# aalborgmediatheque

a sustainable public space with a realm of human experiences

sundeep khatri (ma4-ark6)
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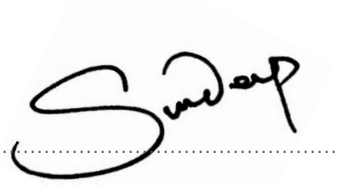


sundeep khatri

# synopsis

The final semester thesis assignment focuses on the creation of a public space with human essence for th city of Aalborg through sustainable architecture following an integrated design process. The project consists of huge public spaces which posse a challenge of energy and climate optimization. The site to the project is at Strandgade on Nørresundby close to the bridge. The site covers around 3000 $m^2$ and lies in a route with a good flow of people.

The proposed building is a mediatheque. Basically it is a library for media stuffs like cds and dvds, but it also contains sections for books. The building will have separate spaces for children and adult use. The design program also consists of a gallery space for exibition, restaurant and other recreational areas, meeting and administrative areas.

Tectonic architecture is the major theme for the techncal for the project which has been tried to achieve from materials and construction system. Another important aspect is the energy consumption of the building is a important factor as the project is a public space and hence contiains demand of the building is an important focal huge spaces with less internal partitions. The idea is to make the design as sustainable as possible with the best use of site condition, architectural design and planning.

architecture is not the design of buildings but that of **spaces** created in or between buildings.....

# abstract

A society is made by human and their social interaction. Hence, for a helathy society, a public space lying around the centre area where people can meet to interact and share their experiences is very essential in a city. Maybe this is why architecture is the only art that has direct effect on society.

Architecture is the design of spaces and it's relations with human emotions. As its an utilitarian art, not only its form but its function is has a key role. Hence, a good architecture should always be able to create a dialogue with its users.

Designing a public space fully catering the demands of the users is already a challange but doing that in a scandinavian site with its freezing weather and strong wind adds an extra requirement. Since the climate is harsh most of the time of the year, the outdoor public space is not very effective. Hence the idea behind the project is to design a indoor public space fulfulling the need of gathering and interacting place.

In addition to these, the design also has a requirement of being sustainable from its location to its construction, from energy consumption to fulfilling social function. Sustianable doesnot mean only energy consumption, but also the cost of construction as well as running of the building. In a public building of this scale, being sustainable in every possbile aspect is a crucial requirement of the design

With all this in mind, the driving idea behind the project is to design a mediatheque that functions as a media library, exbition space and recreational area which act as a social connector between the people. The goal is to create a space in and around a building structure which left a legacy of minimum carbon footprint.

# motivation

The basic motivation behind choosing library as a topic for the master dissertation is its architectural and cultural significance in the society. From the ancient greek to modern age, library has played a central role in the city and its people. We all know about the ancient library of Alexandria, in Alexandria, Egypt and the role it played in flourishing Ptolemaic dynasty. From those days to today, library building is one of the prominent structure of any socialized city. The progressiveness of a society can be measured by the importance it has give to the developmnet educational centres like library. From the seatle library in US, to pompidou cente in France, from sendai mediatheque in Japan to Phillips Exeter Academy Library in US, modern libraries have been able to create not only great educational spaces but  landmarks to the cities through their architectural expressions.

The idea behind selecting mediatheque as the type of library is newness in context and ability to incorporate multiple functions than just library. Mediatheque which is also known as Hybrid Library are mixes of of traditional print material such as books and magazines, as well as electronic based material such as downloadable audio books, electronic journals, e-books, etc [WEB 1]. The need of mediatheque is the rapid developement of world in the digital age and our habits of storing every informations digitally. Hence the concept of mediatheque might sounds futuristic but very soon its going to be everyday part of our life.

Other than function of exchaning informations, my proposal for the mediatheque is to create a space for the public interaction. The mediatheque should be able to attract people and increase face to face social interaction between them which is rapidly loosing in new internet generation.

Apart from them, the goal is also to create an architectural expression with a building that express the intention of the city.

# contents

# method

## integrated design process

The method used for the developement of the project is integrated design process (IDP) formulated by Mary-Ann Knudstrup. Instead of connecting in a linear fashion, in IDP the different phases are interconnected and related to each other back and forth forming loop. The process consists of five phases: program, analysis, sketching, synthesis and presentiation.

In the **program phase**, which is also called project formulation phase or project idea phase, the brief is formulated and basic requirement and knowledge of the project is created.

The **analysis phase** is where we make all the analyses regarding site context, climate, space program, case studies, and different issues like lighting, acoustic, archiectural styles, structure and construction system. Hence, at the end it helps to create the clear cut picture of the vision for the project.

The **sketching phase** is where we look for the solutions of the problem we understood in analysis phase. In this phase we develop the different possible ideas for the project based on our previous analysis, hence is also called concept phase. The phase takes place in several levels and consists of different degree of detailing. For better resulting of the problem, the technical aspects of the project is equally considered from this phase. At the end of the phase, an idea is choosen from different proposed and continued to next phase.

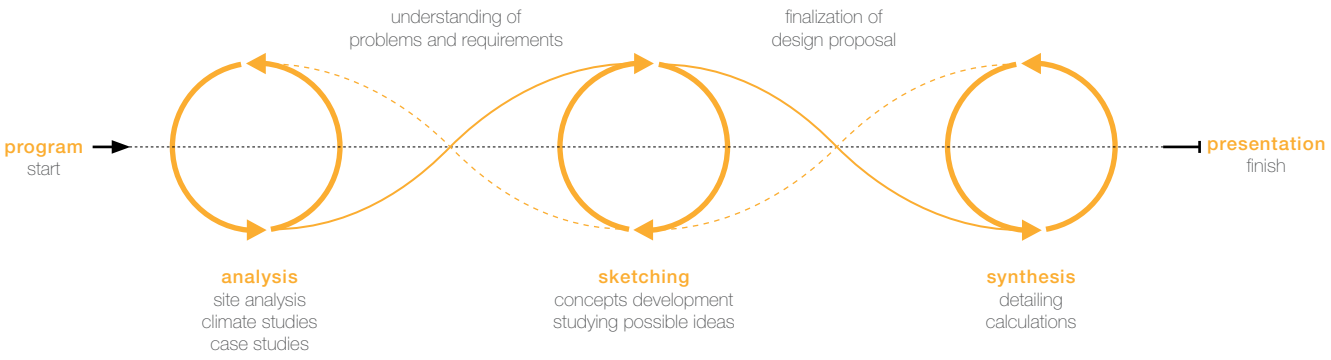
In the **synthesis phase** we have a design idea from the previous phrase which needs to be detailed and developed. The raw idea from sketching phase is polished here at architectural and technical levels with the help of drawings, models and calculations.

The **presentation phase** is the presentation of what we have achieved from our design experiences in a report, drawings, models or visualizations.

The problem based learning (IBP), as used in Aalborg University, helps to exercise IDP and gain maximum possible benefits from it. To better understand the problem, the whole process is divided into three design loops which keeps on making iterations until and unless satisfying result is gained. When we get result in one loop we move to another but later if we found some solutions lacking or some problems unresolved then, there is always the possibility of returning to the previous loop.

The main target of IDP is to combine technical issues with the architectural aspects from the beginning of design process so that if there is any problem, they wouldn't make big obstable at the end.

[Knudstrup, 2004]




ill. Iterations occur within each phase as well as between the phases

# tools

| phase | description | tools / method |
|---|---|---|
| **problem formulation** | • Research – collection of informations<br>• Discussions with supervisors | |
| **analysis** | • Research – collection of informations<br>• Site analysis – mapping, microclimate, surrounding senses<br>• Urban development studies<br>• Case studies<br>• Nordic archiecture<br>• Tectonic architecture<br>• Light study<br>• Acoustic Study<br>• Space program<br>• Vision | • Kevin Lynch's analysis method<br>• Sun data<br>• Wind data<br>• Case Studies |
| **sketching** | • Consideration of defined criteria in the development and evaluation of design solutions through estimation of how sketches meet the defined criteria.<br>• Choosing from different options for building form, plans, program, orientation, construction and material<br>• Drawings – plan, section, facade<br>• Physical models and 3D models<br>• Model studies<br>• Contruction strategies<br>• Material considerations<br>• Calculations – Autodesk Robot<br>• Energy consumption strategies - heating, cooling, ventilation and lighting<br>• Indoor environmental strategies – thermal comfort, air quality, acoustics and lighting qualities<br>• Passive technology strategies – natural ventilation, day lighting, passive heating and cooling developed in consideration of the local climatic context and local energy distribution facilities. | • Physical Models<br>• Hand sketches<br>• 3D Models<br>• Autodesk Robot |
| **synthesis** | • Final decisions for the design of the building<br>• Physical models and 3D models<br>• Drawings – plan, section, facade<br>• Optimization of calculations<br>• Structural systems | • Autodesk Robot<br>• Sketchup (Light study) |
| **presentation** | • Report<br>• Drawings (Plans, Sections, Facades)<br>• Model (Physical model, 3d visualizations)<br>• Diagrams<br>• Details<br>• Calculations | • Adobe CS<br>• 3ds max<br>• Auto CAD<br>• Sketchup<br>• Autodesk Robot<br>• Physical Model |

# **program**study

It is the first step in the design procedure and contains different analysis on site conditions, sustainability issues, project requirements and case studies. These analyses are the basis for the development of vision and concept in the next step of Design Process.

Aalborg


Denmark

# context

## aalborg

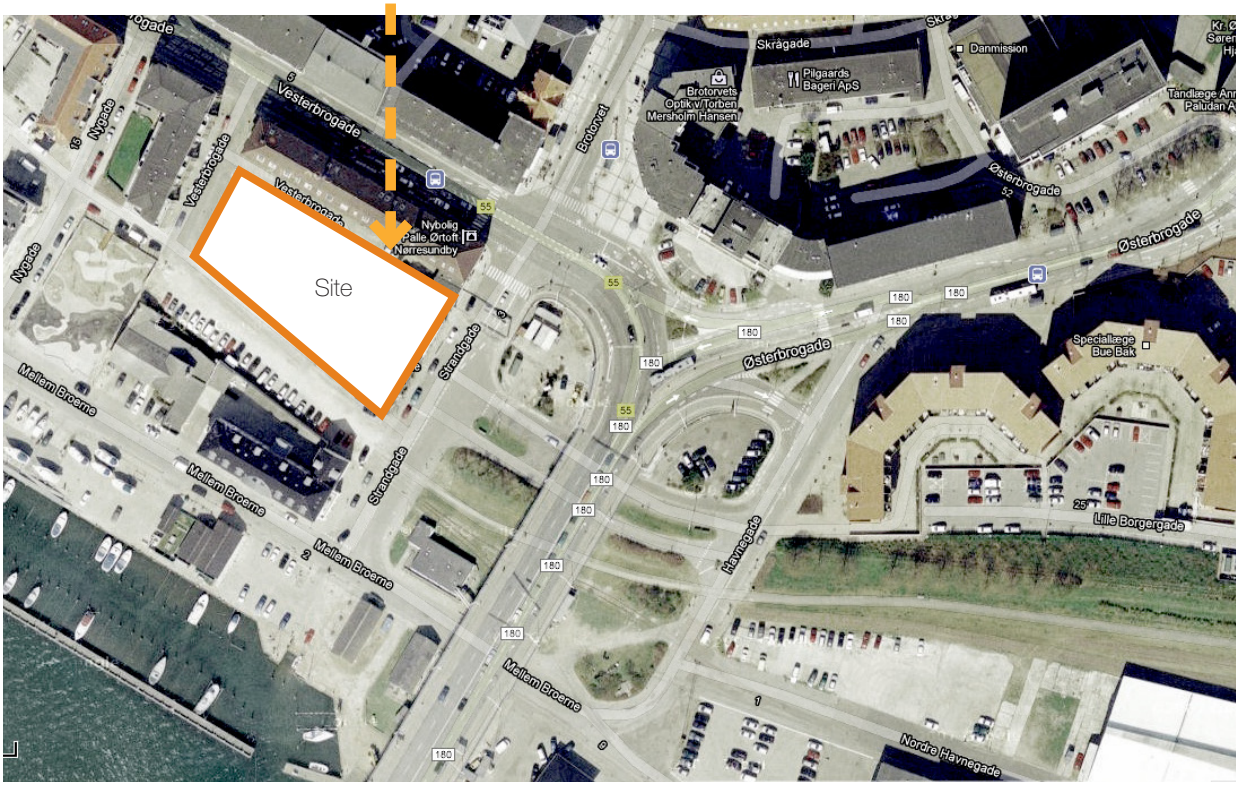
Situated in the Northern part of Denmark at the Limfjord, Aalborg is a city with changing identity. It has a rich industrial past but is on verge of redevelopping into an university city. As a result, the city is getting more and more populated and hence demands better quality living space.  One of such space is social public interacting space.

## site introduction

The site is located at the cross-section of Vesterbrogade and Strandgade in the Nørresundby, near the starting of the bridge. The site is basically surrounded  by residential areas but it's access to main road at south-east makes it viable to high public flow. On the north-east there is a residential building aligned to Vesterbrogade with other mixed function buildings. While on south and west, it is loosely connected to other residential buildings. Although there are few small structures, most of the site is vacant. The site has very good accesses from all direction and is very open visually.


Mellem Broerne
Vesterbrogade
Vestergade
Torvegade
Gammel Østergade
Østergade
Skrågade
Brotorvet
Strandgade
Lille Borgergade
Havnegade
Nordre Havnegade
Engvej
Strandvejen
Vestre Havnepromenade
Nyhavnsgade
Nyhavn
Stigsborg Brygge
Limfjordsvej
Aalborg Auto-Center

Site


Site
Vesterbrogade
Nybolig Palle Ørtoft Nørresundby
Mellem Broerne
Strandgade
Skrågade
Brotorvet
Østerbrogade
Havnegade
Lille Borgergade
Nordre Havnegade
Danmission
Pilgaards Bageri ApS
Brotorvets Optik v/ Torben Mersholm Hansen
Speciallæge Bue Bak


paths
Road
Rail
edges
nodes
landmarks
districts
Residential
Commercial
Institutional
Industrial
Mixed
Residential Area
Site
Industrial Area
Mixed Area
Mixed Area
Instutional Area
Utzon Centre
Commercial Area
Church
Central Station

# mapping

## kevin lynch's analysis method

Ref: The image of the City

The method is created according to users interaction with the urban spaces. According to Kevin Lynch, people experiences public spaces on following basis; paths, nodes, landmarks, edges and districts. The method has no reference with the emotional or historical values of the place.

### paths:

Paths are the elements which act as the link between two areas. Paths can be of different scales depending upon their uses.
As people follow the paths to reach different places, they are hence directly related to their experiences.

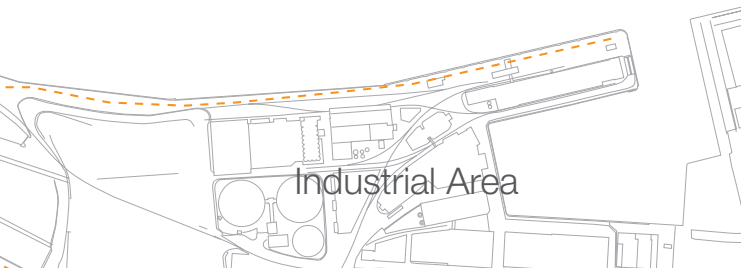
### nodes and landmarks:

The intersections of the paths are defined by nodes. These places have high values especially when the required function is interaction between people.

Landmarks are the public places with particular significanes and hence carry the identity of the space.

### edges and districts:

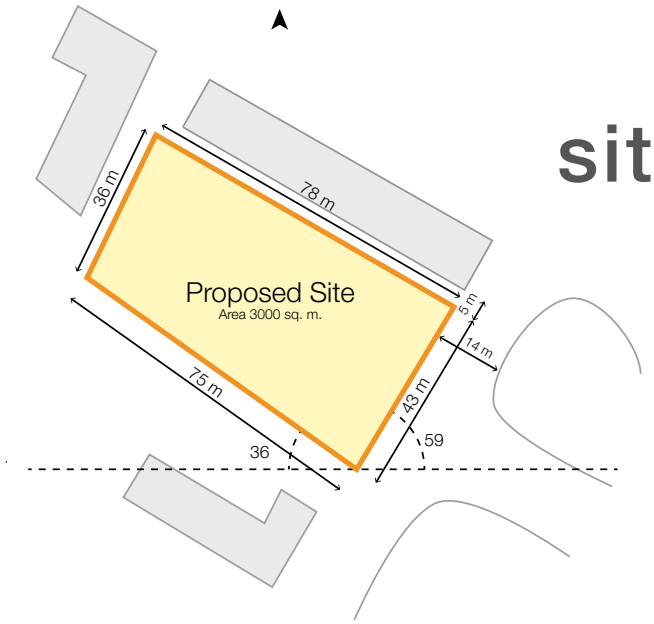
Districts are the division of the areas according to their functions. One can easily observe the demarcation by the edges between two district areas.
[Lynch, 1960]


## conclusion

The analysis is a great help to understand the location and condition of the site. The analysis clearify the development pattern around the site and its potential during the development. Although the site is surrounded by mainly residential area, it's location on the major path and very close to the centre make it ideal for public space design. The site has very good accesses and wide and beautifula visual openings.

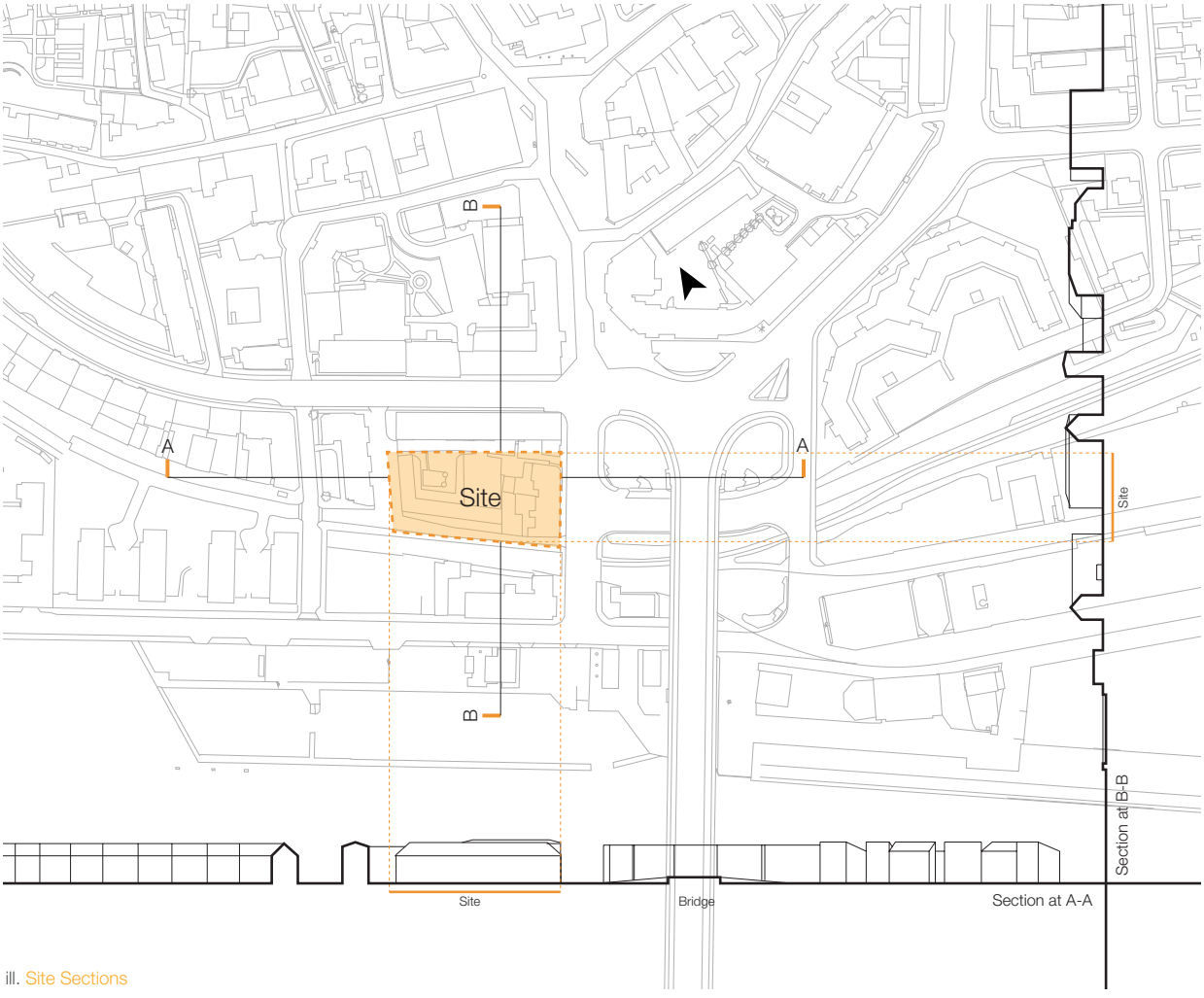
ill. Kevin Lynch Method



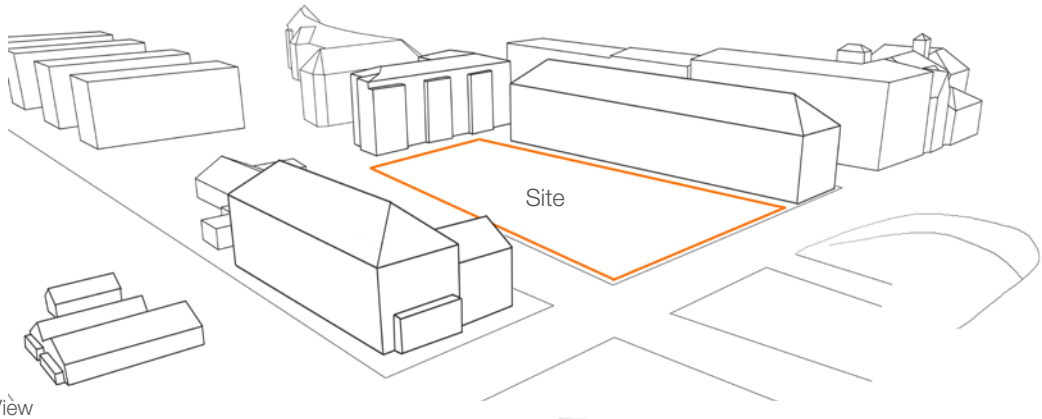

# **site**dimensions

The site is quadrilateral with one side longer than that of other. The longer side is 75 m to 78 m at the longest while the shorter side is 43 m to 36 at the shortest. The area of the site is 3000 m$^2$. The site is not North-South aligned. Its tilted 36° to north. The site has 14 m wide main access on east and is separated from a town house on north by a 5 m internal access.

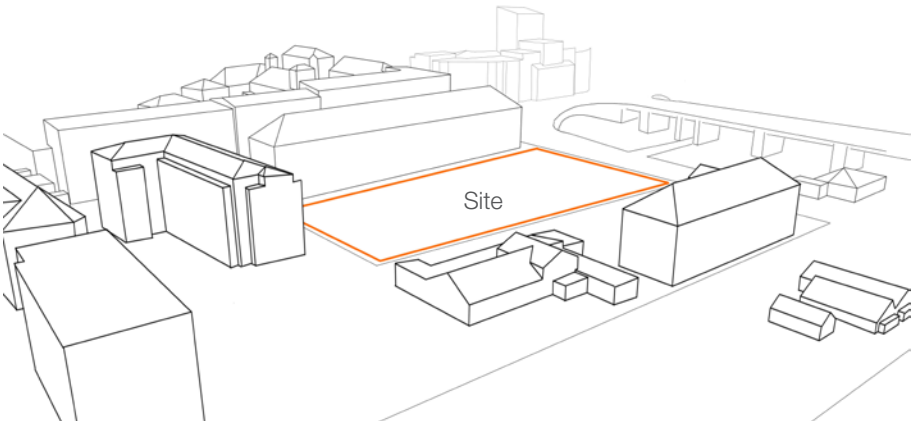
ill. Site Dimensions




ill. Site Sections




South View




West View

ill. Site Edges

# **urban**stretch

The urban fabric of the site should have direct relation to the site hence it is analysed by studying site sections and dominating edges.

## sections

Two sections on the adjacent sides are taken into considerations, to study the building heights and open spaces around. Since the site in not exactly North-South oriented, the sections are designated as Section at A-A and Sections at B-B in the drawing.

### section at A-A

This section cuts the site at longer side and includes the bridge on the site face while town houses on the back. The site has road access on  both side and a good visual clearance on the front.

### section at B-B

This section cuts the site on the shorter side. Here also it has access on the both side, making it an island site. Visually both the sides are restricted by tall buildings but due to open spaces inbetween there are lots of breathing space.

## edges

The different qualities, functions and strcutures around the site are studied on edges

### south edge

The south edge is the most important side of the site as it faces to the main access  and open space upto to the bridge. The visual clearance runs far beyond the bridge. On the north, the site is boarded with town houses with the accesses inbetween.

### west edge

The west edge is the back of the site but still contians lots of open spaces. The tall buildings are far behind providing a very clear view and wind access to the site.

## conclusion

Strategically, the site location is full of potentials. It is an site with access on all side and open spaces to most of the parts. The site is corssed by the major route hence calling for high user flow. Hence, the is ideal for a public related space design.

# surrounding**senses**

It studies the urban fabric development around the site. It helps to understand the development patterns and create the basis for the design.

The prime location of the site on the major route makes it very accessable physically as well as visually. The site contains a 4 stories residential house which is going to be demolished for the clearance of the site. The site is surrounded by residential and mixed used buildings with ground floors serving for commercial purposes.

Due to the increase of the population density, the area is developing from momogenous residential space to heterogeneous mixed used spaces.

1

View of Site form the bridge

2

South view of site from bridge

3

South view of site from bridge

7


Surrounding building in North-east of site

8

Surrounding building in East of site

9


Vesterbrogade on north

13

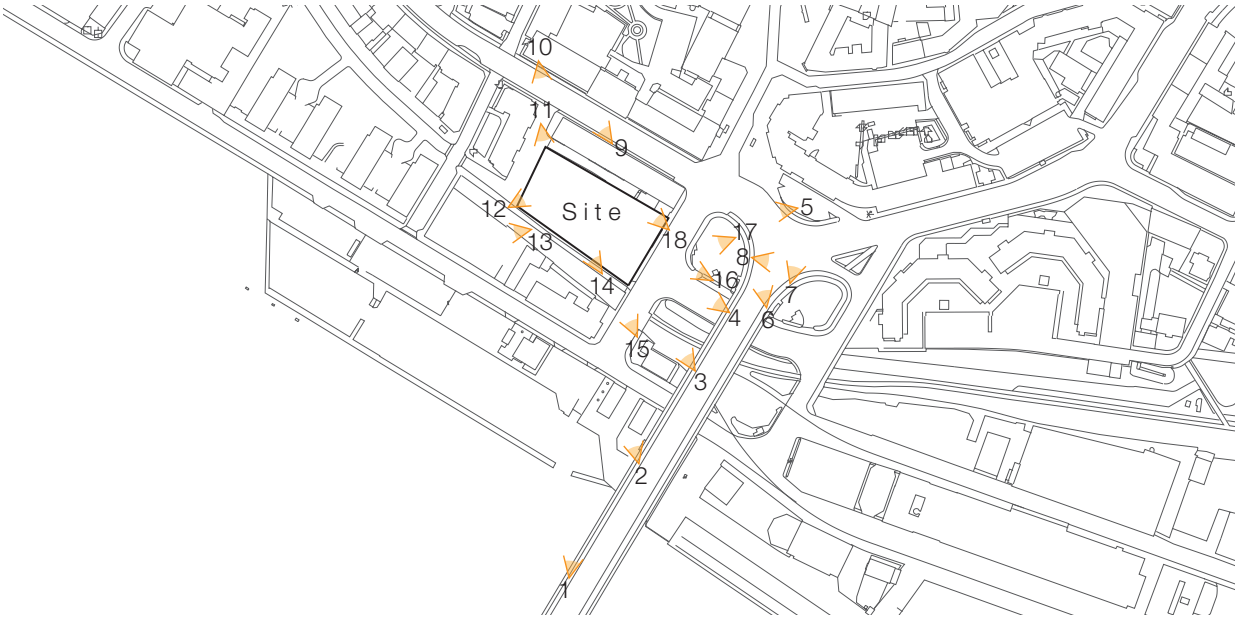
Surrounding building on South-west of site

14

South view of the site

15


South view of the site





4
South-east view of site from bridge


5
North-east view of site from bridge


6
Surrounding buildings on north

10
View of site from vesterbrogade


11
North view of the site


12
West view of the site

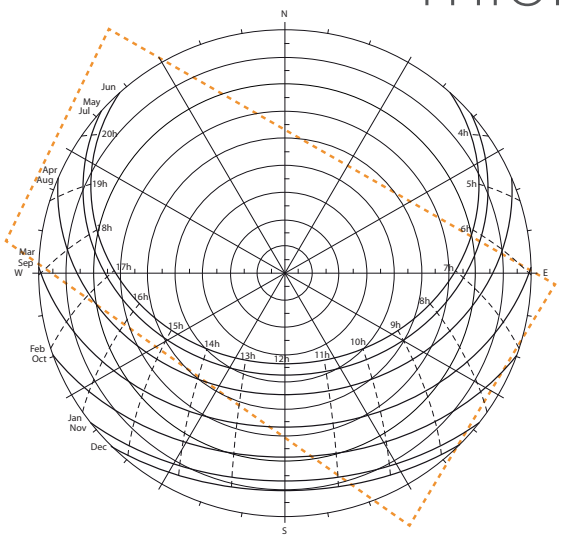

16
South-east view of the site


17
North-east view of the site


18
View of adjacent building on north

# micro**climate**

A building to constructed to protect the humans from the harshs of the weather. Understanding the climate can help to better design the building and interior space. Sun in crucial to heat and light the building while wind is for the cooling. Hence their study if the major part of desing process.




ill. Stereographic Sunpath Diagram, with site

## sunpath

From the study of sterographic sunpath diagram, we can understand the movement of the sun. Primarily it is subjected to south while east and west are its secondary locations. Over the year, the intensity and the length of day light varies significantly. Its shorter in winter, minimum in december while longer in summer maximum in June.

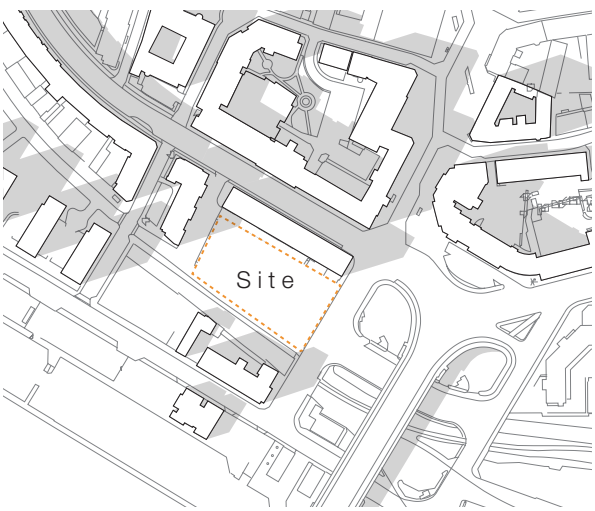
## sun angle

Inorder to make the indoor space comfortable in living throughout the year, it is very important to understand the behavior of the sun. It rises up in summer while docks down in winter.

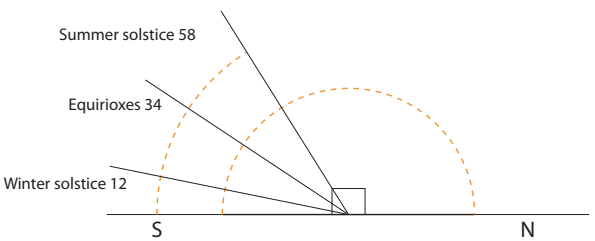
The sun is highest in the summer with an angle of 58 degrees and lowest in the winter with 12 degrees.

## shadow

The site is bordered with tall buildings only on the north side hence the shadow casting on the site is not a big issue. Even the worst conditon of 21st March evening shadow seems unaffecting the site condition. The opening on the east and west and the set backs between the buildings help the site enjoy the sun most of the time.




ill. Shadow, 21 march evening




ill. Sun Angle

## solar radiation

For a building to be energy efficient, heating is the key factor and if we could incorporate solar radiation for the purpose the enegry cost can be decreased significantly. For a building to be energy efficient in cost and comfortable in living, solar heating in winter and avoiding overheating in summer is very important. Hence, yearly temperature table of Aalborg can help to understand the different condition required.

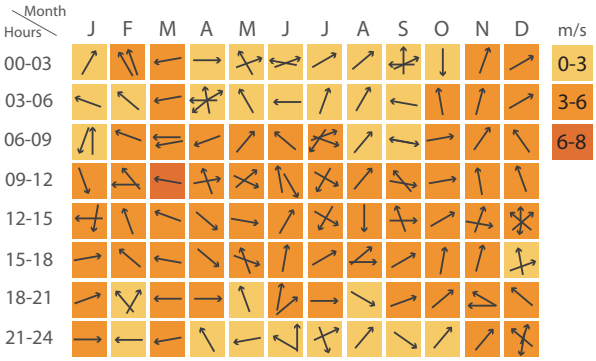
| Hour | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00:00 | 0° | 0° | 1° | 4° | 8° | 13° | 13° | 15° | 14° | 8° | 3° | 0° |
| 03:00 | -1° | -2° | 0° | 4° | 7° | 11° | 12° | 14° | 13° | 7° | 3° | 0° |
| 06:00 | -2° | -3° | 0° | 3° | 6° | 10° | 12° | 11° | 10° | 6° | 2° | -1° |
| 09:00 | -3° | -2° | -1° | 2° | 9° | 13° | 15° | 15° | 9° | 8° | 3° | 0° |
| 12:00 | -1° | 0° | 1° | 4° | 13° | 17° | 18° | 18° | 15° | 10° | 6° | 1° |
| 15:00 | 1° | 1° | 3° | 8° | 16° | 19° | 20° | 20° | 17° | 12° | 5° | 3° |
| 18:00 | 2° | 2° | 5° | 7° | 12° | 16° | 19° | 19° | 16° | 10° | 4° | 2° |
| 21:00 | 0° | 1° | 3° | 5° | 10° | 15° | 16° | 16° | 14° | 9° | 3° | 1° |
| High | 2° | 2° | 6° | 10° | 15° | 19° | 20° | 20° | 16° | 12° | 7° | 3° |
| Low | -3° | -3° | -2° | 2° | 6° | 10° | 12° | 12° | 9° | 6° | 2° | -1° |

ill. Weather Chart, [WEB 1]

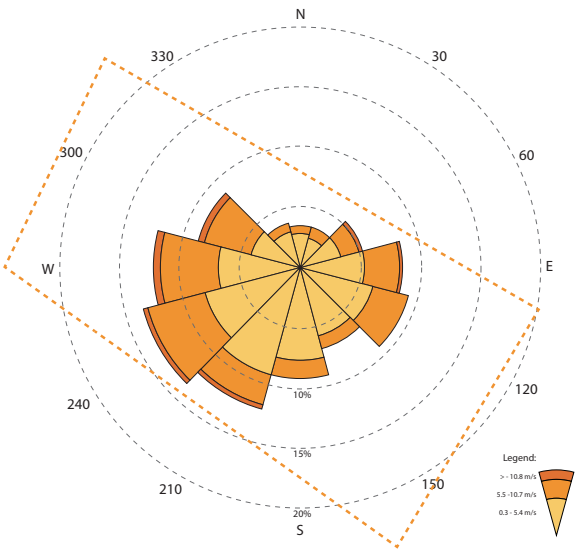
## wind

The wind has a great influence on the sustainability of a building and when the site is on the northern part of the Denmark, it becomes more crucial. The understanding of wind direction and intensity helps to ventilate the building in summer and protect from it in winter.

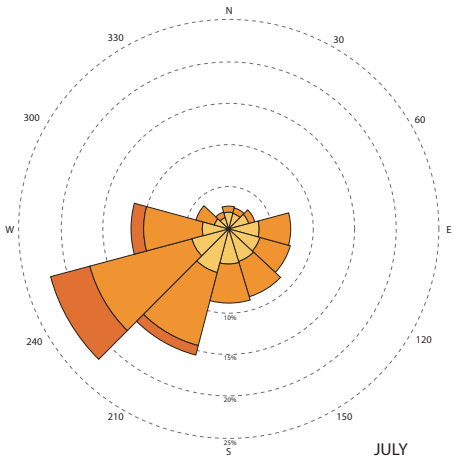
The Wind rose study shows that the wind is in all direction but is particularly strong on the south-west.

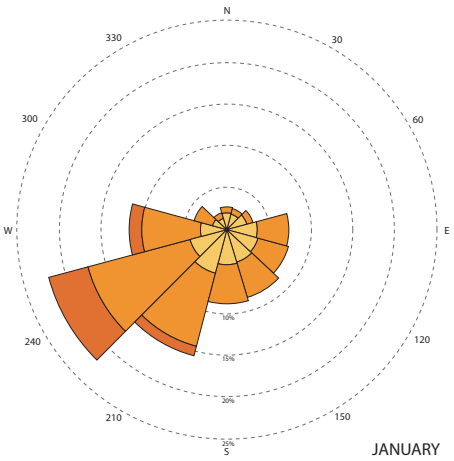


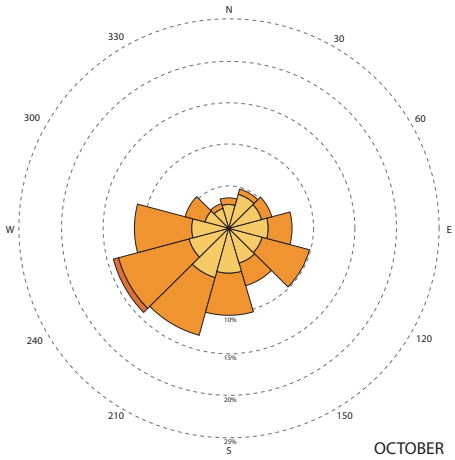

ill. Windsquare

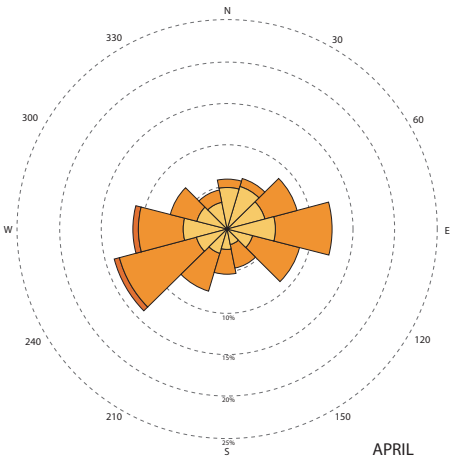



ill. Wind rose, [WEB 2] with site




ill. Seasonal Wind rose, [WEB 2]

# **media**theque

A mediatheque is usually a public institution, with the funciton of preserving and providing access to various types of media. It is a modern form of traditional library. 1980s saw the evolution of the concept of this modern library, after audiovisual contents (audio and video recordings) were considered as record of culture as well as writings. Initially, the term mediatheque was selected in order to better reflect the diversity of works and resources collected and presented to the public, as the collection comprises especially in the form of videotapes to Betacam and VHS. In the 1990s, the collection was extented to cover digital media (CD audio, DVD video) that complemented the traditional media (print, microfilm, vinyl, etc..).

Nowadays, several cities own their media library. Sendai mediatheque in Japan is one of the pioneer in its field. In France, they supplement or are related to inter-municipal libraries and are open to the public who can view the collections on-site and borrow CDs, videos, DVDs, etc. [WEB 3]

# **case**studies

To get the references to the different aspects of design, construction and materials, different case studies to masterworks are made giving particular attention to their characteristic features. The projects range from 20th century to present day conrstruction. The typology consists of mediatheque, mixed used buildings and libraries.

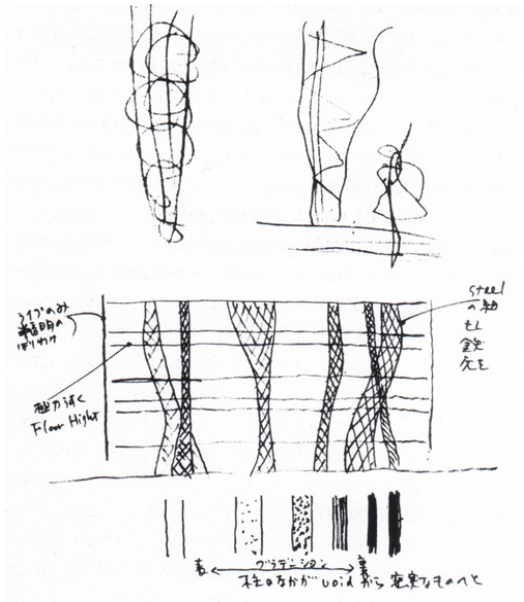
The sendai mediatheque is the project closely related to the proposed design. It is hybrid library which was devised to cater the new requirement of digital age. The buliding has un innovative construction system of tubes and slabs. The building's free flow planning and relation between interior and exterior are its major characteristics.

The second project on the study is pompidou centre, a mixed used building. It's a rectangular box with huge span of steel beam and wall free space. The building has revolutionary concept of exposing services inorder to have partition free interior spaces.

Utzon centre is the another study of a mixed used building. Since the proposed site is closer to the building, it helps to understand the similar conditions. The tent-like shape and centre courtyard are the key features of the design.

Seatle library is another mixed used building with striking exterior form and pleasing interior. The energy efficiency performance of the building is one of its chararcteristic feature.

Phillips Exeter Academy Library is the oldest project in the consideration and only building with pure library function. The design has innovative space planning and maximize the use of daylight.



The building is a mixed program public facility which combine library and art gallery. It's a cubical glass box with seven floor levels serving different functions including book library, film and audio library, a theatre, a cafe and shops. [WEB 4]

The seven floors are supported by 13 non-unifrom steel tubular structures which accoding to the architect represent trees in a forest. These structures give a free flowing interior space which is the characteristics of the building. The large tubes consists of vertical circulations like stairs, lifts and escalators. The structure of the Sendai Mediatheque is composed of three main elements: tubes, plates and skin.

