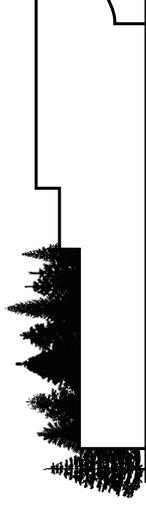


Copenhagen Main Library



MSc04-ARCH22, Juni 2016

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Abstract

This project proposes a design for a new main library in Copenhagen near Axeltorv and Vesterport Station. The current Main Library in Copenhagen at Krystalgade is the most visited cultural attraction in Denmark, and the location needs an upgrade to comply with the amount of visitors. The aim of this project is to create a space that expands the features of the current library and attract even more people, while still keeping the library functions. To do so it is needed to find a fitting location in the center of Copenhagen, that will both create exposure and awareness of its existence - unlike its more hidden predecessor in Krystalgade. The project will work with the block structure of Copenhagen and bring greenery into the city in order to create a place for contemplation and recreation.

Project title: Copenhagen Main Library

About: Master Thesis, MSc04 ARCH
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Group number: 23

Project Period: 01.02.2016 - 25.05.2016

Copies: 6

Pages: 118

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Integrated Design Process

The Integrated Design Process (IDP) enables the designer with the ability to control parameters that should be considered and integrated in the project in order to create a more holistic and sustainable solution. It is an iterative process which means that you always verify the next step with the information previously acquired, which ensures a more complete and thorough design. This is especially needed since there are many requirements and standards that need to be complied with when designing buildings today, and the IDP method makes sure all necessary parameters are considered.

The process starts with a description of the problem and the vision for the project. This is where the direction of the project is outlined.

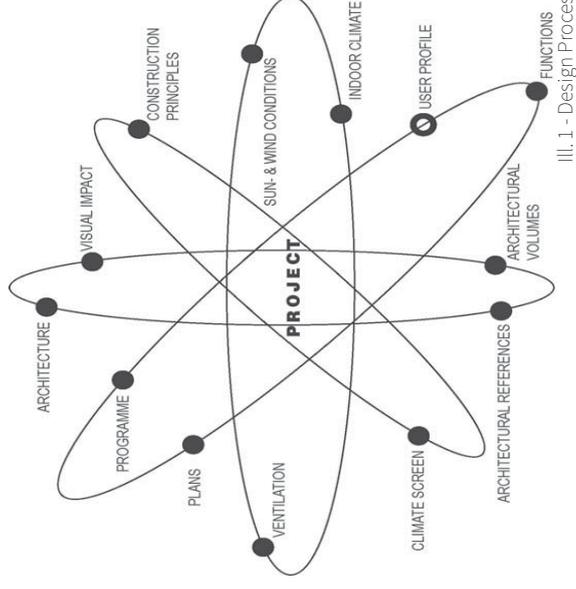
The second phase is where the possibilities and limitations of the building site are being revealed. Analysis of weather conditions, local plans, topography, vegetation and more are done for the area. It is also important to figure out the demands of the users and the client, so the designer knows what should be put in the building in terms of rooms and their sizes. Criteria for indoor climate should also be determined in this phase.

The sketching phase should be based on the information gathered in the analysis phase together with the vision for the project. Design proposals should be formed during this phase and important

design parameters should be determined in order to articulate the best design proposals for further work. The different solutions usually have different strengths and weaknesses so it is important to figure out the most important design parameters to evaluate the suggestions from.

The synthesis phase is where the final form for the design is decided. Every parameter and demand of the design has been met and everything comes together. The project is in its final form and the design is complete.

The last phase is the presentation phase. This is where all the presentation material is being produced and the project is shown from its best sides. Diagrams, illustrations and renderings are being produced to make the project ready for the deadline (Hansen & Knudstrup; P. 894-901).





01 / Introduction

Introduction

The library as a constitution has been one of the grand pillars of society for centuries. Once the sole and prime source for information, its role and function has changed throughout history. Especially through the digital age, the library has seen big changes. The arrival of the Internet has been especially prominent and has greatly affected how we use libraries today.

In today's day and age, the library is home to many different media forms, and while the book is still prevalent, loans are dwindling fast. We do not go to the library for the sole purpose of lending books and magazines. The times they are a changing... The number of visitors are still high, and the main library in Copenhagen and Aarhus are arguably the most visited cultural institutions in Denmark.

So the prevailing question is: How do we make sure that libraries maintains their status in society, while still changing and evolving with time?

This project seeks to find the answer to such a question.

Copenhagen needs a new main library, a building which not only can be a source of information, but a cultural center, bringing the whole city together to exchange knowledge, or just for innocent fun. A new icon for the city branding the Nordic design traditions and lifestyle.

“To ask why we need libraries at all, when there is so much information available elsewhere, is about as sensible as asking if roadmaps are necessary now that there are so very many roads.”

– Jon Bing



02 / Framework

Nordic Design Traditions & Tectonics

The Scandinavian architecture must be able to withstand against a climate with highly varying weather, temperatures, and light conditions. A design situated in this climate must be able to counter act these conditions. Nordic design traditions recognize the importance of nature and comfort, and the functionality in a design is always a great factor when it comes to Scandinavian architecture. The Nordic design traditions resemble that of tectonics where build quality, materials and understanding of their properties are main factors in the design. They also share the use of honesty in a design – the structural elements are often visible and the architects do not try to hide these.

Appreciating nature and bringing it into a design have always been important to the Nordic architecture. A way of doing this could be to use local materials in the residence or simply building in a way that frames the nature from the inside of the building. Natural materials as timber are often used to bring warm colors inside buildings. Nature could also be integrated into the building in the form of natural light sources, which is also a very important aspect of creating designs that fit into the Scandinavian way. Understanding the materials and its uses and limitations is also something that the Nordic architecture has in common with tectonics. Interior design also accommodate the natural light sources and most Nordic buildings use white and brightly colored interiors to maximize the



Ill. 4 - Tietgen Kollegiet

effects of natural light.

Scandinavian buildings also display some very simple and subtle designs with clear lines and solid colors. Usually the facades have no unnecessary features or ornamentation – the lines and shapes of the building require no additional decoration. The clear lines also occur inside of the buildings in the form of open plans and clever use of the space that is available. This is also a very tectonic feature in the Scandinavian design – the building itself and the spaces created are the primary art form that gets displayed rather than decorations.

The Scandinavian libraries have some common features as well, and the style of the libraries is said to be “*light, spacious and informal*”. The libraries also succeeded in being a considerable structure in the cities, and also a building that has many visitors. This makes the Scandinavian library an important place in the community (Dahlkild 2011: 56).

In many ways the Scandinavian library architecture after World War II laid the ground work for how the libraries in the 21st century are designed. They are characterized by large open spaces, few permanent elements, and a consistently implemented modular

system which allow the library to adapt to changes from year to year. No galleries tie down the plan, no walls which will prohibit communication and contact.

The library is not only flexible, it is flexible and rational. The library's possibilities to fulfill its tasks in a rational way is visibility and accessibility.

And even then, the library was characterized as not just an institution focused around the book. The library is a cultural center, with music rooms, exhibitions, lecture halls and study rooms. (Dahlkiid, 2011)

A. G. Curwen reviewed Bengt Hjelmqvist's book 'Folkebiblioteker I Danmark' in 1957 and described the architecture as: "lightness everywhere... These libraries are modern and functional, but they are made pleasant and welcoming by a warm, homely touch." (Dahlkiid, 2011)

Alistair Black concluded on the skandinavian style library architecture: "The attraction that many libraries felt in the 1950s and 1960s towards Scandinavian libraries represented, in essence, a new orthodoxy in library design. Their clean lines, uncluttered space, functional minimalism, and well-lit premise provided environments that seemed like a world apart from the tired Victorian, Edwardian and even inter-war libraries that littered Britain's urban landscapes, despite the efforts of the Luftwaffe to curtail their numbers. The influence of Scandinavian design was crucial to the development of public libraries - as well as a sense of renewal in the library movement more generally - in the 1960s." (Dahlkiid, 2011)

Tectonics is generally regarded as the art of construction, meaning an integration of aesthetics and technology. (Dario Parigi). Tectonics defines the relationship between design, structure, materials and constructional properties.

The following section offers an insight into the essential approach to tectonics and its definition. Ultimately to ensure that the architectural design fulfills the unity between Vitruvius' three pillars



Ill. 5 - The Opera House in Oslo

of architecture; firmatas, utilitas and venustas - that architecture must be durable, useful and beautiful. (Vitruvius)

The construction is a source of inspiration and signification, a process which takes its starting point in the constructional creation. (Anne Beim, 2006)

Tectonics is about the shaping and integration of elements creating a whole. In that sense you can track down a piece of architecture down to its structural core, through the structure to its outer shell. (Anne Beim, 2004)

In 1851, Gottfried Semper published the essay "Die vier Elemente der Baukunst". In it he used a Caribbean hut as the basis from which to deduce the four prime elements of the art of building design. The four elements were: the hearth, the roof, the enclosure and the mound

The mound referred to the elevated podium or earthwork on

which the hut rested. The roof, which provided basic shelter. The enclosure, which protected the hut from the elements. The last element, the hearth refers to the heart of the hut, the source of food and heat, and the social gathering point. (Semper)

Kenneth Frampton put further emphasis on the relationship between the roof and the mound as a conceptual frame in which to analyze architecture. He argued for a need of authenticity in architecture, where a building is first and foremost a construction, and only later becomes a base for surface, volume and plan. Frampton defined that a building, to be tectonic, must utilize the expressive potential of the construction, rather than just reveal it. (Frampton)



Ill. 6 - University Library of Trinity College, Dublin

The function of the library through history

The contents and activities of the libraries:

Until the Renaissance: Collection

From the Enlightenment: Collection + Lending

From the 19th and 20th century: Collection + Lending + Activities

From the end of the 20th century: Collection + Lending + Activities + Digitization

In medieval times and the Renaissance, the library typically consisted of collections in monasteries or in the homes of private collectors. The collections of books usually reflected the interests and hobbies of the owners, and therefore each collection was of a certain order.

With the possibility of manufacturing more copies, the number of books and the accessibility greatly increased. During the Enlightenment, openings of public collections of books began, and the first libraries that resemble the ones of today started emerging – and with this also the possibility of lending books.

It was not until the 1900s that the loan of books became available in a bigger scale. With this also came overviews of which books were out for loan, and a general modernization of the libraries took place to make them similar to the ones we know today. The library underwent a transition to a public space which meant that everyone could equally gather information, and even take the reading material with them. At the same time the library became host of several types of activities during the 20th century.

In the beginning of the 21st century, the library became much more digitalized. The digitization meant that large texts, music



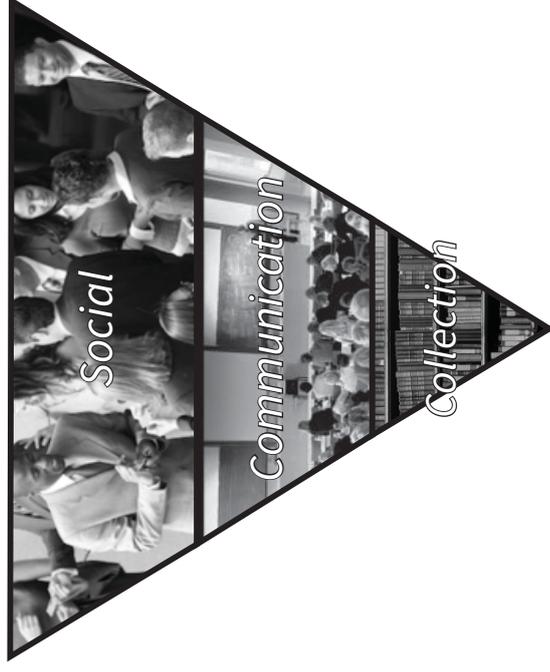
Ill. 7 - Digital Library in South Korea

and other media became available to the broader public, but it has also meant that the library is no longer the main source of information – the internet is (Dahlkild 2011: 14–15).

The library has undergone a lot of changes during its time. It has become a lot more accessible and everyone today can set foot in a library to seek knowledge or participate in activities hosted there. The library itself, in terms of interior design, has changed from being dominated by rooms with shelves of books to a venue of culture, learning and insight (Dahlkild 2011: 69).



The top diagram shows the “old” and traditional role and function of the library. The library used to be the prime source for information and knowledge. Nowadays the pyramid has turned upside down. The library has a lesser role in society as a source of knowledge, but has become a “third place” between work and home, where many groups of society comes for social gatherings.



Ill. 8 - The function of the library

Basis for a new Copenhagen

Main Library

The Main Library in Copenhagen has been located 3 different places in Copenhagen. From 1917 until 1957 at Nikolaj Church, from 1957 until 1993 at Kulturvet, and from 1993 at its current location at Krystalgade 15-17.

However, at neither location, has the library had its own building built for the purpose. The most visited cultural institution in Denmark has never had a real home.

A new main library would further underline the development of Copenhagen as the cultural center of Northern Europe.

Throughout the years, several talks have been made, considering building a new main library. No plans however, has ever come to fruition. Instead the only changes have been minor renovations of the current building. (2010)

Renovations of the current location have not changed the fact that the space is limited in the current facilities. The library is today around 10.000 m² not including the basement.

In 2002 the Kultur- og Fritidsforvaltningen in cooperation with RIA developed "Nyt Hovedbibliotek i København", containing different concepts for a new library building. This folder concluded that a new building would require a floor area of around 20.000-25.000 m².

Even though the amount of borrowed materials has decreased during the last several years. The amount of visitors has increased.

/1917



III. 9 - Sankt Nikolaj Kirke

/1957



III. 10 - Kulturvet

1993

KØBENHAVNS HØVEDBIBLIOTEK



III. 11 - Copenhagen Main Library, Krystalgade



Ill. 12 - Bibliotheca Alexandrina by Snøhetta

Designing a library space

Around the turn of the millennium, the architectural tendency pointed towards a more iconic architecture, this was also true in Scandinavia. For example, Bibliotheca Alexandrina by Snøhetta. A series of metropolitan libraries were built during this period. Like museums or other spectacular buildings, the libraries stand as icons and landmarks. They have become a parameter in the competition between major cities as a means of branding and attracting both locals and tourists.

Furthermore, these new kinds of libraries have played a role in revival of urban areas and to solve social issues.

There is a great variety in the architectural expression, décor, the composition of media and means of organization. The common aspect being the spectacular design as a whole.

Typical for this development has been public spaces with several functions. Books and other materials are still important, however other educational, cultural and social activities play an ever expanding role. Concepts such as "open access" and "open space" are important for these new types of libraries.

The library is defined as 'the third place' between work and home, a place for contemplation and reflection. The libraries are defined by ever changing functions and experiments. (Dahlkid, 2011)



Ill. 13 - Hjørring Library

was, opportunities for informal meetings and social gatherings of the library's many users. (Bedre biblioteker, 2013)

The library as an institution has a large potential to be a meeting place across ethnic, social and economic divisions, and because of that a vital role in the local community.

The prime function of the library is to serve as a meeting place for different people. The entrance area of the library should be open and inviting. It should also suggest and display a variety of offers and functions to accommodate different user groups, and make sure that everybody feels involved in the life of the library.

One of the major challenges in designing a good library space is to make room and flexibility for both quiet contemplation and the project group, the book talk on stage and vocal play.

Activities in the library space

The large open library spaces have to inspire and make the users curious through interaction and exciting communication of what the library has to offer. This can be achieved for example by integrating interactive services involving the user. Another option is to use light, sound, materials and other devices to create a certain atmosphere and mood.

Individuality vs common space

The library has to fulfill contrasting needs. On one end of the scale, there has to be space for individuality. Spaces where one can sit somewhat in private, quiet, calm surroundings. Contrary it is also important to integrate large open areas for social interaction. This is where the library becomes 'the third place' between work and home. This could be lounges, cafés etc.

Furthermore, the library should include space for exhibitions, meetings or other events making the library a gathering point for cultural and communal events. For this a theatre hall, a stage or similar function could be integrated into the design.

- 'Seven deadly sins' by Fed Schlipf and John Moorman
 - *Bad lighting*
 - *Inflexibility*
 - *Bad location*
 - *Complex maintenance*
 - *Insufficient work and storage space*
 - *Bad security*
 - *Signature architecture* (Bryson, 2003)
- Christine Fyfe, *University Librarian at Leicester University*
- *Maximizing natural light*
 - *Providing welcoming and warm ambience with the gravitas of the library*
 - *Creating vistas and visual interest – and intimacy (with nooks and crannies)*
- *Replicating the aesthetics and proportions of the existing building to create a seamless space*
 - *Designing a place that is a pleasure to be in for long periods of time*
 - *Providing clarity and coherence of layout leading to ease of use*
 - *Delivering the most sustainable building possible within the budget*
 - *Using zoning to accommodate a range of behaviors – from silent to social spaces*
 - *Designing settings which encouraged positive behavior* (Rossiter, 2011)
- (Worpole, Ken. *Contemporary Library Architecture*. Print.)
- In 2013, Kulturstyrelsen did a survey, figuring out what the most important function a library should accommodate. The answer

Places for reflection

Similar to the individual spaces, spaces for reflection and peace should be part of the library. These could be spaces with a view to calm surroundings, but also spaces adjacent to more public 'loud' areas, creating what Jan Gehl calls 'passive contact', a place where you can feel part of the community, without taking active part in it.

Performance rooms

Another function to consider is to integrate 'performance spaces': Rooms where users can access tools that support creative and innovative activities. For example, music rooms or tech labs.

Arrival

The arrival area of a library is a complex space. Every user will pass through this area regardless of their errands at the library.

The main function of the space is to invite users into the library space and explore it further. The arrival can also be used for informal social gatherings, maybe placing a café in this area. It is also in this part of the library where you can quickly loan or drop off materials, without engaging further into the library life.

Therefore, the arrival area is complicated to plan. You have to prioritize the many different functions, so they all stand out, without obstructing one another. The experience of the arrival has to have a very clear overview over the library functions, however still ensuring that the user wants to explore deeper into the library. Contrary the arrival cannot just be a clear invitation to the back of the library, because the arrival area still has to exude life and presence.

Steps to insure a warm welcome

A new Main Library in Copenhagen will be a sizeable building. It can therefore be sensible to place a reception or information desk, where a visitor can seek help.

The arrival area should be calm and collected. A place where the



Ill. 14 - Ørestads Biblioteket

user can slow down from the fast paced life outside. A café area or lounge can be a way to create life and social meetings in the welcome area.

The arrival area is where you seek a general overview of the library functions. Clear signs and guidance will help create a clear overview over the building.

The large common space

Every library usually has a large central common space, maybe in connection with the arrival area. This is often times the area, which has the most different functions and services. For example, lounge area, presentation of different materials or a stage for different performances.

- Café
- Stage for performances
- Space for exhibits

Study zone

A library should offer a variety of different entry ways to enlightenment and knowledge. It should appeal to different user groups with a wide span of different needs.

The challenge is to create large open spaces inviting to education, but also more limited closed off spaces which still is in connection with the rest of the library.

The use of the library as a place to study has become one of its most used functions. This area of the library does not necessarily have to be closed off area, since students ask for different study areas, from closed off workspaces to group work and tuition. Flexible larger rooms can be used for meeting and group work. Workspaces can be placed both centrally in the open public area, but also by windows, corners or small niches.



Ill. 15 - Ramp in Dokki

Children's needs

Children's education often works the best in an open learning environment, which is more including towards play and creativity. Many libraries have well-functioning collaboration with schools and day cares. Often classes will visit the library for longer periods at a time. To accommodate this, it would probably be an idea to have a children's zone at the library. A place where the children can both play and learn, without disturbing the flow of the rest of the library.

Workspace for staff

Large formal reception desks are disappearing – replaced by satellite information kiosks or 'hot desks'. Staff can use these when needed, when they are not circulating amongst users. Dutch architect Wiel Arets argues that 'the staff should be able to see that they are working in a library, not just any old office building.' Traditionally the staff has been hidden away in basements or small rooms cut off from the ethos of the public space. (Worpole, 2013)

Opinions and statistics

The amount of material loans has been falling steady during the past years. However, the number of visitors and active loaners have been growing steady during the same period. This underlines the library's changing identity. Its traditional function may be declining, however it becomes overall more important as a social gathering point. (Danmarks Statistik, 2016)

User segments general opinions

Service (and the library being a nice place to be) is by far the most important issue for all user segments.

For the older users, the possibilities for contemplation are important for general satisfaction.

The library as a source for inspiration means relatively more for younger user groups (under 45) than the older users.

Be cautious of changing initiatives that can change the experience of getting the help you need and a attentive staff.

There can be conflicts between the wants of the youngest and older user groups in relation to play and contemplation. (s 45)

It is essential to maintain the level of service, and to maintain the library as a nice place to stay.

what the library can do.

To areas which can help improve the satisfactory level.

