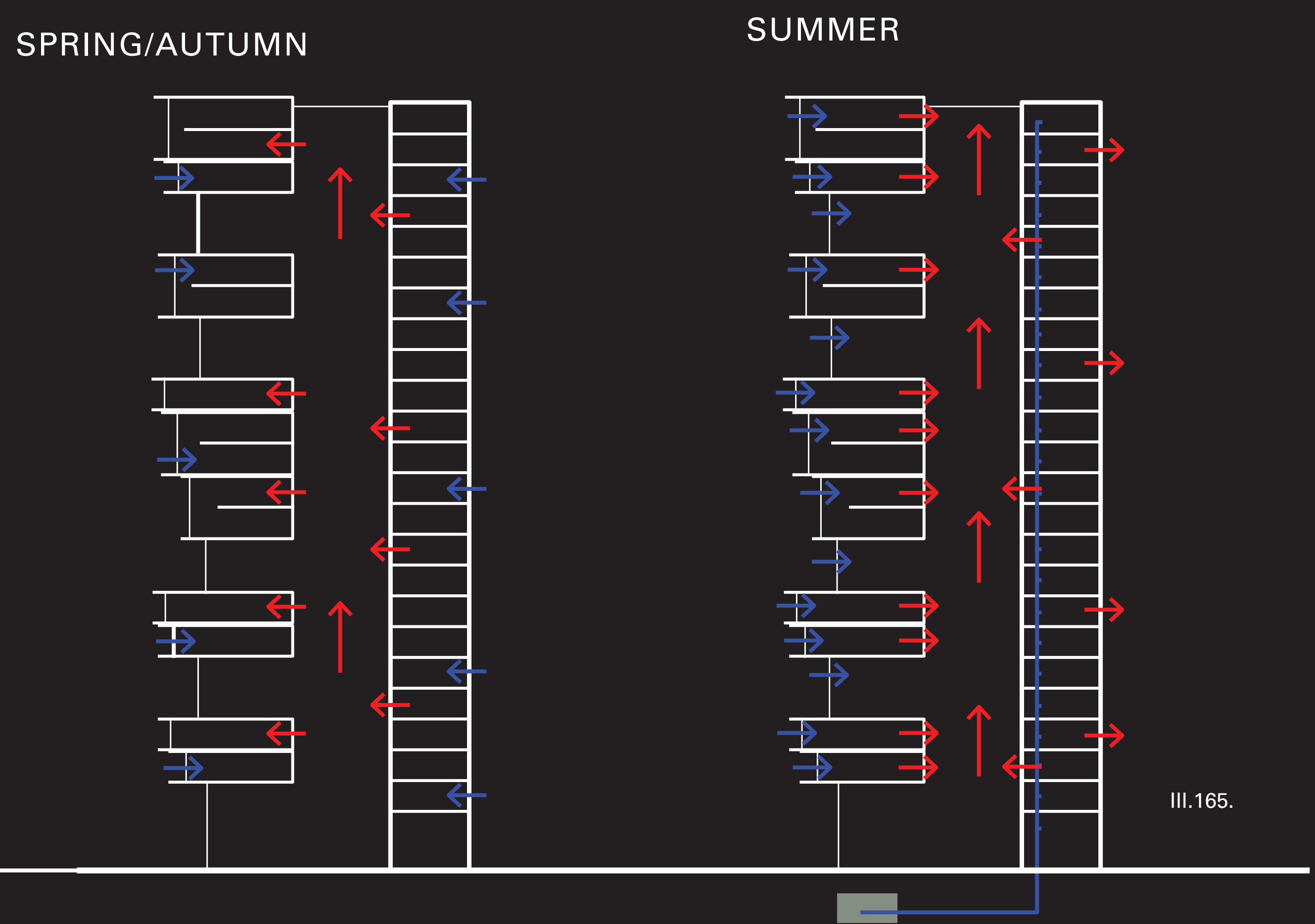
The building is heated by the district heating, which is transferred to the boiler through a heat exchanger that releases heat into the building. The heat is then distributed throughout the building through radiators. The radiators are installed with energy efficient thermostat.

There are some complications regarding acoustics as the direct openness between apartments and a semi public atrium, which can disturb the privateness in the apartments together with the spread of fire. These problems will not be detailed but can be solved within the mechanical solution of the openings.

Heating the apartments and the office could also be by individual heating systems which would make is easier to implement heat recovery to the ventilation strategy, but because of the small heating demand large heating system is estimated as the most beneficial.



Ill. 164.



Ill.165.

