GREENHILL RESEARCH CENTER
RENOVATION OF EX SLAUGHTERHOUSE IN MILAN

MASTER'S DEGREE THESIS

SCHOOL OF ARCHITECTUTE URBAN PLANNING AND CONSTRUCTION ENGINEERING

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Dario, Omar , Valentina

Abstract

"Green Hill Research Center" is the renovation project of an industrial building in Milan located in the area of the Ex-Slaughterhouse. The gallery under consideration has a historical importance to be enhanced both for the monumental structure and for its agri-food functions which are maintained by the proximity of the neighboring food market. The purpose of this project is to modernize and return to give life to an abandoned area with great potential; use and adapt the space by creating a strong connection between the existing and the new project, balancing the use of innovative and modern technologies and the revitalization of the previous walls and roof. The Green Hill research center transforms the gallery into a hybrid form that combines conservation and contemporary technological design. It creates a sense of space that celebrates the present and at the same time establishes connections with both the past and the future, this connection is given by a historically rooted context and will result in a structure that will open towards the future through the function of bio-technological and agri-food research. We will try to create a flexible and receptive, historical, and contemporary environment. The project aims to merge the fields of architecture and engineering, making them interact to create a complete project in all its phases; use innovative technologies that create spaces as attractive and impressive as the structure that hosts them. At the same time, we tried to give importance to the environment, climate change, sustainability, and the reduction of CO_2 emissions through passive and active strategies. The main strategy was to use greenery, to create an area that acts as a purifier of the surroundings and which at the same time acts as an interactive space, for the community and functions as interconnection with the neighborhoods.

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1. INTRODUCTION

1.1. Competition and regulations

Reinventing Cities is a global competition organized by C40 to drive carbon neutral and resilient urban regeneration around the world. When the competition launched at the end of 2017, 15 cities proposed 40 different sites for redevelopment and reuse. The first results of Phase 1 of the Reinventing Cities competition are in, and they are promising. The competition received more than 230 creative proposals across 33 sites – and more are expected in the coming months. More than 1,200 different companies and organizations joined at least one bidder team. Together they have formed creative multi-disciplinary teams of investors, developers, architects, environmental experts, start-ups, civil organizations, and artists. Students Reinventing Cities provides a unique opportunity for academics and students to collaborate with global cities. Together they will imagine a more sustainable and inclusive vision for cities everywhere, by rethinking how neighbourhoods are planned and designed. This competition comes at a key moment – we know that the next decade will determine whether we can avoid runaway climate change. Across the world, cities are strengthening their climate commitments and actions. They are developing an ambitious agenda for a green and just recovery from the COVID-19 crisis and building a broad coalition with youth climate activists, representatives from labour, business, academia and civil society.

1.2. Project aim and vision

The renovation project studied in the thesis is part of the Reinventing Cities competitions. The aim is to give rebirth to an industrial and abandoned area were the "food " theme is crucial and has to be kept. This is the reason why Green-hill became a biological and agricultural research centre, immersed in the nature. The aim is to raise awareness on the importance of agriculture and to keep alive the history of the building. This is the reason why part of the building is open to everyone and part of it are open to the public by request, like the greenhouse, so that there is interaction between the main function and the public.

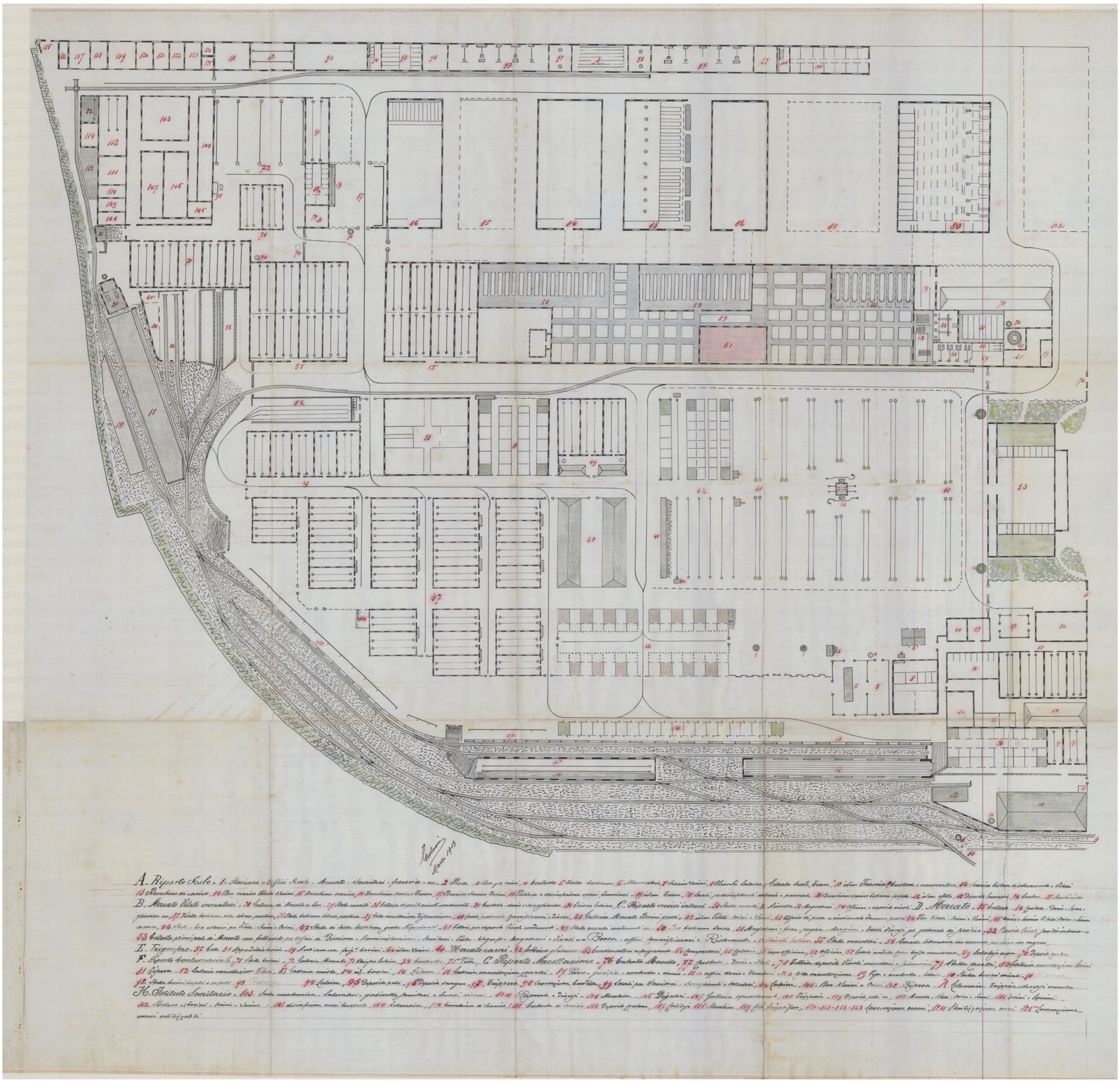
The project will:

•Reduce the impact of emissions due to the buildings. Existing buildings need high levels of retrofit in order to reduce carbon emissions of 50%.

•Support the implementation of new ideas and innovations that can be rolled out on a global scale.

•Actively drive collaboration between the private and public sectors to deliver new approaches to delivering low carbon urbanisation.

•Keep alive the history of the place to people of all ages, and create a community


Marzo 1913
A. Riparto Scalo
B. Mercato Vitelli immaturi
53 Entrata principale di Mercato
E. Frigorifero
61 Mercato carni
F. Riparto Contumaciale
G. Riparto Macellazione
H. Istituto Sanitario

2. HISTORICAL ANALYSIS

1.3. History of slaughterhouse in Italy and Europe

Since the first decade of previous century. The city of Milan was subject to an important campaign of restructuring and reorganization of more conscious and efficient services aimed at an expansion of the capital of Lombardy, the public slaughterhouse of Milan, as well as the expansion of the aqueduct and markets as well as the lighting system of the city, was an integral part of these ambitious projects aimed at achieving greater city well-being. The project, studied by engineers Giannino Ferrini and Giovanni Filippini, was initially carried out between 1912 and 1914. It included an incredibly large area of about 300,000 square meters, nearby the main train stopover and the fruit and vegetable market (now decommissioned). Following the outbreak of World War I and the arms race, the construction of the Milan public slaughterhouse inevitably had delays. It was not until 1924 that engineer Antonio Cecchi finished the ambitious project, continuing to amend it until 1929. This plant was conceived according to the most classic schemes of the European plants then in operation such as those in Dresden, Stuttgart, Cologne and Zurich. The lot located in the former railway station of Porta Vittoria, near Linate airport, hydroscalo and Viale Forlanini, is one of the arteries of Milan. Rectangular in shape, it was equipped with railway junctions, on the north and south sides; obviously the distribution mode of the buildings was closely associated with a functional value more than stylistic. Near the iron-road port, in Viale Molise, there were: offices, slaughter chains, markets and health and veterinary institutes, isolated from the place of production itself. Although the realization of the same has occupied over three lustres, the complex demonstrates a clear evolution of the architectural language as well as the construction techniques used while maintaining, however, a great unity of the whole, faithful to the design and the plant set at the beginning of the century. The purpose of industrial archaeology and the knowledge of monuments and industrial structures, or their localization and the identification of their peculiarity from different points of view, such as history, architecture, technology, urban planning, art, but also customs and social life. Before developing the concept of industrial archaeology it is necessary to define the meaning of the term abandoned areas. It defines those spaces and containers which are no longer used for the activities for which they have been designed and manufactured and which are awaiting use. This phenomenon has been going on for at least a decade and is linked to the cessation of activities and the modernity or services and infrastructure. The disused areas are a sign of the relative stability.

