LIVING IN A FACTORY

TRANSFORMATION OF A PIECE OF THE INDUSTRIAL HERITAGE INTO RESIDENTIAL FUNCTION

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Project title
Living in a Factory
- Transformation and extension of a building part of the industrial heritage into a residential complex

About
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Abstract
The topic of the project is an old factory building which is turned into a residential function. The transformation of the building symobolises the change of Aalborg as it leaves behind its industrial image, however the developing new identity incorporates the inherited values of the past. In addition, emphasis was taken during the project providing flexibility for the future changes. In conclusion, the design process leads to the expression of the designer's own understanding of sustainability.

Contents

1. Introduction

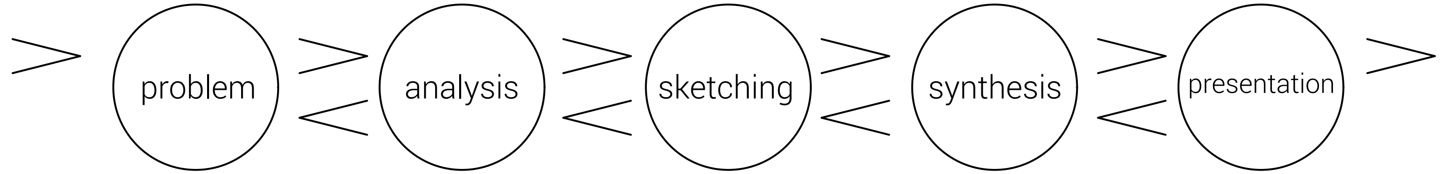
1.1. The background of the project

The project is developed in cooperation with the INBO Holding Aalborg ApS who owns the existing factory building on the Eternitgrunden and plans the transformation of it. They would like to create a block of apartments respecting the industrial heritage that the original house represents. Their experiences have shown that involving students in the early phases of the design has a good effect on the final product, therefore they invited students from the university to participate.

1.2. Objectives

I was among the students who applied for the project, and I found it an exceptional opportunity to work on it during my master thesis. It provides a background for the thesis which is the model of a real-life situation with a specific client, demands and market conditions. My wish is to use the knowledge I gathered during my studies at the university and internships to develop an actual project - which project might be built in the future applying my ideas.

My main goals for the project are related to three main topics. Firstly, I consider it highly important to preserve the cultural heritage of the existing building, because it represents values of the history of the city. Secondly, my intention is using this industrial background to stand in contrast of the future function and create warm homes for the people who will move there. This contrast can enhance the atmosphere of both world, and develop vivid architecture. Thirdly, I wish to emphasise certain aspects of sustainability in order to make the building long-lasting, respect the natural environment and provide adequate living conditions for the future residents.



ill. 1. On the previous page: the main hall of the existing building

ill. 2. The flow and iterations of the integrated design process

1.3. Methodology

Since an architectural project tends to be extremely complex it has a great importance to find an effective way of handling all parameters. For this reason, integrated design process is applied for the project which incorporates design principles and calculations for developing the optimal solution. The combination of architectural considerations and tools from the engineering discipline from the very early testing ensures that the final result will be adequate in relation to both.

The method incorporates 5 main phases: problem formulation, analysis, sketching, synthesis and presentation. These phases are not necessarily linear in time, the usual process includes loops and iterations [Knudstrup, M. A., 2005.] as it is shown on ill. 1.

The problem formulation / project idea

The purpose of the project is to create living space from an old industrial building with special focus on sustainable features like social interaction, flexibility of the layout and the reduction of unfavourable effects on the environment.

The analysis phase

This section includes the examination of the history and current situation regarding the site, climate, regulations, functional demands, theories of transformation, etc in order to gather the required data for solving the problem formulated earlier. The results of this part are the design criteria for the next phase.

Sketching

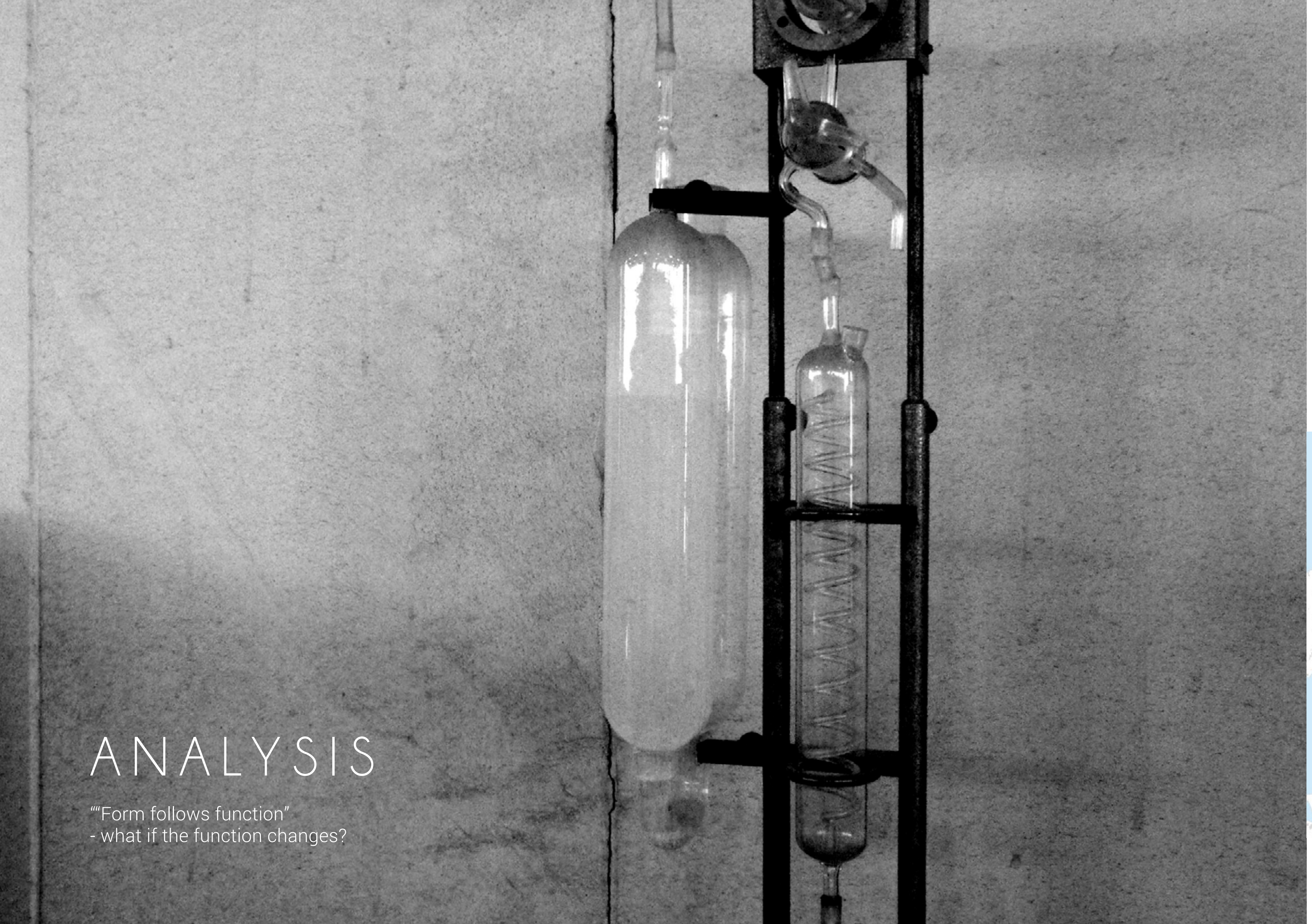
When the analysis has provided the necessary amount of information and established a vision and concept, the design process started with sketching. This phase was done with iterative testing of potential ideas, developing the optimal solutions for all aspects of the project. The use of tools related to fields both of architecture and engineering have been utilized, like hand sketches, computer modeling and calculation, moreover physical models.

Synthesis

This is the phase to achieve synergy fulfilling all design criteria and finalize the design of the building in terms of shape, architectural and technical details, functional aspects, principles of construction, etc.

Presentation

The aim of this chapter is to explain all the details of the designed project in a way which helps understanding it the most.



ANALYSIS

“"Form follows function”
- what if the function changes?

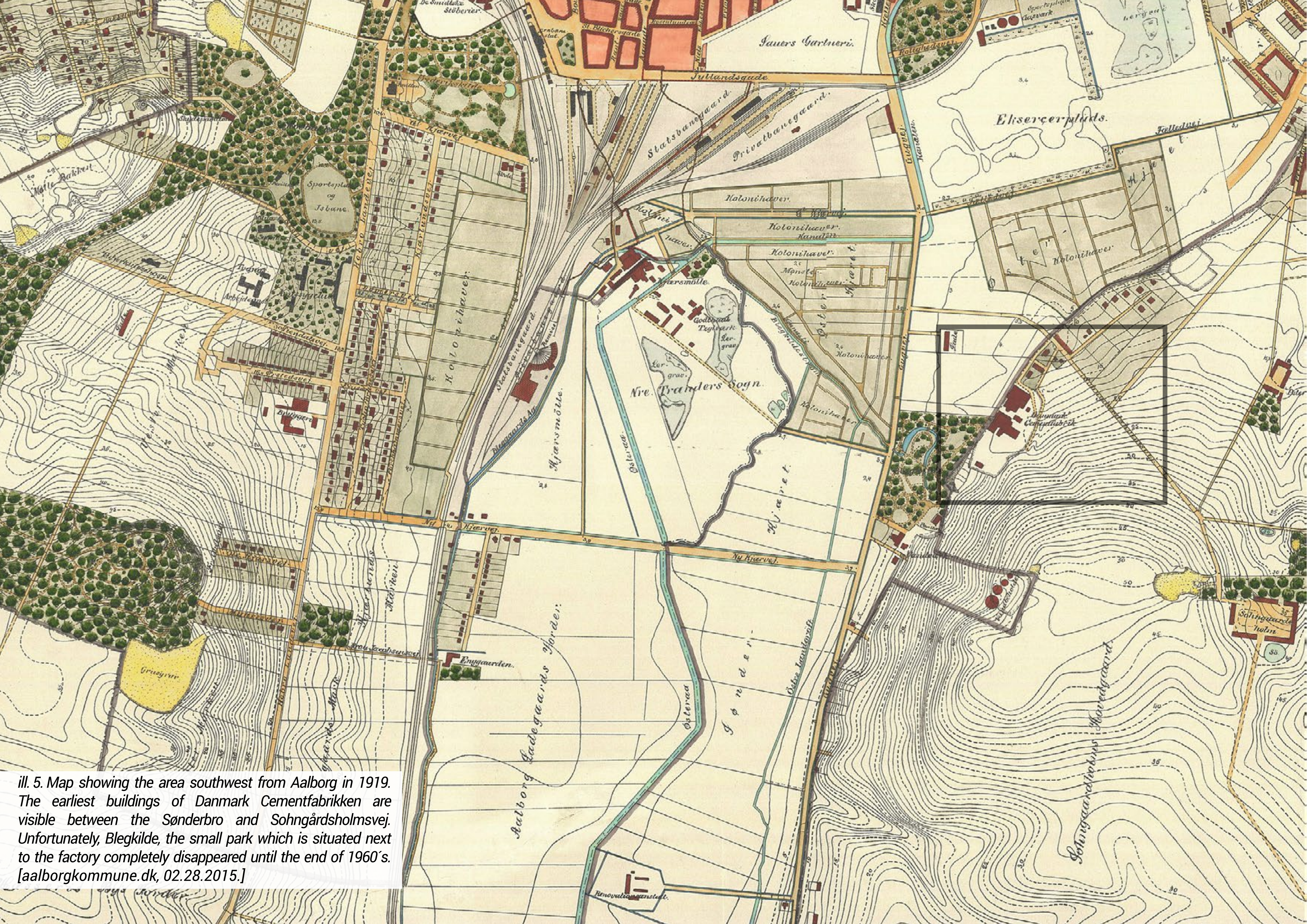
2. Analysis

The project site is located in Aalborg, the third largest city of Denmark, a city with rich industrial history. Aalborg municipality works on changing its image from industrial to an education and culture based city. This transformation has started slowly in the 1970´s when the first part of the university and the Kunstmuseum were built. The process accelerated after 2000 when - among others - the entire waterfront has been changed, replacing the old industrial plants with educational and residential districts. Emphasis was taken during the development to preserve the objects which represent heritage values in order to protect the unique character of the old Aalborg.

The same process can be experienced in the area where the site is located. The territory of the former cement factory is reused and an entire new district of the city is created.

ill. 3. On the previous page: equipments used in the existing laboratory building

ill. 4. The location of the site



ill. 5. Map showing the area southwest from Aalborg in 1919. The earliest buildings of Danmark Cementfabrikken are visible between the Sønderbro and Sohngårdsholmsvej. Unfortunately, Blegkilde, the small park which is situated next to the factory completely disappeared until the end of 1960´s. [aalborgkommune.dk, 02.28.2015.]

2.1. The history of Eternitgrunden

As ill. 3 - ill. 5. show the area is located in the south-eastern part of Aalborg and famous for the cement fabrication which had started as early as 1898 when the first factory opened its gates on the site owing to the rich deposits of clay and lime stone. After a difficult beginning the Portland Cementfabrikken "Danmark" had become one of the largest industries in Aalborg giving job for thousands of people. In 1928 eternit production had been started, firstly using asbestos, but later a decision was made to switch to cellulose fibre in order to reduce health risks. Until the end of the of the century the factory produced around 170 000 tons of fibercement products. The plant worked continuously until 2004, when it closed the main manufacturing departments, however some parts are still functioning. One of them is owned by the company called Cembrit and rents - among others - the building which hosts the current project. They are going to move out until the end of 2015 and find another location for their work.
[Henning, B., Pedersen, M., 2006]

ill. 6. Since the factory was located far from the Limfjorden, it used automobiles for transporting the cement - among the first ones in the region. Photograph from 1919 [Bender, H., Pedersen, M., 2006:37]


ill. 7. Photo of Eternitgrunden viewed from the Østre Alle in February 2015


ill. 8. Photo of Eternitgrunden towards north in February 2015


ill. 9. Photo of the future Bygaden in February 2015

2.2. The present and future of the area

Owing to the central location of Eternitgrunden it is ideal for development which was planned since the former factory closed. The fact that the site is between the university and the centre of Aalborg makes it extremely valuable. In addition, the "letbane" which tramway is going to connect the downtown and the university will be built on the Sohngårdsholmsvej in a couple of years improving the transportation opportunities in this district.
The development started by deep analysis of the area with the involvement of several parties, like the residents from the neighbourhood, representatives of the investors and future users, in addition to architectural, environmental and engineering companies. The analysis of the context of the site is visible on ill. 12 on page 11, presenting the actual conditions.

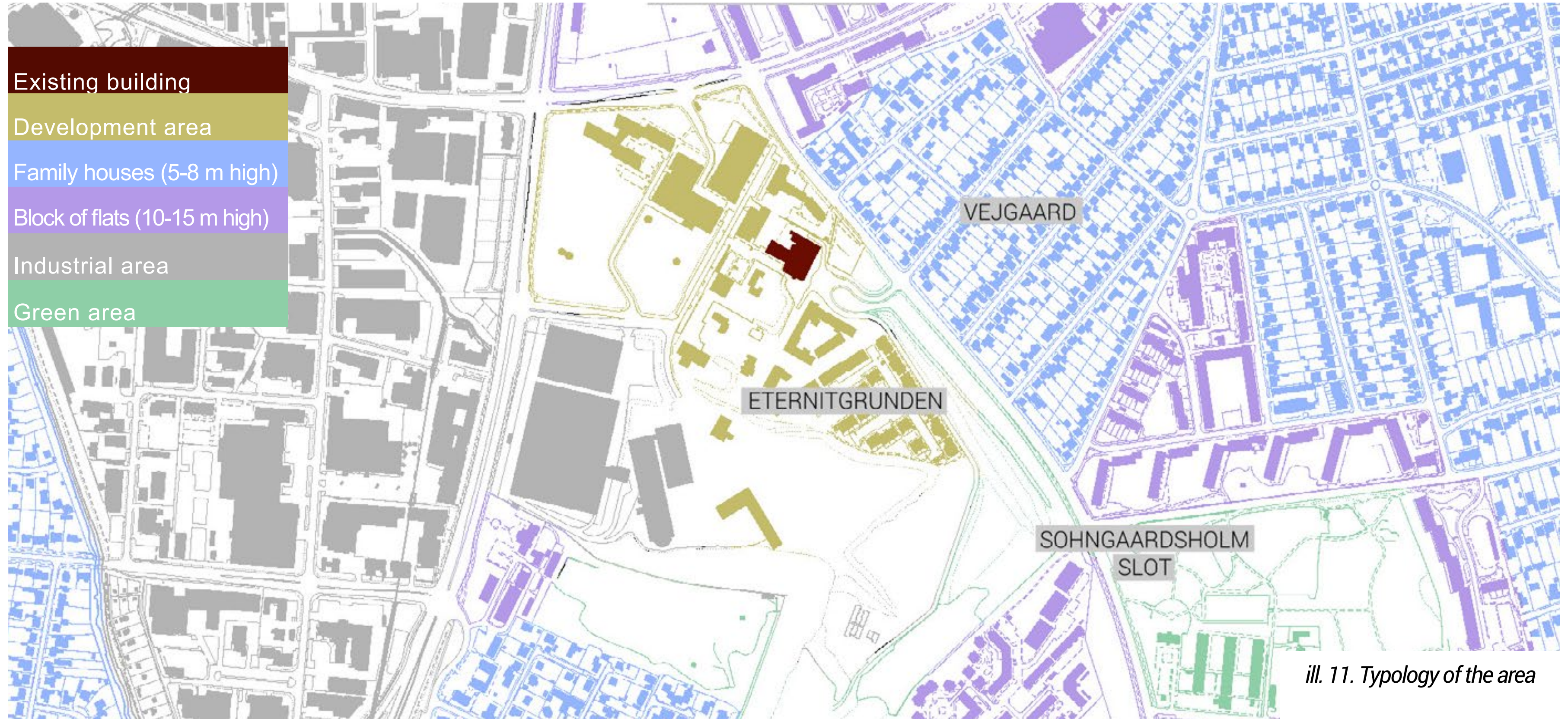
Asbestos

One of the main issues of the development was the fact that the former factory had been producing asbestos-based products for almost 60 years contaminating the ground of the surrounding area with the hazardous material. After the production ended the Kommune started a thorough investigation for the level of the toxic compound in the district and identified several spots where intervention was necessary. It had a great importance to clean especially those sections where residential buildings had been planned to build. Total soil replacement was executed, and the removed material was stored and isolated safely. In addition, the workers had to take special attention to perform the task with causing the possible lowest amount of dust protecting the residential areas next to the site. [DGE, 2013]
Mapping of the district shows that the mostly contaminated areas were not located directly on the site of the project, however they could be found close to it (ill. 10.).

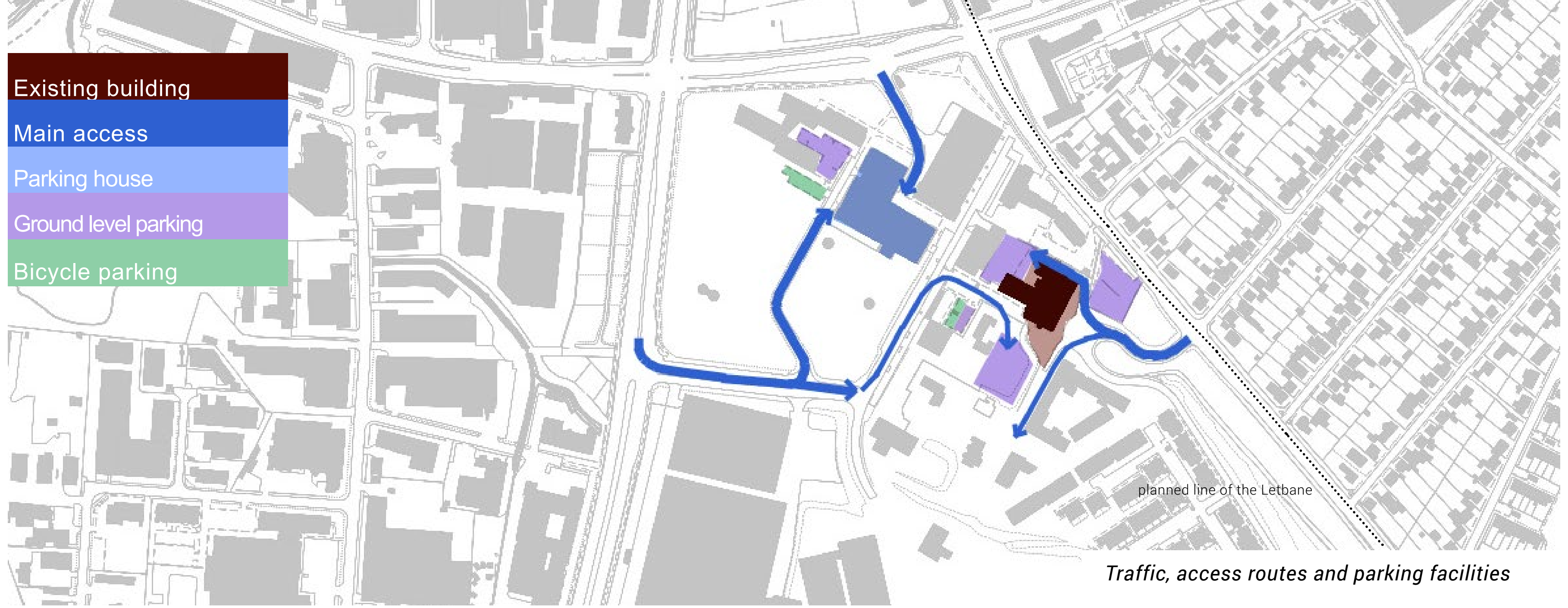
Traffic-related pollution

Car traffic to and from the area is organised through Poul Larsen Road to Sønderbro, however the Østre Alle provides significant traffic load on the northern border. The noise measurements show that a large proportion of the planned buildings on Eternitten are loaded with a noise level exceeding the level of housing (58 dB), and similarly the limit for offices (63 dB) is also exceeded in an extended part of the district. However, the Laboratory building is located far enough from the road with heavy traffic, therefore the noise is on permitted level.
According to the periodical measurements most emissions from traffic are declining. The level of CO, HC and NOx has fallen 40-60% from 2000 to 2004. The positive development - which is expected to continue in the upcoming years - is resulted primarily by fleet renewal, where still more cars have catalytic converters and particulate filters. [Lokalplan 4-2-105, 2010]

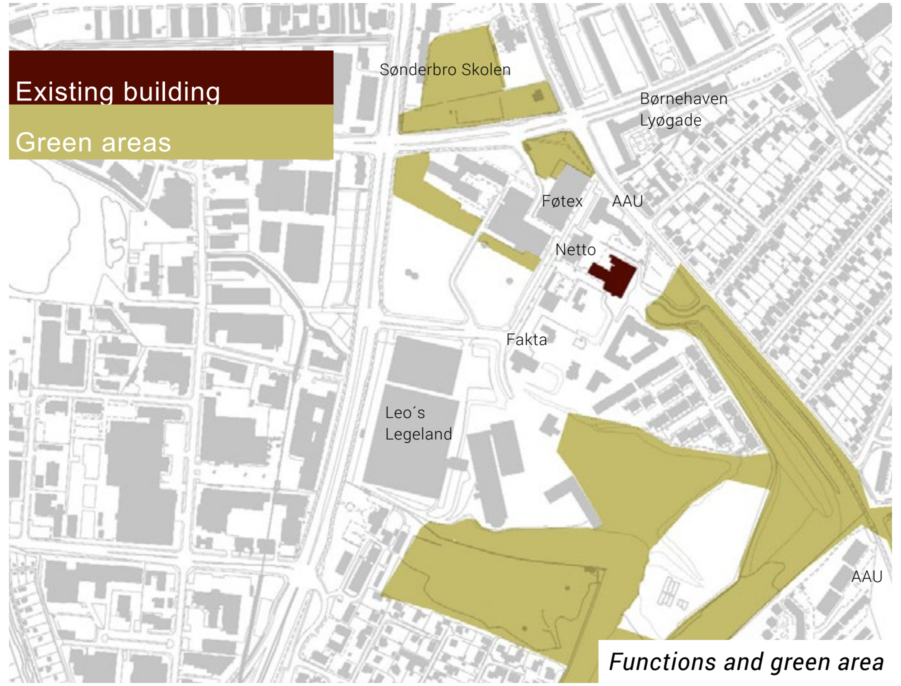
ill. 10. Areas effected by the asbestos contamination before the soil replacement [aalborgkommune.dk, 02.25.2015.]



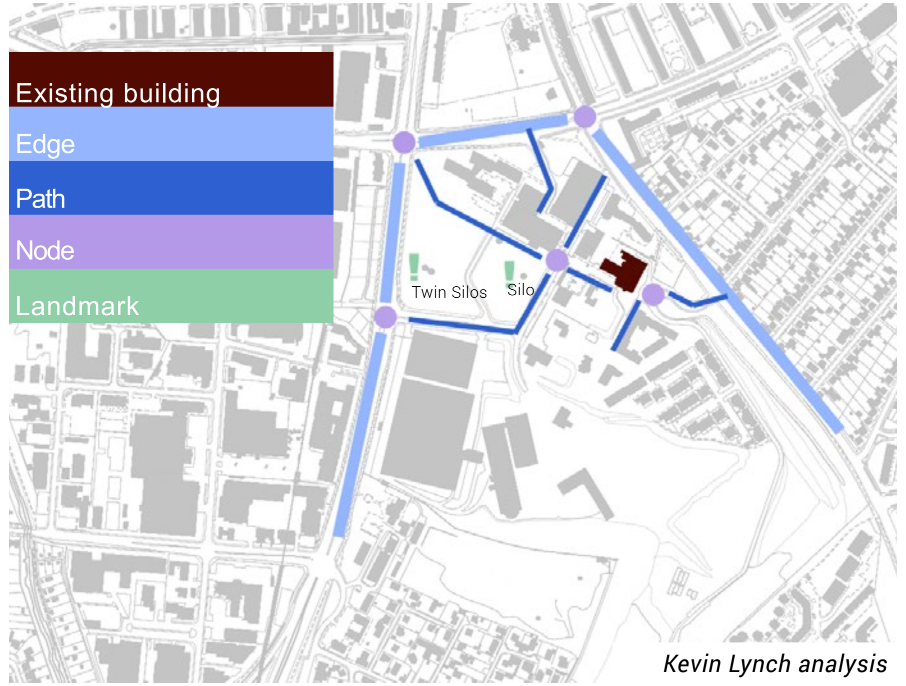
ill. 11. Typology of the area



Traffic, access routes and parking facilities



Functions and green area



Kevin Lynch analysis

ill. 12. Diagrammatic maps showing the Eternitten and the site with the existing building

The main goals of the Kommune according to the local plans [Lokalplan 4-2-105 and 4-2-107]:
- Densification in interaction with heritage. The decision was made considering sustainable factors as well, namely comparing the effect of transforming an existing area inside the city or adding new districts on the outskirts. The previous one proved to be more sustainable due to the reduction in transportation and the possibility of use of existing infrastructures.
- The new district is planned as a mixed-use area, however with the emphasis on residential function. The area should contain most of the daily used functions for providing a self-sufficient district. The only exception is the educational institutions which are not planned to be built here, therefore children who come to stay in the local plan area, may use Sønderbroskolen which has classes from preschool to 9th grade.
- It is also important to cnstruct more small shops (mainly on the Alexander Foss Gade) instead of large-scale supermarkets.
- Creating an architectural “experimentarium” for developing attractive relationship between new and old in terms of materials, volumes, connections, etc. Therefore the new buildings must provide a diverse experience
- Building people-friendly urban spaces with exciting new view-lines
- Creation of a green-urban corridor connecting the surrounding districts
- Vibrant urban areas where pedestrians are expected
- The reduction of big monotonous facades
- Finding sustainable parking solutions, preferable with the use of underground parking houses instead of ground-level parking lots which occupy the potential urban spaces.

The new structure of the area is divided by the planned access routes:

Bygaden is the backbone of the new district and one of the area´s two large public spaces. It will include the focal point of urban life with several commercial facilities, moreover function as a link between Øgadekvarteret and Østre Alle.

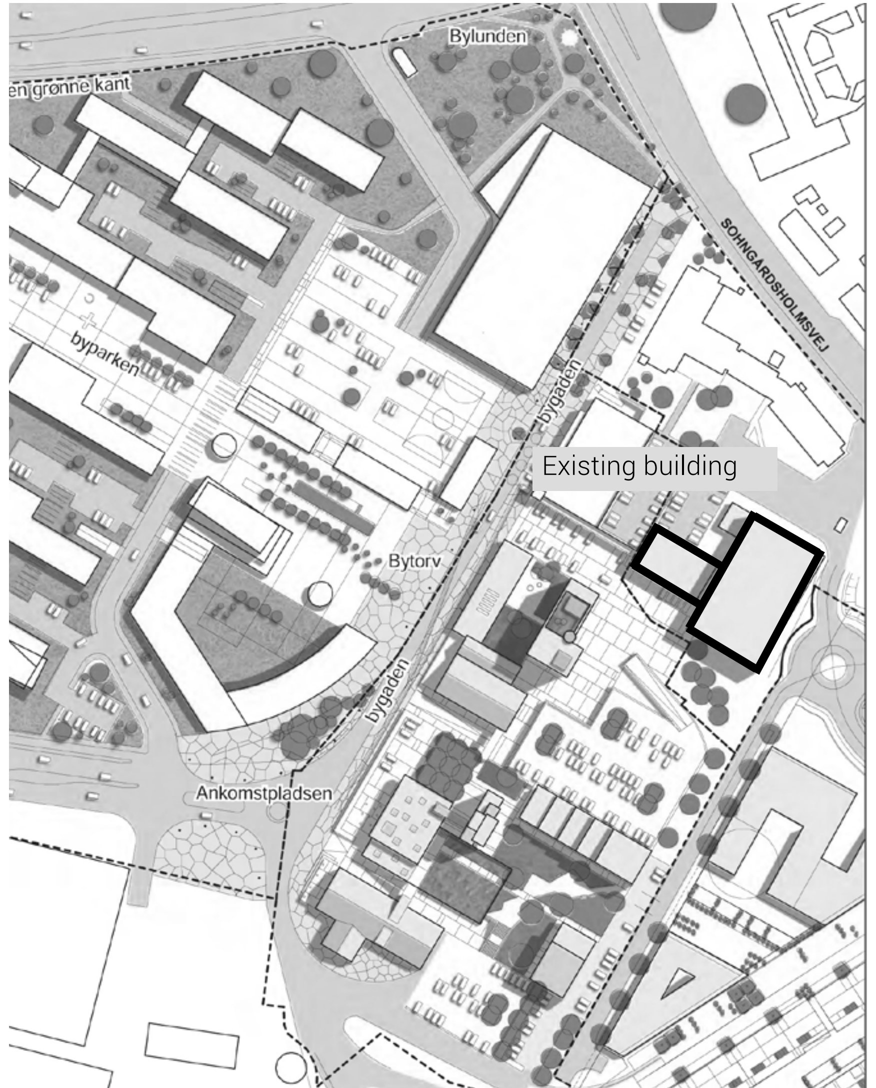
Byparken is the second major public space in Eternitten which is also an important centre for urban life and outdoor activities, but with an enormous recreational twist. This space is intended primarily for pedestrian use and may only provide limited access for driving and parking.