Another feature of sendai mediatheque is its double floor height cafe at ground level separated from exterior by glass facade. The glass facade when opened, removes the barrier between interior and exterior hence bringing nature inside and making the recreational space more attractive to its users.

ill. Concept sketch, Sendai Mediatheque

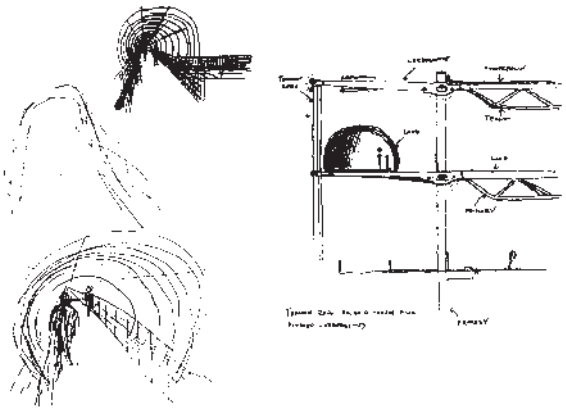
## sendai mediatheque

Sendai mediatheque is a hybrid library located in Sendai, Miyagi Prefecture, Japan, designed by architect Toyo Ito. The design was a competition winner and the construction was completed in 2001.

ill. Entrance, Sendai Mediatheque

ill. Interior, Sendai Mediatheque

ill. Aerial View, Sendai Mediatheque



## pompidou centre

George pompidou centre is a multi-program complex at the centre of Paris, designed by architects Renzo Piano and Richard Rogers in the style of high-tech architecture style. The design was also a competition winner and was built in 1977.

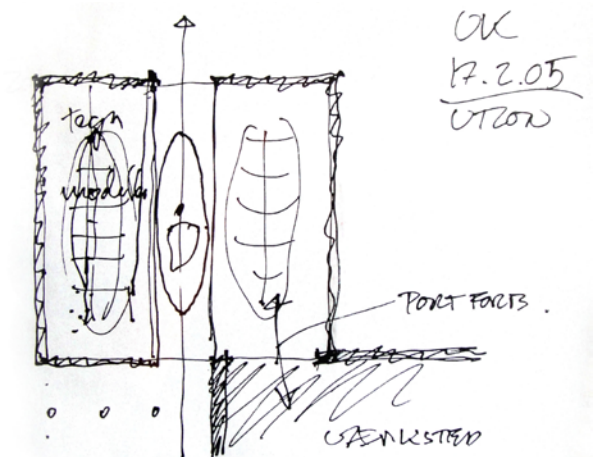
The concept of the building was to design a column free space which can cater vast number of functions. For this, a special structural system was designed. The building structure is a metal framework of 14 porticos with 13 bays, each spanning 48 m and standing 12.8 m apart. On each floor levels, on top of the posts, moulded steel beam hangers of 8 m are placed. Long girders of 45 m rest on the beam hangars, which spread stress through the posts and are balanced by tie-beams anchored on cross-bars. All ther floors are 7 m high floor-to-floor. The free open spaces are enclosed by the glass and steel superstructure [WEB 5].

The functional structural elements of the building were color-coded: green pipes for plumbing, blue ducts for climate control, electrical wires encased in yellow, and circulation elements and devices for safety (e.g., fire extinguishers) are red [WEB 5]. The revolutionary idea was to express the sevice parts of the building as architectural features instead of hiding as in traditional approaches.

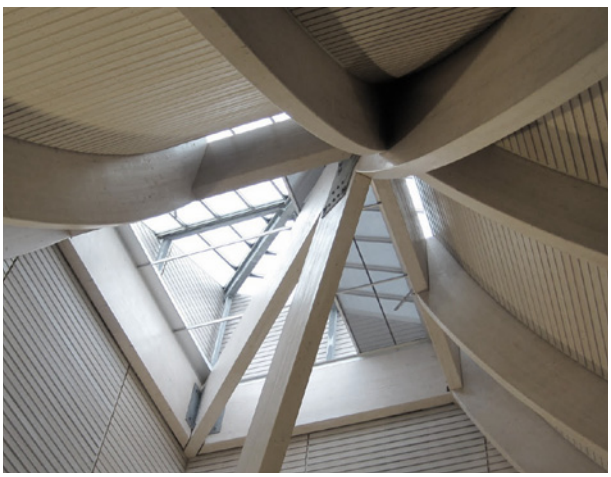
ill. Sketch of Structural Detail, Pompidou Centre
ill. Exterior View, Pompidou Centre
ill. Interior, Pompidou Centre
ill. Exterior showing structural system, Pompidou Centre

## utzon centre

Utzon centre is the last building designed by architect Jørn Utzon, located in Aalborg which was completed in 2008. The building is designed as a gathering and meeting place for the student of architecture.



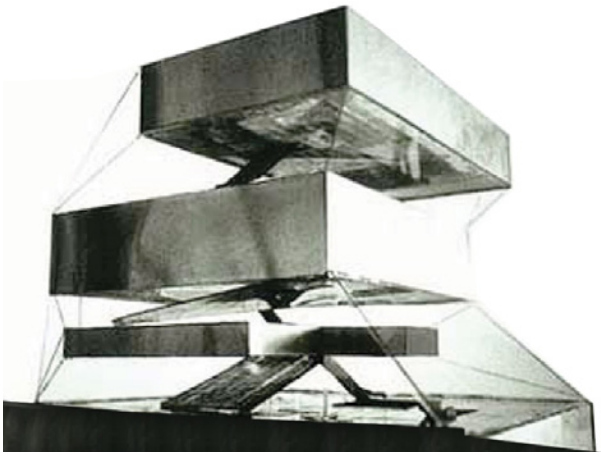

The building is specially designed to withstand the harsh north Jutland wind and to invite soft northern daylight. The building is in form of centre courtyard to represent the idea of get together which also has a practical purpose of sheltering the visitors from strong wind. The highly reflective roof tops also help to withstand the wind and provide the character to the building. The tent like structures cover the huge spaces drawing plenty of daylight from roof top and help to create better acoustic quality. The huge windows on the side facing Lim Fjord offer great view and bring the charater of north Jutland inside.



ill. Exterior View, Utzon Centre
ill. Interior-Skylight, Utzon Centre
ill. Exterior View from courtyard, Utzon Centre

## seatle public library

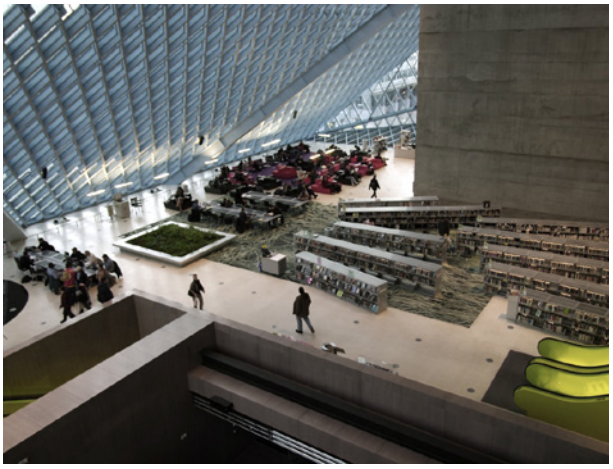
The seatle public library is a 11 floors glass and steel building in downtown seatle designed by architect Rem Koolhaas of OMA which was built in 2004. The unusual shape of the building has attracted lots of acclaims and criticisms.



The external envelope is made with aluminum mesh sandwiched between glass panels which reduces heat and glare on the interior. The glass grid also crucial for seismic stability. The mood inside the soaring atrium changes with respect to every movement of the sun and clouds [WEB 6].

Apart from its staggering form and extremely well energy efficiency, the building is acclaimed for the quality of interior space. Unlike the traditional reading space to read and research, the architect has designed a space to experience in itself rather than perform other function in it. The concept of the space come close to ancient Greek agora, an open meeting space in town. Instead of being at the centre of community, it proclaimes to be the centre for its community [WEB 7].

According to the architect, the philosophy behind the unusual shape from the outside is its functions dictating the form, rather than imposing functions in a predefined form.



*"From now on, anyone who builds a public library will have to first come to Seattle and study this central library."*
Ginnie Cooper, executive director, Brooklyn Public Library [WEB 7]

ill. Conceptual Sketch, Seatle Public Library
ill. Exterior View, Seatle Public Library
ill. Interior View, Seatle Public Library
ill. Exterior View, Seatle Public Library

## phillips exeter academy library

The Phillips Exeter Academy Library in Exeter, is the largest secondary school library in the world designed by architect Louis Kahn, constructed in 1971[WEB 8].

The structure of the building consists of three concentric square rings called doughnuts by the architect [WEB 9]. The outer ring made up of load-bearing brick, includes all four exterior walls and the library carrel spaces immediately inside them. The middle ring made up of reinforced concrete, holds the heavy book stacks. The inner ring is an atrium with massive cross beam and skylight on top and enormous circular openings in its four walls revealing several floors of book stacks.

The demands of the client was a large number of carrels which are placed near windows so they could receive natural light [Brownlee, 1991]. The idea of using natural light as much as possible was infact in favor of Kahn as he himself strongly preferred natural light: "He is also known to have worked by a window, refusing to switch on an electric light even on the darkest of days" [WEB 10].

The dramatic combination of circle and square in the atrium were considered to be the paradigmatic geometric units by the ancient Roman architect Vitruvius.[Brownlee, 1991]

ill. Interior-Central Atrium, Phillips Exeter Academy Library
ill. Interior-Carrels, Phillips Exeter Academy Library
ill. Exterior, Phillips Exeter Academy Library

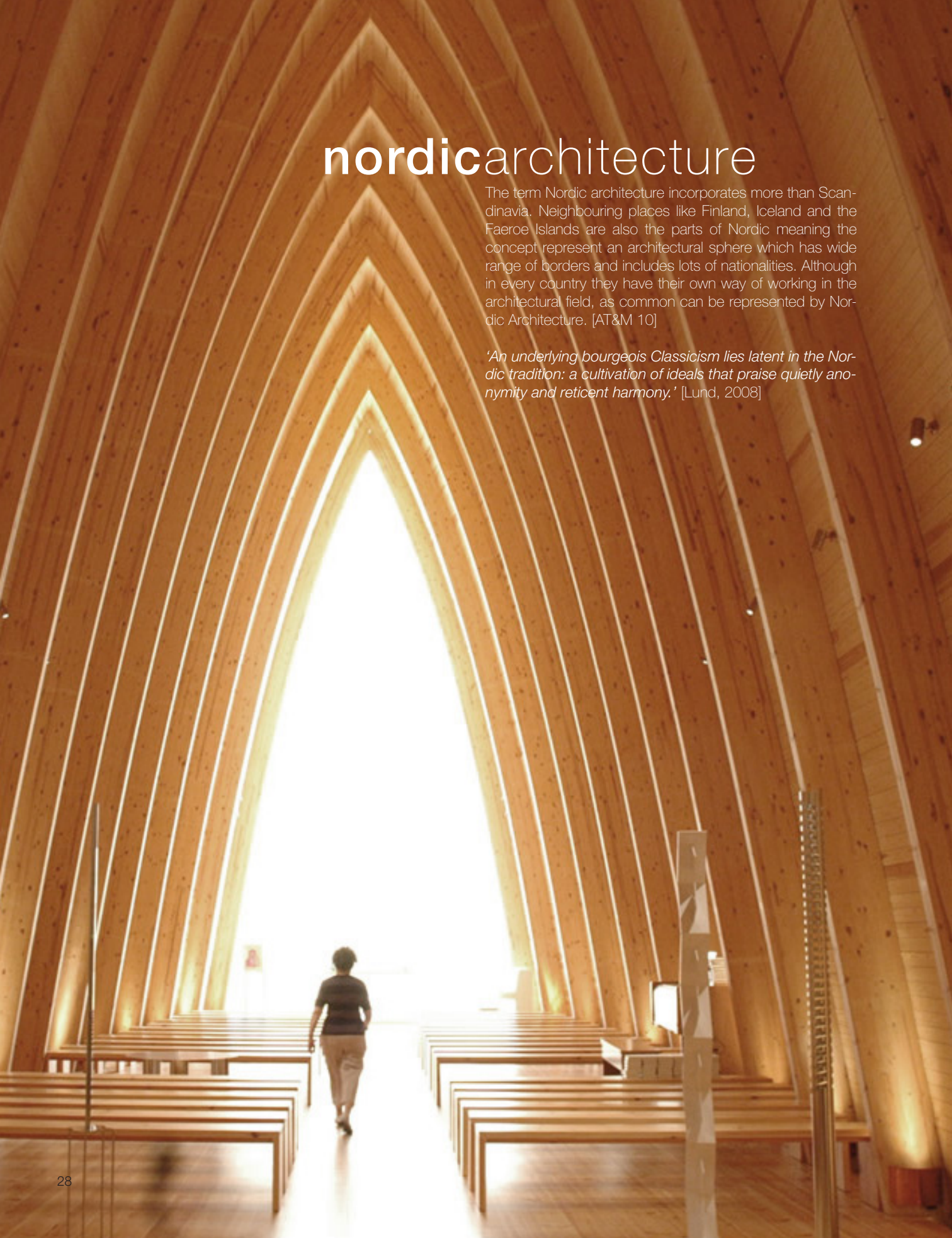
*"From the very beginning of the design process, Kahn conceived of the three types of spaces as if they were three buildings constructed of different materials and of different scales – buildings-within-buildings"*

Robert McCarter, author of Louis I. Kahn [Robert, 2005]

# **nordic**architecture

The term Nordic architecture incorporates more than Scandinavia. Neighbouring places like Finland, Iceland and the Faeroe Islands are also the parts of Nordic meaning the concept represent an architectural sphere which has wide range of borders and includes lots of nationalities. Although in every country they have their own way of working in the architectural field, as common can be represented by Nordic Architecture. [AT&M 10]

*'An underlying bourgeois Classicism lies latent in the Nordic tradition: a cultivation of ideals that praise quietly anonymity and reticent harmony.'* [Lund, 2008]



## history of nordic architecture

The study of first half of 20th century history, upto it's golden age in 50s, is very important in order to understand nordic architecture.

World War I brought Neoclassicism everywhere in Nordic countries as a representation of elegant and mannered architecture. The buildings by Gunnar Asplunds buildings were the best examples of it. [Lund, 2008]

The romantic vision in architecture didn't last more than 15 years after which it turned into more reslistic architecutre. [Lund, 2008] The occassion for the showcase was an exhibition in 1903 in Stockholm resulting the change of people's view and life in Nordic countris. The 1920s Classism was transferred to 1903s Modernism.

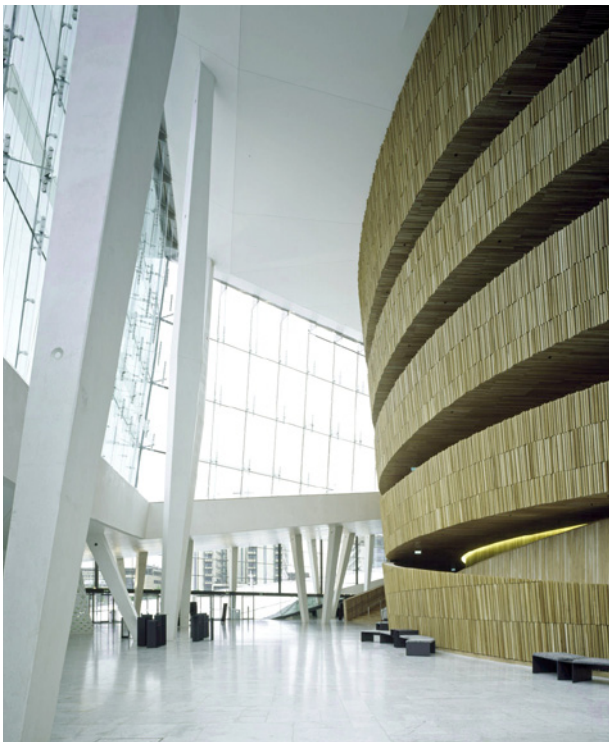
The Modernism which was known as Functionalism, meant the removal of anything without any purpose or function. Hence the architecture was planning of functions supported by its technical necessities.[WEB 11]

Due to its white clear facade, the period was also called 'the white style'. Because of its versatility and smooth surface, concrete was the favourite materials for the archiects in Functionalism. In comparision to German heavy and sober style, the Scandinavian one was light but sophisticated. As the result of scarcity of materials in the World War II, the countries were obliged to use local material for construction, which creates the softer Nordic Functionalism.

In the 1950s the Nordic architecture was represented by architects Arne Jacobsen, Alvar Alto and Jørn Utzon. They matured Nordic architecture in such a way, it became an example to the world. [Lund, 2008] The Nordic architecture was about total human experience with the space and the buildings. 'Architecture is as much about ethics as aesthetics'. [Lund 2008]

ill. Interior, St. Henry's Ecumenical Art Chapel

*'… this is clearly expressed when we in the Nordic countries avoid the spectacular and strive for the well wrought and harmonious.'* Kay Fisker [Lund, 2008]



## features of nordic architecture

Some common characteristics in Nordic architecture are:

### Context orientated approach

According to nordic archiecture, a building grows from the site with repect to its surroundings. Hence, the context of the site is the key feature, from which nordic architecture is derived.

### Light

Nordic countries are located in the northern region hence, the daylight is relatively weak. As a result, the sun is invited most of the time of the year and is the crucial part of design. Actually, the incorporation of soft Nordic light in the architectural design is the trademark feature of Nordic archictecture.

### Simplicity

Due to the following of function over form, the nordic expressions both in case of architecture and structure are clear and simple. Often, the structure of a building is the part of the design.

### Material

The material in nordic style are choosen according to the functions and their capabilites. A brick stay brick and a concrete will remain concrete in nordic architecture. [AT&M 10]

ill. Interior, Norwegian National Opera and Ballet
ill. Interior, Bagsværd Church
ill. Concept Sketch, Bagsværd Church

# **tectonic**architecture

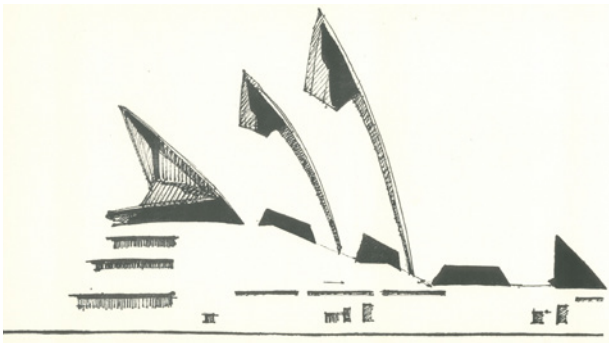
When we refer the term Tectonic, people have different opinions about it. For this project,Tectonic approach used can be understand as the balance between design and contruction, form and function. I strongly believe that in tectonic architecture, material should be true to itself while expressing the design. In a project, the form, function, construction technology and materials, all should speak the same language of design.

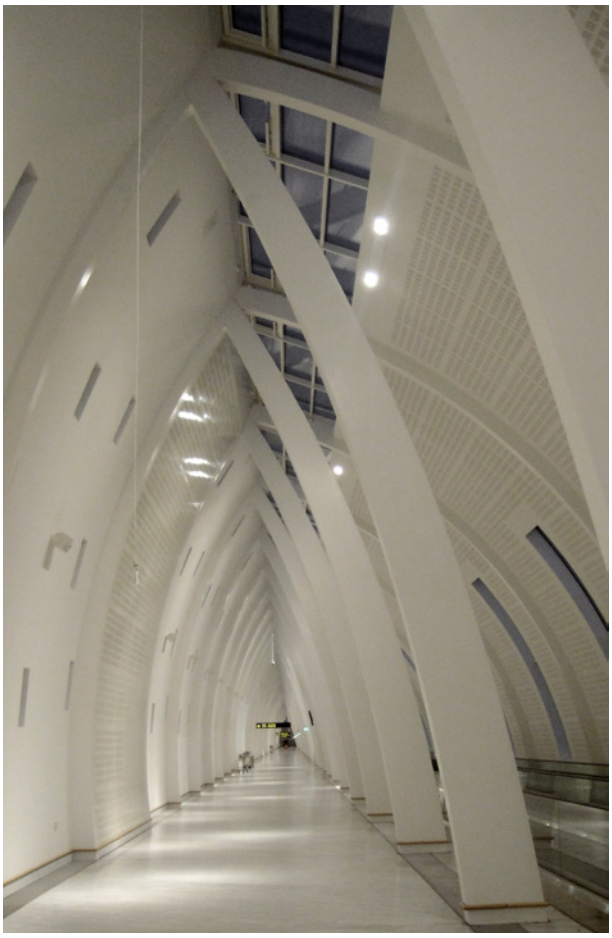
Continuity and integrity between the form of the building and its construction is an intregal part of designing tectonically. The materials and detials are as essential as any other aspects hence should be considered along design process from the beginning hence making the design process integrate in nature.

As far as I have understand tectonic design, I am going to utilised it as a tool to make the structural consideration through out the design process. From the phase of skecthing till the design is finalized, structural aspect and material selection will play equal role in decision making. Hence I hope this approach will give additional depth to design thinking, benefiting the outcome.

In this project, my aim to use tectonic approach to design a project for nordic region, as nordic architecture is one of the best example of its triumph. The tectonic dimension in nordic architecture can be felt in its sense of detailing and exposure of its structural aspects with that of aesthetic concept.

The designs by Utzon and Larsen are some of the remarkable example of tecttonic style. In Sydney opera house, the materials and construction technology have fully supported the design concept where as in Kuwait National Assembly, the structure and details are the expression of functional needs. In Enghoej church, Larsen has been able to use the strength and sensitivity of material to create remarkable interior space.





ill. Sketch, Sydney Opera House
ill. Interior - Ceiling, Enghoej Church
ill. Column Detail, Kuwait National Assembly
ill. Terminal Hallway, Copenhagen Airport



ill. Roof structure, Kuwait National Assembly

# **lighting**studies

The two types of lighting system in building design are Natural lighting system and Artificial lighting system. Natural lighting refers to daylight from the sun and hence can only be observed during daytime. Although daylight is majorly prefered to most of the building functions, it is not available 24 hours a day. Also due to the orientation of the building, the intensity of daylight on some part of the building is insufficient. Hence for these reasons, articial lighting system is utilized which can be different types of electrical lighting.

Both lighting system can futher be divided as direct of reflected lighting. Reflected light, also called diffused light is low in intensity and contrast hence is suitable for certain type of functions.

## lighting in mediatheque

A mediatheque consists of different kind of funcitons which require different types of lighting systems. Reading spaces require soft and low contrast lighting while the stacking area can work with artificial one. Hence it is very necessary to understand the different lighting system inorder to make the space function better.

## natural lighting

The reading spaces and recreational spaces like cafe / restaurant of the mediatheque are the spaces which require natural lighting. At reading spaces, soft and low contrast lighting are required. This kind of lighting can be gained from northern orientation. Northern lights are generally diffused light, hence they have low intensity and doesn't change much through out the day. On the otherhand, south light are best suitable for cafe and restaurant. Unlike reading space, here people are not staring at one thing for long time, hence little high intensity won't affect the condition. The southern light also brings freshness to the space.

## artificial lighting

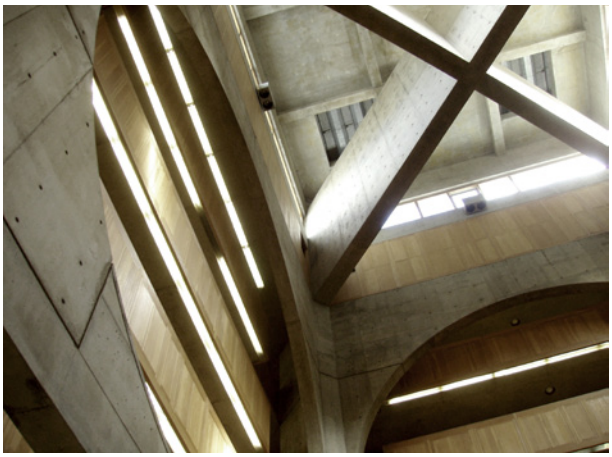
The mediatheque also consists of place which are suitable with artificial lighting. Exhibition galleries, generally work better with artificial lighting as they contains less UV rays and the intensity can be easily modified. Spaces like stacking areas can have both artificial and natural light depending upon the content but its better to have diffused one. Other serive areas like toilets and store can function equally with artificial lighting.

## seatle public library

One of the main feature of Seatle library is its interior space. The architect has maximize the use of daylight in the interior by creating sloped glass wall serving as roof. The double layered exterior partition brings daylight throuh out the day, while traps the heat radiation hence preventing the space from excessive heating. The mood of the space changes according to exterior condtion. This provides an extra dimension of dynamism to the spce. During the night time, the internal artficial lighting provides striking facade treatment to the external glass facade.

## phillips exerter academy library

The architect of the Phillips Exerter library, Louis Kahn is known for using natural lighting in design as much as possible. For this project, when the client demands the reading space to be lit by natural light, the archcitect comes with innovative solution with a simple but very effective planning system. He created three rings of square one above other serving three different funcitons. The centre space is open atrium which was lit naturally by skylight. The outer ring is the reading space which gets its natural light from the window on external walls. The central non natural lighted ring was given to stacking area hence finally solving the problem.



ill. Skylight in atrium, Phillips Exerter Academy Library
ill. Reading Area, Phillips Exerter Academy Library

ill. Interior, Seatle Public Library

# **space**program

The space program studied the different space requirements of the project with respect to surface area ard capacity. It also studies the minimum room height as well as their flexibility on inner floor plan. Different spaces have different lighting requirements according to their use. Hence, the study helps to understand the day light demand and also their possible orientation.

This analysis of space program will be very helpful to next phase of sketching.

| | Area [Minimum, $m^2$] | Room Height [Minimum, m] | Light demands [Minimum] | Need of View [-: no need / +: necessity] | Orientation [north, south, west, east] | Capacity [Minimum, persons] | Flexibility [-: no need / +: necessity] |
|---|---|---|---|---|---|---|---|
| Library | | | | | | | |
| Lending Area | 200 $m^2$ | 3 m | Artificial Light | - | - | 25 | - |
| Children Section | | | | | | | |
| Reading, Listening and Viewing Area | 150 $m^2$ | 3 m | North Daylight | + | North | 20 | + |
| Adult Section | | | | | | | |
| *Books* | | | | | | | |
| Library Area | 200 $m^2$ | 3 m | Indirect Daylight | - | - | - | - |
| Reading Area | 400 $m^2$ | 3 m | North Daylight | + | North | 100 | + |
| *CDs and DVDs* | | | | | | | |
| Library Area | 400 $m^2$ | 3 m | Indirect Daylight | - | - | - | - |
| Vewing and Listening Area | 500 $m^2$ | 3 m | North Daylight | + | North | 100 | + |
| Internet Area | 150 $m^2$ | 3 m | North Daylight | + | North | 20 | + |
| Exhibition Gallery | | | | | | | |
| Permant Display | 200 $m^2$ | 3 m | Indirect Daylight | - | - | 40 | - |
| Temporary Display | 200 $m^2$ | 3 m | Indirect Daylight | - | - | 40 | +++ |
| Recreational Area | | | | | | | |
| Restaurant | 300 $m^2$ | 3 m | Daylight | +++ | South-West | 80 | ++ |
| Kitchen | 100 $m^2$ | 3 m | Artificial Light | - | - | 10 | - |
| Auditorium | 200 $m^2$ | 6 m | Artificial Light | + | - | 120 | - |
| Administrative Area | 50 $m^2$ | 3 m | Indirect Daylight | + | - | 8 | - |
| Meeting / Presentation Room | 30 $m^2$ | 3 m | Indirect Daylight | + | - | 10 | ++ |
| Reception | 15 $m^2$ | 3 m | Artificial Light | - | - | 1 | - |
| Wardrobe | 5 $m^2$ | 3 m | Artificial Light | - | - | 3 | - |
| Kiosk / Shop | 20 $m^2$ | 3 m | Artificial Light | - | - | 5 | + |
| Storage Space | 200 $m^2$ | 3 m | Artificial Light | - | - | - | + |
| Toilet | | | | | | | |
| Staff | 20 $m^2$ | 2.5 m | Artificial Light | - | - | 6 | - |
| Guest | 30 $m^2$ | 2.5 m | Artificial Light | - | - | 8 | - |
| Parking | 500 $m^2$ | 2.8 m | Artificial Light | - | - | 40 | - |

ill. Space Program

# vision

The vision of the project is the summation of the major features of the program that will be integrated in the project. With the help of the studies and analyses made, the vision for the project is drawn in the following two aspects.

## architectural vision

As stated at the beginning of chapter, the major vision of the project is to design a public space which can act as the social melting pot to the city. The site is on the busy public flow of the city hence has a huge potential.

A huge focus is given to the quality of space as I truely believe that is what matters in Architecture. Since the project is a public building, it is very necessay to understand the requirements of huge spaces. The first approach for this problem is free planning which can be achieved through special structure design. The another idea is the inter relation between interior and exterior space. In this project, my vision is to eliminate the barrier between in and out spaces as much as possible creating more natural public spaces.

Another vision of the project is to make it Tectonic in designing approach. Tectonic Architecture refers to designing of a building being true to site and material. Since, the site is in Denmark, Nordic architecture will also be a major influence.

## technical vision

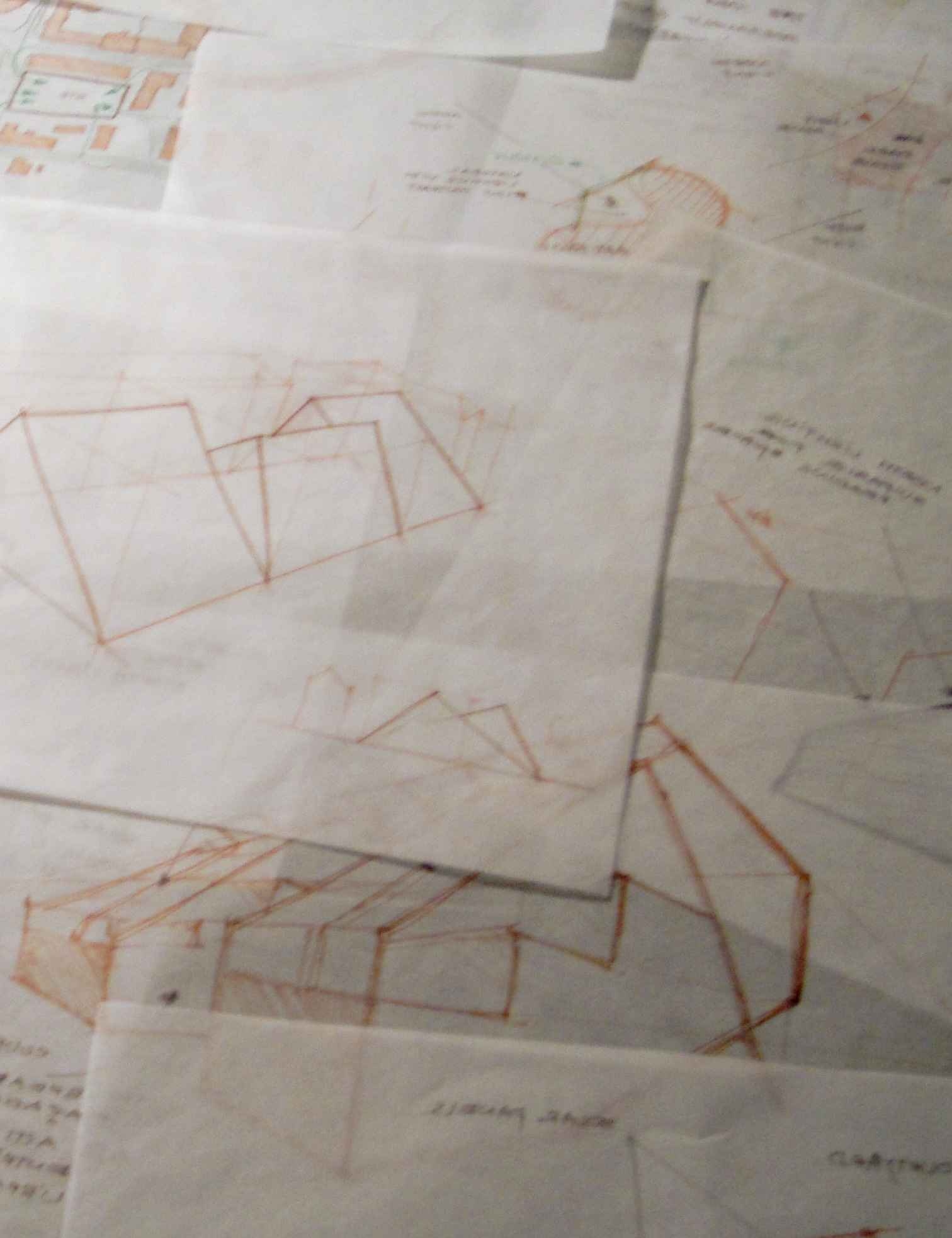
The technical vision of this project is to design large column free structures for free planning concept. Therefore, the design of the structure is equally as the design of the space and should be considered from the beginning. The integrated design method which is being used in this project will be great help to achieve this goal.

Another aspect in tehnical part is an energy efficient, sustainable public building. The sustainability of the project is comprared with the ZEB requirements which are to be achieved by both passive and active design technics. The major design principle to be used is Solar Architecture.

The use solar cells is unavoidable hence the idea is to incorporate in the design. To reudce the heat loss and make the building energy efficient, the ventilation and thermal aspects will also be primary concerns and will be highly integrated in the design.

# **design**process

Based on the vision and design parameters decided in the analysis phase, the next step is developing these into a design concept. The design phase has evolved as a part of the integrated design methodology. The development in the different scales has taken place simultaneously, and has been informing each other continuously during the process. The tools used has been hand drawings, computer drawings, models and technical investigations.



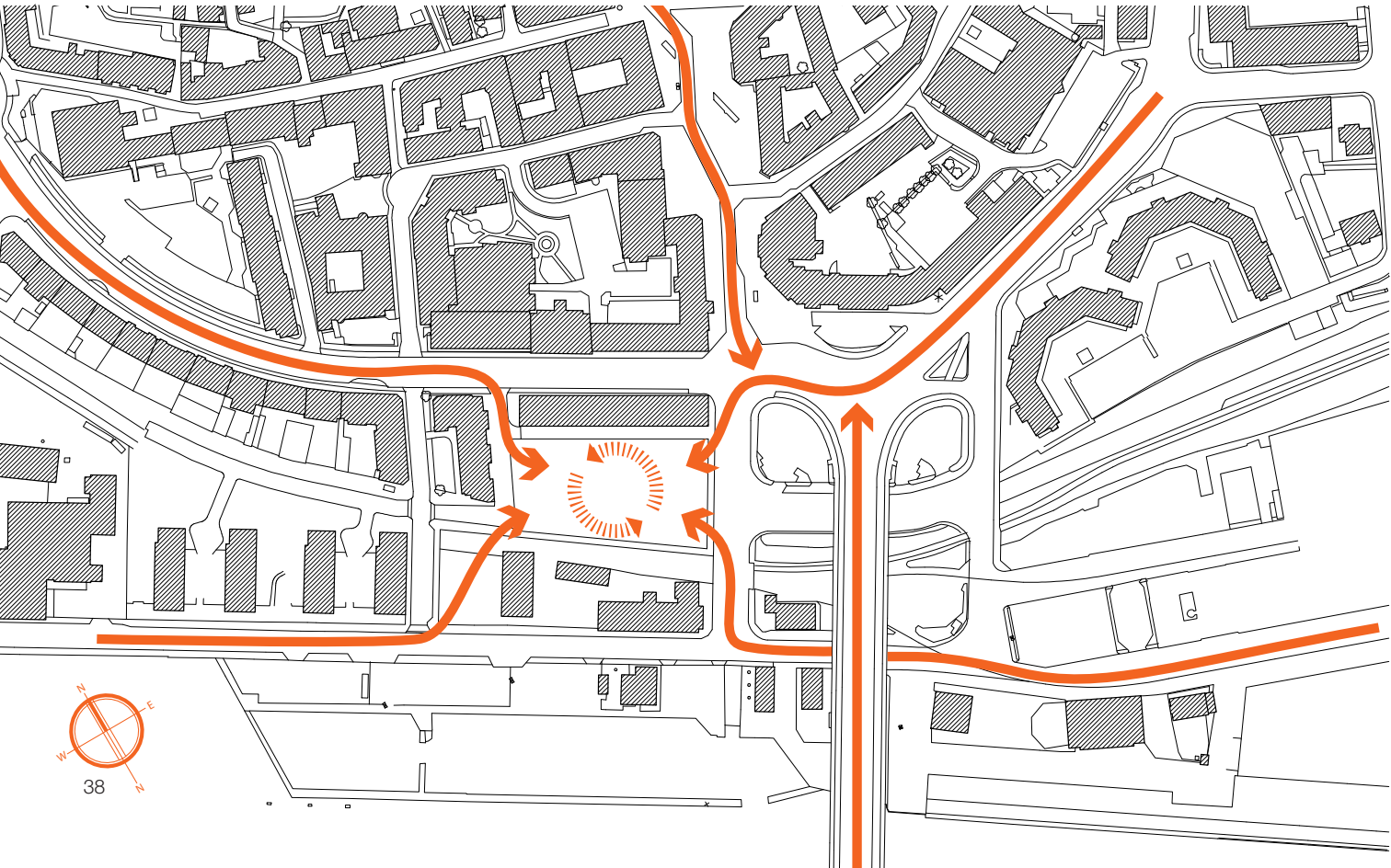
# concept**urban scale**

The influence of a building is not restricted to its site building. The good building is a part bigger urban scale development. Especially when a project is a public building, it has higher demands to fulfill than mere its assigned functions. Hence a building design directly affects surrounding buildings and open spaces and even further the public flow in the city.

## a stop on the journey

Generally a building is design making it a destination to the human movement. The idea behind this project to present a public space which is not a destination but rather a stop or resting place to a journey. Consider the space as a train station with all the amenities like restaurant, shopping place, where people can pass their extra time before they take their next train.

Since the site is on the cross of different major routes, the idea was to make the passing people stop and interact or comminicate with each other before they go. Hence the vision of the design is to provide the a public place where people can relax and interact with each other while learning something.



# a building as a sculpture

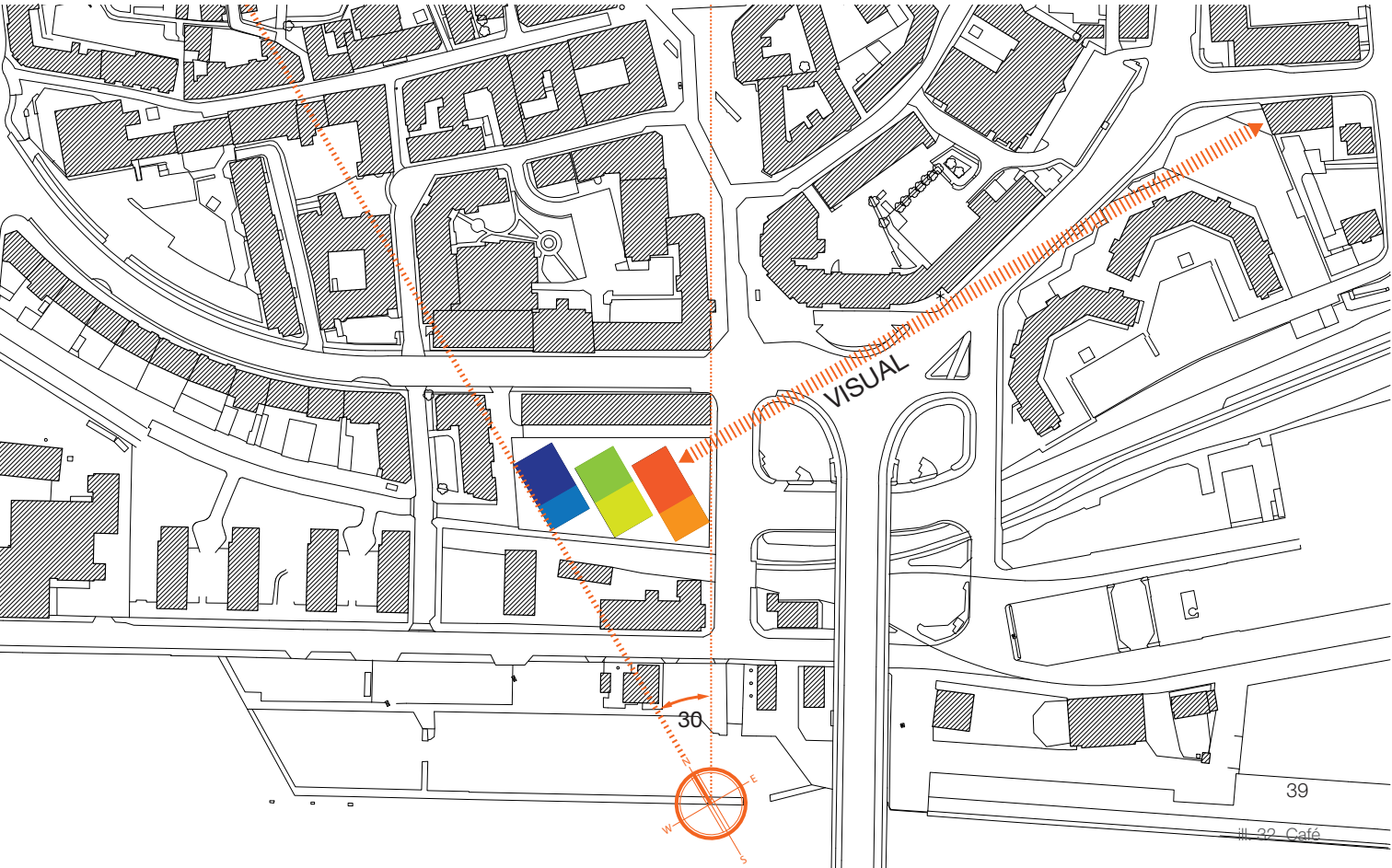
I always believe that the quality of a building is defined by the internal and external spaces it creates. But sometime it is necessary that a building structure acts more than an enclosure to the space. This situation arises when we have very special site and equallly it function.

The site is centrally located to different routes and is visually connected from different angles like Limfjord, bridge, Østerbrogade and others. Hence when a site has so many faces, its not justified that the building residing on it has front and back facade. Therefore, the idea behind the design is to a create a three dimensional building form which can also act as an icon to the city. Since this is a public building, this also helps to attract more people in.

# respect site condition

As I have already mentioned, the effects of a building is not restricted to its site boundaries hence its not only constrained by the shape and size of the site. The surrounding buildings, access to the sites, visual angles all are equally important.

The site in itself is not aligned with the north-south axis. When the proposed building is rotated 30° to aligned with north-south axis inorder to benefit from north and south light, it also address visually to Østerbrogade, which is one of the major access to the site. This also puts the building in perspective view from the brigde hence creating more exciting view to the people passing.