The end of the industrial era in Europe was the cause of the abandonment of the vast production areas and related structures such as worker quarters, railway stations, bridges, power stations, warehouses,etc. there have been profound changes in the form and location of new industrial estates for two reasons: the first is the general tendency of firms to produce intensively and to move industries to cheaper areas, the second being technological innovation and speeding up transport times. Areas are thus abandoned both on the periphery as it is no longer necessary to have ample space for the installation of assembly lines, and within urbanized fabrics as the speed of connections given by the new technology allows you to easily reach several international centres. Moreover, it is often clear that they have always been intensely occupied and are left adrift, while free land is often purchased without apparent need precisely together with the derelict areas are quietly abandoned even in infrastructure, equipment and services, a phenomenon less flashy but no less relevant. Consequently, it can be said that industrial archaeology is not only concerned with specific cases but covers a much wider field.
The impression is that it is not just an area or sector that is in crisis, but that linked to a model and all the urban armour linked to the last technological era, which is being called into question at the same time. According to (Vittorio Gregotti, i territori abbandonati 1990) : The area defined as industrial archaeological heritage, with lives in comma urban centres in harmony or in contrast to recent realizations, preserving the traces of stratification of the various phases of industrialization and have succeeded each other with the numerous generations of industries. The large industrial centres become symbolic places of cities and represent the ways of growth of the city itself. To intervene in these areas, redesigning the and reintegrating them fully into the urban fabric after their divestment, in addition to studying in morphology, it is also necessary to be fully aware of the semantic and structural value they have with respect to the rest of the city precisely in order to redefine the identity of the site and the elements that want to preserve, it is fundamental importance the acquisition of a deep knowledge both of the historical and morphological structure of the surrounding urban reality and of the peculiar characteristics of the areas in question.

THE FIRST PUBLIC SLAUGHTERHOUSE

Observing the Milan plant of 1832 it is possible to outline the south-west area of the city where the first slaughterhouse will be born, an area with poor urbanization. The opening of the Ticino railway station (you can bring Genoa) in 1862, determine the start of a process of total transformation of the area; In fact, the Pubblico Macello (1861-63) is built, on the current Piazza S. Agostino, designedby the engineer Agostino Nazari, the Municipal Technical Office, and the cell prison of S.Vittore (1872-79)of the engineer Francesco Lucca. A number of road arteries are created, including via Olona,the main link between the city centre slaughterhouse.

THE NEW SLAUGHTERHOUSE

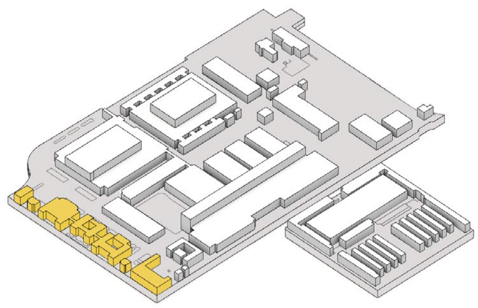
Following the construction in 1911 of the wholesale fruit and vegetable market in progress march 22, the "annotari" interests in Milan move decidedly outside the Spanish walls, in the eastern area of the city. The next new location of Macello pubblico behind the railway station of Porta Vittoria and with the construction of the poultry market in the immediate vicinity of 1925, the conditions were created for the definition of a large south-east area of the city to be used for all activities related to the supply of food. This is due to the position of this area, which facilitates its connection to the main rail, road and air traffic links. Moreover, this area, at the time comma was not yet urbanized (the prerogative for the placement of the slaughterhouse was the distance from the dwellings, mainly due to unpleasant smells) and was large enough to accommodate a large public function such as the slaughterhouse and cattle market.
In this area was then built in the early 60s the current Fruit and Vegetable Market that went to replace the one in progress 22 March. The new slaughterhouse in Milan is inspired by the canons of European public slaughterhouses comma in particular those German comma that provide for the slaughter of large common tunnels connecting different plants comply with the hygienic and sanitary regulations of the time. The new plant came into operation in 1930, although work began in 1914, and occupies about 65,700 sqm , over a total area of 200,000 sqm.

2.1. Transformation of the ex Slaughterhouse along years

In order to understand the typology of the project we need to renovate, It's very important and necessary to demonstrate a clear evolution of massing and functional reallocations among years. That's why highlighting it among time line along years is the main key role to figure out the historical parts that needs to be preserved to keep the identity and also which parts are valid for demolition that will not touch historical value and allowing us to explore new building re-use , adaptive functions, Morphological urban transformations matching with sustainability and new environmental roles. Architectural renovation is taking apart in architecture transformation and is defined as the principle that an architectural concept, structure, or organisation can be altered through a series of discrete manipulations and permutations in response to a specific context or set of conditions without a loss of identity or concept.

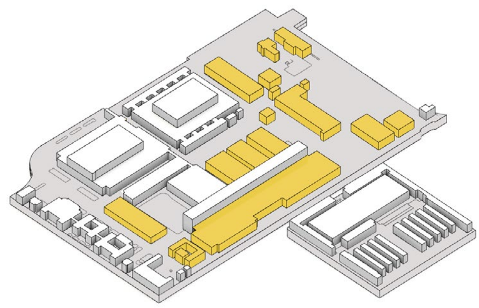
Transformation comes after several investigations going on several basis whether it's urban or renovation or structure and material and also building life cycle that allows us to decide it's good choice to keep , reinforce or to demolish. In following pages we analysed our site location , number of buildings , distribution of functions and each building was subjected to functionally change or even was meant to addition or removal of materials , roofs or extensions. The next time line is stating transformation of the new slaughterhouse after following the construction in 1911 and starting of work in 1914 until the year 1950 after the inauguration of the complex that it is the final state of the site and area with no alter changes till the current moment we are living in now. Noting that also financial condition of the owner and whether the investment is going to get the profit and revenue for him or to keep the land value as it is has to be taken in consideration.

1914-1920



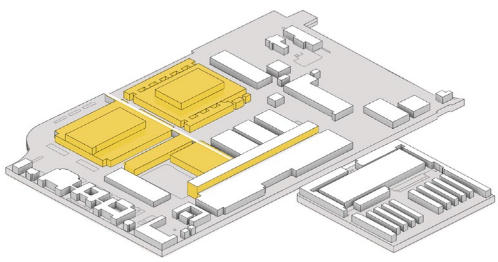
The buildings that faces in Viale Molise hosts the functions of administration, direction, sanitary offices and the livestock exchange building. These lots developed in two floors and are characterized by decorative mouldings inspired by Art Nouveau: such as faux ashlar, coupled windows, bands in coloured ceramic tiles and floral ornamental details. The structure of the Liberty in the middle was completed in 1916 despite the war, while the construction of the lateral ones were interrupted until 1924. This transformed the style into an objective language in which the decorative apparatus is eliminated in favour of the pure exposure of the reinforced concrete structure.

1920



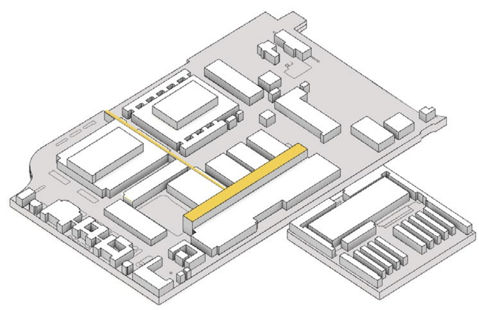
The works started in 1914 continue, once the liberty buildings are finished, the foundation works of the slaughtering galleries and the refrigerator and the complete construction in rustic of some buildings for the services of the livestock market begin. In recent years, to facilitate the supply of building materials, part of the livestock yard was built with a provisional connection to the Porta Vittoria station.

1930



In these years the two large buildings to the north developed with the function of the calf, pig and sheep market and the large cattle market. At this time there was a lot of talk about livestock as by examining the market trend you can get information on the conditions of agriculture as, for example, when drought ruins the countryside it makes it difficult to feed livestock. In the last three years, the meat trade has developed a lot, signifying the improved tone of life of modest social categories. With this third and last lot the works are concluded with a total cost of 17,000,000 lire.

1950



After the inauguration of the complex in 1930, this. The general aspect of the complex was that of a modern and efficient urban equipment, at the levels of European standards. In the 1950s, to increase the hygiene of the exhibition gallery, it was decided to cover it with a metal truss. However, the constant growth of the city has led the slaughterhouse to no longer be part of such a peripheral area. Thus began the decline of the slaughterhouse around the 1970s until 2007 when the business was definitively ceased.

2.2. Milan: Beruto, Pavia-Masera, Albertini, Veneziani plans

The Beruto plan (1884-1889)

Two floors were studied by the engineer Beruto, the first in 1884, who obtained the approval of the City Council in 1886, but was sent back to the Superior Council of Public Works; the second, in 1888, which was approved by law of 1889. With the first floor, Beruto responds to the need for expansion with a radial reticular road system, which is inserted between the original arteries of penetration, forming blocks of about 400 meters on each side so as not to jeopardize future development with a mesh that is too narrow, in order to to allow even large residential or industrial constructions. In fact, Beruto himself states that small blocks are the result of speculation. Beruto's plan, therefore, rejects a dense and undifferentiated road network, which would allow immediate subdivision and would therefore become easily usable for building purposes. Beruto intends to limit himself to marking the main road routes, making up the so-called "general plan", leaving the small subdivision to be studied with partial plans, anticipating what will be the distinction between the General Town Plan and the detailed Implementation Plan. Another characteristic aspect of the plan is the importance assumed by the vast area of expansion envisaged and the modesty of the gutting interventions in the historic centre and within the Spanish walls, when the contemporary city plans of Rome and Naples heavily open the way. to the destruction of historical nuclei. In reality, the birth of urban planning is intertwined with economic interests linked to land rent. In short, the plan of 1884 is an extraordinarily avant-garde plan in the conception of the city and of society itself. Considering all the areas preserved from the building (roads, gardens, public spaces), each of the 250,000 inhabitants settling in the expansion areas would have been entitled to a per capita endowment of at least 25 square meters of public equipment, equal to 10 square meters / in destined for streets. The location of the green spaces, then, is studied with the intention of creating in the future crown of new buildings equidistant public gardens so that each neighbourhood can use them.