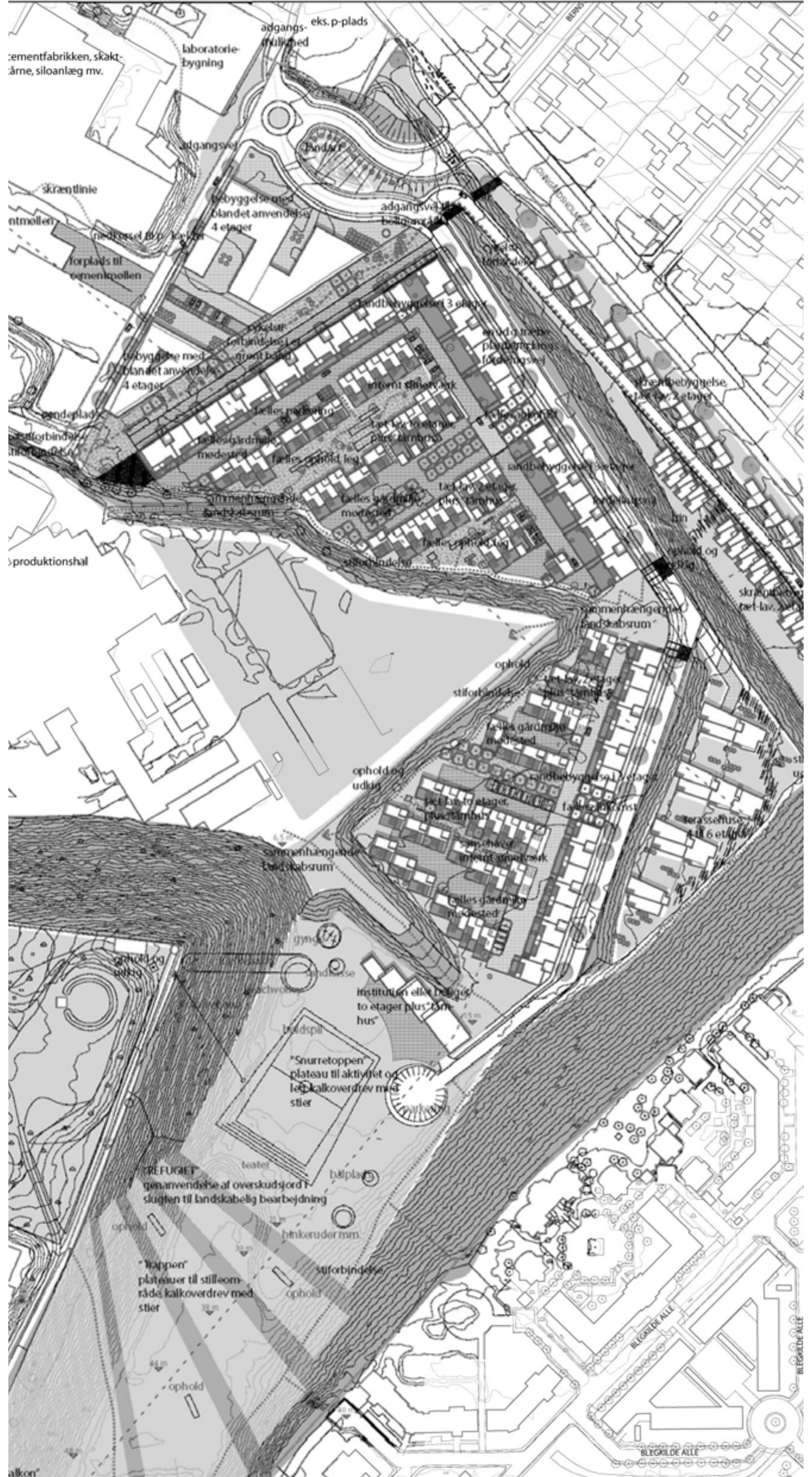
On the place where these two routes intersects, a small square will be constructed, called Bytorv. It is intended to be used as a meeting point, an outdoor forum for the residents of the area and also for the visitors from other parts of the city.

Bylunden is the boundary towards the roads with heavy traffic on the borders of the site. It separates the residential and office buildings from these main roads providing a peaceful island for the users.

These facilities will provide the frame for the development giving access for the new buildings. The places and footprints of the new buildings are shown on ill. 13., but the heights are still under negotiation. The first local plan versions proposed an average height of 3-4 storeys which was lower than the former factory on some parts of the area. Based on the discussion with the investors and residents of the surrounding districts

ill. 13. Sketches showing the northern and southern part of the planned development on Eternitgrunden [Lokalplan 4-2-105.]





the Kommune raised the average height limit, furthermore allowed some highrise blocks up to 9 storeys. [Lokalplan 4-2-105 and 4-2-107 and Startredegørelse, 2014].

Resulted from the presence of occasional high-rise buildings - in addition to sustainability factors - the use of green roofs is strongly recommended for the smaller constructions for providing pleasurable view towards them. Otherwise the roofs must be flat (maximum 5 degree angle) and preferably used as terraces or other outdoor areas. The exceptions from these rules are the existing buildings which will be renovated to the original look.

Allowed functions:
• Residential
• Hotel
• Clinic
• Offices
• Service (shops maximum 1-2-3000 m^2/district A, C, D)
• Print
• Cultural purpose
• Recreational purposes
• Education
• Institutions
• Recreational purpose
• Wholesale

The materials which are allowed for the facades are the following: glass, brick, concrete / fiber concrete, steel

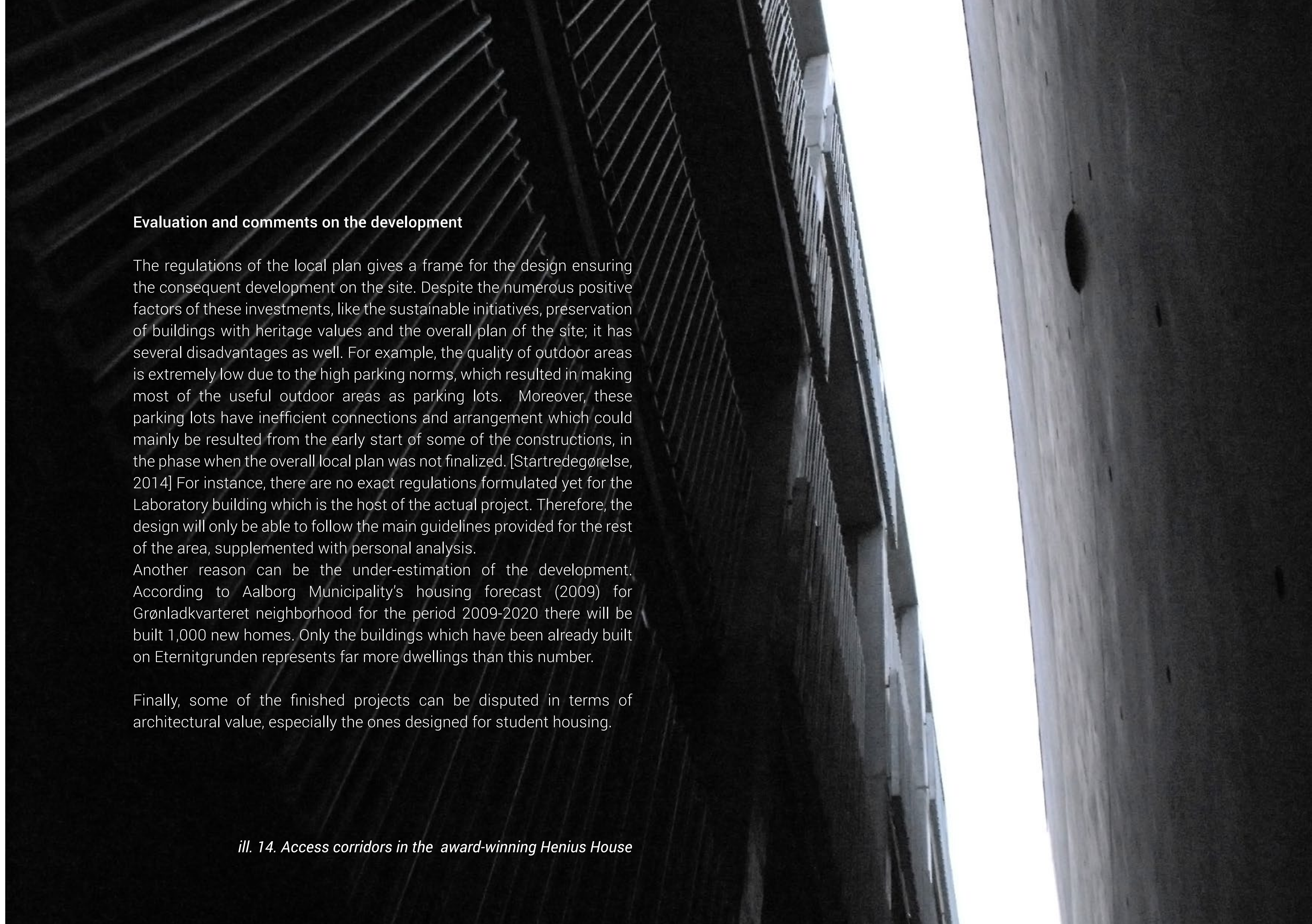
Regarding the methodology of transformation and extension of the few existing buildings the regulation orders creating strong contrast between new and old. Moreover, the construction of parasites are also supported.

Land use:
- Minimum 30% of the building area must be developed as recreational area: green, common rooms, urban space
- Minimum 15 % must be "outside living room" - sheltered area for green or playground, etc. Can be placed on (roof) terraces.

Parking requirements:
Parking should be solved preferably in the form of parking houses. Therefore the existing parking building will be extended with two more storeys.
The general requirement for different functions are under discussion and expected to be changed, however the current regulations state the following parking needs:

Apartments	1,5 per unit
Student housing	0,25 per apartment
Shops	1 per 25 m2 selling area and 1 per 50 gross area
Bicycle storage	2 per apartment and 1 per 100 m2 of shops

Green Vision
In the local plan a characteristic planting strategy is proposed, a more extensive network of bicycle paths, recreational experience elements and utilization of surface water. In addition, the development is imagined as a low-carbon district, therefore the use of district heating or the creation of low-energy housing is a must.



Evaluation and comments on the development

The regulations of the local plan gives a frame for the design ensuring the consequent development on the site. Despite the numerous positive factors of these investments, like the sustainable initiatives, preservation of buildings with heritage values and the overall plan of the site; it has several disadvantages as well. For example, the quality of outdoor areas is extremely low due to the high parking norms, which resulted in making most of the useful outdoor areas as parking lots. Moreover, these parking lots have inefficient connections and arrangement which could mainly be resulted from the early start of some of the constructions, in the phase when the overall local plan was not finalized. [Startredegørelse, 2014] For instance, there are no exact regulations formulated yet for the Laboratory building which is the host of the actual project. Therefore, the design will only be able to follow the main guidelines provided for the rest of the area, supplemented with personal analysis.
Another reason can be the under-estimation of the development. According to Aalborg Municipality's housing forecast (2009) for Grønladkvarteret neighborhood for the period 2009-2020 there will be built 1,000 new homes. Only the buildings which have been already built on Eternitgrunden represents far more dwellings than this number.

Finally, some of the finished projects can be disputed in terms of architectural value, especially the ones designed for student housing.

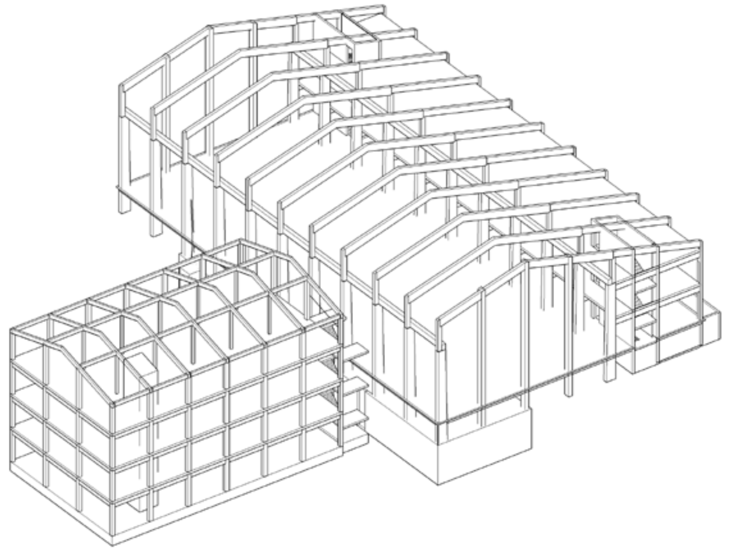
ill. 14. Access corridors in the award-winning Henius House

2.3. The site and existing building of the actual project

The existing building which is the theme of the project used to be the laboratory of the factory and is located on the central-eastern part of Eternitgrunden. It consists of a large hall, now used for manufacturing fibre cement products; and a storage wing which latter one is empty nowadays. The hall was built in 1964 and has an impressive size of 47,5 m (length) by 17,5 m (width) by 12,5 m (height), in addition it has several galleries with offices and other administrative functions.
The storage wing was constructed a couple of years earlier; and has a height of four-storeys with exceptional load bearing capacity (2 tons/ m^2).
Both buildings were made of using prefabricated concrete elements, then clad with Siporex blocks on the external walls and roof.

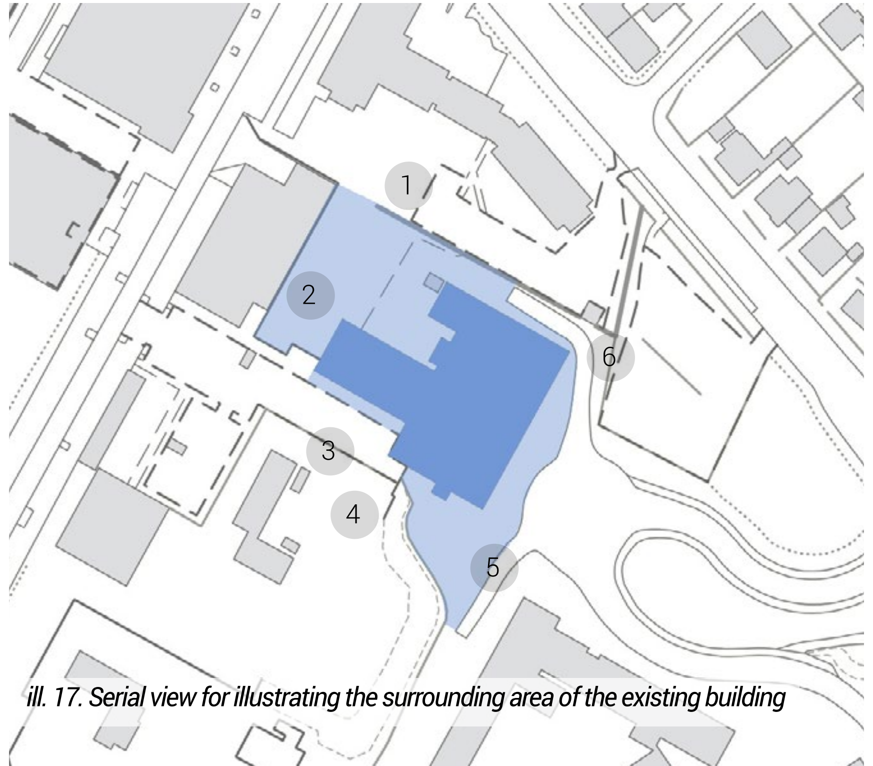
Why preserving it?

The cultural-historical assessment of the building by the Kommune states it is valuable (second grade from three) [Lokalplan 4-2-105.] It has numerous unique features which qualifies the building to be preserved, and these values should be highlighted during the design phase of the project:
- Honest and impressive structure: the main structure is visible throughout the entire building presenting simple and spectacular solutions. (ill. 18.) This airy structure should be kept visible and in the new design in order to enrich its tectonic qualities. Moreover, the opportunity to make some parts of this structure possible to reach and touch - which elements were far above previously - grants a special exhibition to this piece of heritage and standalone mood for the new apartments.
- The use of material: most part of the building was made of concrete, using different type of formworks which gives an interesting playful effect for the surfaces and a strong tactile experience for the observer.
- Spatial quality: the large open space of the hall has an amusing atmosphere and allows exciting views from one adjacent space to another. Using the existing and creating new viewports in this impressive space will certainly enrich the new building.
- Light: the natural light comes from above, through the enormous windows cut at the top of the walls which phenomenon provides an almost transcendent effect. (ill. 1.) In addition, this windows acts in a special way filtering the light. They seem to be transparent surfaces from inside, but opaque areas from outside. This feature can be utilized in order to create light sources which maintain the intimacy of an interior space, and provide safe, hidden feeling for the users.
- Large ceiling height: most of the rooms have ceiling height of 3 meters or more making them quite elegant. (ill. 18.) These rooms are excellent to turn into new apartments allowing adequate daylight conditions, opportunity for natural ventilation, space for new floors and potential suspended ceilings.
- Two big-sized underground rooms with easy access which can have various functions like storage, room for heating, laundry and garage.
- The primary structure survived the decades in good condition, without any sign of damage or corrosion. Moreover, it has high load bearing capacity which factors ensure the safety and cost-efficient development of the new function.
- The character of the building is part of the local identity, and acts as a reminder of the history of Aalborg. The transformation of the building symbolises the change of the entire city, sharing its fate and development.

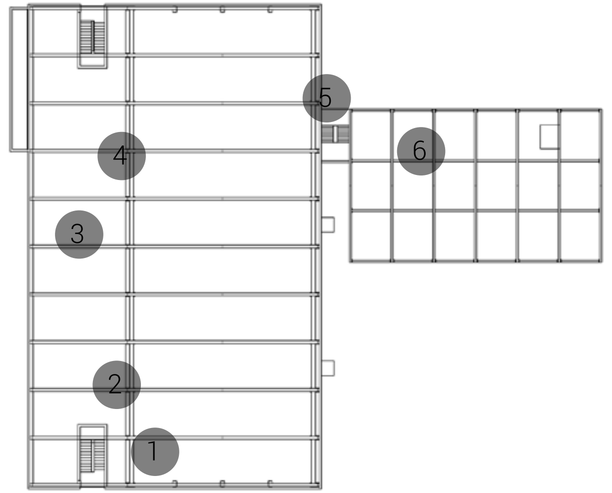


ill. 15. Isometric diagram showing the primary load bearing elements of the building

ill. 16. Photo of the light-filtering phenomenon created by the existing windows



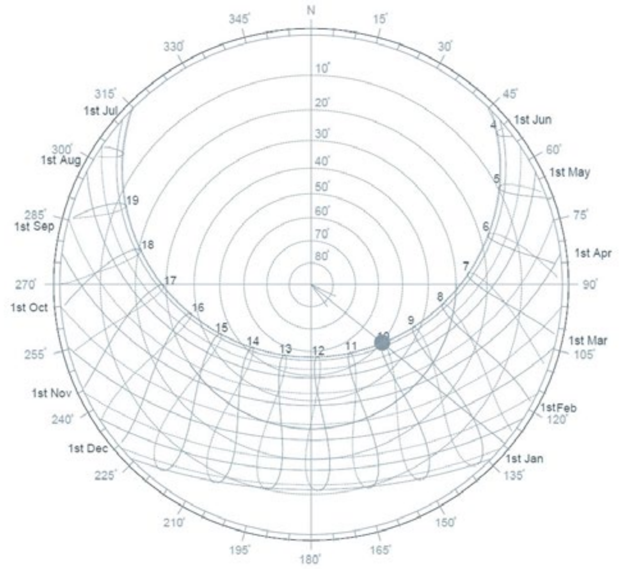
ill. 17. Serial view for illustrating the surrounding area of the existing building



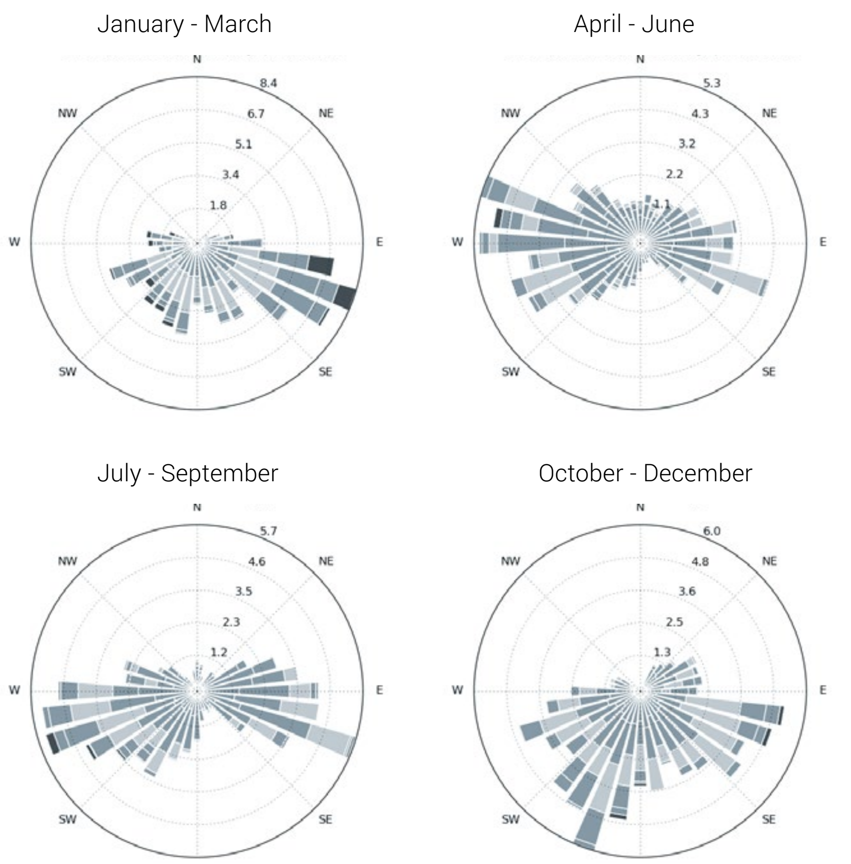
ill. 18. Serial view for the interior of the existing building

2.4. Climatic considerations

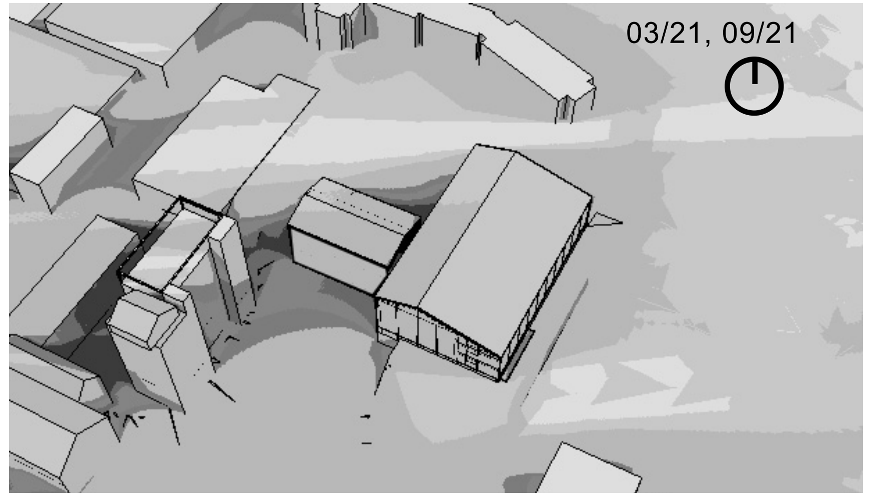
As a final section of the analysis chapter, investigating the climatic conditions helps finding the adequate placement, shaping the building, in addition it has an effect on the choice of materials as well. In case of sustainable architecture it is even more important because these buildings are advisable to live together with nature, rather than constructing an isolated object demanding the sole support of artificial equipment.

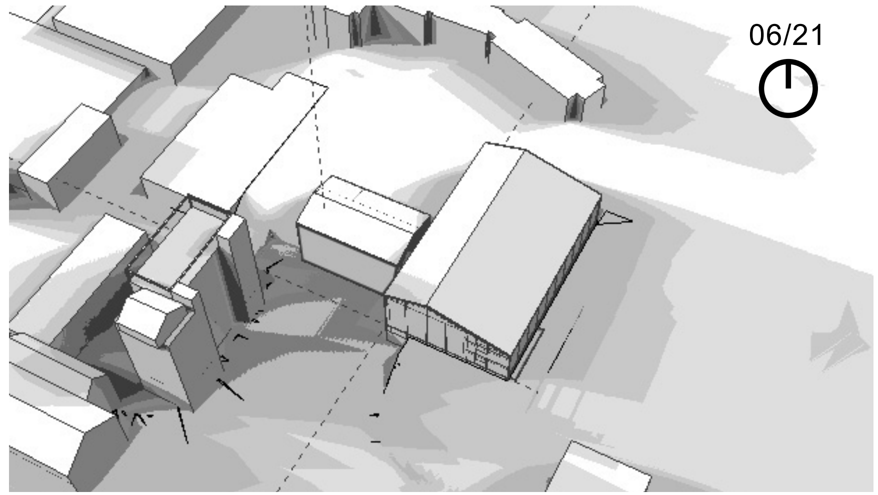


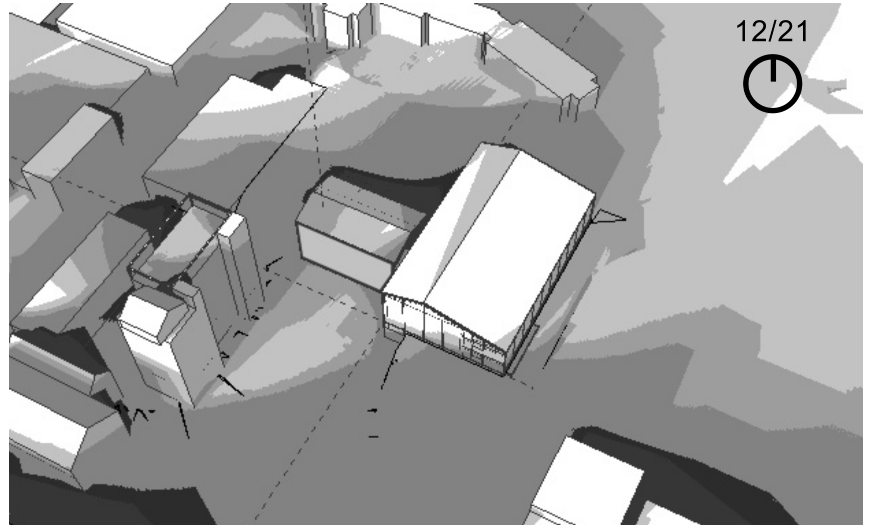
ill. 19. The stereographic diagram (Copenhagen, 2012) shows the height and latitude of the sun in different periods of the year. It is an efficient tool which helps designing for example the outdoor spaces and dimensioning the windows getting the most possible direct sunlight into the rooms.



ill. 20. Wind roses for the four segments of a year. They indicate that the cold winter wind usually come from southwest - southeast, therefore the designed building should be sheltered from these directions.
On the other hand the wind slightly changes during the summer and it comes from west, so this direction is ideal for open areas in order to promote natural ventilation.







ill. 21. Shadow analysis of the site
The diagrams show the relative shaded areas in each season (the darker the area it is shaded the larger part of daytime)

According to the diagrams, the adjacent high-rise building does not provide a significant shading effect on the laboratory.

The area between the Netto and the western wing of the laboratory is well-lit during the entire year, therefore it is suitable for outdoor activity.

The most appropriate place for possible solar cells is the south-eastern part of the large hall´s roof which has the best solar conditions.

The small "square" on the northern corner of the building, located between the two wings is well lit during the summer, especially afternoons, thus it might be suitable for placing a rest-area.

2.5. Conclusion of the analysis

The results of the analysis chapter are firstly used in order to develop a vision, then a design which fits into the area. The understanding of the historical background of the district is crucial for providing continuity with the new building, thus respecting the heritage.

Secondly, the consideration of the larger context ensures the connections with the surroundings and makes the planned building part of the city. It also reveals the strength and weaknesses of the area which need special attention during the design.

Thirdly, the investigation of the potentials of the existing building and the site highlights the opportunities which are utilised during the latter part of the work.

Finally, the examination of the climatic conditions made it possible to provide interaction with the natural environment which is an absolute requirement for sustainable design.

"... utopia might lie hidden within the existing world, attainable without the total destruction of the existing."
[Scott F. 2008:104]

VISION

3. Vision

Based on the knowledge gathered during the analysis, the vision of the project can be established, which defines the following design parameters:

1. From industrial to living
- How to transform a former factory into a warm home?
My main intention is finding the ways for creating welcoming homes for the future residents while protecting the industrial heritage which the building represents. The combination of these two objectives ensures that the building fulfils its function for the direct users as a place to live, and for the city as a place to remember the past.

2. From polluter to environmentally conscious
- How to turn a contaminator into a symbol of sustainability?
Reducing the negative effects on the environment is crucial and necessary for any profitable investment in terms of economy, ecology and social aspects.

3. From rigid to flexible
- How to ensure the possibility of future changes and make the building long-lasting?
The planned building might change function in the future - as all buildings do, especially those which are for rent. The design has to allow changes in order to prevent obsolescence and destruction.

ill. 22. On the previous page: view of the roof of the storage wing in the existing building

ill. 23. View of the production hall

CONCEPT DEVELOPMENT

4. Developing the concept

4.1. About the realm of transformations

As a start of the development of a concept rooted in the values of the vision, firstly the theoretical background of transformations should be observed briefly. According to Fred Scott the transformation of buildings is akin to translation or transcription in the art of literature as it converts the subject from one age to another, from past to the present [Scott, F., 2008: 79]. This approach makes the rearrangement, extension or change in function highly special tasks. It is a necessity in all cases to find the values of something existing, then form it in a way which emphasizes these qualities while on the other hand fulfilling the actual demands. Like translation the alteration of buildings also requires a critical approach towards the original work, meanwhile respects it as well. It is unavoidable to make changes on it but the manner of this process has determinant effect on the result. These complex projects apply special way of thinking of materials, structures, spaces, functions and require strong cooperation of various disciplines in order to prepare something old for the contemporary expectations.

In addition, transformation projects have great potential regarding sustainability as well. If one observes the entire life cycle of the building, the transformation is an essential tool for extending it. In this case, if the existing building would have been totally demolished, then followed by a new one, then the energy consumption of the project could be at least twice compared to a possible alteration.
Moreover, the use of recycled materials is common in transformation projects which makes it possible to decrease the embodied energy. While the decrease of operational energy consumption is in focus nowadays, the embodied energy of building materials should also be analysed and reduced by careful choice of them. [Thormark C., 2005: 429]

On the other hand, these type of projects raise several questions. Most importantly, the uncertainty of authenticity - how the changes effect the credibility of the original building? A poorly designed alteration or even a restoration carry the risk of damaging the heritage. [Ruskin, J., 1849] Therefore, mechanistic or standardised procedures should be avoided during the assessment of the values of the heritage, and the alteration of these values, therefore results might vary from culture to culture and time to time. [Lemaire R., Stovel H., 1994] The changes and additions should develop a harmonious composition with the existing in a way which avoids both imitation and over-ruling. The first one poses the threat of blurring the border between new an old, making it impossible to find the original parts. While the latter one destroys the majesty of the existing, and creates a noisy competition with the added elements. The judgement of whether the new parts are dominating the original ones or not is highly dependent on one's taste, however some basic rules can be formulated, like applying similar material, following the existing system of the volumes, keeping the construction lines, and avoiding too dynamic compositions in general.

The above discussed principle is illustrated by the following case study analysing a building complex which have been extended and transformed numerous times during its long life.

