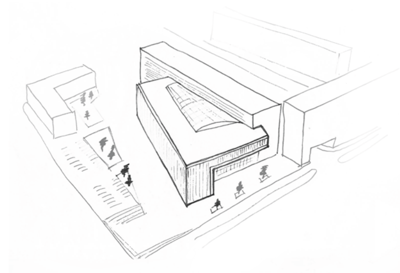
RESEARCH & DEVELOPMENT NANOCENTER



Aalborg University, Architecture & Design
MSc04 ARCH, Group 37, May 2016

ABSTRACT

This paper describes a design proposal for the new Research and Development Nanocenter in the West of Amsterdam, the Netherlands. The purpose of the building is to create synergy between science and business which would assist with development of products and commercialization of new inventions. Special focus was on collaboration areas where knowledge, skills and experience are exchanged. Location of the site has provided opportunities for access and logistics. The performed analysis has revealed challenges of the site and special requirements for the program, which have been addressed during the integrated design process, combining sustainable and tectonic aspects.

INTRODUCTION

This is a Master Thesis project is composed by Group 37, A&D (MSc04 ARC) at Aalborg University. The task of this project is to create a Research and Development Nanocenter in the urban setting of Amsterdam, the Netherlands. The objective of this report is to outline the proposal, its concept, process and analysis. The aim for the project is to design a center of workspaces for researchers, business employees and their inter-collaboration. The scope of work also includes regenerating the site by increasing sense of security, improving people's flows, integrating into the context of the area, meeting specific technical and safety demands. The goals for the quality of design are based on the combination of tectonic and sustainable parameters, as well as investigating for new theoretical aspects for this particular project.

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ABOUT R&D

Research and development is a form of collaboration between innovators and scientists coming from the industry and from the public institutions. Typically, Research stands for knowledge and Development stands for money. [Hill and Solt, 2010] R&D is a way to bring science and business together and to acquire funding for innovation.

NANOTECHNOLOGY

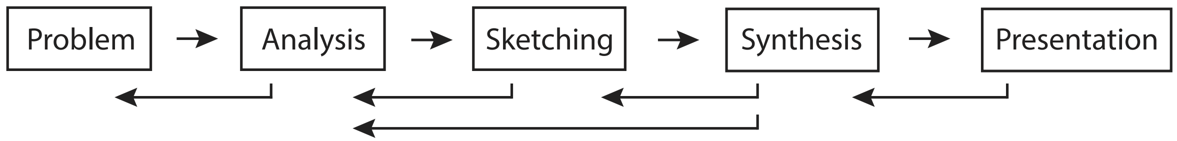
Nanotechnology is among leading and most innovative scientific research fields of XXI century. It has endless applications not only for today's needs but also for future demands and problems to solve. It is relatively new science, but yet it has a major role in sustainable technology development.

It is expected that nanotechnologies will be crucial principle in the next decade for creating sustainablehuman habitats. This includes new efficient light sources, advanced technologies for windows, photovoltaic systems and systems for optimization of energy consumption. [Diallo and Brinker, 2011]

Despite that, nanotechnology is a vital part of other fields such as efficient production of fuel, biochemistry, bioengineering, development of conductors, storage of electricity, medicine, security etc. [Nano.gov, 2016]

Since this type of technology is seemed to have broad perspectives, the decision was made to put a focus of Research and Development on nanotechnology.

METHODOLOGY



Ill. 01// The integrated design process

MAPPING

Mapping is a method to record and represent information about an area. Unlike tracing and conveying only physical data, such as terrain, mapping is a creative tool that collects also phenomenological and subjective parameters. Furthermore, it is not only for analyzing space but also activities and processes. With the use of cartography, the information is presented on maps in scale. As well as recording, the methods include processing, interpreting and evaluating gathered data. It helps to reveal opportunities. [Corner, 1999]

PERCEPTION OF THE AREA

This study is based on subjective measures described by Kevin Lynch in “The image of the city”. The methods described are to identify objects and phenomena in the area that help people drawing their mental maps which they use to orient themselves in the city. Those mental maps are formed by the following elements: paths, edges, nodes, districts and landmarks. This method was chosen as it can be clearly noticed that the site is located at the point where the grid of the city bends, therefore interpreted as an edge, and it became a point of interest to see what impact it has. [Lynch, 1960]

PROBLEM-BASED LEARNING

PBL is a learning method based on student’s own ability to learn. This is done via making projects by formulating the problem first and finding the solution afterwards. This theoretical learning approach is the closed to the practice. [en.aau.dk]

INTEGRATED DESIGN

Integrated design approach includes 5 design phases: problem, analysis, sketching, synthesis and presentation. The first one consists of creation of a vision which sets directions for the project. Afterwards the analysis phase is to understand the site and the area, and outline possibilities. The following is sketching where the important design parameters are set, forming design solutions. Then there is synthesis which includes detailing. The last one is presentation where documentation and visualization is prepared. It is however very important to go back and check all previous phases to verify if design solutions work and test other possibilities. [Knudstrup, 2005]

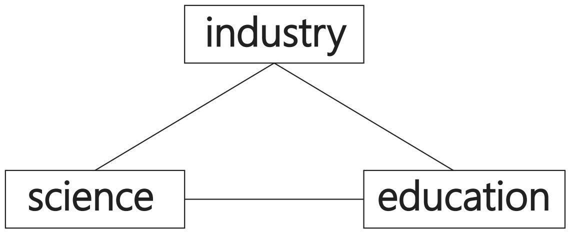
01
PRESENTATION

VISION

The vision of this project is to create a Research and Development Nanocenter where Science, Business and Education work together simultaneously complementing each other.

The aim is to create a place for collaboration between different fields by the use of combined approach with the focus on tectonics, sustainability, flexibility and quality performance.

PROBLEM FORMULATION



Ill. 02// Synergy scheme

INDUSTRY

It is often crucial for companies to carry out research in order to create and develop new products and technologies. Therefore, Research and Development is a major driving force in the economy. [Hernandez, 2013] However, research requires a lot of resources and is risky to invest to since the payback is not guaranteed. It is however a common practice that companies out-source their research to other organizations or universities.

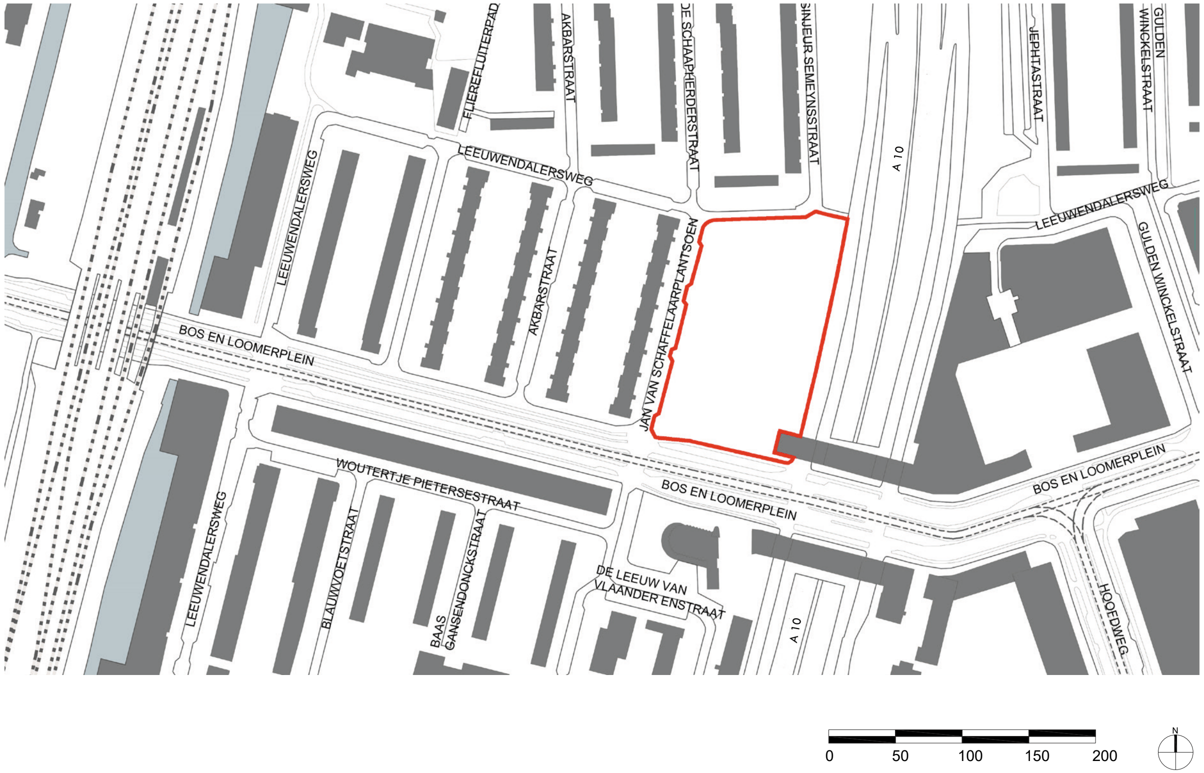
SCIENCE

Scientific research and innovations play a major role contributing to the wellness of the society. New technologies in various fields improve the quality of our lives, therefore our demands keep rising. This phenomenon creates the market and shapes problems. Nevertheless, science is expensive to fund. Creation of products and services, and their commercialization is a way to earn money and fund it. That's why it is important to create synergy between the business and science. [Tamulevicius, 2015]

EDUCATION

Higher education programs often rely on theories and lack practical approach. Employers prefer hiring experienced applicants, creating a challenge for recent graduates to find employment. Therefore it is important to create opportunities for students to gain experience in their field during their studies. [Ogunjimi, 2016]

INTRODUCTION TO THE SITE



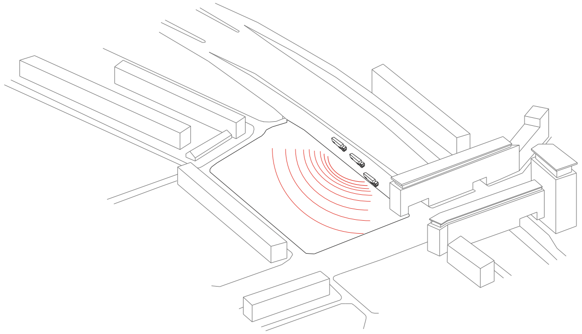
Ill. 03// Site location map

The site is a vacant plot of approximately 1,4 hectare at the high-density Bos en Lommer area in the West of Amsterdam, at the intersection of Bos en Lommerweg and Jan van Schaffelaar-plantsoen streets. The Eastern edge of the site is facing A10 ring road which surrounds the city. Bos en Lommerweg street is on the South side, which is also followed by a tram line. The De Vlugtlaan metro station is 300 meters away.

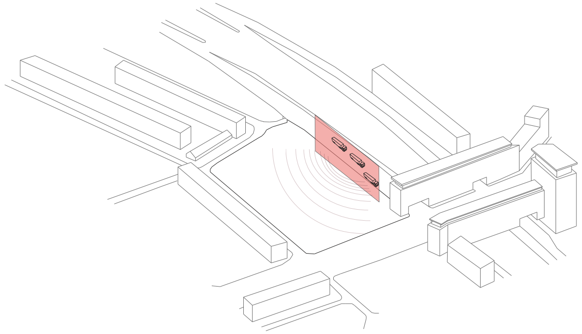
CONCEPT

A very significant character of the site is that it is located in the city of Amsterdam and adjacent to a motorway. The concept is mainly based on adressing critical site issues, flows and built context of the area.

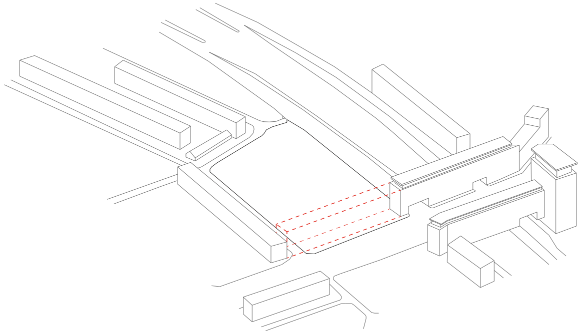
Having studied requirements for different purposes in similar cases, it has been decided to use the most strict form for reseach areas, more flexible form for office spaces and allow a great design freedom for the informal meeting areas.



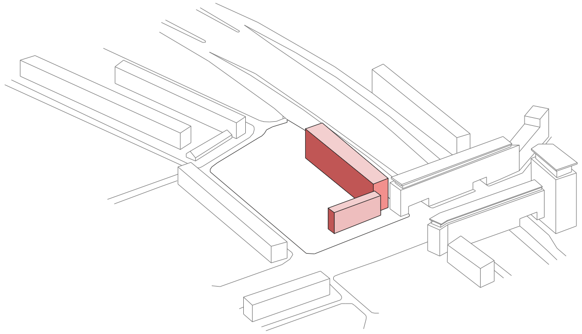
Ill. 04// Currently there is a lot of noise on site generated by the traffic in the motorway.



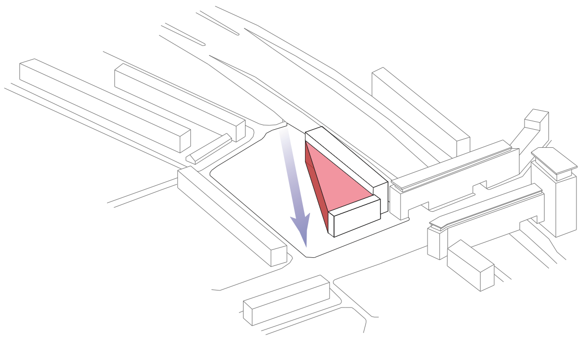
Ill. 05// A noise barrier has been proposed.



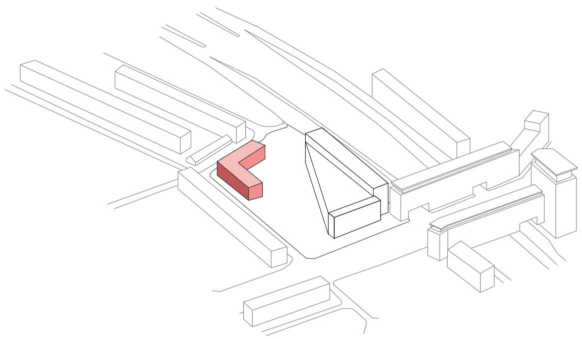
Ill. 06// Continuing the built line of the street.



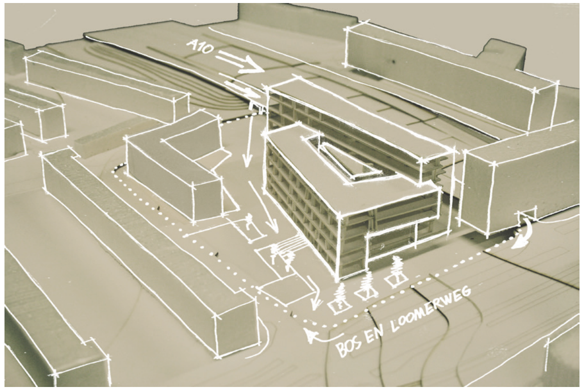
Ill. 07// 2 volumes emerge due to the noise and the street line.



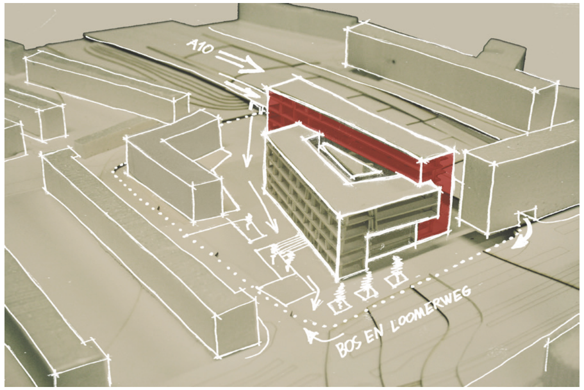
Ill. 08// Connecting 2 volumes with a third one, shaping it in order to propose a passage from the underground tunnel.



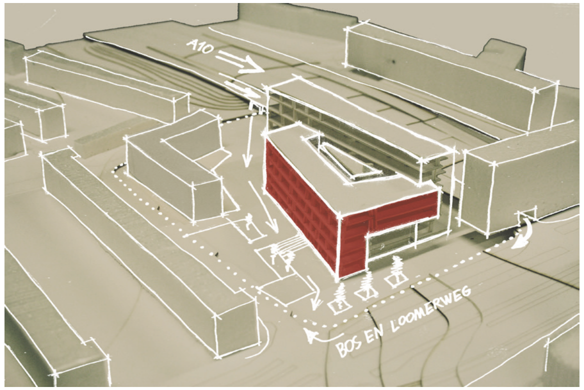
Ill. 09// Completing the opposite corner and proposing a residential building there.



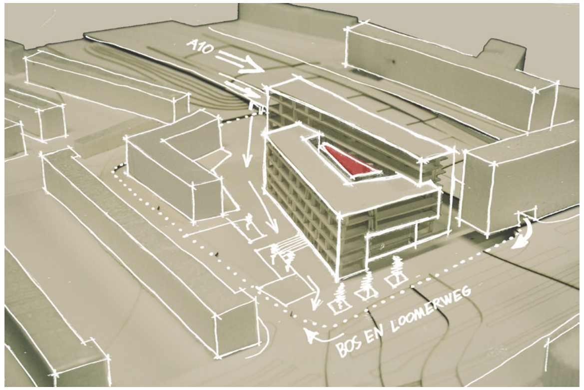
Ill. 10// Dividing the outdoor area into smaller segments and assigning purposes to them.



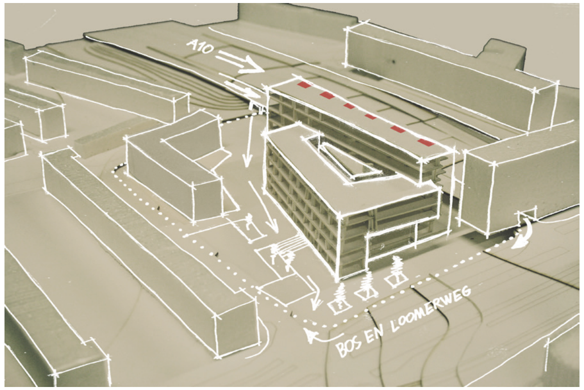
Ill. 11// Research wing placed next to the motorway.



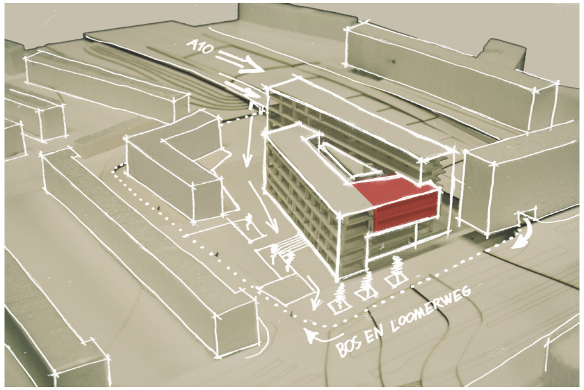
Ill. 12// Office wing placed diagonally on site.



Ill. 13// Creating a hub in the centre for collaboration.



Ill. 14// Early consideration to use decentralized service system for research areas.



Ill. 15// Lecture hall is hung above the entrance to create a dramatic threshold.

SITE PLAN

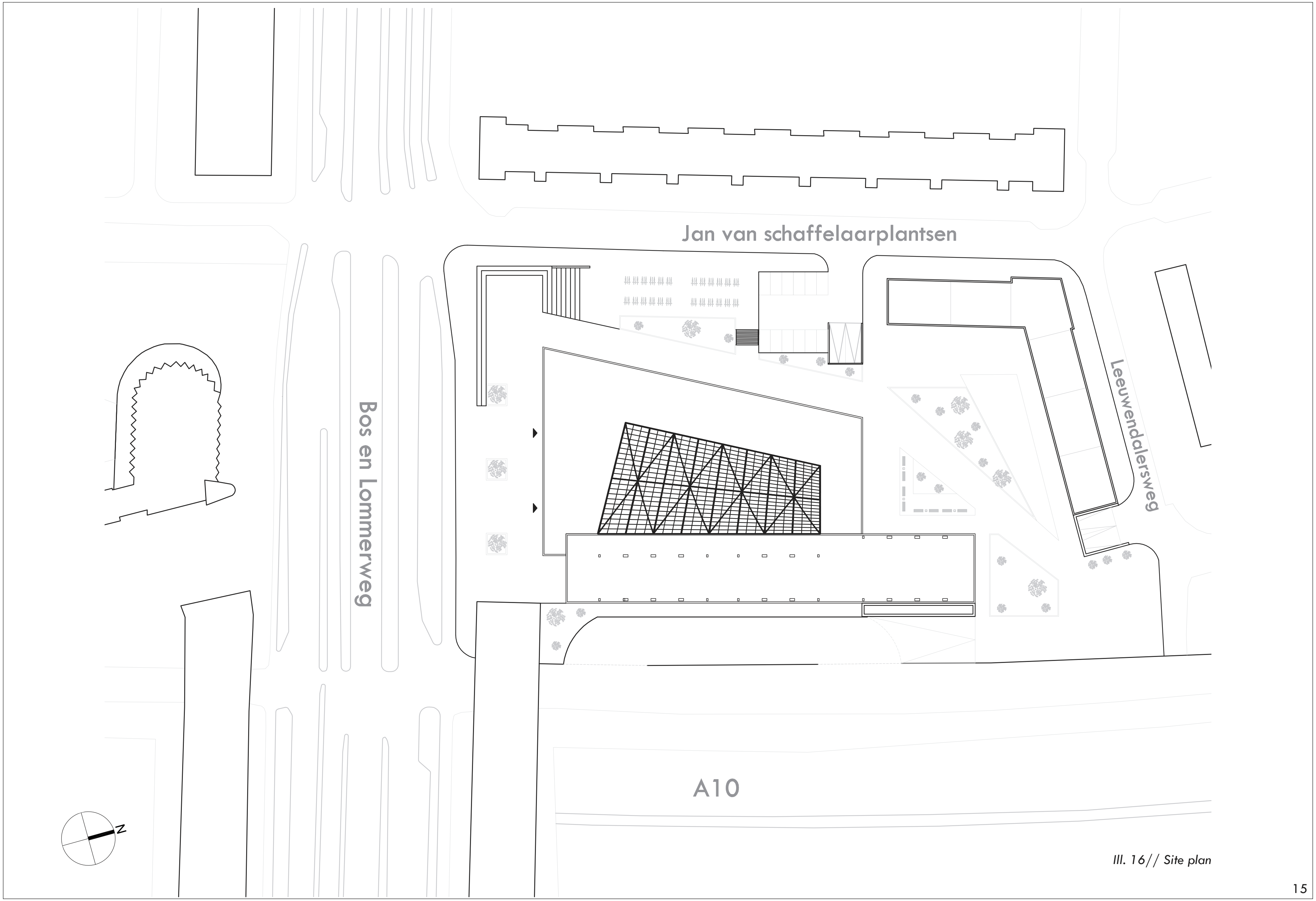
One of the key factors for shaping and placing the building on site was the potential of a flow axis from the tunnel under A10 motorway to Bos en Lommerweg, therefore a path for pedestrians and cyclists has been proposed.

As Bos en Lommerweg is sloping downwards, the building stands flat on the ground. The western edge of the site stairs down from the level of building's entrance to the level of the street. The front of the building is pushed back from the pavement, just like the church across the street. The space becomes wider, therefore it creates an image of a public place. The research wing is pushed back even further in order to make space between it and the existing building.

There are several car parking spaces for services and bicycle parking in the west part of the site. The building can be conveniently accessed through the side entrance from there. Small green plots are proposed in order to compensate the rough atmosphere dictated by concrete and asphalt. The users of the center can use the underground parking.

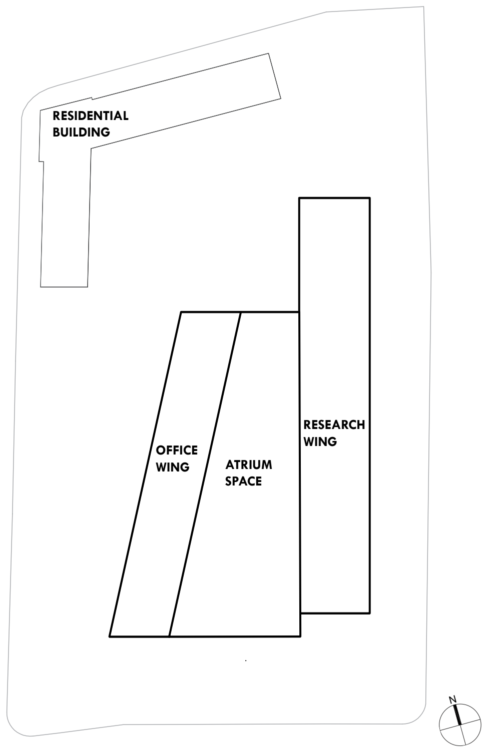
A delivery area is located at the east part of the site, which can be directly entered from the motorway or through the streets of the residential area, Leeuwendalersweg. A ramp is installed for the convenience of unloading cargo vehicles.

A residential building is proposed at the north side of the site in order to mix functions of the site, complete the corner and form enclosure. It also has a separate underground parking proposed, entering from Leeuwendalersweg. The residential building, much like other buildings of the same type, has a semi-private outdoor area adjacent to it. It is further followed by small public areas with benches and greenery that would also be greatly used for relaxation by the users of R&D facility.



Ill. 16// Site plan

BUILDING ORGANIZATION



Ill. 17// Building organization diagram

RESEARCH WING

This main purpose of this part of the building is to contain laboratories, cleanrooms and other workspaces for researchers. The design intension was to keep those areas separated from the rest of the building. Rigorous appearance and strict layout suggest a link to the clean, sterile and highly controlled environment. Furthermore, restricted access is an important aspect in the design of those areas.

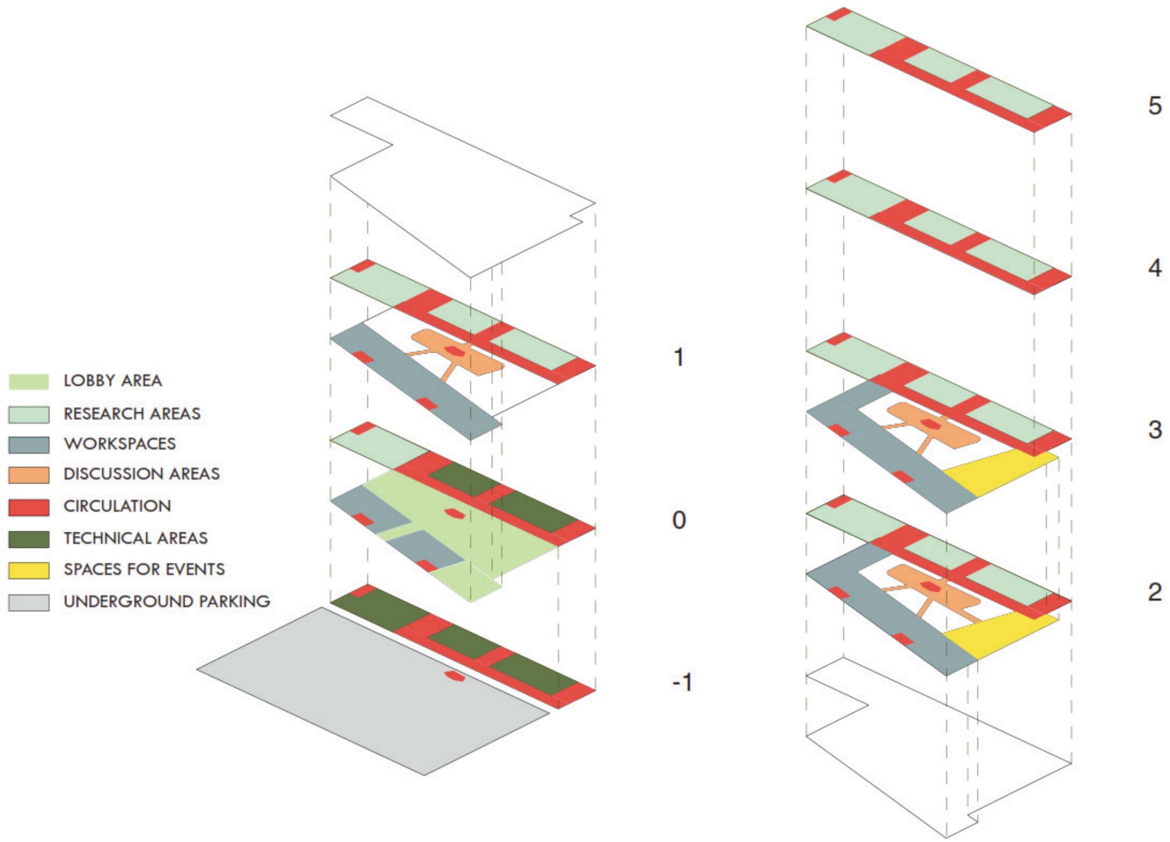
OFFICE WING

The primary design aim was to introduce an open-plan office space for business employees. One of the key design parameters was flexibility, therefore the space is divided into three rows. It allows to separate and isolate workspaces using partition walls. Hence this part of the building has more design freedom than the research wing.

ATRIUM SPACE

This part of the building is placed between the office and research wings. The aim was to connect the two wings by introducing spaces for meeting of users from both disciplines. Those areas are intended to have more dynamic and informal atmosphere. This was achieved by introducing more design freedom to it than for both wings. Relaxation lounges, meeting rooms and discussion areas are arranged in a more organic layout.

FUNCTIONAL DIAGRAM



Ill. 18// Functional diagram

This diagram describes how functions are allocated within the building. Basement level consists of an underground car park and technical areas for the research wing. On the ground level there is entrance lobby with exhibition area and a cafeteria. Storage rooms are on the ground level in the research wing allowing convenient access for deliveries. The central part of the atrium, with the hub inside of it. Lecture hall is placed above the main entrance.

FLOOR PLANS

RESEARCH WING

This part of the building is mainly for scientific purposes. It consists of labs and cleanrooms in ground to third levels, and office space with simulation labs in fourth and fifth levels. The plans of those spaces show different arrangements in order to illustrate adaptability, hence the rooms for research may be modified according to specific requirements of each research program. Each lab and cleanroom has individual decentralized service shafts. In front of entrances to cleanrooms there are areas for changing and decontamination.

OFFICE WING

As its primary purpose, the wing provides open-plan office space. There are 2 stairwells placed at the western edge, having previously made sure that escape distances do not exceed 25 meters. Toilet cores are placed in the center, which are also accompanied by kitchenettes. Enclosed meeting rooms are also placed in the middle and are glazed from both sides to increase the amount of daylight. This type of arrangement helps to separate the work spaces into 2 sides but still keep the space flexible. Furthermore, a library is placed at the north side of the wing on the ground level together with a reading room. On the south side of the wing on the ground level there is a cafeteria facing the street, allowing it to be accessed by people from outside. A cloakroom and an office for security personnel are located next to the side entrance.