However, the Plan was rejected in Rome by the Higher Council of Public Works and sent back to Milan for a new draft. The refusal to approve the first project by the government authority is motivated by a series of reasons mainly of a formal nature: isolated with too large meshes; irregularly shaped blocks; excessive frequency of curved lines in the shape of the squares and in the layout of the streets. To the observations made by the Ministry, Beruto in 1887 proposed a detailed report with which he tried to justify the design choices he made. In the first place, he justifies the large size of the blocks by arguing that this would have allowed a lot of freedom to construction, thus also allowing the settlement of industrial complexes and large building complexes. Linked to this was the choice of limiting the road layouts only to the main ones, so that case by case the subdivision would have been carried out, depending on the type of intervention and the context. Secondly, he affirms that the choice not to have used a rectangular subdivision but to have opted for an irregular subdivision was born both from the desire to reject the regularity of the cities that arose from scratch, and the possibility of guaranteeing a radial-type road system layout. Diagonal, which would have constituted a way of saving time in the journeys according to the relationship between the hypotenuse and the sum of the legs. Finally, as regards the choice of circular squares, Beruto affirms the desire to include Milan among the European cities, citing a series of foreign examples (including Berlin and Paris). However, the Ministry's observations have their effect and the municipal administration orders Beruto to compile a new plan. Beruto, in this second version, then subdivides the blocks with more intense road links, sometimes eliminating some diagonal roads, some roundabouts, some triangular blocks: in substance much of the space intended for public use and green spaces is reduced and greater extension is guaranteed to building surface, making new lots faster to build. The special municipal commission deliberate the plan on 20 June 1888 and the ministry approves it with law 11 July 1889 no. 6210. The internal area, included between the ramparts, appears in the plan table with only the main radial arteries that branch off as ramifications from the Piazza del Duomo. You can find via Orefici, piazza Cordusio, via Mercanti, via Dante and the system of the Foro Bonaparte. The area of the Forum up to the Arco della Pace is left blank.

The Pavia Masera Plan (1910-1912)

The potential of the Beruto Plan therefore did not find adequate realization. The lack of planning is in fact increasingly accentuated by the economic interests linked to urban development. In the historic centre the process of demolition and tertiary transformation is accentuated while the suburbs are enlarged like wildfire in all directions, setting the new road network on the already partially defined radio centric type. So the Municipality of Milan commissioned a new plan from its engineers Angelo Pavia and Giovanni Masera, which was adopted in 1910 and approved by the Ministry in 1912. For the area inside the Bastioni, the decision to demolish large areas is continued: the creation of Corso Matteotti, the opening of Corso Italia, the enlargement of other streets, including Corso Garibaldi. As for the area outside the Spanish Walls, an urban expansion of 2,240 hectares and the settlement of 560,000 inhabitants is planned. The road scheme resumes that of Beruto, extending the interrupted radials and creating new roads perpendicular to them. All these choices lead to the creation of an urban aggregate increasingly gravitating around the centre and weighed down and suffocated by concentric rings. It is therefore an expansion plan, which does not tend to develop the expansion of the city towards the north, because by now the expansion has almost reached the municipal boundaries, and which as the only criterion for differentiating the destinations has the different size of the lots, wider for industrial locations, smaller for residential ones. In the areas adjacent to the more densely built ones, the road network is rather dense, in particular to the east and north-east where the buildings have now reached the boundary of the previous plan, while further outside, along the railway and along the arch southern and western, the road network is large mesh. The new element contained in the plan is the railway. The old railway belt constitutes a barrier and therefore a new and wider one is planned, in the shape of an inverted C, which is based on the transformation of the Central from a transit station to a head station, placing it more externally. In summary, the Pavia-Masera Plan takes up the second Beruto Plan in its general lines and gives complete form to the transformations to which the Beruto Plan had been subjected: the build-ability of many land is guaranteed while public destinations are almost completely forgotten. The First World War marks a setback in the implementation of the new plan.

The stagnation due to the conflict (1914-1918) was followed by a huge building recovery, mainly towards the north and north-east. Thus it happens that in 1926 the Prefectural Commissioner of the Municipality of Milan announces a national competition for the preliminary project for the Town Plan for the expansion of the city of Milan. In reality, the Pavia-Masera plan had not yet been completed. The competition notice requires precise indications for the inner city area for public services and green spaces, highlighting the need for free areas in relation to the built, and raises awareness of the need to conceive Milan and the surrounding municipalities through separate regulatory plans. that do not accentuate monocentrism. He also mentions, albeit briefly, the concept of zoning, ie the distinction between the intended uses (residential, commercial, industrial). The winning plan bears the signature of the architect Portaluppi and the engineer Semenza. Immediately after, a municipal planning office was created headed by the engineer Albertini, for the final draft, with the declared aim of collecting the best proposals among those presented in the competition. Albertini, who takes six years to draft the new plan, does not take into account the information from the 1926 call.

The Albertini palan (1934)

It should be remembered that the period following the First World War marks a very difficult moment for the history of Italy. The strong inflation is felt above all for the workers and for the middle class. The workers, after having fought in the trenches, find themselves with poor wages and few rights. Not everyone has a job, as industrial productivity comes to a halt. Meanwhile in Russia, from 1917, Lenin gave way to the Revolution. From 1919 to 1920, Italy was crossed by the so-called "red two-year period": workers went down to fight against the high cost of living, to raise wages, for an eight-hour working day and to have more rights inside the factories. Between August and September 1920 the factories are occupied. Meanwhile, in 1919 the Fasci di Combattimento were born in Milan, founded by Benito Mussolini and a group of ex-combatants. Industrialists are turning to these armed groups to try to quell the riots. The Fasci quickly became the National Fascist Party and, in the climate of general disorder, gathered thousands of support, especially from the middle classes and the industrialists. On 2 August 1922, the fascists occupied Palazzo Marino, the seat of the municipality, and violently dissolved the socialist municipal administration.

At the beginning of the century Milan had incorporated the towns of Turro and Greco Milanese. But after the war, given the strong development of the industrial city, especially towards the north-east, it was decided to aggregate eleven other neighbouring municipalities (1923). Today they are all neighbourhoods of the city. In this period Milan reaches a territorial extension of 185 square km, practically analogous to that of today, and a population of about 860,000 inhabitants. In fact, the industry is in full production: in 1927 it produces ten times more than in 1914. The industrialists have financial and fiscal facilities but there is still strong inflation and a strong deficit in foreign trade. In 1926 Mussolini decides the revaluation of the lira, with the consequence of the decline in exports and the crisis of small industries. The answer is a decrease in wages by 20% in 1927. In 1929 the world crisis produced by the collapse of Wall Street has its consequences also in Italy. The Thirties were difficult years: the very serious economic crisis produced the collapse of the national income. Wages are still decreasing until they are reduced in 1934 to half of those of 1926. In the country there are a million unemployed but the censorship prevents it from being known. To save the major industries, the fascist government favors concentration with the foundation in 1933 of the IRI (Institute for Industrial Reconstruction). To stop the crisis and unemployment, the government is carrying out numerous public works (construction and reclamation). The war in Ethiopia sends a good number of unemployed to Africa, turning them into troops. It also produces excellent business for the industry, with the mirage of a new rich land to be exploited. The result, however, is political isolation on the part of the League of Nations. It is forbidden to trade with Italy. Mussolini reacts to the sanctions with Autarchy, an extreme form of protectionism: it forbids buying foreign products, giving incentives to produce, consume and recycle only Italian products. After 1935, Milan continues to grow at a rate of 50,000 inhabitants per year. In 1940 it reached 1,327,000 inhabitants. The neighbouring municipalities, such as Sesto San Giovanni and Cesano Maderno, are also growing. This is the period in which the so-called “recovery pickaxe” is put into action on the city center. ”Restoring” a neighbourhood means demolishing the old houses, considered unhealthy, and sending the inhabitants to the suburbs: in Lorenteggio, Ortica, Baggio, Bruzzano. , Vialba, San Siro as poor were evicted.

And in the heart of the city, in the grandiose style dear to the regime, the construction of new neighbourhoods begins. The San Babila area changes face. Instead of an old neighbourhood, the Toro Insurance building (architect Piero Portaluppi), the Teatro Nuovo and other buildings with arcades for shops, offices and luxury homes were built. In the same style, the buildings along Corso Matteotti, called Corso Littorio (1934). The Galleria del Corso with its cinemas was built from Corso Vittorio Emanuele to Piazza Beccaria. From the evictions south of Piazza Cordusio rises the new business district, with the stock exchange building. Piazza Diaz was also created with the two twin buildings of the Arengario (architects Griffini, Magistretti, Muzio and Portaluppi). In 1931 the Central Station (architect Ulisse Stacchini) came into operation, with an Assyrian-Babylonian style. In place of the ancient station of the times of the Unification of Italy, the current Piazza della Repubblica is opened. The Planetarium, built by Portaluppi, is also from this era. The publisher Ulrico Hoepli gave it to the city. Many bourgeois houses are built along the ramparts and along the avenues obtained from the demolition of the ancient nineteenth-century railway belt. The plan drawn up by the engineer Cesare Albertini provides for all these demolitions in the centre, ignoring the interesting indications of the 1926 notice and tending to ensure an intense building development of the city, from the centre to the municipal borders. In the central area, therefore, a network of large arteries 30 meters wide, drawn with the intention of de congesting the Piazza del Duomo and its immediate surroundings, produce a gutting of various city sectors. The declared intentions are to activate the building renovation. It is stated that through numerous arteries converging towards the centre it is possible to determine centrifugal thrusts towards the periphery. In reality, the effects that this type of approach generated were mainly the growing outsourcing of the centre, a process that had already begun in the decade 1921-1931, and the widening of the centre-periphery gap. It should be remembered that between 1928 and 1930 the Navigli were covered, a procedure initiated to make the centre more functional to the needs of offices and traffic as well as for hygienic reasons. This is an event that radically changes the image of the city, as was the demolition of the Spanish ramparts planned by Beruto.