- Users using the events offered by the library are more satisfied.
- Areas for contemplation is important, especially for the older user groups. (p. 46) (Resultater og anbefalinger, bedre biblioteker 2013)

- For groups (especially students) who have very little contact with the staff, it can be important to show other facets of



The libraries are the **most visited** cultural institution
Number of visitors to public libraries is steadily around 36 million a year



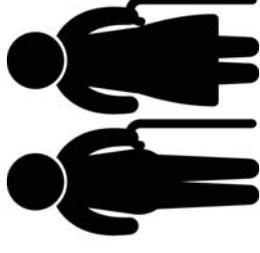
Service is by far the most important quality at the libraries



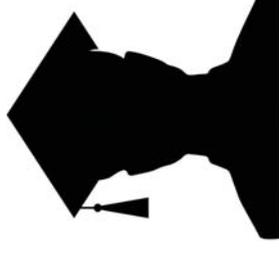
The library as a source of **inspiration** and **events** are
important for all user groups



Overall loans are **declining**
From 48 million in 2009 to 37 million in 2014



Older users finds space for **contemplation** especially important



Students does not interact with the staff, and needs **different stimulus**

<http://www.arkitekturfoto.com/arkitekturarkiv/Havnefronten%20-%20K%C3%B8benhavn/Den%20Sorte%20Diamant/slides/Den%20Sorte%20Diamant%203.jpg>

Wants and needs for new location

There are some general requirements for the new placement of the library building.

The new Copenhagen Main Library should be placed central in the city, to ensure maximum exposure of the library and utilization of its services. This could also be a way to connect the library with other culturally important facilities.

The building should be clearly visible in the cityscape.

According to a preliminary analysis done by the municipality, a new library building would require a ground floor area of 20.000-25.000 m². This would require a building site of a certain size in the city center of Copenhagen.

(Byens hus: foranalyse til nyt hovedbibliotek i København 2008 (2003))



Ill. 17 - Den Sorte Diamant

Copenhagen

Copenhagen is the Capital of Denmark and its largest city with a population of 1.26 million people (Danmarks Statistik, 2015). The city is the administrative, economic and cultural center of Denmark. Thus, key institutions such as the Parliament, the Danish Royal Family, the Supreme Court and the central administration is placed in the city. Its cultural and logistical importance in Scandinavia can be seen in it having the largest airport in Scandinavia, the largest train station in Denmark and one of the biggest ports. Furthermore, Copenhagen is also home to the most iconic cultural institutions in Denmark such as Tivoli, Parken, The National Museum and The Opera. Today, the city is also an economic driving force in Northern Europe, with companies such as A.P. Møller, Carlsberg and Novo Nordisk having their headquarters in Copenhagen.

Copenhagen is also home to the largest number of university students in any Danish city with over 100.000 (KU).

The architecture of Copenhagen cannot be described by a single movement, since it consists of several different ages of buildings. A fire in 1795 destroyed a great deal of old buildings, but there are still some left from before the fire such as Sankt Petri Church and Konsistoriehuset, which are both from the early 1400s. Architecture in Copenhagen is really diverse with a mix of old and modern buildings. (Den Store Danske)



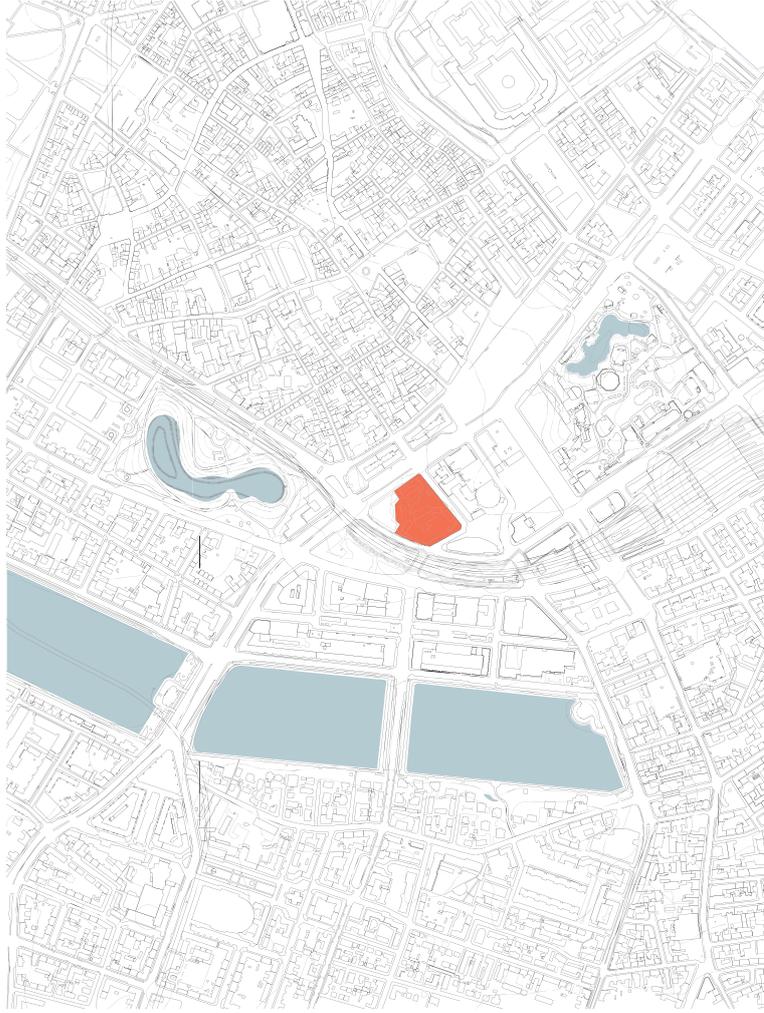
Ill. 18 - Map of Denmark

Vandværksgrunden

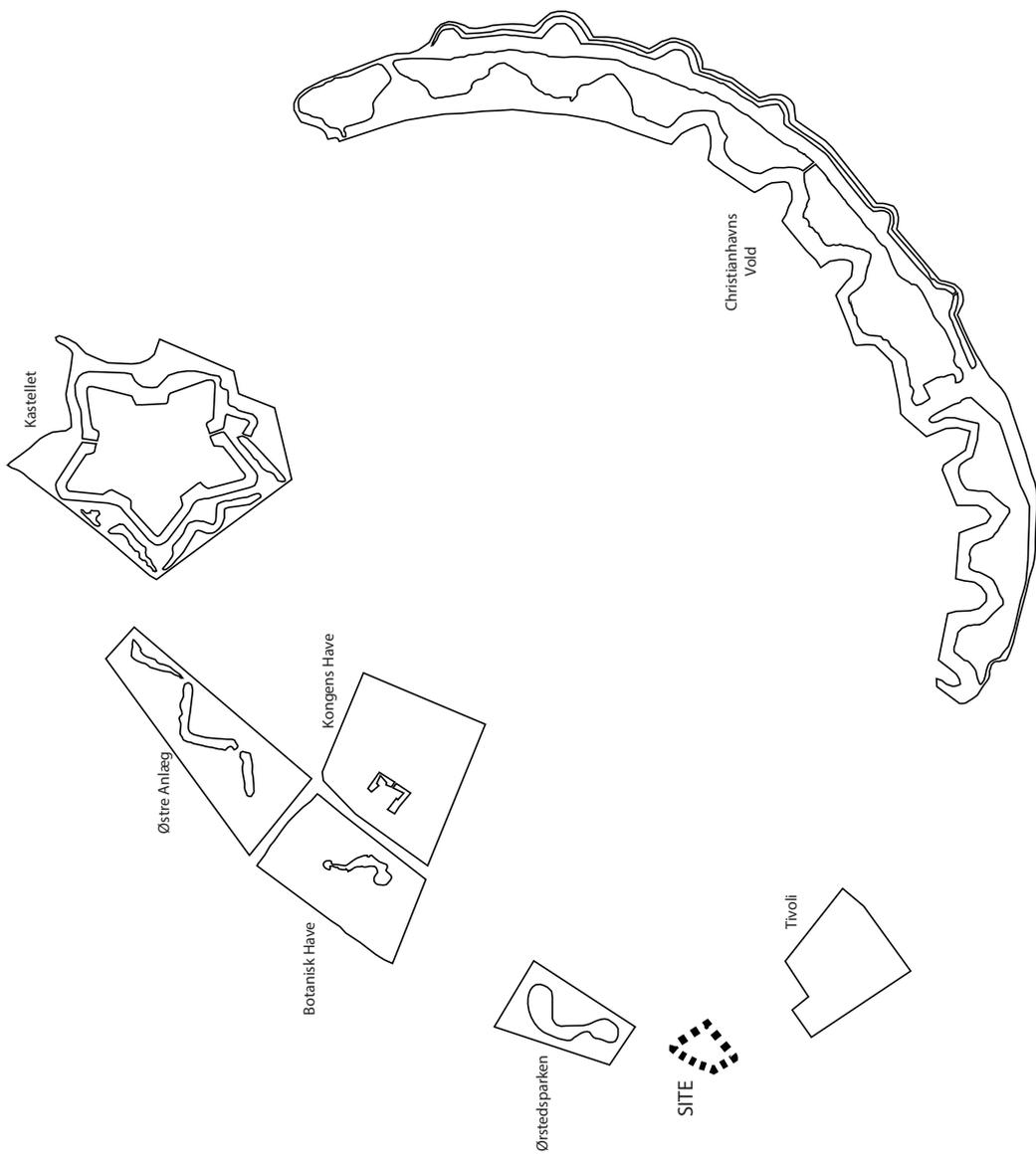
Vandværksgrunden is located central in Copenhagen close to Vesterport Station and Tivoli. Zooming out the site is part of a green ring called Fæstningsringen consisting of Tivoli, HC Ørstedsparken, Botanisk Have, Østre Anlæg, Kastellet and bastionsrækken at Christianshavn. This would also make it relevant to integrate green areas in the overall design of the new library.

A local plan does not exist for the site, however a plan regarding the site just south from Vandværksgrunden states that a building must not be taller than 31 m. (Lokalplan 496)

Currently the site holds many different buildings. Pumpehuset, a concert venue might be worth saving, or somehow integrating it into the new space. However, integrating it into the building as it is now would require that the new library would be built around the venue.



III. 19 - Site Location in Copenhagen



III.20 - Fæstningsringen

Case study: Copenhagen Main Library

Location: Copenhagen, Denmark

Client: The Municipality of Copenhagen

Year: 1993

Program: Library for the city of Copenhagen, Denmark

Area: 10000 m²

The current main library of Copenhagen is a building with open floor plans and a large atrium with a skylight that lights up the entire building. You almost enter the atrium as soon as you walk through the main entrance of the library – there is a small lounge area first. This makes the building transparent and easy to navigate for the visitors. Openness and transparency seem to be something that was a priority when the building was designed.

There are many places to sit in the library. Each floor has got at least 50 chairs or other objects that can be used as a stay. Many of these are placed so they face the atrium. This brings a certain atmosphere to the facility, as it is always possible to see other people – it is a feeling of being part of a community with a common agenda. There are also places to stay in the library that are a bit more private and hidden, so no matter your preference, there is something for everyone. There is also variety in the type of seating at the library; there are both normal chairs but also softer options as sofas and armchairs – so whether you are working with your



Ill. 21 - Copenhagen Main Library Atrium

laptop or just reading a book, there is a place to sit that fits your needs.

When walking past the building outside there really is not anything to suggest that it is a library, other than the writing on the building. The building blends in with the rest of the street and does nothing to get people's attention. The library in Copenhagen is the city's most visited cultural building, so the fact that it does nothing to stage itself seems peculiar. The entrance can basically only be seen if you stand right in front of the building. The interior of the building has a white base and dark flooring in



Ill. 22 - Copenhagen Main Library Atrium

the atrium. There are escalators floating in the atrium to all the floors. Wood detailing has been used in the atrium at some of the openings to give a warm contrast to the otherwise rather colorless material choices. The shelves with books in all kinds of different colors also help bring some contrast to the black and white interior, and it gives the books a certain kind of attention that stages them.



III. 23 - Outside Copenhagen Main Library

Case study: Seattle Central Library

Location: Seattle, USA

Client: The Seattle Public Library

Year: 1999-2004

Program: Central library for Seattle's 28-branch library system, including 33,700 m² of hq, reading room, book spiral, mixing chamber, meeting platform, living room, staff floor, children's collection, and auditorium, and 4,600 m² of parking

Area: 38,300 m² (412,000 sf)

Cost: \$169.2 million (project)

Architect: OMA | LMN

The Seattle Central Library is to many the defining "new" library of the 21st century. This building redefined the libraries, no longer an institution exclusively dedicated to the books, but now to all forms of media.

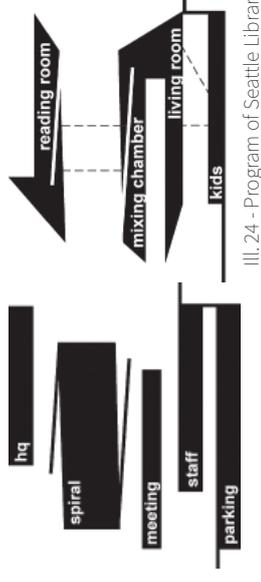
The inside of the building is flexible throughout every plan; no function or arrangement is specifically designed for a certain floor. The idea was to make it flexible for future expansions, making it possible to create group spaces according to different needs, and also providing open spaces for work and social interaction.

This ambiguous flexibility means that the library could promote a more distinguished approach in organizing the libraries spatial sections, each dedicated and equipped for specific functions. The

space would be flexible within each compartment, but without the danger of one section obstructing another. (Arch Daily, 2009)

The flexibility might also be one of its major flaws. There is no doubt that the library has done its job for the city of Seattle as an icon for the city. The library also seems like a work of wonder when you first glance at it, and walk around it for the first time. However, when you spend more and more time in the building, you become aware of its shortcomings. The building lacks 'warmth'. The problem lies especially with its more intimate spaces and functions. The materials used and the spaces created for intimate study and reading do not comply well at all with the quiet and calm atmosphere of a library.

The library is both inside and outside so radical that the only remaining part of the traditional library is the book shelves. The building is of theatrical dimensions, and it seems to have no time for contemplative thoughts for the individual. (Lawrence Cheek, 2007)



Ill. 24 - Program of Seattle Library



III. 25 - Seattle Library

Case study: Halmstad Library

Location: Halmstad, Sweden

Client: The Municipality of Halmstad

Year: 2004-2006

Program: Library for the city of Halmstad, Sweden.

Area: 8000 m²

Cost: €17 Million

Architect: Schmidt Hammer Lassen Architects

The Halmstad Library is situated within a park next to the Nissan River. The building extends from the city, through a group of trees and out above the river. Round columns carry the structure in the river, and the building as a whole become very light due to this. An atrium in the center of the library is encircling a large chestnut tree to bring nature in to the building. The façade consists of con-

crete glazing suspended between the floor and the roof – giving the illusion that the floor-plates are floating. The glazed facades make the library transparent and nature almost becomes part of the construction itself. Every opening reveals the nature outside. The open floor plan of the library makes it very easy to navigate through, but it also brings everything together. Similarities between the vertical columns of the library and outside trees make sure that the library fits well within the surroundings. The material choices are very few and simple; concrete floor-plates and columns, glass facades and larch floor cladding. This also ensures that a great deal of natural lighting gets into the building since the materials reflect a great deal of light.

The Halmstad Library acts as a link between the city and nature (Roth 2011: 219).



III.26 - Halmstad Library

Case studies conclusion

Going forward, there are several features from the each of the libraries in the case study that should be implemented in the design of Copenhagen's new main library.

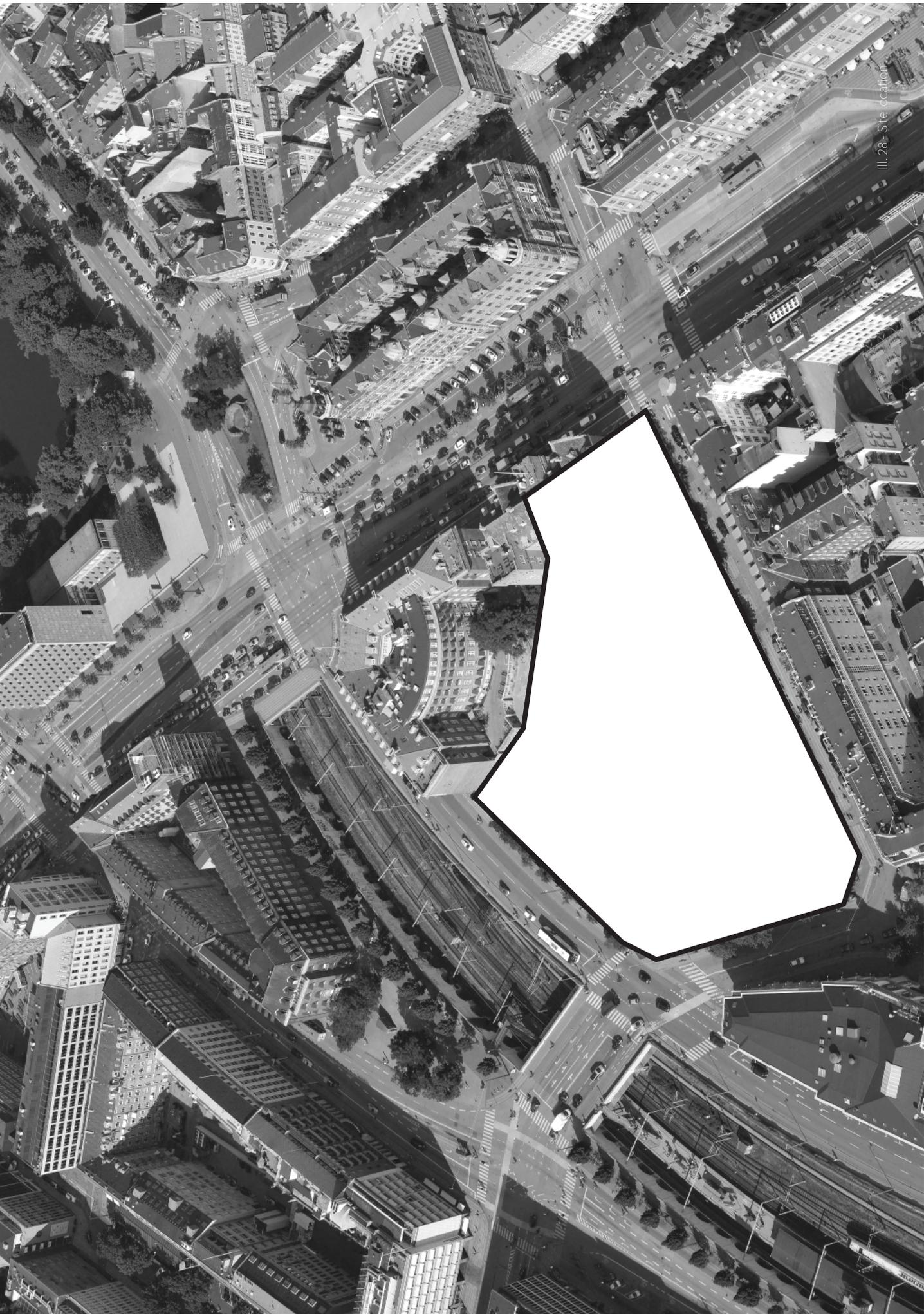
The Halmstad Library in Sweden connects the city with nature, which is a feature that can help create a place for contemplating and recreation. The barrier between inside and outside is broken down with the translucent façade, and nature is drawn in to the building.

With the Seattle Library, OMA has succeeded in creating an icon and a gathering place for the whole city. The library receives a great amount of exposure – this is due to the placement of the building, but also its theatrical design. A new main library in Copenhagen should also create awareness of itself. The interior of

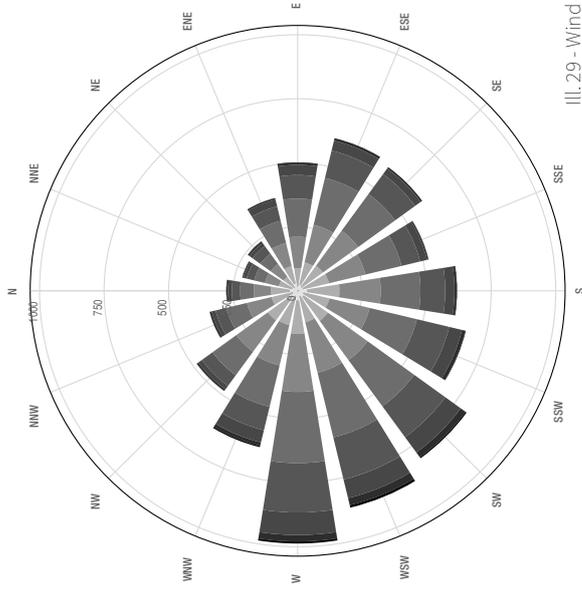
the Seattle library is very open and designed with flexibility in focus. These features would also be an asset to a library in Copenhagen, since it would allow the library to change over time if the needs for room types should change.

The current Copenhagen Main Library offers a great diversity in areas for studying. Many students of the various universities and institutions in Copenhagen use the library as a meeting place when studying. There are multiple different seating options in the library – both for groups and individuals. The library has open floor plans with a large central atrium to obtain an overview of the complex. These features are appreciated in the current Copenhagen Library and should be preserved in the new library.