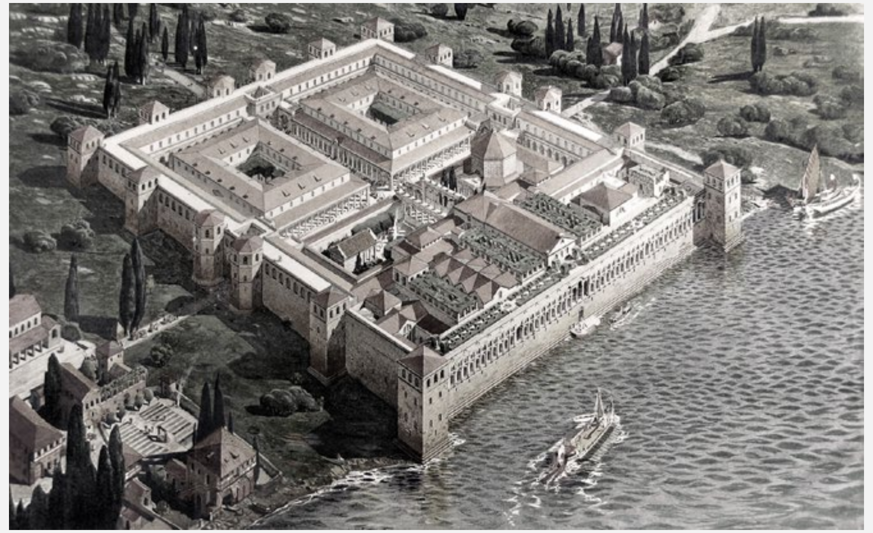
4.1.1. Case study - Diocletian´s Palace in Split

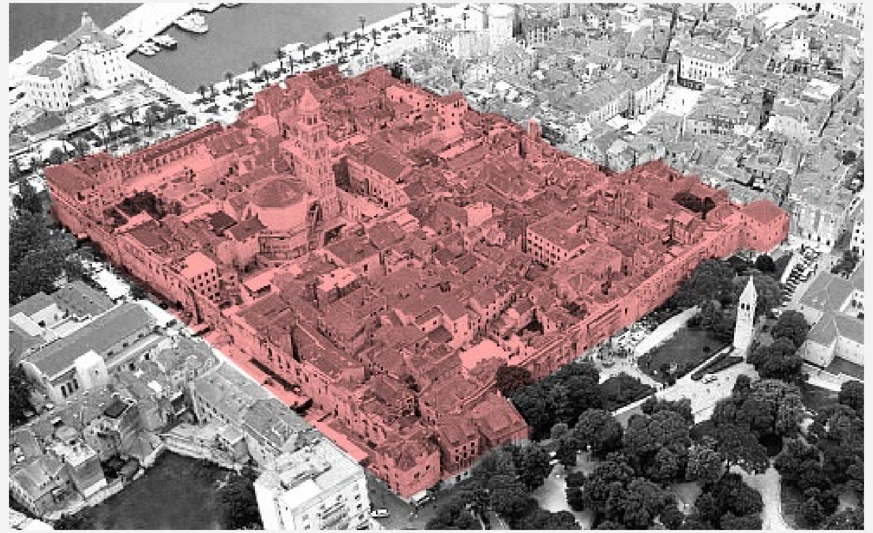
"Buildings change as the city changes."
[Scott, F., 2008]

Description

The emperor Diocletian built this outstanding palace as his retirement residence in 305 which complex was also highly fortified and included a military garrison. It was constructed on the coast, six kilometers away from Salona, the capital of the province Dalmatia. The builders used mostly the limestone and marble brought from quarries close to the site and supplemented it with luxurious imported elements like Egyptian granite columns. [wikipedia.org, 01.05.2015.]

The Romans soon abandoned the site and it remained unused for almost three hundred years. In the 7th century nearby residents fled to the fortress in order to survive the Slavic invasion, and then they started building a new city inside and around the walls. The spaces of the ancient complex were occupied according to the social hierarchy



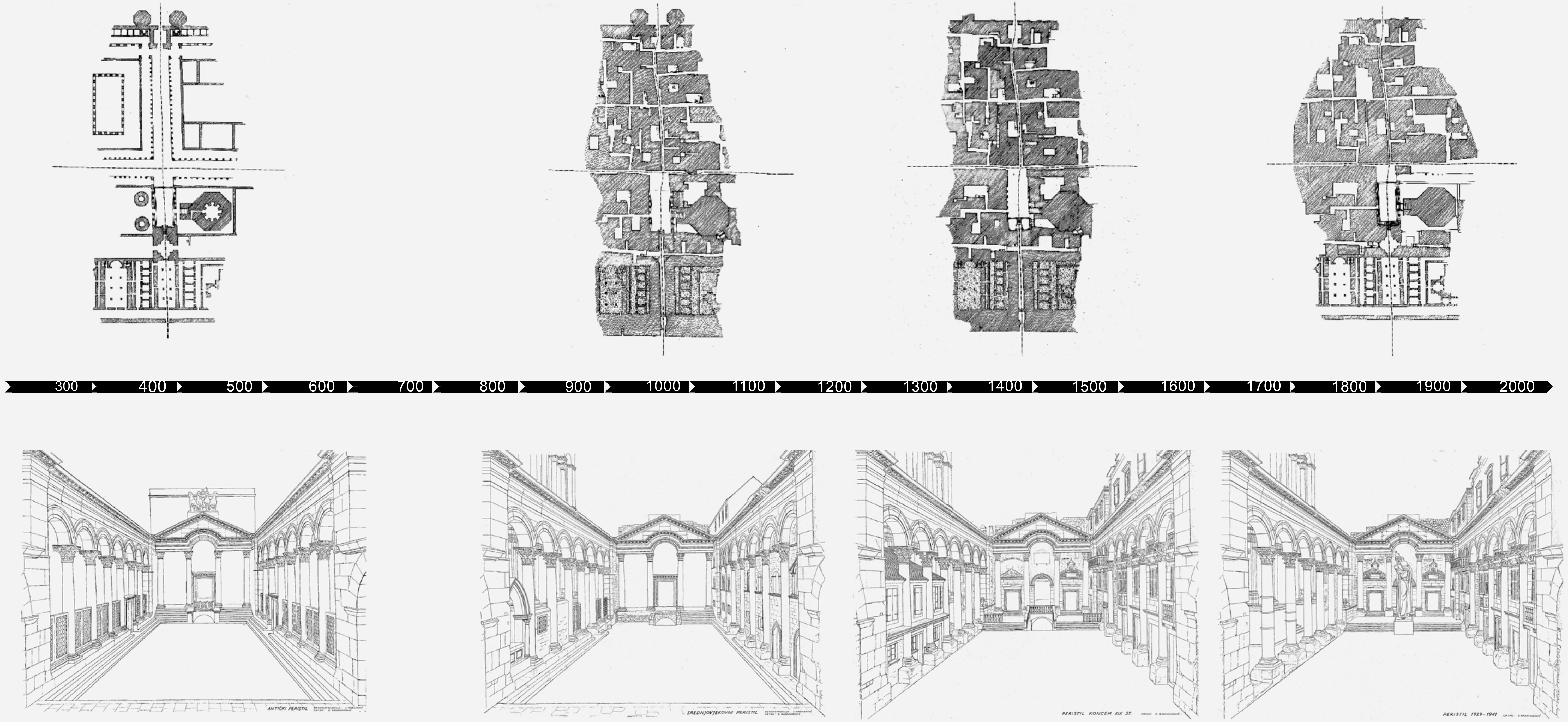


ill. 24. The Palace as the Romans built it and the city today

ill. 25. On the previous page: view of one of the streets today with the medieval additions on the Roman Colonnade of the new residents: the large rooms of the palace were taken by the leaders, the smaller ones in the garrison by the poor, and finally the vaults of the basement by the slaves. The Peristyle was transformed into a typical medieval town square with the municipal centre, in addition the Mausoleum of Diocletian became a Christian cathedral, while the Temple of Jupiter was turned into a baptistery. The city became more and more crowded therefore it was necessary to enlarge the existing buildings, fill the colonnades with houses and reduce the streets. Using the Roman palace as a frame the city grew like a living organism throughout the centuries. The alteration of the buildings were naturally developed according to the actual style, thus today the palace looks like a harmonious patchwork of Roman, Gothic, Renaissance and Baroque additions. Owing to the massive construction and the fact that the buildings were kept in use, several parts of the original structure have survived. The complex now is one the most valuable example of Roman architecture on the eastern coast of the Adriatic, and has been declared a UNESCO World Heritage Monument.

Relevance for the actual project

The change in function can help the building to survive and to keep it occupied.
Alteration should develop a combination of the existing building and the addition in a way that the perception of the original is enhanced by the supplementation of the new. However, the new additions naturally do not try to imitate the original work; they follow the actual style in order to have proper functionality. The key for harmonious additions is analyzing the system of the existing, finding the leading idea why it was created as it was, and continue this idea fulfilling the actual demands [Piero, G., 1964].



ill. 26. Transformations of the Peristyle over time

4.2. Sustainable strategies

As it is stated in the vision, sustainability has special emphasis during the project. Naturally, there are certain areas in focus, however the project embraces all the three aspects of sustainability: social, environmental and economical. Their balance and implementation during the design are the responsibility of the integrated approach which has been discussed in the Methodology section.

Social sustainability ensures strong bond of the community, which require vibrant urban and common spaces making it easier to discover the companionship of others. In addition, creating own identity for the complex and the residents who live there also enhance this process. The preservation of the existing heritage is an exceptional tool for remembrance and strengthening the identity of the place. [Scott, F., 2008:193] Thus, parts of the original industrial atmosphere must be kept and integrated into the new residential function.
Moreover, people can benefit from each other in case of mixed user groups where they are able to meet different types of residents in terms of age, culture or even income levels. Therefore the intention of the project is to invite people with various background.
Finally, it has a great importance making the users active part of the design, for example promoting physical activity and interaction.

The analysis of environmental aspects helps creating a building which respects its surroundings and nature. According to calculations is Norway, only the change of construction methods from regular systems to mass timber could make a larger reduction in carbon emission than removing all the cars from the roads. [Liddell, H., 2013:94] Therefore, the choice of materials have a crucial role in the effect on the environment and the decision must be made considering embodied energy and recyclability in addition to the architectural and engineering parameters. Furthermore, the energy source is also determinant for the carbon footprint of a structure. Since the existing building is already connected to the local district heating system, it is a reasonable choice to keep this infrastructure, and possibly balance it with on-site renewable sources.
Finally, the protection of future users can also be part of environmental considerations. The use of healthy materials and creation of adequate indoor climate where the user has the ability to control the systems, are preconditions for avoiding the Sick Building Syndrome.

Since the different aspects of sustainability are interrelated with each other, most of the social and environmental investments are also economical on the long run. For instance, building a dense residential area close to the city centre is an environmentally well-founded decision, because it reduces the transportation requirements. On the other hand it can also be economical from the investors´ view, since these apartments are easier to rent out for higher price.
Another example which one can mention is flexibility. Learning from the past, the demands and functions usually change after a period of time. If a building is not able to follow such changes then it is going to be demolished, regardless its other qualities. Therefore, the design and construction of houses must make the buildings capable of adopting to the new condition and provide opportunities for uncomplicated alteration.

In this project flexibility is involved in two different scales: firstly, the layout of the entire building creates a frame within changes are possible. Secondly, the apartments are designed in a way that certain shifts are provided depending on the season, time of day or functional need.

In order to achieve a sustainable complex, the delicate balance of the above mentioned factors are necessary. Defining the requirements in the early phase of the project ensures their consequent implementation during the entire process.

The targeted values for different design parameters are listed on ill. 27.

Parameter	Target
Energy frame	BR 2020 (maximum 20 kWh/m^{2}a)
Indoor air quality	Minimum Class II (according to CR 1752 standard)
Thermal comfort	Minimum Class II Temp. summer: 24.5 ± 1.5°C - max 100 hours above 26°C - max 25 hours above 27°C Temp. Winter: 22.5 ± 2.5°C - not under 21°C
Atmospheric comfort	CO_2 - level: preferable 500 ppm above outdoor level (not above 1000 ppm)
Daylight	Average DF min. 3 % for living spaces, Preferred DF min. 5 %
Ventilation	Hybrid, maximise natural ventilation Air flow rate for dwelling: more than 0.3 l/s/m2 heated floor area, for other: 0.35 l/s/m2 + 3 l/s/m2 per child + 5 l/s/m2 per adult
Noise	Noise from outdoor lower than 58 dB
Energy source	Minimise fossil fuels

ill. 27. Summary of the technical criteria for the project

4.3. The function and targeted user groups

As part of social sustainability the project intends to combine different user groups. Their interaction is beneficial for each of them, moreover their mix reduces segmentation, thus creates a more lively district of the city. According to the local plans and observing the buildings already built, the combination of different residents is also part of the concept of the Kommune,

The following user groups are included, based on the local features:

1. Students
Since the site is located between the university and the centre it is ideal for student accommodation. They usually need small and cheap apartments, and live there alone or with their friend(s), sometimes partner. The apartment must contain a place to study, a bedroom or alcove, a small kitchen and a bathroom. It has a great importance to provide them with common facilities like laundry and a room to meet each other.

2. Young couples
They are usually still students or fresh graduates, and live on small budget, therefore prefer small apartments. According to Christopher Alexander, an adequate house for a couple must include a space for being together, and a space for being alone. This latter one can be a separate corner, part of a room screened off by a half-wall or even a furniture, but it is necessary for each person to maintain his / her privacy, on the other hand find joy being together with each other during the rest of the time. [Alexander, C. et al, 1977: 386]
Another special feature of a home for a couple lies in the dynamism of their relationship. "The gradual evolution of the couple´s home can play a vital role in the growth of their own relationship: it provides a frame for learning about on another, brings up conflicts and gives joy. Therefore the possibility for Improving their home, making small changes, fixing it up is important in this kind of house. – to create their own world together." [Alexander, C. et al, 1977: 387]
Therefore, the apartment designed for them should not be fully finished, entirely furnished and strictly regulated prohibiting any changes.

3. Families with one or two children
If a family decides to live in the centre, instead of the suburbs it certainly has several advantages, like easy access to the educational institutions, sport and cultural facilities. However, their demand for spacious home and closeness to green areas must be fulfilled.
Their home should contain three well-defined space in order to develop proper functionality. Firstly, it must include the couple´s realm. This place meant to sustain them as adults, but not as mother and father. They can retreat here, relax and find a quiet minute for themselves. It should have a small sitting area, the bed(room), dressing area and optionally a bath, all of them close to the children´s part of the house, to be able to reach them fast in case. However, this realm should be at least psychologically separated, so the children feel as guests when they come here.
Secondly, the apartment must contain an independent area for the children which is a playspace designed specifically for them. It should

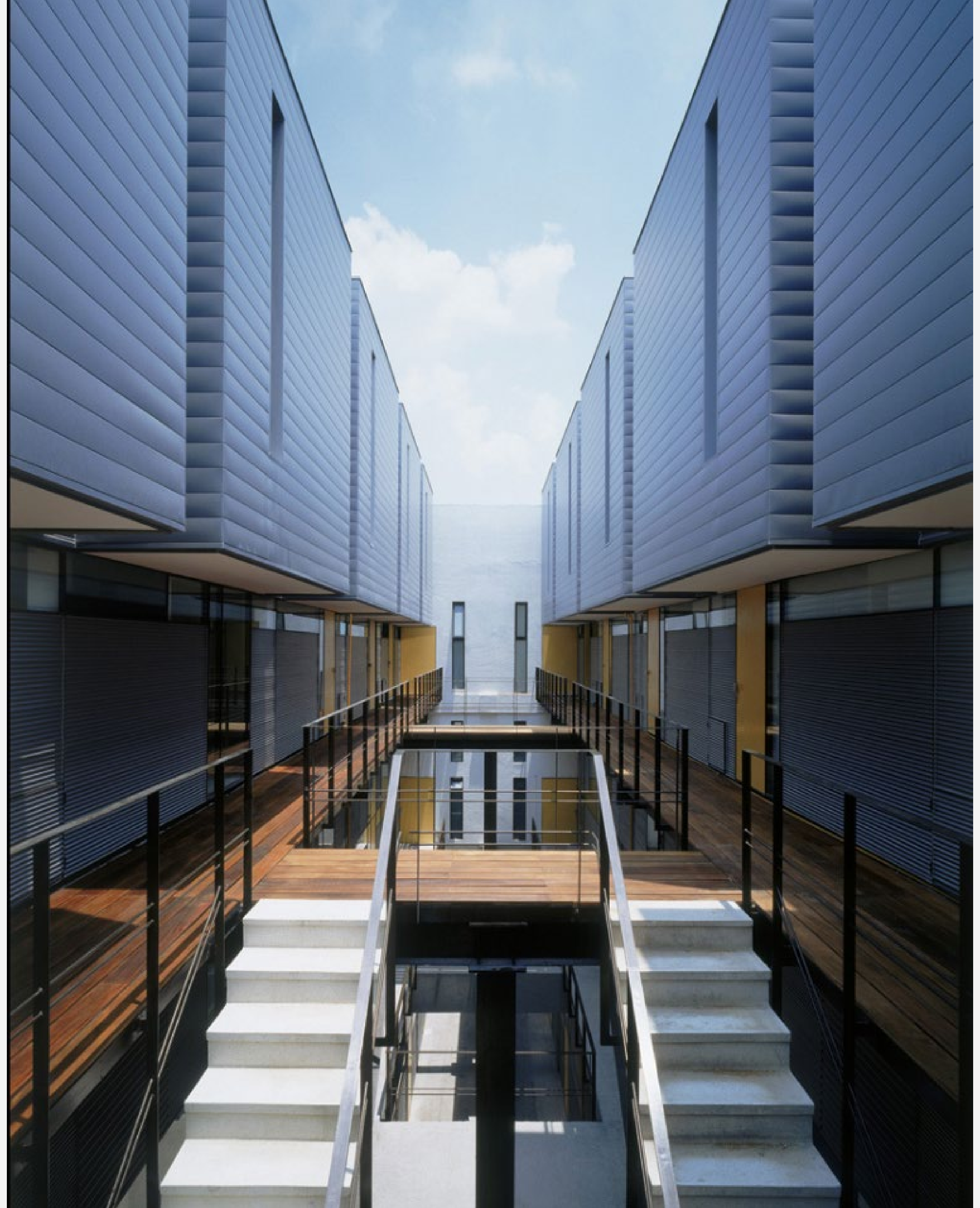
have different levels; form one continuous circulation path following their daily activities; and be tangential to the common space because children always require attention.
Thirdly, the family should have a common space, where they spend most of the day, being together. This part is the largest and should include the living room, kitchen, dining room, and preferably a terrace. [Alexander, C. et al, 1977: 382]

Beside the above mentioned functional and apparent physical demands, all the three groups have their special expectations towards their home. Everybody defines differently what makes a home, what the factors are which make one feel at home. According to the psychologist Linda Papadopoulos, the notion "home" means a place where one can feel safe and connected to other people he likes. [psychologies.co.uk, 02.25.2015] Therefore, the protection of privacy, the sense of "closed door" is one of the most important factors during the design of a home. In addition, the used materials also have an effect on the feeling, influencing the warmth of the place. The ceiling height can also be a tool for providing intimacy for spaces, or making them more common. [Alexander, C. et al, 1977: 868] Besides, the connection of spaces and their transparency can help to feel secure. [Alexander, C. et al, 1977] One can also mention the ability to control and change the house, which is important to feel at home. If one does not have the right to make alterations (also in case of rent), he is not going to feel the place belong to himself. Since one´s home is place for self-expression and exhibition of memories, the ability of changing the place is crucial.

Outdoor areas
Beside the interior, a home should connect to several outdoor space. Preferably, it contains a direct connection to a private balcony or terrace which function as an extension of the inside spaces.

In addition, the block of apartments should include a larger common outside area where the residents can meet each other, and maybe with guests from other areas. For the design of this place it must be considered that people have a tendency to move towards and stay in areas where there is already life and activity. This interest is based on the discomfort of empty spaces, and the phenomenon that visited areas feel safer. Therefore, the common space should have location close such areas or attract people with view to them. It need to accommodate the different ways people inhabit a space: walking, standing, sitting, seeing, hearing and talking. Adequate arrangement and orientation of planting, sitting places and other facilities enhance the use of common outdoor areas. [Gehl, J. 2011]

The following case study highlights some of the mentioned parameters and serve as an excellent example for their utilisation.



4.3.1. Case study - 13 de Septiembre Complex

Designer: JSª Arquitectos
Location: Mexico City, Mexico
Date: 2004
Project type: Urban housing complex containing 37 apartments

Description

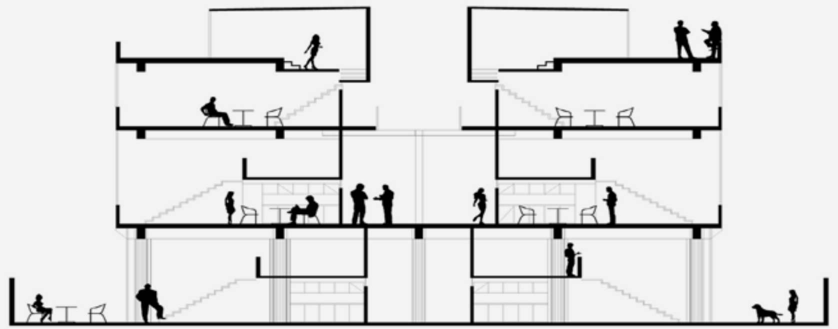
This project transformed an old trade-union warehouse into a block of apartments on the outskirts of Mexico City. The main intervention to the existing building was forming a ventral patio by cutting the floor slabs. This atrium integrated several functions: it gives easy access to the apartments by the means of staircases and bridges, and creates a common space for the residents. Moreover, this change made it possible to provide sufficient daylight and natural cross ventilation for each unit. Finally, keeping the original structure intact and visible adds a tectonic quality to the building.

ill. 28. On the previous page: view of the courtyard [JSª Arquitectos, 2014]

ill. 29. Image of the construction of central patio; and the finished block of complex [JSª Arquitectos, 2014]

In the basement and on parts of the ground floor parking areas were placed, while the apartments were built on the stories above. The building was extended by adding one more level for further living space. This addition was possible by taking advantage of the unutilized load bearing capacity of the existing reinforced concrete structure. The extension is made of stainless steel minimizing the extra load acting on the original building.

All of the apartments are two-storey high which design allows reducing the number of access corridors from three to one saving space. The size of the apartments vary between 59 and 114 m^2 and each of them includes at least one double-height room. This way the interiour is well-lit and has better spatial quality owing to the views from one level to another.



ill. 30. Cross-section of the building [JSª Arquitectos, 2014]

Relevance for the actual project

Buildings with wide span can be effectively divided by a central courtyard, thus providing access and increasing the quality of indoor climate in the apartments. The dimensions of the patio must be designed carefully according to the orientation, structural conditions, size of apartments, etc. Since the analysed project is located in Mexico, the atrium is narrow and deep protecting the residents from the strong sunshine.

The use of materials is also exemplary, and illustrates that the extensions should always be made of light-weight materials like steel or timber and consider the existing structural system.

Finally, the double-height apartments serve as a source of inspiration, too. They can achieve significant reduction of access areas and provide additional spatial quality to the units.

ill. 31. Interior view of an apartment [JSª Arquitectos, 2014]

ill. 32. Facade of a double-height apartment inside the patio [JSª Arquitectos, 2014]

4.4. Expectations of the investor

They layout of the new building have to meet the requirements of the client company who must look on the project as an investment. They want to create high quality living space which fulfills and exceeds the expactations of the Kommune stated in the localplan and negotiated during a continuous discussion between the parties. In addition, they need to follow the possible demands of their future tenants, as well.

On the other hand, they need to make the project profitable and construct a certain amounf of rentable space for a reasonable price. The targeted amount is 6000 m^2 at least, consisting of apartments mainly, because they have greater chance to be rented out. However, commercial and office functions might be popular in the future, therefore the possibility to change the building should be provided.

The apartments should vary in size and price making them easier to rent out. There must be apartments for students in small size, and for different type of families provifing larger space.

4.5. Summary of the concept - design parameters

The discussions in this chapter encompassed the theoritical background of extensions, in addition the specification of the main focus areas regarding sustainability, the examination of the functional needs and the demands of the investor company, This knowledge supplements the information gathered in the Analysis earlier in order to establish a framework for the following design process. These parameters clarify the track which should be followed to develop a final product applying the values stated in the vision. They are utilised in all scale of the planned building, from the masterplan to the apartments and even the tiniest details like furnitures and structural elements.

The following table summarizes the room programme based on the functional demands and indoor comfort requirements.

		Spatiality		Placement		Light		Room temperature
		Min. size	Room height	Zone	Connection	Min. light level	Time of light	Compared to general operative temperature
		[m^2]	[m]	[-]	[-]	[lux]	[-]	[-]
Student / Young couple apartment	Entrance	3	2,3-2,7	Shared	Bathroom, Living area	200	Morning, evening	Cooler
	Kitchen area	4,5	2,3-3,2	Shared	Living area	500	Afternoon	Cooler
	Living area	12	2,5-3,2	Shared, and potential private parts	Kitchen, Entrance, Bedroom	500	Afternoon	General
	Bedroom	8	2,3-2,7	Private	Living area, Bathroom	200	Morning	Summer: cooler, winter: warmer
	Bathroom	4	2,3-2,7	Shared	Bedroom, Living area	200	Morning	Warmer
Family apartment	Entrance	5	2,3-3	Shared	Bathroom, Living area	200	Morning, Evening	Cooler
	Kitchen area	10	2,5-3,5	Shared	Living area	500	Afternoon	Cooler
	Dining area	10	2,5-3,5	Shared	Kitchen, Living area	500	Noon, Afternoon	General
	Living area	25	2,5-4,5	Shared	Dining, Entrance	500	Afternoon	General
	Master bedroom	12	2,3-2,7	Parents	Living area, Bathroom	200	Morning	Summer: cooler, Winter: warmer
	Children bedroom	10	2,3-2,7	Children	Living area, Bathroom	200	Morning, day	General
	Bathroom	8	2,3-2,7	Children, Parents	Bedrooms, Living area	200	Morning	Warmer

ill. 33. Room programme

5. Design development

5.1. The choice of materials and structures

Environmental factors

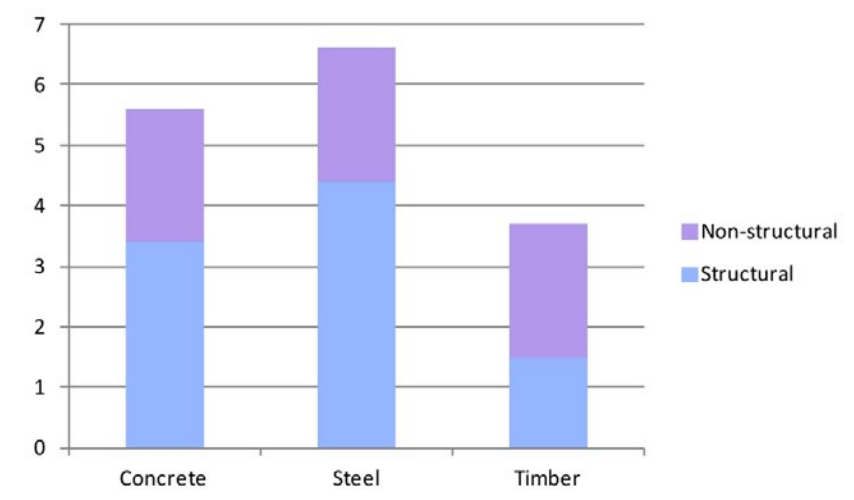
Avoiding "camouflage architecture" [Liddell, H, 2013:43] has a great importance by applying materials whose sustainability is proven by deep analysis, not only those which are trendy. For instance, timber cladding is often a symbol of sustainable buildings, however it can be misleading if the wood is gathered from unidentified source or treated with a nonporous petrochemical paint. Therefore, the choice of materials has to be the result of thorough investigation of the environmental, architectural and engineering aspects. Moreover, the different building materials are not comparable simply on their own, since they are always part of a certain construction system. A comparison based on typical wall structures in 1 m^2 size is visible on ill. 36, developed with the use of BEAT 2002 software. According to this chart, timber structure has far the lowest negative effect on the environment, followed by concrete, brick and steel in order.

In addition, considering embodied energy, timber structures have the lowest values again (ill. 35). The order of the other materials investigated highly dependent on the manufacturer. For example, brick can be produced from mine tailings and sawdust can be used during the burnout process. [Boral Inc, 2009]

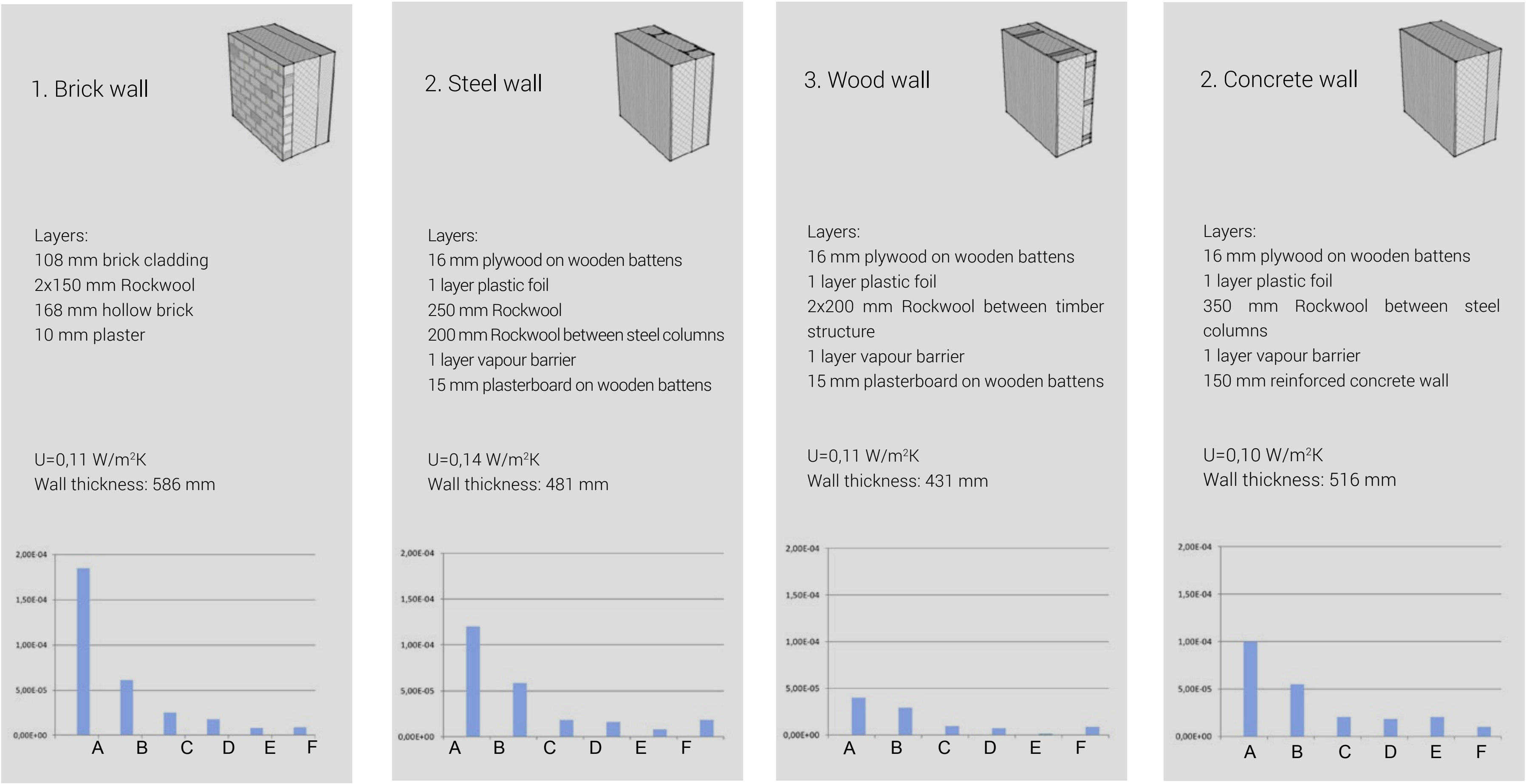
Moreover, timber´s is a highly recyclable material. Nowadays, almost all types of materials can be recycled, but the main issue is the cost and energy spent during the procedure. [Liddell, H, 2013:89] Wooden elements are easy to assemble and dismount, thus they are ideal in terms of recyclability.

