POLITECNICO
MILANO 1863

MASTER'S DEGREE THESIS

SCHOOL OF ARCHITECTURE
URBAN PLANNING
CONSTRUCTION ENGINEERING

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Building And Architectural Engineering
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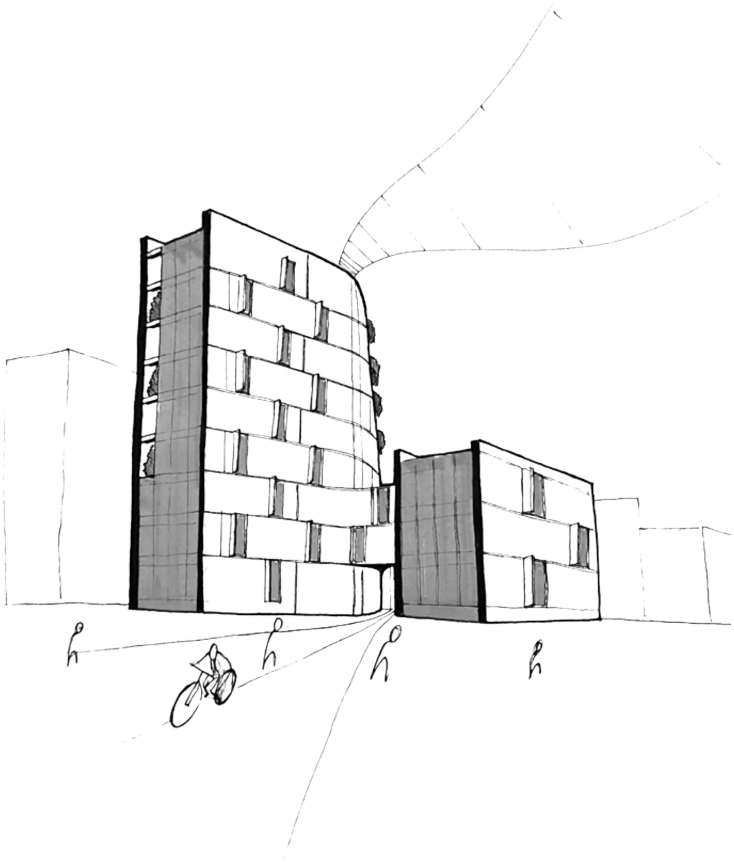
VERSO

Vertical Society
Multi-use Building in Piazzale Martesana
in Milan



CONTENTS

1 URBAN Transit-Oriented Development

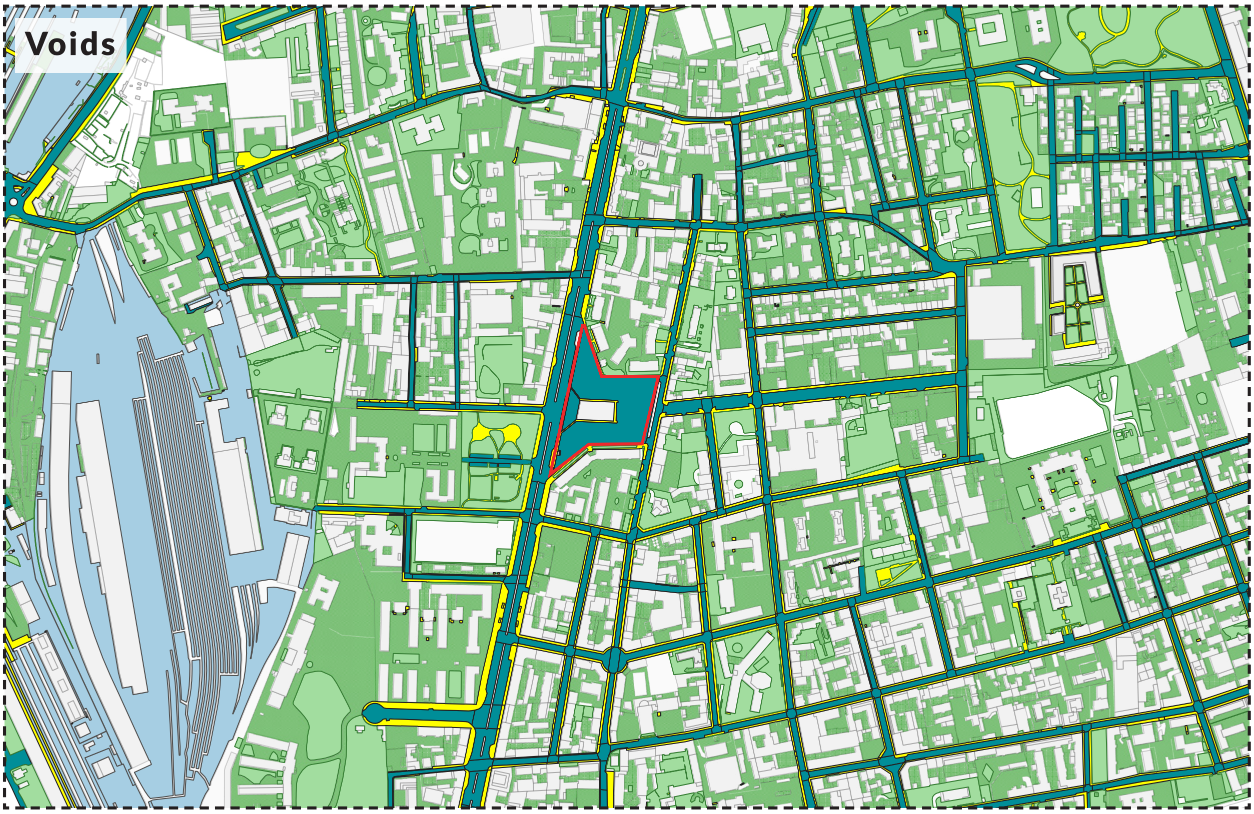
Piazzale Martesana

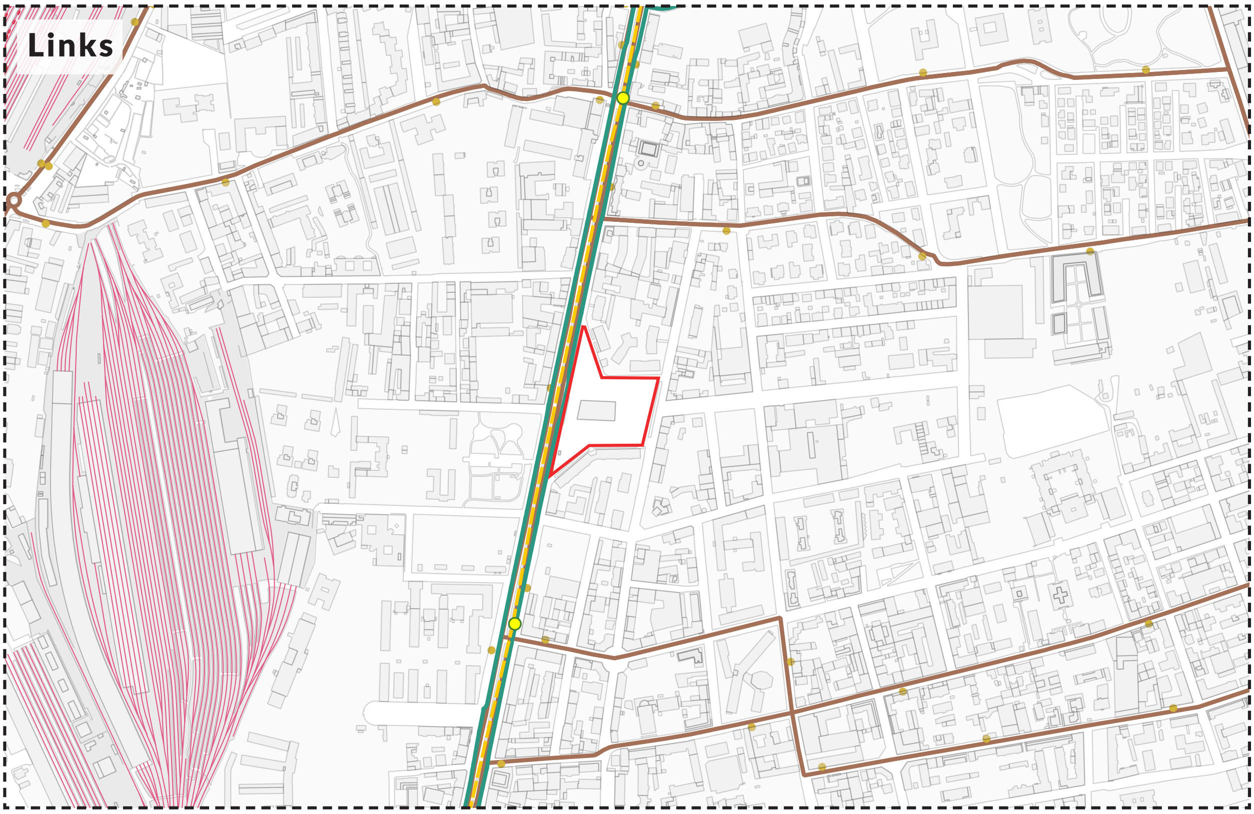
Piazzale Martesana is located in Milan's Zone 2 on the Viale Monza road axis, about 300 metres from the line 1 Gorla and Precotto metro stations.

The site is approximately 11,700 square metres and is currently used as a public car park level with an electricity substation managed by ATM.
The presence of the Naviglio Martesana, along with numerous existing and newly planned green areas in the area, defines an ecological corridor that characterises the territory.The surrounding urban context is primarily residential, with neighbourhood services, as well as significant areas of Public Residential Construction. Numerous health, sports, and educational structures have been identified, as well as significant urban-environmental transformation initiatives, New areas are also being developed for social housing, which will be available for rent and sale at regulated prices.

Site Ownership : Municipality of Milan

Horizontal Urban Investigation is crucial to understand the existing urban fabric, identify potential challenges and opportunities, and develop strategies for creating more livable, sustainable, and vibrant cities. Investigating the quality and availability of public spaces, such as plazas, squares, is to understand their social and cultural significance and their role in promoting community interaction.





Studying Transportation network and Mobility, including roads, sidewalks, bike lanes, and public transit systems, to assess how people move within the city and the accessibility of different areas can identify how public transport work in urban layers.
In order to understand precisely if these systems are working well, the vertical investigations are crucial and they should be taken into consideration in the problem-solving process of the urban development.
The investigation of the green areas can better manage the greenery continuity, which is also known as green connectivity or green corridors, refers to the connected network of green spaces, parks, gardens, and natural areas within an urban environment.
The concept of greenery in this project is crucial for connectivity and accessibility. Green corridors provide pedestrian and cycling paths, enhancing connectivity between different neighborhoods and improving accessibility to green spaces for all residents.
Moreover, enhancing biodiversity from the other hand is another aspect of having a continuous greenery to provide habitats for plants and animal species. Last but not least, The interconnected green spaces within a city can offer a range of ecosystem services such as air purification, temperature regulation, and carbon sequestration, contributing to a healthier and more sustainable urban environment.

Challenges

Urban Pattern :
Electricity substation

Environment/EcoSystem :
Discontinuity of Greenery

Public Facilities/Mobility :
No available cycling in vicinity of site
Disconnected Walkable Area
Unbalanced Proximity near the site

Solutions

Urban Pattern :
Relocation of Electricity substation

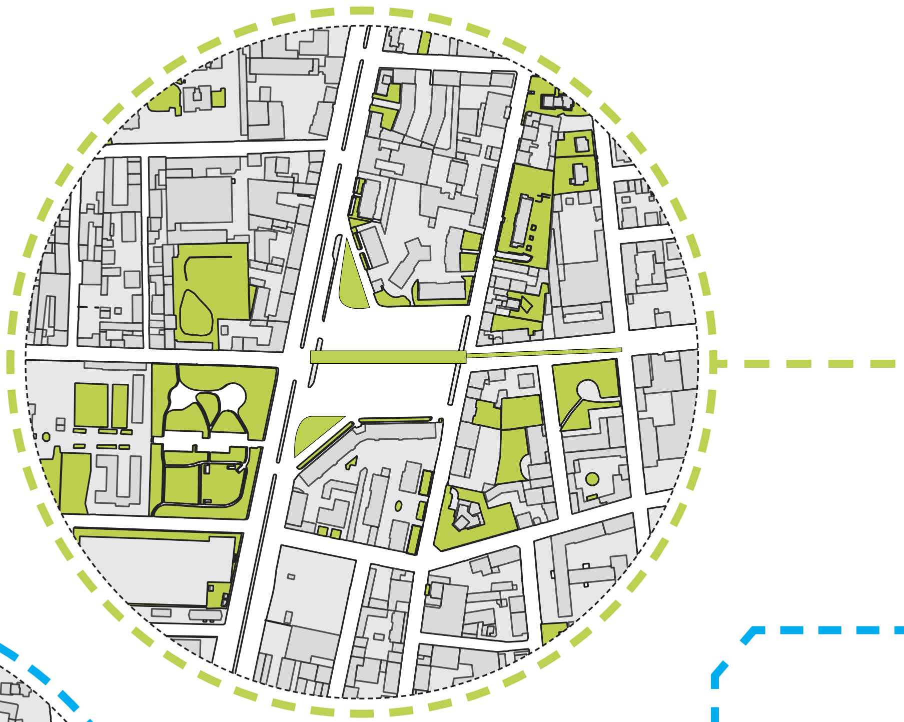
Environment/EcoSystem :
Improving the Greenery on site

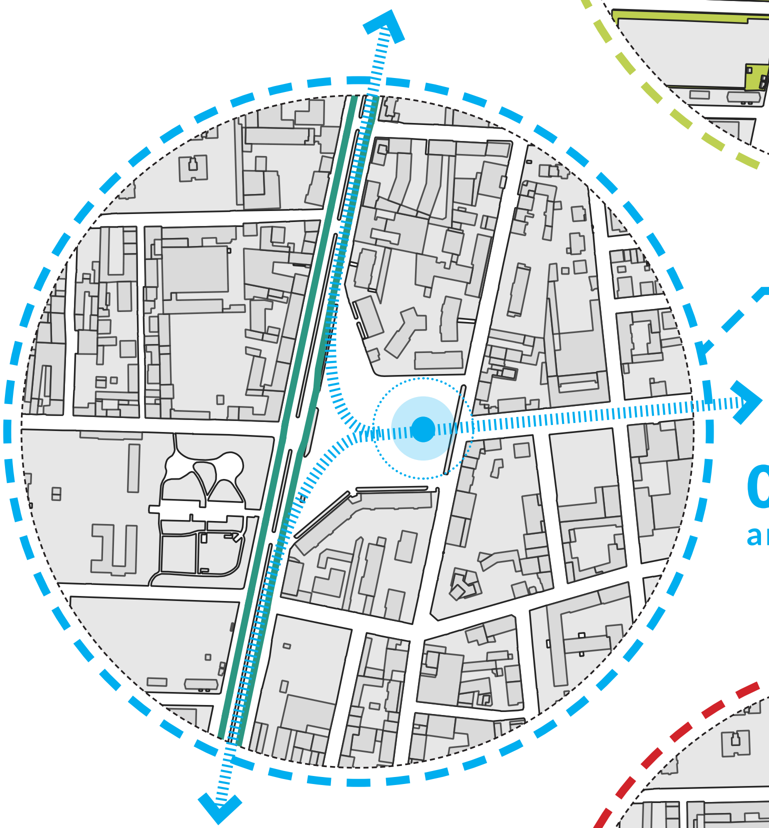
Public Facilities/Mobility :
Adding bike sharing and cycling line
Improving the walkability
Adding a bus station
Intermodality improvement

Metro stations isochrones (5 min)
Electricity substation
Out of cycling
Public Greenery
Site Boundary
Cycling Disconnection
Disconnection of greenery
Cycling path

Solutions

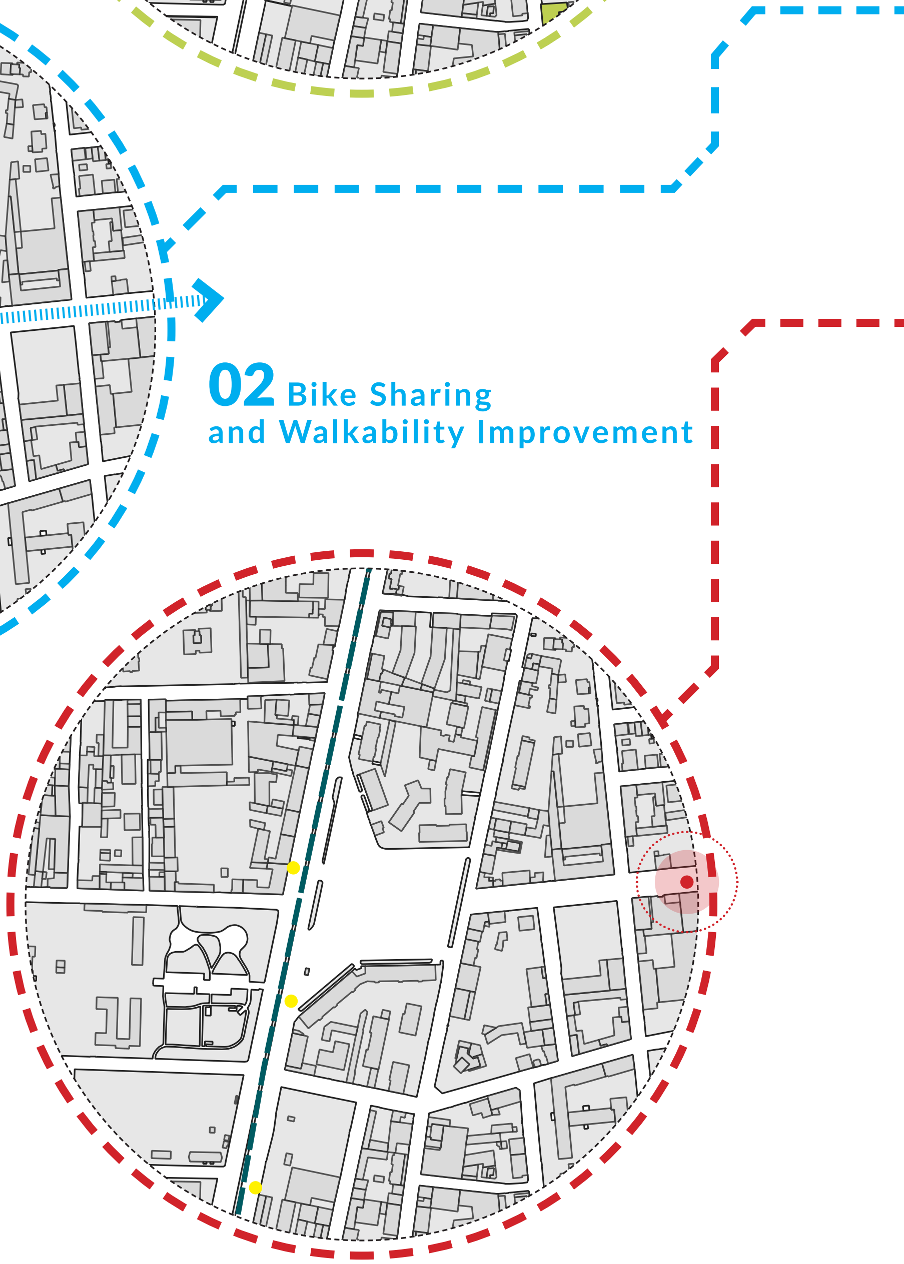
01 Greenery Continuity and Open Space Improvement





02 Bike Sharing and Walkability Improvement

03 Adding Bus Station and Intermodality Improvement

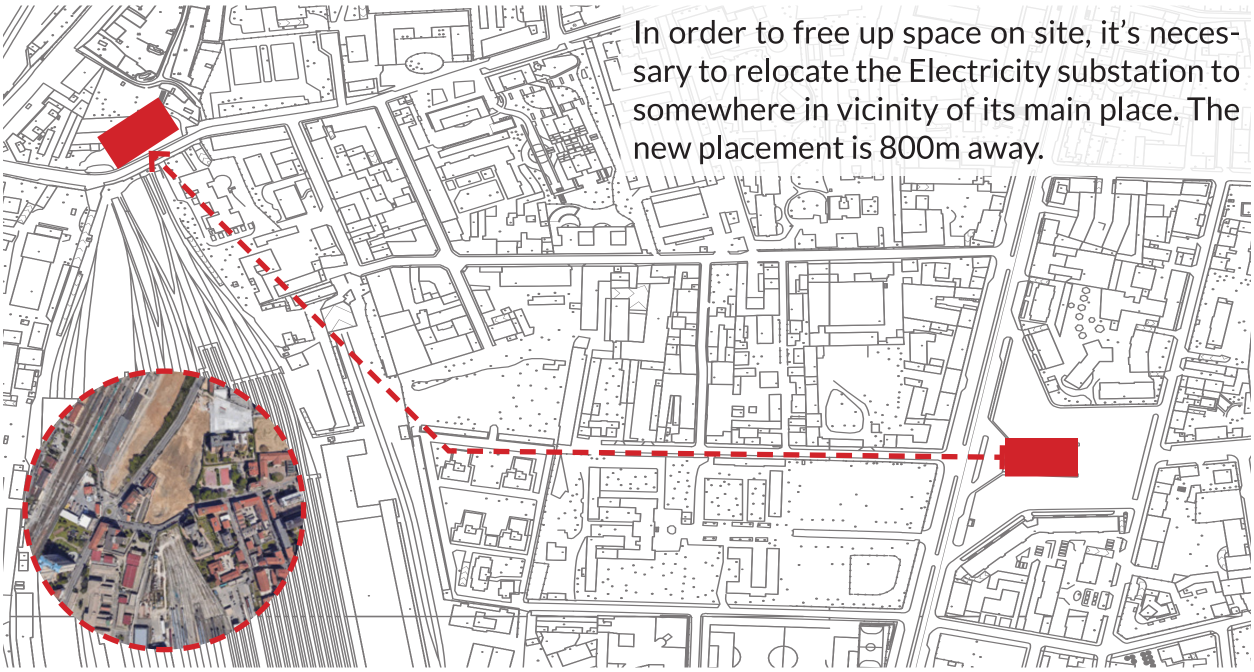


Green corridors through the site of construction can connect the open spaces in the surrounding of the site and it can extend the sense of the open space. By maintaining greenery continuity, cities and regions can support diverse ecosystems and protect native plant and animal species. Greenery continuity enhances the delivery of ecosystem services, such as air and water purification, climate regulation, soil health, and pollination, contributing to the overall ecological health of the area.
Moreover, a green environment can have several positive effects on employees in the workplace :
Stress Reduction, Mental health improvement, Creativity enhancement and Job satisfaction.
Cities and regions can enjoy a wide range of advantages by giving importance to and allocating resources for greenery continuity. These benefits encompass heightened biodiversity, a better quality of life for inhabitants, and greater ecological resilience to cope with the challenges of urbanization and climate change.

It was achieved as result through the investigations that although the site is well-accessed in case of public transportation, there is no bike sharing in vicinity to make the transportation more intermodal. To solve this challenge, considering a bike sharing station on site and some more near the site is vital. bike sharing and walkability improvement are integral components of sustainable and people-centric urban design. By embracing these initiatives, cities can create healthier, greener, and more connected communities, fostering a higher quality of life for their residents while building a foundation for a sustainable and resilient future.

According to the proximity, the eastern part of the site is a bit far from the nearest bus station so to consider a bus station in the range of 2-4 minutes of foot-walking can enhance the situation of the proximity of the site.

04 Relocation of Electricity substation

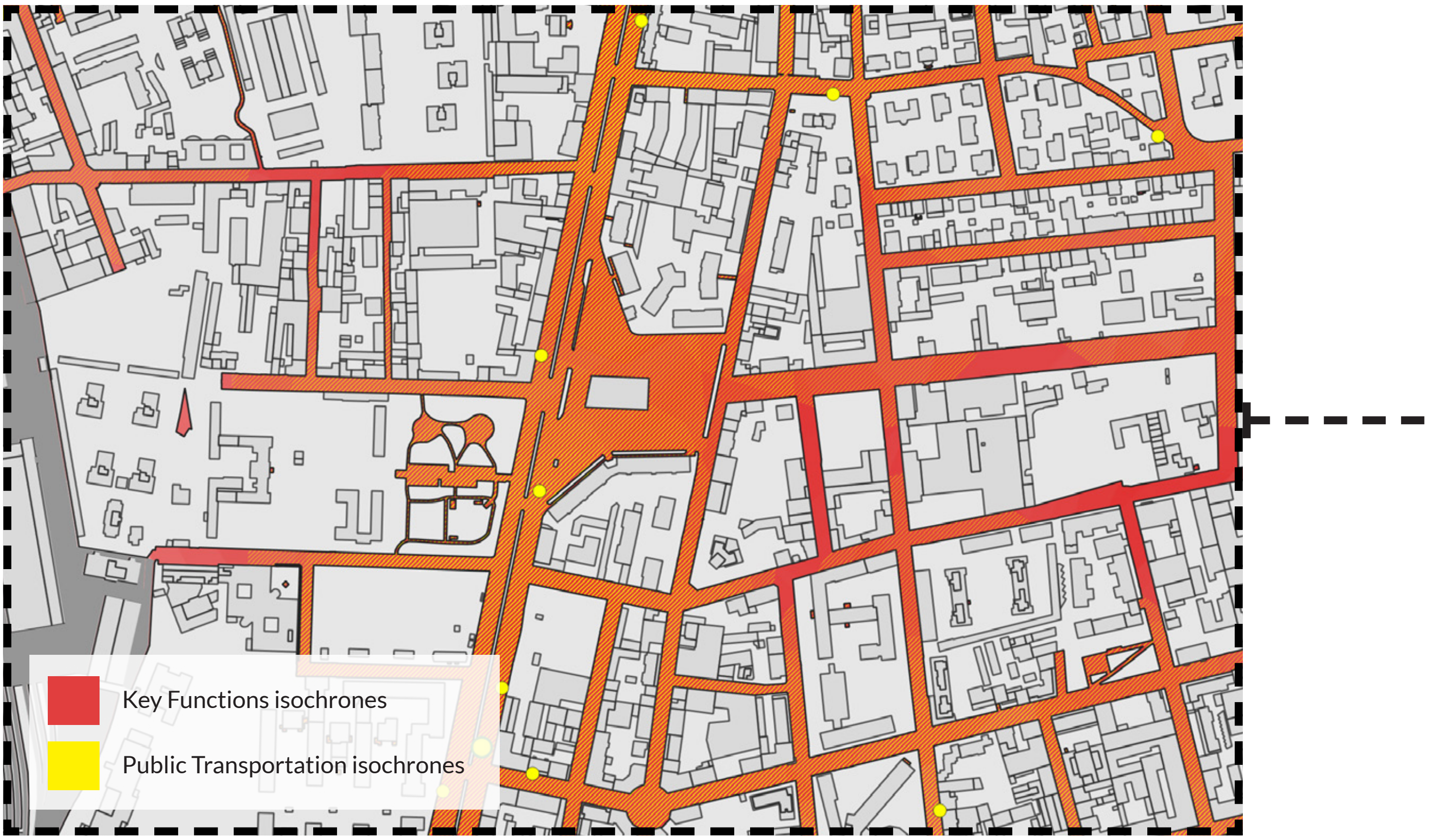


In order to free up space on site, it's necessary to relocate the Electricity substation to somewhere in vicinity of its main place. The new placement is 800m away.

Before

Accessibility Map

Proximity Map

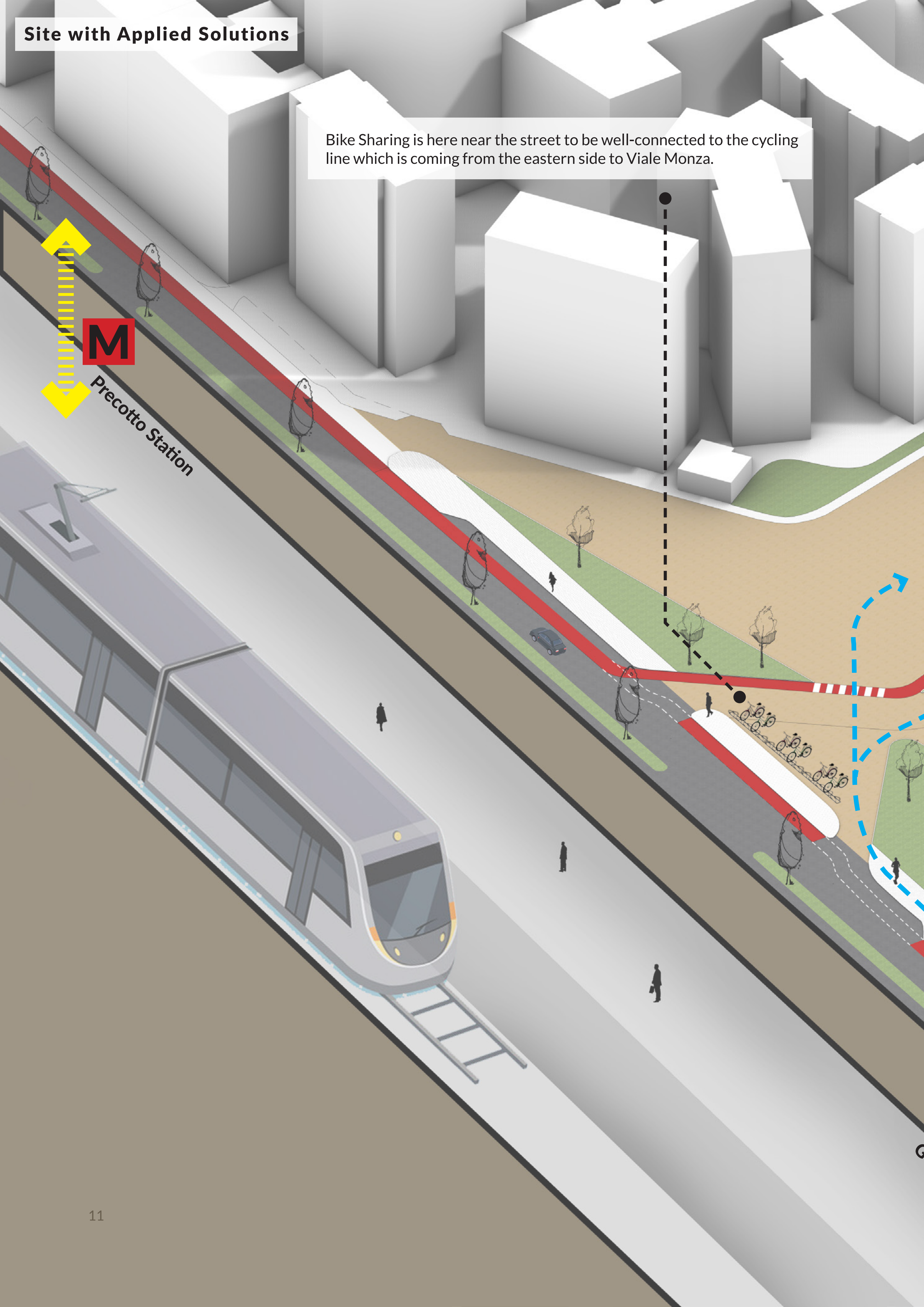


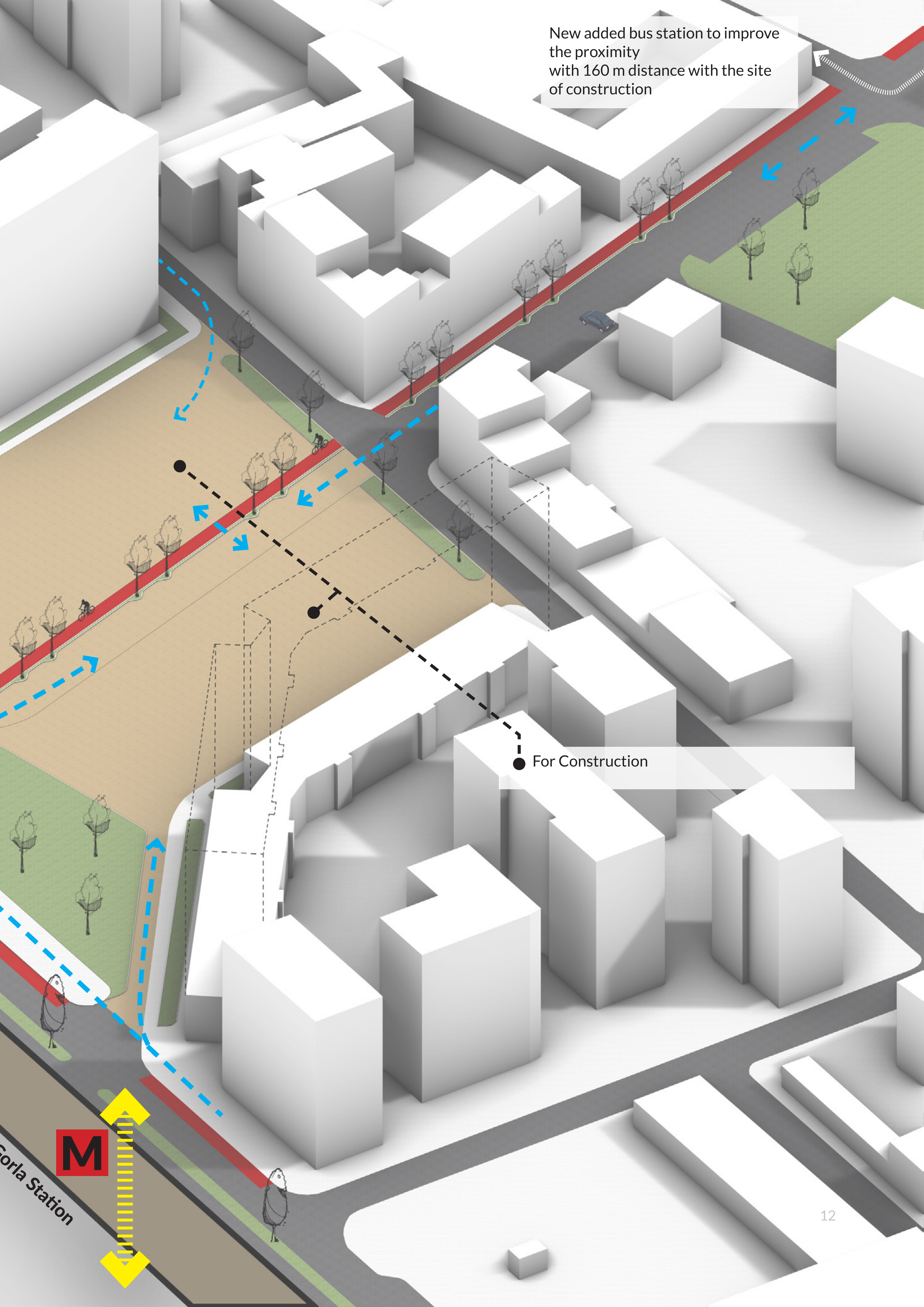
After

Accessibility Map

Proximity Map

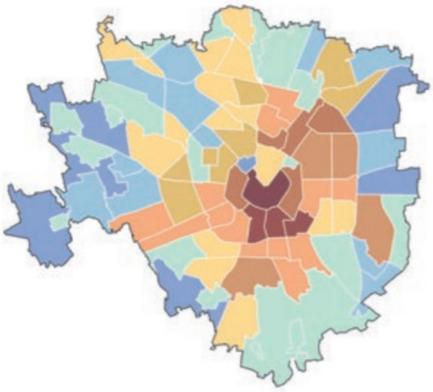
Site with Applied Solutions




New added bus station to improve
the proximity
with 160 m distance with the site
of construction
For Construction
M
Gorla Station

2 CLIMATIC and SITE ANALYSIS

State:	Italy
Region:	Lombardy
City:	Milan
Latitude:	45°28′01′′N
Longitude:	9°11′24′′E
Altitude:	120 m
Sismic area:	4
Climate zone:	E
ASHRAE cz:	4



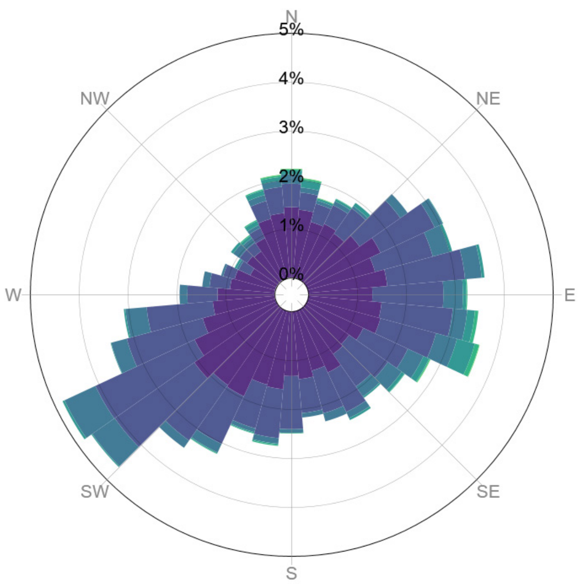
Milan, located in northern Italy, experiences a humid subtropical climate with distinct seasonal variations. The city's climate is characterized by hot summers and relatively cold winters, with moderate rainfall throughout the year. Understanding the local climatic conditions is essential in architectural design as it helps shape the building's form, orientation, materials, and overall energy efficiency.

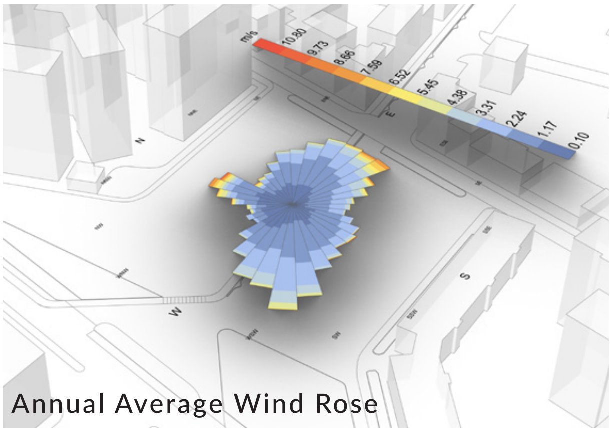
In summer, Milan is typically hot and humid, with temperatures often exceeding 30°C during July and August. The high humidity levels can make the heat feel more intense. Architects need to consider passive cooling strategies to minimize reliance on air conditioning.
In winter, Milan experiences cold temperatures with occasional snowfall. The average temperature in January hovers around 2-4°C. Architects should focus on providing proper insulation and heating systems to maintain comfortable indoor conditions during the colder months. Additionally, maximizing solar gain through south-facing windows can help reduce heating demands.

Urban Heat Island Effect:
As a major urban center, Milan experiences the urban heat island effect, where the city's temperature is slightly higher than the surrounding rural areas due to human activities and infrastructure. Green spaces, vegetated roofs, and reflective materials can be incorporated into architectural design to mitigate the heat island effect and improve overall comfort.

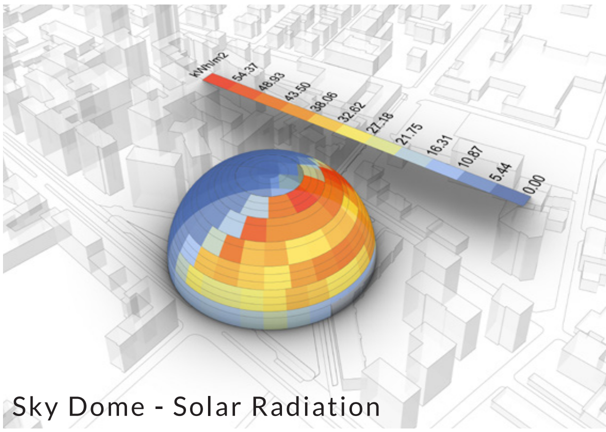
Moreover, Milan receives moderate rainfall throughout the year, with slightly wetter periods in spring and autumn. Proper drainage systems and water management strategies are crucial in architectural design to prevent water infiltration and potential damage to the building's structure and foundation.

Wind Rose:
Milan is susceptible to cool winds during the winter months, which can contribute to increased heat loss. Building orientation and layout should consider wind direction to minimize exposure to cold drafts, while also allowing for natural ventilation during milder weather.
The predominant average hourly wind direction in Milan is from the east throughout the year.

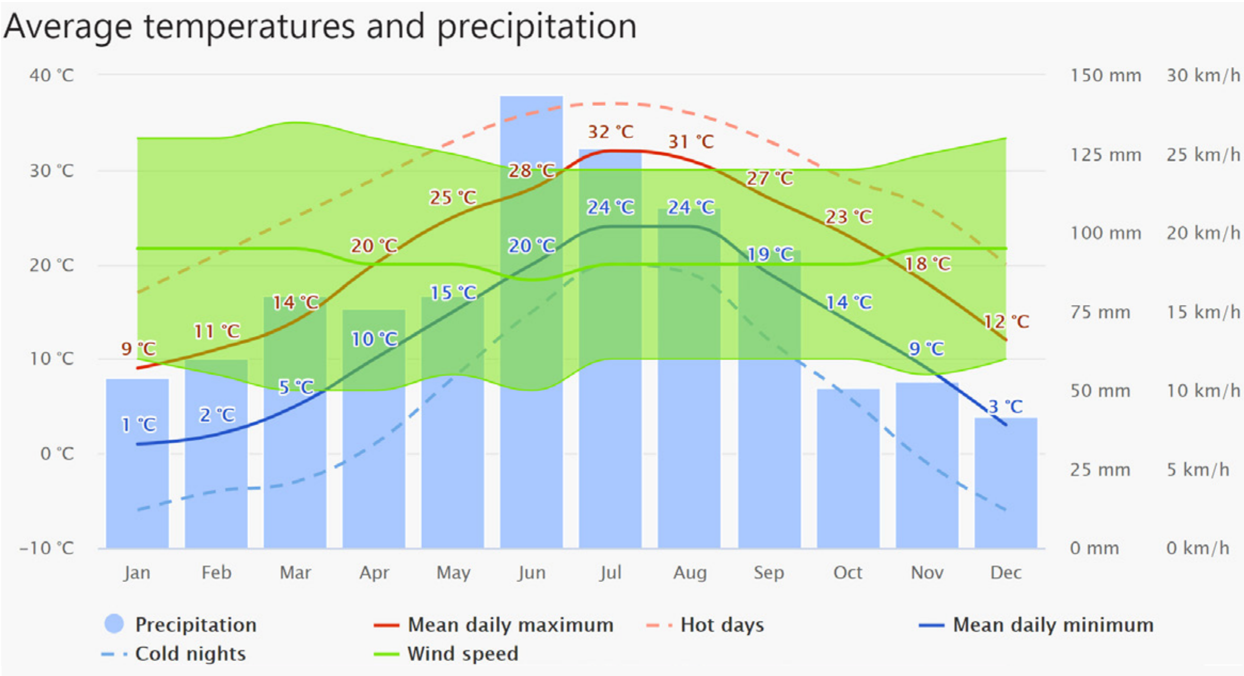




Annual Average Wind Rose



Sky Dome - Solar Radiation



Winter

Summer

Shadow Analysis:

Shadow analysis has been done to recognize the best placement of the mass in terms of both achieving sufficient daylight and maximum energy production.

According to the analysis, the western part of the site is more on the exposure of the shadows of surrounding buildings so the mass of the building is better to be placed on the estern side to avoid the critical situation in winter.

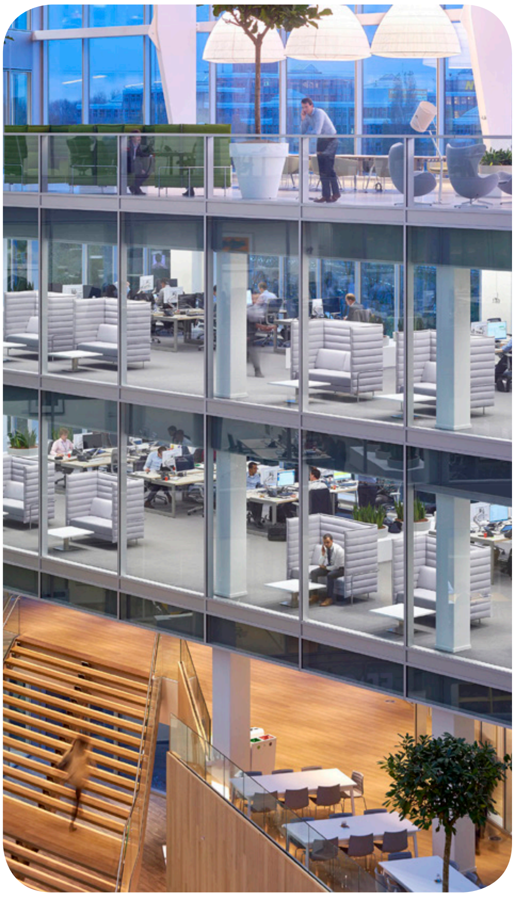
3

CASE STUDIES

and Samples

Project 1

Name :	The Edge
Architect :	PLP Architects
Location :	Amsterdam, The Netherlands
Area :	40000 sqm
Year :	2015



Atrium

- Ventilating the office space

- A buffer between the workspace and the environment

- Reduce the energy use passing the air through a heat exchange to make use of any warmth

- Allow the natural light come inside the building

Solar Panels

- There are 65000 sqm of solar panels located on the facades and roof, and remotely on the roofs of buildings of the University of Amsterdam, thereby making use of neighbourhood level energy sourcing.
- The solar pannel on the South faceda provide enough sustanible elettricity to power all smartphones, laptops and electricity cars.

Personalised Workspace

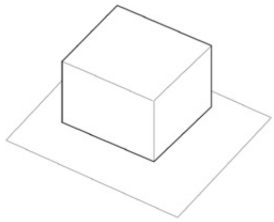
- Employees no longer have assigned desk, they can choose where to work.
- Employees can custimise the temperature and light levels
- The mobile app allow also to locate colleagues and find desks.
- The technology is also designed to make users aware of how much energy they use

Smart Orientation

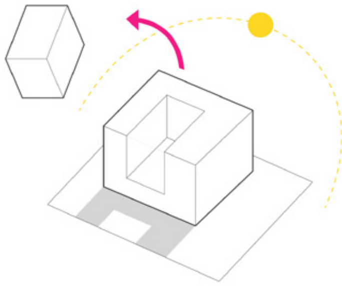
The building's form and orientation is based on the path of the sun. The atrium bathes the workspaces with daylight, while the solar panels that are placed on the southern façade shield the workspaces from the sun.
The walls to the south, east and west have smaller openings to provide thermal mass and shading, and solid openable panels for ventilation. Louvers on the south façades are designed according to sun angles and provide additional shading for the office spaces, reducing solar heat gain.

What To Learn

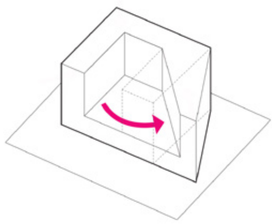
This project has motivated me to design a free and open working space, where specific desk allocation is no more required.
For my building I have decided to include solar panels that are oriented to sun to generate more power and using the atrium for ventilation, daylight absorption and a thermal buffer.
To control the situation in summer, I will use louvers for the southern facades and for the east and west smaller openings will be included in the process of designing.



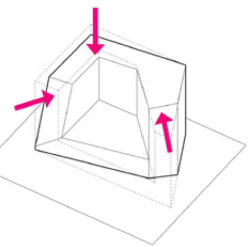
1. The starting point is a simple orthogonal extrusion.



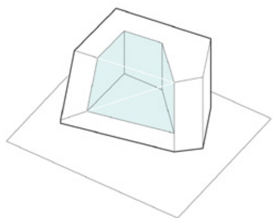
2. The volume is hollowed out to the north, introducing an even and consistent light.



3. The eastern wing is rotated outward to capture the morning sun.



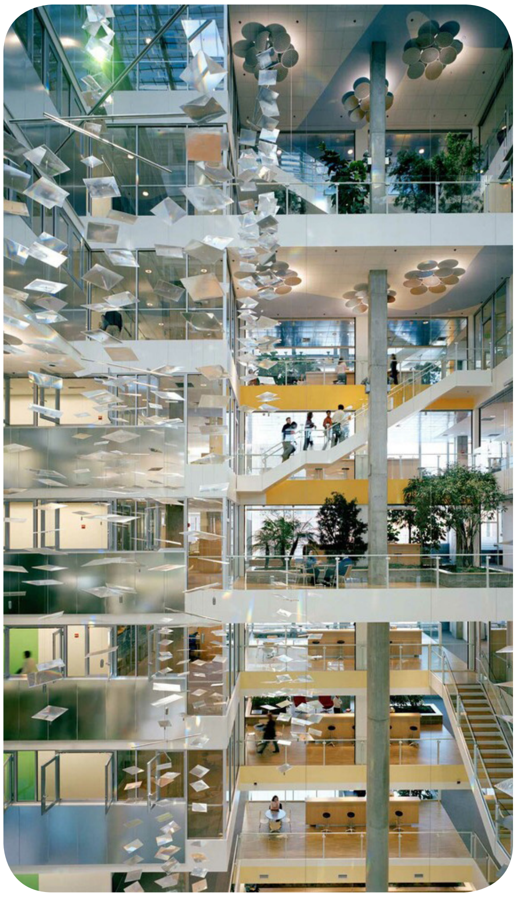
4. The remaining volume is further chiselled to optimise daylight.



5. The result of these stereotomic operations is an atrium, an optical device for letting light in as well as for projecting the glow of the building outward.

Project 2

Name :	Genzyme Center
Architect :	Behnisch Architekten
Location :	Cambridge, MA
Area :	32516 sqm
Year :	2004



Lighting Efficiency

- Photo sensors and occupancy sensors were installed in offices to make sure lights are off when employees leave the room.
- Energy efficient halogen metal vapor ceiling lamps are used at night.
- Light from these spotlights is reflected off the prismchandelier, which results in sufficient light in the atrium.

Water Conservation

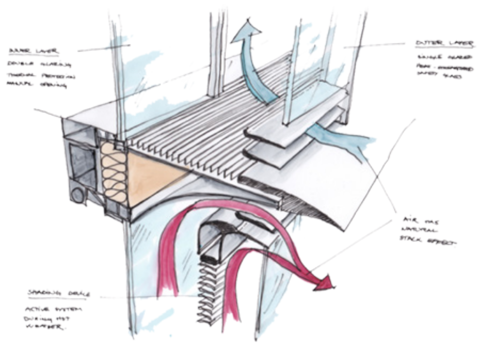
Water is used for restrooms, showers, the cafeteria, water fountains, irrigation of outside landscaping and
indoor gardens, a reflection pool in the lobby, and cooling towers.
The facility is expected to use 34 percent less water than is used in a similar sized building. Exact numbers are unavailable, but it is estimated that the building's conservation measures are saving more than 500,000 gallons annually in internal water use.

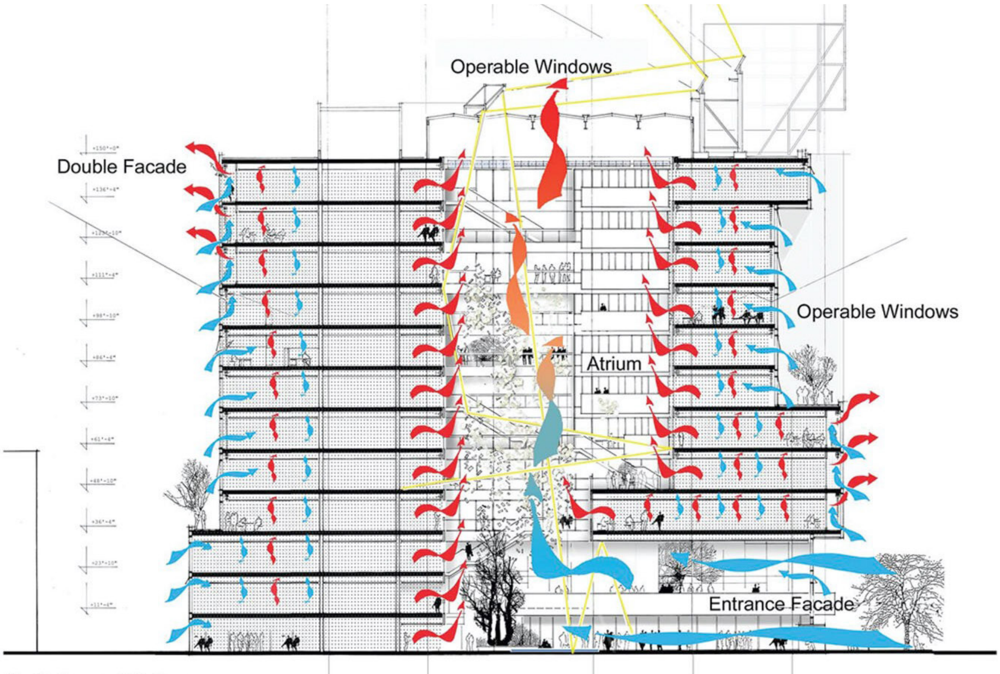
Construction

- Filigree wideslab construction was incorporated because of its many environmental benefits.
- Parking was located below ground to reduce the square footage of dark surfaces and the heat island effect they create with the absorption of the sun's heat.
- Over 93% of construction and demolition waste was recycled.

Energy

- Building envelope: 46% singleglazed, 22% solid cladding, 40% double façade which helps the building maintain its thermal conditions.
- Green roof: 50% plantings, 50% energy star rated reflective surfaces.
- The reflective pool on the ground floor also functions as a light

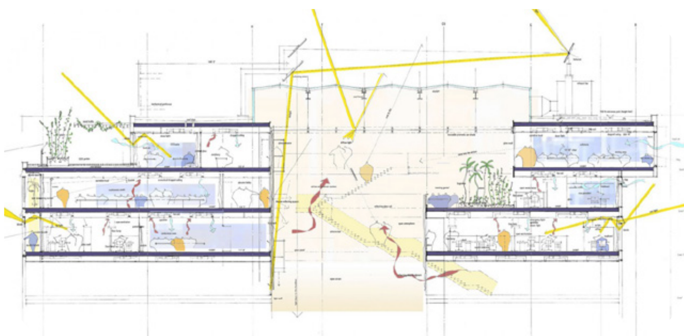




Ventilation and Airflow

What To Learn

This project has motivated us to consider a free and open working space, where specific desk allocation is no more required in spite of having more private spaces.
For our building we have decided to include solar panels that are oriented to sun to generate more power and using the atrium for ventilation, daylight absorption and a thermal buffer.
To control the situation in summer, we will use louvers for the facades.



Project 3

Name :	Debis Headquarters
Architect :	Renzo Piano
Location :	Berlin, Germany
Area :	-
Year :	1998

Design Aim

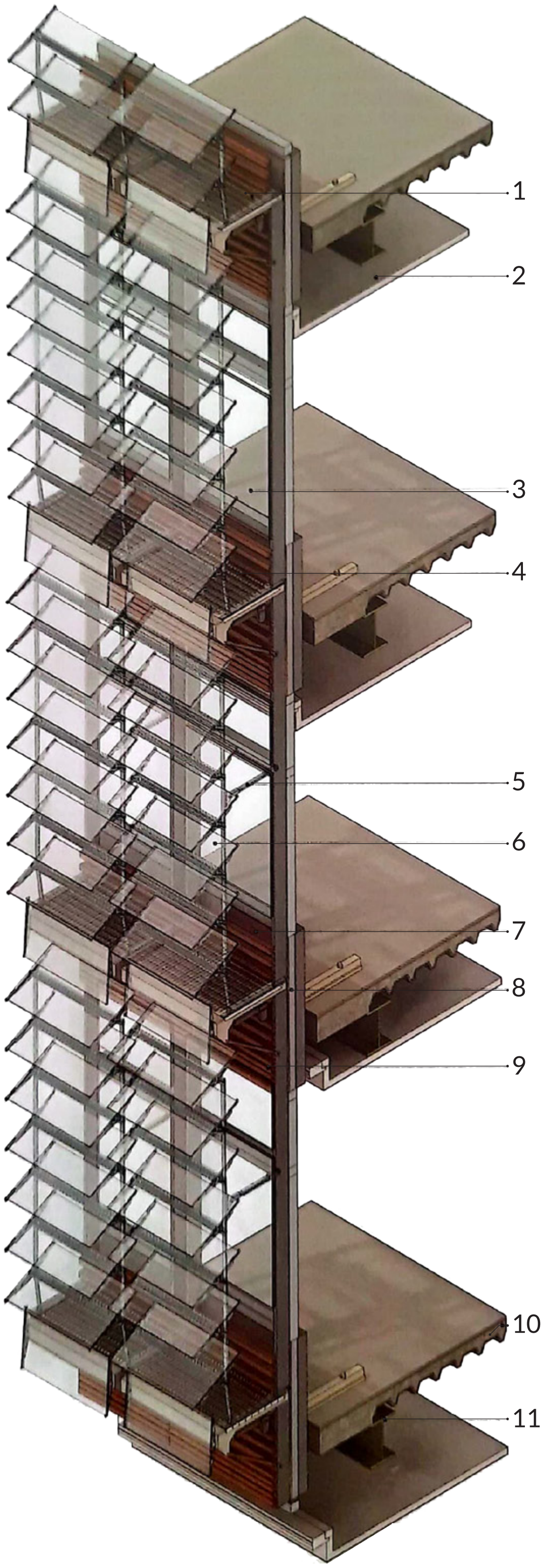
The building complex is designed to accommodate office spaces as well as retail and food services in the lower levels. The interior organization of the building is designed to provide healthy working conditions through access to natural light and ventilation. The building utilizes double- skin façades with various degrees of transparency to respond to the solar orientation and provide occupant comfort.

Building Envelope

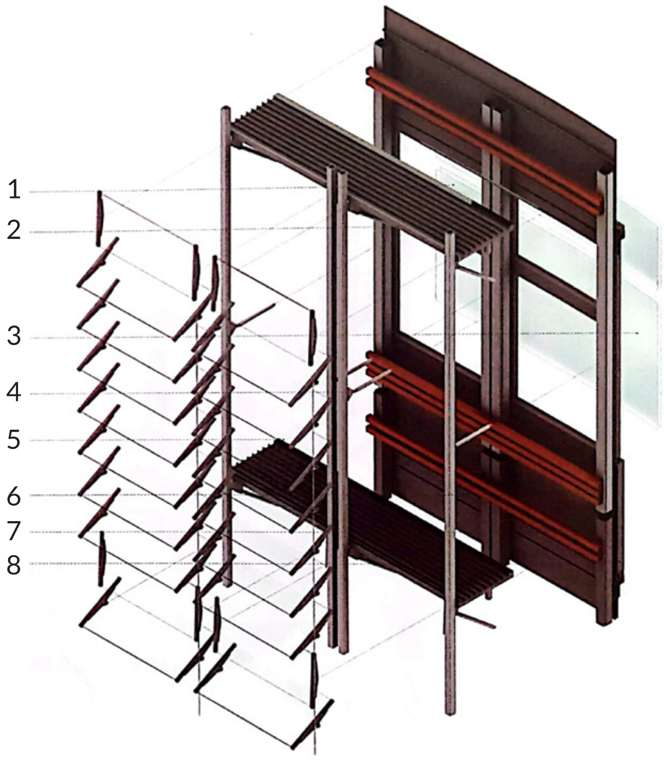
The building's envelope and double-skin façades serve as examples of energy efficient design achieved through the integration of envelope and mechanical systems. The building is comprised of intelligent features that monitor external conditions to initiate and adjust passive and active thermal controls. The double-skin façade is regulated by mechanical thermal controls when the ambient temperature is not adequate to provide the desired interior environment. The building envelope provides ample natural daylight and ventilation to achieve thermal comfort.

Shading

OPEN LOUVERS : When open in conjunction with the inner layer it helps to remove the heat in the intermediate space and provides fresh air to the interior of the building.
CLOSED BLINDS : The west façade is equiped with retractable blinds that provide solar protection and glare control. The blinds are sensor controlled with a manual override.



1 Laminated Glass
2 Drop Ceiling
3 Operable Windows
4 Maintenance Grating
5 Tilt Mechanism
6 Laminated Glass Blades
7 Safety Glass Blades
8 Insulation
9 Terra-Cotta Cladding
10 Concrete Floor Slab
11 Steel Beam
12 External Blind
13 Pivot Motor



1. Laminated Glass
2 Maintenance Grating
3 Operable Windows
4 Tilt Mechanism
5 Laminated Glass Blades
6 Safety Glass-Clad insulated
7 Terra-Cotta Cladding
8 Insulation

Performance

NORTH
The entry of sunlight is controlled throughout the day in order to achieve thermal comfort.

EAST
In summer, large amounts of solar radiation enter at a shallow angle. Solar screening is provided by terra-cotta cladding elements.

SOUTH
This façade receives light at a steep angle during the summer. Shading is provided by terra-cotta shading devices without reducing daylight entry. This façade is exposed to solar heat gain in winter.

WEST
In summer, the west façade receives large amounts of solar radiation at a shallow angle. Retractable blinds provide solar screening. In winter, this façade is heated by the sun and functions as a thermal blanket to keep the building warm.

Facade

The west façade is the most transparent. The inner skin layer is composed of a conventional glazed curtain wall with two double-pane windows. This layer is the main weather barrier of the building and provides the occupants with control of natural ventilation. The outer skin of the façade is composed of louvered-glass blades on metal frames that pivot up to 70 degrees vertical to open.' These blades are controlled by sensors that respond to climatic conditions. This layer has several functions when it is closed: it reduces the wind impact on the inner wall, keeps the rain out, and provides thermal insulation during the winter months. When open, in conjunction with the inner layer it helps to remove the heat from the intermediate space and provides fresh air to the interior of the building.

The space between the two skins is separated by a maintenance walkway at each floor level. This space is equipped with retractable blinds that provide solar protection and glare control. The blinds are sensor controlled with a manual override. In addition to the retractable blinds, the intermediate space utilizes terra-cotta-cladding elements for additional shading and thermal insulation.

The east and south walls of the building also utilize double-skin façades However, in order to protect the building from intense exposure to the sun, they use terra-cotta shading devices more extensively. As a result, these façades appear to be more opaque. The covered central atrium space is surrounded by an internal innovative façade as well. This façade is clad with angled blades to provide privacy for the offices while admitting daylight from the large glass roof of the atrium.

NORTH
The entry of sunlight is controlled throughout the day in order to achieve thermal comfort.

EAST
In summer, large amounts of solar radiation enter at a shallow angle. Solar screening is provided by terra-cotta cladding elements.

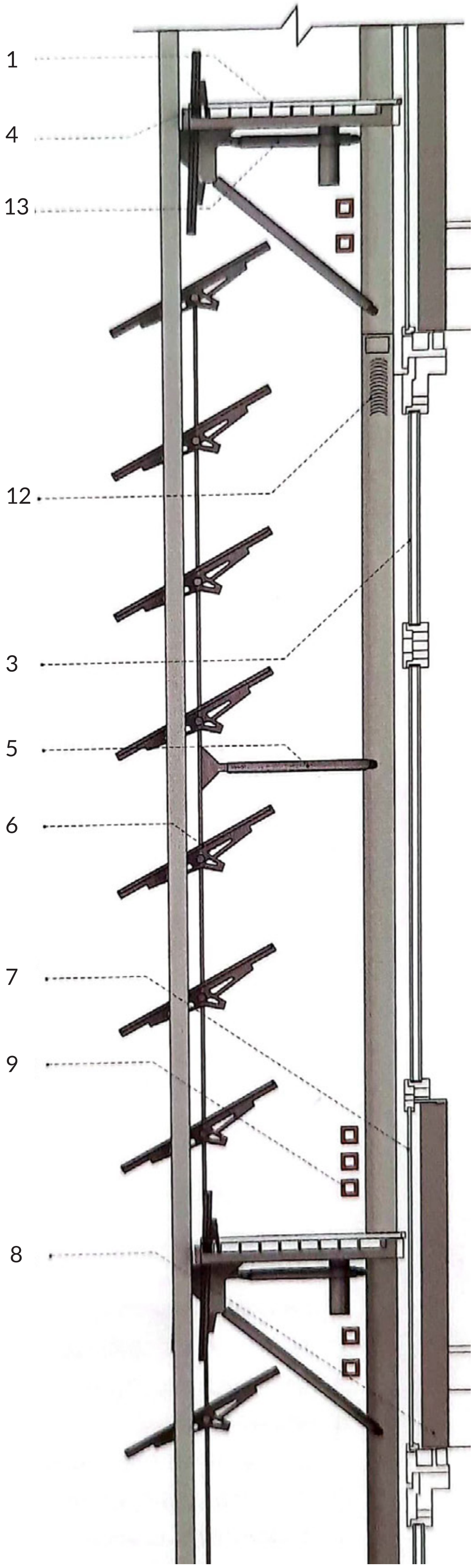
SOUTH
This façade receives light at a steep angle during the summer. Shading is provided by terra-cotta shading devices without reducing daylight entry. This façade is exposed to solar heat gain in winter.

WEST
In summer, the west façade receives large amounts of solar radiation at a shallow angle. Retractable blinds provide solar screening. In winter, this façade is heated by the sun and functions as a thermal blanket to keep the building warm.

What To Learn

This project has motivated us to consider the natural ventilation through the openings and control the glare with the louvers facilitated with the solar panels to produce the electricity. Shading is provided by terra-cotta shading devices without reducing daylight entry to make the façade exposed to solar heat gain in winter.