The 1945 competition and Venazi Plan

The king and the government flee to Brindisi, under the protection of former enemies, now allies. The Germans immediately spread to Italy and free Mussolini, putting him at the head of a puppet state, the Italian Social Republic, with its capital in Salò. But the decisive role is played by Milan, taken by the Germans three days after the armistice. The Italian army was left without a guide and in a few weeks the Germans captured and deported six hundred thousand soldiers en mass to German and Polish concentration camps, establishing the death penalty for draft dodgers and their relatives. Those who do not want to obey hides or joins the partisan formations in the mountains and on the Oltrepò hills. Guerrilla groups are also formed in the city to organize attacks and sabotages (the GAPs, Patriotic Action Groups). However, for every German dead, many more were the Italian convicts. In short, Milan lives in a climate of terror, in the absence of all basic necessities. In the spring of 1945 the Allies broke through the German defenses on the Apennines and the partisans descended from the mountains. April Mussolini flees to Switzerland. On the night of April 26, the GAPs occupy the strategic points of the city and during the day the center is liberated, while the partisan brigades enter the city. The Allies arrive on April 29th. The Germans surrendered only on 1 May, when Mussolini was already captured and shot by the partisans. suspension of the validity of the Albertini plan and with the competition of ideas launched in November 1945 for the drafting of the new master plan, also in relation to the indications of urban planning law no. 1150. The Albertini plan had made it possible to make every single lot immediately build-able through demolition and demolition in the center and through a very dense road network, from the center to the periphery. The only attention to greenery was guaranteed by the rows of trees along the new arteries, which from that moment on will strongly characterize the Milanese urban fabric. Faced with this deficiency, it is evident that the requests of the 1945 competition announcement for the drafting of the new plan place particular emphasis on the use of large areas for public services as well as the creation of new green spaces and the conservation of existing ones. It should be emphasized that the spirit that animates the competition of ideas of 1945 is that of the participation not only of technicians but also of all citizens who want to make proposals or highlight needs in order to achieve a real rebirth of the city after the war.

The result is a long public discussion in the rooms of the Castello Sforzesco that meets for thirty sessions in order to draw a picture of the possible development of the new Milan. The proposals of the AR plan (Architetti Riuniti, i.e. Albini, Bottoni, Gardella, Mucchi, Peressutti, Pucci, Putelli, Rogers) are the most incisive. They refuse the outsourcing of the historic center and propose the establishment of the new business center in the area of the former Scalo Sempione and are already thinking of the need for an integrated underground railway network mainly serving the province. After the debates, the junta that governs Milan after World War II entrusts the councilor Venanzi with the drafting of the new master plan. The study of the new plan officially began in July 1946. The Municipality decided to prepare an articulated work program through the collaboration of several commissions. A General Commission is specifically appointed, with the councilor Mario Venanzi as chairman, headed by a Technical Office, a Commission for implementation practices as well as a Central Commission divided into a series of Study Commissions for the various areas of the city and in a series of Advisory Commissions for specific topics (traffic, art, transport, hygiene, etc.). Operationally, a model analysis sheet is prepared to be applied to the various sectors of the city. The inspections take six months of work. In addition to the specific cards for each district, overall illustrative tables are created that highlight the condition of the entire city, for example with regard to the location of industries and the hygienic condition of existing buildings. On the basis of all this information, collected and processed, the Central Commission, which until now has supervised the activity of the Study and Consultative Commissions, prepares a plan scheme starting from three fundamental aspects: the location of the New Headquarters, the road and a sketch of functional subdivision between residential and industrial areas. The Venanzi Plan was then adopted in March 1948, starting from the proposals of the AR plan and the awareness that in Milan it is necessary to invest in the interest of the community, dealing with the reality of things, neighborhood by neighborhood. It is precisely from this moment that the lack of public spaces begins to be evident, in each neighborhood. In the 1948 plan, Venanzi proposes to move the business center from Scalo Sempione, as proposed by the AR Plan, to the area between the Garibaldi station and the Central Station and introduces the system of ring roads, subways and large urban parks.

MILAN CITY MAPPING BY MUNICIPALITY I,II

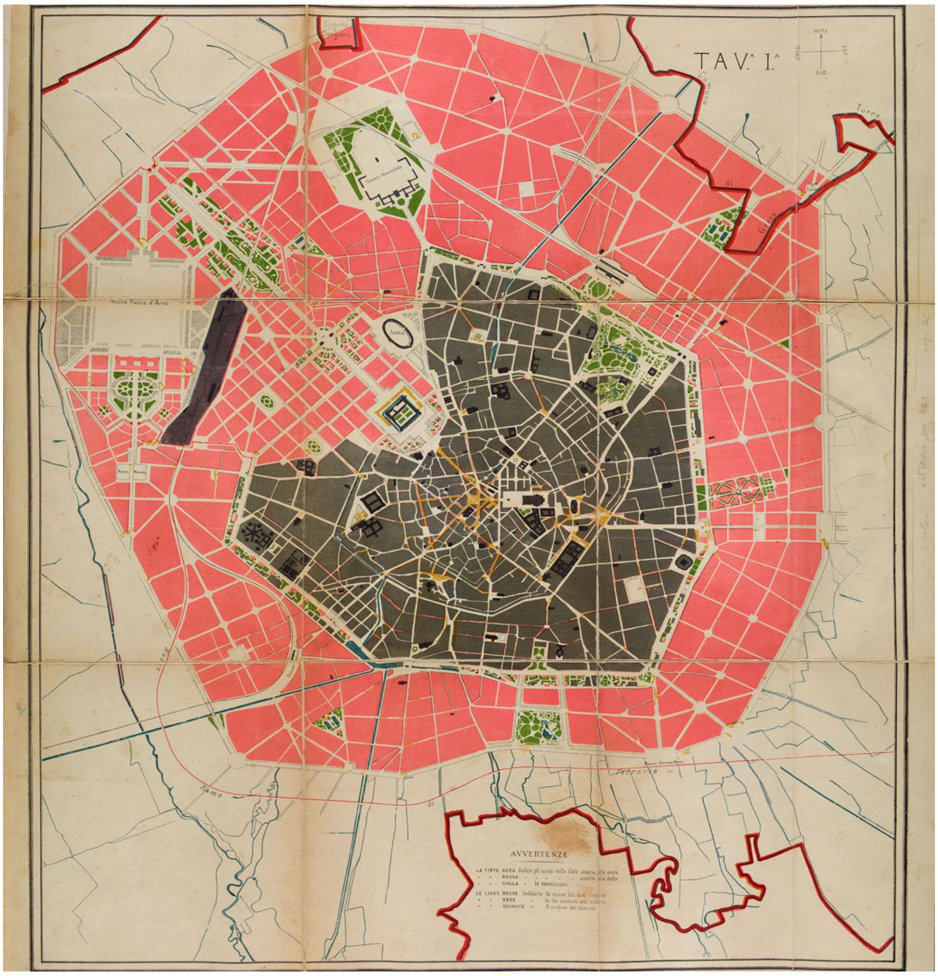


Fig.1: Regular plan of Milan city by Engineer Cesare Bruto.

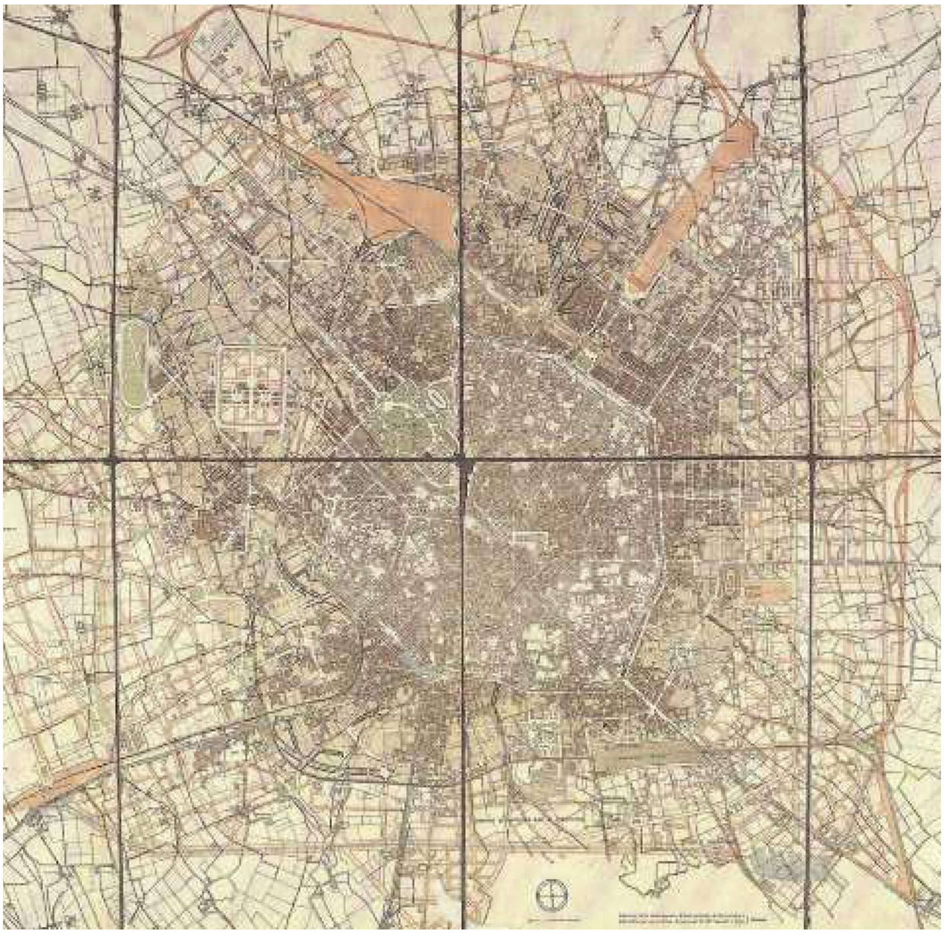


Fig.2: The regulatory and expansion plan of Milan. Drawn up by Angelo Pavia and Giovanni Masera