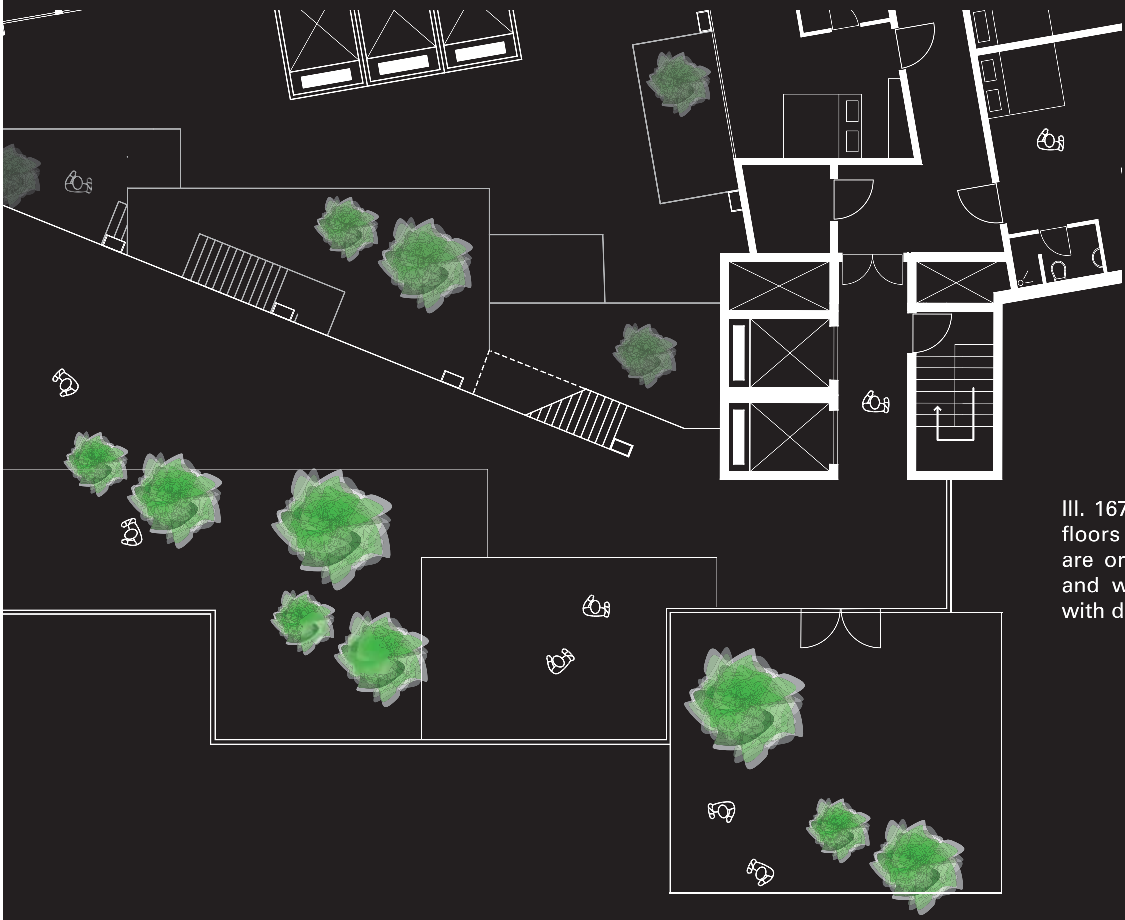
DETAILING - TOP FLOORS

The top floors contain the hotel and the sky garden. The layout of plans of the three top floors is therefore different from the other floors.

The hotel is connected to the ground level though the office elevators and the lobby. The hotel rooms are connected though a hall way in the middle of the building. The rooms have different size and have thereby room for one or two people. All of the rooms have an extraordinary view over the city because of the placement the roof top, see ill. 166.

The hotel is also connected to the sky garden that is a common space for the people living in the building. The sky garden is the most open green space in the building and has like the hotel rooms an enchanting view over the city. The gardens situated in and outside of the building and is connected to the other levels of the apartments though the elevators and the stairs in the atrium see, ill 167.

ill. 166. The hotel rooms and the reception. The hotel is connected to the ground level thought the office elevators but also have a separated reception. The hotel rooms are detailed with individual bathrooms and different size making them able to contain different amount of guests.



Ill. 167. The sky garden at the top floors in the building. The gardens are orientated to the east, south and west and are thereby filled with daylight all day.

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ILLUSTRATION

The illustration in the paper is made by the author unless mentioned in the following list:

Ill 05:

www.skyscrapercity.com

Ill 06:

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Ill 07:

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Ill 08:

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Ill 18 – 20 (appendix)

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APPENDIX

The appendix contains the needed calculations that are use in the investigation in the sketching phase

APPENDIX 1. CORE CALCULATIO

Calculation of the relationship between core geometry and loads from buildings begin 15, 20 and 25 stories high. All of the calculations are based on the facts in ill. 01 and with variation of the core size and thickness.

The calculation shows that the concrete core can not only be the only carrying element if the building has a height of 25 stories but can because the tension becomes higher than 200 Mpa. In some cases be sufficient if the building is 20 stories high.

Furthermore, it is also clear that the difference between a core wide of one or two meters has a very small importance in relation to the difference between 0.5 and 1 meter it can therefore be concluded that the core thickness such be no more than one meter. It is therefore very likely that the building will need a supporting structure in the facade.

FLOOR PLAN: 600M2
WIDE OF BUILDING: 35M
BUILDING LOAD: 2,5 KN/M2

Ill. 01. The facts used in the co

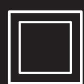
CORE 5 X 5m
THICKNESS 0,5m

STORIES	15	20
N/A + M/W	150	250

CORE 5 X 5m
THICKNESS 1m

STORIES	15	20
N/A + M/W	150	250

CORE 5 X 5m
THICKNESS 2m



STORIES	15	20
N/A + M/W	110	200

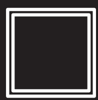
ONS

2

e core calculations and the result of the investigations.

25
370

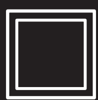
CORE 6 X 6m
THICKNESS 0,5m



STORIES	15	20	25
N/A + M/W	110	180	270

25
370

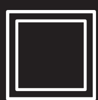
CORE 6 X 6m
THICKNESS 1m



STORIES	15	20	25
N/A + M/W	90	150	230

25
310

CORE 6 X 6m
THICKNESS 2m



STORIES	15	20	25
N/A + M/W	80	140	210

APPENDIX 2. COLUMNS

To estimate the size of the columns the resulting line load originating from the area carried of the column is calculated. The line load that each column has to carry is calculated which a distance between each column of four meters. The worst case scenario of the columns is evaluated from the floor plan, see in ill. 03.

The worst load case is 32 m2. Given the 23 story high building the total area that the columns needs to carry is 736 m2 and the payload of the office being 2,5 kN/m2 the total load becomes approx 1850 kN. The needed size of the column is then estimated from the chart in ill. 2. The maximum length of the column is 7 meter (two stories) where the atrium meets the ground floor.

The needed size of the column is estimated to be 0.2 x 0.2m and with a thickness of 0.02m. The needed load resistance of the columns is not part of the chart and it there estimated to be efficient.

The investigation of having more or less columns goes though the same calculations that are evident in the design evaluation of the atrium.

	længde	a × t mm											
	m	50×3	50×5	80×4	80×6	100×5	100×8	120×5	120×8	150×6	150×10	200×6,3	200×10
kvadratiske rør	1,5	97,0	146	268	386	436	668	543	839	834	1335	1202	1858
EN 10210	2,0	67,8	99,2	242	345	411	627	522	804	812	1298	1181	1824
S275	2,5	47,0	68,1	204	287	376	568	495	760	786	1254	1158	1788
	3,0	33,9	48,9	164	228	331	493	459	701	755	1200	1133	1748
	3,5	25,5	36,7	130	179	280	412	415	628	716	1133	1104	1701
	4,0	•19,8	•28,5	104	143	232	340	364	547	668	1050	1071	1647
	5,0			69,6	95,6	162	234	269	400	550	851	985	1508
	6,0			•49,5	67,9	117	169	200	295	433	663	872	1324
	8,0					•68,2	•98,5	119	175	270	409	621	931
kvadratiske rør	1,5	109	162	334	479	551	843	690	1066	1065	1705	1541	2381
EN 10210	2,0	71,4	104	287	406	508	771	655	1009	1030	1646	1509	2330
S355	2,5	48,4	69,8	228	318	447	669	609	932	988	1574	1473	2273
	3,0	34,6	49,8	175	242	373	551	547	829	934	1480	1433	2208
	3,5	25,9	37,2	135	186	303	443	473	711	865	1361	1384	2130
	4,0	•20,1	•28,8	107	147	245	357	400	596	782	1219	1327	2035
	5,0			70,9	97,2	166	241	283	418	604	928	1176	[illegible]
	6,0			50,2	68,8	119	172	206	303	457	697	990	1494
	8,0			•28,9		•69,1	•100	121	178	277	419	658	982

Ill. 02. Diagram from Teknisk Stobi with shows the load resistance of a steel pibe and the size of the construction.