The way that the building utilizes double- skin façades with various degrees of transparency to respond to the solar orientation and provide occupant comfort guides us to consider the best orientation of the building and the placement of the glazing.



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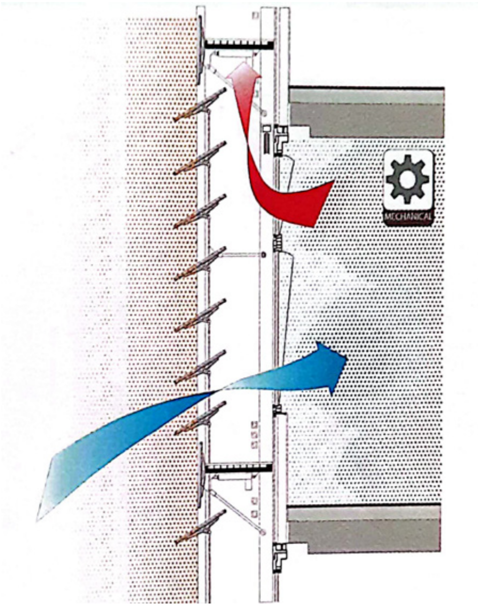
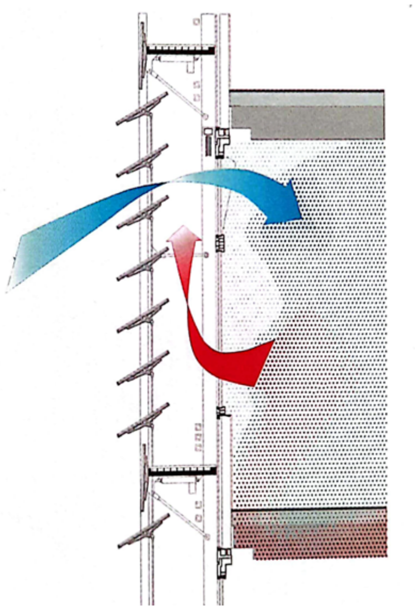
Natural Ventilation



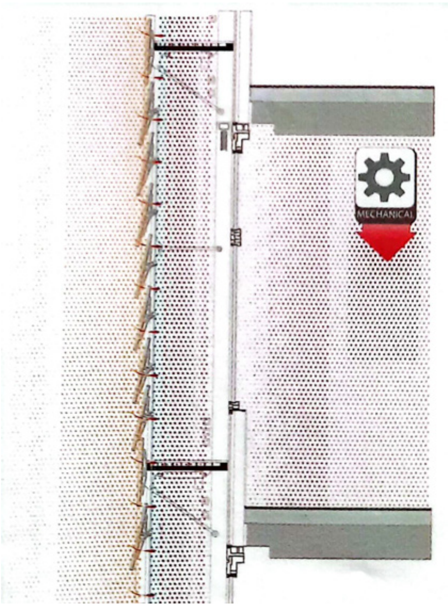
SUMMER: [No mechanical ventilation]
(A) DAY VENTILATION

During the summer, natural ventilation is achieved by opening both skins: the louvered glass blades on the outer skin and the upper windows on the inner skin. The air movement between these two layers allows cool breezes to penetrate the space and enter the building. As the hot air inside the building rises, it is channeled up and away from the building. When ambient temperature rises above 68°F (20°C), mechanical ventilation is activated.



(B) NIGHT COOLING

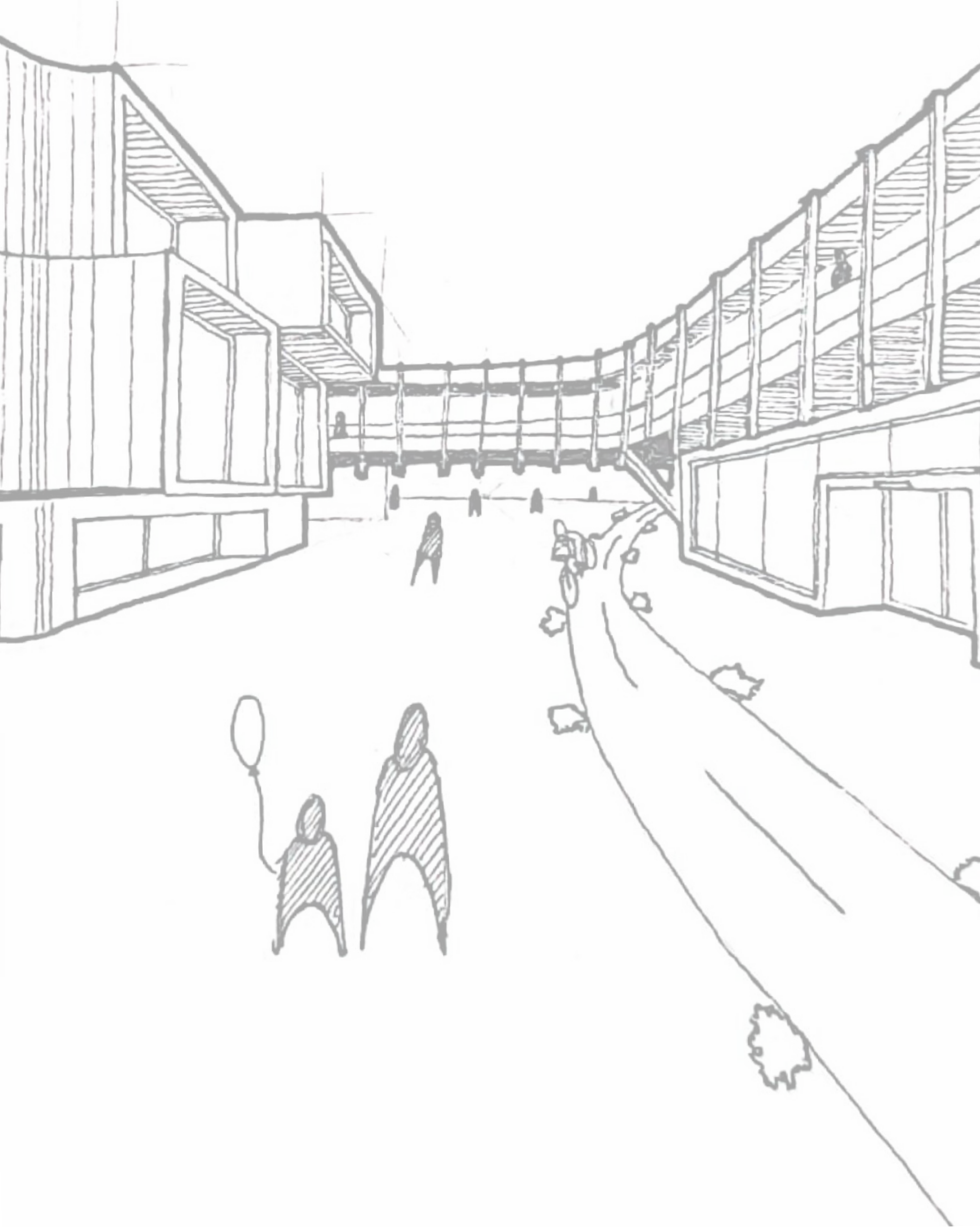
In warm weather, night cooling is used to remove the accumulated heat during the
day from the building. At night, the upper windows on the inside skin open automatically to ventilate the interior space, Cool air flows into the building, removing hot air. The concrete floor slab is left exposed at the outer edges to absorb and store cooling energy for the next day.

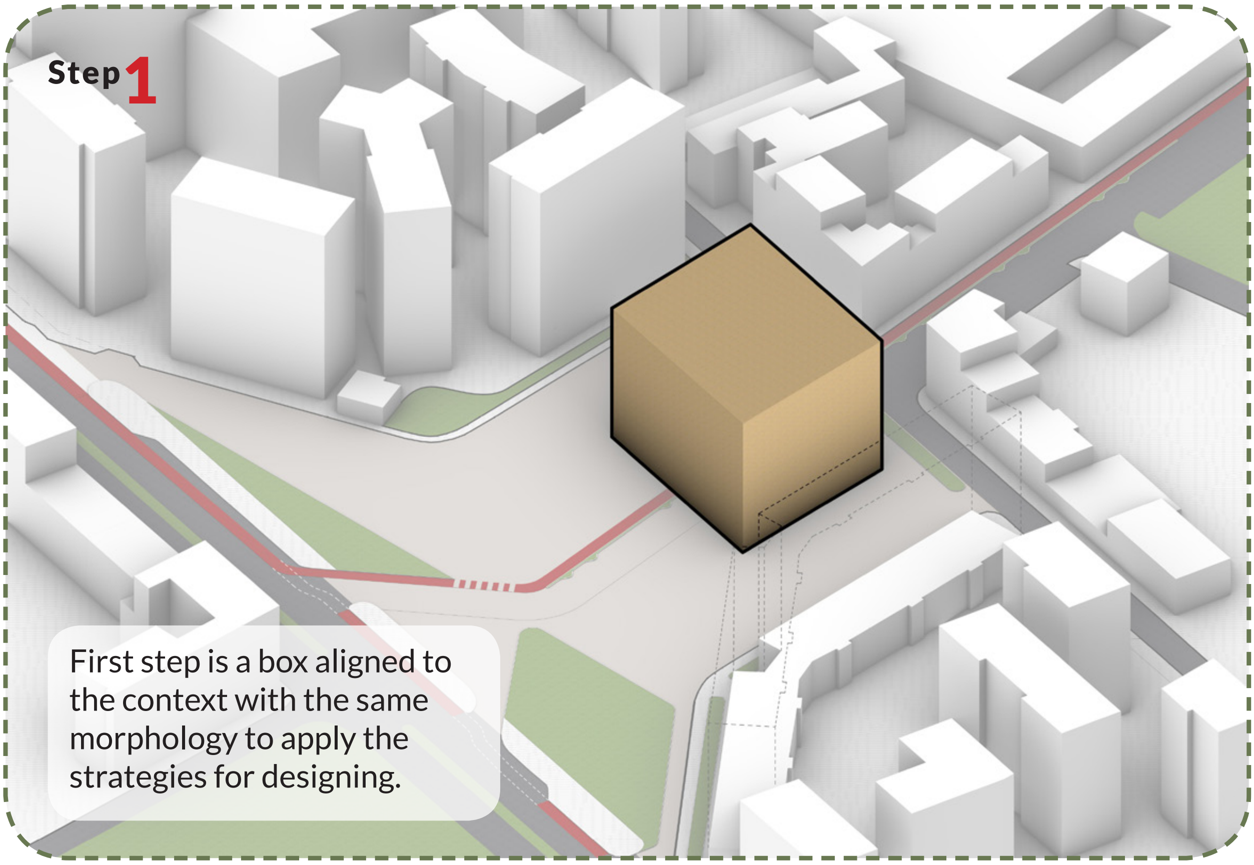


WINTER:

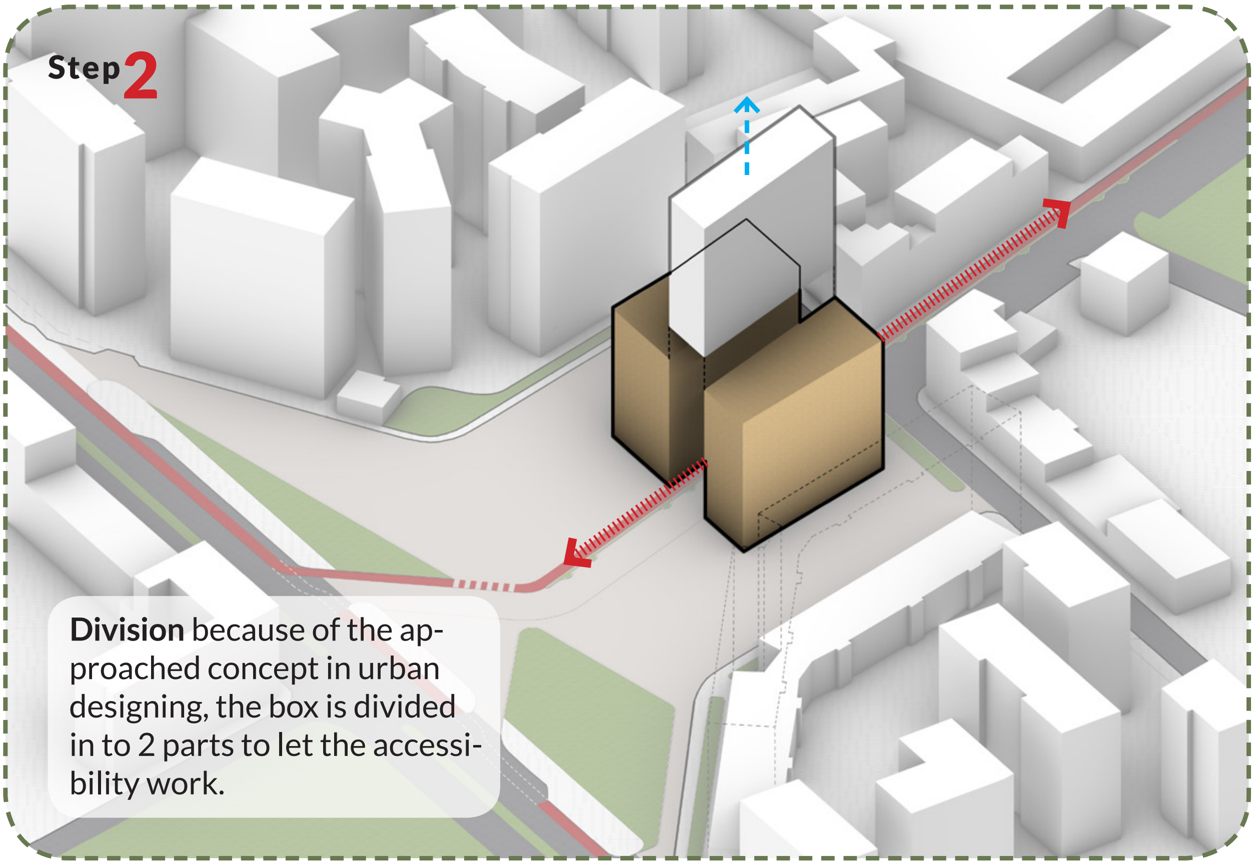
(C) THERMAL BUFFER During the winter, the building uses a mechanical heating system. In cold temperatures, both skin layers are closed to prevent heat loss. Warm air escaping from the interior of the building is stored between the two skins. This space, which is also heated by the sun, acts as a thermal blanket and protects the interior space from the cold weather.

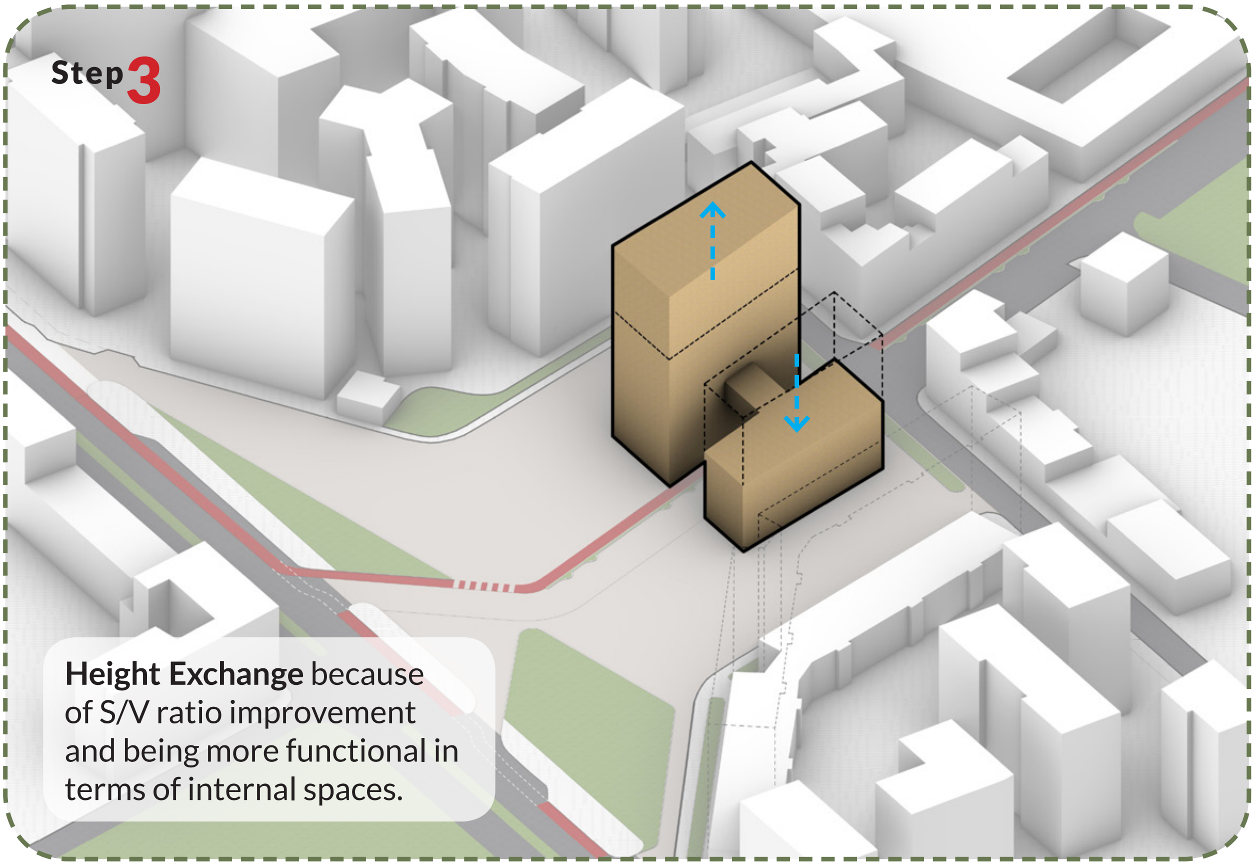
4 MASS DEVELOPMENT and Energy Performance



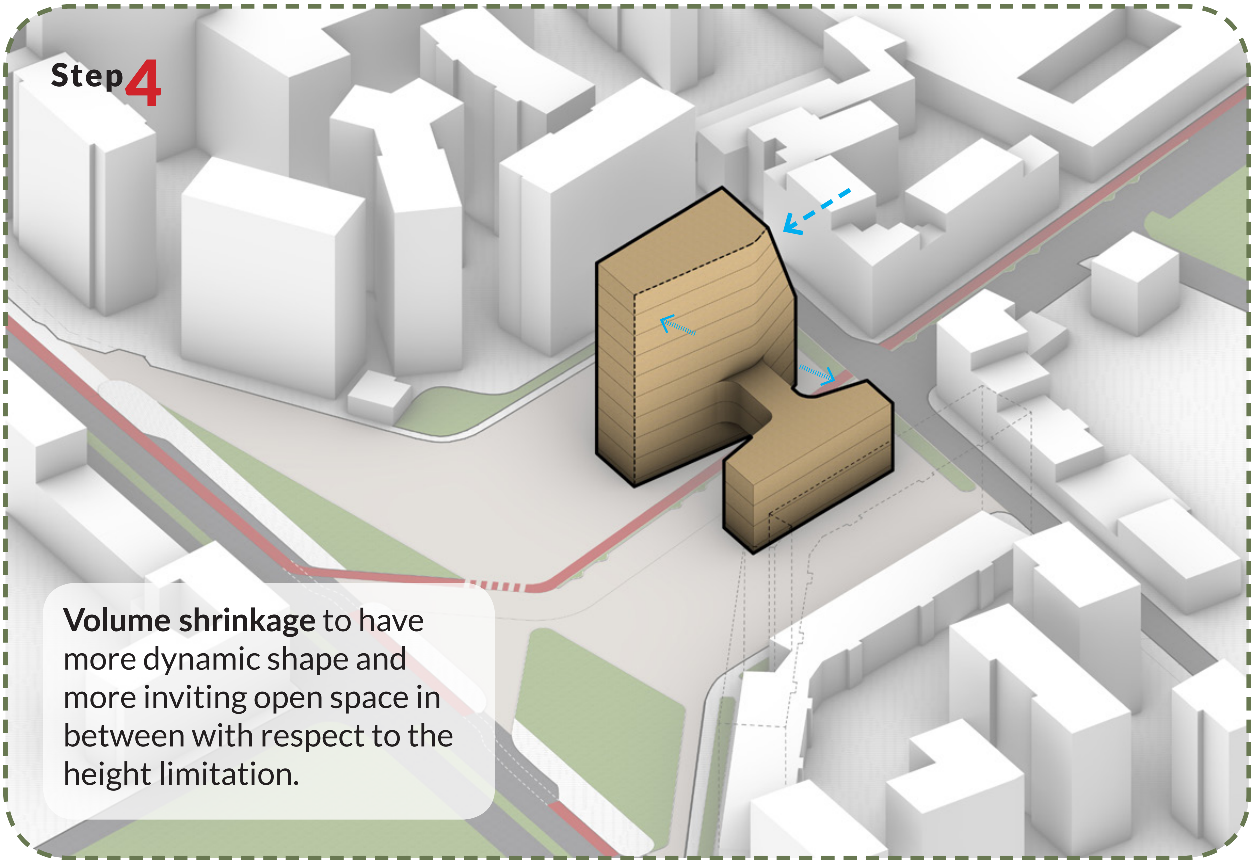


As it has been mentioned precisely in Urban Designing part, the main concept of the project in terms of the form of the building has been shaped because of the proposed solutions to improve the accessibility and cycling.



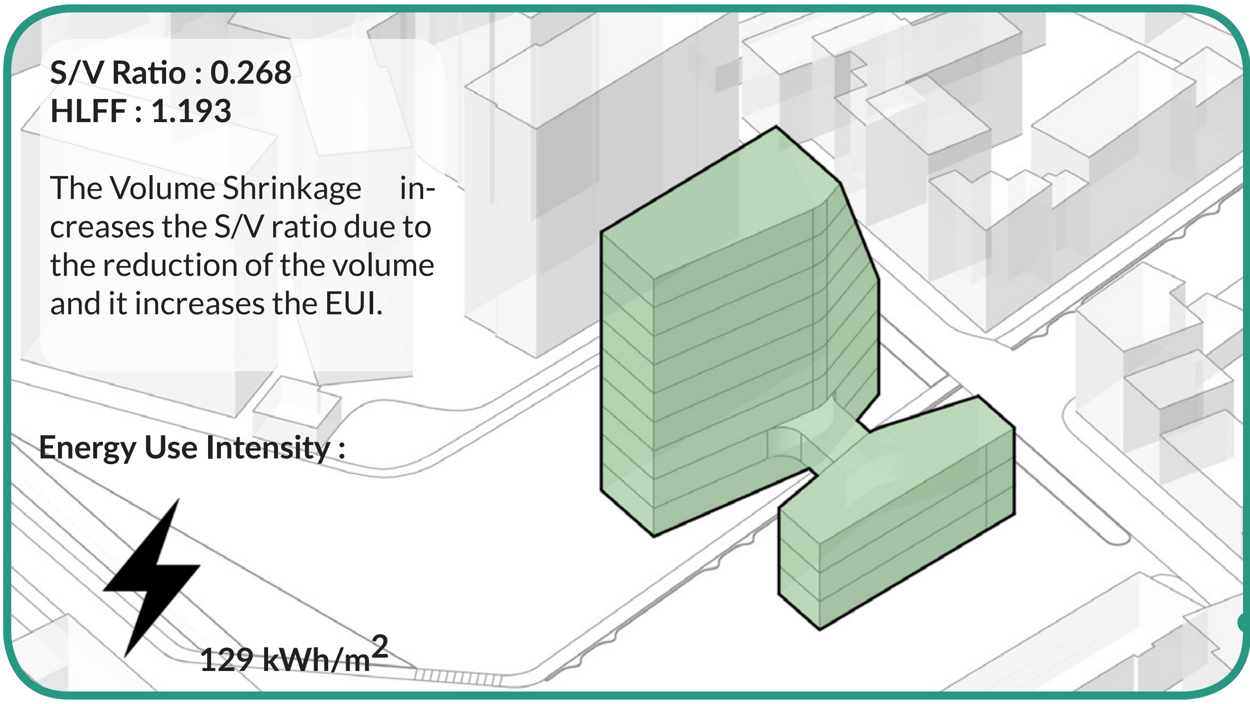


To improve the S/V ratio and energy consumption and also to respect the neighbourhood regulations, the form has been undergone a height exchange and volume shrinkage. Moreover, it enhanced the form in terms of function.



Mass Optioneering

- **The Heat Loss Form Factor (HLFF)** is a term commonly used in building physics and thermal engineering to quantify the heat loss characteristics of a building. It is a dimensionless factor that represents the relationship between the actual heat loss from a building and the heat loss that would occur if the entire building envelope had the same temperature as the indoor air and It is the ratio between the building's envelope area and it's net floor area . **Passive houses aim to achieve HLFF 3 or less.**
- **The Surface-to-Volume ratio (S/V)** has implications for heat transfer, energy efficiency, and thermal performance. Buildings with a higher surface-to-volume ratio have a larger surface area relative to their enclosed volume. This means they have more external surface exposed to the surrounding environment, which can result in increased heat loss or gain. **The recommended S/V ratio for a Passive house is less than 0.8 .**



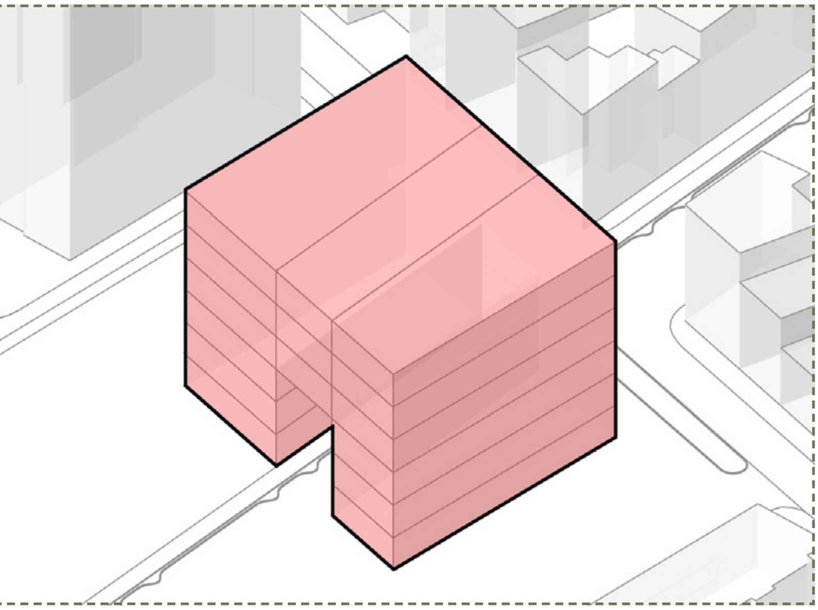
The comparison of these last options is taking mainly the orientation of the building into consideration and its impact on energy consumption of the building. In the last option in which the building is more west-oriented than the previous one because of the volume shrinkage in the facade, the energy use intensity is bigger.
The west facade of a building typically receives intense afternoon sunlight, which can lead to solar heat gain. During hot seasons, the setting sun can contribute to high solar radiation and increased cooling demands. As a result, buildings with a west-facing facade may require additional cooling efforts, leading to higher energy consumption. In regions with a hot climate, energy waste on the west facade can be substantial due to the need for effective shading, insulation, and solar control measures. The east facade receives morning sunlight, which tends to be less intense compared to the afternoon sun. While energy waste may be lower on this facade in terms of cooling requirements, there could still be a need for effective insulation and glazing to balance indoor comfort.
- So the main reason to have more EUI on the selected option is that the building is receiving afternoon sun more than the option with the EUI of 90 kWh/m^2.

S/V Ratio : 0.226
HLFF : 1.018

The best result in S/V ratio is obtained from this mass which is the preliminar option to design to respect the limitations.

Energy Use Intensity :

89 kWh/m^2

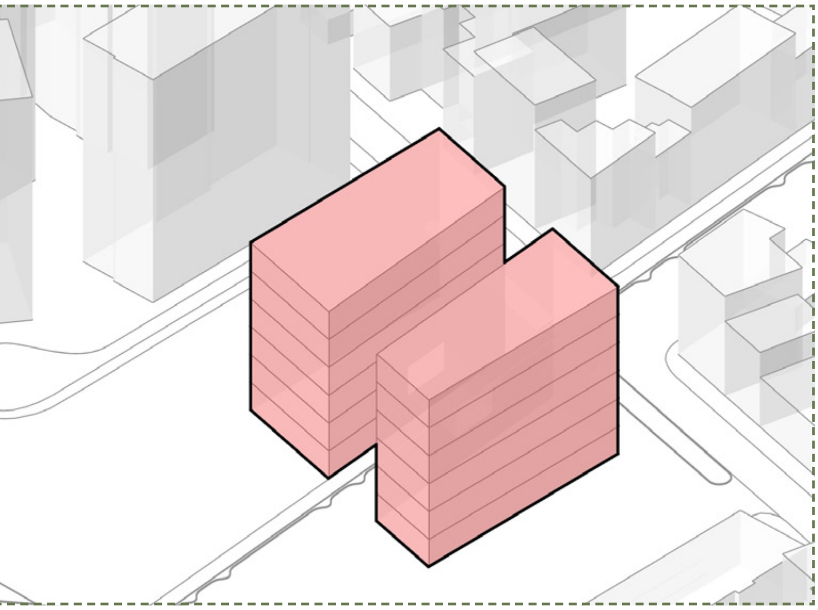


S/V Ratio : 0.267
HLFF : 1.201

The devision considerably increased the S/V ratio due to the reduction of the volume in between.

Energy Use Intensity :

95 kWh/m^2

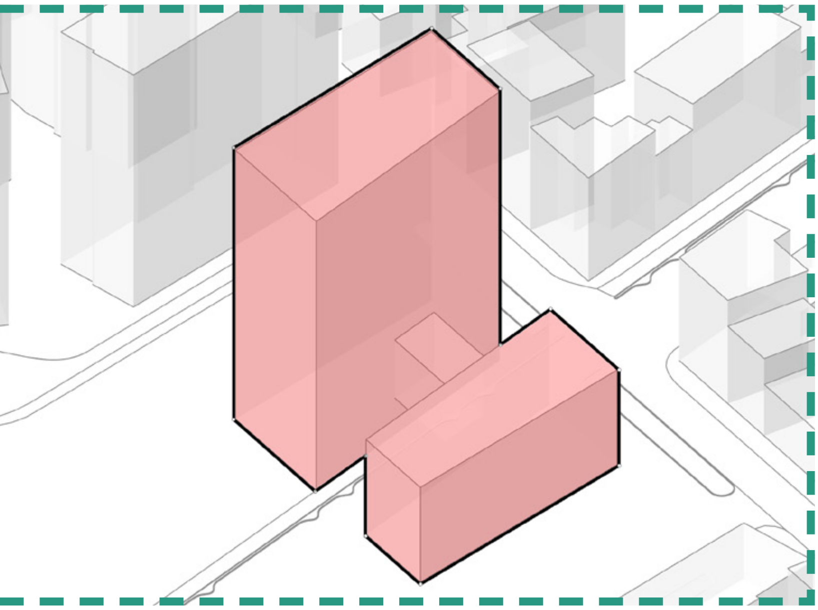


S/V Ratio : 0.252
HLFF : 1.148

The height exchange compensate the S/V ratio due to the reduction of the volume of the smaller zone.

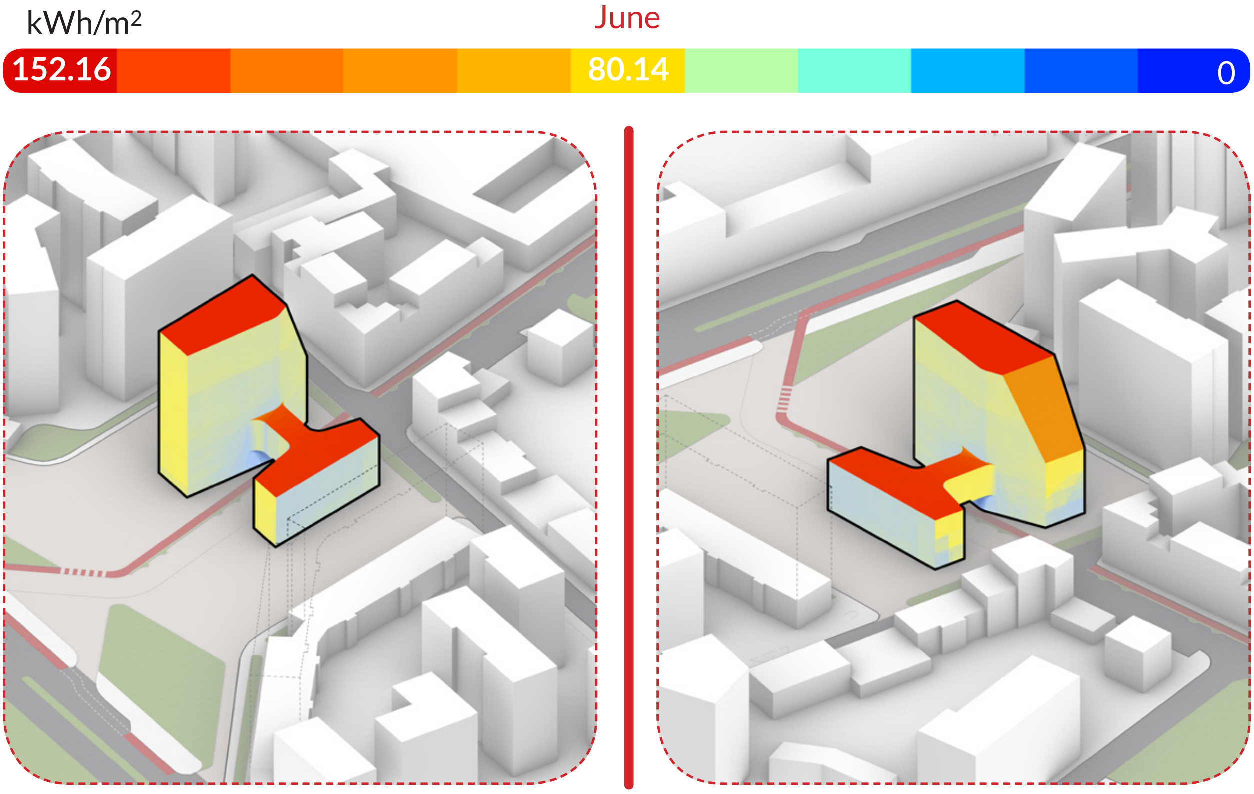
Energy Use Intensity :

90 kWh/m^2



Incident Radiation Analysis

- This analysis aided us to understand how solar radiation interacts with a building's surfaces allows us to optimize the building's orientation, form, and materials. **By analyzing incident radiation, they can identify areas prone to excessive heat gain or loss, enabling the implementation of design strategies** that enhance energy efficiency and reduce the building's environmental impact.
- Incident radiation analysis **aids in the implementation of passive design strategies**. For example, by knowing where and when solar radiation hits the building, we can strategically place windows, shading devices, and insulation to harness solar energy for heating and lighting during the colder months while minimizing heat gain during warmer months.
- Incident radiation analysis is crucial for **assessing the feasibility of integrating renewable energy systems** like solar panels or solar water heaters. It provides insights into the building's solar energy potential, aiding in the design of systems that harness and convert sunlight into usable energy.



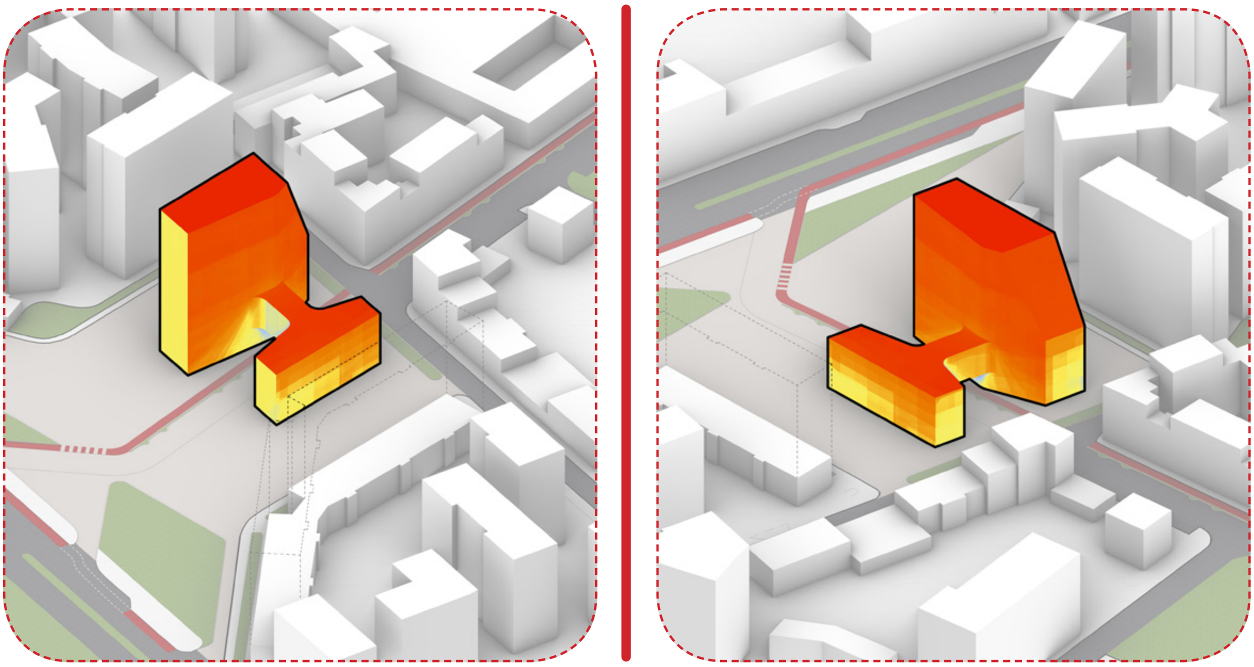
During June as a hot month in summer, fortunately the facade is receiving less radiation which will have positive impact on daylight analysis and heat gain. The roof is a potentially better producer of electrical energy through solar panels in June.
By analyzing incident radiation in June, we can identify areas prone to overheating and implement shading solutions to maintain a comfortable indoor environment, reducing the reliance on energy-intensive air conditioning systems. We can provide solar shadings on the facade faces the south as well as gaining considerable natural daylight inside the building.
We can use greenery as thermal buffer on the roofs to avoid heat exchange and also staying more in the comfort zone in terms of temperature in this critical month in order to make the artificial cooling use diminished which will be greatly affect the energy use intensity of the building in terms of nearly to get nZEB features.

September

kWh/m²

96.02 | 51.14 | 0

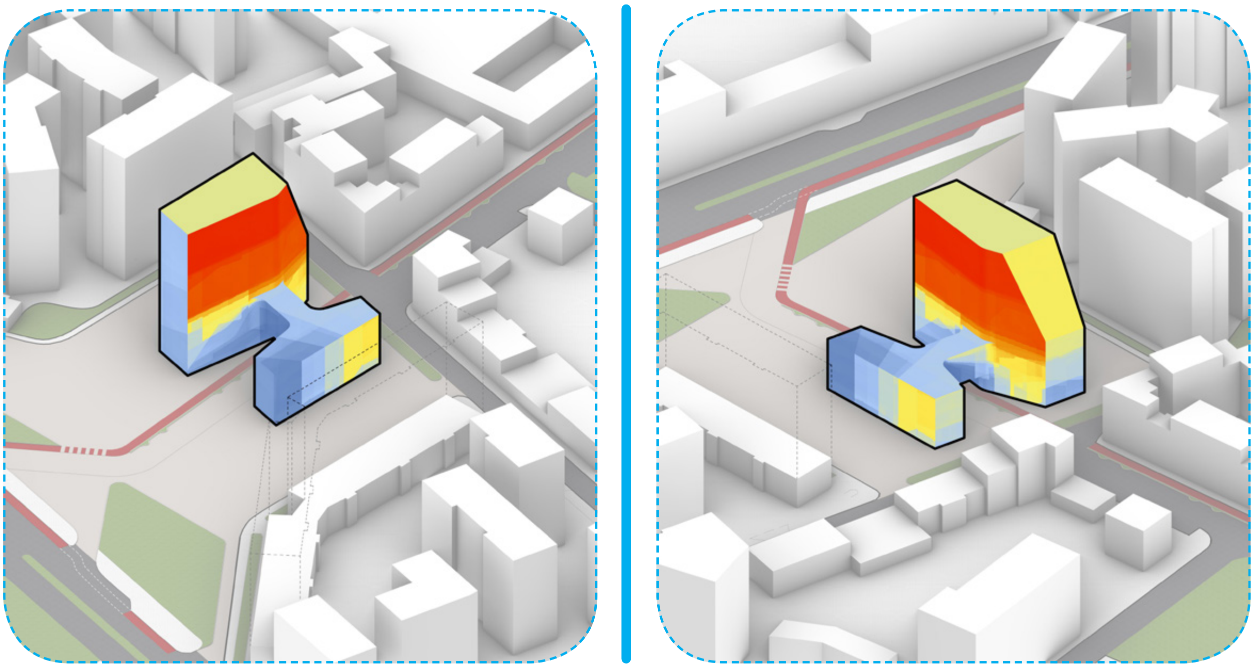
In this month because of the orientation of the sun, southern facades are receiving considerable amount of radiation which is useful for energy generation. East and west radiation is limited as June.
The southern facade has the potential to have solar shadings provided with the solar panels to produce electricity as well as the surface of the roof. In this case, we would have more surface by chance to consider as energy-productive surface in the building.



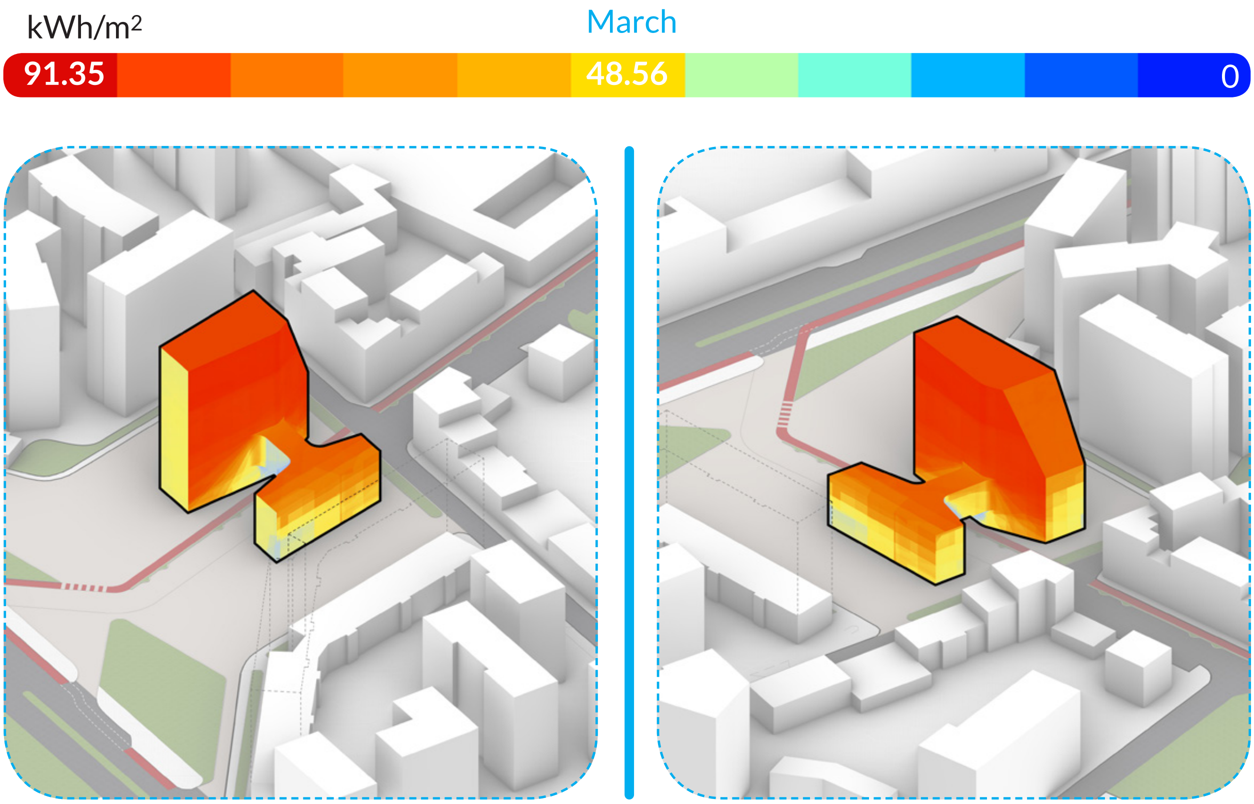
December

kWh/m²

64.49 | 33.69 | 0



This month is the critical month but we have some radiation from south and for energy generation and heat gain. Southern facade can be the best option for placing the solar panels to have the energy production also in December as the critical month in solar radiation point of view. For the upper floors, we can consider more glazing to enter more heat and we can control it with shading during the critical month of summer.



For March, we receive good radiation in terms of energy generation and also heat gain. The situation is like September but the heat gain is useful here to reduce energy consumption.
In almost all months, the critical floors are ground-floor to the second floor is the fact that guides us to have more openings and glazing in those parts.

The tilt angle of solar panels refers to their inclination relative to the horizontal plane. The optimal tilt angle varies based on factors such as the latitude of the location and the season. For Milan, which is at a latitude of approximately 45 degrees North, a general guideline for the tilt angle is often set at around 45 degrees. This angle helps maximize solar energy capture throughout the year by accounting for the changing angle of the sun's position in the sky.

In summary, the optimal orientation of shading devices in Milan depends on finding a balance between mitigating solar heat gain, maximizing daylight penetration, and maintaining energy efficiency. Careful consideration of the building's orientation, local climate, and desired indoor environment is essential for developing effective shading strategies that enhance both comfort and energy performance.
In addition to the **Incident Radiation Analysis**, the exposed **Sun Hours** has been taken into consideration as a more precised way before daylight analysis to help in decision-making process to find a way to optimize the glazing and openings.

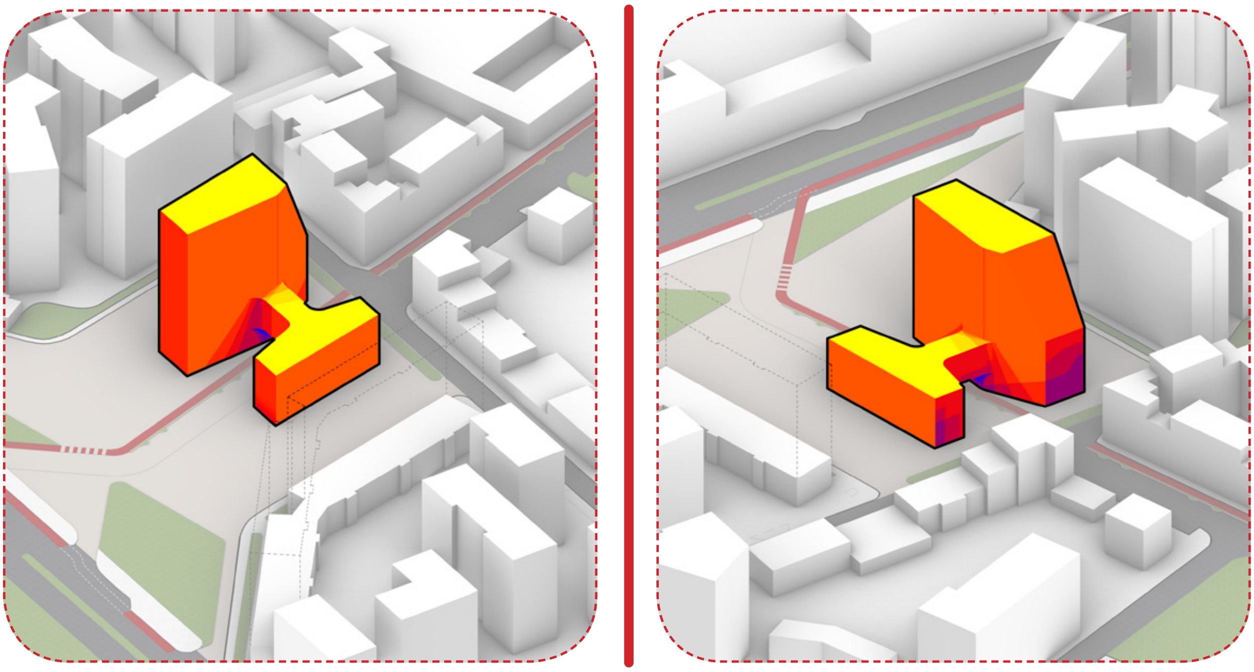
Sun Hour Analysis

- This analysis has been done as a more deep guidance to find excessive sun exposure which can lead to thermal discomfort for occupants. By analyzing sun hours, we can determine areas that may require additional insulation or shading to prevent overheating. This enhances indoor thermal comfort and reduces the reliance on air conditioning systems.

Sun hour analysis is a component of passive solar design. Designers can use this analysis to optimize the building's orientation, window placement, and shading strategies. By aligning windows with the sun's path and shading areas prone to overheating, passive solar design maximizes solar energy gain during winter while minimizing heat gain during summer.

Sun hour analysis is closely tied to energy consumption. It helps identify areas that might be prone to excessive solar heat gain, which could lead to increased cooling demands. By knowing which areas receive more sun exposure, we can implement shading solutions, such as overhangs, louvers, or solar control glazing, to reduce energy consumption for cooling and improve overall energy efficiency.

The east and west are receiving excessive amount of sun so the transferred sun should be limited with shading for the comfort reasons and energy consumption in summer.



As mentioned in the incident radiation analysis, the roof is always on the exposure of the sun and the southern facade has the sun exposure more than the east and west and the sun glare should be limited for all the facades for this critical month to reduce the heat gain.

According to the critical months, west and east ar less exposed to sun and the south facade should be controled in terms of glare by louvers or blinds as mentioned before.

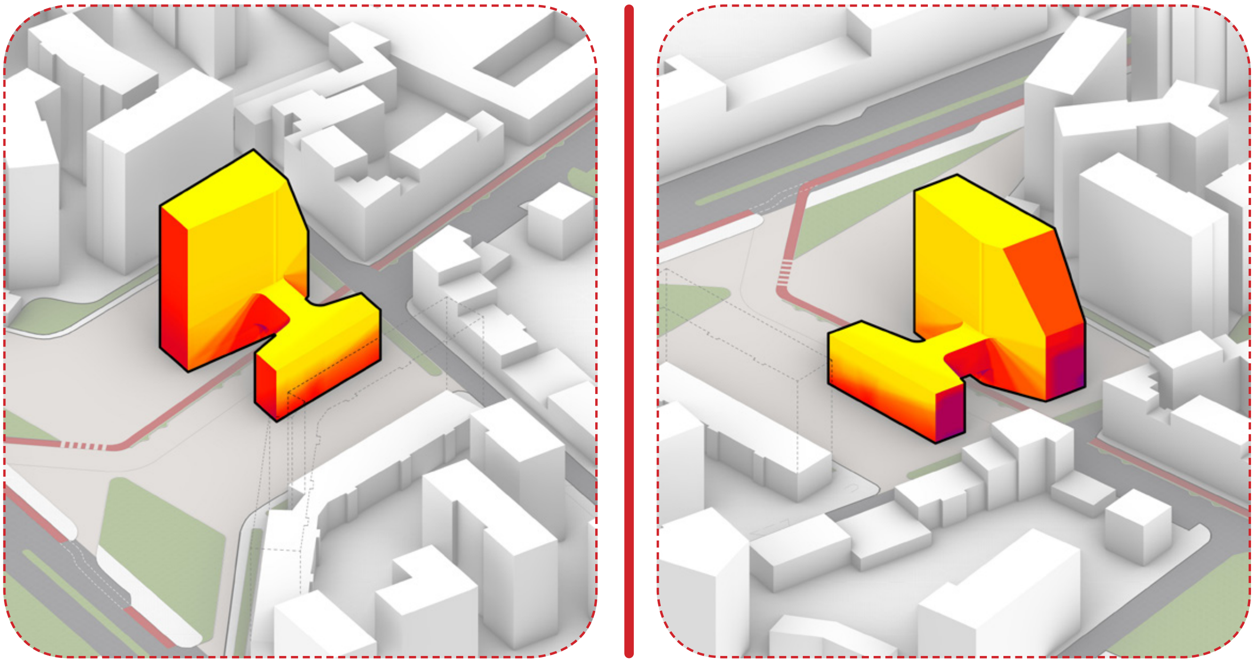
It can be a strong proof that the shaders with inclination of 45 degree in summer can produce sufficient energy if they become provided by solar panels. As it is obvious from other months such as September or December which is the critical month in winter.

September

Hour

291 | 145.5 | 0

The southern facade is receiving considerable amount of sun so the transferred sun should be controled for the comfort reasons and energy consumption in this month.

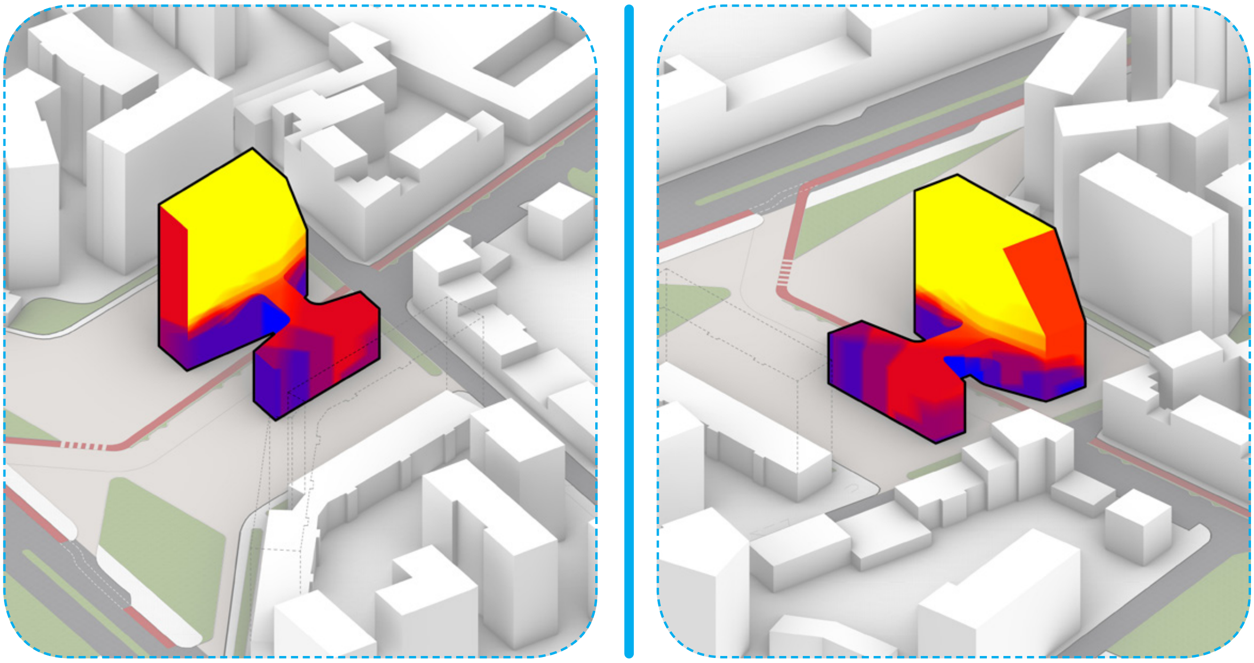


December

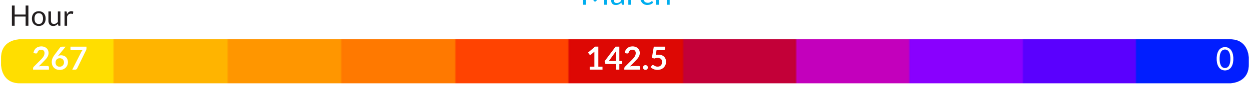
Hours

217 | 108.5 | 0

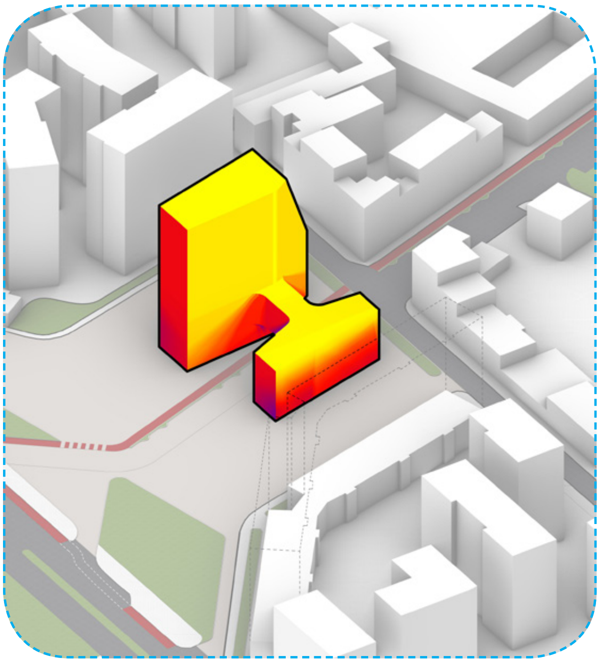
This month is the critical month and we need heat gain through sun so we need to open the louvers and the blinds to let sun heat come inside. Maybe if the horizontal shadings are going to be used, they have to be partially transparent The southern facade of the mid-rise part is the best place to generate on-site energy.

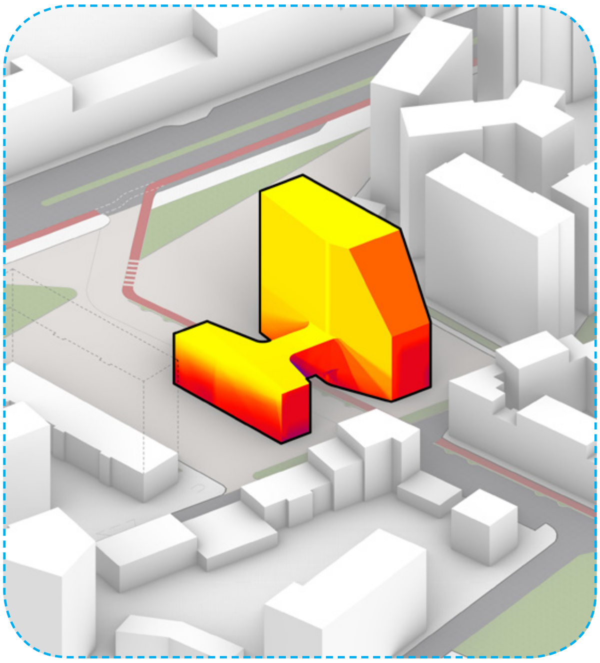


March

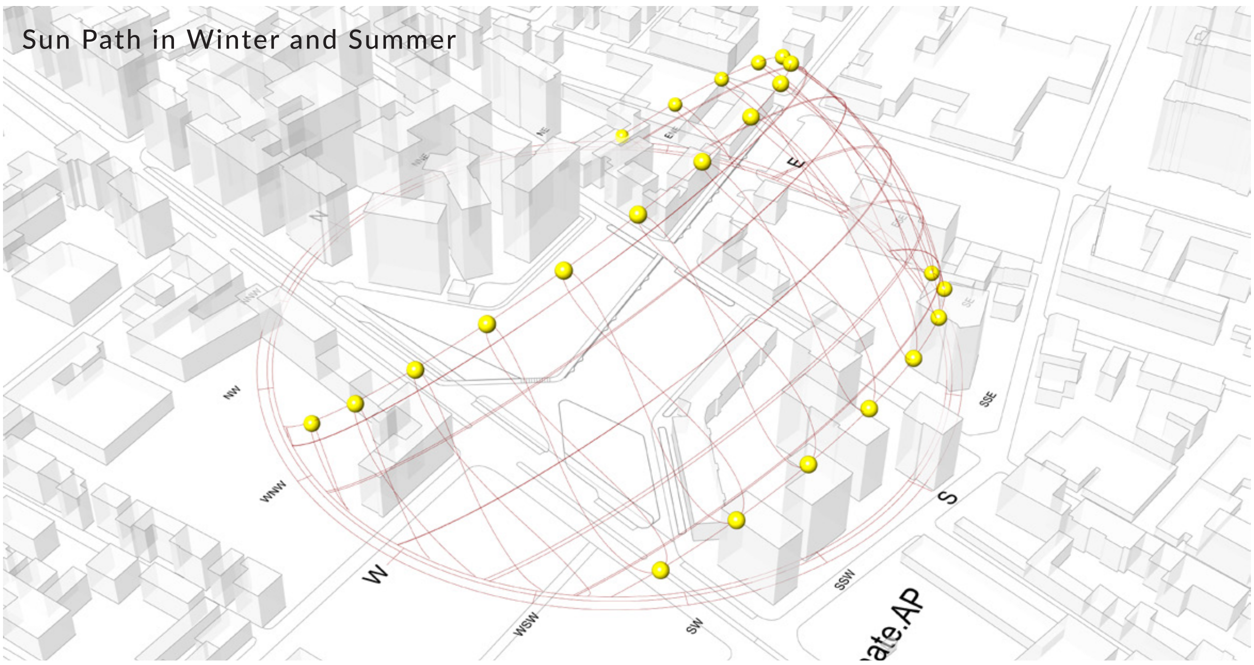


Situation in March is as same as September. The difference is we need the heat gain through the sun because of the ambient temperature and having more hours in comfort zone.



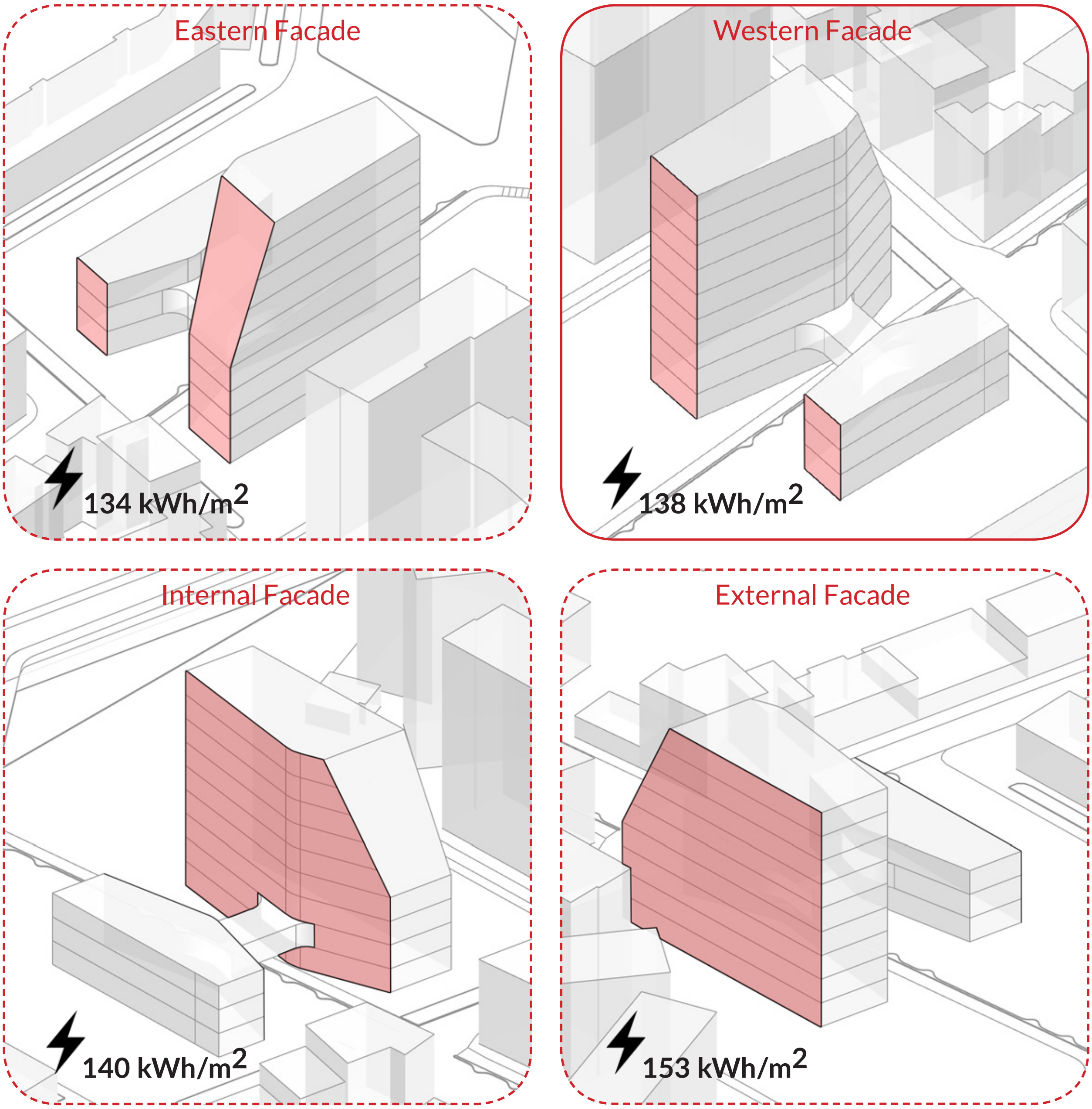


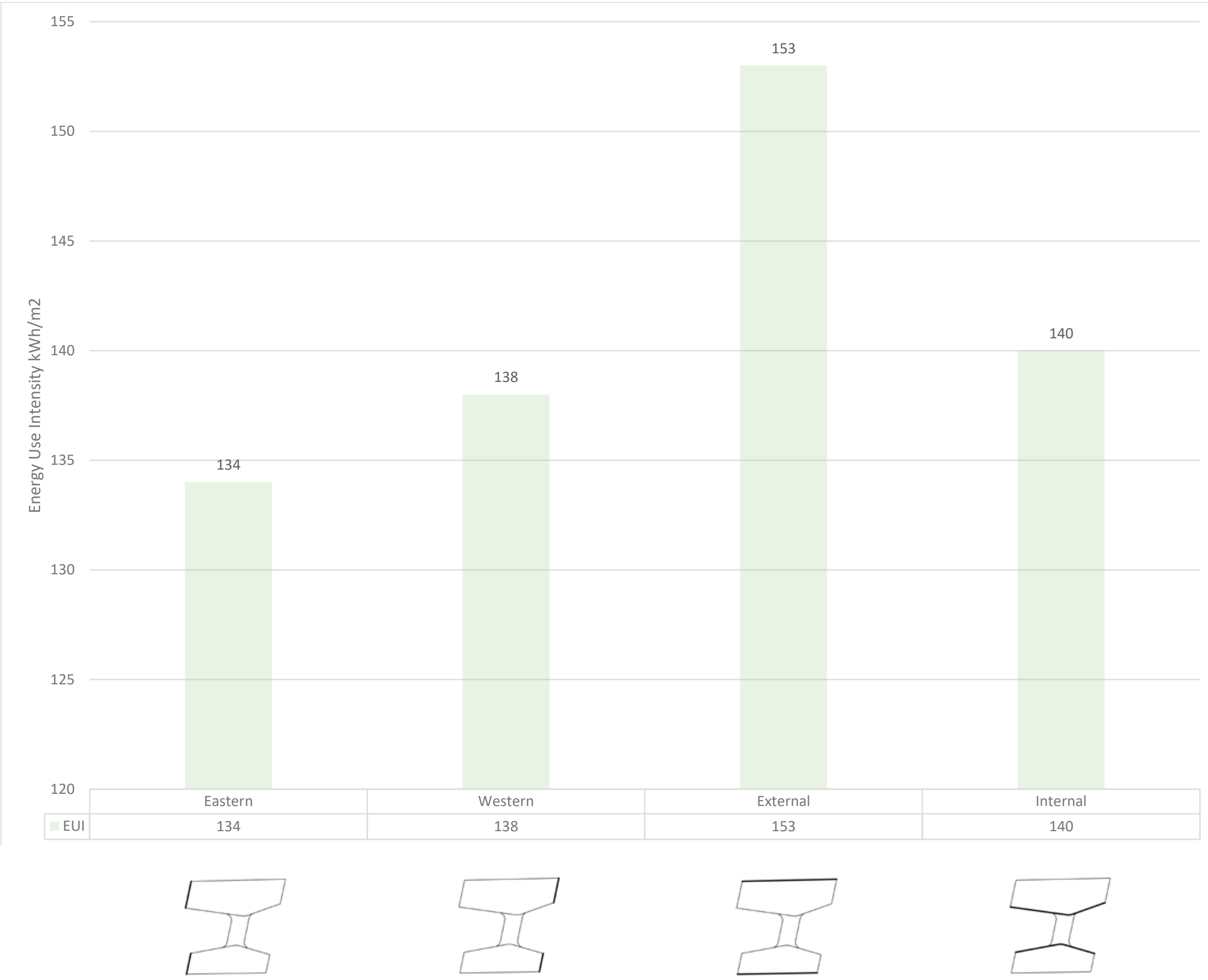
Around the summer solstice, which occurs around June 21, the sun's angle is relatively high in the sky in Milan. The approximate solar noon elevation Angle (highest point in the sky) is 75-80 degrees above the horizon.
During the winter solstice, which occurs around December 21, the sun's angle is lower in the sky in Milan. The approximate solar noon elevation Angle (lower point in the sky) is Approximately 20-25 degrees above the horizon.