MILAN CITY MAPPING BY MUNICIPALITY III,IV

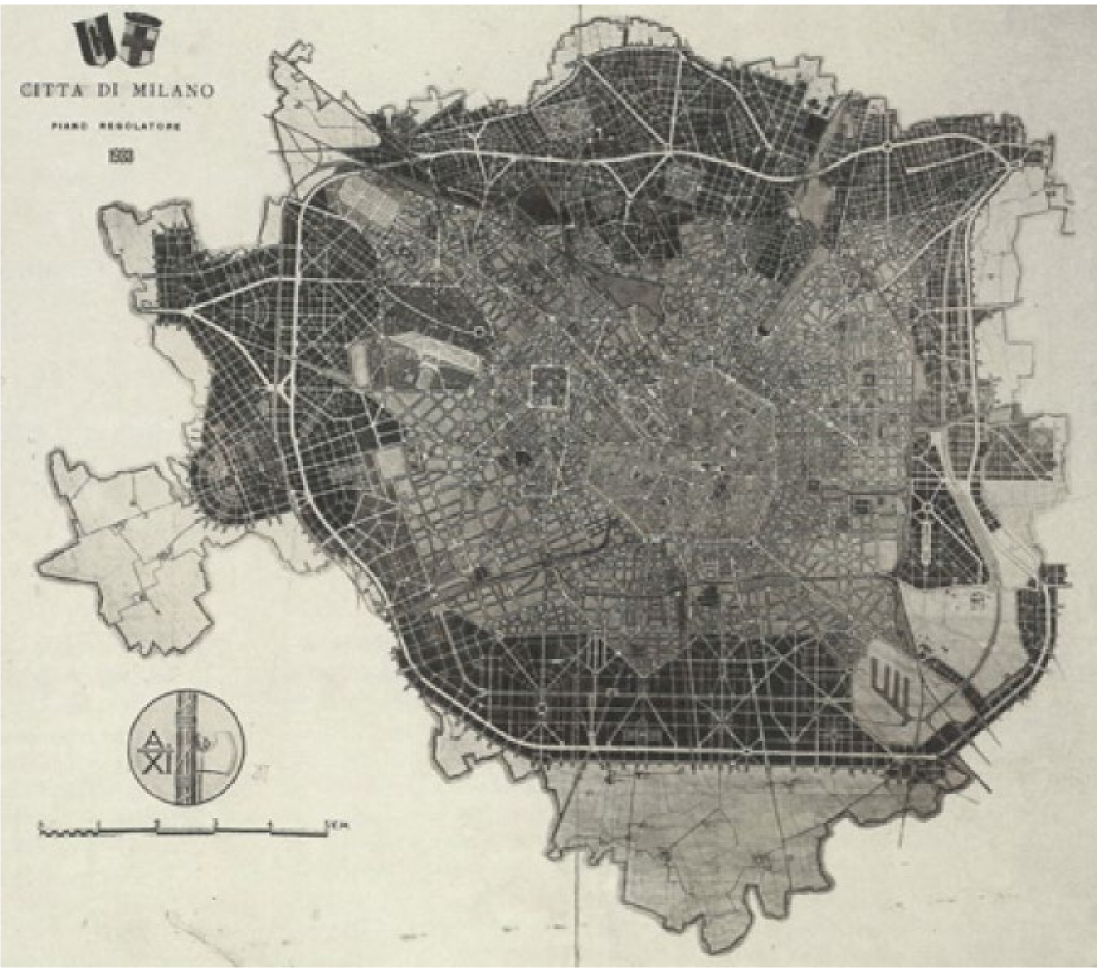


Fig.4:Milan City expansion to Garibaldi by Municipal Engineer Albertini

Fig.3:The New Masterplan of Milan city by the councilor Venanzi competition

2.3. Technical sheets and specifications

A data sheet or technical specifications sheet is a document that summarizes the performance and other building characteristics including foundations, plans and 3d buildings to understand the role of the component in the overall system. Typically, a datasheet is created by a technical committee and begins with an introductory page describing the rest of the document, followed by listings of specific characteristics, with further information on the connectivity of the buildings. In cases where there is relevant source code to include, it is usually attached near the end of the document or separated into another file. Datasheets are created, stored, and distributed via product information management or product data management systems.

Depending on the specific purpose, a datasheet may offer an average value, a typical value, a typical range, engineering tolerances, or a nominal value. The type and source of data are usually stated on the datasheet. A datasheet is usually used for commercial or technical communication to describe the characteristics of an item. It can be published by the manufacturer or responsibile municipalities. By contrast, a technical specification is an explicit set of requirements to be satisfied by a material, product, or service.

In the upcoming sheets we started to define clearly each building of our masterplan. Defining building location and providing a brief discription about the use of that building and the purpose of functioning it. In addition to the last original version of architectural plans including general information about year of construction , built up area , total building volume and building dimensions. As well as the building typology and images reflecting the current building state.Meanwhile while performing analysis on the building we found several structural and building systems using different types of materials connected together in which creating a masterpiece using building latest building technologies at that time. under conservation state , it was defined the current level of it and if it's applicable to conserve or not in iddition to architectural interest and flexibility reuse.

MAINTENANCE WORKSHOP

BUILDING N 8

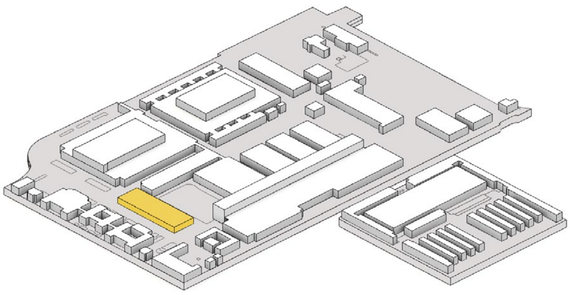


Fig.6: Building location

The slaughterhouse complex was made up of mechanical structures and systems that required constant maintenance and control, to avoid slowing down the slaughtering cycle. For this reason, the building is divided into several rooms with a very variable surface and is intended for laboratories (carpentry and blacksmith) and maintenance depots.

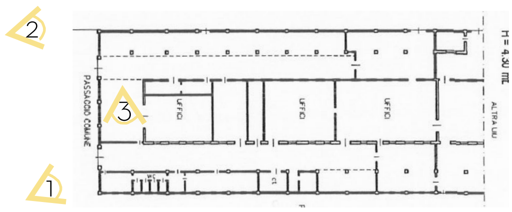


Fig.5: Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	2 277 m2
Volume	6 675 m3
Height	4,3 m
Structure	
Foundations	Strip foundations in concrete
Vertical	Full bricks.
Horizontal	Beams: ---
	Slab: hollow block
Roof	Wood structure and corrugated roofing
Finishes: int and ex	Plaster internally and externally, concrete floors
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Medium
Flexibility reuse	Low

OFFICES AND STORES

BUILDING N 9

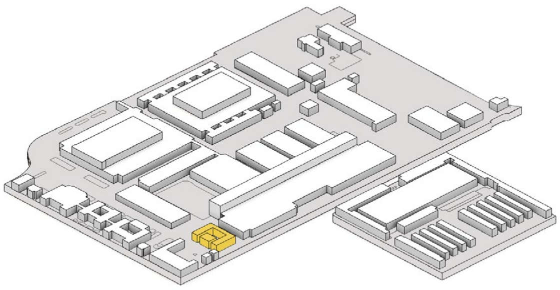


Fig.8: Building location

The building essentially consists of a building with a total of 3 floors, 1 of which is underground and 2 above ground and an uncovered area intended for a common courtyard. The basement is intended for deposits, while the central building is intended for offices and related services both on the ground floor and on the first floor.

Fig.7:Ground floor and first floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	1 169 m2
Volume	4 558 m3
Height	8,4 m
Structure	
Foundations	Strip foundations in concrete
Vertical	Full bricks
Horizontal	Beams: ---
	Slab: hollow block floor
Roof	Wood structure and corrugated roofing
Finishes: int and ex	Plaster and grit floor internally and externally, smooth shot blasted and hammered
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Medium
Flexibility reuse	Medium

EX MEAT MARKET

BUILDING N 10-11

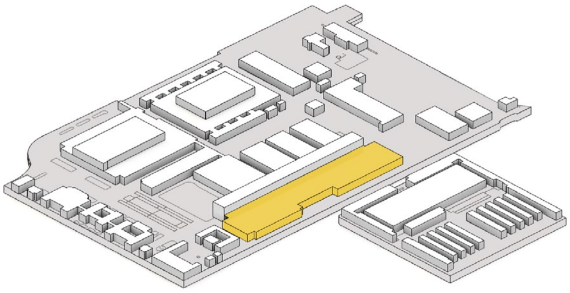


Fig.10:Building location

This building is divided into several volumes connected by a majestic central gallery. The bodies intended for preparation and slaughter are made up of three sheds, with just a single floor above ground, with a structure in reinforced concrete pillars. In these there are large tiled rooms in which some secondary operations were carried out, well lit by numerous windows. These parts are located north of the tunnel, so as to connect to it perpendicularly.

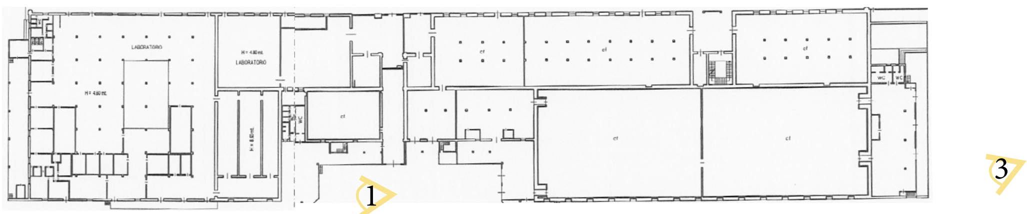


Fig.9:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	9 000 m2
Volume	90 900 m3
Height	6,4 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: mixed in iron and Hollow block floor
Roof	Wood structure and corrugated roofing
Finishes: int and ex	Plaster internally and externally, concrete floors
Windows frame	Iron
Conservation	
Conservation state	High
Architectural interest	Medium
Flexibility reuse	High

VITELLO HALL

BUILDING N 12

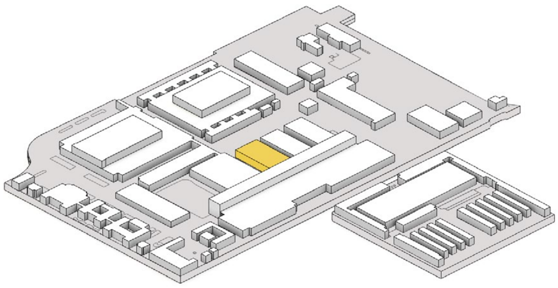


Fig.12:Building location

Industrial style with 1 floor above ground and service tunnels.The building has a vertical load-bearing masonry structures for the perimeter walls and in steel pillars and reinforced concrete and iron beams with a mixed brick concrete floor. The roof is flat with iron and glass skylights. In this building, sheep calves were slaughtered only at certain times of the year.