Ill. 03. Diagram showing the plan of the building and where the biggest line load is situated.

APPENDIX 3. BSIM APARTMENT

The element of the BSim model and the geometry can be seen in ill 04 and 05.

The construction of the walls, the roof and the floor are all facing the zones itself to simulate the apartment as being at part of the overall building complex, and thereby represent the majority of the apartment. This will also represent the worst case scenario in terms of overheating.

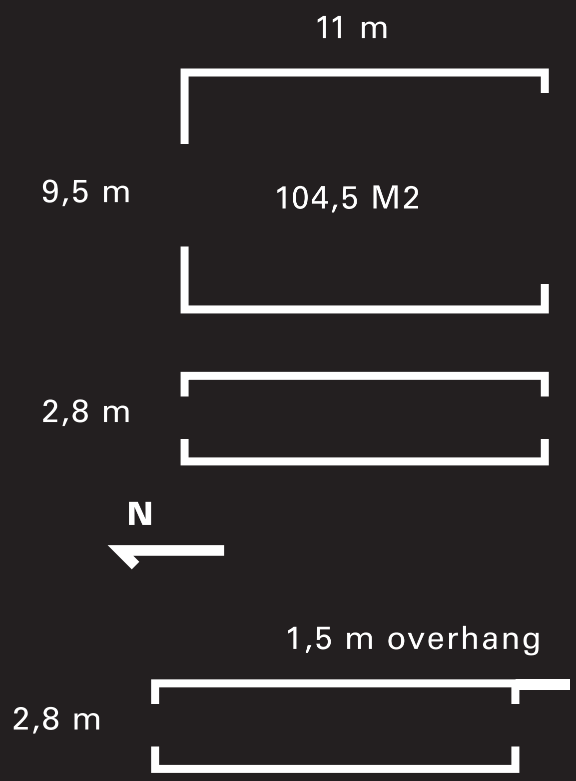
The apartment is simulated in 4 different scenarios; the reference building, with atrium, with overhang and with shading control. The result can be seen in the apartment section of the report.

The atrium is added to the north side of the apartment. The atrium simulation is done by estimations because a real model of the atrium is not possible represent.

To simulate the atrium the U-value of the north facade are improved from being 0,21 to 0,17 and the U value of the window from 0,14 to 0,07 see ill 5.

Maximum natural ventilation is 5 h-1 high but not unrealistic for an apartment.

The venting control is set to max 800 ppm. CO2 (450 ppm. higher than outdoor) which will create a good indoor climate and a low percent of dissatisfied [CR1752] see ill. 06 and 07.



Ill. 04. The geometry of the reference model of the apartment

GLASS AREA

WINDOW NORTH	6,4 m2 (3,2 * 2)
WINDOW SOUTH	19,55 m2 (8,5 * 2,3)

SIMULATION OF ATRIUM

	BEFORE	AFTER
WINDOW (NORTH)	U-VALUE 0,14	U-VALUE 0,07
FACADE (NORTH)	U-VALUE 0,21	U-VALUE 0,17

Ill. 05. The size of the windows and there U-values. The diagram also showed how the U-values are changes to simulated the atrium.

Building	Design Heat Loss, W	Rotation, deg	Net - Gross Volume, m³	
room 1		90	239,429	292,6
Site	**Weather File**	**Ground**	**Terrain Type**	
Site538	Danmark.dry	Ground541	Country with scattered windbreaks	

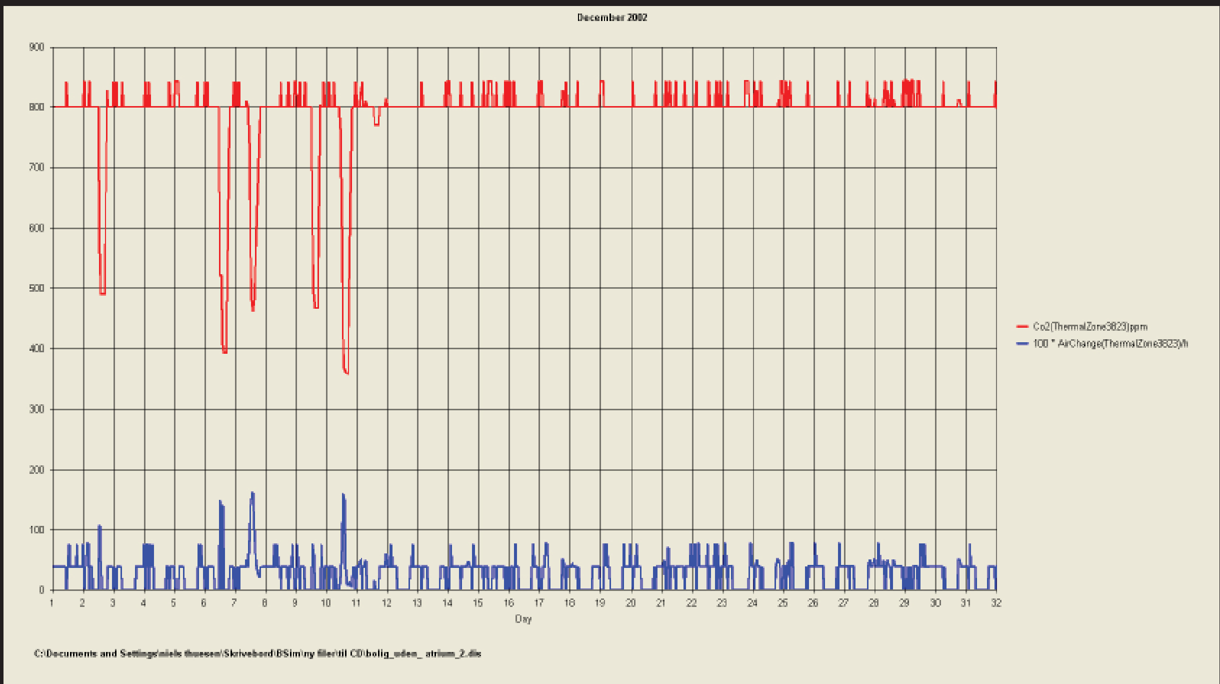
Thermal Zone	Design Heat Loss, W	Net - Gross Floor Area, m²		Net - Gross Volume, m³	
ThermalZone3823		94,245	104,5	239,429	292,6
stor 4		94,245	104,5	239,429	292,6
Enclosing Elements	**Building Element**	**Thick, m - U, W/m² K**		**Net - Gross Area, m²**	
Constructions	Timber Flooring 25 væg 200 iso Wd 39I300 vent	0,197 0,35 0,322	0,227654 0,209386 0,122765	94,245 72,8754 94,245	104,5 114,8 104,5
Enclosing Elements	**Building Element**	**Orient, deg - U, W/m² K**		**Glass - Opening Area, m²**	
Windoors	LavE i træramme	180	0,140972	22,821	25,95
Systems	**Component**	**Control**		**Time**	
Equipment	Equipment6722	weekend profile weekend profile		weekend man-fre	
PeopleLoad	PeopleLoad	DayProfile rigtig bolig_men_hverdag		weekend man-fre	
Lighting	Lighting	DaylightCtrl DaylightCtrl		man-fre weekend	
Venting	Venting8344	VentingCtr		all day	
Ventilation (inactive)	Ventilation954	ZoneTempCtrl		all day	