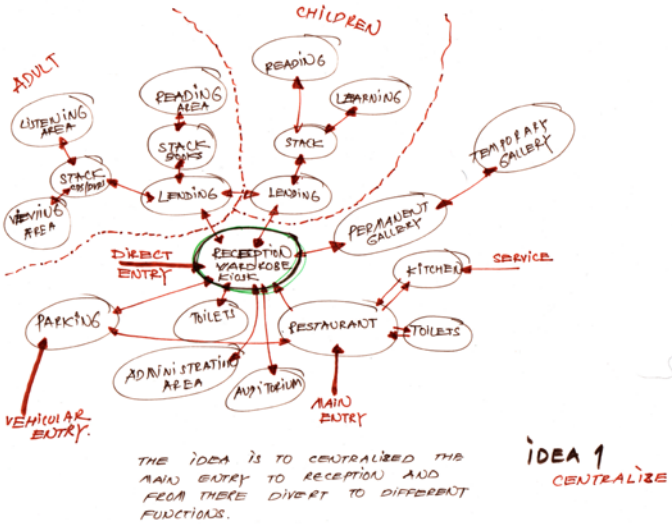





Ill. 32 Café

# conceptfucntion

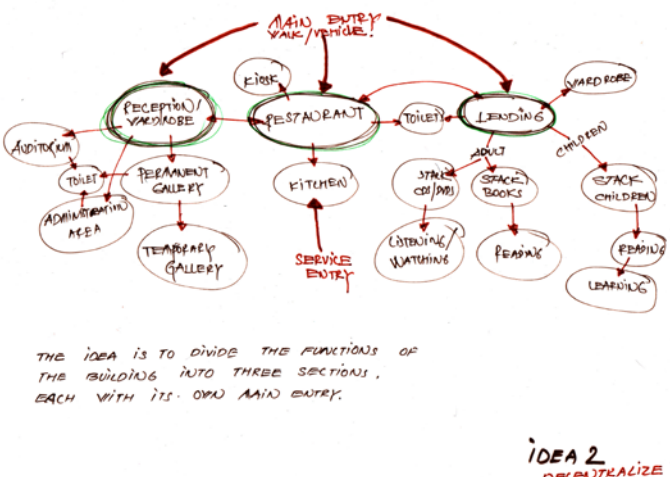
The building is based on the idea of learn, interact and relax, hence to accomply with this motto, the three major functions incorporated in the project are Library Area, Auditorium and Gallery area and Restaurant area. Since these functions are cater diiferent nature of public at different time of the day, the interlink between them is very essential.




## centralized planning

The first idea studied for the space organization is centralized planning system. In this system, the flow of circulation is controlled from a single central point. Here, the people will access to a different spaces passing through this check point.

The merit of this idea is it has less entry point and easy to control.
The demerit is that our site is accessed from all sides, so having just one one to the building is not feasible.
Another demerits is that different functions have different opening and closing time which will be difficult to incoporate with single entry system.




## decentralized planning

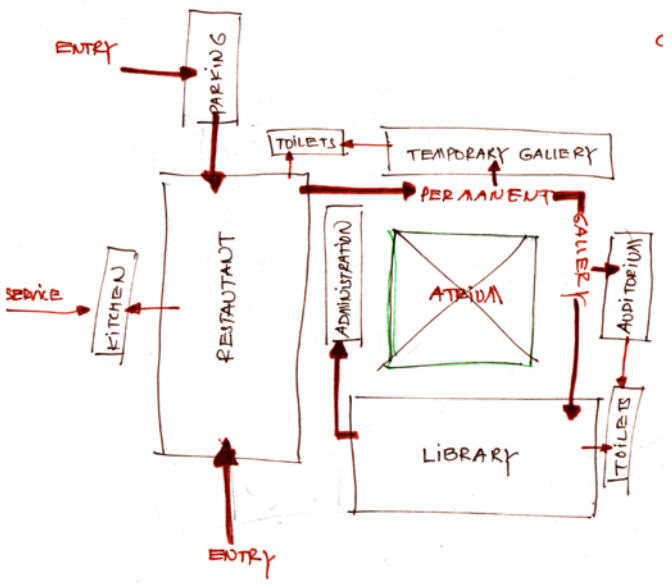
Another idea studied for the space organization is decentralized planning system which is just opposite to the other. In this system, the different functions are divided into different groups which have their own entry and exit. This provide much fexibility to the planning.

The merit of this idea is individual function can open or close independantly to others.
The demerit is that there are less interaction between different functions.

## conclusion

The conclusion of the study is that, no individual function can satisfy the need of the project. Hence the idea is to combime the properties of two planning system. This result a decentralized planning system with more internal interactions between different functions.

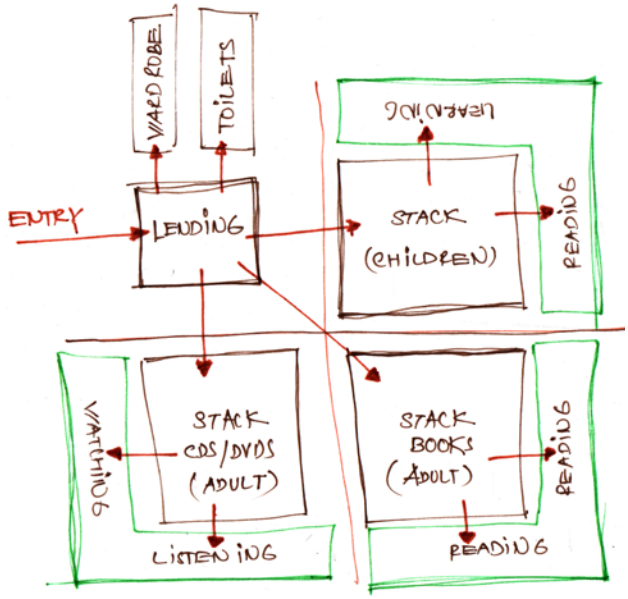
# different other studied ideas




## spiral circulation

One of the idea studied during the sketching phase was spiral circulation. In this, different functions are placed along a circular path surrounding an open atrium. This helps to use the circulation space more than just a path to reach from A to B. The circulation space can also be used as open gallery hence increasing more public interaction.

Athough this system provides a better use for the otherwise dead circulation space, the different spaces have difficulty in functioning independantly.

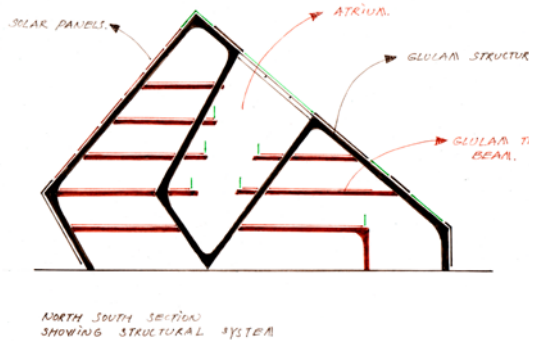



## close stack planning

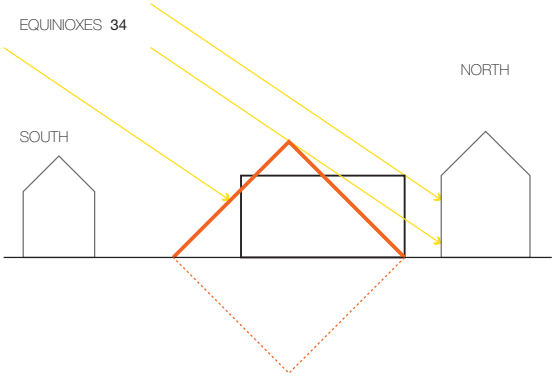
This is one pf the planning idea for library area. The idea is to keep all the stack area which needs less daylihgt to the centre while surrounding it by reading spaces. This system is very effective in case of maximizing the use of daylight but lacks the interaction between the users as the reading spaces are closely linked to stack areas

# conceptform

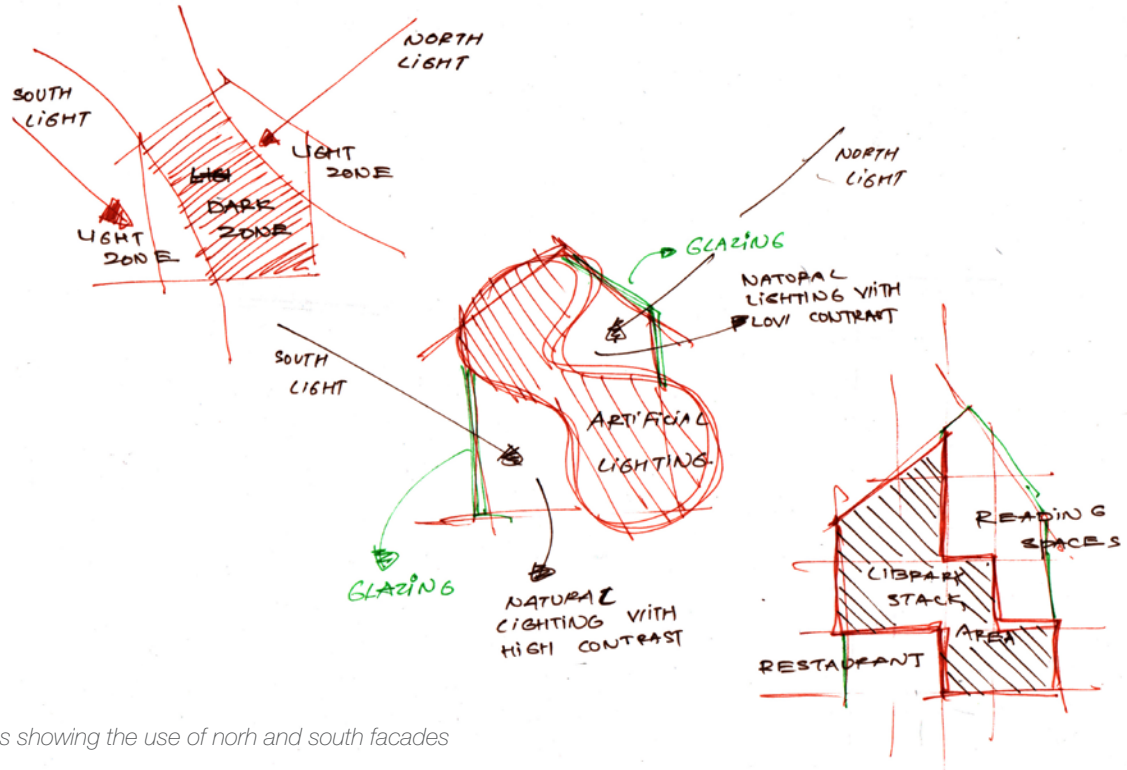
The form of the building should directly depend on its functions. For this project two dominating funcitons are library area and restaurant area. Both the funnction have different requirements interms of placement, orientation or the light condtition. Restaurant is a relaxing place hence is better if placed on south where it can enjoy the warm south sun. Library is reading space hence soft north light is ideal for this space. This basic idea helps to propose a tilted block facing north-south rather than traditional rectangualr cross section. The triangular cross section also helps to address the surrounding by not being too imposing.




*Sketches showing an atrium dividing the library*

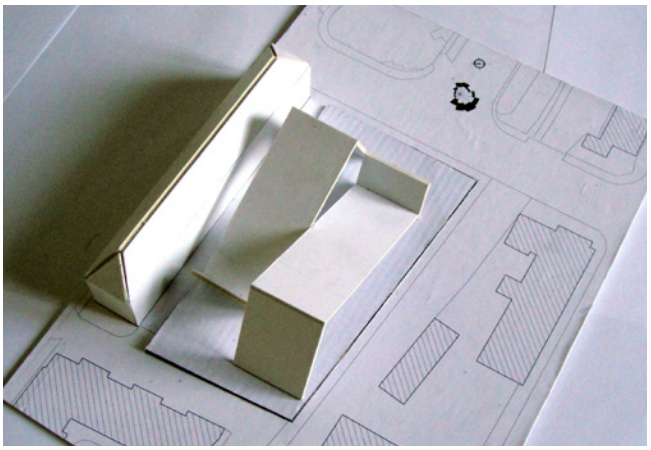



*Sketches showing comparision between two possible building forms*



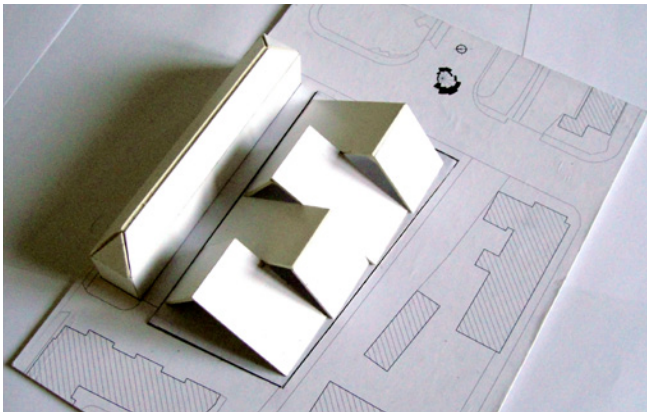

*Sketches showing the use of norh and south facades*

Study of different form arrangements



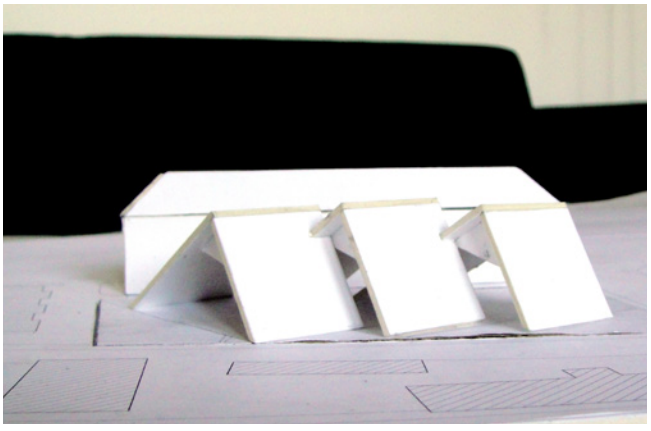
1. Two tilted blocks along the length of the site:

The building blocks are very massive.
Does not quite represent the functions.
Although the orientation are alignd to the site, it does not give any significant benefits.



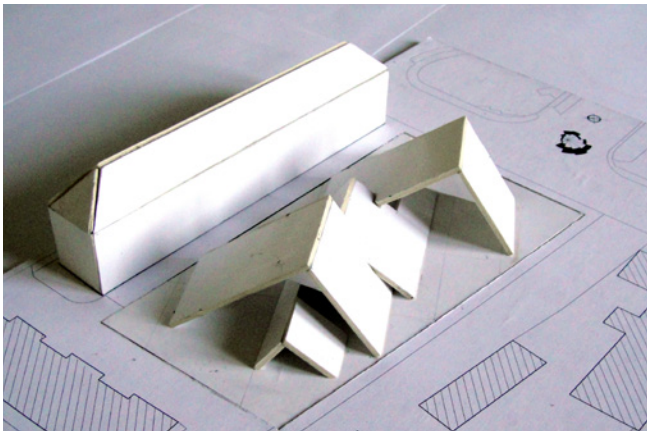
2. Four tilted blocks along the width of the site:

The building blocks are propotional to surrounding.
Two many individual blocks, hence difficult to incorporate the functions with in.
Orientation is much better than option 1.



3. Three tilted blocks along the north-south axis:

The building blocks are propotional to surrounding.
Represent the functions.
Orientation is best as it is aligned north-south axis.
But the repetation create a monotonous feel.



4. Three diffirent sized tilted blocks along the north-south axis:

The building blocks are propotional to surrounding.
Blocks are sized according to the function it holds
North-south axis orientation is perfect.
Different sizes break the monotomy and create a sense of excitement.

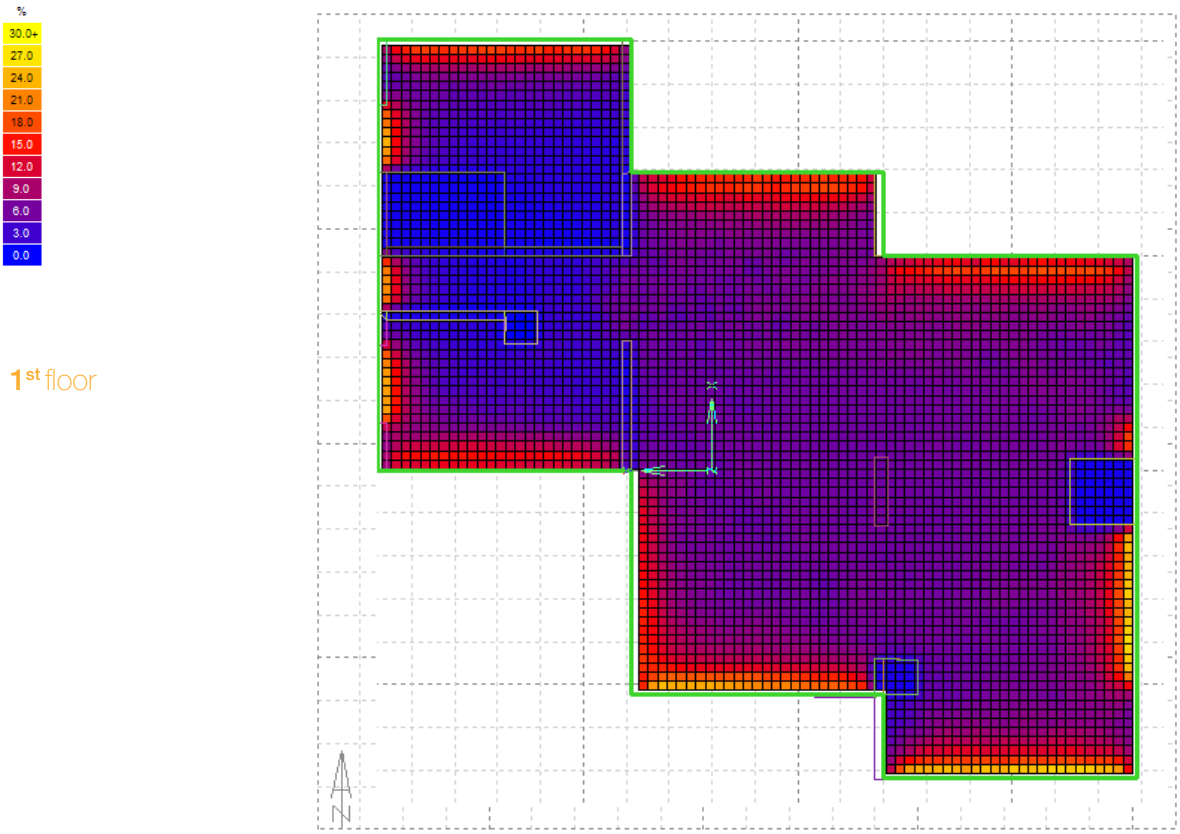
# **light**studies

Daylight is one of the most vital aspect that influence the desgin of a buildign hence, it's studies is major part in a design process. Since this project is totally based on the use of the diffrenent kinds of daylight inside the building environment, the study of light becomes even more prominent. The soft north light is better for reading while the contrast south light is more for relaxing.

## **ecotect**analysis

The daylight in the different parts of the building are studied using ecotect inorder to understand if the orientation of the building and the placement and the sizes of the openings are suitable to acquire the desire condition.

The analysis clearly support the idea of having openings on the south and north facade of the bulding. Although there are huge glass facade on the east and west of the building, their impact is considerably lower due to their orientations.

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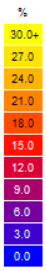
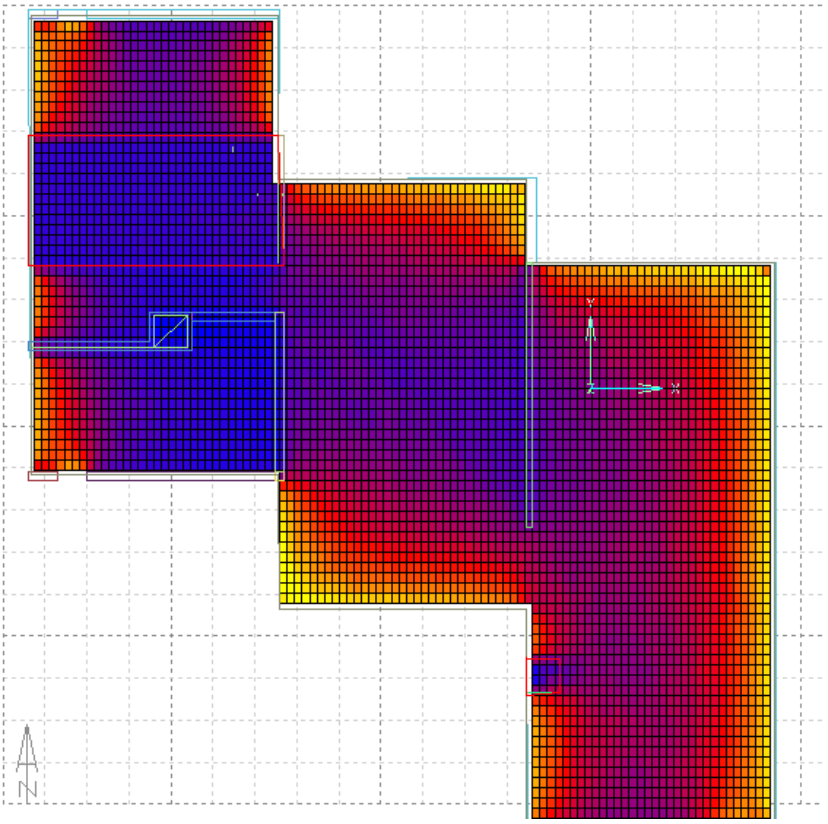
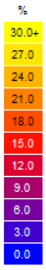
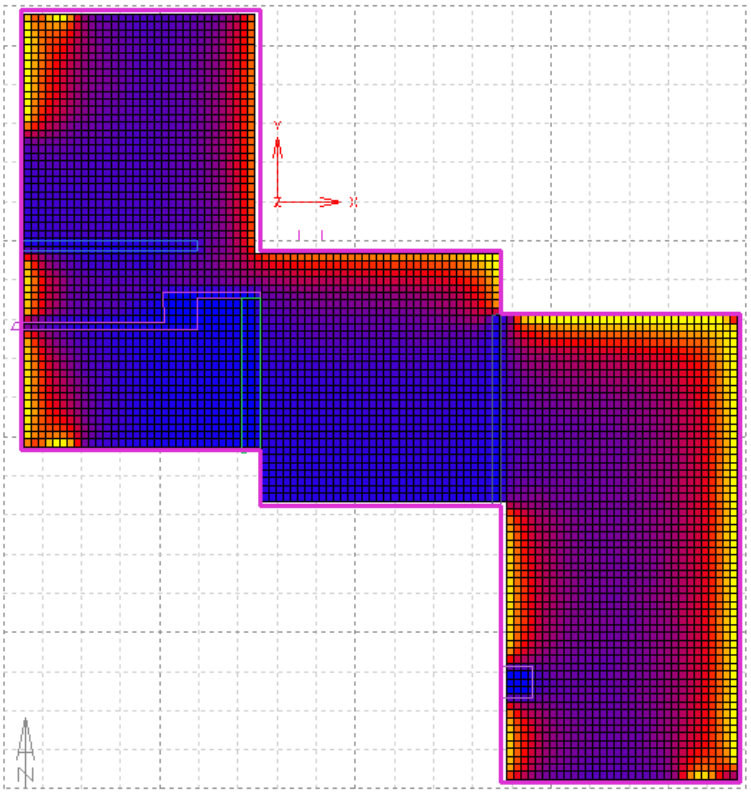



## 2nd floor




## 3rd floor

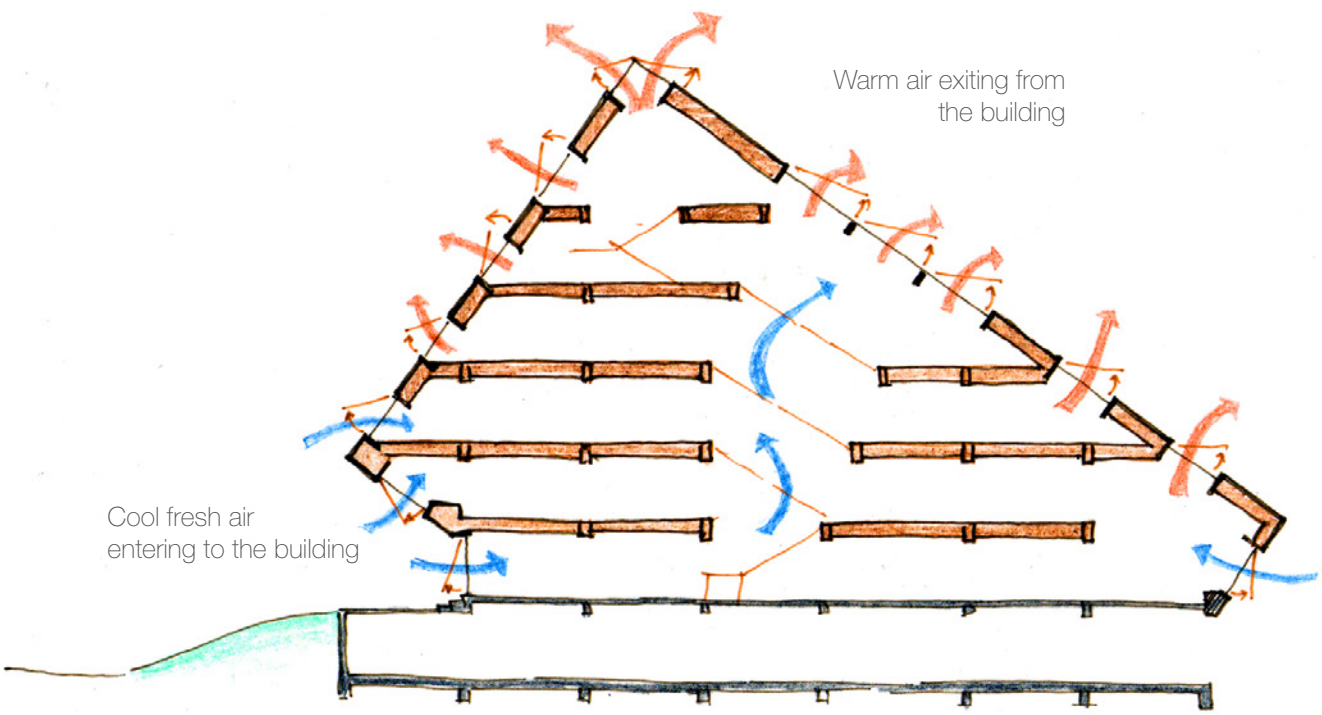


# **vent**ilation

The strategy applied for the ventilation of the building is natural ventilation in the summer and mechanical ventilation (heat recovery) in the winter. This helps to minimize the amount of energy needed by the mechanical ventilation.

The natural ventialation in summer is based on the wind force and thermal buoyancy. The atrium and the mezzanine flloors helps to collect the internal warm air and exit them from roof skylight. This warm air is pushed from the below by the fresh cool air which enters from the openings at the lower levels. A lots of opening on the south direction helps to capture wind which will run the air circulation.

The size of the openings are adjustable, hence the required air change can be achieved.

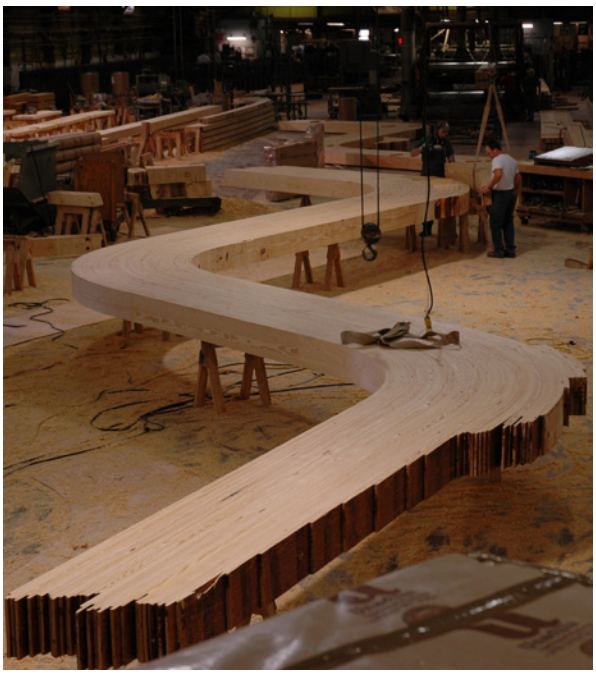



*Sketch showing natural ventilation in summer*

# materials

The major materials considered for the building construction are glulam for the superstructure and glass and timber panels for the envelopes. Apart from these the ground floor and foundation are designed with RCC for maximum stability. Even the solar panels, which are used for energy generation, are used as a means of facade treatment.

## glulam



Glued laminated timber, which is also called Glulam, is a type of structural timber product composed of several layers of finished and standard cut timber bonded together with durable, moisture-resistant adhesives.

A single large, strong, structural member is manufactured by laminating several smaller pieces of timber. These structural members can be used as vertical columns or horizontal beams, as well as curved, arched shapes. The design possibilites are unlimited, hence making it very flexible. *[WEB 12]*

The connections between two members are usually made with bolts or plain steel dowels and steel plates.

The source of the material is renewable and the system of manufacture minimize the its use, as smaller trees harvested from second- and third-growth forests and plantations can be used to create large members. *[WEB 12]*

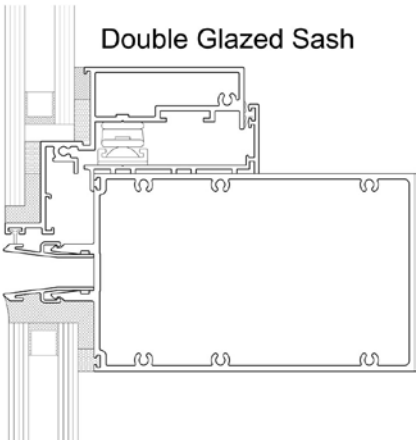
Glulam has much lower embodied energy than reinforced concrete and steel, although of course it does entail more embodied energy than solid timber.

Weight, Glulam = 2/3 steel = 1/6 concrete
(the embodied energy to produce it is 6 times less than steel) ref. 2

Tensile strength, Wood > steel
(two times on a strength-to-weight basis)

Compressive resistance strength, Wood > Concrete. ref. 3

This high strength and stiffness of laminated timbers enable glulam beams and arches to span large distances without intermediate columns, allowing more design flexibility than with traditional timber construction. *[WEB 15]*




## glass panels

Energy efficient, double glazed glass panels are used for the most of the covering of the structure. Generally these panels are used on the facade light and transparancy and on the roof for the light.

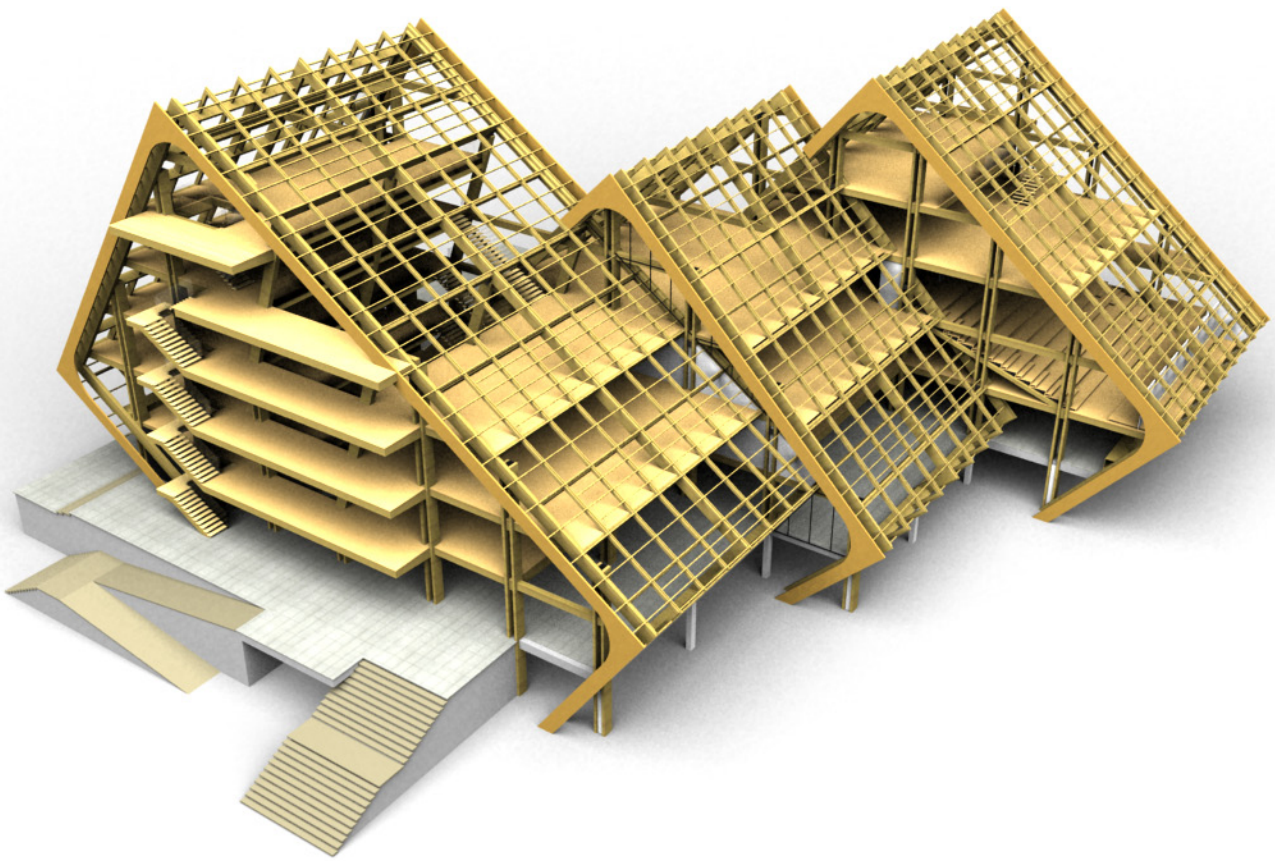
The main concept behind the design was to make a build light and transparent where people can interact through the structure. The clear glass panels on the facade helps to blurr the partition between externernal and internal environment, giving a feeling of openness. While the skylight on the roof helps to maximize the use of north and south light on the different part of the building.

# **construction**system

The structural system selected for project is closed frame beam-column sytem. The glulam frame comprises of the main superstructure, which is based on the RCC ground floor and foundation.

The building consist of three closed blocks which are interlinked with each other structurally which increases the whole all strength of the structue.

Although there are no live loads on roof structure, the dead laods are high as they have to withstand the loads of photovoltaic panels and skylight. These loads are considered during the calculations in structural analysis.



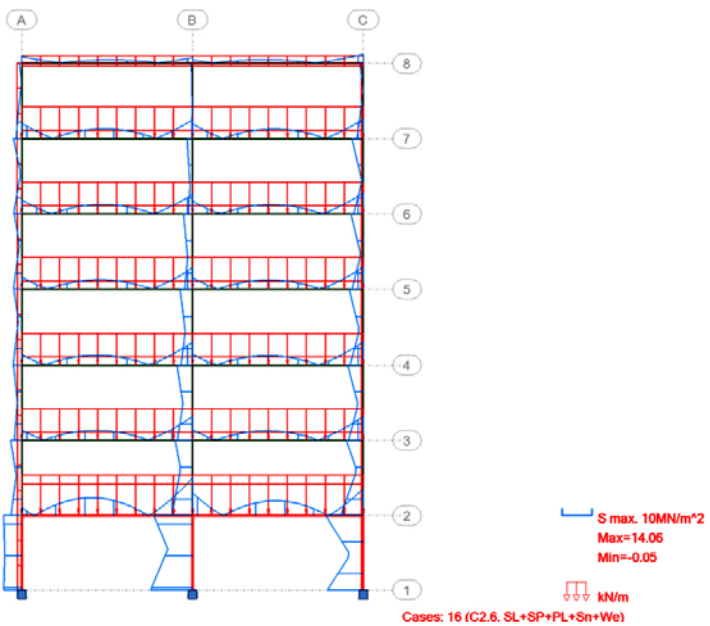
view showing the structural skelection of the three blocks

# **structural**analysis

Structural analysis is the major technical consideration for the project. The methods used for the analysis are hand calculations for load and analysis on the robot. Two sections from one of the three blocks from the project is taken into consideration. These two sections represent the whole structural possibilites considered on the project.

The hand calculations for the loads are can be studied from the appendix  of the report.


north-southsection

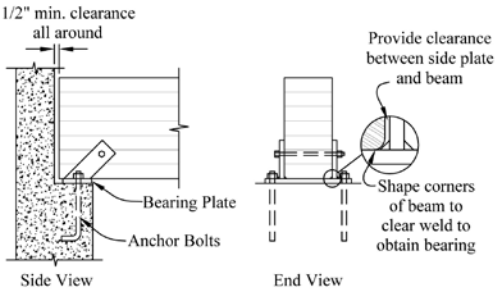



east-westsection

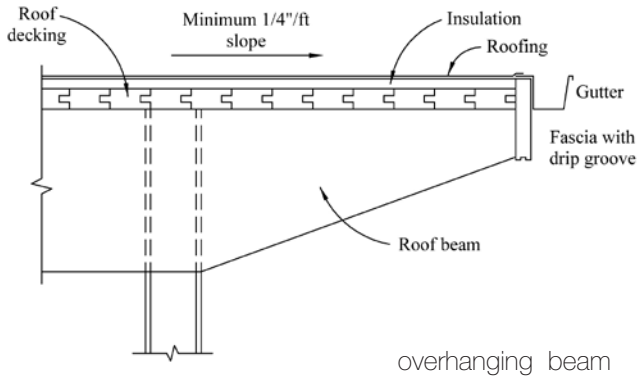
two sections showing maximum load combination from robot

# **joint**study

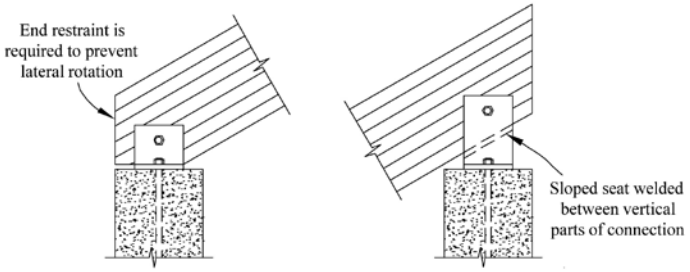
Timber construction system consists of lots of joints hence the study of connection detial is very crucial for better use of timber as structural member. Joints between two beams, between beam-column and column with the floor are studied as they are the most used in the project.



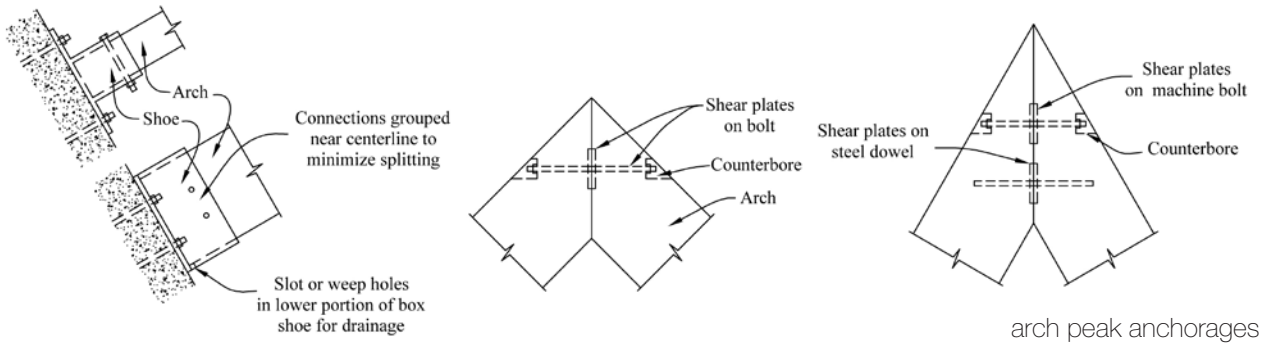

beam to masonry anchorages (horizontal beams)



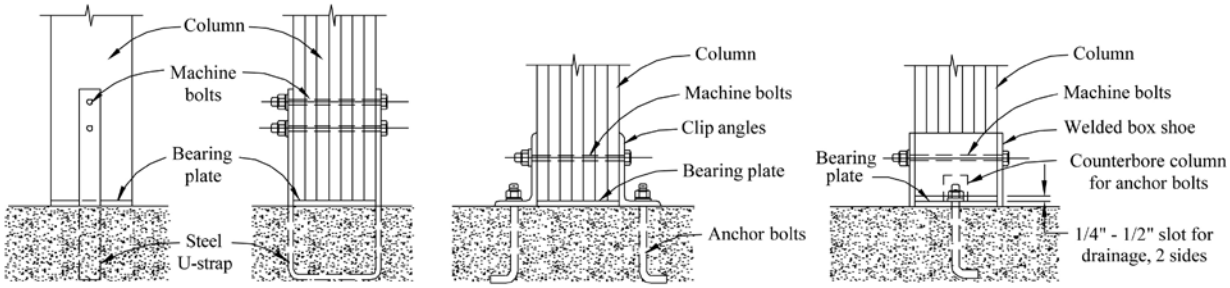

overhanging beam




beam to masonry anchorages(sloped beam)




arch peak anchorages

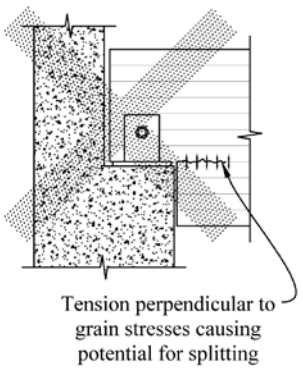



column to masonry anchorages

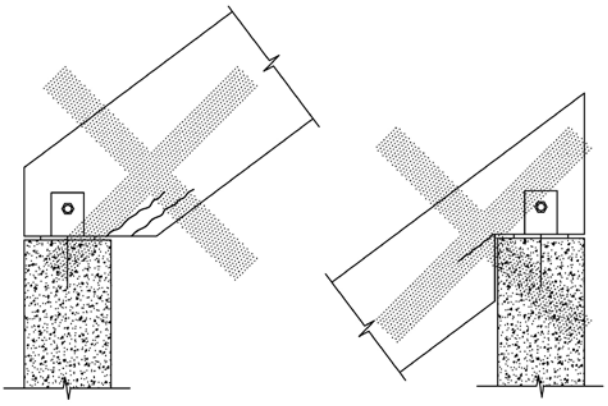
*Ref: Typical Construction Detail [American Institute of Timber Construction]* [WEB 16]

## Connection to be avoided

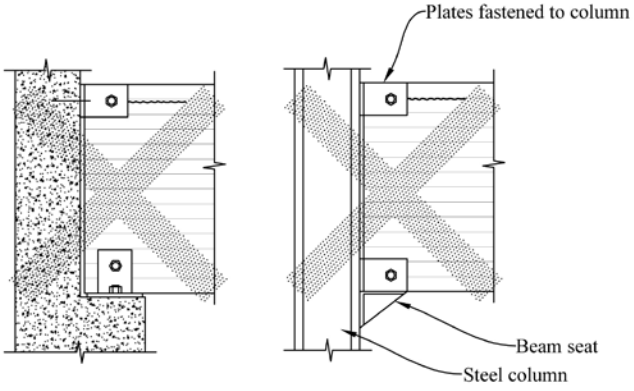
While we talk about timber contruction joints, there are some connection joints that should be avoided inorder to maximize the strenght of the structure. No matter how strong the structural members are, if the joints are not properly done, we might me risking the strength of whole structure. Since, glulam are made by gluing number of thin strips of timber, it should be considered that the joints between the member should not put pressure on the glued timbers.