In summary, it can be stated that timber structures cause the lowest possible negative effect on the environment, thus they are particularly suitable for sustainable buildings.

ill. 34. Previous page: Visualisation test for the small atrium with visible existing concrete structure



ill. 35. Embodied energy in different types of buildings



ill. 36. Environmental effect (PE) of typical wall structures made of different materials according to the BEAT 2002 software Calculated values: A: global warming; B: acidification; C: nutrient enrichment; D: human toxicity; E: persistent toxicity; F: photochemical ozone formation

Thermal properties

Timber has relatively low value for thermal conductivity, which makes it a good insulator. However, its density is low, therefore wood is not efficient in storing heat. In order to create a building which is able to protect from the extremities of the outside temperature materials with high thermal capacity are needed. Moreover, these types of materials are also required for providing the conditions for effective natural ventilation. Therefore, we need to combine the previously chosen timber structure should be combined with brick or concrete.

Social factors

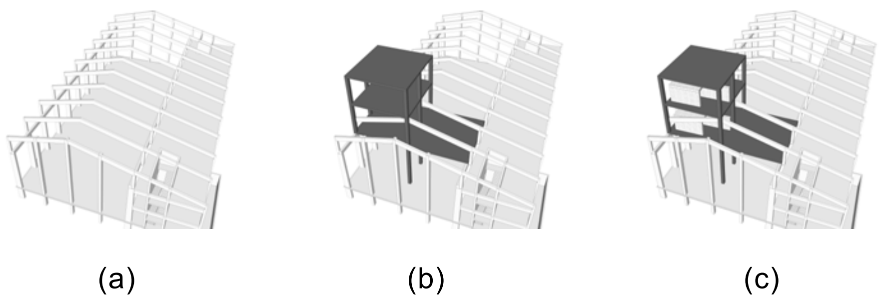
The existing building is made of concrete, and its partial preservation is crucial, based on the necessity of local identity and heritage protection discussed in the analysis (chapter 2.2 and 2.3.). Thus, the structure must be the combination of timber and concrete elements.

Wood is always related to soft and warm atmosphere which can stand in contrast to the harsh industrial look of concrete. This opposition can be utilised during the design for marking different spaces and creating a vibrant place to live.

Flexibility

Another part of the vision is flexibility which parameter has to be considered during the choice of structural system.

The combination of concrete and timber structure should be developed in a way which allows easy changes of the functions in the future. Owing to the large span of the existing building, the additional structure inside can be designed relatively freely. Two different options were compared: one with horizontally and one with vertically arranged reinforced concrete primary load bearing system. In order to maximise flexibility, the continuous vertical divisions presented on the second option should be avoided. The first option easily solves this problem, on the other hand still makes it possible to create double-height apartments, in case of applying the concrete slabs on every second floor only. The thermal mass of the slabs can be utilised if the concrete is exposed and the adjacent windows are dimensioned according to the wish of providing sunlight for the floors (ill. 37).



ill. 37. Diagram of the structural system: The existing concrete structure (a) is utilized and extended with new concrete elements (b) to form the primary load bearing system. The secondary elements - including additional floors and walls - are made of cross-laminated timber (c)

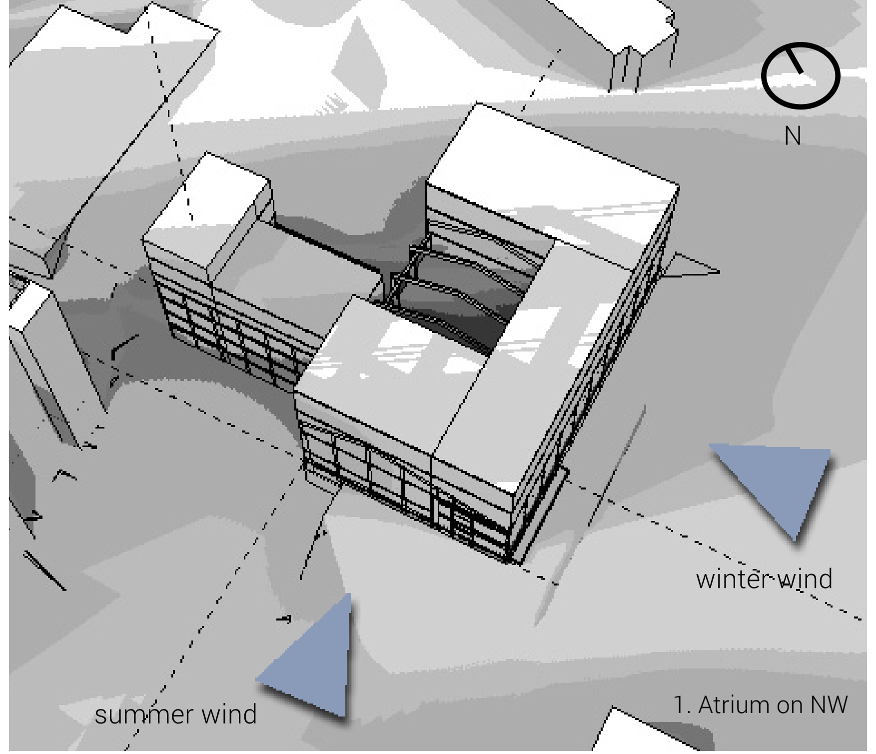
5.2. Volume studies

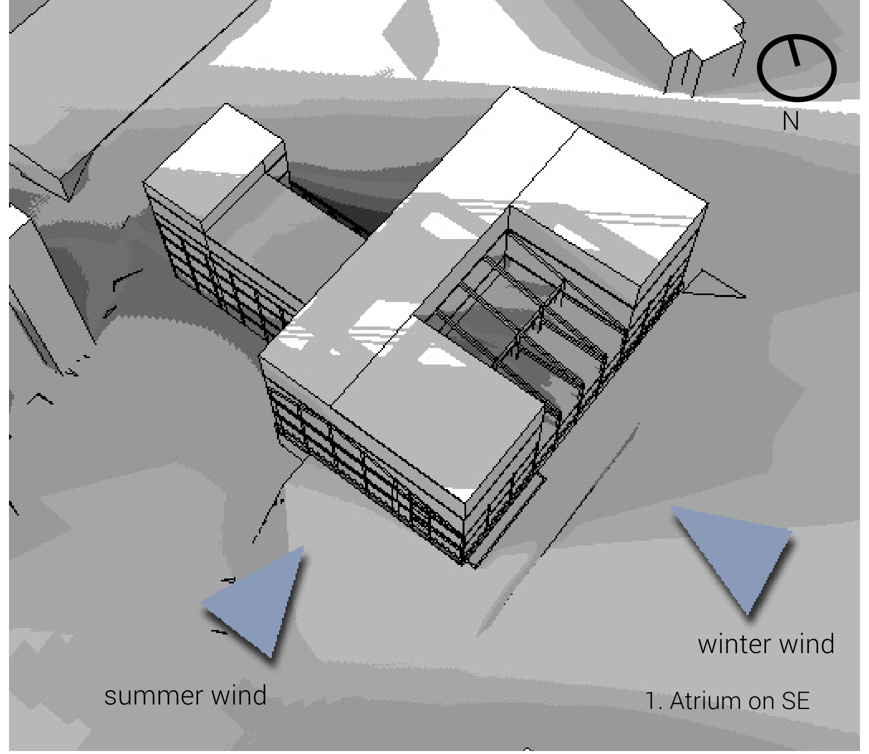
The sizes of the existing building exceed the optimal length and width for the residential function (the demands for natural light and ventilation), therefore the volume must be divided into smaller parts.
A central atrium can be used for providing access and light for the apartments, moreover it enhances the natural ventilation owing to the phenomenon of thermal buoyancy.

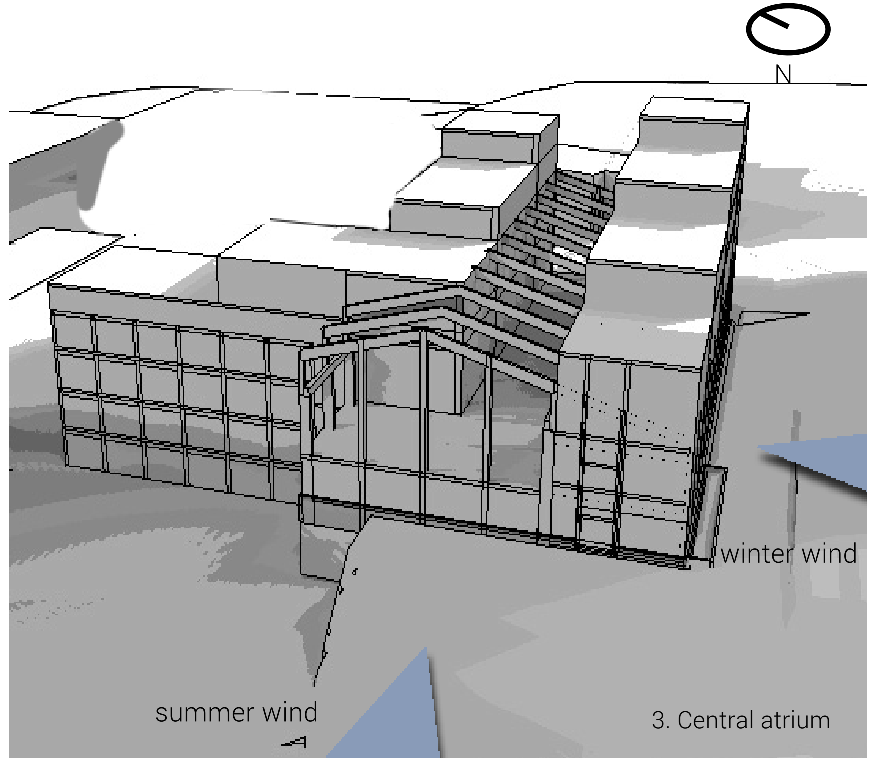
This atrium can be placed to the northwest or southeast side of the main hall or in the centre. The advantages and disadvantages of the three placements of the atrium are summarised by the following table, and their shadow analysis is shown on ill. 35.

	1. Atrium on the NW	**2. Atrium on the SE**	**3. Central atrium (opening to SW)**
+	+ The atrium forms a sheltered semi-private courtyard + The most well-lit facades are occupied by apartments + The original staircases can be utilised + The atrium has harmonius proportions and created from the existing hall space	+ The atrium is well-lit, providing more light for the adjacent spaces + The atrium forms a sheltered semi-private courtyard	+ The SW opening provide good light conditions inside the atrium + The enlarged opening space (SW) is suitable for a common terrace + Most of the living rooms facing SW...SE. + The existing access structures can be utilized
-	- The atrium is relatively dark, therefore the rooms facing to the atrium have few light, too - Complicated to connect the existing wings of the building - Wind conditions are not optimal	- The original structure of the building is not followed: demolishing several existing and building new parts - Dark apartments on the N-NW corner - The original staircases can hardly be utilised	- Relatively large amount of space is taken by the atrium - Narrow shape - The existing beams create high amount of thermal bridges

ill. 38. Advantages and disadvantages of the three possible placement of the atrium



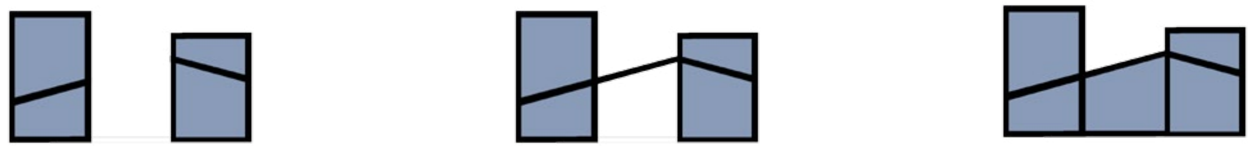




ill. 39. Shadow analysis of the options

Further tests on the central atrium

Based on the results of the previous investigation, the centrally placed atrium was chosen for further testing. The atrium offers three different possibilities for utiliziation: firstly, it can be kept open and part of the natural environment. This way the apartments have closer connection to the outside area which grants good daylight conditions and more effective natural ventilation. Secondly, the atrium can be covered but unheated in order to create a sheltered access area and common space to meet other people all year round. Finally, it can be covered and heated, which grants the most comfortable space. The three options were examined and compared in relation to architectural values, energy consumption using BE 10, indoor climate, functionality and structural behaviour.



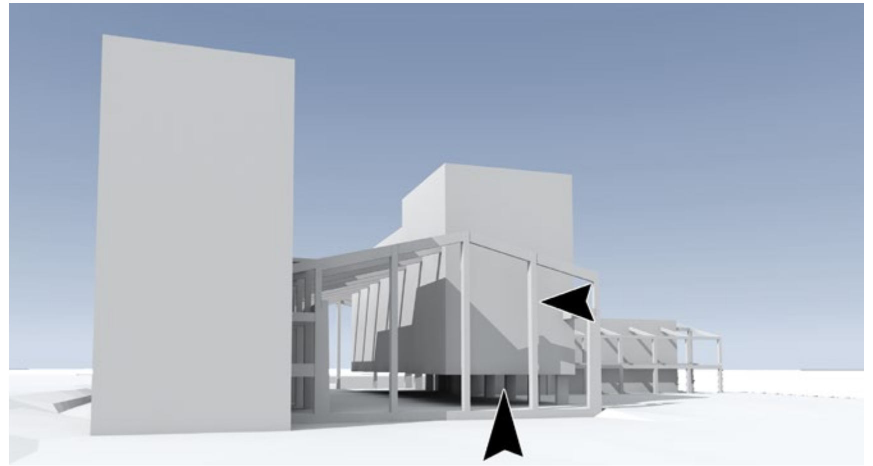
	Open atrium	Closed but unheated atrium	Closed and heated atrium
Energy requirement (BR 2020)	23,7 kWh/m²a	23,0 kWh/m²a	33,6 kWh/m²a But reduction of thermal bridges
Indoor climate	Possibility for natural ventilation and good daylight.	Natural ventilation is complicated. Glass roof is required for providing light inside the apartments below.	Natural ventilation is blocked, and high risk of overheating, because glass roof is required for granting light inside the apartments
Structure	If the existing structure is kept, it causes serious thermal bridges.	Utilizing the existing structure.	Utilising the existing structure.
Function	The atrium is used as outdoor area	The atrium is used as transition between inside and outside	The atrium is used as indoor area.
Architectural values	The outside space flows through between the buildings.	Sheltered access and common area which can be used in every season.	The existing building is integrated to the new.

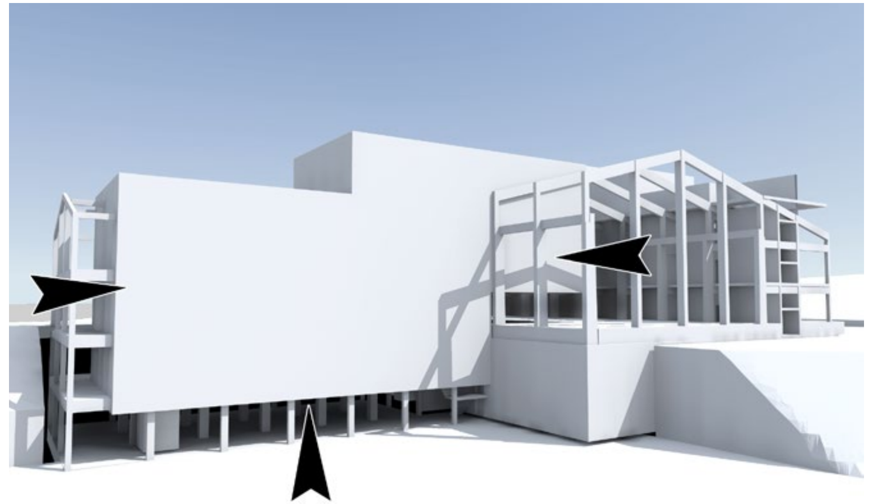
ill. 40. Comparison of the different utilization options of the atrium

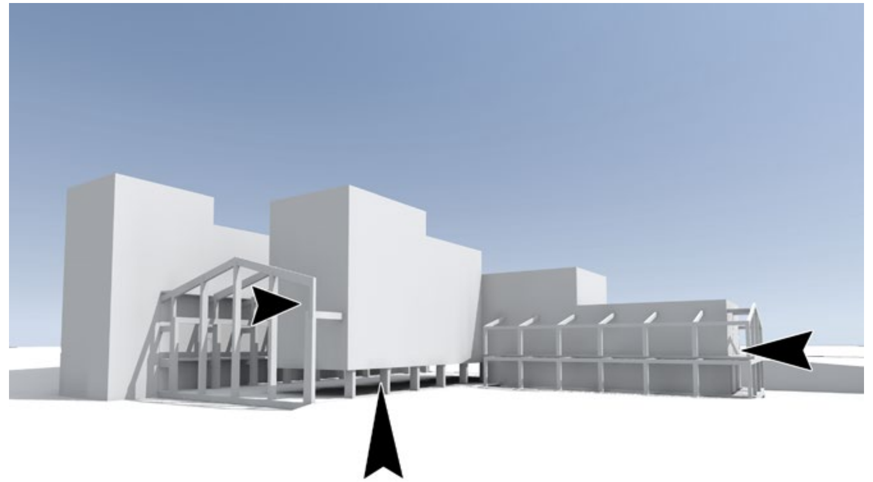
Relationship between new and old

The evaluation of the tests lead to chose the closed but unheated atrium as primary focus for the later design steps.

In parallel to this examination, the relationship between the original building and the extensions had to be clarified. The concept defined this connection as a natural cooperation, but created in a way which makes it easy to distinguish between the original and additions. When one observes the final product, he should be able to read it clearly and recognize the development of the building through its history. One tool for this clarification was the introduction of slight shifts in the volume, in order to reveal the shape of the old building.







ill. 41. The shifts of the volume which reveal the original building

5.3. Distribution of functions

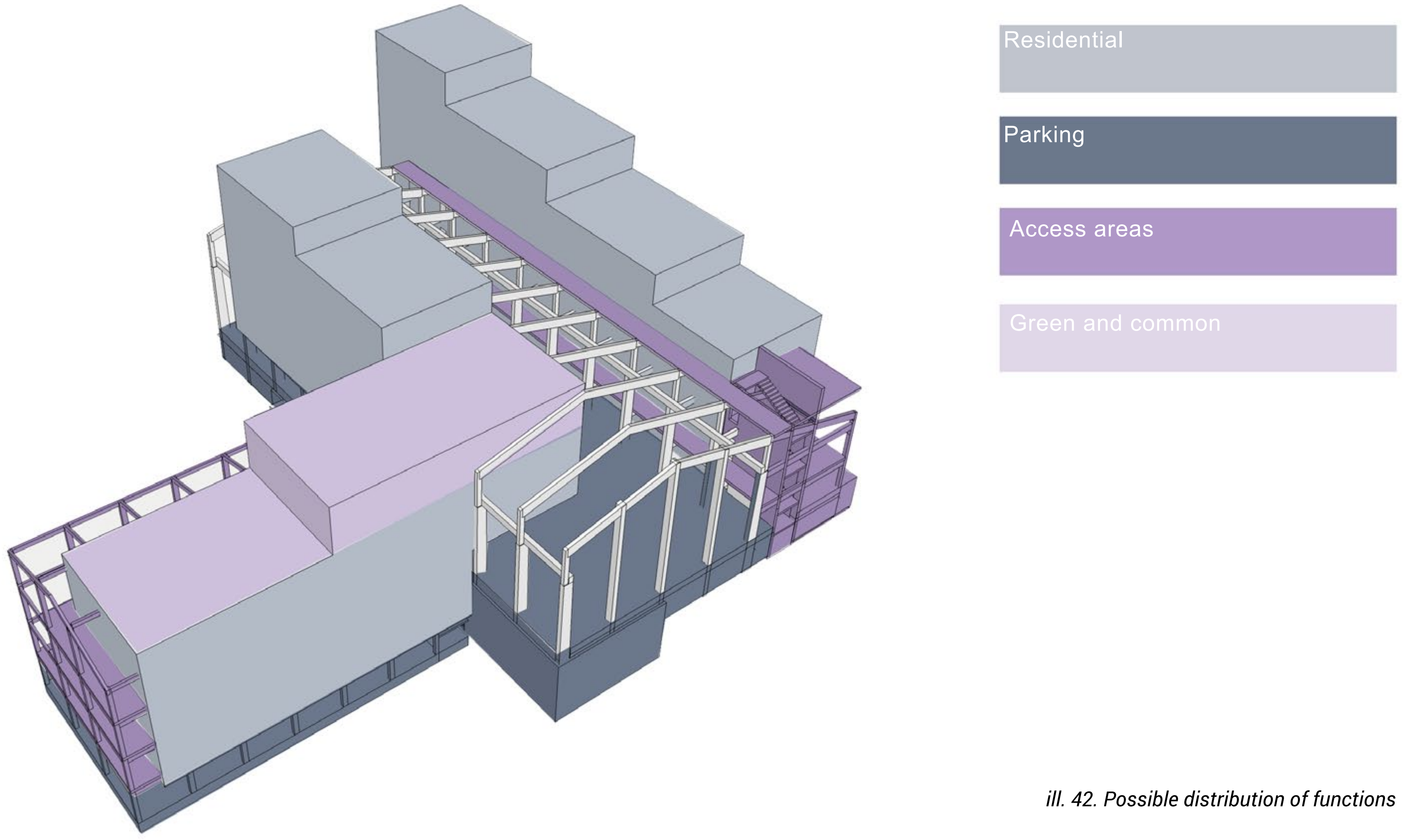
In addition to the development of the volume, the functional arrangement had to be considered.

Parking
It was clear based on the analysis that the high parking requirements result in the necessity of indoor parking supplementing to the outdoor parking lots. These indoor parking areas can be established on the ground floor of the storage wing which is located partly underground making any other utilization diifcult. Moreover, this area has excellent access to the main street of the future district filled with shops and cafes. Another option for the parking is the ground level in the main hall, where the placement of apartments might result in lack of privacy. This area also has good connections to existing parking lots, and grants the opportunity to add 40 extra spaces. The final distribution depends on the number of apartments and other usage options of these areas.

Apartments
Since the storage wing is built up with smaller raster of columns it can be used for student apartments easier, while the family apartments can be placed in the main hall and office wing.

Common areas
The common room should have a location close to the student apartments, for example on the top of them with the utilization of the large roof terrace facing towards the the amazing view of the city. On the other hand, outside or covered shared areas should be provided for the families as well to grant them meeting places. These can be created inside the atrium and in the courtyard on the north.

The following diagram illustrates a potential distribution according to the mentioned factors.



ill. 42. Possible distribution of functions

5.4. The quality of the atrium

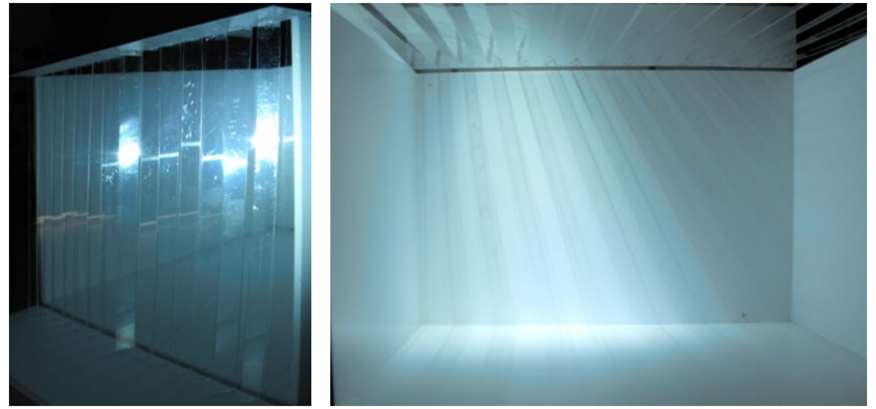
The investigation during the previous design phases showed that the most efficient way for utilizing the atrium is making it closed but unheated. Thus, this place provides excellent opportunity for a sheltered, safe area where the residents can meet each other and enjoy the view towards the city. This space mediates between inside and outside, welcomes people arriving home or prepares them to go somewhere.

The spatial experience of the original production hall can be partly preserved and developed with new viewpoints. In addition, the future users can be granted with closer contact with the original structure, with the possibility of seeing and touching parts which were impossible to reach before. Therefore, distant elements becomes involved enriching the atmosphere of the room, in addition they grant exposed thermal mass as well.

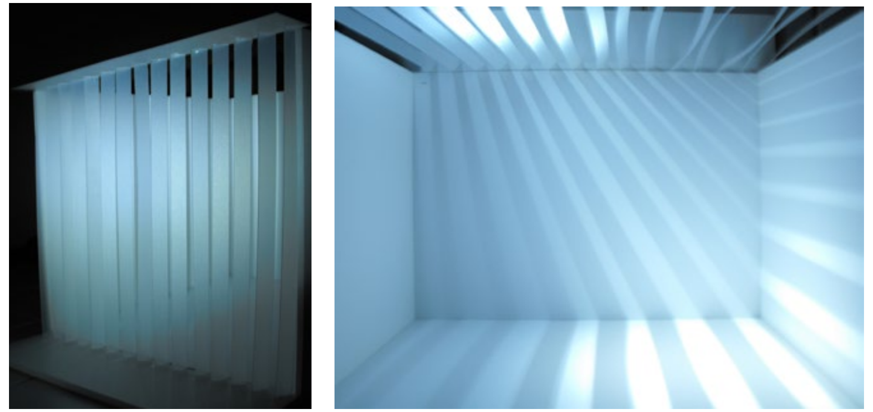
Another feature which increases the quality of the atrium is applying vegetation. It has several advantages, firstly, vegetation and open water surfaces decrease the temperature of the room by 2-3 ^{o}C on average [Larsen, O. K., 2014]. Secondly, they provide better air quality in relation to CO_2-concentration and smell. Thirdly, they enhance the use of the space, because people tend to spend time in places which look more natural.

In addition to space and vegetation, light was a crucial feature during the design process. The existing windows create an amazing phenomenon filtering the incoming light, especially during the late afternoon hours. Moreover, they make intimate indoor space seeming opaque from outside but transparent from inside. This behaviour is based on their material, which is a semi-transparent panel forming a series of waves. These windows can be used as a source of inspiration for the new building, granting the same experience for the new users. Several experiments were made during the design in order to achieve the mentioned phenomenons. Firstly, the atrium was covered with glass as a protection of the interior. Secondly, lamellas were added on the outside for filtering the light. Numerous arrangements and materials were examined, mostly on physical models (ill. 43.) in order to find the one which meets the requirements. After the tests, an acid-etched glass was chosen made from a solar-control glass with g-value as low as 0,17 (Pilkington SunCool™). Building lamellas from this material grants low glare, good shading properties, and still relatively high level of transparency (LT=0,27). Applying them all over the atrium creates an outstanding diffuse light inside, and protecting the privacy of the residents.

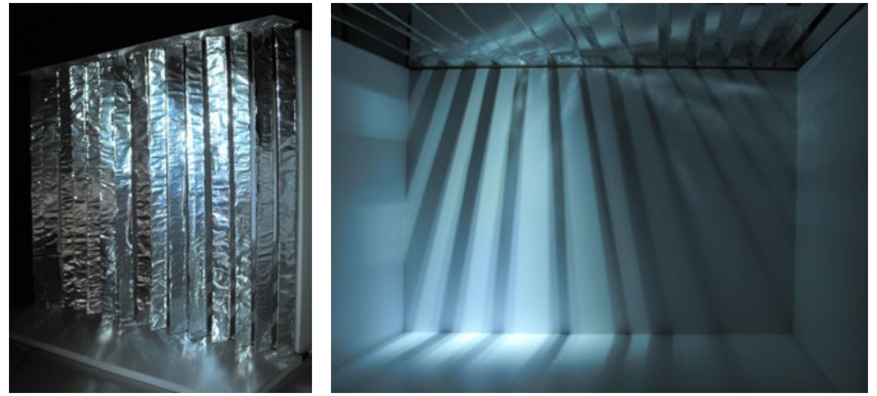
As final part of the design of the atrium, large openings were added on the bottom of the walls and on the roof. These windows are operated automatically with the possibility of manual interruption in order to provide the required air for natural ventilation, both in the atrium and the apartments. They can also be used in case of fire by the firefighters to regulate the oxygen concentration inside the building.



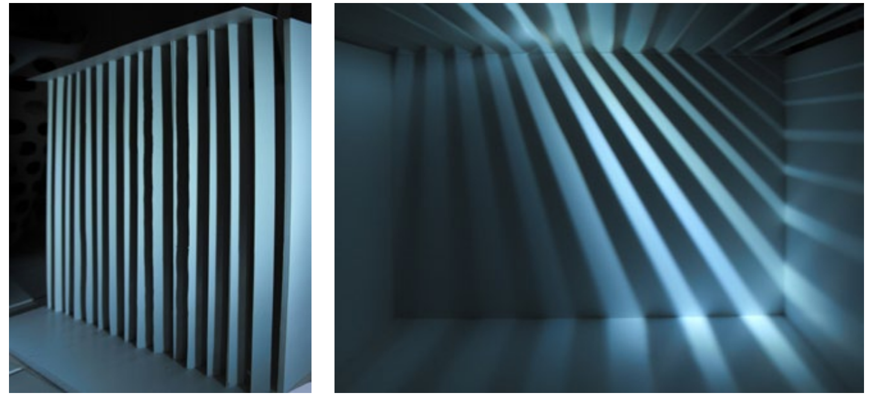
Totally transparent (clear glass)



Partly transparent (sandblasted / acid-etched glass)



Totally reflective (mirror)



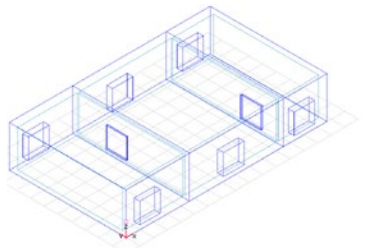
Totally opaque (fiber cement board)

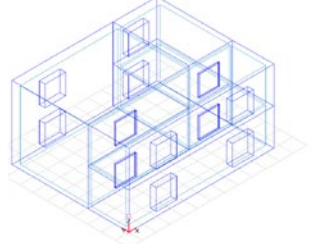
ill. 43. Experiments with lamellas made of different materials

5.5. Apartment layouts

5.5.1. Family apartments

These apartments are located in the former production hall and office wing, where the distance between the columns is relatively large (4,6 m). Based on the modular system which was defined by the existing main structure and on the fact that the apartments should be 90-140 m^2 large, they could be made of using either 3 modules on the same level or 2x2 modules creating two storey-high units. The second version has a two level high room, therefore both options have almost the same floor area. Each of them has various advantages and disadvantages which had to be clarified to be able to make decisions for the further design. The possibilities were examined integrating architectural and engineering factors as well, like indoor climate (with BSim) and energy consumption (with BE10). The summary of the results are shown on ill. 44.