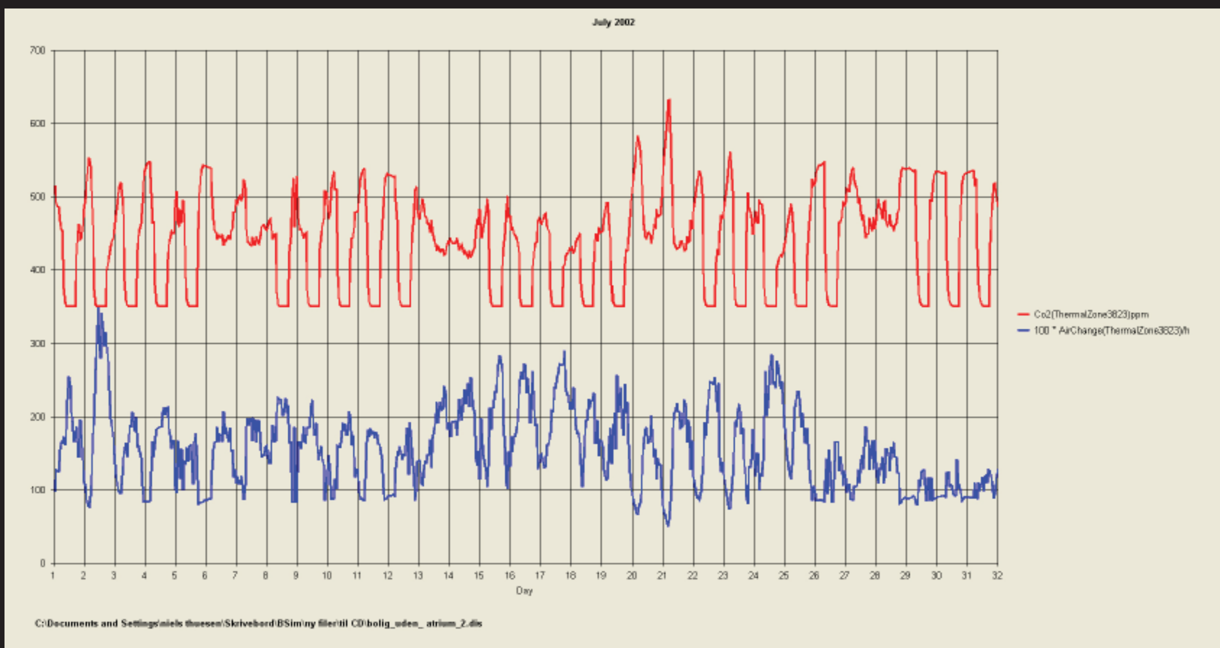
Ill. 05. The building elements and their properties in the BSim model.

APPENDIX 3. BSIM APARTMENT

system	description	schedule	
		control	indication of time
human load	2 persons	0-24: 100 %	mon-fri: 18-07 sat-sun: 0-24
equipment	0,2 kW heat load	100%	mon-fri: 17-08 sat-sun: 0-24
lightning	200 lux gen. lightning level 0,03 kW general lightning	daylight control 200 lux lightning level control form: no/off	mon-fri: 17-08 sat-sun: 0-24
venting	max air changes 5 $^{h-1}$ factor 1	venting control set point 23^0 700 SetPCO2 (ppm)	all time
solar shading	south window shading eff 95%	shading control set point 22 ^{0} continuous control form	all time
ventilation	max power 2 kW in-let: supply air 0,05 m^2/s pressure rise 400 Pa total eff 0,8 out-let: supply air 0,05 m^2/s pressure rise 400 Pa total eff 0,8	Zone temp. control min inlet 15^0 max intel 40^0 heating set point 20^0	all time

Ill. 06. The functions and time schedules that are use in the simulation in BSim of the apartment





Ill. 07. Illustration showing the air flow changes in the apartment in the winter (December) and in the summer (July). The CO2 levels never rise above 850 which ensure a good indoor climate. The air change in the building is higher in the summer time because of the natural ventilation that prevents overheating.

APPENDIX 4. BSIM APARTMENT

The energy use for heating is simulated in BSim. The simulation is made to see how high the energy performance of the building. The result and the can be seen in ill. 08 – 11.

The energy use of the apartment is very low and the simulation makes it evident that with a heat recovery of 80% the energy use for heating becomes 0.

Ventilation	supply m³/s heat recovery (on and off)	heating set point 21 ⁰	all time