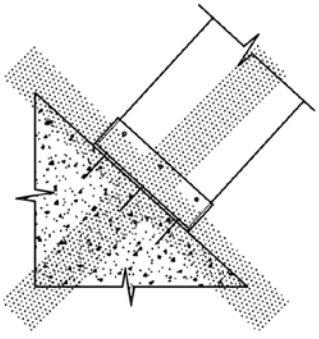

beam to masonry anchorages(horizontal beam)

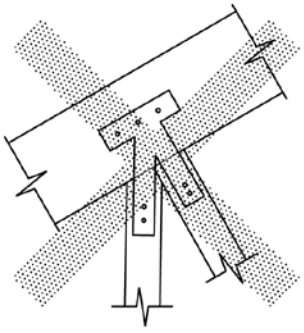


beam to masonry anchorages(sloped beam)

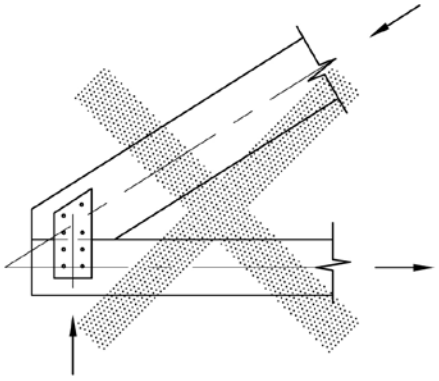



beam to masonry anchorages(horizontal beam)





sloped column to masonry anchorages

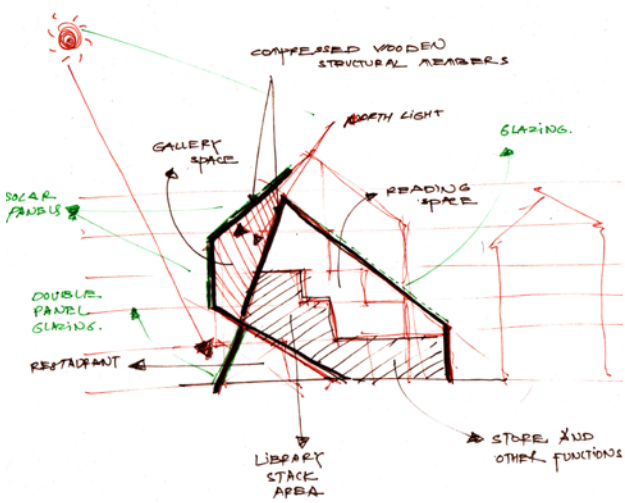


anchorages between timber members

*Ref: Typical Construction Detail [American Institute of Timber Construction]* [WEB 16]

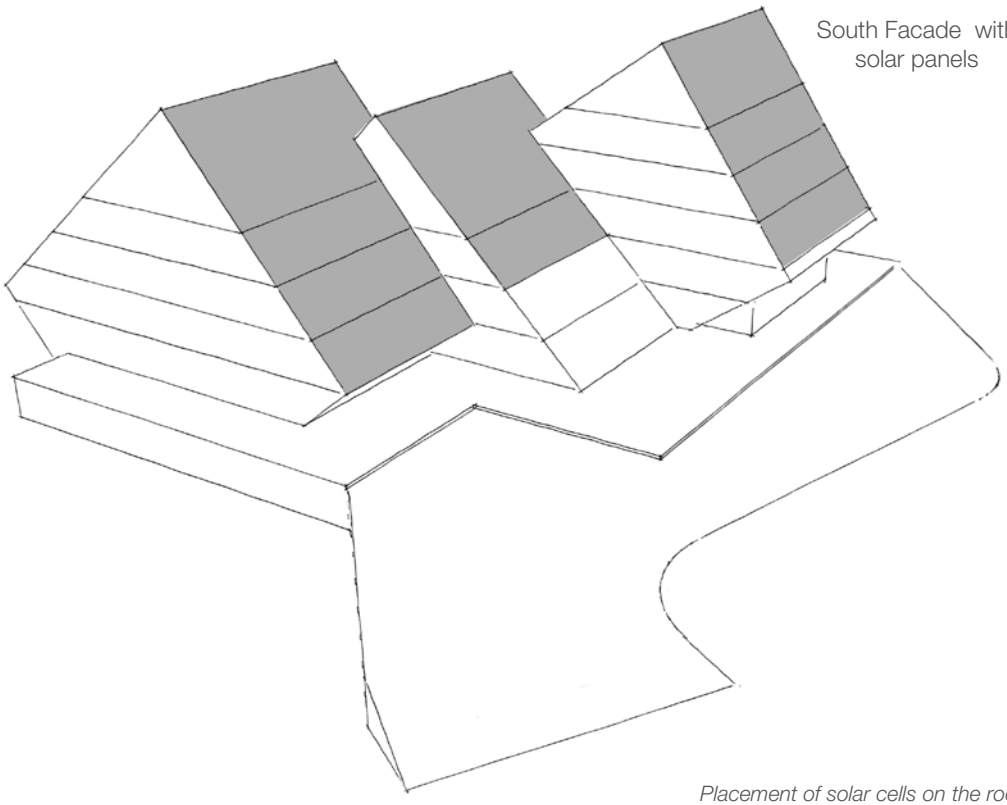
# **solar**cells

In today's energy crisis world it it very necessary that a building is self sustainable in its energy consumption. Hence it would be a good idea to treat solar cells as a part of the building rather than an additional features. In this project, I have tried to use solar panels as an asthetic features to the facade treatment. The placement of the solar panels are considered from the early phase of sketching. It helps to dictate the form and orientation of the building.




*Initial sketch of building with solar cells on the south facade.*

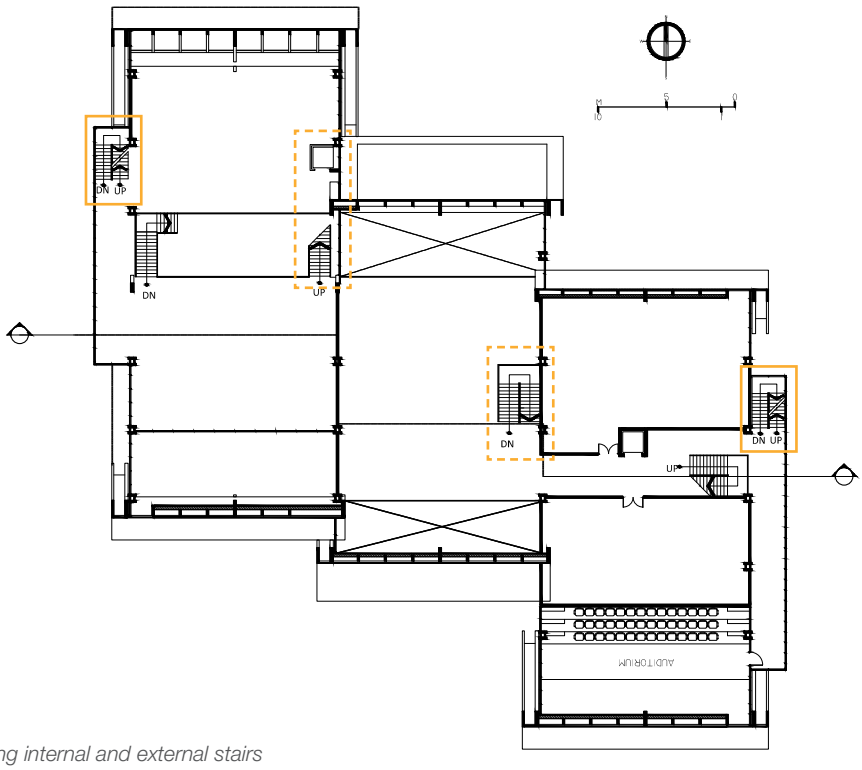
South Facade with solar panels



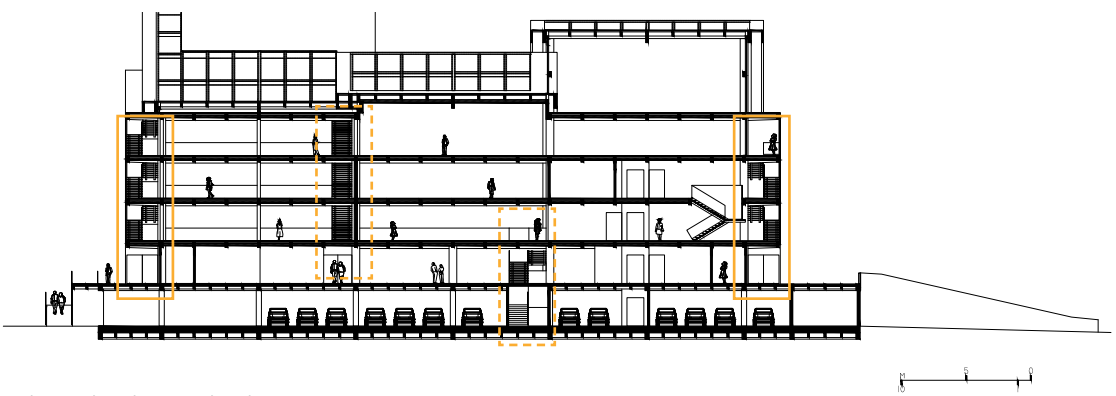
*Placement of solar cells on the roof*

# **fire**escape

A pair of external fire escape stairs are provided on the two opposite faces of the building along with internal stairs. Hence every point on the building is less than 25 m away from emergency exit. The direction to the emergery exits are direct hence, help to minimise the chaos during emergency.



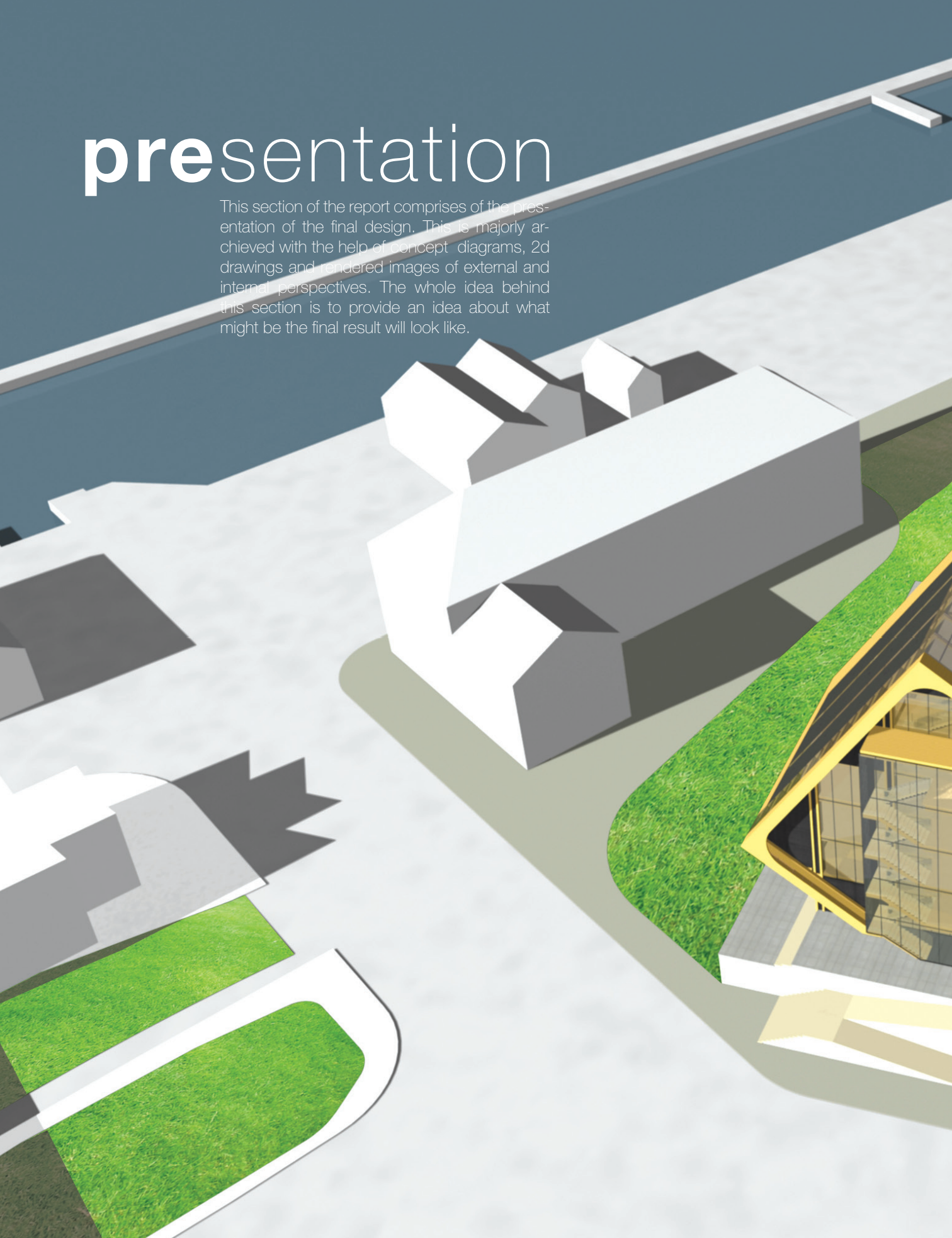

*Flloor Plan showing internal and external stairs*

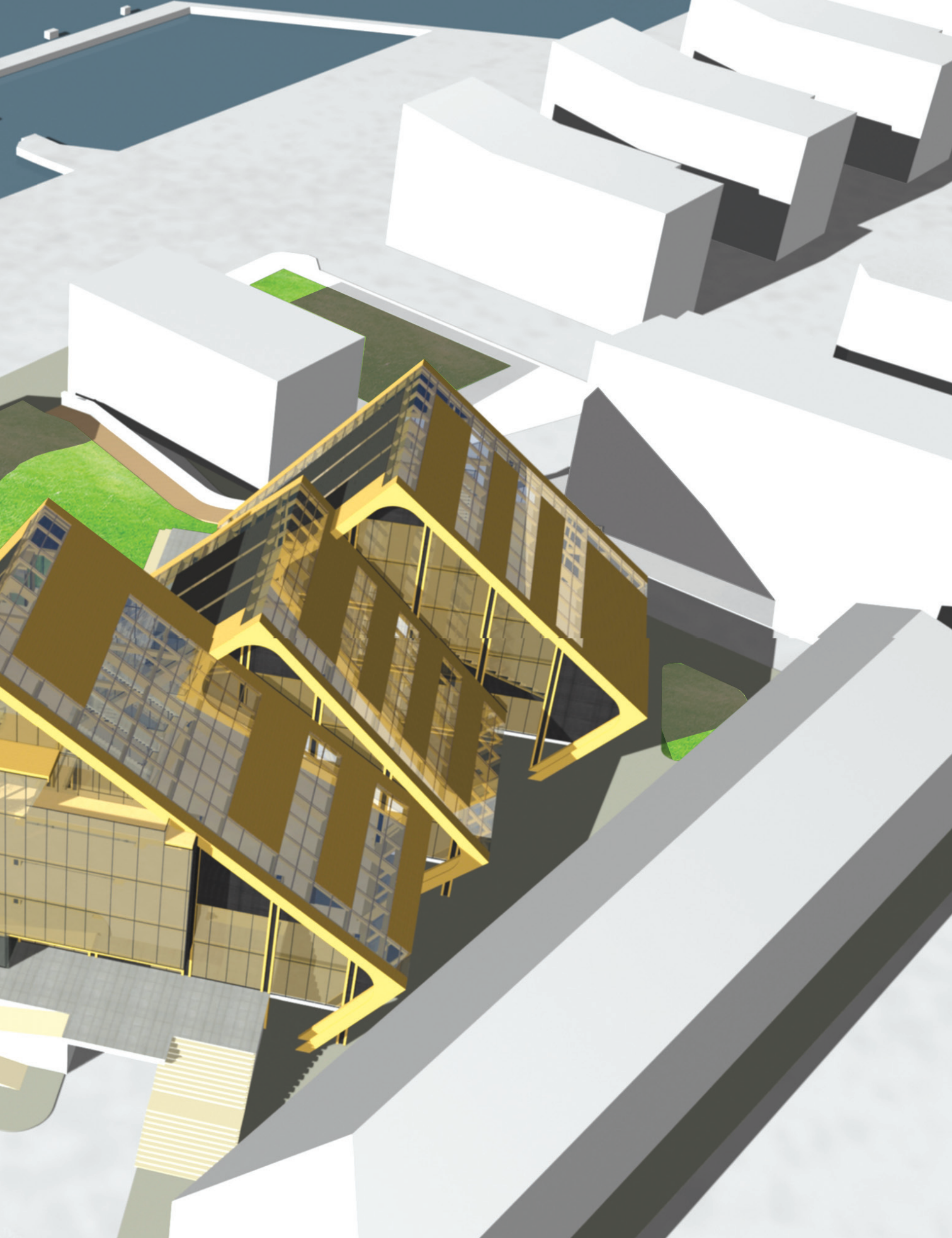


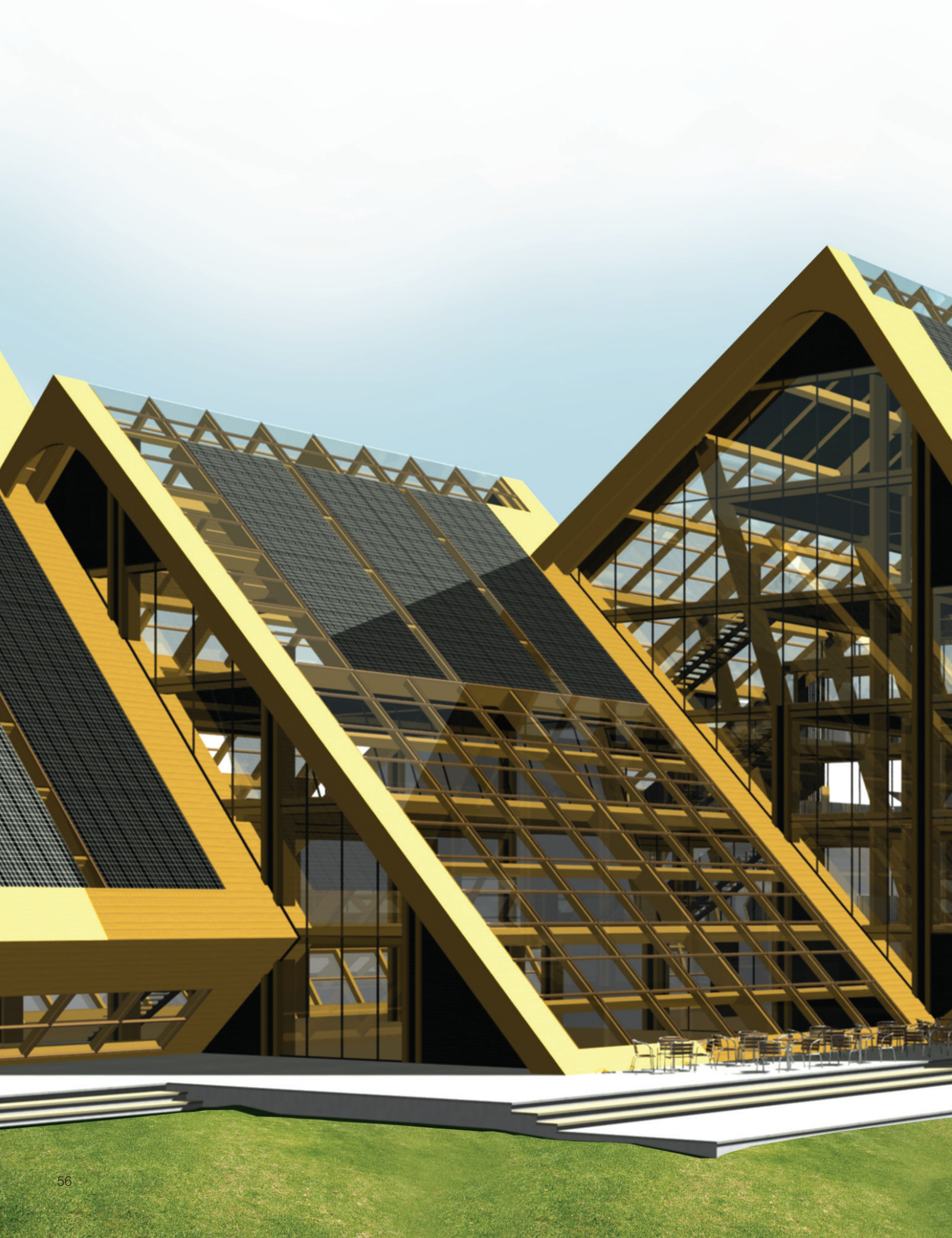
*Section showing internal and external stairs*

# **pre**sentation

This section of the report comprises of the presentation of the final design. This is majorly archieved with the help of concept diagrams, 2d drawings and rendered images of external and internal perspectives. The whole idea behind this section is to provide an idea about what might be the final result will look like.

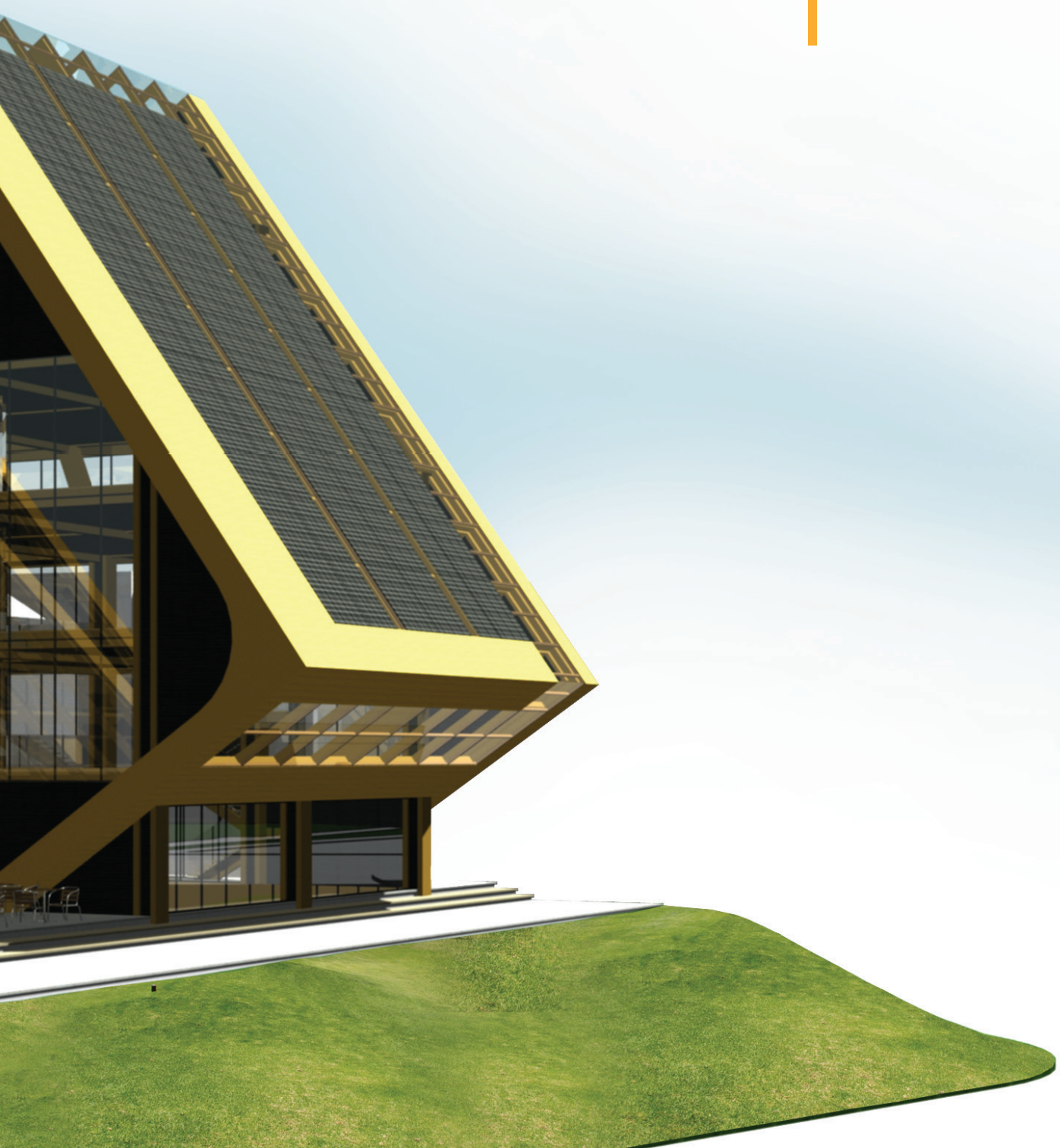






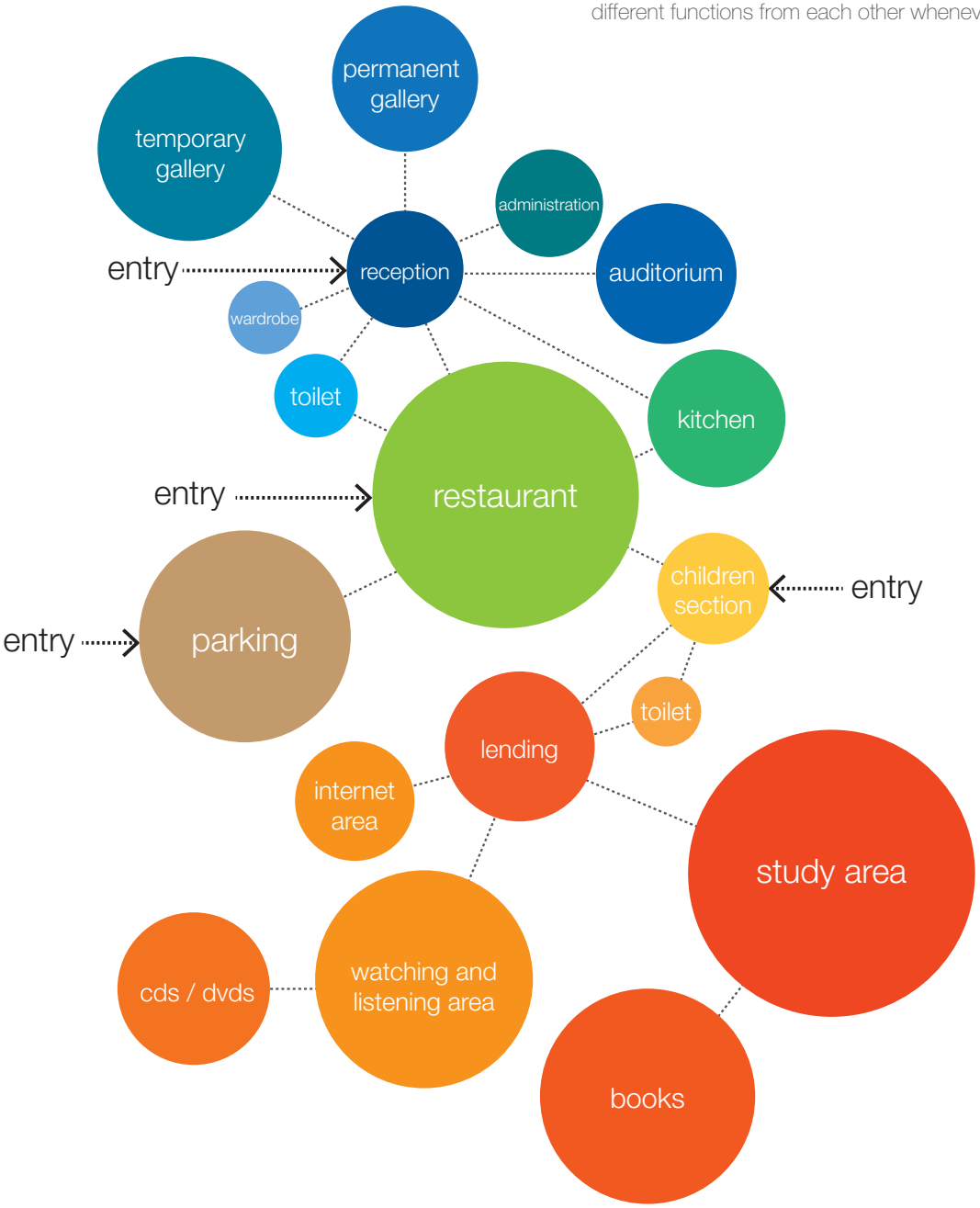
# aalborgmediatheque

a sustainable public space with a realm of human experiences



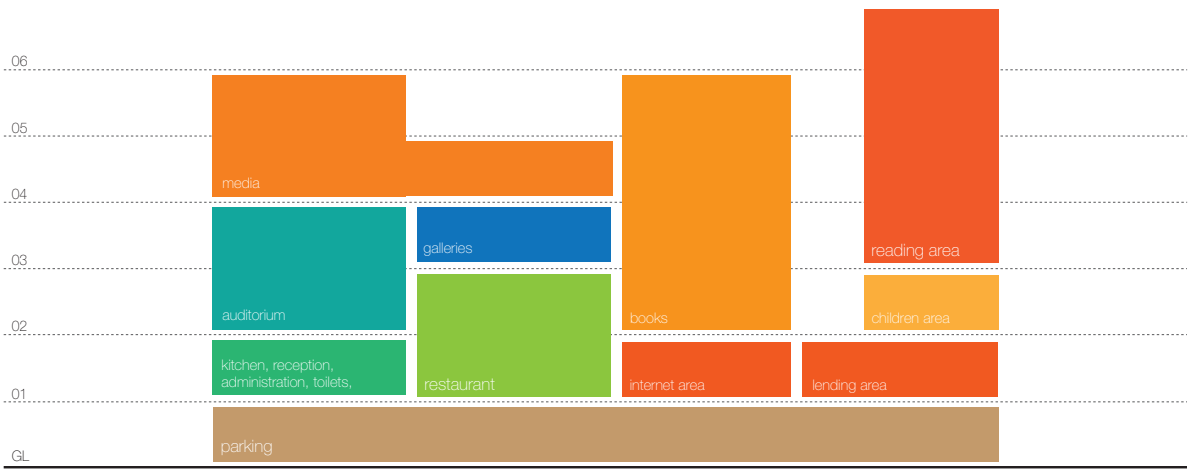
# **space**organisation

The project is divided into three major functions: Library area, Restaurant Area and Galleries and Auditorium Area. The idea is to have three separate blocks for three different funtions but are connected with each other. There are different entry points to the building but all eventually are linked to the restaurant area. Although all the functions are public, among all, restaurant is the most public. Hence the spaces are organized in such a way that it is possible to segregate different functions from each other whenever necessary.

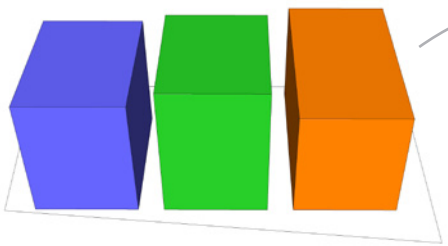


# **vertical**circulation

Vertical circulation refers to how the different functions are organized in different floors. Since different functions have different kind of public interaction at different time of the day, the fucntions are organized accordingly. Restaurant space is one of the most accessed space by wide range of public for wide span of time, it is placed on the first floor and has accesses from all direction. The opening hour of restaurant can be prolonged even after the closing of other functions. The placement of parking on ground floor provide, easy access to vehicles and a much need platform to the building. The Library area has tunnelled to a single entry-exit point helping to ease the control of public flow. Although, the library space in internally linked to restaurant area, its closing has no effect on the access of restaurant. Like Library area, Auditorium and galleries have their own accesses and are also linked internally to the restaurant. Their opening schedules are also independant to that of restaurant.



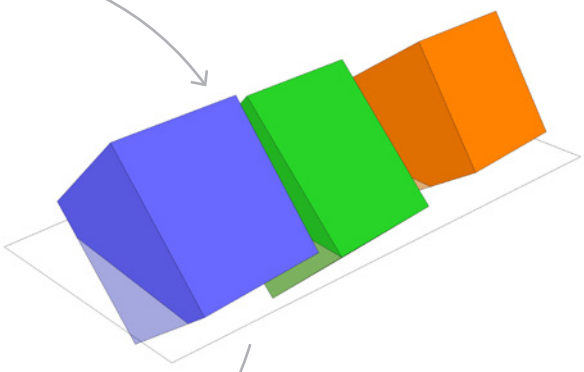
# genisis

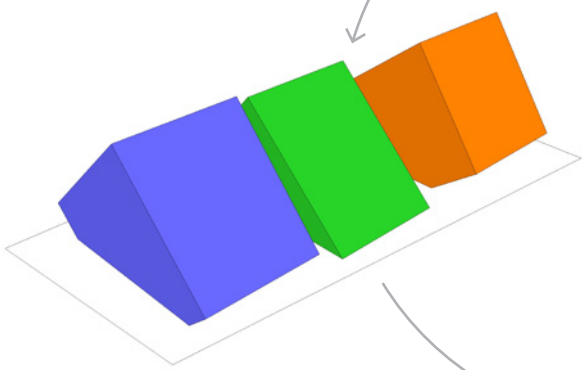


Three blocks representing three major functions

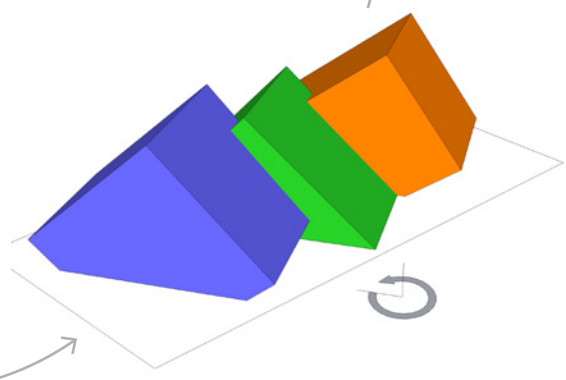
- Library
- Restaurant
- Auditorium and Galleries

The blocks are turned horizontally in-order to maximize the north and south facing facades.



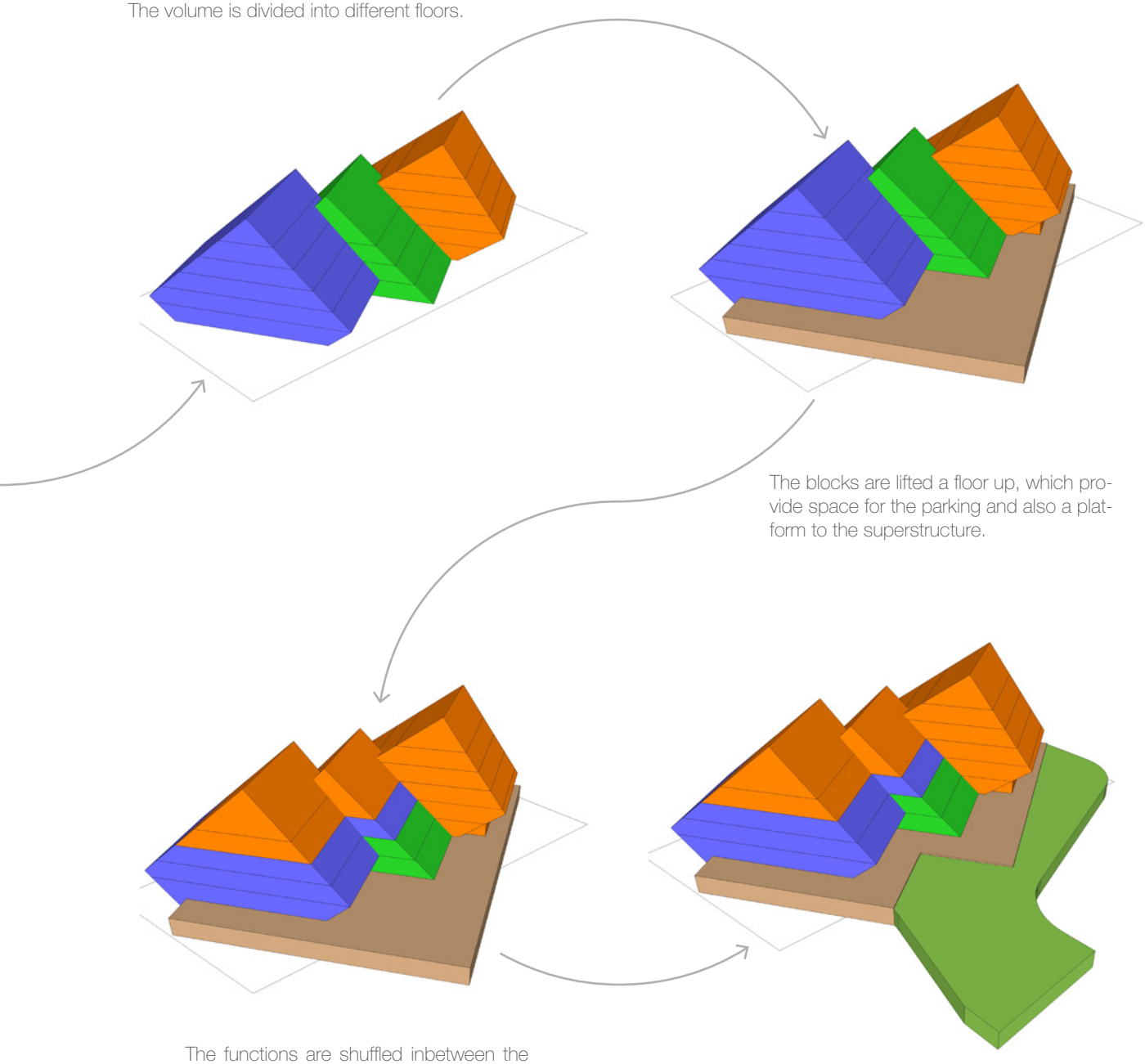


The superstructure above the ground is taken into consideration as the building structure.



The blocks are turned 30 degree inorder to aligned with north-south axis and face main access road to the site.

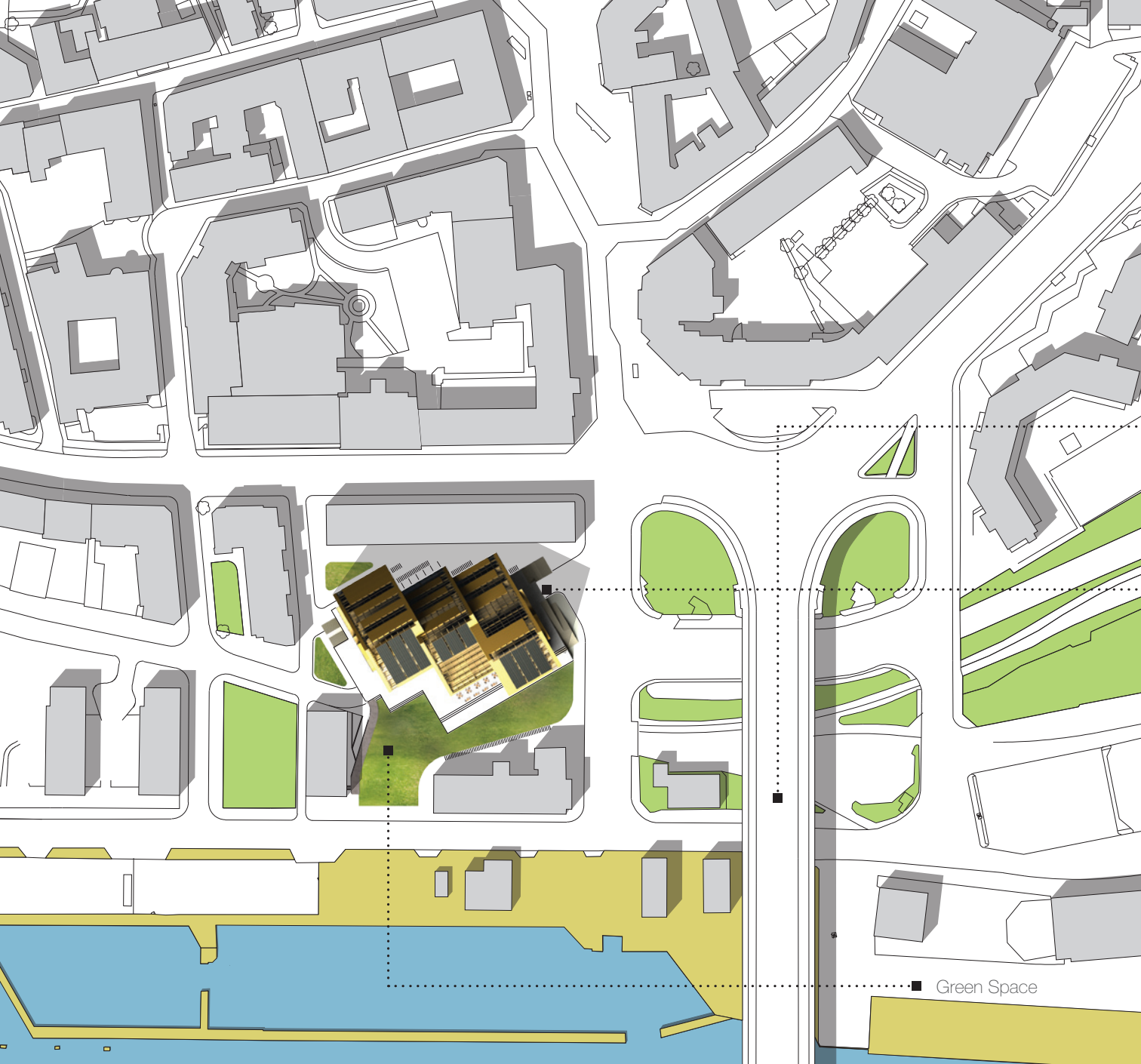
The volume is divided into different floors.



The blocks are lifted a floor up, which provide space for the parking and also a platform to the superstructure.

The functions are shuffled inbetween the blocks which provide connection to different blocks.