03/site



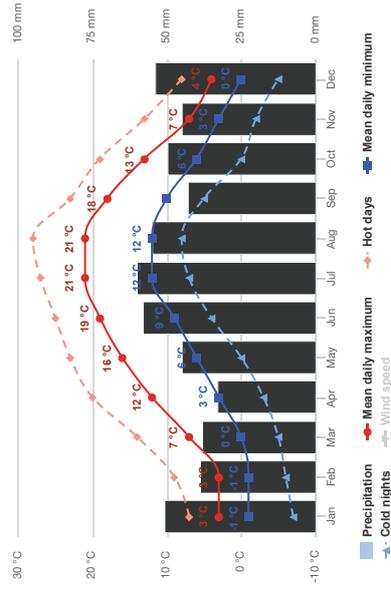
III. 28 - Site location



Ill. 29 - Wind

Wind

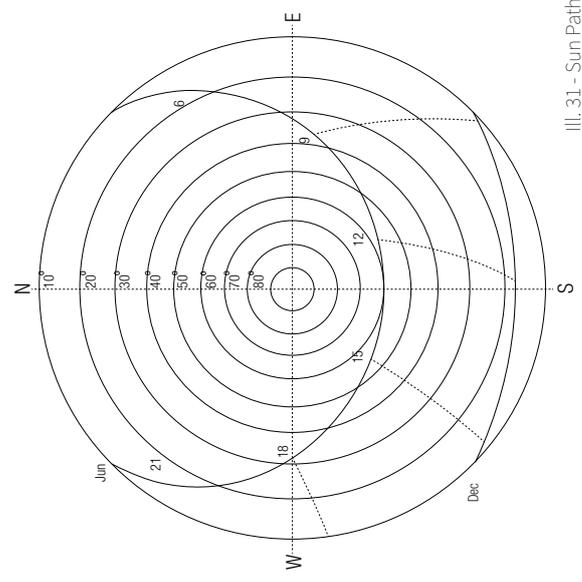
In Denmark the wind predominantly blows from west. It is possible to utilize the wind for natural ventilation, but it can also create unpleasant environment on public spaces, which the project need to address. (Meteoblue, 2015)



Ill. 30 - Precipitation

Temperature & precipitation

Denmark does not experience extreme hot or cold seasons. It varies from a mean daily minimum just below freezing during the winter, and a mean daily maximum of just above 20 degrees celcius during the summer. This means, that building should both be able to cool during summer and maintain heat during winter. Autumn is the season with the most precipitation in Copenhagen, however rain fall occurs during the whole year. This means rain water can be utilized in the design - as grey water in buildings and for outdoor greenery. (Meteoblue, 2015)



Ill. 31 - Sun Path

Sun

The amount of sunlight in Denmark varies greatly, the shortest day is in winter solstice, with only 7 hours of sun compared to summer solstice, the longest day provides 17,5 hours of sun (DMI). The sun angle is down to 12 degrees in the winter and up to 58 degrees in the summer. In general Denmark the amount of sunny days changes according to season. It is important to notice sun in the design of the building, both as a light source, and its impact on human mental and physical well being, as well as the impact of sunlight on energy use for heating and cooling. (Meteoblue, 2015)

Shading

The shading diagram shows the shading conditions on the site on three different times of the year: Summer Solstice, the 22nd of June, Fall Equinox, the 22nd of September and Winter Solstice, the 22nd December.

The diagram shows that there is actually very little shading on the site all year around. It is only during the winter that the block south of the site will have an impact. And at this time of year it will not make much of a difference anyway.



III: 32 - Shading in the area



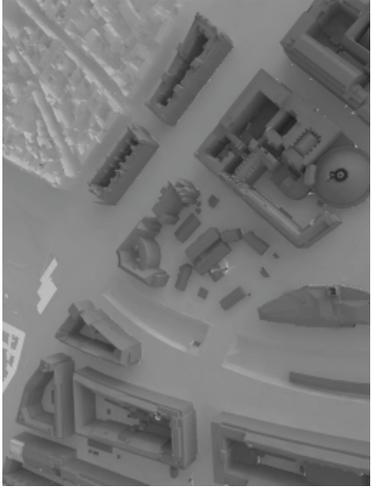
Summer Solstice 09:00



Summer Solstice 12:00



Summer Solstice 15:00



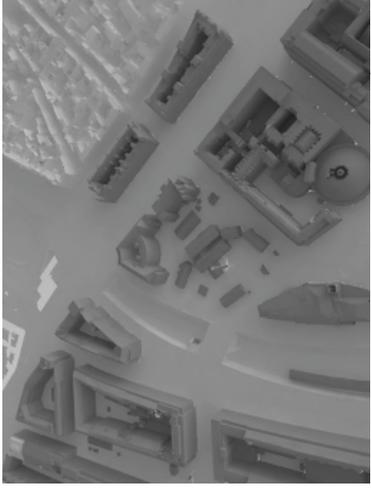
Equinox 09:00



Equinox 12:00



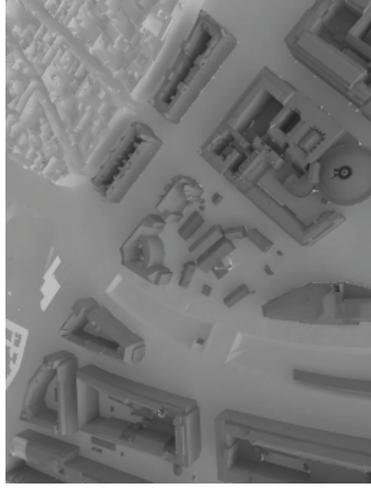
Equinox 15:00



Winter Solstice 09:00



Winter Solstice 12:00



Winter Solstice 15:00

III. 33 - Shading at the site

Infrastructure

The site is surrounded by Studiestræde, H.C. Andersens Boulevard, Hammerichsgade and Axeltorv. Roads which are very different in size and feel.

H.C. Andersens Boulevard north of the site is the busiest regular road in Denmark, with around 50.000 cars and 20.000 cyclists passing through on a daily basis (Københavns Kommune, 2013) Axeltorv is a public square south from the site, where Cirkusbygningen an Palads is located. In 2016 the new Axel Towers, home to offices, cafés and shops, will open to create more life around Axeltorv.

Hammerichsgade is a larger road (7000 cars and 6000 cyclists) west of the site running alongside the railway tracks. (Københavns Kommune, 2013)

Studiestræde is a street south of the site, running from Axeltorv through the inner city to Vor Frues Kirke. The street is filled with small shops and cafés.

From the site there is also easy access to public transportation.

The S-train station Vesterport Station is located right by the site.

Both the Central Station and Nørreport Station, which also includes a metro station is in walking distance from the site.

The site is furthermore located in very attractive distance to calmer surroundings, for example Ørstedsparken, a green park area, or

The Lakes just west of the site.



III. 34 - Surroundings

Serial Vision

The site itself is hidden away by fences or buildings all around it. It is definitely not a place made for longer stays but rather just a place made to pass by. Adjacent to the site is a heavy trafficked road that creates a sort of border to the other side of the road. The road and its sidewalk are not friendly for pedestrians – this is due to both the fast traffic but also the noise created from this. It is not pleasant to walk on the east side of the site because of this.

The road west of the site is also not made for pedestrians. The sidewalks are narrow and the road is heavily used. This means that the site almost becomes isolated from the traffic and it is definitely noticeable when walking there.

Accessing the site becomes a lot more possible when coming from the south. The road there is not very busy, and adjacent to Palads and Cirkusbygningen there is a square for pedestrians only. The pace from the south is a lot calmer because of this.

The site is very rejecting in the sense that it does not open up to its surroundings in any direction. You almost get funneled towards the site from the south, but once you reach the site itself it closes off. The area is characterized by car traffic and fast pace which does not attract pedestrians.



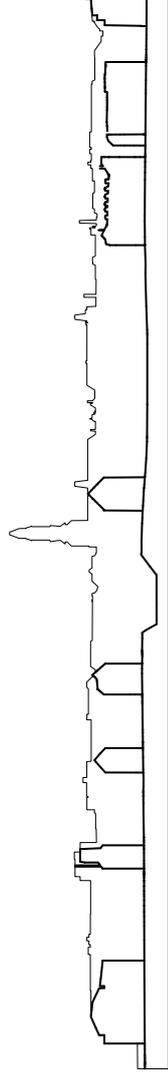
Ill. 35 - Pictures around the site

Scale

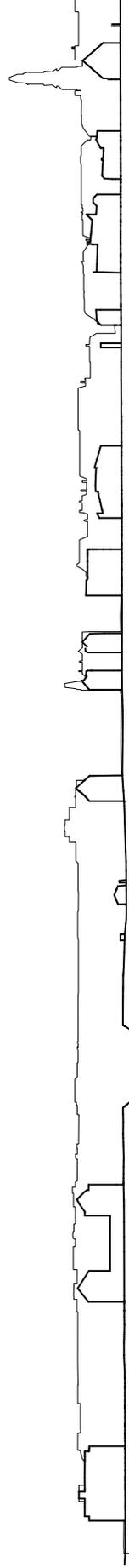
The scale of the buildings around the site is quite characteristic for all of Copenhagen. Most surrounding buildings are between 6-8 stories tall.

The site is placed in a dense city context made of block structures. However the specific block that makes up the building site is actually somewhat more open compared to its surroundings. This is because the railway runs next to the site, and the busy roads running along the site.

According to the local plan for one of the neighboring blocks, the maximum building height is 31 meters (Dagmarhus, kommuneplan, 2013).



III. 36 - Scale from south



III. 37 - Scale from west



III. 38 - Scale of site

Typologies

Palads is located just south west of the site. The building is made in a neo-baroque style and it really differs from the surrounding buildings in the area. Its exterior has been painted in pink, light blue, orange and white, so it really separates itself from the rest of the city. It acts as a cinema and there are a lot of visitors to the building.

Cirkusbygningen is also placed nearby the site. It is also a building with a lot of visitors as it is used for concerts, performances and similar events. The characteristics of the building are its large dome and round shape that makes it stand out. There is currently also another set of buildings being made in the area with a round shape – the Axel Towers. The towers are situated a bit further

south from the Cirkusbygning. When they are finished the tallest tower will be 61 meters tall, so it will be quite a landmark for the city – especially since most buildings in Copenhagen are six or seven stories tall.

On the building site itself there are two brick buildings that will need to be preserved. They are made in a red-toned brick and are 6-7 stories tall. H. C. Andersens Boulevard is a large road just to the east of the site, and the two brick buildings act as a shield for all the noise that comes from the highly trafficked road.

The area is not characterized by a specific architectural style but rather many different styles. Some of the surrounding buildings follow the scheme of the block typology, and others are placed

independently with no real coherence to the adjacent buildings. The site and its surroundings are in need of a building that can help tie the area together architecturally. Designing buildings that are disconnected with the rest of the city will definitely make it stand out in the city, but if every building is designed to stand out, the effect of this will faint. Building within the traditional block structure of the rest of the city could therefore prove to be the best option for a new library in this context.



Ill. 39 - typologies in the area

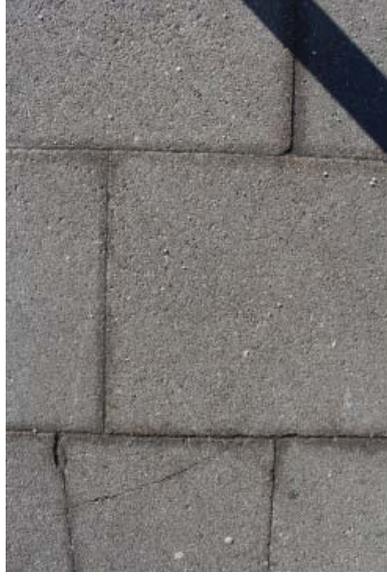
Materiality

The materials used on and around the site are very different in style and texture. Like most of Copenhagen, brick and concrete are the preferred material of choice due to its neoclassicist and modernistic style.

The materials used on the ground is also very typical for the city. Cobbles or regular paving is used for pedestrian roads and regular black asphalt is used on the roads. There is not much greenery around the site. The only greenery is actually on the site itself, where large trees surround the site. This will be a focus point to implement and keep this green environment on the site.

The color scheme is also very traditional. Red and yellow bricks dominate the scene, with some white or grey concrete thrown into the mix.

Especially one building takes a lot of attention at the site. Palads Theatre's strong pastel colors dominate the cityscape, but also underlines the variegated environment that the library will be a part of.



III. 40 - Materials in the area

04/Room Program



Room Program

The library will have 5 main departments: An Experience Area, a Factual Area, an Information Area, the Logistics and Administration.

The Experience Area includes: Children and Young People, Danish and Foreign Fiction, Art and Music. The Factual Area includes History and Geography, Humanities and Social Science, Technology, Nature and Medicine.

Each of the four main departments includes an audience section, activity/meeting rooms and offices. The logistics/handling is placed in connection to the entrance, lounge area etc.

In relation to the distinct areas is placed multimedia facilities. The Learning Centre with IKT-auditoriums and meeting facilities for education of both audience and employees will be integrated with the large meeting rooms or the Factual Area.

In connection with this are technical facilities, depot, wardrobe, bathrooms and kitchen facilities.

The café will be placed on the ground floor. A canteen/restaurant can be placed on the top floor.

The Administration includes meeting rooms for the management, office spaces for employees working with management, economy and HR administration, kitchenette, wardrobe and bathrooms.

This section will be in close relation with the Development/IT department and a small department for outsourcing assignments.

A new large conference and meeting department with auditorium, a multi-functional hall, which can also be used for music or theatre. (Biblioteksstyrelsens Udviklingscenter, 2003)

The plans can presentation chapter of the booklet.

Ground Floor	<i>Function</i>	<i>No.</i>	<i>Total m2</i>
	Kids and Youth Section	1	
	Fiction Section	1	
	Art & Music Section	1	
	Reading Room	1	153
	Activity Room	2	38
	Project Room	7	302
	Exhibition	1	
	Book Store	1	77
	Café	1	
	Kitchen	1	52
	Lounge	1	
	Self-Service	1	
	Sorting/Delivery Area	1	212
	WC	16	52
	HC WC	6	42
	Pumpehuset	1	333
	Total		5824

2nd Floor	<i>Function</i>	<i>No.</i>	<i>Total m2</i>
	Offices	28	594
	Meeting Rooms	6	311
	Lounge Area		
	Printer Room	1	21
	WC	8	40
	Kitchenette	2	
	Total		3518

1st Floor	<i>Function</i>	<i>No.</i>	<i>Total m2</i>
	Humanities & Social Sciences Section		
	Science Section		
	History Section		
	Auditorium	2	597
	Reading Room	1	114
	Project Room	13	317
	WC	16	52
	HC WC	6	42
	Storage	1	23
	Total		6285

3rd Floor	<i>Function</i>	<i>No.</i>	<i>Total m2</i>
	Offices	23	433
	Meeting Rooms	5	250
	Lounge Area		
	Printer Room	1	21
	WC	8	40
	Kitchenette	2	
	Canteen	1	
	Kitchen	1	48
	Total		3155

Total **18782**

Vision

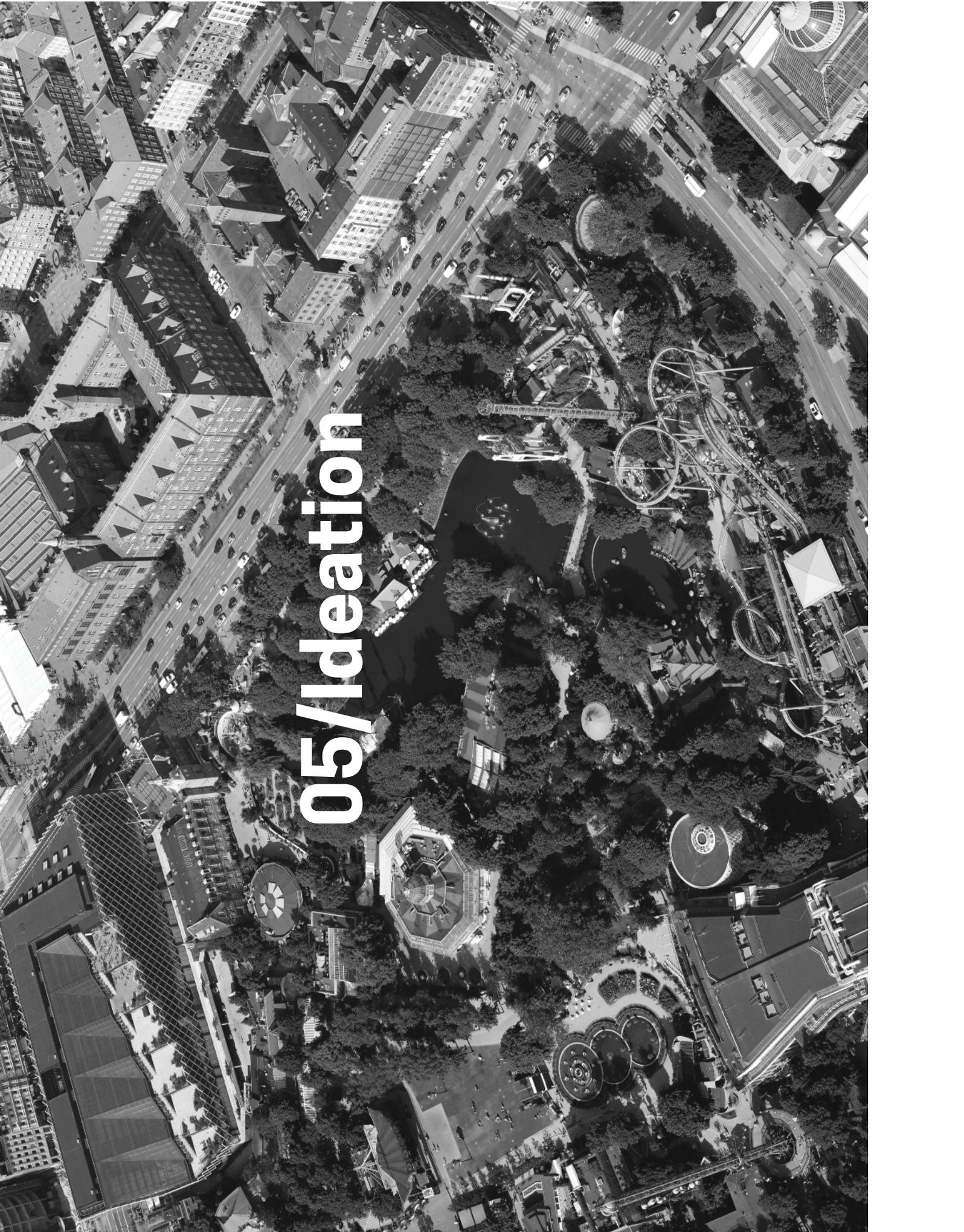
The new Copenhagen Main Library shall be a new cultural hub in Denmark and Scandinavia, a unique metropolitan library.

The library shall have a unique character in the cityscape, while still being balanced and maintaining a connection to its surroundings. It should express light, lightness and openness with an organic center.

The library will be a space for both fantasy and play and contemplation and knowledge. The building will create a frame and shelter from the buzzing city, and create a calm and contemplative center of nature.

The essence of the building is not an cold official building with old dusty books, but a 'third place' between work and home. A common meeting place, a center of knowledge and culture, both in a current and historic perspective. A both physical and virtual learning center for students and all citizens alike.

In the library, people of all ages will get their needs for relaxation and personal development through culture and art satisfied.



05/Idation

Concept Configurations

Crossing the railway

Initially the idea was to unite and utilize both sides of the railway cutting, and build across it. The concept was to design a library in many different levels. The current infrastructure for cars, bikes and pedestrians. Then further develop the infrastructure by doing an underground connection with the train station Vesterport and parking, and do a pedestrian road up in the sky across the railway cutting. The building would utilize different levels for crossing the site, and the flow inside and outside. However, the conclusion was that logistically, this would make the library a mess.

Pumpehuset at focus

Another idea was to maintain the current concert venue Pumpehuset, and build the library around it. Pumpehuset is an old and famous venue, which it would make sense to keep at the site. This way, the design could be an integration of old and new, connecting the new library to the site. It would prove a difficult task to design around Pumpehuset. As of now the concert venue is situated almost completely at the center of the site. This would make it very difficult to create an efficient flow and logistic in the library. It would also create some unattractive sides of the building, because the library would have to 'face' a certain direction.