Ill. 08 Ventilation control in the BSim model

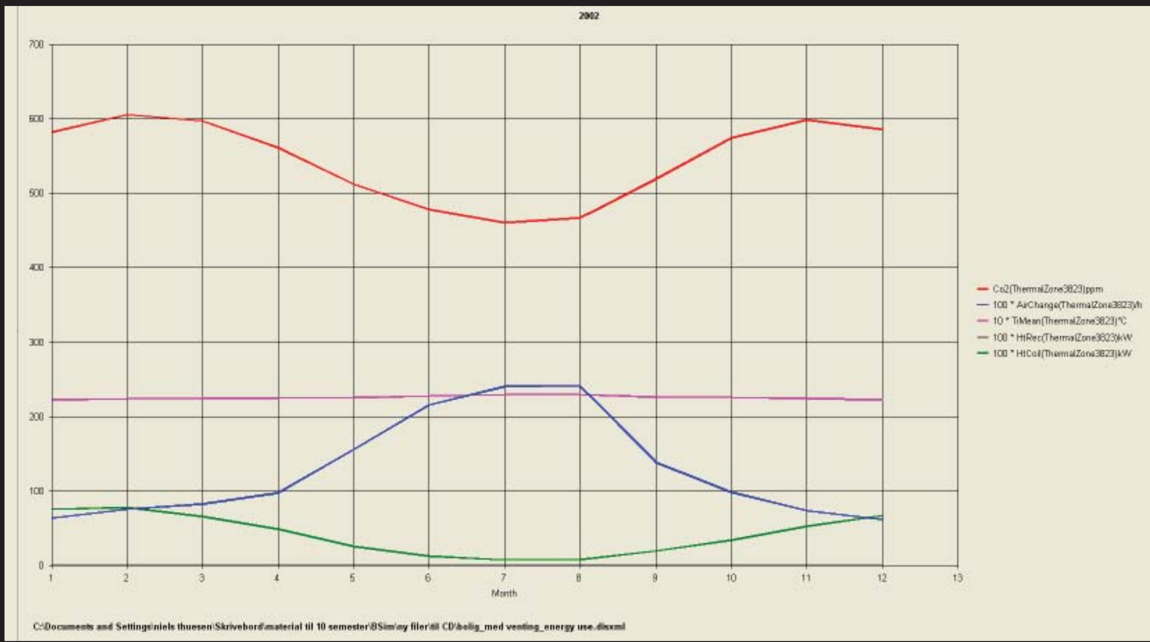
APARTMENT NO HEAT RECOVERY

	SUM MEAN	MONTH OF THE YEAR 1	2	3	4	5	6	7	8	9	10	11	12
HEAT REC. kW	0	0	0	0	0	0	0	0	0	0	0	0	0
HEATING kW	0.41	0.76	0.78	0.66	0.5	0.26	0.13	0.01	0.01	0.2	0.34	0.53	0.67

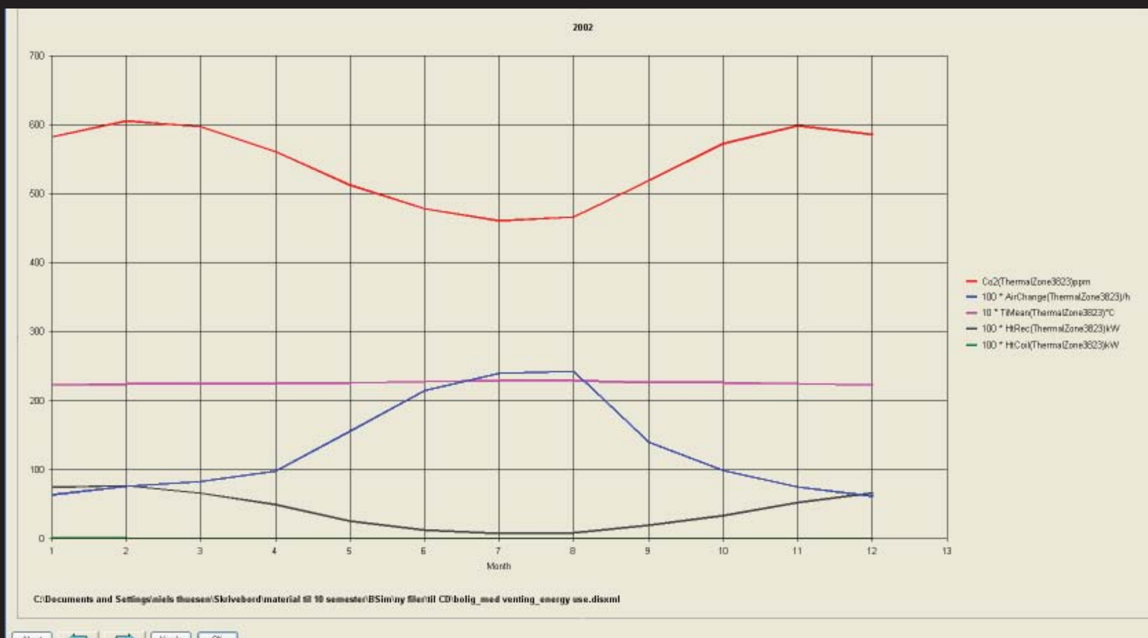
APARTMENT WITH 80% HEAT RECOVERY

	SUM MEAN	MONTH OF THE YEAR 1	2	3	4	5	6	7	8	9	10	11	12
HEAT REC. kW	0,41	0.76	0.78	0.66	0.5	0.26	0.13	0.01	0.01	0.2	0.34	0.53	0.67
HEATING kW	0	0	0	0	0	0	0	0	0	0	0	0	0

Ill. 09The energy use of the apartment



Ill. 10 Graph showing the energy use for heating of the apartment with no heat recovery



Ill. 11 Graph showing the energy use for heating of the apartment with 80 % heat recovery

APPENDIX 4. BSIM OFFICE

C:\Docu

The element of the BSim model of the office can be seen in ill 12 and ill 14.

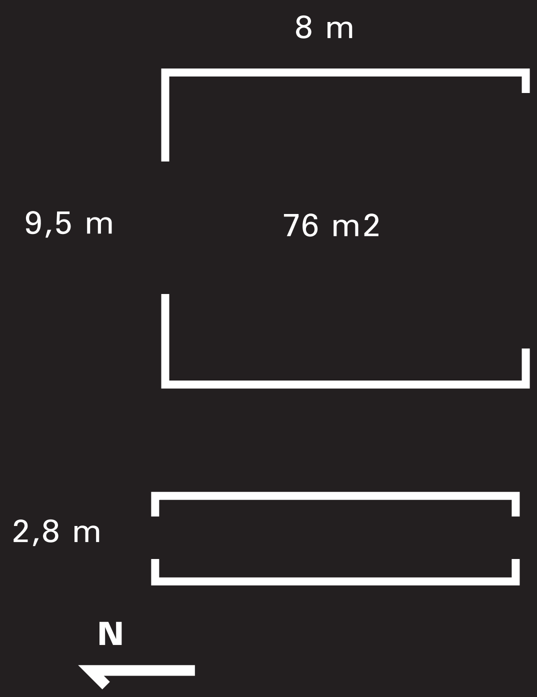
The office is simulated like the space of the apartment to see how the internal heat load affects the thermal conditions and to clarify the difference between the functions.

The walls, floor and roof is also in this case facing the thermal zone to simulate an office space that is situated in the middle of the building.

To simulate the atrium estimation are made like in the apartment, see ill 13. The south window is removed to because it is estimated that there will be any solar radiation gain into the office space when adding the atrium.

The venting control is set to max 800 ppm CO_2 (450 ppm higher than outdoor) which will create a good working environment and a low percent of dissatisfied [CR1752] see ill. 11. This also creates a high ventilation need because of the high people load see ill 16.

The maximum natural ventilation is set to 3 h-1 lower than in the apartment to avoid inconvenience at the work space.



Ill. 12. Illustration of the geometry of the reference model used to simulate the office space.