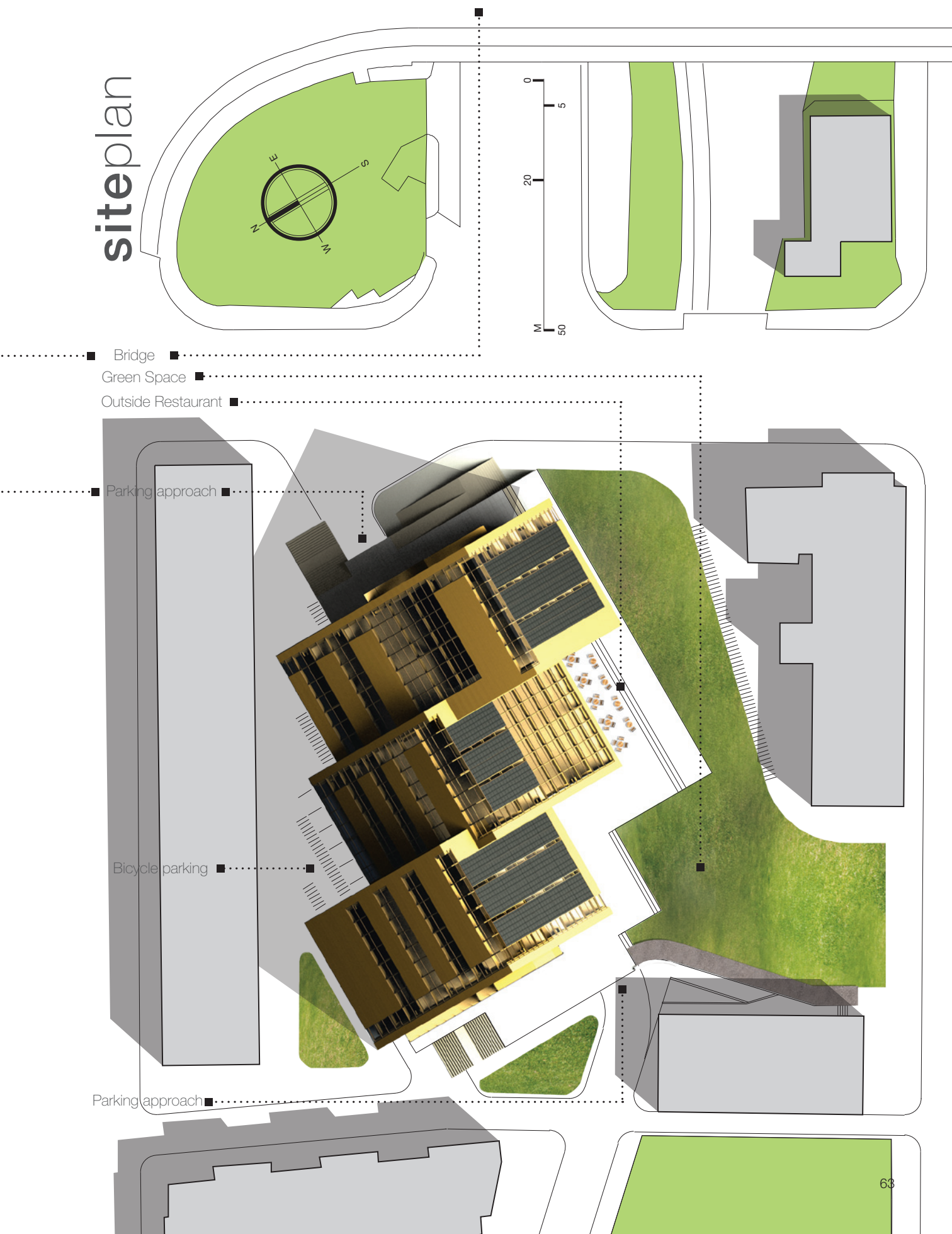
A green space is added to south face of the parking space.




# **master**plan

The site is located on the interation of different pubilc routes. Hence, the basic idea of the project is to design a stop point to learn, relax and interact on a journey to somewhere. Instead of being a destination, the project intents to be a spot be the pause. The site also enjoys multiple viewing point from the bridge and different accesses. To address this benefit, the building is design like a sculpture with no back facade  rather than like a painting with a front and back face. This gives the design an iconic feature and increases a sense of inthusiasm to people passing by. Hence, the building provide a complete journey from **seeing** to **discovering** to finally **experiencing** it.

# siteplan


E
S
N
W
0
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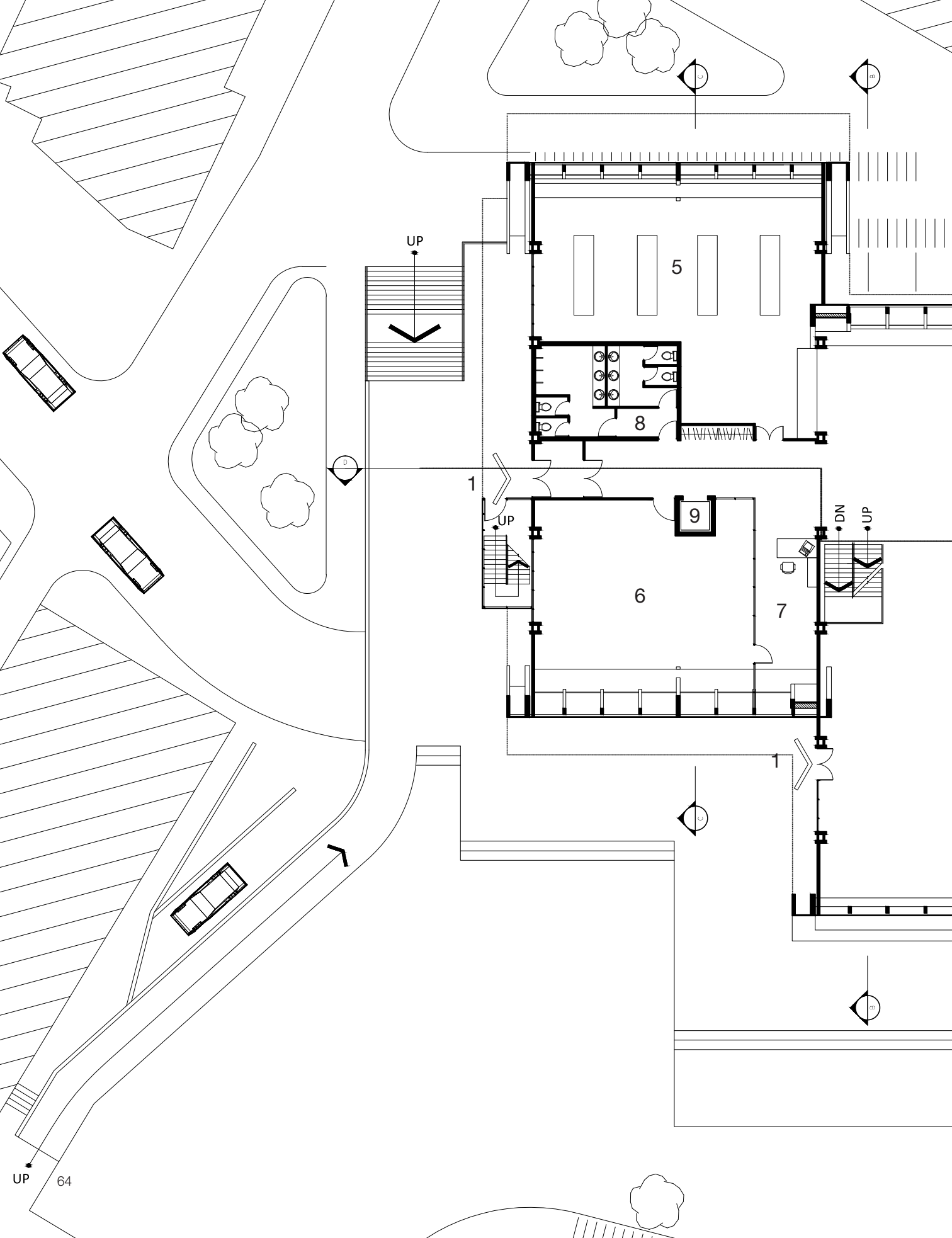
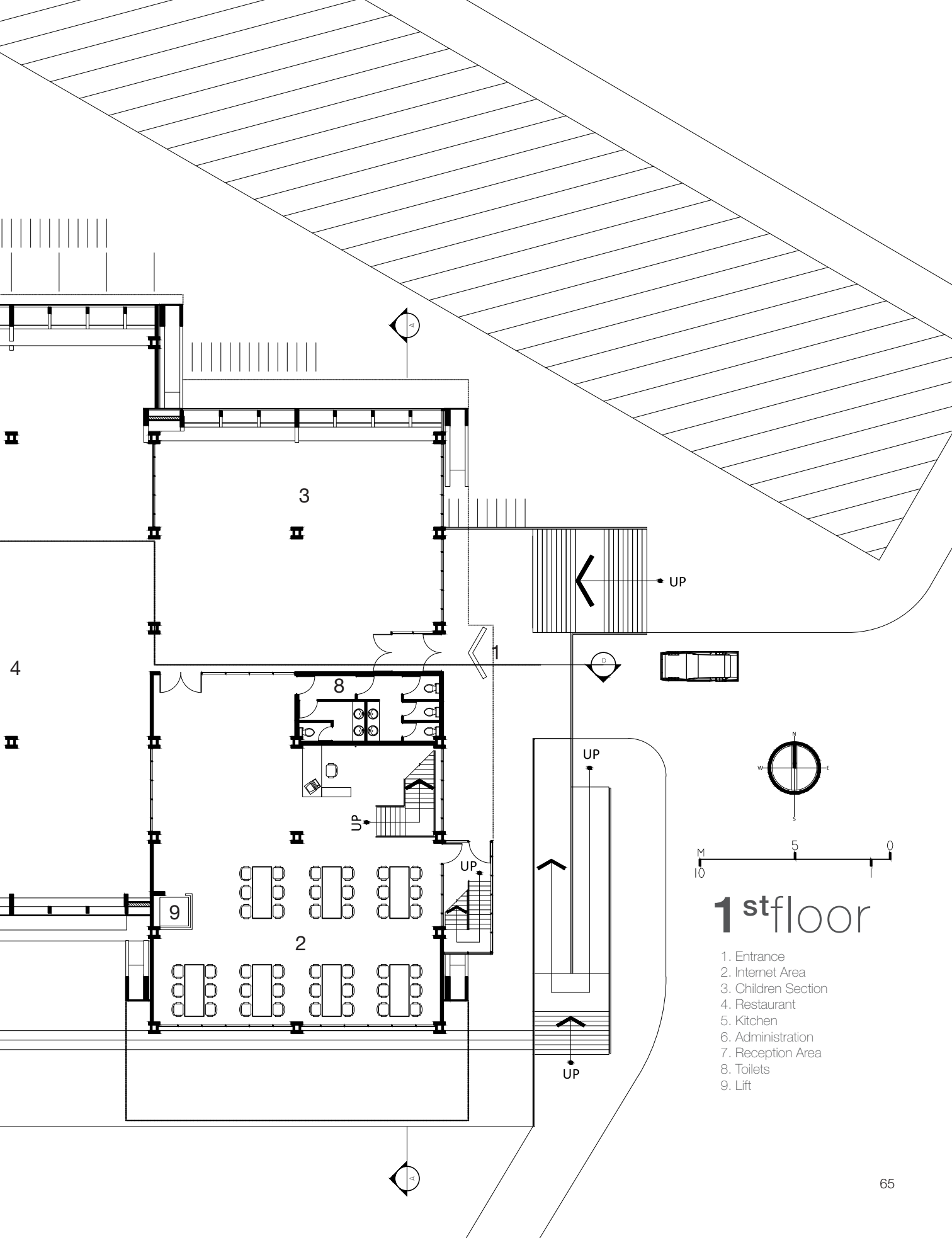
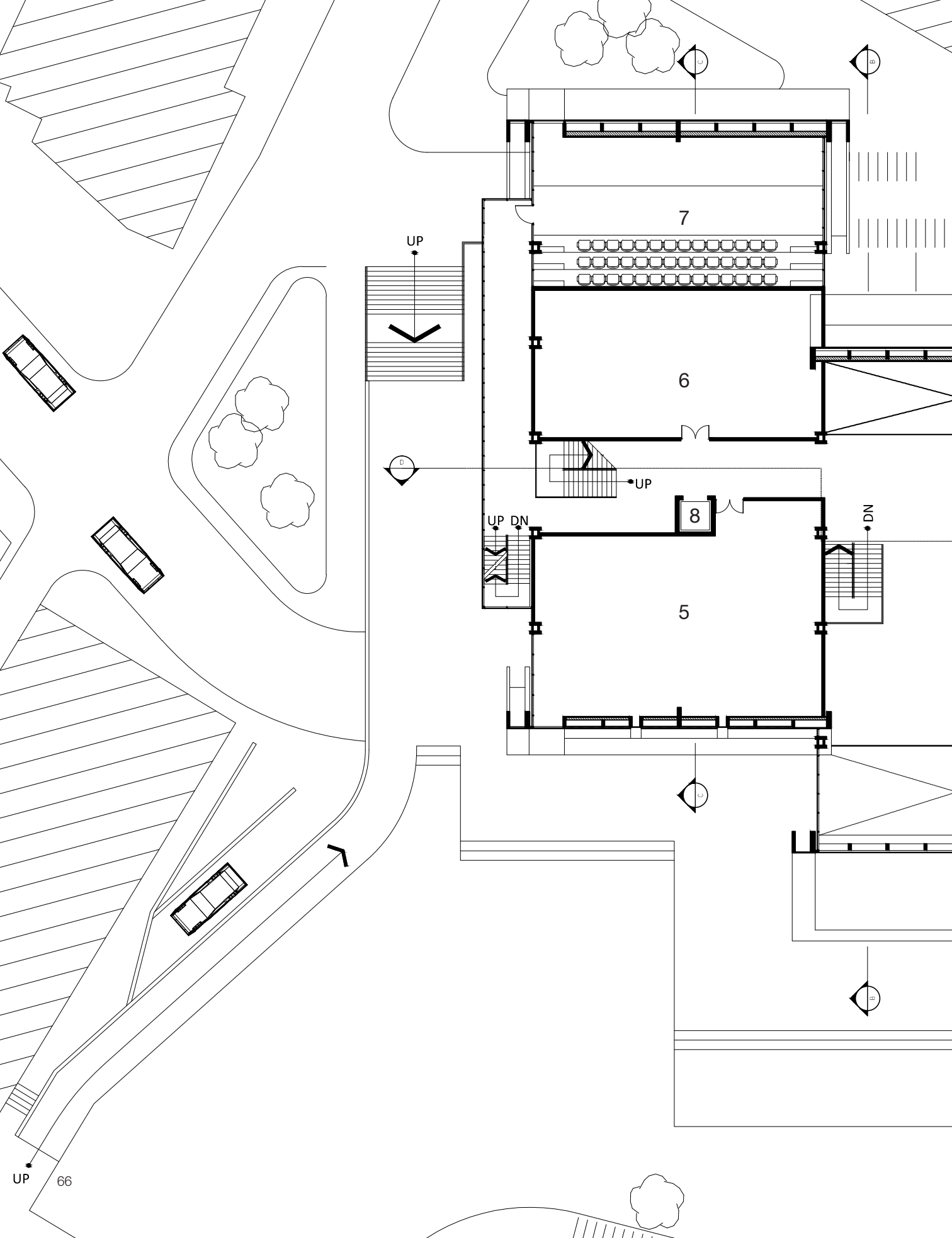
20
M
50
Bridge
Green Space
Outside Restaurant
Parking approach
Bicycle parking
Parking approach


UP
5
8
1
UP
9
6
7
DN
UP
1
UP




# 1st floor

1. Entrance
2. Internet Area
3. Children Section
4. Restaurant
5. Kitchen
6. Administration
7. Reception Area
8. Toilets
9. Lift


7
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8
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UP
UP
UP DN
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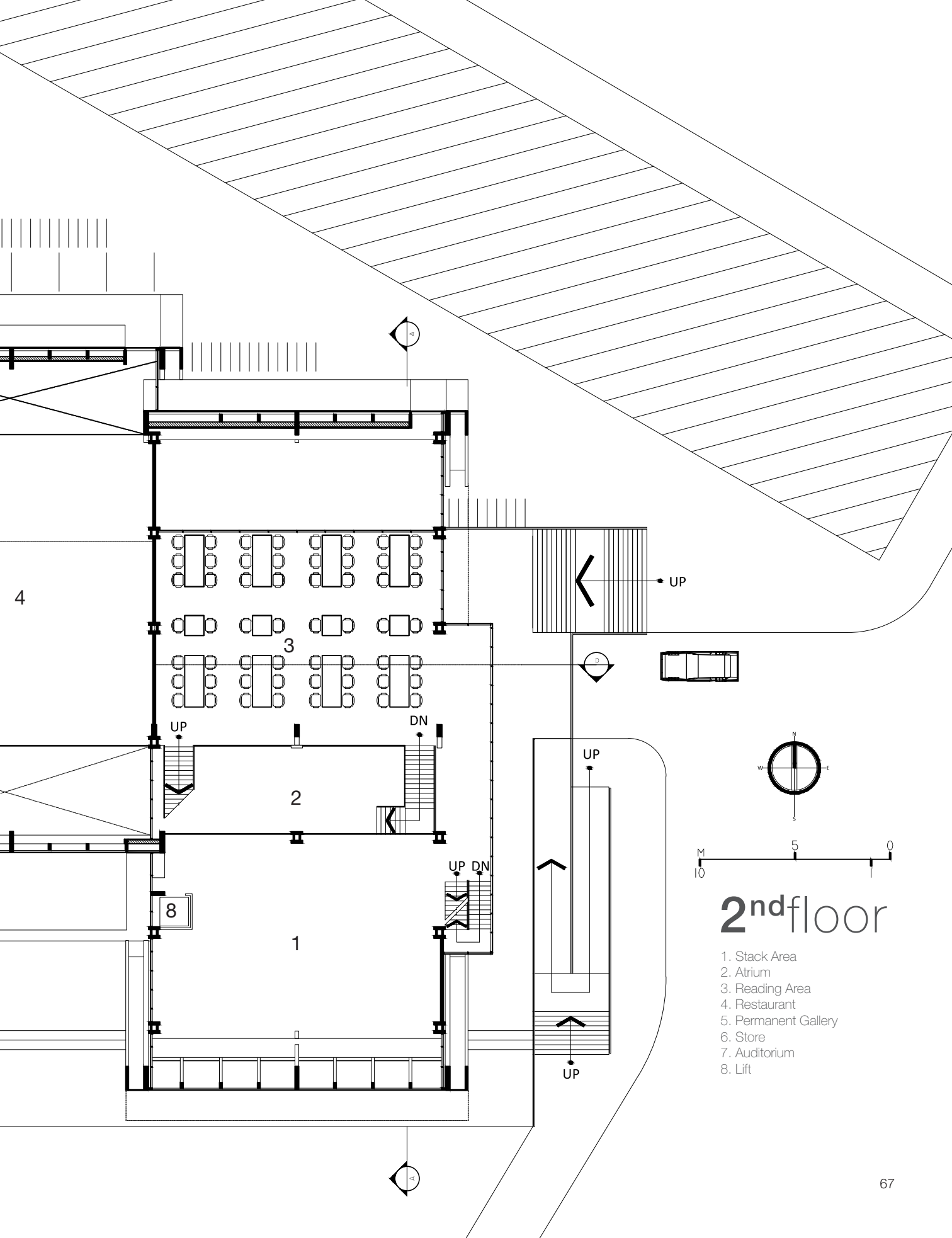
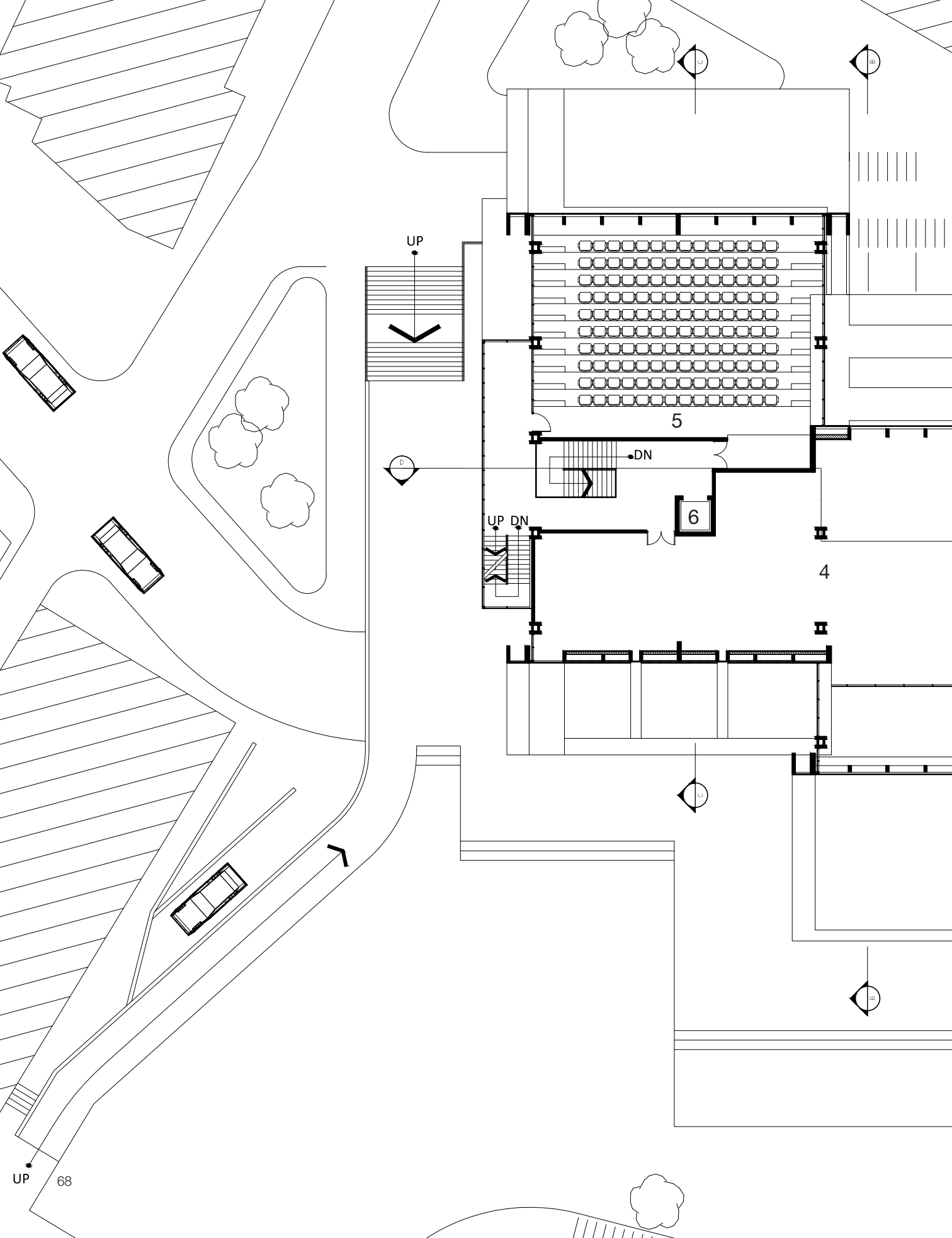
UP




# 2nd floor

1. Stack Area
2. Atrium
3. Reading Area
4. Restaurant
5. Permanent Gallery
6. Store
7. Auditorium
8. Lift


UP
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UP DN
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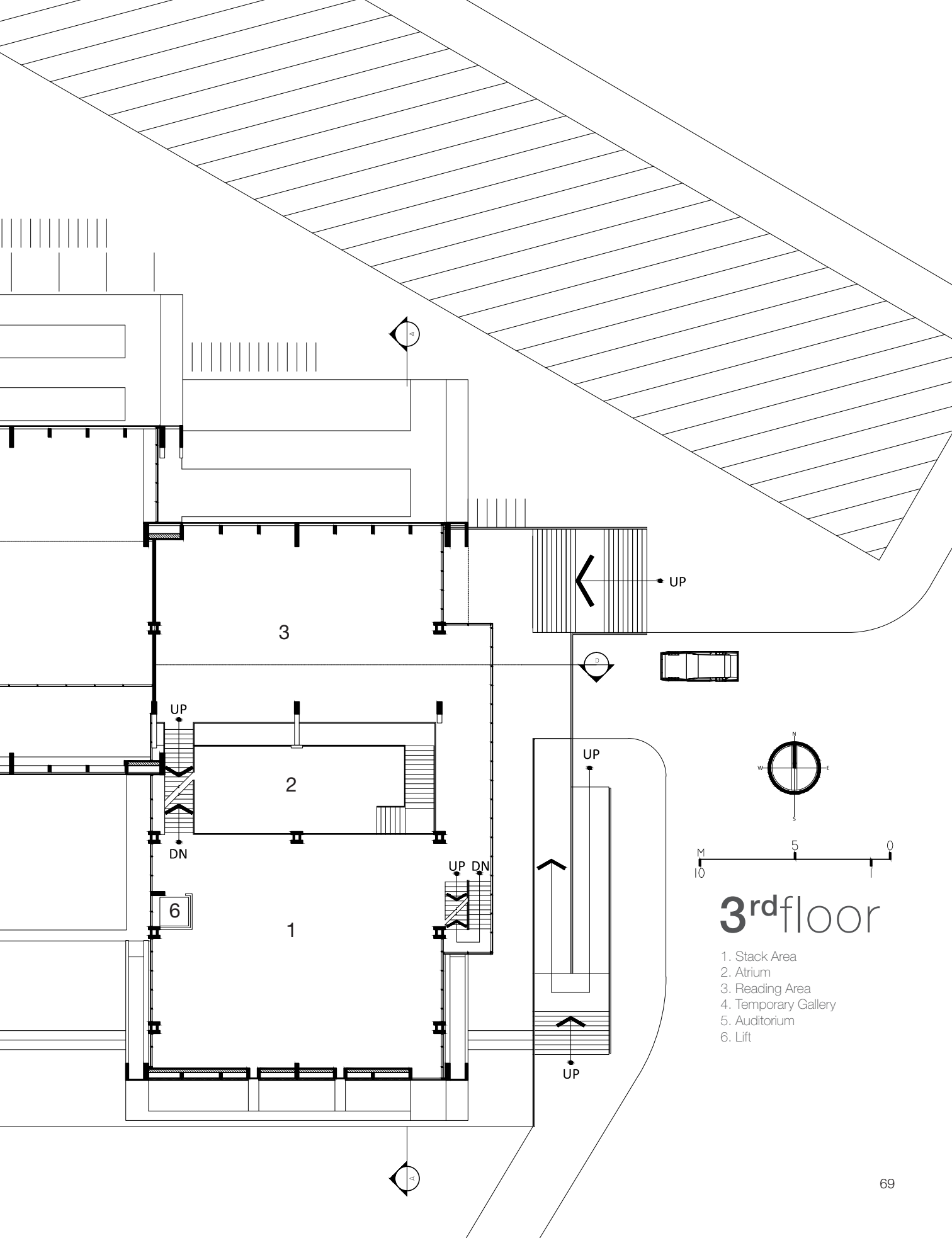
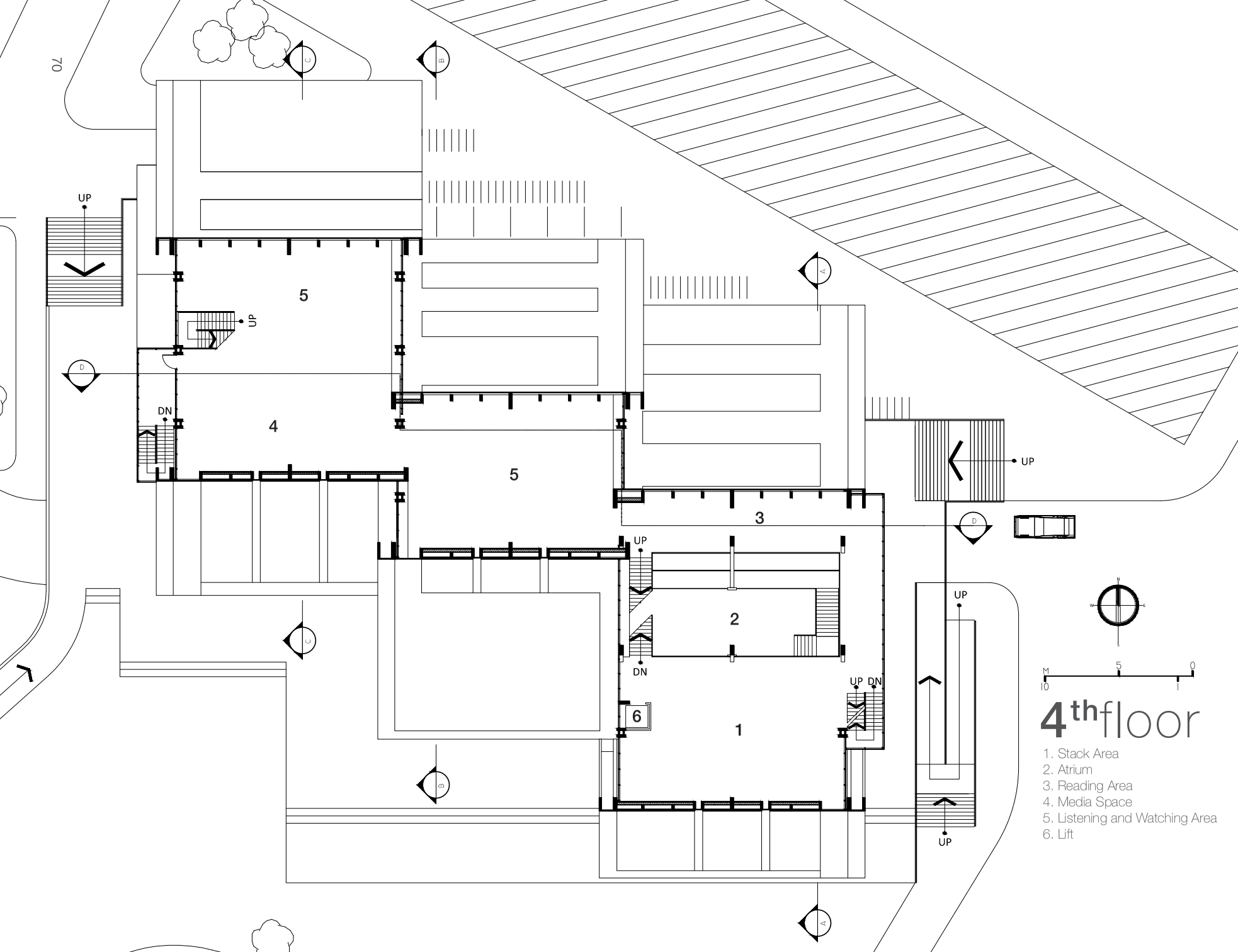
UP



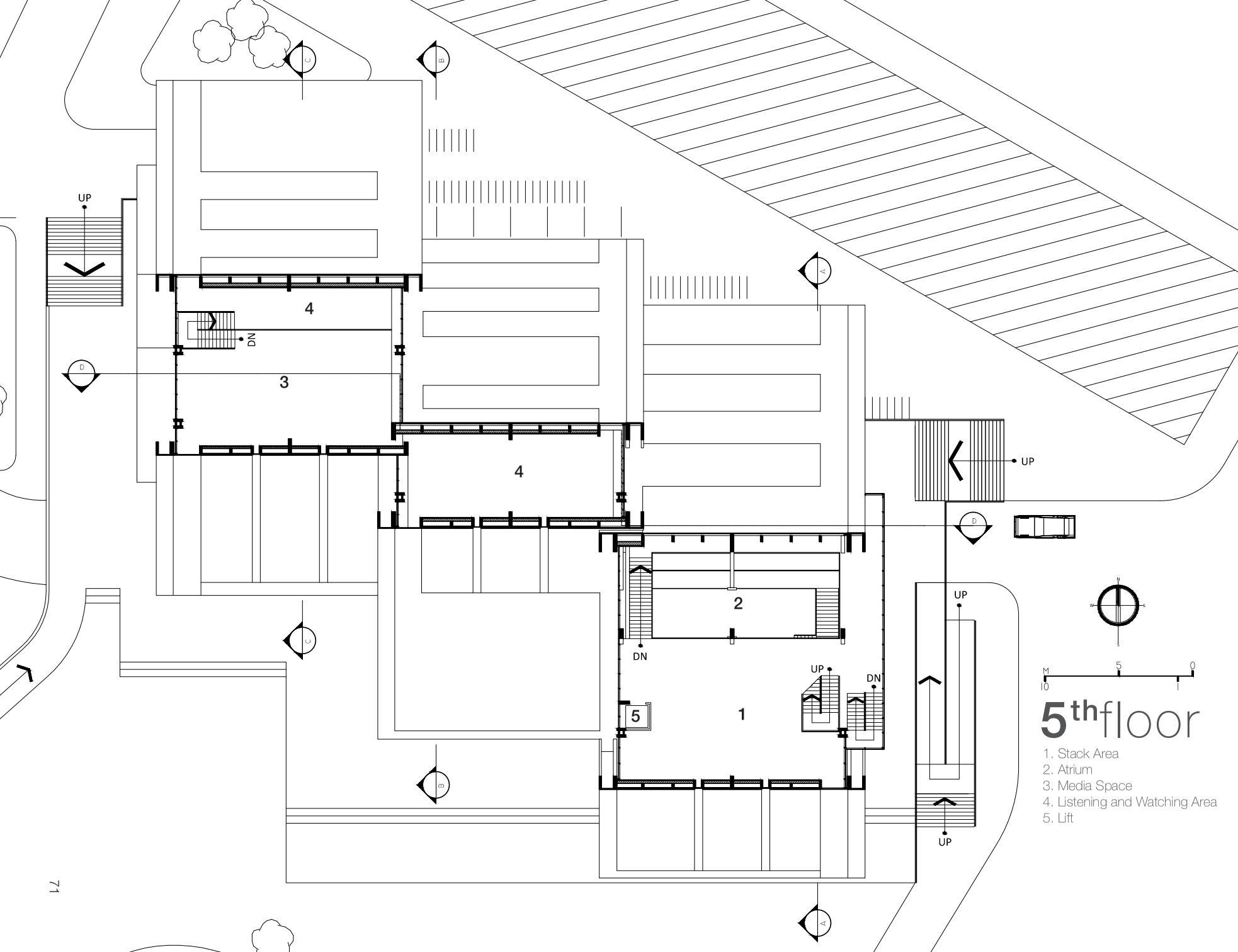

# 3rd floor

1. Stack Area
2. Atrium
3. Reading Area
4. Temporary Gallery
5. Auditorium
6. Lift



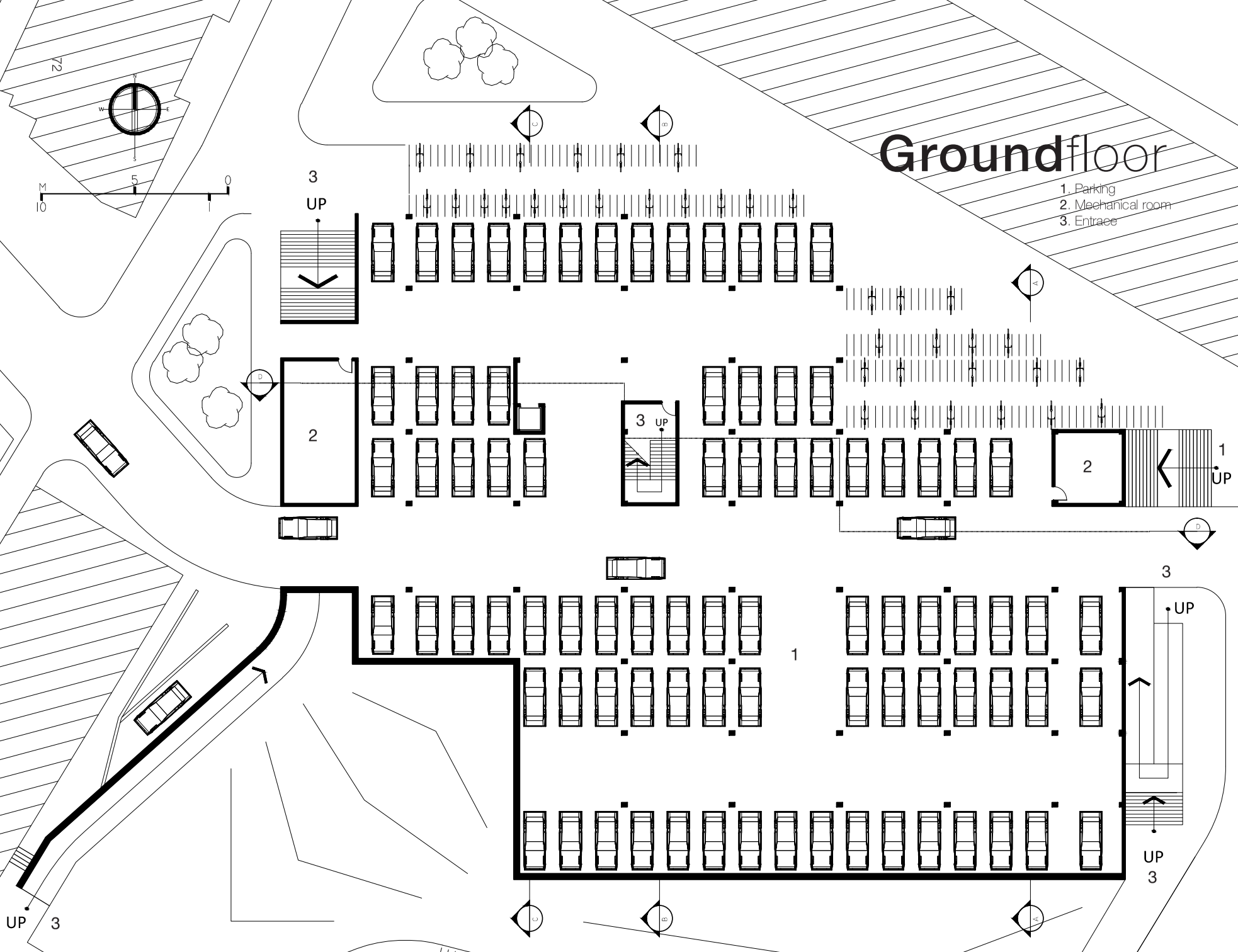

# 4th floor

1. Stack Area
2. Atrium
3. Reading Area
4. Media Space
5. Listening and Watching Area
6. Lift




# 5th floor

1. Stack Area
2. Atrium
3. Media Space
4. Listening and Watching Area
5. Lift


Groundfloor
1. Parking
2. Mechanical room
3. Entrace
N
W
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S
M
5
0
10
3
UP
2
3
UP
2
1
UP
3
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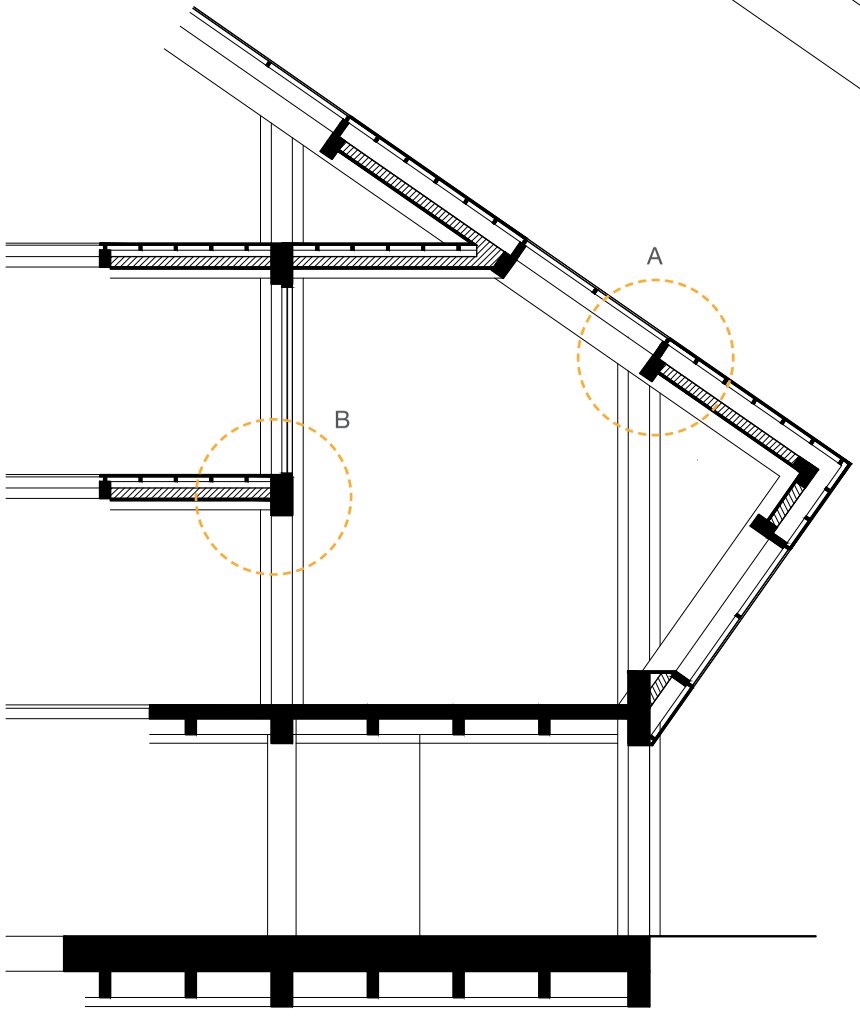
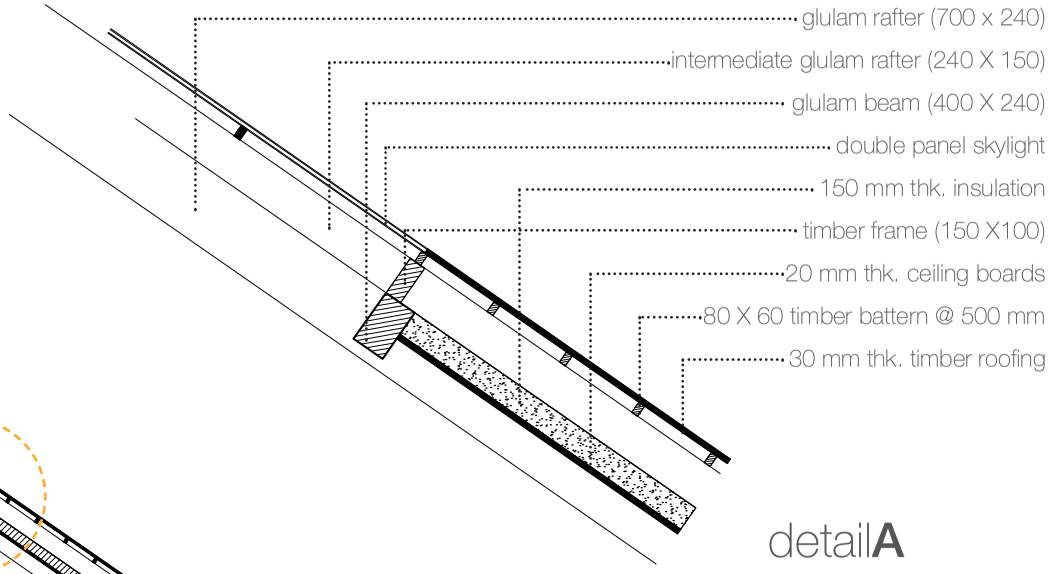
UP
UP
3
UP
3
A
B
C
D