Glazing Optioneering 1

- This analysis has been done as a more deep guidance to find excessive sun exposure which can lead to thermal discomfort for occupants. By analyzing sun hours, we can determine areas that may require additional insulation or shading to prevent overheating. This enhances indoor thermal comfort and reduces the reliance on air conditioning systems.
Sun hour analysis is a component of passive solar design. Designers can use this analysis to optimize the building's orientation, window placement, and shading strategies. By aligning windows with the sun's path and shading areas prone to overheating, passive solar design maximizes solar energy gain during winter while minimizing heat gain during summer.
Sun hour analysis is closely tied to energy consumption. It helps identify areas that might be prone to excessive solar heat gain, which could lead to increased cooling demands. By knowing which areas receive more sun exposure, we can implement shading solutions, such as overhangs, louvers, or solar control glazing, to reduce energy consumption for cooling and improve overall energy efficiency.





Conclusion :

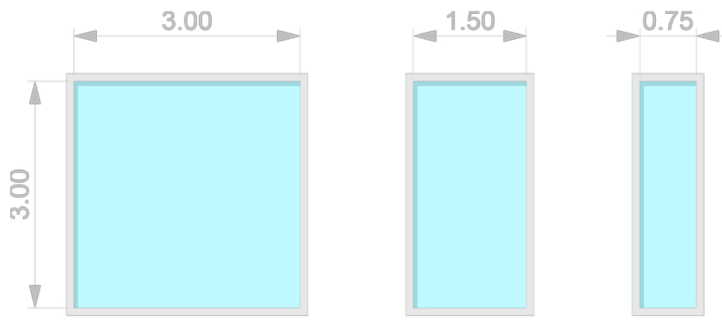
- **Glazing Optioneering** is done to analyze the energy use intensity in case of considering each side of the building in glazing. As it results, the building has the less energy consumption if the east and west are in glazing. The glazing area on the external facade should be the least and the internal facade should be controlled in terms of daylight and heat gain.
- According to the **Incident Radiation Analysis**, heat gain from the south would be at the worst situation in September and the glazing of the internal facade would be a problem if it's not undergone the daylight analysis.
So the less quantity in glazing area is considered for this facade and instead, solar panels can be placed here to absorb the energy as an active strategy to produce on-site energy.
- **Sun Hour Analysis** is done to see which parts of the facades are mostly on the exposure of sun in order to consider the quantity of glazing. Ground floor and the first floor has the least daylight because of the formation of the building and it plays an important roll in having more ratio of window over wall to have a standard daylight and the least heat gain.

So the west can be fully glazed and the east can be partially glazed and the internal facade can have openings but limited in terms of quantity and size and all the glazing parts need the horizontal shaders.
In the further steps, Daylight analysis should be considered to analyze the building in terms of sDA and ASE from zone to zone in the residential and the office areas.

Glazing Optioneering 2 - W/O Ratio

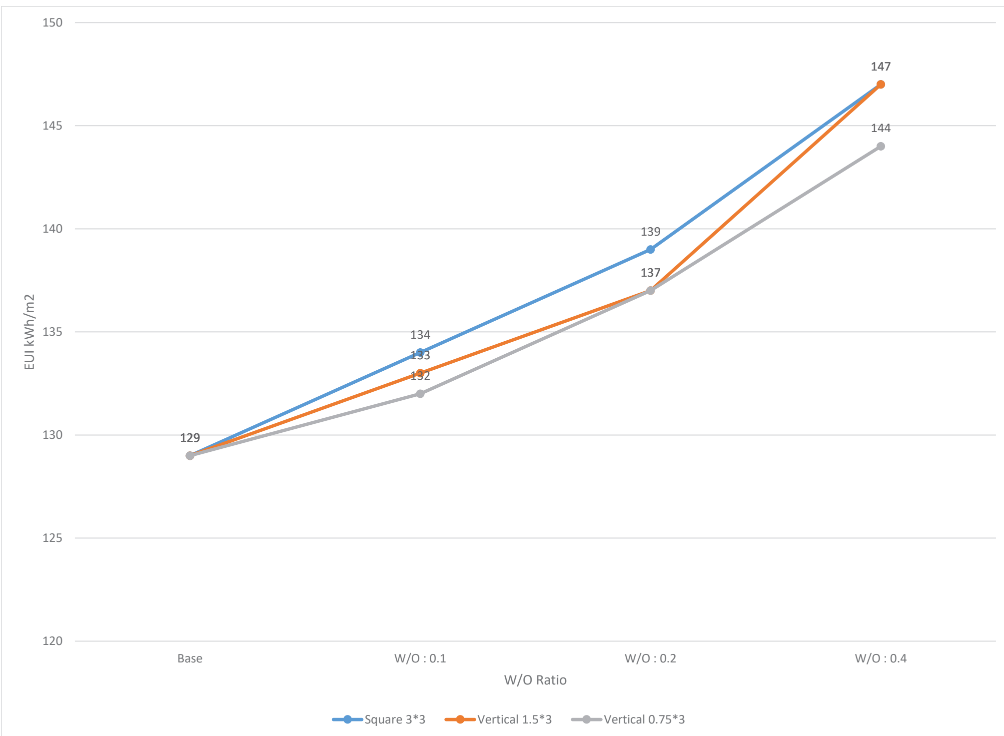
The window-to-opaque ratio, often referred to as the window-to-wall ratio (WWR), is a critical architectural and design concept used to describe the relationship between the glazed or transparent portions of a building's facade (windows) and the solid, non-transparent portions (opaque walls). It is expressed as a percentage and represents the amount of the exterior wall area that is occupied by windows compared to the total exterior wall area.
- A higher window-to-opaque ratio allows more natural light to enter the interior spaces, reducing the need for artificial lighting during the day. This can enhance the visual comfort and well-being of building occupants.
- The W/O ratio impacts a building's energy performance. More windows can lead to increased heat gain in the summer and heat loss in the winter, affecting heating, cooling, and overall energy consumption.

Certainly, when considering the window-to-opaque ratio for the south facade of the building, we are specifically focusing on how much of the southern-facing exterior wall is comprised of windows or other transparent elements compared to solid, opaque walls. This ratio has unique implications and considerations due to the orientation of the south facade in relation to sunlight and climate.

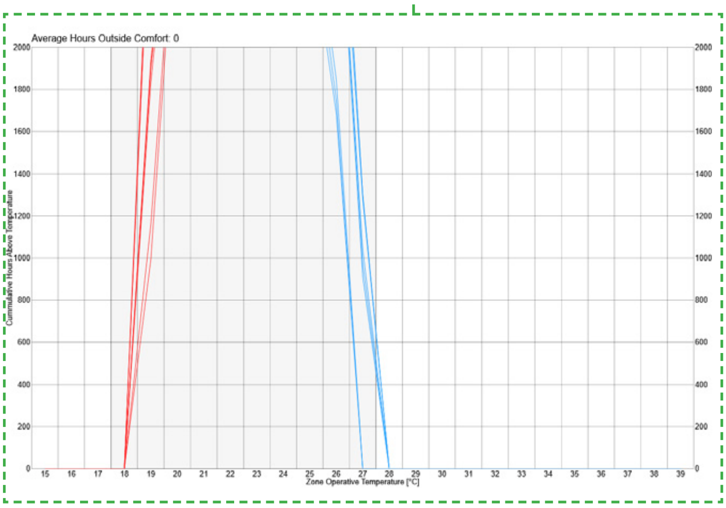


The choice between square and vertical openings can have a substantial impact on the window-to-opaque ratio and the building's overall aesthetics.

EUI Comparison between different options and different ratios :



In this thesis, we conducted a comprehensive analysis of the south facade's window-to-opaque ratio to determine the most appropriate dimensions and quantity of openings. Our study involved a comparison of three distinct opening types in terms of shape and size. After rigorous evaluation, we found that vertical windows with a ratio ranging from 10 to 20 percent offer the optimal solution for this particular architectural context.



The south facade typically receives the most direct sunlight in many regions. Therefore, the window-to-opaque ratio on this side of the building can significantly impact the building's energy performance. A higher ratio may allow more solar heat to enter the building in the winter, which can be beneficial for passive solar heating. However, in hot climates, too much sunlight could lead to overheating, making it important to strike a balance.

Windows on the south facade can provide ample natural daylighting to the interior spaces. This can reduce the need for artificial lighting during the day, enhancing energy efficiency and occupant comfort.

- To consider the energy efficiency implications of our chosen window sizes and shapes, we optimize energy performance. We may need to incorporate shading devices, such as blinds or external shading, to control heat gain during the summer months and the daylight to use less artificial lighting which is going to be analyzed in the next chapter.

Daylight Analysis

- Daylight analysis helps architects and designers understand how natural light penetrates a building's interior spaces throughout the day. It provides information about the availability and distribution of daylight, which is crucial for creating well-lit and visually comfortable environments for occupants.
- Proper utilization of natural daylight can significantly reduce the need for artificial lighting during daylight hours. By analyzing how daylight interacts with various building elements, designers can optimize window placements, sizes, and shading devices to minimize energy consumption associated with lighting.
- A well-designed daylighting strategy contributes to occupant well-being and visual comfort. By simulating daylight conditions, architects can ensure that interior spaces receive adequate, uniform illumination, reducing glare and creating visually pleasing environments.

Spatial Daylight Autonomy (sDA), Annual Sunlight Exposure (ASE) and Daylight Factor with Annual Glare have been taken into consideration in this analysis.

sDA : Spatial Daylight Autonomy measures the percentage of occupied hours during which a specific area or point in a space receives a desired minimum illuminance level from natural daylight alone which is 300 lux. It indicates the extent to which a space is adequately lit by daylight without the need for artificial lighting. sDA values help assess whether a space meets or exceeds certain visual comfort and energy efficiency criteria. Higher sDA values suggest that the space is well-illuminated by daylight.

ASE : Annual Sunlight Exposure calculates the percentage of a space's floor area that exceeds a certain direct sunlight threshold over the course of a year.
Annual Sunlight Exposure refers to the percentage of space that receives too much direct sunlight (1000 Lux or more for at least 250 occupied hours per year), which can cause glare or increased cooling loads.

Daylight Factor : The Daylight Factor is a measure of the interior illuminance level in a room compared to the exterior illuminance under overcast sky conditions. It expresses the ratio of the indoor illuminance to the outdoor illuminance. The Daylight Factor provides insight into the overall brightness of a space due to daylight. Higher Daylight Factor values indicate brighter indoor environments with greater natural lighting. The standard DF rate in a workplace is approximately %2.5 .

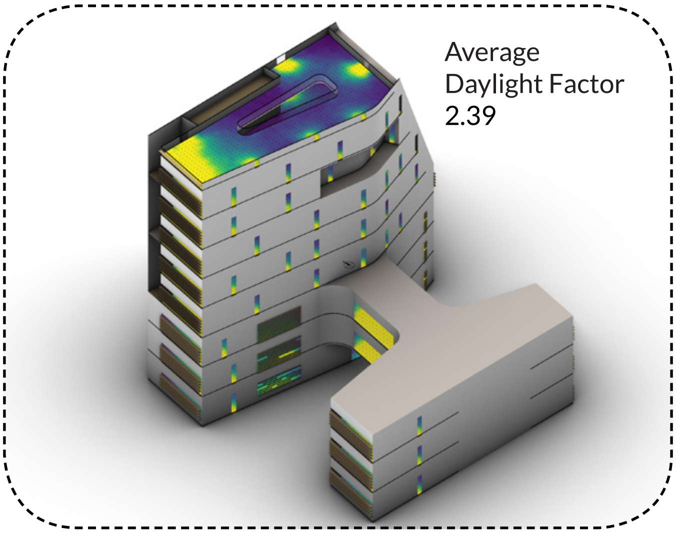
Annual Glare : Annual Glare assesses the potential discomfort caused by glare from direct sunlight or bright sky conditions. It considers factors such as the position of the sun, the visual task, and the geometry of the space. Annual Glare calculations help designers identify areas where glare might be problematic and implement appropriate shading or glare mitigation strategies.

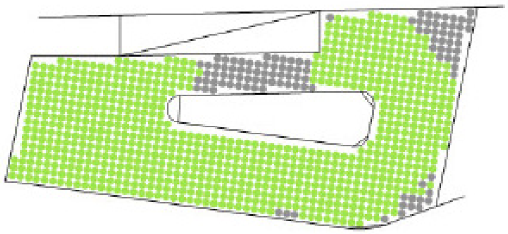
Imperceptible glare	Perceptible glare	Disturbing glare	Intolerable glare
DGP ≤ 34%	34% < DGP ≤ 38%	38% < DGP ≤ 45%	45% < DGP

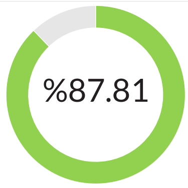
Phase 1 : Firstly, all the workplaces have been considered as a unique place in each floor without seperated private rooms and they have undergone the daylight analysis.

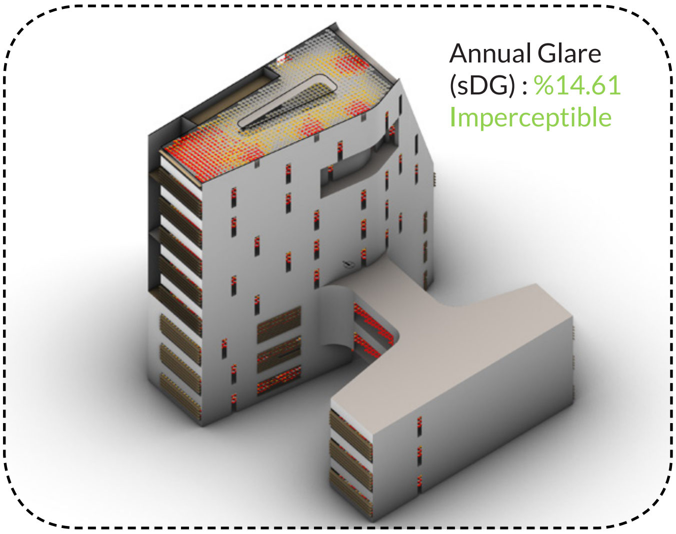
8^{th} FLOOR

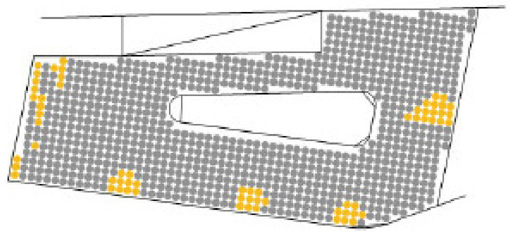
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is :
North ; 1pcs (1.5*3)m^2 - South ; 3pcs (0.75*3)m^2 - East ; 1pcs (1.5*3)m^2
West ; Complete Glazing with 40cm horizontal shading without inclination

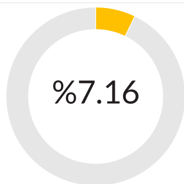


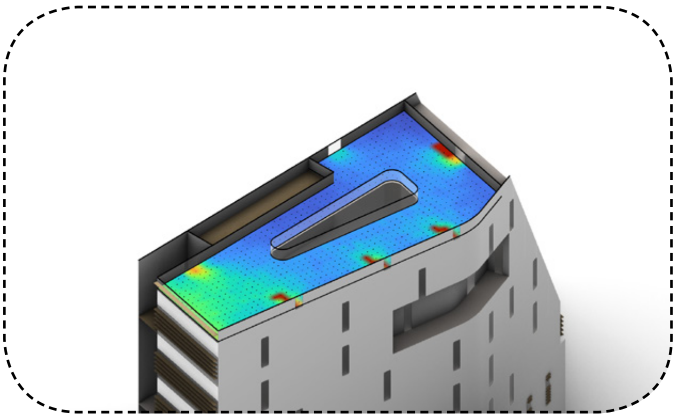










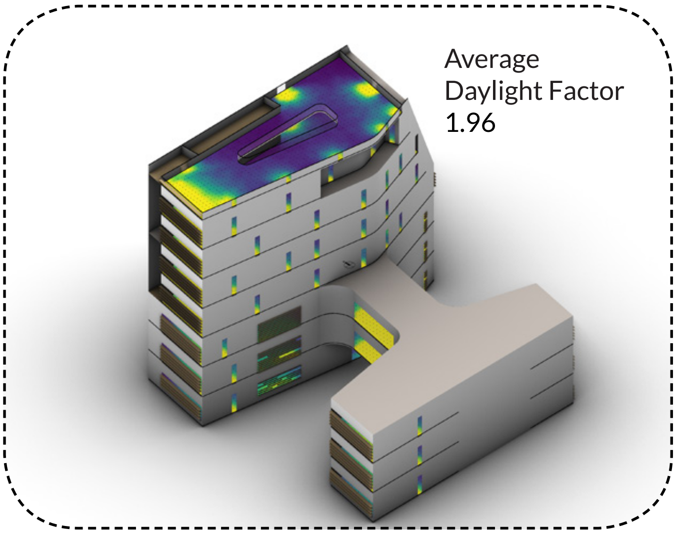


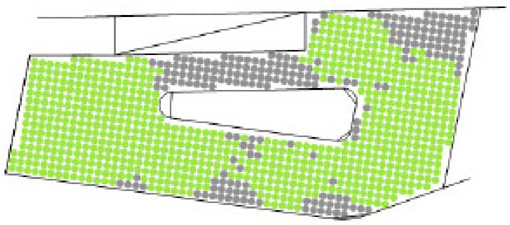
Point-in-time Illuminance :

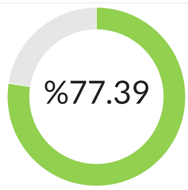
Mean Lux : 1257
According to the quantity of the lumens the blue places are suitable for computer workstations and screen visibility and the places nearly yellow are the places which can be dedicated to team-work and conference rooms.

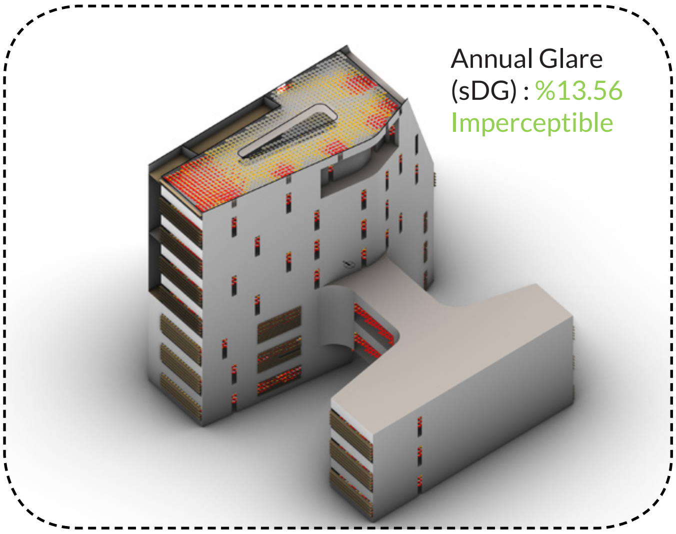
7th FLOOR

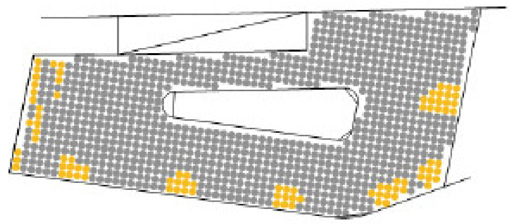
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is :
North ; 1pcs (1.5*3)m^2 - South ; 5pcs (0.75*3)m^2 - East ; 1pcs (1.5*3)m^2
West ; Complete Glazing with 40cm horizontal shading without inclination

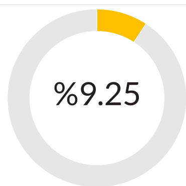




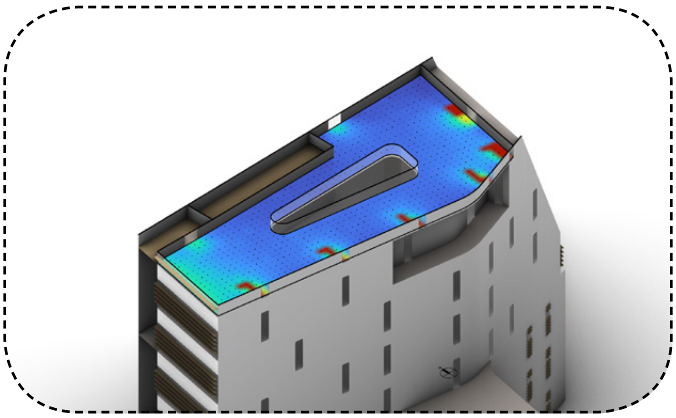








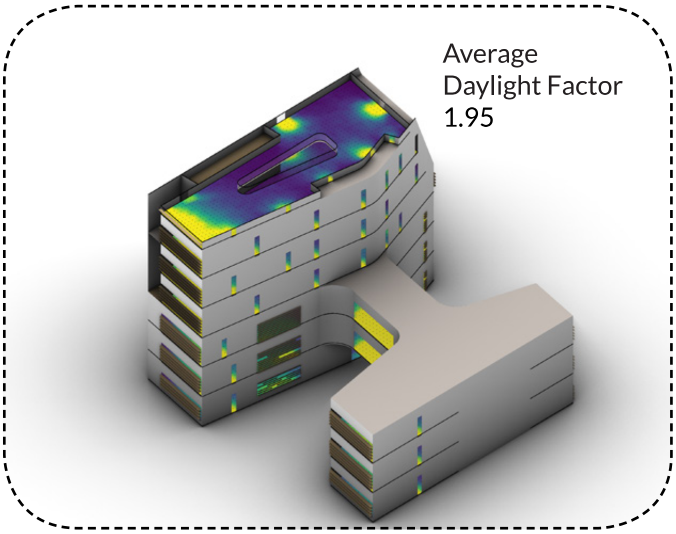
Point-in-time Illuminance :

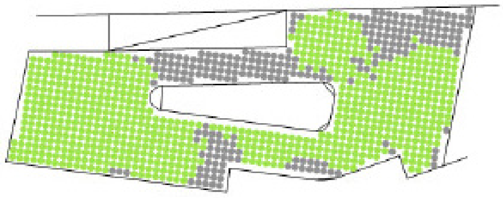


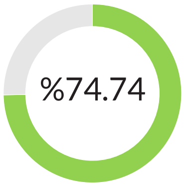
Mean Lux : 1357
According to the quantity of the lumens almost all this floor can be dedicated to those types of work which involve computer workstations and screen visibility like programmers and graphic designers.

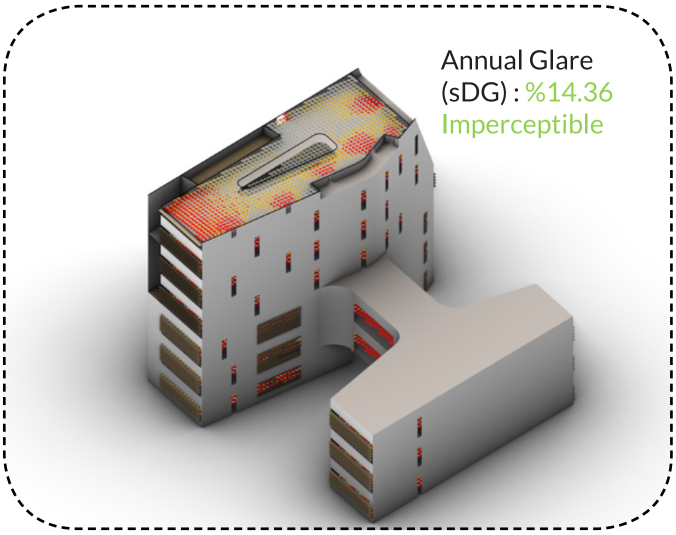
6th FLOOR

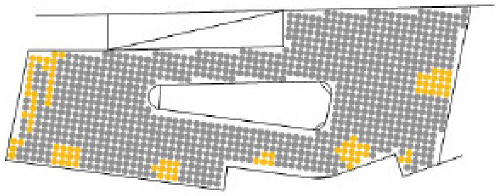
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is :
North ; 1pcs (1.5*3)m^2 - South ; 5pcs (0.75*3)m^2 - East ; 1pcs (1.5*3)m^2
West ; Complete Glazing with 40cm horizontal shading without inclination

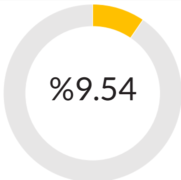




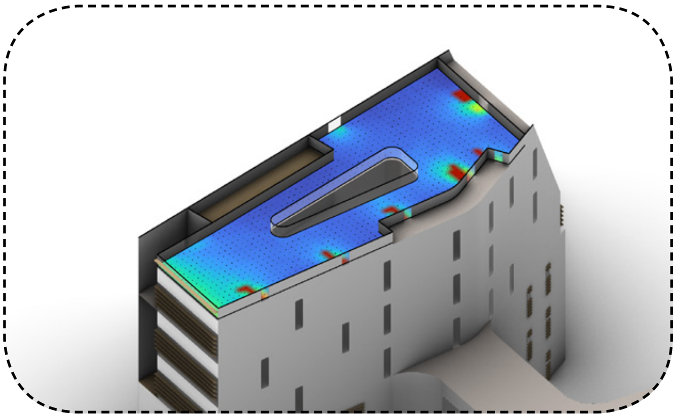








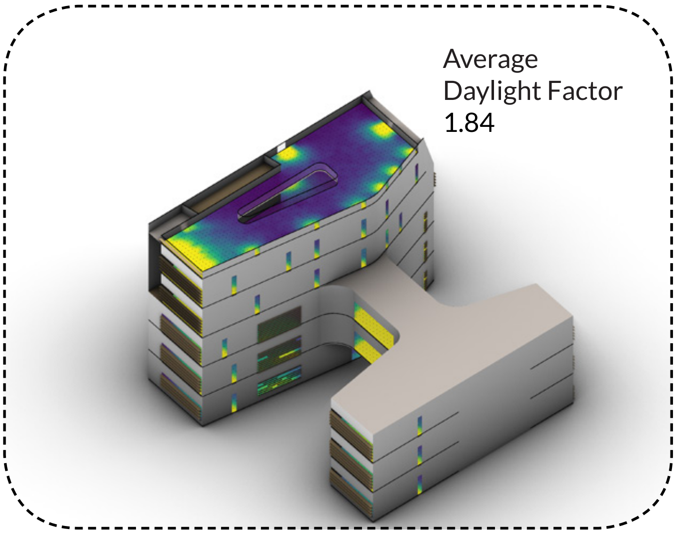
Point-in-time Illuminance :

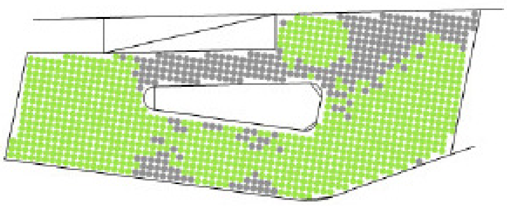


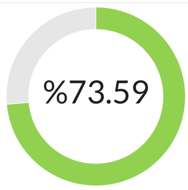
Mean Lux : 1280
According to the quantity of the lumens almost all this floor can be dedicated to the architectural design studio since the illuminance is suitable for screen visibility it can provide places for meeting room for the clients or the team-work.

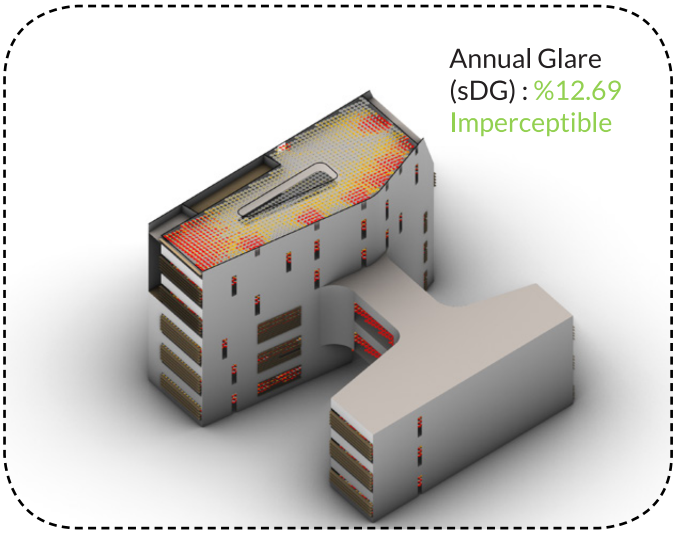
5th FLOOR

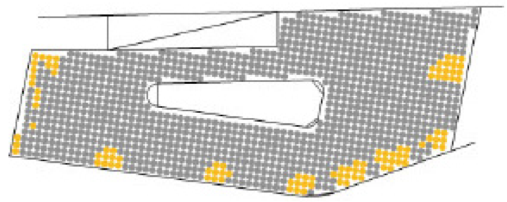
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is :
North ; 1pcs $(1.5*3)m^2$ - South ; 6pcs $(0.75*3)m^2$ - East ; 1pcs $(1.5*3)m^2$
West ; Complete Glazing with 40cm horizontal shading without inclination

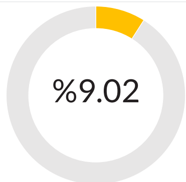




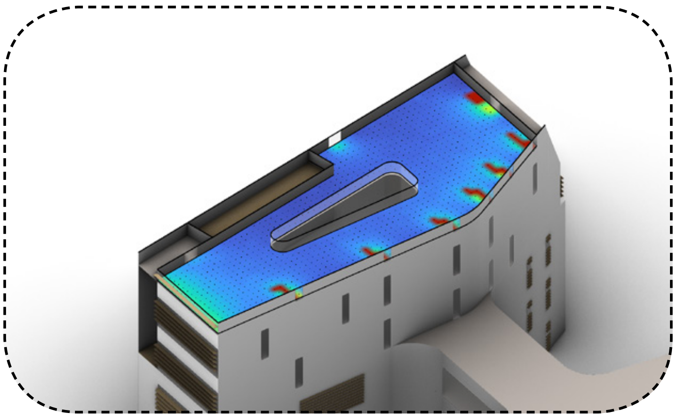








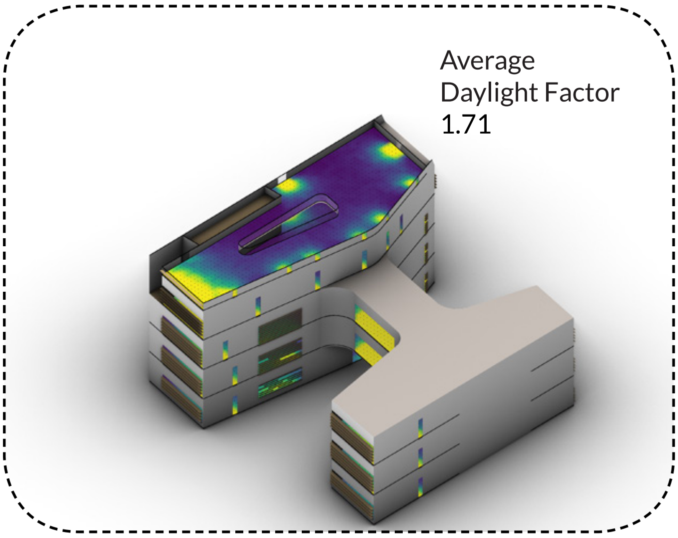
Point-in-time Illuminance :

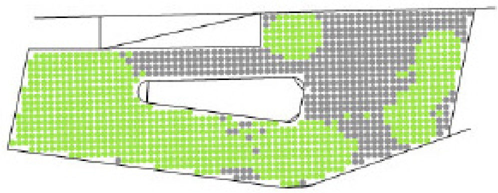


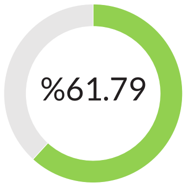
Mean Lux : 1372
According to the quantity of the lumens almost all this floor can be dedicated to the workstation with screen visibility and computer. The blue points are in the range between 100 to 500 lumens.

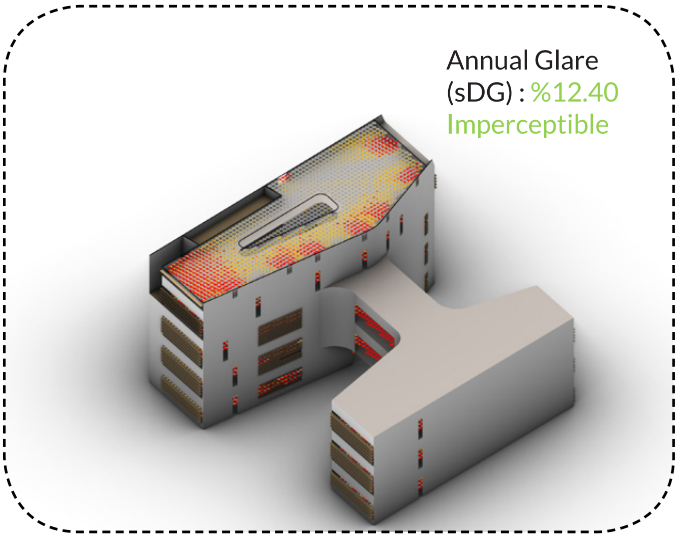
4^{th} FLOOR

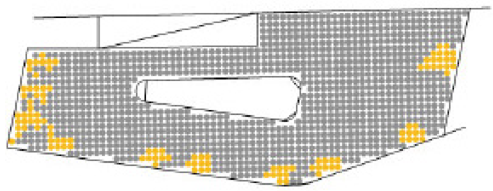
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is :
North ; 1pcs (1.5*3)m^2 - South ; 3pcs (0.75*3)m^2 - East ; 1pcs (1.5*3)m^2
West ; Complete Glazing with 40cm horizontal shading without inclination

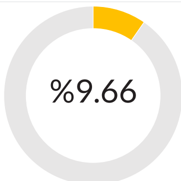




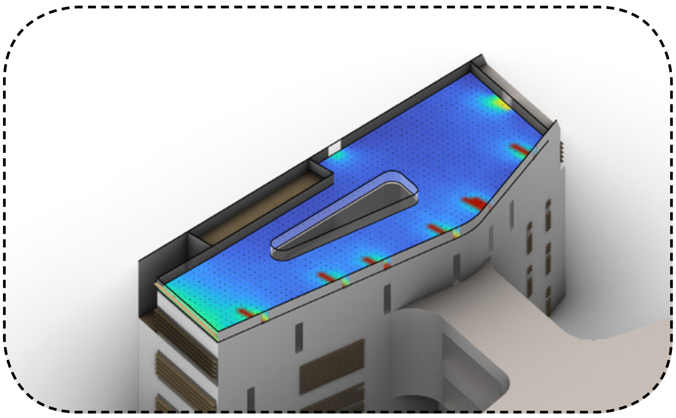








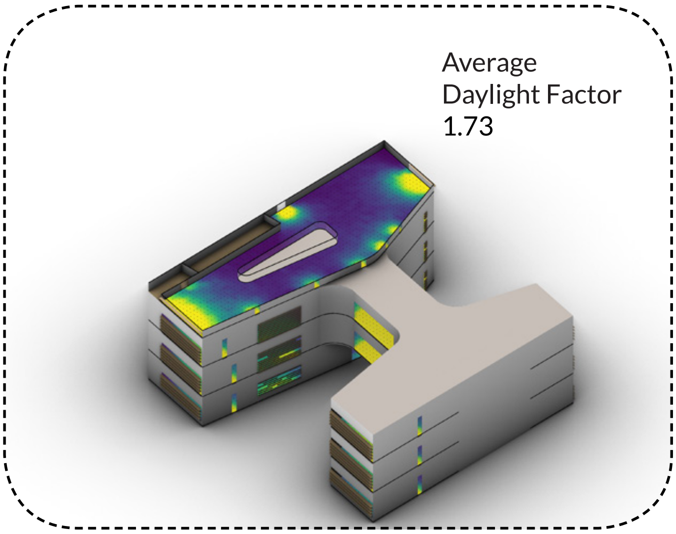
Point-in-time Illuminance :

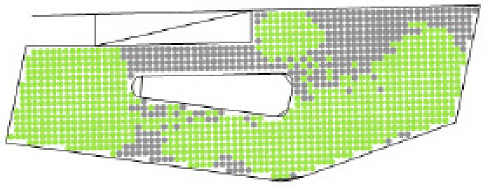


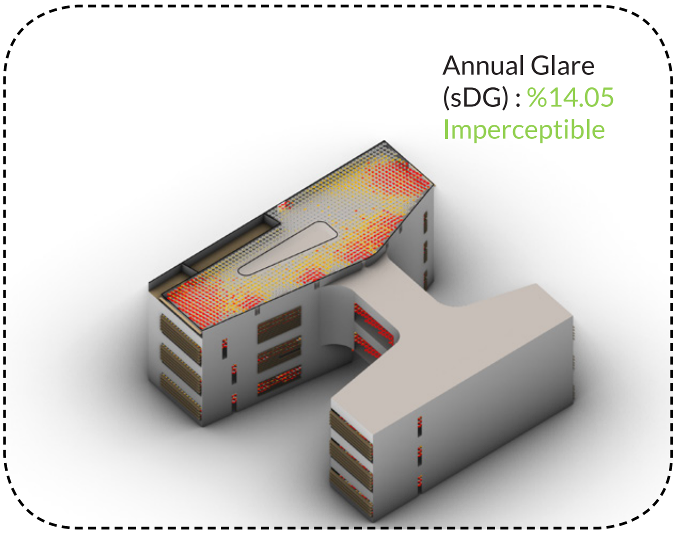
Mean Lux : 1192
Like the 8th floor, the quantity of the lumens the blue places are suitable for computer workstations and screen visibility and the places nearly yellow are the places which can be dedicated to team-work and conference rooms.

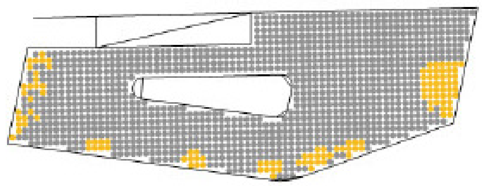
3rd FLOOR

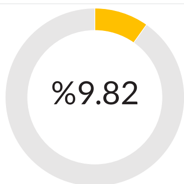
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is :
North ; 1pcs (1.5*3)m^2 - South ; 3pcs (0.75*3)m^2 - East ; 1pcs (1.5*3)m^2
West ; Complete Glazing with 40cm horizontal shading without inclination



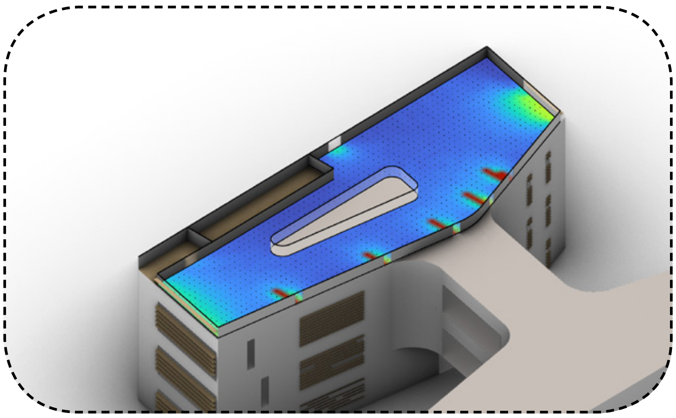








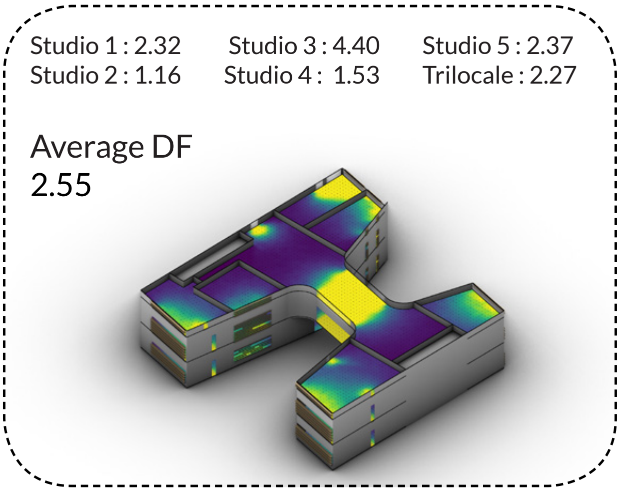
Point-in-time Illuminance :

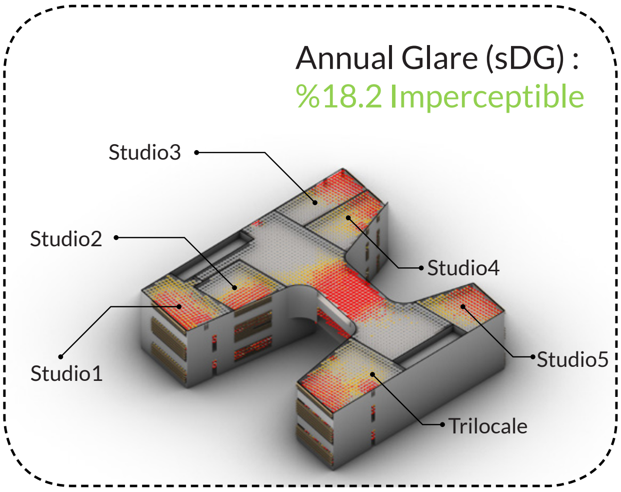


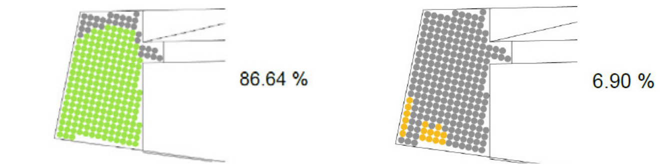
Mean Lux : 998
According to the quantity of the lumens almost all this floor can be dedicated to the workstation with screen visibility and computer. The blue points are in the range between 100 to 500 lumens.

2nd FLOOR

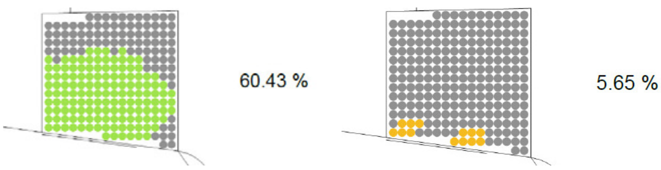
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is given in the order.
Second floor is dedicated to the residential floor and each residential floor is devided into 5 studios and 1 trilocale.



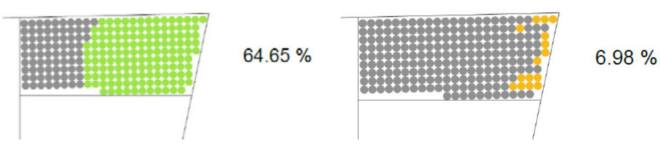




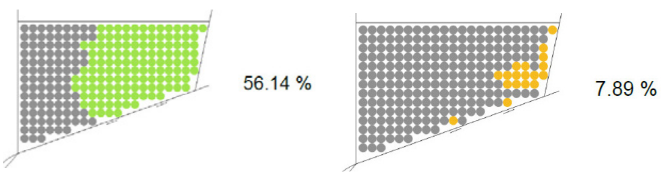
South ; 1pc (0.75*3)m^2
West ; Complete Glazing with 40cm horizontal shading without inclination



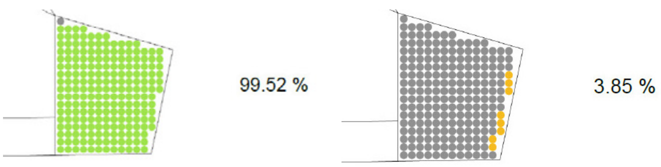
South ; 1pc (6.75*3)m^2
with 40cm horizontal shading with inclination of 45 degree



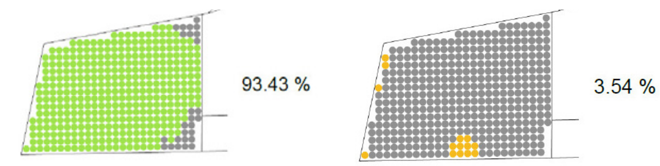
North ; 3pcs (1.5*3)m^2
East ; Complete Glazing with 40cm horizontal shading with inclination of 45 degree



South ; 2pcs (1.5*3)m^2 Cwith inclined shading 45 degree
East ; Complete Glazing with 40cm horizontal shading with inclination



East ; Complete Glazing with 40cm horizontal shading with inclination of 45 degree



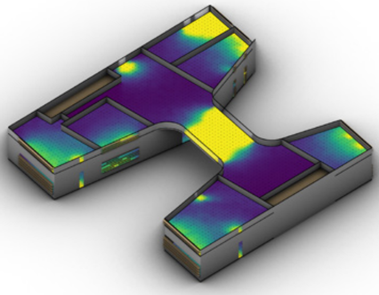
West ; Complete Glazing with shading
North ; 1pcs (1.5*3)m^2
South ; 1pcs (1.5*3)m^2

1st FLOOR

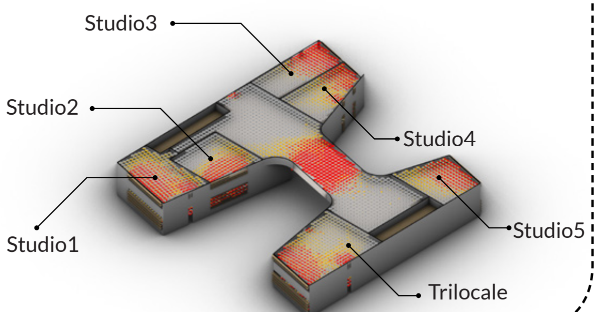
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is given in the order.
First floor is dedicated to the residential floor and each residential floor is devided into 5 studios and 1 trilocale.

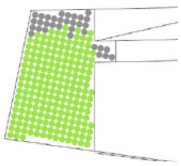
Studio 1 : 2.40 Studio 3 : 4.68 Studio 5 : 1.96
Studio 2 : 1.42 Studio 4 : 1.64 Trilocale : 1.77

Average DF
2.28

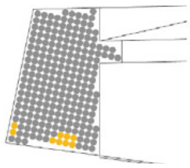


Annual Glare (sDG) :
%16.9 Imperceptible





85.78 %



3.88 %

South ; 1pc (0.75*3)m^2
West ; Complete Glazing with 40cm horizontal shading without inclination

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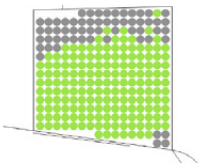
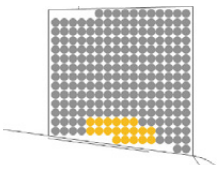
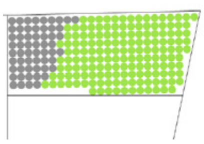


74.78 %

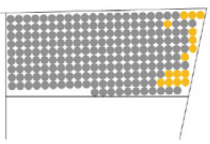


8.26 %

South ; 1pc (6.75*3)m^2
with 40cm horizontal shading with inclination of 45 degree



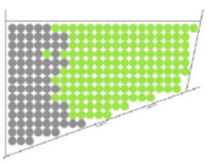
73.49 %



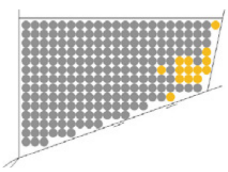
6.98 %

North ; 3pcs (1.5*3)m^2
East ; Complete Glazing with 40cm horizontal shading with inclination of 45 degree

---



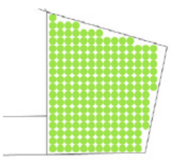
62.72 %



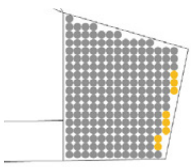
6.14 %

South ; 2pcs (1.5*3)m^2 Cwith inclined shading 45 degree
East ; Complete Glazing with 40cm horizontal shading with inclination

---



100.00 %



3.85 %

East ; Complete Glazing with 40cm horizontal shading with inclination of 45 degree

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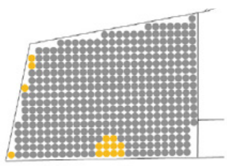
75.51 %



3.54 %

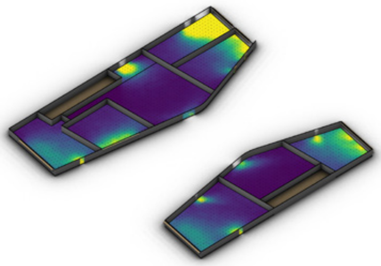
West ; Complete Glazing with shading
North ; 1pcs (1.5*3)m^2
South ; 1pcs (1.5*3)m^2

Ground FLOOR

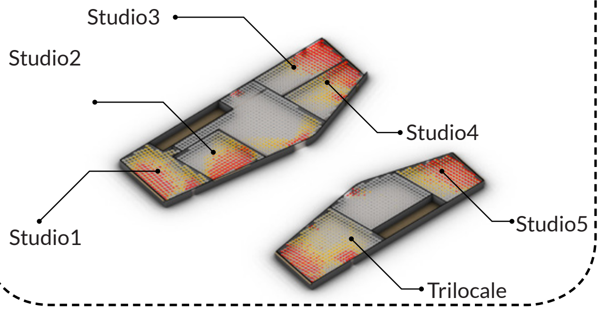
The floor area is in optimum condition in terms of sDA, ASE and the glare. The conclusion to obtain this level of daylight is given in the order.
First floor is dedicated to the residential floor and each residential floor is devided into 5 studios and 1 trilocale.

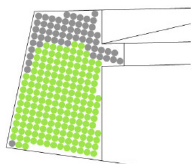
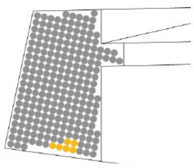
Studio 1 : 1.64 Studio 2 : 1.36 Studio 3 : 4.68 Studio 4 : 1.6 Studio 5 : 2.28 Trilocale : 1.35

Average DF
1.5

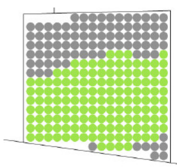
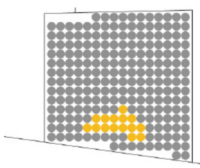


Annual Glare (sDG) :
%10.3 Imperceptible

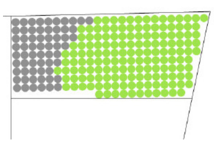
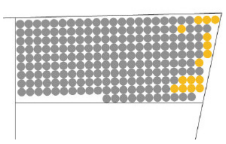



75.00 %

2.59 %

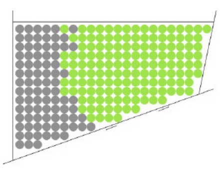
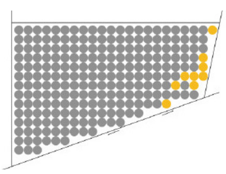
South ; 1pc $(0.75*3)m^2$
West ; Complete Glazing with 40cm horizontal shading without inclination


62.17 %

6.52 %

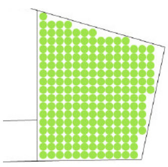
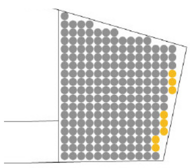
South ; 1pc $(6.75*3)m^2$
with 40cm horizontal shading with inclination of 45 degree


71.16 %

6.98 %

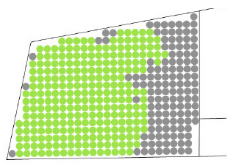
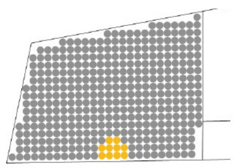
North ; 3pcs $(1.5*3)m^2$
East ; Complete Glazing with 40cm horizontal shading with inclination of 45 degree


62.72 %

3.95 %

South ; 2pcs $(1.5*3)m^2$ Cwith inclined shading 45 degree
East ; Complete Glazing with 40cm horizontal shading with inclination


100.00 %

3.85 %

East ; Complete Glazing with 40cm horizontal shading with inclination of 45 degree

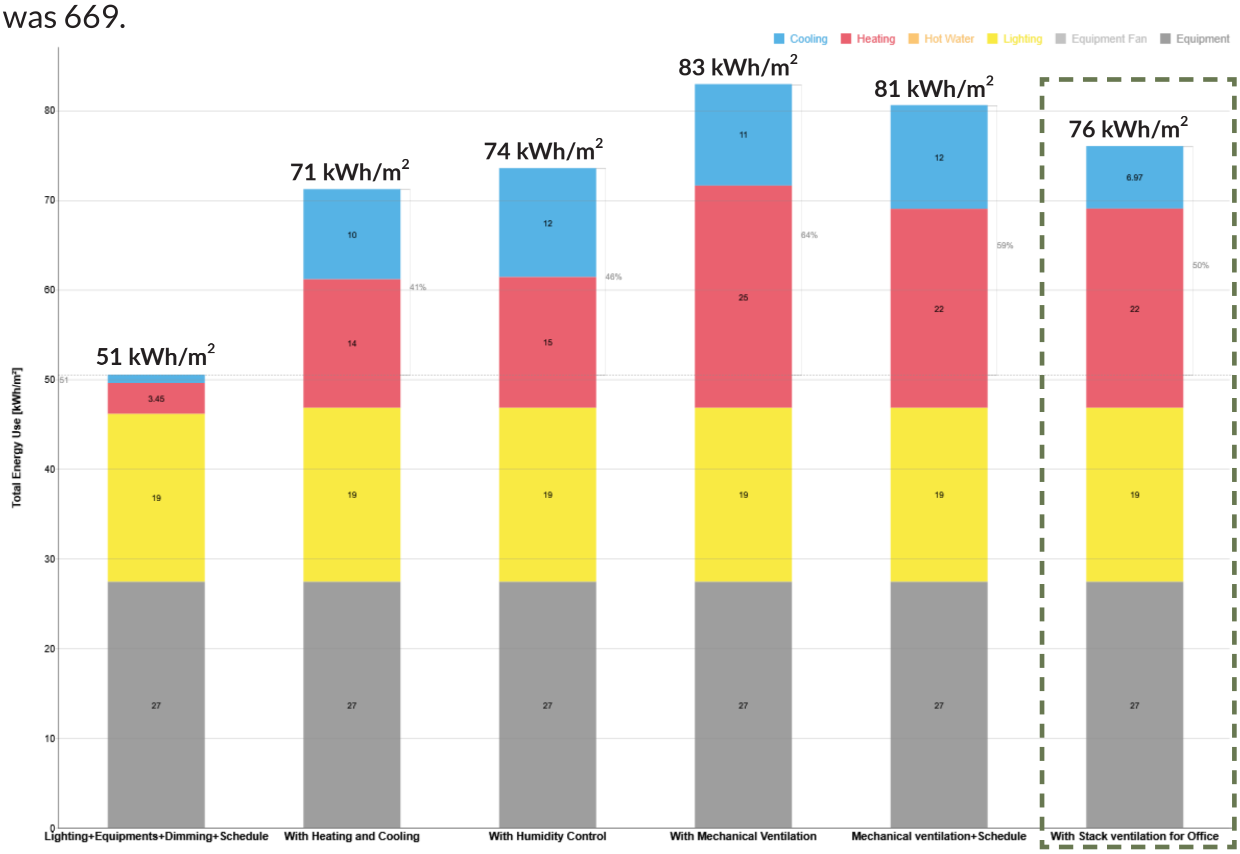

66.92 %

2.53 %

West ; Complete Glazing with shading
North ; 1pcs $(1.5*3)m^2$
South ; 1pcs $(1.5*3)m^2$

Energy Performance - Phase 1

Energy performance of a building refers to its efficiency in using energy to provide a comfortable and functional indoor environment while minimizing energy consumption and its associated environmental impacts. It's an essential aspect of sustainable construction and design, as buildings are significant contributors to energy consumption and greenhouse gas emissions.
Building Envelope: The materials and design of the building's exterior shell, including walls, windows, doors, roof, and insulation, play a crucial role in controlling heat gain and loss. For instance , proper insulation helps maintain a consistent indoor temperature, while thermal mass materials (e.g., concrete) can absorb and release heat slowly, stabilizing indoor temperatures.
Energy-efficient lighting systems, such as LED technology, along with effective daylighting strategies, can reduce electricity consumption for lighting.
Incorporating renewable energy sources like solar panels can offset a building's energy demand.
The layout of a building can influence its energy performance. For example, strategic placement of windows can maximize natural ventilation and daylight.

- As the first step, the EUI of the building has been calculated with taking into consideration the lighting and dimming with schedule which resulted in 51 kWh/m^2 .
- In the further step, the heating and cooling with humidity control has been included with the capacity of 140 W/m^2.
- With having the Mechanical Ventilation, the EUI and the average hours out of comfort zone have been increased regarding the charts.
- The Stack ventilation of the Office zone has a considerable impact on the reduction of the EUI and the hours in comfort zone and in the end the average hours out of comfort zone was 669.



- Also the humidity control didn't have any impact on reduction of hours out of comfort zone and it increased only the EUI.
- In the further steps and with turning off the mechanical ventilation, Humidity control and developing the U-value of the external and internal walls, better results have been obtained in terms of EUI and reduction in average hours out of comfort zone. This step has been done just as an experiment and the mechanical ventilation will be On in the phase 2 of analysis.

Here are the obtained results :

With Humidity Control :

Average Hours out of Comfort Zone : 314

74	27	31
Site EUI kWh/m^2	Op. Carbon $kgCO^2/m^2$	Energy Cost $\$/m^2$

With Mechanical Ventilation :

Average Hours out of Comfort Zone : 704

83	28	32
Site EUI kWh/m^2	Op. Carbon $kgCO^2/m^2$	Energy Cost $\$/m^2$

With Stack Ventilation of Office zone for the whole period of the year :

Average Hours out of Comfort Zone : 768

74	25	29
Site EUI kWh/m^2	Op. Carbon $kgCO^2/m^2$	Energy Cost $\$/m^2$

With Stack Ventilation of Office zone for summer only :

Average Hours out of Comfort Zone : 669

76	26	29
Site EUI kWh/m^2	Op. Carbon $kgCO^2/m^2$	Energy Cost $\$/m^2$

This is the **baseline quantities** for the U-Values of the building elements of the project and the previous results have been derived from these U-Values.
According to the fact that with lower U-value we can have lower energy use intensity, we can develope more this quantity for the external and internal walls to have lower U-values. For the external walls the U-value of 0.26 and for the internal walls the U-value of 3.5 has been considered in designing.
In phase 2, the combination of materials with higher insulation and more thickness and improved U-values will be analyzed.

Building Elemant	U-Value
Roof	0.22
External Walls	0.26
Groud Floor	0.26
Window	1.4

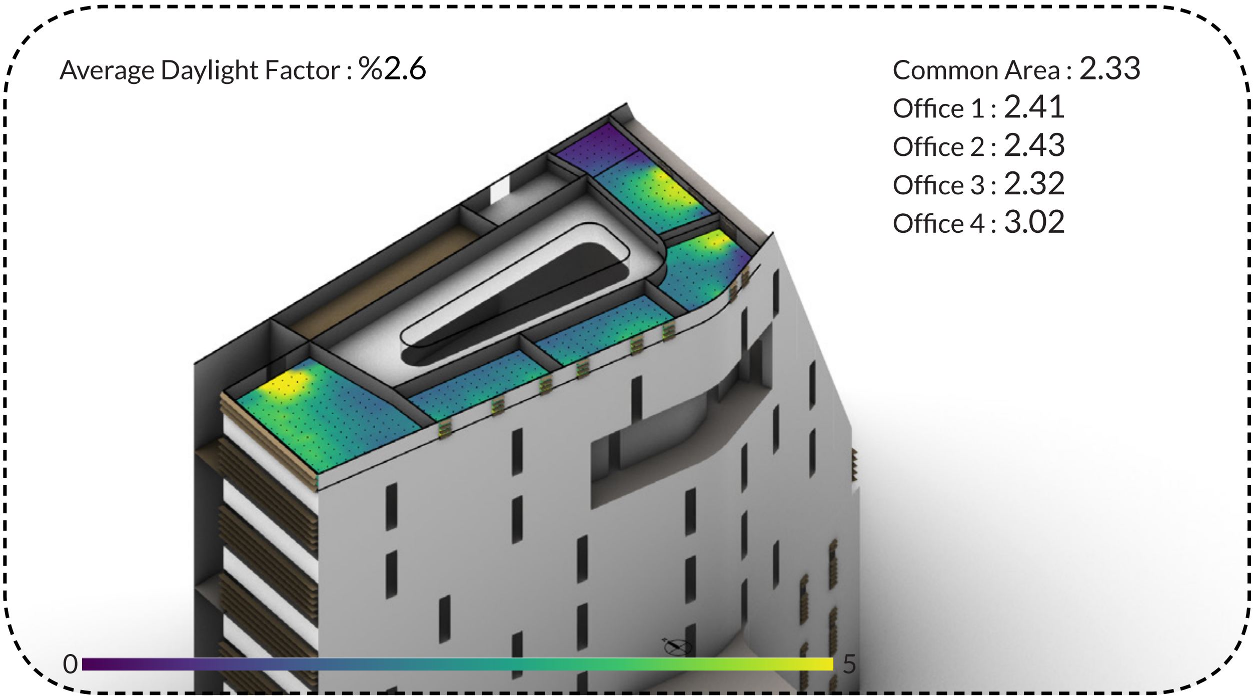
The U-value, also known as thermal transmittance, represents the rate of heat transfer through a building element (such as walls, roofs, windows, and floors). It's typically measured in watts per square meter Kelvin (W/m^2K).