ATRIUM

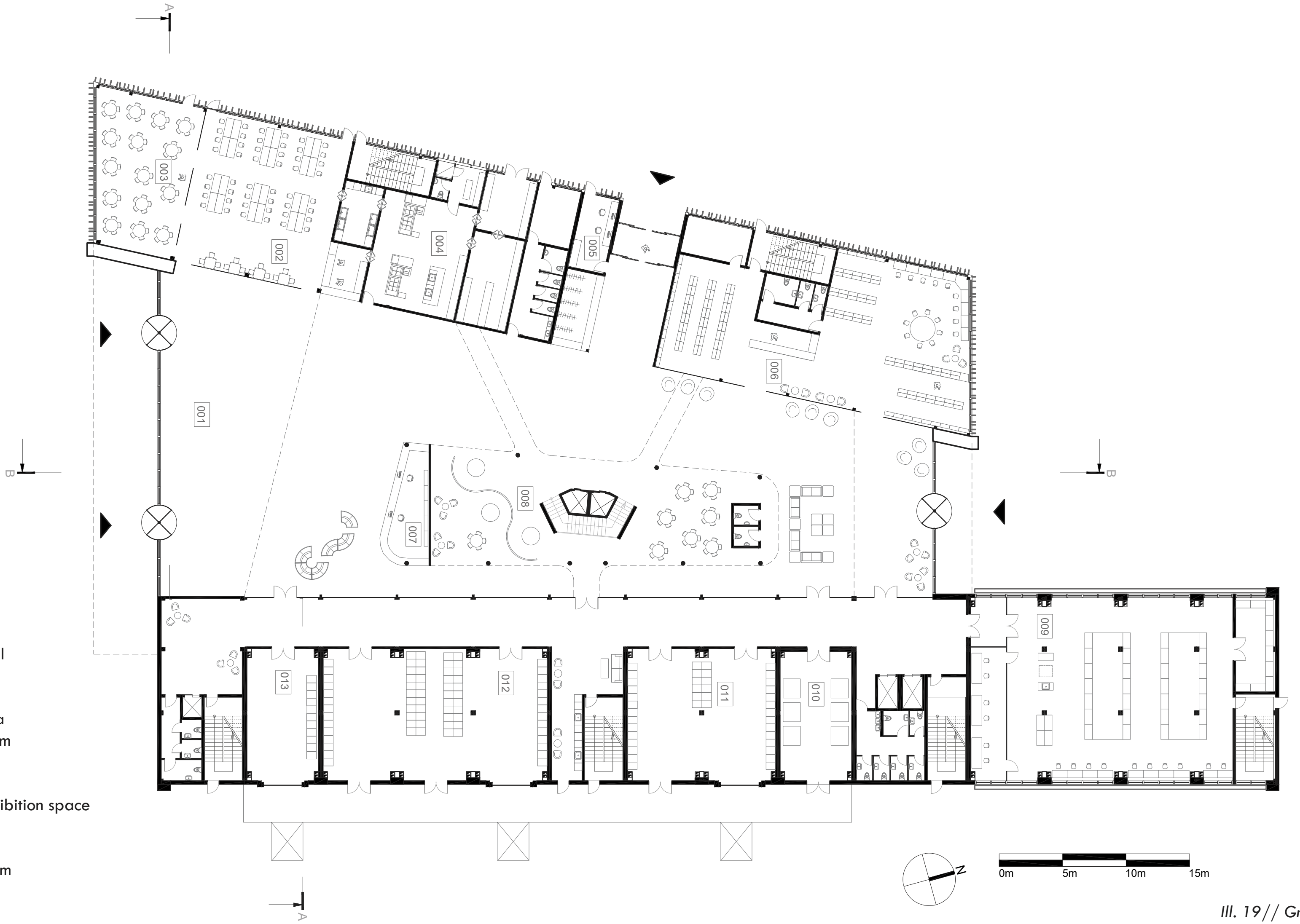
The atrium is the airiest and the most dominant space in the building. It accommodates an exhibition area on the ground level. A collaboration hub is built in the atrium as a separate structure to connect other parts of the building. The hub is divided into 2 zones: a quiet discussion and collaboration area at the south side of the hub and a relaxation zone at the north side of the hub with comfortable couches, games, toilets and a kitchenette or a bar. On the second floor the hub provides a connection to the lecture hall and accommodates a reception hall for the participants of events.

OTHER AREAS

The underground car park is located on site under the office wing and the atrium, but does not extend to the research wing. Nanocenter can be accessed via the central staircase and lifts.

Lecture hall has seating with the slope which may be dismantled in need for a flat floor. The comfort for spectators and ability to adapt the floor creates a balance between flexibility and quality performance in the room. Entrance to the lecture hall at the top level would be closed if the seating removed. There is also storage space at the back of the room and a backstage room is at the south corner of the cantilever which serves as a space for the guest speakers for preparation.

GROUND FLOOR PLAN

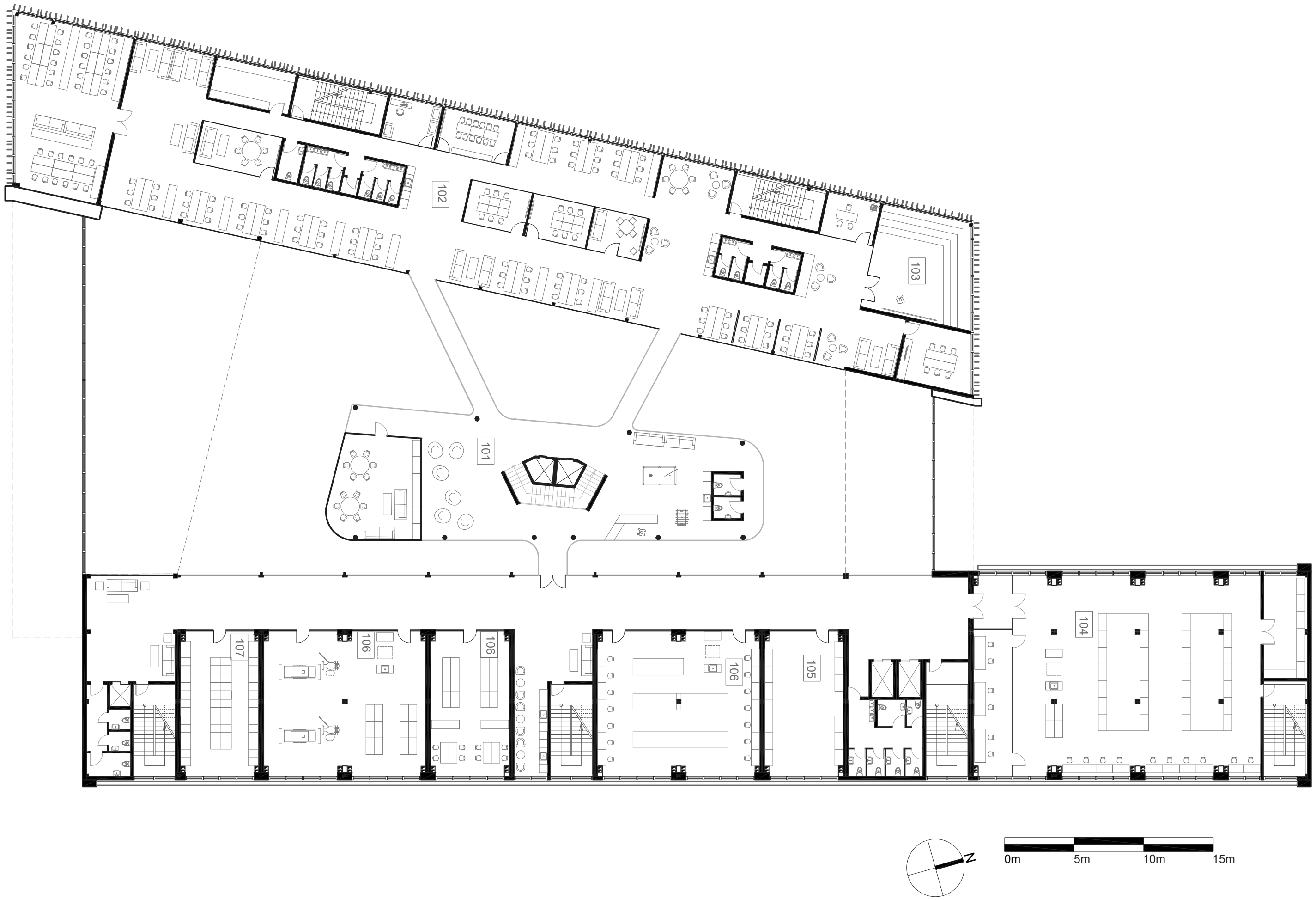


LEGEND:

001 Entrance hall
002 Canteen
003 Cafeteria
004 Kitchen area
005 Security room
006 Library
007 Reception
008 Flexible exhibition space
009 Cleanroom
010 Waste
011 Storage room
012 warehouse
013 Plant room

Ill. 19// Ground floor plan

FIRST FLOOR PLAN

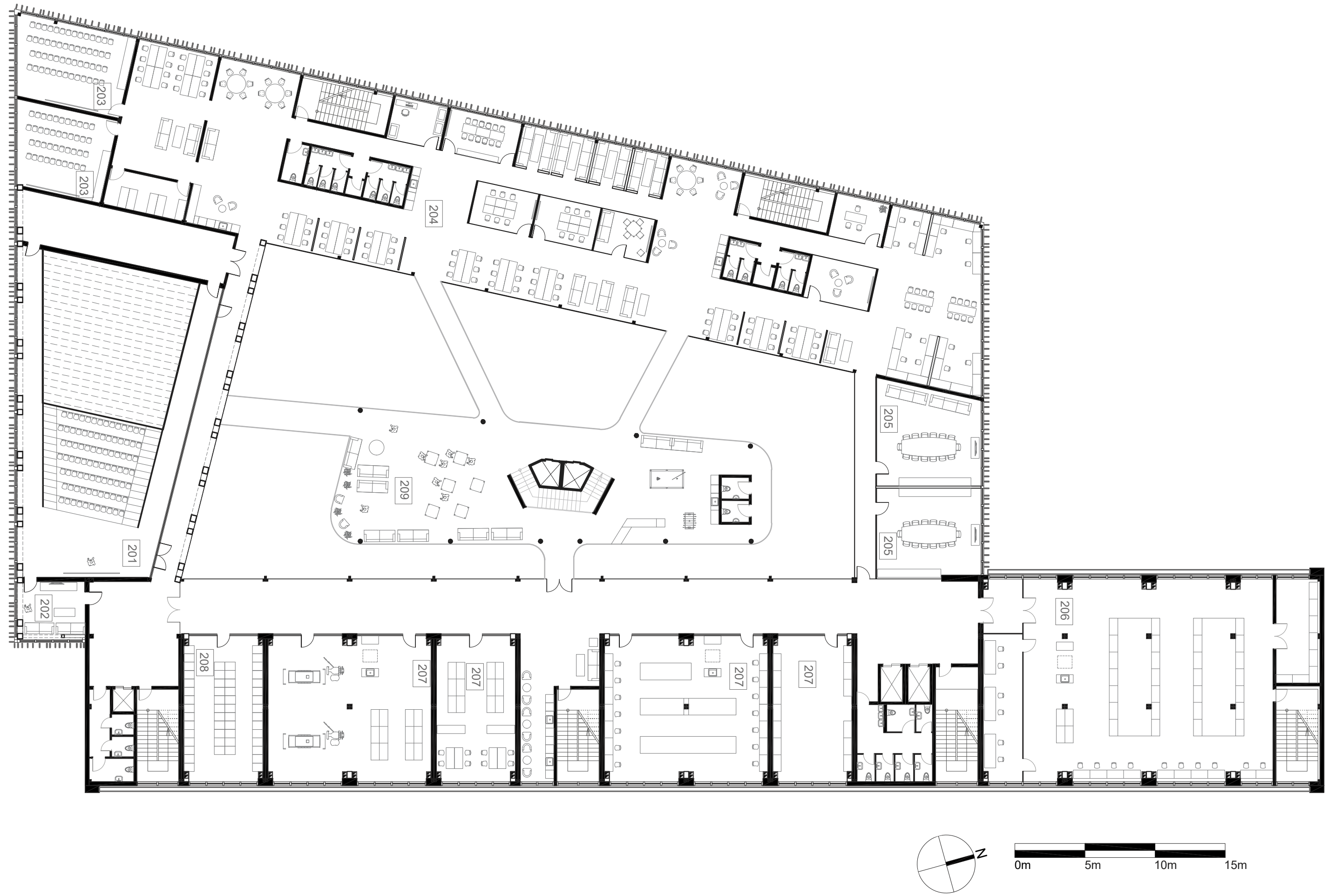


LEGEND:

101 Meeting hub
102 Office
103 Presentation zone
104 Cleanroom
105 Storage
106 Laboratories
107 Storage

Ill. 20// First floor plan

SECOND FLOOR PLAN

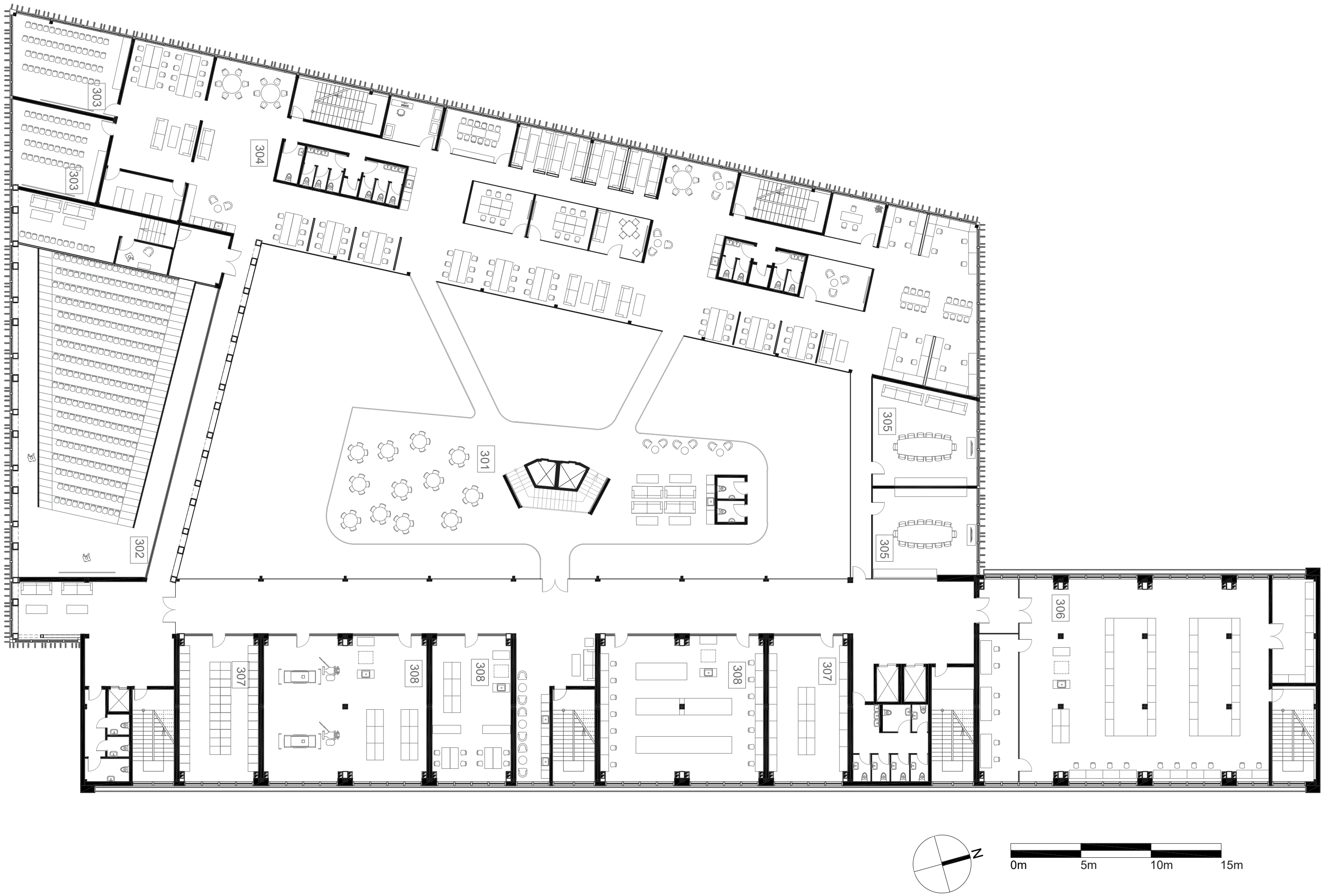


LEGEND:

201 Lecture hall
202 Backstage room
203 Classrooms
204 Office
205 Meeting rooms
206 Cleanroom
207 Laboratories
208 Storage
209 Meeting hub

Ill. 21// Second floor plan

THIRD FLOOR PLAN

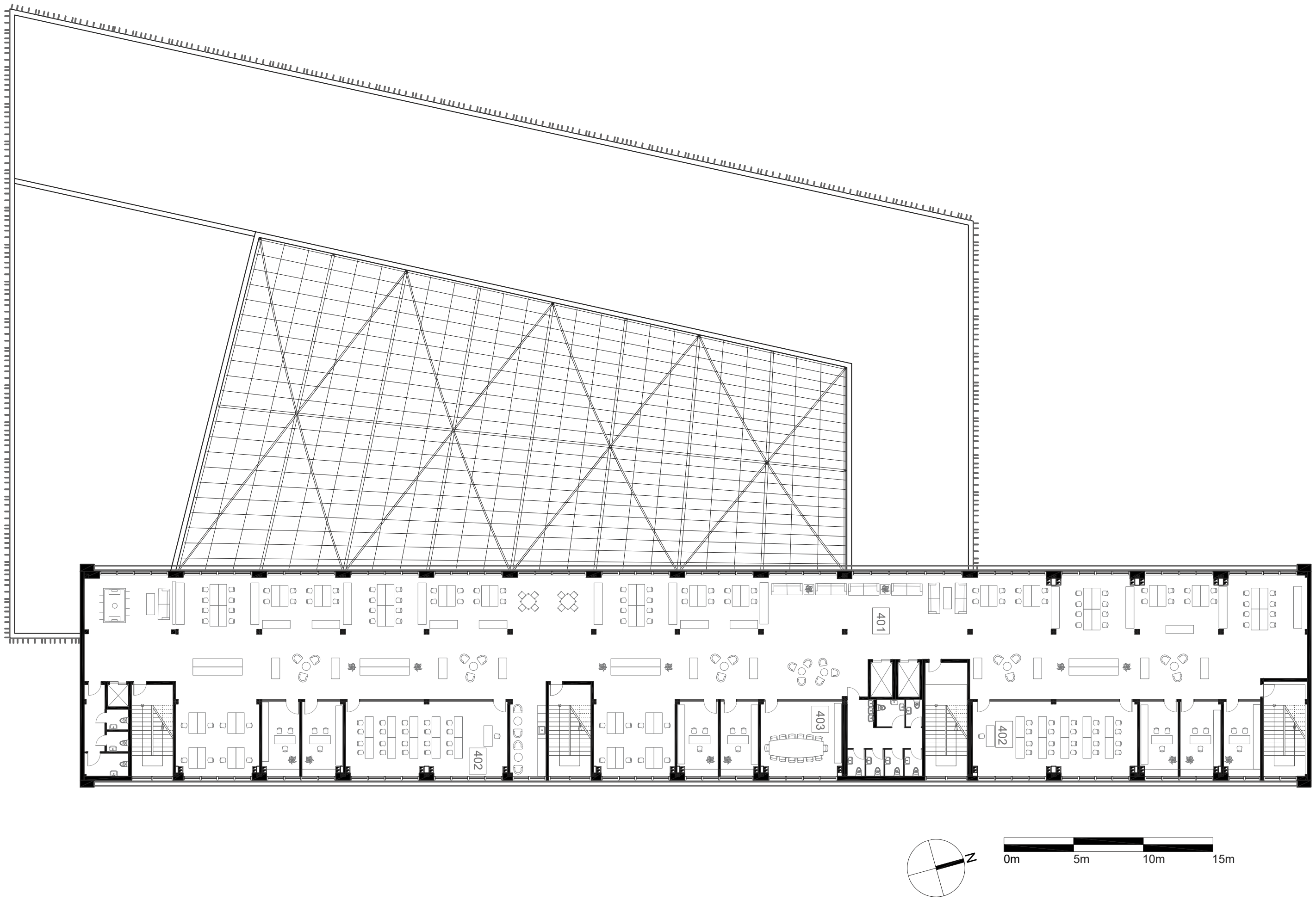


LEGEND:

301 Meeting hub
302 Lecture hall
303 Classrooms
304 Office
305 Meeting rooms
306 Cleanroom
307 Storage
308 Laboratories

Ill. 22// Third floor plan

FOURTH FLOOR PLAN

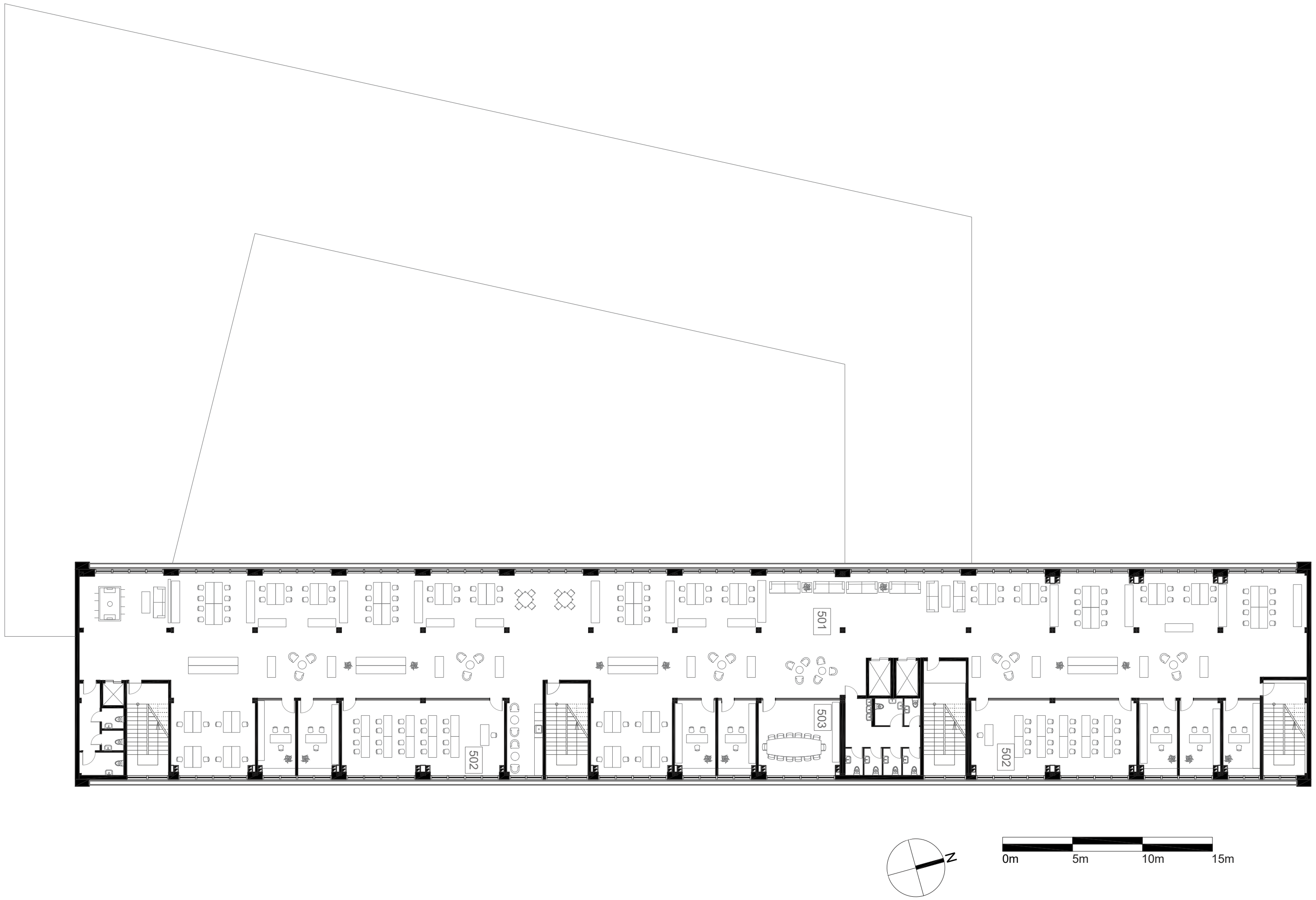


LEGEND:

401 Flexible workspaces
402 Classrooms
403 Meeting room

Ill. 23// Fourth floor plan

FIFTH FLOOR PLAN

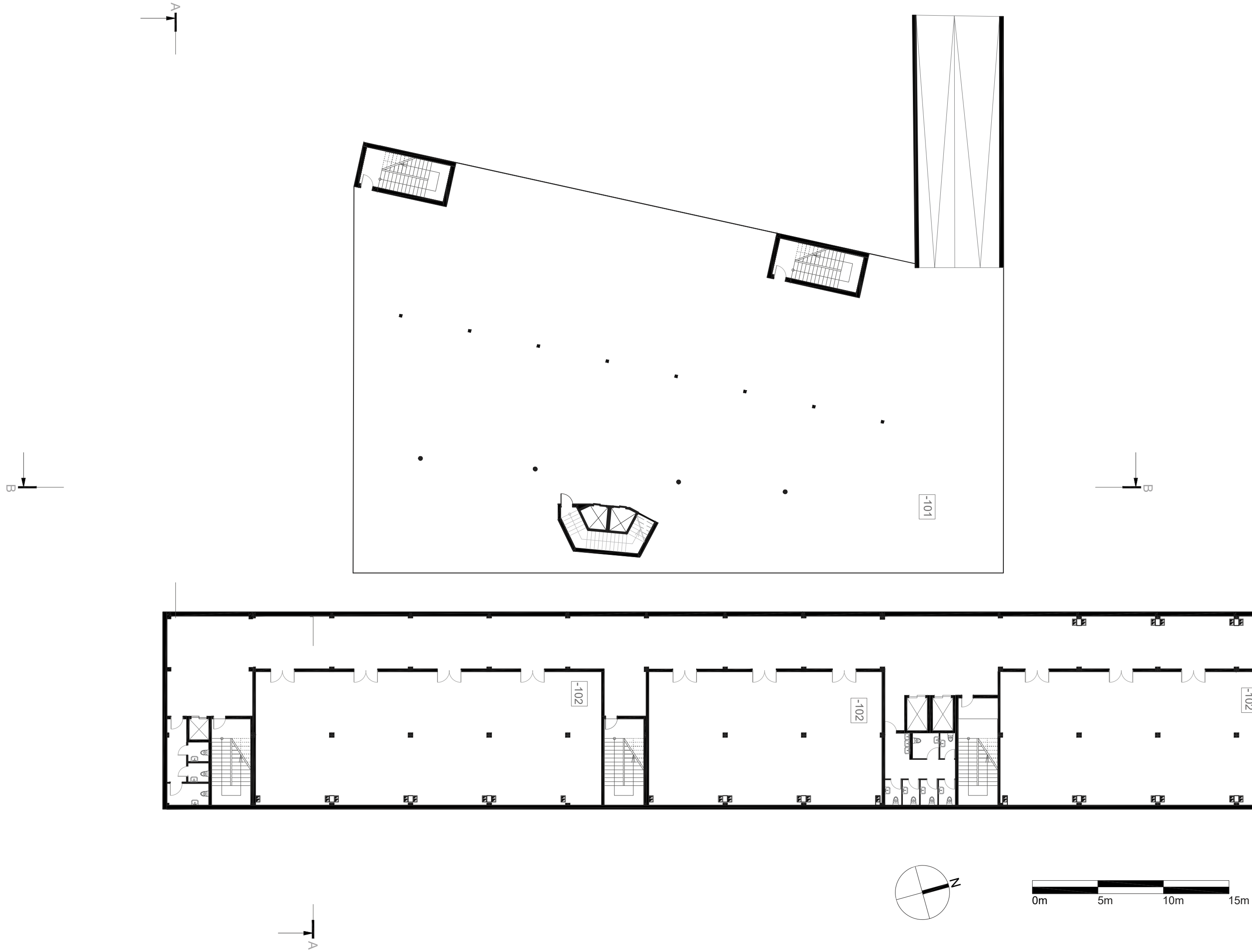


LEGEND:

501 Flexible workspaces
502 Classrooms
503 Meeting room

Ill. 24// Fifth floor plan

BASEMENT PLAN

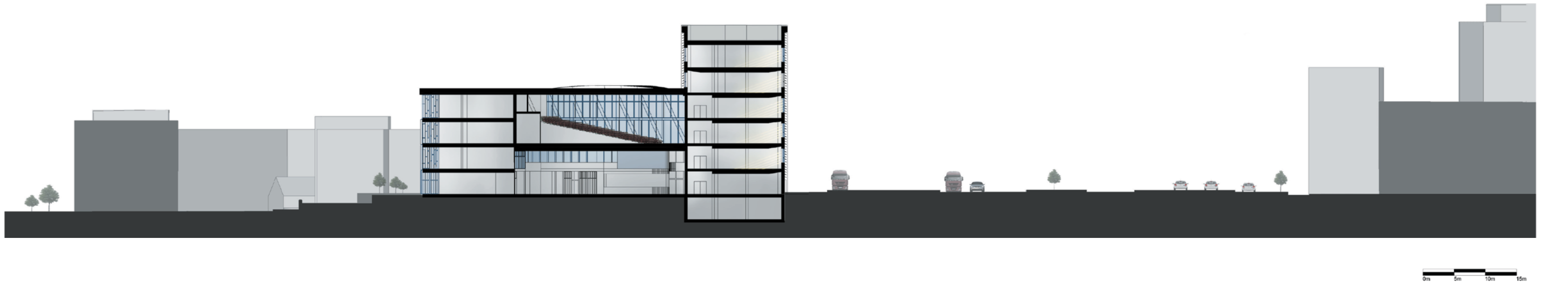


LEGEND:

-101 Parking space
-102 Technical rooms

Ill. 25// Basement plan

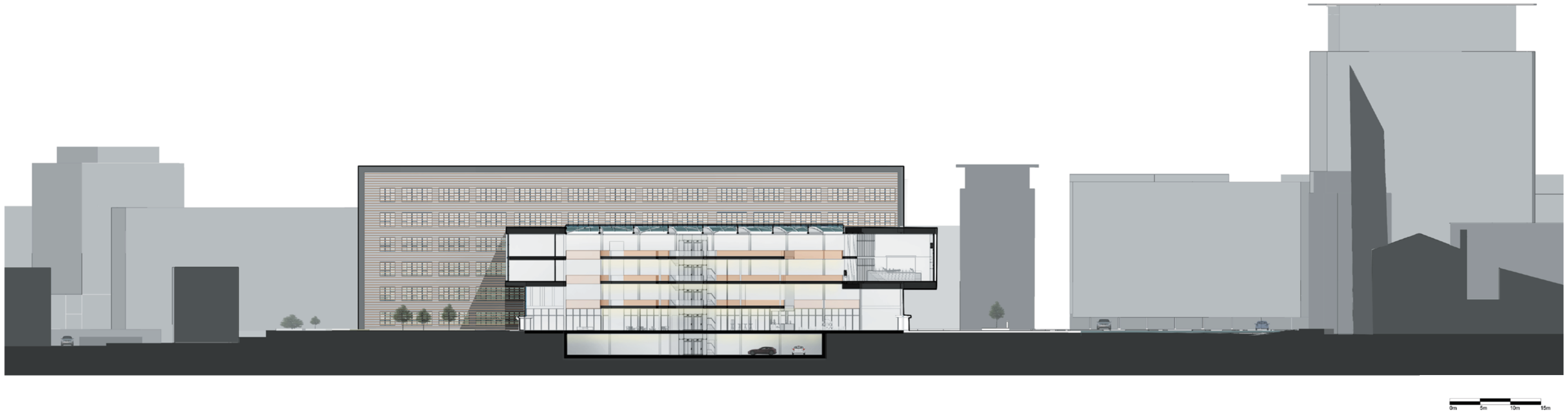
SECTIONS



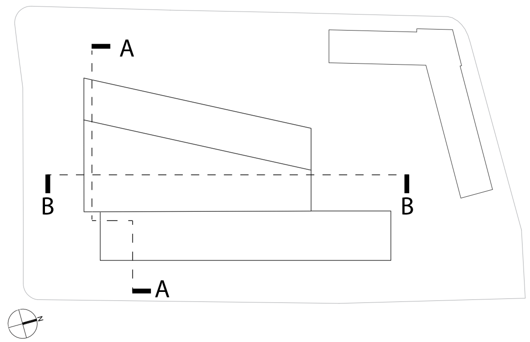
Ill. 26// Section A-A

The context of the Nano centre design is addressed by placing the research wing, the six-storey structure, next to the motorway, along which many tall buildings are built. Moreover, it corresponds to the buildings to the east of the site, which are rather tall. The four-storey office wing corresponds to the residential buildings consisting of four floors. Furthermore, the front of the Nano centre is pushed back from the street, therefore embraces the church across as a landmark.