1x3 modules		**2x2 modules**
Longer external access corridor but no need for internal staircase	Access	66 % shorter external corridor but need for internal staircase
The entire family is on one storey	Functionality	The children or parents live upstairs
Lower energy consumption	Energy demand	28 % higher energy consumption due to larger surface area
Less efficient ventilation, more hours above 26 °C (12 % difference) or higher air-change rate is required	Indoor climate	More efficient natural ventilation Better light conditions
Less spatial experience	Architectural quality	Better spatial experience

ill. 44. Comparison of arrangement options for the family apartment

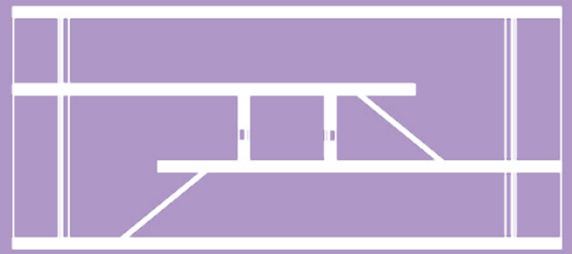
Evolution of the plans

Both apartment layouts were developed further, and included in different parts of the building. For instance, the one level high arrangement was utilized in the former office wing, where the construction of two-level-high spaces would be complicated due to the existing floor slabs, while the other version could easily be built in the extensions. In summary, based on the results of the previously mentioned examination, the two level high apartment was in the main focus during the further design steps. Its detailed development process is described in the next section.

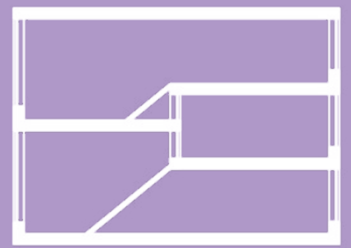
5.5.2. The two level high family apartments

Phase 1: Dividing the space

One of the advantages of multi-storey apartments is the reduction of the relative length of access corridors. Various systems are possible, each of them offers different exterior and interior arrangements.



(a)

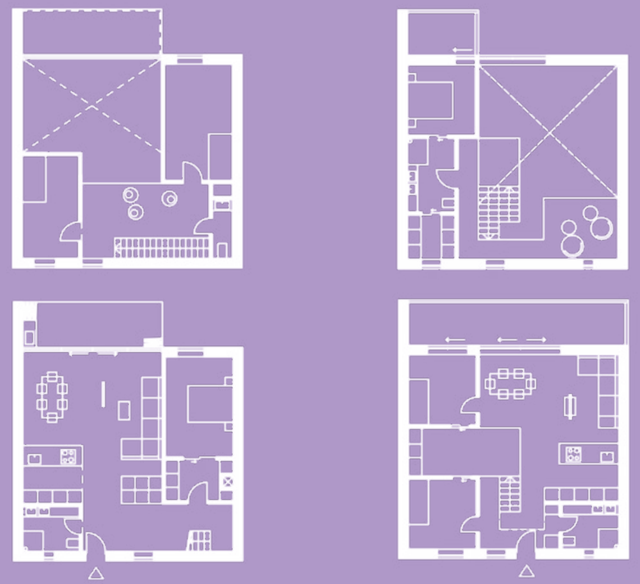


(b)

ill. 45. Position of access systems and arrangement of apartments (section view)
a) Central corridor, conceptual drawing based on the Unite d´Habitation by Le Corbusier
b) Corridor on the side, conceptual drawing based on the Narkomfin Building by Moisei Ginzburg

Phase 2: Variations for the floor plan

Firstly, decision had to be made on the location and connection of the three main zones: the children´s realm, the parents´ area and the shared parts of the apartment. The main issue was the placement of the children´s territory: if it is on the first level, then it has close relation to the shared space. On the other hand, if it is located upstairs, it can be more independent.

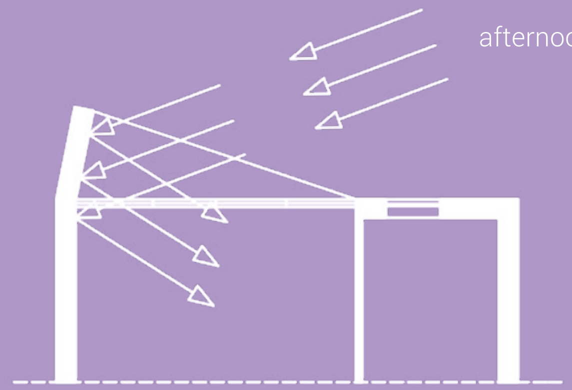


(a) (b)

ill. 46. The versions for the floor plans (upstairs are on top, downstairs are on the bottom)
a) The children are upstairs, b) They are downstairs

Phase 3: Balconies

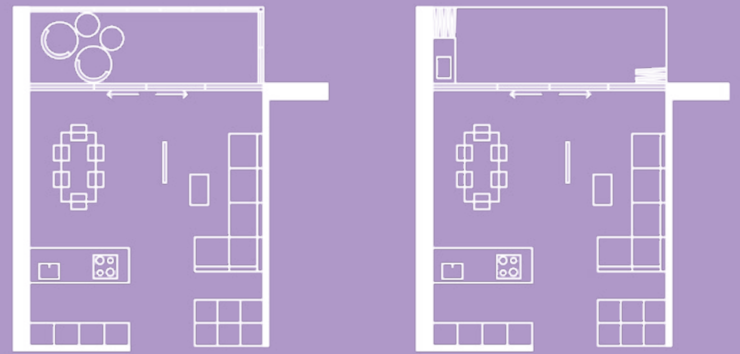
The balconies had two functions: inviting the outdoor area for the use of the apartments, in addition acting as a reflector of sunlight improving the daylight conditions inside. Therefore, special attention had to be paid for finding the optimal shape and materials for the balconies. The form had to minimize the shading during the afternoon hours and reflect the sun towards the living areas. The results of the simulation made by the Velux Daylight Visualizer software showed 15-20% higher values with the application of a reflector surface (page 97)



ill. 47. Principle of the behaviour of the balconies

Phase 4: Flexible use options

Since the apartments will be rented, the users will not be able to make comprehensive changes. Therefore, it is important to provide a flexible layout which makes small modifications possible with the way of furnishing for instance. The bedrooms can easily be turned into a guestroom, and there is a multi-functioning space upstairs which can be used as living area, study or guestroom. Another consideration was placing sliding glass sheets to the outside of the balconies to form a winter garden during the colder seasons and extend the time of use of this space.



(a) (b)

ill. 48. Transforming a balcony into a wintergarden
a) Plan for winter, b) Plan for summer

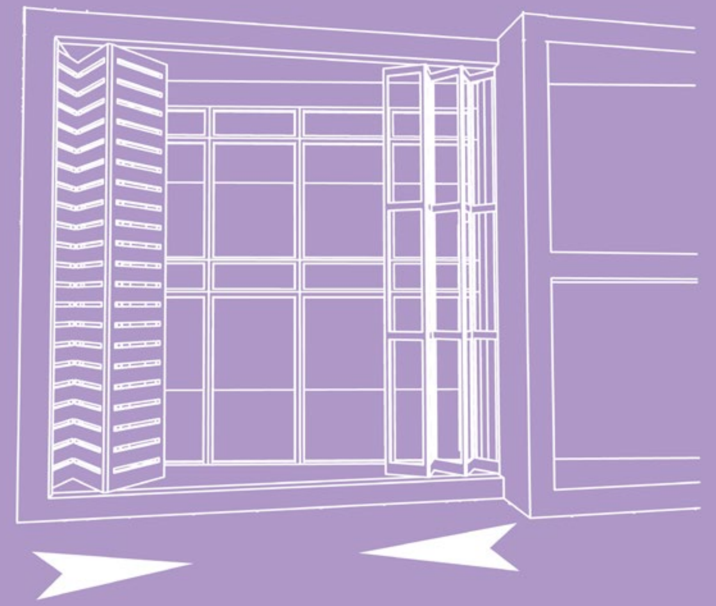
Phase 5: Optimization

Energy consumption and indoor climate were important factors through the entire process, thus simulations were made for embedding these aspects. Some of the modifications and their effects are listed below.

Modification	Effect	Change
Changes on the floor plan in order to make cross ventilation possible	Increase of average DF	+0.5
	Reduction of hours above 26 °C	- 15 %
	Reduction of overall energy consumption	- 3 %
Introducing overhangs for the SW and NE windows	Reduction of hours above 26 °C	- 39 %
	Reduction of overall energy consumption	- 4 %
Placing window on the bedroom facing towards the living room	Reduction of hours above 26 °C	- 22 %
	Increase of DF	+0.3

Phase 6: Detailing

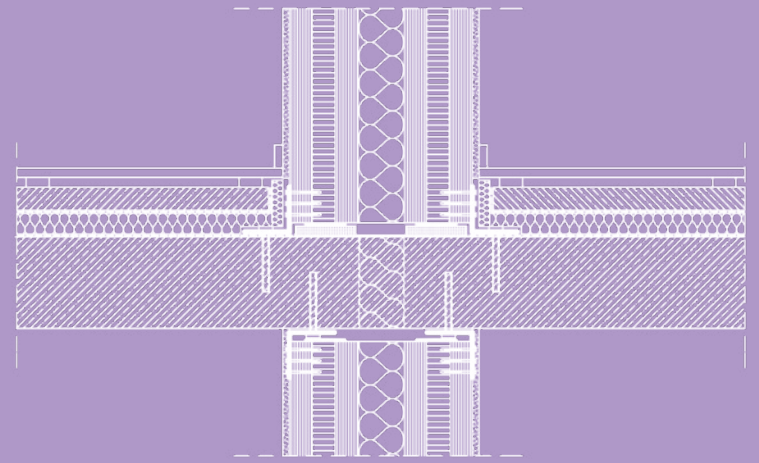
Details like the children´s play area; the operation of shading devices and folding lass sheets; the perception of the original structure; and the use of materials inside were developed in this phase.



ill. 49. The use of the shading panels and glass sheets on the balcony

Phase 7: Structural considerations

For providing comfort and durability, structural details were also considered and developed consequently. One of the main challenges were isoluting the apartments to avoid sound transmission between the units. The application of floating floors, and the cover of some of the existing structure proved to be necessary for achieving sound insulation.



ill. 50. Wall between apartments,
Acoustic performance: R_w=68dB
Fire resistance: min REI 90

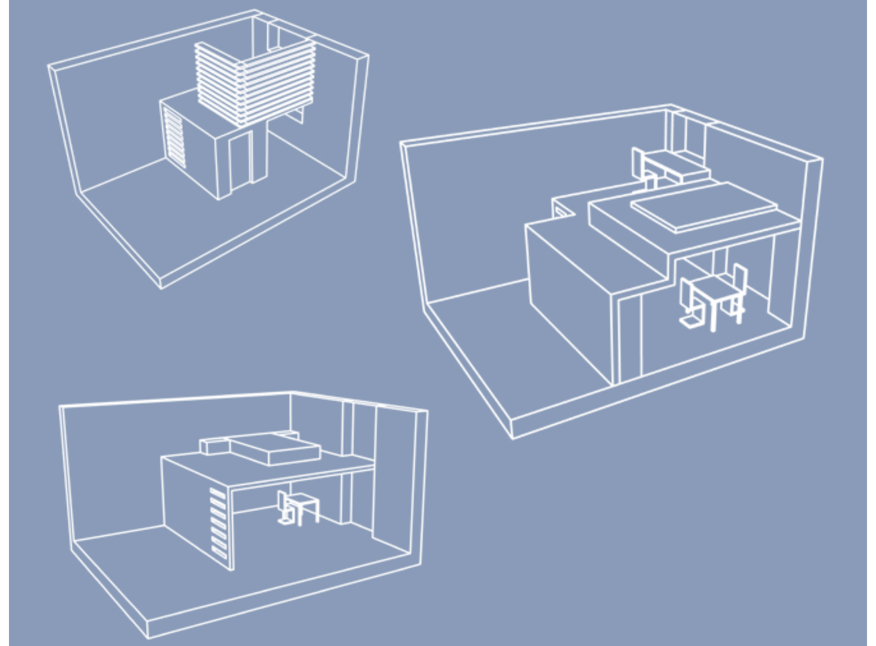
The final design of the two level high apartments

Naturally, several of the listed phases were developed in parallel, at least on conceptual level. Their interplay lead to the final design which can be found in the Presentation section (page 82).

5.5.3. Development of the student apartments

Phase 1: Dividing the space

The main structure of the existing storage wing of the building defined a module for the apartments, which unit granted cca. 55 m² area for each apartment and 3,4 m room height (4,7 m for a few apartments which are placed in the former roof structure). This ceiling height was not suitable for creating two separate storeys, but more than enough for one, with the possibility for a gallery or bunk beds.



ill. 51. Gallery experiments for dividing the space

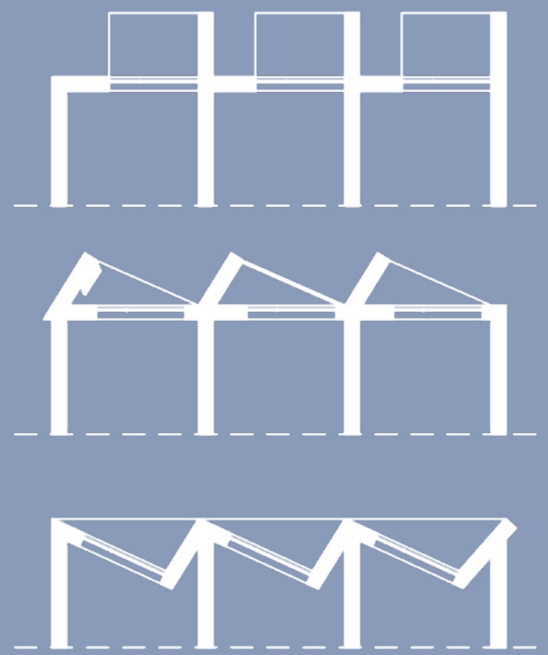
Phase 2: Variations for the floor plan

Based on the ideas for different fractions, combinations for the entire apartment were put together.

ill. 52. Sketches for the floor plan

Phase 3: Balconies

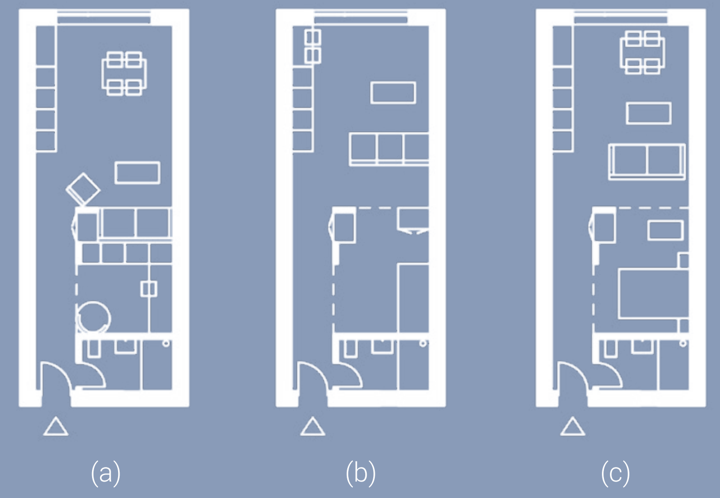
Finding a solution which integrated the outside space in the form of balconies had a great importance during the design, therefore several ideas were generated and compared. Emphasise was taken to provide a space which can be used all-year-round, sheltering it with sliding or folding panels introducing a winter garden for the colder months.



ill. 53. Ideas for the balconies (plan view)

Phase 4: Flexible use options

Flexibility is a crucial part of the vision, therefore it must be involved in all scale of the design. Flexibilty helps creating an apartment which can comfortably used by several different users granting extra value.



ill. 54. Furnishing options for a) young couples, b) friends, c) couple and a baby

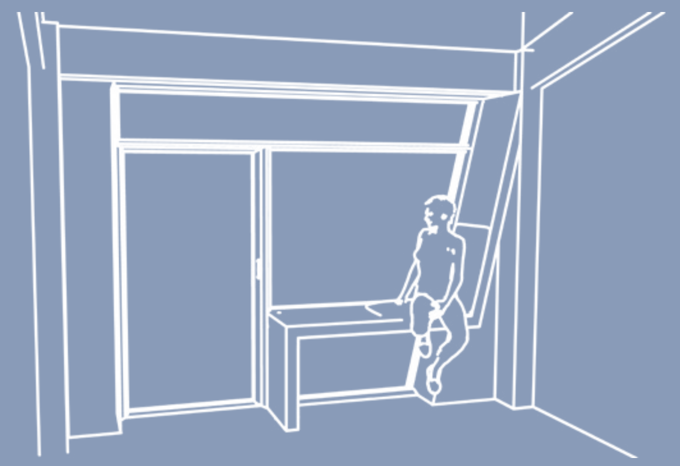
Phase 5: Optimization

The next step was making better living conditions in relation to indoor climate. Several changes were implemented and their results carefully examined.

Adding window to the bathroom	Increase of DF	+2.5
	Reduction of hours above 26 °C	- 24 %
	Increase of overall energy consumption	+ 2 %
Increasing the ventilation rate during the winter	Reduction of CO_2 level	- 10 %
	Reduction of smell	-38 %
	Increase of overall energy consumption	+ 6 %
Placing shading on the windows towards SW and lower their g-value	Reduction of hours above 26 °C	- 74 %
	Reduction of overall energy consumption	- 3 %

Phase 6: Detailing

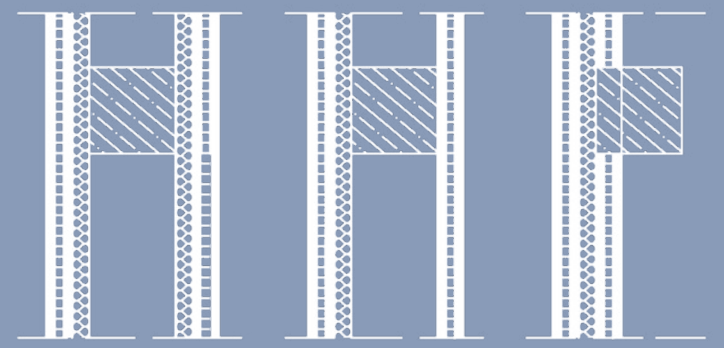
In this step, numerous small details were clarified like the fixing and operation of the external shading, or the use of baywindows.



ill. 55. Idea for the baywindow

Phase 7: Structural considerations

In order to ensure the best user experience several structural details were analysed and developed in a way which guarantees a comfortable living space. The investigation included for instance the layers of the wall between apartments, possibilities of floating floor, connection of CLT-elements, reduction of fire hazard, etc.



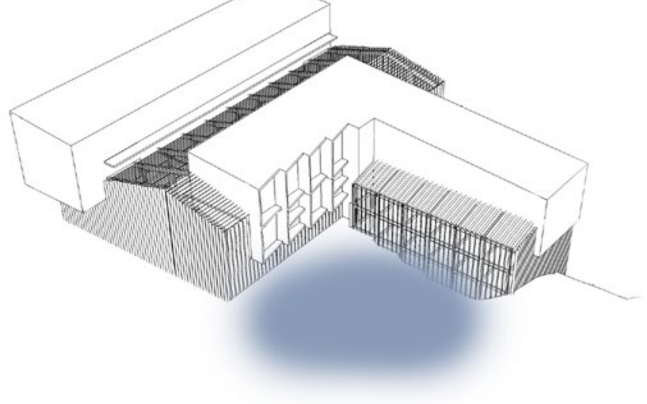
ill. 56. Options for the wall between apartments in relation to the existing reinforced concrete columns (plan view)
a) Double isolated; layers: CLT, rockwool, concrete column / cavity, rockwool, CLT. Total wall thickness: 100 cm
b) Covered; layers: CLT, rockwool, concrete column / cavity, CLT. Total wall thickness: 90 cm
c) Visible; layers: CLT, rockwool, concrete column / CLT. Total wall thickness: 40 cm

The final design of the student apartments

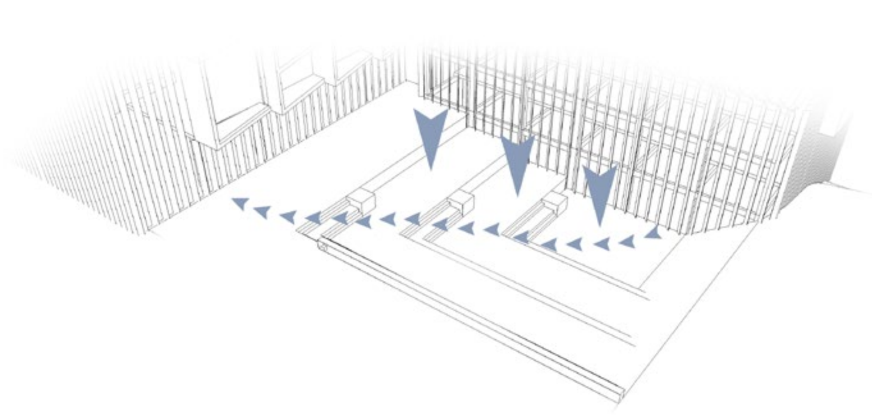
The previous pages illustrated the main line of the process, however several of the mentioned steps acted in parallel to each other, and the design was made in continuous iterations.

The final plans are presented on page 78.

5.6. Integration of outdoor areas



ill. 57. Location of the courtyard



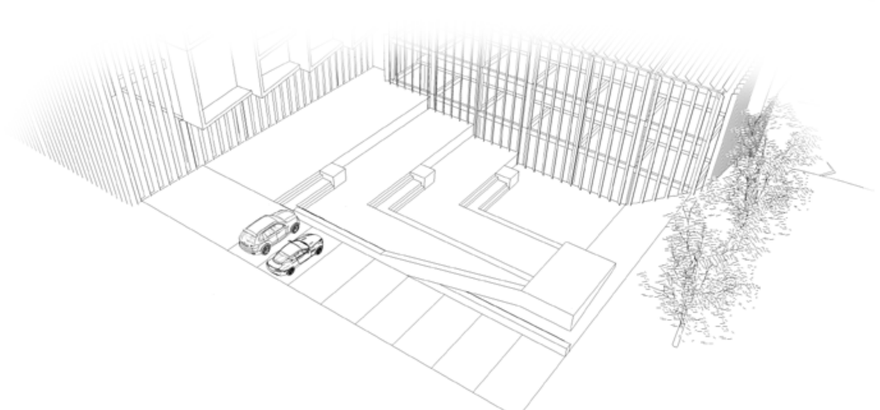
ill. 58. Stepping and connection with other parts of the complex

In addition to inviting nature to the atrium which gesture was described in section 5.4, several of the outside areas were embraced for the use of the residents.

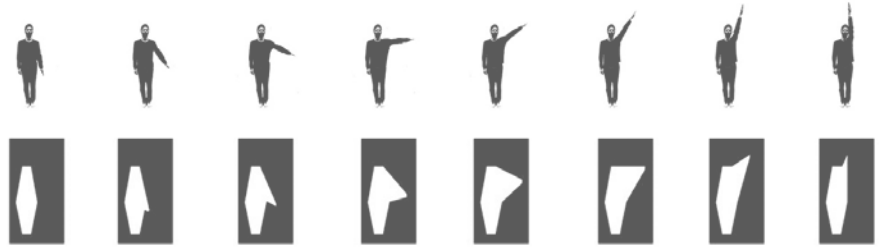
The area which had the most potential is located on the hilltop, behind the new student apartment. One standing there is able to enjoy the wonderful view towards the new main street of the Eternitten district and down to the entire city. Placing a larger outdoor area here connects the different access points of the new building forming a continuous flow.

Stepping down

Owing to the conditions of the existing building there is a height difference of 3,2 m between the floor level of the atrium and the lowest student apartment. Three large steps were introduced to compensate this level difference and to shape the terrain in a way which creates a living urban environment. In addition, openings were placed facing to this new courtyard, therefore a new link was created between various parts of the complex.



ill. 59. Existing trees and parking lot on the edges, and the lookout tower



ill. 60. Human movements and the sequence of elements which form a meditation tunnel together [Esocoff, J., 2015]

Existing trees

There are two trees in big size on the edge of the area which should be preserved.

Car park

Based on the number of apartments additional parking spaces had to be created to meet the requirements of the local plan. This parking lot can be placed on the other edge of the courtyard granting a sheltering border.

Lookout tower

Since the orientation of the courtyard is not ideal (NW...NE), the use of an elevated platform makes it more comfortable.

Meditation tunnel

Based on a study by Jacob Esocoff simple motions can be translated into a physical space. He developed several experiments for capturing human movements, than creating a sequence of plates with holes which are able to frame one walking around and doing the exact move. This study can be effectively utilized in order to enrich any outdoor space. [Esocoff, J., 2015]

PRESENTATION

ill. 61. Overview of the designed building

6. Presentation

6.1. Overall layout of the building

The experience

The newly designed building is rooted in the rich history of Aalborg, and reacts for today´s challenges. It offers modern homes for the new residents, with the contrast of industrial heritage which makes the apartments exciting to use. Moreover, people are able to feel the history of the building without losing the comfort and quality of a contemporary living space. The recognisable original building and its exposed airy structure gives a special identity for the complex. Walking around the building and touching the walls, feeling the delicate balance of the smooth, new materials and the original rough concrete surfaces is a unique experience refreshing those who live here.

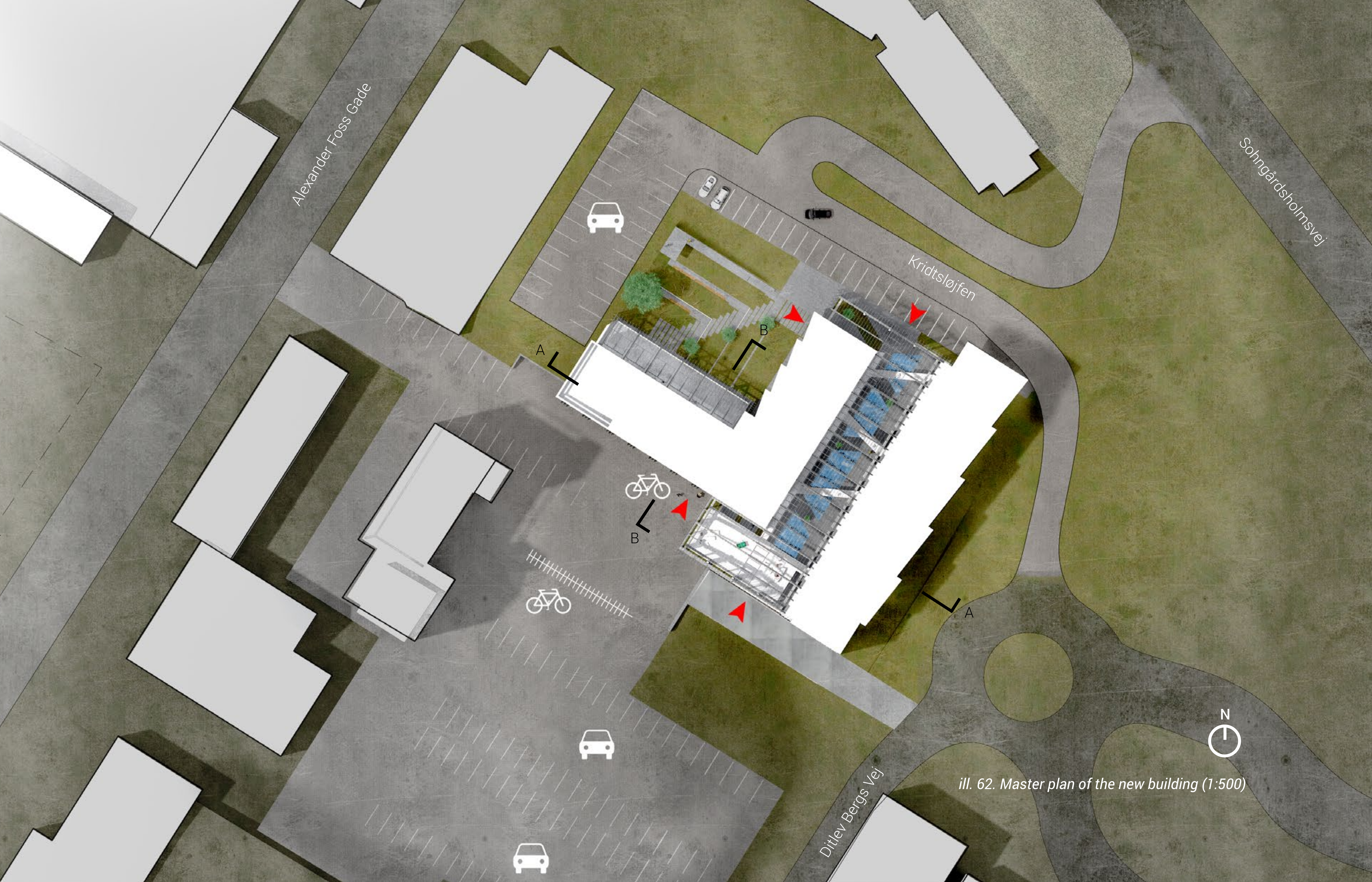
Areas of the building with different levels of publicity enhances the interaction between the residents which is another important feature regarding everyday life. In addition to their own private apartments, they can find semi-private spaces inside the atria which are warm and bright owing to the light filtered through the lamellas made of sandblasted glass. Finally, there is a more public courtyard outside which connects to the urban space surrounding the building.

Placement and access

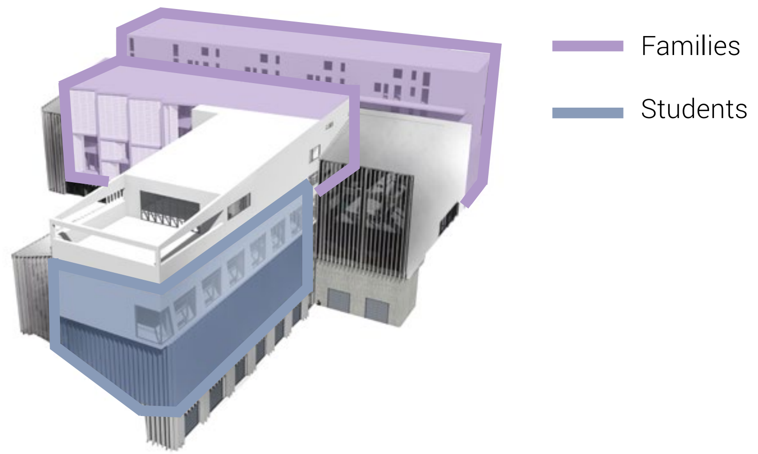
The new building utilizes the entire space of the existing building and extends it in several directions, for instance, it adds two more levels on the highest point. Therefore, the floor area is increased up to 8790 m^2 consisting of apartments mainly (61%) .

The building can be approached from the Sohngårdsholmsvej and the Alexander Foss Gade, the new central street of Eternitten district. Parking is possible outside the building, in the parking lots on the northern part. The residents can access their home through three staircases: one of them is located between the students´ wing and the short family wing; and the other two stairs can be found on the ends of the long family wing. In addition, connection is granted between the different wings on the first floor inside the main atrium which makes closer relationship between the residents, and improves fire safety. After leaving the staircases and elevators, most of the apartments are accessible through corridors. Considering energy consumption and comfort, these corridors are placed inside a covered but unheated space. This makes the corridors easier to use during the colder months, in addition prepares people to leave the building or welcomes them home.