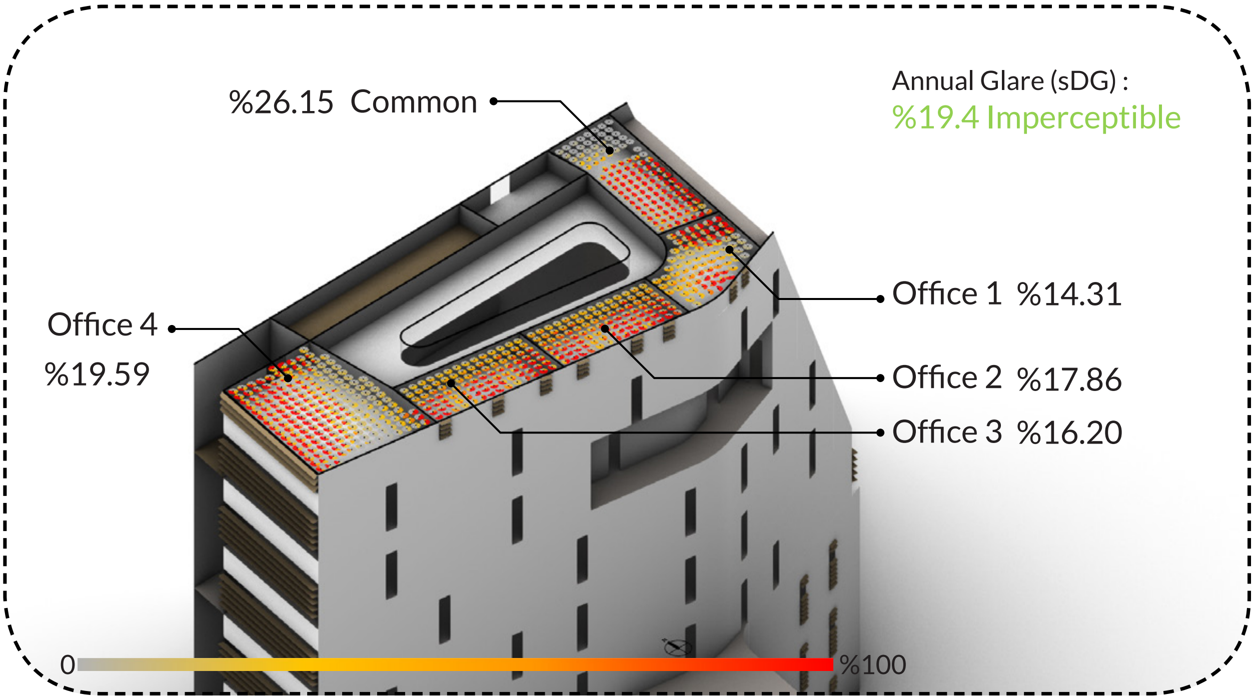
Daylight Optimisation for WorkPlaces

Phase 2 : In this phase, to have more daylight, more openings have been considered for the office part which are glare-controlled by shadings. This is final phase of daylight analysis.

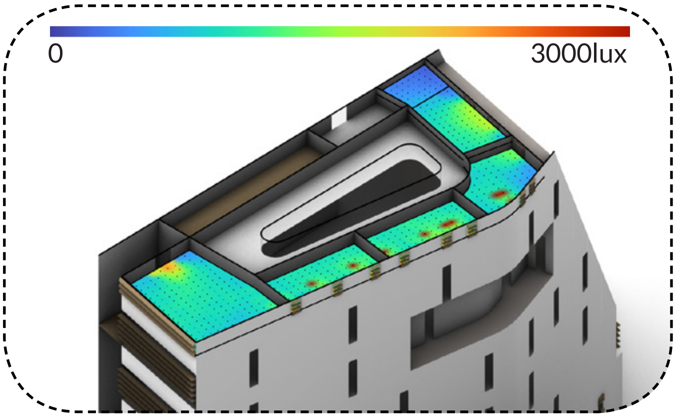
8th FLOOR

Each office is provided by 3 openings in size of (0.75*3m) covered by shadings with 45 degree inclination. The width of the shadings of the Office 4 is 40 cm while the width of the others is 20 cm. The common area is the place where staff meet to rest, drink and eat.
The white part will be dedicated to the toilets for men and women separately.
The detail of the analysis are here in the order given :



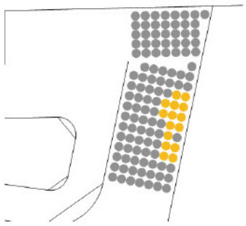


Point-in-time Illuminance at 21 September 12:00



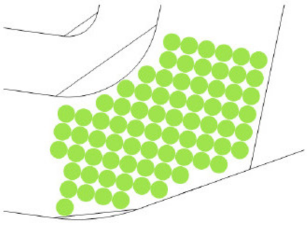
Mean Lux : 1856
Median Lux : 921

90.00 %

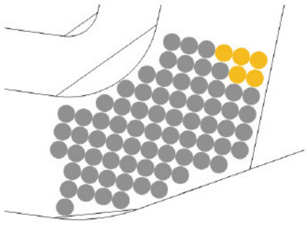


12.50 %

Common Area

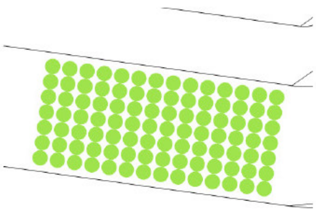


100.00 %

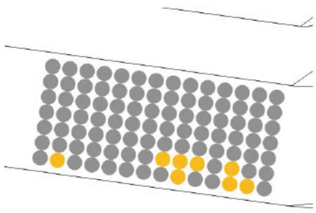


6.58 %

Office 1

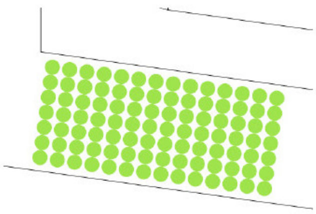


100.00 %

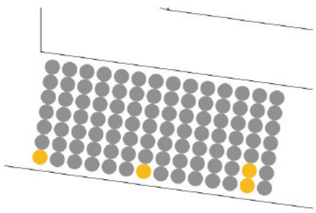


8.16 %

Office 2

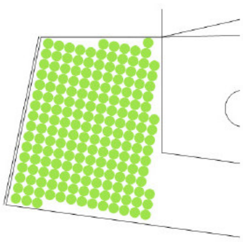


100.00 %

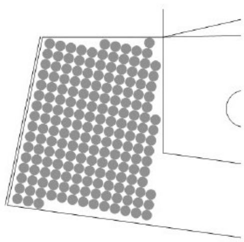


4.08 %

Office 3



100.00 %

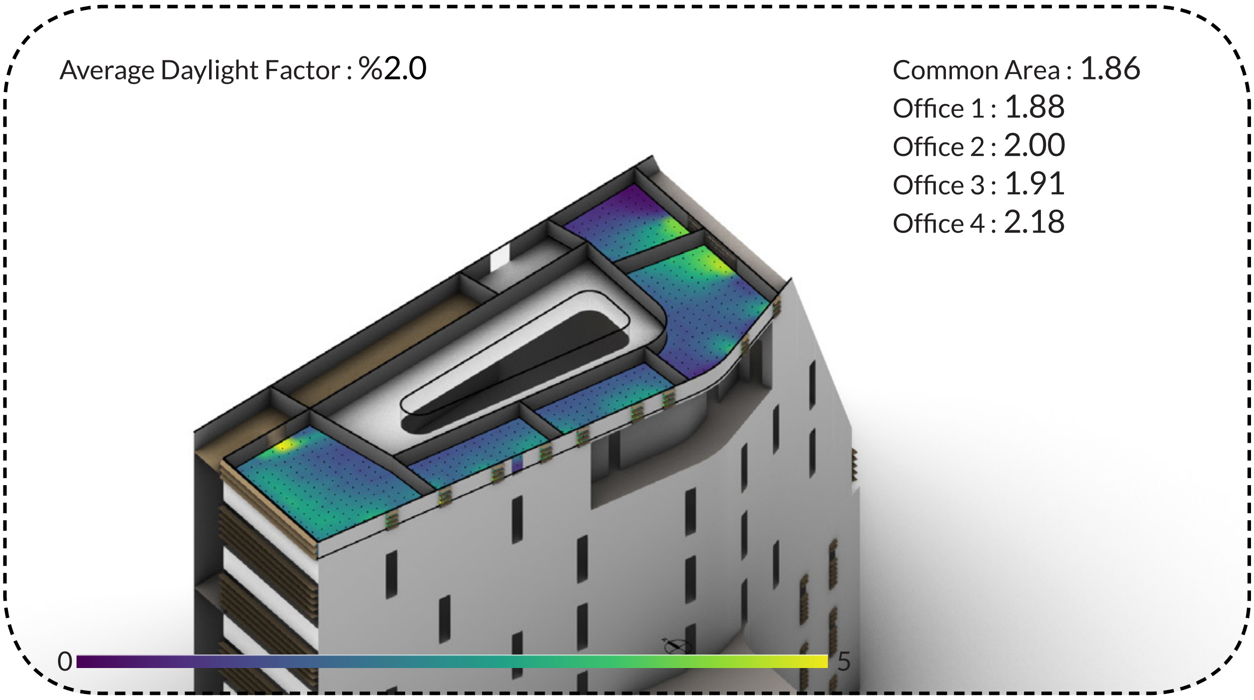


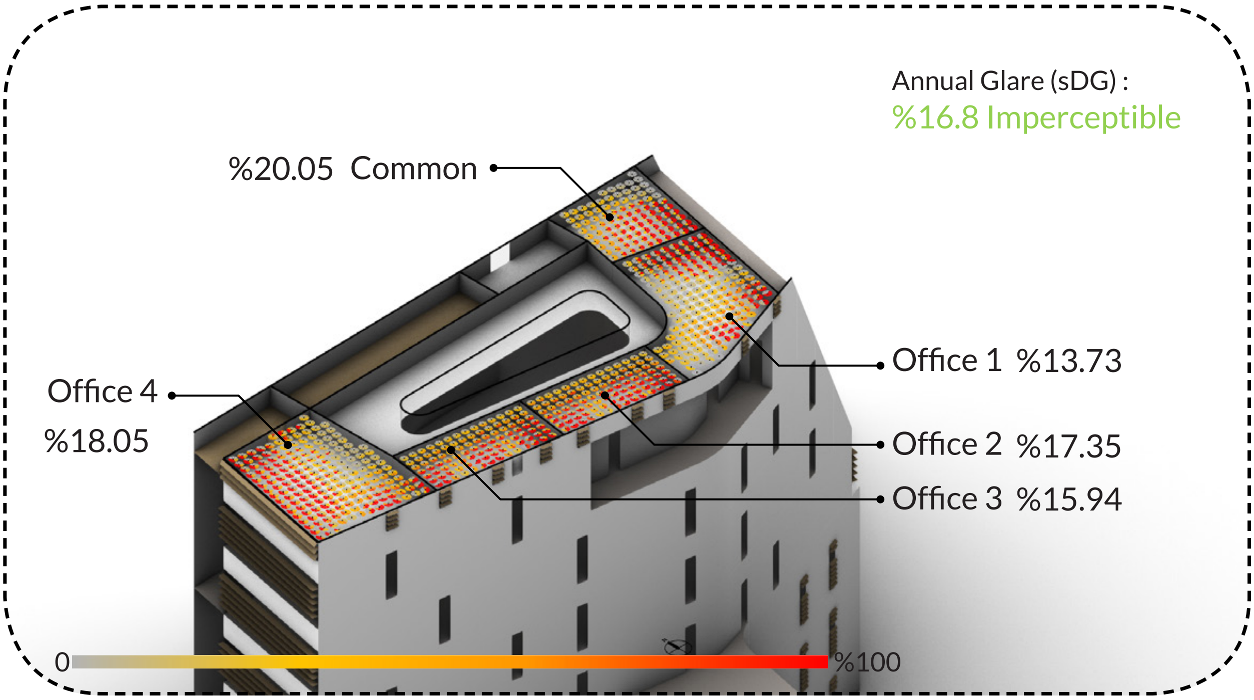
0.00 %

Office 4

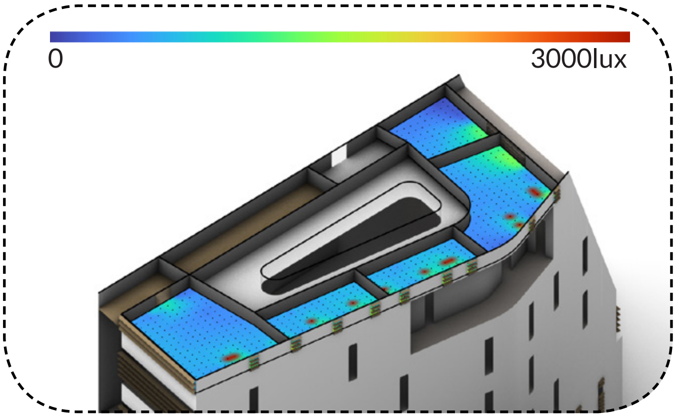
7th FLOOR

Offices 2 and 3 have 3 openings in size of (0.75*3m) covered by shadings with 45 degree inclination. The width of the shadings of the Office 4 is 40 cm while the width of the others is 20 cm. The common area is the place where staff meet to rest, drink and eat.
The white part will be dedicated to the toilets for men and women separately.
Office 4 is lit from the west facade in complete glazing and from the south an opening in size of (0.75*3m) and the common area is provided by 2 openings in the same size. All the units are sparated with a glazed wall so they can lit the corridor and they can use the central light in the days without sufficient daylight.
The detail of the analysis are here in the order given :

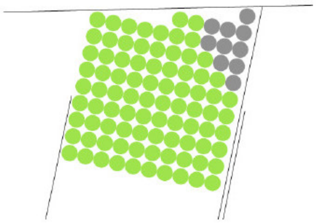




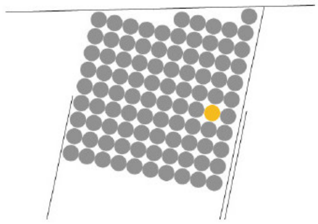
Point-in-time Illuminance at 21 September 12:00



Mean Lux : 1573
Median Lux : 562

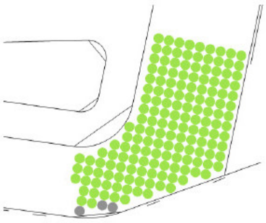


89.58 %

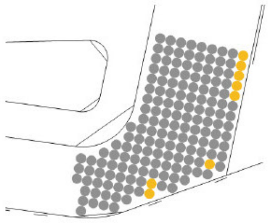


1.04 %

Common Area

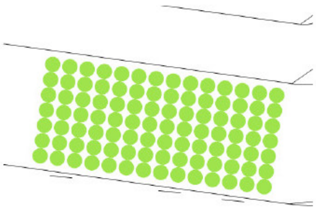


98.15 %

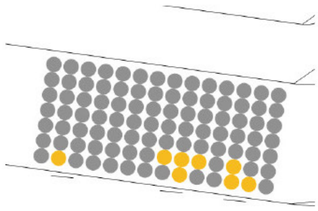


4.94 %

Office 1

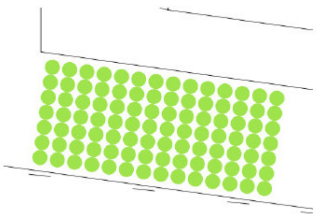


100.00 %

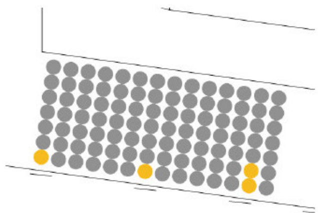


8.16 %

Office 2

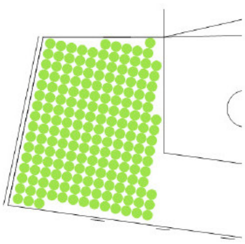


100.00 %

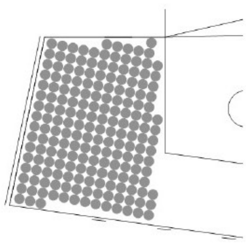


4.08 %

Office 3



100.00 %

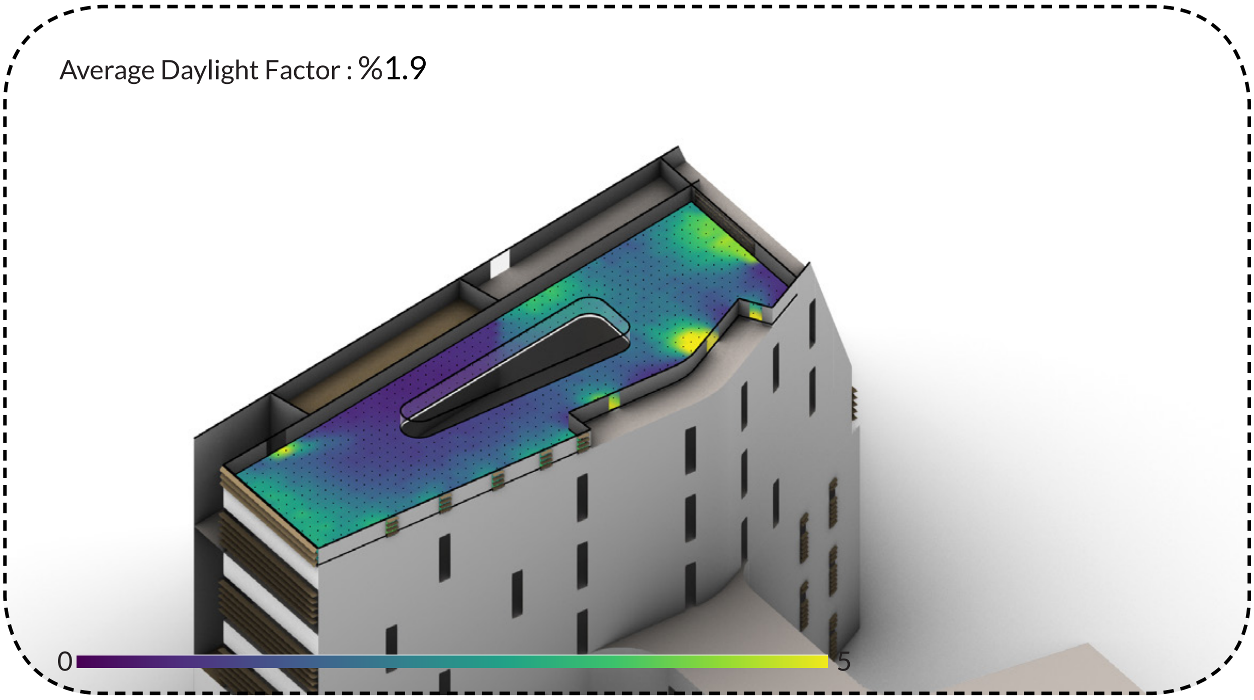


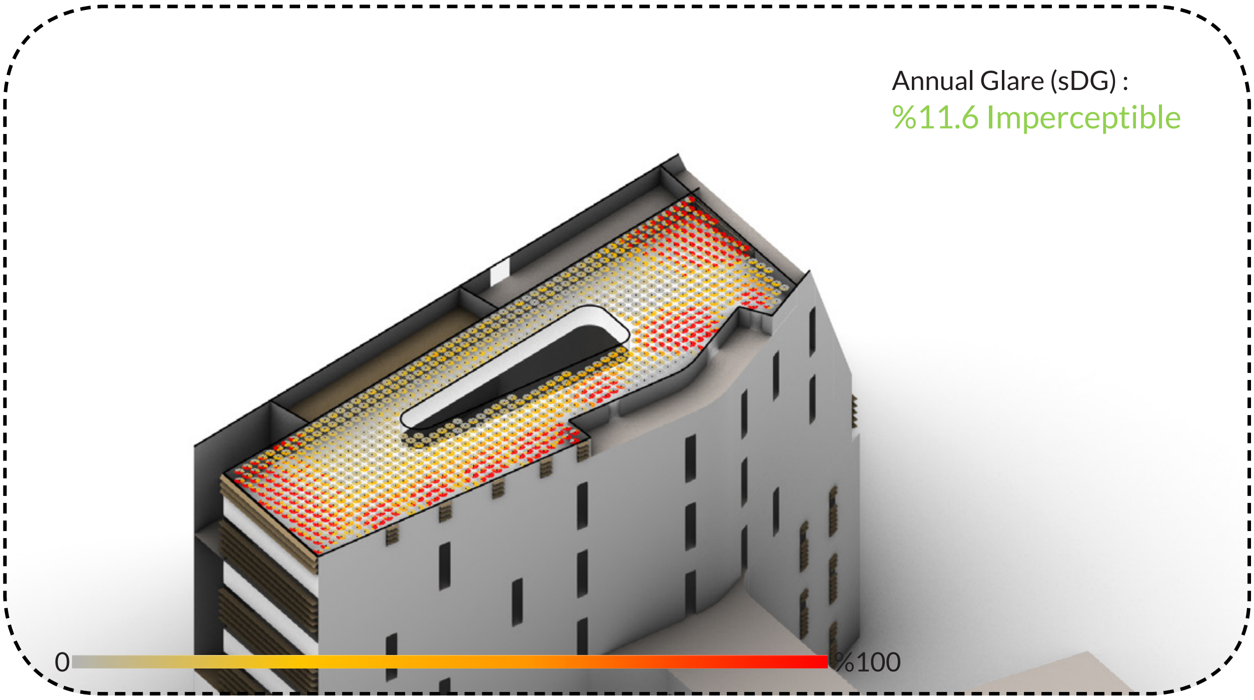
0.00 %

Office 4

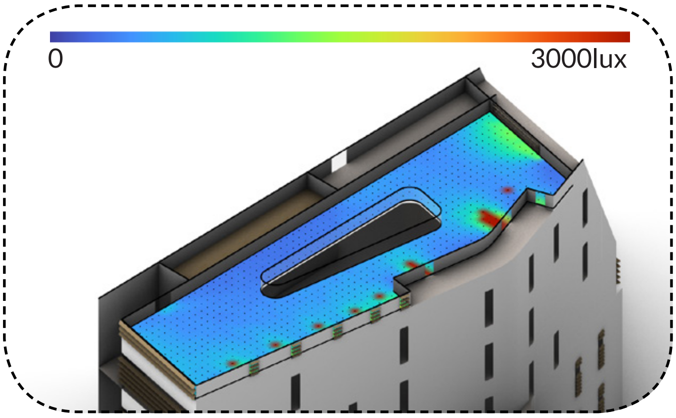
6th FLOOR

This floor is completely dedicated to an architectural firm. The daylight of which is provided by 8 openings in size of (0.75*3m) facing south partially covered by shadings to control the glare because the most of the space inside should be suitable for screen visibility.
The west is completely glazed with inclined shading and the east is provided by 4 shaded openings.
The east and west of the studio can be dedicated to the meeting rooms and team-work space which might need brighter lighting and these spaces can be separated from each other by glazed internal partitions.
The detail of the analysis are here in the order given :





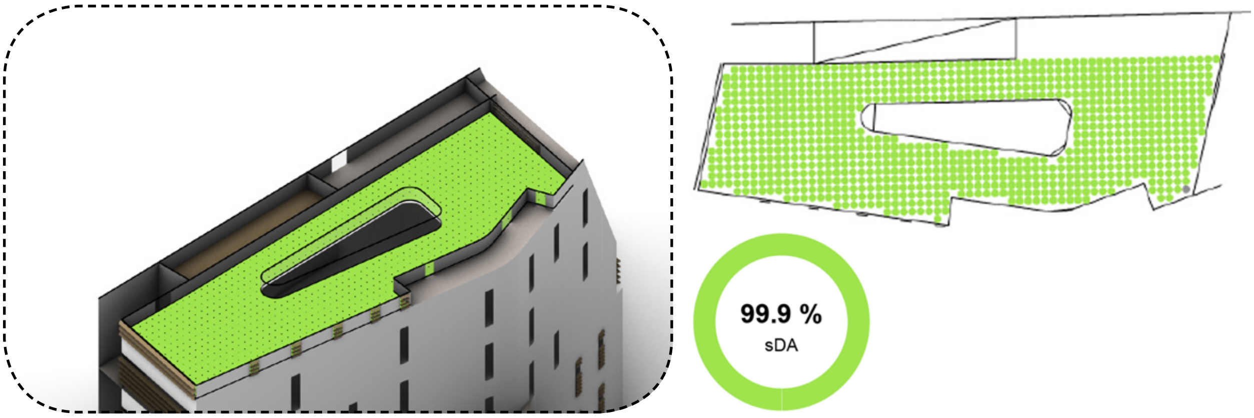
Point-in-time Illuminance at 21 September 12:00

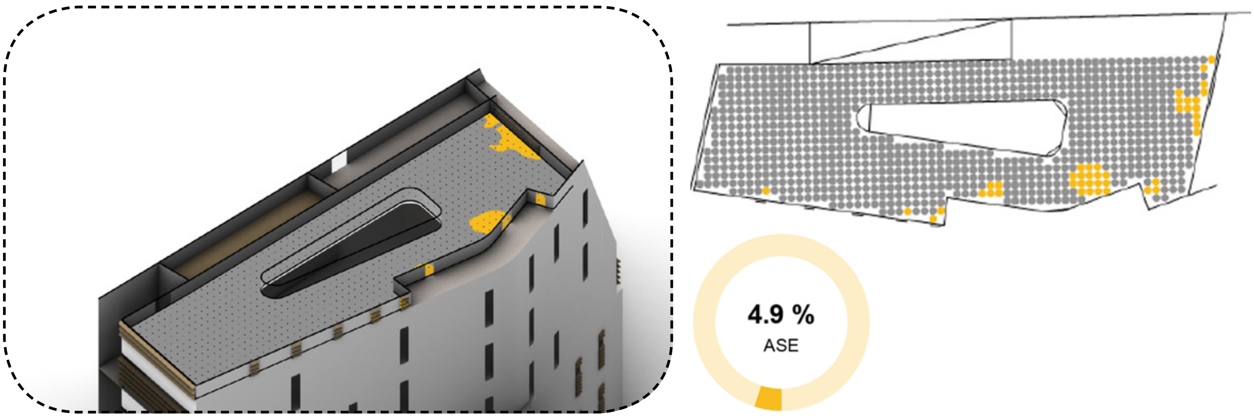


Mean Lux : 1150
Median Lux : 487

Illuminance is the measure of the amount of light falling on a surface. For an architectural studio, recommended illuminance levels can range from 300 to 500 lux (lux is the unit of illuminance) for general work areas. For more detailed tasks such as drafting or design work, higher illuminance levels in the range of 500 to 750 lux might be preferred.
While sufficient daylight is essential, glare control is equally important. Direct sunlight entering the space can create glare on screens and work surfaces, causing discomfort and reduced visibility. Proper shading devices, such as blinds or adjustable louvers, can help manage glare while still allowing daylight to enter.
Designing with flexibility in mind allows occupants to adjust lighting levels according to their needs. Incorporating adjustable lighting fixtures and curtains/blinds can give occupants control over the amount of natural light entering the space.

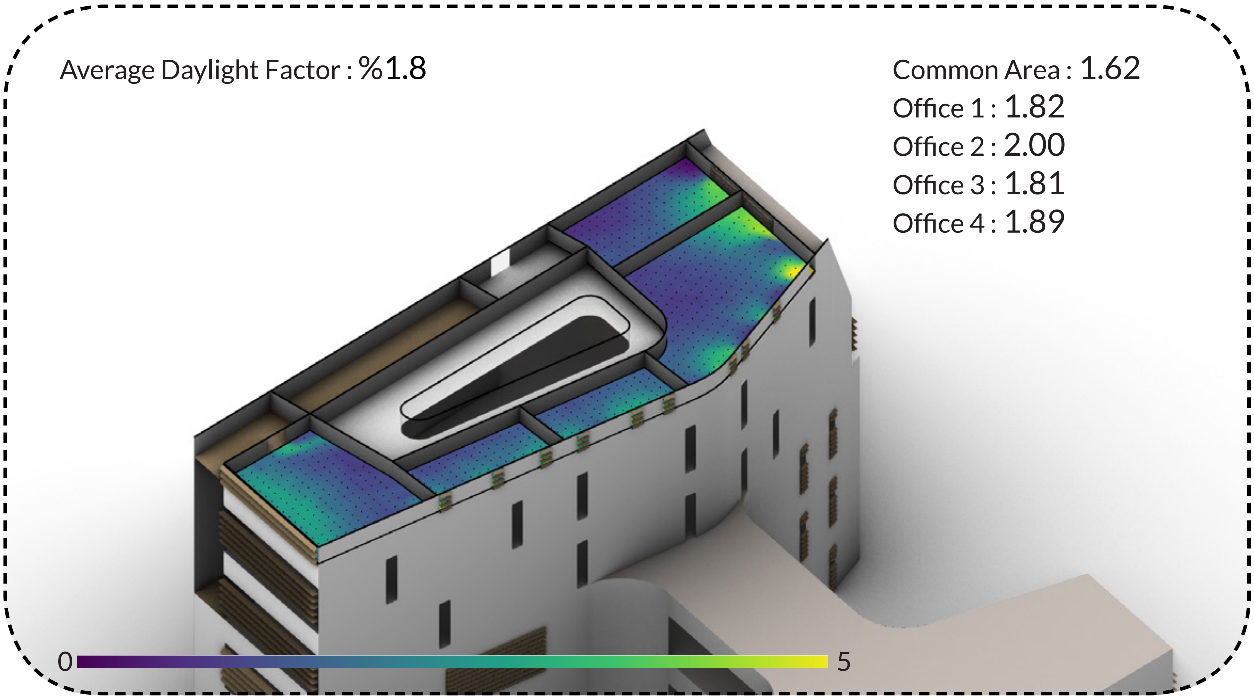
The Obtained sDA and ASE for this floor is here in the order given :

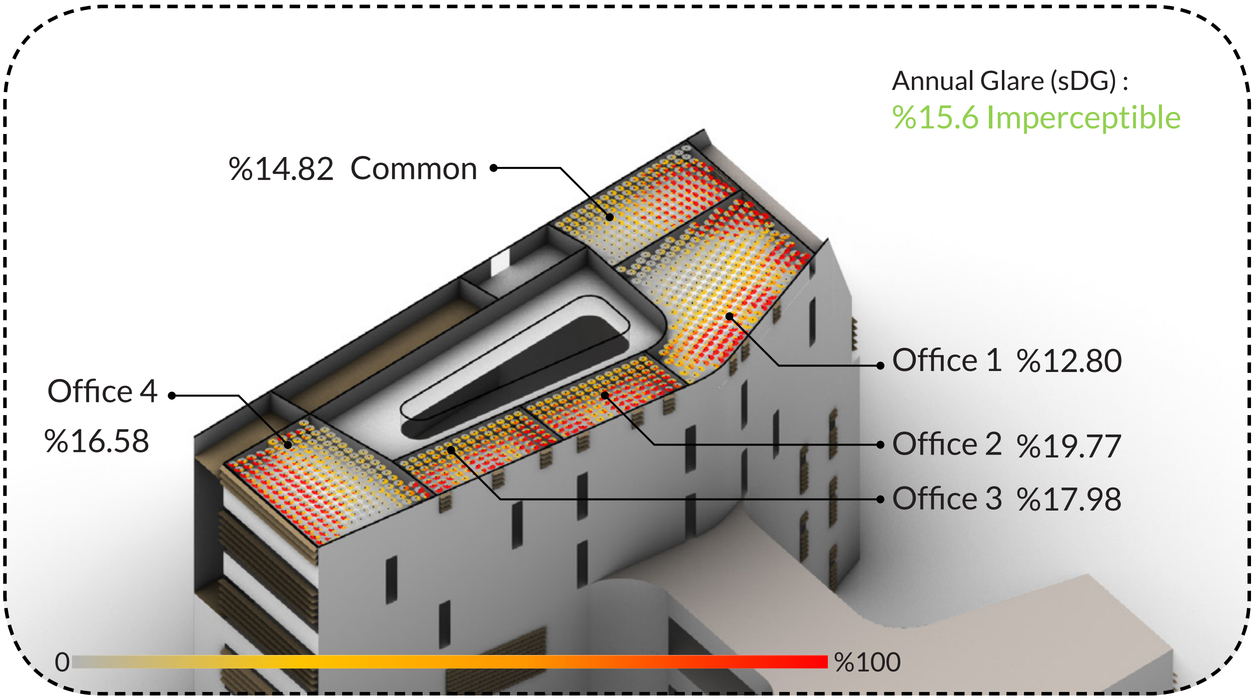




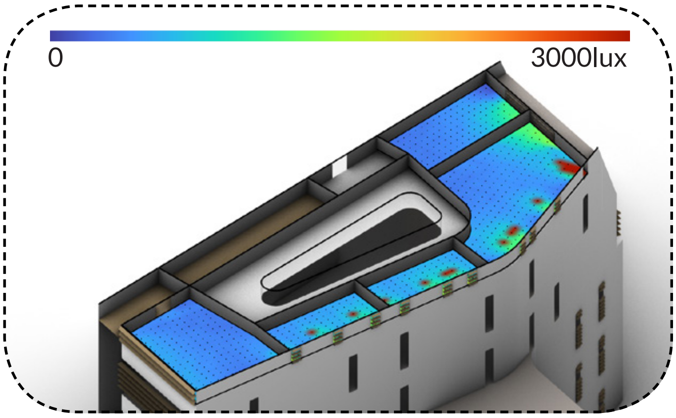
5th FLOOR

Offices 2 and 3 have 3 openings in size of (0.75*3m) covered by shadings with 45 degree inclination. The width of the shadings of the Office 4 is 40 cm while the width of the others is 20 cm. The common area is the place where staff meet to rest, drink and eat.
The white part will be dedicated to the toilets for men and women separately.
Office 4 is lit from the west facade in complete glazing and the common area is provided by 2 openings in the same size. All the units are sparated with a glazed wall so they can lit the corridor and they can use the central light in the days without sufficient daylight. In this floor, Office 1 is bigger so it has one extra opening without shading to have sufficient daylight. The detail of the analysis are here in the order given :

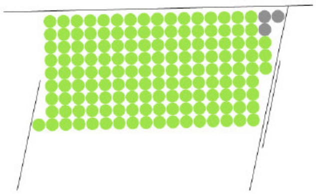




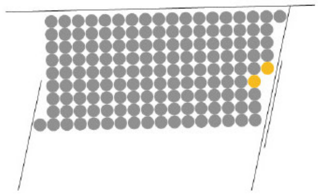
Point-in-time Illuminance at 21 September 12:00



Mean Lux : 1487
Median Lux : 491

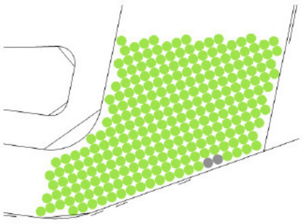


98.01 %

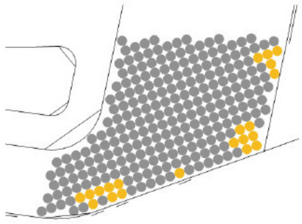


1.32 %

Common Area

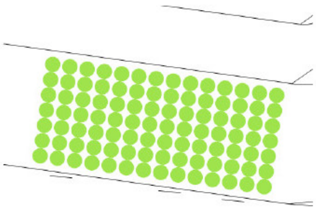


99.19 %

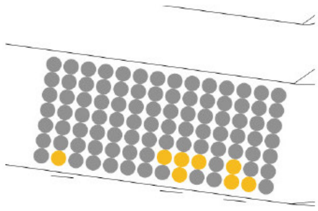


8.47 %

Office 1

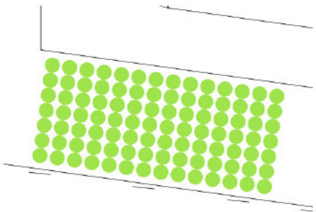


100.00 %

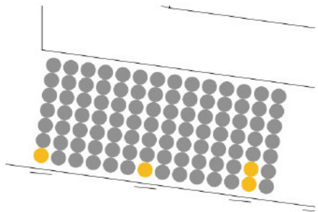


8.16 %

Office 2

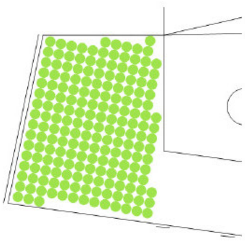


100.00 %

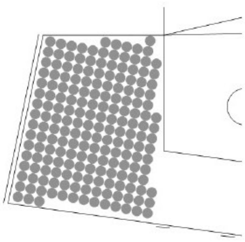


4.08 %

Office 3



100.00 %

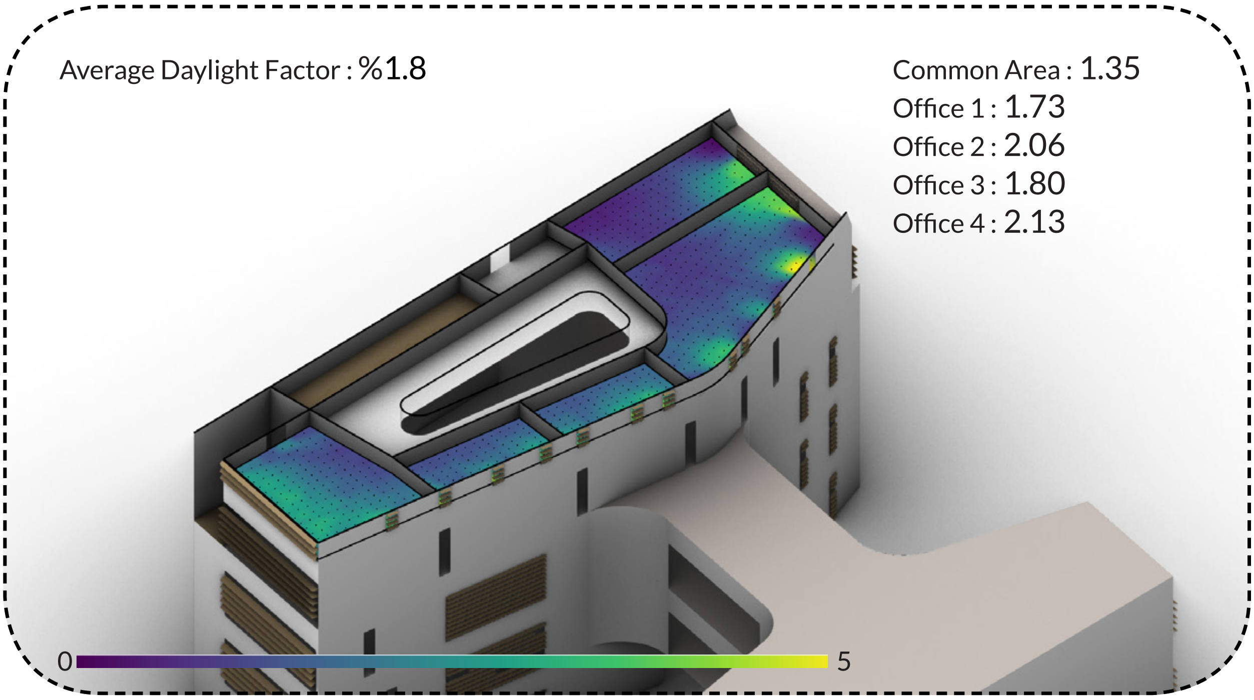


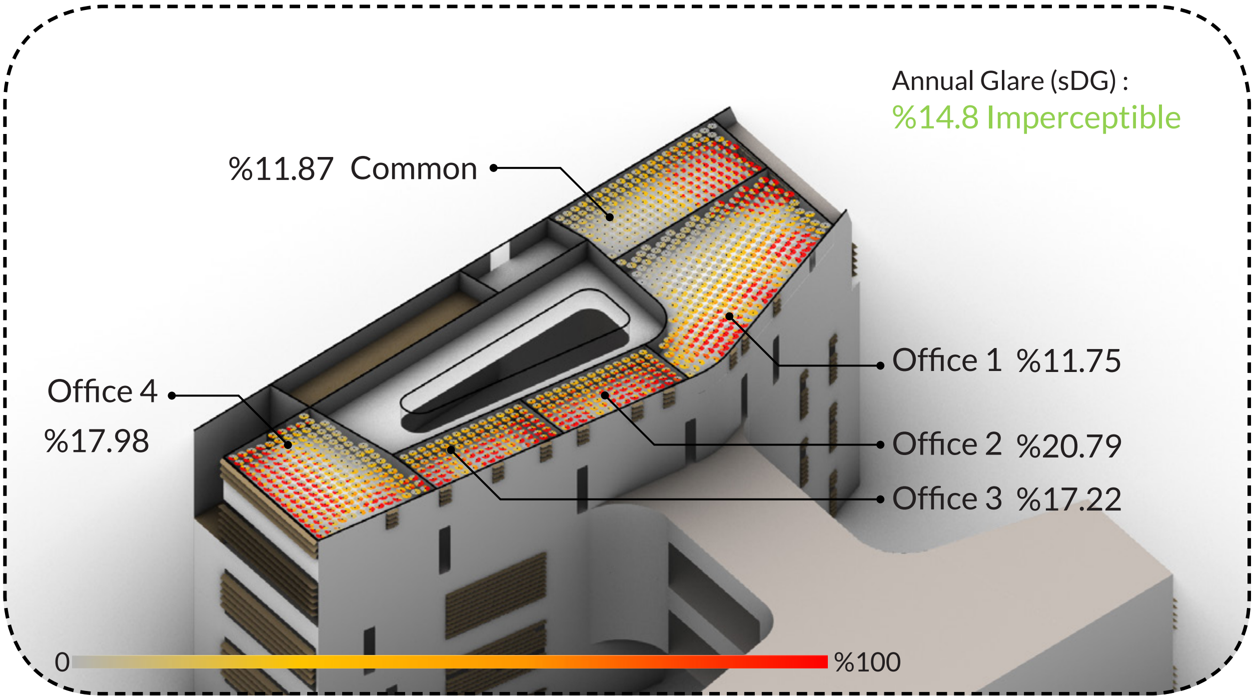
0.00 %

Office 4

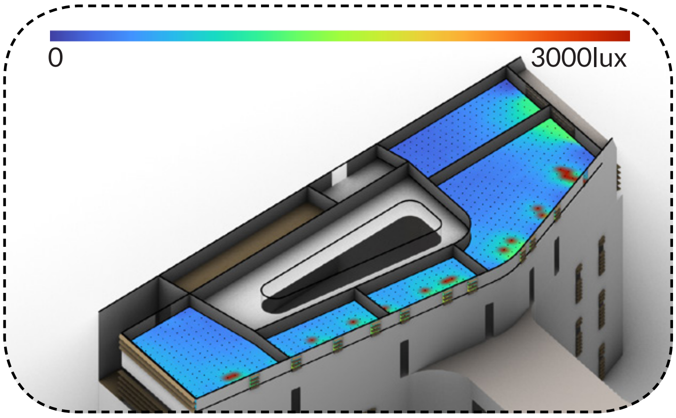
4th FLOOR

Like 5th floor, Offices 2 and 3 have 3 openings in size of (0.75*3m) covered by shadings with 45 degree inclination. The width of the shadings of the Office 4 is 40 cm while the width of the others is 20 cm. The common area is the place where staff meet to rest, drink and eat. The white part will be dedicated to the toilets for men and women separately.
Office 4 is lit from the west facade in complete glazing and the common area is provided by 2 openings in the same size. All the units are sparated with a glazed wall so they can lit the corridor and they can use the central light in the days without sufficient daylight. In this floor, Office 1 is bigger so it has one extra opening without shading to have sufficient daylight. The detail of the analysis are here in the order given :

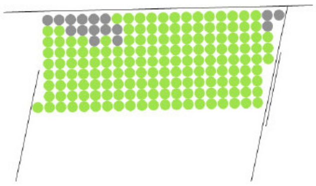




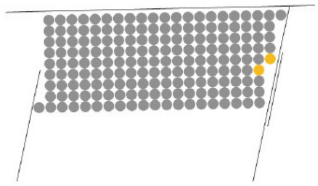
Point-in-time Illuminance at 21 September 12:00



Mean Lux : 1486
Median Lux : 506

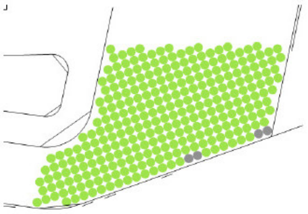


91.01 %

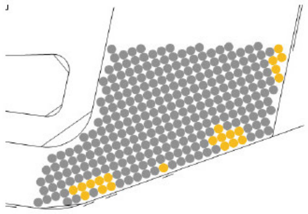


1.12 %

Common Area

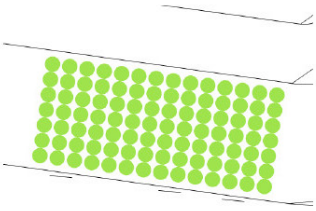


98.59 %

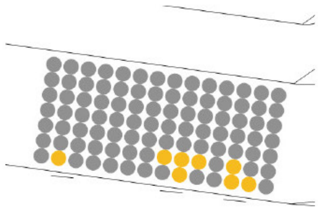


7.75 %

Office 1

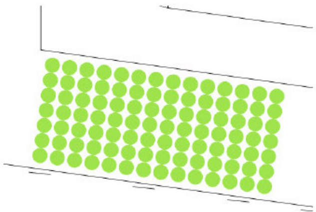


100.00 %

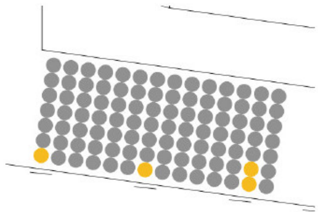


8.16 %

Office 2

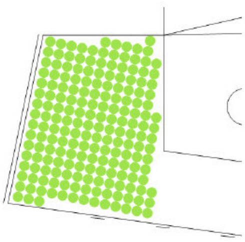


100.00 %



4.08 %

Office 3



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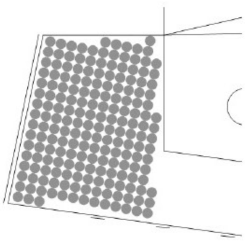
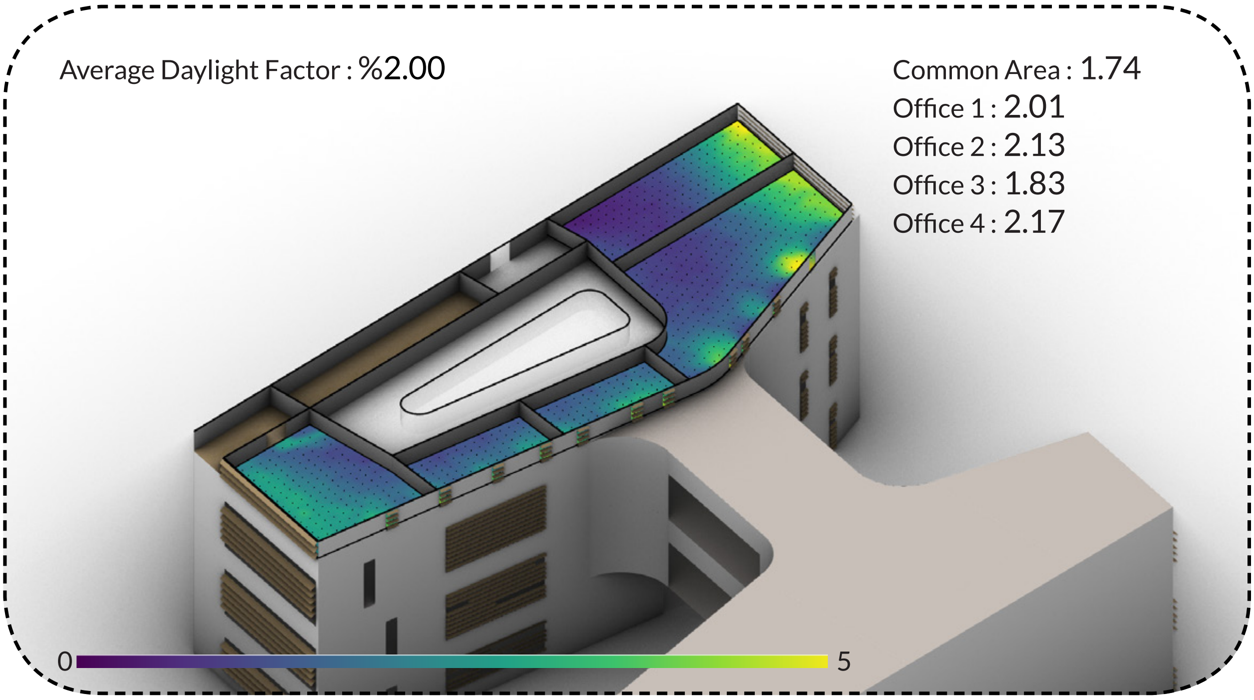


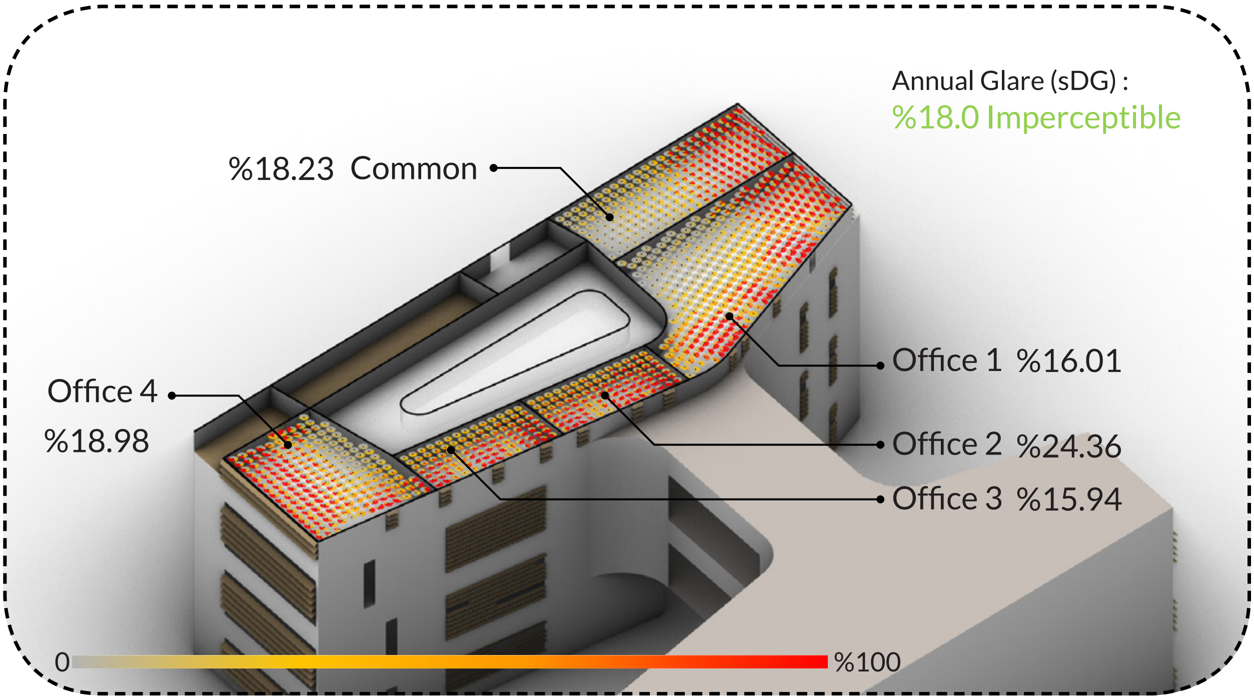
0.00 %

Office 4

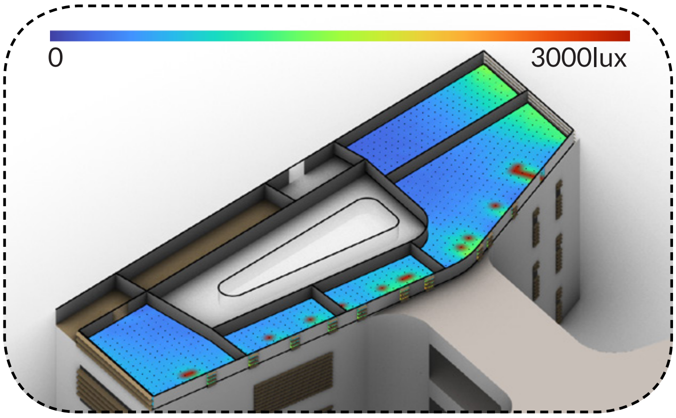
3rd FLOOR

Like 4th floor, Offices 2 and 3 have 3 openings in size of (0.75*3m) covered by shadings with 45 degree inclination. The width of the shadings of the Office 4 is 40 cm while the width of the others is 20 cm. The common area is the place where staff meet to rest, drink and eat. The white part will be dedicated to the toilets for men and women separately.
Office 4 is lit from the west facade in complete glazing and the common area is provided by a full-glazed facade on its east. All the units are sparated with a glazed wall so they can lit the corridor and they can use the central light in the days without sufficient daylight. In this floor, Office 1 is bigger so it has one extra opening without shading to have sufficient daylight. The detail of the analysis are here in the order given :

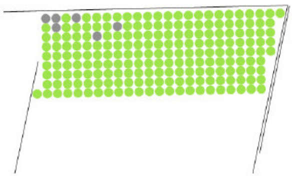




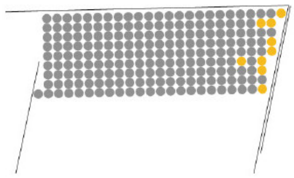
Point-in-time Illuminance at 21 September 12:00



Mean Lux : 1422
Median Lux : 530

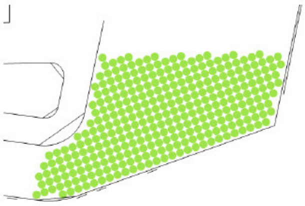


97.07 %

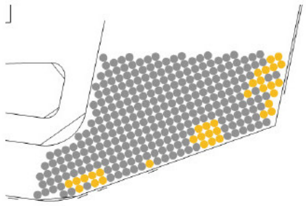


4.39 %

Common Area

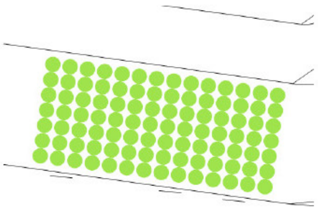


100.00 %

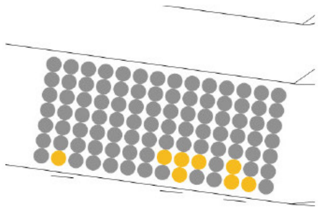


11.18 %

Office 1

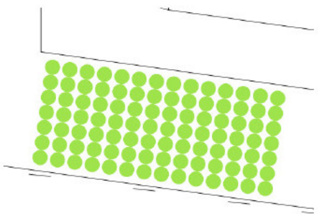


100.00 %

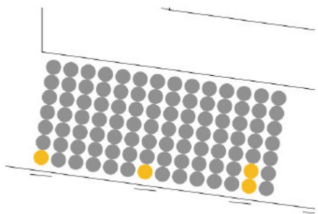


8.16 %

Office 2

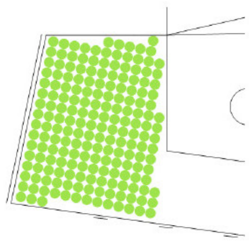


100.00 %

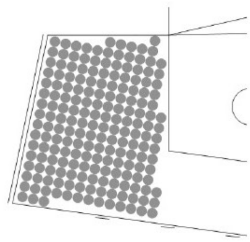


4.08 %

Office 3



100.00 %



0.00 %

Office 4

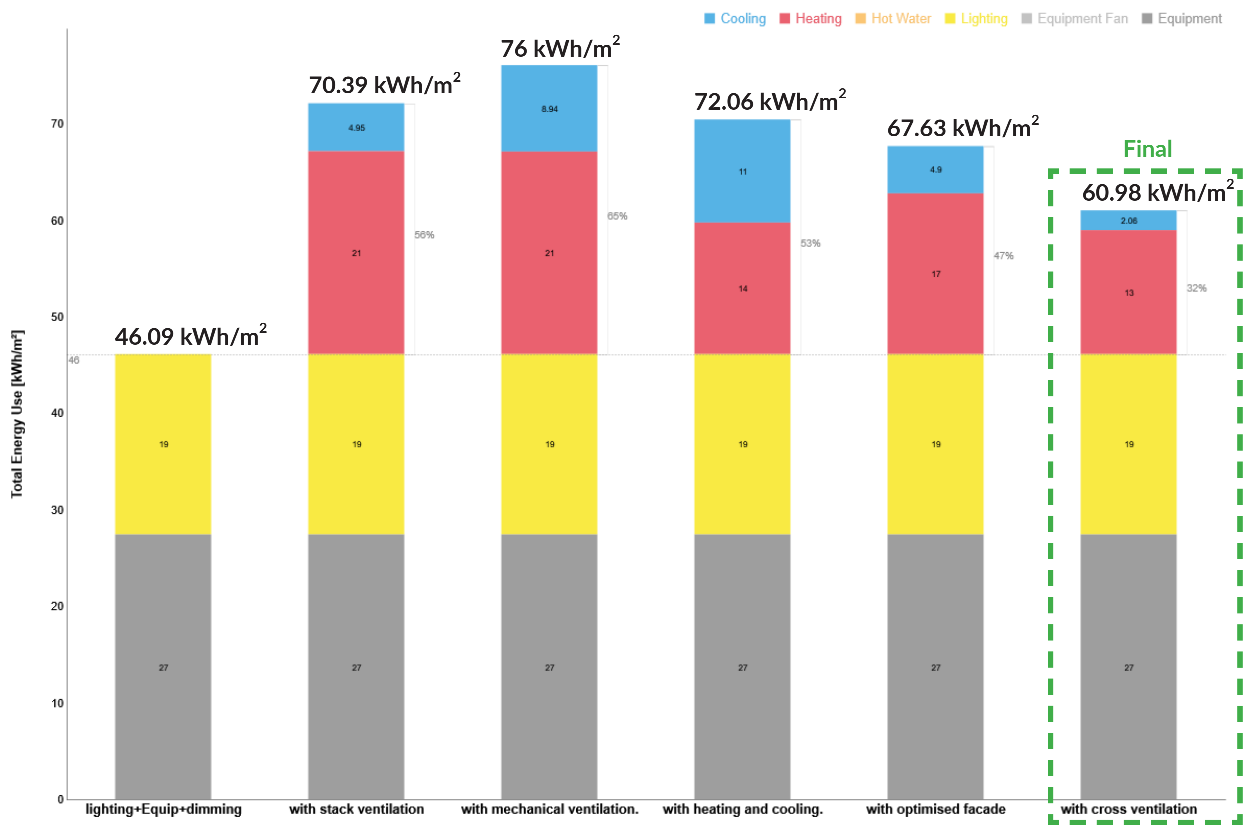
Energy Performance - Phase 2

1. As the first step, the EUI of the building has been calculated with taking into consideration the lighting and dimming with schedule which resulted in 46 kWh/m^2 .
2. In the further step, the heating and cooling has been included with the capacity of 140 W/m^2 and the EUI resulted in 71 kWh/m^2 .
3. With having the Mechanical Ventilation, the EUI and the average hours out of comfort zone have been increased regarding the charts and the result was 76 kWh/m^2.
4. The Stack ventilation of the Office zone has a considerable impact on the reduction of the EUI and the hours in comfort zone and in the end the average hours out of comfort zone was 586.
5. After all, optimisation in the u-value of the facade and the internal wall have caused the reduction in both energy use intensity and the hours out of comfort zone.

All the simulations have been started with the basline quantities in terms of U-value and then we have taken the optimisation into consideration.
The comparison is given in the order below which illustrates the enhancementin the energy performance of the building.

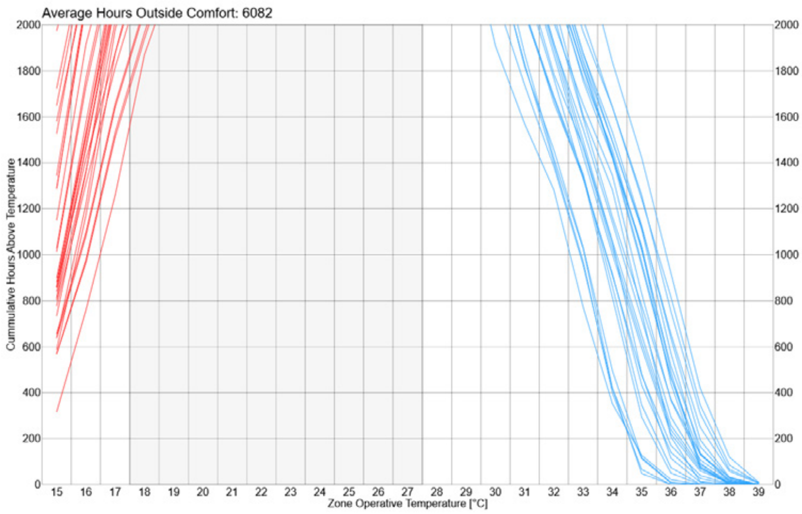
Building Elemant	U-Value
Roof	0.22
External Walls	0.26
Groud Floor	0.26
Window	1.4

The U-value, also known as thermal transmittance, represents the rate of heat transfer through a building element (such as walls, roofs, windows, and floors). It's typically measured in watts per square meter Kelvin (W/m^2K).