The entrances greet the users by the double-storey, 8 meters tall overhang where the lecture hall is located. It contains sloped removable seating. Other parts of the building are 4 meters high, floor to floor. The roof of the atrium covers the heights of 4 floors. The meeting collaboration hub is built in the atrium as a separate structure, which connects main circulation routes and links to the lecture hall and the underground car park.



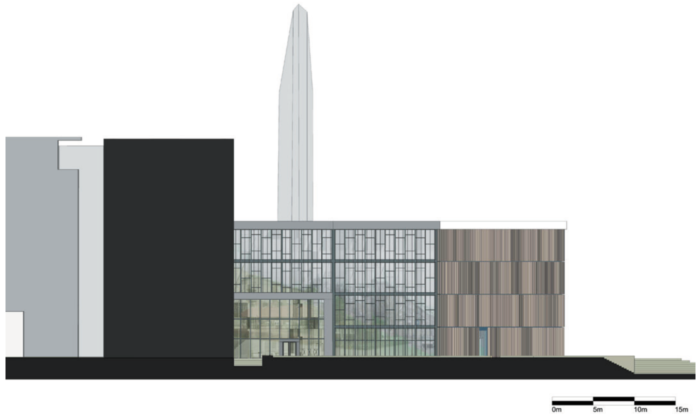
Ill. 27// Section B-B



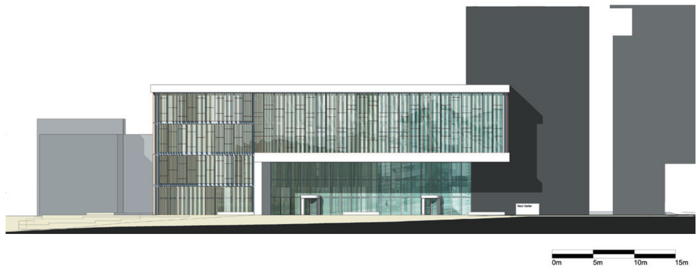
ELEVATIONS

Façade expression is dominated by its shading. Vertical shading fins are applied on the part of the building, which is 4-storey high. The position of those elements were chosen due to the more positive feeling they provide by framing views rather than obstructing them. Shading system is controllable in order to adjust appropriate amount of daylight and solar gain. Gaps between the fins vary in width, therefore an interesting pattern is visible, especially when looking from a side. Furthermore, exterior is chosen to be covered with curtain walls to enhance flexibility, allowing to be replaced with other materials. The divisions of the frames express a continuous rhythm.

Horizontal shading elements are applied on the research wing. They appear more dynamic, therefore are expressed as a parallel to the movement of the motorway. The back walls of the wing are left blank and clad in reflective black panels. The walls clad with sandwich panels and windows



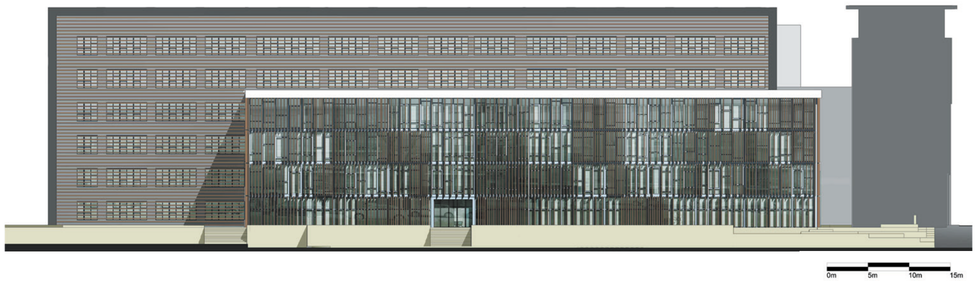
Ill. 28// North elevation



Ill. 29// South elevation

are placed between the columns and the service shafts.

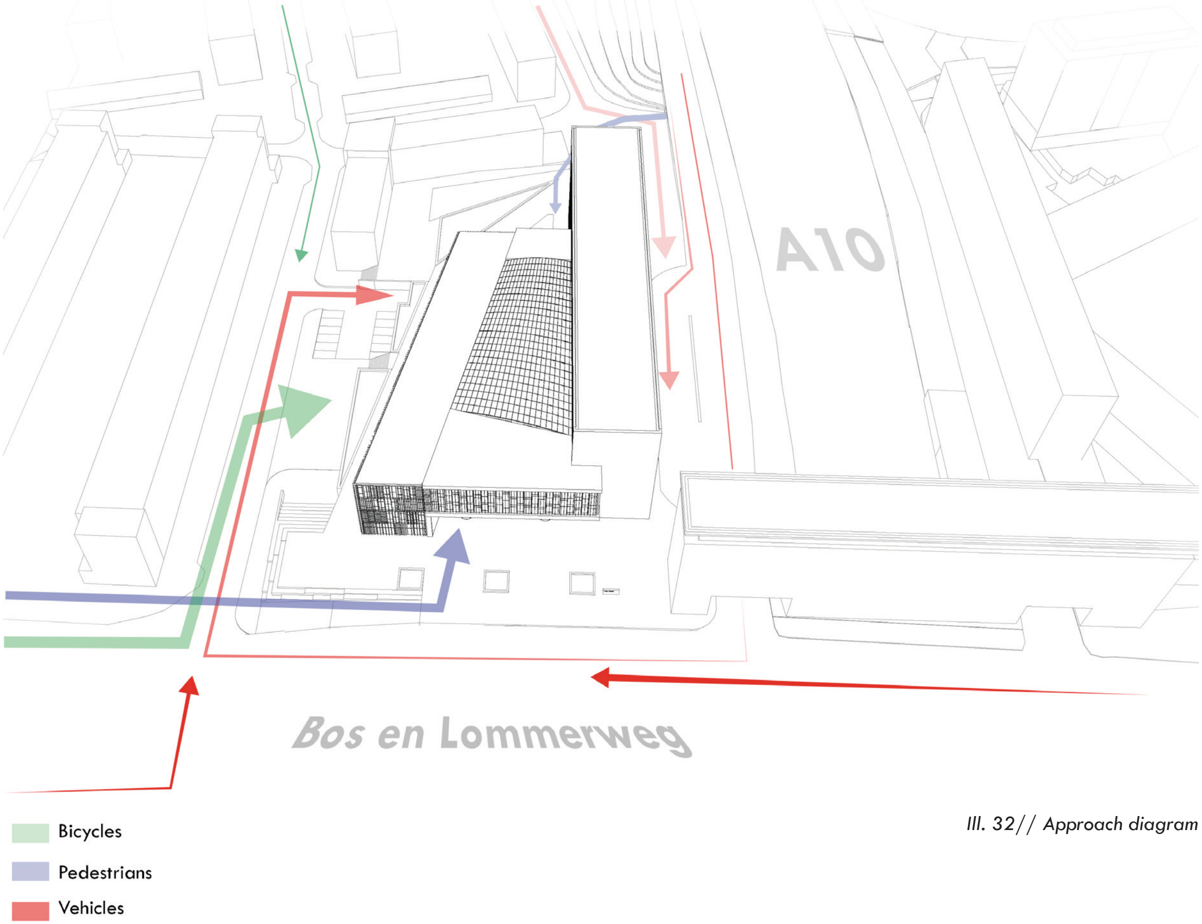
The thick edges of walls and roofs highlight the contour of the building and frame the shading elements. This expression is used throughout the building, therefore continues the same language around the façade. Moreover, the front, back and side entrances are unshaded, hence provide transparency to the street and back facades.



Ill. 30// East elevation

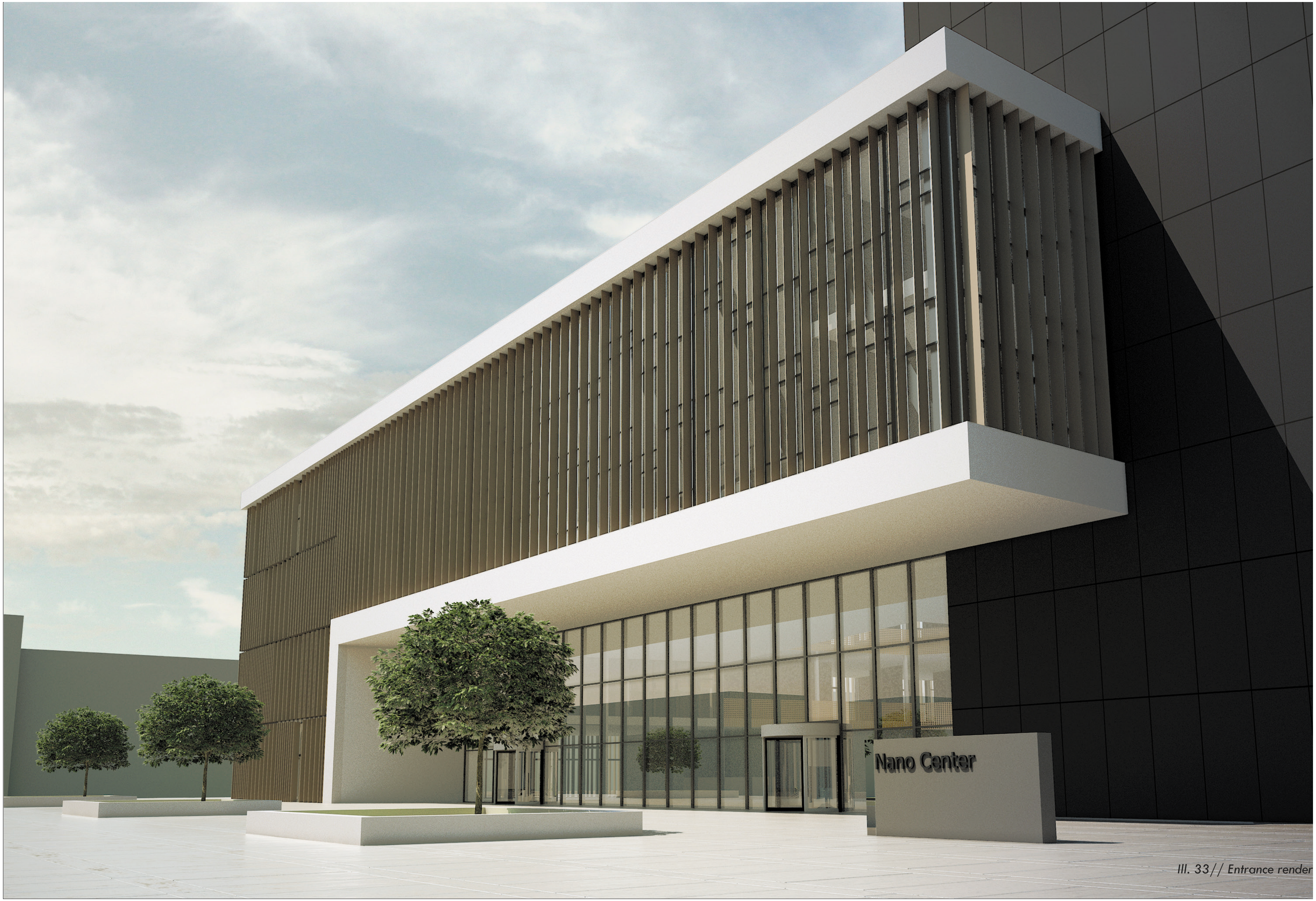
Ill. 31// West elevation

APPROACH



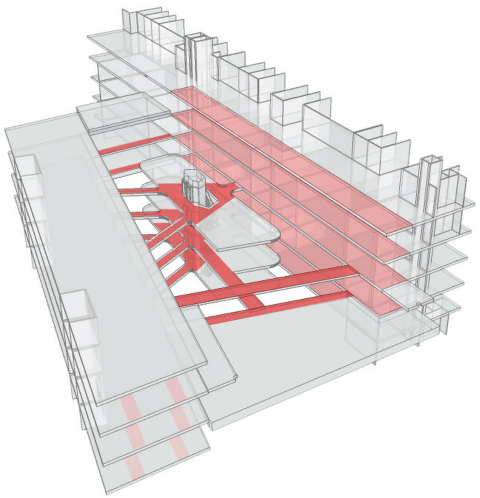
Ill. 32// Approach diagram

The three main means of transportation to approach the building is by bicycle, by car and by public transport. It is convenient to reach the site by car through the city or the A10 motorway. Parking spaces for vehicles are located underground, from which the building can be accessed directly through the main staircase or elevators. Cyclists can arrive from other areas of the city and park on the west side of the site at the designated bicycle racks. Side entrance can be conveniently reached from there. Those arriving by metro, trams or buses may enter via the main entrance from the street, Bos en Lommerweg.

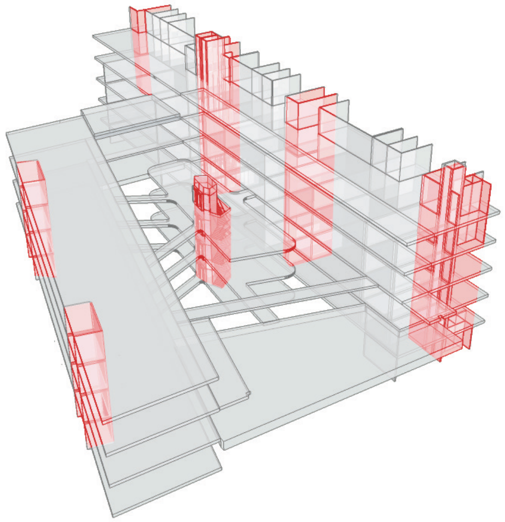


Ill. 33// Entrance render

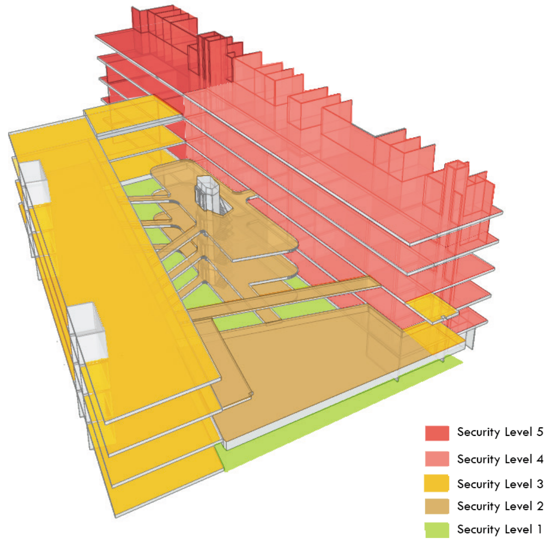
FLOWS



Ill. 34// Horizontal circulation diagram



Ill. 35// Vertical circulation diagram



Ill. 36// Security diagram

HORIZONTAL CIRCULATION

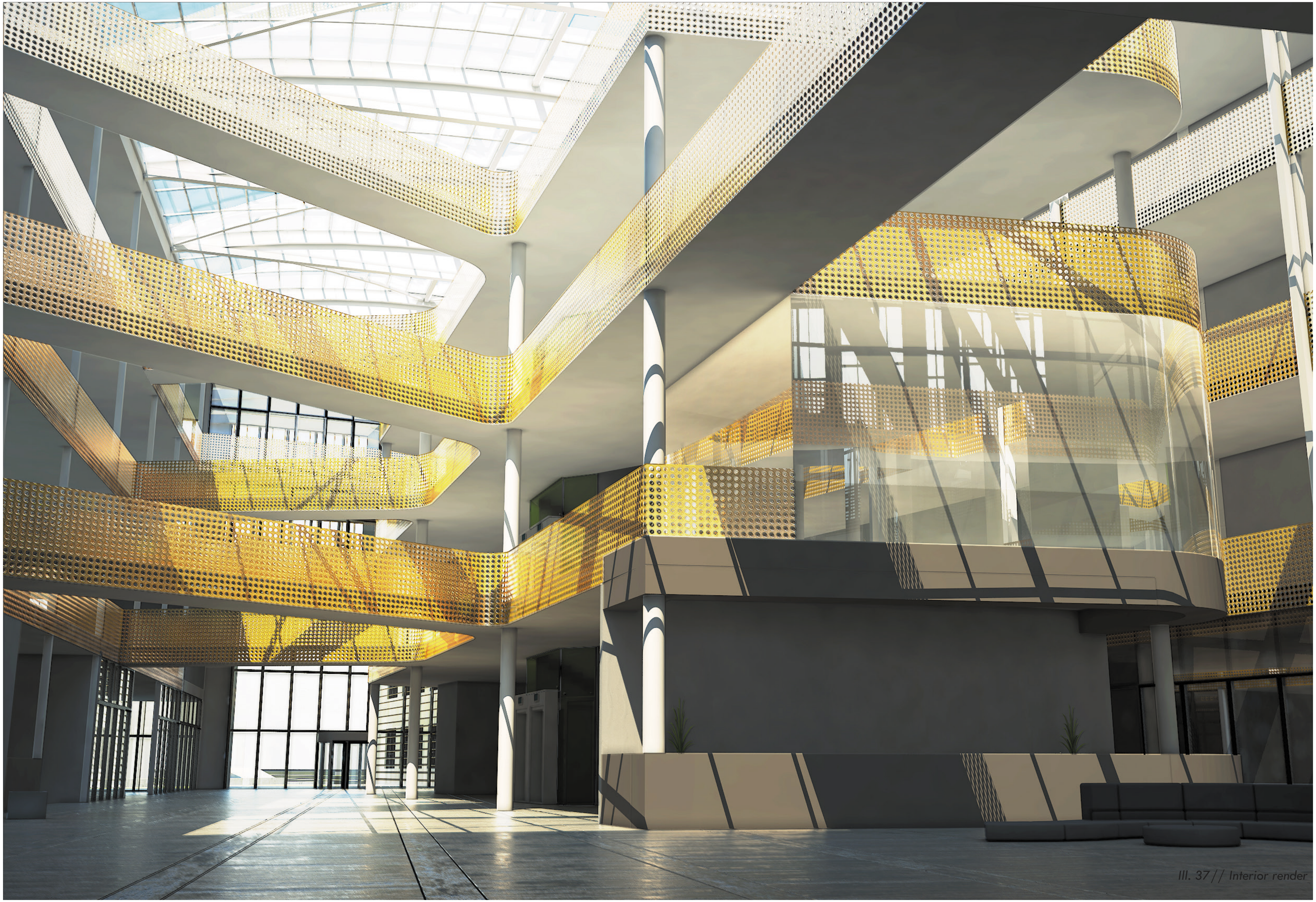
The most important part for vertical circulation are the bridges which connect the hub with research and office wings at three levels and lecture hall at the second floor. Research wing has corridors adjacent to the atrium, which provides positive visual atmosphere. Circulation in office wing is based on two rows between workspaces. Two corridors are located adjacent to the lecture hall, making it more convenient to be accessed, also serving as emergency exit routes.

VERTICAL CIRCULATION

The main staircase and 2 elevators are placed in the hub, which constitute the core of vertical circulation in the building. Office wing is accompanied with 2 staircases which are primarily emergency exits but can also be used on regular basis. In research wing 4 staircases are placed on the east edge of the building, of which 3 are to be used on regular basis and one at the back of the wing would serve only as an emergency exit from cleanrooms. There are also 3 elevators to be used for the vertical circulation of researchers and for the transportation of goods.

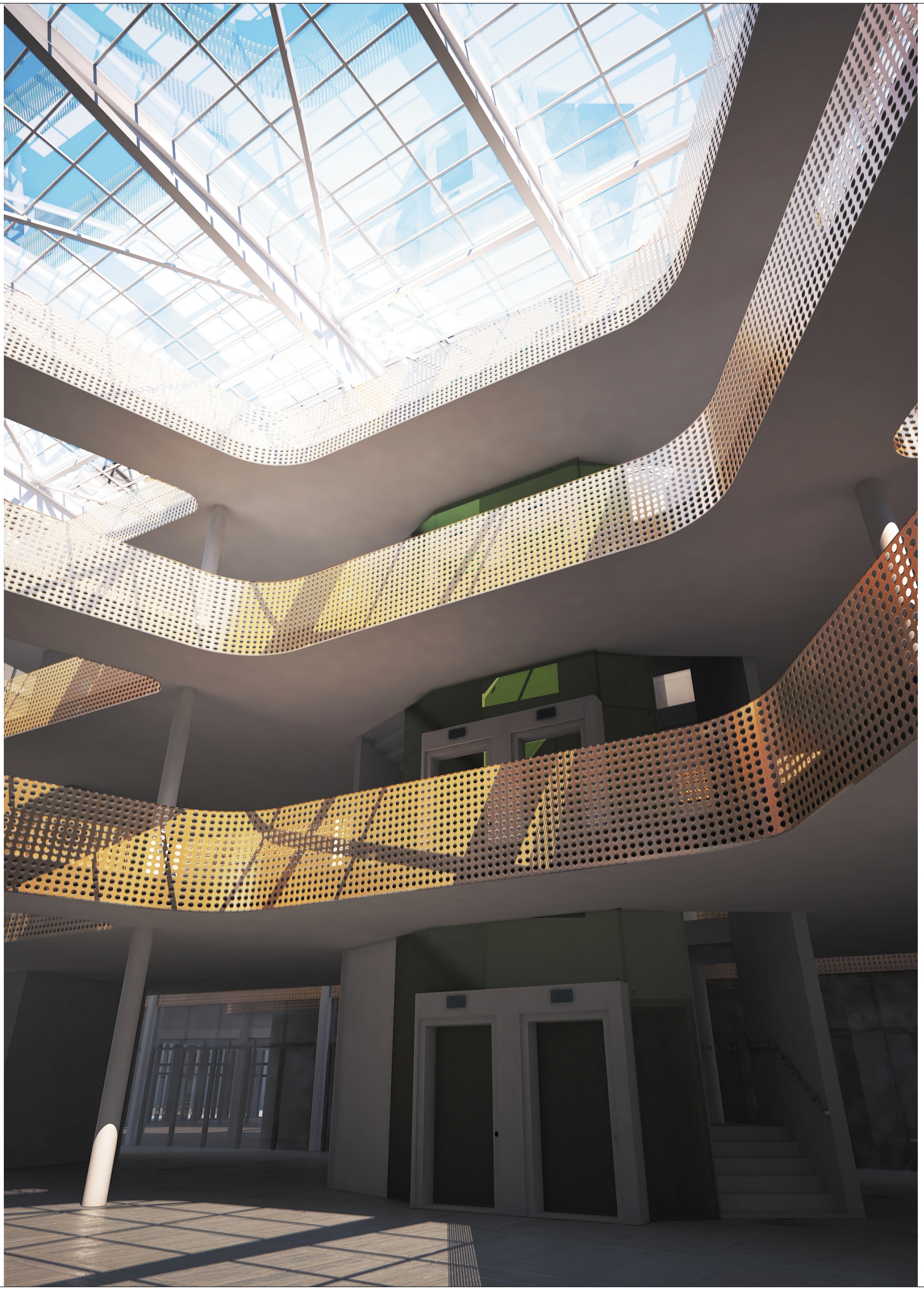
CONTROLLED ACCESS

This is a very important aspect for building's operation in order comply with security and safety measures. Therefore 5 levels of security have been introduced: 1 is the least strict and 5 is the strictest. Security level 1 is on the ground level, hence it can be freely accessed from the street to see exhibitions and use cafeteria. Level 2 is for the lecture hall, therefore invited guests are allowed in. Level 3 is in offices for business employees. Level 4 is for laboratories due to safety reasons and level 5 is for cleanrooms as only authorized and properly instructed personnel can be admitted in order not to damage their environment.



Ill. 37// Interior render

Ill. 38// Exterior render



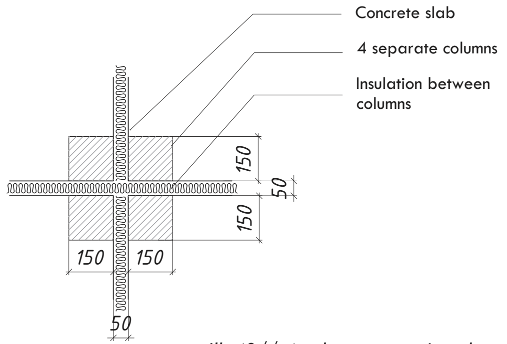
Ill. 39// Interior render

CONSTRUCTION PRINCIPLE

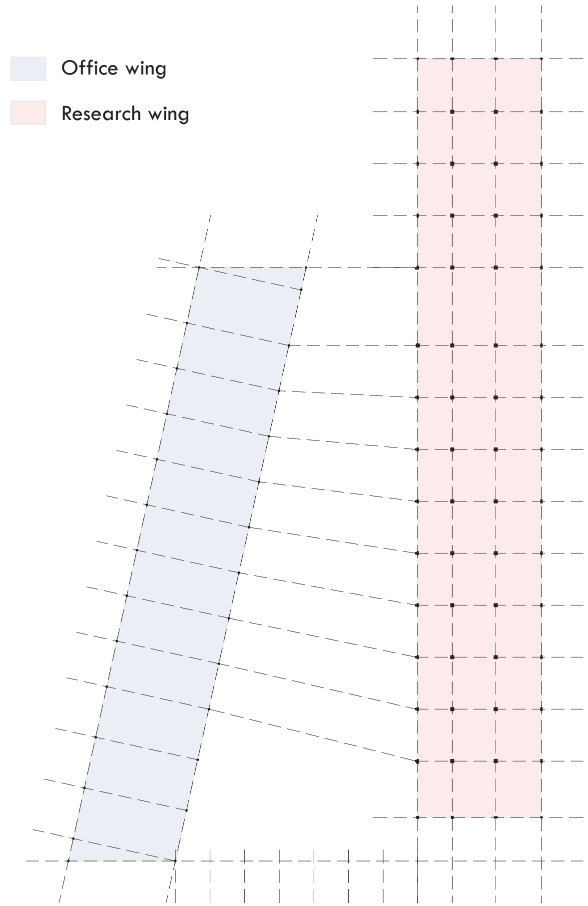
In order to minimize impact of vibration to laboratories and cleanrooms, the structure in research wing is divided into separate segments. Shorter spans between columns and isolated floor slabs allow reducing affection from one part of the building to another. However, this type of arrangement makes it challenging to organize space inside.

In-situ concrete structure is chosen due to stiffness and thermal performance. Pile foundations are to be used since the ground conditions are fairly good but not perfect.

Meanwhile steel structure is used in the office wing due to its capability to provide long spans and possibility to construct trusses and cantilevers. Steel columns are also placed between the atrium and research wing to carry the roof of the atrium. This is to isolate the labs and cleanrooms from vibration.



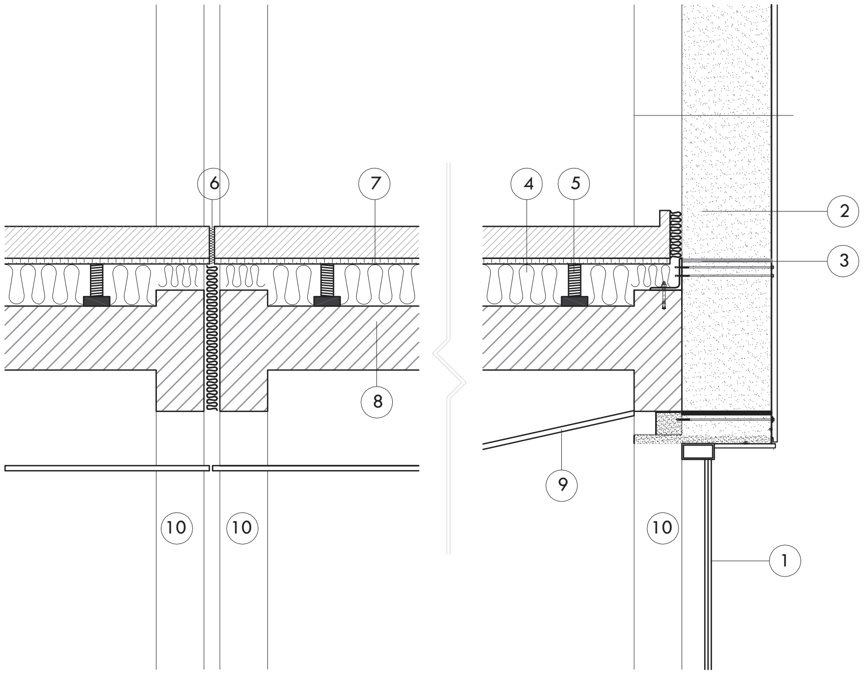
Ill. 40// 4-column composite scheme



Ill. 41// Structural grid diagram

FLOATING FLOOR DETAIL

As vibration is a major issue for research facilities of nanotechnologies, the following precautions have been addressed: structure has been segmented and floating floors have been installed in order to eliminate unwanted movement. Therefore dampers have been placed between the structural slabs and the floors. Empty space around the dampers have been filled with flexible insulation.



Ill. 42// Floating floor detail

1 Glazing

2 100 mm Insulation

3 Air seal

4 Insulation

5 Damper

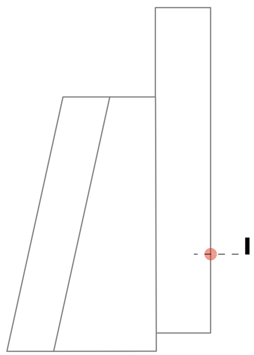
6 Floor separation

7 Plywood

8 In-situ concrete slab

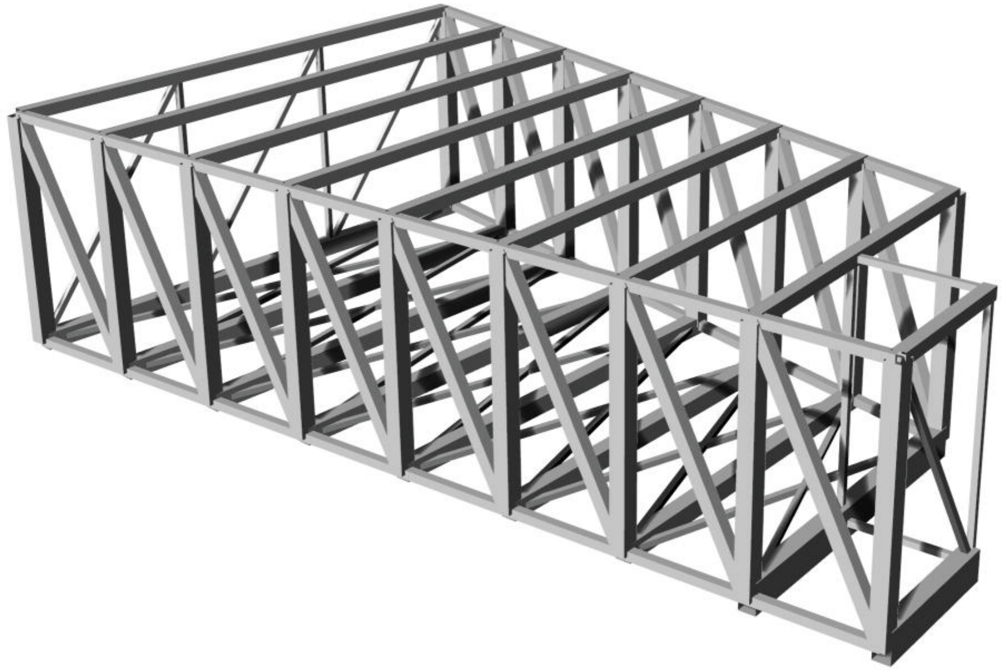
9 Suspended ceiling

10 In-situ concrete column



THE CANTILEVER

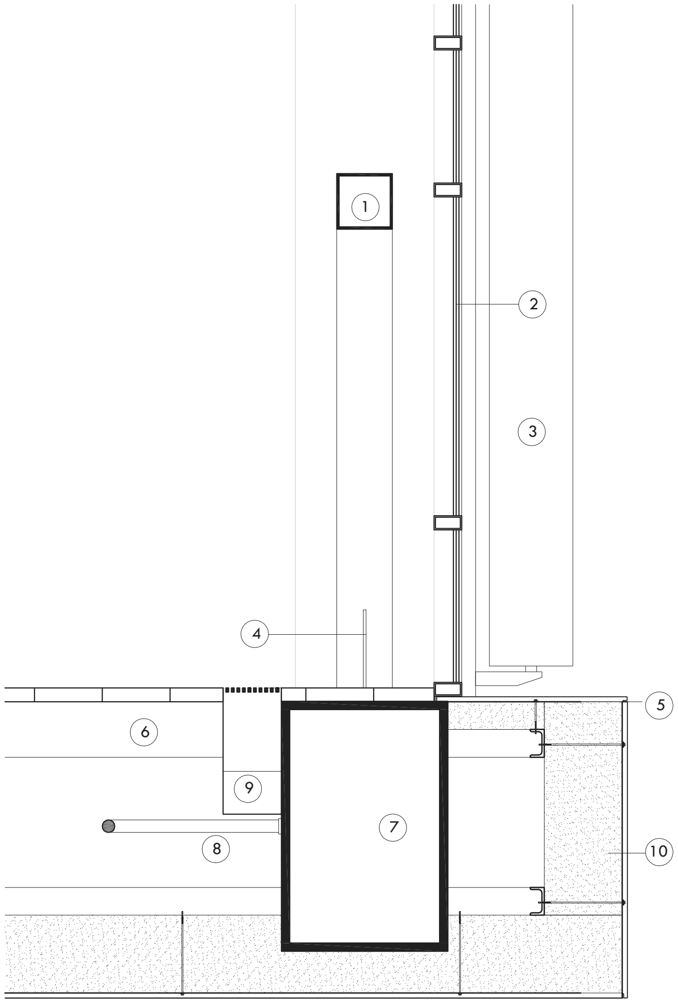
From the outside the cage appears to be intersected into the research wing. The structure is hung above the main entrance and signifies importance by its presence. The structural principle is based on two 900 mm high beams sticking out of the research wing, acting as cantilevers and supporting the front truss of the cage. The front truss is divided into 8 equal sections, of which one is set to match the width of the corridor in the research wing, therefore it extends the walkway. The truss at the back is supported on 2 sides of the building and has 7 divisions. The height of the vertical and diagonal structural elements extends through 2 floors, hence the elements are large and significant, inevitably becoming an important part of the building's tectonic expression.