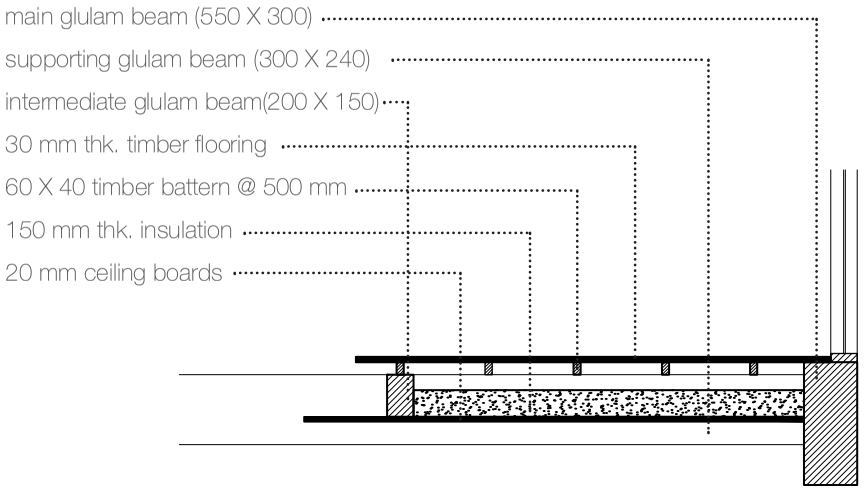
# details



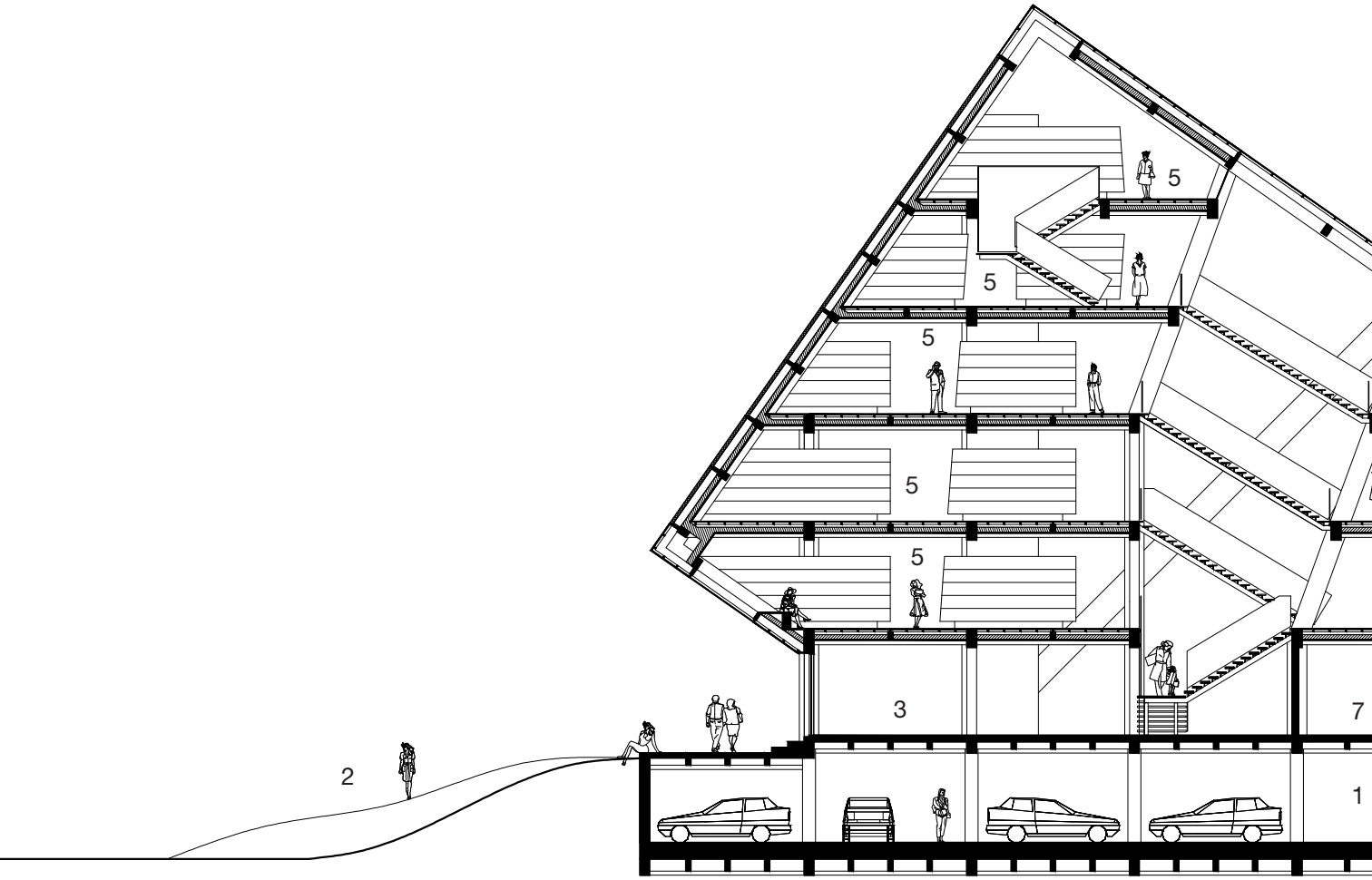

**typical**section




detail**A**

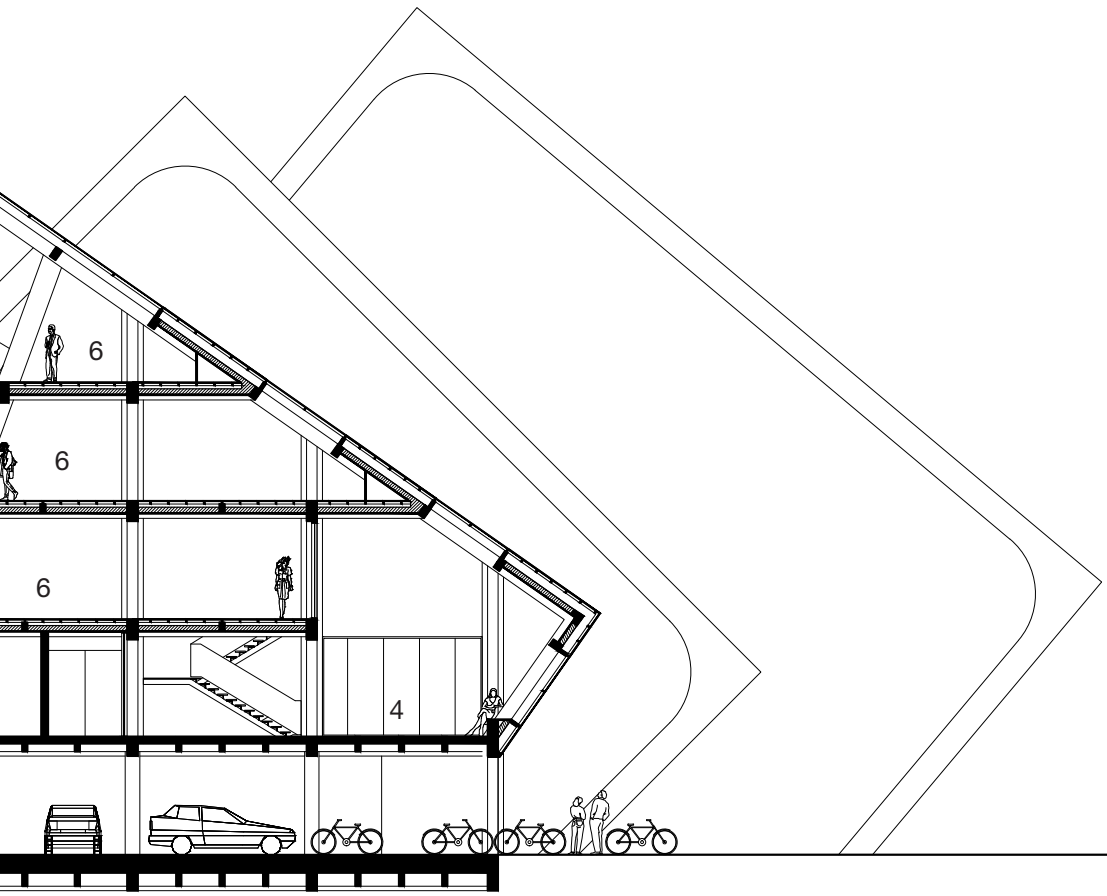


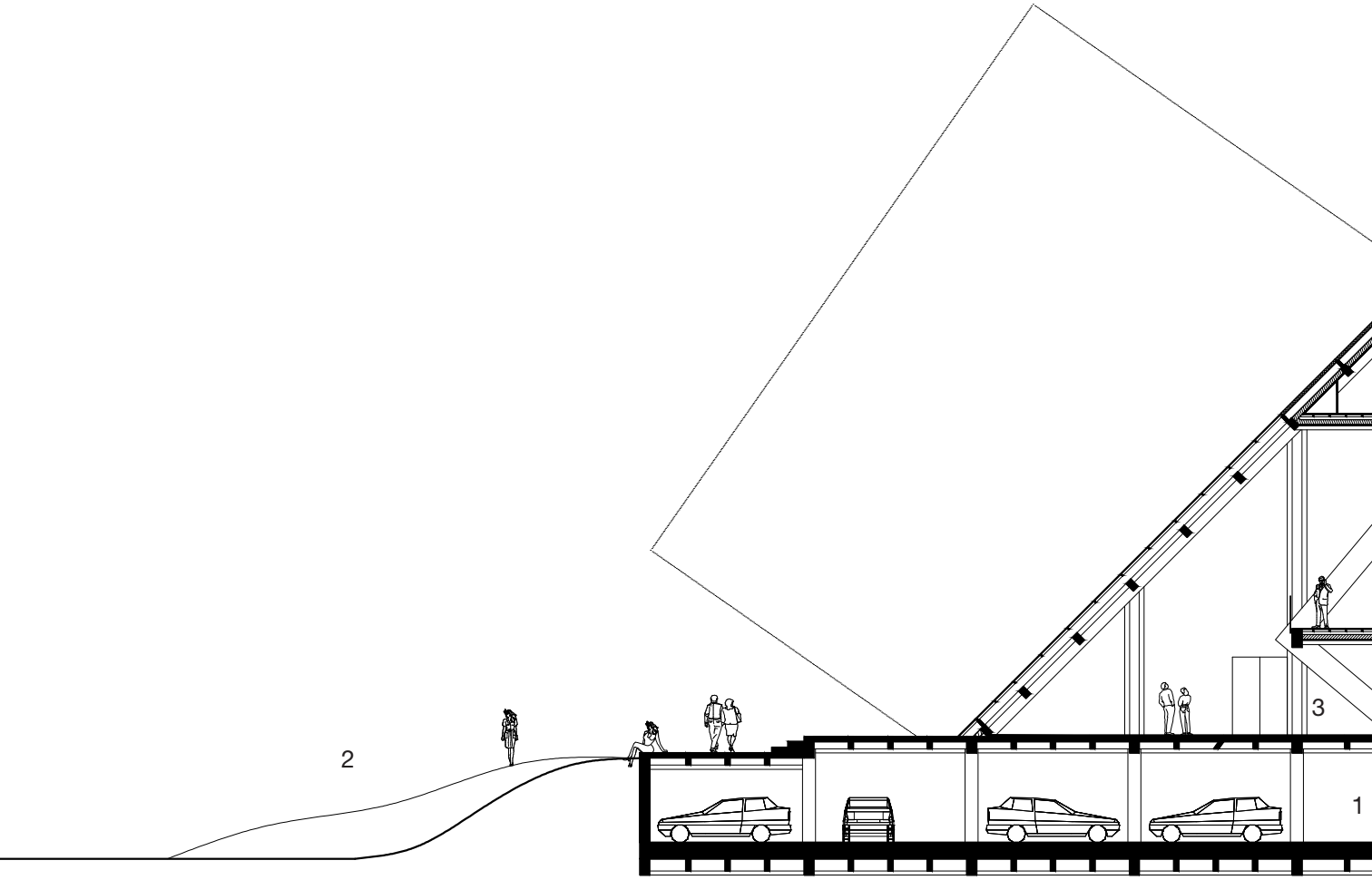

detail**B**


5
5
5
5
5
3
7
2
1

# section**A**

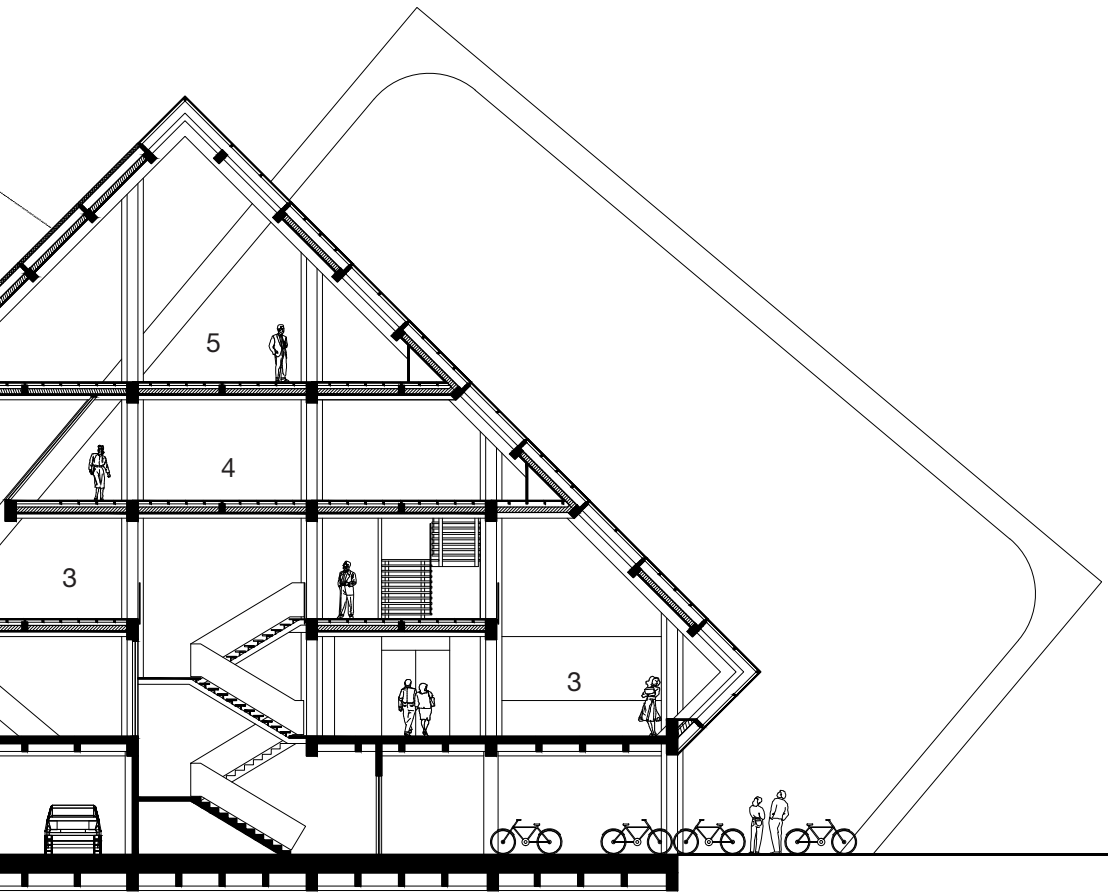
1. Parking
2. Green Space
3. Interner Area
4. Children Section
5. Stack Area
6. Reading Area
7. Toilets

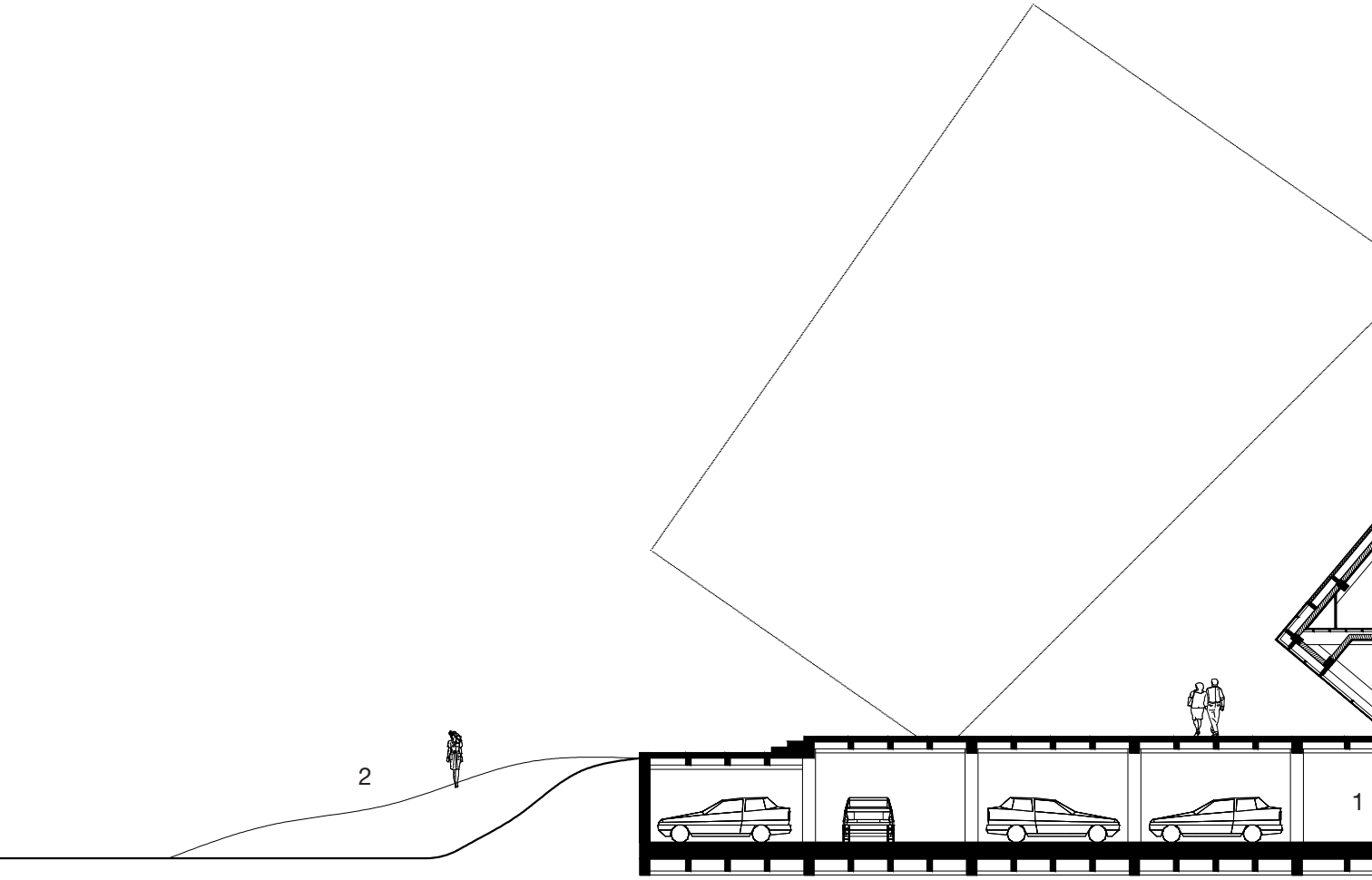




3
2
1

# section**B**

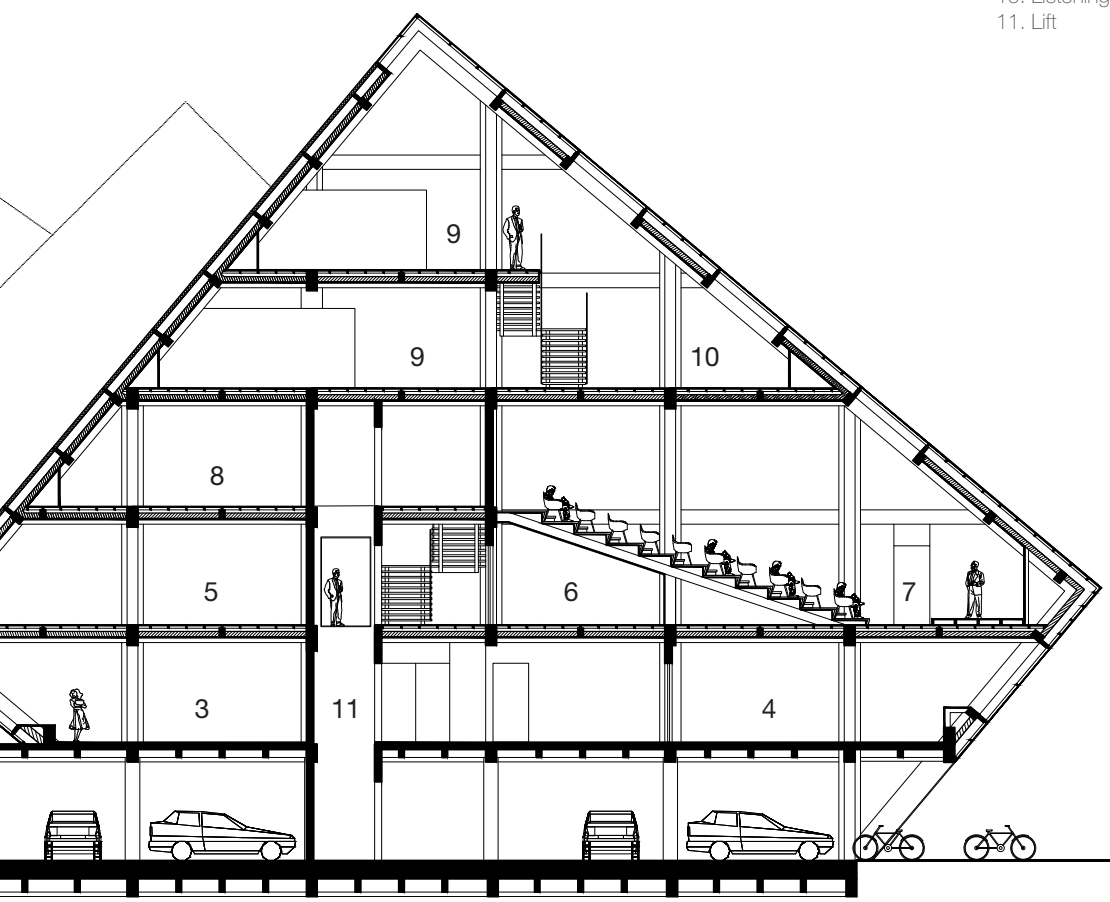
1. Parking
2. Green Space
3. Restaurant
4. Temporary Gallery
5. Library Area

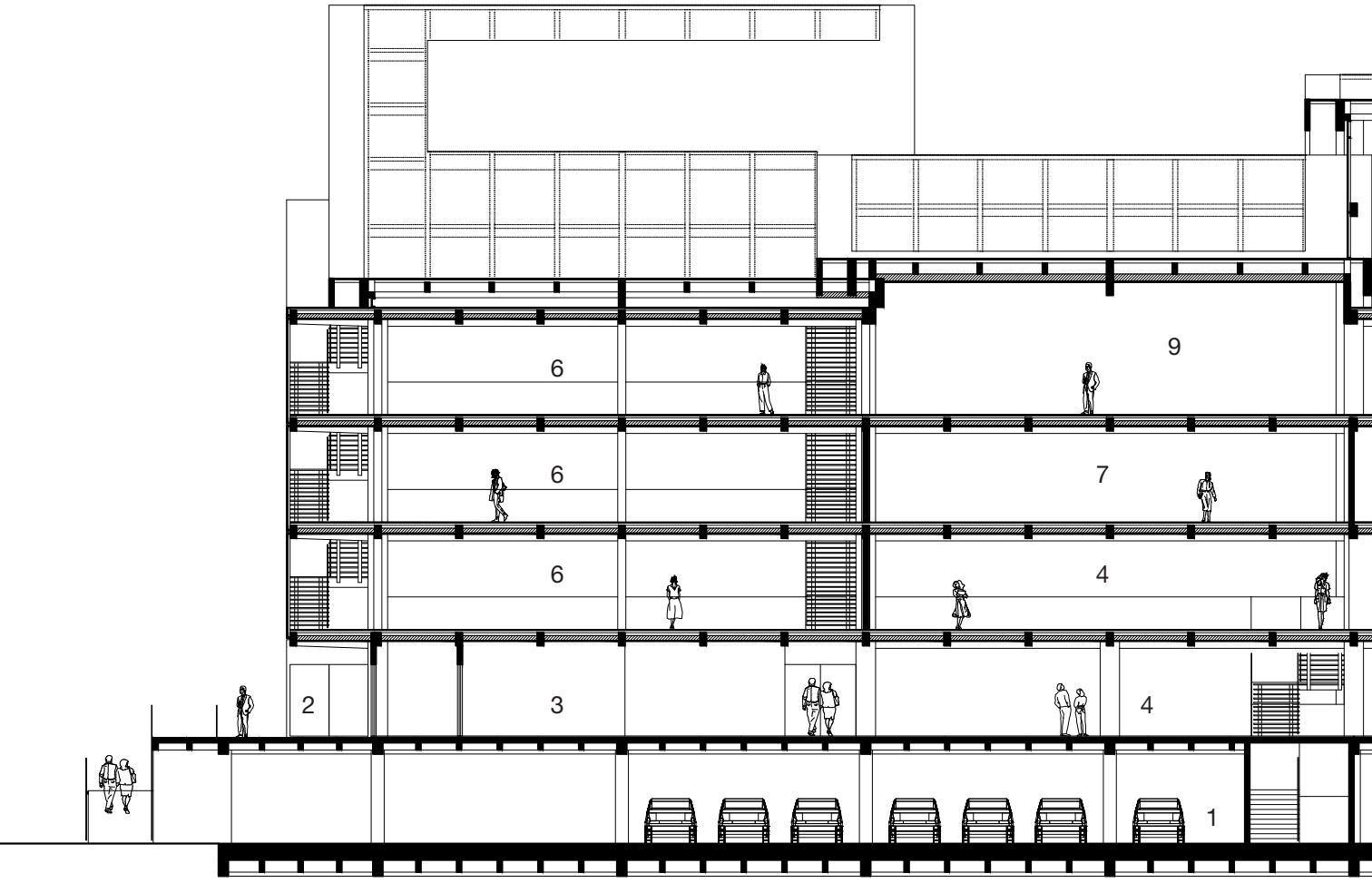




2
1

# section**C**

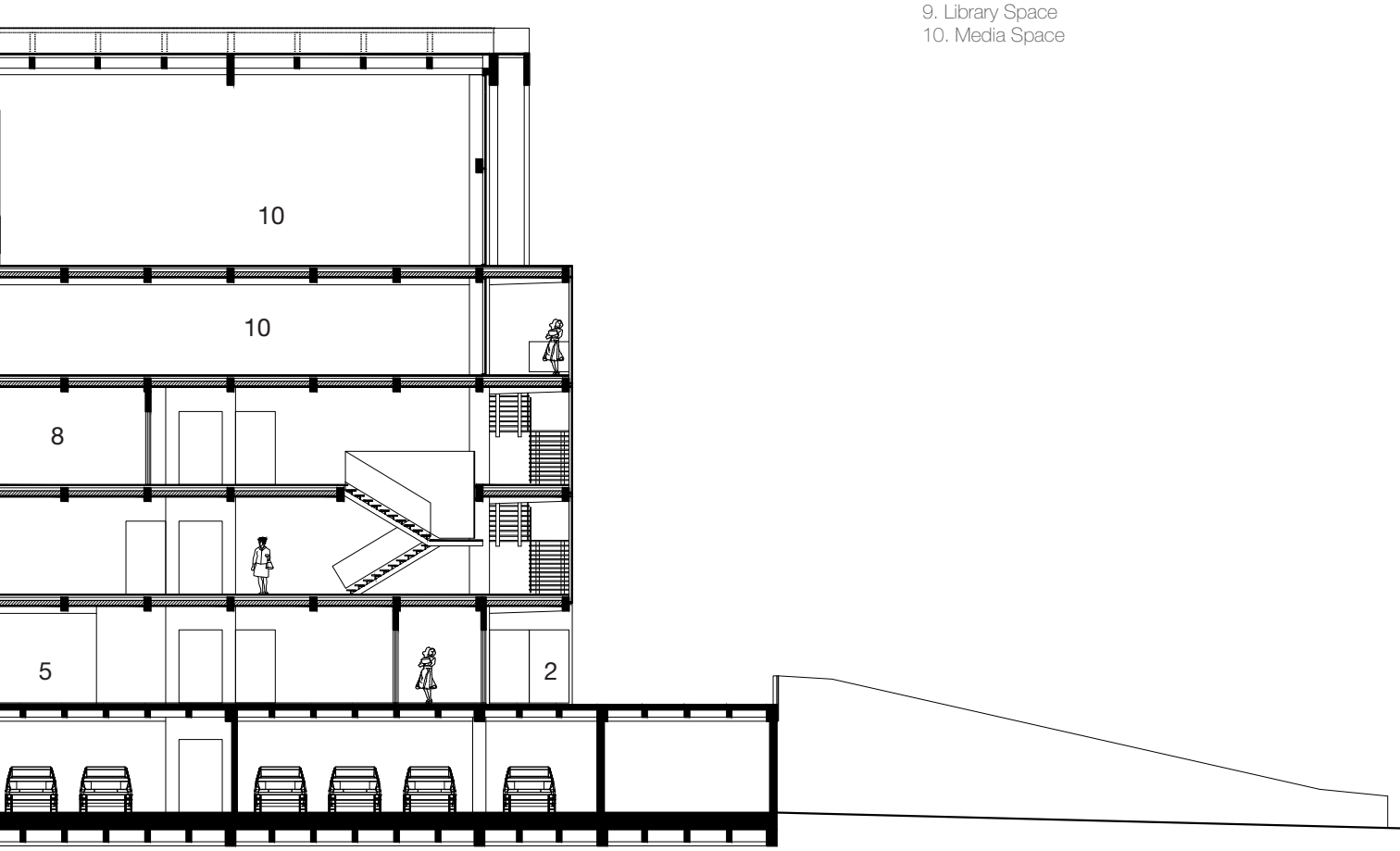
1. Parking
2. Greeen Space
3. Administration
4. Kitchen
5. Permanent Gallery
6. Store
8. Auditorium
9. Media Stack Area
10. Listening and Watching Area
11. Lift

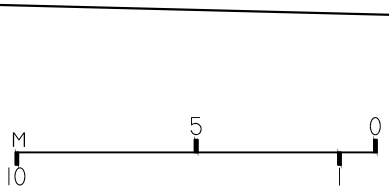


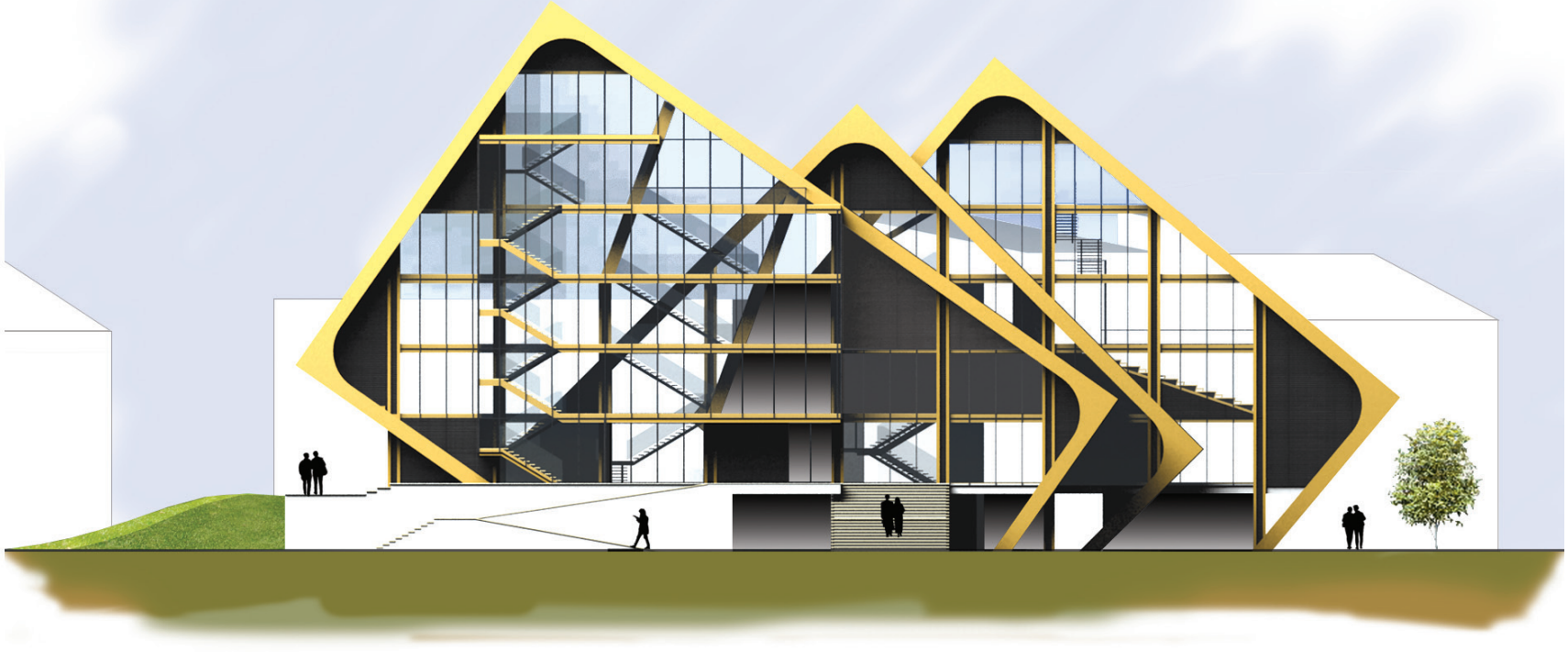


6
6
6
9
7
4
2
3
4
1

# section**D**

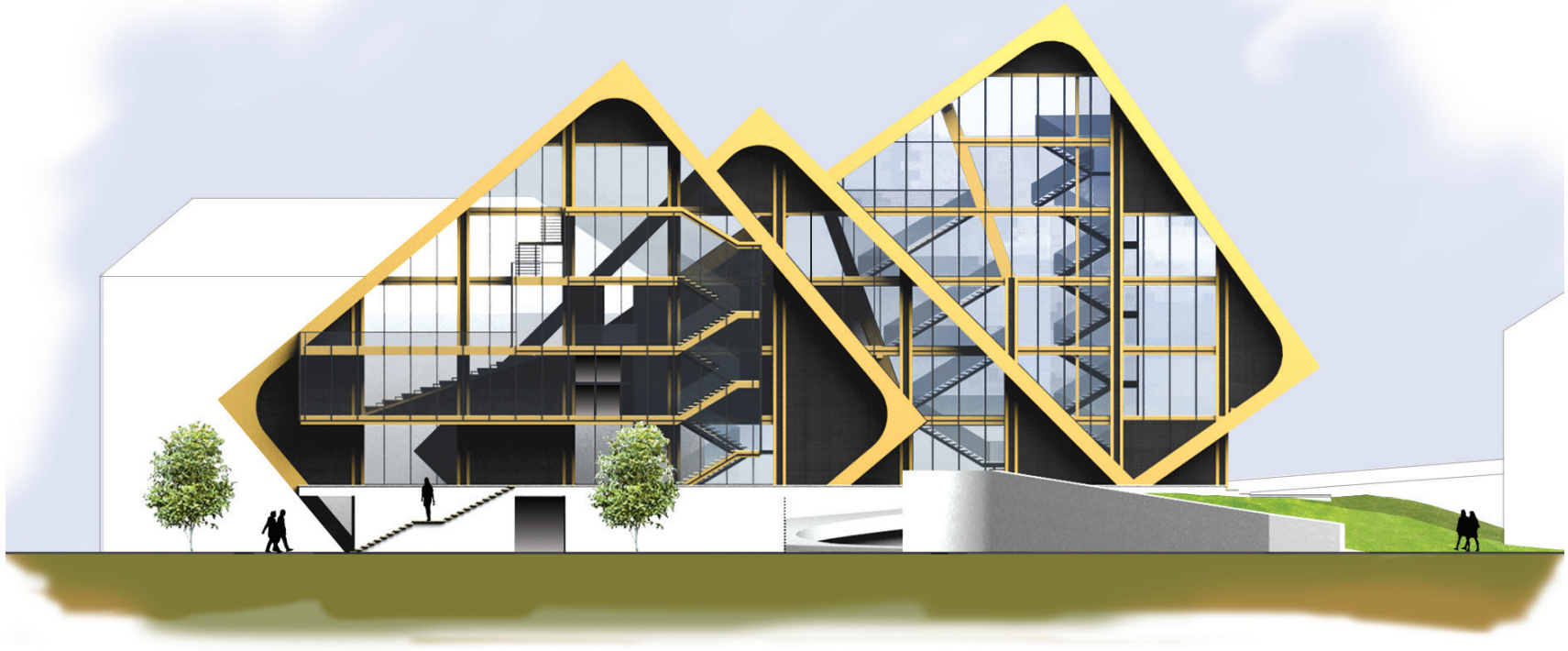
1. Parking
2. Entrance
3. Children Section
4. Restaurant
5. Reception Area
6. Reading Space
7. Temporary Gallery
8. Auditorium
9. Library Space
10. Media Space