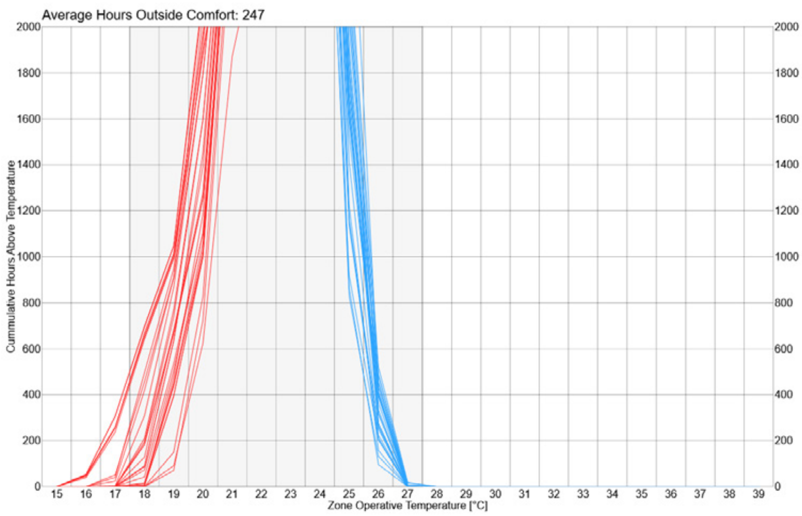
With Lighting + Dimming + Equipments + Scheduled :
Average Hours out of Comfort Zone : 6082

46	18	23	80%	233
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m²	kgCO²/m²	$/m²	Vs. Baseline	kWh/m²



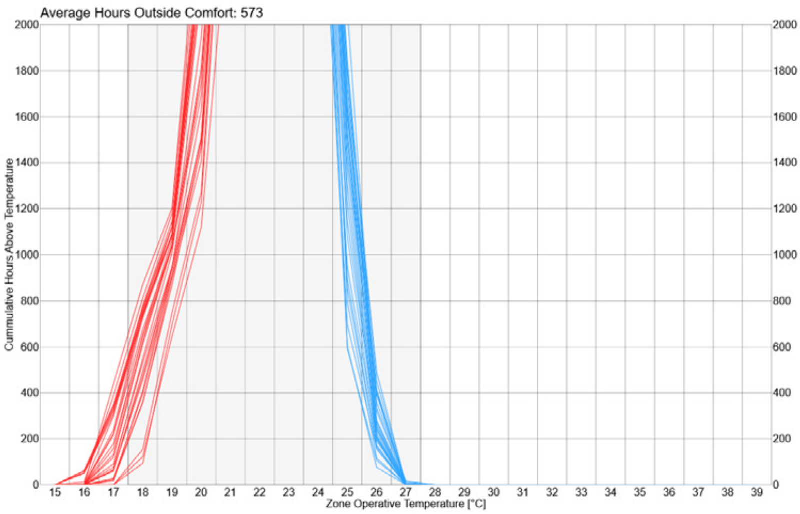
With Using Heating and Cooling :
Average Hours out of Comfort Zone : 247

70	25	30	70%	233
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m²	kgCO²/m²	$/m²	Vs. Baseline	kWh/m²



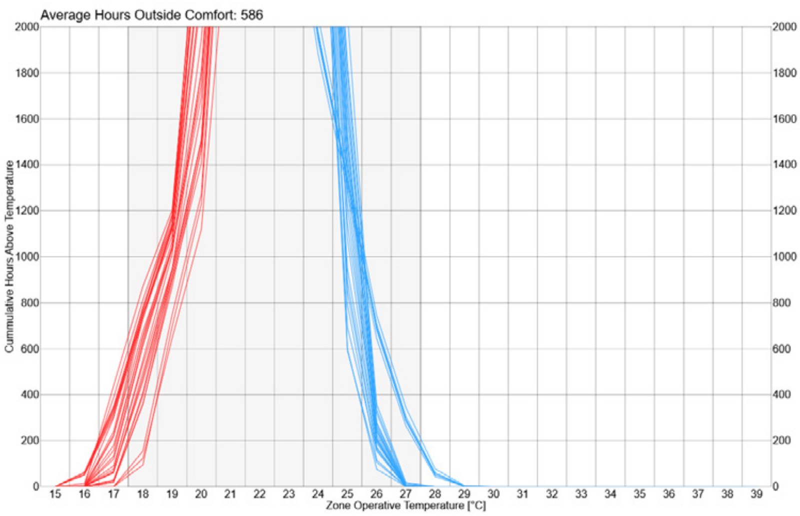
With Scheduled Mechanical Ventilation :
Average Hours out of Comfort Zone : 573

76	26	30	67%	233
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m²	kgCO²/m²	$/m²	Vs. Baseline	kWh/m²



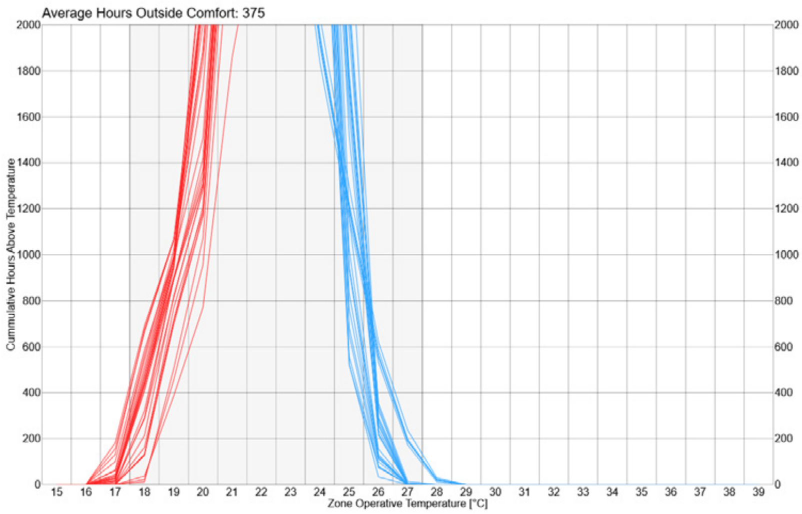
With Stack Ventilation only for the workplaces :
Average Hours out of Comfort Zone : 586

72	25	28	69%	233
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m²	kgCO²/m²	$/m²	Vs. Baseline	kWh/m²



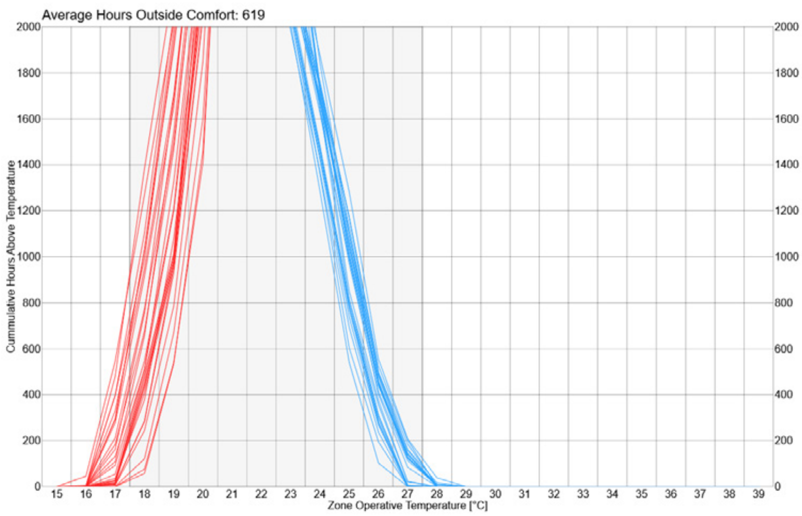
With Optimised Facade and Internal walls :
Average Hours out of Comfort Zone : 375

68	24	27	71%	233
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m²	kgCO²/m²	$/m²	Vs. Baseline	kWh/m²



With Cross Ventilation through the windows for both residentials and workplaces :
Average Hours out of Comfort Zone : 619

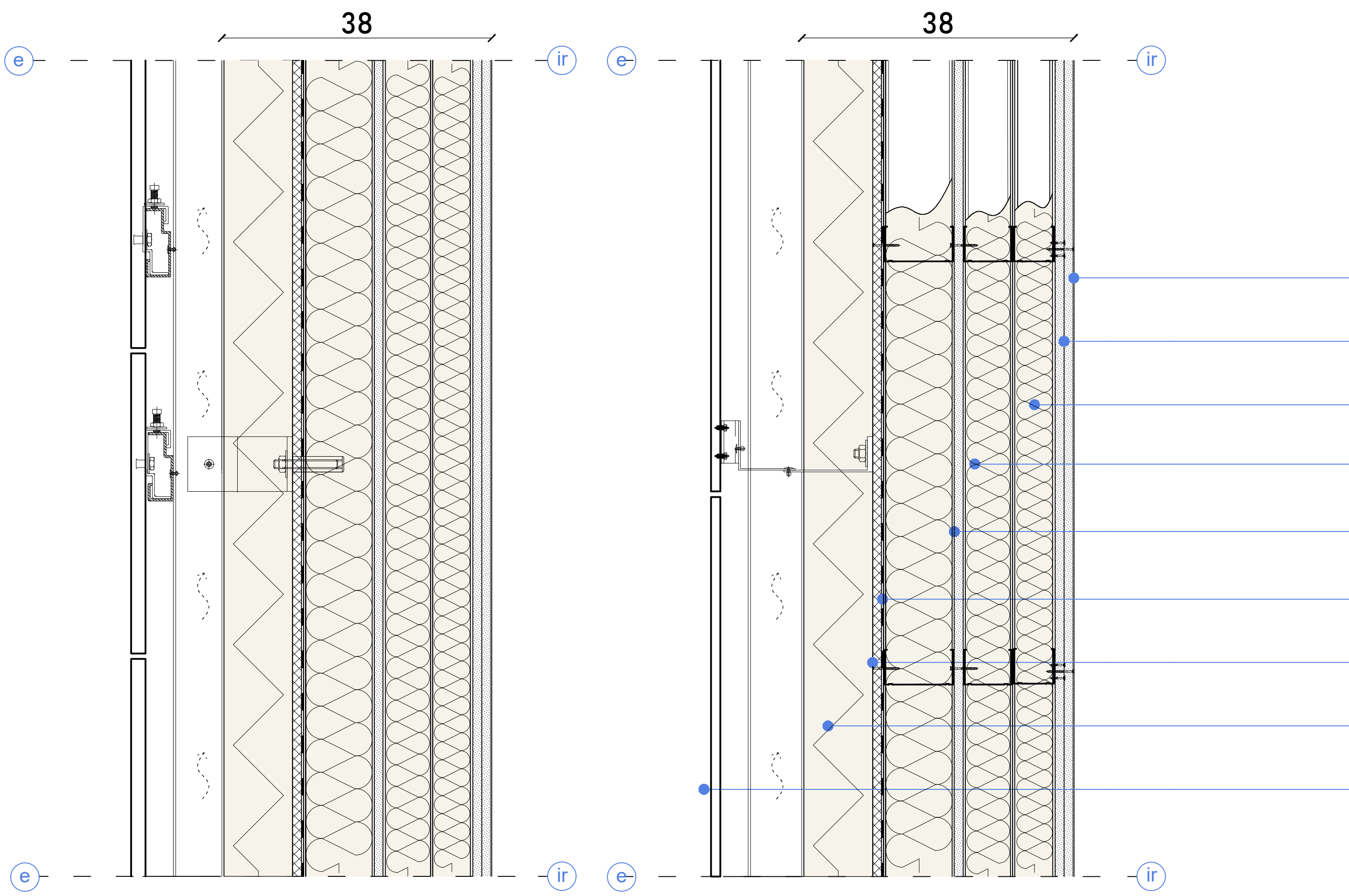
61	22	25	74%	233
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m²	kgCO²/m²	$/m²	Vs. Baseline	kWh/m²



Opaque Task - External Wall

External Wall : th. 38.15 cm

1. Finishing layer, Fugenfuller leicht di Knauf, sp. 0,15cm (Internal)
2. Double plasterboard, dim. 120 x 200 cm, th. 1,25 cm, th. tot. 2,5 cm, GKB(A) di Knauf
3. Internal insulation in mineral rock wool, dim. 120x60cm, th. 6 cm, λ =0,038 W/(m.K), Acoustic 225 Plus di Rockwool
4. Internal insulation in mineral rock wool, dim. 120x60cm, th. 7 cm, λ=0,038 W/(m.K), Acoustic 225 Plus di Rockwool
5. Internal insulation in mineral rock wool, dim. 120x60cm, th. 10 cm, λ=0,038 W/(m.K), Acoustic 225 Plus di Rockwool
6. Plasterboard, dim. 120 x 200 cm, th. 1,25 cm, GKB(A) di Knauf
7. Wind barrier, th. 220 μm, Tyvek UV Facade di Ampack
8. Fiber reinforced concrete panel, dim. 200 x 120 cm, sp. 1,25cm, Aquapanel Outdoor di Knauf
9. Thermic Insulation in XPS, sp. 10 cm, λ=0,035 W/(m.K), XDUR300 di Lape
10. ÖKO SKIN By RIEDER - Vivid Facade slats (External Finishing)



V. H.

Layer	Thickness (cm)	Thermal Conductivity (W/m.k)	Heat Resistance (m^2k/W)	Specific Heat (J/kgK)	Density (kg/m^3)
1	0.15	0.7	0.029	1000	1500
2	2.5	0.2	0.0625	1000	680
3	6	0.038	1.71	1030	70
4	7	0.038	2.00	1030	70
5	10	0.038	2.8571	1030	70
6	1.25	0.2	0.0625	1004	680
7	-	-	-	-	-
8	1.25	0.35	0.036	922	1450
9	10	0.034	2.94	1030	70
10	1.3 (Panel only)	1	0.006	1000	1800

Since a lower U-value indicates better insulation and reduced heat loss or gain, in this case a U-value of 0.1 suggests that the wall has excellent thermal performance and is very resistant to heat flow. This is particularly important for energy-efficient buildings, as walls with low U-values contribute to lower energy consumption for heating and cooling. The previous tests have been done with the baseline quantity of U-value for the external walls and it was 0.26 W/m^2k. Thanks to the improvements for this wall, the new U-value of 0.1 W/m^2k has been obtained that had great impact on the Energy Use Intensity of the building.

External Heat Resistance	0.04
Internal Heat Resistance	0.13
R Total	10.038
U-Value (W/m^2k)	**0.10**

Finishing layer, Fugenfuller leicht di Knauf, sp. 0,15cm

Double plasterboard, dim. 120 x 200 cm, th. 1,25 cm, th. tot. 2,5 cm, GKB(A) di Knauf

Internal insulation in mineral rock wool, dim. 120x60cm, th. 6 cm, λ=0,038 W/(m·K), Acoustic 225 Plus di Rockwool

Internal insulation in mineral rock wool, dim. 120x60cm, th. 10 cm, 7 cm, th. tot. 17 cm, λ=0,038 W/(m·K), Acoustic 225 Plus di Rockwool

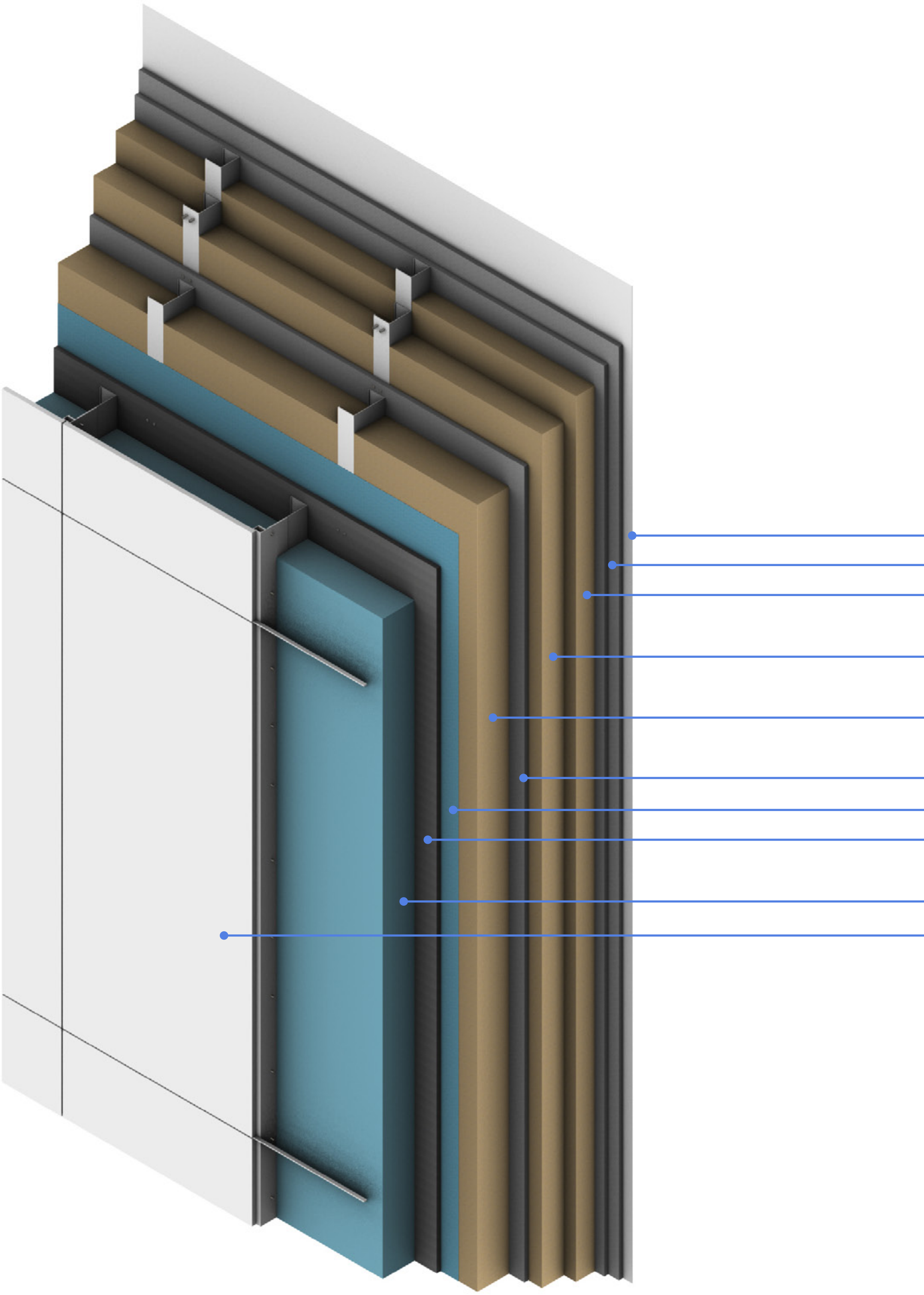
Plasterboard, dim. 120x200 cm, th. 1,25 cm, GKB Knauf

Wind barrier, th. 220 μm, Tyvek UV Facade di Ampack

Fiber reinforced concrete panel, dim. 200 x 120 cm, sp. 1,25cm, Aquapanel Outdoor di Knauf

Thermic Insulation in XPS, sp. 10 cm, λ=0,035 W/(m·K), XDUR300 di Lape

Finishing in Laminam Panel and archors.



1. Finishing layer, Fugenfuller leicht di Knauf, sp. 0,15cm (Internal)
2. Double plasterboard, dim. 120 x 200 cm, th. 1,25 cm, th. tot. 2,5 cm, GKB(A) di Knauf
3. Internal insulation in mineral rock wool, dim. 120x60cm, th. 6 cm, λ =0,038 W/(m.K), Acoustic 225 Plus di Rockwool
4. Internal insulation in mineral rock wool, dim. 120x60cm, th. 7 cm, λ=0,038 W/(m.K), Acoustic 225 Plus di Rockwool
5. Internal insulation in mineral rock wool, dim. 120x60cm, th. 10 cm, λ=0,038 W/(m.K), Acoustic 225 Plus di Rockwool
6. Plasterboard, dim. 120 x 200 cm, th. 1,25 cm, GKB(A) di Knauf
7. Wind barrier, th. 220 μm, Tyvek UV Facade di Ampack
8. Fiber reinforced concrete panel, dim. 200 x 120 cm, sp. 1,25cm, Aquapanel Outdoor di Knauf
9. Thermic Insulation in XPS, sp. 10 cm, λ=0,035 W/(m.K), XDUR300 di Lape
10. ÖKO SKIN By RIEDER - Vivid Facade slats (External Finishing)

Colours	1 colour	2 colours
Surfaces	Mix of ferro light + ferro	Mix of matt + ferro light + ferro (extra contrast)

Material	
Length	2500 mm, 3100 mm / *98.42“, 122“ (US)*
Width	70 mm, 147 mm and 302 mm / *2.76“, 5.79” and 11.89“ (US)* sequencing of slats is pre-defined
Thickness	13 mm / *0.5“ (US)*
Colour collection	greyscale, pietra, timber, bricky
Texture	standard

Handling	
Mounting	Manually or with vacuum suction; slats must be handled with special care

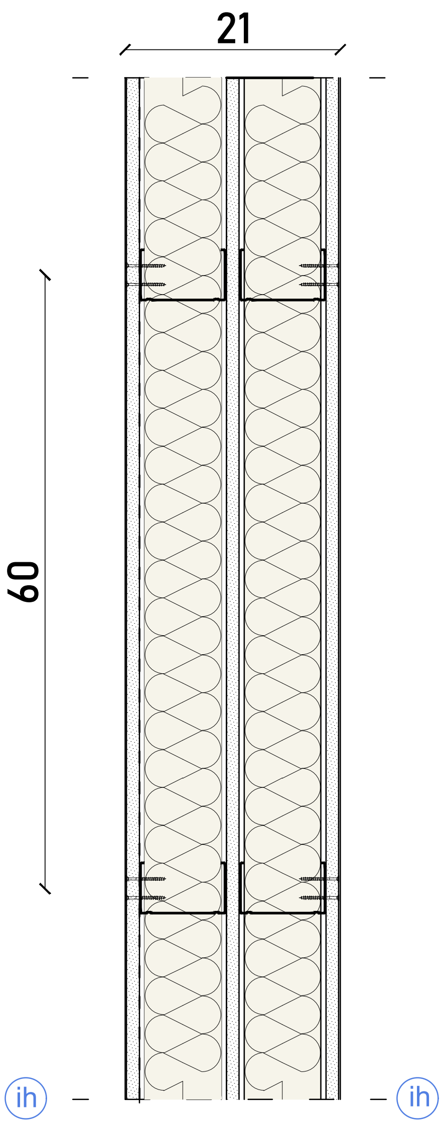
Fixing	
Visible: rivet, screw	Distance to slat edge at least 30 mm / *1.18“ (US)*
Concealed: adhesive, undercut anchor (on request)	Distance to slat edge (vertically) at least 100 mm / *3.93“ (US)* Distance to slat edge (horizontally): with 70 mm and 147 mm / *2.76“ and 5.79“ (US)* once in the middle; with 302 mm / *11.89“ (US)* minimum distance to slat edge 60 mm / *2.36“ (US)* (with point attachment: 2 pieces) Maximum distance between two vertical attachment points: 600 mm / *23.62“ (US)* Additional supporting structure or bracing required depending on statics.

Opaque Task - Internal Wall

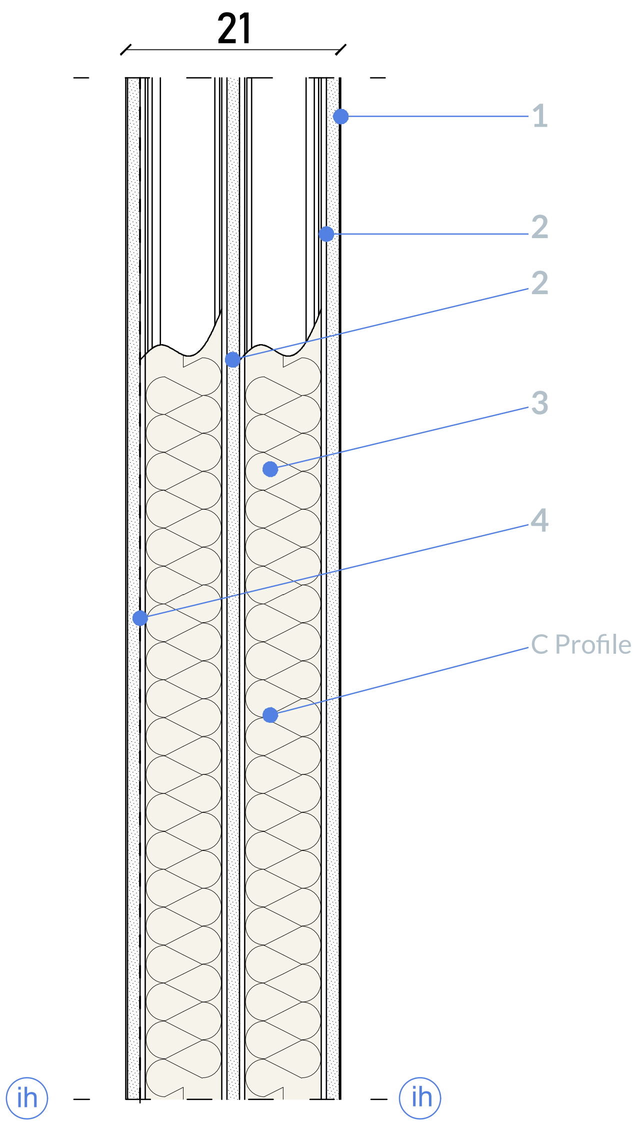
Internal Wall : th. 21.25 cm

1. Finishing layer, Fugenfuller leicht di Knauf, sp. 0,15cm (Internal)
2. Standard Wallboard Plasterboard, dim. 120 x 200 cm, sp. 1,25 cm, tot. 2.5 cm, GKB(A) di Knauf
3. Double Internal insulation in Rockwool Flexi, dim. 120x60cm, th. 8,5 cm, th. tot. 17 cm, λ=0,035 W/(m.K), tipo Acoustic
4. Polyethylene/polythene, low density 0.15 mm (0.15 mm)
5. Standard Wallboard Plasterboard, dim. 120 x 200 cm, sp. 1,25 cm, GKB(A) di Knauf
6. Finishing layer, Fugenfuller leicht di Knauf, sp. 0,15cm (External)

- Fixing System : C profile (50/75/50), th. 1 mm, passo 60 cm, with self dwelling screws to fix the plasterboards



H.

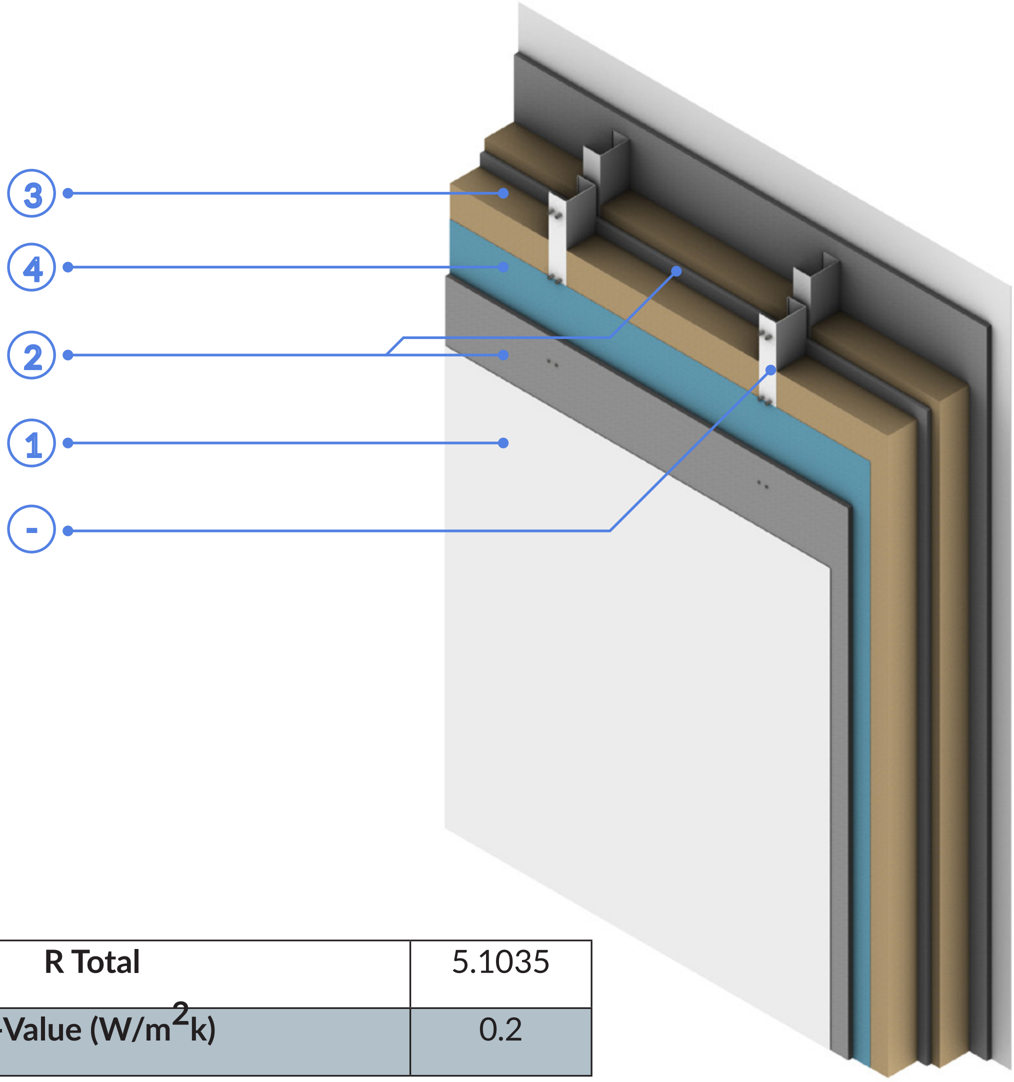


V.

Layer	Thickness (cm)	Thermal Conductivity (W/m.k)	Heat Resistance (m^2k/W)	Specific Heat (J/kgK)	Density (kg/m^3)
1	0.15	0.7	0.029	1000	1500
2	2.5	0.2	0.125	1000	680
3	17	0.035	4.8571	1030	35
4	0.015	0.17	0.0009	2200	920
5	1.25	0.2	0.0625	1000	680
6	0.15	0.7	0.029	1000	1500

ROCKWOOL FLEXI® has been designed as a multi-use, dual purpose acoustic and thermal stone wool insulation with a unique flexible edge along one side.

Reaction to fire (Euroclass)	Euroclass A1
Thermal conductivity	50-120mm 0.038 W/mK 140mm> 0.035 W/mK
Acoustic	Achieves Part E (resistance to sound) when installed in accordance to ROCKWOOL guidelines



R Total	5.1035
U-Value (W/m^2k)	0.2

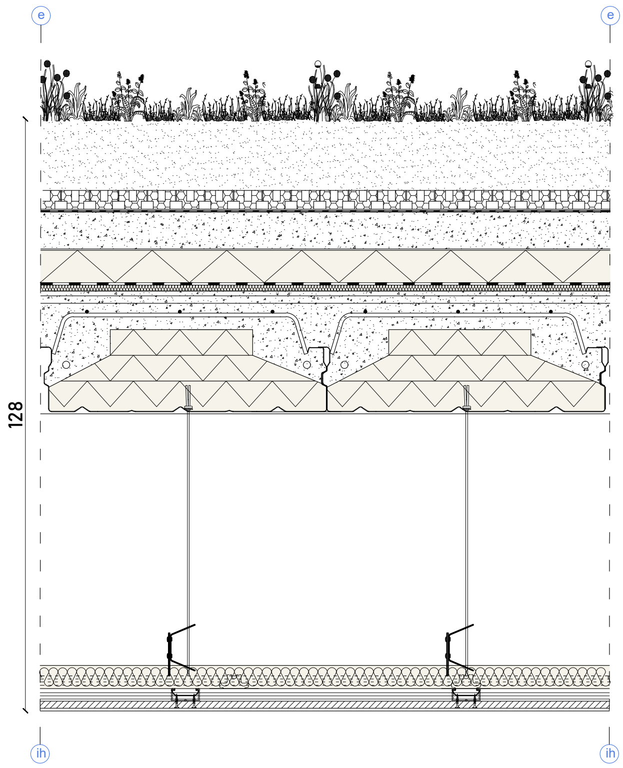
Opaque Task - Green Roof

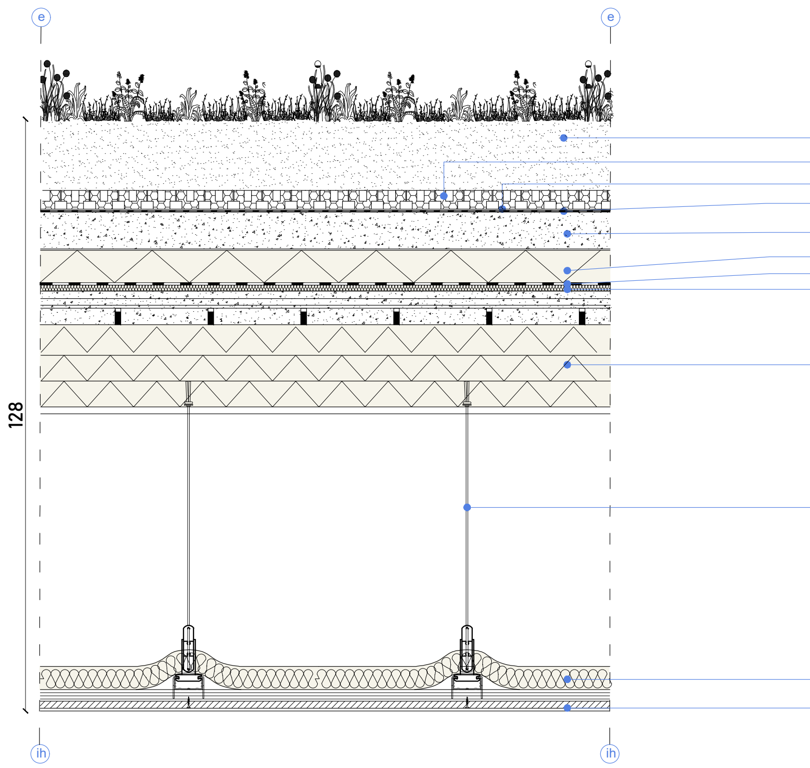
Green Roof : th. 128 cm

Layer	Thickness (cm)	Thermal Conductivity (W/m.k)	Heat Resistance (m^2k/W)	Specific Heat (J/kgK)	Density (kg/m^3)
1	15	2.25	0.066		700
2	4	/	/	/	/
3	0.08	0.17	0.005	1400	275
4	0.4	0.17	0.0235	1000	1200
5	8	0.33	0.24	1000	1200
6	8	0.039	2.1	1030	155
7	0.22	0.4	0.006	1800	500
8	1.3	0.04	0.313		
9	26	0.3	0.866		
10	/	/	/	/	/
11	5	0.033	1.5151	1030	70
12	1.5	0.23	0.073	1000	760

External Heat Resistance	0.04
Internal Heat Resistance	0.1
R Total	5.303
U-Value (W/m^2k)	**0.19**

Green Roof External - Internal Heated





1. Ground
2. Drainage layer with moldedge layer with molded sintered polystyrene plates, th. 4cm Tecno dreno Knauf
3. Macro-holed, non-woven polypropylene fabric for reinforcing waterproofing membranes, 200 gr/m², FIOCCOTEX PES/CE 200 GR di Biemme.
4. Waterproof membrane, th. 0,4cm, INDEX Lighterflex HPCP Helasto.
5. Concrete screed, th. 8cm
6. Rigid thermo-acoustic insulation layer in high density rock wool, dim. 120x100cm, sp. 8 cm, λ = 0.039 W / mK, ROCKACIER B
7. Synthetic vapor barrier, th. 0,22 cm, DS 46 PE Riwega.
8. Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel by Mapei.
9. Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of EPS
10. False ceiling support structure, D112, Knauf
11. Thermic and acoustic insulation in rock wool, dim. 60 cm x 120 cm, sp. 5 cm, λ= 0,033 W/(m•K), Ceilingrock Plus Rockwool
12. Fiber cement support board for plaster, th. 1,5 cm. Exterior plaster with reinforcing net, th. 0,7 cm with finishing layer of 0.6 cm

Ground
Drainage layer with molded sintered polystyrene plates, th. 4cm **Tecno dreno Knauf**
Macro-holed, non-woven polypropylene fabric for reinforcing waterproofing membranes, 200 gr/m², FIOCCOTEX PES/CE 200 GR di Biemme.
Waterproof membrane, th. 0,3cm, INDEX Lighterflex HPCP Helasto.
Concrete screed, th. 8cm, slope 1%
Rigid thermo-acoustic insulation layer in high density rock wool, dim. 120x100cm, sp. 7 cm, λ = 0.039 W / mK, ROCKACIER B
Synthetic vapor barrier, th. 0,22 cm, DS 46 PE Riwega.
Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel by Mapei.
Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of EPS
False ceiling support structure, D112, Knauf
Thermic and acoustic insulation in rock wool, dim. 60 cm x 120 cm, sp. 5 cm, λ= 0,033 W/(m•K), Ceilingrock Plus Rockwool
Fiber cement support board for plaster, th. 1,5 cm. Exterior plaster with reinforcing net, th. 0,7 cm.

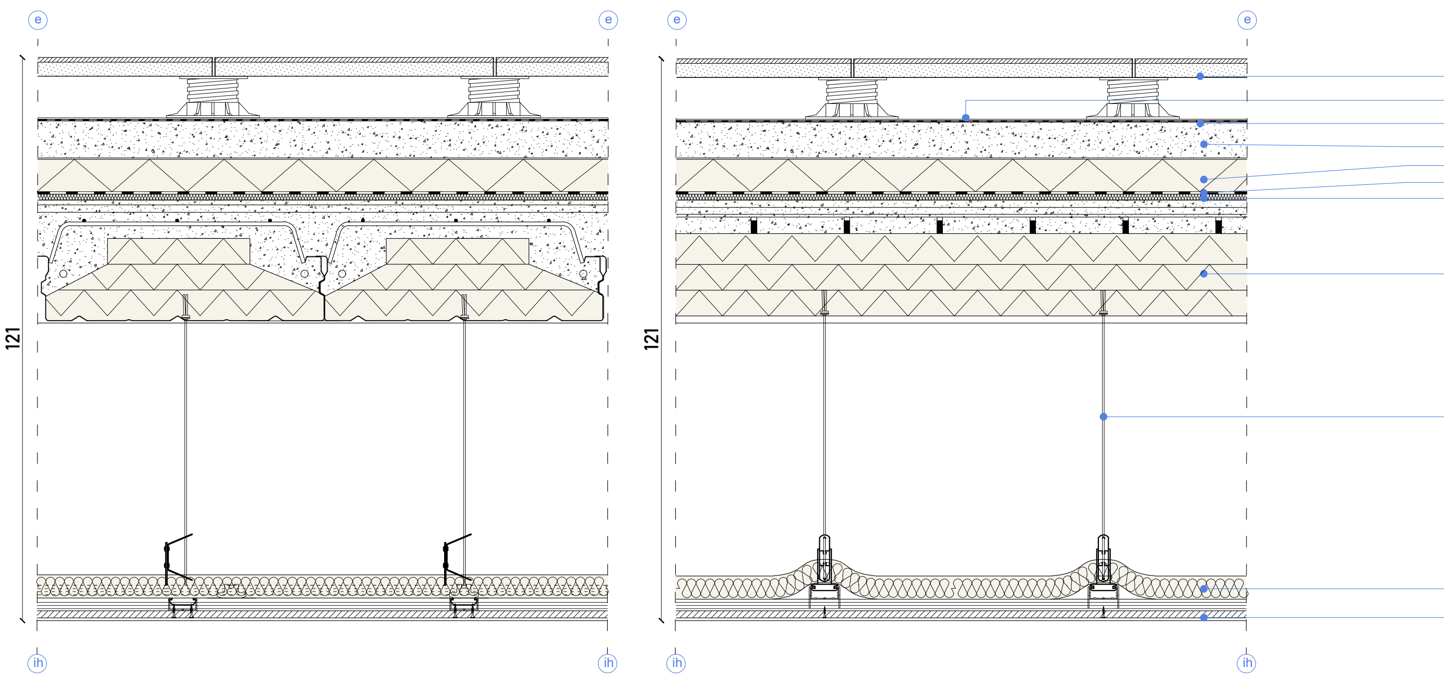
Opaque Task - Walkable Roof

Green Roof : th. 121 cm

Layer	Thickness (cm)	Thermal Conductivity (W/m.k)	Heat Resistance (m^2k/W)	Specific Heat (J/kgK)	Density (kg/m^3)
1	3	0.11	0.2727	/	1100
2	0.08	0.17	0.005	1400	275
3	0.4	0.17	0.0235	1000	1200
4	8	0.33	0.24	1000	1200
5	8	0.039	2.1	1030	155
6	0.22	0.4	0.006	1800	500
7	1.3	0.04	0.313		
8	26	0.3	0.866		
9	/	/	/	/	/
10	5	0.033	1.5151	1030	70
11	1.5	0.23	0.073	1000	760

External Heat Resistance	0.04
Internal Heat Resistance	0.1
R Total	5.509
U-Value (W/m^2k)	**0.18**

Roof External - Internal Heated



1. Floating floor for exterior with gres tiles NEWFLOOR G30ATK.
2. Macro-holed, non-woven polypropylene fabric for reinforcing waterproofing membranes, 200 gr/m², FIOCCOTEX PES/CE 200 GR di Biemme.
3. Waterproof membrane, th. 0,4cm, INDEX Lighterflex HPCP Helasto.
4. Concrete screed, th. 8cm
5. Rigid thermo-acoustic insulation layer in high density rock wool, dim. 120x100cm, sp. 8 cm, λ = 0.039 W / mK, ROCKACIER B
6. Synthetic vapor barrier, th. 0,22 cm, DS 46 PE Riwega.
7. Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel by Mapei.
8. Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of EPS
9. False ceiling support structure, D112, Knauf
10. Thermic and acoustic insulation in rock wool, dim. 60 cm x 120 cm, sp. 5 cm, λ= 0,033 W/(m•K), Ceilingrock Plus Rockwool
11. Fiber cement support board for plaster, th. 1,5 cm. Exterior plaster with reinforcing net, th. 0,7 cm with finishing layer of 0.6 cm

Floating floor for exterior with gres tiles NEWFLOOR G30ATK.
Macro-holed, non-woven polypropylene fabric for reinforcing waterproofing membranes, 200 gr/m², FIOCCOTEX PES/CE 200 GR di Biemme.
Waterproof membrane, th. 0,4cm, INDEX Lighterflex HPCP Helasto.
Slope in concrete screed, th. 8 cm (1%)
Rigid thermo-acoustic insulation layer in high density rock wool, dim. 120x100cm, th. 7 cm, λ = 0.039 W / mK
Synthetic vapor barrier, th. 0,22 cm, DS 46 PE Riwega.
Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel by Mapei.

Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of EPS

False ceiling support structure, D112, Knauf

Thermic and acoustic insulation in rock wool, dim. 60 cm x 120 cm, sp. 5 cm, λ= 0,033 W/(m•K), Ceilingrock Plus Rockwool
Fiber cement support board for plaster, th. 1,5 cm. Exterior plaster with reinforcing net, th. 0,7 cm.

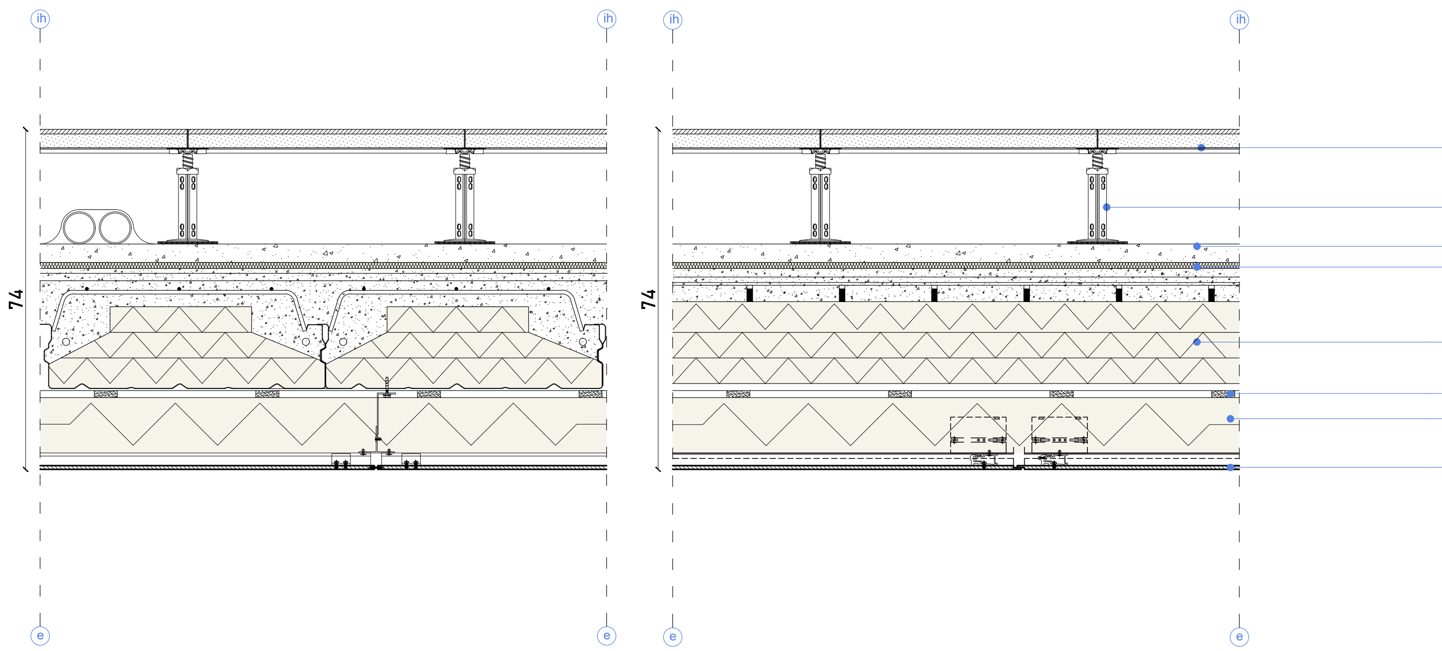
Opaque Task - Slab

Slab : th. 74 cm without False Ceiling

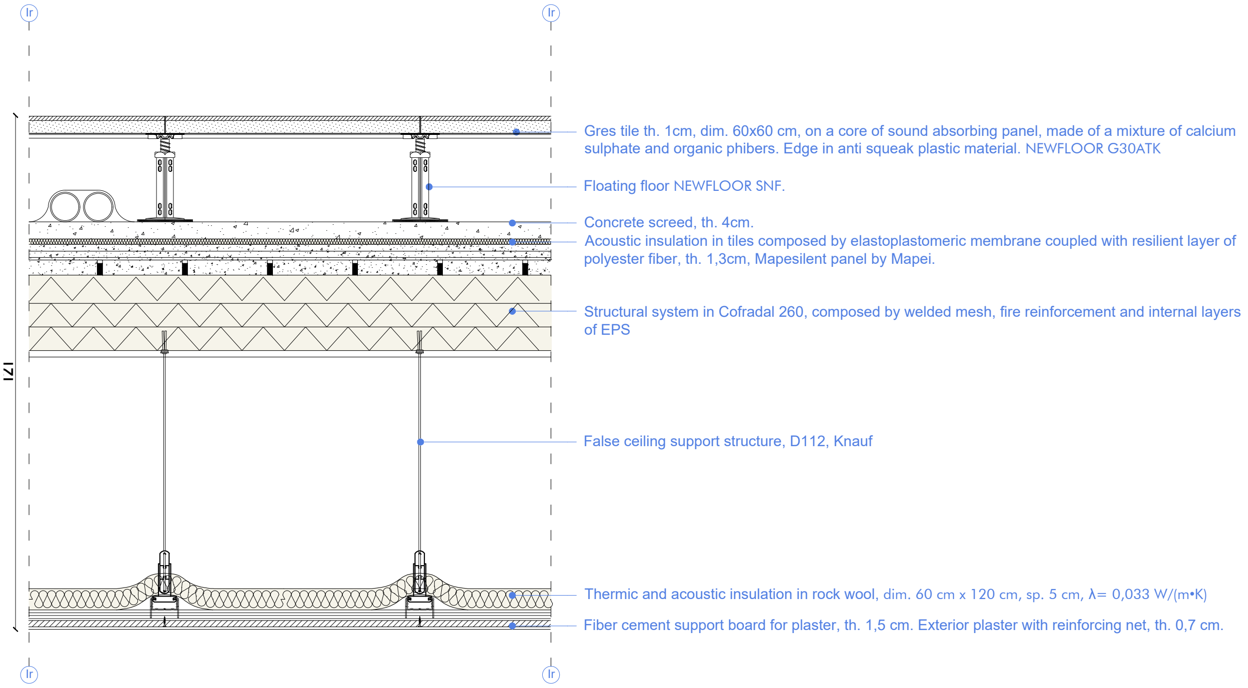
Layer	Thickness (cm)	Thermal Conductivity (W/m.k)	Heat Resistance (m^2k/W)	Specific Heat (J/kgK)	Density (kg/m^3)
1	3	0.11	0.2727	/	1100
2	0.08	0.17	0.005	1400	275
3	0.4	0.17	0.0235	1000	1200
4	8	0.33	0.24	1000	1200
5	8	0.039	2.1	1030	155
6	0.22	0.4	0.006	1800	500
7	1.3	0.04	0.313		
8	26	0.3	0.866		

1. Gres tile th. 1cm, dim. 60x60 cm, on a core of sound absorbing panel, made of a mixture of calcium sulphate and organic phibers. Edge in anti squeak plastic material. NEWFLOOR G30ATK. With total th. 3 cm
2. Floating floor NEWFLOOR SNF.
3. Concrete screed, th. 4cm.
4. Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel, Mapei.
5. Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of EPS
6. Adhesive in cement mortar, th. 1,5 cm
7. Expanded polyurethane insulation, th. 12 cm, dim. 1250x600 mm, sp. 15 cm, λ=0,036 W/(m·K), XPS BT Isover
8. Aluminum cladding and coating in Laminam panels

Internal Heated - External



Slab : th.121 cm with False Ceiling



External Heat Resistance	0.04
Internal Heat Resistance	0.1
R Total	5.701
U-Value (W/m²k)	**0.18**

Gres tile th. 1cm, dim. 60x60 cm, on a core of sound absorbing panel, made of a mixture of calcium sulphate and organic phibers. Edge in anti squeak plastic material. NEWFLOOR G30ATK

Floating floor NEWFLOOR SNF.

Concrete screed, th. 4cm.

Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel, Mapei.

Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of EPS

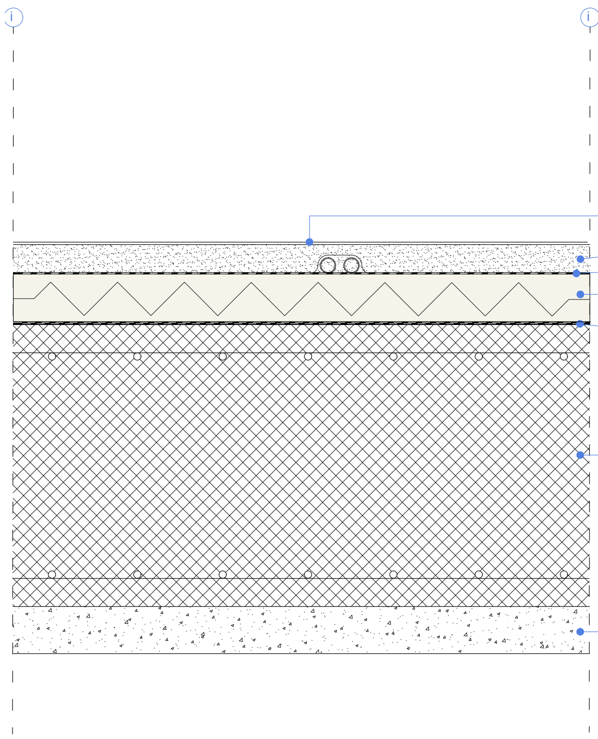
Adhesive in cement mortar, th. 1,5 cm

Expanded polyurethane insulation, th. 12 cm, dim. 1250x600 mm,λ=0,036 W/(m·K), XPS BT Isover

Aluminum cladding and coating in Laminam panels

Opaque Task - Ground Level Slab

Ground Floor without IGLU : th. 87.5 cm



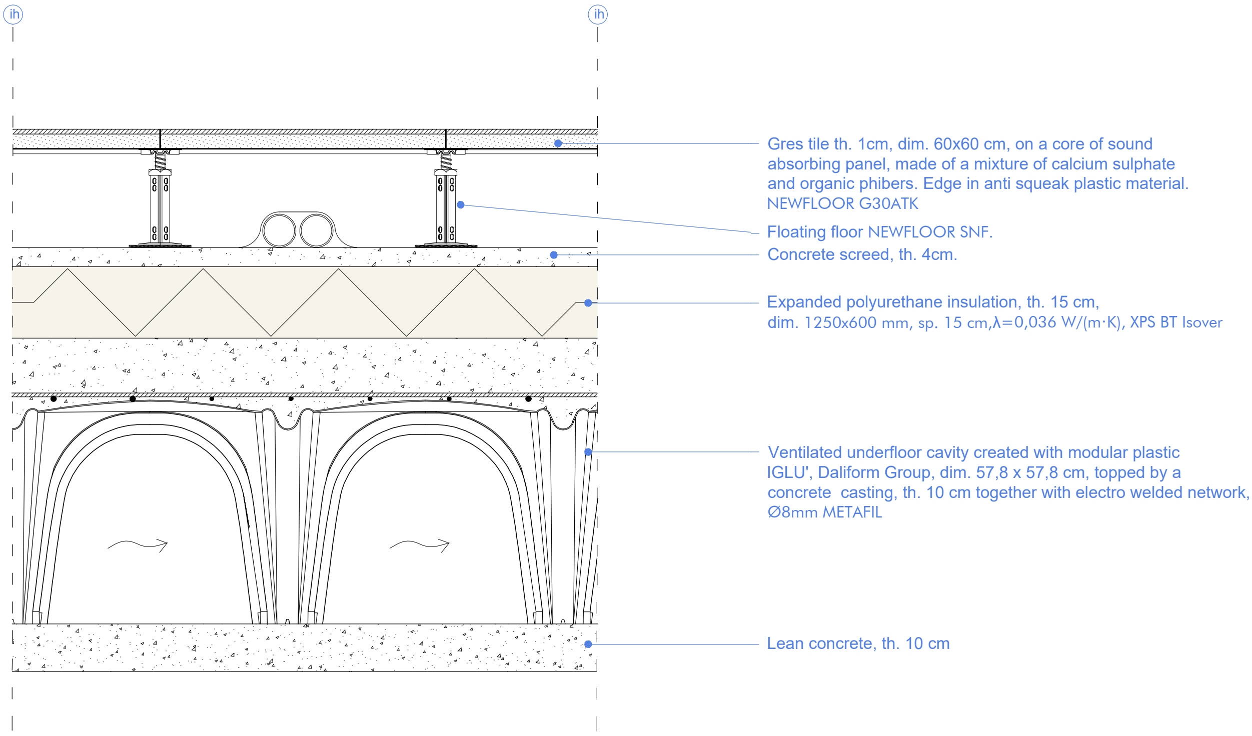
1. Finishing layer in MICROTOPPING, th. 0,5 cm
2. Regulation layer in sand cement, th. 6 cm
3. Synthetic vapor barrier, th. 0,22 cm, DS 46 PE Riwega.
4. Expanded polyurethane insulation, th. 10 cm, dim. 1250x600 mm, sp. 15 cm, λ=0,036 W/(m·K), XPS BT Isover
5. Waterproof membrane, th. 0,4 cm, INDEX Lighterflex HPCP Helasto
6. System Vasca Bianca Drytech, reinforced watertight concrete casting th. 60 cm, injected of expanding DRYflex resin, providing the overflow of radon gases
7. Lean concrete, th. 10 cm

Layer	Thickness (cm)	Thermal Conductivity (W/m.k)	Heat Resistance (m^2k/W)	Specific Heat (J/kgK)	Density (kg/m^3)
1	0.5	0.46	0.0108	1000	/
2	6	0.134	0.45	1000	600
3	0.22	0.4	0.006	1800	500
4	10	0.036	2.78	/	/
5	0.4	0.17	0.02	1000	1200
6	60	0.7	0.9	100	1800
7	10	0.7	0.1	100	1800

External Heat Resistance	0.04
Internal Heat Resistance	0.17
R Total	4.492
U-Value (W/m^2k)	**0.22**

Opaque Task - Ground Level Slab

Ground Floor with IGLU : th. 114 cm



1. Gres tile th. 1cm, dim. 60x60 cm, on a core of sound absorbing panel, made of a mixture of calcium sul- phate and organic phibers. Edge in anti squeak plastic material. NEWFLOOR G30ATK. With total th. 3 cm
2. Floating floor NEWFLOOR SNF.
3. Concrete screed, th. 4cm.
4. Expanded polyurethane insulation, th. 15 cm, dim. 1250x600 mm, sp. 15 cm, λ=0,036 W/(m·K), XPS BT Isover
5. Ventilated underfloor cavity created with modular plastic IGLU', Daliform Group, dim. 57,8 x 57,8 cm, top- ped by a concrete casting, th. 10 cm together with electro welded net- work, , Ø8mm METAFIL
6. Lean concrete, th. 10 cm

Layer	Thickness (cm)	Thermal Conductivity (W/m.k)	Heat Resistance (m^2k/W)	Specific Heat (J/kgK)	Density (kg/m^3)
1	3	0.11	0.26	/	1.100
2	/	/	/	/	/
3	4	0.134	0.3	1000	600
4	15	0.036	4.17	/	/
5	10	0.7	0.1	100	1800
6	10	0.7	0.1	100	1800

External Heat Resistance	0.04
Internal Heat Resistance	0.17
R Total	5.221
U-Value (W/m^2k)	**0.19**

Solar Panels

You have a total of 74 square meters of space available for installing solar panels. This space is divided into two categories :

Roof-Mounted Panels (48 sqm): 48 square meters of your available space are dedicated to roof-mounted solar panels. Roof-mounted panels are a popular choice for solar installations, as they utilize the existing structure and optimize sun exposure.

Building-Integrated Panels (26 sqm): The remaining 26 square meters are allocated for building-integrated solar panels (BIPV). BIPV technology integrates solar panels directly into building materials, such as windows, facades, or other architectural elements. This approach seamlessly blends solar energy generation with the aesthetics of the building.

The allocated area has a peak power capacity of 10 kWp (kilowatts peak). This measurement represents the maximum power output the solar panels can generate under ideal conditions, which typically means peak sunlight.
Also they can automatically change the angle to get the maximum benefit from the sun in different hours and seasons of the year.

PVGIS-5 estimates of solar electricity generation:

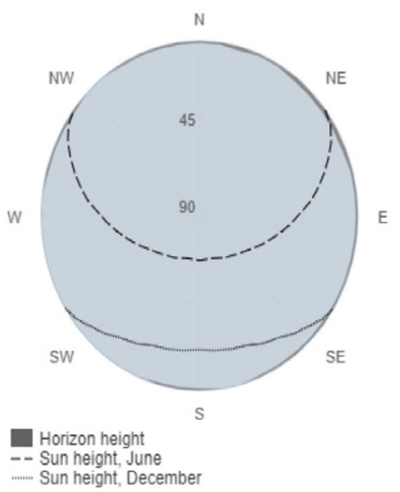
Provided inputs:

Latitude/Longitude:	45.509,9.224
Horizon:	Calculated
Database used:	PVGIS-SARAH2
PV technology:	Crystalline silicon
PV installed:	10 kWp
System loss:	14 %

Simulation outputs

Slope angle:	39 (opt) °
Azimuth angle:	0 °
Yearly PV energy production:	12908.41 kWh
Yearly in-plane irradiation:	1740.81 kWh/m²
Year-to-year variability:	636.89 kWh
Changes in output due to:	
Angle of incidence:	-2.64 %
Spectral effects:	1.17 %
Temperature and low irradiance:	-12.46 %
Total loss:	-25.85 %

Outline of horizon at chosen location :

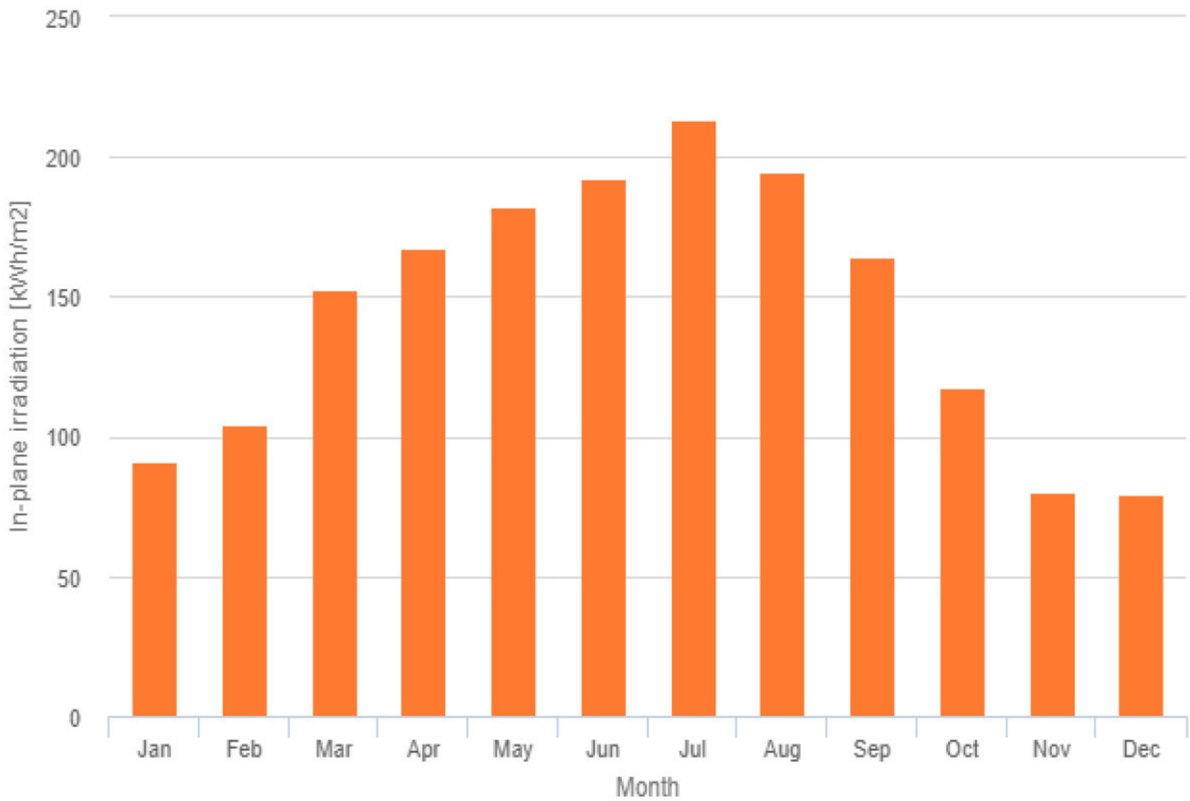


The tilt angle of the solar PV panels throughout the year to optimize the solar generation in Milan, Italy as follows:

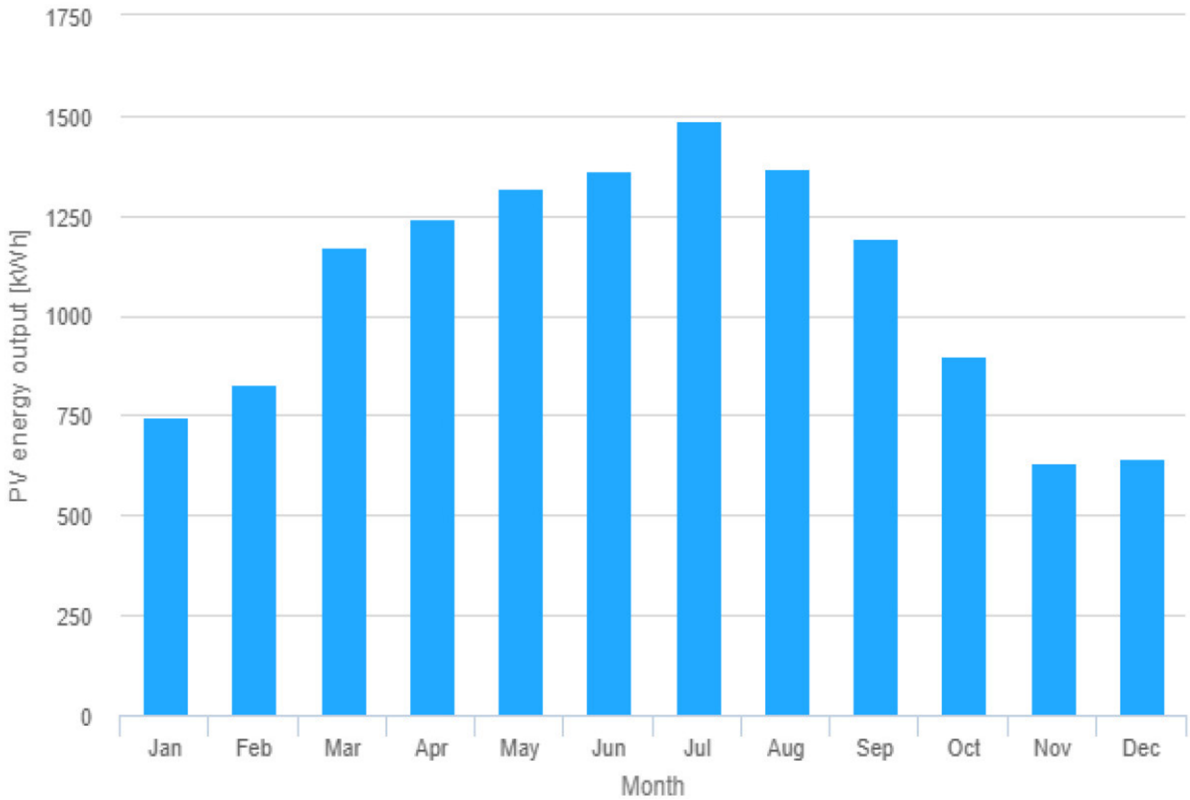
In Summer, set the angle of your panels to 29° facing South.
In Autumn, tilt panels to 49° facing South for maximum generation.
During Winter, adjustion of the solar panels to a 60° angle towards the South for optimal energy production.
Lastly, in Spring, the panels at a 38° angle facing South can capture the most solar energy in Milan, Italy.

Overall Best Summer Angle	Overall Best Autumn Angle	Overall Best Winter Angle	Overall Best Spring Angle
29° South in Summer	49° South in Autumn	60° South in Winter	38° South in Spring

Monthly in-plane irridiation for fixed-angle :



Monthly energy output from fixed-angle PV system :



61	22	25	74%	233
Site EUI	Op. Carbon	Energy Cost	Saved	Baseline EUI
kWh/m²	kgCO²/m²	$/m²	Vs. Baseline	kWh/m²

Average Hours out of Comfort Zone : 619

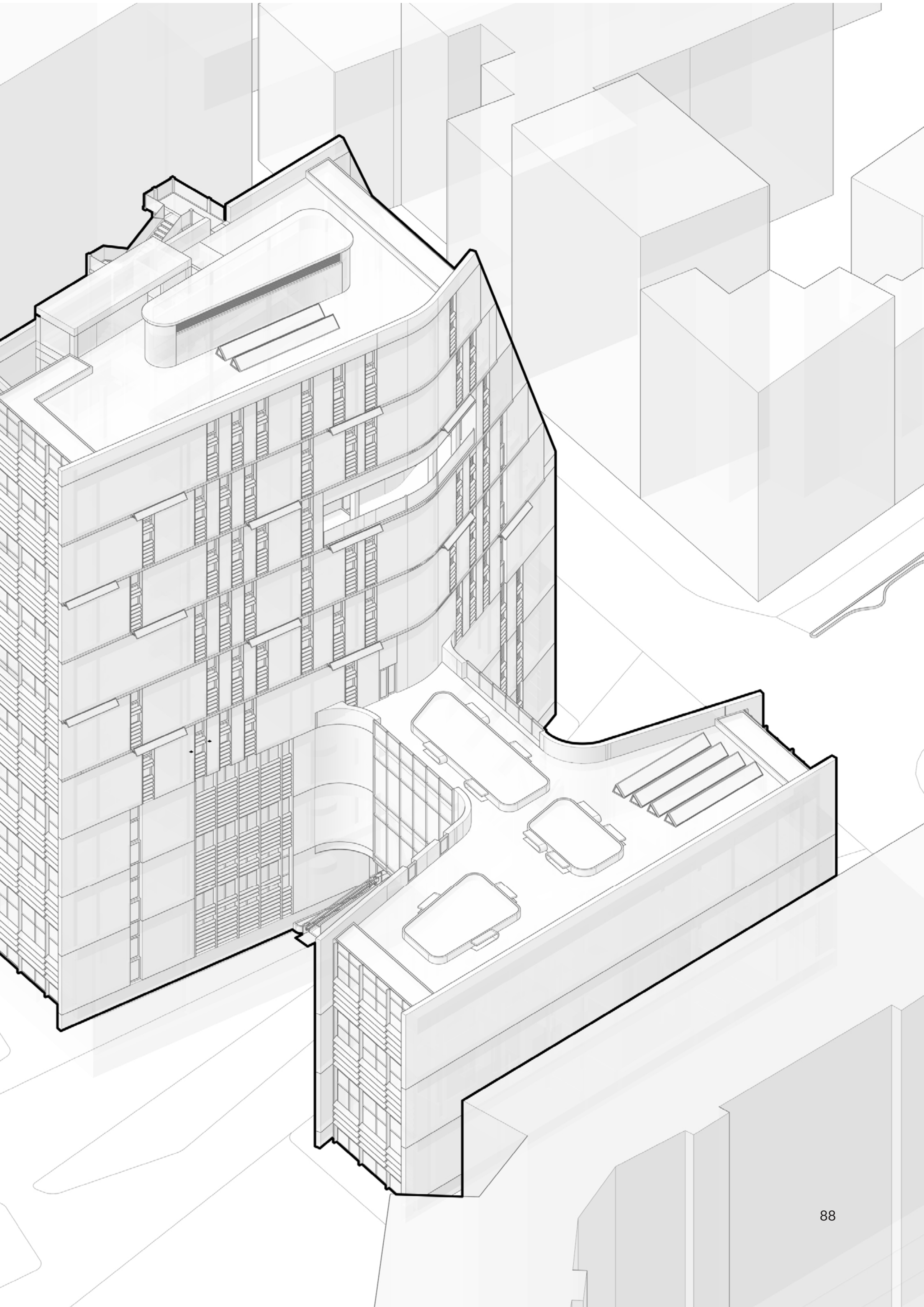
S/V Ratio : 0.268
HLFF : 1.193

In the pursuit of creating an energy-efficient and environmentally conscious building design, careful consideration of solar orientation and shading strategies has been paramount. This chapter elucidates the shading strategy implemented in our building model, which aligns with the overarching goal of optimizing energy efficiency and enhancing occupant comfort.