Completing the block

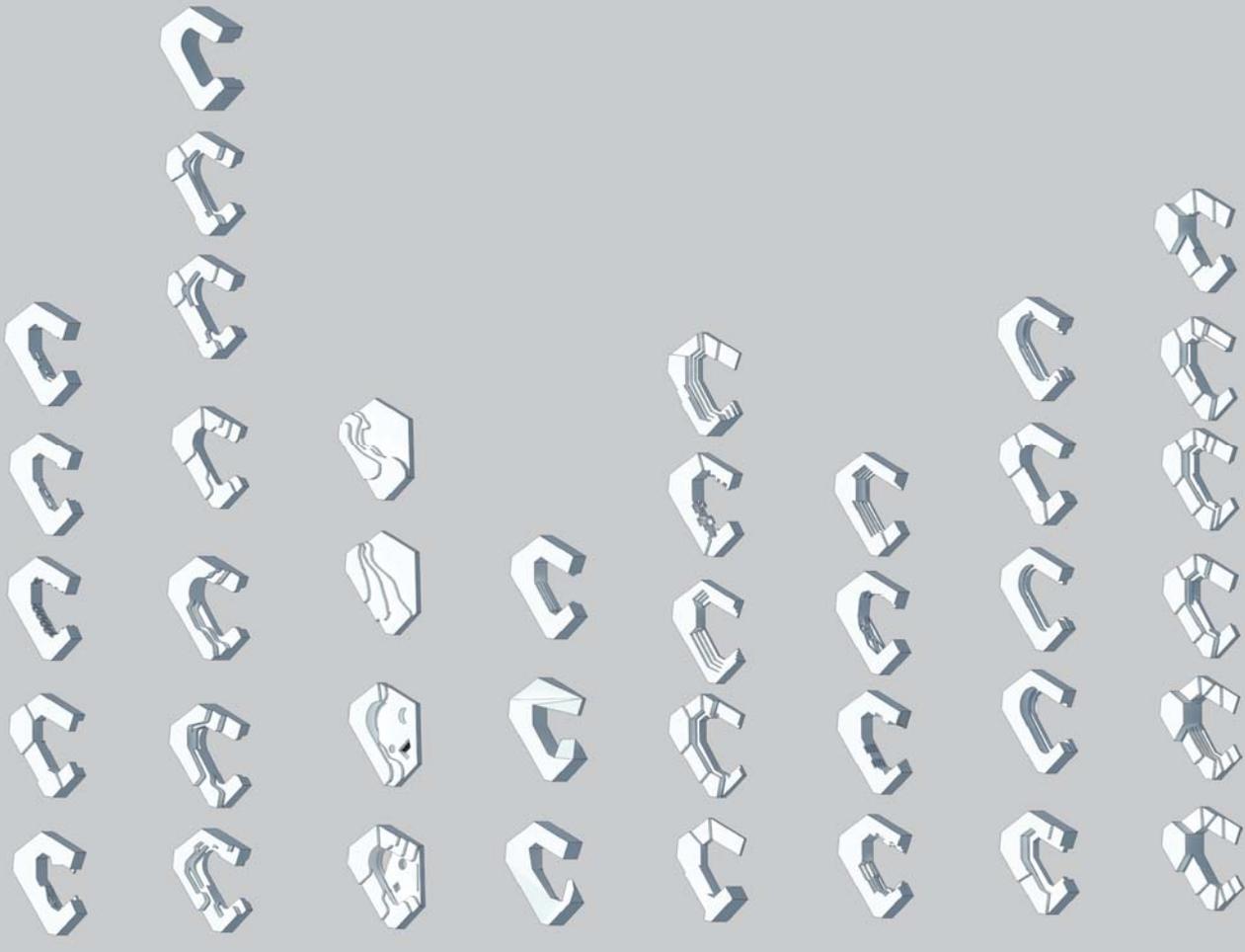
The final configuration was to evolve and develop the block structure, which is the most common feature of the surrounding context.

This concept would allow the library to seemingly integrate with the site and context. Because of the very busy and large infrastructure surrounding the site, the block structure would act as a 'protective barrier' between the library space and the city. Furthermore, this would allow for a building, which do not 'turn its back' on the current building on the site, Kulturausstyrelsen, but rather utilizes it to create a common space. This would also make it possible to create a green public space, and continue 'the green ring' in Copenhagen.

Throughout the course of the process, the idea was to keep a massive and strict outer façade towards the street. Working with this concept, the main focus was to create an inner façade and space which brought down the scale of the structure to a more human scale. To attain this, the main feature was to terrace the inside façade in different ways, and by doing this, scaling the façade down, and make it flow together with the green space to break down the barrier between the outside greenery and the interior of the library space.



Ill. 43 - Pumpehuset at focus



III. 44 - Concept iterations

Structural System

The overall concept throughout the process was to create a 'forest of columns', which was both honest structurally, but also architecturally connected to the concept of the library.

To achieve this sense of and organic structure, different parameters were chosen, specifically the size of the columns and the placement of the columns.

Iteration 1

The columns are placed in a grid system.

Iteration 2

The columns are square instead of circular.

Iteration 3

The columns are used as a tool to create flow and different spaces.

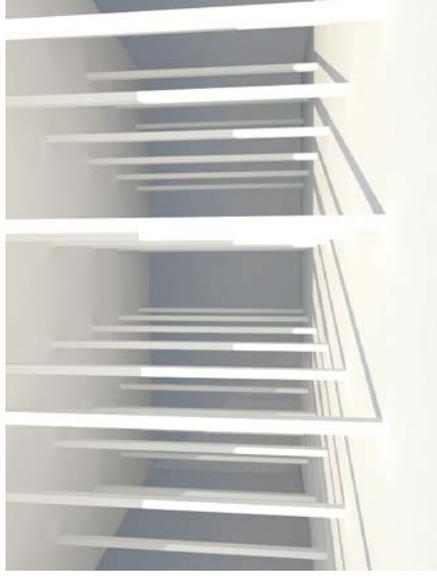
The columns are still placed 'randomly' structurally, but placed on purpose to create open spaces and flow.

Iteration 4

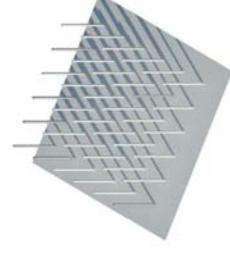
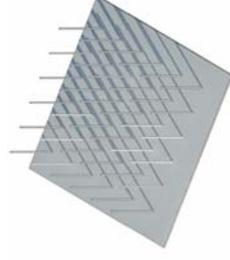
The columns are placed on a close grid, still creating a sense of organic development throughout the plan, but more structurally honest. This iteration has both square and circular columns.



Ill. 45 - Iteration 1

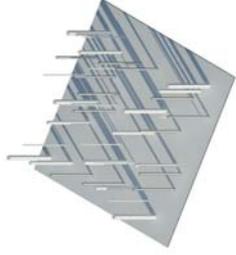


Ill. 46 - Iteration 2

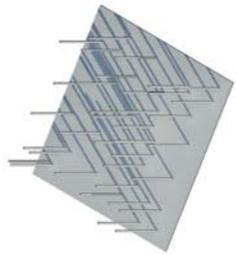


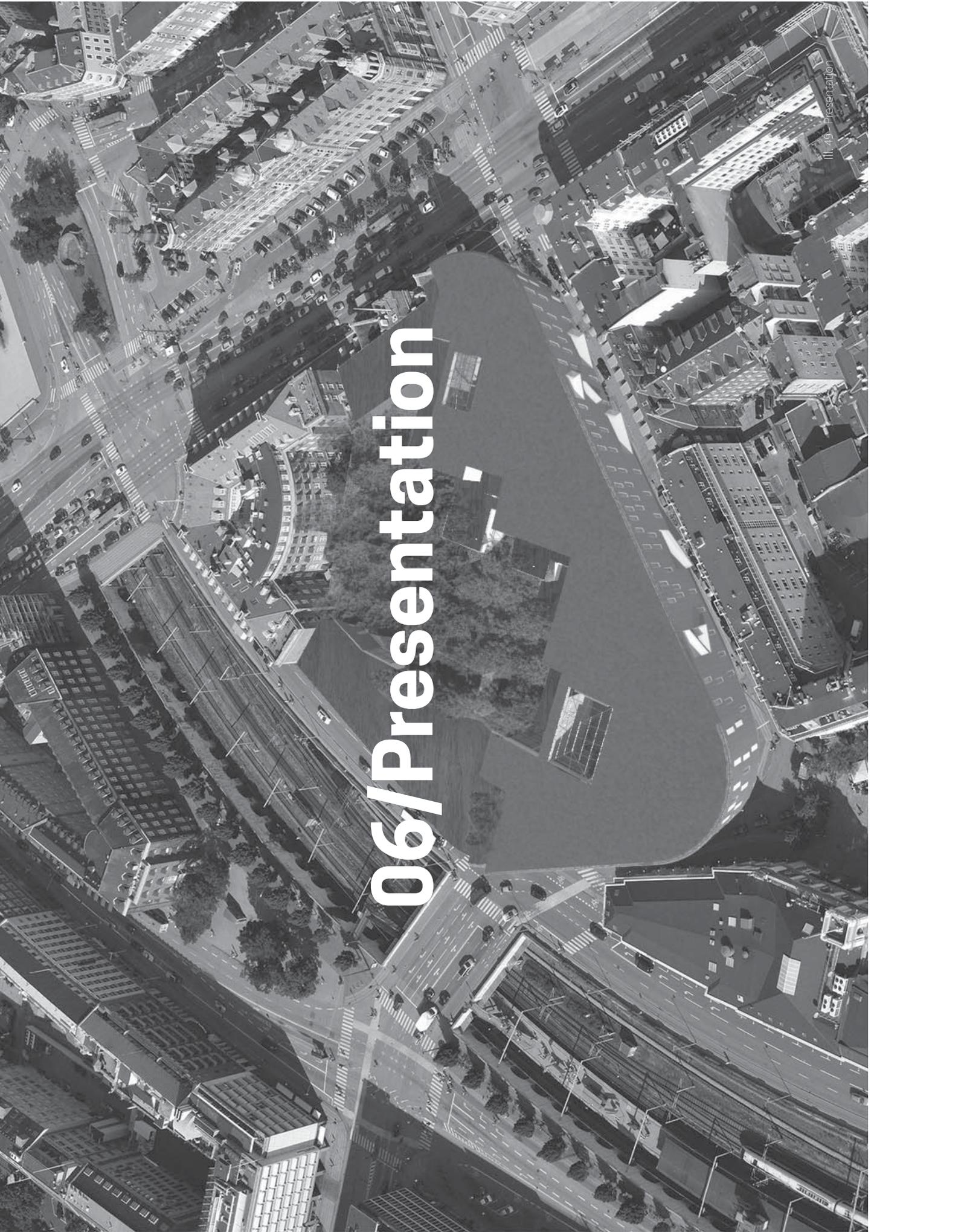


Ill. 48 - Iteration 4



Ill. 47 - Iteration 3





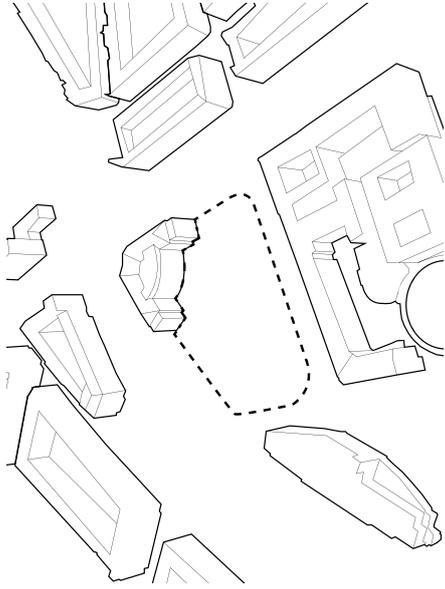
06/Presentation

Concept

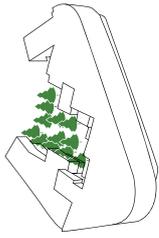
The concept builds upon the block structure building type. This typology is prevalent throughout Copenhagen. This will connect the new library with the immediate surrounding context, an area which is very messy architecturally.

By using this block structure, a central courtyard will be created. The building structure will be a protecting shell from the outside, an area surrounded by large busy roads, creating a calm area in the middle.

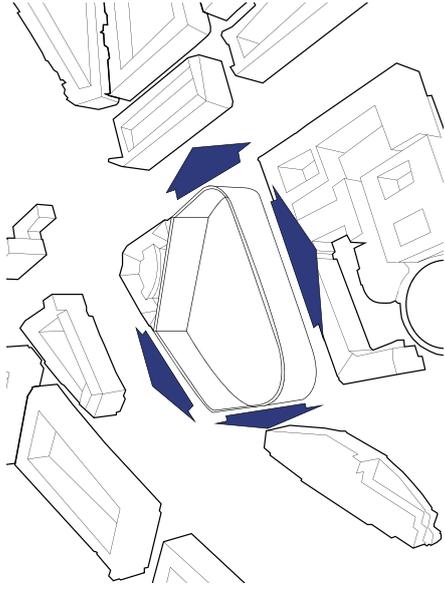
The idea is to create a building, space and atmosphere which is very strict and tough towards the outside. Towards the inside, central courtyard the building façade will dissolve and fragment towards the courtyard, which will be a green forest like area.



1. Integration to the context: Continuing the block structure.



4. The courtyard becomes a green forest like landscape, continuing "the green ring" in Copenhagen



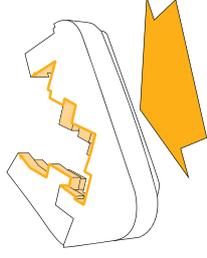
2. Creating a barrier, protecting the library space from the loud surroundings



5. The ground floor contains public facilities for social gatherings and play



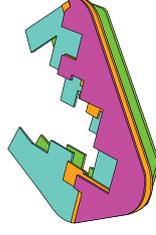
7. The 2nd floor contains functions for employees



3. The ground floor and facade facing the courtyard is exploded to create a human scale



6. The 1st floor contains facilities for contemplation and studying



8. The same applies for the 3rd floor

***“If you have a garden
and a library, you have
everything you need.”***

*– Marcus Tullius Cicero
Ad Familiares IX, 4, to Varro.*



Atmospheres

From the street

From the street the library seems to be an integrated part of the cityscape, connecting to the existing building, closing the block structure. The façade creates a unified shell which flows along the site. The building seems massive and heavy from the street, creating a sense of both connections to the site, but also a feeling of importance. However, the tall ground floor, made up of almost completely glass creates a sense of openness on ground level, and creates a contrast between the light ground floor and the heavy massive façade on top.

Entrance area

When you step inside the atmosphere changes from the heavy façade. The inside is clad in white concrete and steel, while wood panels and furniture gives a warm and light feeling to the library space.

The ground floor is 8 m in height, making it a very large open space. The structural system underlines the lightness and openness of the space. The columns give an association to walking in a forest, where the trees lead your way through nature.

Courtyard

Making your way through the library, the courtyard is the final form, the ultimate sense of contemplation and calmness. The courtyard is a forest in the middle of the city, sheltered by the li-

brary.

Floor Description

The overall organization of the library is centered around the inner courtyard. A main atrium creates a central meeting point and a horizontal level. From a vertical perspective, the library becomes more private the further up you go.

The two bottom floors are the ones that hold the primary library functions for the public while the two top floors are dedicated to office areas for employees of the library.

Ground Floor

The ground floor is the most public library space, and more for fantasy, play, art and music and social interaction. Placed on the ground floor are the Kids & Youth-section, the Fiction-section and the Art & Music-section. A café and exhibition area is also situated on the ground floor.

When you enter from the main entrance, from Axeltorv, first you will meet the Information area. Here you can get info from the employees, or use the PC-workstations to search for information yourself. The self-service stations are also situated here, making it easy to lend or deliver material.

If you walk straight ahead you will enter a large atrium, from where you can access the other floors. Moving further forward, the café and restaurant is placed towards the courtyard area. This is also the main entrance area to the courtyard.

If you turn left from the main entrance you will enter the Fiction-section, and an adjacent reading room. Moving through this section you will enter the Kids & Youth-section, the area differs in atmosphere from the Fiction-section, separating them.

On the right side of the ground floor the Art & Music-section is placed. You can also enter this section of the library via the secondary entrance facing H.C. Andersens Boulevard. Here you will also find an exhibition area. The concert place, Pumpehuset is adjacent to this wing, however the entrance to the venue will happen through its own entrance from the outside. This will help separate the two functions.

Second Floor

The second floor is also part of the public library space. However, this part of the library is more reserved towards students and other guests who want to delve deeper into the library material. The factual wings are placed on this floor together with an auditorium and many project rooms directed towards students.

Entering through the atrium in the main entrance you will arrive at the Technology, Nature & Medicine-section. If you move through this area in the west wing, you will enter the Humanities & Social Sciences-section. On the right side of the floor towards the secondary atrium, the History-section is situated. Throughout

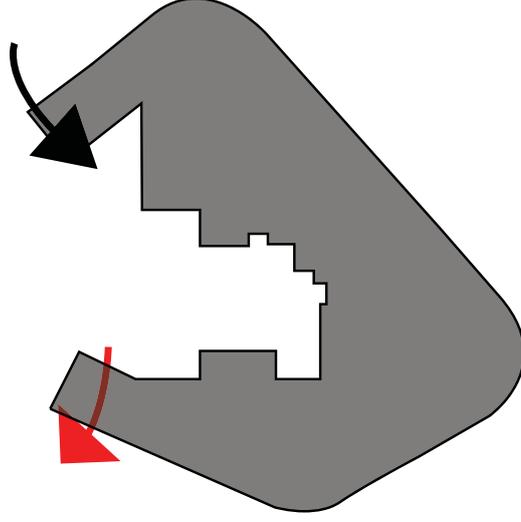
the floor both open and closed study areas will be available for visitors.

Third and Fourth Floor

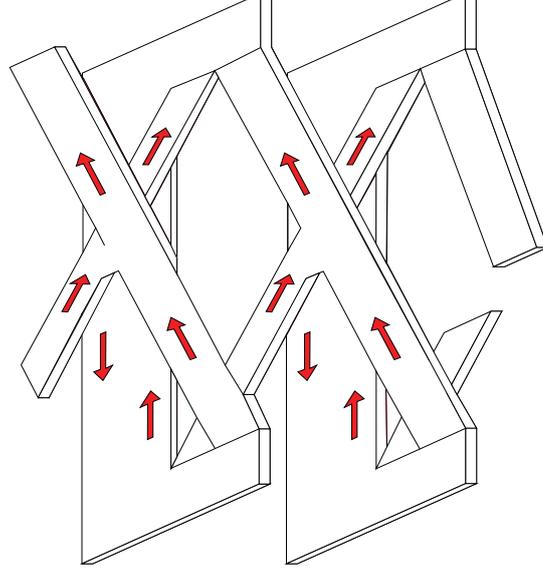
The two top floors are reserved for employees only. Both floors contain offices and meeting rooms for employees of the library. Furthermore, the fourth floor includes a canteen.

Parking

The library has underground parking possibilities that are accessed by driving in an opening to the courtyard from H. C. Andersen Boulevard. The opening contains a ramp that will go down under street level to the parking facilities. There are three parking levels under the library which contains 44 parking spots each - so a total of 132 parking spots. The visitors that chose to park at these levels will have the option to take the stairs up to the courtyard level, or go through a small corridor to reach the elevators, which take them up inside the library.

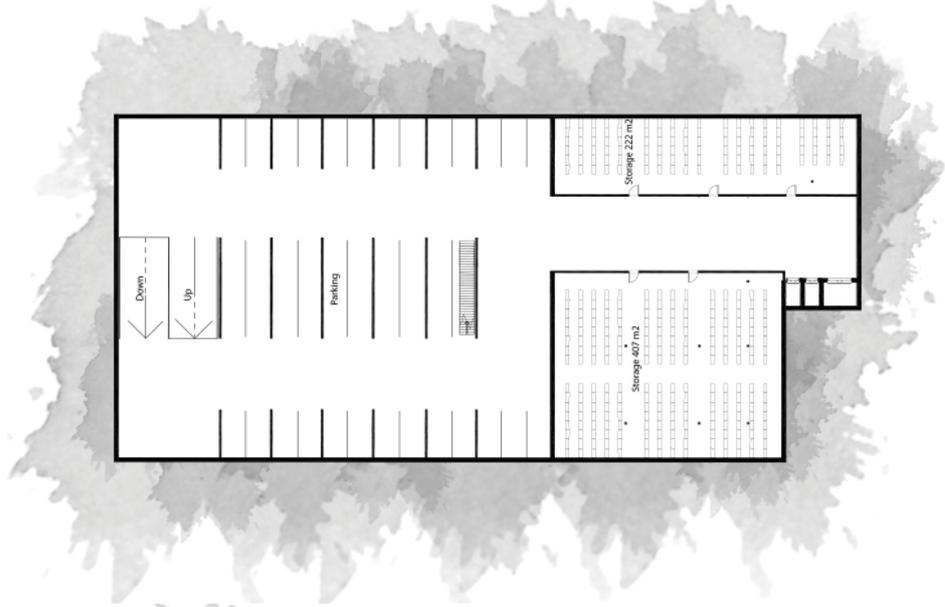
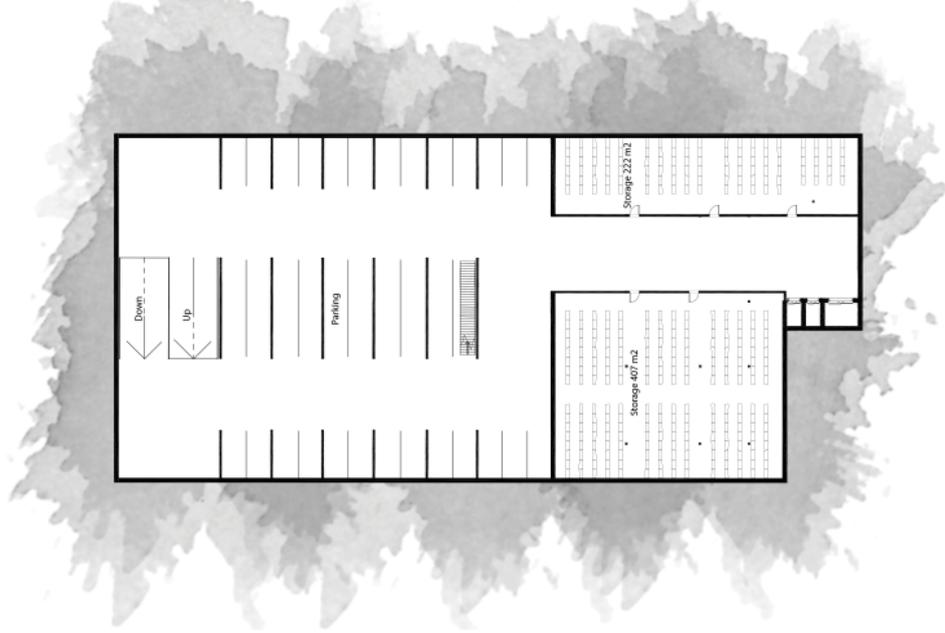
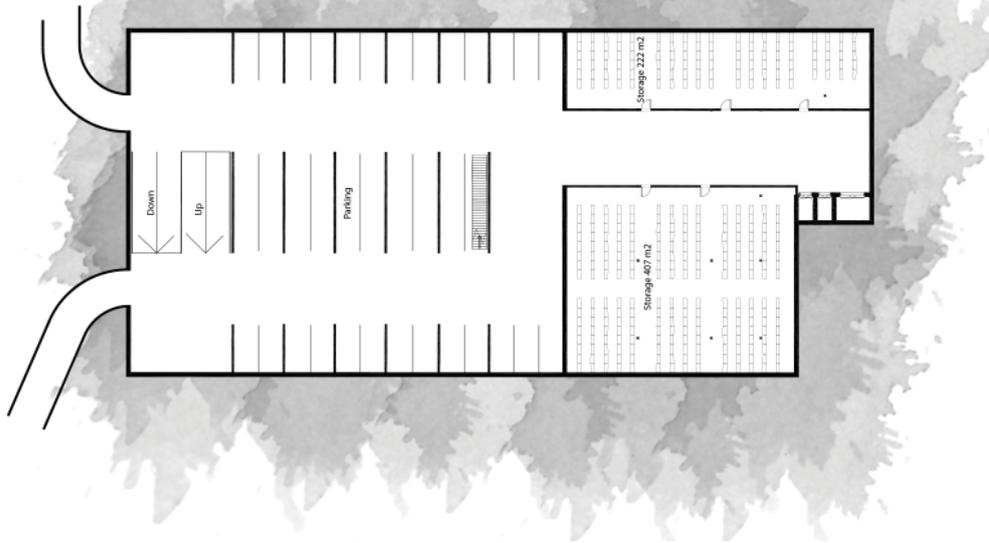


Ill. 52 - Entrance and exit to parking area



Ill. 53 - Ramp system

Floor plans





III. 57 - Level 0
1:750

III. 59 - Level 2
1:750





III.60 - Level 3
1:750

Materiality

The main idea of choosing the exterior material, is to make the exterior seem like a massive organic form. The bricks from Petersen Tegl are burned with coal, giving them a rough and varied color. Bricks are chosen, because it is deeply rooted in Danish architecture. Much of surrounding context is clad in red bricks. Using bricks will create a connection to the surrounding building, and underline the overall concept, the block structure.