Ill. 43// Structure scheme

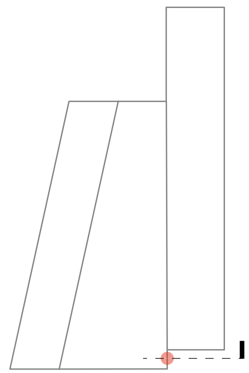
CANTILEVER DETAIL

The key elements to support the cantilever are 2 beams of 900 mm in height and 600 mm in width. The members connecting the 2 trusses at opposite sides are also connected by steel cables in tension. The floor is placed on the steel floor joists, which are connected to the structural beams. The edge of the structure is extended outwards beyond edge of the shading fins in order to create a clear boundary to frame the volume of the building. Window frames and elements holding the solar shading fins are attached to the vertical truss members. Air supply duct is a part of the heating system, which receives warm air from heat exchange units.



Ill. 44// Cantilever detail

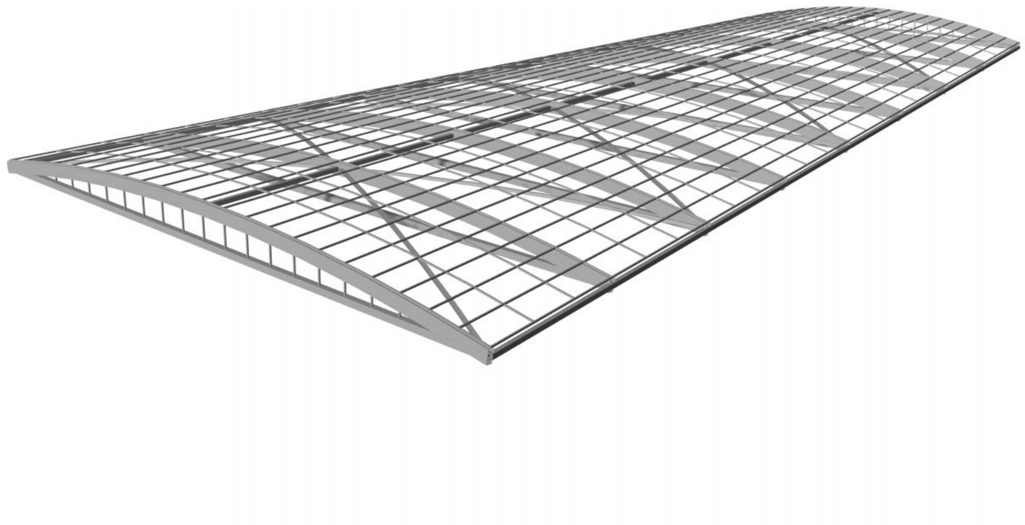
1. Bracing 200x200 mm
2. Glazing
3. Solar shading fin 300x20 mm
4. Truss joint
5. Air seal
6. Floor joist 200x200 mm
7. Beam 900x600 mm
8. Cross-bracing
9. Air supply duct
10. 300 mm Insulation



ATRIUM ROOF

The roof of the atrium is based on an arc form. The choice upon its sloping direction was influenced by the fact that neither it should block windows of labs nor should interfere with the internal space of the atrium. It is supported on 2 opposite sides, therefore it connects 2 structural grids: from the research wing and from the office wing.

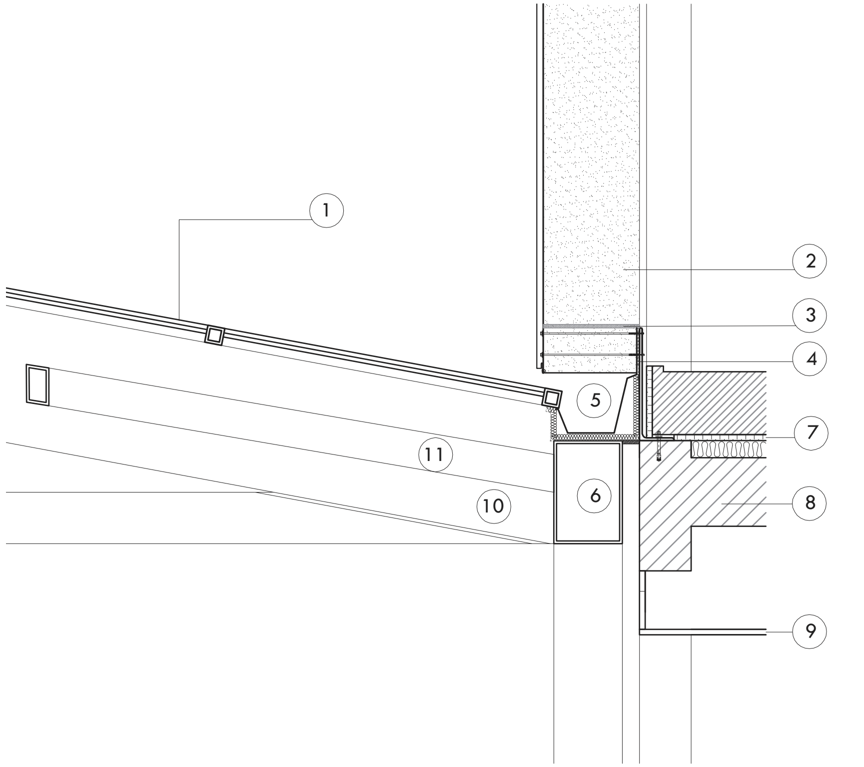
The aim was to compose it into a homogenous whole, continuously stretching through the atrium as one element. The structure speaks for itself and communicates that the main arcs transfer loads to their supports and the beams connecting them act in tension and keep them in place. There are panels installed between them for solar shading. The slender 3-dimensional arcs assist them with horizontal stability. Therefore, it all comes to the tectonic quality as the shape and structure of the roof contribute to the clarity of the atmosphere.



Ill. 45// Structure scheme

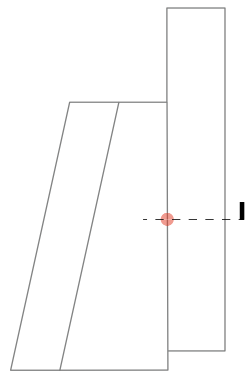
ATRIUM ROOF DETAIL

Structure of labs consists of separate reinforced concrete units, each of which is made of 4 columns and a slab. The floors in labs are insulated from vibration in two ways: separate structure and installed vibration isolators. Water is collected from the atrium roof in the gutter which is placed adjacent to the wall of the research wing. Air supply duct is a part of the heating system, which receives warm air from heat exchange units.

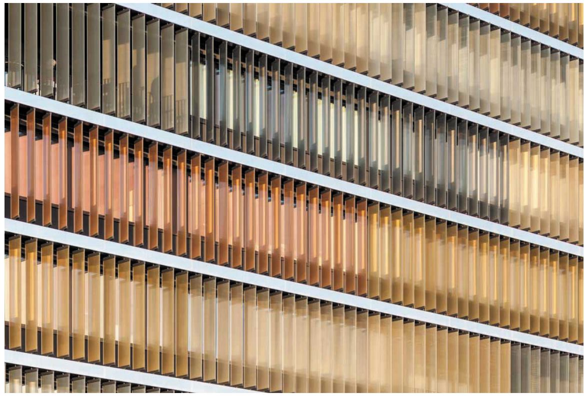


Ill. 46// Structure scheme

1. Glazing
2. 300 mm Insulation
3. Air seal
4. EPDM Membrane
5. Gutter
6. Steel beam supporting the roof 300x200 mm
7. Plywood
8. In-situ concrete slab
9. Suspended ceiling
10. Roof arch
11. 3-dimensional arch

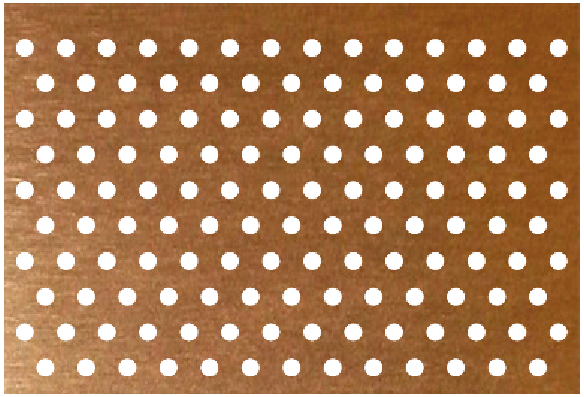


MATERIALS



Ill. 47// Facade shading example

Ill. 48// Sandwich panel cladding example



Ill. 49// Perforated copper example

EXTERIOR

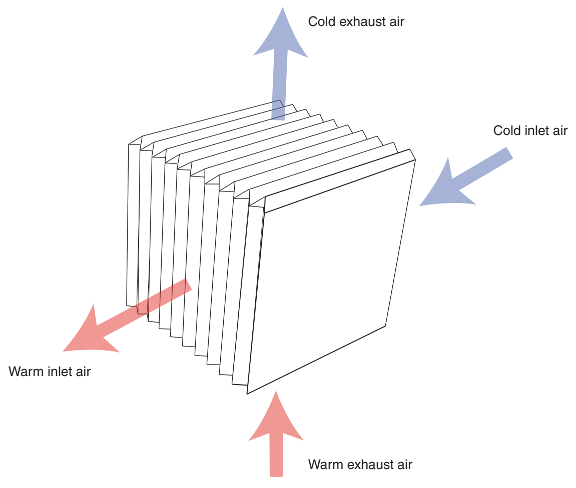
Office wing, entrances and facades above them are covered with glazed curtain walls, which have similar expression as the building across the motorway. The frames are dark grey and are expressed in a continuous rhythm. The curtain walls contribute to flexibility as a quality since they can be replaced with other materials after some years without affecting the structure. The façade is covered with vertical copper shading fins.

Research wing is clad with sandwich panels, consisting of steel sheets and insulation in the middle. The panels are particularly suitable for clean-room applications. [ruukki.com, 2016]. East and west walls are covered with boards of bright and rough texture, whilst north and south walls are covered with polished black panels on the exterior. East and west walls are covered with horizontal copper shading.

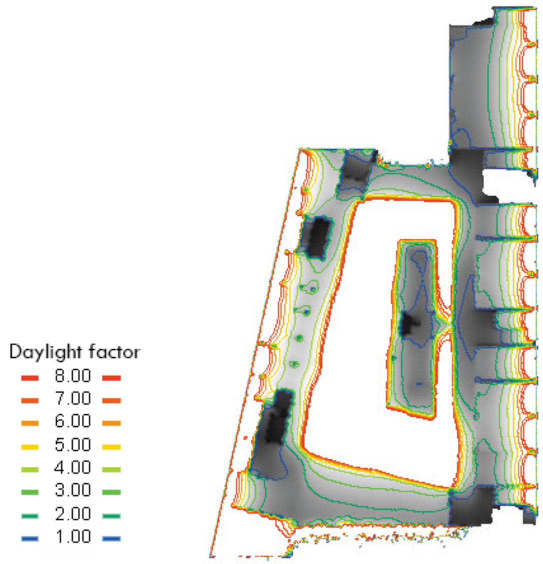
INTERIOR

Railings along interior bridges and edges between offices and the atrium are made of perforated copper sheets. The application of the same material becomes a dominant feature merging all parts of the building inside. Walls and ceilings are painted white in order to reflect light and appear neutral.

OTHER TECHNICAL PARAMETERS



Ill. 50// Heat exchange diagram



Ill. 51// Daylight diagram

HEAT LOAD

Research and manufacturing rooms for nanotechnologies require a lot of equipment. The appliances are of diferrent purposes and a lot of them have high power load, therefore emit a lot of heat into the air. The equipment varies from computers and microscopes to microwave ovens, autoclaves, rapid processing ovens and even furnaces for smelting metals.

Since the indoor climate in research facilities needs to be tightly controlled, a lot of pressure is put on HVAC systems to keep constant temperatures. In order not to waste exhaust warm air, an example has been taken from Swedish town of Kiruna [Braw, 2015], where the excess heat produced in the mining factory is used to heat the town. Therefore the idea was to use heat produced in the research facilities to heat other parts of the building.

Since the processes in labs and cleanrooms may involve the use of hazardous materials and fumes, it is important to consider a method to prevent the air from cross-contamination. Therefore the choise was to use a passive regenerator as an air exchange unit. It is suitable for space heating and reliable at isolating separate air channels. [Pacific Gas and Electric Company, 1997)

DAYLIGHT

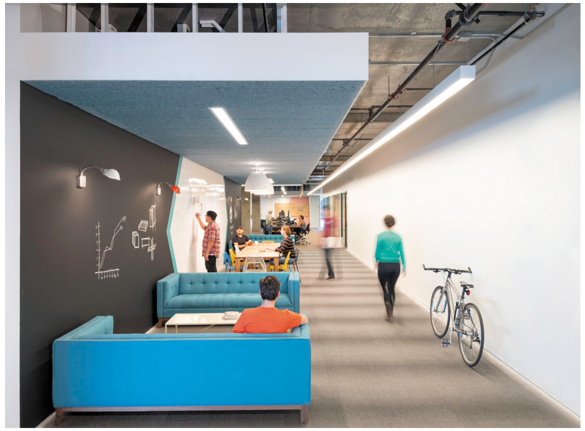
Analysis has been performed for the first floor as it was seen as the most critical one. As seen in the diagram, large amounts of daylight are around the openings and the atrium. The intension was to have at least 2% of daylight in offices. Lower values are around bathrooms, which are enclosed, corridor in the research wing and the center of the hub. Issues are seen in areas at the north part of the office wing as they are shaded by the building itself.

02
SITE ANALYSIS

CASE STUDY:
CISCO OFFICES

Ill. 52// Open flexible space

Ill. 53// Hub workspace



Ill. 54// Multiple interaction zones

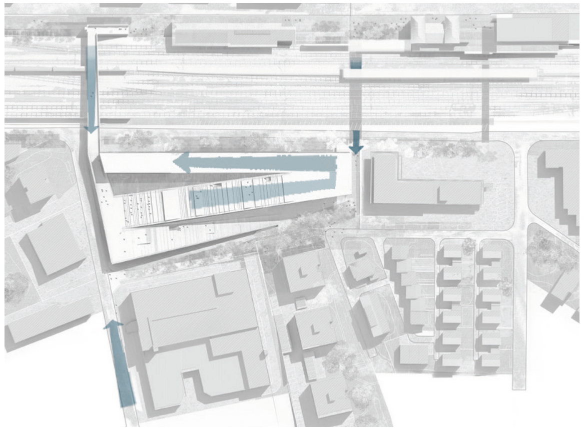
Cisco employees are increasingly mobile and spending less and less time at the particular work-space. Therefore new design scenario was made with mobility in mind and with implementation of certain wireless technologies ensures convenient work conditions through the all building.

The floor plan provides flexible places for spontaneous meetings ensuring sharing of ideas and communication. Cisco office doesn't have permanent assigned seating, which is empty most of the time. Due to this the building accommodates 140 employees instead of 88, which would be common case, thus reducing real estate costs. Furthermore, flexible open office spaces requires less cabling and furniture witch is one of the most expensive components.

This study proves to be relevant for our case because open office space turns out to have more tectonic quality and makes pleasant working environment. On the downside some employees might feel distracted in a big common space office, thus quiet zones and smaller hubs should also be considered. As it depends on the personal preference, some people like to settle down in fixed place, so permanent places for working also should be included. [Cisco, 2016; ArchDaily, 2014]

CASE STUDY: SUPSI CAMPUS

Ill. 55// Exterior perspective



Ill. 56// Flow diagram

Ill. 57// Railway

SUPSI (La Scuola Universitaria Professionale Della Svizzera Italiana) is an institute of applied science in Mendrisio, Switzerland to which Kengo Kuma and Studio d`Architettura Martino Pedrozzi have designed an addition.

The location is near the railway, therefore infrastructure is an issue and it limits people's flows as it results in a barrier in the city. There is an underground crossing to the East of the building and a bridge crossing to the West of the building. The structure is supposed to be not only the building itself but also a part of landscape and infrastructure as it connects and links both railway crossings at different levels, connects 2 pats of the city and also contributes being a public outdoor space itself. Movements and flows are the main design drivers, what makes the building well integrated into the landscape.

The campus should have large areas of glazing providing sufficient amount of natural light solar gain. Simultaneously it has good thermal insulation, which is important as Swiss winters tend to get cold.

The solutions for the site problem of obstructed people's flows and integration into the landscape is a good example for the R&D project as the motorway and generates similar problems as the railway does. [ArchDaily, 2013]

ABOUT AMSTERDAM

Ill. 58//Amsterdam

Amsterdam is the capital city of the Netherlands. The population of the city exceeds 830000 people while the area is 220 sq.km, hence the density is high. Amsterdam is a very popular tourist destination attracting more than 4.5 million people each year. [Amsterdam.info, 2016]

EDUCATION

The are two main universities, University of Amsterdam (UvA) and Vrije Universiteit (VU) that constitute the basis for the higher education system in various fields, focus on research and offer doctoral degrees. They have good rankings and compete with the best world's universities. There are also other educational institutions more specialized to a special field that only provide bachelor's and master's degrees. [iamsterdam.com, 2016]

ARCHITECTURE

The city has a network canals which have long been an important part of city's planning and served multiple purposes: trade, transportation, water drainage and defense. Amsterdam has a large old town with many old buildings of which 6700 are listed as monuments. The oldest building is Oude Kirke and is of Gothic style. Amsterdam canal houses and their facades are probably the most unique pieces of architecture, which are also city's icons. [iamsterdam.com, 2016]

ECONOMY

Amsterdam is the financial capital of the country and is one of the most important financial centers in Europe. Biggest financial companies have been expanding and moving away from the city center. One of the areas is next to the Slotedijk station, which is only one metro station away from the site. Amsterdam port is one of the busiest in Europe and second biggest in the Netherlands. [iamsterdam.com, 2016]

INTRODUCTION TO NEIGHBOURHOOD

Ill. 59//District view

KOLENKITBUURT

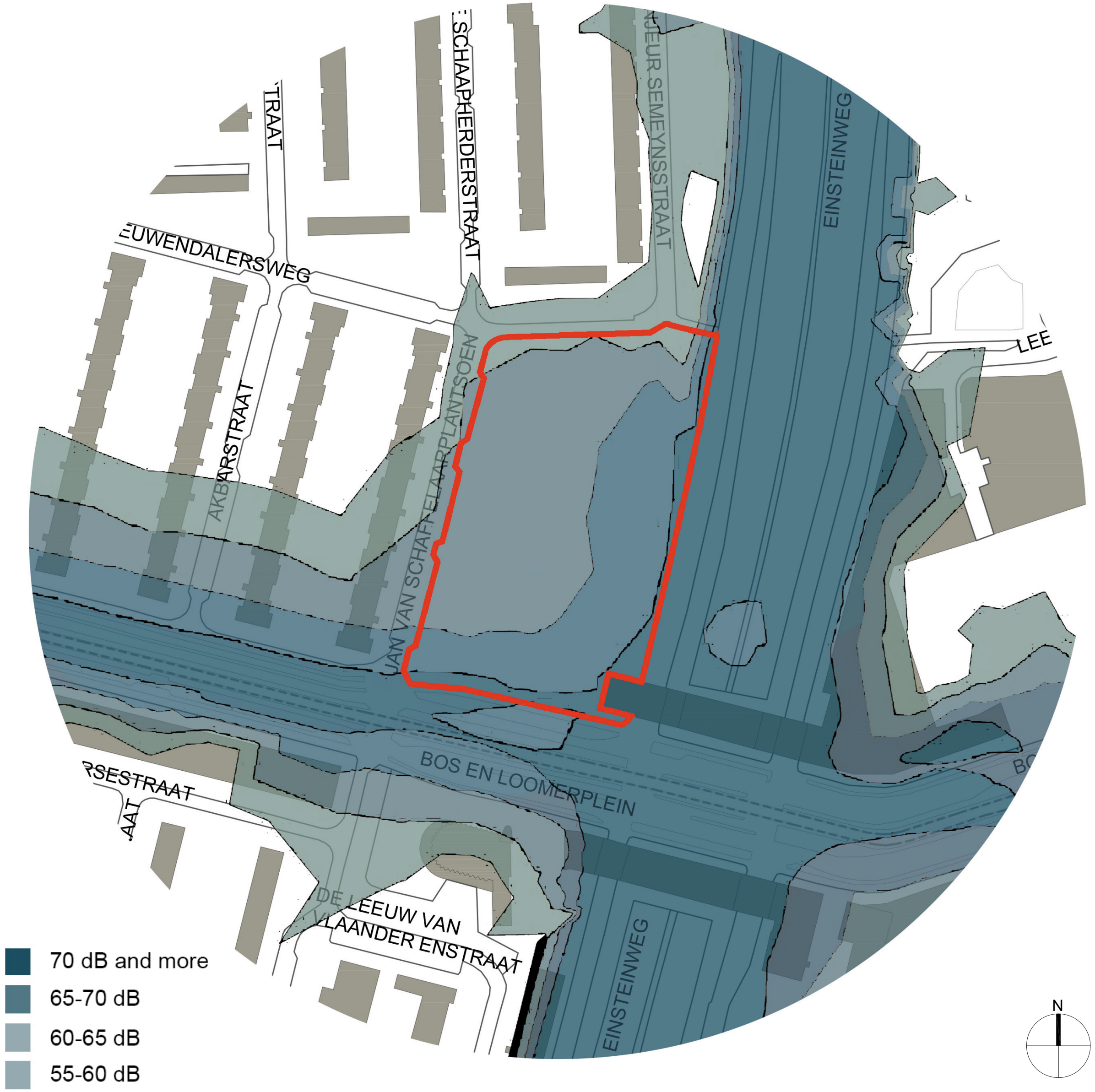
Kolenkitbuurt, the neighborhood to the East of the site has been named as the worst of "40 problem neighborhoods"[Expatica.com, 2016] of Amsterdam by the Housing minister. The area has a high unemployment rate and issues with security. Most of the residents have low income and the housing is predominantly occupied by immigrant families. The neighborhood is at risk of evolving into a ghetto. However, recently a group of artists and local enthusiasts supported by the local district council started carrying out projects for the community: urban gardening, communal cooking. The area mainly consists of 4-story blocks of apartments.

BOS EN LOMMER

Bos en Lommer is the neighborhood to the West of the site and the motorway. It has access to the A10 and is relatively close to the city center. Much like Kolenkitbuurt, the area mainly consists of 4-storey residential blocks oriented towards families with low rent rates. The neighborhood is located close to the city center. There is Bos en Lommerplein, a public square that hosts an outdoor market. There are a lot of green areas, of which the most notable one is Erasmuspark. [Iamsterdam.com, 2016]

NOISE POLUTION

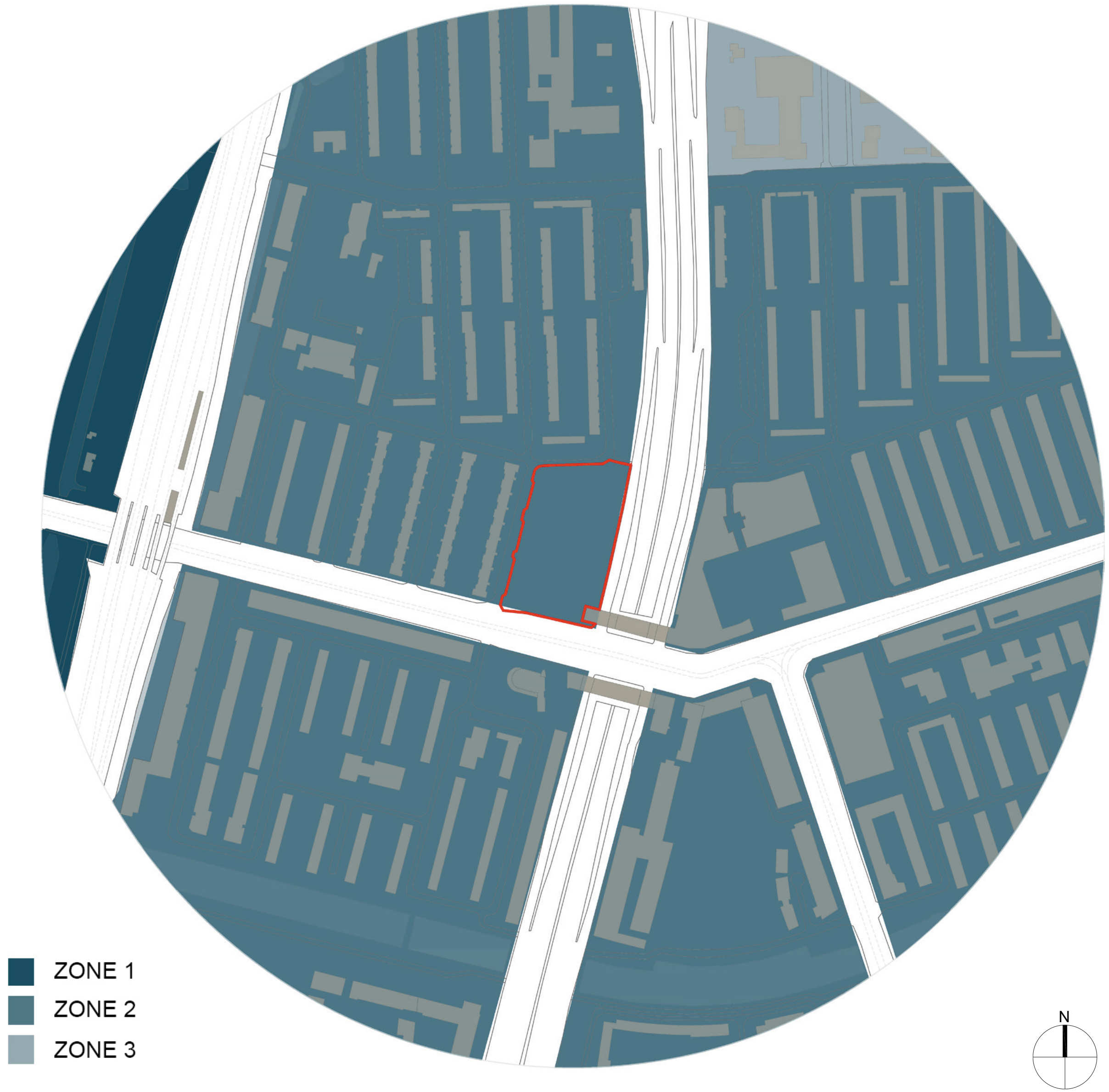
Since site is bordered by A10 Highway, noise pollution is a major problem. There are noise barriers installed which partly block the pollution but they Aare not sufficient in the area. Only day time noise levels are considered because they are most intense. As we can see from the diagram, all site area suffers from the noise up to 60-65db, and significant part of are is polluted by 65-70db noise. According to the Dutch law, the acceptable noise level in residential areas next to motorways are 59 dB and all new motorways have to be surrounded by walls. Therefore it will require a careful consideration to reduce the noise levels.
[Hiil.org, 2016]



Ill. 60//Noise pollution

SOIL CONDITIONS

The city is mostly below sea level, therefore ground conditions are often an issue. Soil quality zone map describes ground conditions in the city and it is categorized into 6 zones: the lower the zone number, the better the soil conditions are. The soil conditions in the site belongs to zone 2, therefore, according to the regulations, the ground conditions are good and almost any activity and construction may take place there. This is important to know since some functions of the complex might require a basement and an underground parking. [Gemeente Amsterdam, 2013]



Ill. 61//Soil conditions

SHADING

SHADING WINTER

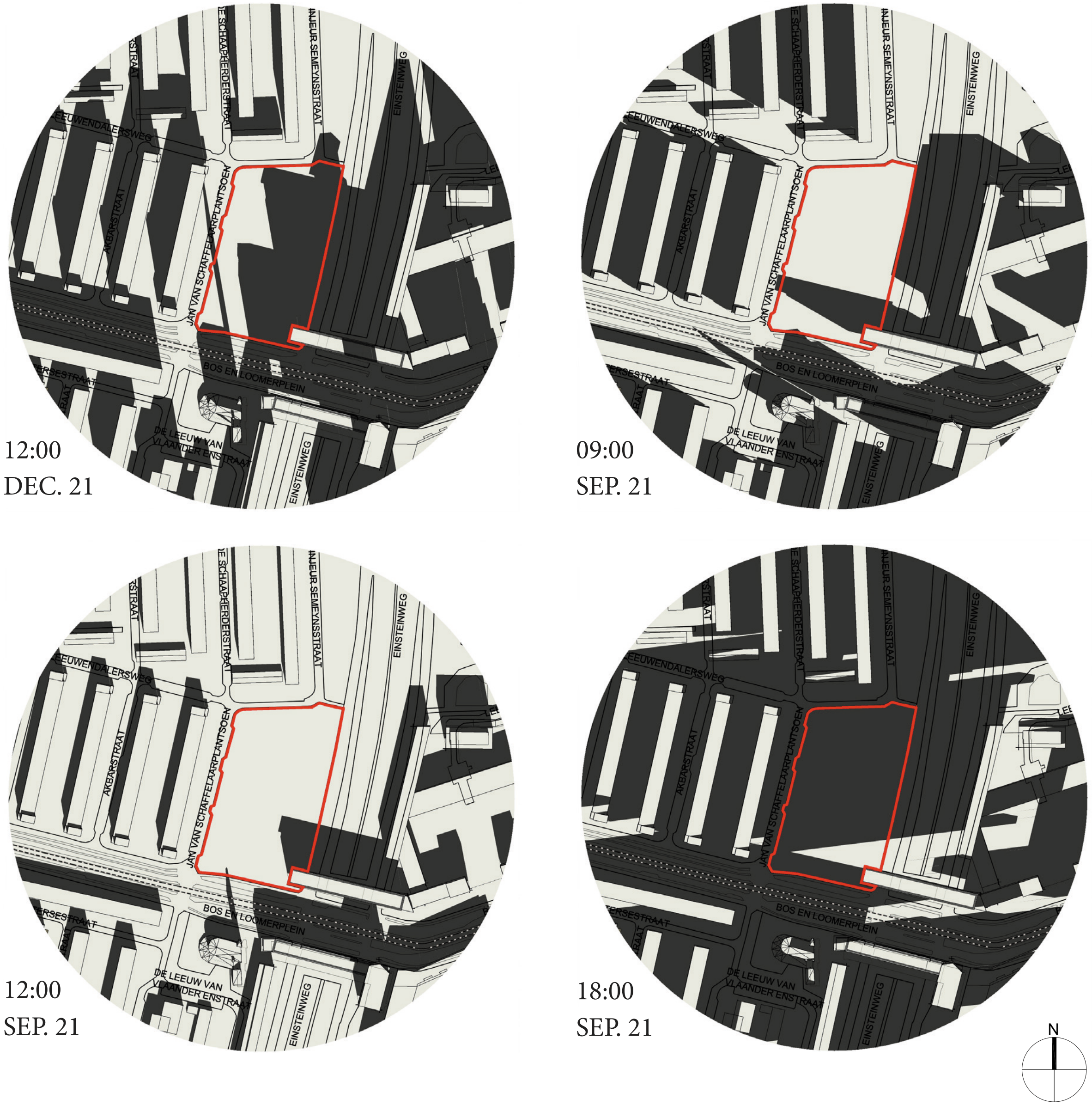
During winter solstice there is very little sun exposure on the site. The sun rises at 8.48 and sets at 16.29, and reaches the height of only 14 degrees and casts very long shadows. During almost entire day the site is covered in shade, only in the afternoon hours there is some direct light on the site.