The primary objective of our shading strategy is to enhance energy efficiency within the building. By limiting solar heat gain, we reduce the dependency on artificial cooling systems during hot seasons and ensure a more stable indoor temperature throughout the year. Moreover, this strategy contributes to a reduction in energy consumption and, subsequently, a decrease in the building's environmental footprint.

East and west-facing openings receive direct sunlight at different times, presenting unique challenges. To address these challenges, we have opted for wider shading devices, measuring 40 cm in width. This broader shading not only minimizes heat gain but also reduces the risk of discomfort caused by glare during sunrise and sunset hours.

South-facing windows are exposed to direct sunlight for a substantial portion of the day. To mitigate excessive solar heat gain and glare, we have installed shading devices with a width of 20 cm. This choice allows for effective heat control while maintaining ample natural daylighting.



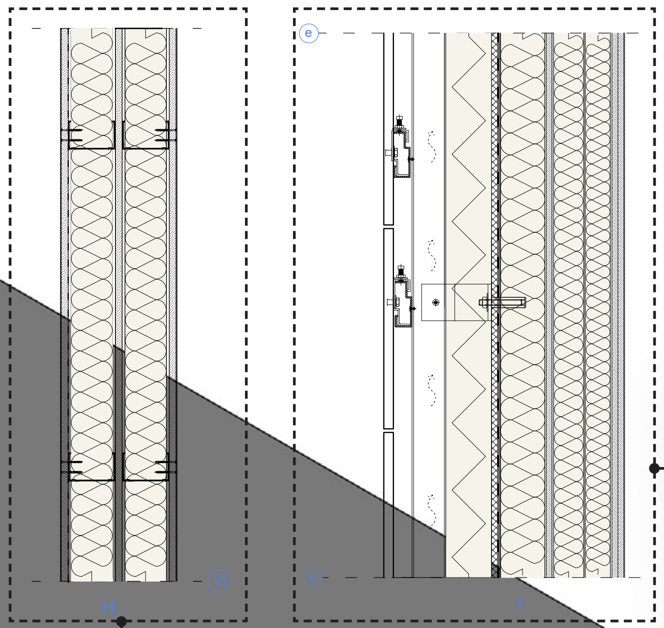
5

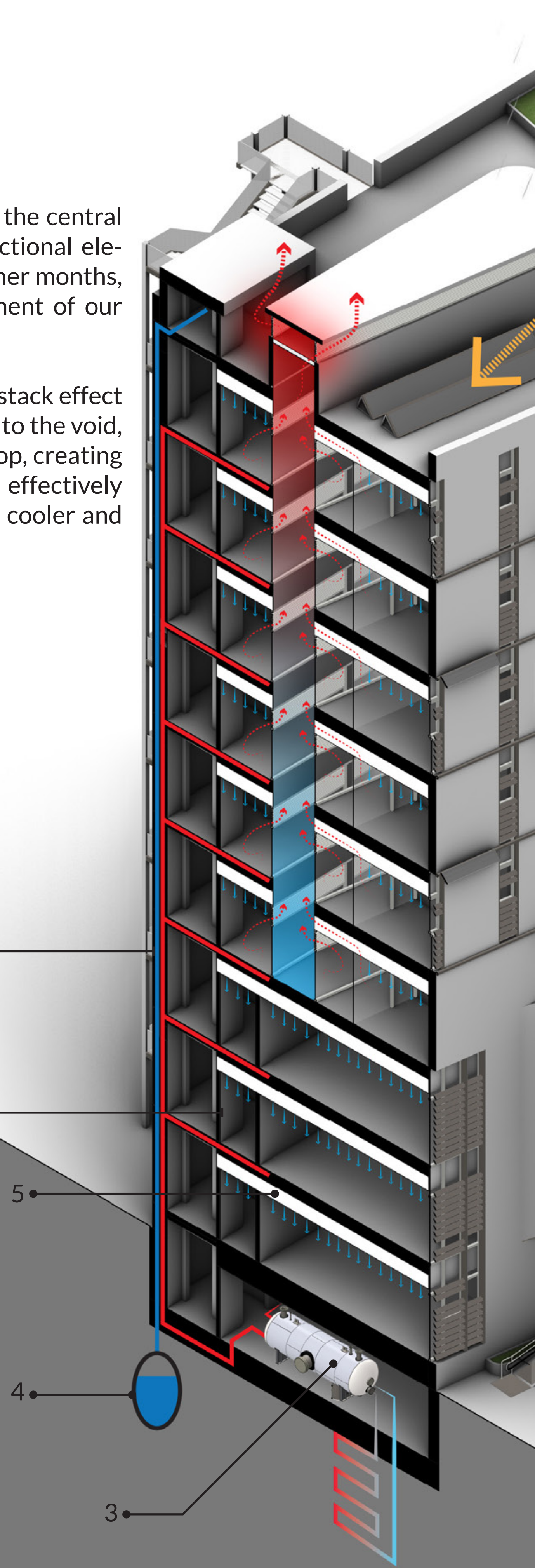
PASSIVE/Active DESIGN STRATEGIES

Summer

One of the defining features of our building design is the central void, strategically positioned to serve as a multi-functional element throughout the year. During the scorching summer months, this central void transforms into an integral component of our passive cooling strategy.

When the sun beats down on the building, it creates a stack effect within the central void. As warm air rises, it is drawn into the void, where it is channeled upward and expelled from the top, creating a continuous flow of air. This stack ventilation system effectively rids the building of accumulated warm air, ensuring a cooler and more comfortable indoor environment.

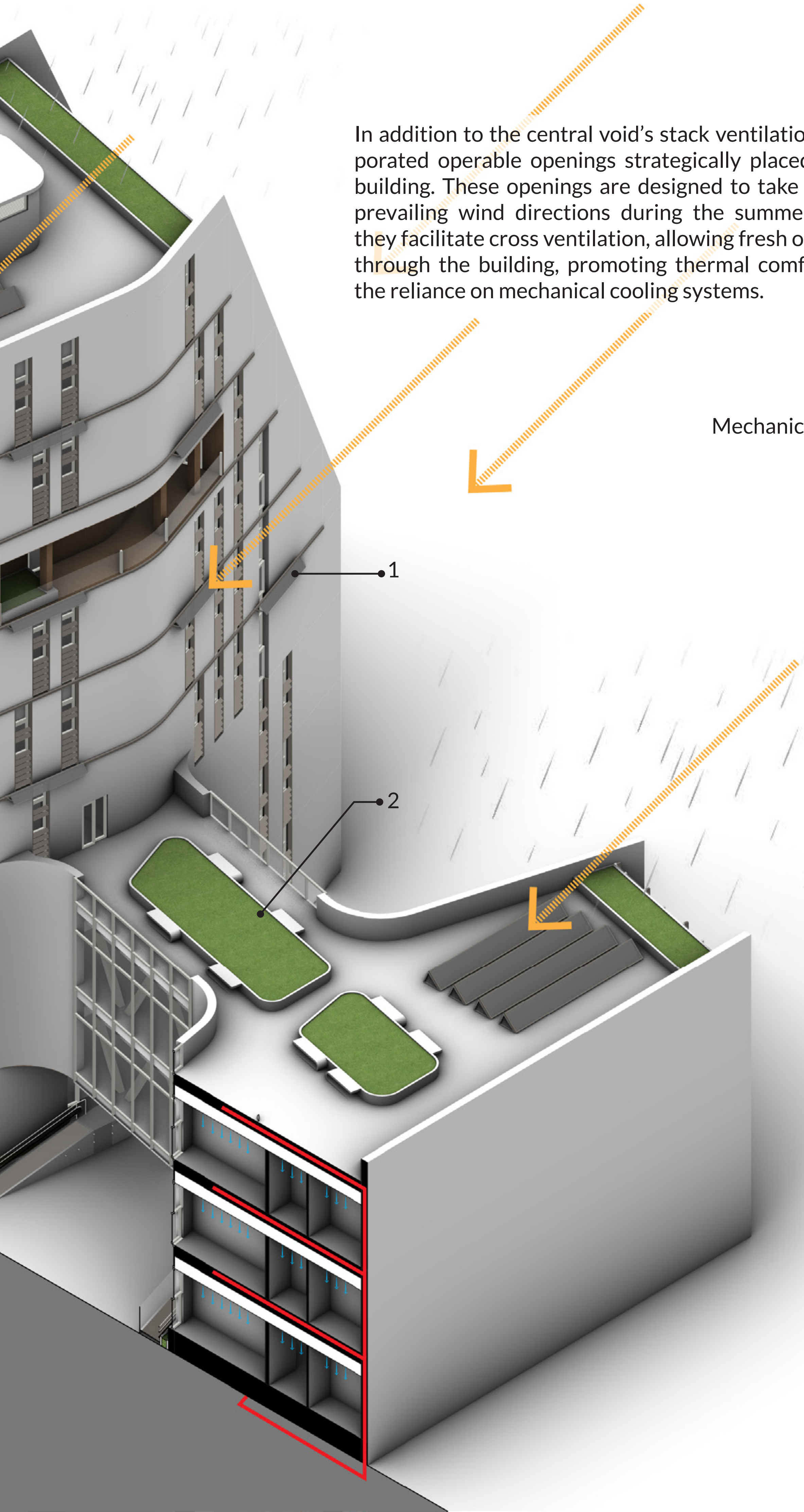




1. PV panels
2. Green terraces act as insulation
3. Underground heat exchanger
4. Rainwater harvesting
5. Chilled beams cooling

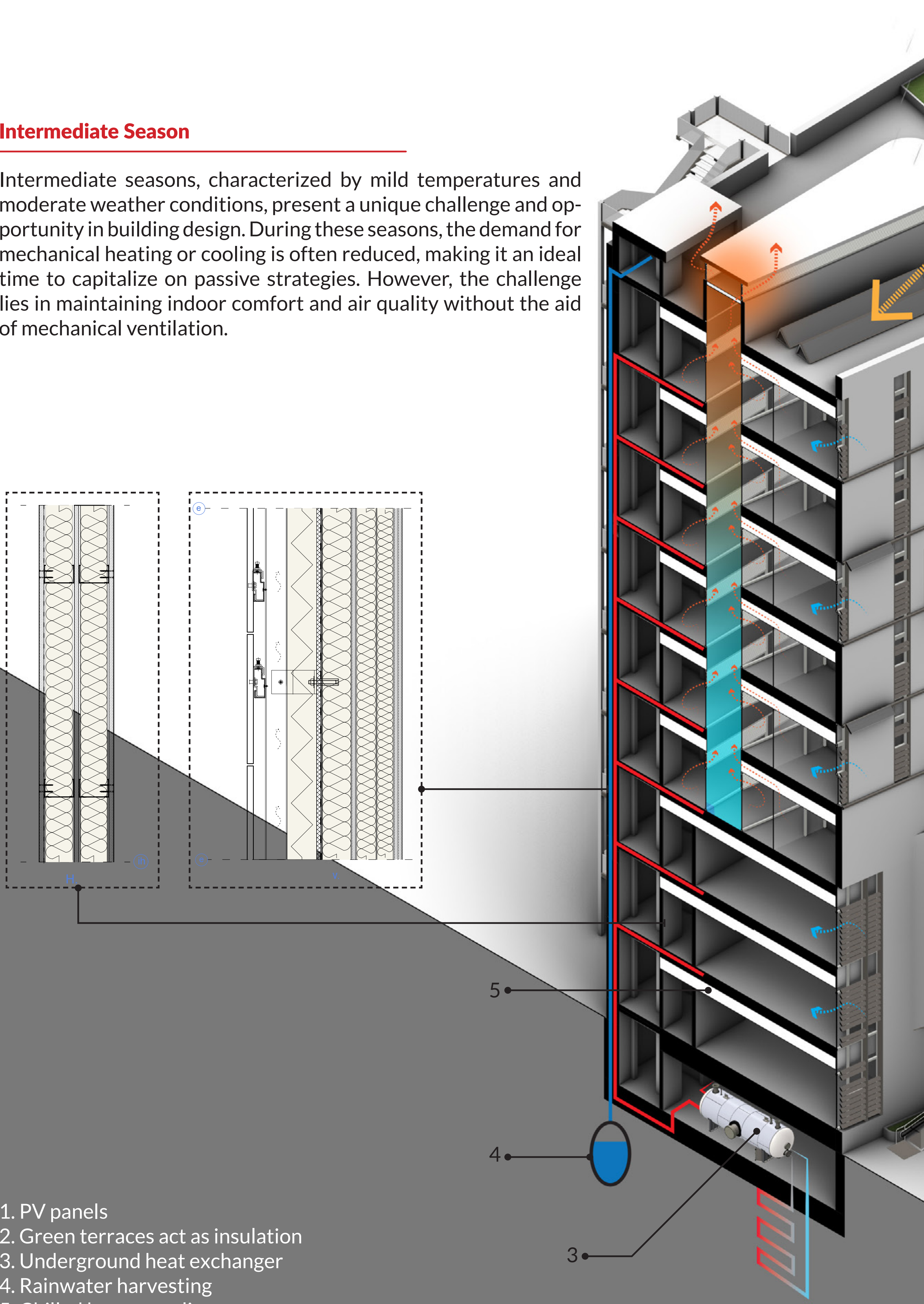
In addition to the central void's stack ventilation, we have incorporated operable openings strategically placed throughout the building. These openings are designed to take full advantage of prevailing wind directions during the summer. When opened, they facilitate cross ventilation, allowing fresh outdoor air to flow through the building, promoting thermal comfort and reducing the reliance on mechanical cooling systems.

Mechanical Ventilation **ON**



Intermediate Season

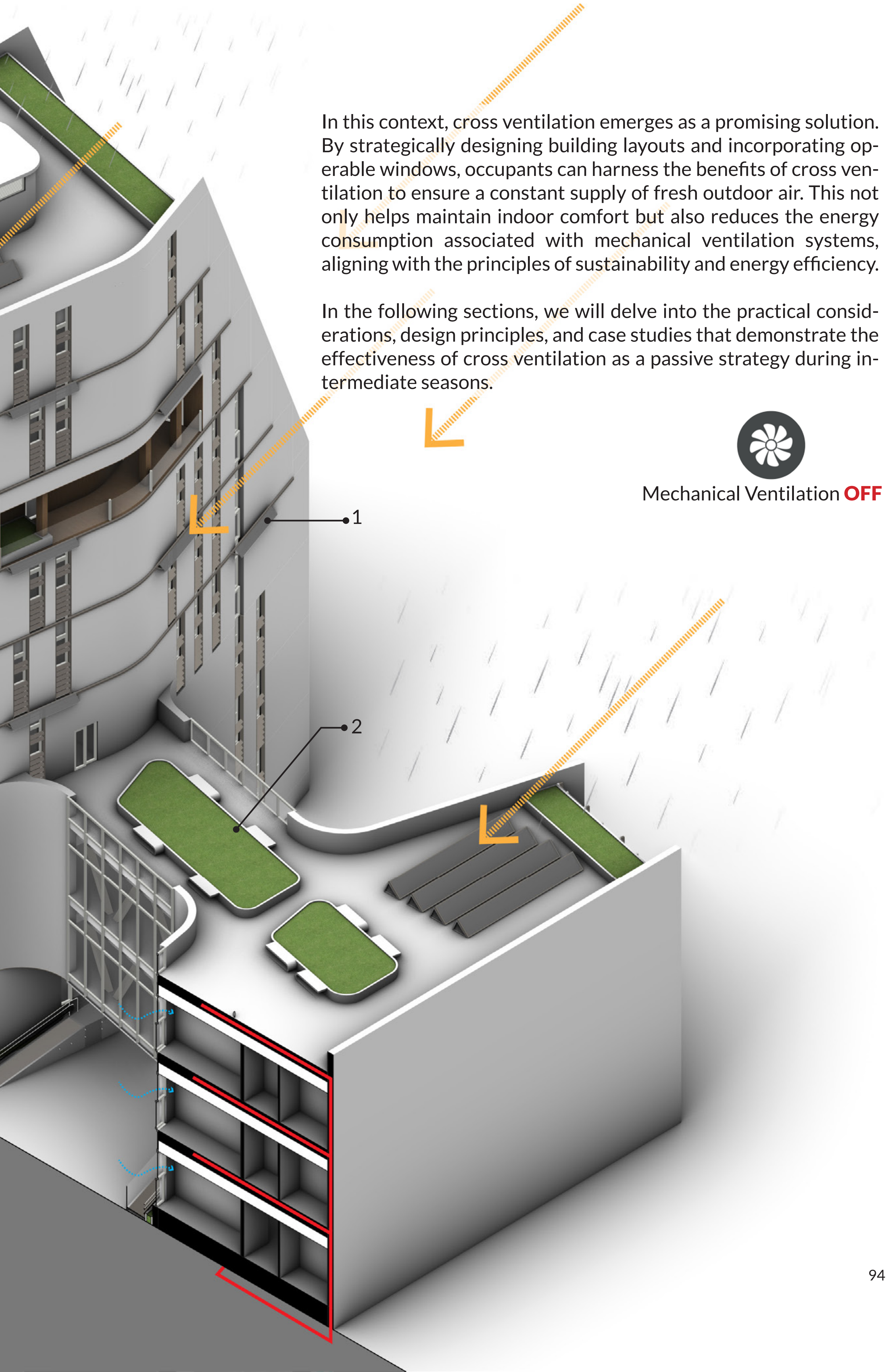
Intermediate seasons, characterized by mild temperatures and moderate weather conditions, present a unique challenge and opportunity in building design. During these seasons, the demand for mechanical heating or cooling is often reduced, making it an ideal time to capitalize on passive strategies. However, the challenge lies in maintaining indoor comfort and air quality without the aid of mechanical ventilation.



1. PV panels
2. Green terraces act as insulation
3. Underground heat exchanger
4. Rainwater harvesting
5. Chilled beams cooling

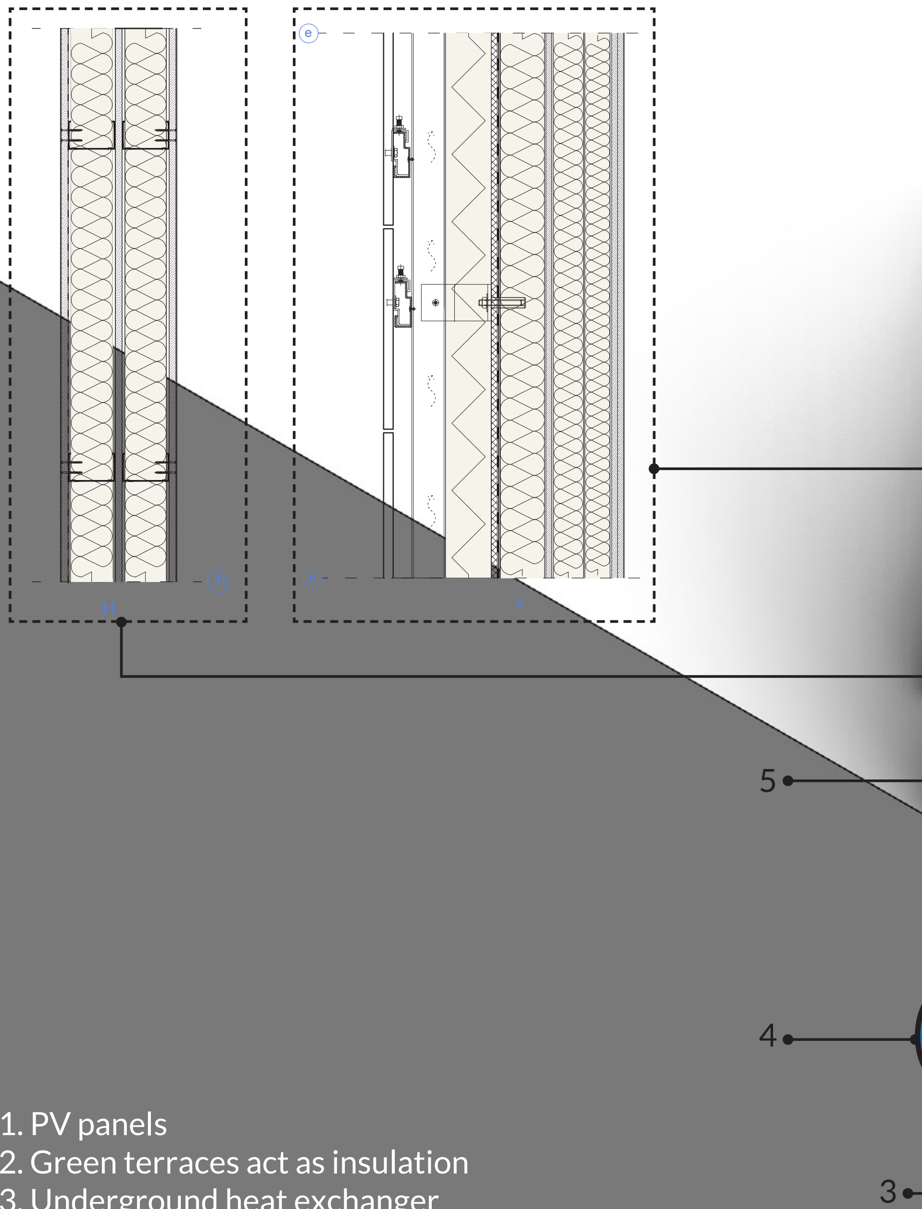
In this context, cross ventilation emerges as a promising solution. By strategically designing building layouts and incorporating operable windows, occupants can harness the benefits of cross ventilation to ensure a constant supply of fresh outdoor air. This not only helps maintain indoor comfort but also reduces the energy consumption associated with mechanical ventilation systems, aligning with the principles of sustainability and energy efficiency.

In the following sections, we will delve into the practical considerations, design principles, and case studies that demonstrate the effectiveness of cross ventilation as a passive strategy during intermediate seasons.



Winter

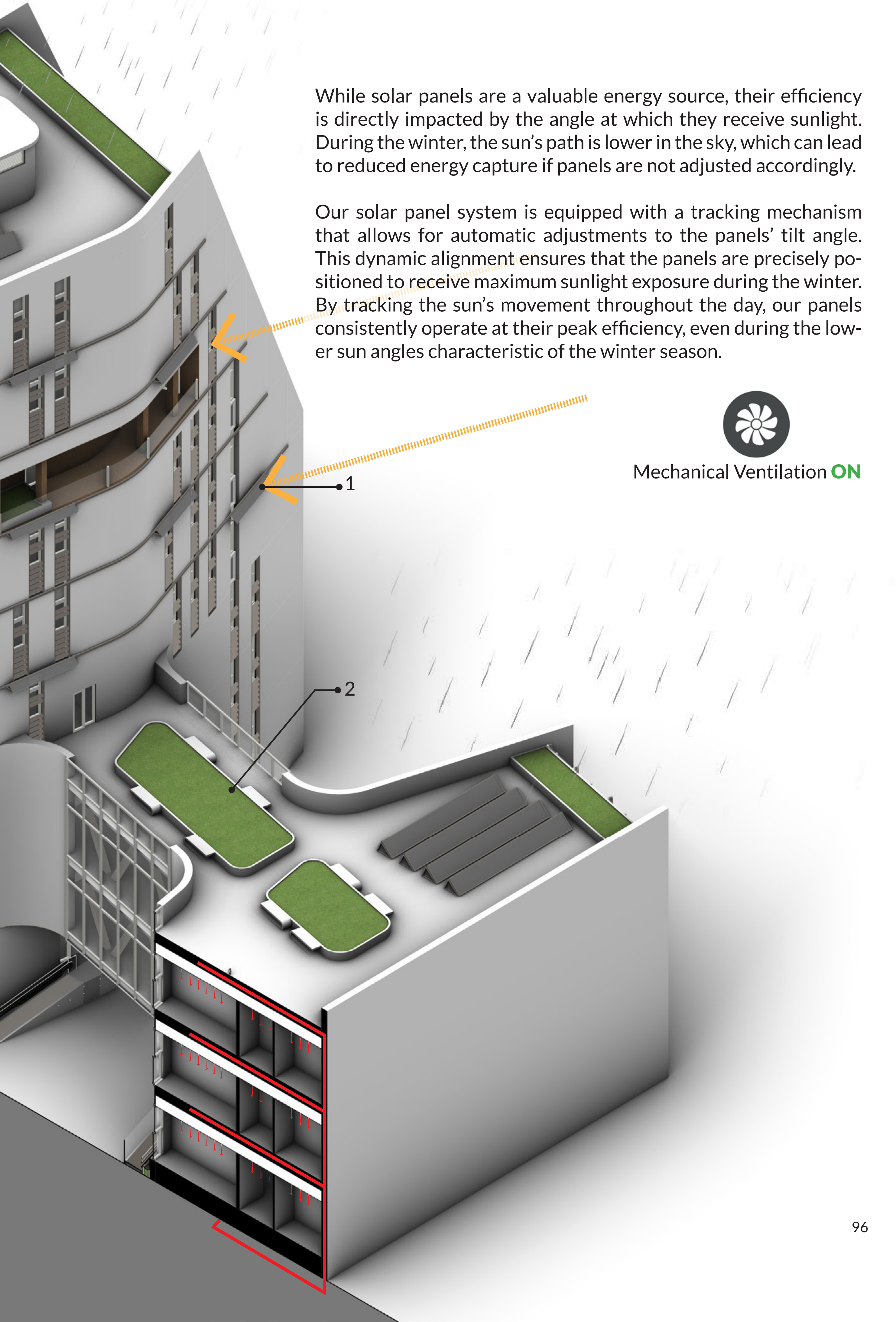
As the winter season descends upon our building, we transform the central void into a thermal reservoir, capturing and storing warm air within this architectural feature. The central void, which is enclosed at the top, effectively traps and retains heat generated within the building. This strategic containment of warm air becomes a key component of our passive heating strategy.
The accumulation of warm air within the central void serves a dual purpose. Firstly, it reduces the building's reliance on conventional heating systems, significantly cutting down on energy consumption and associated costs. This alignment with passive heating principles contributes to our overarching goal of minimizing the building's environmental footprint.



1. PV panels
2. Green terraces act as insulation
3. Underground heat exchanger
4. Rainwater harvesting
5. Chilled beams heating

While solar panels are a valuable energy source, their efficiency is directly impacted by the angle at which they receive sunlight. During the winter, the sun's path is lower in the sky, which can lead to reduced energy capture if panels are not adjusted accordingly.

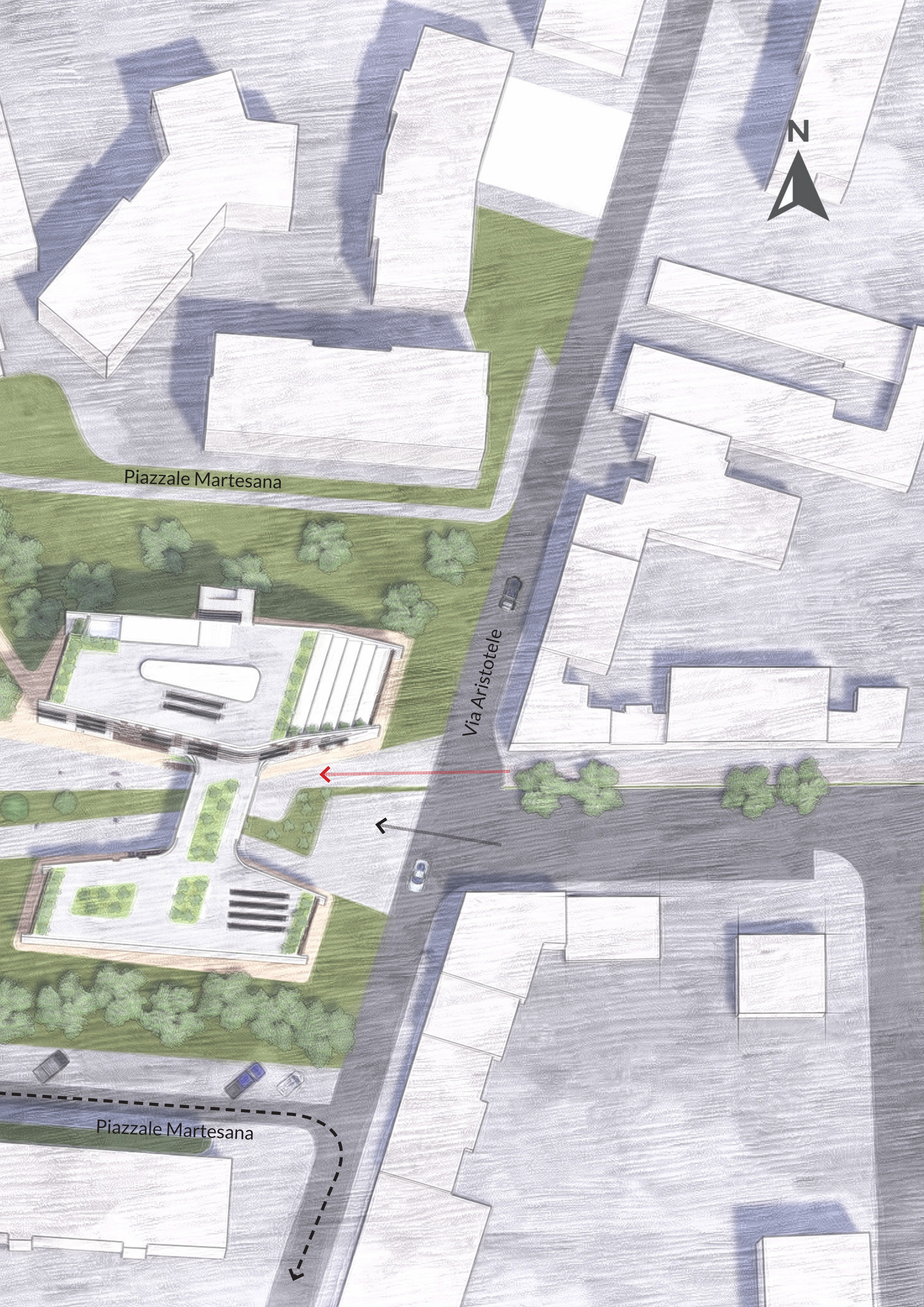
Our solar panel system is equipped with a tracking mechanism that allows for automatic adjustments to the panels' tilt angle. This dynamic alignment ensures that the panels are precisely positioned to receive maximum sunlight exposure during the winter. By tracking the sun's movement throughout the day, our panels consistently operate at their peak efficiency, even during the lower sun angles characteristic of the winter season.



6 ARCHITECTURE

Designing

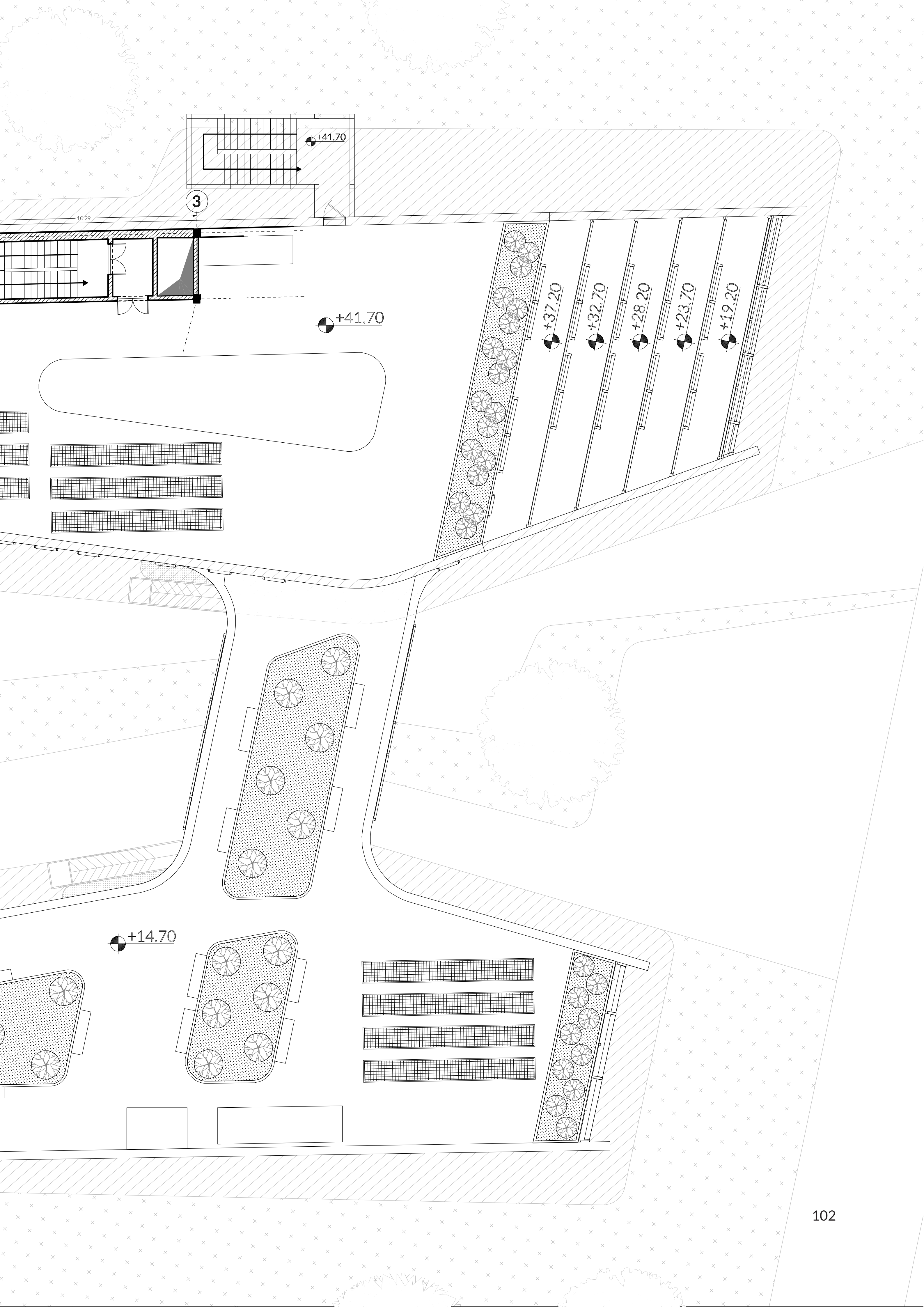
MasterPlan



N
Piazzale Martesana
Via Aristotele
Piazzale Martesana

Roof Top

Scale 1.200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+37.20
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+23.70
+19.20
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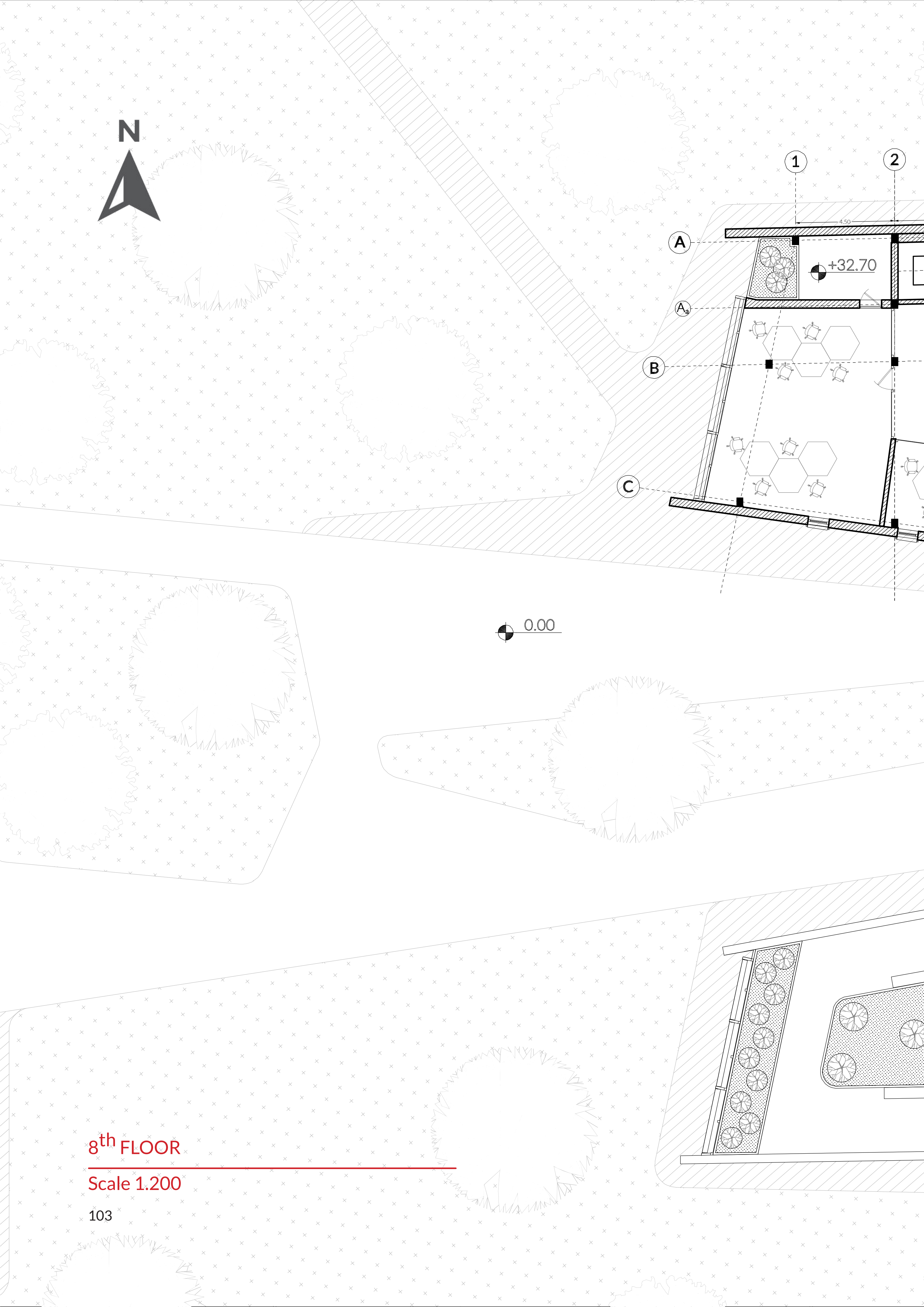
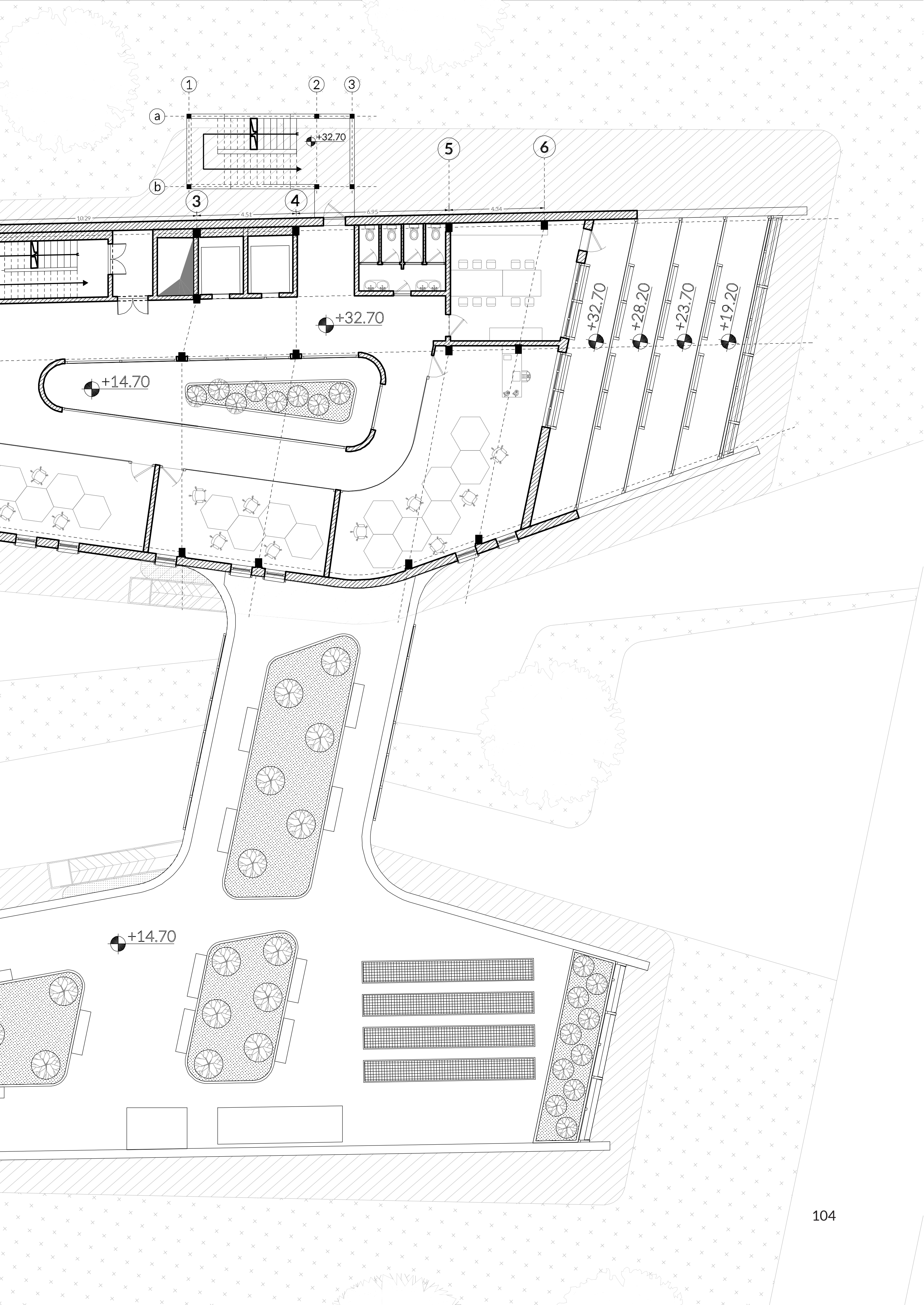


8th FLOOR

Scale 1.200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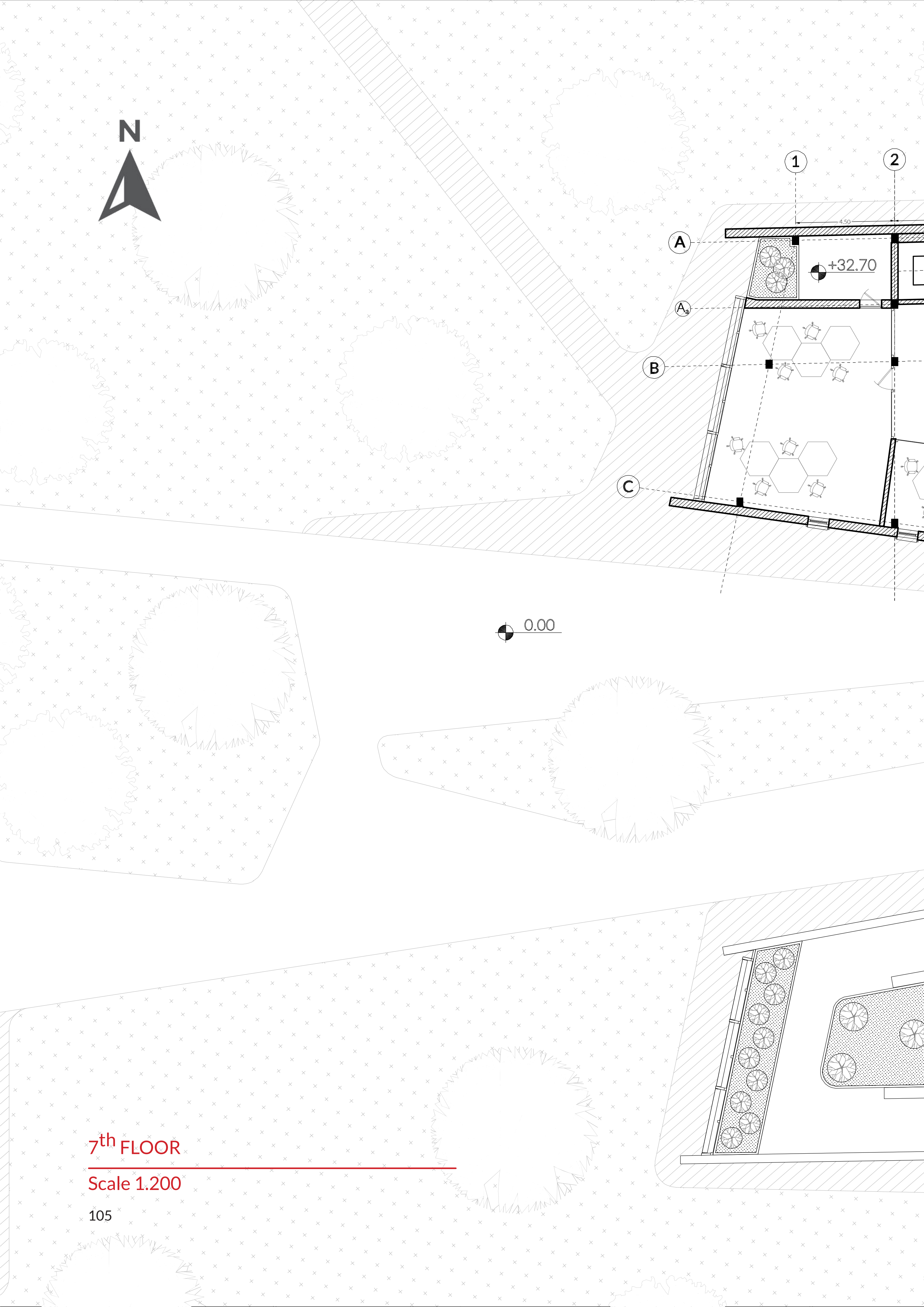
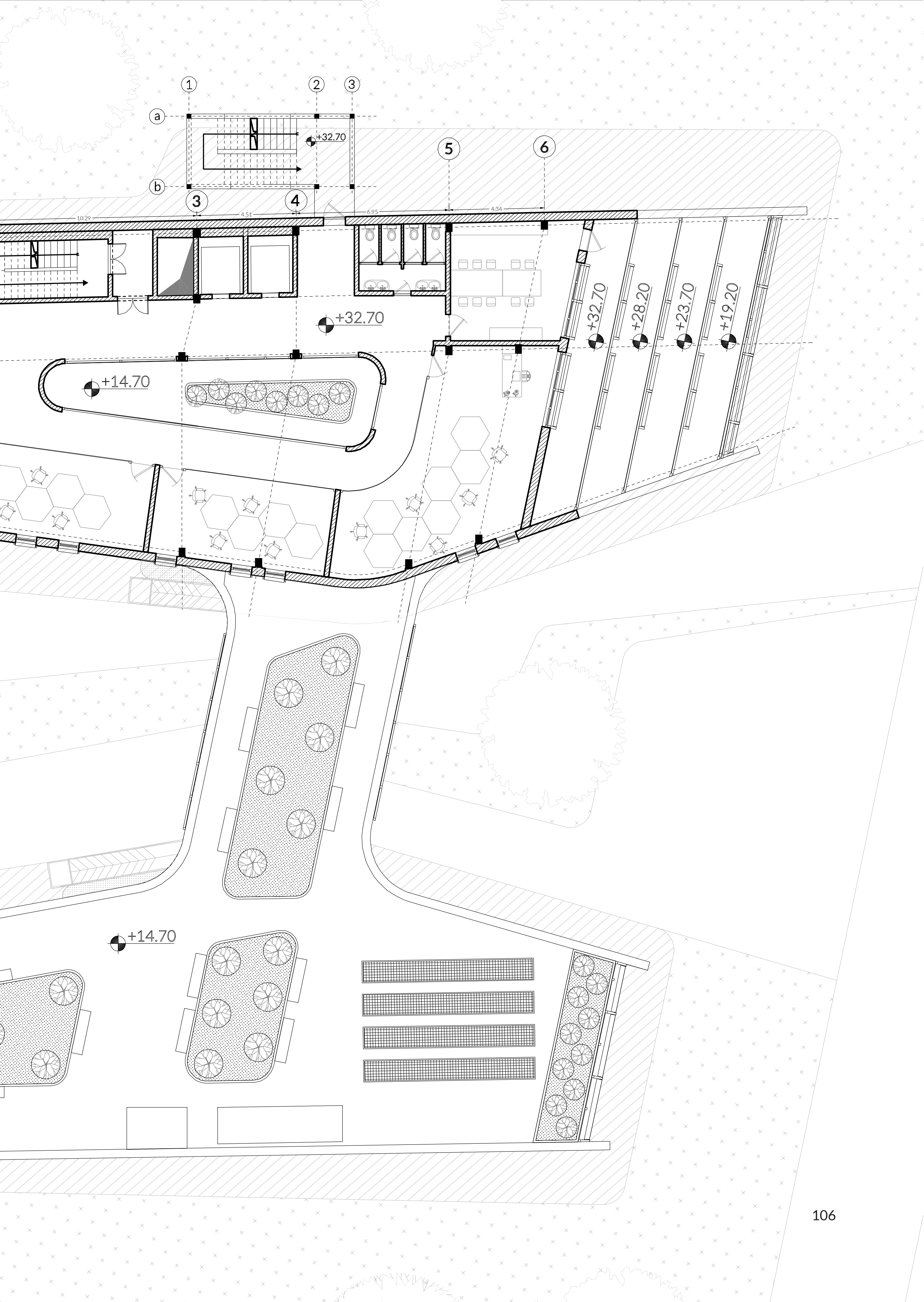


7th FLOOR

Scale 1.200



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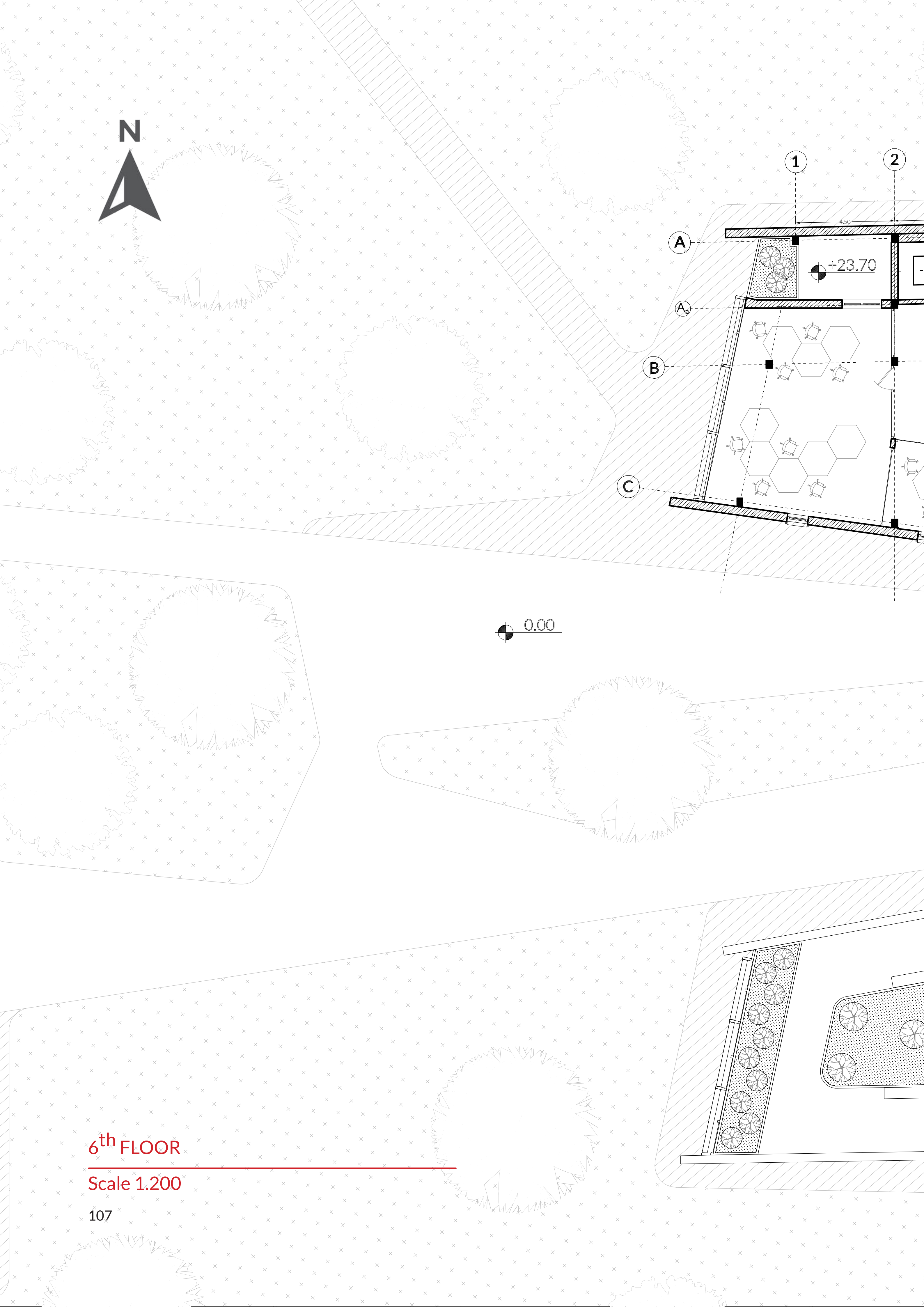
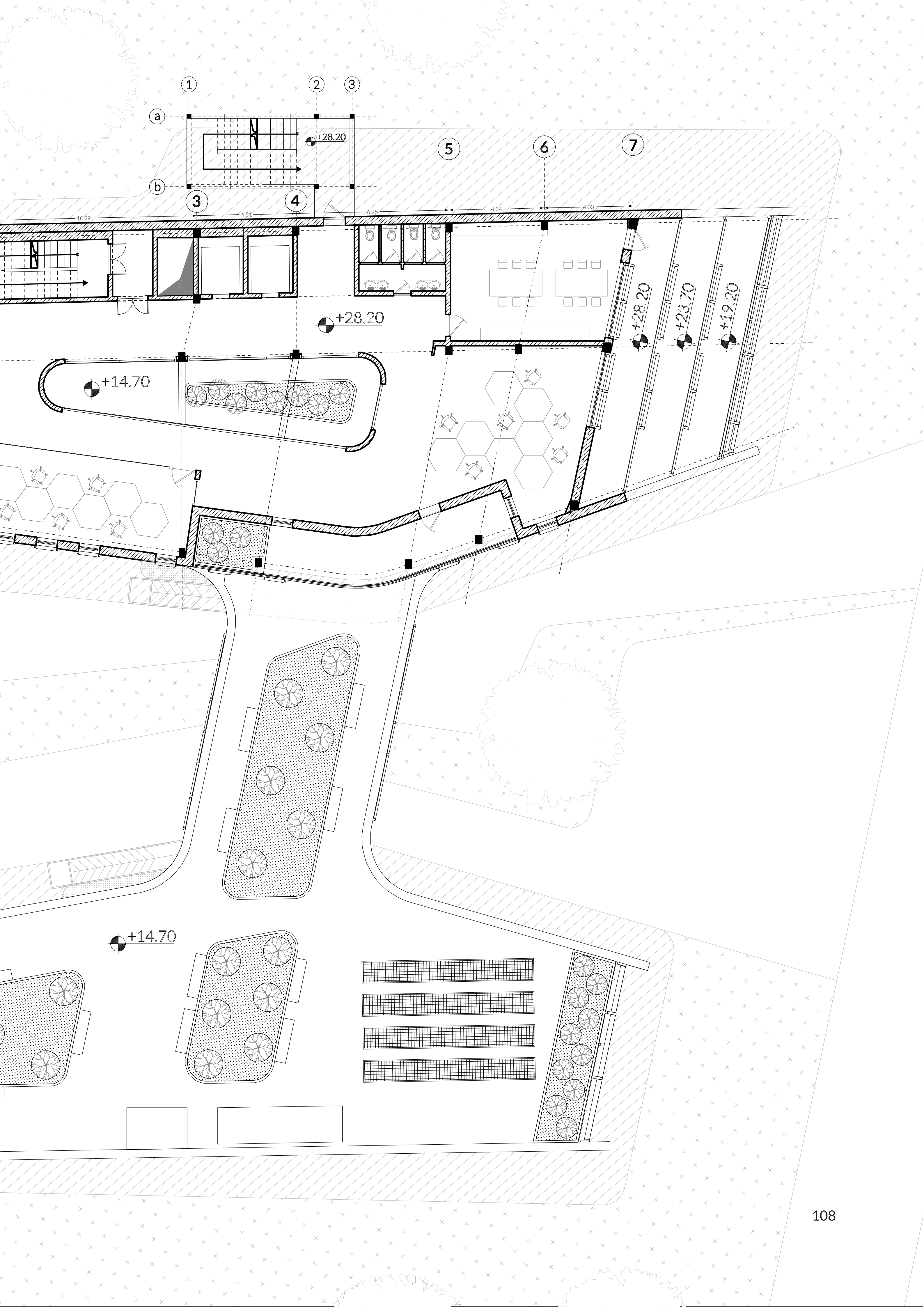


6th FLOOR

Scale 1.200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+14.70
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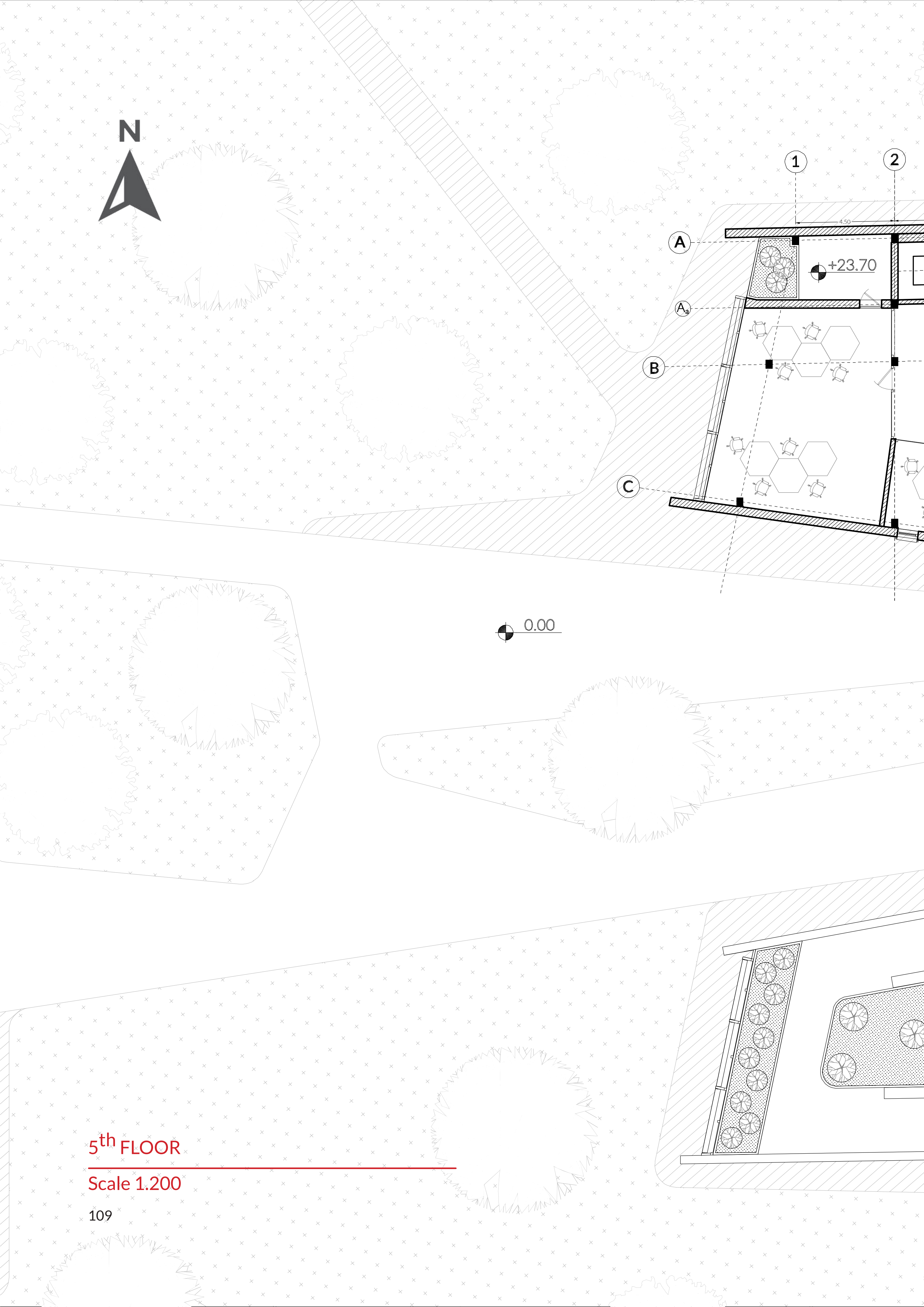
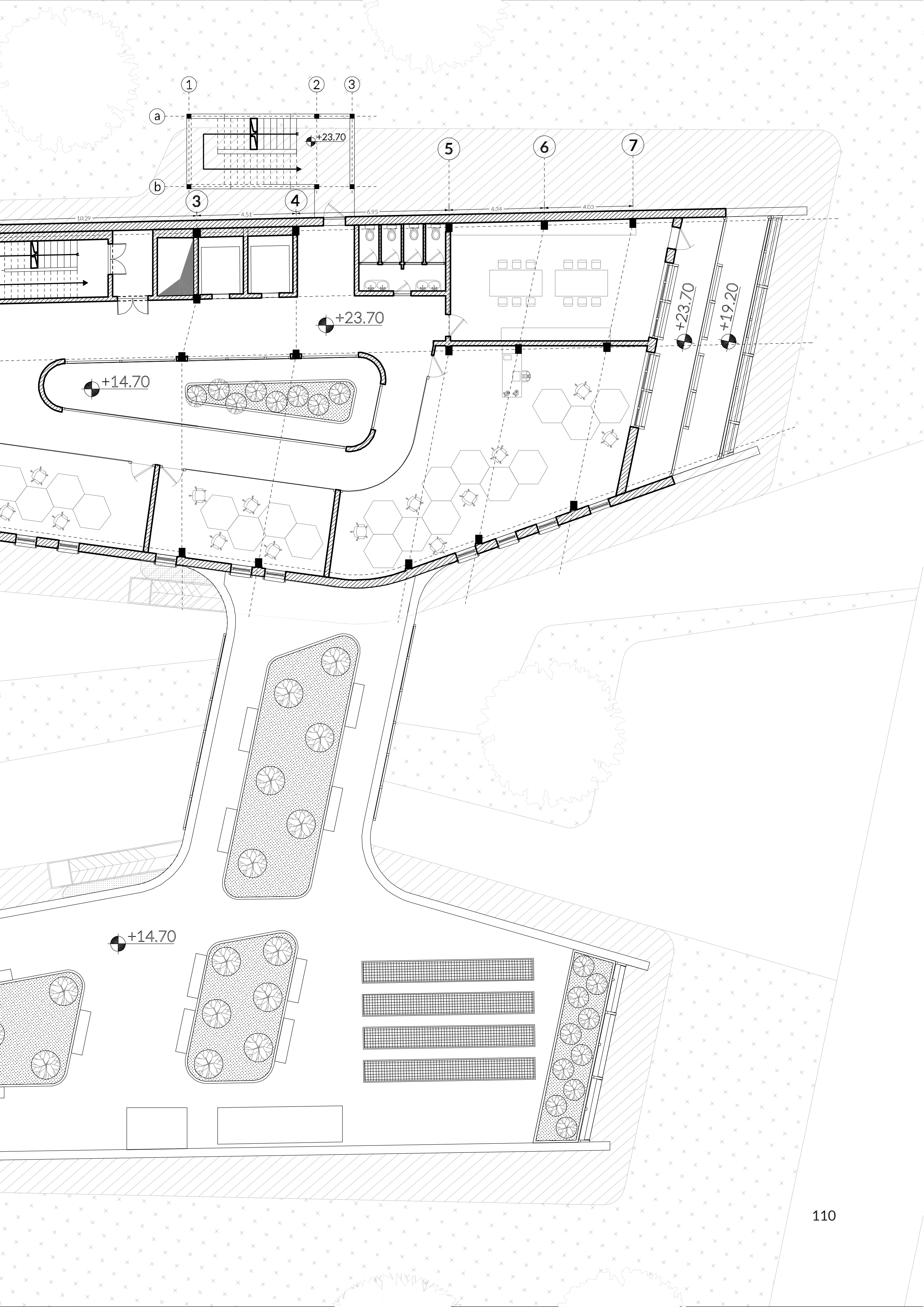