When you step inside the library the choice of materials will change the atmosphere significantly from the exterior. Wood, white steel and white colored gypsum dominate the interior cladding. The white color palette will give the inside a light and open feeling, while wood will give the place a sense of texture and warmth for contrast.

The façade facing the courtyard will be all glass and aluminum. this will be in stark contrast to the exterior façade facing the street. This will make the library seem very open, and the fragmented transparent façade will melt together with the green courtyard.



Ill. 61 - Wood



Ill. 62 - Aluminum



Ill. 63 - Brick cladding

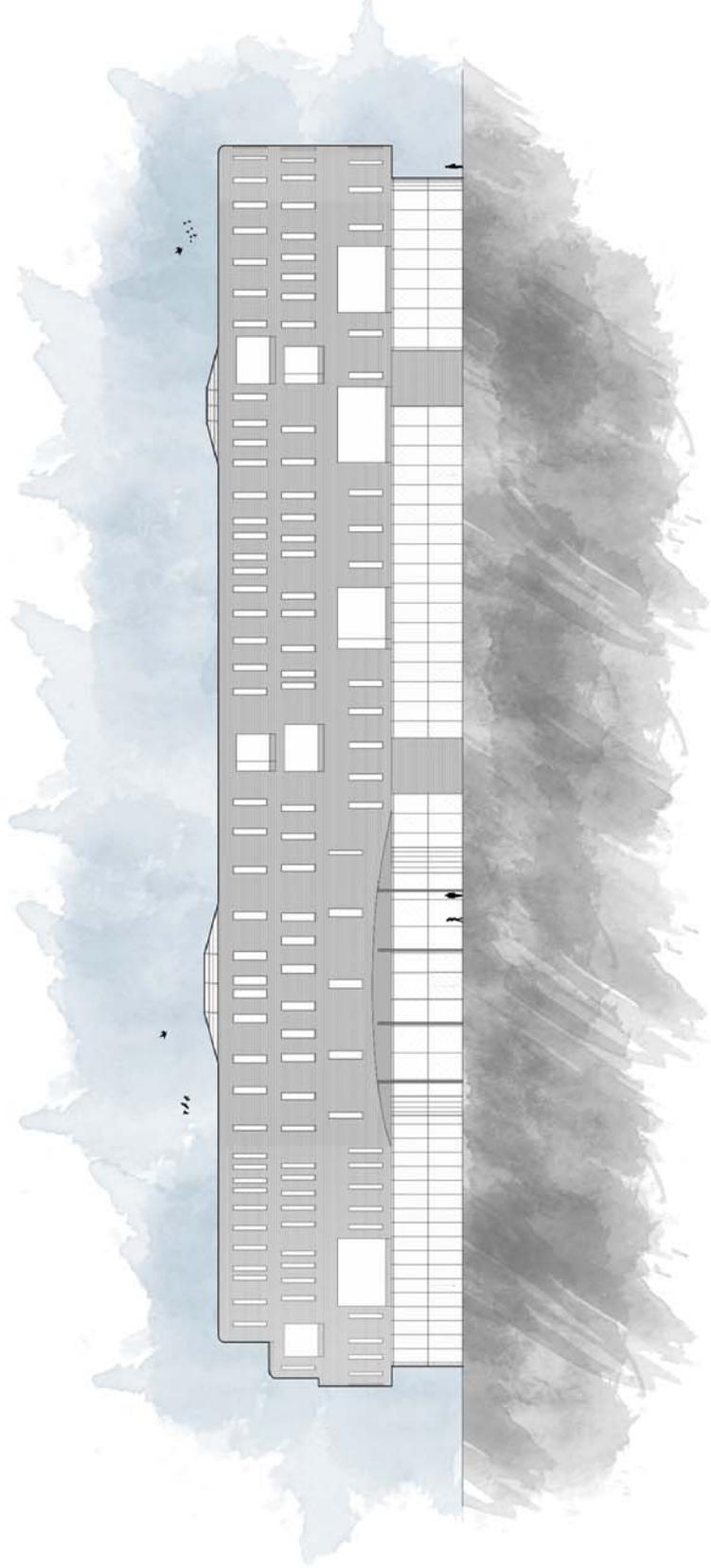
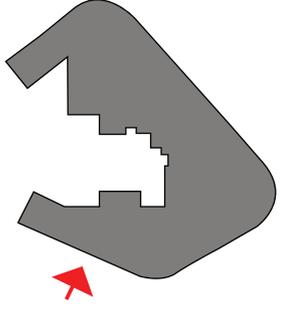


Ill. 64 - White gypsum

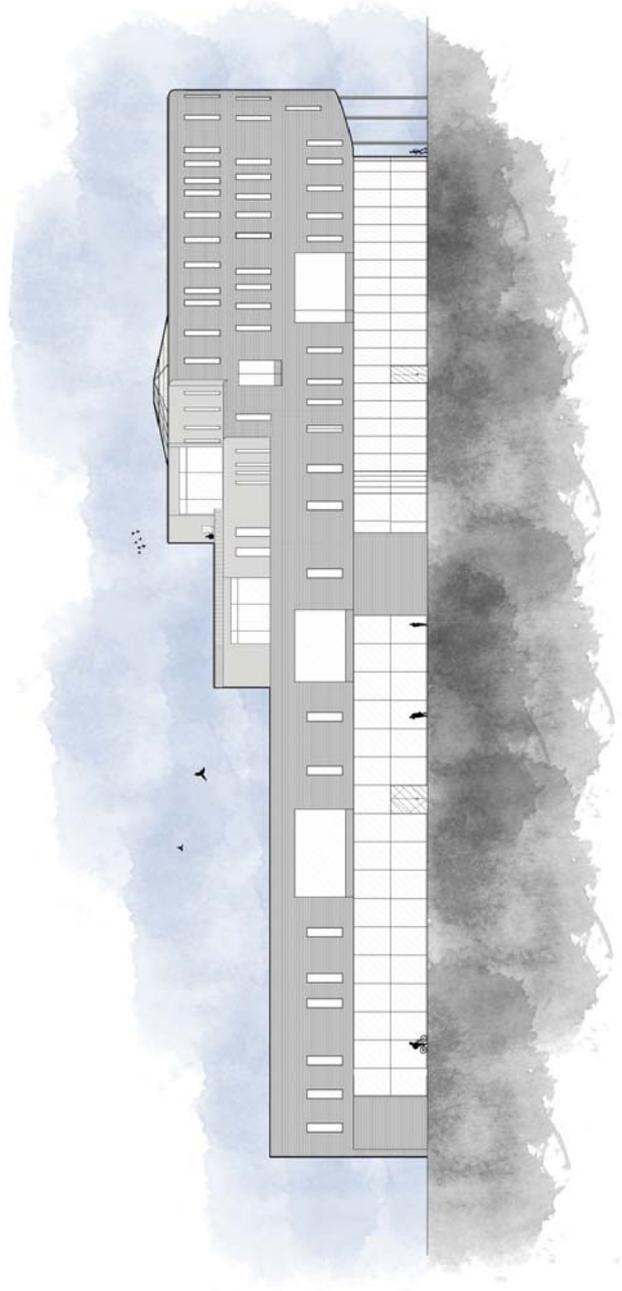
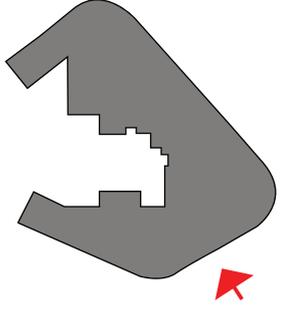
Facades

The idea of the facade expression is to show the duality of massive and transparent, heavy and light. The façade facing the street is a continuing of current building, finishing the block. The expression is massive and closed off and the organic shape, makes it seem like a continuous form.

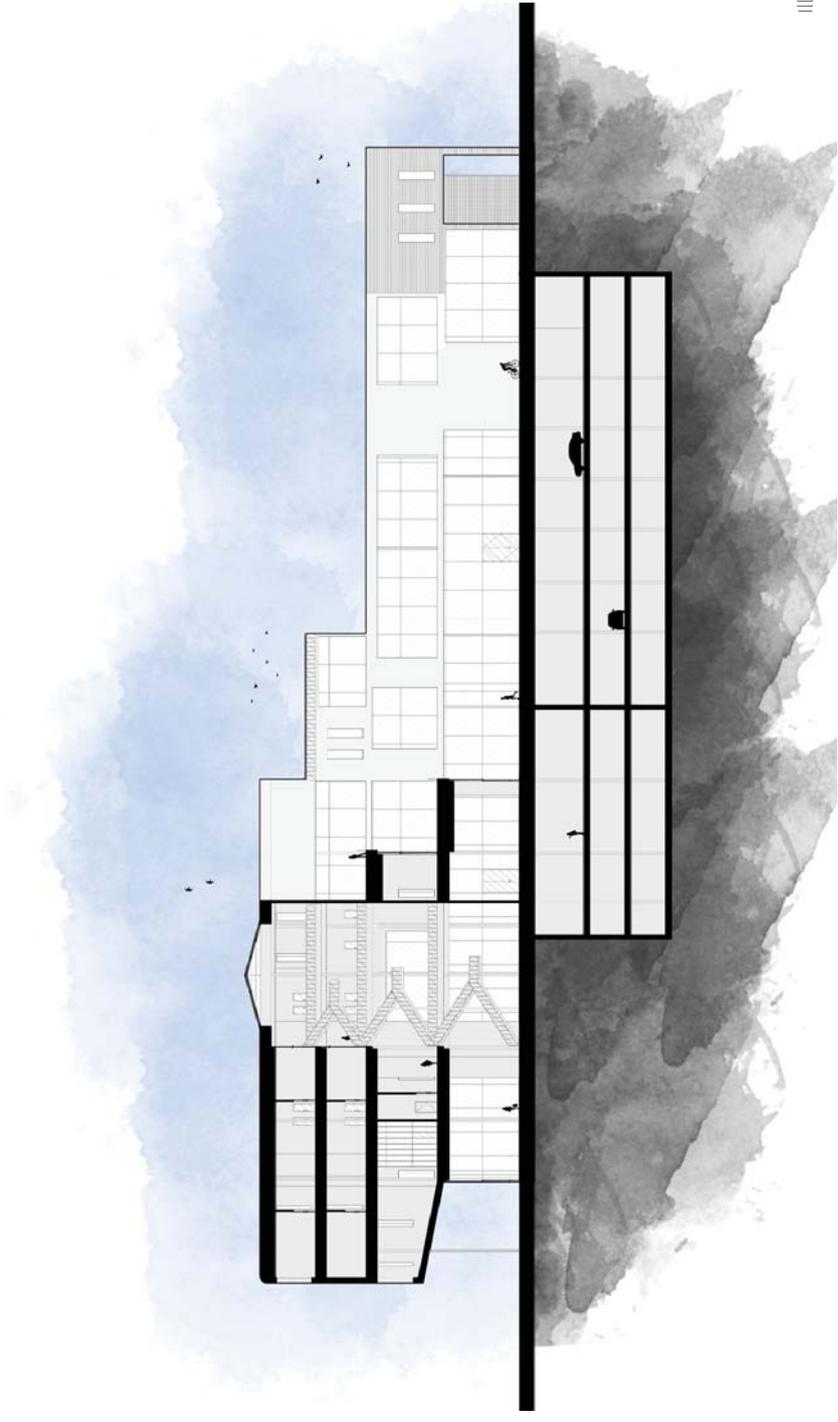
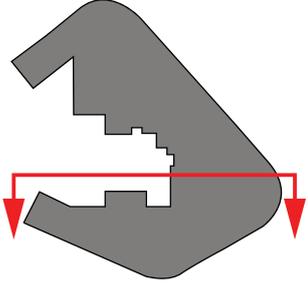
The keywords characterizing the façades facing the inner courtyard are open and light. The fragmented 'glass boxes' brings down the scale of the building, and make the inside and outside flow together.



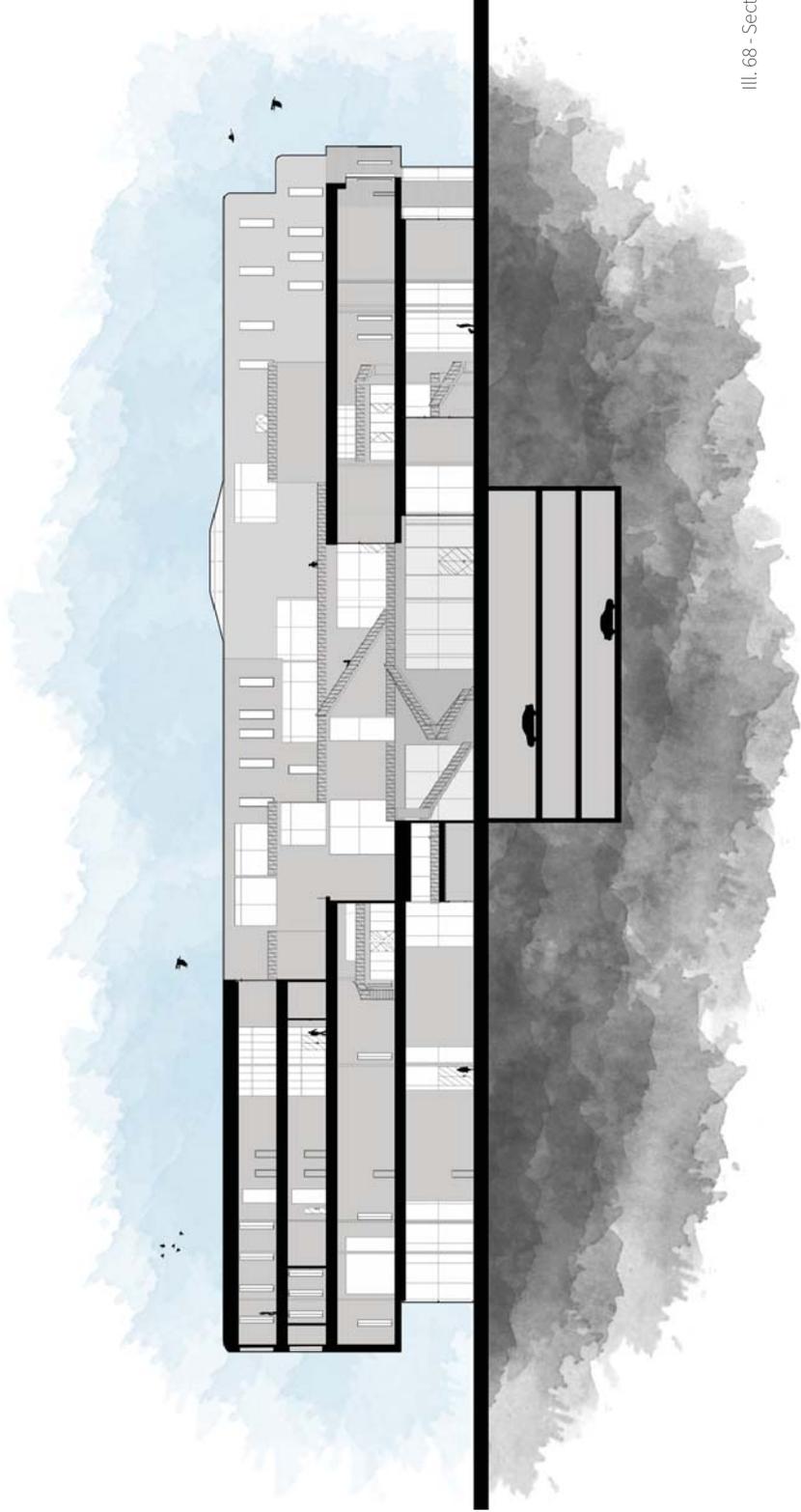
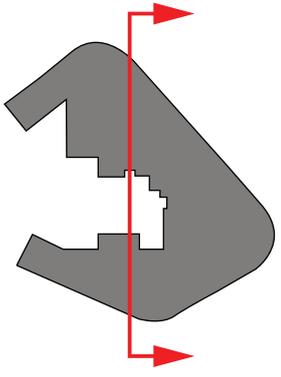
III. 65 - Elevation North East



Ill. 66 - Elevation South West



Ill. 67 - Section A-A



Ill. 68 - Section B-B

Arriving at the library

From the outside, the library continues the building style already in the city with a continuation of the block structure that exists in the nearby proximity. The ground level facade is made very transparent and the upper portion of the building has a more massive expression to it. The contrast between these two expressions results in the illusion of the upper part being almost floating.



Oasis in the middle of the city

The enclosed courtyard offers a unique experience that is uncommon in the city center. Inside and outside blend together to create a green space that flows on the building and in the courtyard.

Openings in the library allow for the greenery to penetrate the building, and sitting on the green terraces feels you are sitting in a part of the landscape.



Room for contemplation

The library offers places to its visitors where it is possible to sit down and immerse yourself in something within a quiet and slow-paced environment. It is possible to sit amongst the collection or in a reading room with views towards the green in the courtyard.



Places to study

Many students use the library to study. It can be both alone if a change of surroundings is needed, or in groups if there is a matter that needs to be dealt with in a group. The library offers places to both study alone and in groups. The two bottom floors also offer seating on top of some of the project rooms, which allow visitors to get a better overview of the library while contemplating.



A library for everyone

The library is a public building with a wide diversity of visitors in different ages, and it is therefore important to attend to everyone's needs. The youngest visitors have the possibility to play around and have fun.



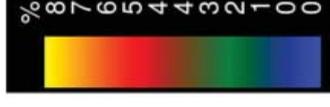
Light studies

The daylight studies show well how the overall atmosphere and division of the different levels. The ground floor has the highest overall daylight factor due to its complete glass façade and tall floor height. The ground floor is mostly for the public, reserved for social activities and play, which interacts well with the very light spaces.