GLASS AREA

WINDOW NORTH	6,4 m2 (3,2 * 2)
WINDOW SOUTH	19,55 m2 (8,5 * 2,3)

SIMULATION OF ATRIUM

	BEFORE	AFTER
WINDOW (SOUTH)	U-VALUE 0,14	NON
FACADE (NORTH)	U-VALUE 0,21	U-VALUE 0,17

Ill. 13. The size of the windows and there U-values of the office. The diagram also showed how the U-values are changes to simulate the atrium.

office_uden atrium_med shading_2373_ny 10.05.2010 23.57

Building	**Design Heat Loss, W**	**Rotation, deg**	**Net - Gross Volume, m³**	
office		90	163,201	212,8
Site	**Weather File**	**Ground**	**Terrain Type**	
Site538	Danmark.dry	Ground541	Country with scattered windbreaks	

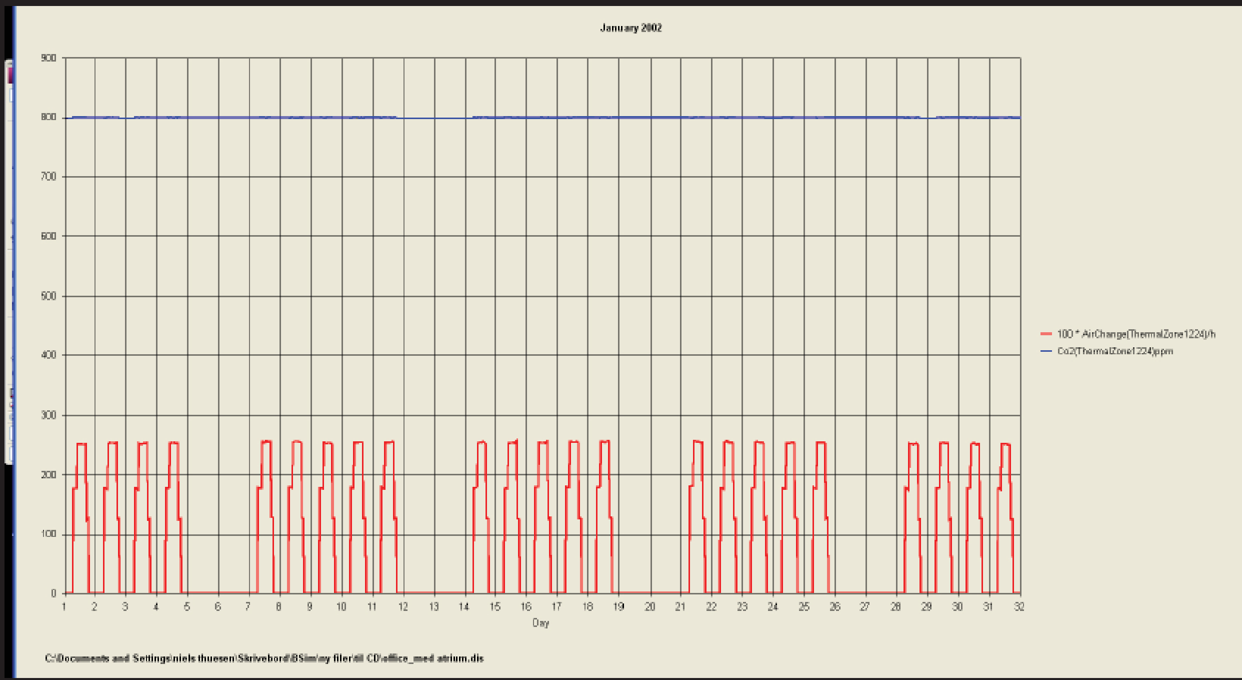
Thermal Zone	**Design Heat Loss, W**	**Net - Gross Floor Area, m²**		**Net - Gross Volume, m³**	
ThermalZone1224		66,6125	76	163,201	212,8
office2		66,6125	76	163,201	212,8
Enclosing Elements	**Building Element**	**Thick, m - U, W/m² K**		**Net - Gross Area, m²**	
Constructions	væg 200 iso væg 250 iso	0,35 0,4	0,208948 0,169866	176,272 17,885	227,6 22,4
Enclosing Elements	**Building Element**	**Orient, deg - U, W/m² K**		**Glass - Opening Area, m²**	
Windoors	LavE i træramme	1,17516e-008	0,140972	17,43	19,55
Systems	**Component**	**Control**		**Time**	
Equipment	Equipment2021	office_hverdag office_weekend		office_hverdag office_weekend	
Lighting	office light	DaylightCtrl DaylightCtrl		office_hverdag office_weekend	
PeopleLoad	PeopleLoad1615	office_hverdag_men		office_hverdag	
Venting	Venting	VentingCtrl939		all day	

Ill. 14. The office building elements and their properties in the BSim model.

APPENDIX 4. BSIM OFFICE

system	description	schedule	
		control	indication of time
human load	9 persons	0% 0-7 70% 7-9 100% 10-17 50% 17-19	mon-fri: 7-19
equipment	0,7 kW heat load	20% 0-8 100 % 9 -17 20% 18-24 15% 0-24 (sat - sun)	mon-fri: 7-19 sat-sun: 0-24
lightning	200 lux gen. lightning level 0,22 kW general lightning 0,15 Kw task Lighting	daylight control 200 lux lightning level control form: no/off	mon-fri: 7-19 sat-sun: 0-24
venting	max air changes 3 $^{h-1}$ factor 1	venting control set point 23^0 800 SetPCO2 (PPM)	all time
solar shading	south window shading eff 95%	shading control set point 22 ^{0} continuous control form	all time

Ill. 15. The functions and time schedules that are use in the simulation in BSim of the office



Ill. 16. Illustration showing the air flow changes in the office in the winter (December) and in the summer (July). The CO2 levels never rise above 800 which ensure a good indoor climate. The air change in the building is higher in the summer time because of the natural ventilation that prevents overheating but is never above 3 h-1.

APPENDIX 5. FIRE

Fire regulations are important to have in mind when design high rise because they can have a great influence in the layout of the plan. There are many different parameters that influence the demands concerning fire, where the most significant are the function of the building and the expected number of people occupying the building.

Tall buildings have two key issues when compared with other buildings. The issues begin the greater vertical distances for escape and the increased fire fighting difficulties. "I en bygning, hvor gulv i øverste etage ligger mere end 22 m over terræn, eller hvor redningsåbningerne ikke kan nås af redningsberedskabets stiger, jf. kapitel 6.6.1, stk. 2, skal der ved indretning af bygningen tages særligt hensyn til muligheden for evakuering fra bygningen, redningsberedskabets indsatstid og adgang til etagerne." [BR95]

The application class of the building is determinate by the use of the building. The mix use of the building makes the building contain different fire categorized from 1- 5, depending on the number of people and their knowledge of the building layout.