5th FLOOR

Scale 1.200



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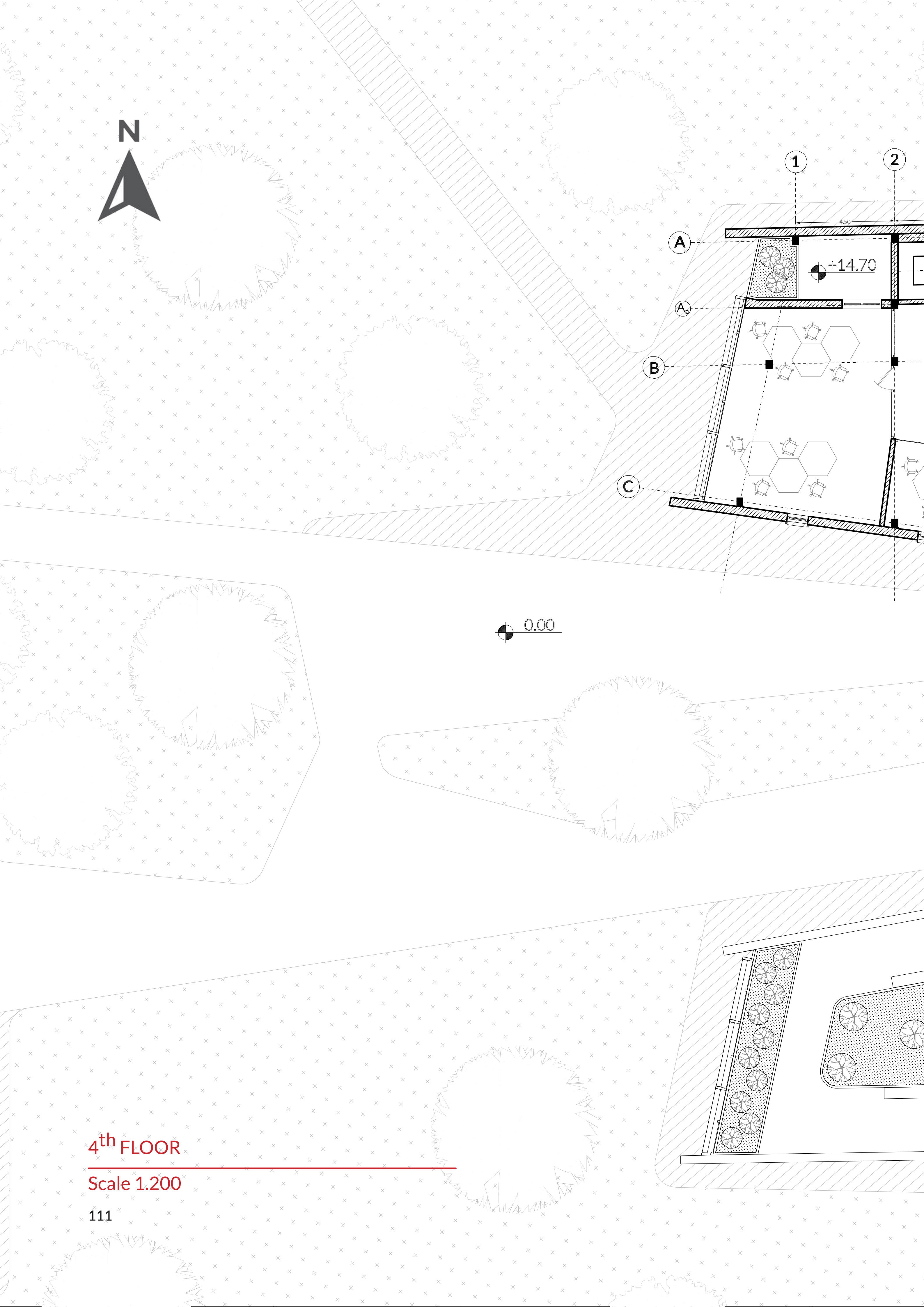
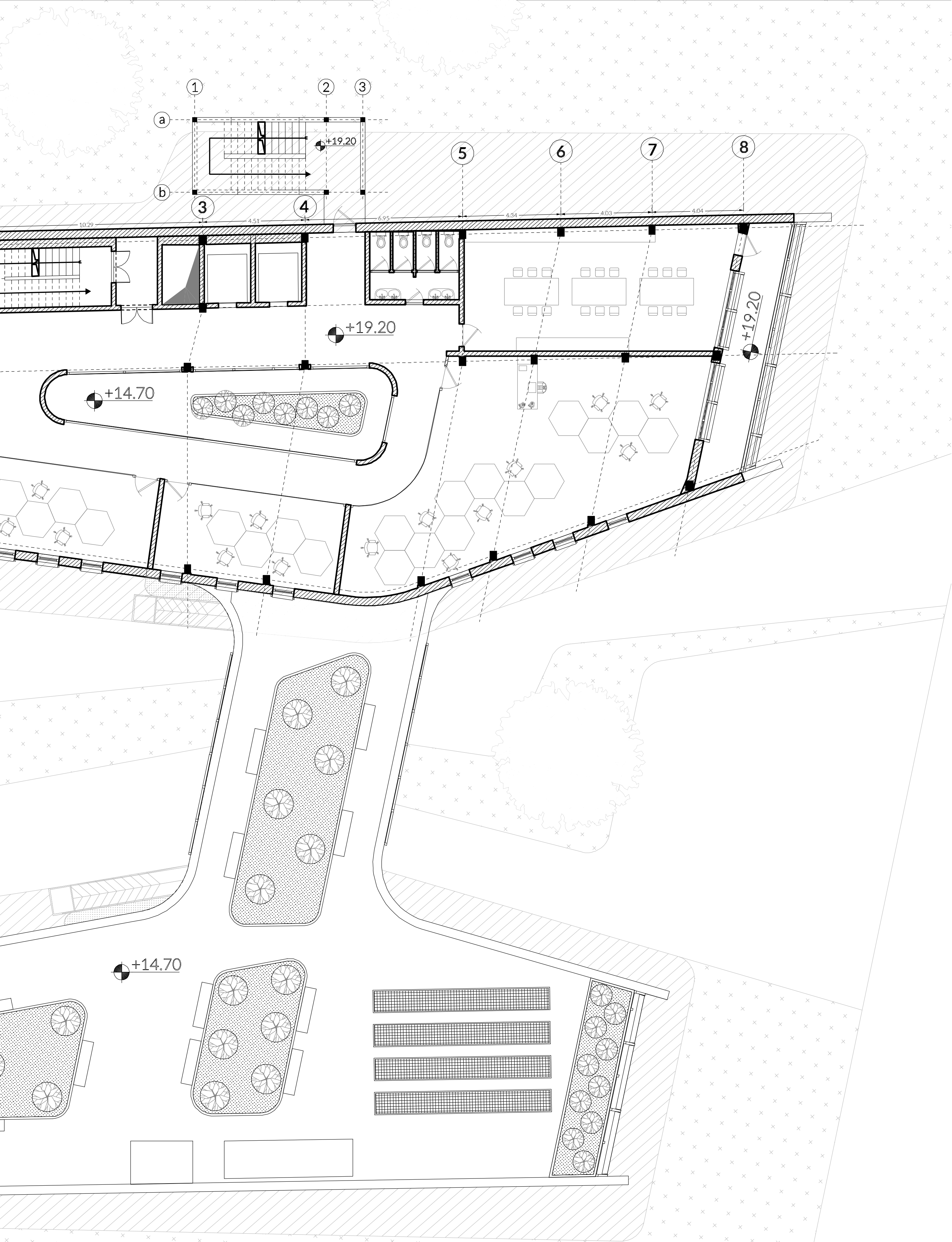
+23.70
+14.70
+23.70
+19.20
+14.70



4^{th} FLOOR

Scale 1.200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+19.20
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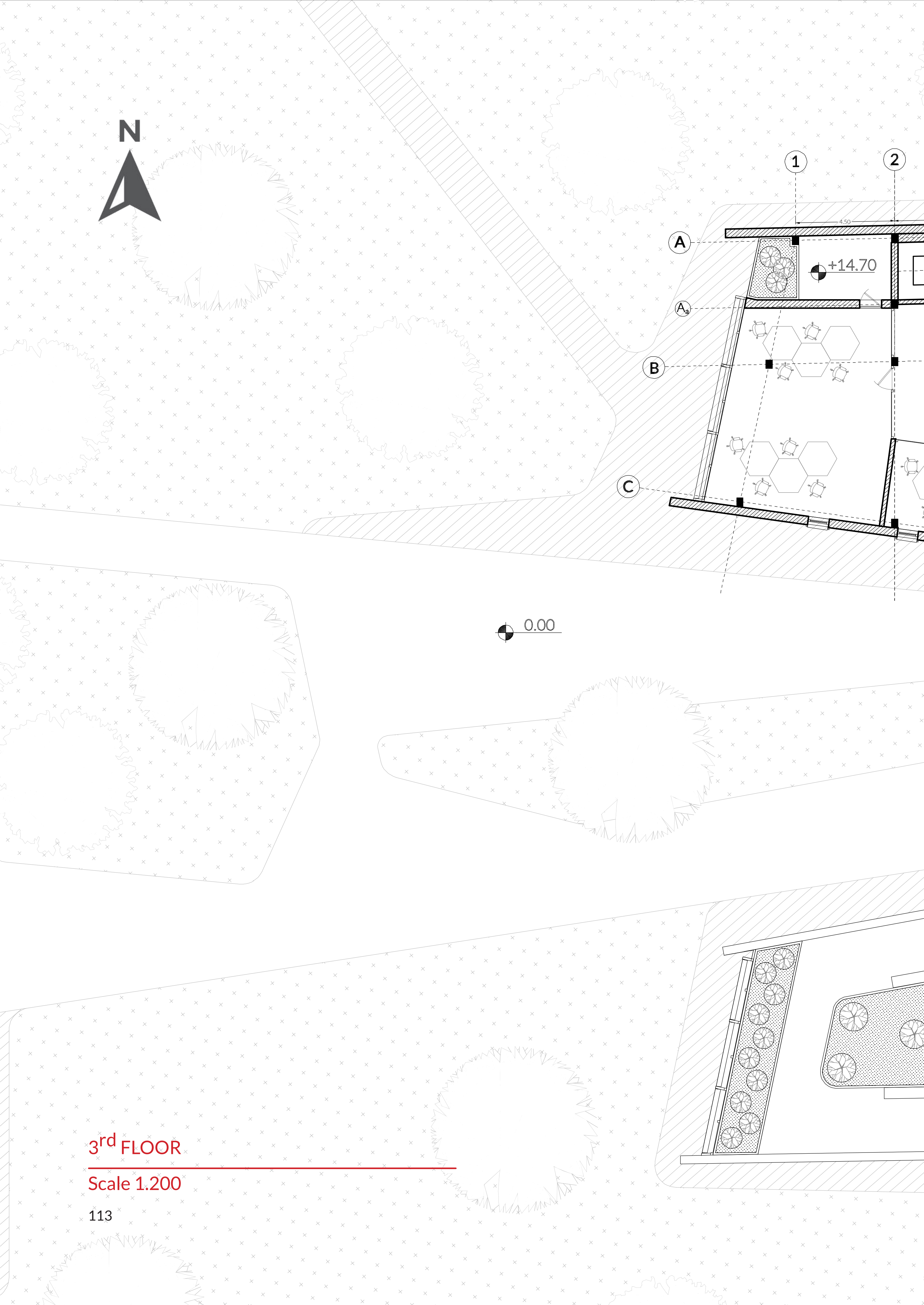
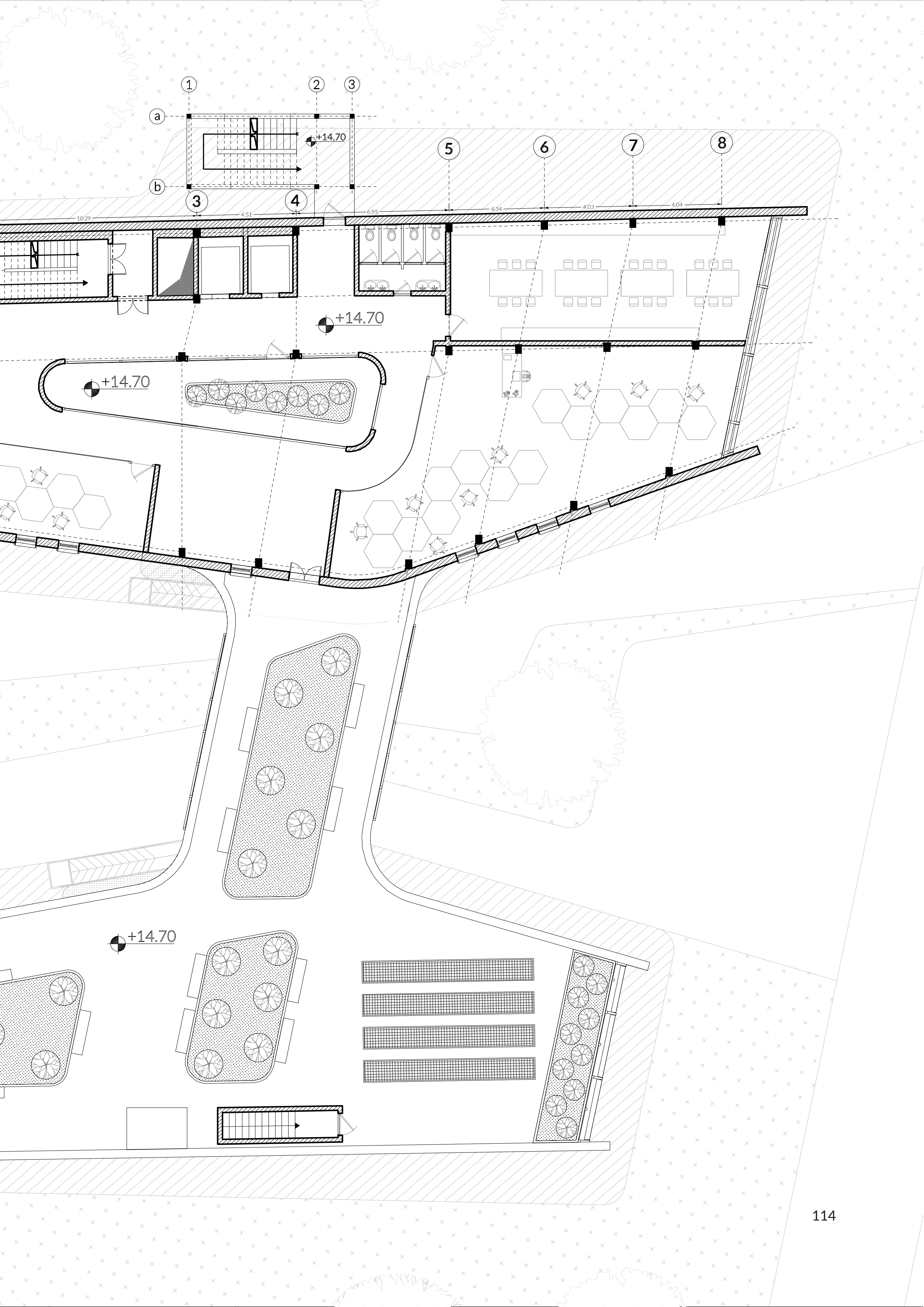
+19.20
+14.70



3rd FLOOR

Scale 1.200



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5
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7
8
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4
10.29
4.51
6.95
4.34
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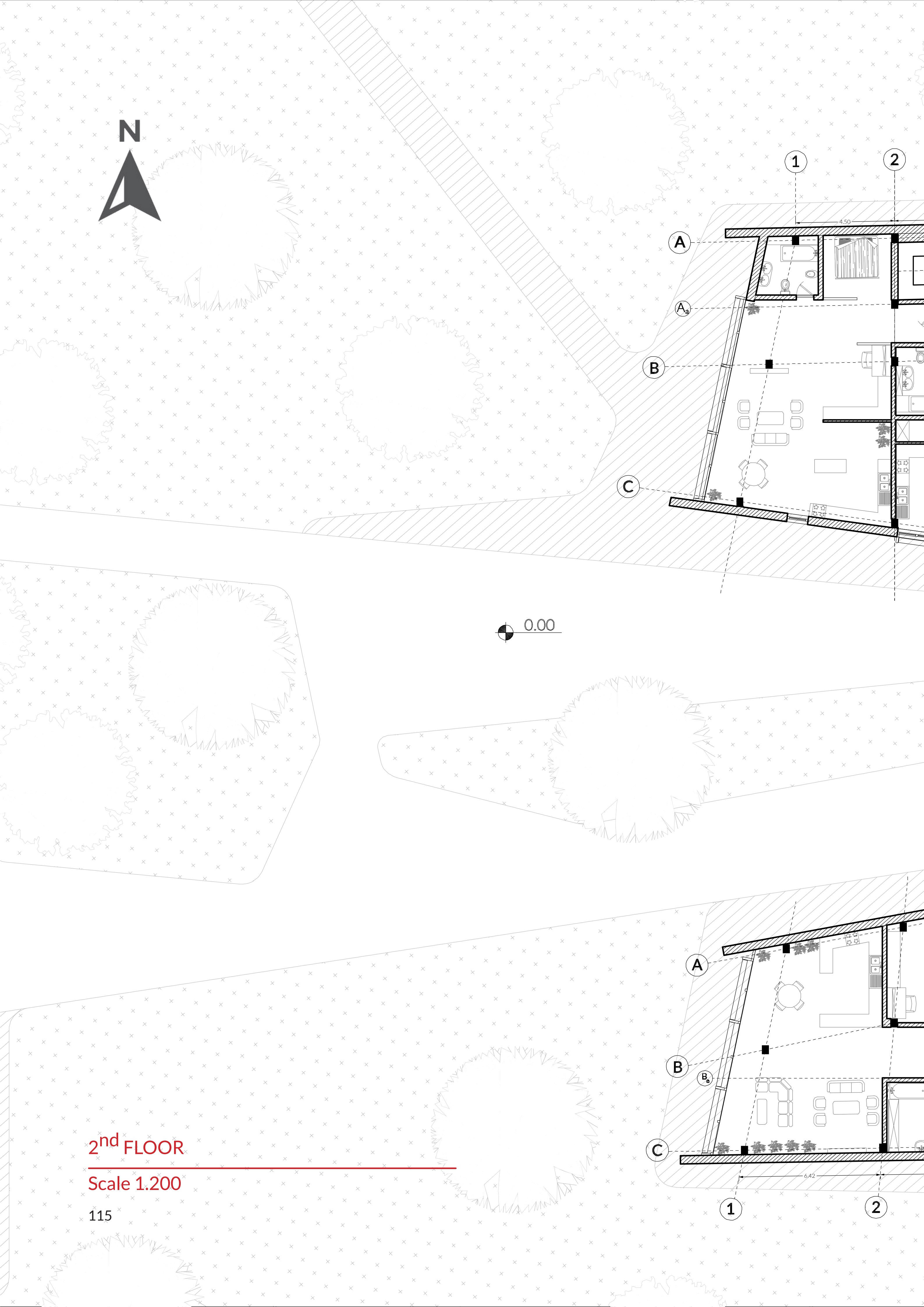
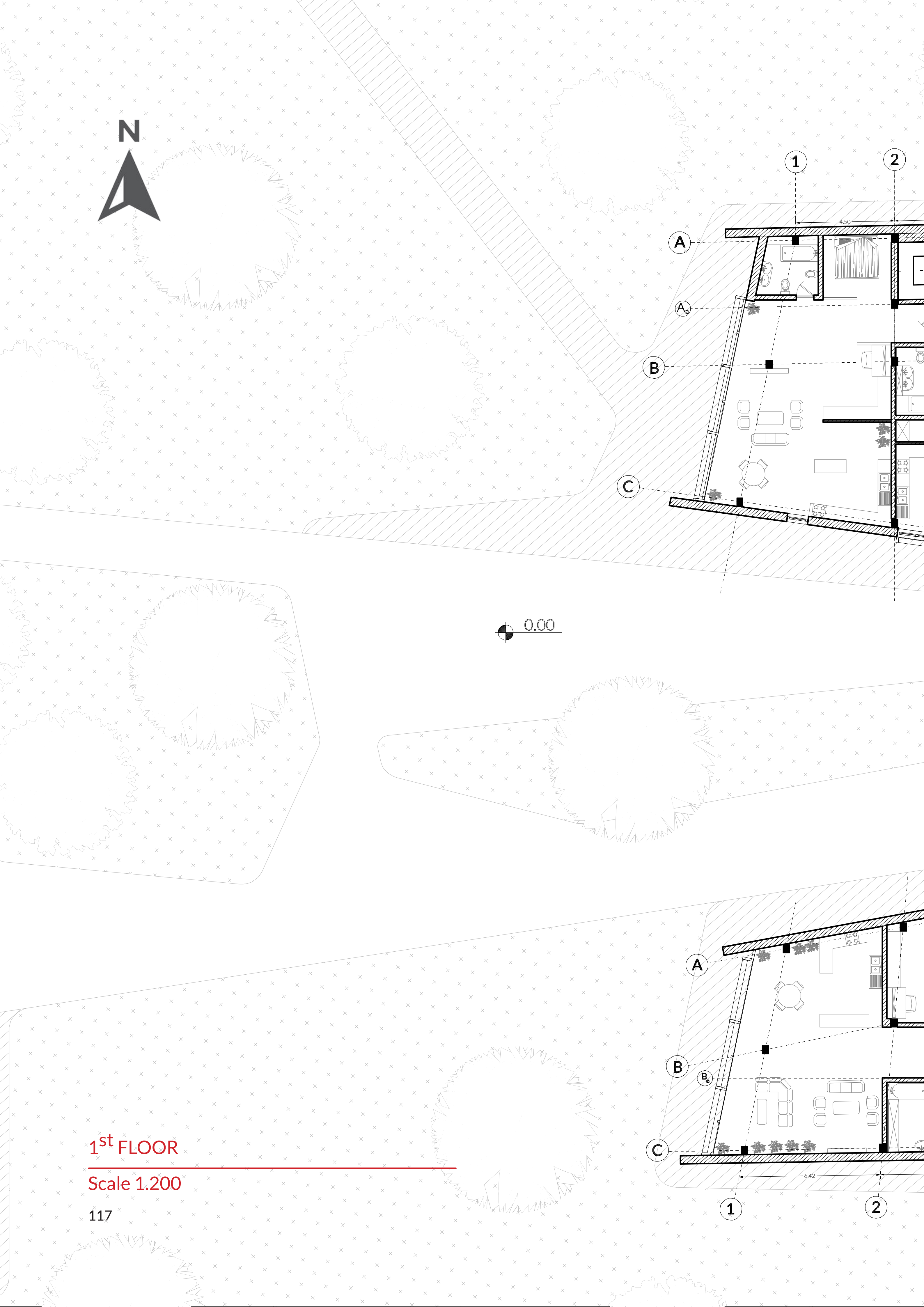
+14.70
+14.70
+14.70



2nd FLOOR

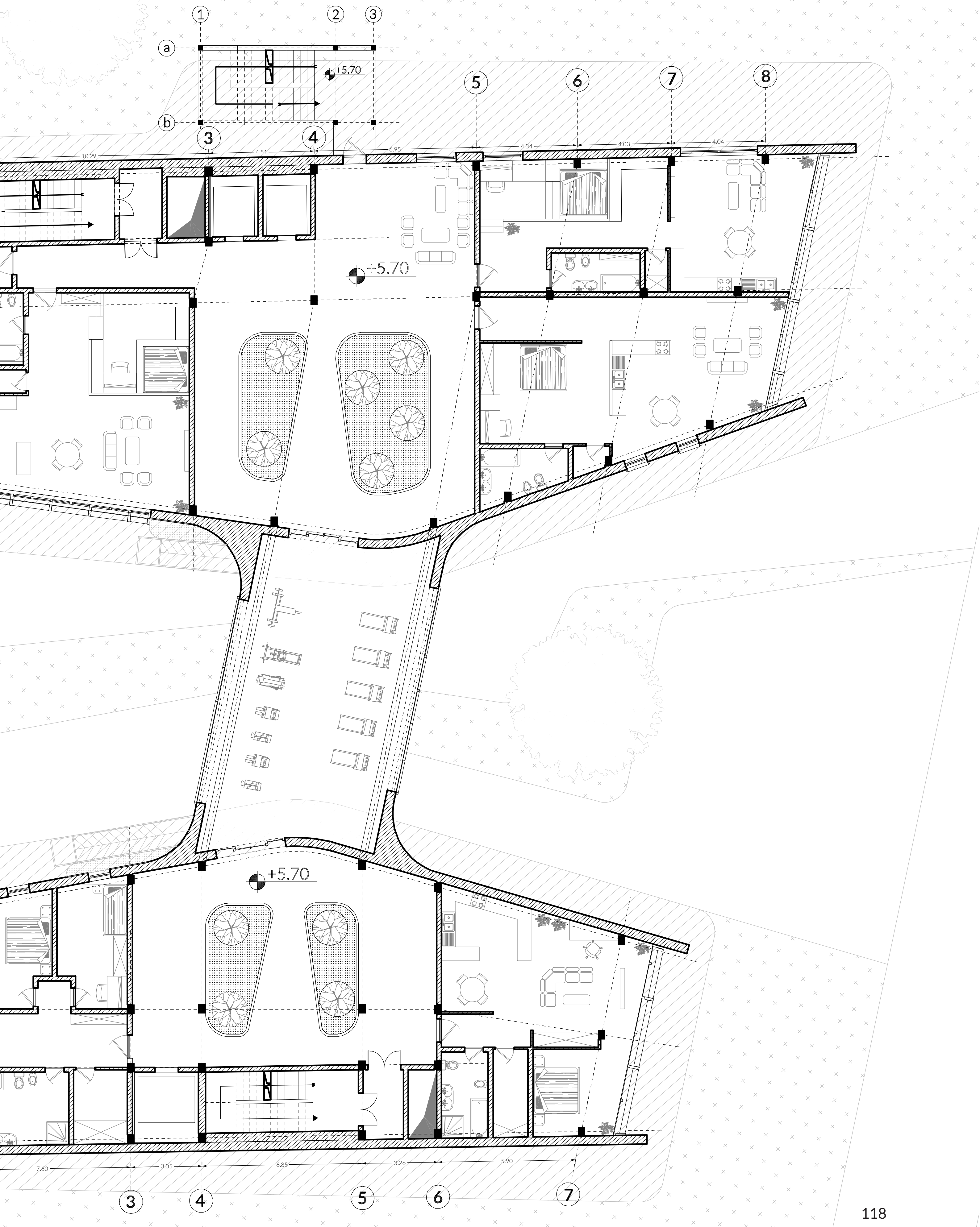
Scale 1.200

1
2
3
a
b
+10.20
5
6
7
8
3
4
10.29
4.51
6.95
4.34
4.03
4.04
+10.20
+10.20
7.60
3.05
6.85
3.26
5.90
3
4
5
6
7

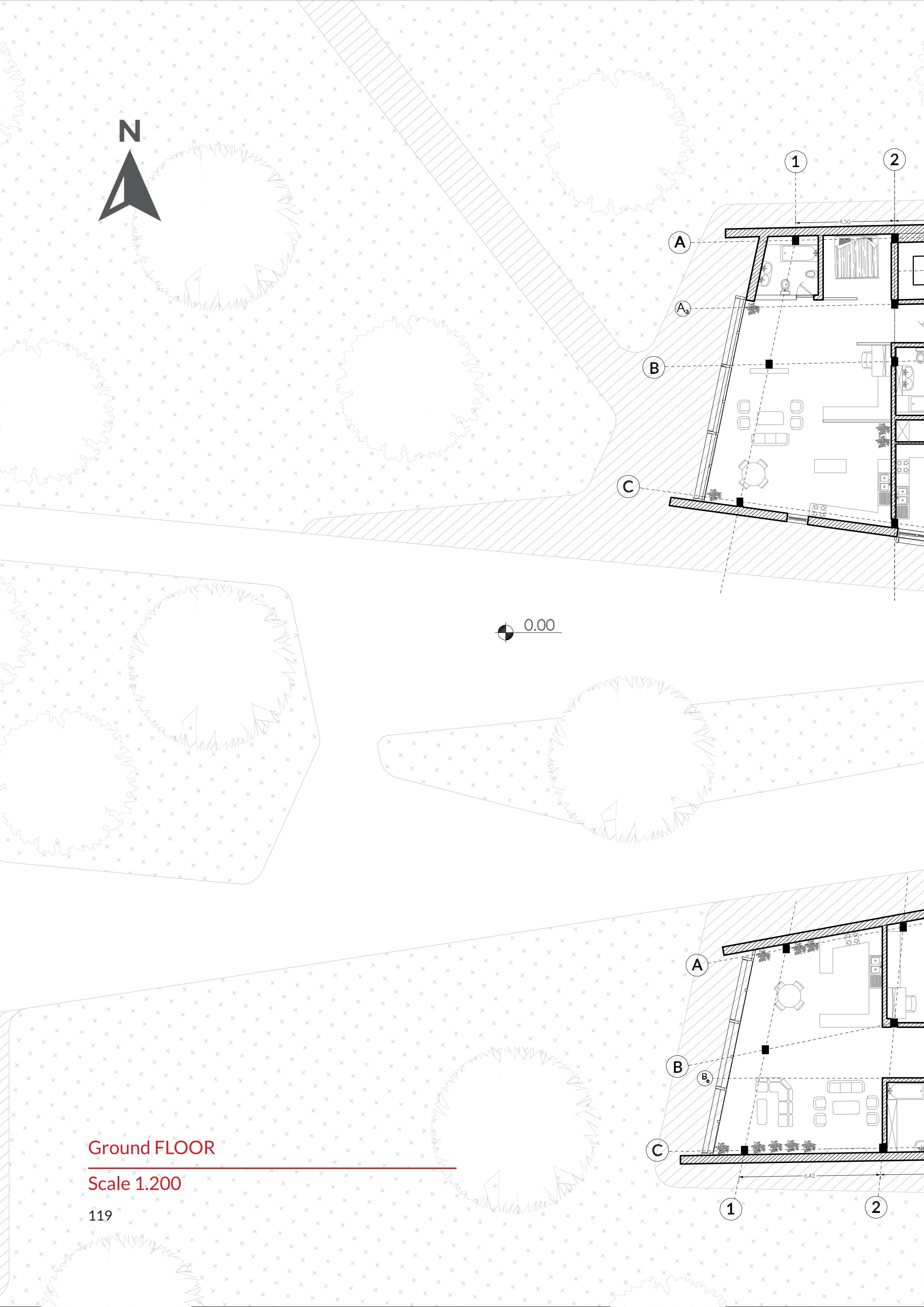


1st FLOOR

Scale 1.200

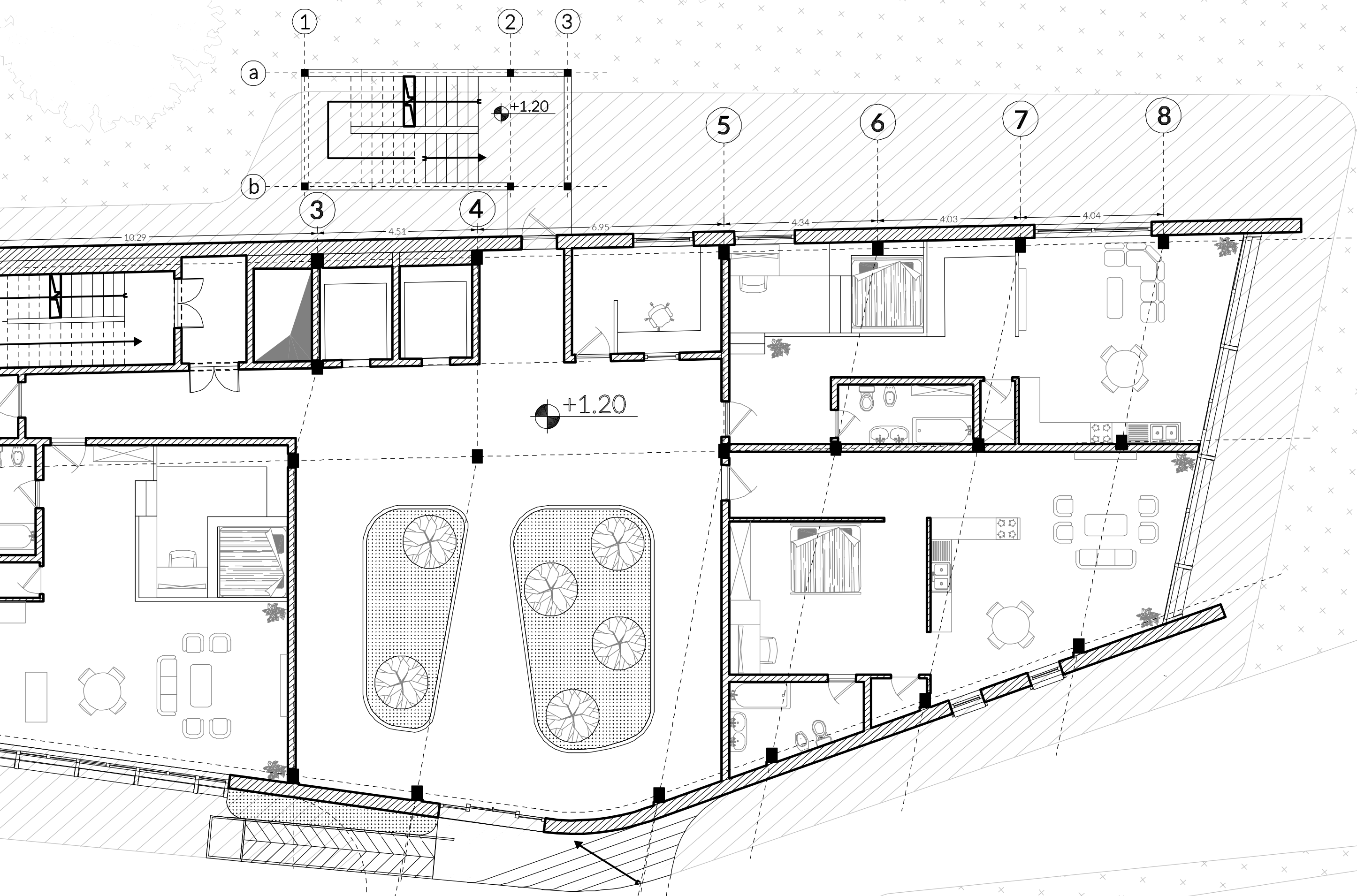


1
2
3
a
b
+5.70
5
6
7
8
3
4
10.29
4.51
6.95
4.34
4.03
4.04
+5.70
+5.70
7.60
3.05
6.85
3.26
5.90
3
4
5
6
7



Ground FLOOR

Scale 1.200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a
b
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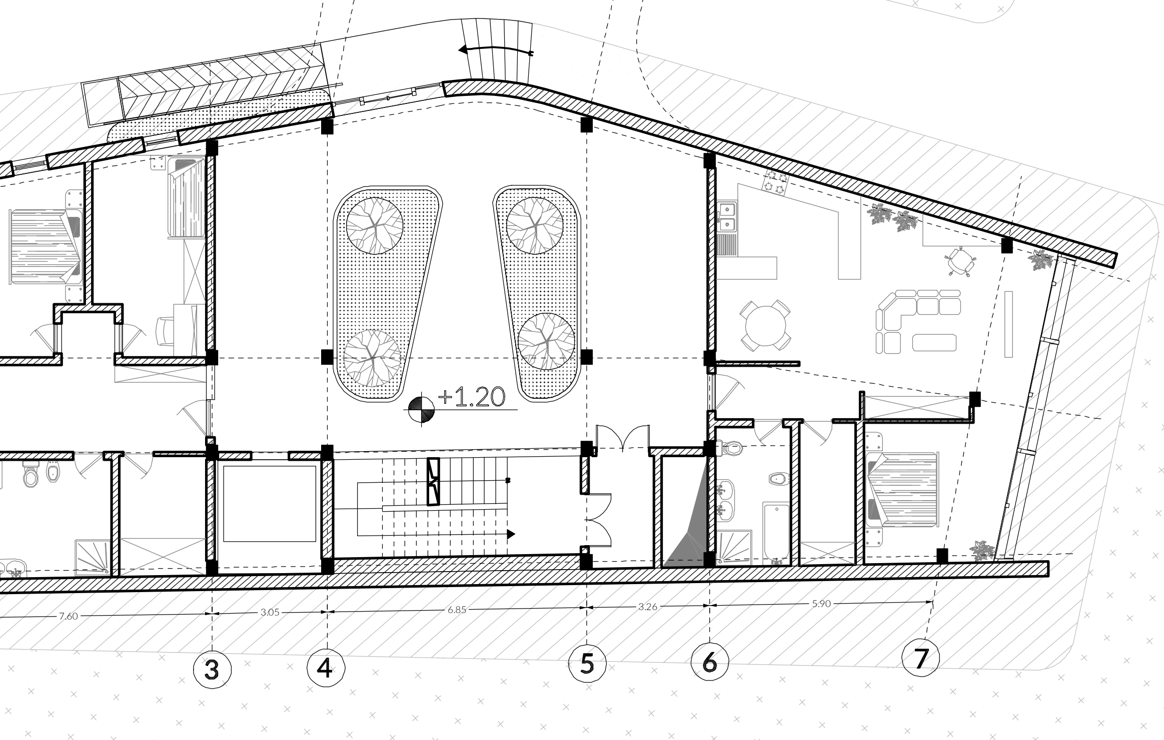
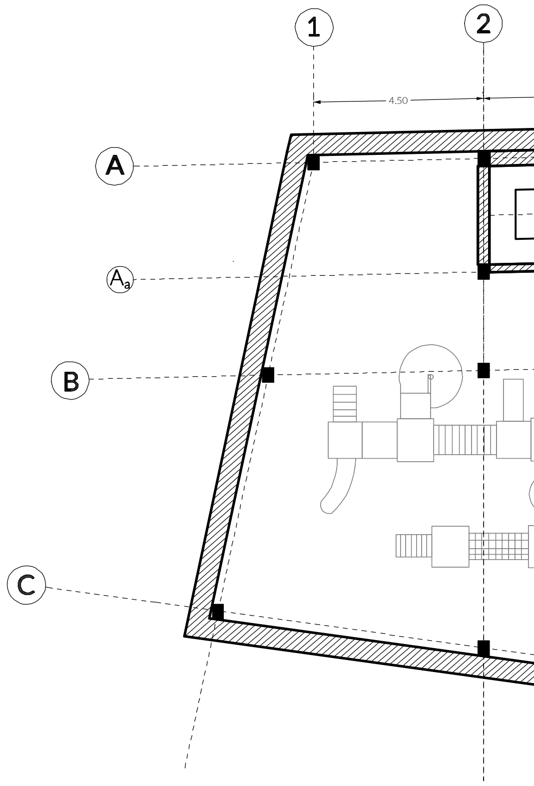
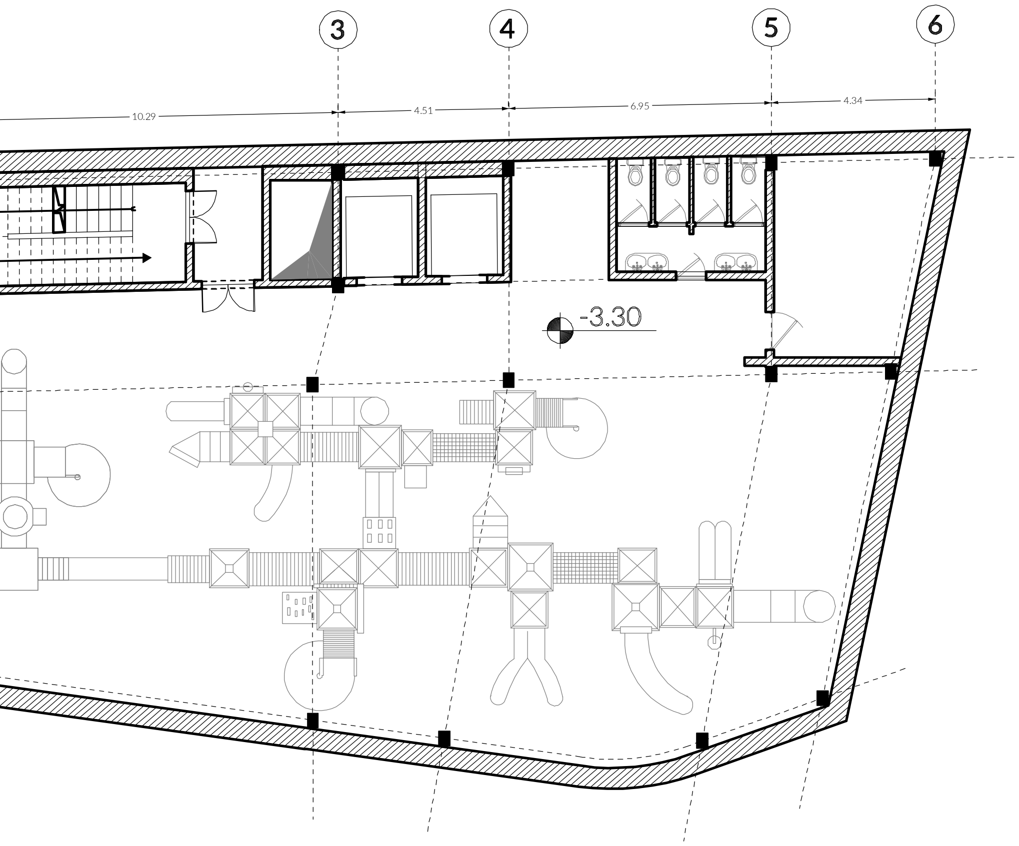
5
6
7
8
3
4
10.29
4.51
6.95
4.34
4.03
4.04
+1.20


+1.20
7.60
3.05
6.85
3.26
5.90
3
4
5
6
7



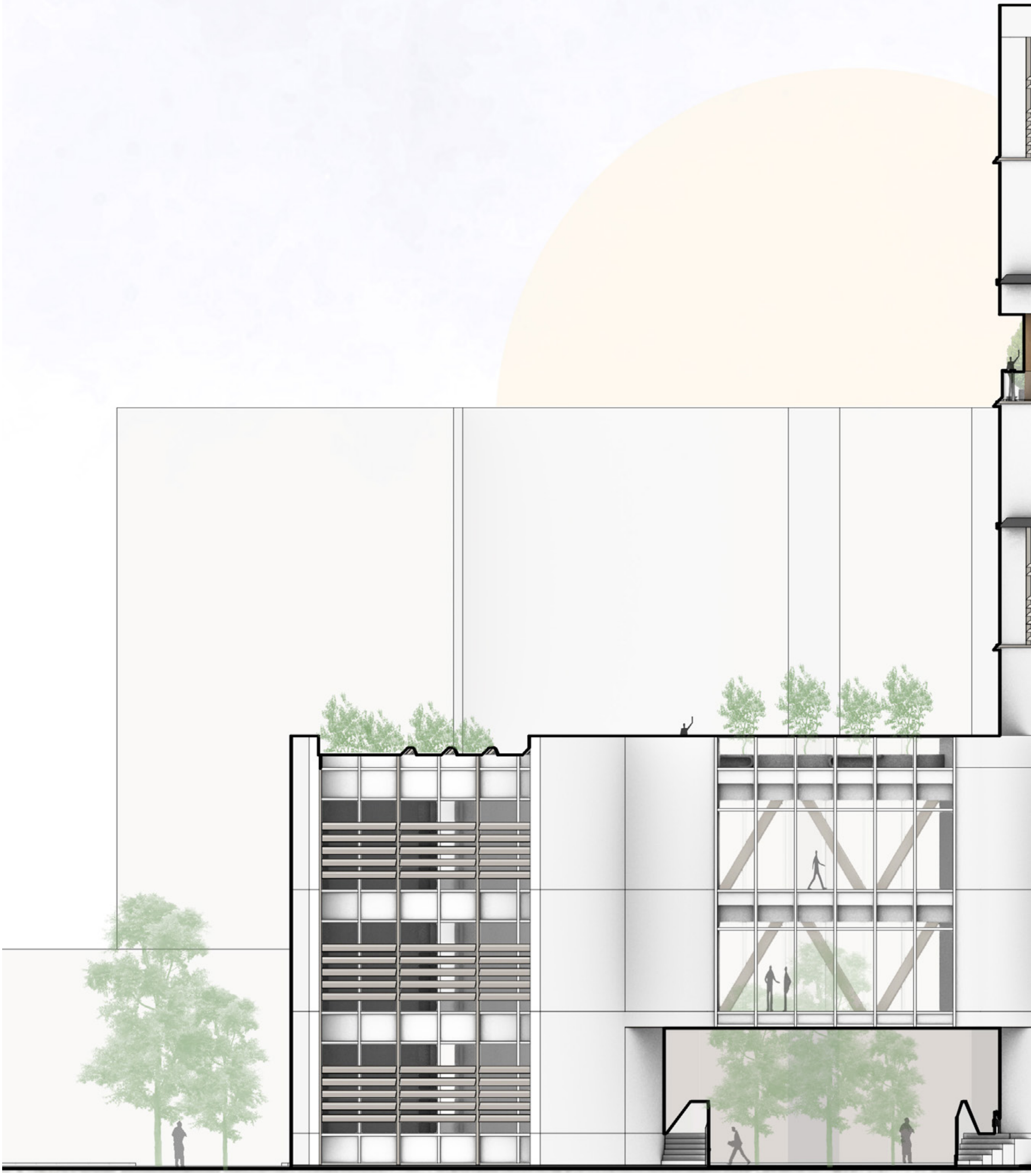
UnderGround FLOOR

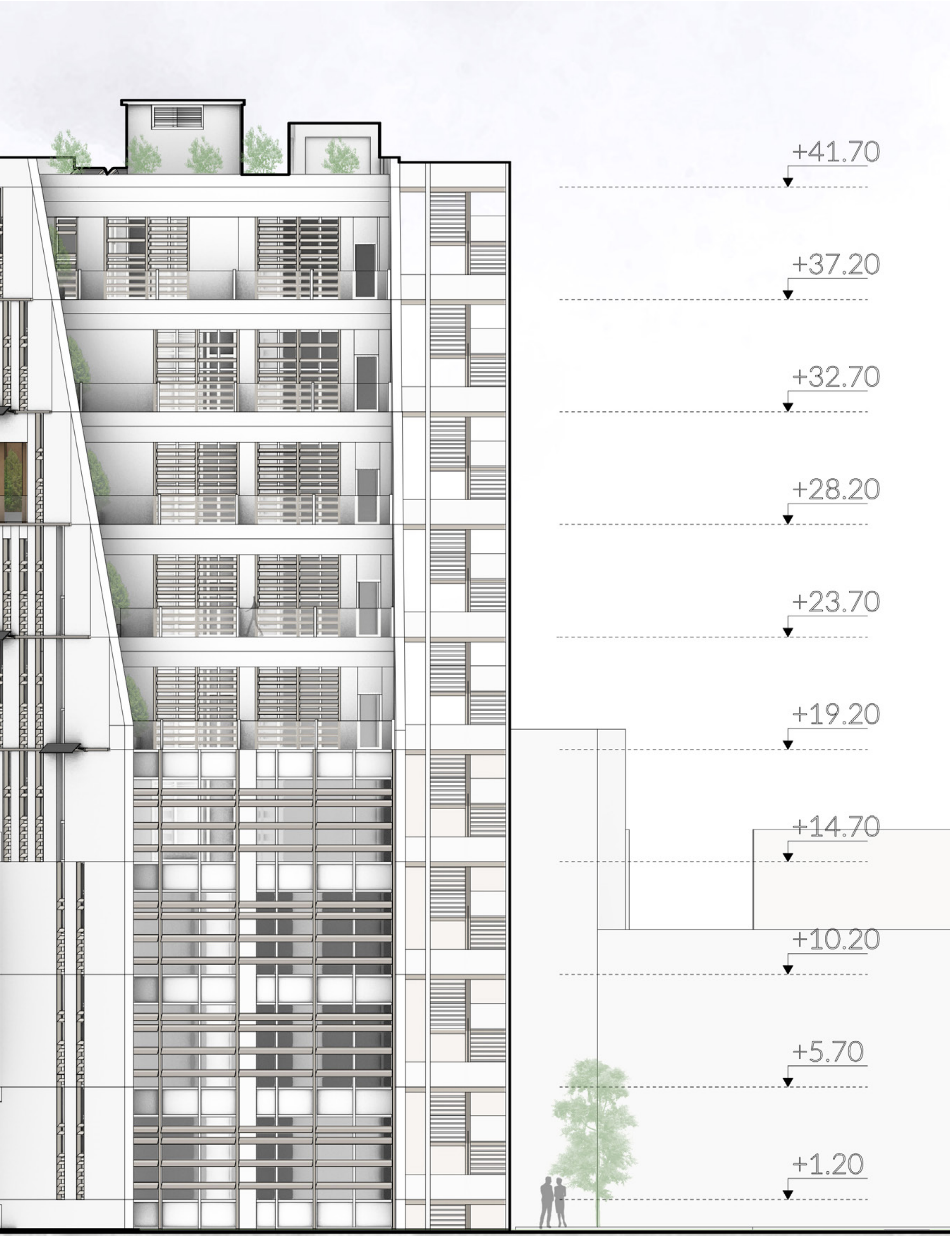
Scale 1.200


3
4
5
6
10.29
4.51
6.95
4.34
-3.30

East Elevation

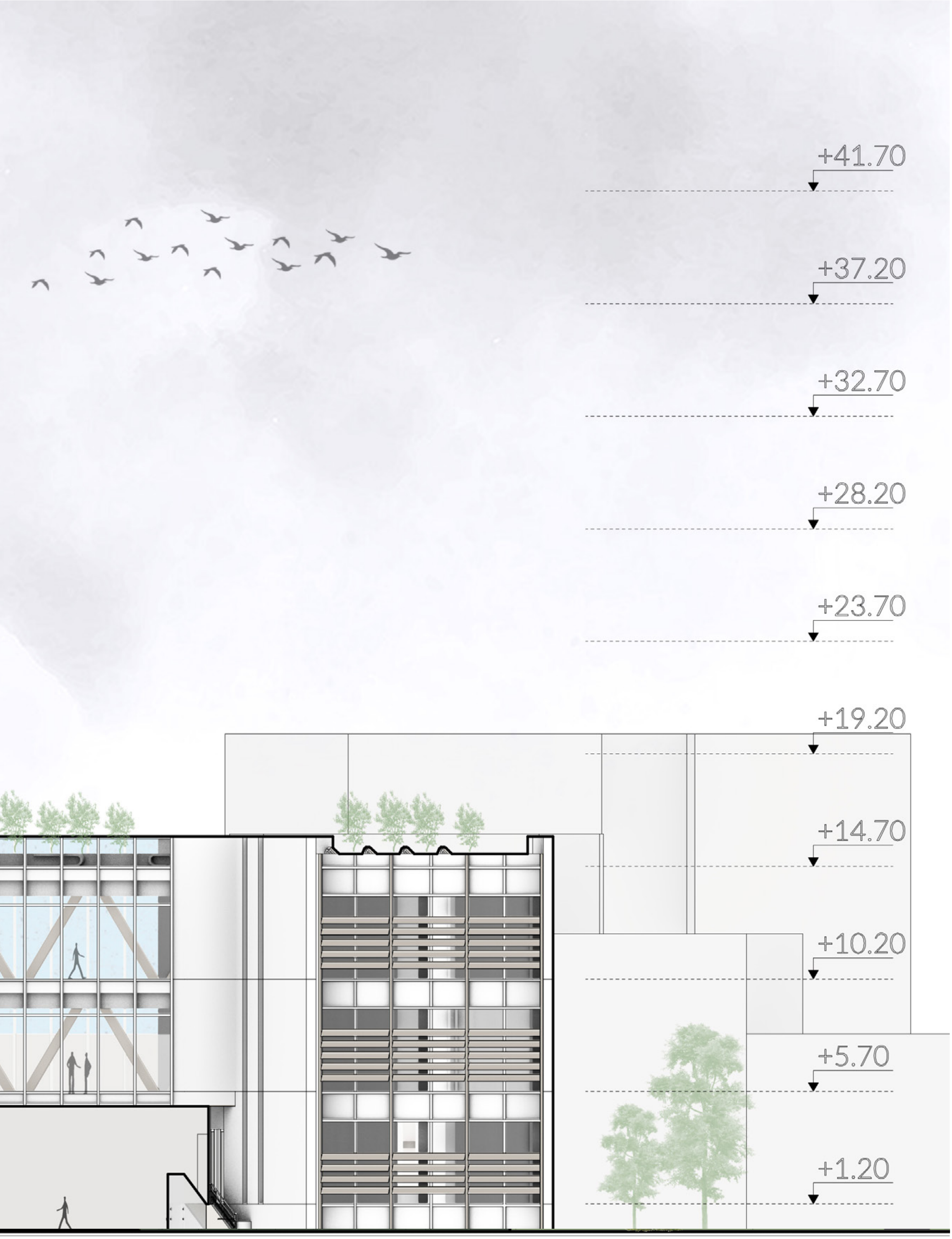
Scale 1.200




+41.70
+37.20
+32.70
+28.20
+23.70
+19.20
+14.70
+10.20
+5.70
+1.20

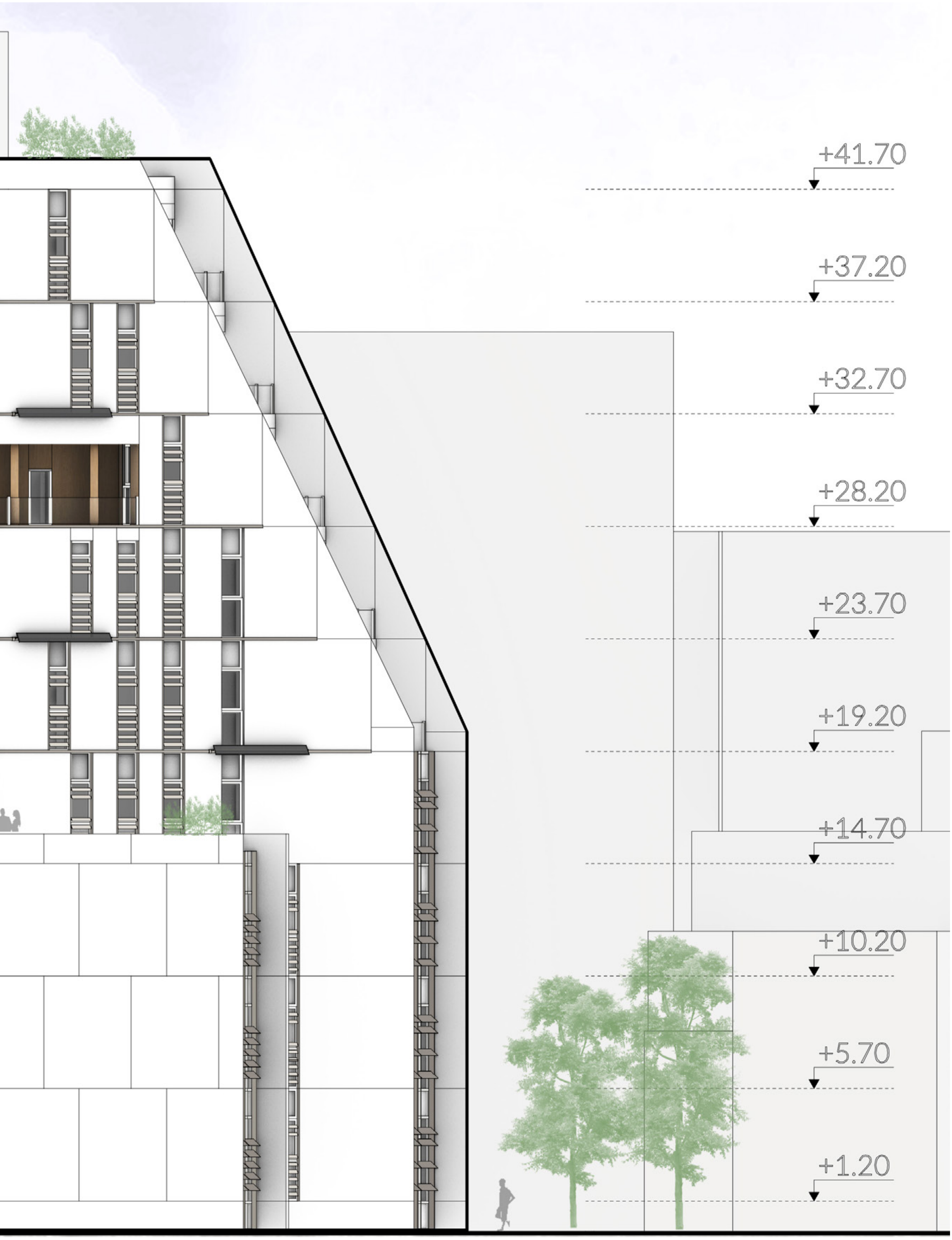
West Elevation

Scale 1.200


+41.70
+37.20
+32.70
+28.20
+23.70
+19.20
+14.70
+10.20
+5.70
+1.20

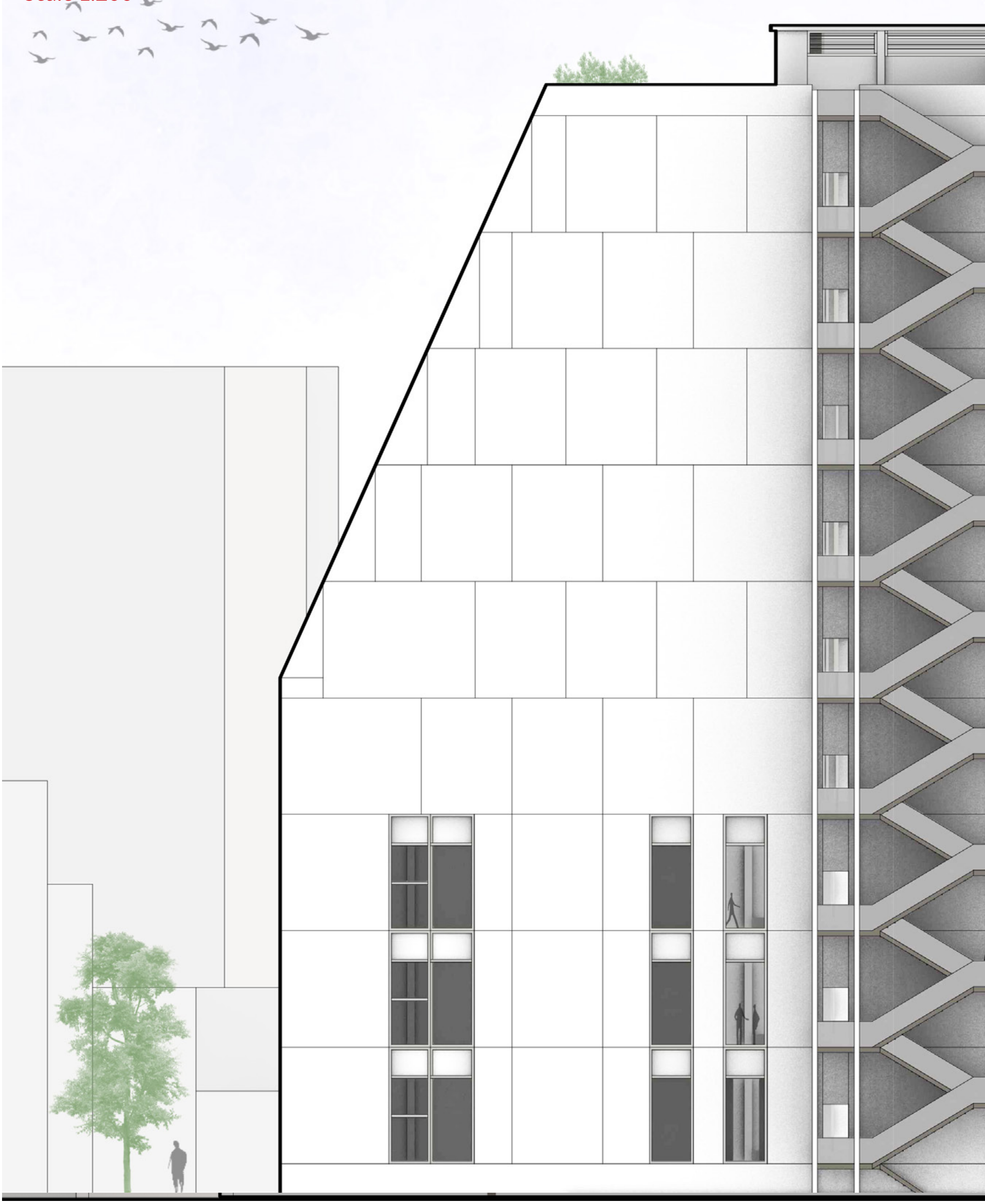
South Elevation

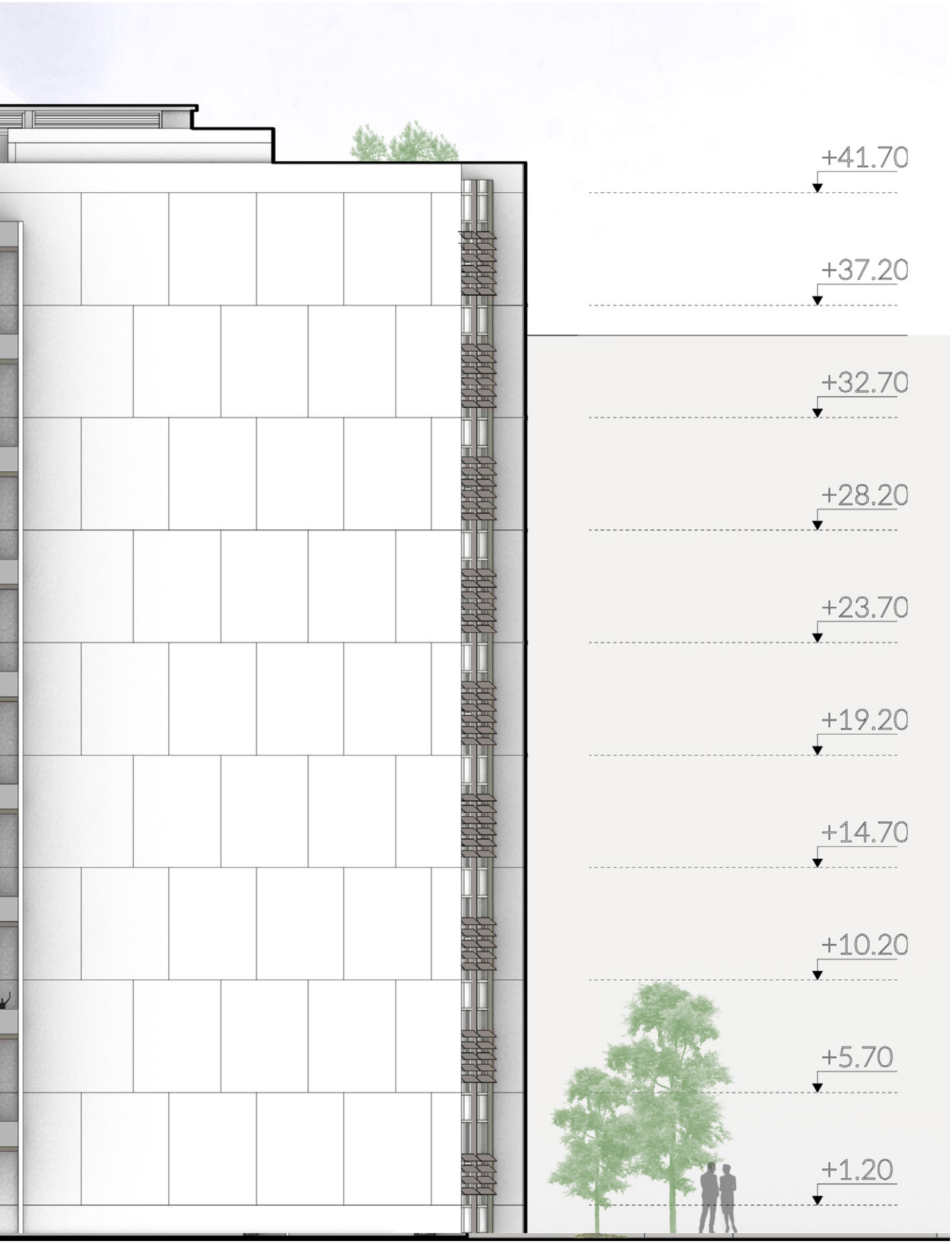
Scale 1.200


+41.70
+37.20
+32.70
+28.20
+23.70
+19.20
+14.70
+10.20
+5.70
+1.20

North Elevation

Scale 1.200

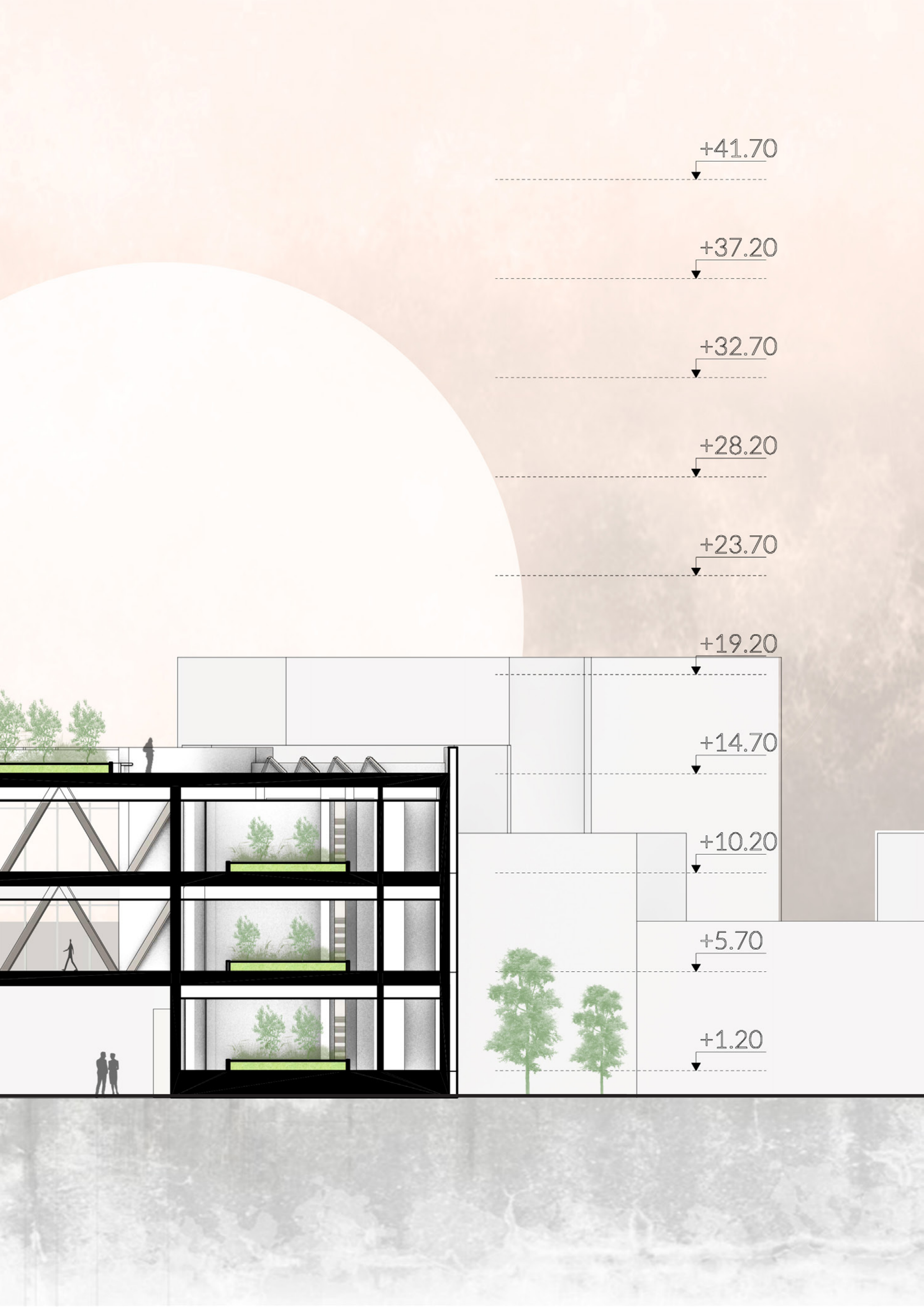



+41.70
+37.20
+32.70
+28.20
+23.70
+19.20
+14.70
+10.20
+5.70
+1.20

Section A - A’