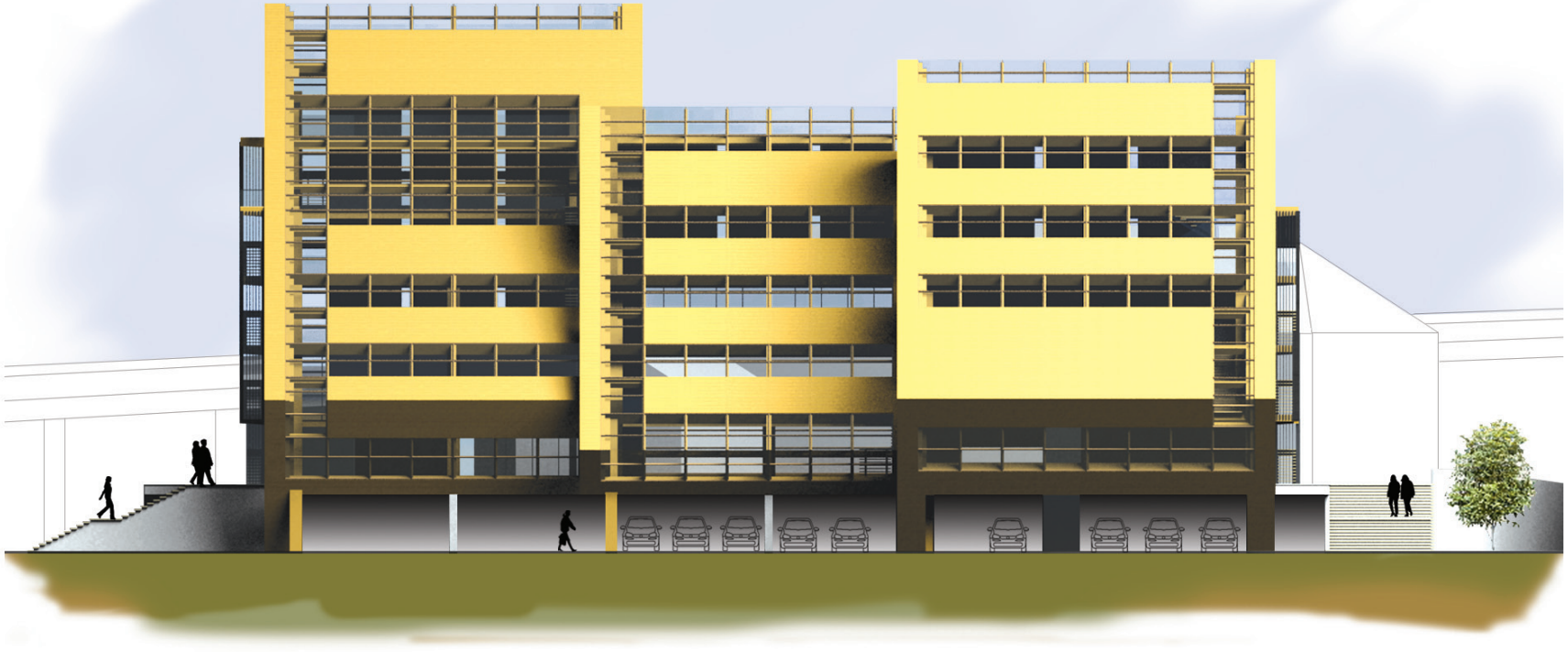





**east**elevation

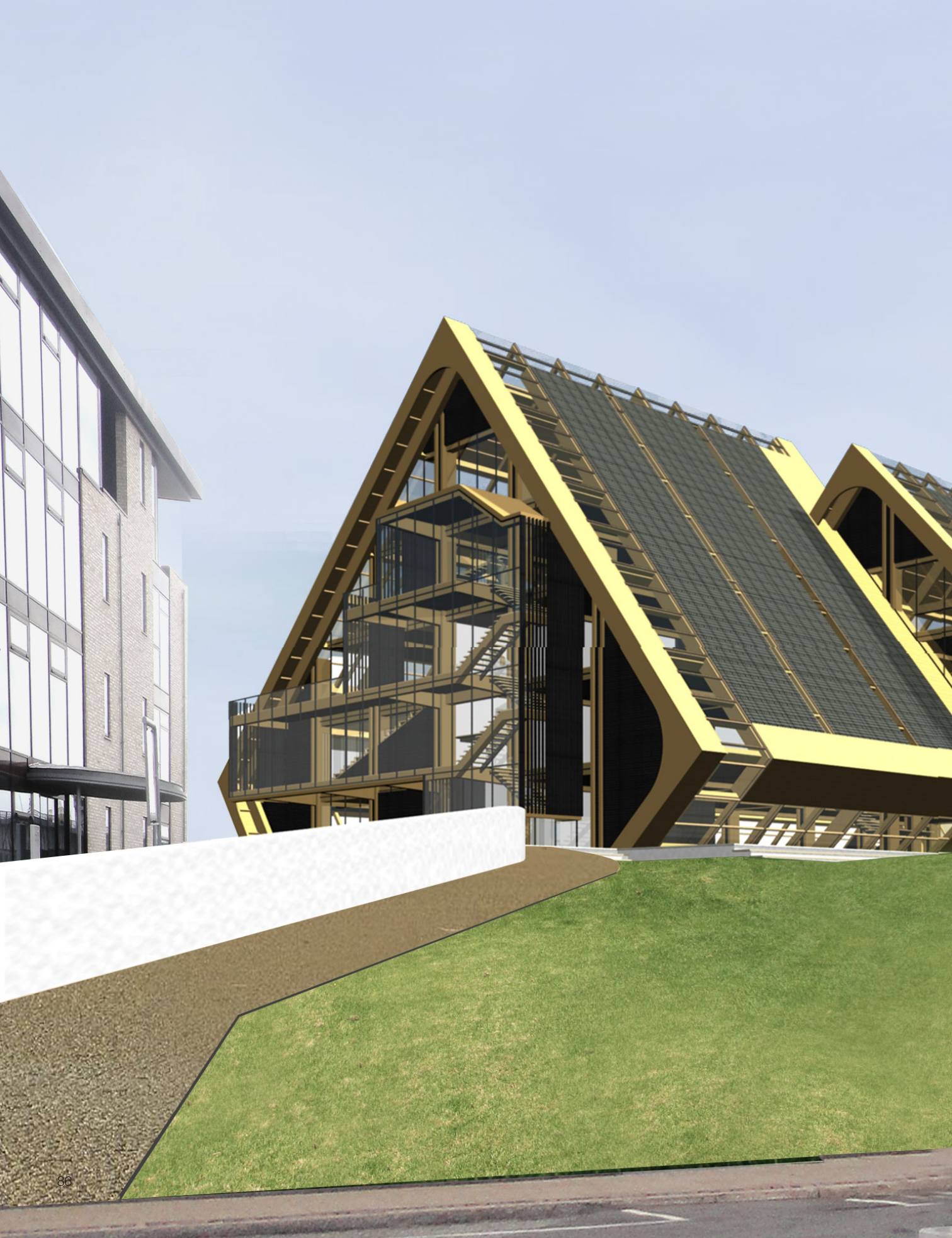


**west**elevation



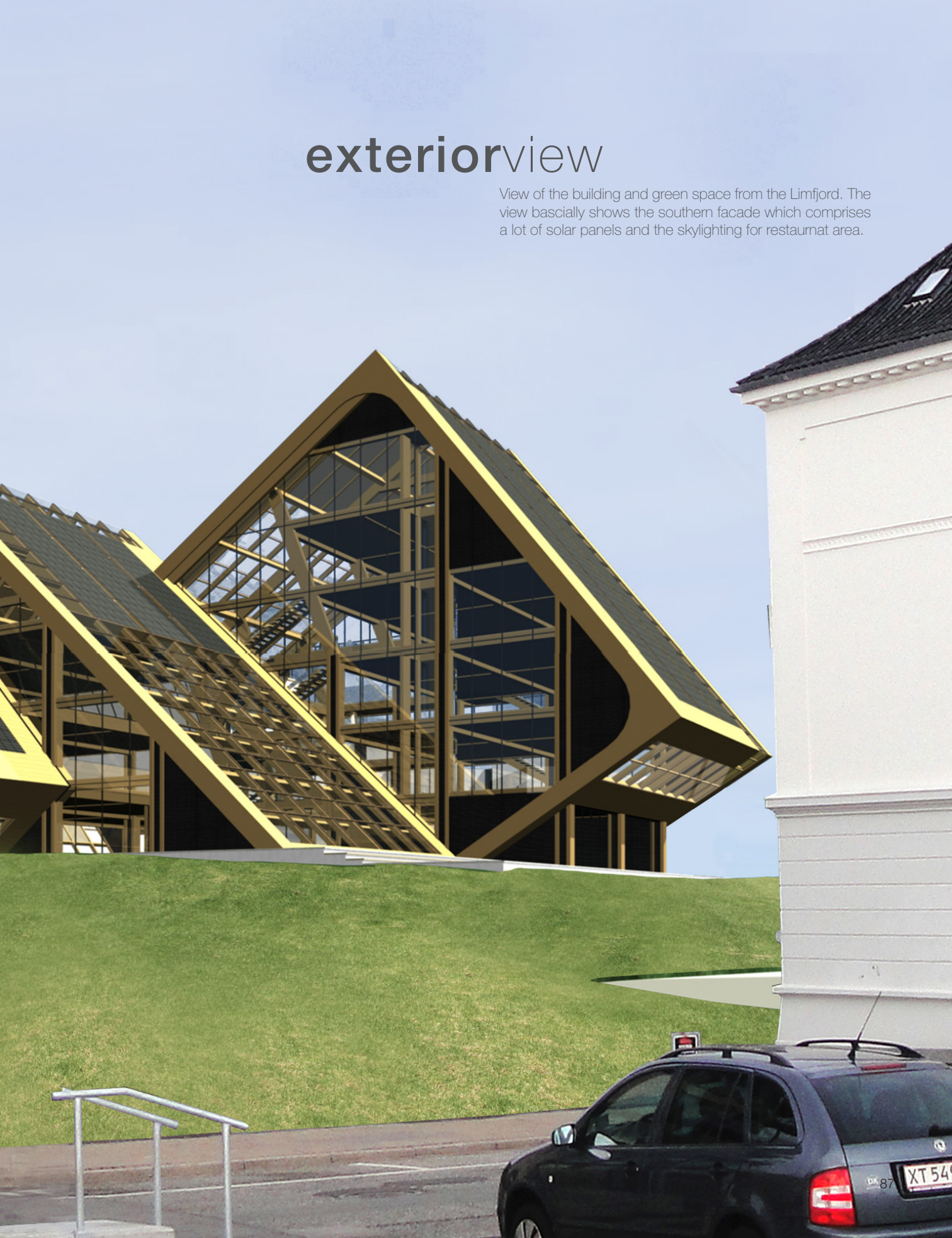
# **north**elevation

**south**elevation



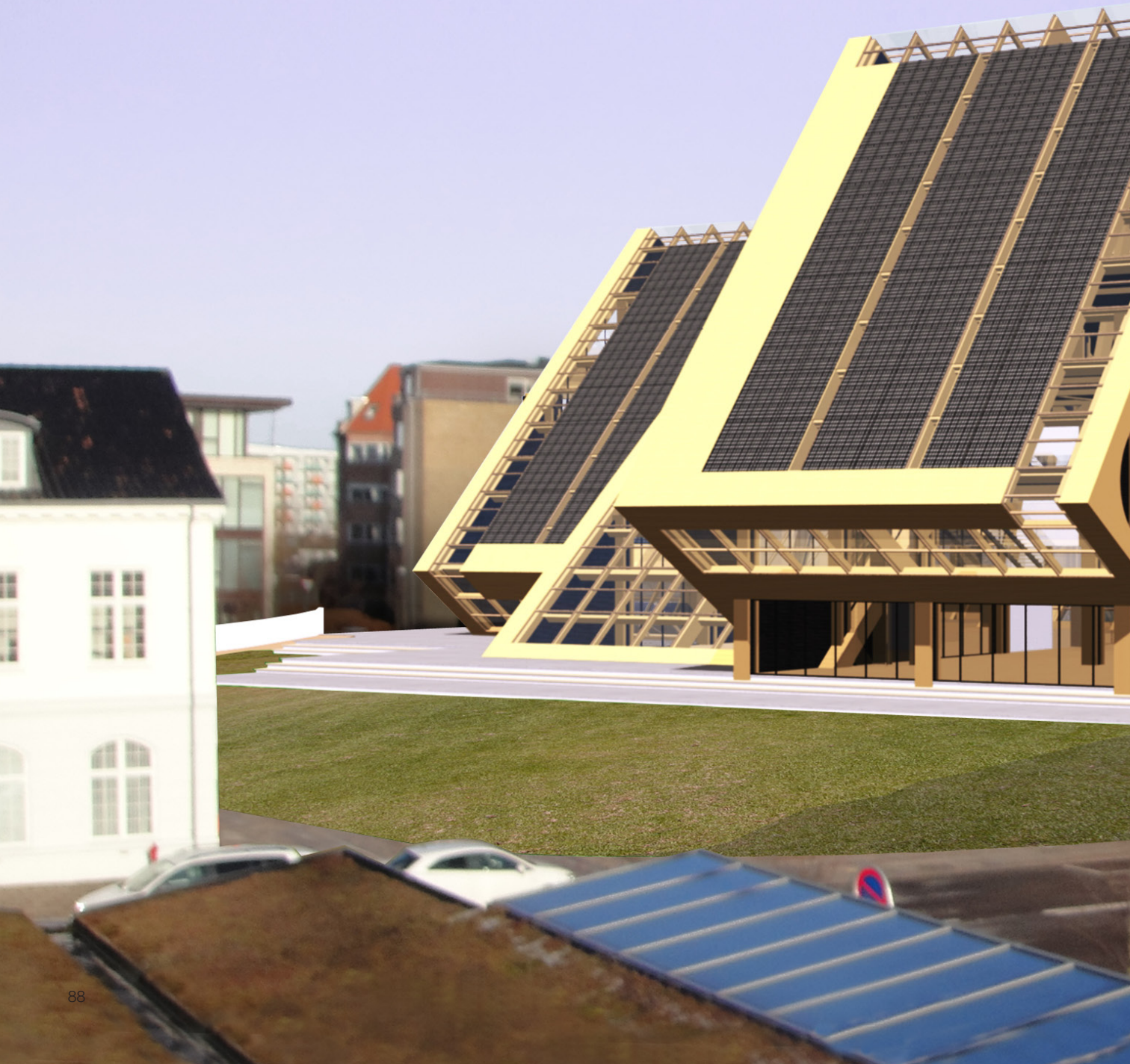
# **exterior**view

View of the building and green space from the Limfjord. The view bascially shows the southern facade which comprises a lot of solar panels and the skylighting for restaurnat area.



# **exterior**view

View of the building and green space from the bridge. This view shows the buullding in perspective with solar panelled south facade and clear glass panelled east facade. Due to the nice viewing point from the bridge, we can see a really good view of  the building.



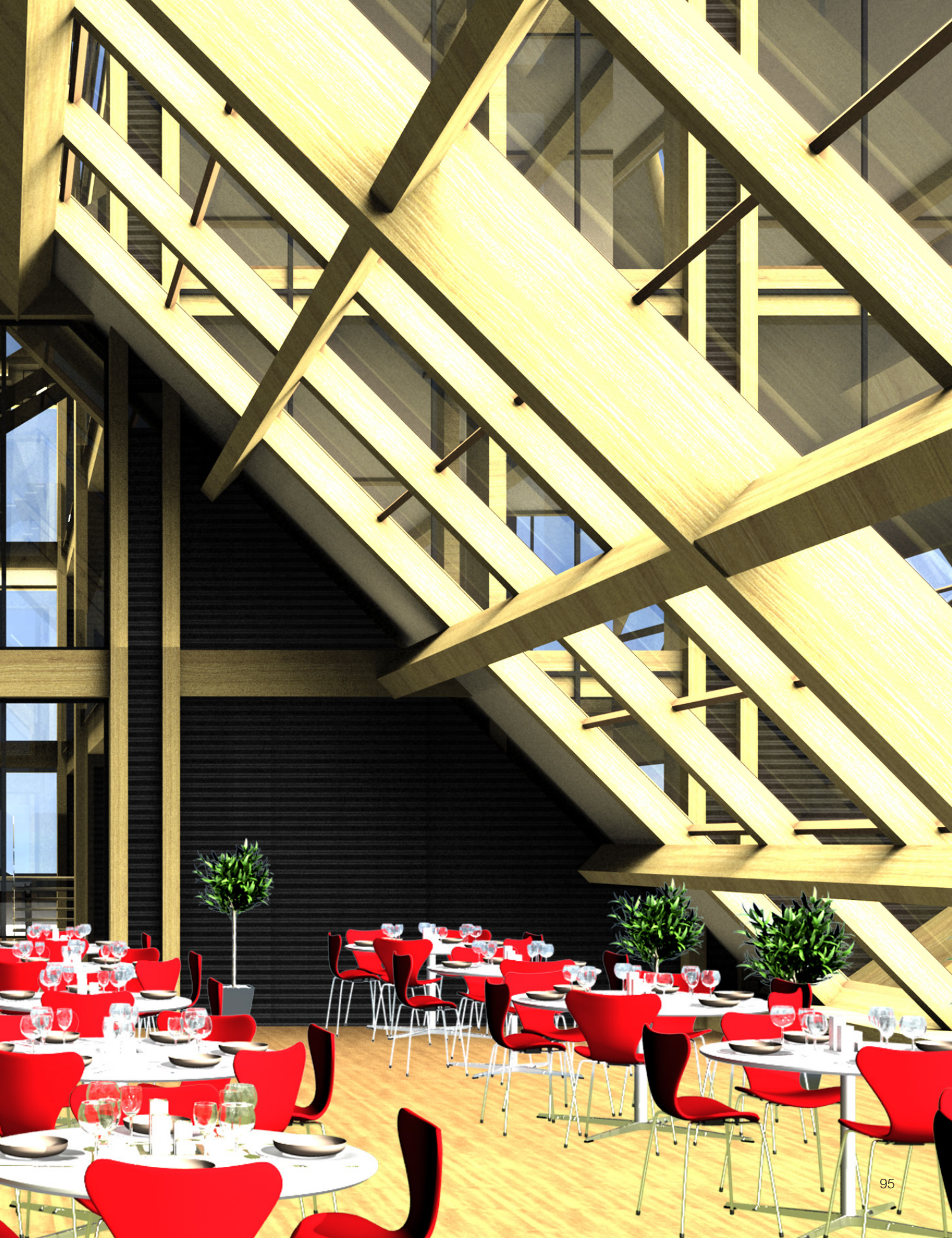
# **exterior**view

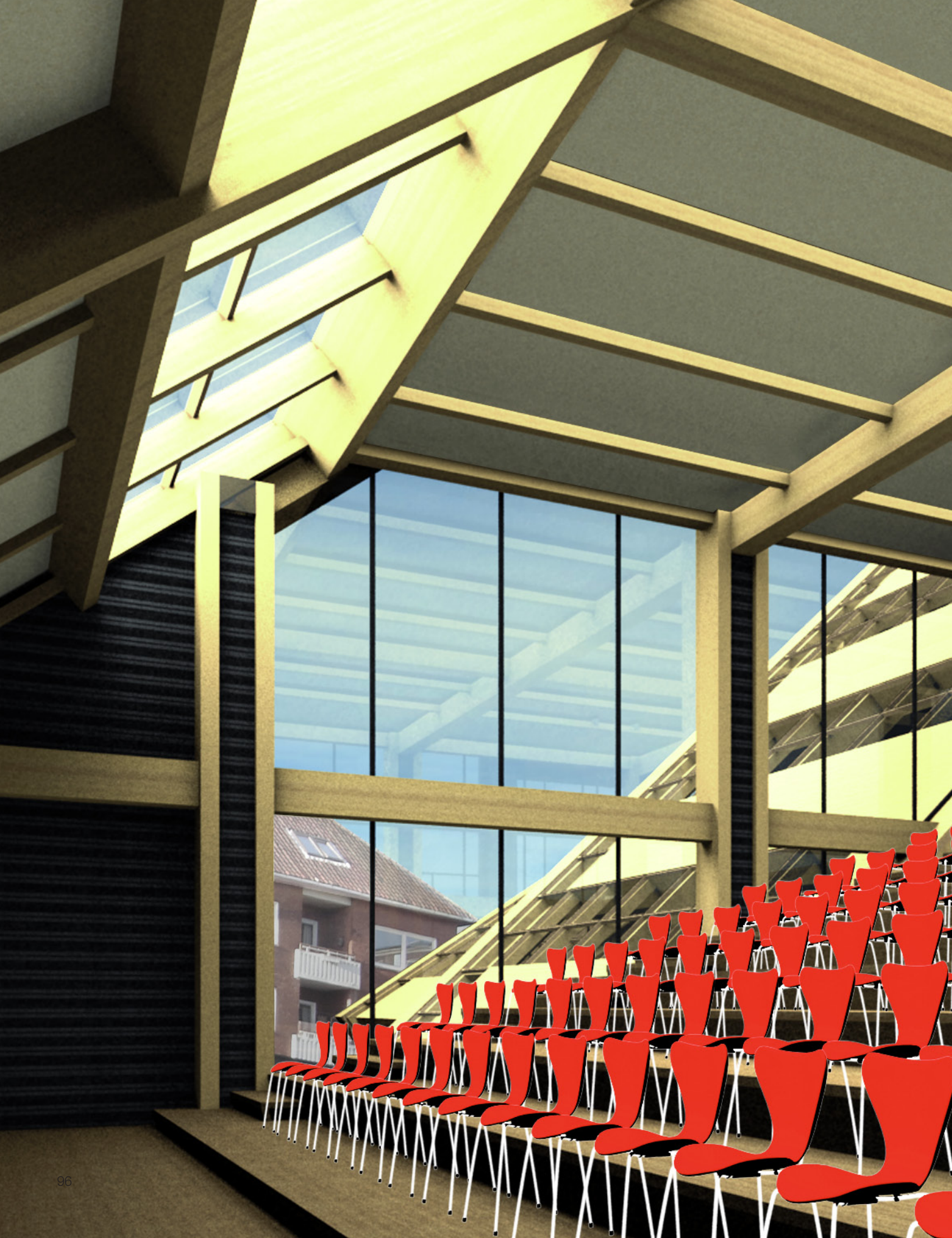
View of the building from Østerbrogade, which is one of the major access to the site. The view shows the main entry to the parking on the ground floor and to the library on the first floor.

# **library**area

Interior view of the library space showing reading area and the atrium the separates it from stack area.

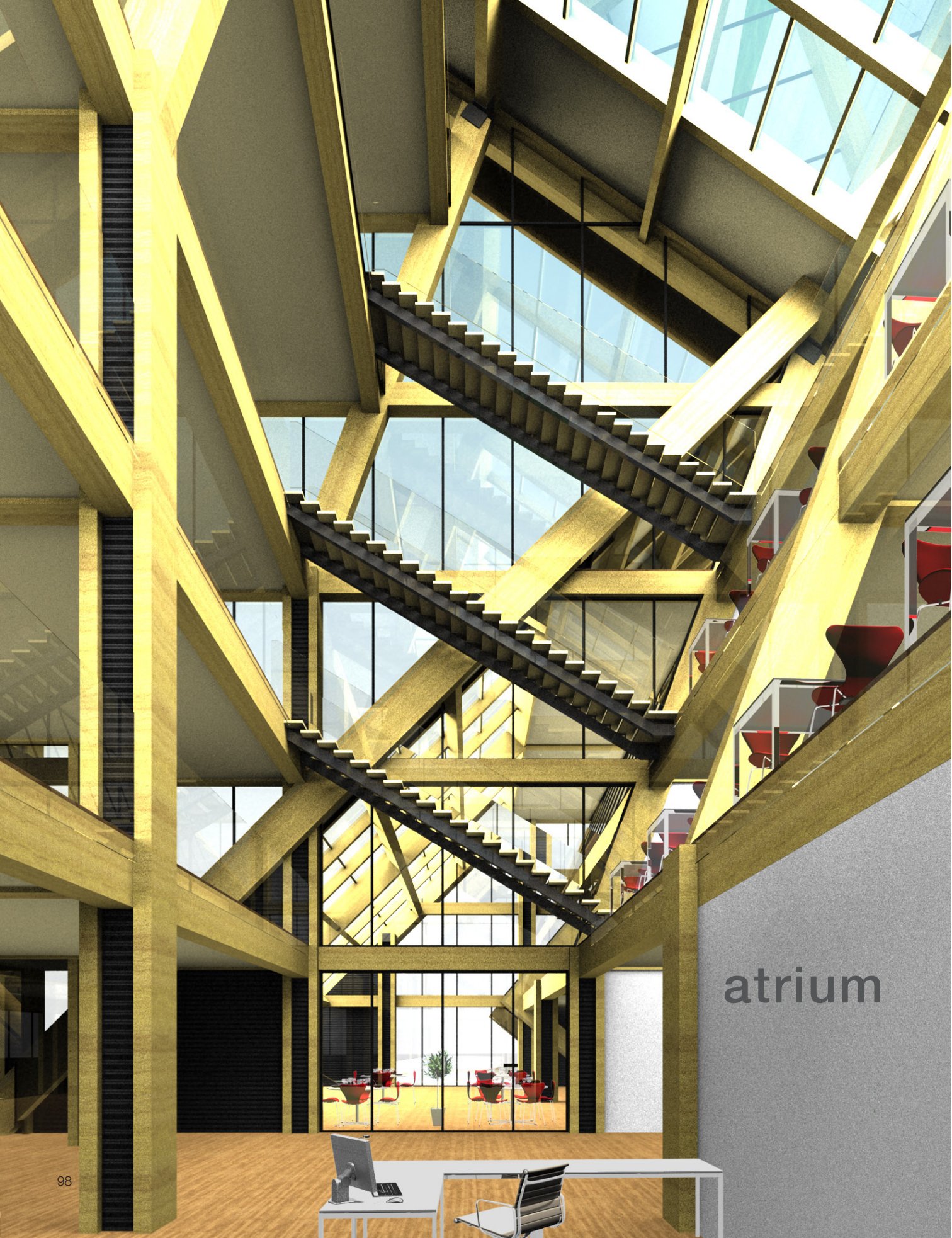
**restaurant**area





# **auditorium**area

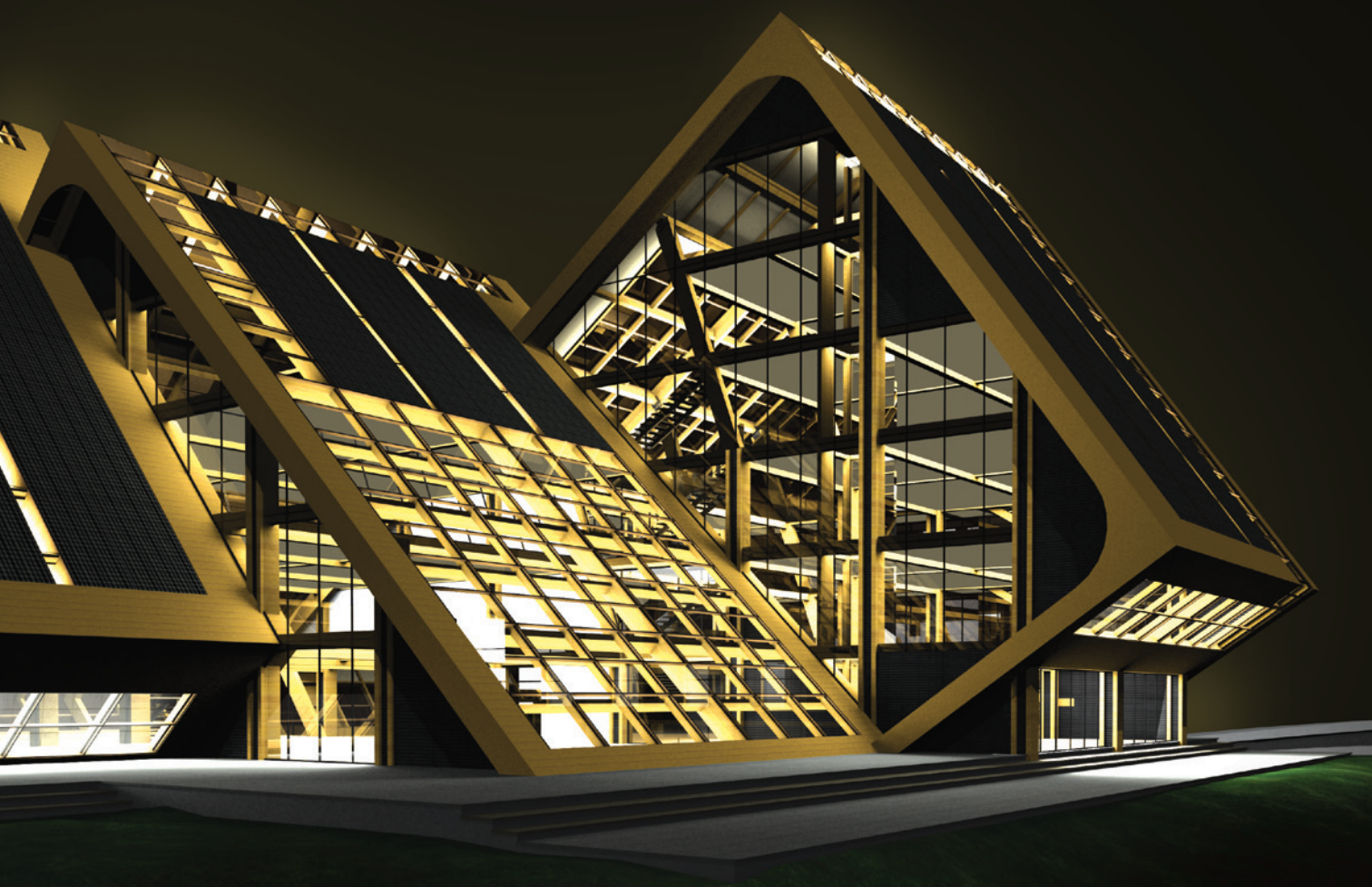
The view of the auditorium showing skylight and sitting spaces.

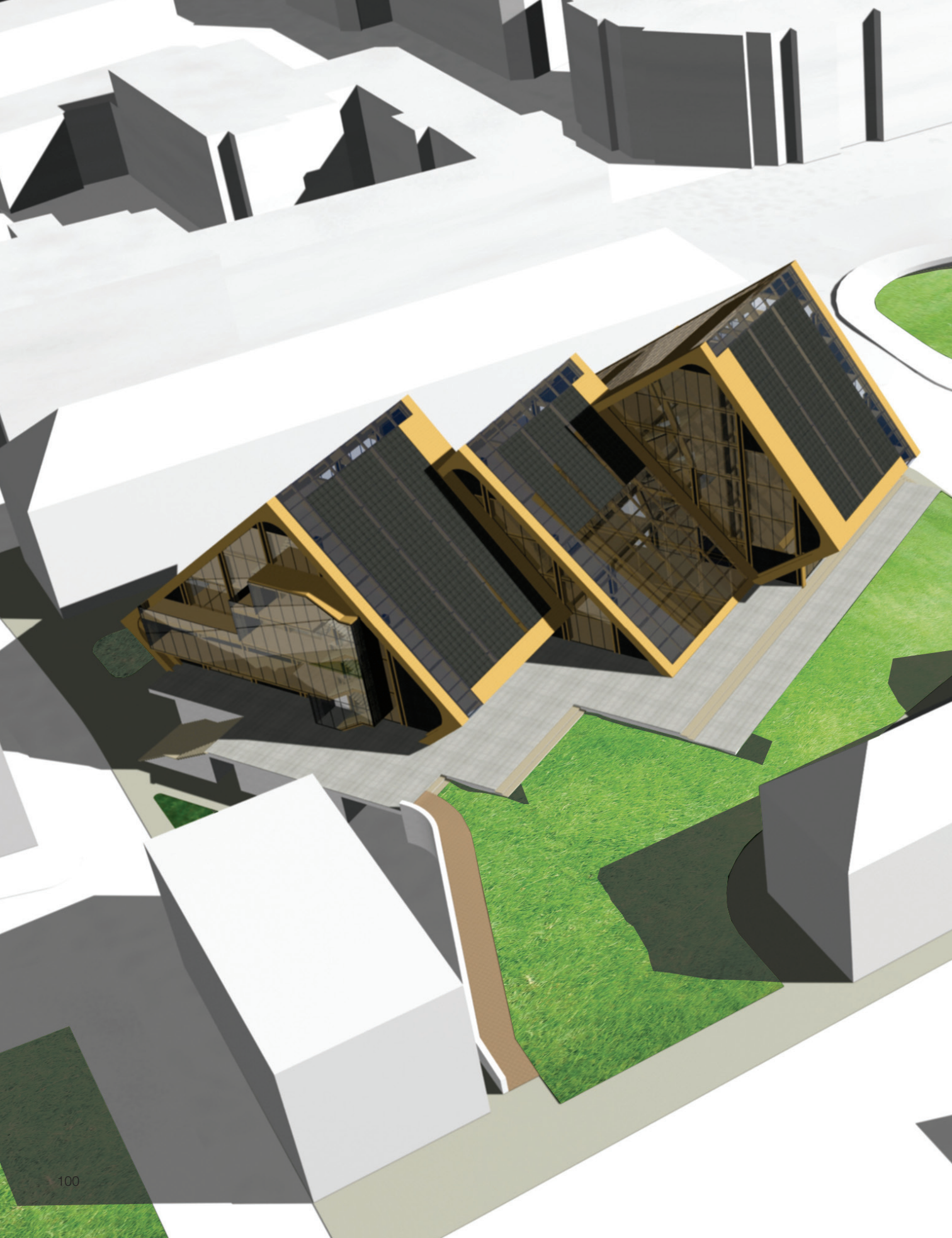


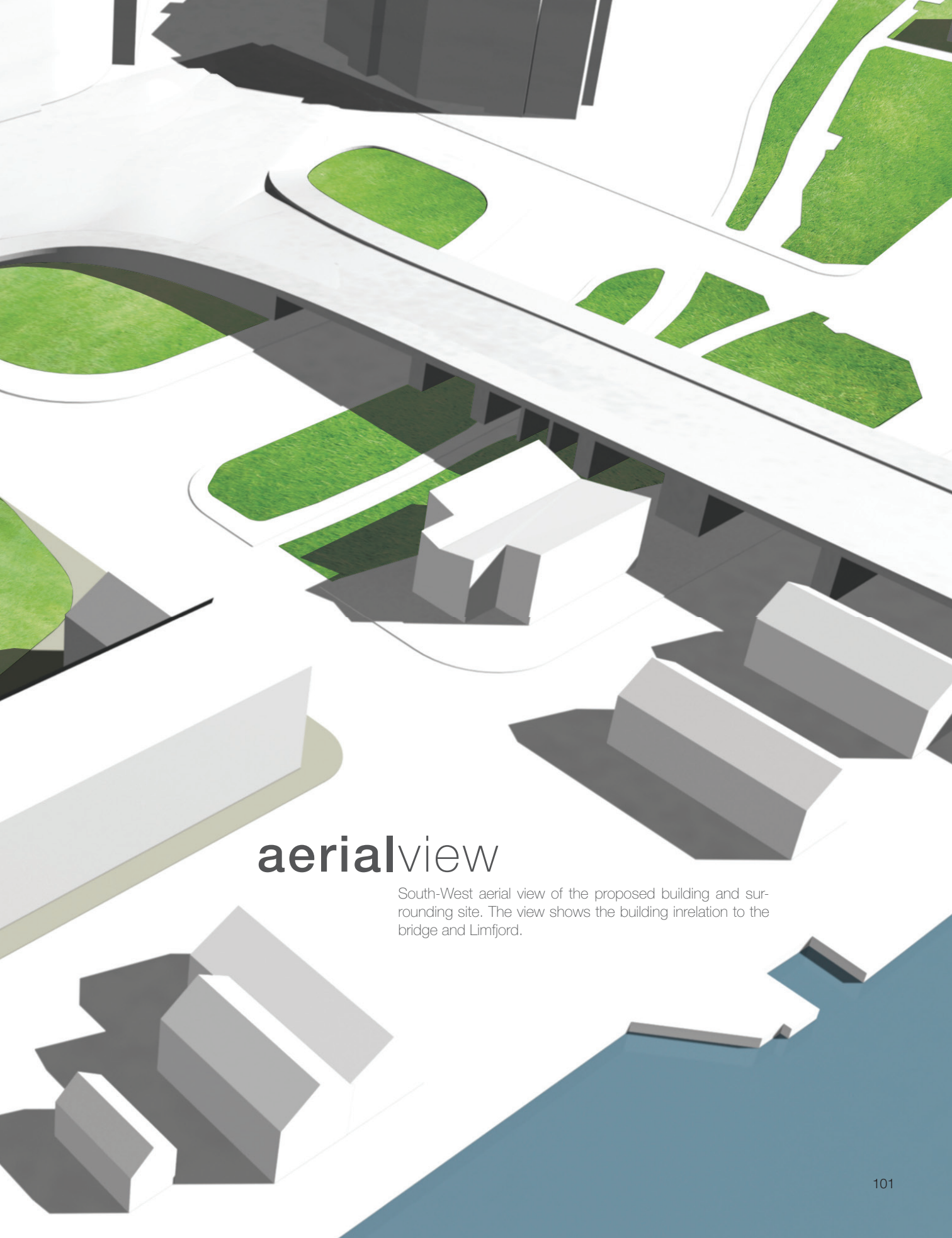
# atrium

# **evening**view

The evening view showing the interplay of mass and void on the south facade of the building. The builidng changes its character when the source of light is inside the building unlike daytime.







# **aerial**view

South-West aerial view of the proposed building and surrounding site. The view shows the building inrelation to the bridge and Limfjord.

# **con**clusion

The main idea behind the project is to design apublic space with the realm of human experiences. The concept behind the project is Tectonic architecture in the sense of structure and materials and sustainable architecture.

The basic principle behind the project is that an architecture is the not the design of buildings but that of spaces created by the buildings. The statement doesn't devalue the importance of bulding but emphasize on the true reason of its existence, which is the creation of space.

The first step of the project was the selection of the site. Since the vision of the project is to creat a public space, it is very necessary to choose a site which has a high public flow. Hence a 3000 $m^2$ plot on the cross section of different major routes in Nørresundby is chosen for the project. The site also enjoys unrestricted views from the bridge and different other places.

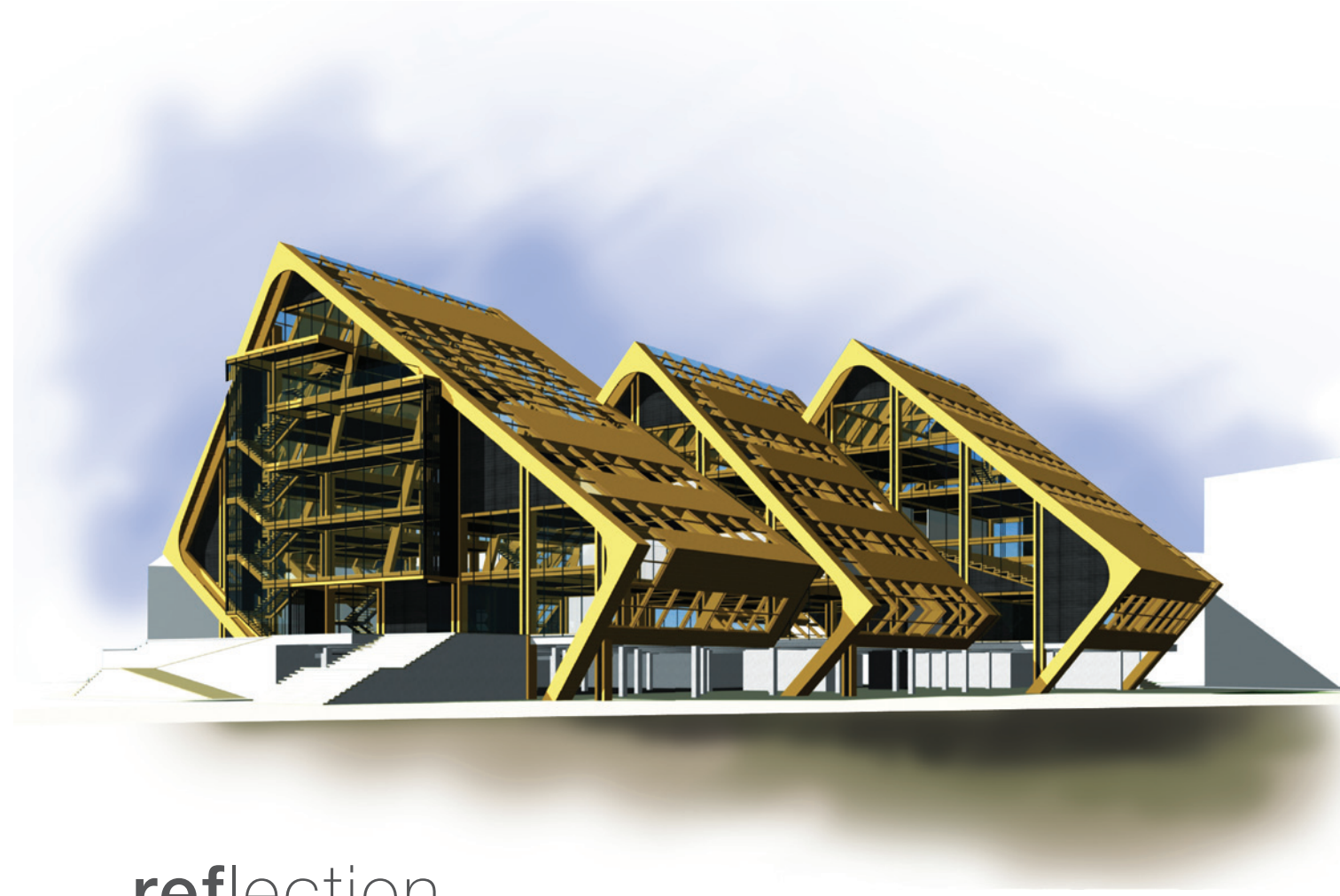
The vision of the project is to create a self sustaining public space where people can learn, interact and relax. Hence the building comprises of library space for learning, galleries and auditorium for interacting and restauant and green space for relaxing.

As it is a pubic building, its first job is to bring the public in, which means the building should be welcoming in nature. This has been tried to achieve by its orientation, form development and material selection.

The idea behind the form was to represent and interprete functions. To represent the three funcitons of the project, the building form is divided into 3 building blocks. Another major factor in the building is light. A good design should be able to address the local lighting condition to facilitate the functions it inhabits. Hence, the building form is rotated to make maximum facade face north and south. The program of the project demands north light for the reading purposes in library and south light for relaxing in restaurant. The south face is also used for solar panels, which is an ideal location for them.

Another influencing factor in design is the site. It is centrally located but tilts 30° to norh-south axis. Hence to aligned to the axis, the blocks are rotated 30°. This gives the benefits of aligning the facades to north and south lights. Further, the builidng blocks are elevated one floor up and the ground floor now hosts the parking. Along with solving parkng issue, this also provide a much needed height to the restaurant areas and a platform to the building. The people sitting on the restaurant can now enjoy the view of Limfjord and Aalborg city. The parking space on the ground floor is closed with green landscape on the south. This space is idealy placed for enjoy the summer as it faces south but is clearly hidden from south-west wind by the surrounding buildings.

The design become an icon, a sculpture which people can and see and appriciate while passing by. It contains different kinds of space intelligently placed and linked to maximize the human interaction. The spaces in and out of the building provide different kinds of human experiences which was one the basic vision of the building.Thus, the motivation for this project is to create the building as a journey from seeing to discovering to finally experiencing the spaces.



# **ref**lection

The most important aspect behaind this thesis project is to learn something at the end of the process. When I started the project, there were some ideas I would like to contemplate during the project development. Some of the ideas pondered during the design process were, Tectonic Architecture, Nordic Architecture, Integrated Design Process and Structural system.

## Tectonic Architecture

One of the first issue, I have tried to address in the project is Tectonic Design Process. The term was little unfamiliar to me as I didn't have much idea about the it before I started my master, here in Aalborg University. In our first semester of Master cousre, I got chance to learn a good deal about it. Hence in order to consolidte the idea further, I decided to work on the topic for my master thesis. If we ask five different people about Tectonic Architecture, then there is a possibility that we might get five different answer. This is because, the idea of Tectonic Architecture is very broad and it is very difficult to incoporate all in one. For me, tectonic architecture is a design of space where it's structure is honest to its requirements. The building, form, material and construction technology, all should comply together to create a sensible space.

## Nordic Architecture

Another design idea for the project was Nordic Architecture. Since the project site is located in Aalborg, Denmark, it is very obvious to have an understanding about Nordic Architecture as site consideration is very important factor in design process. Nordic Architecture is highly influnced by nordic light which is low and soft in nature. The whole effort behind the Nordic Architecture is the effective use of natural light inside a building space. In this project, the building form, orientation is directly guided by the use of light. Another important factor in Nordic Architecture is the use of material. The use Glulam as a prime material is a result of its light construction and warm welcoming nature.

## Integrated Design Process

One of the major outcome of this master course is Integrated Design Process. The idea behind IDP is to link different process in a loop so that each process can provide an effective contribution. During the process, IDP was specially applied between structural and architectural aspect. Instead of designing a form and looking for a structural solution, IDP helps structural consideration directly affect the design it the sketching phase. From the beginning one has a very good idea of material and construction system.

Hence, this thesis project has been a great learning experience for my architectural career and I look forward to implement them in future.