SHADING EQUINOX

During equinox the sun rises at 7.27 and sets at 19.37, and reaches height of 38 degrees. The best sunlight conditions are met in the morning and at the mid-day, when the site is only partly shaded from the building in a south-east. Only southern part is affected, while the rest of the site stays shadeless. Later, at 4pm the shade from the wester building enters the site.

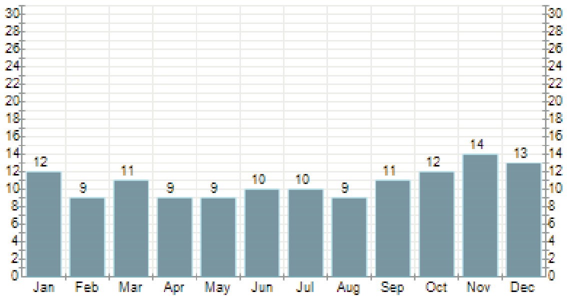
SHADING SUMMER

During summertime the site is lit very well. There are no obstacles to cast a shadow. On the day of summer solstice, the sun rises at 05:18 and sets at 22:07and reaches the height of 60 degrees. Thus the site is lit the whole day.



Ill. 62//Shading

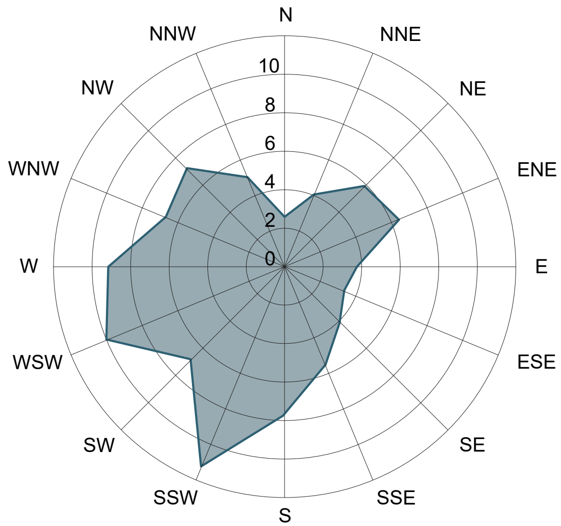
PRECIPITATION



Ill. 63//Precipitation

In northern Holland precipitation is very common through the all course of year. Every month 9-14days of rain could be expected. Most rainy days occurs from October to January (12-14 per month) November is most humid with 14 rainy days. Spring and summer seasons are a bit less rainy and has 9-11 rainy days per month. [yr.no, 2016] Therefore it is safe to assume that the climate is rather wet in the area.

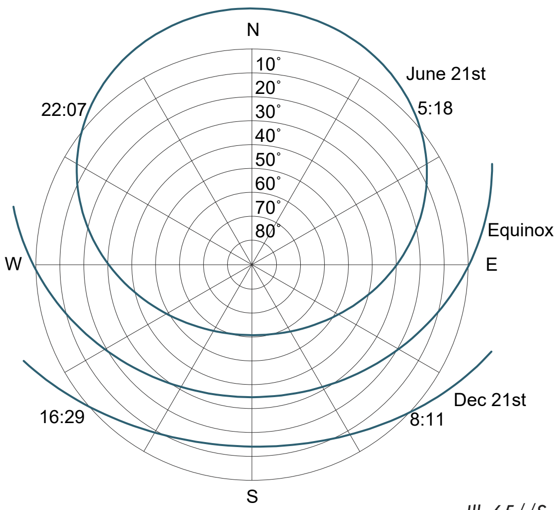
WIND CONDITIONS



Ill. 64//Wind

Picture above provides information about wind statistics registered in Amsterdam-Schiphol Airport, Northern Holland, Netherlands, which is 7,5km from the site. The strong winds in Amsterdam usually come from south-west direction. Average Wind speed reaches up to 20km/h. In the South-Southwest direction site meets Bos en Lommerweg street with low height building, which provides some wind tunneling. Buildings should be planed accordingly to block the wind and prevent drafting into the site. Dominating wind direction should also influence natural ventilation decisions.

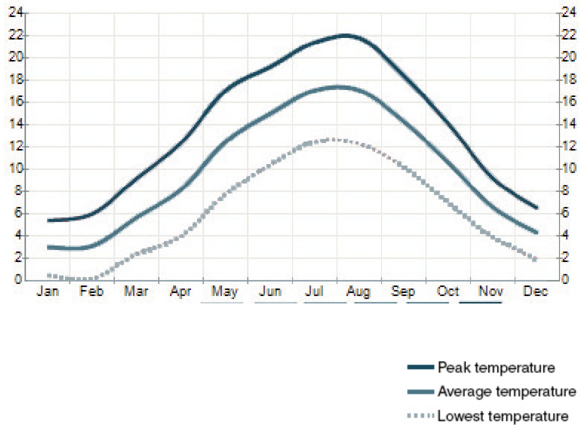
SUN PATH



Ill. 65//Sun

The sun path diagram shows the path of the sun on the shortest and longest day of year, and on equinox. The length of the day varies significantly over the course of the year. The shortest day is December 21st: 7:42 hours of daylight; the longest day is June 21th: 16:49 hours of daylight. [Gaisma.com, 2016] Therefore the prediction is that the site is at risk of having a lack of sun in winter and a surplus of sun in the summer. Those aspects will be included into design considerations.

TEMPERATURE



Ill. 66//Temperature

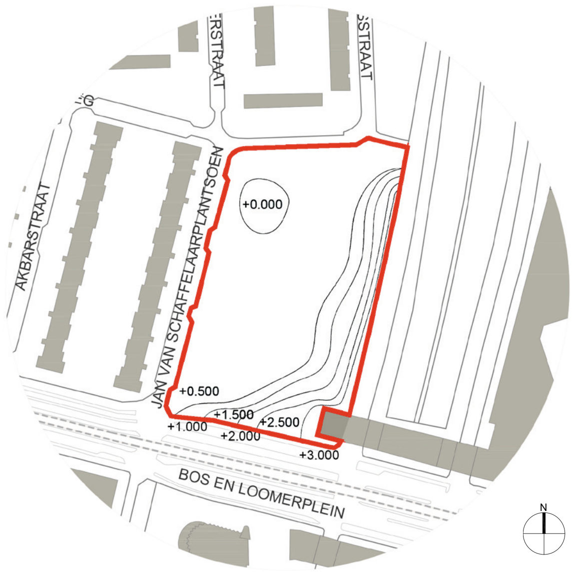
Over the course of a year the usual average temperature varies between 5 degrees Celsius in January and February to 20 degrees Celsius in July and August and doesn't change drastically. Overall average yearly temperature is 12 degrees Celsius. [yr.no, 2016] This proves that it is rather mild there without major fluctuations.

GREENERY

Ill. 67//Map

Currently the site is vacant, thus almost entirely covered in grass. Despite that, the area is not very attractive, and the greenery is wild. There are two parks (Gerbrandypark and Erasmuspark) nearby, approximately 500m away from the site to the South-East and South-West. Between the surrounding buildings there are semi-private common green plots separating parallel buildings. The aspect of having those plots will be considered when designing outdoor areas.

TERRAIN



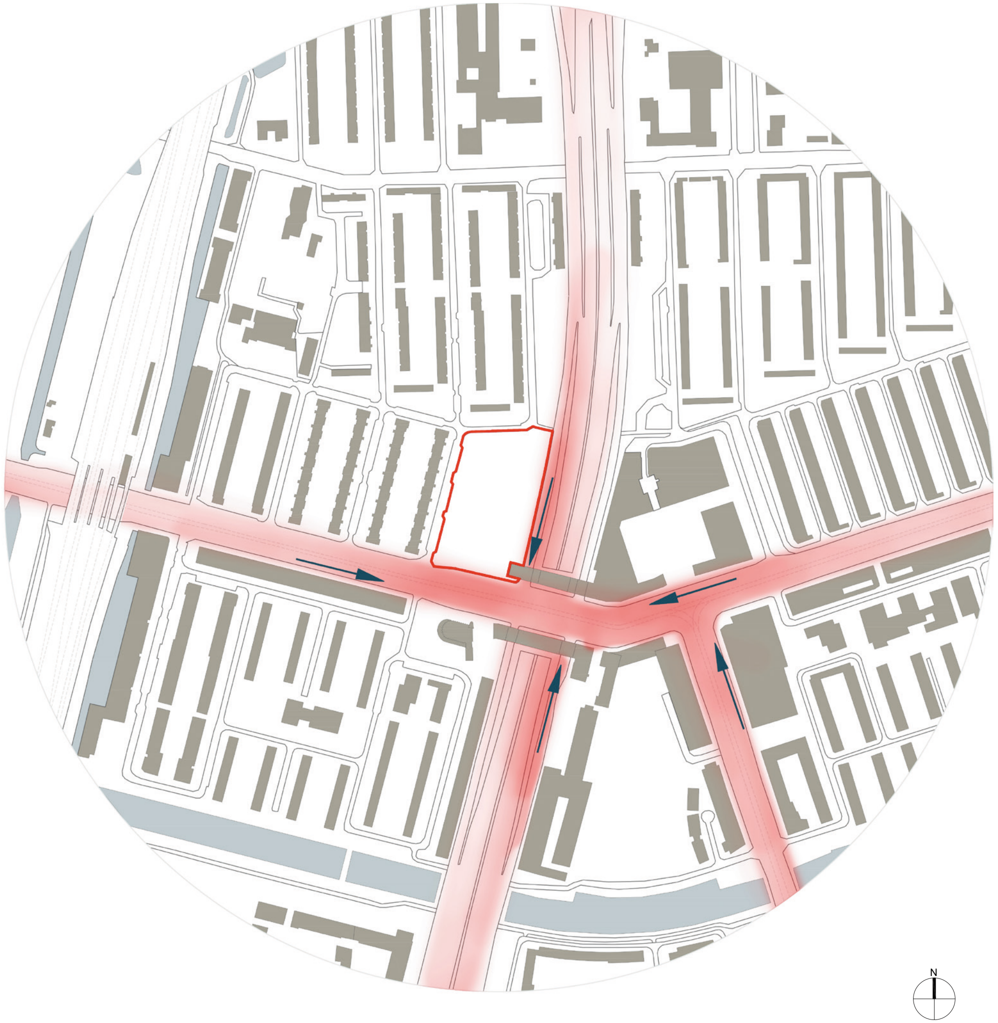
Ill. 68//Terrain

The site has a slope of 3-4m difference through the site. The Highest point is in the east part, near the A10 motorway. The level there drops suddenly, and later evens out. The lowest point is in the middle of the site. Despite big slope in the east part, the rest of the site is rather even. The architectural aim will be to integrate the complex into the existing landscape.

ACCESS

CARS

The A10 ring road is a major transport artery of Amsterdam. It is a bypass motorway around the city which connects 5 other motorways. The motorway has a speed limit of 80km/h, therefore generates a lot of noise. The A10 has 19 exits to the city of which one is located next to the site. The ring road exits to Bos en Lommerweg, a busy 4-lane street running East to West and on the North edge of the site. Since the A10 creates a separation in the area, the street is an important place to cross the motorway. This transport hub assures convenient access for vehicles.

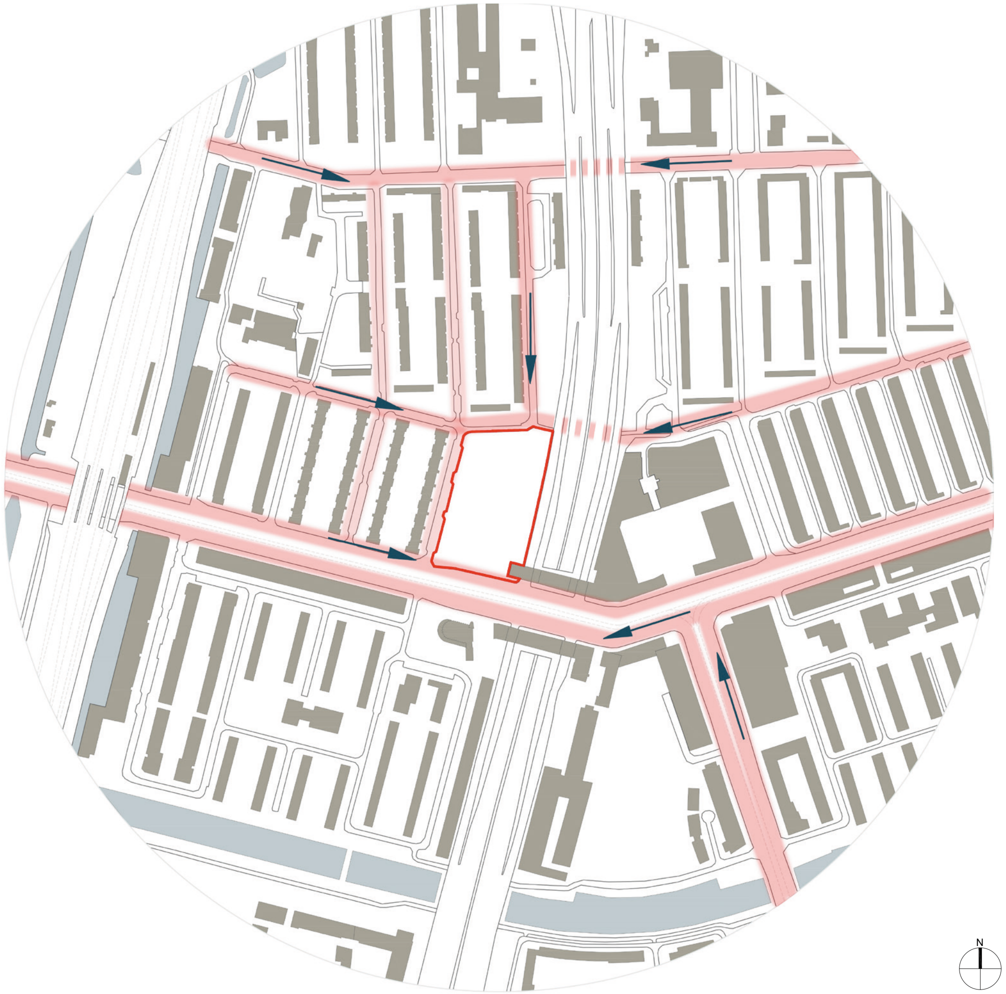


Ill. 69//Map

ACCESS

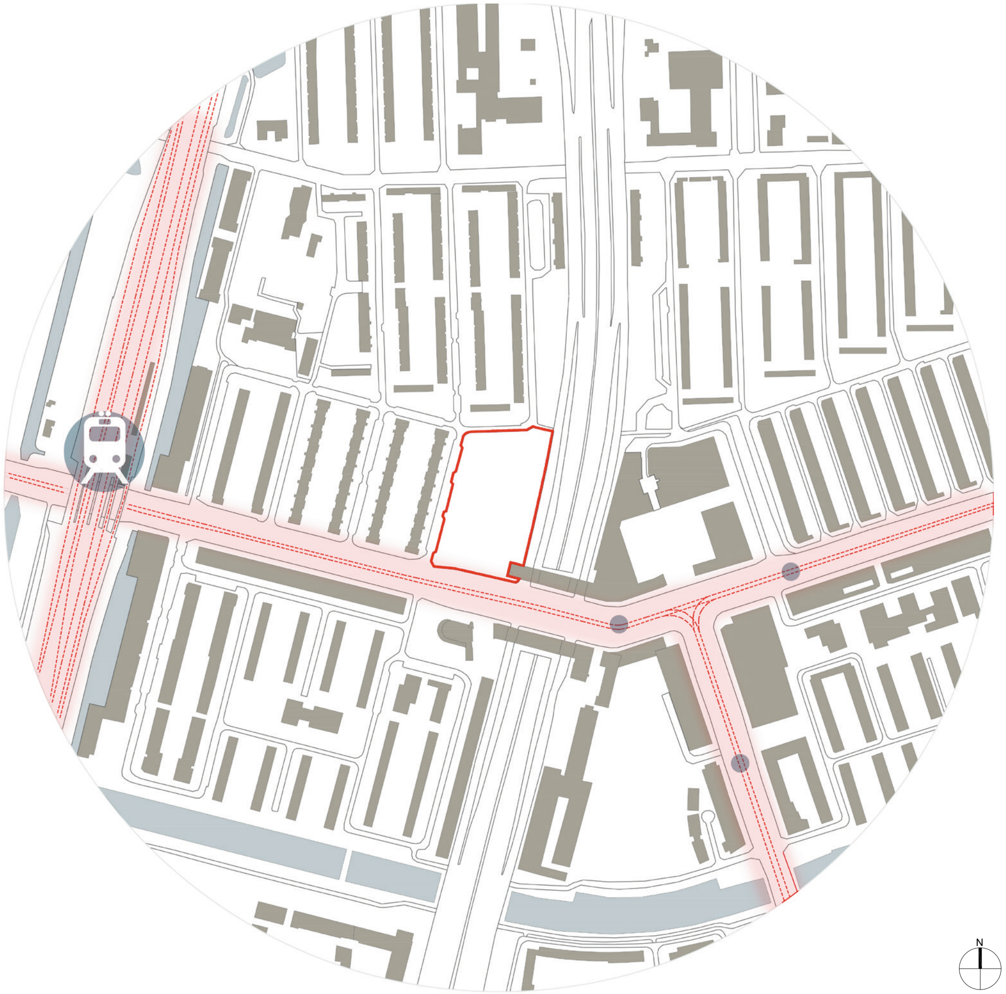
BICYCLES

Bike paths run along Bos en Lommerweg and are a part of city’s infrastructure and cross the A10. Bicycles are allowed on streets in residential areas, but are forbidden to enter the motorway. There is a network of footpaths ensuring the pedestrian flow. However, there is a major intersection of Bos en Lommerweg and A10 with multiple exits and traffic lights, therefore it disturbs the consistency of pedestrian flow. Furthermore, there is a pedestrian tunnel under the motorway which is something opposite to a feeling of cosiness and security. [the Guardian, 2014]



Ill. 70//Map

ACCESS

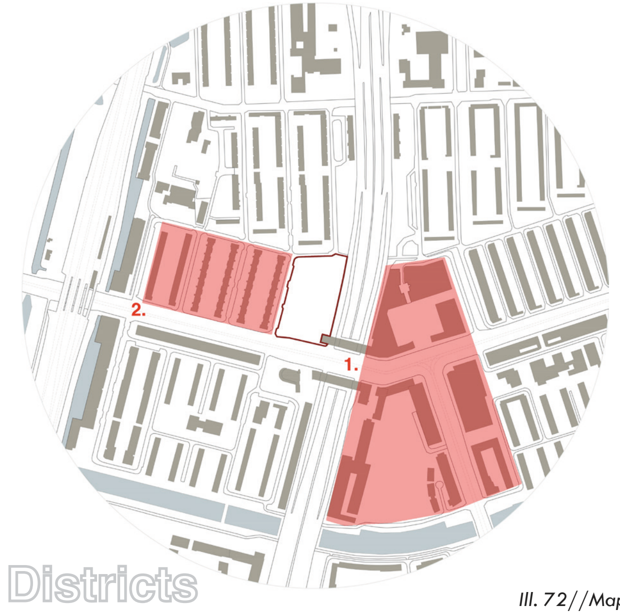


Ill. 71//Map

PUBLIC TRANSPORT

The site can be conveniently accessed via the public transport. Tram lines run along Bos en Lommerweg and the stops are a short walk from the site. Tram 7 connects the eastern and the western parts of Amsterdam while tram 14 rides to the city center. De Vlugtlaan metro station is 300 meters away. One of the main public transport hubs, Sloterdijk station, is only 1 metro station away, which allows to reach the airport in 15 minutes. There also 4 bus lines which connect to the outskirts of Amsterdam. [9292.nl, 2016]

PERCEPTION OF THE AREA



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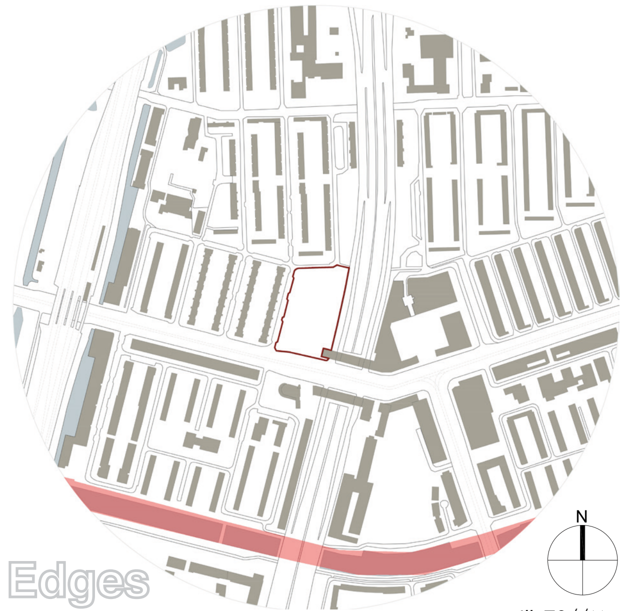


Ill. 73//Map

DISTRICTS

Districts are groups of elements that have a common character. They may also be medium– or large-sized landmarks that differ from the rest of context in two dimensions.

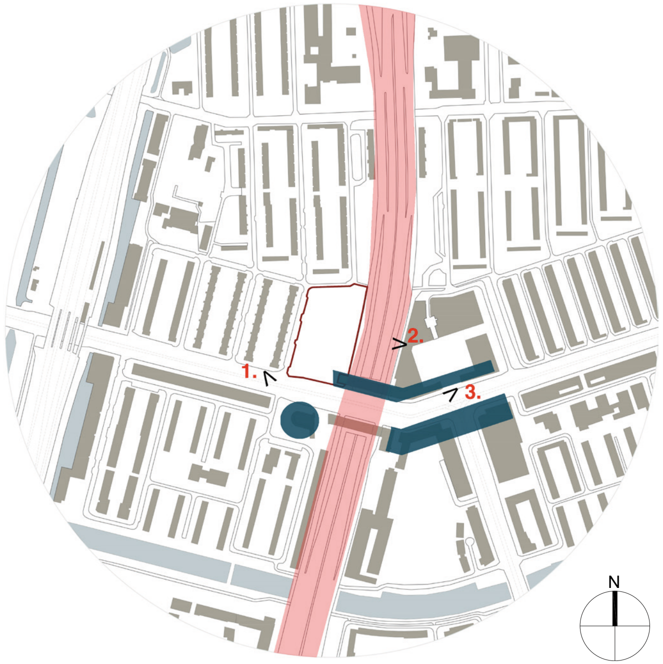
1) The cluster of buildings is different to the grid structure and the rest of residential buildings.
2) The 4-storey residential blocks are linear and there 2 types of gaps between them: either it is a road or it is a courtyard.

EGDES

Egdes are linear boundaries that are not paths. They often consist of water bodies, shores, walls or buildings.

1) Erasmusgracht does a curve, therefore does the impact on the grid of in the area.

PERCEPTION OF THE AREA



Ill. 74//Map

LANDMARKS

Landmarks are reference points in the area. They are different from other objects and contrast to the image of the area.

1) The church has a distinct character from the rest of the buildings in the area and has its own identity.
2) The motorway: a wide road and cars traveling at high speed, generating a lot of noise.
3) Buildings at the crossing of the motorway are higher than others and have a different character.

1

Ill. 75//View

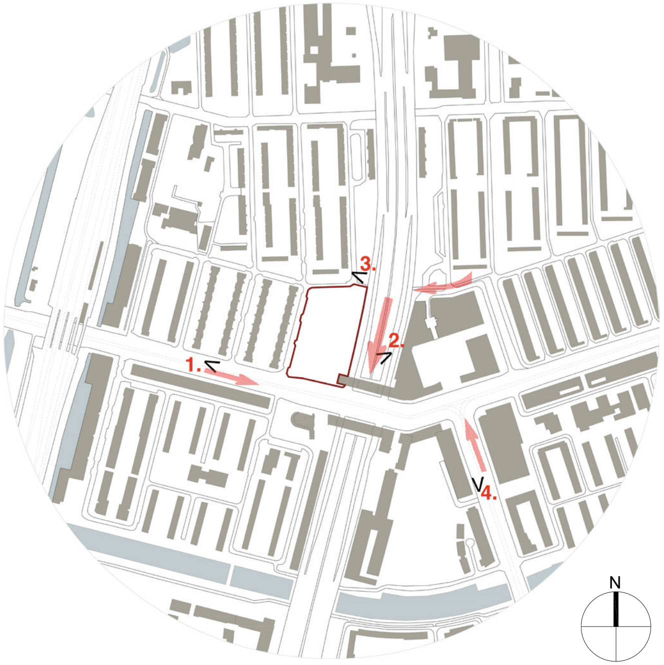
2

Ill. 76//View

3

Ill. 77//View

PERCEPTION OF THE AREA



III. 78//View

2

III. 80//View

3

III. 81//View

PATHS

Paths are channels the observers flow in. They are often influenced by the topography. A serious of images seen while traveling the path may constitute effects of sequences that one might associate with particular feeling. The observer's perception is also influenced by the wideness, narrowness of the path or by a sudden change of width.

1) Walking from the metro. Wide street, large gaps between buildings.
2) Arriving via the motorway. Noticing a building ahead across the A10 and the tunnel under it.
3) Arriving via Hoofweg. Crossing the Eramusgracht. Bumping into Bos en Lommerplein
4)Walking/cycling through the backs of stores, then passing under the motorway. Does not provide a cozy feeling.

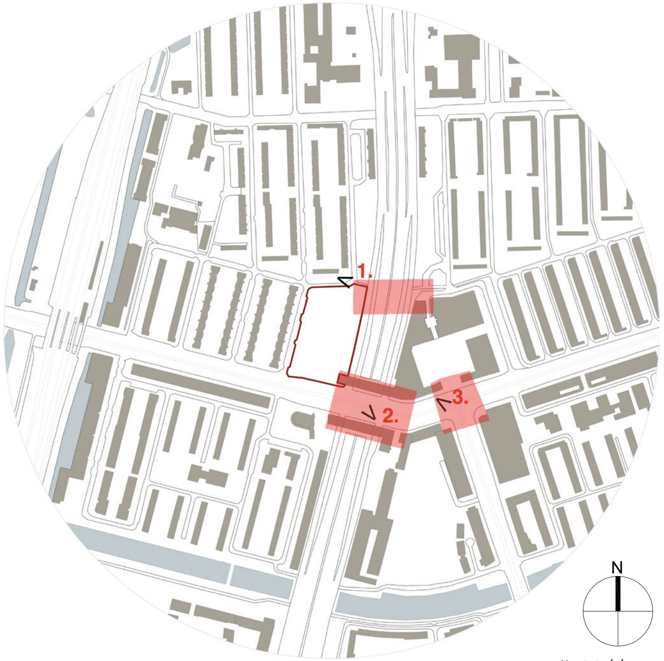
1

III. 79//View

4

III. 82//View

PERCEPTION OF THE AREA



Ill. 83//Map

1

Ill. 84//View

2

Ill. 85//View

3

Ill. 86//View

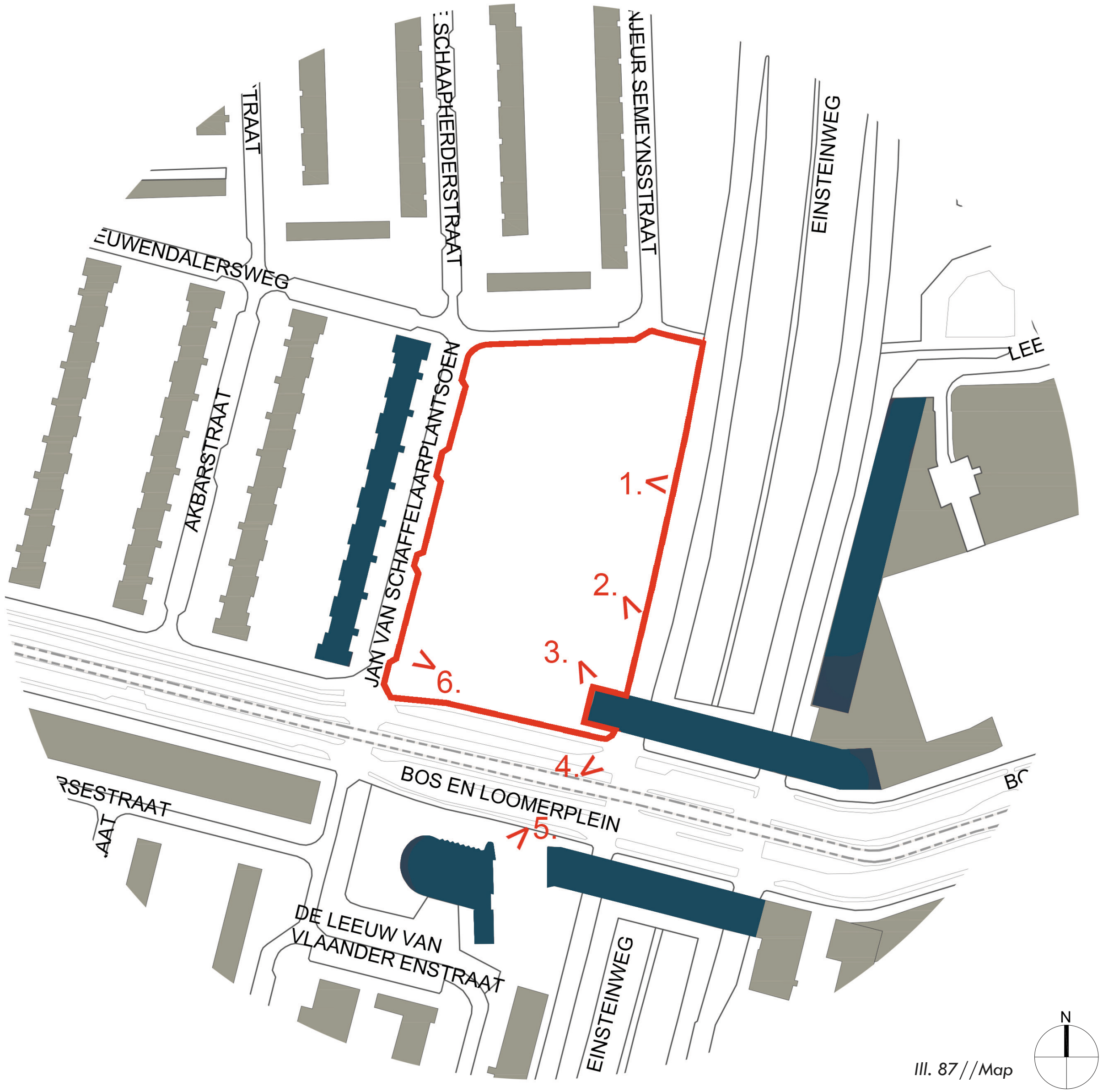
NODES

Nodes are intense intersection points or junctions where a transport flow breaks and one has a choice to move from one channel of flow to another. Those points often become focal points of areas.