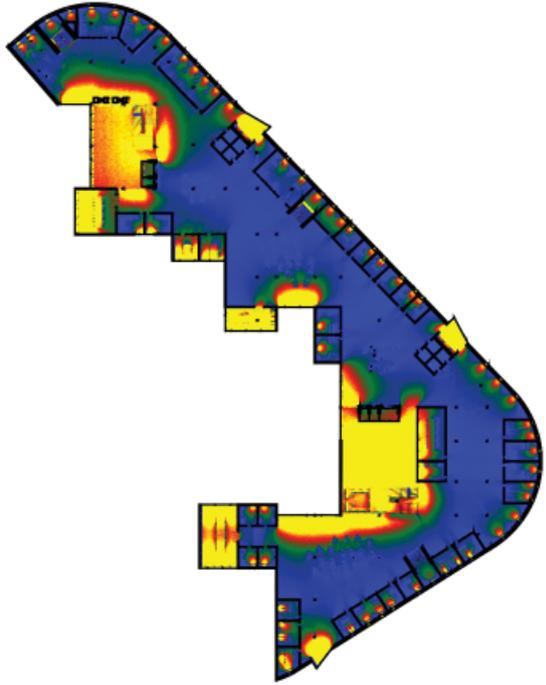
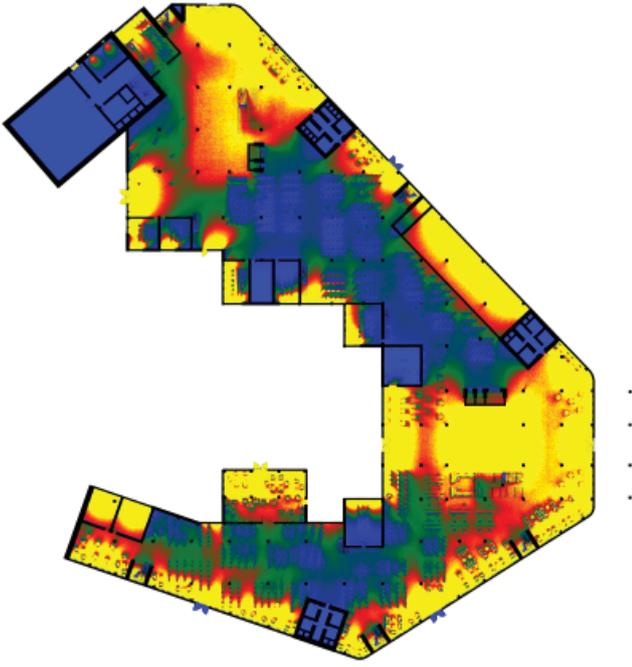
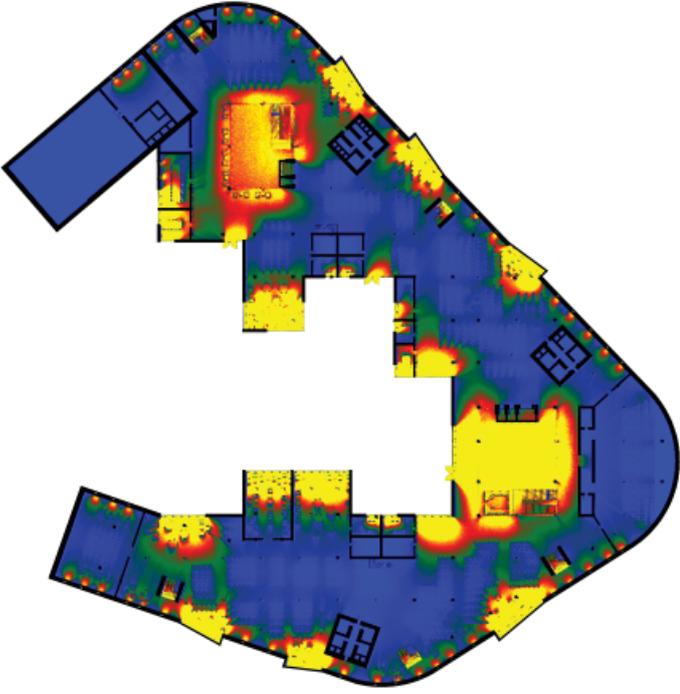
The second floor is home to the factual material selection. This floor is reserved for more contemplative activities such as studying and meetings. The amount is changed accordingly. There is still a good amount of light at the rooms and spaces by the façade.

The overall conditions however are more subdued for a more private and calm atmosphere.

The top floors reserved for employees with office facilities are similar to the second floor. Rooms facing the façade are largely reserved for offices, but also larger common spaces. While the corridors have more mellow light conditions.



III. 69 - Daylight factor scale



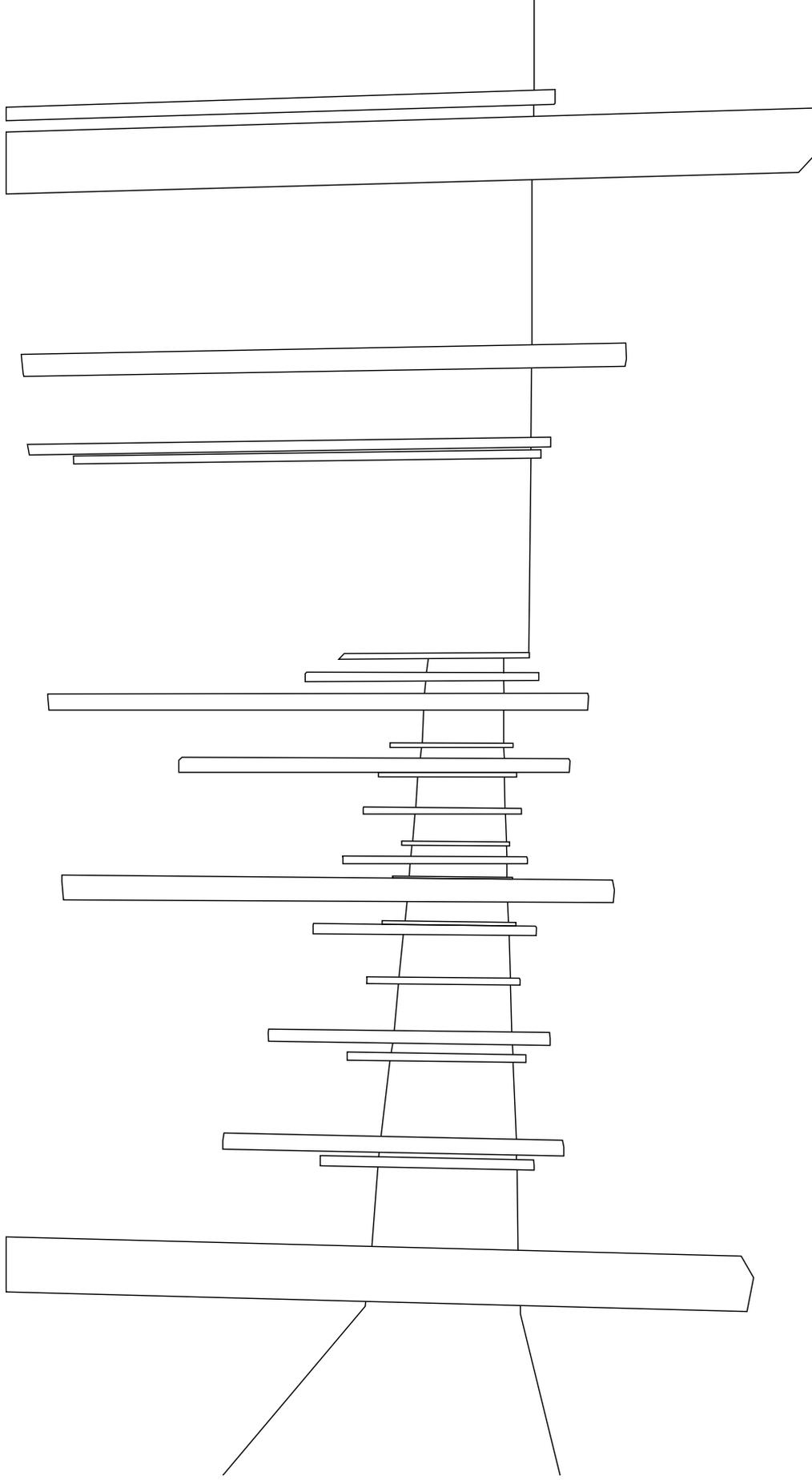
Ill. 70 - Daylight Factor

Structural Concept

The idea behind the general structural system was to create a structure, which both structurally and architectonically gave the wanted atmosphere inside and outside. On the inside, the goal was to create an atmosphere and sense of light, lightness and openness. Because of this a light steel structure was chosen, making it possible to create both thin floor slabs (see floor system), but also slim columns.

The overall concept and evolution of the library space was to have a heavy massive exterior towards the street, which gradually disintegrated towards the courtyard, essentially melting together with the greenery.

Therefore, the structure should exude a sense of nature and greenery. Because of this, the concept for the structure was to create a 'forest of columns', which would melt the interior library space with the exterior courtyard.



Ill. 71 - Structural concept

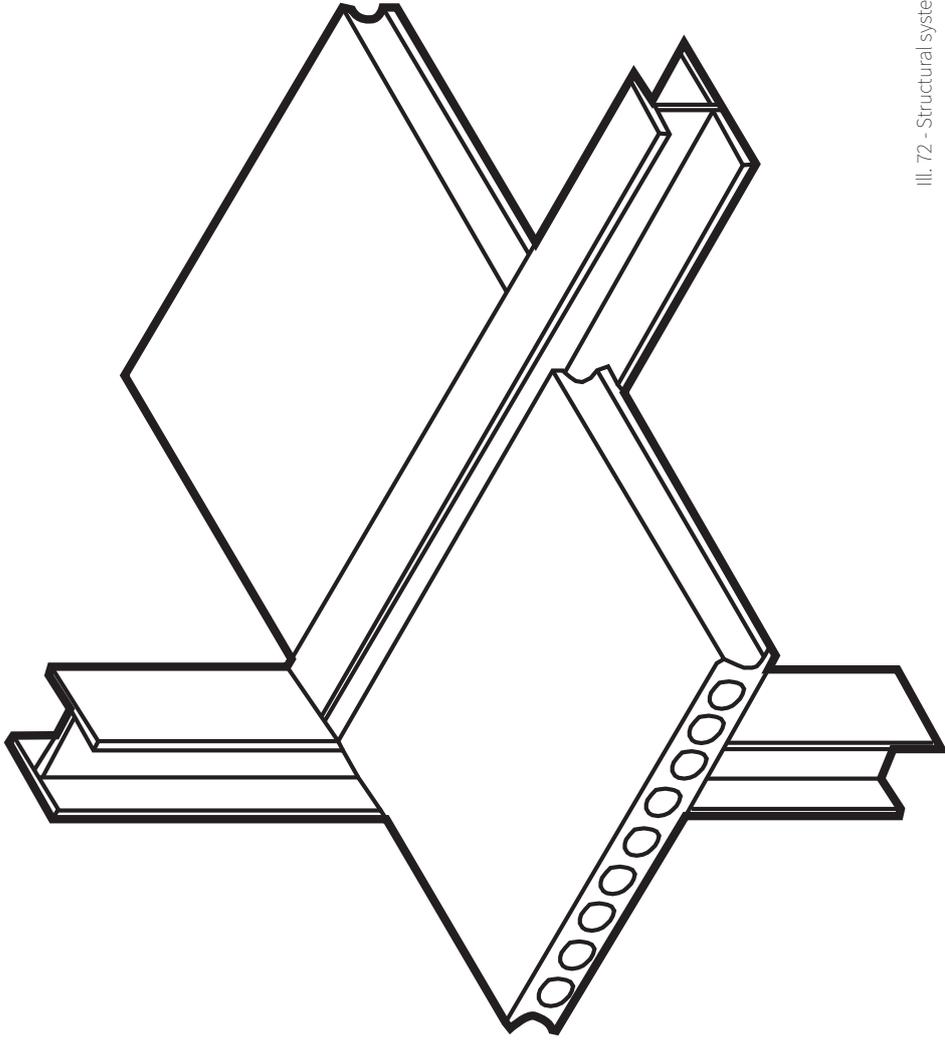
Structural System

The structure is comprised of a steel frame system. Beams are made of ½ HE 650 M slim floor beams (Arcelor Mittal) http://sections.arcelormittal.com/fileadmin/redaction/4-Library/1-Sales_programme_Brochures/SlimFloor/SlimFloor_EN.pdf, beams with a longer lower flange, making them suitable for this particular structural system. The columns are made of HE 220.

The advantage of the slim floor system is, as the name hints, makes it possible to have thin floor heights. The prefabricated concrete floor slabs are supported between the beams, resting on the wider lower flange of the beams, instead of resting on top of the beams. The concrete deck used for the slabs is a Xtrumax from Spæncom (Spæncom).

The beams span approximately 8 m in each direction. The beams are connected to the columns by fixed supports, the columns also have fixed supports at the base.

The elevator shafts, staircases and bathrooms are also stabilizing structures.



Ill. 72 - Structural system

Dimensioning of steel beam in SLS

Dimensioning of steel beam in SLS

First the load, which is affect the beam in SLS is defined. The beam, is situated in the groundfloor. The beam is affected by an evenly distributed load.

$$\text{Line load } \left(\frac{kN}{m}\right) = \text{Area load } \left(\frac{kN}{m^2}\right) * \text{Load width (m)}$$

Permanent loads

Floor slab

$$4,94 \frac{kN}{m^2}$$

Variable loads

Live loa

$$5,0 \frac{kN}{m^2}$$

The area loads are converted to line loads. The length of the line load affecting the beam is 6,85 m.

Own load

$$4,94 \frac{kN}{m^2} * 6,85m = 33,8 \frac{kN}{m}$$

Live load

$$5,0 \frac{kN}{m^2} * 6,85 m = 34,25 \frac{kN}{m}$$

The load in SLS is calculated

$$p_q = G + 0,6 * q + 0 * s + 0 * w$$

$$p_q = 33,8 \frac{kN}{m} + 0,6 * 34,25 \frac{kN}{m} = 54,35 kN/m$$

Material data

½ HE.A 650 M 500 x 35 (Arceilor Mittal)

Steel quality: S355

Length: 7110 mm

The allowed deflection is

$$u_{max}(\text{etagedskillelse}) = \frac{1}{400} * L$$

$$L = 7110 \text{ mm}$$

$$u_{max} = \frac{1}{400} * 7110mm = \mathbf{17,8 \text{ mm}}$$

The deflection of the beam is determined:

$$u_{max} = \frac{5 * p * L^4}{384 * E * I}$$

Hvor

Elastic modulus of steel, $E = 0,21 * 10^6 \text{ MPa}$

$I_x = 850,35 * 10^6 mm^4$ (½ HE.A 650 M, 500 x 35)

p , load

$$u_{max} = \frac{5 * p * L^4}{384 * E * I}$$

$$u_{max} = \frac{5 * 54,35 * (7110m)^4}{384 * (0,21 * 10^6 MPa) * (850,35 * 10^6 mm^4)}$$

$$= \mathbf{10,1 \text{ mm}}$$

The beam thus comply with the permitted deflection.

Strength requirement

This calculation is done to see, if the beam profile chosen, will fulfill the strength requirement, which is defined as:

$$M_{Ed} \leq \frac{W * f_y}{\lambda_{M0}}$$

First, the largest design torque.

$$M = \frac{1}{8} * q_{Ed} * L^2$$

$$M_{Ed} = \frac{1}{8} * 65,92 \frac{kN}{m} * (7,11m)^2 = 416,55 kNm$$

The material's characteristic troop level f_y (MPa) is determined according to the steel's steel grade and thickness, t . (Statik og styrkelære, p. 231)

$$f_y (MPa) = 345 MPa$$

The section modulus, W is determined by the profile table of the beam

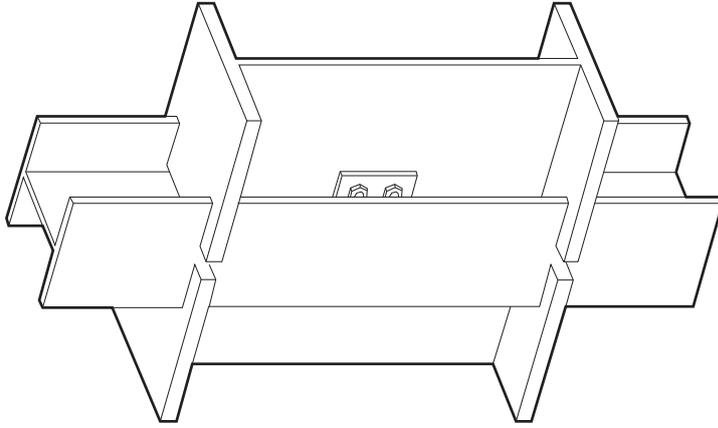
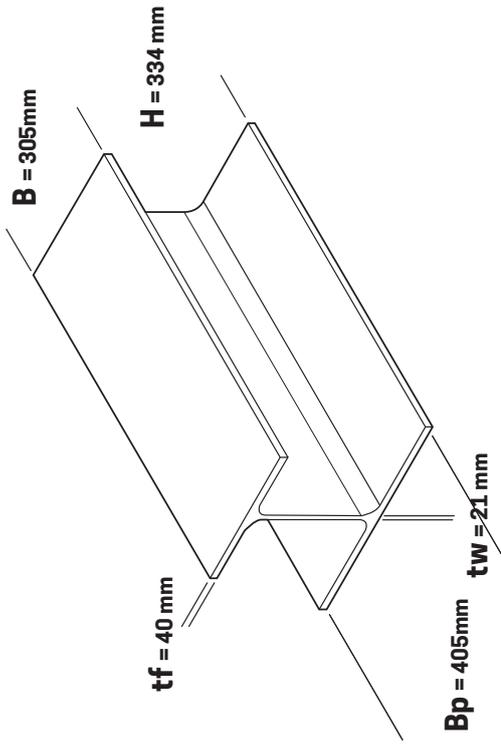
$$W = 4068 * 10^3 mm^3$$

$$M_{Ed} \leq \frac{W * f_y}{\lambda_{M0}}$$

$$416,55 kNm \leq \frac{4068 * 10^3 * 345}{1,1}$$

$$416550 * 10^3 \leq 1275872,727 * 10^3$$

Thus, the beam fulfills the strength requirement

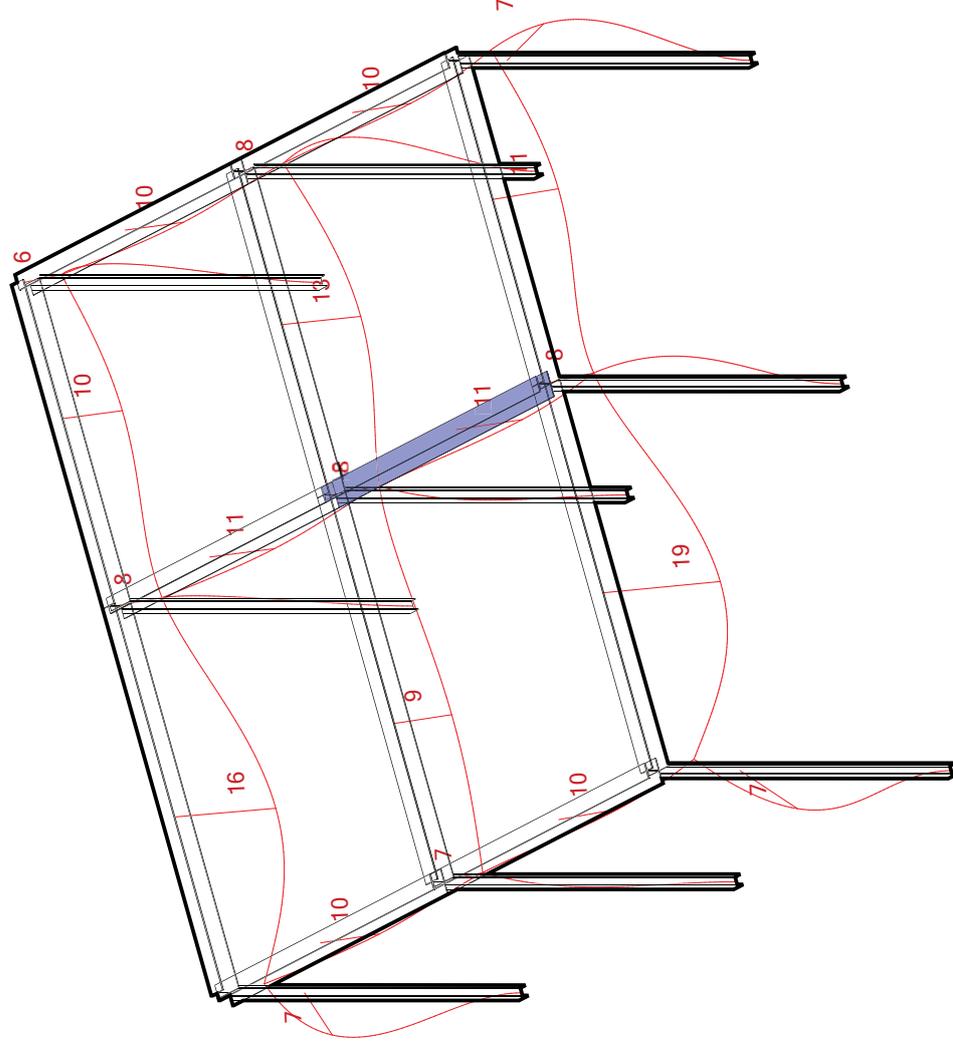


Ill. 73 - Steel Beam

Control using ROBOT FEM-analysis

A small section of the structure including the calculated beam is defined in Robot-Autodesk, to see if the beam deflection still complies with the permitted values.

The highlighted (blue) beam is the one calculated manually. The deflection is actually smaller, 11 mm, but still well within the permitted deflection of 17 mm.



III. 74 - ROBOT FEM-analysis

Dimensioning of steel column in ULS

Dimensioning the steel column (ULS)

First step is to determine the load, which the is affection the column.

The column is placed in on the ground floor, and carries an area of 46,2 m². It is affected by the following permanent loads.