# **app**endix

# **bib**liography

## websites:


[WEB 1]: http://www.weather.com 2012
[WEB 2] : www.solarserver.de 2006
[WEB 3] : http://fr.wikipedia.org/wiki/M%C3%A9diath%C3%A8que 2012
[WEB 4] : http://www.designboom.com/eng/interview/ando.html 2012
[WEB 5] : http://www.centrepompidou.fr/pompidou/Communication.nsf/0/B90DF3E7C7F18CAEC1256D970053FA6D?OpenDocument&sessionM=3.1.12&L=2 2012
[WEB 6] : http://blog.aia.org/favorites/2007/02/108_seattle_public_library_200.html 2012
[WEB 7] : http://www.libraryjournal.com/article/CA633326.html 2012
[WEB 8] : http://www.nytimes.com/2008/01/26/business/26prep.html?pagewanted=all 2012
[WEB 9] : http://www.exeter.edu/documents/Exeter_Bulletin/spring_04/Kahn.pdf 2012
[WEB 10]: http://ogma.newcastle.edu.au:8080/vital/access/services/Download/uon:950/SOURCE1?view=true 2012
[WEB 11]: www.denstoredanske.dk/Kunst_og_kultur/Arkitektur/Europa/Stilretninger_og_perioder_i_kunsten/Funktionalisme 2012
[WEB 12]: http://www.apawood.org/pdfs/download_pdf.cfm?PDFFilename=managed/X440.pdf
[WEB 13]: http://www.timberengineeringeurope.com/glu_bea.html
[WEB 14]: http://w3.gazi.edu.tr/web/akurt/ders/mak204/prop_eng_materials.pdf
[WEB 15]: http://www.aitc-glulam.org/glulam.asp
[WEB 16]: http://www.aitc-glulam.org/shopcart/index.asp (Design Standards - Typical Construction Details)


## literature:


[Lynch, 1960] The images of the city, The MIT Press, Massachusetts.
[Knudstrup, 2004]
[Robert, 2005] Louis I. Kahn, Phaidon Press, London.
[Brownlee, 1991] Louis I. Kahn: In the Realm of Architecture, Rizzoli International Publications, New York.
[Lund, 2008] Nordisk Arkitektur, 3rd Edition, Arkitektens Forlag.
[Tonkin, 2008] Sustainable Medium Density Housing - A Resource Book, Development Action Group.
[Jacobs, 1961] The Death and Life of Great American Cities. New York: Random House. February 1993.
[De Jonge, 1967-68] Applied psychology.
[Ærø, 2002 ]Boligpræferencer, boligvalg og livsstil, Book Partner.
[Jacobson, 2009] Design Guidelines for Sustainable Housing, Yonsei University.
[ISOVER 2010] Isover, Komforthusene, 1. Udg, 2010


## lectures:


[ZEB 2011]
[AT&M 10] : Architectural Theory and Methods 10, 20th September 2010, Nils-Ole Lund
[Study guide 2011]: Study guide 2011
[PETES 2011]
[Hansen 2010] : Hansen, Hanne Tine Ring, ArCID3 2010

# appendix**acoustics**

## calculations of difference in SPL

The drop of the SPL, sound pressure level, can be calculated by:

$$L_{pe,m}=10\log_{10}((1/4*\pi*r^2)+((4-(1-\alpha)/A)$$

r is the distance to the speaker in meters
α is the average absorption coefficient,
in the auditorium α =0.17
A is the average absorption area,
in the auditorium A= 266.38

Situation A, seating closest to the speaker:
r= 3.5 m
Sound pressure drop, $L_{pe,\ 2}$

$$L_{pe,\ 3.5}= 10\log_{10}((1/4*\pi*3.5^2)+((4-(1-0.17)/58.28)$$

$$L_{pe,\ 3.5}=-11.34\ dB$$

Situation B, seating most far away from the speaker:
r= 11.5 m
Sound pressure drop, $L_{pe,\ 8,3}$

$$L_{pe,\ 11.5}= 10\log_{10}((1/4*\pi*11.5^2)+((4-(1-0.17)/58.28)$$

$$L_{pe,\ 11.5}=-20.33\ dB$$

Difference between situation A and B:

$$L_{pe,\ 2\text{-}8,3}=8.99\ dB$$

## calculations of ITDG

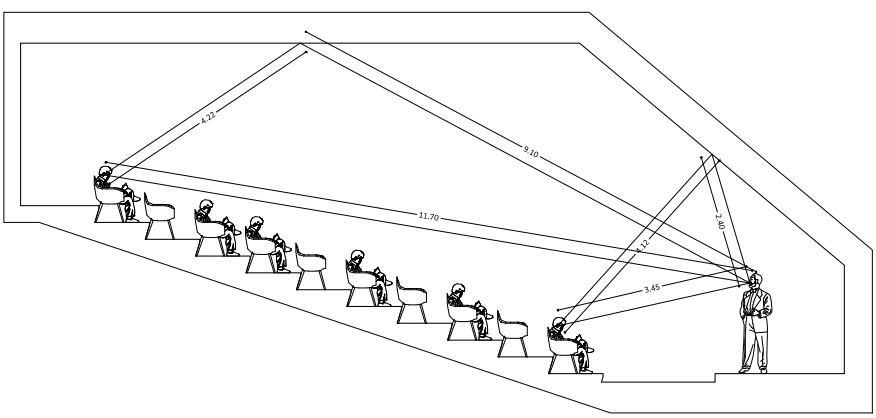
The ITDG, initial-time-delay gab is calculated for a person in the front row and a person in the back row.
Both ITDGs has to be lower than 17 meter, to prevent echoes.

ITDG, front row:

| | | |
|---|---|---|
| Distance in direct sound source: | | 3.45 m |
| Distance in in the reflected sound source: | | 6.52 m |
| Difference : (6.52 - 3.45)m | = | 3.07 m |

ITDG, back row:

| | | |
|---|---|---|
| Distance in direct sound source: | | 11.7 m |
| Distance in the reflected sound source: | | 13.32 m |
| Difference : (13.32 - 11.7)m | = | 1.62 m |



# reverberation time calculation

| **Volume ($m^3$)** | 993.98 | | **Frequency (Hz)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 125 | | 250 | | 500 | | 1000 | | 2000 | | 4000 | |
| **Surfaces** | **Area $S_1$ ($m^2$)** | **Material** | **$\alpha_I$** | **$A_I=\alpha*S$** | **$\alpha_I$** | **$A_I=\alpha*S$** | **$\alpha_I$** | **$A_I=\alpha*S$** | **$\alpha_I$** | **$A_I=\alpha*S$** | **$\alpha_I$** | **$A_I=\alpha*S$** | **$\alpha_I$** | **$A_I=\alpha*S$** |
| North Wall | 29.41 | Wood | 0.15 | 4.41 | 0.11 | 3.24 | 0.1 | 2.94 | 0.07 | 2.06 | 0.06 | 1.76 | 0.07 | 2.06 |
| South Wall | 44.08 | Wood | 0.15 | 6.61 | 0.11 | 4.85 | 0.1 | 4.41 | 0.07 | 3.09 | 0.06 | 2.64 | 0.07 | 3.09 |
| East Wall | 61.45 | Glass | 0.1 | 6.15 | 0.07 | 4.3 | 0.05 | 3.07 | 0.05 | 3.07 | 0.02 | 1.23 | 0.02 | 1.23 |
| West Wall | 61.45 | Glass | 0.1 | 6.15 | 0.07 | 4.3 | 0.05 | 3.07 | 0.05 | 3.07 | 0.02 | 1.23 | 0.02 | 1.23 |
| Floor | 287.29 | Wood | 0.15 | 43.09 | 0.11 | 31.6 | 0.1 | 28.73 | 0.07 | 20.11 | 0.06 | 17.24 | 0.07 | 20.11 |
| Ceiling | 245.48 | Absorbing Ceiling Quattro 50 | 0.25 | 61.37 | 0.65 | 159.56 | 1 | 245.48 | 0.95 | 233.21 | 0.65 | 159.56 | 0.65 | 159.56 |
| 1 Door | 3.3 | Wood | 0.15 | 0.5 | 0.11 | 0.36 | 0.1 | 0.33 | 0.07 | 0.23 | 0.06 | 0.2 | 0.07 | 0.23 |
| Chairs | 140 | Wood with person | 0.15 | 21 | 0.3 | 42 | 0.44 | 61.6 | 0.45 | 63 | 0.46 | 64.4 | 0.46 | 64.4 |
| Chairs | 140 | Wood without person | 0.01 | 1.4 | 0.01 | 1.4 | 0.01 | 1.4 | 0.02 | 2.8 | 0.04 | 5.6 | 0.05 | 7 |
| Total absorption | | **A** | | 150.68 | | 251.61 | | 351.03 | | 330.64 | | 253.86 | | 258.91 |
| Reverberation Time | | **T = 0.16 * V/A** (sec) | | 1.06 | | 0.63 | | 0.45 | | 0.48 | | 0.63 | | 0.61 |
| Average Reverberation Time | | **$T_{average}$** (sec) | | | | | | 0.64 | | | | | | |

[BT&AD 3][WEB 15]

# appendix**structure**

## loads:

The different forces acting on the structure are defined inorder to determined the load combinations for the structure:

Self weight ($G_{self\ weight}$)
Soil pressure ($G_{soil}$)
Service load ($q_{service}$)
Wind load ($q_{wind}$)
Snow load ($q_{snow}$)

Service, wind and snow load are all variable loads, while self weight and soil pressure are permanent loads.

### self weight:

The self weight is calculated by considering different materials in the structure, and there after adding all those weights.

$$G_{self\ weight} = \sum_{i \geq 1} (\gamma_i \cdot t_i)$$

$\gamma$ density of the material
t thickness of the material

The self weight in this project is partly calculated by Robot and partly by hand.

### soil pressure:

Since the building has soil cover on one side of the structure, it is important to take into considerations the pressure from the soil on the outer walls, where it is necessary.

Weight of the water can be put to 10 kN/m$^3$
Weight of the soil can also be put to 10 kN/m$^3$
The total weight of the saturated soil is therefore 20 kN/m$^3$

However the effort of the soil is not the same vertical as horizontal, and there for it has to be multiplied with coefficient $K_o = 0.5$.

The horizontal effort of the saturated soil is:

$$10\ kN/m^3 + 0.5 \cdot 10\ kN/m^3 = 15\ kN/m^3$$

### service load:

The service load is determined by the type of the use of the building. The service load is not required for the roof but is calculated for floors.

Since this is a public building, large crowd is expected hence category C1 is choosen, and by looking it up in a table, the service load can be determined. *[Eurocode 1-1, table 6.1 + 6.2 p. 21 and 22]*

$$q_{service} = 3\ kN/m^2$$

### wind load:

The load from wind pressure can be determined as:

$$q_{wind} = q_{p(ze)} \cdot c_p \quad \textit{[Eurocode 1-4, p. 24]}$$

$q_{p(ze)}$ peak velocity pressure (at the height of ze)
$c_p$ pressure coefficient (for the given form)

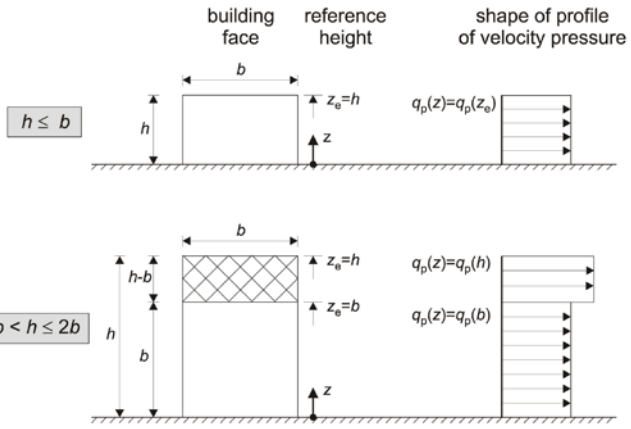
peak velocity pressure:

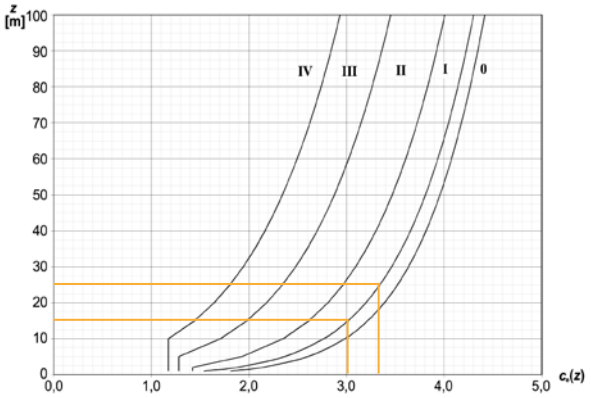
Because the building height is lower than the width in one side and higher on other side . Hence, the pressure is different on different side.

The peak velocity pressure is determined as:

$$q_{p(ze)} = c_{e(z)} \cdot q_b \quad \textit{[Eurocode 1-4, p. 35]}$$

$c_{e(z)}$ exposure coefficient
$q_b$ basic velocity pressure



exposure coefficient:

The exposure coefficient can be defined by reading a figure. It depends on the type of terrain and height of the building.

For the project the terrain is flat, so $C_o(z) = 1$ and the exposure factor is derived from following figure. *[Eurocode 1-4, p. 23 figure 4.2]*

For wind coming from east and west:

h = 25 m > b (depth) = 15 m

Upto 15m, $z_e$ = 15 m, $Ce(z)_{e\text{-}w\text{-}15} = 3.01$

Above 15 m, $z_e$ = 25 m, $Ce(z)_{e\text{-}w\text{-}25} = 3.34$

For wind coming from north and south:

h = 25 m < b (depth) = 40 m

$Ce(z)_{n\text{-}s} = 3.34$

basic velocity pressure:

The basic velocity pressure is determent as:

$$q_b = 0.5 \cdot \rho \cdot v_b^2$$

$\rho$ = air density, and
recommended value 1.25 kg/m$^3$

$v_b$ = basic wind velocity,
recommended value 24 m/s

The basic velocity pressure can thereby be calculated:

$q_b$ = 0,5 · 1.25 kg/m$^3$ · 24 m/s
= 360 Pa
= 0.36 kN/m$^2$

Hereby the peak velocity pressure can be calculated:

For wind coming from east and west:

Upto 15m, $z_e$ = 15 m,

$q_{p(ze)e\text{-}w\text{-}15}$ = 3.01 · 0.36 kN/m$^2$
= 1.0836 kN/m$^2$

Above 15 m, $z_e$ = 25 m,

$q_{p(ze)e\text{-}w\text{-}25}$ = 3.34 · 0.36 kN/m$^2$
= 1.2024 kN/m$^2$

For wind coming from north and south:

$q_{p(ze)}$ = 3.34 · 0.36 kN/m$^2$
= 1.2024 kN/m$^2$

pressure coefficient:

The pressure coefficient depends on the shape and orientation of the building, and also in which part of the building the structure is.

To simplify the wind loads, it is decided to calculate as if the building have a flat roof, and to only have one pressure coefficient on each of the walls, and on the roof.

Wind pressure on the walls:

$C_{pe,10}$: is used for the design of the overall load bearing structure of buildings *[Eurocode 1-4, p. 37]*

Because reading the table, the ratio between height and depth has to be calculated.

h height of the building
d depth of the building

For wind coming from east and west:

h/d = 25/15 = 1.67

For wind coming from north and south:

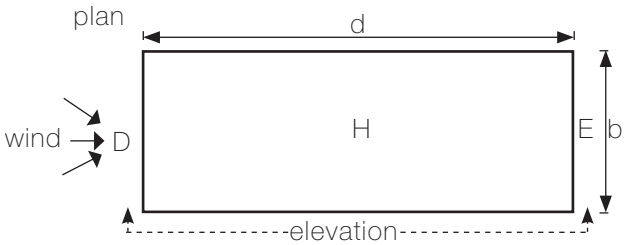
h/d = 25/40 = 0.625

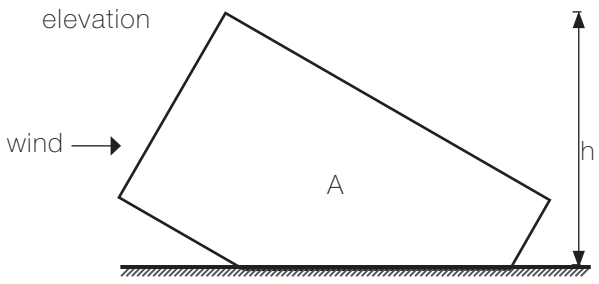
| Zone | A | | B | | C | | D | | E | |
|---|---|---|---|---|---|---|---|---|---|---|
| *h/d* | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ |
| 5 | -1,2 | -1,4 | -0,8 | -1,1 | -0,5 | | +0,8 | +1,0 | -0,7 | |
| 1 | -1,2 | -1,4 | -0,8 | -1,1 | -0,5 | | +0,8 | +1,0 | -0,5 | |
| ≤ 0,25 | -1,2 | -1,4 | -0,8 | -1,1 | -0,5 | | +0,7 | +1,0 | -0,3 | |

wind pressure on the roof:

Beccause there are no railing on the walls, roof type selected is sharp eaves.

| Roof type | | Zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | F | | G | | H | | I | |
| | | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ |
| Sharp eaves | | -1,8 | -2,5 | -1,2 | -2,0 | -0,7 | -1,2 | +0,2 | |
| | | | | | | | | -0,2 | |
| With Parapets | $h_p/h$=0,025 | -1,6 | -2,2 | -1,1 | -1,8 | -0,7 | -1,2 | +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 | |
| | $h_p/h$=0,10 | -1,2 | -1,8 | -0,8 | -1,4 | -0,7 | -1,2 | +0,2 | |
| | | | | | | | | -0,2 | |



## snow load:

For persistent and transient design situation, the snow load can be defined as:

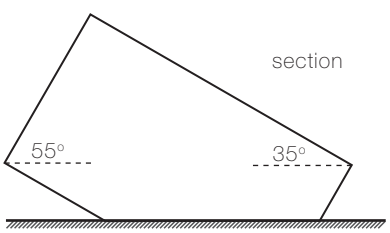
$$q_{snow} = \mu_i \cdot C_e \cdot C_t \cdot S_k \quad \textit{[Eurocode 1-3, p. 19]}$$

$\mu_i$ snow load shape coefficient.
$C_e$ exposure coefficient
$C_t$ thermal coefficient
$S_k$ characteristic value of snow load on the ground

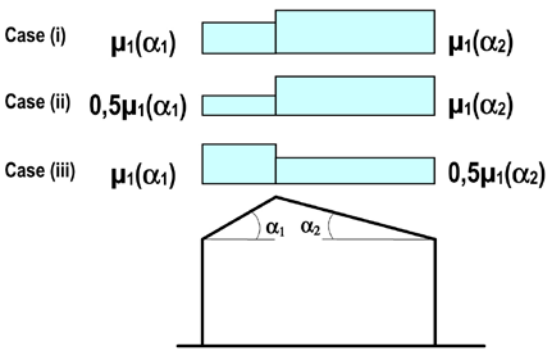
### shape coefficient:

The shape coefficient depends on the shape and angle of the roof. For the pitched roof the values can be calculated from the tables. *[Eurocode 1-3, p. 22-23, table 5.2 - 5.3]*

| Angle of pitch of roof $\alpha$ | $0° \le \alpha \le 30°$ | $30° < \alpha < 60°$ | $\alpha \ge 60°$ |
|---|---|---|---|
| $\mu_1$ | 0,8 | $0,8(60 - \alpha)/30$ | 0,0 |
| $\mu_2$ | $0,8 + 0,8\,\alpha/30$ | 1,6 | -- |




$\mu_i$ $= 0.8 \cdot (60-55)/30 = 0.13$
$\mu_i$ $= 0.8 \cdot (60-35)/30 = 0.67$




Case I, is selected, as the load arrangement is undrifted.

### exposure coefficient:

The exposure coefficient depends on the topography around the building. In this project the topography is chosen to be normal, where there is no significant removal of snow.

$C_e = 1$ *[Eurocode 1-3, p. 20, table 5.1]*

### thermal coefficient:

The thermal coefficient is always set to 1, except for roofs with high thermal transmission especially for some glass cover roofs etc, where the coefficient is reduced because of melting.

$C_t = 1$ *[Eurocode 1-3, p. 20]*

### characteristic value of snow load on the ground:

The characteristic value of the snow load on the ground is given in the national annex of Denmark, and is the same for all situations.

$S_k = 0.9\ kN/m^2$ *[Eurocode 1-3 DK NA, page 4]*

The snow load can thereby be calculated:

$q_{snow} = 0.13 \cdot 1 \cdot 1 \cdot 0.9\ kN/m^2 = 0.117\ kN/m^2$
$q_{snow} = 0.67 \cdot 1 \cdot 1 \cdot 0.9\ kN/m^2 = 0.603\ kN/m^2$

# loads combinations:

The demands for the safety and function of the construction are determined by the limit states. Limit states can be divided into service limit states and ultimate limit states.

Service limit states are the limit for what is acceptable in the use of the building. For instance how much deflecting there maximum can be in the floor.

Ultimate limit states are the limit for when there will be too much stress in the construction causing burst on the entire or part of the structure.

consequence class:

For both of the limit stats, it is important to define the consequence class. In this project the consequence class is medium, CC2. This class is for residential and office buildings where the consequences of failure are medium. *[Eurocode 0, p. 58, 59]*

Consequence class CC2: $K_{FI}=1$

*Ψ factors:*

Besides defining the consequence class one also have to define the Ψ – factor. The Ψ factors for the different loads are:

Service load: $\Psi_0 = 0.6$
Wind load: $\Psi_0 = 0.3$
Snow load: $\Psi_0 = 0.3$
($\Psi_0 = 0$ when the wind load is dominating)
*[Eurocode 0 DK NA, page 3]*

## service limit states:

The load combinations for the service limit are defined by the equation: *[Eurocode 0, p. 47, 6.14]*

6.14.a – Permanent loads as the dominating load:

$\sum_{i\geq 1} (K_{FI} \cdot 1.2^{\#} \cdot G_i)$
$^{\#}$ 1, if the load is from soil and water

6.14.b – with variable loads as the dominating load:

$\sum_{i>1} (K_F \cdot 1 \cdot G_i) + K_{FI} \cdot q_{dominating} + \sum_{i>1}(K_{FI} \cdot \Psi_{0,i} \cdot q_i)$
$^{*}$0.9, if the dominating variable load are favorable

The load combinations for service limit states can here by be defined:

Permanent loads as the dominating load
*[Teknisk Ståbi, p. 139]:*
6.14.a : $1 \cdot 1.2 \cdot G_{selfweight} + 1 \cdot 1 \cdot G_{soil}$

Service load as the dominating load:
6.14.b (1): $1 \cdot 1 \cdot G_{selfweight} + 1 \cdot 1 \cdot G_{soil} + q_{service} + 1 \cdot 0.3 \cdot q_{wind} + 1 \cdot 0.3 \cdot q_{snow}$

Wind load as the dominating load (Wind unfavorable):
6.14.b (2): $1 \cdot 1 \cdot G_{selfweight} + 1 \cdot 1 \cdot G_{soil} + q_{wind} + 1 \cdot 0,6 \cdot q_{service}$

Wind load as the dominating load(Wind favorable):
6.14.b (3): $1 \cdot 0,9 \cdot G_{selfweight} + 1 \cdot 1 \cdot G_{soil} + q_{wind} + 1 \cdot 0.6 \cdot q_{service}$

Snow load as the dominating load:
6.14.b (4): $1 \cdot 1 \cdot G_{selfweight} + 1 \cdot 1 \cdot G_{soil} + q_{snow} + 1 \cdot 0,6 \cdot q_{service} + 1 \cdot 0.3 \cdot q_{wind}$

## ultimate limit states:

The load combinations for the service limit are defined by the equation:

6.10.a – Permanent loads as the dominating load:
*[Teknis Ståbi, page 139]*

$\sum_{i\geq 1} (K_{FI} \cdot 1.2^{\#} \cdot Gi)$
$^{\#}$ 1, if the load is from soil and water

6.10.b – with variable loads as the dominating load:

$\sum_{i>1} (K_{FI} \cdot 1^{*} \cdot G_i) + K_{FI} \cdot 1,5 \cdot q_{dominating} + \sum_{i>1}(K_{FI} \cdot 1.5^{*} \cdot \Psi_{0,i} \cdot q_i)$
$^{*}$0.9, if the dominating variable load are favorable

The load combinations for ultimate limit states can here by be defined:

Permanent loads as the dominating load:
6.10.a : $1 \cdot 1.2 \cdot G_{self\ weight} + 1 \cdot 1 \cdot G_{soil}$

Service load as the dominating load:
6.10.b (1): $1 \cdot 1 \cdot G_{self\ weight} + 1 \cdot 1 \cdot G_{soil} + 1 \cdot 1.5 \cdot q_{service} + 1 \cdot 1.5 \cdot 0.3 \cdot q_{wind} + 1 \cdot 1.5 \cdot 0.3 \cdot q_{snow}$

Wind load as the dominating load (wind unfavorable):
6.10.b (2): $1 \cdot 1 \cdot G_{self\ weight} + 1 \cdot 1 \cdot G_{soil} + 1 \cdot 1.5 \cdot q_{wind} + 1 \cdot 1.5 \cdot 0.6 \cdot q_{service}$

Wind load as the dominating load (wind favorable):
6.10.b (3): $1 \cdot 0.9 \cdot G_{self\ weight} + 1 \cdot 1 \cdot G_{soil} + 1 \cdot 1.5 \cdot q_{wind} + 1 \cdot 1.5 \cdot 0.6 \cdot q_{service}$

Snow load as the dominating load:
6.10.b (4): $1 \cdot 1 \cdot G_{self\ weight} + 1 \cdot 1 \cdot G_{soil} + 1 \cdot 1.5 \cdot q_{snow} + 1 \cdot 1.5 \cdot 0.6 \cdot q_{service} + 1 \cdot 1.5 \cdot 0.3 \cdot q_{wind}$

# loads for robot:

## self load:

The self load is determined according to the different materials in the floor slabs on top of the beams. The beam itself is not included in the self load, Robot automatically calculates that. For this project there are two types of self load; on the floors and on the roof.

$G_{\text{self weight, roof, timber}} = 0.74$ kN/m
$G_{\text{self weight, roof, skylight}} = 0.4$ kN/m
$G_{\text{self weight, roof, solar cells}} = 0.75$ kN/m
$G_{\text{self weight, floor, timber}} = 0.76$ kN/m
$G_{\text{self weight, floor, concrete}} = 3.85$ kN/m

East-west section:
The distance between the beams is 5 m.

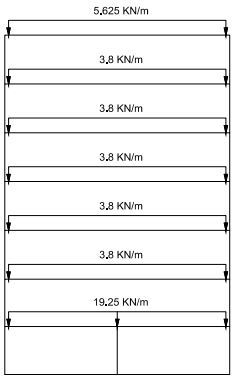
$G_{\text{self weight,e-w, roof, timber}} = 3.7$ kN/m
$G_{\text{self weight,e-w, floor, timber}} = 3.8$ kN/m
$G_{\text{self weight,e-w, floor, concrete}} = 19.25$ kN/m

North-south section:
The distance between the beams is 7.5 m.

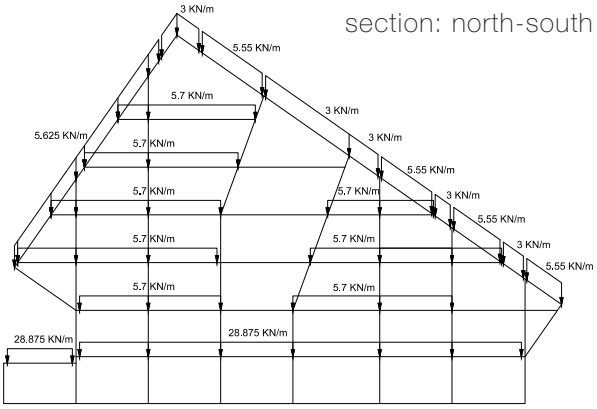
$G_{\text{self weight,n-s, roof, timber}} = 5.55$ kN/m
$G_{\text{self weight,n-s, roof, skylight}} = 3$ kN/m
$G_{\text{self weight,n-s, roof, solar cells}} = 5.625$kN/m
$G_{\text{self weight,n-s, floor, timber}} = 5.7$ kN/m
$G_{\text{self weight,n-s, floor, concrete}} = 28.875$ kN/m

To see the self load calculation, please look in the excel file on the cd.

section: east-west




section: north-south




## soil pressure, vertical

The horizontal effort of the saturated soil is:

$10\ \text{kN/m}^3 + 0.5 \cdot 10\ \text{kN/m}^3 = 15\ \text{kN/m}^3$

Because the soil is saturated by groundwater, the pressure on the wall will raise according to the depth.
Hereby the soil pressure can be calculated in the depth of z meters.

$G_{\text{soil, z m}} = 15\ \text{kN/m}^3 \cdot z\ \text{m}$

Soil pressure first floor level at 2.8 above ground:

$G_{\text{soil, 0 m}} = 15\ \text{kN/m}^3 \cdot 0\ \text{m} = 0\ \text{kN/m}^2$

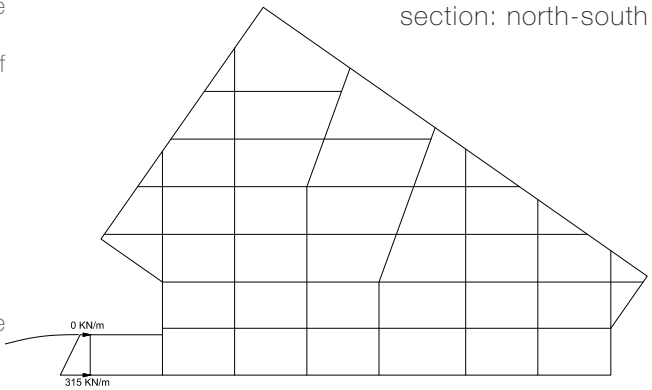
Soil pressure at ground level, where soil is 2.8m deep:

$G_{\text{soil, 2.8 m}} = 15\ \text{kN/m}^3 \cdot 2.8\ \text{m} = 42\ \text{kN/m}^2$

The soil pressure is only relevant for south face, where the structure is partly covered with soil.

The soil pressure is solved for 1 meter width, and the load should therefore be multiplied with the distance between the beams to get the final load.

section: north-south



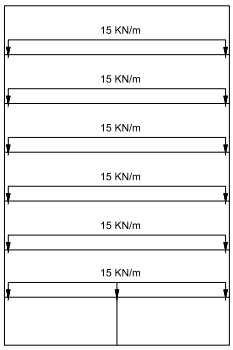
## service load:

The service load depends on the usage of the specific part of the building. In this case, the roof is not susceptible for service load but are the inner floors.

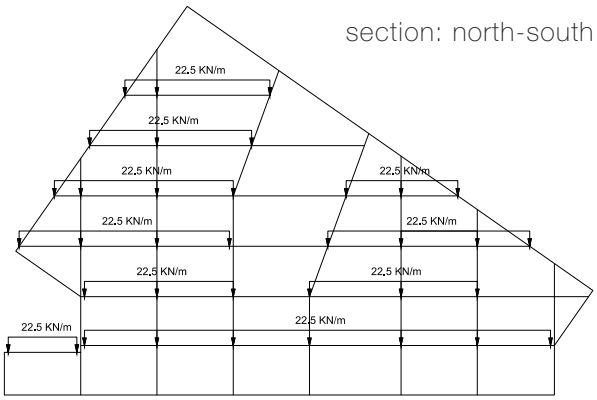
$q_{service} = 3\ kN/m^2$

The service load is calculated for 1 meter width, hence should be multiplied by the distance between the beams to get the final load.

section: east-west



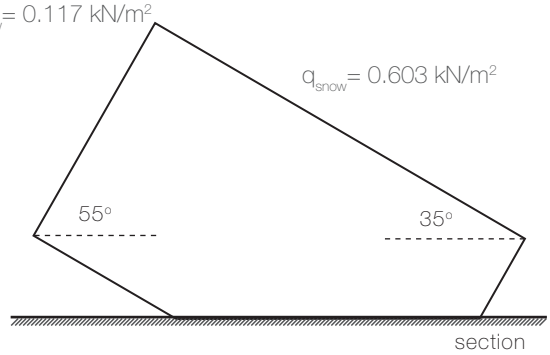

section: north-south




## snow load:

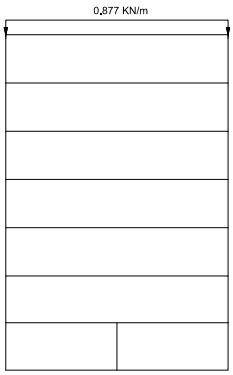
$q_{snow} = 0.117\ kN/m^2$

$q_{snow} = 0.603\ kN/m^2$

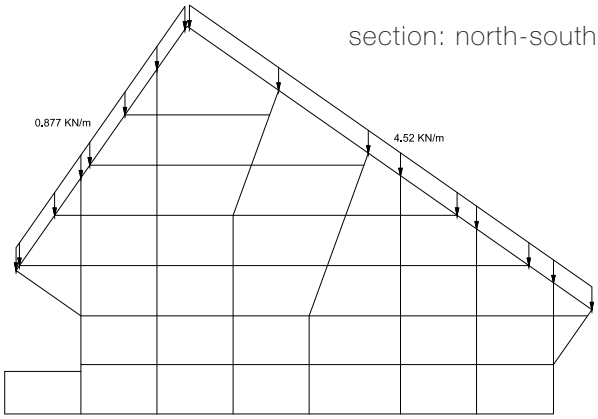



The snow load is calculated for 1 meter width, hence should be multiplied by the distance between the beams to get the final load.

section: east-west




section: north-south



## wind load:

$$q_{wind} = q_{p(ze)} \cdot c_p$$

To see the calculations of the peak velocity pressure, $q_{p(ze)}$, please check the paragraph about loads.

The pressure coefficient, $c_p$, depends on the shape, the orientation and which part od the building it is situated.

| Zone | A | | B | | C | | D | | E | |
|---|---|---|---|---|---|---|---|---|---|---|
| *h/d* | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ |
| 5 | -1,2 | -1,4 | -0,8 | -1,1 | -0,5 | | +0,8 | +1,0 | -0,7 | |
| 1 | -1,2 | -1,4 | -0,8 | -1,1 | -0,5 | | +0,8 | +1,0 | -0,5 | |
| ≤ 0,25 | -1,2 | -1,4 | -0,8 | -1,1 | -0,5 | | +0,7 | +1,0 | -0,3 | |

| Roof type | | Zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | F | | G | | H | | I | |
| | | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ | $c_{pe,10}$ | $c_{pe,1}$ |
| Sharp eaves | | -1,8 | -2,5 | -1,2 | -2,0 | -0,7 | -1,2 | +0,2 | |
| | | | | | | | | -0,2 | |
| With Parapets | $h_p/h$=0,025 | -1,6 | -2,2 | -1,1 | -1,8 | -0,7 | -1,2 | +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 | |
| | $h_p/h$=0,10 | -1,2 | -1,8 | -0,8 | -1,4 | -0,7 | -1,2 | +0,2 | |
| | | | | | | | | -0,2 | |

### wind from east and west:

When wind comes from east and west, h/d = 1.67

Upto 15 m,

$q_{wind,A} = (-1.2) \cdot 1.0836\ kN/m^2 = -1.3\ kN/m^2$
$q_{wind,D} = (0.8-(-0.5)) \cdot 1.0836 kN/m^2 = 1.408\ kN/m^2$
$q_{wind,E} = (-0.5) \cdot 1.0836 kN/m^2 = -0.542\ kN/m^2$
$q_{wind,H} = (-0.7) \cdot 1.0836\ kN/m^2 = -0.758\ kN/m^2$

Above 15 m,

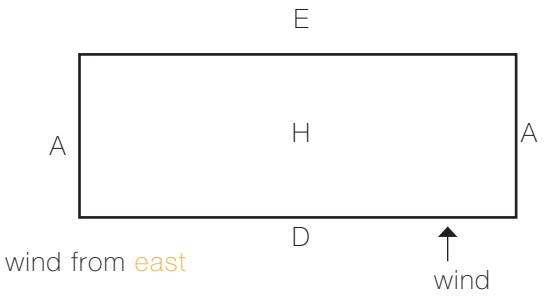
$q_{wind,A} = (-1.2) \cdot 1.2024\ kN/m^2 = -1.443\ kN/m^2$
$q_{wind,D} = (0.8-(-0.5)) \cdot 1.2024\ kN/m^2 = 1.56\ kN/m^2$
$q_{wind,E} = (-0.5) \cdot 1.2024\ kN/m^2 = -0.601\ kN/m^2$
$q_{wind,H} = (-0.7) \cdot 1.2024\ kN/m^2 = -0.842\ kN/m^2$

### wind from north and south:

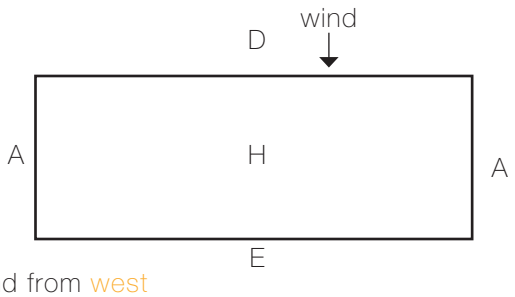
When wind comes from north and south, h/d = 0.625

$q_{wind,A} = (-1.2) \cdot 1.2024\ kN/m^2 = -1.443\ kN/m^2$
$q_{wind,D} = (0.8-(-0.5)) \cdot 1.2024\ kN/m^2 = 1.56\ kN/m^2$
$q_{wind,E} = (-0.3) \cdot 1.2024\ kN/m^2 = -0.361\ kN/m^2$
$q_{wind,H} = (-0.7) \cdot 1.2024\ kN/m^2 = -0.842\ kN/m^2$

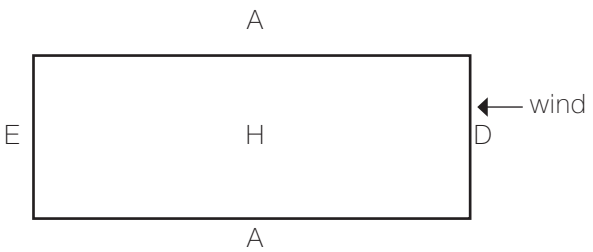
The wind load is calculated for 1 meter width, hence should be multiplied by the distance between the beams to get the final load.



wind from east



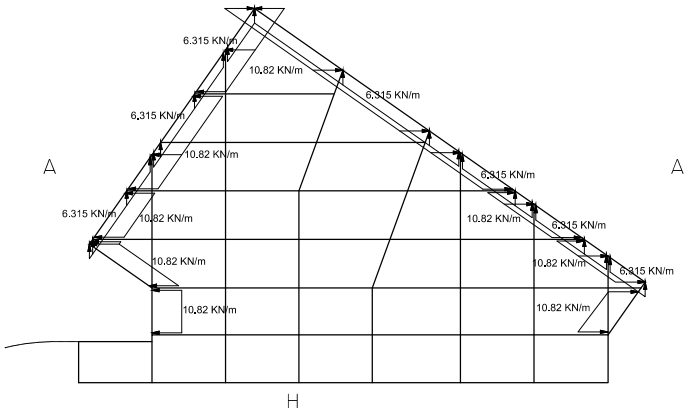
wind from west



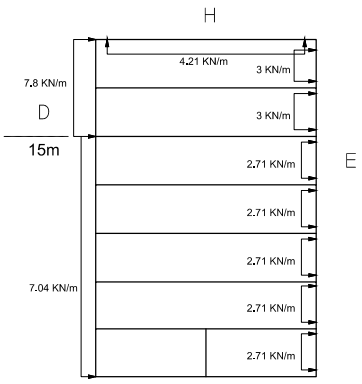
wind from north

wind from south

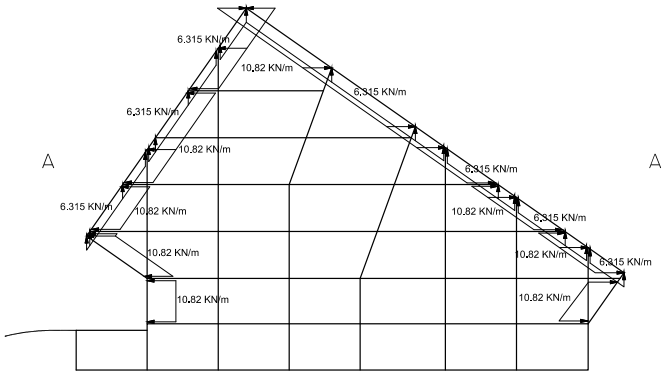
section: north-south

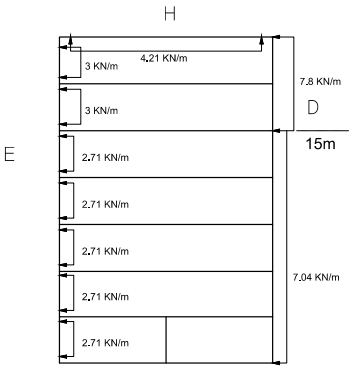



section: east-west

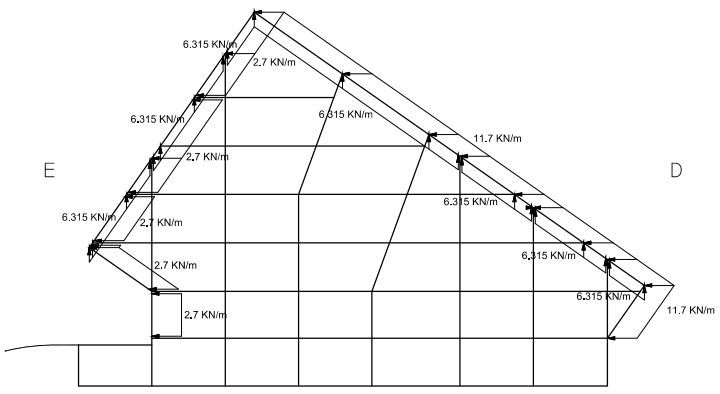


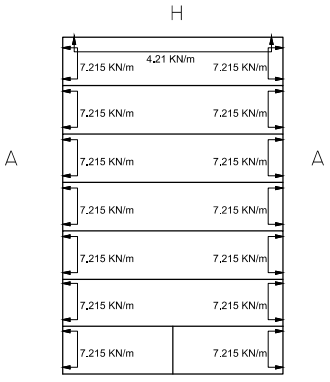

wind from east



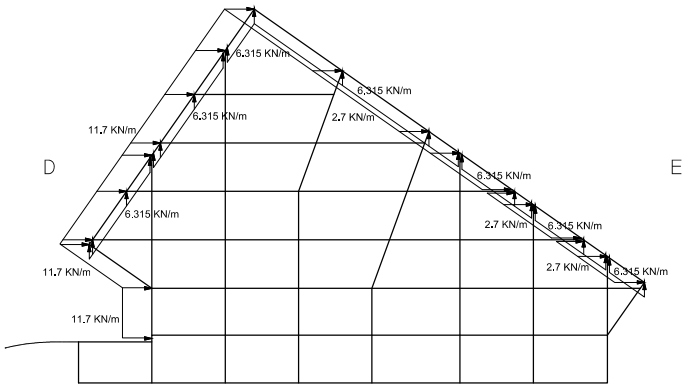



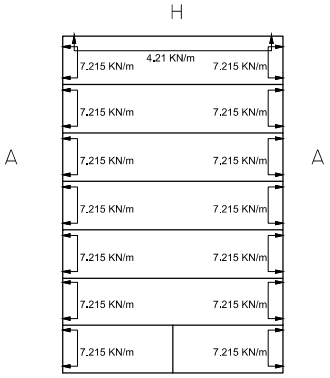

wind from west




wind from north




wind from south

# appendix**room program**

| | Area [Actual, m²] | Area [Minimum, m²] |
|---|---|---|
| Library | | |
| Lending Area | 200 m² | 225 m² |
| Children Section | | |
| Reading, Listening and Viewing Area | 150 m² | 160 m² |
| Adult Section | | |
| *Books* | | |
| Library Area | 200 m² | 205 m² |
| Reading Area | 400 m² | 450 m² |
| *CDs and DVDs* | | |
| Library Area | 400 m² | 450 m² |
| Vewing and Listening Area | 500 m² | 600 m² |
| Internet Area | 150 m² | 150 m² |
| Exhibition Gallery | | |
| Permant Display | 200 m² | 150 m² |
| Temporary Display | 200 m² | 300 m² |
| Recreational Area | | |
| Restaurant | 300 m² | 475 m² |
| Kitchen | 100 m² | 150 m² |
| Auditorium | 200 m² | 225 m² |
| Administrative Area | 50 m² | 65 m² |
| Meeting / Presentation Room | 30 m² | 25 m² |
| Reception | 15 m² | 30 m² |
| Wardrobe | 5 m² | 5 m² |
| Kiosk / Shop | 20 m² | 75 m² |
| Storage Space | 200 m² | 157 m² |
| Toilet | | |
| Staff | 7 m² | 30 m² |
| Guest | 15 m² | 40 m² |
| Parking | 150 m² | 1950 m² |

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