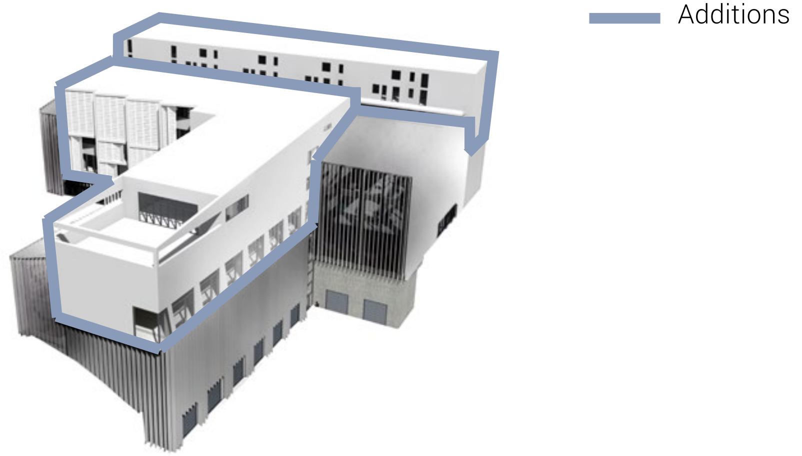
Floor plans can be found in the attached drawing folder.



ill. 62. Master plan of the new building (1:500)



ill. 63. Placement of different types of apartments



ill. 64. The lamellas distinguish between the original and additions

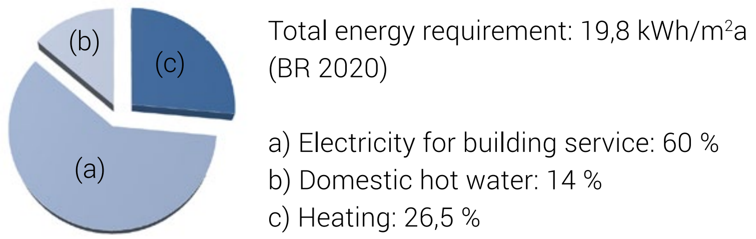
Distribution of functions

The apartments are located inside the existing building and the extensions. Homes for students are provided in the former storage wing, while the family apartments are placed in the production hall and office wing. Both of the user groups have access to the common room on the roof of the storage wing, and other common spaces inside and outside. Storage rooms, parking place for bikes and the laundry can be found in the basement.

The old and the new

The shape of the building and the materials were chosen in order to make a clear border between the original parts and the additions. The extensions have a distinguishing volume floating above the existing building. In addition, sandblasted glass lamellas were used, which structure has three functions: firstly, covering the original building, thus visualizing its original shape. Secondly, managing the light by shading and filtering. Thirdly, providing intimacy inside, without interrupting the experience of the view.

ill. 65. Section cut through the main atrium and the students´ apartments (A-A on ill. 62.)



ill. 66. Distribution of energy use

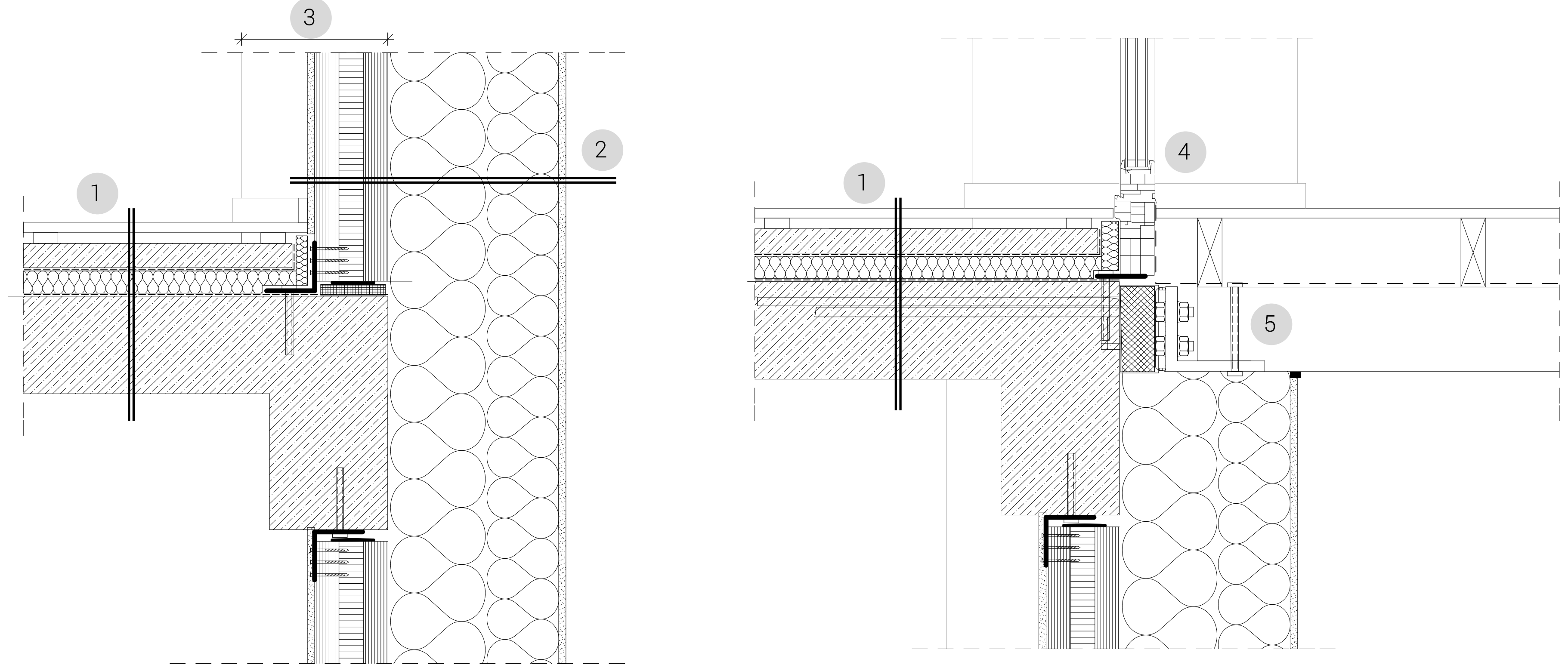
Structure

The old primary concrete structure have been extended by new concrete elements holding together the secondary structure made of cross laminated timber.
The height levels were developed in respect to the original structural system to create a natural collaboration (ill. 65). In addition, the height of the apartments were chosen according to the existing staircases, therefore all of the original access structures could be preserved.

Energy performance

The total energy consumption of the building is 19,8 kWh/m^{2}a, therefore meets the requirements of BR 2020. This low value was achieved by a complex approach developing an airtight and insulated building envelope, effective hybrid ventilation, optimal utilization of solar and other gains, the use of exposed thermal mass, etc. On the other hand, appropriate indoor climate was also in the focus of the project, the results can be found in the presentation of the apartments (page 81 and 85).

ill. 67. North-east facade and section B-B (drawings in scale can be found in the attached drawing folder)



(1.)
Wooden floor on battens
Screed
PE-foil separation layer
EPS insulation
Smoothing
Existing reinforced concrete slab

(2.)
Gypsum plasterboard
CLT panel
Rockwool
Plaster

(3.)
Thickness of the original column: 30 cm

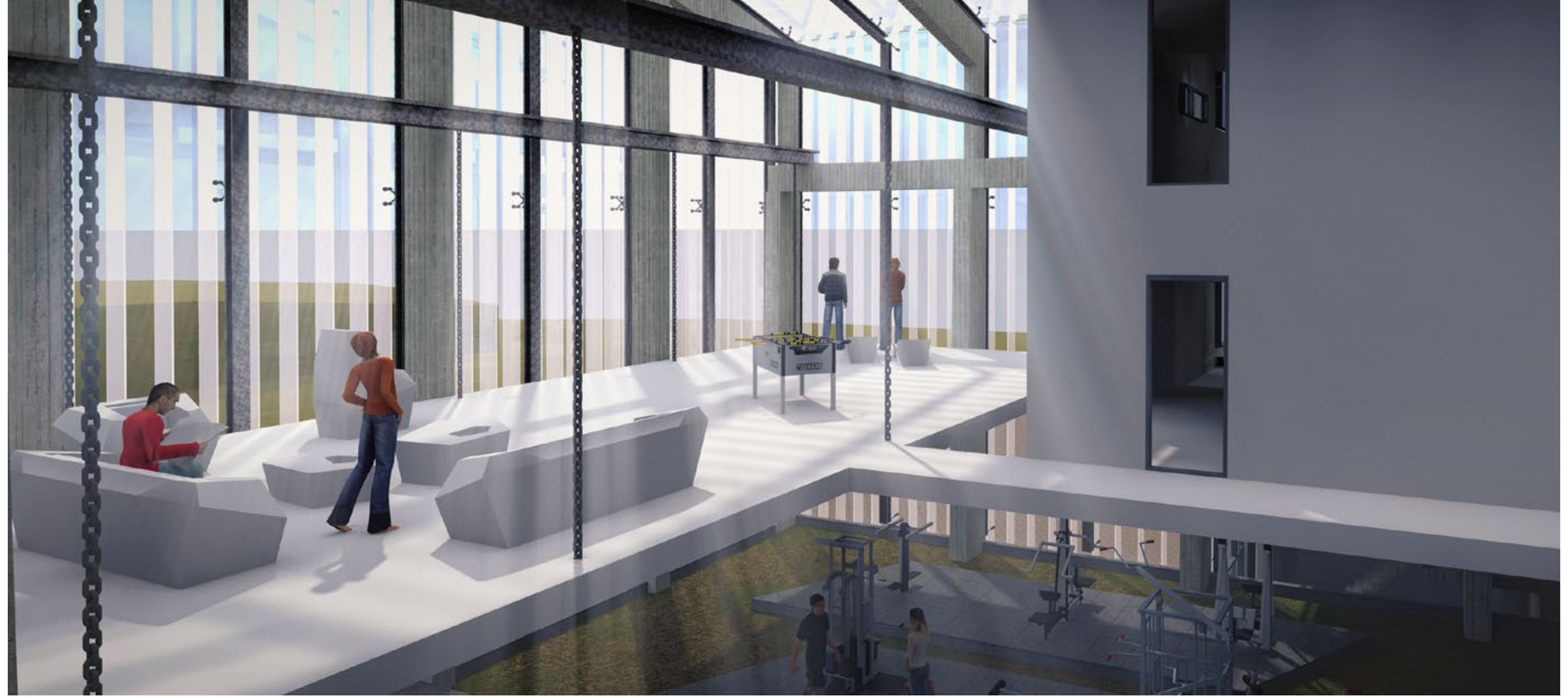
(4.)
Aluminium sliding door to the balcony with triple glazing

(5.)
Schöck Isokorb Type R thermal brake fixed with injected chemical bond to the existing structure, and holding a prefabricated concrete slab for the balcony

ill. 68. Detail D1 without / with balcony, 1:15

6.2. Common areas

ill. 69. Late afternoon view of the main atrium



ill. 70. Elevated platform as common space and viewpoint

6.2.1. The atria

Although the atria´s main function is providing access to the apartments, they grant much more. They are intermediate spaces between inside and outside, giving comfortable conditions for meeting the neighbours in the sheltered common areas or using the gym located in the western part. In addition, the residents are able to enjoy the view towards the city from the terrace which is placed on an elevated platform on the south-west. The dense vegetation of the atria seems to be as an extension of the outside garden, forming a continuous flow of nature.

These spaces utilize several qualities of the existing building. The light experience is preserved and developed: a filtered, diffuse light is penetrating through the slightly transparent lamellas, making the entire space glow, on the other hand blocking view from the outside. Another original quality is the spatial experience, which is provided by the variations between spaces in different size, and view from one to another. Finally, a strong tactile experience can be felt by the contrast of the rough concrete structure made with timber formwork and the new smooth materials.

Physically, the atria are the spaces which give preheated fresh air for the apartments and provide natural light. In order to avoid overheating, large openings are placed on the bottom and top, glass with low solar factor were used, and shading devices were constructed (ill. 71) in addition to the utilization of the shading effect of the building itself.

ill. 71. The semi-transparent lamellas from outside

ill. 72. View of the public garden

6.2.2. Common room

The common room can be found close to the student apartments, on the roof with outstanding view towards west and north. Its large ceiling height allows constructing a gallery for more private meetings for instance study groups. A large terrace also belongs to this room with tall walls for sheltering from the harsh weather.

Another common function is the laundry in the basement with easy access for both the families and students.

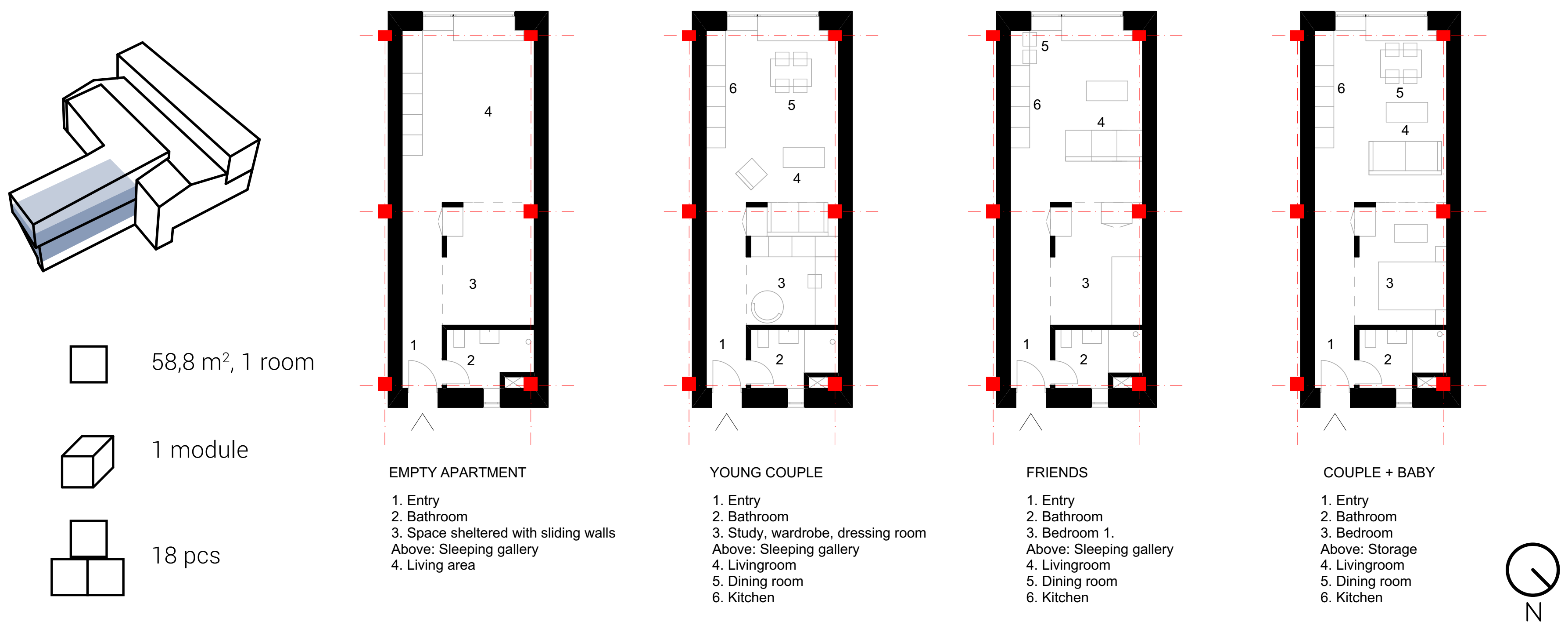
6.2.3. Outside areas

The garden on the northern side provides a rest area for the residents and anybody who walks in this new district of Aalborg. Owing to the stepping feature it creates a continuous flow of nature connecting the students´ wing and the main atrium. In addition, there is a look-out tower on the corner of the courtyard where people are able to enjoy the view towards the new main street of Eternitten and the rest of the city. Another feature is the meditation tunnel which is located in the centre of the garden. It consists of a series of human-shaped statues, which form frames together for a specific motion. If somebody walks through these frames, he is forced to make this movement. Concentrating on moving alone, relaxes the mind and refreshes the body.

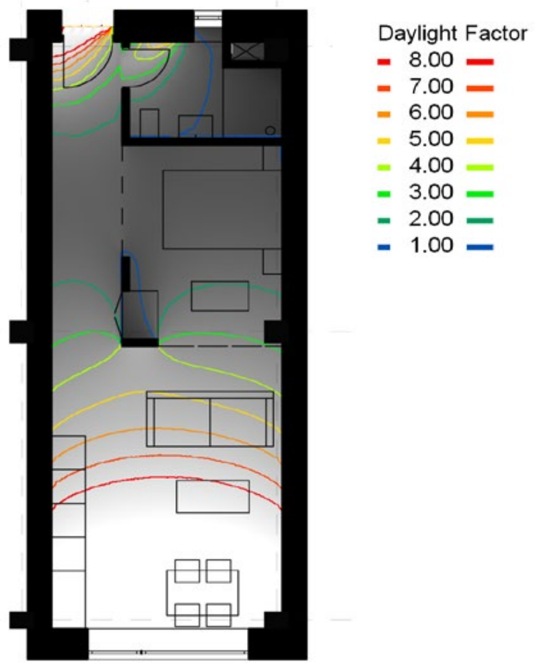
6.3. The apartments

6.3.1. The student apartments

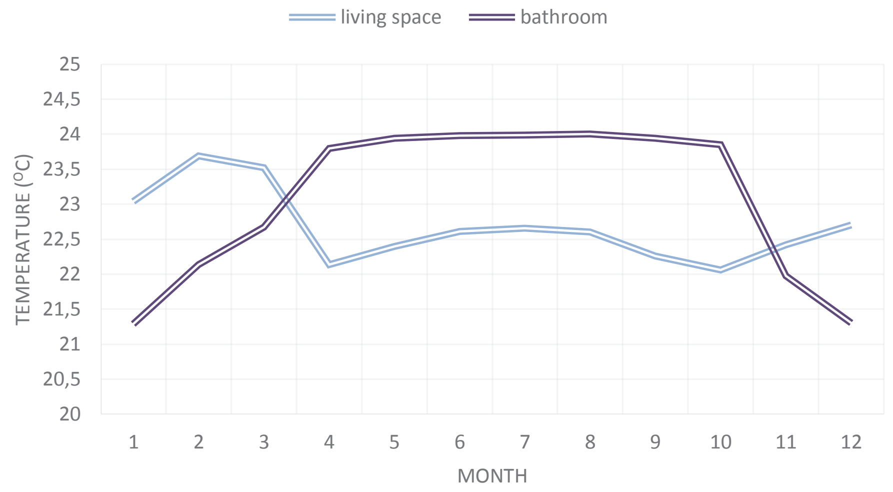
ill. 73. Cooking dinner - view of the living space inside a student´s apartment



ill. 74. Floor plan and possible variations according to the users (1:200)



ill. 75. Daylight factor simulation by Velux Daylight Visualizer



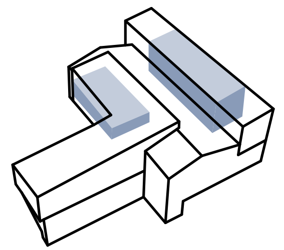
ill. 76. Graph showing the temperature inside (by BSim)

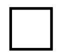
The student apartments are located in the former storage wing and have wonderful orientation as their living rooms are facing south-west. The relatively large ceiling height (3,2 m) which was defined by the original structure creates elegant spaces and allows constructing a gallery or bunk-bed for sleeping. The flexible layout of the floor plan makes adaptation easy, therefore several different users are able to feel at home, for instance friends, young couples, or couple with a baby (ill. 74). Regarding materiality, the original concrete beams and ceiling appear in some parts and stand in contrast to the new white painted plasterboard walls. The floor is covered with nail-free wooden floor which gives warm

atmosphere for the room.
The energy use and indoor climate was optimized in order to meet the requirements listed in the concept section (page 33). Several factors were balanced, like parameters for natural venting during the summer and mechanical ventilation for winter (see calculation in the Appendix, section 9.2), connection of spaces, window sizes, heat control, etc. All apartments have shading devices, some of them fixed lamellas, while other ones moveable panels.

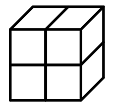
6.3.2. The family apartments

ill. 77. View of the shared zone

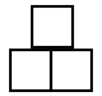




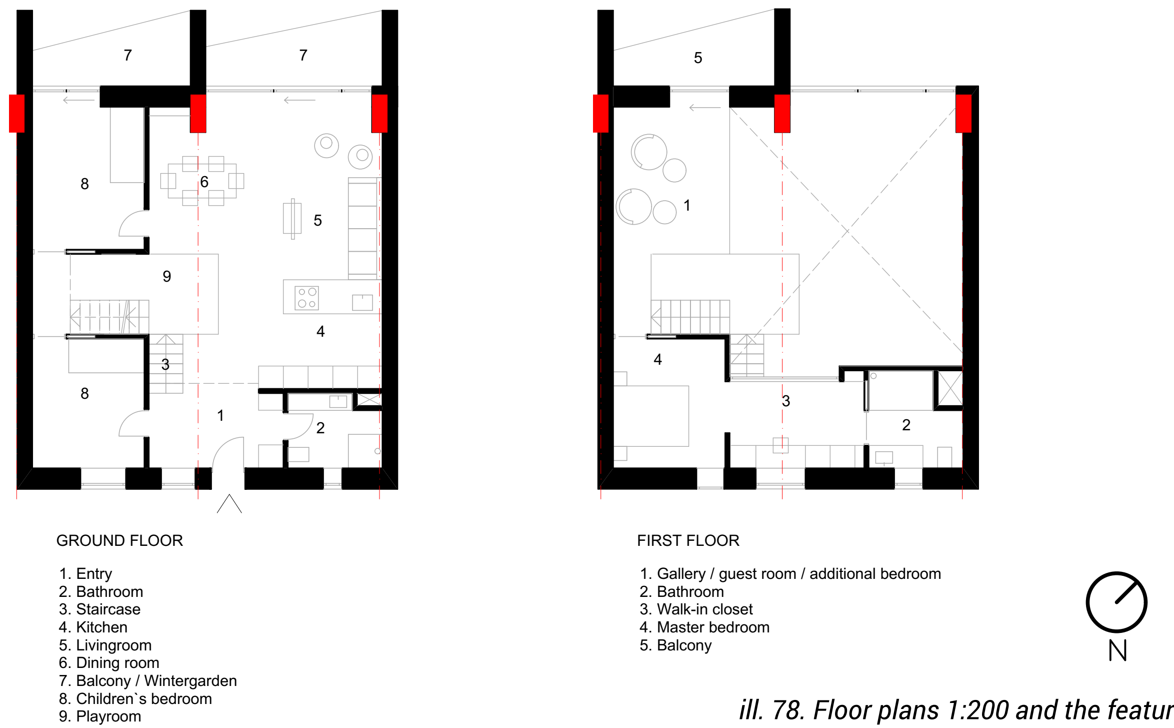
176.7 m², 5 rooms



2x2 modules

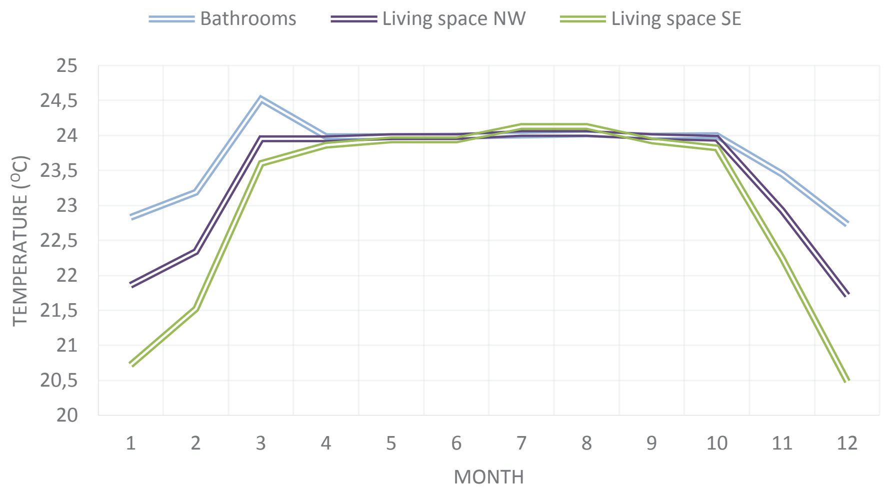


8 pcs



ill. 78. Floor plans 1:200 and the features

ill. 79. Daylight factor simulation by Velux Daylight Visualizer

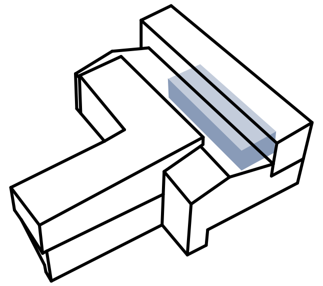


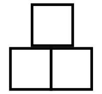
ill. 80. Graph showing the temperature inside (by BSim)

The two-level-high family apartments are located in the former office wing and production hall, and accessible from the main atrium. Their orientation is not ideal, their living rooms are facing towards south-east or north-west depending on their location. Therefore the balconies are shaped to reflect the sunlight inside the room (see page 97), and minimize the shading effect during the late afternoon hours.
Their floor plan follows the idea about zoning the space described in the concept section (page 34). The shared area is located on the first level, adjacent to the children's realm, while the parents own territory is upstairs. This arrangement grants the required level of privacy for each member of the family, on the other hand offers the opportunity for time spent together. The layout works well especially for families with young children who need more attention from their parent, therefore their area has close connection to the shared part. If the playroom is not needed any more it can easily be merged into the bedrooms.
The apartment preserves several velues of the existing building, for instance the presence of the original structure. The previously unreachable concrete columns are now part of the interior becomig a visible element inside the space, thus giving emphsise and tectonic quality for these parts. They are countervailed by warm surfaces made of timber, located mostly upstairs in the private zone.

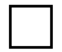
The indoor climate is optimized to avoid indoor temperatures above 26 degrees, high level of CO_2-concentration, and give enough daylight inside all living spaces (the average DF is above 5%, ill. 79). The detailed results of the simulations can be found in the appendix (page 92).

6.3.3. Other apartment types

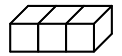




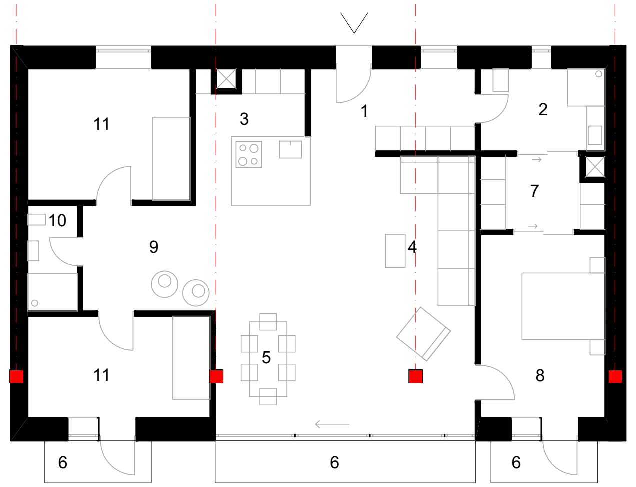
4 pcs



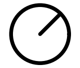
148,1 m², 4 rooms



1x3 modules



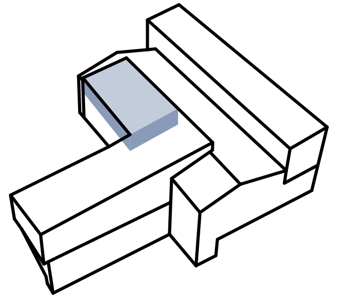
1. Entry
2. Bathroom
3. Kitchen
4. Livingroom
5. Dining room
6. Terrace
7. Wardrobe
8. Master bedroom
9. Playroom
10. Bathroom
11. Children´s bedroom

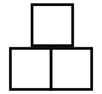


ill. 81. Floor plan 1:200 and the features

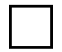
One-level-high family apartment
This type is placed in the original office wing, therefore some of them have direct access to a small garden on the south-east. However, the modular system, and the placement of the pipes allow free choice regarding the location of these apartments. They can be replaced by other versions presented earlier, which provides further options for the investor of the project.

The apartment´s layout is arranged to accomplish the same zoning system which was discussed earlier: the shared area is in the center, the childrens´ realm is placed on one side, and the parents´ on the other one. A small play-space between the two children´s bedroom is partly hidden from the living room, but still close to it.

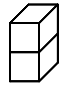




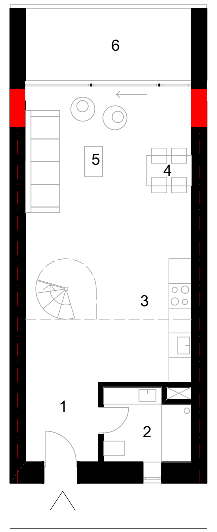
4 pcs



81,1 m², 2-3 rooms

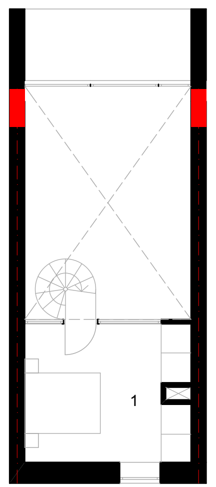


1x2 modules



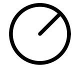
FIRST STOREY

1. Entry
2. Bathroom
3. Kitchen
4. Dining room
5. Living room
6. Balcony / Wintergarden



SECOND STOREY

1. Bedroom



ill. 82. Floor plan 1:200 and the features

Two-level high apartment, small version
This type offers accomodation for a couple or a young family with one children as the bedroom upstairs can easily be split to two smaller rooms.
These apartments are located above the larger versions, reaching through the former roof structure, therefore the experience is based on the contrast of the two materials: the original concrete beams are partly visible, and holding the timber box containing the bedrooms. This gesture is emphasised by the airy spiral staircase, making the apartment seemingly larger and more spacious.

7. Conclusion

" It is always life which is right, and it is the architect who is wrong."
Le Corbusier seeing the changes made on his famous buildings in Pessac [Scott, F., 2008]

Sustainability through ages

One of the most mysterious challenges for designing a building is the time-span which need to be considered. The life of a building is usually much longer than the life of its creators, therefore nobody is able to foresee the fate of such creation. Thus, it is not enough meeting only the requirements of present needs, but focus is necessary to grant the ability of adapting to changes for a product like a building, otherwise the risk of early demolition is unavoidable, even before reaching the obsolescence of the main structure.

On the other hand, a building should be connected to the past and history of the region where it stands in order to become part of it. A building which is totally alien from the surrounding context can hardly be successful and accepted by its users [Frampton, K., 1983]. It might be the most energy efficient house with perfect indoor climate if nobody is willing to use it because of the lack of the local spirit, disrespect towards the "genius loci".

In summary, sustainability means for me an awareness which starts considering the vaules of the past, then answering the demands of the present and preparing flexibility for the future changes.

Reflection

The redesign of the building which is the topic of this report was made according to the mentioned idea about sustainability, as an illustration of the theory. The process was developed focusing on the entire time-span of the building:

Firstly, the history of the area had to be understood, the existing building analysed, and its values highlighted. The design of the transformation preserved several from these qualities and enhanced their perception.

Secondly, the current demands were answered in relation to functionality, energy use, indoor climate, etc. These considerations were crucial for providing a living space for the residents which is easy to use in all aspects of everyday life.

Thirdly, flexibility was introduced on several levels to allow future changes. For instance, the apartments can be used by several different user groups; their modular layout makes replacement possible; moreover, total change of the function is feasible owing to the chosen structural system.

Personally, the design of the building lead me through a journey toward a more complex understanding of sustainability, and its use in practice. I have found this knowledge useful while working for an investor as client, as well, as it was the background for this project. Sustainability proved to be an investment which pays for itself, considering long-term costs. Both the investor and me had the interest in developing a solution which attracts people to rent the apartments in the present, and provides safety for the future investments.