1) The passage under the motorway is only for pedestrians and cyclists therefore the flow of vehiclesis interrupted.
2) There are 4 exits and entries to and from the motorway, which result in a double inter section with traffic lights. One might need to stop twice there, hence it might disturb and delay a journey.
3) The intersection where Bos en Lommerweg, Hoofweg and Bose n Lommerplein meet.

MATERIALITY & EXPRESSION

The site now is a vacant place. It used to be used as a parking, now there are some greenery inside, which is rather scattered. Surrounding buildings have diverse variety of materials and expression. There are some 4-storey apartment buildings built in the 1950's which have typical red brick facade material expression, so does the local church located in the southern part, across the street. In the east and south-east we have more recent buildings with modern facade expressions, and different materiality, in which the glass aluminum and copper are the dominant ones. There are more recent brick buildings as well, which have more modern, darker brick facades. All in all, there are significant variety of materials, and combinations in the neighborhood which will be used as a reference to design a building for this particular context.



Ill. 87//Map

MATERIALITY
& EXPRESSION


Ill. 88//View


Ill. 89//View

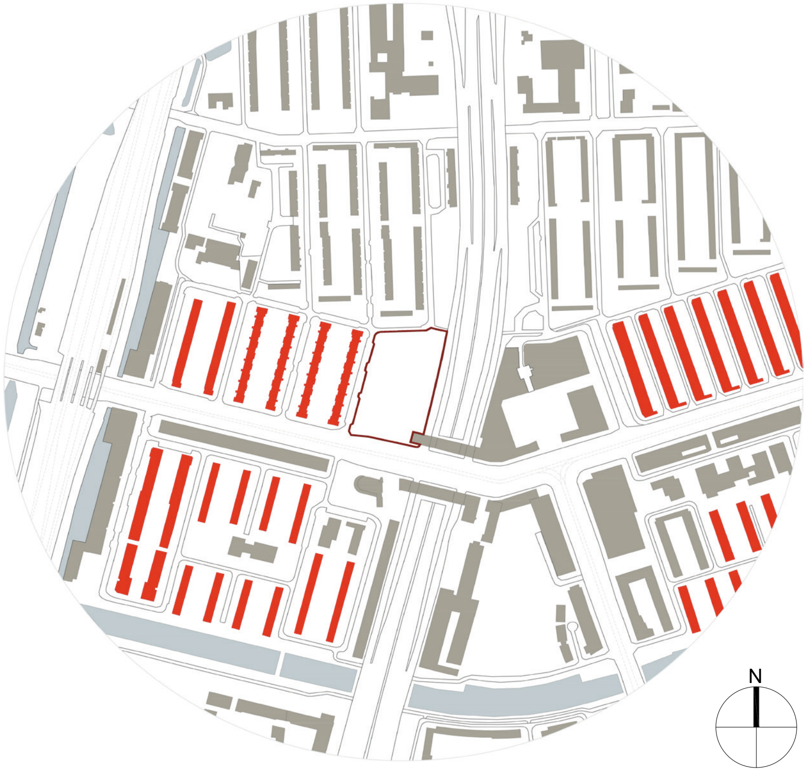

Ill. 90//View


Ill. 91//View


Ill. 92//View


Ill. 93//View

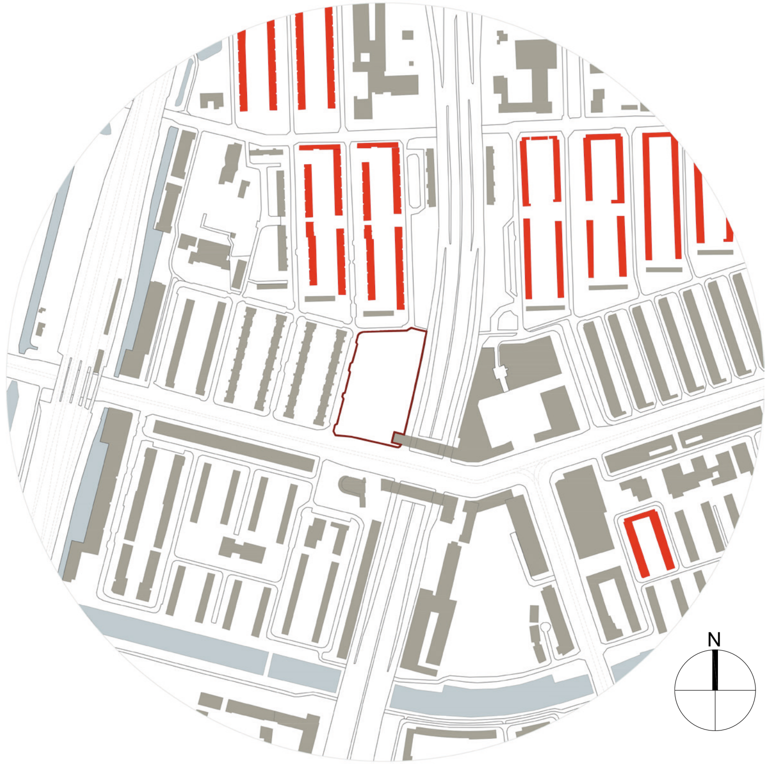
URBAN STRUCTURE



PARALLEL BLOCKS

Ill. 94//Map

The most common building type in the area is a 4-storey block of apartments. Some of them are longitudinal and juxtaposed parallel to each other. 2 blocks share 1 common outdoor space, which is visually open (transparent) but most of them have controlled access.

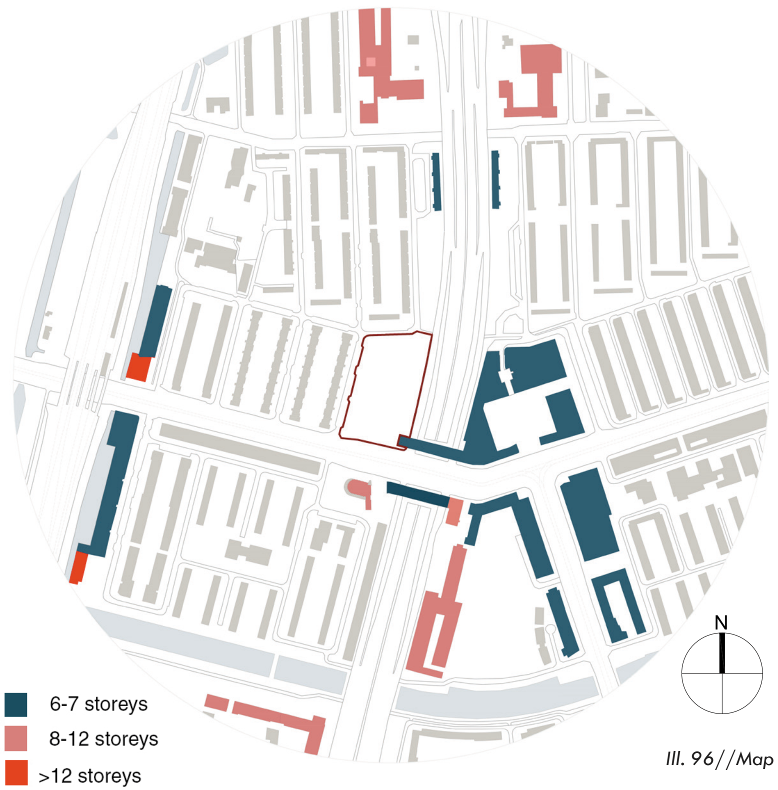


U-SHAPED BLOCKS

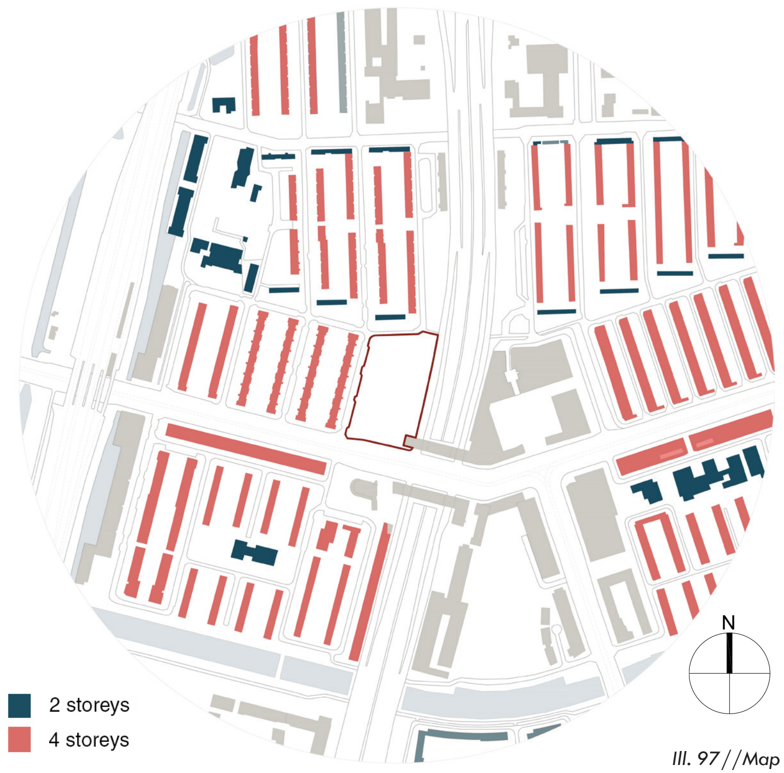
Ill. 95//Map

Some buildings of the same type have different arrangement – U-shape. They also share semi-public outdoor spaces but they are visually enclosed and have controlled access. The types of outdoor spaces will be considered when deciding upon the outdoor space for the R&D complex.

BUILDING HEIGHTS



Ill. 96//Map



Ill. 97//Map

High-rise buildings in Amsterdam are mostly allocated around highways. To the West of the A10 the recommendation is to build 30-60 meters high. Furthermore, the city council is encouraging to have transparent facades to force buildings' interaction with the street. [Amsterdam Gemeente, 2011]

The area is dominated by 4-storey apartment blocks. Some secondary structures are there to support them with communal areas and they are typically of a lower height.

ACTIVITIES IN THE AREA

Along the Bos en Lommerweg there are mainly retail facilities and a few civic amenities. To the both sides of this street there are 4-storey residential blocks. A fitness club and a few offices are where the street is crossing the motorway. Most of the offices are located next to Sloterdijk station, one metro station away from the area to the North. The square of Bos en Lommerplein has restaurants, a market, post office, municipality office and a library. There is a church across the Bos en Lommerweg from the site. An R&D facility will blend well into the site since it is next to a cluster of various functions. [Haan, 2016]

Ill. 98//Map

CONCLUSION FOR SITE ANALYSIS

Since Kolenkitbuurt is named as the most problematic neighborhood in the city, it is important to take measures to increase security in the area. As most of surrounding blocks have common green plots, the aim will be to create a public or semi-public space. The characteristic landscape will be addressed by integrating the R&D complex into the terrain. The occurrence of wind tunnels will have to be dealt with by providing shielding. It is also important to block the noise coming from the motorway. Pedestrian access through the tunnel under the A10 will be intended to improve. Local materials such as red bricks, glass and cladding will also be addressed when choosing materials for the new complex.

03
THEME ANALYSIS

DESIGN APPROACH

TECTONICS

Generally speaking, the notion of tectonics is a term to define good architectural quality. Traditionally it is known as a poetic potential of a structure, a combination of rational and artistic aspects. The structure is used to generate an image to create an atmosphere. [Frampton and Cava, 1995].

Gottfried Semper has outlined the 4 elements that define architecture: mould, enclosure, hearth and roof. Raising environmental concerns of short buildings' lifespan bring new trends of making buildings and structures flexible in order to provide them with opportunities to be changed and reused. [Rassia and Pardalos, n.d.] Hence it conflicts now with this notion [Semper, 1989] that enclosure and roof are inseparable parts of a building. Nowadays building envelopes can be replaced without major difficulties, therefore flexible and self-supporting structure becomes the point of interest. However, architectural principles outlined by Vitruvius - Firmitas, Utilitas, Venustas (strength, utility and beauty) and their interdependency [Vitruvius Pollio. et al., 1969] still apply nowadays.

Inventions of new materials and change of fabrication and design methods lead into new discussions about tectonics. Previously tectonics were mostly associated with wood and its crafting. Today, however, processes include CAD and CAM, and material choice is highly influenced by the impact of their life cycle. [Beim et al., 2014] Furthermore, tectonic principles do not solely apply for the structure but for the homogeneous whole of architecture, landscape, materials and details. Frascari's notion that details should tell about themselves are still relevant for the clear expression of a structure [Frascari, 1984]. This is an important aspect that provides a feeling of safety and comfort, proving that the structure complies with the laws of physics.

Although previously construction highly depended on craftsmen who were shaping local identities, nowadays the processes became more international and versatile. This is however an acceptable approach for a R&D center to which international aspects are important. The integrated process of design and modern tools allow to consider more aspects at earlier design changes, therefore they can be controlled and managed by one person or one party. This brings us back to the notion of a master builder.

SUSTAINABILITY

Lately sustainability has become an architectural quality with the aim to control impact on future generations. Being grouped into 3 categories, (Social, Environmental and Economic), in architecture it is often associated with low energy consumption, safe and healthy environment, and affordability [Thwink.org, 2016]. Therefore it is important to know that it does not occur by simply adding extra layers of insulation and mounting solar panels after the design is finished. Instead, careful considerations at early stages are crucial.

Environmental sustainable qualities can be achieved by choosing right materials, assessing their life cycle impact, carbon footprint, and implementing strategies to minimize energy consumption and extend building's lifespan [Le Dreau, 2015]. The reason why those aspects need to be reflected at early stages are that some of the problems might be fixed via the design without using any extra features. This would help to bring down the cost and benefit for the economy. Positive atmospheric qualities would improve people's well-being and increase productivity.

However, having considered the building's program, it became apparent that some laboratories and cleanrooms use equipment that generates heat and requires tight climatic control, therefore an increased energy consumption is expected there. Nevertheless, sustainability is a very broad term and includes a lot of aspects but the focus point of this project will be to implement a flexible structure in case the building needs to change its purpose in the future to be adapted.

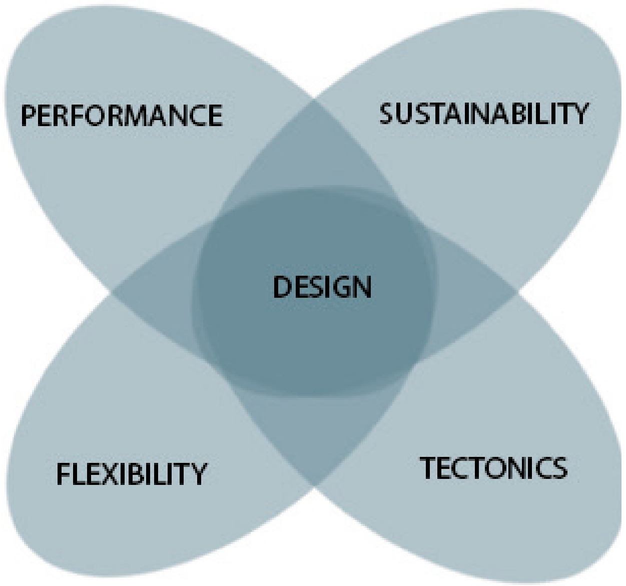
COMBINED APPROACH

Needless to say that present day demands are different than the ones in the past, architects are forced to investigate for new ways to approach the design. Both tectonics and sustainability are important qualities of a building. A design cannot be of a good quality without one of the aspects. Moreover, both are driven by natural phenomena: tectonics by gravity and sustainability - by climate.

Tectonics can be used as an efficient way to utilize materials. Minimized material consumption reduces negative impact on the environment. A structure may be a part of positive atmosphere a building provides and help to maintain building users' well-being, hence it contributes to social sustainability.

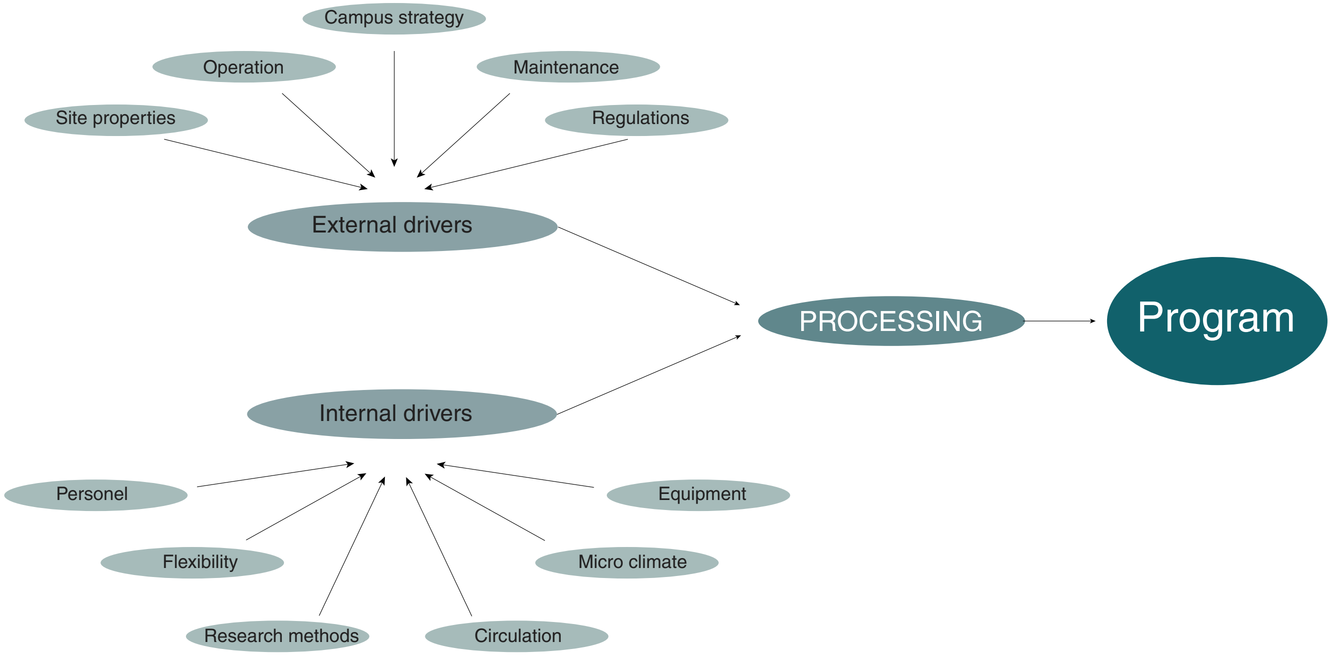
Consideration for an ability to adapt the building for different users and functions may help to prolong building's life span. Hence flexibility becomes a design parameter. Moreover, the structure of a building should be clear in order to help the user to discover building's potential. [Bech-Danielsen et al., 2012]

At the same time quality and performance deserve as much attention. Research facility should provide good and stable environment, and should meet tight regulations. Thus it should be designed with a special attention towards maintaining the highest quality of work possible by assuring good working conditions.



Ill. 99// Design diagram

PROGRAMMING PROCESS



Ill. 100// Programming diagram

Programs in research institutions are driven by external and internal influences. Each party and stakeholder has specific needs and requirements, therefore it is important to gather information from each team to get a good understanding what each group is seeking for. Afterwards a special approach is needed to process the gathered information, hence classification is needed. [Watch, 2001]

PROGRAM ORGANIZATION

Different parties (researchers, government, contractors, users etc.) have different interests and preferences in the project. Those factors can be classified into 2 categories: external drivers and internal drivers, which then have to be synthesized. Furthermore, room programs of research institutes are often subdivided into 5 categories: office administration, program support, research labs, core labs and building support. [Watch, 2001]

OFFICES AND ADMINISTRATION

When arranging plans for this type of rooms, it is important to know how the work is organized: should it be organized according to teams, departments or have a matrix organization. Since the aim is to design a flexible place and promote interdisciplinary collaboration and communication between scientists, students and companies. Therefore, the aim is to propose and open-plan office, which are typically dimensioned 6 sq. m per person. The recommended floor heights are 2,9-3,4 m. [Braun, Grömling and Bleher, 2005]

PROGRAM SUPPORT

This category describes spaces that provide connections among researchers and, more importantly, their work. Those include libraries, lecture halls, meeting rooms etc., also common areas and lounges which offer space for informal discussions. [Watch, 2001]

RESEARCH LABS

This category includes labs that are open and flexible, and lab-support areas. The spaces are sized according to the discipline research they are used for. To achieve efficient solutions and avoid unused space, labs are typically designed according to a grid. Its recommended width is set by the distance between the centers of construction elements, which is 6,9 meters. Lab's depth ranges between 6 and 10 meters, but should correspond to a lab unit, which is approx. 1,2 meters. Approximately they are calculated to be built 10-12 sq.m per person. The recommended floor heights are 3,8-4,1 m. [Braun, Grömling and Bleher, 2005]

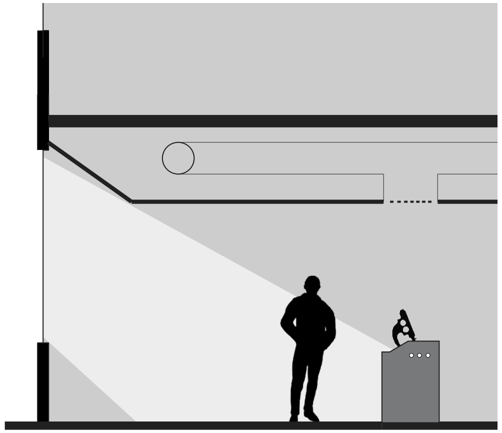
CORE LABS

Those are often shared resources of the building since they are complicated to establish and they have expensive equipment. The facilities may also be used by someone who does not work in the building. With regards of this project, cleanrooms would fall into this category since they are essential for nano-centers. [Watch, 2001]

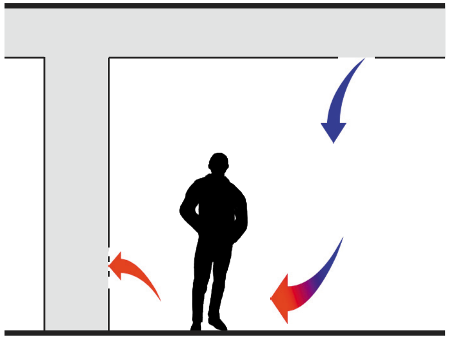
BUILDING SUPPORT

Building support part consists of bathrooms, stockrooms, loading areas, security, IT department, waste management, storage, maintenance etc. It is important to decide upon a system of arrangement of services, should they be organized in cores and distributed under the ceiling or in individual shafts. Furthermore, most of the service rooms (water cooling plant, backup power room etc.) are placed in the basement. [Watch, 2001]

DESIGN PARAMETERS



Ill. 101// Daylight diagram



Ill. 102// Ventilation diagram

DAYLIGHT

Good lighting conditions are important for the workers to ensure comfortable working environment. As a matter of fact, daylighting is a more sustainable solution than artificial lighting, therefore its use should be maximized. A design solution as a part of an early design consideration can be the utilization of the interstitial layer around windows to increase the floor-to-ceiling height as the natural light can reach deeper into the room. Considerations are also needed with regards of direct sunlight and possible occurrence of glare. [NREL, 2003] However, it is important to have a good daylight factor and it should not fall below 2%. [Becker, 2015] This will be considered when choosing building's depth.

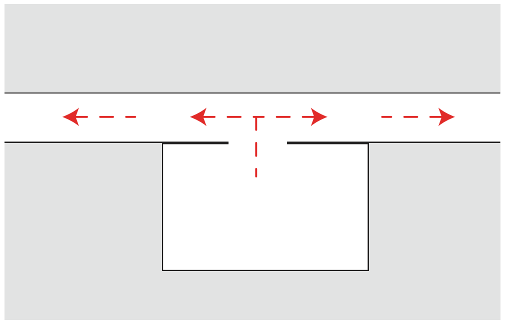
VENTILATION

A major challenge is ventilation. Labs and cleanrooms require good air change for extraction of hazardous fumes and controlling indoor climate (temperature and humidity). What makes it even a bigger challenge is that equipment generates a lot of heat. Therefore, it is recommended to segregate mini-areas that require intense temperature control. Furthermore, constant use air conditioning is not an efficient method. It is however recommended to install a Variable-Air-Volume (VAV), a more efficient HVAC system that is able to supply air at variable temperatures according to occupied and unoccupied modes. Moreover, it is also recommended to employ a heat recovery system, facades have to be equipped with exterior solar shading devices, use of thermal mass principles and ensuring night cooling. [Braun, Grömling and Bleher, 2005] [LABS FOR THE 21ST CENTURY, 2016]

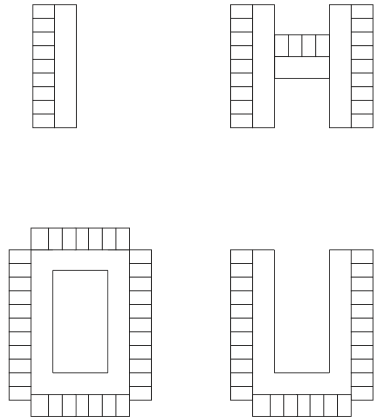
Normally in labs air supply is lower than extraction, causing negative pressure inside. Lower pressure helps to stop from spreading contaminants around the building. On the contrary, cleanrooms have positive air pressure inside in order to keep the inside out of contaminants. Moreover, the requirements for storage of chemicals differ. Cabinets for corrosive materials should be vented while cabinets for flammable liquids should not. Furthermore, air change rate for offices is 0,5-4 times per hour, whereas cleanrooms require 50-600 times per hour. [Braun, Grömling and Bleher, 2005]

Furthermore, typically the air is supplied through the ceiling and extracted low in the walls. It is important to note that supply diffusers need space around them. Moreover, fume hoods must be placed away from doors so people entering are not directly exposed. [TSI, 2014]

DESIGN PARAMETERS



Ill. 103// Fire escape diagram



Ill. 104// Plans diagram

FIRE SAFETY

Fire safety is a major concern since some labs might be at an increased risk of fire. Escape distances vary and depend differently on each building type and a number of people that constitute the flow. However, there should be at least 2 directions for flight and the routes should be protected. Emergency exits should be kept clear; sliding and revolving doors are not allowed as they might not be reliable enough. [Vrom.bouwbesluit.com, 2016]

COMMUNICATION AND COMFORT

Good communication in a laboratory is essential part and has to be supported by the architecture measures that encourage opportunities to socialize and communicate. The layout clarity is necessary and an essential part of worker's comfort so they don't have to distract themselves and focus on their work to achieve successful results.

Visual aesthetic quality is also important. Too often lab buildings are designed only considering performance, and lacking architectural and visual quality, thus being depressing to work in. The design should merge performance and tectonic quality, which should contribute to the workers wellbeing and satisfaction. [Braun, Grömling and Bleher, 2005]

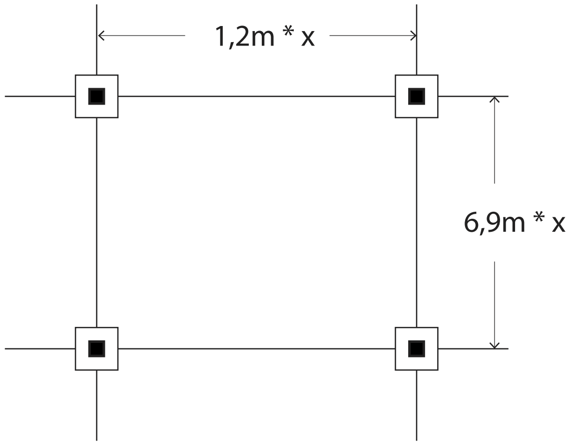
PROXIMITY OF OFFICE AND LABORATORY SPACES

These days, scientists spend about half day in a laboratory and another half in the office, where they document their research. Since this work flow is not linear, laboratory and office spaces are merging, creating new integrated structures. [Braun, Grömling and Bleher, 2005]

PLAN ARRANGEMENTS

Plans in research centers are normally arranged in 2 ways: either horizontally by zoning or vertically by stacking. It is a practical approach to have offices and labs in the same building. Hence there are a few popular approaches for room arrangements, such as linear, U-shaped, H-shaped, core-based etc. Site properties (noise from the motorway) signal that linear layout might be a good solution. Furthermore, it is important to make the building sub-divided into sections which later could be closed off for maintenance or reconstruction. [Braun, Grömling and Bleher, 2005]

DESIGN PARAMETERS



Ill. 105// Plans diagram

SERVICES

Services are a very important part in a R&D building, therefore it is important to choose a correct layout for them. They may be set up in cores or in individual shafts. Cores result in smaller plant rooms and in increased ceiling thickness. The benefits of individual shafts are that they can be shut for maintenance and lower required ceiling height. However, they take up a larger floor area and have a limit of height. [Watch, 2001]

DELIVERY AREAS

Delivery and loading areas will do a major impact on the design when the building is in operation. Those will be necessary in order to receive packages, of which come in large sizes, therefore require access for trucks. Typically, loading areas influence aesthetics negatively, hence they cannot be ignored.

FLEXIBILITY AND GRID STRUCTURE.

To achieve efficient solutions and avoid unused space, labs are typically designed according to a grid. Its recommended width is set by the distance between the centers of construction elements, which is 6,9 meters. Lab's depth ranges between 6 and 10 meters, but should correspond to a lab unit, which is approx. 1,2 meters, based on lab interior module. The use of the module makes it easier to rearrange spaces. The most common grid dimension is 7,2 x 6,9 m. [Braun, Grömling and Bleher, 2005]

Load-bearing walls and central cores limits functionality and circulation hence buildings also suffers from lack of flexibility. Smaller structures having more open plan can overcome these disadvantages.
They are much more likely to adapt for a future needs, or a change of a room program. [Braun, Grömling and Bleher, 2005]

DEALING WITH VIBRATION

Research facilities, and in particular - nanoscience laboratories are extremely sensitive towards any kind of vibrations. Special decisions should be made in early design phases to resolve this issue. Those include special floating floors inside the building, isolation of structure elements with absorption material, special tables for vibration cancellation, Negative-Stiffness Vibration Isolators and addressing equipment placement. One of the most potential elements causing large vibrations is the backup power plant, the diesel unit, therefore it is normally placed in the basement. (Minusk.com, 2016)

SUMMARY

Research facilities have a specific hierarchy of priorities. Research areas are the most important, followed by administrative spaces. Recreational spaces are the least important but they have more design freedom. This signals that the challenge will be to find a compromise between architectural goals of creating good atmosphere and technical – to meet requirements and make good quality high-tech facilities.

SPECIAL REQUIREMENTS

LABORATORIES

Laboratories are facilities with specific equipment to carry out research and experiments, mostly in the fields related to chemistry and biology. Labs have specific requirements for safety and also raise an energy concern as they consume 5-10 more energy than a typical space in an office building. [LABS FOR THE 21ST CENTURY, 2016]

LAB SAFETY

There are strict safety requirements for the establishment of labs. According to the Laboratory Safety Design Guide by Washington University, each type of laboratories has different safety precautions:

1. If radiation is used – it should be designed so that personnel and environment have minimized exposure. Surfaces shall be impervious and smooth; floors need to be non-porous.
2. Laser areas must have special doors, no combustible materials can be used and must have laser barriers (safety layers), which cannot not be made of glass.
3. Shielding is needed if radio frequencies or magnetic fields are used higher than a human can tolerate.
4. Required to have installed emergency eyewash and safety shower where chemicals are used. Safety shower should be 10 seconds walk away from hazardous areas.
5. If bio-hazard materials are used: surfaces shall be of impervious materials and they need to be easy to clean.