To contain the spread of fire the building is divided up into different fire sections. A fire section is a portion of a building that is designed so that a fire will not spread to other fire sections in the time required for evacuation and rescue emergency rescue persons. Each office space is thereby a cell and each apartment. [BR95]

In assessing the sufficiency of the escape routes the number of people, the building's fire separation and layout and use of the building need to be considerate. The building regulation does not give exact number and the adequate sizes of the exits are therefore estimated from the guide lines. See ill 17 for the exits sizes and escapes routes

Ill. 17. The distances and the sizes of the escape routes in the building layout.

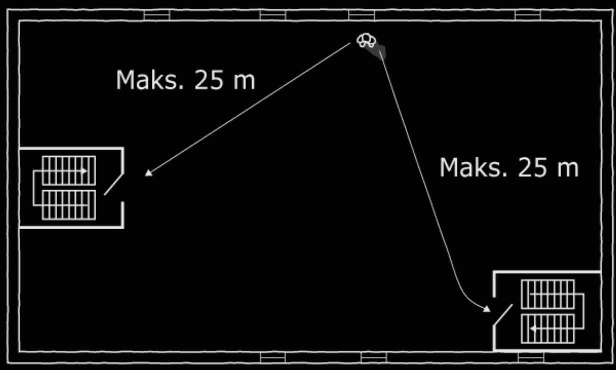
APPENDIX 5. FIRE

From each cell there have to be minimum two escapes routes see ill 18 – 19, placed in a adequate distance from each other that will prevent the fire of blocking both exit at the same time. The time it takes to reach the exits are also crucial which means that the maximum distance to each exit in the fire cell need to be maximum 25 meters.

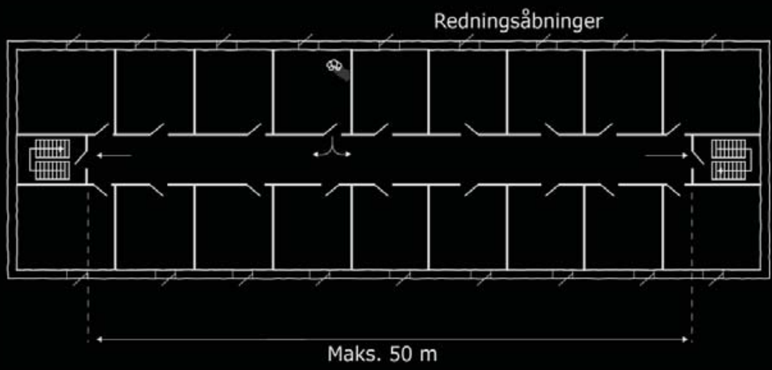
The most critical space in the building is the office space because of the greater number of people working there. In one floor it is estimated that there will be maximum 40 people working and the escape exit wide of 1.2 m is therefore sufficient. See ill 17.

The two main fire staircases have a wide of 1.2 m. The staircases have to provide escape routes from all of the people within the building. The staircases are therefore the most critical point concerning fire, but the layout of the plan makes it possible to enlarge the exits if not proven to be large enough.

The atrium needs to be optimized to prevent the fire spreading inside the atrium. Sprinklers will therefore be added which will prevent the fire of spreading and the material needs fire preventing coating. This will prevent the fire from starting and to spread.



Ill. 18. The maximum distance of the escape routes the office section.



Ill. 19. The maximum distance of the escape routes in the apartments and hotel section of the building


Ill. 20. The most beneficial way to open doors placed in the escapes routes

APPENDIX 6. AIR FLOW ATRIUM

The wind pressure between top and bottom of the atrium can become too high because of the thermal bouncy.

Spreadsheets are use to calculated potential problems. The calculations are made with windows openings on 10m2 in the top and bottom of the atrium that are 80 meters high. The deferens between the inside and outside temperature is 4 degrees because of the passive heating of the atrium by the sun.

The resulting air change becomes 25 m3/s which is equal to approx 7h-1. High air changes like this can cause problems when for example opening doors to the atrium. Therefore the openings need to be controlled or the atrium needs to be divided up into smaller sections.

Pressure Coefficient				Windfactor
Windward	-0,2			Vmeteo
Leeward	-0,19			Vref
roof	-0,38			
Location of neutral plan, H		40,5	m	
Outdoor temperature		20	C	
Zone temperature		25	C	
Discharge coefficient		0,7		
Air density		1,25	kg/m3	
	Area m2	Eff. Area m2	Height m	Thermal Buoyancy AF pa
south opening	10	7,000	1	8,135
north opening	10	7,000	80	-8,135
		0,000		8,341
		0,000		8,341
		0,000		8,341
				Massebalance