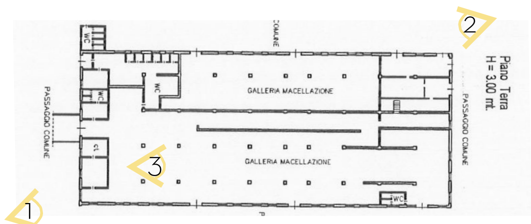


Fig.11:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	841 m2
Volume	9 681m3
Height	3 m
Structure	
Foundations	Concrete bearing slab
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: mixed in iron-ore cement
Roof	Hollow block structure
Finishes: int and ex	Plaster internally and externally, plaster + smooth shot blasted and hammered
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Low
Flexibility reuse	Medium

SLAUGHTERHOUSE A

BUILDING N 13

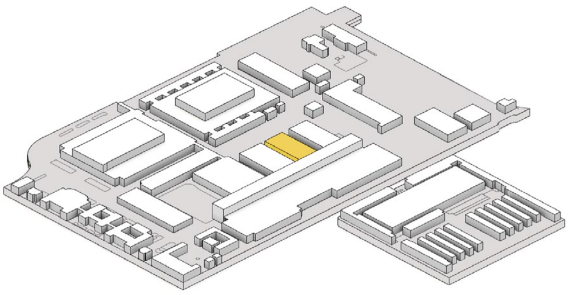


Fig.14:Building location

Industrial style with one floor above ground and service tunnels. The building has vertical load-bearing masonry structures for the perimeter walls and in steel pillars and beams in reinforced concrete and iron with mixed slab in brick concrete. The roof is flat with iron skylights and glasses.
Adult cattle were slaughtered in this building. It was therefore the most used slaughterhouse.

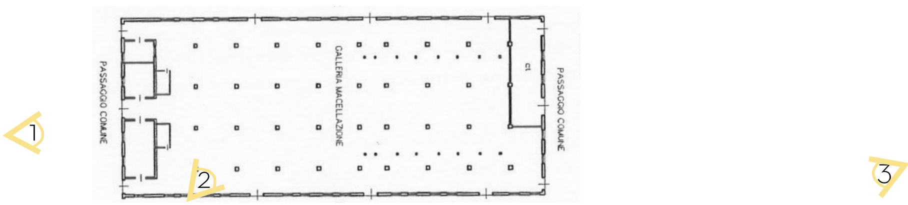


Fig.13:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	839 m2
Volume	8 945 m3
Height	7,5 m
Structure	
Foundations	Concrete bearing slab
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: mixed hollow block floor
Roof	Flat roof with hollow block structure
Finishes: int and ex	Plaster internally and externally, smooth shot blasted and hammered
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Low
Flexibility reuse	Medium

SLAUGHTERHOUSE B

BUILDING N 14

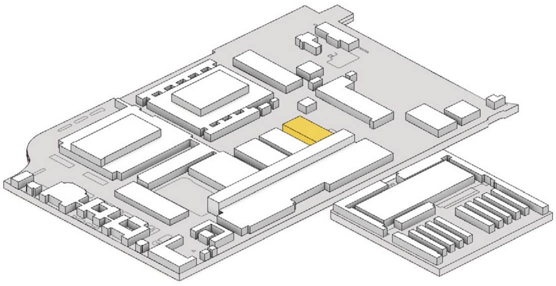
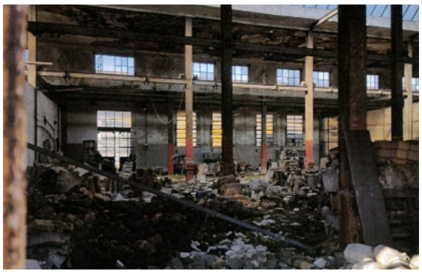
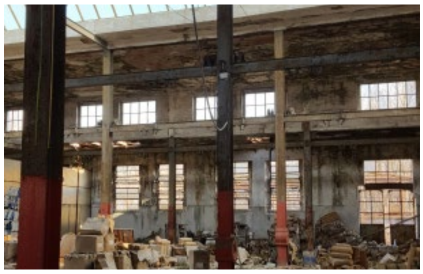


Fig.16:Building location

Industrial style with 1 floor above ground and service tunnels. The building has vertical load-bearing masonry structures for the perimeter walls and in steel pillars and beams in reinforced concrete and iron with mixed slab in brick concrete. The roof is flat with iron skylights and glasses.
In this building horses were slaughtered on the one hand, while the skins and fats were processed on the other.





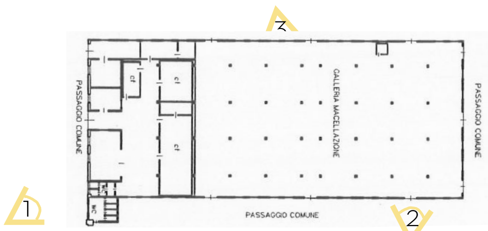


Fig.15:Ground floor and first floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	860 m2
Volume	9 842 m3
Height	7,5 m
Structure	
Foundations	Strip foundations in concrete
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: mixed hollow block floor
Roof	Flat roof with hollow block structure
Finishes: int and ex	Plaster internally and externally, smooth shot blasted and hammered
Windows frame	Iron
Conservation	
Conservation state	Good
Architectural interest	Low
Flexibility reuse	Medium

BOOKING BUILDING

BUILDING N 15

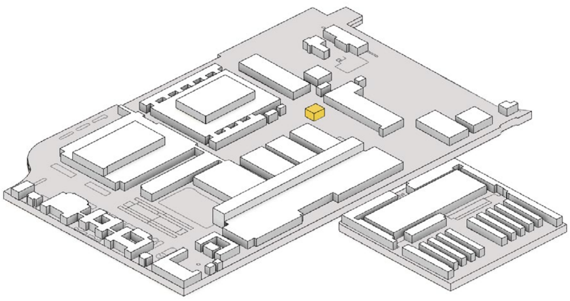


Fig.18:Building location

The building consists of a civil type building for office use with two floors above ground and a basement. The state of conservation is very poor even if the load-bearing structures do not show any damage, but the building and plant components no longer fulfill their function including the roof covering from which copious infiltrations occur which affect the underlying floors. Two weighing systems are combined with the building.

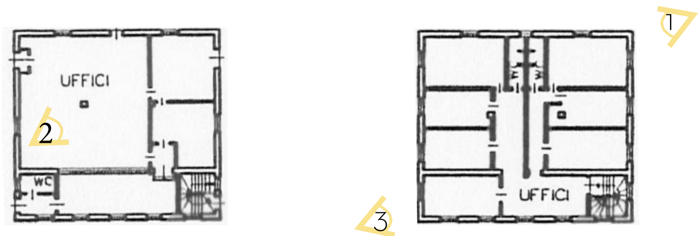


Fig.17:Ground floor and first floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	207 m2
Volume	2 070 m3
Height	10,7 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks
Horizontal	Beams: reinforced concrete
	Slab: Hollow block floor
Roof	Wood structure and corrugated roofing
Finishes: int and ex	Plaster internally and smooth and hammered grit externally; marble floors
Windows frame	Wood
Conservation	
Conservation state	Low
Architectural interest	Low
Flexibility reuse	Medium

LIVESTOCK INSURANCE OFFICES

BUILDING N 16

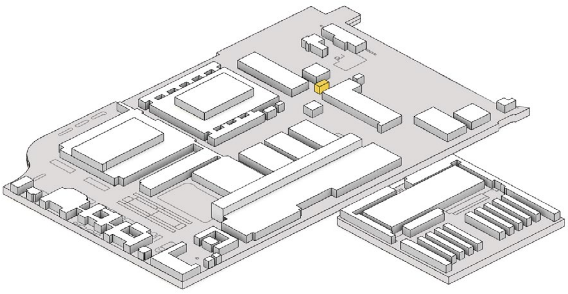
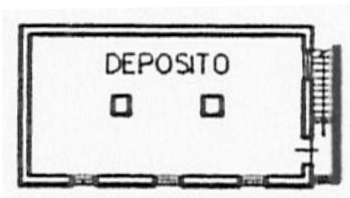


Fig.20:Building location

Slaughtering is a long and delicate process, this is why it requires the supervision of different types of workers.
For this reason, small buildings like this one housed the offices and the sourvailance necessary.

The basement floor is a storage area, while the ground floor is destined to offices and survailance. The building, although it has been abandoned for several years, does not present major structural



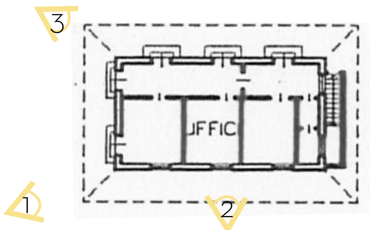


Fig.19:Ground floor and first floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	98 m2
Volume	399 m3
Height	2,6 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks
Horizontal	Beams: ---
	Slab: Hollow block floor
Roof	Flat roof
Finishes: int and ex	Plaster internally and smooth and hammered grit externally; marble floors
Windows frame	Iron
Conservation	
Conservation state	Medium
Architectural interest	Low
Flexibility reuse	Low

PRE-SLAUGHTER STABLE

BUILDING 17

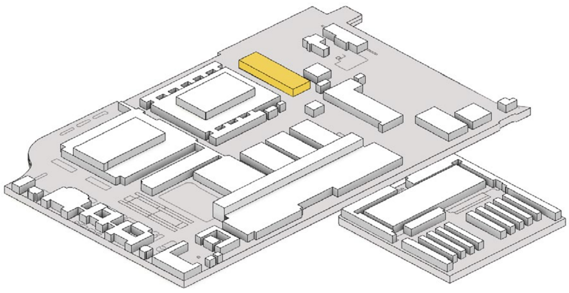


Fig.22:Building location

The cattle arriving by road or rail were temporarily stopped in the stable, to be checked before slaughter. Although the building has a modest function, it has particular architectural features (friezes, decorations), which are still evident, despite being abandoned.