CLEANROOMS

Cleanrooms are specific type of laboratories that have tightly controlled environments. Particularly, air pressure, particles in the air, temperature and humidity are carefully controlled. They need high air change rate, depending on type, usage and cleanroom class. The bigger the air change is the bigger fans are needed. Strict design and construction requirements are set by ISO 14644-4:2001 standard. For instance, only approved materials shall be used, such as aluminum, stainless steel, PVC, polypropylene etc. [ISO 14644-4:2001, 2001]
For practical and economic reasons, cleanrooms are often surrounded by other rooms of lower cleanliness requirements. Moreover, careful consideration is needed for the workers' flow since increased movements between the cleanrooms increase risk of contamination. Changing rooms need to be established before entering and exiting the cleanrooms with airlocks to control pressure and amount of particles in the air. [Angtrakool, 2016]

CONCLUSION FOR THEME ANALYSIS

The aim is to integrate industry, science and education, therefore to encourage their inter-collaboration. Nanotechnology proves to be a suitable field for this purpose and has great perspectives. Design approach will be through combining qualities of tectonic and sustainability principles. An important aspect is to have a flexible building with a good quality performance. Hence the complex will have to meet specific requirements for certain functions that will require early design considerations.

04
DESIGN PROCESS

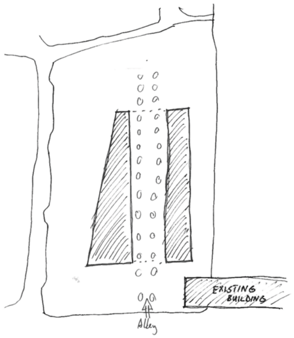
INTRODUCTION

This section describes the development of the concept and how the project arrived to its current stage. The design processes explained include arrangement on site, shape and volume of the building, design of atrium and its spaces, the roof over the atrium and considerations for the structural layout for the laboratory wing. The key factors that influenced design decisions were noise, vibration and built context.

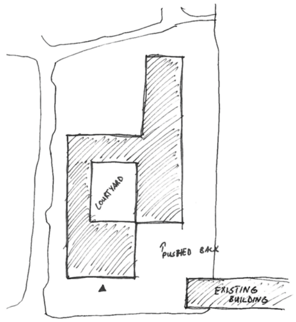
Design processes explained:
1) arrangement on site,
2) shape and volume of the building,
3) design of the atrium and its spaces,
4) the roof covering the atrium
5) considerations for the structural layout for the laboratory wing.

PLACEMENT ON SITE

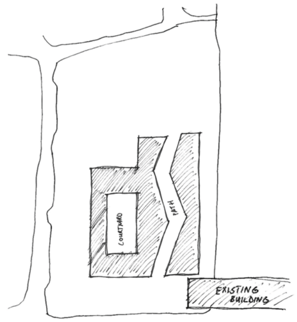
A study of a series of options has been carried out to explore best places to juxtapose the volumes. People's flows have influenced the decisions heavily since one of the aims is to improve pedestrian and bicycle routes. Built environment has a major impact since the wish is to integrate the building into its context. A significant amount of noise from the motorway requires a sound barrier, therefore the idea is to integrate it so it becomes a part of design. Another factor is the program arrangement due to the desire to connect users of two different functions. Furthermore, it was important to take into account the specific requirements for research facilities.



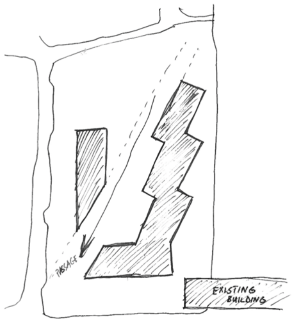
Ill. 106// Consideration for an alley that would continue from one side of the site to the other and pass through the building



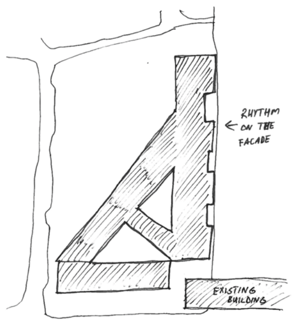
Ill. 107//Pushing a part of the building towards the north to keep distance from the existing building and shaping it to create a courtyard.



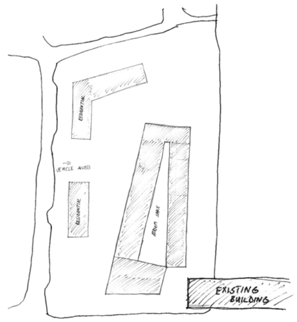
Ill. 108// Creating a courtyard and shaping a path through the building.



Ill. 109// Dividing the volume at the east part of the side and twisting it so it creates a diagonal path through the site and simultaneously generates a rhythm.



Ill. 110// Arranging the building according to the diagonal path and experimenting with the rhythm on the east part.



Ill. 111// Combining the volumes together and creating an internal space. Proposing buildings on the west part to have an enclosure on site.

VOLUME

A volumetric study has been conducted to shape the building. The goals set for this process was to set a hierarchy. The wing for research facilities should appear strict and rectilinear. The wing for workspaces has been provided with more flexibility and the informal spaces had a lot of design freedom.

Ill. 112// 3 volumes with covered paths between them and a courtyard.

Ill. 113// Combining open spaces into one and shaping the volume on the west side.

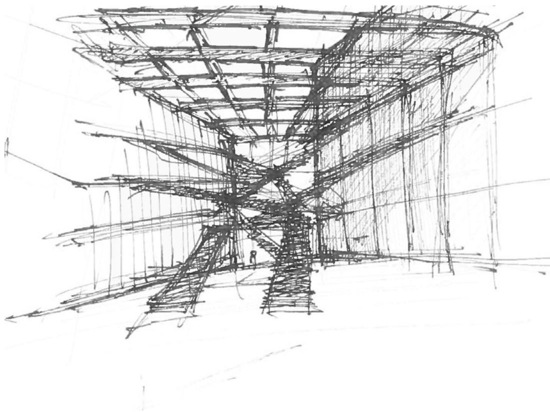
Ill. 114// Extending the front of the west wing further to the street.

Ill. 115// Keeping the west wing straight.

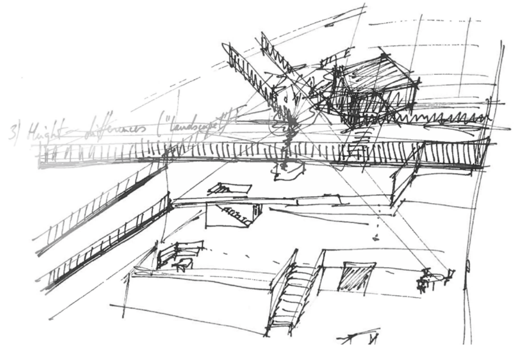
Ill. 116// Experimenting with the front from street side and internal open space.

Ill. 117// Connecting the volumes together, proposing a cantilever and joining the open space.

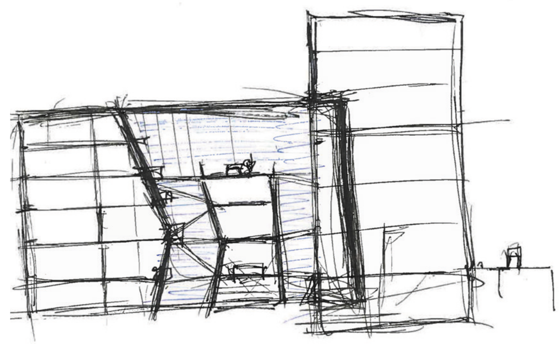
ATRIUM



Ill. 118//Perspective sketch

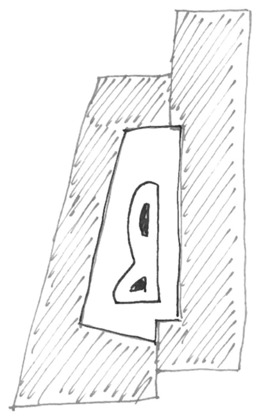


Ill. 119//Perspective sketch

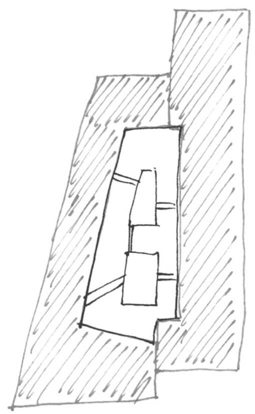


Ill. 120//Section sketch

The design process of the atrium proved to be the most complicated part. It included a lot of restrictions and ambitions to fulfil. Firstly, its shape is fairly complex and the size is difficult to be fit in. Secondly, the desire was to create a less formal and more dynamic atmosphere, simultaneously providing with a more dominant appearance from the entrance, which is in contrast to the rest of the building. Furthermore, it had to provide with collaboration spaces and lounges, a promenade through the building, have controlled access with possibility to directly reach the lecture hall and provide with connections to both sides of the building. The complex system of those parameters was a tough challenge.

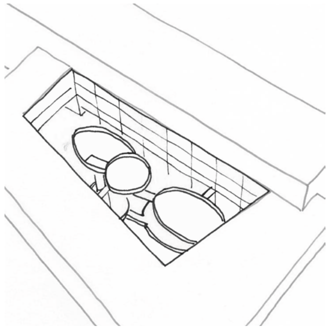


Ill. 121//Plan sketch

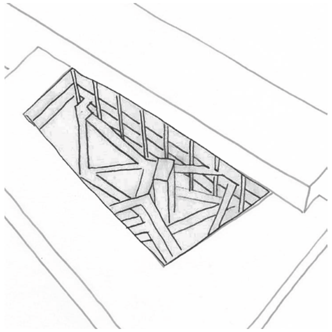


Ill. 122//Plan sketch

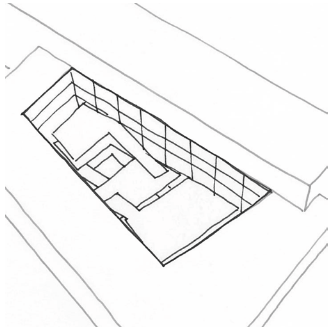
ATRIUM



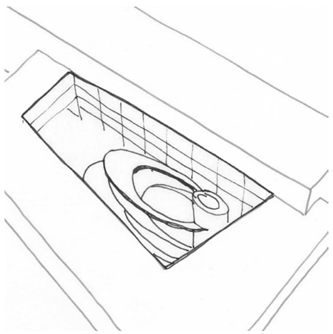
Ill. 123//Introducing several separate spaces.



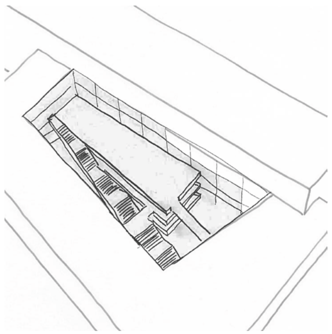
Ill. 124//Exploring a network of bridges.



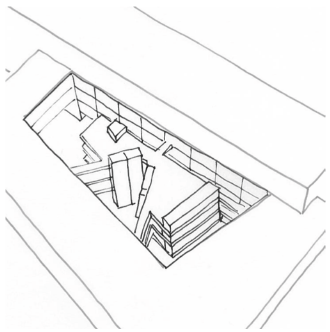
Ill. 125//Splitting the hubs and connecting them with staircases.



Ill. 126//Experimenting with curved stairs connecting different levels and trying to integrate the with the of shape the hubs.

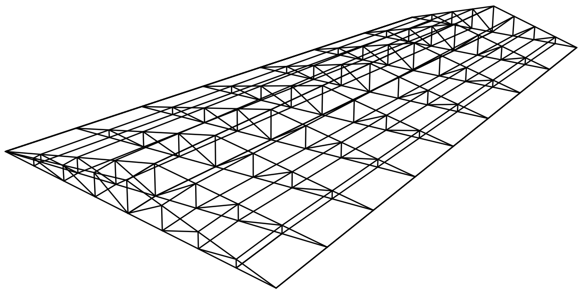


Ill. 127//Testing stairs with a continuous run.

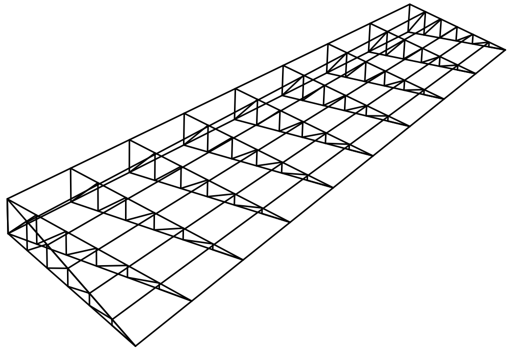


Ill. 128//Keeping floors of hubs leveled to the rest of the building and integrating the bridges.

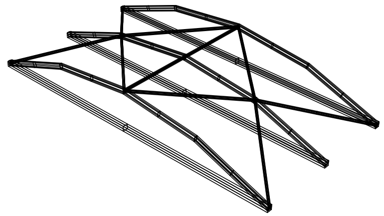
ATRIUM ROOF



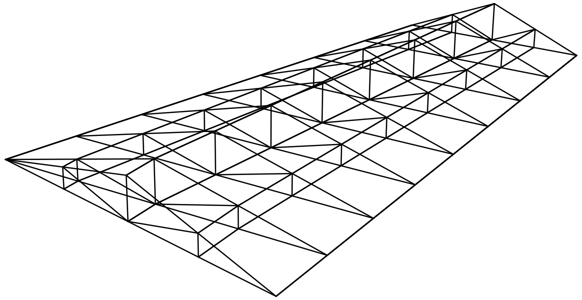
Ill. 129// Shape: decided to use slopes due to the shape of the atrium.



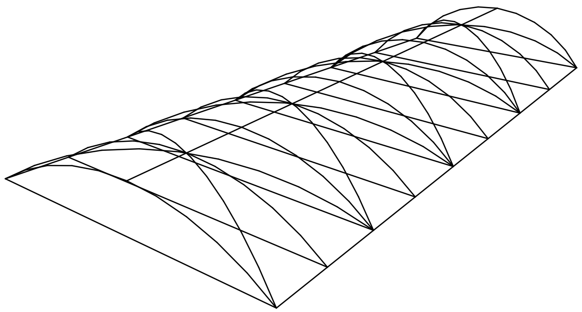
Ill. 130// Mono-pitch: blocks windows for the labs or raises very high on the other side.



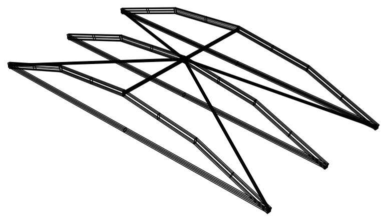
Ill. 133// Structure A simplification: a lot of divisions



Ill. 131// Double pitch: trusses look too industrial



Ill. 132// Curved shape: smooth and elegant lightweight expression

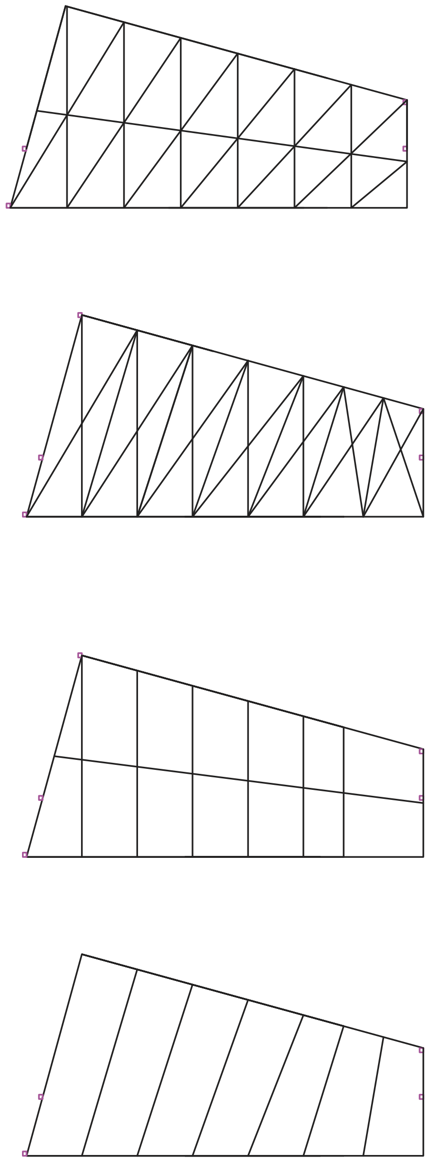


Ill. 134// Structure B simplification: less crossing elements and they look more slender and elegant. Materials are used in a more efficient way.

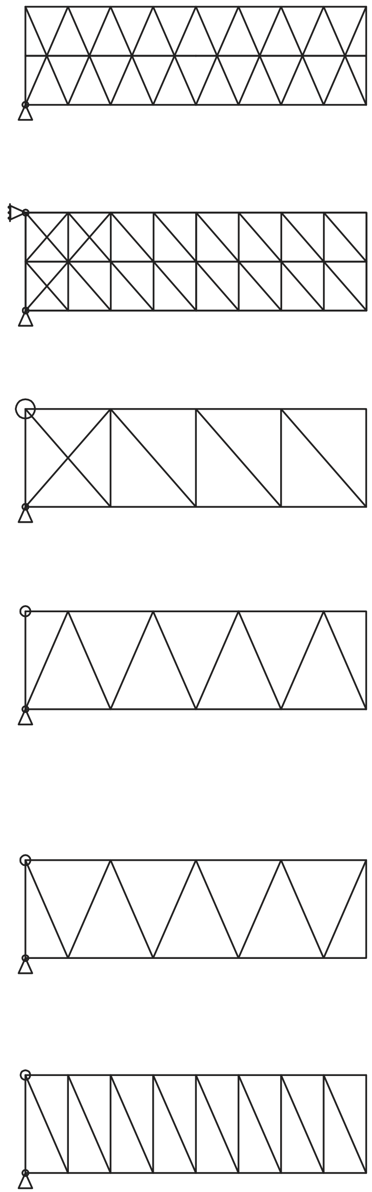
The aim for this study was to test options for the atrium roof shape and structure, having previously defined its sloping directions. The ideas outlined include considerations upon structure, tectonic expression and possible efficient ways to utilize materials. Afterwards the roof structure has been analysed and optimized using digital parametric tools.

CANTILEVER

The design process of the cantilever involved a few challenges. The decision upon divisions of trusses depended on the width of the corridor in the research wing. The aim was to match the width of the corridor with one truss segment as it would extend the walkway. A study has been carried out to experiment with composite structural elements and to investigate which have best expressions, therefore the decision has been made to make them full height of two floors. The performed structural analysis proved that single bracing was more effective that cross-bracing.

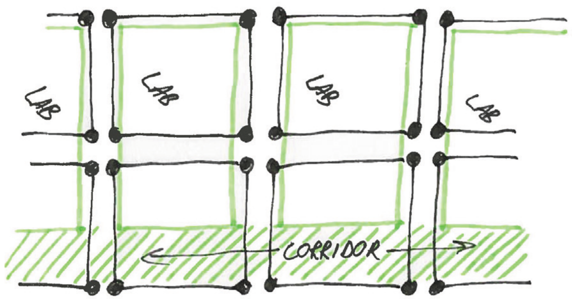


Ill. 135// Considerations upon arrangement of floor beams

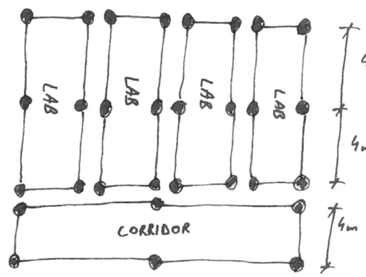


Ill. 136// Considerations upon divisions of trusses

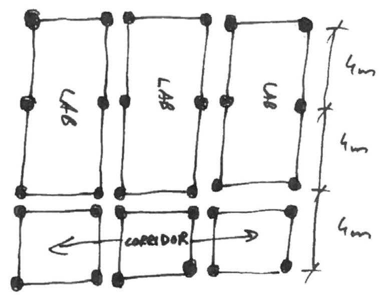
STRUCTURE



Ill. 137// Lab placed on the same structural unit as the corridor would receive vibration from walking.



Ill. 138// The whole corridor built as a single structure.



Ill. 139// The corridors have been divided in the same amount of segments as the rest of the structure.

The arrangement of columns in the research wing was based upon the aim to reduce vibration in the building. The solution was to divide the structure into separate segments. The distances between the columns had to be of a short span, therefore the challenge was to arrange spaces around them. It was important to take into account that structural arrangement may compromise spatial arrangement in the upper floors.

05
ENDING

CONCLUSION

The goal for this project was to create a place for collaboration of industry and science. This was achieved by introducing workplaces for both disciplines and spaces for their collaboration. Central circulation system in the building encourages employees to meet each other on a daily basis.

The design approach was based on a combination of four qualities: tectonics, sustainability, flexibility and quality performance. Tectonics were used to communicate the atmosphere through structure. The atrium roof suggests homogeneous and continuous expression, not over-dominating the space. The complex structure for the lecture hall, based on cantilever and truss principles, provides a special feeling and importance of the space. Structural arrangement in the research wing indicates a special strict character to it.

Sustainable approach was based on efficient use of materials and ability to adapt the building in the future for different needs and purposes, therefore prolonging lifespan of the building. Flexibility has been accounted for when designing offices, laboratories and cleanrooms as the workspaces can be rearranged with minimum effort. Furthermore, a decision has been made to reuse excess heat produced in research areas for other parts of the building.

Having accounted for general architectural qualities, it was also important to address special requirements for the program of the building, therefore quality performance became an important parameter. To provide stable and tightly controlled environment in the research areas, adequate measures have been implemented in the design of the structure.

Relevant case studies have been explored to assist with the following issues: arrangement of office spaces and dealing with site adjacent to a major transport artery. A case study of Cisco offices has been used as an example for creation of an open-plan office space. This type of arrangement provides a dynamic atmosphere and is efficient with regards of use of space. However, the issue of being distracted at a workplace has been addressed by introducing more quiet spaces. Moreover, SUPSI campus case study has been used as an example to improve people's flows crossing the motorway as it acts as a barrier. A path is proposed to provide a connection between the tunnel under the motorway and Bos en Lommerweg street.

Controlled access was a major concern for the center, therefore 5 levels of security have been introduced. This was due to both security and safety reasons as laboratories and cleanrooms should be accessed only by authorized personnel.

Materials used for the project have been intended to express strict and clean image, suggesting rigidity, responsibility and safety. Vertical and horizontal shading elements have become a dominant feature on facades. Large glazing areas provide sufficient amount of daylight.

A residential building is proposed at the north corner of the site to increase the density of the built area on site, provide enclosure and mix functions, therefore creating transition of purposes from public and commercial to residential. Furthermore, two separate underground car parks are proposed for the users of Nano enter and for the residents.

REFLECTION

This project allowed us to have an insight into the process of investigating a problem of present days and propose a solution to it through architecture. Research and Development centres are good examples of a specific typology where scientists and business employees can network, make contacts, share knowledge, experiences and employ each other.

Nano centres have broad applications and the demand of nanotechnology-based products are subject to increase in the future. Since this subject has good prospects to be further explored, it suggests that the building will serve its purpose and will not be altered in the near future.

The combined design approach based on tectonics, sustainability, flexibility and quality performance allowed us to investigate how those principles can be combined. Although some of the traditional tectonic principles still apply nowadays, they can be compared with other qualities. The poetics of construction [Frampton and Cava, 1995] and strength, utility and beauty [Vitruvius Pollio. et al., 1969] create a positive environment, which contributes to the well-being of building's users, therefore act as a part of social sustainability. However, there is an increasing demand of flexibility and ability to replace building's facades, therefore the importance of a building's envelope becomes less significant.

When choosing strategies for sustainability, energy goals often become dominant and the focus is directed too much on technical aspects. It often results in lack of integration, fails to provide effective visual quality, therefore results in poor design quality. However, sustainability is a crucial measure with regards of raising environmental demands, therefore the sustainable strategies proposed consist of flexible structure and the use of heat exchange within the building.

Flexibility affects design freedom as loadbearing walls are preferred not to be used. Despite the ability to replace facades and internal walls, structural arrangement of the research wing is quite characteristic and might be challenging to be reused for other purposes. Furthermore, structures left after research centres are sometimes contaminated, therefore the question remains whether the building will be suitable for other purposes, e.g. residential.

To ensure good quality performance of the program, a number of literature sources had to be explored in order to identify the demands and how they may be implemented within desired architectural qualities. Therefore, a number of issues had to be addressed, especially tight safety and stability requirements.

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ILLUSTRATIONS LIST

APPENDIX 1, SNOW LOAD CALCULATION

CALCULATION OF SNOWLOAD

$s = \mu_i \times C_e \times C_t \times S_k$; where

μ_i - snow load shape coefficient
C_e – exposure coefficient
C_t – thermal coefficient
S_k - characteristic value of snow on the ground

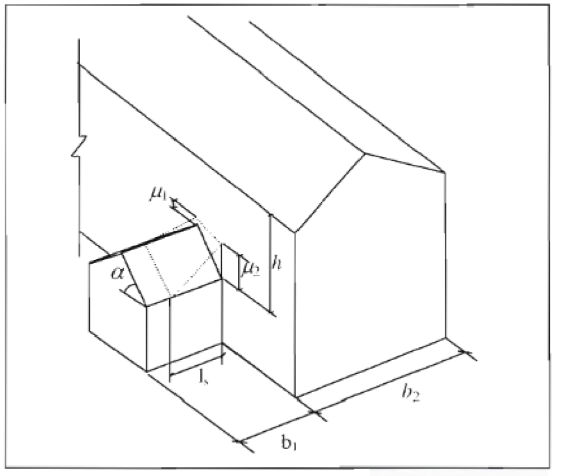
[Eurocodes 5.3]

$C_t = 1$; because area type is normal [eurocodes 5.1]

$C_e = 1$; [eurocodes 5.2 (7)]

$S_k = 0{,}2\ kN/m^2$ [eurocodes Figure C.7.]

Accounting for snow drifts



Ill. 201// Figure B2

$h = 9m$
$b_1 = 20m$
$b_2 = 14m$
$l_s = 15m$ (drift length)

$\mu_3 = 2 \times b_1 / l_s$

$\mu_3 = 20m \times 2 / 15m$

$\mu_3 = 2{,}6$; therefore

<u>$s = 2{,}6 \times 1 \times 1 \times 0{,}2\ kN/m^2 = 0{,}52\ kN/m^2$</u>

APPENDIX 2, WIND LOAD ON ATRIUM ROOF

WIND PRESSURE

$w_e = q_p(Z_e) \times C_{pe}$; where

$q_p(Z_e)$ - peak velocity pressure
Z_e - reference height for external pressure
Z_e - pressure coefficient for the external pressure

$q_p(Z_e)$ = [1 + 7 + $I_v(Z)$] x 0,5 ρ x v_m^2 (Z) = C_e(Z) x q_b ; where

I_v – wind turbulence

I_v – σ_v /V_m(Z)

σ_v = k_r x V_b x k_l

k_l = 1 [Eurocode recommended 4.4]
ρ = 1,25 km/m³ [Eurocode recommended 4.5]

σ_v = 0.234 x 30m/s x 1

σ_v = 7,02 m/s
I_v = 7,02 m/s x 19,5 m/s

I_v = 0,36

$q_p(Z_e)$ = [1+7+0,36] x 0,5 1,25 km/m³ x (19,5m/s)²

$q_p(Z_e)$ = 836,55 N/m²

MEAN WIND VELOCITY

$V_m(Z) = C_r(Z) \times C_0(Z) \times V_b$; where

$C_0(Z)$ - orography factor. Picked according to the slope on the site

$C_r(Z)$ - roughness factor

V_b - high wind speed in the area

$C_0(Z)$ = 1; since the site is quite flat

V_b = 30m/s [Eurocodes, ENV 1991-2-4:1995]

$C_r(Z) = k_r \times \ln(Z / Z_0)$; where

Z_0 - roughness length

k_r - terrain factor

Z – height above the terrain (height of the wall)

Terrain category		z_0 m	z_{min} m
0	Sea or coastal area exposed to the open sea	0,003	1
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	0,01	1
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0,05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0,3	5
IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1,0	10
NOTE: The terrain categories are illustrated in A.1.			