		Pwind	35,2 pa	
3,2	m/s	Pmin	-13,4 pa	
7,5	m/s	Pmax	-7,0 pa	
	Buildingvol.	12000	m3	
	Volume		m3/section/floor	
	Internal pressure	pa	-6,86	
AFR (thermal)	**Pres Coefficient**	**Wind pressure**	**AFR Wind)**	**Wind**
m3/s		**pa**	**m3/s**	
25,25	-0,2	-0,176	-3,712	
-25,25	-0,19	0,176	3,712	
0,00		6,855	0,000	
0,00		6,855	0,000	
0,00		6,855	0,00	
0,00		Massebalance	0,00	
-7,58	h-1			
-25254,82	l/s			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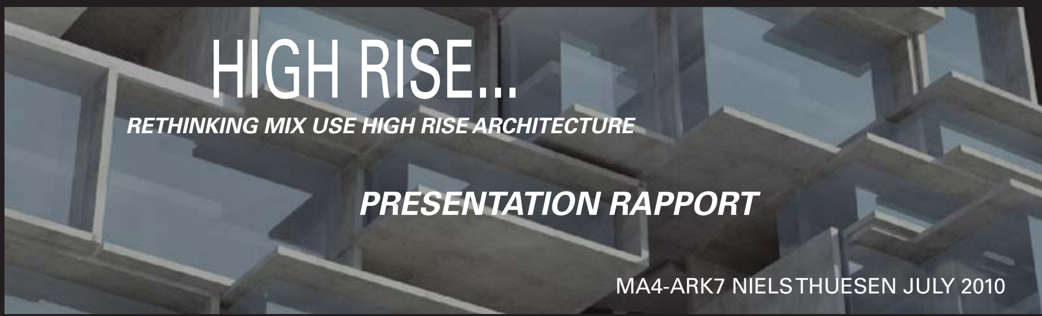
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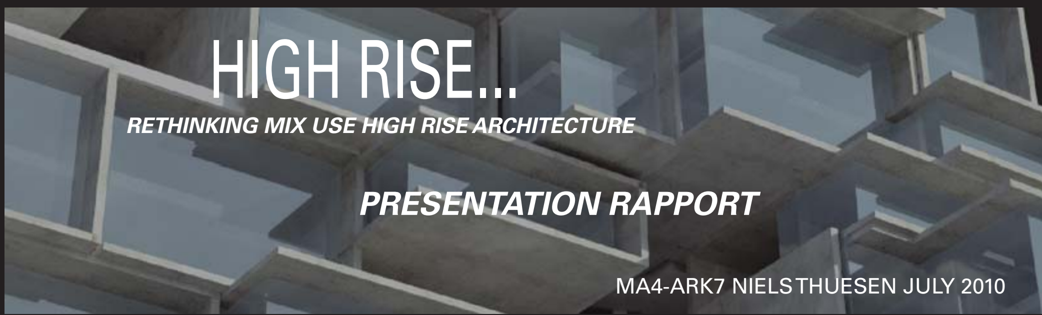
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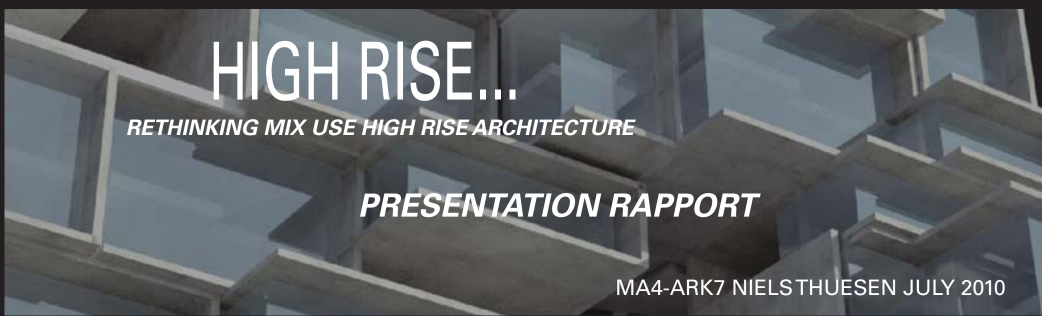
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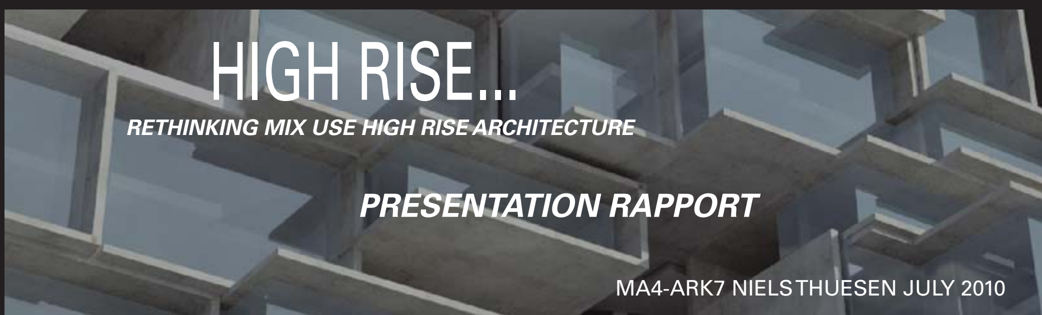
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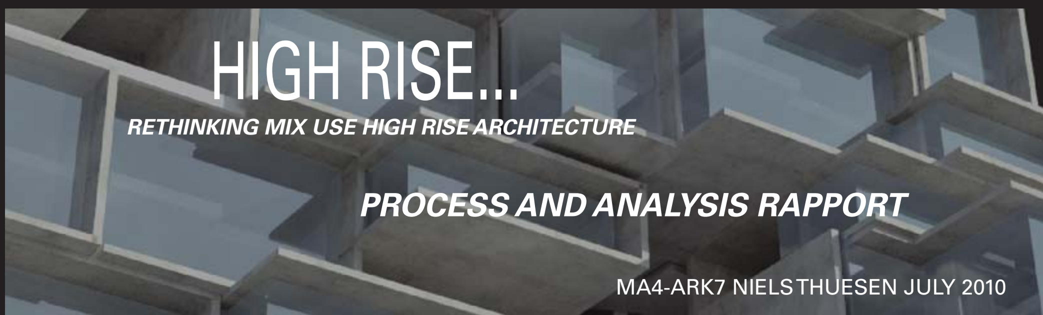
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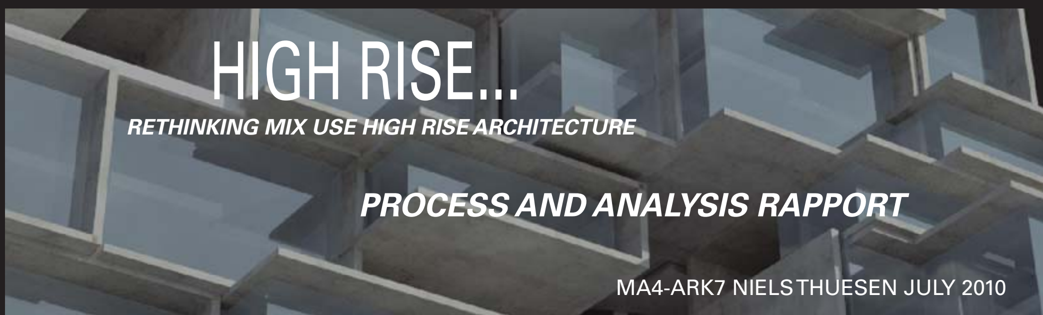
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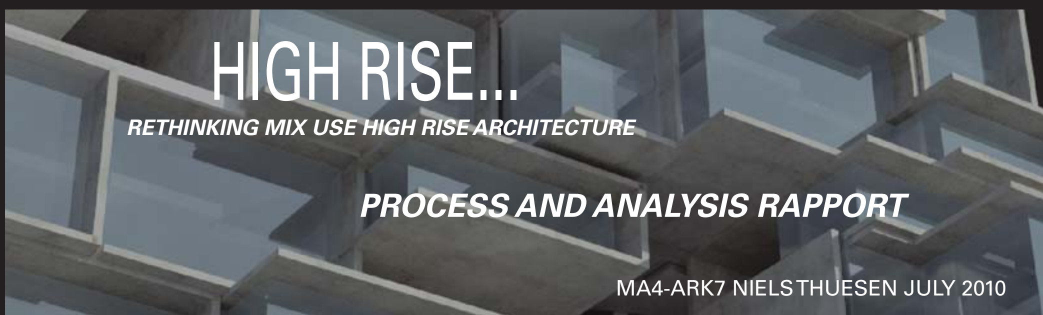
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