Scale 1.200

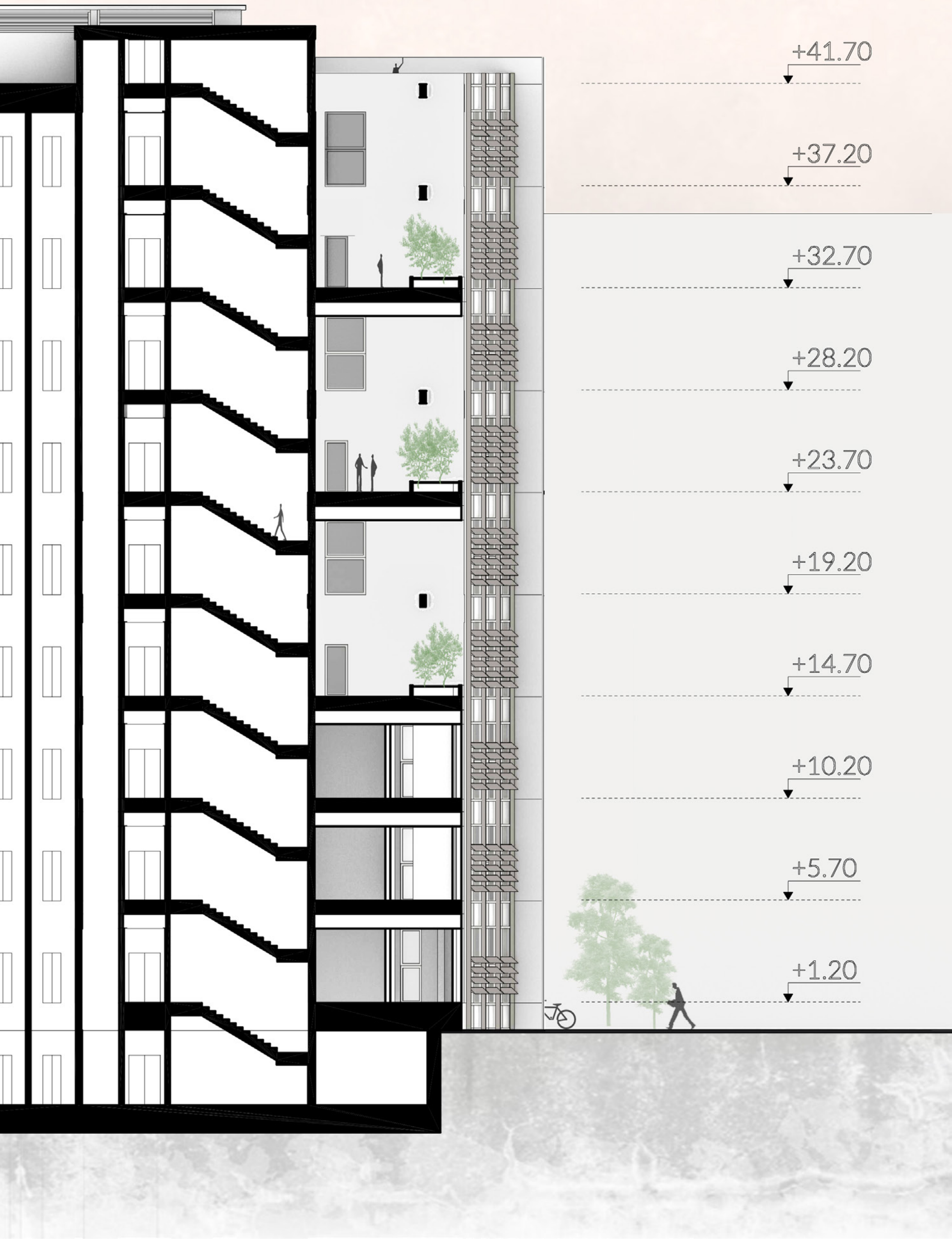
SECTION/ HYBRID DRAWING OASIS 1 500


+41.70
+37.20
+32.70
+28.20
+23.70
+19.20
+14.70
+10.20
+5.70
+1.20

Section B - B’

Scale 1.200

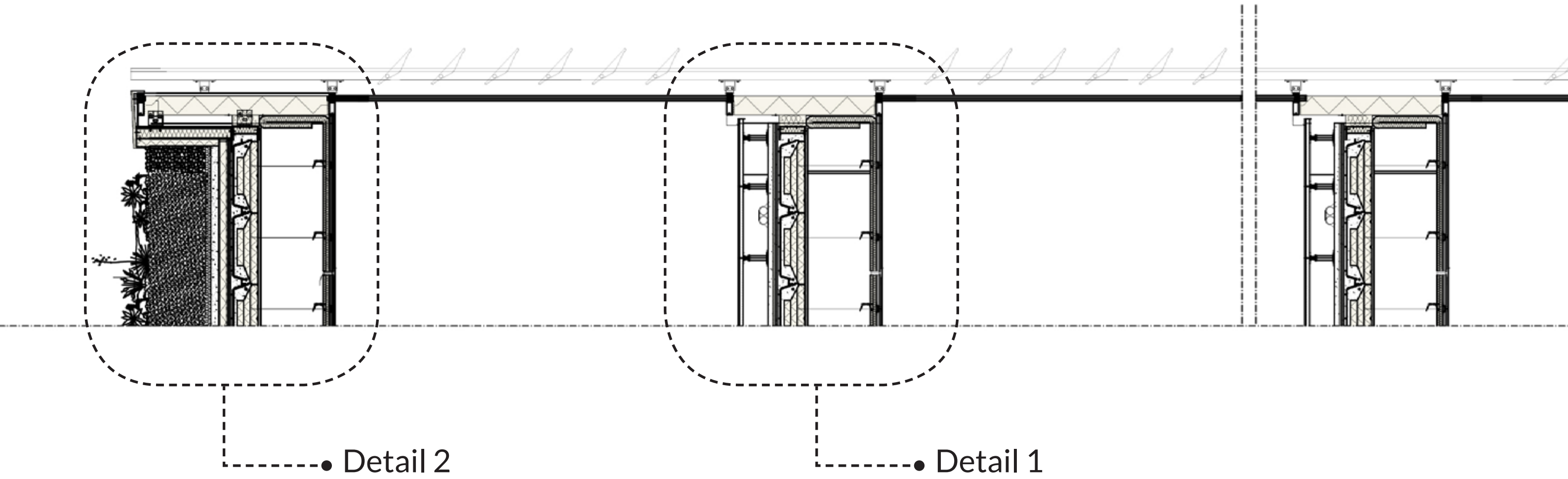
SECTION/ HYBRID DRAWING OASIS 1 500

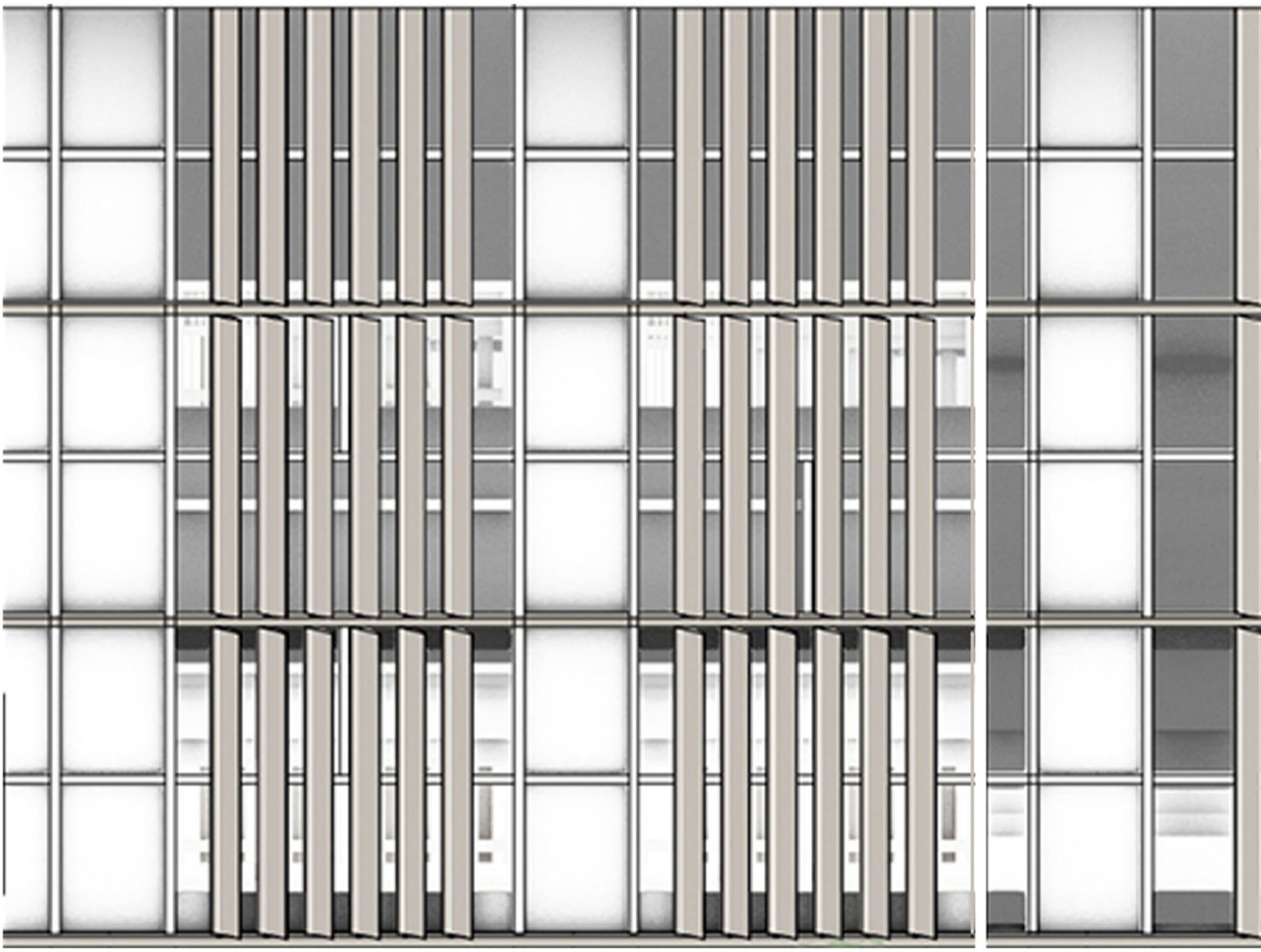


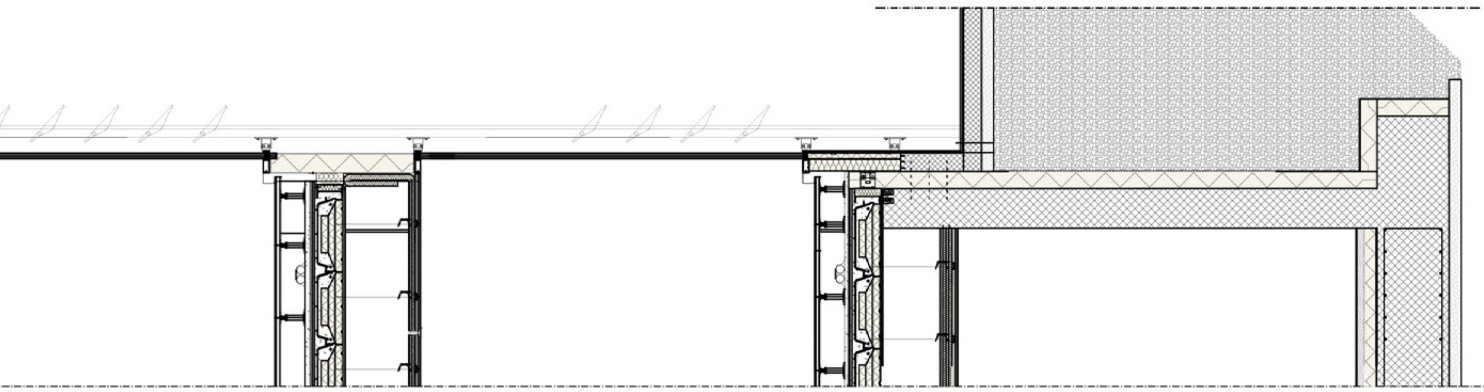
+41.70
+37.20
+32.70
+28.20
+23.70
+19.20
+14.70
+10.20
+5.70
+1.20

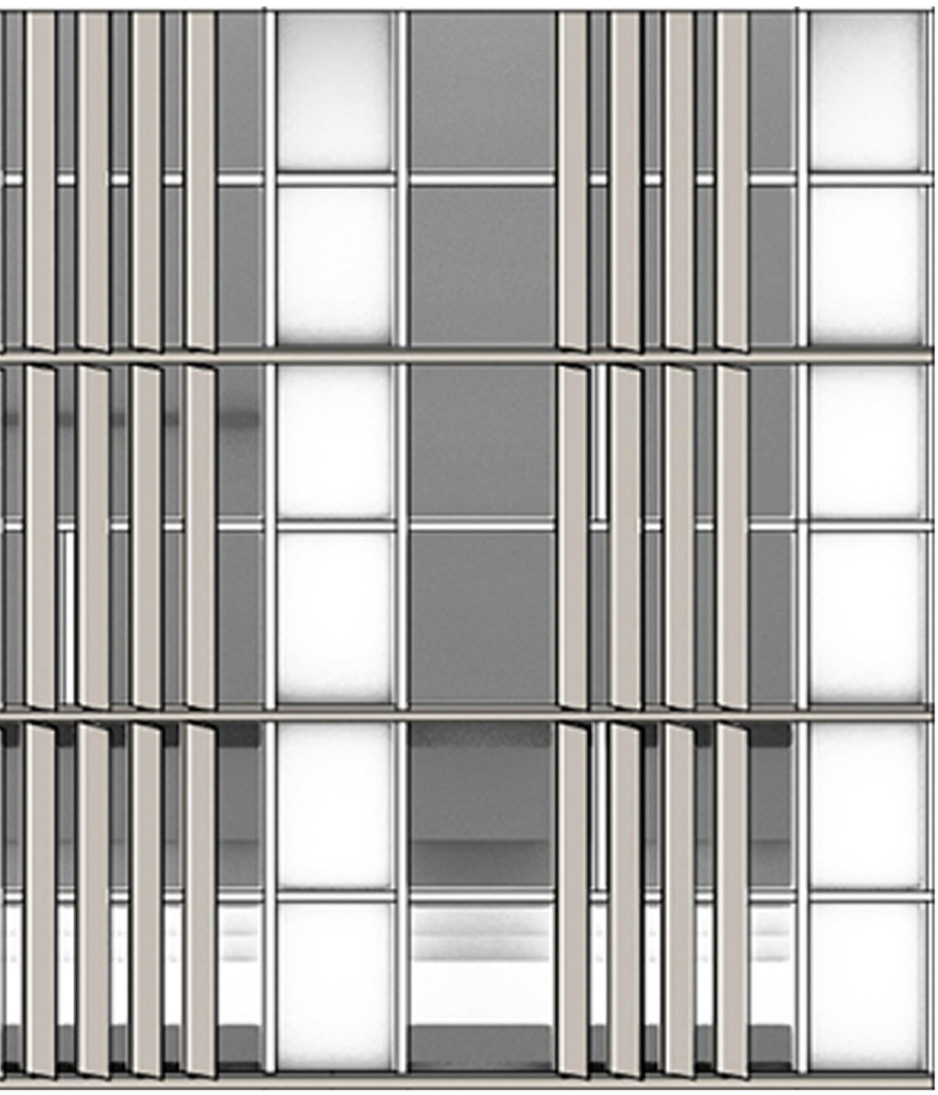
BLOW UP

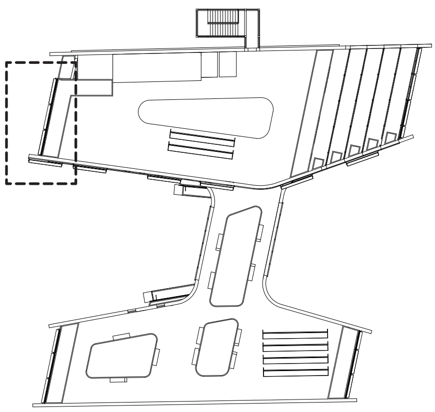
Scale 1.10

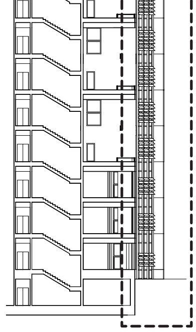








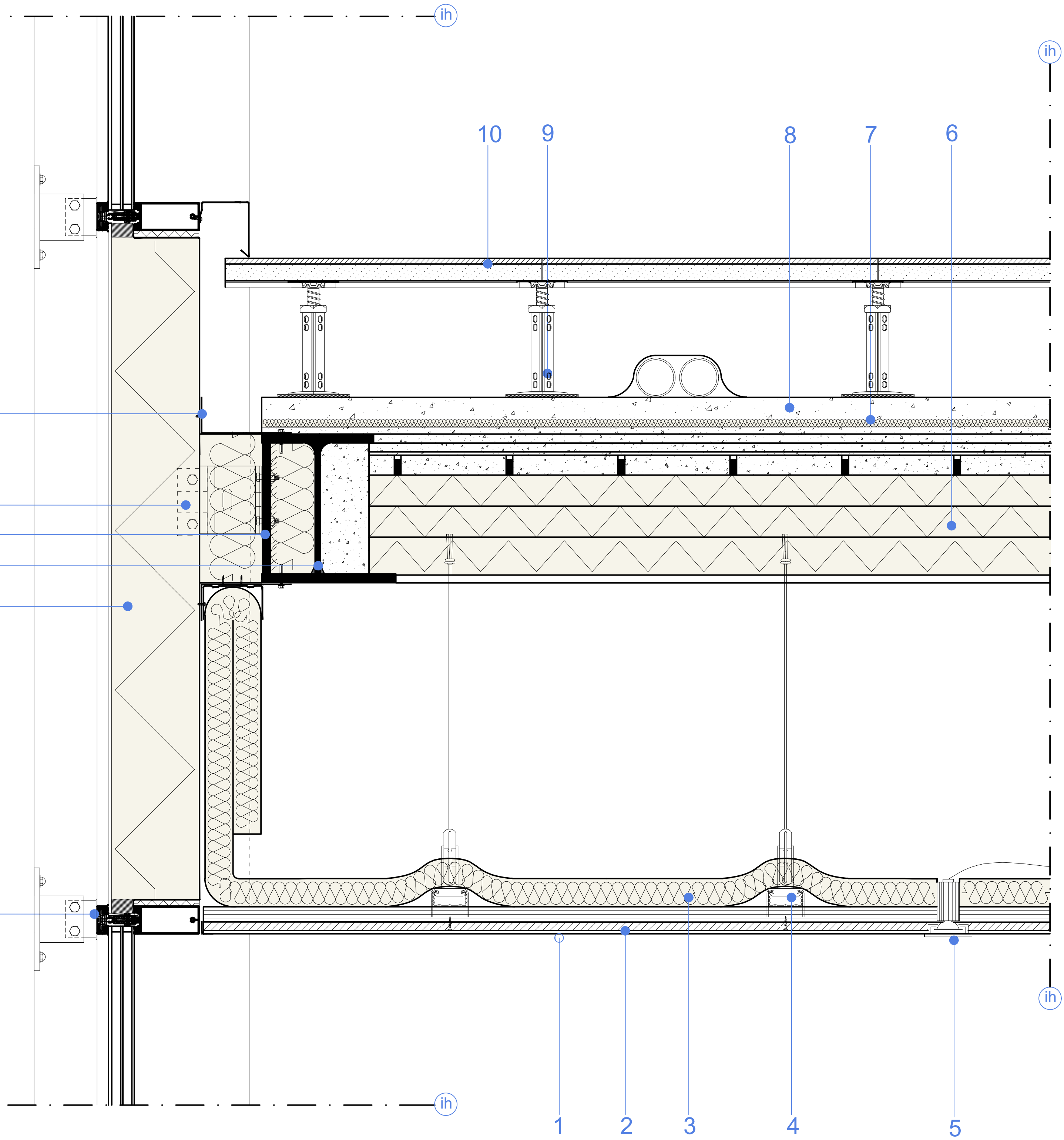




Joints - Detail 1

Scale 1.1

1. Exterior plaster with reinforcing net, th. 0,7 cm
2. Fiber cement support board for plaster, th. 1,5 cm.
3. Thermic and acoustic insulation in rock wool, dim. 60 cm x 120 cm, sp. 5 cm, λ= 0,033 W/ (m•K), Ceilingrock Plus Rockwool
4. False ceiling support structure, D112, Knauf
5. LIghting element
6. Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of insulation
7. Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel by Mapei.
8. Concrete screed, th. 4cm.
9. Floating floor NEWFLOOR SNF.
10. Gres tile th. 1cm, dim. 60x60 cm, on a core of sound absorbing panel, made of a mixture of calcium sulphate and organic phibers. Edge in anti squeak plastic material. NEWFLOOR G30ATK. With total th. 3 cm
11. Movable louver systems
12. Shading support element
13. L profile
14. Bolted anchor plate for the curtain wall mullion
15. Steel plate welded to the beam for anchoring the upright of the curtain wall
16. Beam IFB, 280x266
17. Closing element for the slab, made of rigid insulation closed by an alluminum cladding and an opaque glass
18. Curtain wall transom, SCHUCO, th. 5cm, length 11 cm, triple glass



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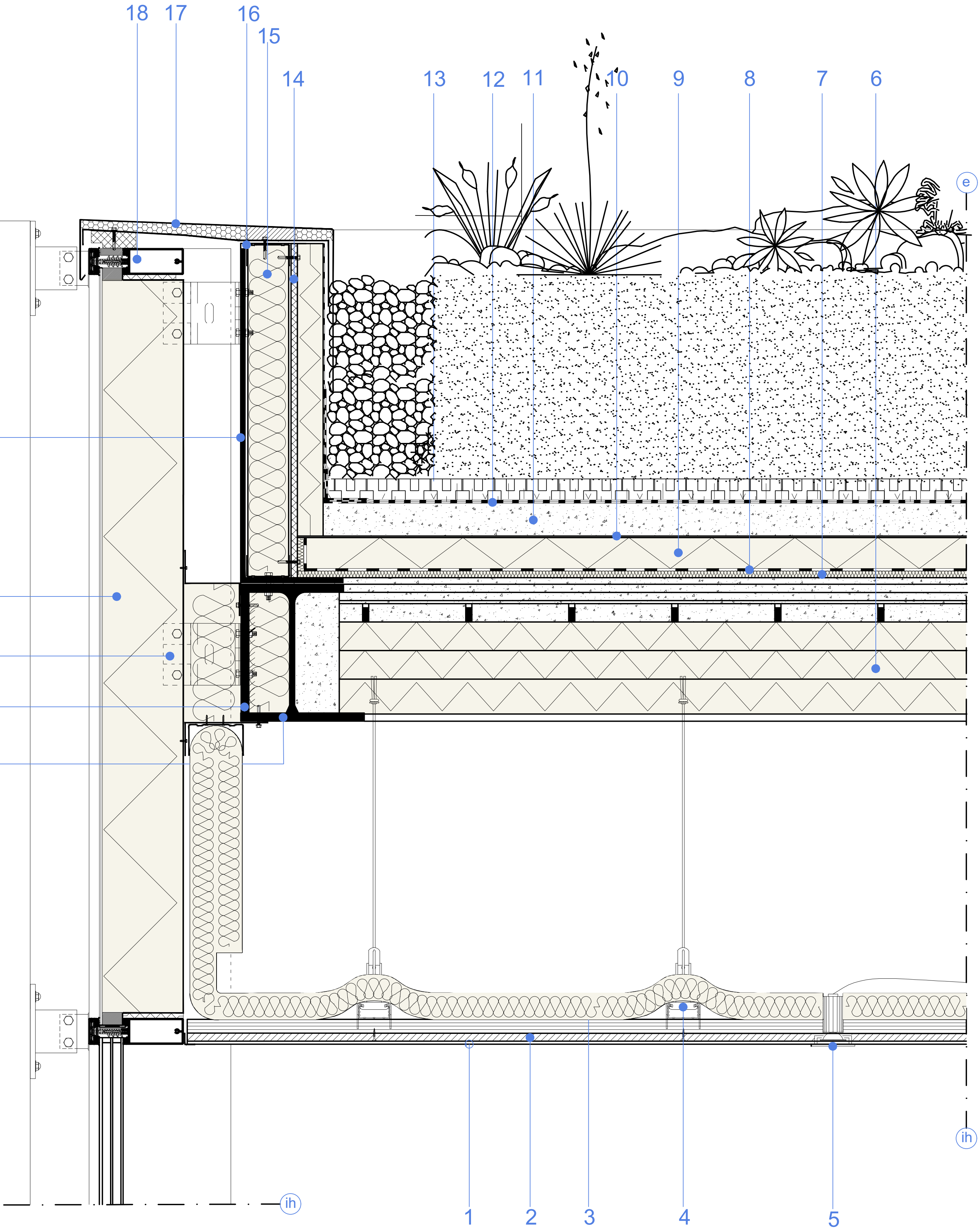
Joints - Detail 2

Scale 1.1

1. Exterior plaster with reinforcing net, th. 0,7 cm
2. Fiber cement support board for plaster, th. 1,5 cm.
3. Thermic and acoustic insulation in rock wool, dim. 60 cm x 120 cm, sp. 5 cm, λ= 0,033 W/ (m•K), Ceilingrock Plus Rockwool
4. False ceiling support structure, D112, Knauf
5. LIghting element
6. Structural system in Cofradal 260, composed by welded mesh, fire reinforcement and internal layers of insulation
7. Acoustic insulation in tiles composed by elastoplastomeric membrane coupled with resilient layer of polyester fiber, th. 1,3cm, Mapesilent panel by Mapei.
8. Synthetic vapor barrier th. 0,22 cm, DS 46 PE Riwega.
9. Rigid thermo-acoustic insulation layer in high density rock wool, dim. 120x100cm, sp. 8 cm, λ = 0.039 W / Mk, ROCKACIER B
10. Slope in concrete screed, th. 8 cm
11. Waterproof membrane, th. 0,4cm, INDEX Lighterflex HPCP Helasto.
12. Macro-holed, non-woven polypropylene fabric for reinforcing waterproofing membranes, 200 gr/ m^2, FIOCCOTEX PES/CE 200 GR di Biemme.
13. Gravel
14. Fiber reinforced concrete panel, dim. 200 x 120 cm, sp. 1,25cm, Aquapanel Outdoor di Knauf
15. Layer of insulation in rockwool, th. 8 cm
16. U profile
17. Steel profile cover, filled of insulation
18. Curtain wall transom, SCHUCO, th. 5cm, length 11 cm, triple glass
19. Mouvable louver systems
20. L steel profile
21. Shading support element
22. Closing element for the upper part of the curtain wall, closed by an alluminum cladding and an opaque glass
23. Bolted anchor plate for the curtain wall mullion
24. Steel plate welded to the beam for anchoring the upright of the curtain wall
25. Beam IFB, 280x266



18
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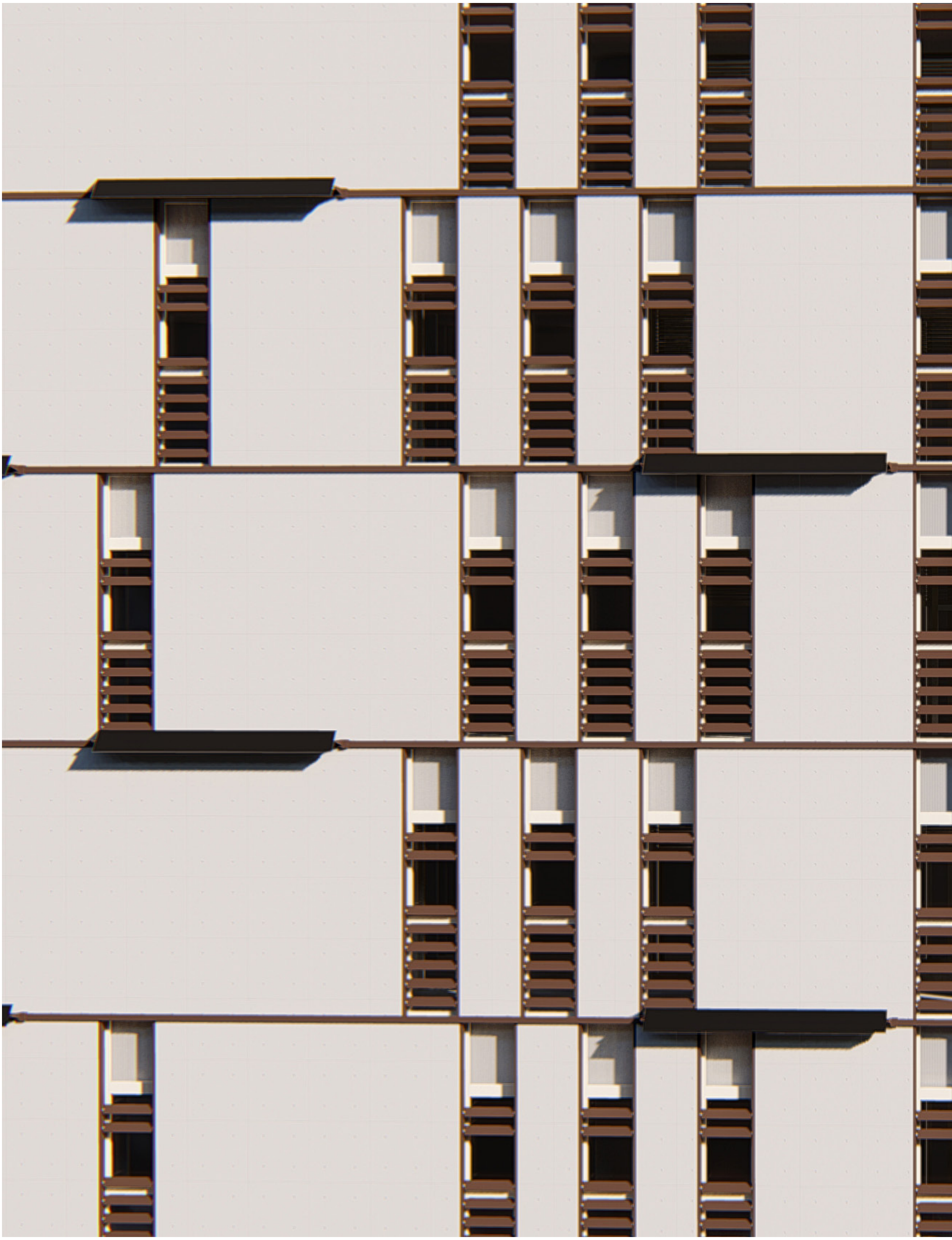
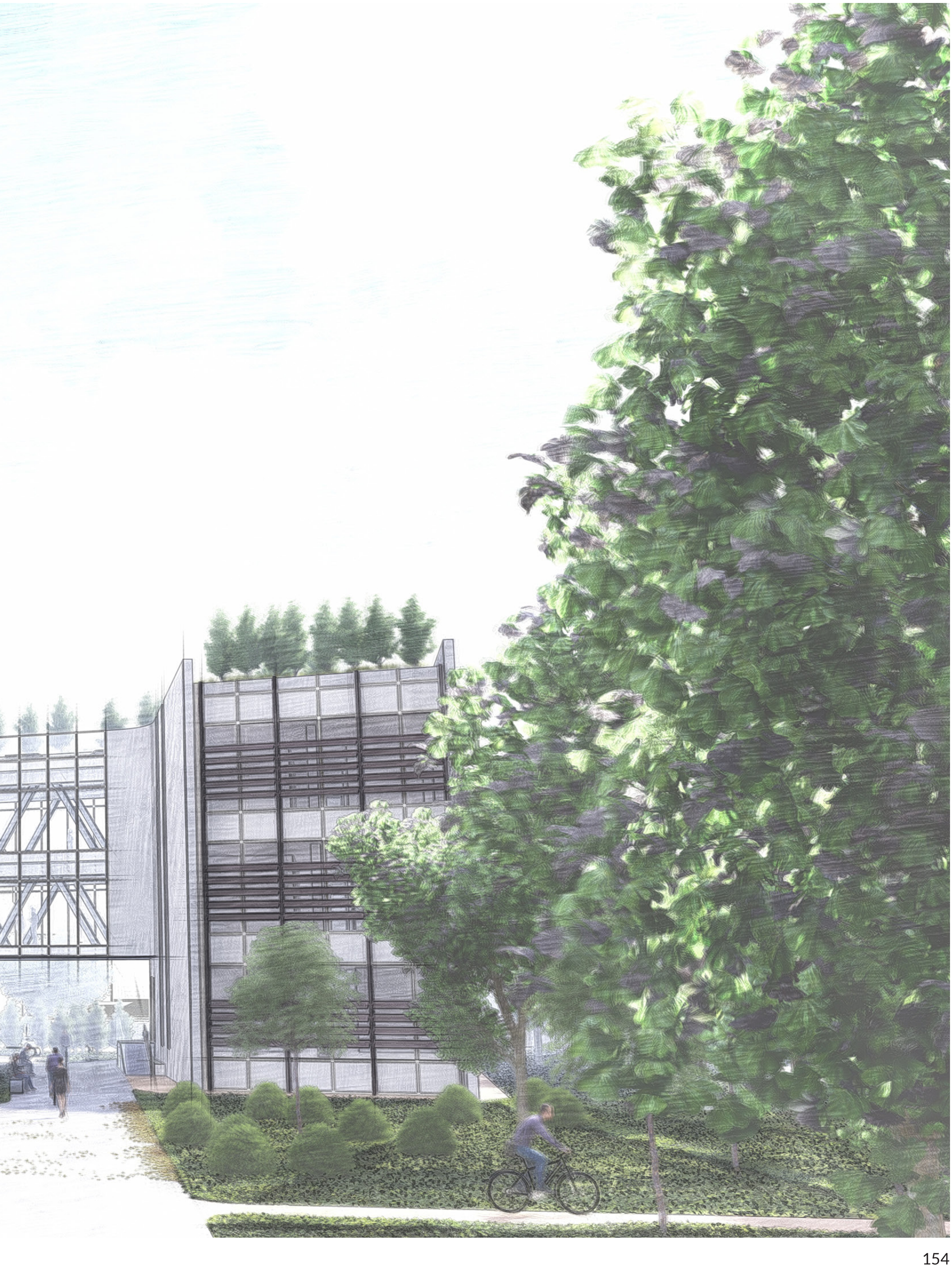
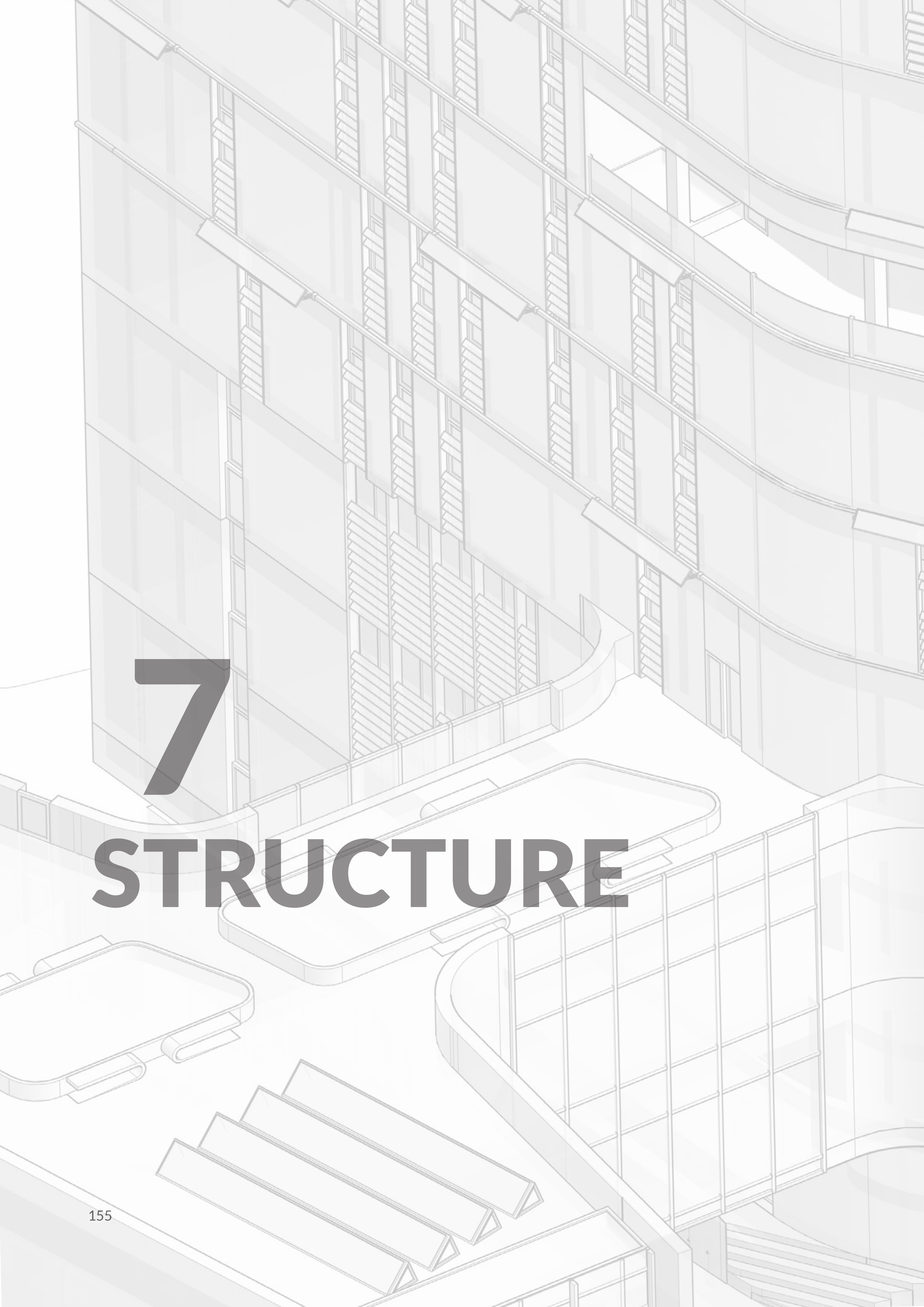
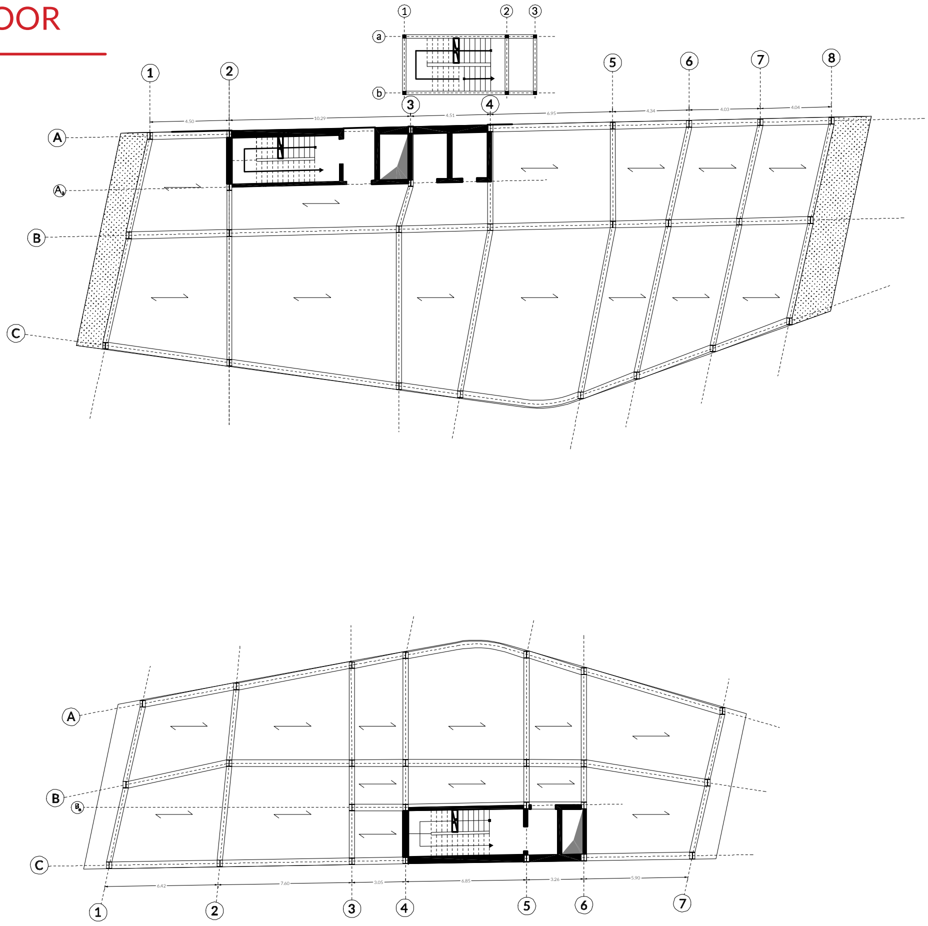




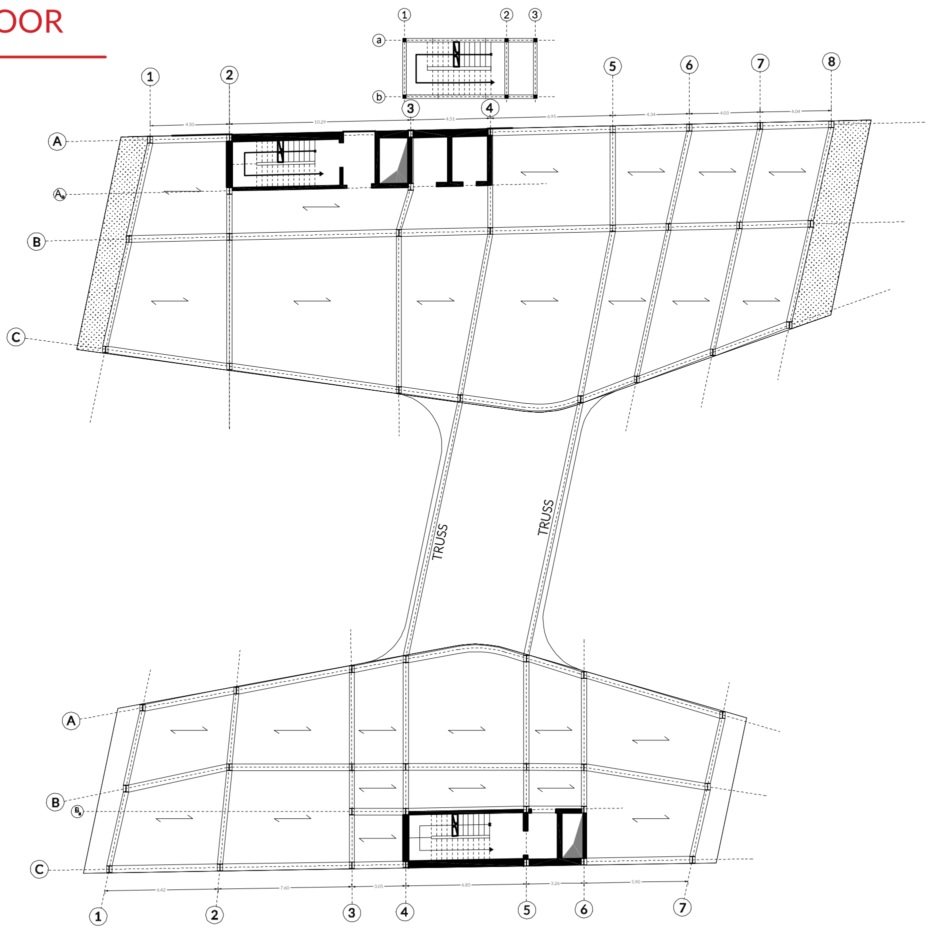


7 STRUCTURE

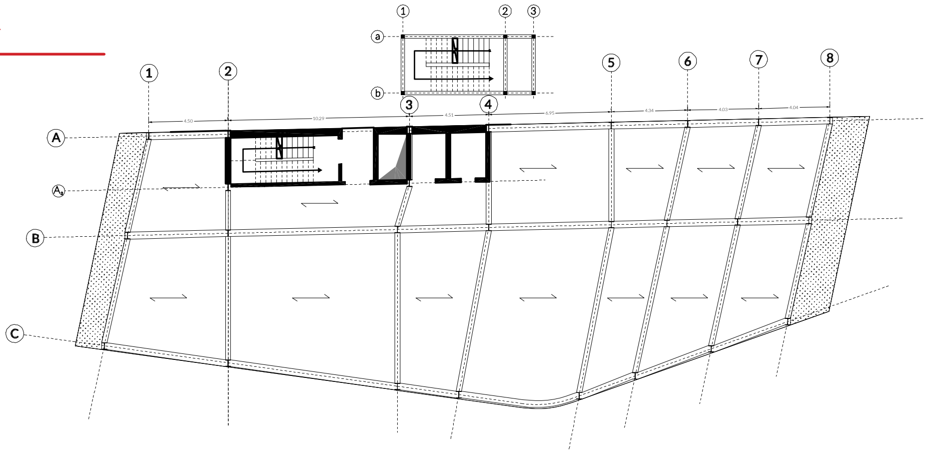
Ground FLOOR



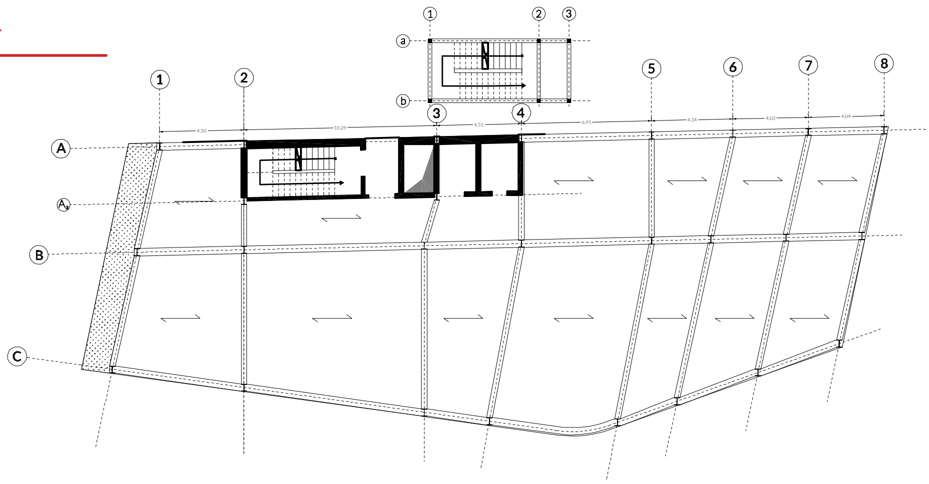
1st/2nd FLOOR



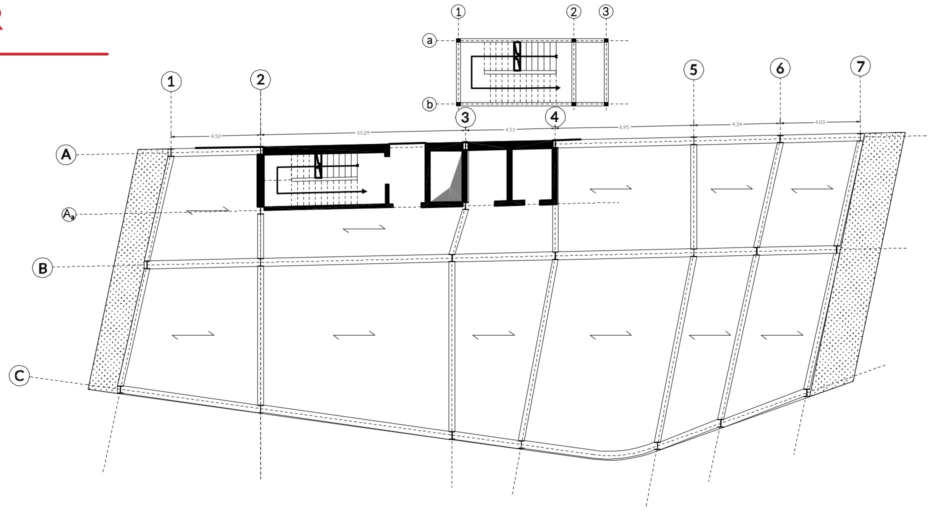
3rd FLOOR



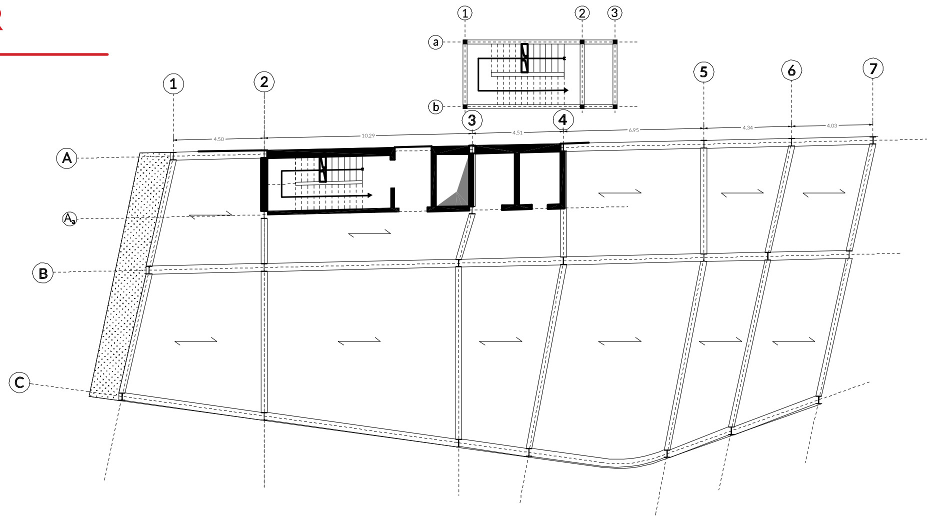
4th FLOOR



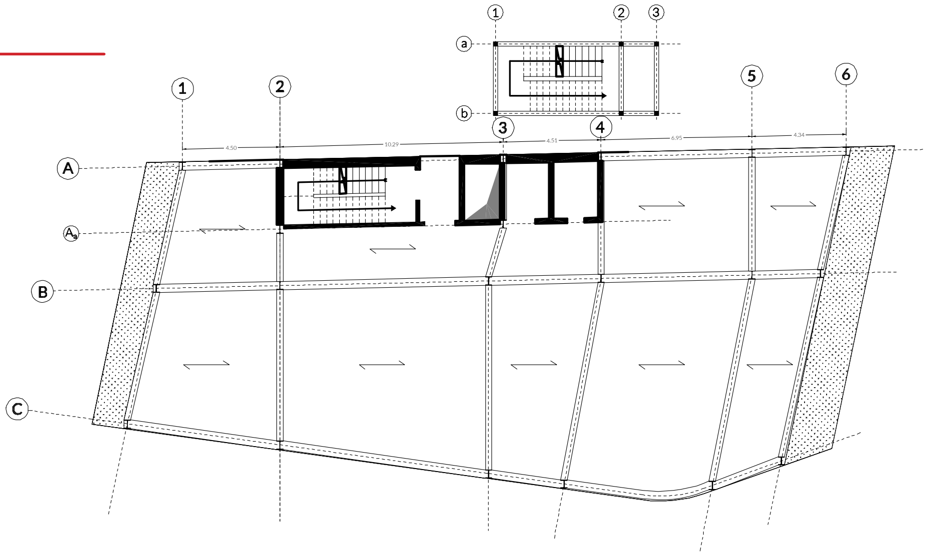
5th FLOOR



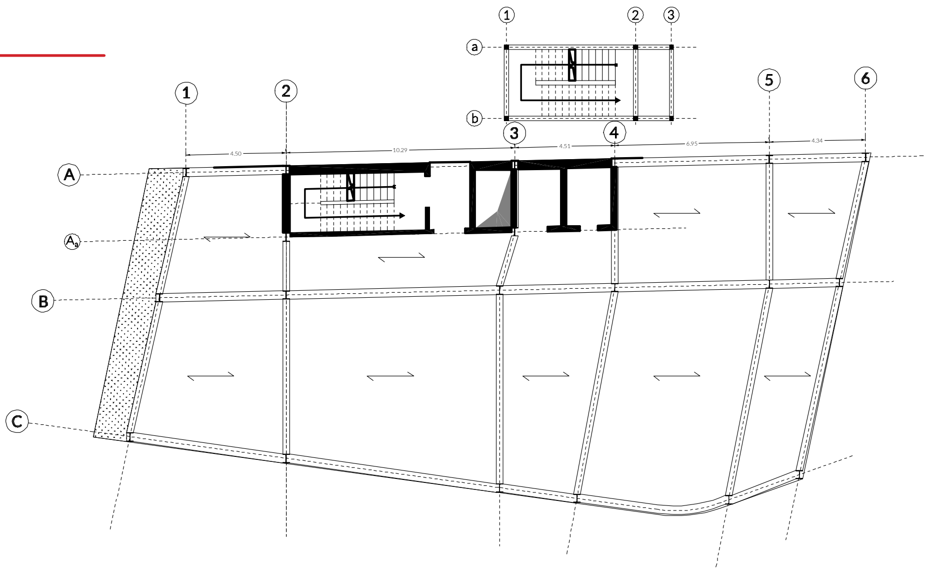
6th FLOOR



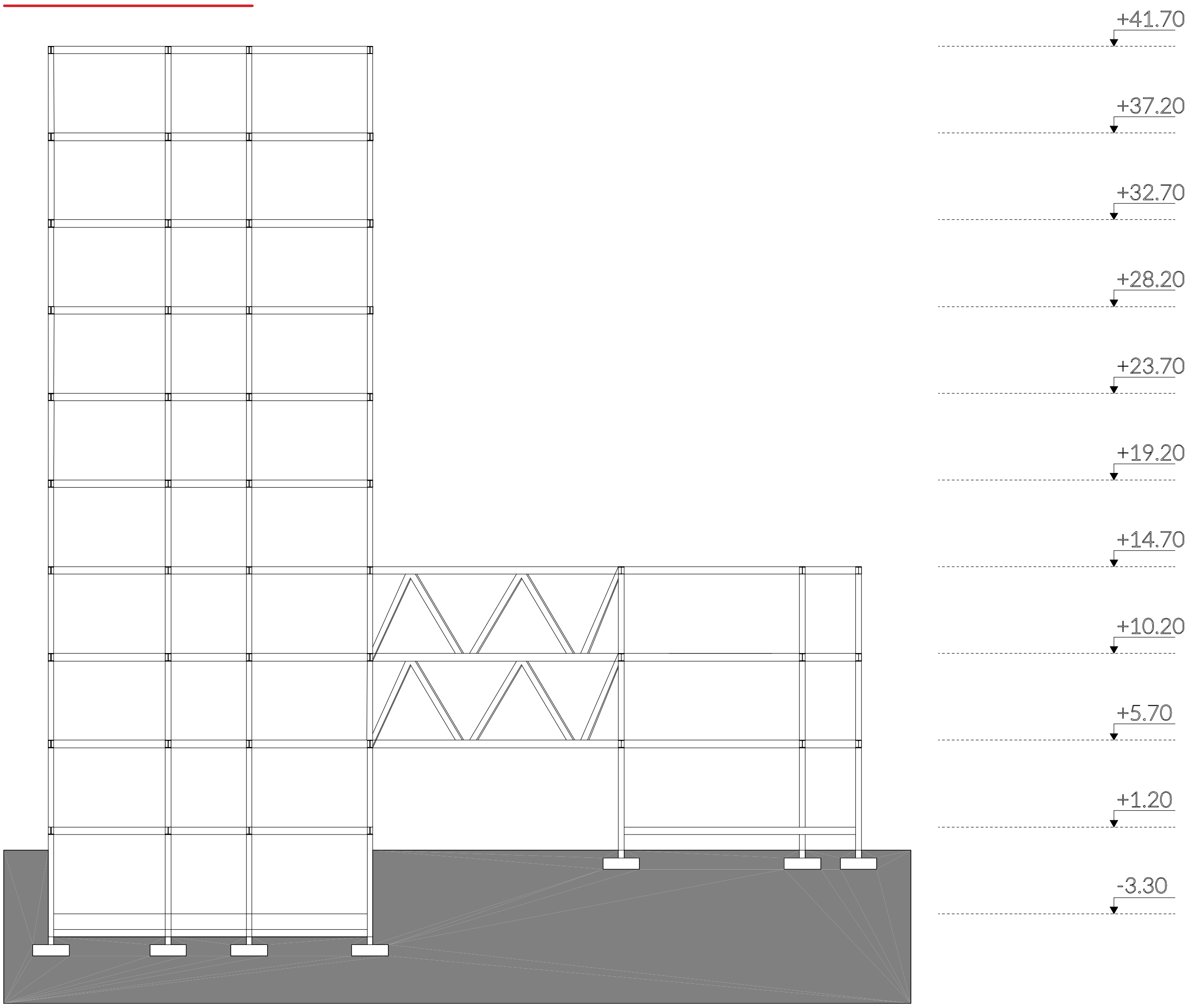
7th FLOOR

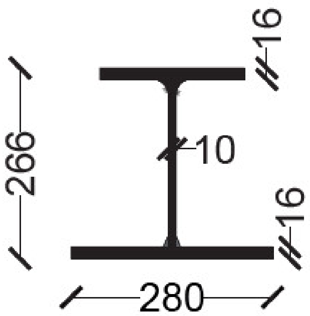


8th FLOOR

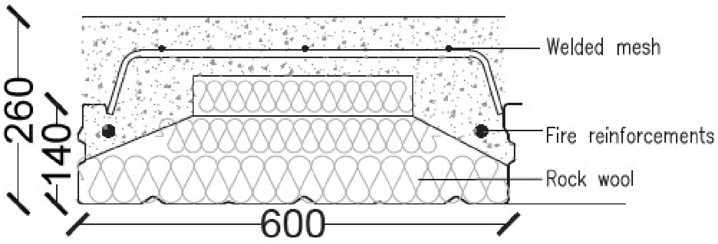


Section

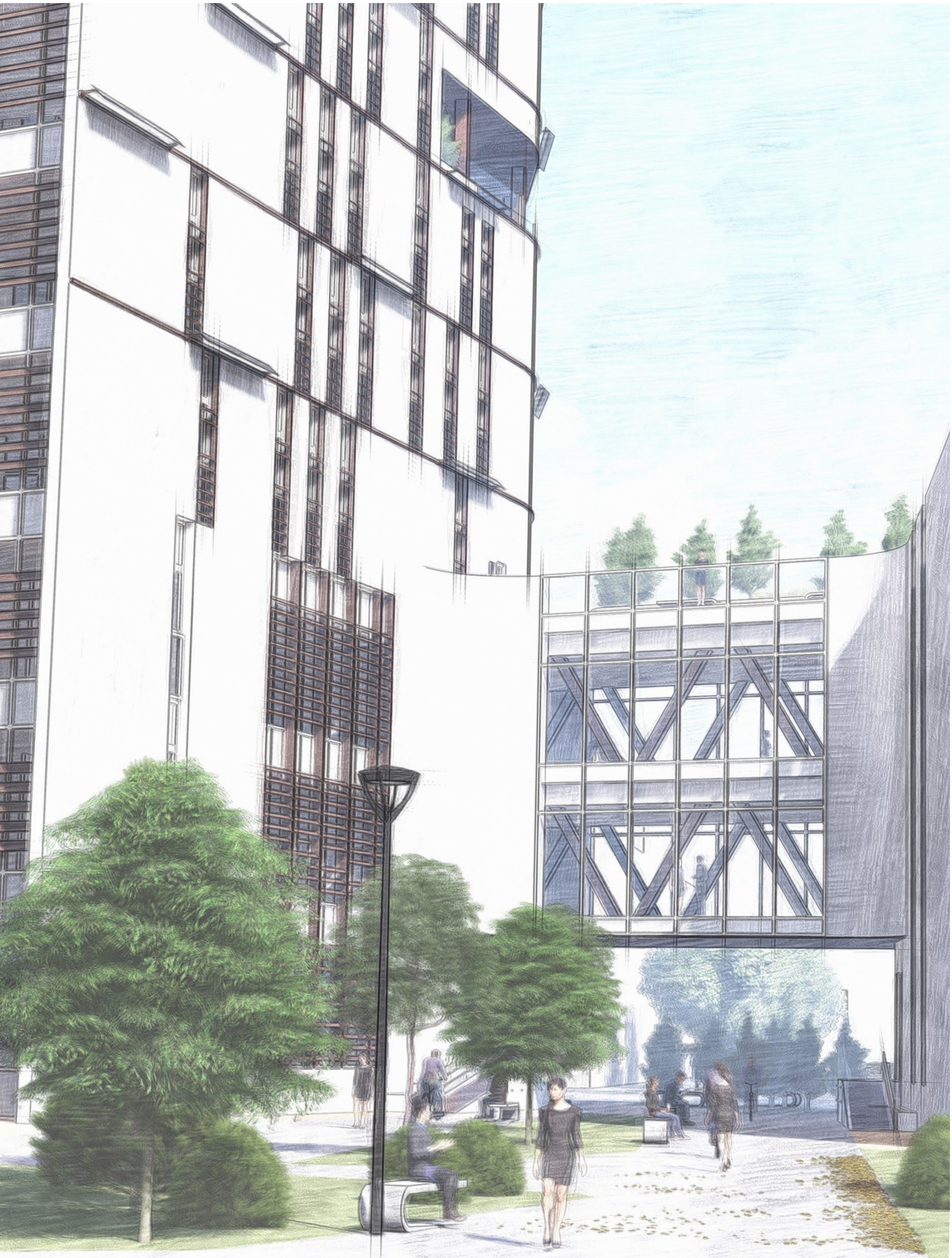




IFB Type A



Cofradal 260



Thanks for your Attention !