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9. Illustrations

10. Appendix

10.1. Main facts

Gross areas

Function	Area (m²)
Residential	5288,1
Garage	258,8
Storage (bikes and other)	421,8
Access	1410,3
Utility	81
Common room	265,7
Covered rest area	1064,8
In total	**8790,5**

Floor plans can be found in the attached drawing folder.

Apartments and parking

Number of family apartments: 26
Number of student apartments: 18
Required parking spaces according to the Localplan: 33,1
Provided parking lots: 57
Expected number of residents: 102

10.2. Energy performance

BE10 results

Energy frame

BR 2010	29,2 kWh/m²a
Low energy buildings 2015	27,2 kWh/m²a
BR 2020	19,8 kWh/m²a

Contribution to energy requirement

Heat	10,2 kWh/m²a
El. for operation of building	7,6 kWh/m²a
Excessive in rooms	0 kWh/m²a

Net requirement

Room heating	5,5 kWh/m²a
Domestic hot water	5,2 kWh/m²a
Cooling	0 kWh/m²a

The files used for the simulations can be found on the attached CD.

10.3. Indoor climate

Calculation of the airchange rates

Minimum requirement according to the CR1752 standard

- Student apartment
Living area (48 m²)
0,3 l/sm² -> 14,4 l/s
+ 5 l/s per person -> 10 l/s
+ 20 l/s for the kitchen -> 20 l/s
--> in total: 44,4 l/s = 0,92 l/sm²
Bathroom (5 m²)
0,3 l/sm² -> 1,5 l/s
+ 5 l/s per person-> 5 l/s
--> in total: 6,5 l/s², but the minimum is 15 l/s -> 15 l/s = 3 l/sm²
In total for the student apartment: 59,4 l/s

- Family apartment
Living area on the SE (60 m²)
0,3 l/sm² -> 18 l/s
+ 5 l/s per adult -> 10 l/s
+ 3 l/s per children -> 6 l/s
+ 20 l/s for the kitchen -> 20 l/s
--> in total: 54 l/s = 0,9 l/sm²
Living area on the NW (57,9 m²)
0,3 l/sm² -> 17,4 l/s
+ 5 l/s per adult -> 10 l/s
+ 3 l/s per children -> 6 l/s
--> in total: 33,4 l/s = 0,57 l/sm²
Bathrooms (16 m²)
0,3 l/sm² -> 4,8 l/s
+ 5 l/s per person-> 5 l/s
--> in total: 9,8 l/s², but the minimum is 2x15 l/s -> 30 l/s = 2 l/sm²
In total for the family apartment= 117,4 l/s

Airchange rate based on smell

c_i= c + 10 x q/V_l
c_i= experienced air quality=1,4 based on percentage of dissatisfaction (maximum 20 %)
c= outdoor air quality, which represents the level of pollution in cities = 0,05
q= pollution load by persons and the structures of the apartment= 1 + 1 + 1,2 + 1,3 + 0,1 x 153,3 = 19,83 olf
-> V_l = 146,8 l/s for the family apartment
-> V_l = 57,4 l/s for the student apartment

In conclusion, the higher values must be used, which is 59,4 l/s for the student apartment and 146,8 l/s for the family apartment.
Finally, these airchange rates were checked for the required maximum level of CO_2-concentration with the simulations.

Calculation of the sizes of the ventilation pipes

$A = V_i/v$
v= optimal air speed = 4 m/s

-Student apartments: 3 apartments above each other
-> A = 0,043 m^3 , which means a pipe with 11,7 cm diameter

- Family apartments I.: 2 apartments above each other
-> A = 0,073 m^2 , which means a pipe with 15,2 cm diameter

- Family apartments II.: 4 apartments above each other
-> A = 0,147 m^2 , which means a pipe with 21,6 cm diameter

BSim results for the student apartment

	Thermal zone	
	Living area	Bathroom
Ti mean (°C)	23,1	22,7
Hours above 26 °C	0	0
Hours above 27 °C	0	0
Hours below 20 °C	0	0
Average CO_2 (ppm)	764,3	350

BSim results for the family apartment

	Thermal zone		
	Living NW	Living SE	Bathrooms
Ti mean (°C)	23,4	23,1	23,7
Hours above 26 °C	0	67	0
Hours above 27 °C	0	3	0
Hours below 20 °C	0	29	0
Average CO_2 (ppm)	350	681,2	350

The files used for the simulations can be found on the attached CD.

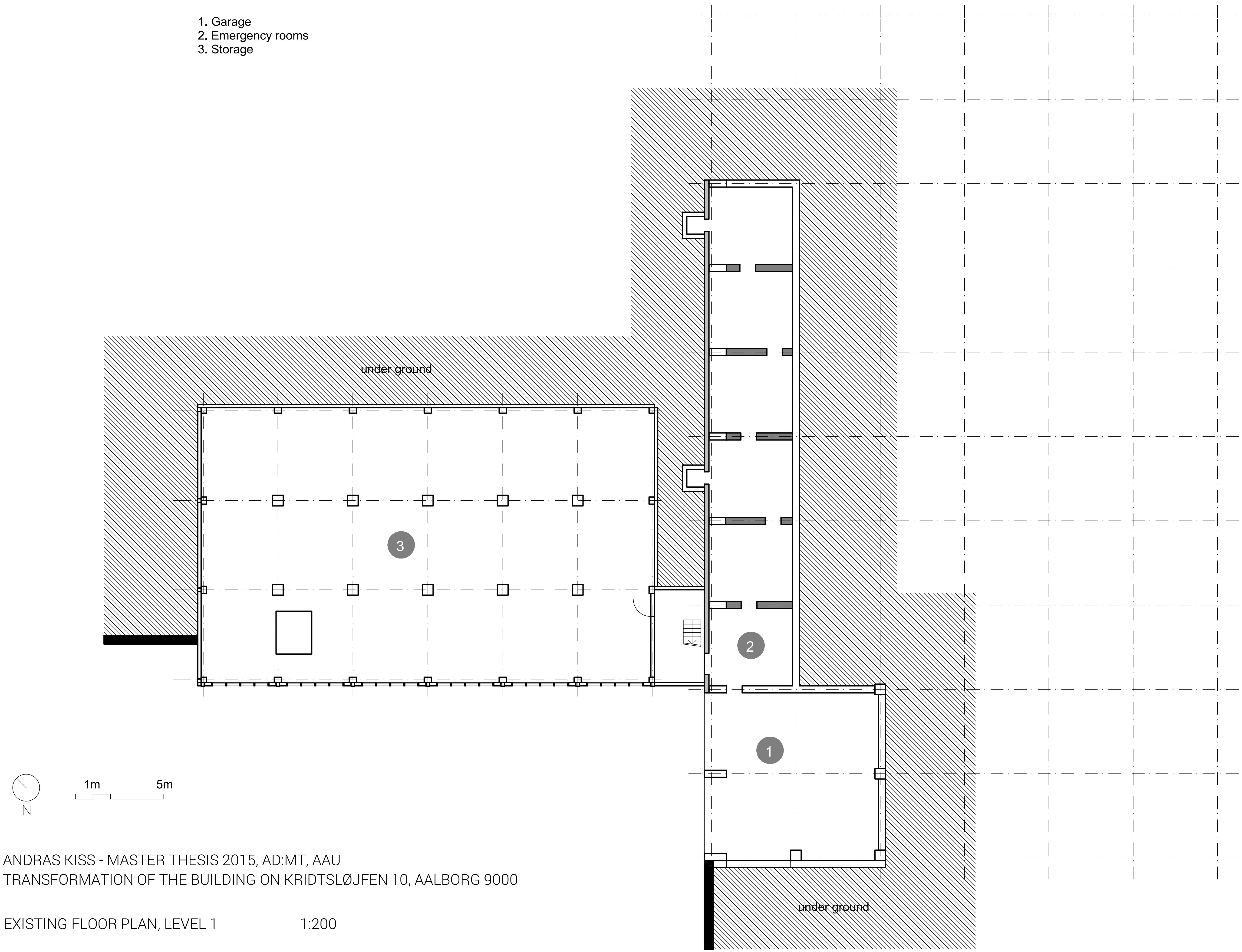
10.4. Daylight experiment

Tests for the effect of a reflective surface placed outside the window, in 90 degrees.

Luminance values of the adjacent wall on a sunny day, without outside reflector

Luminance values of the adjacent wall on a sunny day, with outside reflector

1. Garage
2. Emergency rooms
3. Storage



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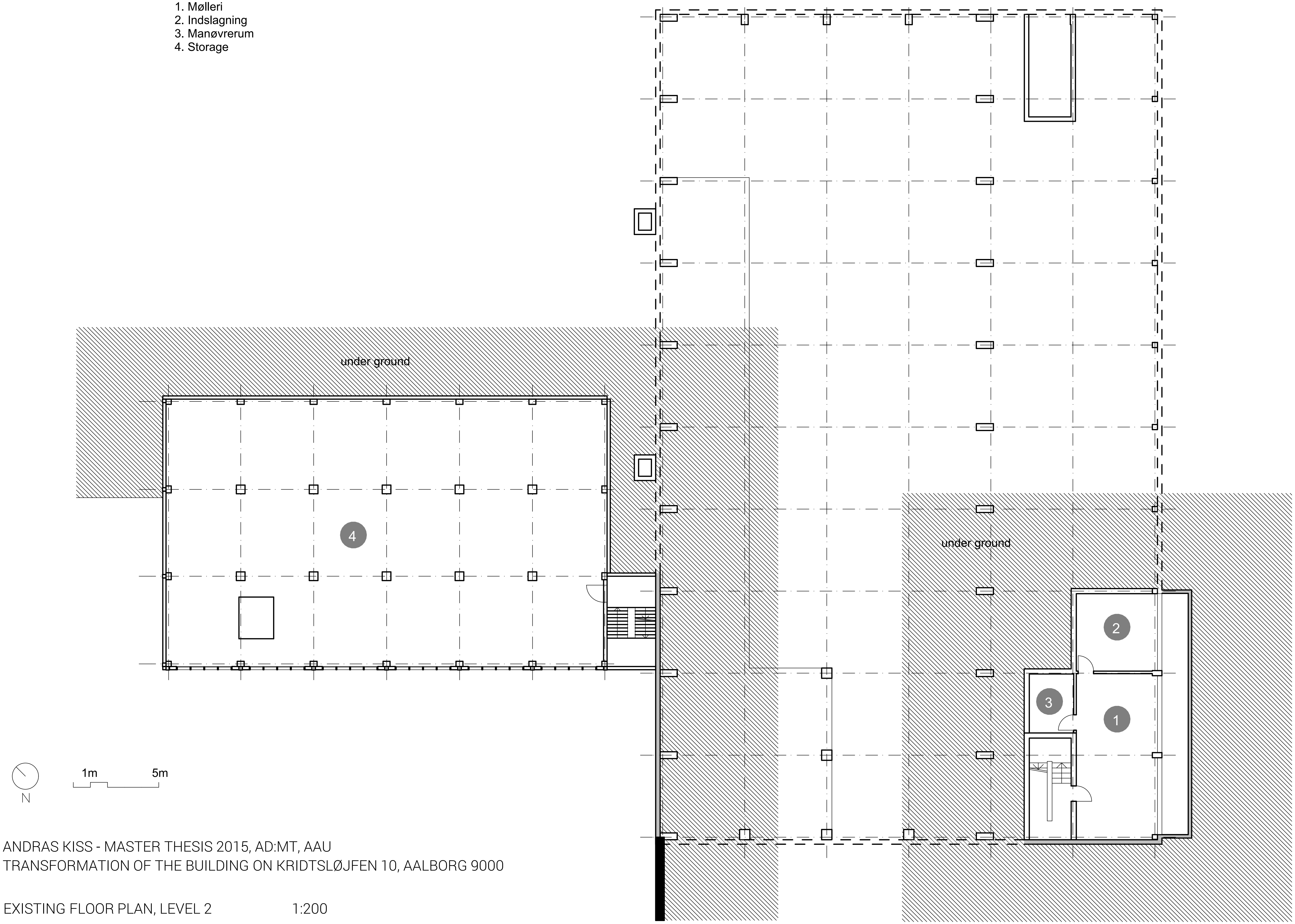
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

EXISTING FLOOR PLAN, LEVEL 1 1:200

1. Mølleri
2. Indslagning
3. Manøvrerum
4. Storage



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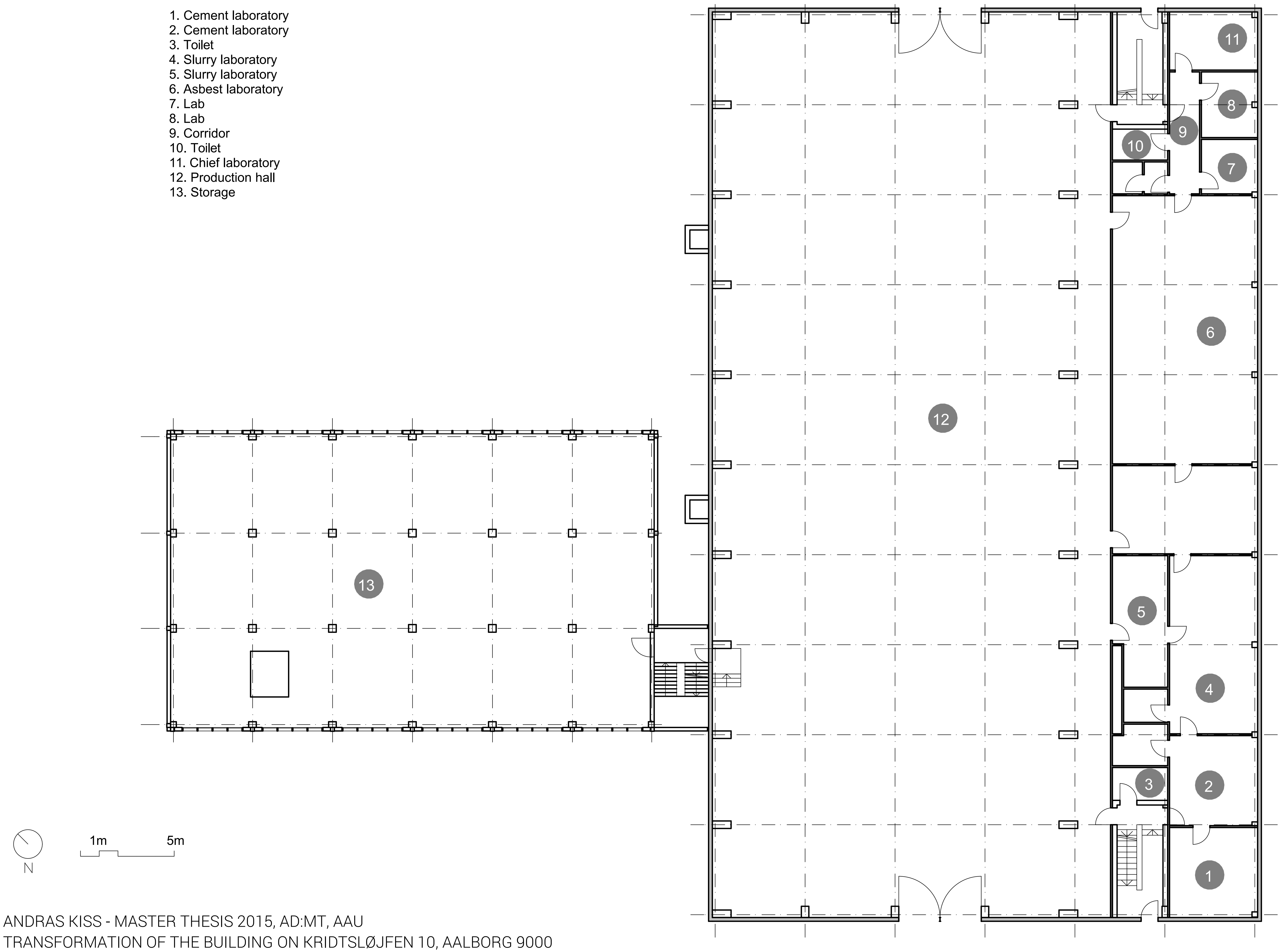
EXISTING FLOOR PLAN, LEVEL 2 1:200

1. Cement laboratory
2. Cement laboratory
3. Toilet
4. Slurry laboratory
5. Slurry laboratory
6. Asbest laboratory
7. Lab
8. Lab
9. Corridor
10. Toilet
11. Chief laboratory
12. Production hall
13. Storage



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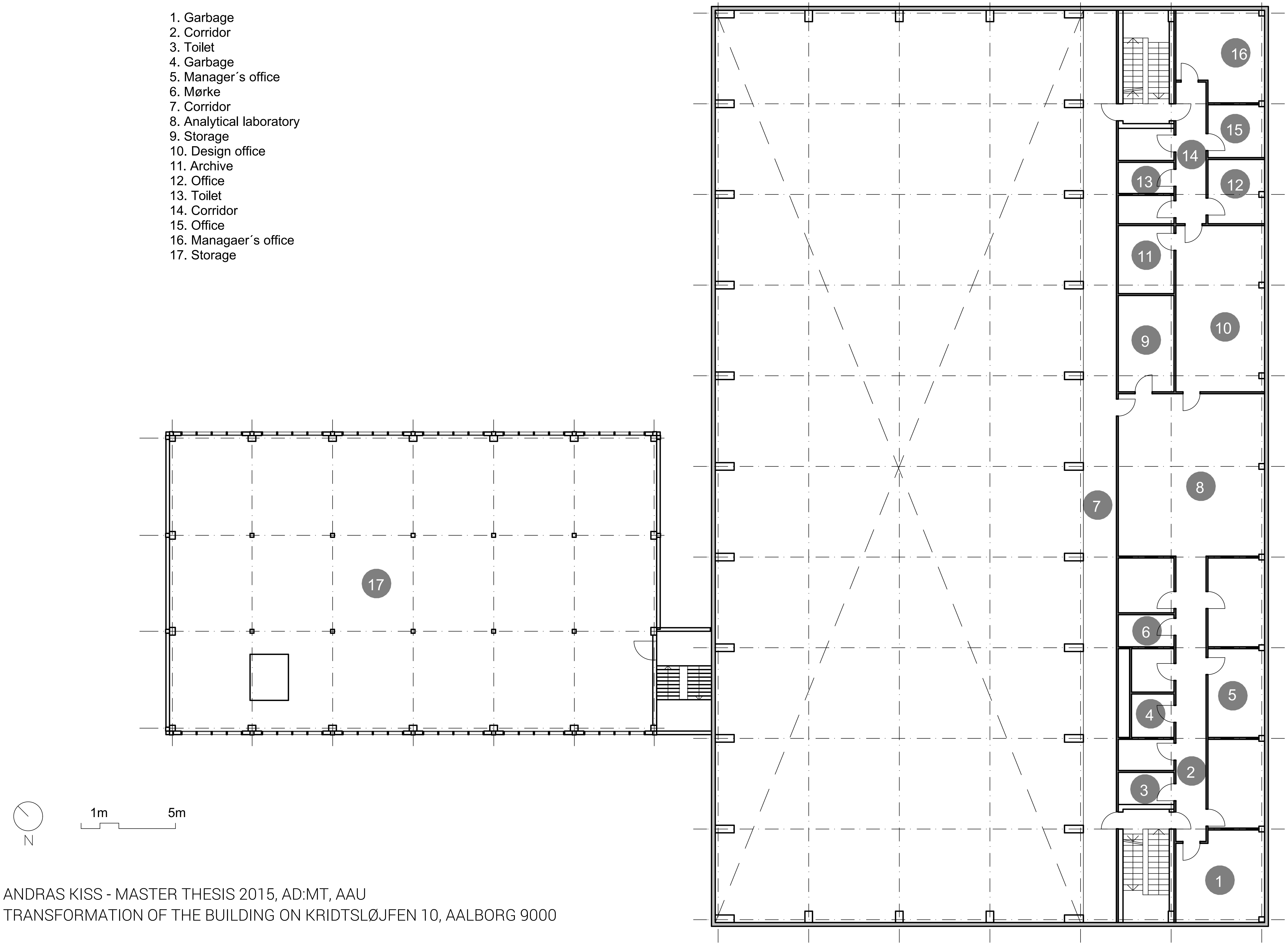
EXISTING FLOOR PLAN, LEVEL 3 1:200

1. Garbage
2. Corridor
3. Toilet
4. Garbage
5. Manager´s office
6. Mørke
7. Corridor
8. Analytical laboratory
9. Storage
10. Design office
11. Archive
12. Office
13. Toilet
14. Corridor
15. Office
16. Managaer´s office
17. Storage



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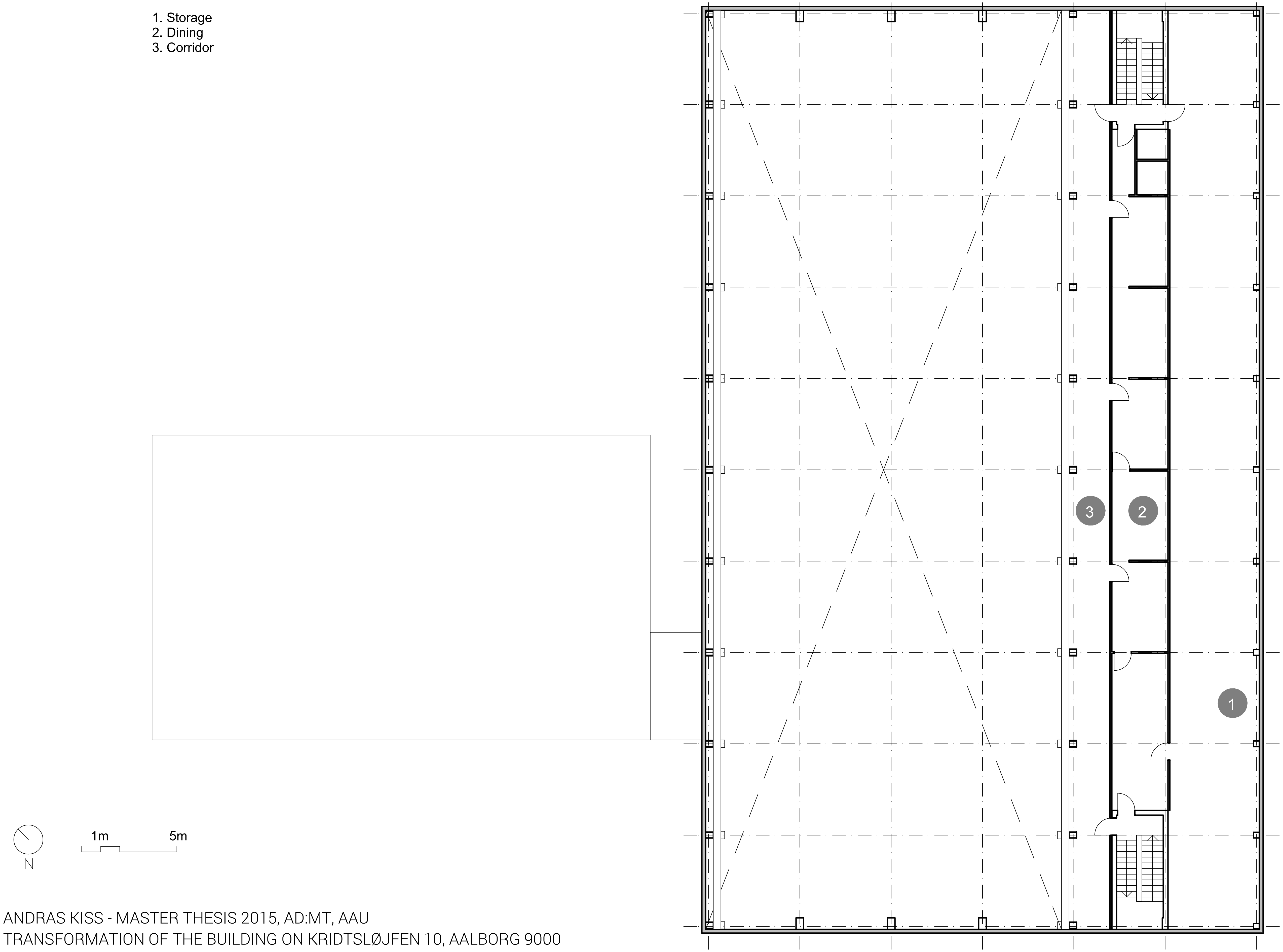
EXISTING FLOOR PLAN, LEVEL 4 1:200

1. Storage
2. Dining
3. Corridor



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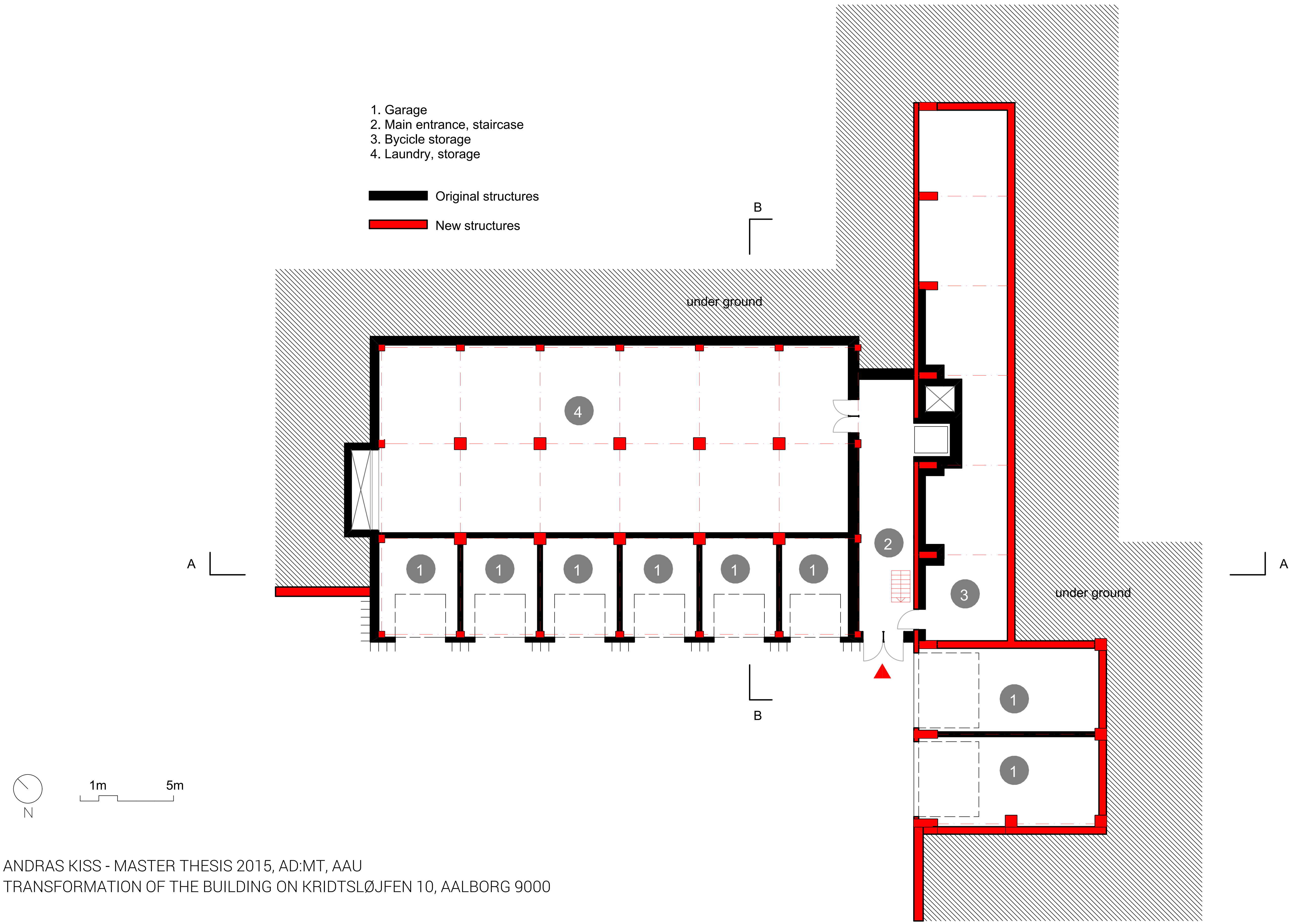
EXISTING FLOOR PLAN, LEVEL 5 1:200



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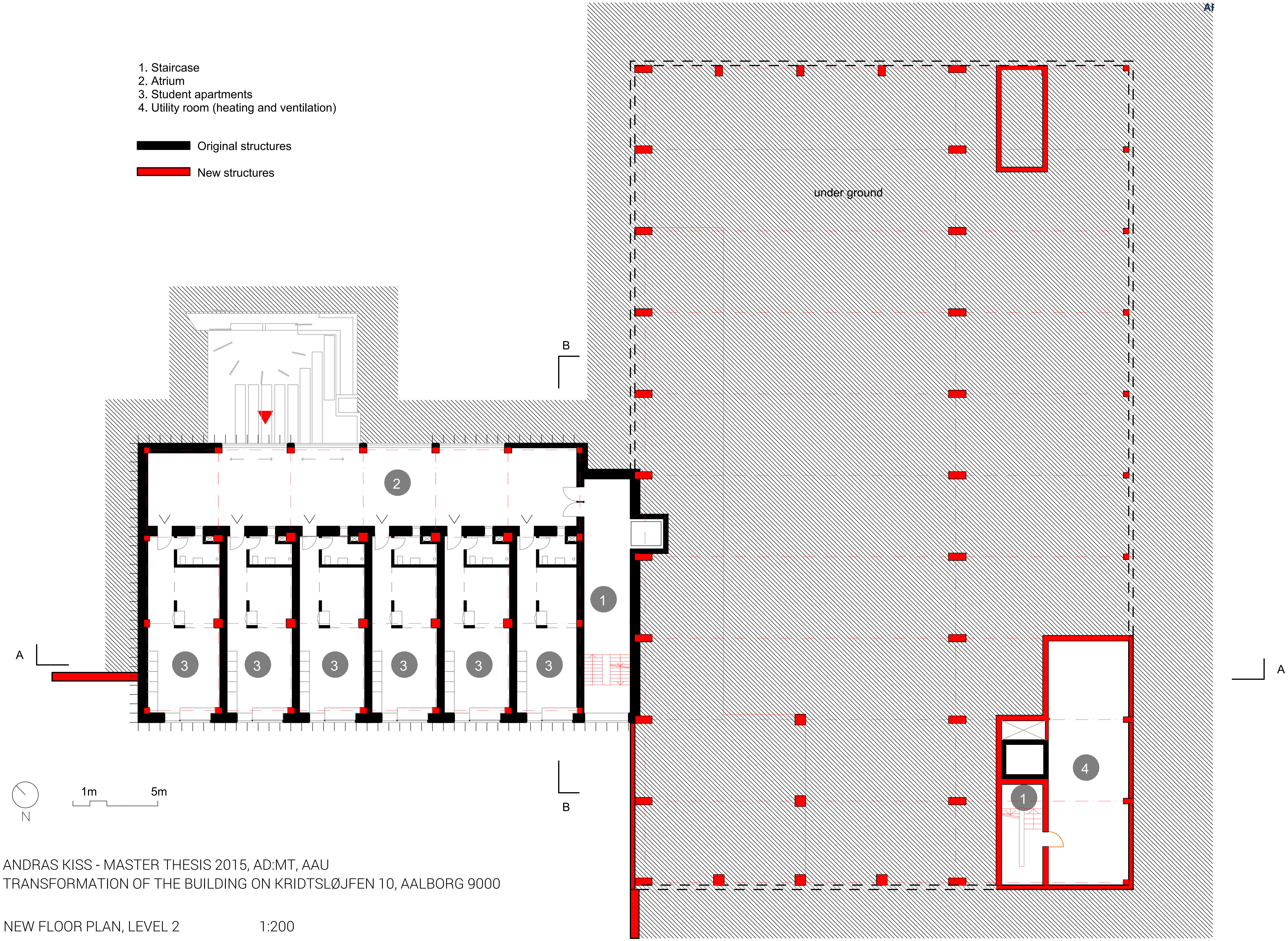
NEW FLOOR PLAN, LEVEL 1 1:200