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
1st floor	46,2	4,94	228,3
Floor slab			

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
2nd floor	46,2	4,94	228,3
Floor slab			

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
3rd floor	4,6	4,94	228,3
Floor slab			

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
Roof	46,2	5,14	237,5
Roof			

Total permanent load: **1832,888 kN**

Live loads affecting the column

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
1st floor			
Area load (kN/m ²)			
Nodal load (kN)			

Live load	46,2	5,0	231,0
2nd floor			
Area (m ²)			
Area load (kN/m ²)			
Nodal load (kN)			

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
Live load	46,2	2,5	115,5
2nd floor			
Area (m ²)			
Area load (kN/m ²)			
Nodal load (kN)			

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
Live load	46,2	2,5	115,5
3rd floor			
Area (m ²)			
Area load (kN/m ²)			
Nodal load (kN)			

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
Live load	46,2	0	0
Tag			
Area (m ²)			
Area load (kN/m ²)			
Nodal load (kN)			

Total live load: 928,1 kN

Snow load

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
Snow load	46,2	0,576	26,6
Roof			
Area (m ²)			
Area load (kN/m ²)			
Nodal load (kN)			

Wind load

	Area (m ²)	Area load (kN/m ²)	Nodal load (kN)
Wind load	46,2	0,134	6,19
Roof			
Area (m ²)			
Area load (kN/m ²)			
Nodal load (kN)			

Load combination ULS

Dominant live load

$$p_q = 1,0 * 1,0 * G + " 1,5 * 0,6 * S + " 1,5 * q + " 1,5 * 0,6 * w$$

$$p = 1,0 * 1,0 * 922,1 \text{ kN} + 1,5 * 0,6 * 26,6 \text{ kN} + 1,5 * 462,0 \text{ kN} + 1,5 * 0,6 * 6,19 \text{ kN}$$

$$= \mathbf{1644,611 \text{ kN}}$$

Now a steel column profile is chosen and determined if the column is strong enough.

Material data

HE.B 220x220

Steel grade: S355

Length: 8000 mm

f_y (characteristic troop level) = 355 MPa (S355, $t \leq 16$) (table 5.1, statik og styrkelære)

Partial factors for control classes:

$$\gamma_{M1} = 1,2 * \gamma_3$$

γ_3 takes into consideration the control class of the product.

Faktoren γ_3 tager hensyn til produktets kontrolklasse. Lempet kontrolklasse anvendes ikke.

$$\gamma_3(\text{normal control class}) = 1,00$$

l_s , buckling length of column

$$LASTEN \leq \frac{0,73 * 9,10 * 10^3 \text{ mm}^2 * 355 \text{ MPa}}{1,2} = 1965220 \text{ N} \approx \mathbf{1965 \text{ kN}}$$

Column data:

$$A = 9,10 * 10^3 \text{ mm}^2 (\text{profiltabel, statik og styrkelære})$$

$$i_y = 55,9 \text{ mm} (\text{profiltabel, statik og styrkelære})$$

$$I_y = 28,4 * 10^6 \text{ mm}^4 (\text{profiltabel, statik og styrkelære})$$

$$\varepsilon = 0,83 (\text{p 243, tabel 5.3, statik og styrkelære})$$

i is the cross-sectional radius of gyration:

$$i = \sqrt{\frac{I}{A}}$$

I cross-sectional inertia, mm^4

A cross sectional area mm^2

ε is a relative material parameter which is determined in Table 5.3 to the design of the material yield strength.

$$i = \sqrt{\frac{28,4 * 10^6 \text{ mm}^4}{9,10 * 10^3 \text{ mm}^2}} = 55,86$$

Strength requirement for a column

$$F_{Ed} \leq \frac{\chi * A * f_y}{\gamma_M}$$

$$f_y = 355 \text{ MPa}$$

$$i = 55,86$$

$$\varepsilon = 0,83$$

F_{Ed} design load

χ load reduction factor (tabel 5.2 statik og styrkelære)

$$\lambda = \frac{4000 \text{ mm}}{93,9 * 55,86 * 0,83} = 0,92$$

A cross sectional area mm^2

Column case is determined:

f_y yield stress, MPa

S_{ϕ} letilfælde 'a'

γ_M partial factor

χ is then estimated from a table

$$\chi = 0,73$$

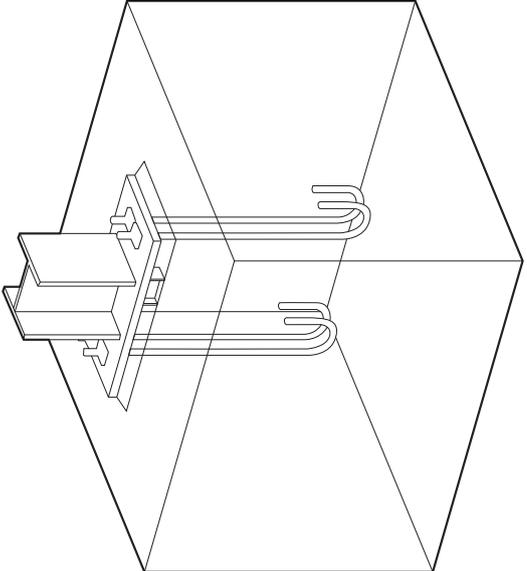
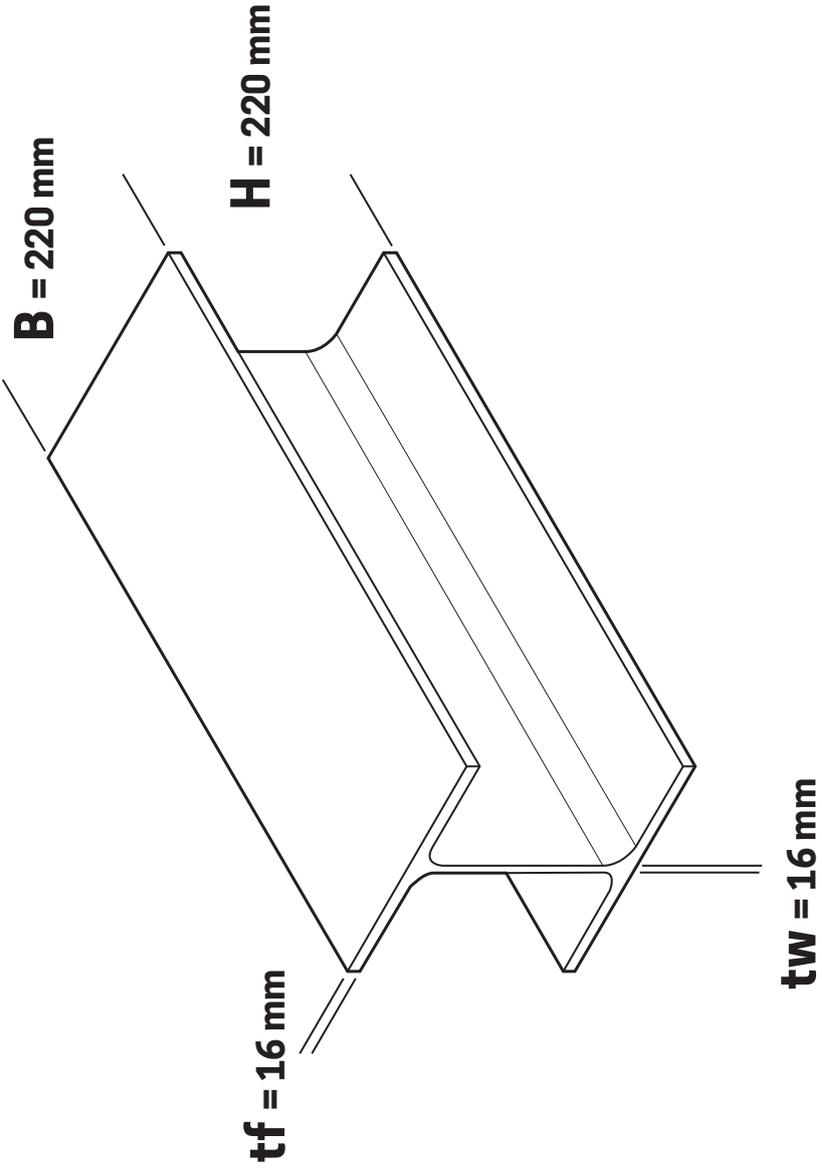
χ is determined by the slenderness ratio, λ , λ , is then determined:

$$\lambda = \frac{l_s}{93,9 * i * \varepsilon}$$

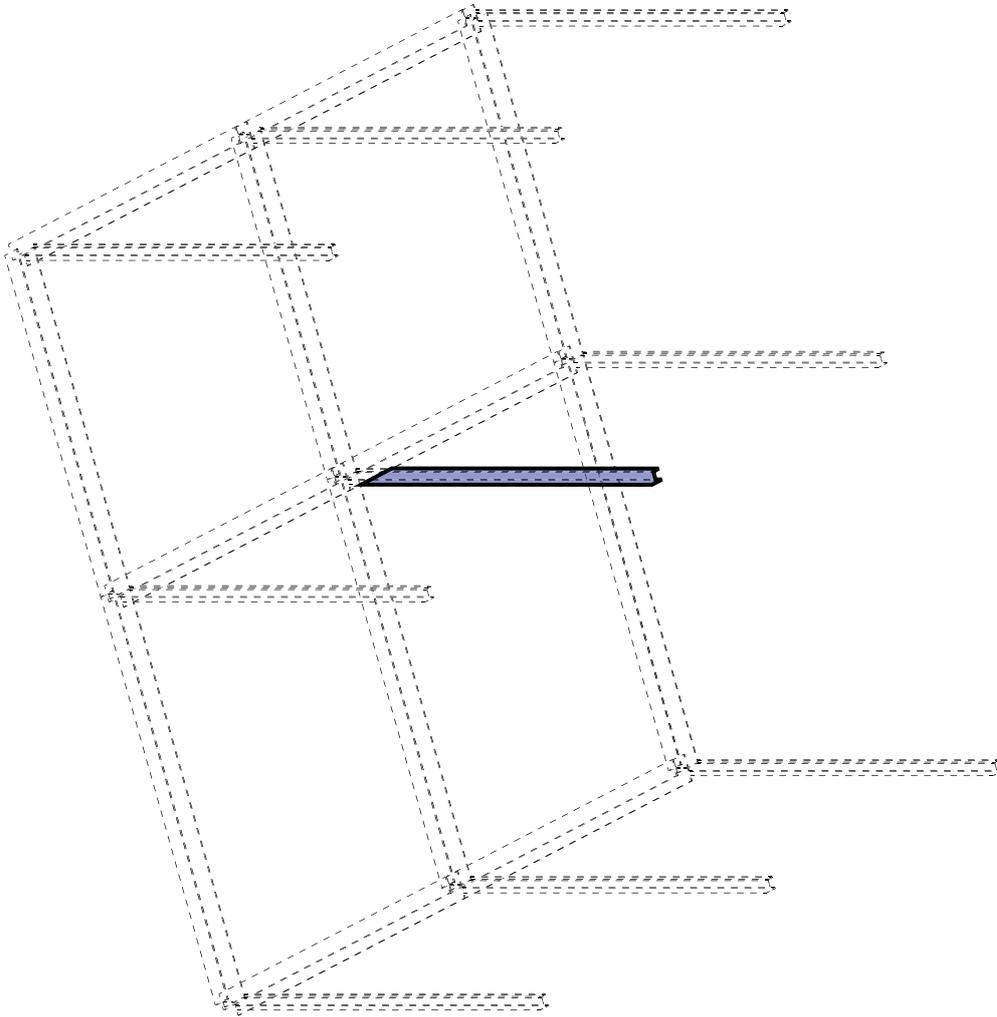
$$\gamma * A * f_y$$

Thus, the column will stand.

$$\mathbf{1965 \text{ kN} \geq 1644,611 \text{ kN}}$$



III.75 - Steel beam



III. 76 - Analyzed column

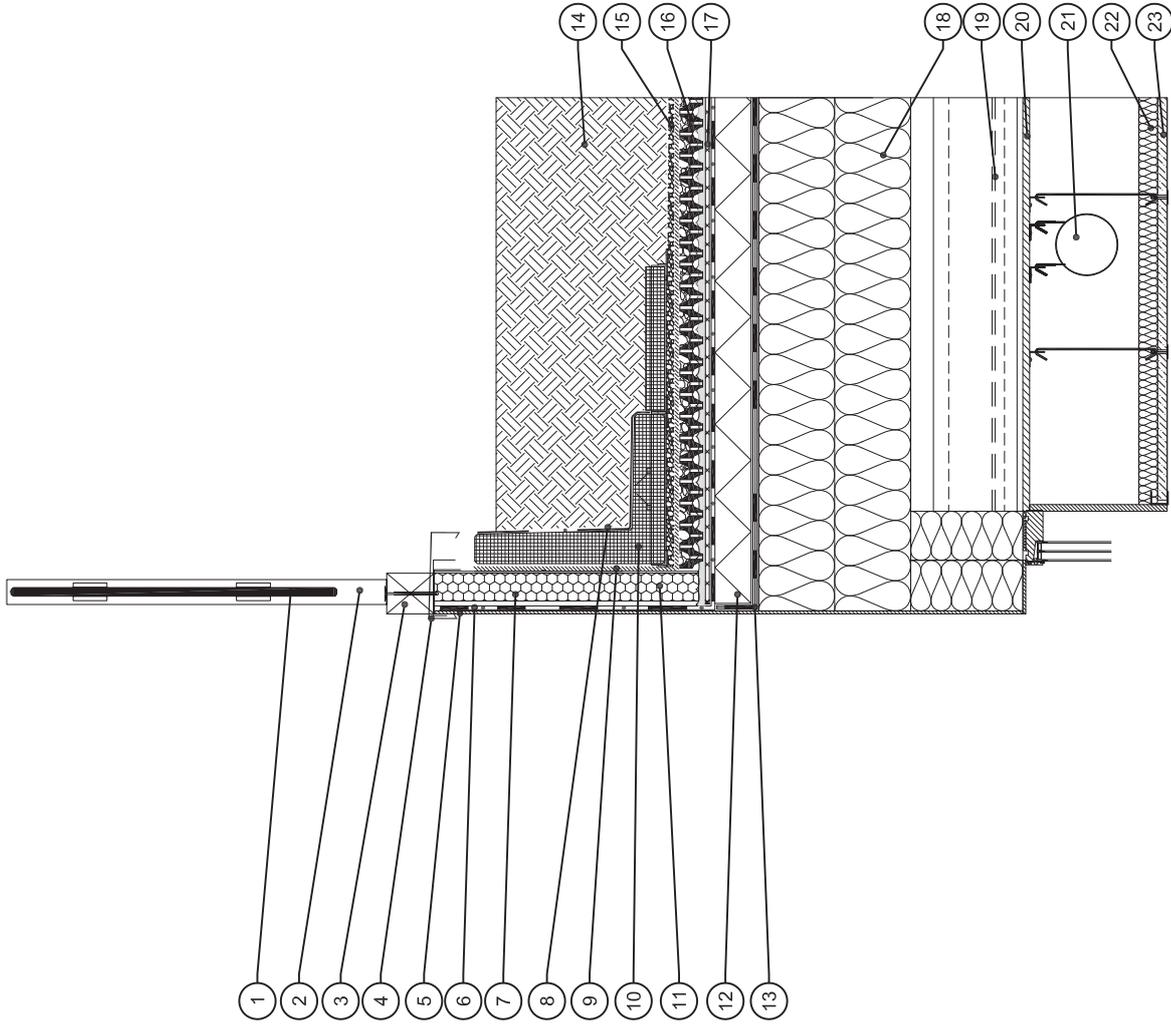
Detail drawings

The details shown are of the rounded roof construction inspired by the OZW Institute by Jeanne Dekkers Architectuur.

The second detail is of one of the roof terraces. The construction is inspired by the products by Vegtech.

The third detail shows the roof slab. The elements used in the detail is by Spæncorn and Arcelor Mittal.

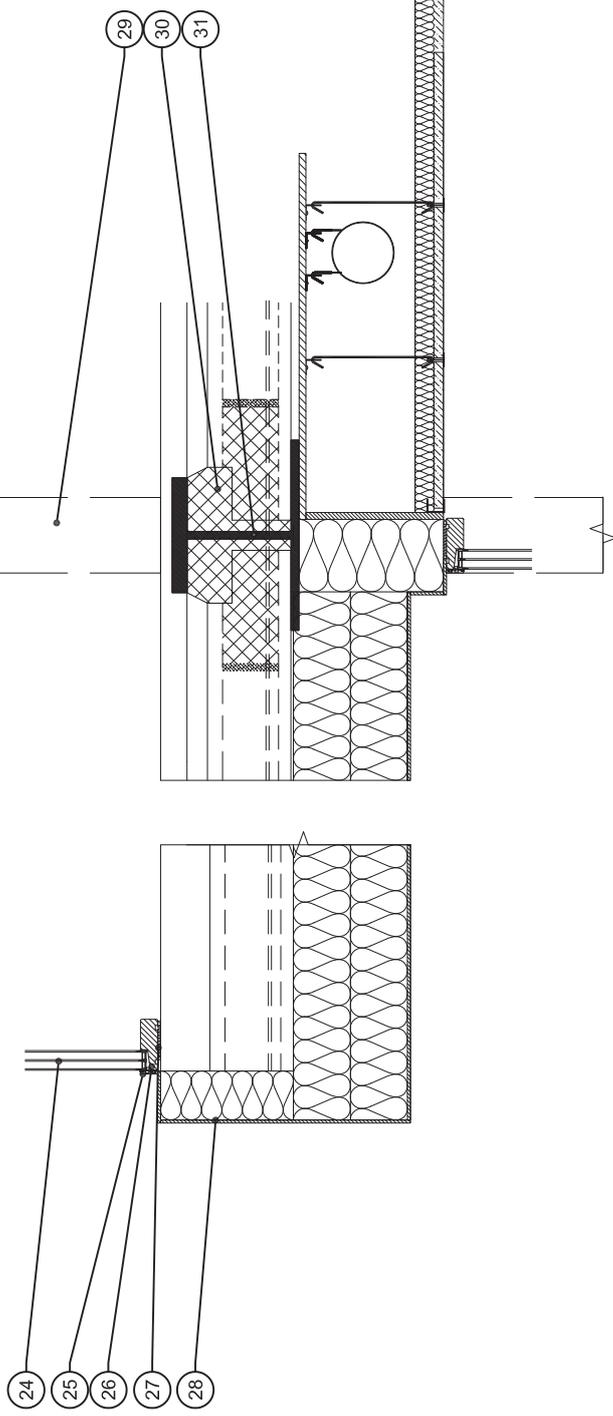
- ① Glass railing
- ② Metal pole
- ③ Wooden battens-facade 150 x 25 mm
- ④ Metal cap flashing
- ⑤ Rock Panel Cladding 8 mm
- ⑥ Root and waterproof membrane
- ⑦ Extruded polystyrene XPS
- ⑧ Bitumentape
- ⑨ Filtration
- ⑩ Edge element in concrete
- ⑪ Extruded polystyrene XPS
- ⑫ Hard Insulation
- ⑬ Vapor barrier
- ⑭ Light Soil
- ⑮ Gravel
- ⑯ Drain
- ⑰ Mechanical protective cover
- ⑱ Insulation
- ⑲ Reinforced Joints
- ⑳ OBS board 18 mm
- ㉑ Ventilation pipe \varnothing 160 mm
- ㉒ Thermal insulation 50 mm
- ㉓ Acoustic ceiling 25 mm



III. 78 - Detail of roof terrace

- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31

- 3 - layer glass
- Aluminium Sill
- Insulation
- Wood frame
- Rock Panel Cladding 8mm
- Steel Column HE.B 220
- Casting
- Steel Beam $\frac{1}{2}$ HE. B 650M



III. 79 - Floor slab

08/Epilogue

Conclusion

The new Copenhagen Main Library is the answer to finally giving a real home to Denmark's most visited cultural institution. The new location gives the library a proper library building, which has the space and functions required for a modern cultural center fit for a cultural capital such as Copenhagen.

The library is often referred to as 'the third place' between home and work, a fusion between the two. While, the location is very central in the center of Copenhagen, the experience of the library is a private one, a green haven in the middle of the buzzing city.

The location continues a green circle running through the city, incorporating a large green courtyard protected from the city. Moving around and being in nature is a strong metaphor for contemplation and calmness. The library is also a place for reflection, and a place where you can be separated from all the noise of everyday life, and just immerse yourself in a fantasy world.

The courtyard is a forest like landscape, and not a park like feel you can get several places in the city anyway. The green landscape will not have specific functions and areas as such, but instead a green organism which flows and intertwines with the library building, blurring the line between inside and outside.

However, the library is not just a place for privacy and contemplation of self. It is as much a place for gatherings and meeting new people. The central location in the middle of Copenhagen will cre-

ate optimum conditions for such. The new library will have much improved facilities for such happenings compared to the current building. The library will include space for exhibitions, auditoriums for lectures, meeting rooms and project rooms. A new café area will also open on the ground floor. The site is the current home for the well-known concert venue Pumpehuset. The venue will live on in new facilities in connection with the library building. Together this will create a new cultural hub in Copenhagen, a place for a wide array of cultural events of music and art.

The new library took inspiration in the Nordic design traditions, implementing local materials, bricks and wood for a robust and warm expression, while combining them with white surfaces and light structures allowing for sense of air and light. Last but not least, the connection to nature plays a big role, integrating the dense structured cityscape with the wild organically growing nature.

The design is created with a tectonic approach in mind as defined by such figures as Kenneth Frampton and Gottfried Semper. The new library has found a balance between the combination of materials, structural system and space in plan and human scale. The structural system acts as a creator of space and atmosphere, while

the materials connects the building with the city on a larger scale, but also helps create atmospheres and experiences on a human scale, when moving around the library space.