Furthermore, it does not present serious structural problems and it conserves some of the old decorations.

Fig.21:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	1 550 m2
Volume	9 572 m3
Height	5,4 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks
Horizontal	Beams: ---
	Slab: Hollow block floor
Roof	Wood structure and tiles
Finishes: int and ex	Plaster internally and hammered grit externally; concrete floors
Windows frame	Iron
Conservation	
Conservation state	Medium
Architectural interest	High
Flexibility reuse	High

FORAGE STORAGE

BUILDING N 18

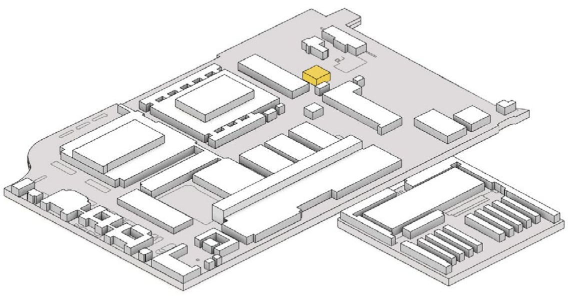


Fig.24:Building location

The cattle stayed a few days in the stables (the slaughter was carried out on 10 animals at a time). Close to the stable there were therefore special structures for the maintenance of the animal.

The building located near the stable has the same architectural characteristics as the latter. like the stable, it does not present serious structural problems.

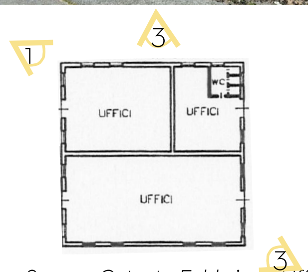


Fig.23:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	400 m2
Volume	2 000 m3
Height	7 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks
Horizontal	Beams: ---
	Slab: Hollow block floor
Roof	Wood structure and tiles
Finishes: int and ex	Plaster internally and hammered grit externally; concrete floors
Windows frame	Iron
Conservation	
Conservation state	Medium
Architectural interest	Medium
Flexibility reuse	High

SLAUGHTER-HOUSE C

BUILDING N 19

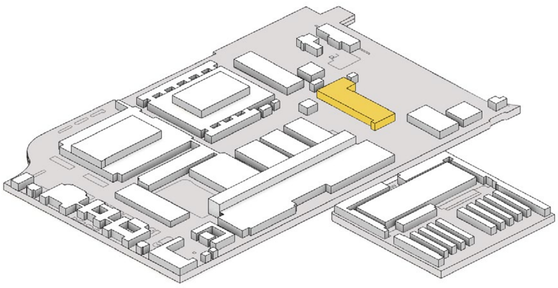


Fig.26:Building location

For each balance that he added to the complex, a sample was observed; the animal was selected in all its parts and sampled to check its state of health.
The basement is destined to storage while the ground floor has the function of offices.

The northernmost part of the building is in a bad state of conservation. Sud, on the other hand, was used until a few years ago, but does not have a particular architectural character.

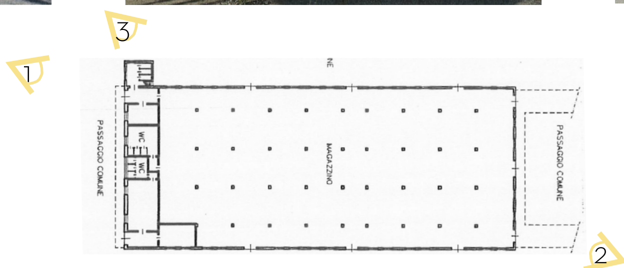


Fig.25:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	860 m2
Volume	9 842 m3
Height	8 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: Hollow block floor
Roof	Flat roof
Finishes: int and ex	Plaster internally and hammered grit externally; marble floors and gres
Windows frame	Iron
Conservation	
Conservation state	High
Architectural interest	Medium
Flexibility reuse	Medium

HORSE STABLE

BUILDING N 20

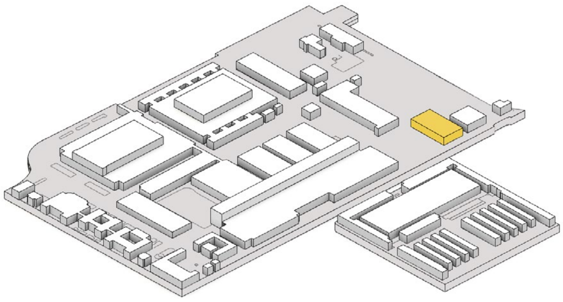


Fig.28:Building location

In the slaughterhouse complex there were also workshops for the accommodation and repair of heavy vehicles such as trucks and trucks.

The building, although not presenting a particular architectural character, is in a fairly good state of conservation, having been used until a few years ago by a private individual as a warehouse for fish.

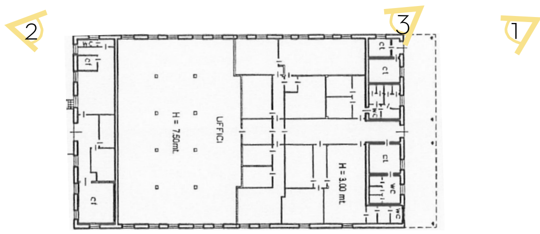


Fig.27:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	1 161 m2
Volume	6 922 m3
Height	8,2 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: Hollow block floor
Roof	Flat
Finishes: int and ex	Plaster internally and externally, marble floors
Windows frame	Iron
Conservation	
Conservation state	Good
Architectural interest	Medium
Flexibility rehuse	Medium

STORAGE FOR MEAT TRANSPORTATION

BUILDING N 21

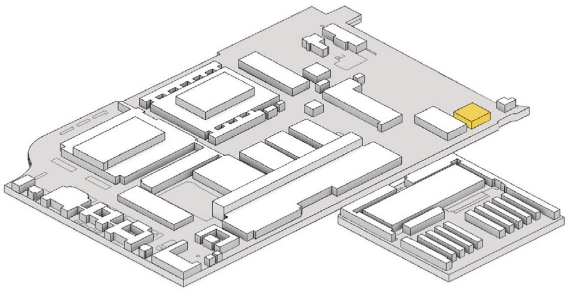


Fig.30:Building location

The building had two functions: it was a reseption and it was a cistern in which the waste resulting from the disinfestation of animals was collected.

The building turns into a state of complete abandonment and therefore in a poor state of conservation, both architecturally and structurally.

Fig.29: Basement floor and ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	302 m2
Volume	4 257 m3
Height	8,2 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: Hollow block floor
Roof	Flat
Finishes: int and ex	Plaster internally and externally, floors in gres
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Medium
Flexibility rehuse	Medium

WASHING AND DISINFESTATION

BUILDING N 22

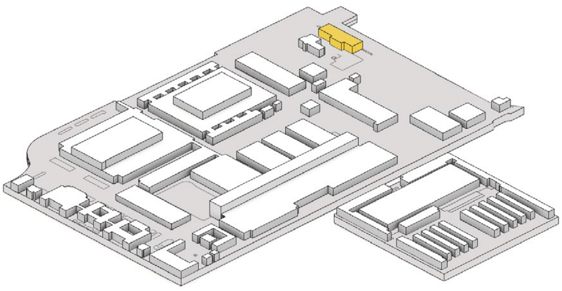


Fig.32:Building location

In this area of the slaughterhouse, road vehicles that came from outside were disinfected because they could often present bacteria, especially if they had transported a garment infected with some disease.

This area turns into a state of complete abandonment.

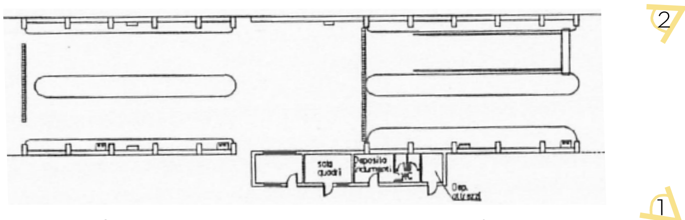


Fig.31: Gound floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1920
Surface	525 m2
Volume	2 730 m3
Height	5,2 m
Structure	
Foundations	Strip foundations in concret
Vertical	Reinforced concrete pillars
Horizontal	Beams: reinforced concrete
	Slab: Hollow block floor
Roof	Flat
Finishes: int and ex	Plaster internally and externally, concrete floors
Windows frame	Iron
Conservation	
Conservation state	Medium
Architectural interest	Low
Flexibility reuse	Low

CENTRAL GALLERY

BUILDING N 23

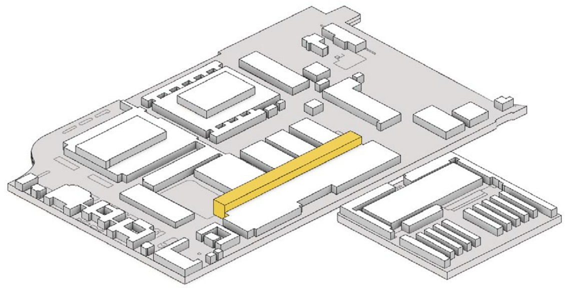
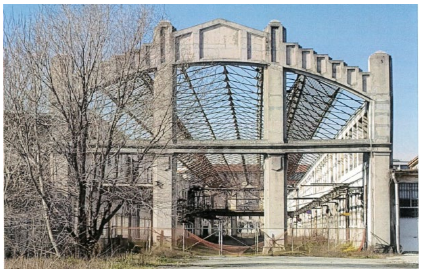


Fig.34:Building location

In the years 20, the connecting road between the various slaughterhouses has emerged as an important space inside the slaughterhouse. Those on the short sides became the symbol of the whole complex. In the 50's, as a result of hygienic-sanitary needs, and due to the importance of the gallery within the complex, it was decided to create a roof, defining a real covered road. The roof is very deteriorated due to the fact that the glass in the skylights is now completely absent and has an asbestos infill.