1. Staircase
2. Atrium
3. Student apartments
4. Utility room (heating and ventilation)

Original structures

New structures



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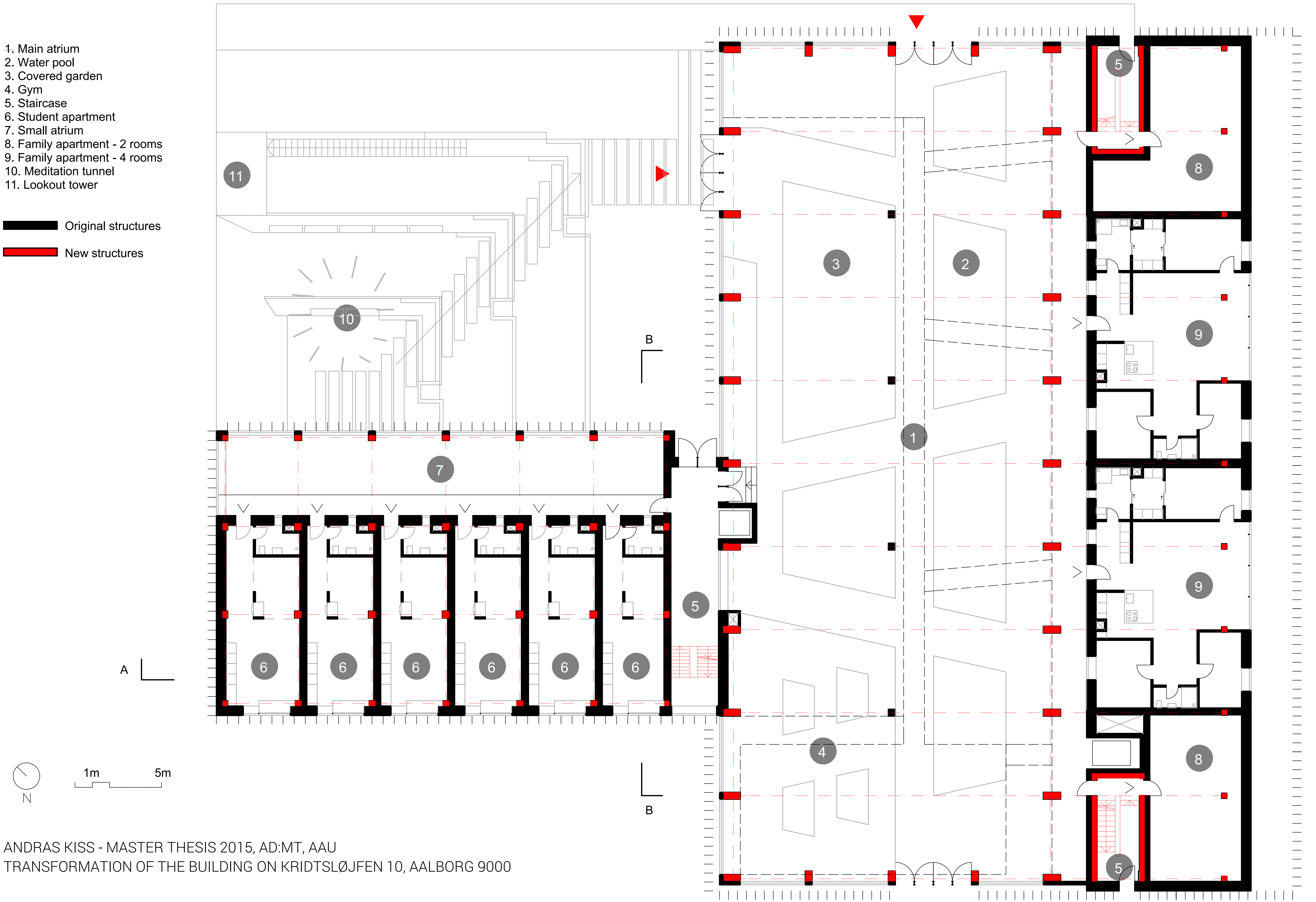
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

NEW FLOOR PLAN, LEVEL 2 1:200

1. Main atrium
2. Water pool
3. Covered garden
4. Gym
5. Staircase
6. Student apartment
7. Small atrium
8. Family apartment - 2 rooms
9. Family apartment - 4 rooms
10. Meditation tunnel
11. Lookout tower

Original structures

New structures



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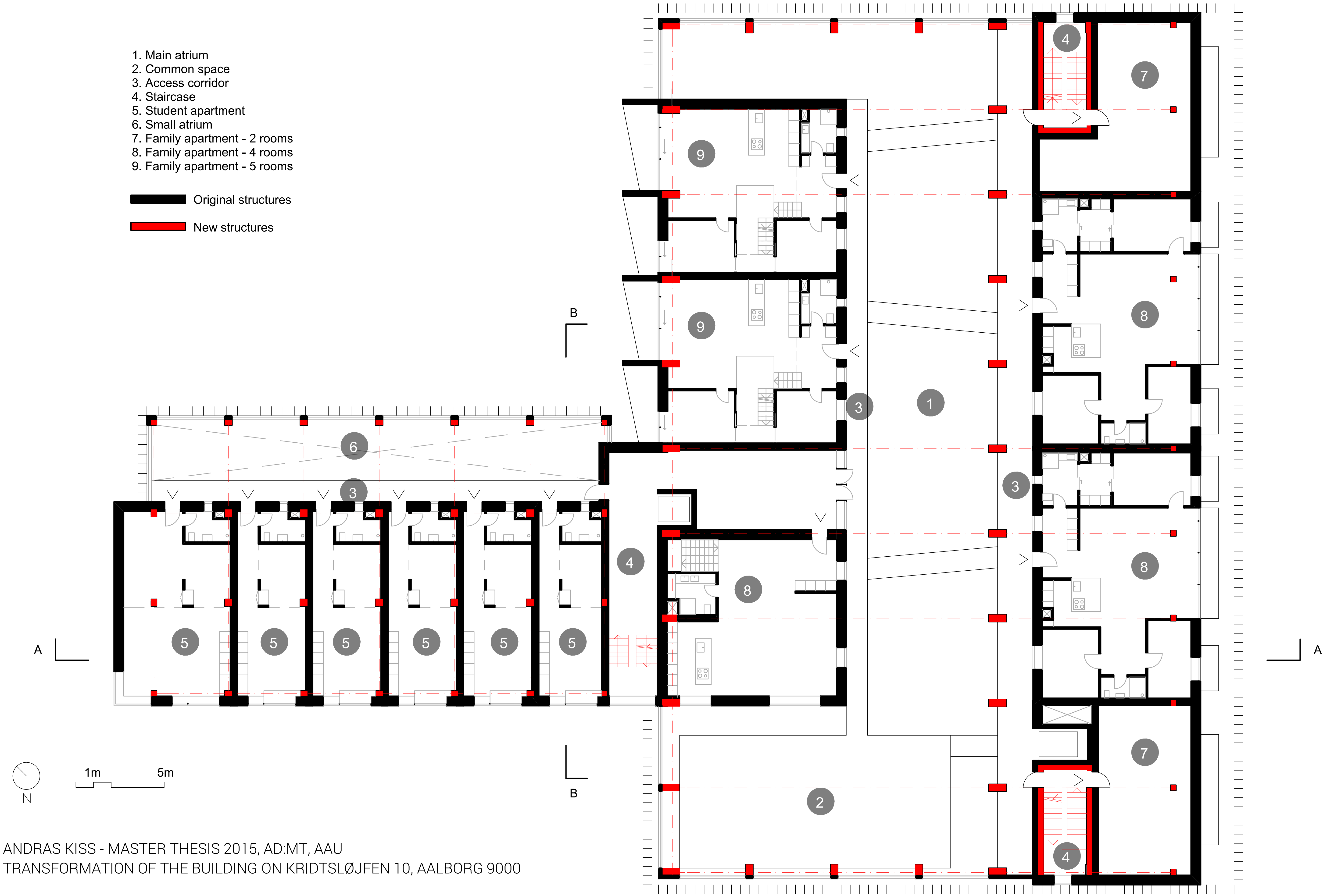
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

NEW FLOOR PLAN, LEVEL 3 1:200



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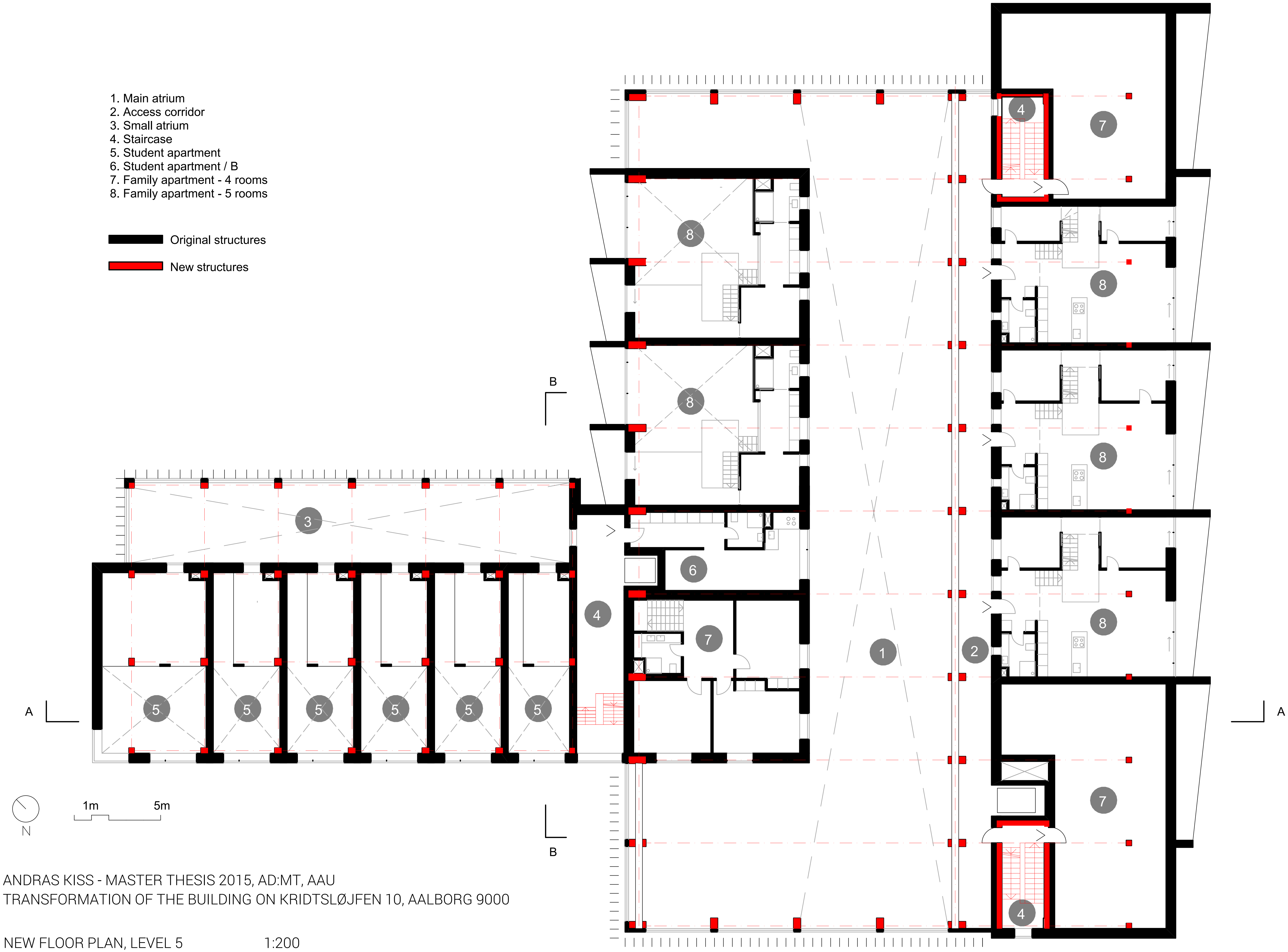
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

NEW FLOOR PLAN, LEVEL 4 1:200

1. Main atrium
2. Access corridor
3. Small atrium
4. Staircase
5. Student apartment
6. Student apartment / B
7. Family apartment - 4 rooms
8. Family apartment - 5 rooms

Original structures

New structures



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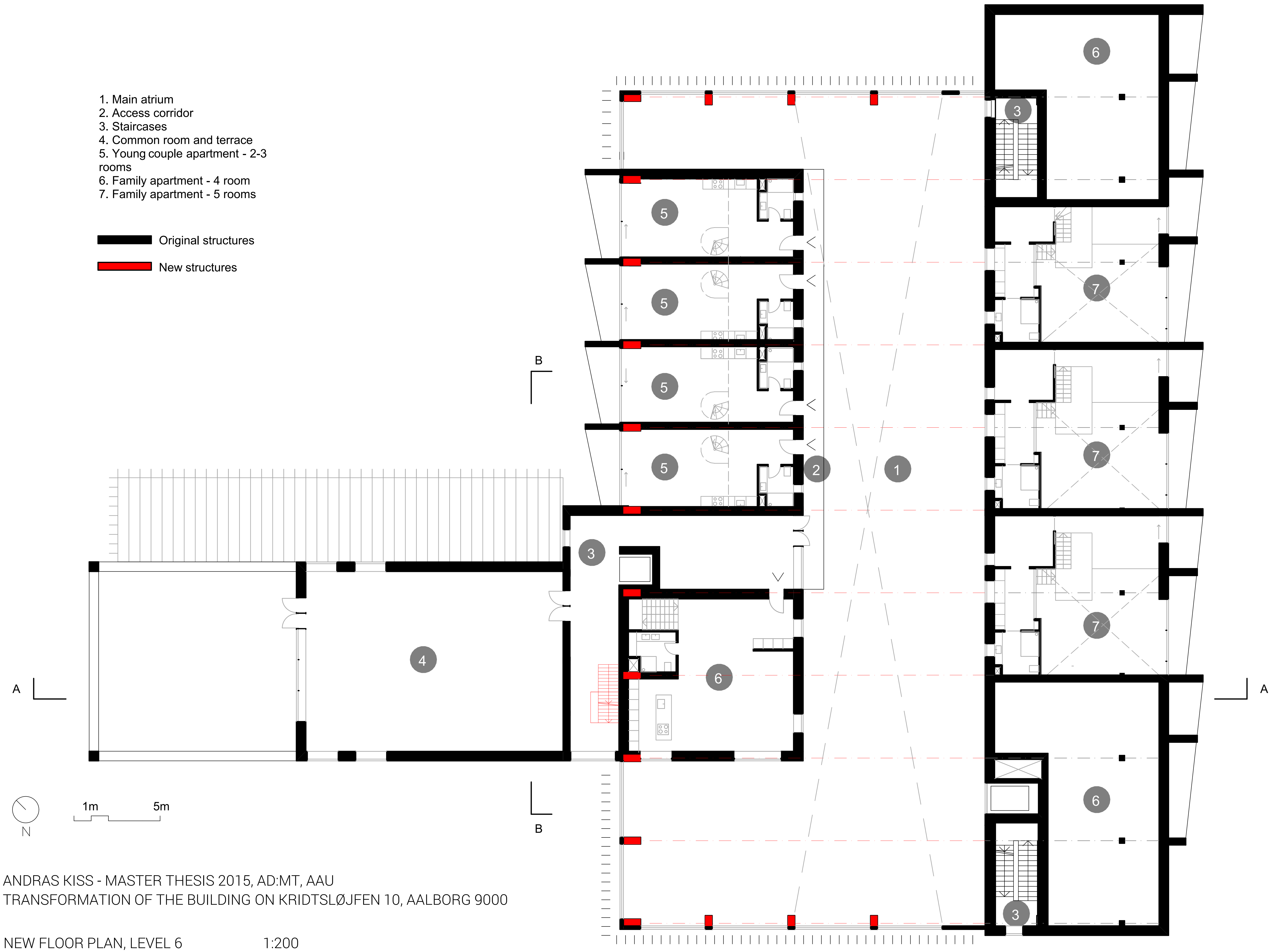
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

NEW FLOOR PLAN, LEVEL 5 1:200



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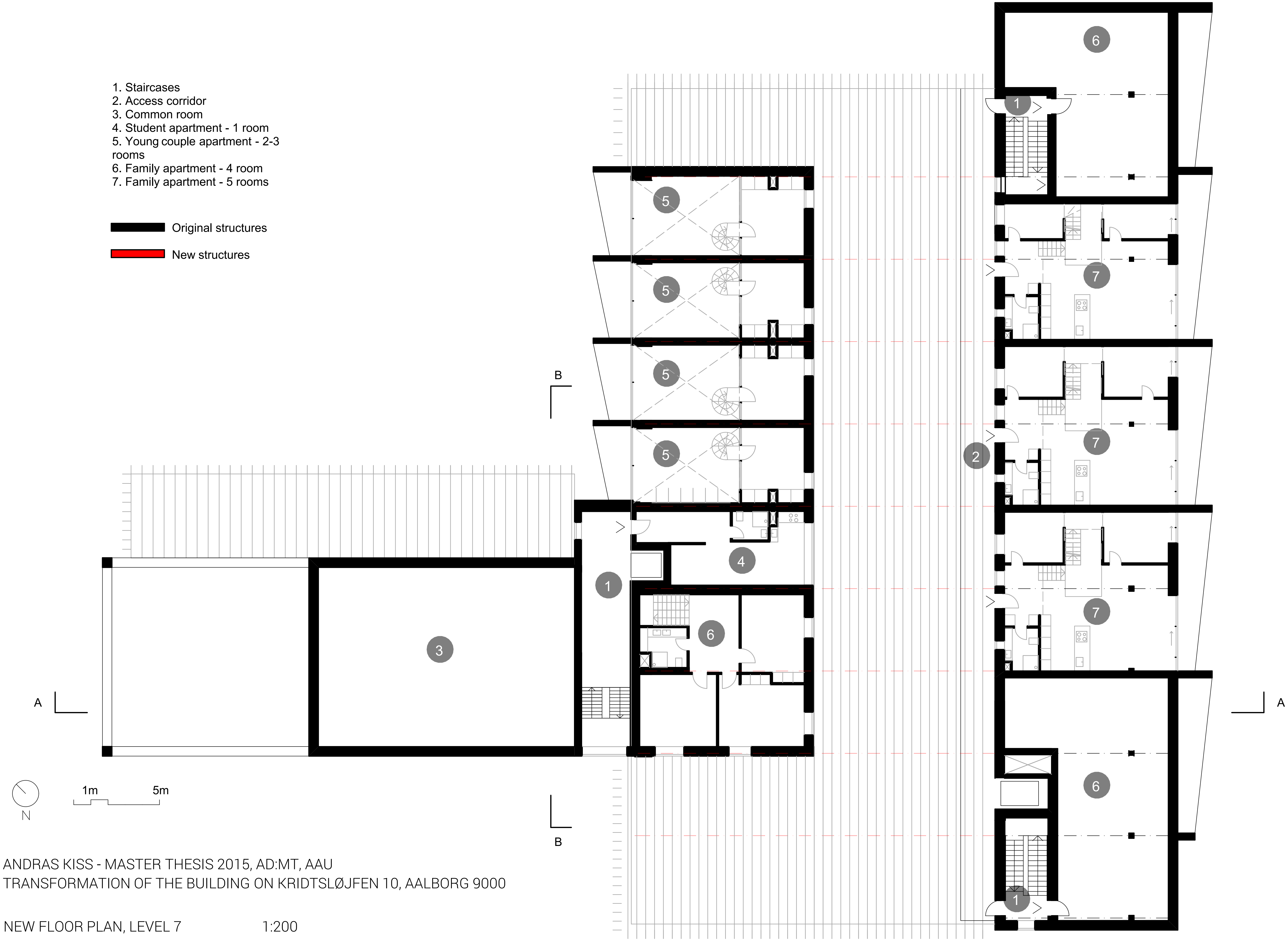
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

NEW FLOOR PLAN, LEVEL 6 1:200

1. Staircases
2. Access corridor
3. Common room
4. Student apartment - 1 room
5. Young couple apartment - 2-3 rooms
6. Family apartment - 4 room
7. Family apartment - 5 rooms

Original structures

New structures



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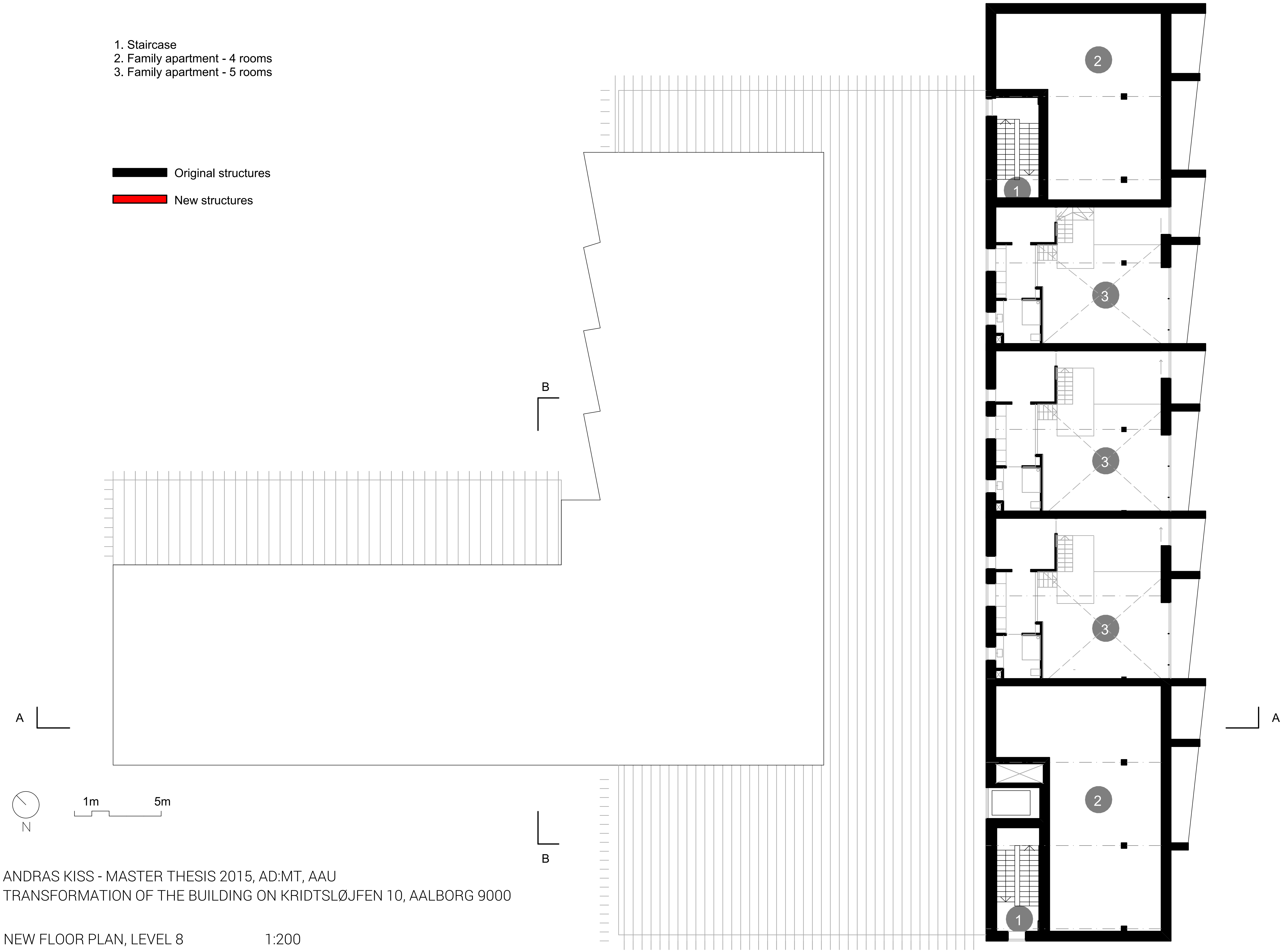
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

NEW FLOOR PLAN, LEVEL 7 1:200

1. Staircase
2. Family apartment - 4 rooms
3. Family apartment - 5 rooms

Original structures

New structures



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TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

NEW FLOOR PLAN, LEVEL 8 1:200

NORTHEAST FACADE 1:250

SOUTHWEST FACADE 1:250

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FACADES 1:250

NORTHWEST FACADE 1:250

SOUTHEAST FACADE 1:250

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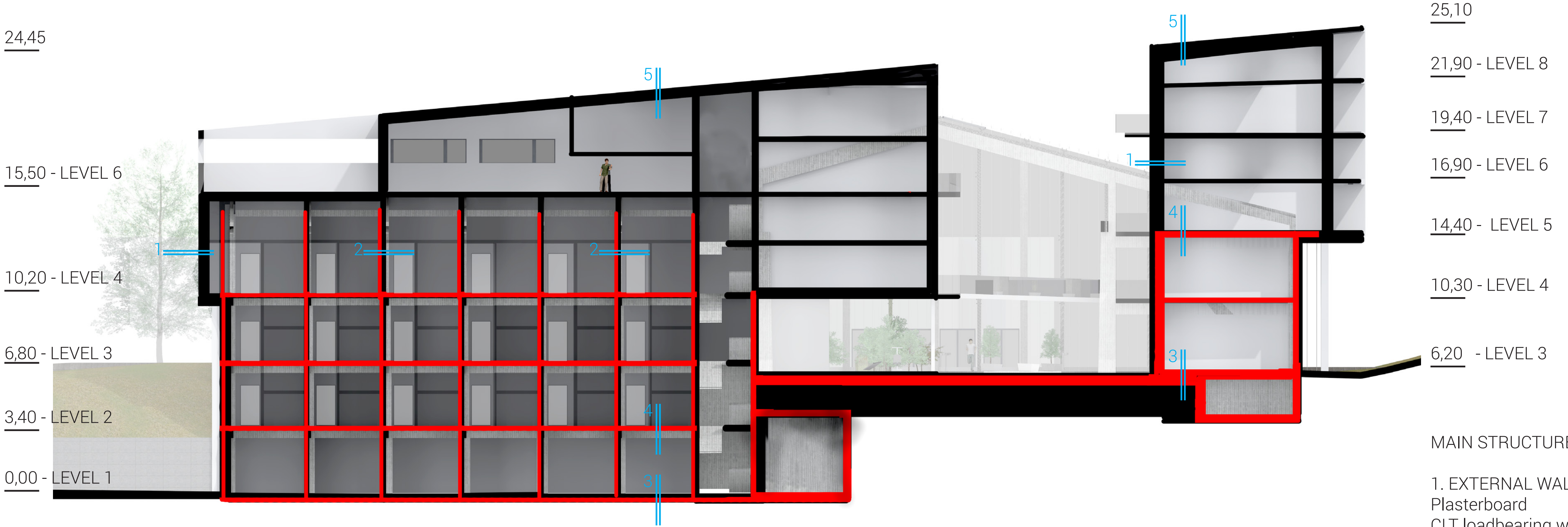
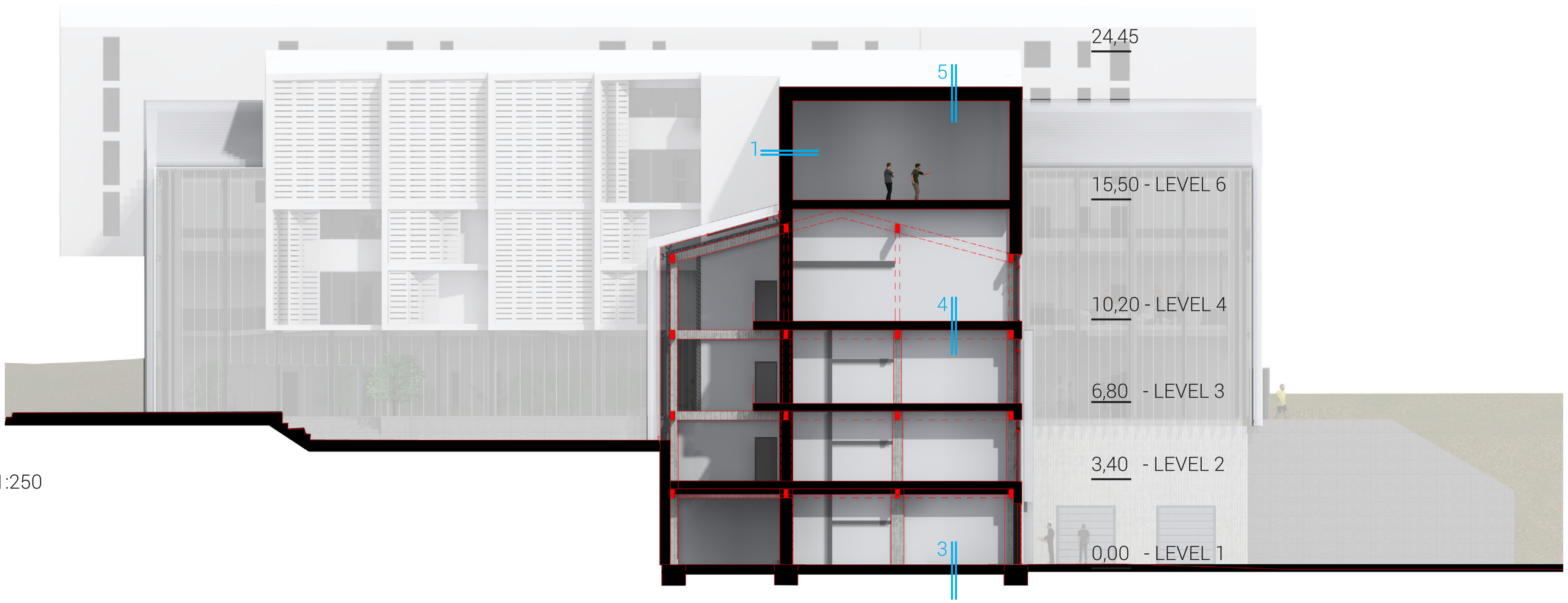
TRANSFORMATION OF THE BUILDING ON KRIDTSLØJFEN 10, AALBORG 9000

FACADES 1:250



Original structure
New structure

SECTION A-A 1:250



SECTION B-B 1:250

MAIN STRUCTURES:

1. EXTERNAL WALL

Plasterboard	1,2 cm
CLT loadbearing wall	20 cm
Rockwool	35 cm
Plaster (white)	1,5 cm

2. WALL BETWEEN APARTMENTS

CLT wall	15 cm
Rockwool	10 cm
CLT wall / existing concrete column	15 cm

3. FLOOR ON GROUND

Nail free timber floor	1,7 cm
PE-foam separation layer	
Screed	5 cm
PE-foil separation layer	
EPS insulation	15 cm
Existing concrete slab	10 cm
Existing Siporex slab	30 cm
Existing concrete	8 cm
Existing gravel fill	25 cm
Ground	

4. FLOOR BETWEEN APARTMENTS

Nail free timber floor	1,7 cm
PE-foam separation layer	
Screed	5 cm
PE-foil separation layer	
EPS insulation	5 cm
Existing concrete slab	20 cm

5. ROOF

2 layer modified bitumen roofing membrane	
Rockwool insulation	45 cm
Concrete slab	20 cm

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SECTIONS 1:250