Ill. 202// Table 4.1

Terrain category used: IV, therefore:

Z_0 = 1m

Z_{min} = 10m

Z = 16m (wall height)

$Z_{0,II}$ = 0,05m [Eurocodes 4.3.2]

$$k_r = 0{,}19\left(\frac{Z_0}{Z_{0,II}}\right)^{0,07}$$

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

k_r = <u>0,234</u>; therefore

$$C_r(Z) = 0{,}234 \times \ln(16m / 1m)$$

$$C_r(Z) = \underline{0{,}648}$$

$$V_m(Z) = 0{,}648 \times 1 \times 30 m/s$$

$$V_m(Z) = \underline{19{,}5 m/s}$$

WIND PRESSURE

$w_e = q_p(Z_e) \times C_{pe}$; where

$q_p(Z_e)$ - peak velocity pressure
Z_e - reference height for external pressure
Z_e - pressure coefficient for the external pressure

$q_p(Z_e)$ = [1 + 7 + I_v(Z)] x 0,5 ρ x v_m^2 (Z) = C_e(Z) x q_b ; where

I_v – wind turbulence

I_v – σ_v /V_m(Z)

σ_v = k_r x V_b x k_I

k_I = 1 [Eurocode recommended 4.4]
ρ = 1,25 km/m^3 [Eurocode recommended 4.5]

σ_v = 0.234 x 30m/s x 1

σ_v = 7,02 m/s
I_v = 7,02 m/s x 19,5 m/s

I_v = 0,36

$q_p(Z_e)$ = [1+7+0,36] x 0,5 1,25 km/m^3 x (19,5m/s)^2

$q_p(Z_e)$ = 836,55 N/m^2

PRESSURE COEFFICIENT

Roof angle $\alpha = 5°$

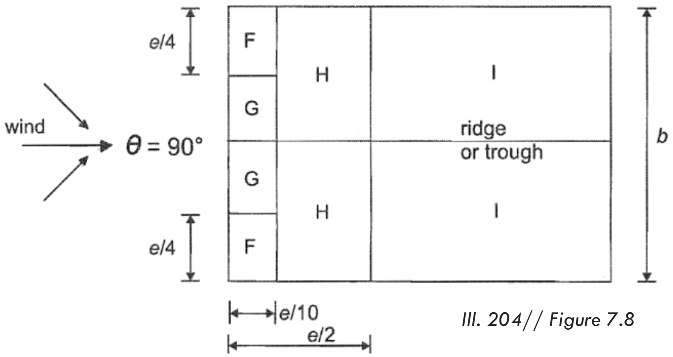
$h = 16m + 2m = 18m$

wind angle $\Theta = 90°$

$b = 24{,}1m$
$e = 14{,}2m$

Pitch angle α	Zone for wind direction $\theta = 90°$							
	F		G		H		I	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
-45°	-1,4	-2,0	-1,2	-2,0	-1,0	-1,3	-0,9	-1,2
-30°	-1,5	-2,1	-1,2	-2,0	-1,0	-1,3	-0,9	-1,2
-15°	-1,9	-2,5	-1,2	-2,0	-0,8	-1,2	-0,8	-1,2
-5°	-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	-0,6	-1,2
5°	-1,6	-2,2	-1,3	-2,0	-0,7	-1,2	-0,6	
15°	-1,3	-2,0	-1,3	-2,0	-0,6	-1,2	-0,5	
30°	-1,1	-1,5	-1,4	-2,0	-0,8	-1,2	-0,5	
45°	-1,1	-1,5	-1,4	-2,0	-0,9	-1,2	-0,5	
60°	-1,1	-1,5	-1,2	-2,0	-0,8	-1,0	-0,5	
75°	-1,1	-1,5	-1,2	-2,0	-0,8	-1,0	-0,5	

Ill. 203// Table 7.4b



Ill. 204// Figure 7.8

F:

w_e = 836,6 N/m^2 x (-1,6) = -1338,56 N/m^2

A_F = 2 x e/10 x b/4

A_F = 2 x 14,2m/10 x 24,1m/4 = 17,1m^2

w_{eF} = -1338,56 N/m^2 x 17,1m^2 = -22,9 kN

G:

w_e = 836,6 N/m^2 x (-1,3) = -1087,6 N/m^2

A_G = 2 x e/10 x b/4

A_G = 2 x 14,2m /10 x 24,1m /4 = 17,1m^2

w_{eG} = -1087,6 N/m^2 x 17,1m^2 = -18,6 kN

H:

w_e = 836,6 N/m^2 x (-0,7) = -585,6 N/m^2

A_H = 6 x 9/10 x e

A_H = 24,1m x 9/10 x 14,2m = 308 m^2

w_{eH} = -585,6 N/m^2 x 810 m^2 = -180,4 kN

I:

w_e = 836,6 N/m^2 x (-0,6) = -501,96 N/m^2

A_I = e/2 x b

A_I = 14,2m /2 x 24,1m = 171,1 m^2

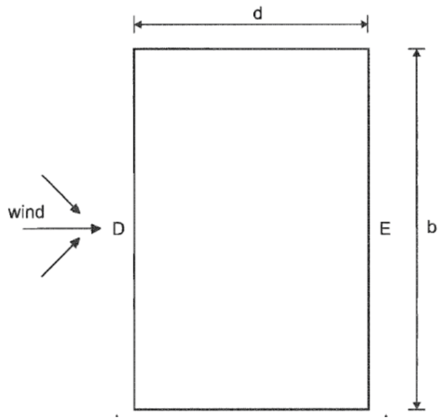
w_{eI} = -501,96 N/m^2 x 450 m^2 = -85,9 kN

AVERAGE WIND PRESSURE

$$\frac{-22{,}9\text{ kN} -18{,}6\text{ kN} -180{,}4\text{ kN} -85{,}9\text{ kN}}{14{,}2\text{m} \times 24{,}1\text{m}}$$

Average Wind Pressure On The Roof = -0,899 kN/m^2

WIND PRESSURE ON THE SIDE WALL:



Ill. 205// Figure 7.5

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	

Ill. 206// Table 7.1

Calculating for wall D, which is facing the predominant wind direction

h/d = 1/48

$C_{pe,10}$ = +0,7

w_e = 836,6 N/m² x 0,7 = 585,6 N/m² = -0,59kN/m²

A_D= 1 x 48 x 0,5 = 24 m²

w_{eD} = 585.6 N/m2 x 24 m² = 14 kN

DEADLOAD

Sizes for estimated windows for the roof: 2000mm x 1000mm

Steel:
Window profile: 50mm x 50mm. Hollow section, 8mm thick
Window perimeter: 6000mm
Volume of metal in the frames: 0,0024 m^3
Density of steel: 8,050 km/m^3

$F_s = \rho \times V \times 10$

$F_s = 8{,}050\ km/m^3 \times 0{,}0024\ m^3 \times 10\ m/s^2$

$F_s = 0{,}19\ N$

Steel load: $0{,}19\ N\ /\ 2m^2 = 0{,}095\ N/m^2$

Glass:

Density of glass = 2500 kg/m^3
Thickness = 3 x 5mm (triple glazed)

$F_g = 2500\ kg/m^3 \times 0{,}015m = 375\ N/m^2 = 0{,}375\ kN/m^2$

Total Dead Load:

$F = F_s + F_g$

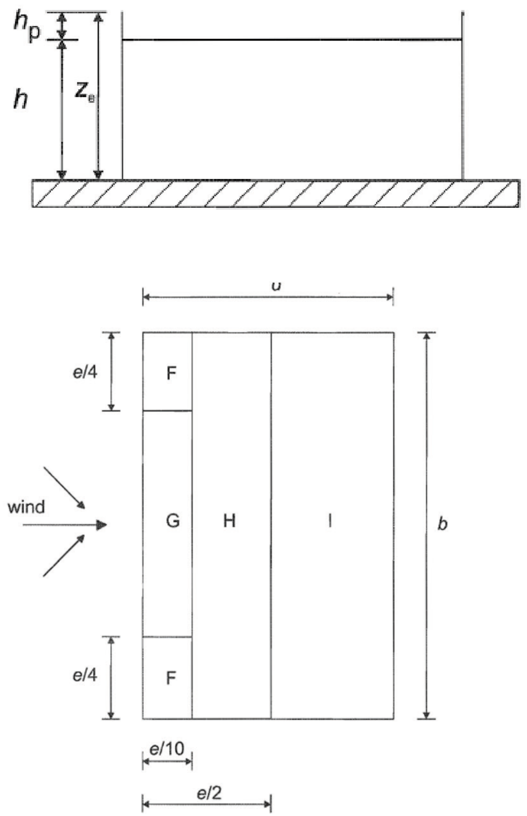
$F = 0{,}095\ N/m^2 + 375\ N/m^2$

$\underline{F = 0{,}375\ kN/m^2}$

APPENDIX 3, WIND LOAD ON CANTILEVER

THE CANTILEVER

Wind pressure on the roof



Ill. 207// Figure 7.6

Roof type		Zone F $c_{pe,10}$	F $c_{pe,1}$	G $c_{pe,10}$	G $c_{pe,1}$	H $c_{pe,10}$	H $c_{pe,1}$	I $c_{pe,10}$	I $c_{pe,1}$
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	
Curved Eaves	r/h = 0,05	-1,0	-1,5	-1,2	-1,8	-0,4		+0,2 -0,2	
	r/h = 0,10	-0,7	-1,2	-0,8	-1,4	-0,3		+0,2 -0,2	
	r/h = 0,20	-0,5	-0,8	-0,5	-0,8	-0,3		+0,2 -0,2	
Mansard Eaves	α = 30°	-1,0	-1,5	-1,0	-1,5	-0,3		+0,2 -0,2	
	α = 45°	-1,2	-1,8	-1,3	-1,9	-0,4		+0,2 -0,2	
	α = 60°	-1,3	-1,9	-1,3	-1,9	-0,5		+0,2 -0,2	

Ill. 208// Table 7.2

e = 2 x b = 30m
d = 15m

F:

$w_e = 836{,}6\ N/m^2 \times (-1{,}4) = -1171{,}17\ N/m^2$

$A_F = e/4 \times 2 \times e/10$

$A_F = 2 \times 30m/4 \times 30m/10 = 45m^2$

$w_{eF} = -1171{,}17\ N/m^2 \times 45m^2 = -52{,}7\ kN$

G:

$w_e = 836{,}6\ N/m^2 \times (-0{,}9) = -752{,}895\ N/m^2$

$A_G = e/2 \times e/10$

$A_G = 30m\ /2 \times 30m\ /10 = 45m^2$

$w_{eG} = -752{,}895\ N/m^2 \times 45m^2 = -33{,}9\ kN$

H:

$w_e = 836{,}6\ N/m^2 \times (-0{,}7) = -585{,}6\ N/m^2$

$A_H = (e/2 - e/10) \times e$

$A_H = (30m/2 - 30/10) \times 30m = 360\ m^2$

$w_{eH} = -585{,}6\ N/m^2 \times 360\ m^2 = -210{,}8\ kN$

I:

$w_e = 836{,}6\ N/m^2 \times (-0{,}2) = -167{,}3\ N/m^2$

$A_I = 0$; therefore

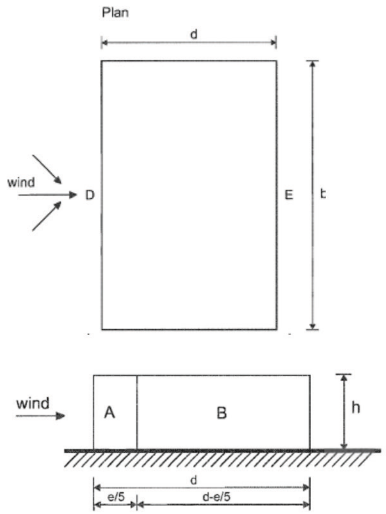
$w_e = 0$

AVERAGE WIND PRESSURE ON ROOF:

$$\frac{-57{,}7\ kN\ -33{,}7\ kN\ -210{,}8\ kN}{15m \times 30m}$$

Average Wind Pressure On The Roof = $-0{,}66\ kN/m^2$

WIND PRESSURE ON WALLS



Ill. 209// Figure

$d = 15m$
$h = 8m$
$e = 2h\ 16m$

$h/d = 8m/15m = 0{,}53$

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	

Ill. 210// Table 7.1

A:

$\underline{w_e = 836{,}6\ N/m^2 \times (-1{,}2) = -1004\ N/m^2 = -1\ kN/\ m^2}$

$A_A = e/5 - h$

$A_A = 16m/5 \times 8m = 25{,}6m^2$

$w_{eA} = -1004\ N/m^2 \times 26{,}6\ m^2 = -26{,}7kN$

D:

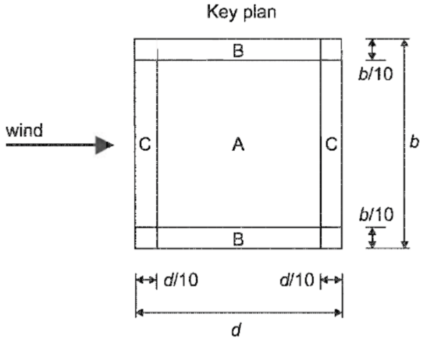
$\underline{w_e = 836{,}6\ N/m^2 \times (0{,}8) = 669{,}24\ N/m^2 = 0{,}7\ kN/\ m^2}$

$A_D = h * d$

$A_D = 8m \times 15m = 120m^2$

$w_{eD} = 669{,}24\ N/m^2 \times 120\ m^2 = 80{,}3kN$

WIND PRESSURE TO THE BOTTOM: CALCULATING USING CALCULATION METHOD FOR CANOPIES



Roof angle α	Blockage φ	Overall Force Coefficients c_f	Zone A	Zone B	Zone C
0°	Maximum all φ	+ 0,2	+ 0,5	+ 1,8	+ 1,1
	Minimum $\varphi = 0$	- 0,5	- 0,6	- 1,3	- 1,4
	Minimum $\varphi = 1$	- 1,3	- 1,5	- 1,8	- 2,2
5°	Maximum all φ	+ 0,4	+ 0,8	+ 2,1	+ 1,3
	Minimum $\varphi = 0$	- 0,7	- 1,1	- 1,7	- 1,8
	Minimum $\varphi = 1$	- 1,4	- 1,6	- 2,2	- 2,5
10°	Maximum all φ	+ 0,5	+ 1,2	+ 2,4	+ 1,6
	Minimum $\varphi = 0$	- 0,9	- 1,5	- 2,0	- 2,1
	Minimum $\varphi = 1$	- 1,4	AC2 - 1,6 AC2	- 2,6	- 2,7
15°	Maximum all φ	+ 0,7	+ 1,4	+ 2,7	+ 1,8
	Minimum $\varphi = 0$	- 1,1	- 1,8	- 2,4	- 2,5
	Minimum $\varphi = 1$	- 1,4	- 1,6	- 2,9	- 3,0
20°	Maximum all φ	+ 0,8	+ 1,7	+ 2,9	+ 2,1
	Minimum $\varphi = 0$	- 1,3	- 2,2	- 2,8	- 2,9
	Minimum $\varphi = 1$	- 1,4	- 1,6	- 2,9	- 3,0
25°	Maximum all φ	+ 1,0	+ 2,0	+ 3,1	+ 2,3
	Minimum $\varphi = 0$	- 1,6	- 2,6	- 3,2	- 3,2
	Minimum $\varphi = 1$	- 1,4	- 1,5	- 2,5	- 2,8
30°	Maximum all φ	+ 1,2	+ 2,2	+ 3,2	+ 2,4
	Minimum $\varphi = 0$	- 1,8	- 3,0	- 3,8	- 3,6
	Minimum $\varphi = 1$	- 1,4	- 1,5	- 2,2	- 2,7

Ill. 211// Figure 7.16

h = 8m
d = 5m
b = 36m
$\alpha = 0°$
φ = 1 (canopy blocked to the downhill eaves by stored goods) [eurocodes Figure 7.15]

C:

w_e = 836,6 N/m² x (-2,2) = -1840 N/m² = -1,84 kN/m²
A_C = 2 x d/10 x b/10 x 8
A_C = 2 x 32m/10 x 5m/10 x 8 = 25,6m²
w_{eC} = -1,84 kN/ m² x 25,6 m² = -47,1 kN (wind is going upward)

B:

w_e = 836,6 N/m² x (-1,8) = -1506 N/m² = -1,5 kN/m²
A_B = 2 x d/10 x b/10 x
A_B = 2 x 5m/10 x 32m/10 x 8 = 25,6m²
w_{eB} = -1,5 kN/ m² x 25,6 m² = -38,4 kN

A:

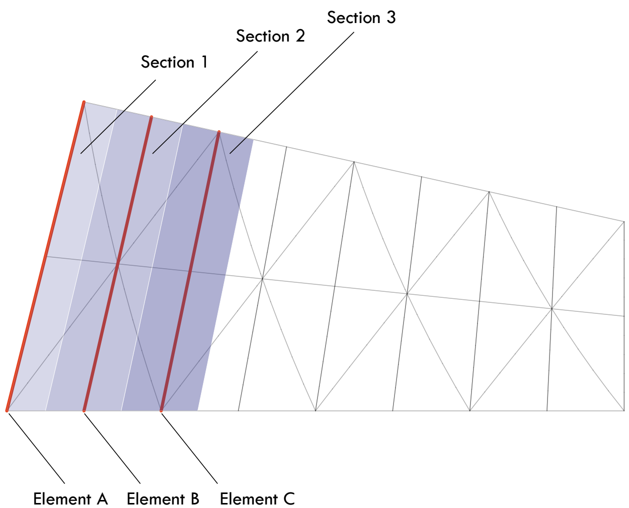
w_e = 836,6 N/m² x (-1,5) = -1255 N/m² = -1,26 kN/m²
A_A = 8/10 x b x 8/10 x d
A_A = 8/10 x 32m x 8/10 x 5m = 102,4m²
w_{eA} = -1,26 kN/ m² x 102,4 m² = -129,024 kN

AVERAGE WIND PRESSURE ON THE BOTTOM:

$$\frac{-47{,}1\text{ kN} -38{,}4\text{ kN} -129{,}024\text{ kN}}{5\text{m} \times 32\text{m}}$$

<u>Average Wind Pressure On The Bottom = -1,34 kN/m²</u>

APPENDIX 4, ATRIUM ROOF OPTIMIZATION



Ill. 212// Roof diagram

THE ROOF

Total roof area: 883 m^2

Area of the roof Section 1 = 134 m^2
Area of the roof Section 2 = 127 m^2
Area of the roof Section 3 = 120 m^2

Load distribution for element A is calculated as: F x 131m^2/2
Load distribution for element B is calculated as: F x (131m^2/2 + 127m^2/2)
Load distribution for element A is calculated as: F x (127m^2/2 + 120m^2/2); where

F – load applied on an element per m^2

DEADLOAD

Sizes for estimated windows for the roof: 2000mm x 1000mm

Steel:
Window profile: 50mm x 50mm. Hollow section, 8mm thick
Window perimeter: 6000mm
Volume of metal in the frames: 0,0024 m^3
Density of steel: 8,050 km/m^3

$F_s = \rho \times V \times 10$

F_s = 8,050 km/m^3 x 0,0024 m^3 x 10 m/s^2

F_s = 0,19 N

Steel load: 0,19 N / 2m^2 = 0,095 N/m^2

Glass:

Density of glass = 2500 kg/m^3
Thickness = 3 x 5mm (triple glazed)

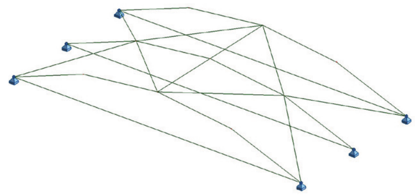
F_g = 2500 kg/m^3 x 0,015m = 375 N/m^2 = 0,375 kN/m^2

Total Dead Load:

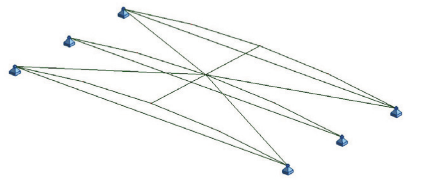
$F = F_s + F_g$

F = 0,095 N/m^2 + 375 N/m^2

<u>F = 0,375 kN/m^2</u>



Ill. 213// Option A



Ill. 214// Option B

CALCULATIONS AND OPTIMIZATION

The analysis was performed for a ¼ of the roof. The section chosen was at the southern side as it has the largest span and is affected by the wind load to the side. The span at the beginning of the roof is 24,7m and 22,1m at the other end of the section. Distances between each arch is 6m adjacent to the research wing and 5,4m adjacent to the office wing. The height of the structure is 1,1m.

The roof structure is composed of:
o Main arches
o Bottom chords connecting bottom points of arches
o Slender arcs acting in 3 dimensions and providing horizontal stability

The method was to model the structure has been modelled in Grasshopper and exported to Autodesk Robot for calculations. The modelling method was to convert arcs into lines and joining them with fixed connections. The bottom parts of the aforementioned lines were connected to the supports with hinges. Furthermore, a set of loads has been applied: wind load to the roof acting in suction, wind load to the side acting in compression, snow load with snow drifts and dead load of glass and metal profile. SLS and ULS multiplication factors have been entered and summed in Grasshopper, and exported to Robot.

PROCESS

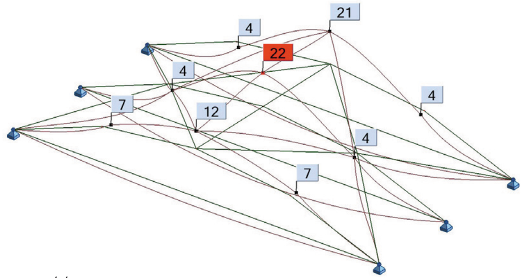
The investigation was carried out in order to find out the optimal way to utilize materials. The study was based on arrangement of 3-dimensional arches. Option A had more members than option B. Both options were calculated in Autodesk Robot with assigned smallest sections of members possible. This was because of the aim for optimization: ratio values should not be close to 0 and not too close to 1 in order to make sure the structure is stable and the materials are used efficiently.

Option A:

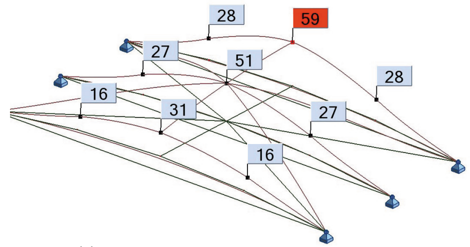
- More members crossing diagonally
- Dimensions:
    o Top arches: 400x200
    o 3-dimensional arches: 150x150
    o Bottom beams: 240x240
-Ratios vary from 0,19 to 0,60

Option B:

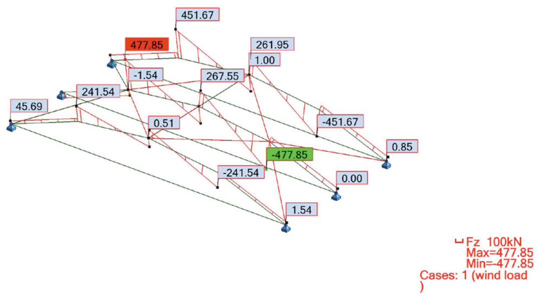
- Less members crossing diagonally
- Dimensions:
    o Top arches: 430x190
    o 3-dimensional arches: 100x110
    o Bottom beams: 220x220
- Ratios vary from 0,2 to 0,71



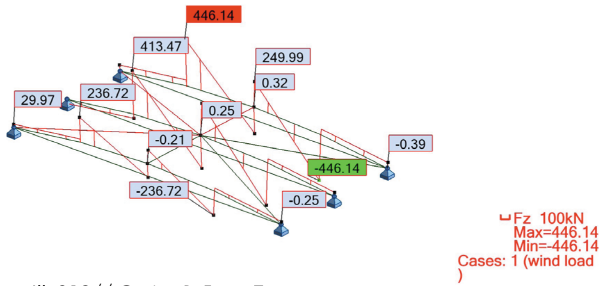
Ill. 215// Option A, Max displacement = 22mm



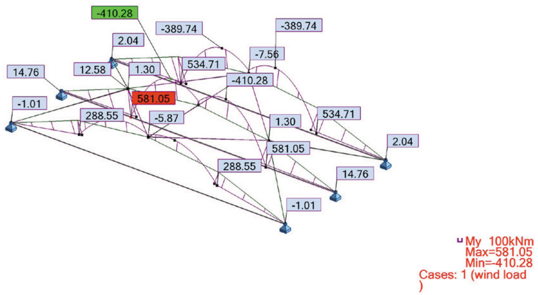
Ill. 218// Option B, Max displacement = 59mm



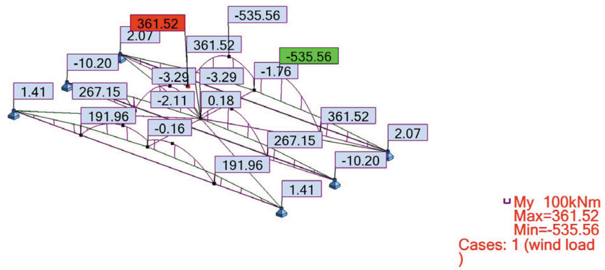
Ill. 216// Option A, Force Z



Ill. 219// Option B, Force Z



Ill. 217// Option A, Moment Y



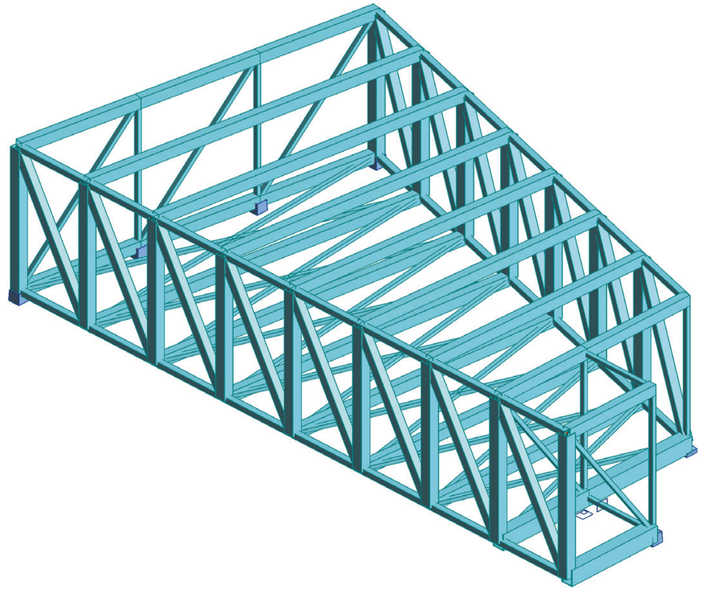
Ill. 220// Option B Moment Y

RESULT

The decision has been made to use option B. Although the sections of top arches have increased, the bottom beams and 3-dimensional arches were reduced in size and in their quantity. Therefore, the structure remains stable despite higher ratio numbers, hence the structure is utilized in a more efficient way.

APPENDIX 5, CANTILEVER OPTIMIZATION

Live people load -5kN/m2
Dead load roof -1 kN/m2
Dead load floor -1.2kN/m2
Wind load south - 0.66kN/m2
Snow load -0.25 kN/m2
Gravity load – calculated automatically by Robot.



Ill. 221// Structure diagram

STRUCTURE

The analysis was performed on the cantilever structure which is one of the most complex parts of the building. The metal frame consists of several different member types and 8 types of steel profile elements. The span varies from 18 to 11,5 meters in one direction and from 32 to 25 meters in the other. Structure is mainly formed by two main trusses in southern and northern sides, and horizontal beams connecting them. On the west side metal frame is supported at four points and distributes loads to the columns below.

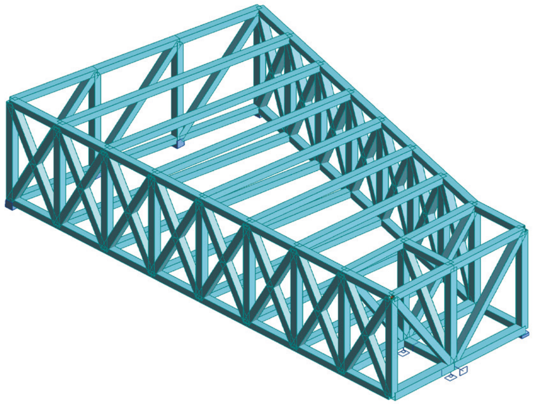
OPTIMALISATION

Since the cantilever structure is one of the main elements seen from the street and has strong representative gesture, it had to have tectonic approach to it, thus it was important to find a balance point between tectonic aesthetic measures and practical economy based reasoning. It was clear that the structure must span across two building's wings and the structural principle should be clearly visible from the street. It was also important to design an open plan structure which would leave room for easy customizable inside layout. It was decided to use only
rectangular cross sections, due a simplicity, aesthetics and also structural stability.

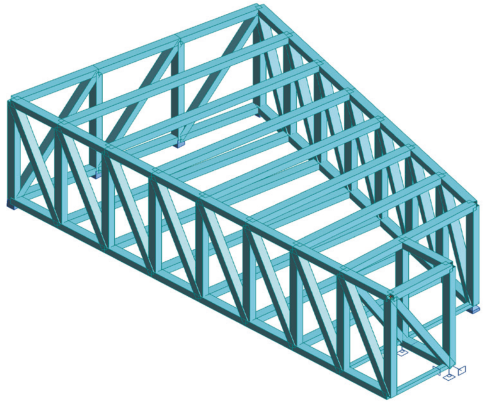
Criteria's for optimization boiled down to :
*Truss's vertical elements placement (span)
*member' s cross section optimization
*Optimal number of bars.

The structure was modelled in Rhino Grasshopper and exported to Autodesk Robot.

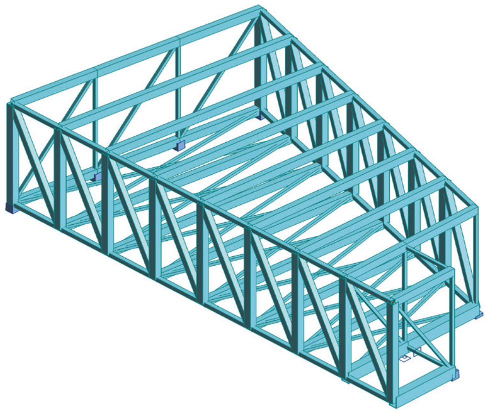
Set of loads has been applied: Wind load to the side acting in compression, snow load with snow drifts, dead load of the structure, ceiling and floor, and live people load. SLS and ULS multiplication factors have been entered and summed in Grasshopper, and the model was exported to Robot for verification.



Ill. 222// Step 1



Ill. 223// Step 2



Ill. 224// Step 3

STEP1

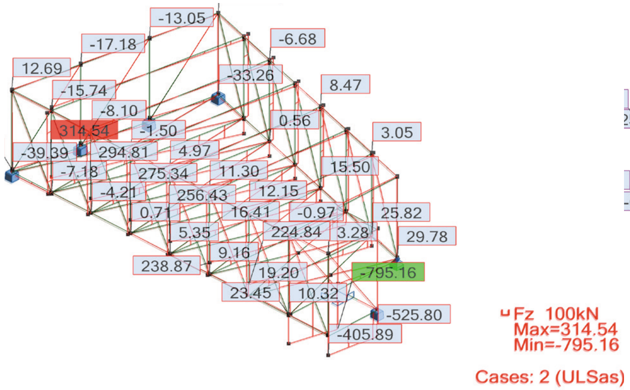
First step was to design a structure which was stable and had unobstructed layout inside.
After analyzing structure in Autodesk Robot, it was clear, that structure had excessive amount of members and optimization was necessary.

STEP2

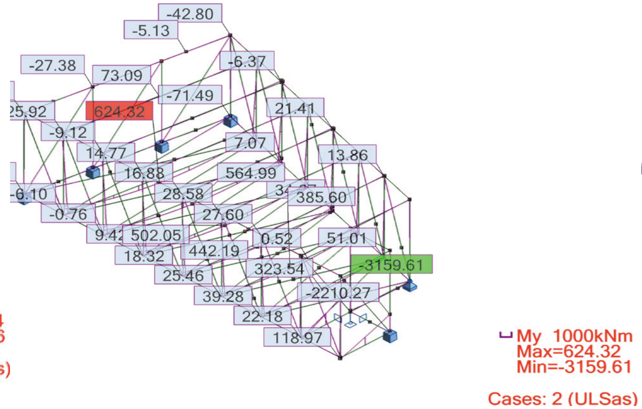
It turned out that the structure was still rigid with much less elements. Furthermore, experiments were done with different amount of truss segments. Structure was optimized by changing truss segments from 7segments 5meters long, to 8segments 4meters long. Even with higher amount of segments, structure displacement was lower due to shorter span, which was reduced by 3 meters. New placing also worked better with the rest of the building's column grid.

STEP3

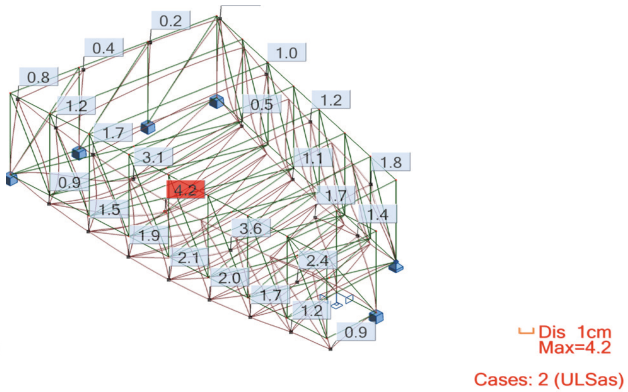
Bottom stability cords were added to make the structure more stable.
It was time to finally optimize cross-section of all the elements.



Ill. 225// Force Z



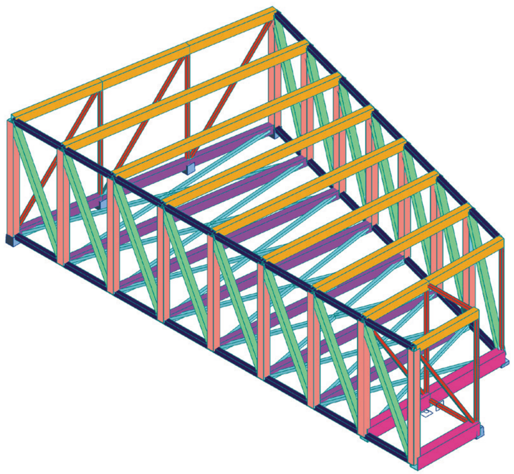
Ill. 226// Moment Y



Ill. 227// Displcement

RESULT

Structure ended up having 8 different cross section groups. Ratio of the elements varied from 0,05 to ,98 with most of the elements being over 0,5 mark. Cross section measurements were picked for the most extreme cases of the longer elements, but due simplicity and aesthetics maintained the same for the rest of elements in the group.



Ill. 228// Cross section diagram

- Horizontal elements 300x300x12 mm
- Vertical elements 500x500x16 mm
- Diagonal elements 400x400x16 mm
- Bottom stability cords 200x200x10 mm
- Main bottom beams 900x600x30 mm
- Floor bars 600x400x15 mm
- Roof bars 600x300x12,5
- Additional elements 200x200x10 mm

APPENDIX 6,
ROOM PROGRAM

Function	Floor area	No.	Remarks
RESEARCH WING			
Lab Unit	59 m2	21	Can be joined with adjacent lab units
Cleanroom	290 m2	4	2 rooms for experimenting and 2 rooms for fabrication.
Warehouse	184 m2	1	For general goods
Storage	121 m2	1	For research purposes
Backup Power	59 m2	1	
Water Cooler	59 m2	1	Plant supplying cooled water to laboratories
Server Room	120 m2	1	
Plant Room	59 m2	1	
Waste Room	59 m2	1	
Office Space	1064 m2	2	Open-plan offices for researchers
WC	50 m2	6	
ATRIUM			
Meeting hub	270 m2	3	Includes formal and informal meeting areas.
Entrance Lobby	1190 m2	1	Includes entrance areas, reception, exhibition hall and lounges
WC	6 m2	4	

APPENDIX 5,
ROOM PROGRAM

Function	Floor area	No.	Remarks
OFFICE WING			
Office space	590 m2	3	Open-plan offices for business emloyees
Library	235 m2	1	
Cafeteria	236 m2	1	
Kitchen	160 m2	2	
Building Service Office	170 m2	1	
Archive	17 m2	3	
WC	50 m2	3	
Presentation Area	55 m2	3	
OTHER			
Lecture Hall	320 m2	1	
TOTAL BUILDING AREA	15500 m2		