Reflection

Reflection

The design of a new main library in Copenhagen is an answer to an ever occurring question; is the library still relevant? Some people would probably say, why use money and space for a new library building when book sales and loans are dwindling every year? The answer is not as simple as 'yes or no'. The traditional function of the library, home to knowledge found in books is probably disappearing. However, we feel that the library is as relevant as ever. Attendance figures are still high, and the current Main Library in Copenhagen together with the new library building DOKK1 in Aarhus are some of the most visited cultural institutions in Denmark. The library has become a place for human interaction, a place between home and work, where people can meet to exchange and share cultural experiences such as art exhibitions and musical acts. That is why this new library is not simply a home for books, as you might feel if you visit the current library. Instead it is thought as a cultural center where knowledge and entertainment is in focus. As the book's role is diminishing, new media forms are created. The library's role is to be the 'sense maker', to make sense of all these new media forms.

Our main focus designing the library was on integration in context and flow of organization. Especially the first point greatly influenced the overall form and design. We argued that due to the

dense city context, and the 'colorful' neighboring attractions, the design would benefit from having a connection to the context instead of an 'unique' 'iconic' shape. That is how the 'block structure' became the inspiration for the overall design. Some would probably argue in favor of a larger than life, iconic shape, a beacon in the cityscape. Instead we favored a shape, which could emphasize our Scandinavian and Danish design aspirations, and metaphorical image of the function of the library.

The library as an architectural entity stands on line between art and utility. During the analysis phase, we argued that while libraries such as the Seattle Central Library might be a great architectural experience at first sight, the actual utility of the space as a place for contemplation and studying is pretty poor. Case studies such as these made us focus on the organization and flow of the library space, because it is a workplace for a lot of people, and a space where you as a visitor can spend many hours in a row, for example as a university student. Therefore, it was important to create a framework for such an experience.



09/References

Litterature

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10/Appendix



Defining the loads

First, the permanent loads defining the construction is calculated. The loads are divided into different construction types.

Dead loads

Calculation of surface load for steel beam HE-A 650M

$$G = 284,1 \frac{kg}{m}$$

$$Length\ of\ line\ load = 13,6\ m$$

$$Load\ area = 46,2\ m^2$$

$$g = 9,82\ m/s^2$$

$$284,1 \frac{kg}{m} * 13,6\ m = 3863,8\ kg$$

$$\frac{3863,8\ kg}{46,2\ m^2} = 83,6\ kg/m^2$$

$$\frac{83kg}{m^2} * 9,82 \frac{m}{s^2} = 0,82\ kN/m^2$$

Roof Construction				
Material	Thickness (m)	Specific Weight (kN/m3)	Area Load (kN/m2)	
½ HE 600 M			0,90	
A-murbatts	0,4	0,3**	0,12	
Suspended Roof incl. Installations			0,80	
Plywood	0,012	7		0,08

Spæncom Extramax 220 9 L12,5	0,220		3,24
Total load			5,144

Tagkonstruktion (med udeområder)				
Material	Thickness (m)	Specific Weight (kN/m3)	Area Load (kN/m2)	
Spæncom Extramax 220 9 L12,5	0,220		3,24	
½ HE 600 M	0,200		0,90	
A-murbatts	0,300	0,3**	0,09	
Suspended Roof incl. Installations			0,80	
Plywood	0,012	7	0,08	
Lightweight soil	0,45		4,91	
Sundolitt S 150*	0,100		0,23	
Total load			10,25	

*<http://www.sundolitt.dk/sundolitt/produkter/tag>

Floor Slabb				
Material	Thickness (m)	Specific Weight (kN/m3)	Area Load (kN/m2)	
Spæncom Extramax 220 9 L12,5	0,220		3,24	
½ HE 600 M	0,200		0,9	
Suspended Roof incl. Installations			0,8**	
Total load			4,94	

Skillevægge (gips)				
Material	Thickness (m)	Specific Weight (kN/m3)	Area Load (kN/m2)	
Gips	0,013	1,2*	0,0156	
Stolper, U-profil 70x35 mm, c/c 600 mm				
45 mm ROCKWOOL SKILLEVÆGSBAT TS	0,045	0,1**	0,0045	
13 mm gipsplade	0,013		0,0156	

$$Samlet\ last = 0,0357 \frac{kN}{m^2}$$

Skillevægge (glas)				
Material	Thickness (m)	Specific Weight (kN/m3)	Area Load (kN/m2)	
Vinduer/glas	0,025****	26*	0,65	
Aluminium	0,025	2,75**	0,06875	
Curtain wall			0,4-0,6	

Søjler (antal)				
Material	Thickness (m)	Specific Weight (kN/m3)	Area Load (kN/m2)	
Stål			1,2	

Glass facade				
Material	Thickness (m)	Specific Weight (kN/m3)	Area Load (kN/m2)	

Vinduer/glas	26*	
Aluminium	2,75**	
Curtain wall		0,4-0,6

$$S_{\text{milet last}} = 0,5 \frac{\text{kN}}{\text{m}^2}$$

Material	Thickness (m)	Specific Weight (kN/m ³)	Area Load (kN/m ²)
Mursten	0,108	17*	1,836
A-murbatts	0,2	0,3**	0,06
Gips	0,012	9	0,108

$$S_{\text{milet last}} = 2,004 \frac{\text{kN}}{\text{m}^2}$$

Live Load

The library floors is specified as Category C5, while the two top floors are categorized as Category B according to DS/EN 1991-1-1 DK NA:2013.

Live load, category C5

$$q_k = 5,0 \text{ kN/m}^2 \quad Q_k = 4,0 \text{ kN}$$

Lastværdierne for kategori B er:

$$q_k = 2,5 \text{ kN/m}^2 \quad Q_k = 2,5 \text{ kN}$$

The roof terraces are categorized as a balcony:

$$q_k = 2,5 \frac{\text{kN}}{\text{m}^2} \quad Q_k = 2,0 \text{ kN}$$

Snow Load

The roof shape coefficient is given by a roof pitch, α of 0-30 degrees.

The exposure coefficient, thermal coefficient and the characteristic value of the ground snow load for the relevant altitude is given according to the national annex EN 1991-1-3 DK NA

$$S = \mu_i * C_e * C_t * S_k$$

μ_i is the roof shape coefficient

S_k is the characteristic value of the ground snow load for the relevant altitude

C_e is the exposure coefficient

C_t is the thermal coefficient

$C_e = 0,8$ (windy topography, the building is tall and exposed)

$$\mu_i = 0,8$$

$$C_t = 1,0$$

$$S_k = 0,9 \text{ kN/m}^2$$

The snow load is therefore:

$$S = 0,576 \text{ kN/m}^2$$

Wind Load

To calculate the wind load imposed on the building, first the basic wind velocity needs to be calculated.

$$v_b = c_{dir} * c_{season} * v_{b,0}$$

c_{dir}^2 is the basic wind velocity defined as a function of the direction and season at a level of 10 m above ground level of category II

$v_{b,0}$ is the fundamental value of basic wind velocity, 24 m/s in Denmark

c_{dir} is the directional factor

c_{season} is the seasonal factor

c_{dir}^2 is determined according to the wind direction. This is assumed to be 270 degrees, West.

$$c_{dir}^2 = 1,0$$

c_{season}^2 is assumed at its worst.

$$c_{season}^2 = 1,0$$

The basic wind velocity is as such:

$$v_b = 1,0 * 1,0 * 24 \frac{\text{m}}{\text{s}} = 24 \text{ m/s}$$

Mean Velocity

Height variation

The mean velocity $v_m(z)$ at a height, z above terrain, depends on the terrain roughness and orography.

$$v_m(z) = c_r(z) * c_o(z) * v_b$$

Hvor

$c_r(z)$ is the roughness factor

$c_o(z)$ is the orography factor (usually taken as 1,0)

Terrain roughness

$c_r(z)$ takes into account the mean velocity's variation on the site depending on:

Height above terrain

Roughness of the terrain windward

tager højde for middelvindhastighedens variation på byggepladsen som følge af:

The roughness factor is:

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

$$c_r(z) = c_r(z_{min}) \text{ for } z \leq z_{min}$$

hvor

z_0 is the roughness length

k_r is the terrain factor dependent by the roughness length

$$k_r = 0,19 * \left(\frac{z_0}{z_{0,II}}\right)^{0,07}$$

Where,

$$z_{0,II} = 0,05 \text{ m (terrain category II)}$$

z_{min} is the minimum height (defined in 4.1, DS/EN 1991-1-4 FU:2010) z_{max} skal regnes til 200 m

z_0 and z_{min} depends on the terrain category

The terrain category assumed to be category IV, an area where at least 15% of the surface is covered by buildings with a mean height of 15 m.

$$z_0 = 1,0 \text{ m}$$

$$z_{min} = 10 \text{ m}$$

Terrain factor

$$k_r = 0,19 * \left(\frac{1,0\text{m}}{0,05\text{m}}\right)^{0,07} = 0,234$$

$$z = 27 \text{ m}$$

Roughness factor

$$c_r(z) = 0,234 * \ln\left(\frac{27\text{m}}{1,0\text{m}}\right) = 0,772$$

Thereby, the mean velocity is calculated

$$v_m(z) = 0,772 * 1,0 * 24 \frac{\text{m}}{\text{s}} = 18,54 \frac{\text{m}}{\text{s}}$$

Wind turbulence

The turbulence $I_v(z)$ is defined as:

$$I_v(z) = \frac{k_t}{c_o(z) * \ln\left(\frac{z}{z_0}\right)}$$

$c_o(z)$ is the orography factor (takes into account isolated changes in

the terrain height), $c_o(z) = 1,0$

$$z = 27 \text{ m}$$

$$z_0 = 1,0 \text{ m}$$

Turbulensintensiteten er:

$$I_v(z) = \frac{1,0}{1,0 * \ln\left(\frac{27}{1}\right)} = 0,303$$

Peak pressure

The peak pressure $q_p(z)$ at the height, z , is defined as such.

$$q_p(z) = [1 + 7 * I_v(z)] * \frac{1}{2} * \rho * v_m^2(z)$$

ρ is the density of air, dependent on the height, temperature and pressure during a storm. Assumed to be $1,25 \text{ kg/m}^3$

$I_v(z)$ is the turbulence

$v_m(z)$ is the mean velocity

$$q_p(z) = [1 + 7 * 0,303] * \frac{1}{2} * 1,25 \frac{\text{kg}}{\text{m}^3} * 18,54 \frac{\text{m}}{\text{s}}^2 = 670,49 \frac{\text{N}}{\text{m}^2} \rightarrow 0,67 \frac{\text{kN}}{\text{m}^2}$$

The peak pressure is used to determine the wind pressure on different of the areas of the construction.

Wind pressure

The wind pressure, acting on external surfaces w_e is defined as:

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

Where,

w_e is the wind pressure on external surface [kN/m^2]

$q_p(z_e)$ is the peak pressure [kN/m^2]

z_e is the reference height of the considered building [m]

c_{pe} is the external pressure coefficient

The wind pressure, acting on internal surfaces w_i is defined as:

$$w_i = q_p(z_i) * c_{pi}$$

Hvor

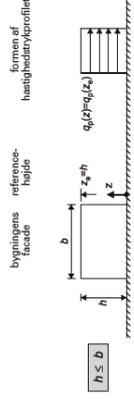
w_i is the wind pressure on internal surface [kN/m^2]

$q_p(z_i)$ is the peak pressure [kN/m^2]

z_i is the reference height of the considered building [m]

c_{pi} is the internal pressure coefficient

Wind load on facades



When calculating the wind pressure on a surface, a reference height is taking into account.

The reference height is dependent of the relationship between h and b.

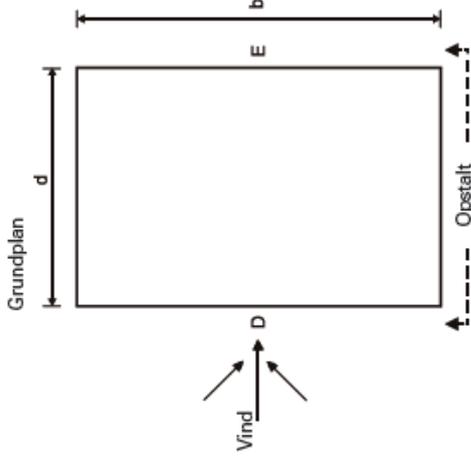
In this instance $h > b$. Therefore, the construction is considered as one whole.

The construction is affected by the wind pressure at one height.

For cases where $e \geq d$. The wind pressure on the facades is dividedes into zones A, B, D and E.

Konstruktionen belastes af vindtrykket i én højde.

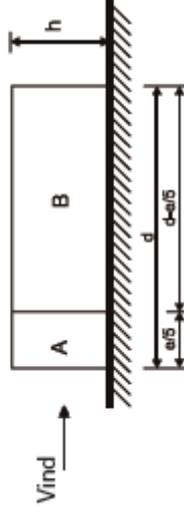
The wind pressure for zones A, B, D and E is calculated using global factors, since the affected area is greater than 10 m².



e = den mindste værdi af b eller 2h

b : dimension på tværs af vinden

Opstalt for $e \geq d$



The form coefficients is determined by the relationship between h and d.

Zone	A		B	
	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
h/d				
5	-1,2	-1,4	-0,8	-1,1
1	-1,2	-1,4	-0,8	-1,1
$\leq 0,25$	-1,2	-1,4	-0,8	-1,1

h/d :

$$\frac{25,5m}{28,0m} = 0,911$$

Since $\frac{h}{d} = 0,911$, the value is interpolated linear on zone D and E.

$$y = \frac{y_1 - y_0}{x_1 - x_0} (x - x_0) + y_0$$

Zone D

$$y = \frac{0,8 - 0,7}{1,0 - 0,25} (0,911 - 0,25) + 0,7 = 0,788$$

Zone E

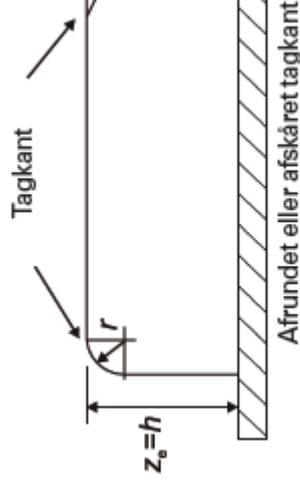
$$y = \frac{(-0,5) - (-0,3)}{1,0 - 0,25} (0,911 - 0,25) + (-0,3) = -0,476$$

The wind pressure acting on external surfaces, W_e :

$$W_e = q_p(z_e) * C_{pe}$$

Facade zone	Load [kN/m^2]
$\omega_e A$	-0,804
$\omega_e B$	-0,536
$\omega_e D$	+0,528
$\omega_e E$	-0,319

Wind load on the roof



Tabél 72 – Formfaktorer for udvædige tryk på flade tage

Tagtype	Zone									
	F		G		H		I		I	
	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
Skarp tagkant	-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	-0,2	-0,2	-0,2	-0,2
Med brymin-ger	$h_p/h = 0,025$	-1,6	-2,2	-1,1	-1,8	-0,7	-1,2	-0,2	-0,2	-0,2
	$h_p/h = 0,05$	-1,4	-2,0	-0,9	-1,6	-0,7	-1,2	-0,2	-0,2	-0,2
Afrundet tagkant	$h_p/h = 0,10$	-1,2	-1,8	-0,8	-1,4	-0,7	-1,2	-0,2	-0,2	-0,2
	$rh = 0,06$	-1,0	-1,5	-1,2	-1,8	-0,4	-0,2	-0,2	-0,2	-0,2
Afskåret tagkant	$rh = 0,10$	-0,7	-1,2	-0,8	-1,4	-0,3	-0,2	-0,2	-0,2	-0,2
	$rh = 0,20$	-0,5	-0,8	-0,5	-0,8	-0,3	-0,2	-0,2	-0,2	-0,2
	$\alpha = 30^\circ$	-1,0	-1,5	-1,0	-1,5	-0,3	-0,2	-0,2	-0,2	-0,2
	$\alpha = 45^\circ$	-1,2	-1,8	-1,3	-1,9	-0,4	-0,2	-0,2	-0,2	-0,2
	$\alpha = 60^\circ$	-1,3	-1,9	-1,3	-1,9	-0,5	-0,2	-0,2	-0,2	-0,2

NOTE 1 – For tage med brymin-ger eller afrundet tagkant kan der interpoleres værdier for mellemtilgænde værdier af h_p/h og rh .
 NOTE 2 – For tage med afskåret tagkant kan der interpoleres værdier mellem $\alpha = 30^\circ$, 45° og $\alpha = 60^\circ$. For $\alpha > 60^\circ$ kan der interpoleres værdier mellem værdierne for $\alpha = 60^\circ$ og værdierne for flade tage med skarp tagkant.
 NOTE 3 – Zone I, hvor der er angivet positive og negative værdier, tages begge værdier i betragtning.
 NOTE 4 – For sølv den afskårede tagkant er formfaktorer for udvædige tryk angivet i tabel 72a. Formfaktorer for udvædige tryk på sadel- og trugtag: vindretning 0°. Zone F og G afhænger af den afskårede tagkants hældningsvinkel.
 NOTE 5 – For sølv den afrundede tagkant er formfaktorer for udvædige tryk givet ved lineær interpolation langs afrundingen mellem værdier på væggen og på taget.

Calculating on a rounded roof edge.

$$\frac{r}{h} = \frac{1,0m}{25,5m} = 0,039$$

The value for $\frac{r}{h} = 0,05$ is used

$C_{pe,10}$ -values for roof zones

Zone	$C_{pe,10}$
F	-1,0
G	-1,2
H	-0,4
I	+0,2 & -0,2

The wind pressure

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

$$q_p(z_e) = 0,67 \frac{kN}{m^2}$$

Zone	Sug [kN/m ²]	Tryk [kN/m ²]
F	-0,67	
G	-0,804	
H	-0,268	
I	-0,134	+0,134

Load Combinations

To describe the load combinations, the consequence class CC3 has been chosen for the library due to its size and use.

Ultimate Limit State

The design loads is defined by load combination 6.10a and 6.10b Eurocode 0 [DS/EN 1990, 2007].

- 1) $\sum \gamma_{G,j} * G_{k,j} + \psi_{0,1} * P + \gamma_{Q,1} * \psi_{0,1} * Q_{k,1} + \sum \gamma_{Q,i} * \psi_{0,i} * Q_{k,i}$
- 2) $\sum \xi * \gamma_{G,j} * G_{k,j} + \psi_{0,1} * P + \gamma_{Q,1} * Q_{k,1} + \sum \gamma_{Q,i} * \psi_{0,i} * Q_{k,i}$

$\gamma_{G,j}$ partial factor for permanent loads

$G_{k,j}$ characteristic value of permanent action, j

γ_P partial factor for prestressed loads

P relevant value of prestressing action

$\gamma_{Q,1}$ partial factor for dominating variable load

$Q_{k,1}$ characteristic value of dominating variable load,

$\gamma_{Q,i}$ partial factor for additional variable loads

$\psi_{0,i}$ factor for combination value of a variable load

$Q_{k,i}$ additional variable loads

ξ reduction factor for dead load

Partial factors, combination factors and reduction factor is found according to the national annex for Eurocode 1 [EN 1990 DK NA, 2007].

Equation 1, concerns permanent loads. A load combination for dominating own load is established.

The remaining load combinations are established according to equation 2.

Dominant own load

Considering dominating own load, the partial factor, $\gamma_{G,j} = 1,0$. The remaining loads are not considered in this load combination.

$$p_G = 1, 2 * G$$

Dominant live load

For permanent load, $\gamma_{G,j} = 1,0$, for variable loads, $\gamma_{Q,i} = 1,5$, unless the load is beneficial, in that case $\gamma_{Q,i} = 0$.

$$p_L = 1, 0 * 1, 0 * G + " 1, 5 * 0, 6 * S " + " 1, 5 * q " + " 1, 5 * 0, 6 * w$$

Dominant snow load

$$p_S = 1, 0 * 1, 0 * G + 1, 5 * S + 1, 5 * 0, 6 * q + 1, 5 * 0, 3 * w$$

Dominant wind load

$$p_W = 1, 0 * 1, 0 * G + 1, 5 * 0 * S + 1, 5 * 0, 6 * q + 1, 5 * w$$

Serviceability limit state (SLS)

In the serviceability limit state, the frequent combination for reversible limit states is used, load combination which apply to cases with no

$$\sum G_{k,j} + P + \psi_{1,1} * Q_{k,1} + \sum \psi_{2,i} * Q_{k,i}$$

Hvor:

$G_{k,j}$ characteristic value of permanent action, j

$\psi_{1,1}$ factor for combination value of dominant variable load

$Q_{k,1}$ characteristic value of dominating variable load

$Q_{k,i}$ additional variable loads

$\psi_{2,i}$ factor on $Q_{k,i}$

$\psi_{2,j}$ factor for quasipermanent value of variable load

P relevant value of prestressing action

Dominant live load

$$p_q = G + (0,4 * q + 0,6 * q) + 0 * s + 0 * w$$

Dominant snow load

$$p_q = G + 0,2 * s + (0,2 * q + 0,5 * q) + 0 * w$$

Dominant wind load

$$p_q = G + 0,2 * v + (0,2 * q + 0,5 * q) + 0 * s$$

Hereby are the load combinations for ultimate limit state and Serviceability limit state established, and subsequently performing a dimensioning of the relevant elements of the structure.