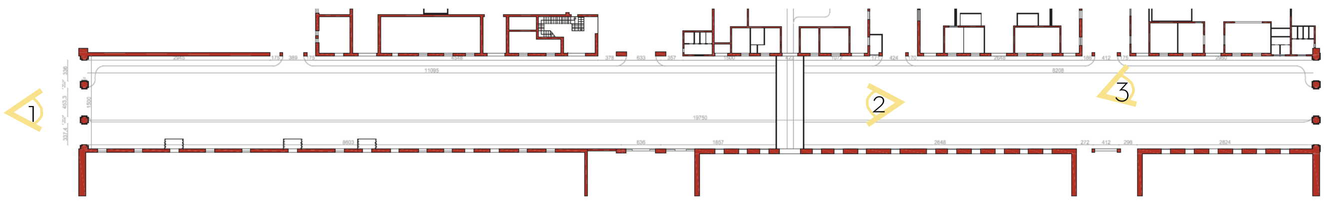


Fig.33:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1930 - 1950
Surface	3 000 m2
Volume	32 100 m3
Height	15,2 m
Structure	
Foundations	Strip foundations in concret
Vertical	Reinforced concrete
Horizontal	Beams:---
	Slab: ---
Roof	Metallic structure with asbestos shingle and reinforced glass
Finishes: int and ex	Exposed reinforced concrete and flooring in asphalt
Windows frame	Iron
Conservation	
Conservation state	Medium
Architectural interest	High
Flexibility reuse	High

TRIPE SHOP

BUILDING N 24

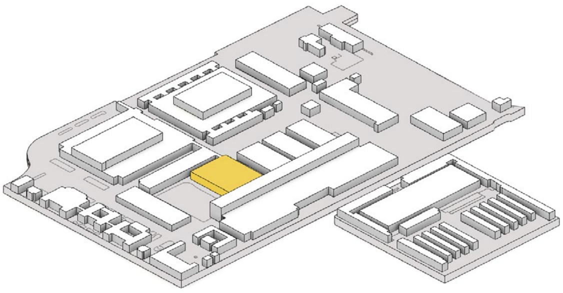


Fig.36:Building location

Ten animals at the time were brought from the weighing department for slaughter. in this building the slaughtering of pigs and the processing of tripe or the internal parts of the animal took place

The building turns into a state of complete abandonment.

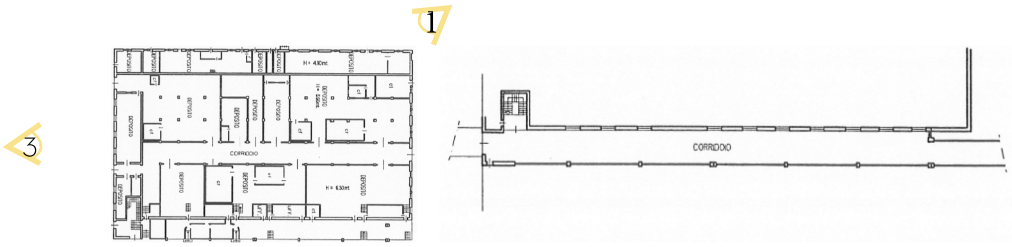


Fig.35:Ground floor and first floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1930
Surface	2 984 m2
Volume	21 294 m3
Height	6,4 m
Structure	
Foundations	Strip foundations in concret
Vertical	Full bricks + steel pillars
Horizontal	Beams: reinforced concrete and steel
	Slab: mixed in iron-ore cement
Roof	Steel structure and corrugated roofing
Finishes: int and ex	Plaster internally and externally, concrete floors
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Medium
Flexibility reuse	High

MARKET MEAT REFRIGERATOR

BUILDING N 25

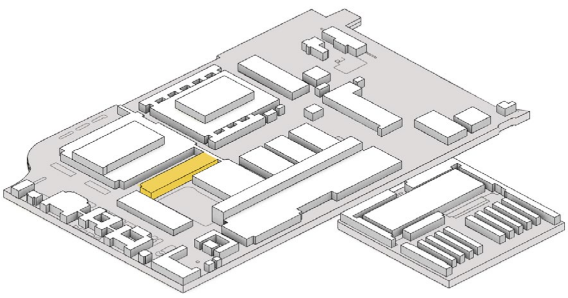


Fig.38:Building location

The industrial-type building consists of two floors, one underground and one above ground with vertical masonry structures of solid bricks and iron and brick floors as well as an attic service floor for the passage of systems. It contained the cold rooms which had the function of storing the unsold goods which were stored the following days at lower prices.

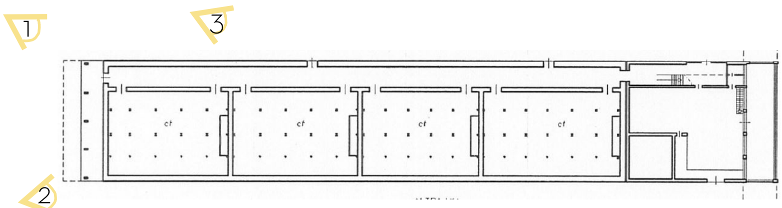


Fig.37:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1930
Surface	1 518 m2
Volume	30 736 m3
Height	6,4 m
Structure	
Foundations	Strip foundations in concrete
Vertical	Full bricks
Horizontal	Beams: ---
	Slab: mixed in iron-ore cement
Roof	Wood structure and corrugated roofing
Finishes: int and ex	Plaster internally and externally, smooth shot blasted and hammered
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Low
Flexibility reuse	Low

GARAGE

BUILDING N 26

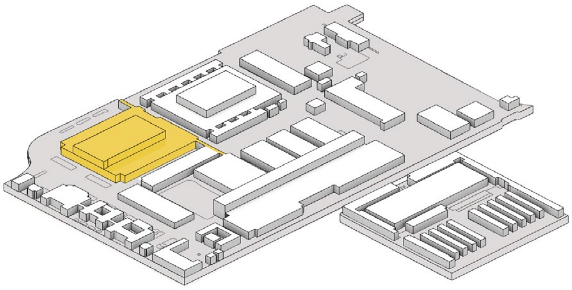


Fig.40:Building

The industrial building with a single floor above ground has load-bearing structures in reinforced concrete consisting of pillars and beams that support a brick concrete floor which also forms the roof. In the central part the roof has a brick vault.
It was used as a warehouse for the machinery and vehicles used in the complex.

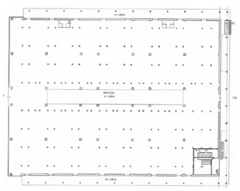


Fig.39:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1930
Surface	8680 m2
Volume	60 000 m3
Height	3,9 m
Structure	
Foundations	Concrete bearing slab
Vertical	Semi-solid hollow bricks
Horizontal	Beams: reinforced concrete
	Slab: hollow blocks floor
Roof	Flat roof with hollow block structure and a waterproof bitumen roofing felt
Finishes: int and ex	Plaster internally and externally, plaster + smooth shot blasted and hammered
Windows frame	Iron
Conservation	
Conservation state	Low
Architectural interest	Medium
Flexibility reuse	High

LIVESTOCK MARKET

BUILDING N 27

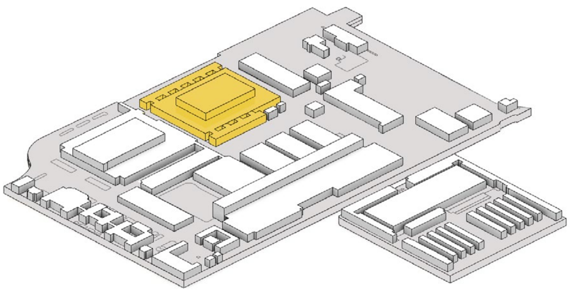


Fig.42:Building location

The shed housed the market there, open to the public on Tuesdays and Thursdays. The cattle arrived by train stopping in the north platform. The goods were sold by weight, with a different value from that of the meat already processed.

Like the meat market, the building is located in an inaccessible area and it is therefore difficult to reach it and understand its state of conservation

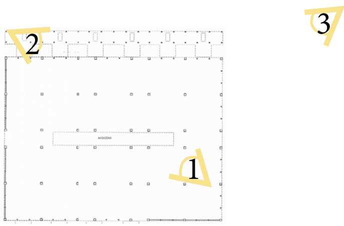


Fig.41:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

General informations	
Year of construction	1930
Surface	8 531 m2
Volume	103 446 m3
Height	12 m
Structure	
Foundations	Strip foundations in concret
Vertical	Reinforced concrete pillars
Horizontal	Beams: reinforced concrete
	Slab: Hollow block floor
Roof	Flat in hollow block
Finishes: int and ex	Plaster internally and externally, concrete floors
Windows frame	---
Conservation	
Conservation state	Medium
Architectural interest	High
Flexibility reuse	High

3. STATE OF AFFAIRS (GALLERY)

2.4. Introduction

The Ex Macello site is a disused area spanning around 15 hectares, the site of the communal slaughter house and of the poultry and rabbit market in the real estate compendium of the Milan wholesale market. The large covered passage, where the gallery is defined by tables and articles found in the archive, is part of a complex with several volumes intended for the preparation and slaughter of meat. the long passage, or covered gallery, is a connecting element between the slaughtering galleries and the refrigeration departments. With a basilica section, it has two double-height gabled facades, tripartite and oriented along the east-west axis. the building has an internal width of 15 meters and a length of about 200 meters. along the walls, on both levels, there are windows of different sizes. It is assumed that many openings located at the top and facing the outside were made following the covering of the long passage, to facilitate ventilation. In fact, it is unusual for the roof trusses to unload their weight above the openings and not on the solid wall partitions. Twenty-seven iron trusses support the roof consisting of two decks and wooden joists.

Situated in the south-east district of the city, in the district of Calvairate in Municipality 4, the area is a stone's throw away from the Milan Porta Vittoria station , which is served by the suburban lines that link the metropolitan area to the city centre through the railway link. This enables the business centre of Porta Nuova and Repubblica to be reached in a few minutes, as with the Rogoredo station, which is served by high-speed trains, and the Forlanini station, linked to Linate airport by the M4. The Milan 2030 Plan identifies one of the "Piani Attuativi Obbligatori" (obligatory implementation plans) on site, one of the areas in which is provided a specific town planning regulation aimed at managing the regeneration of the areas. It provides a mix of urban functions including social housing at accessible prices.

3.1. Architectural Drawings - Municipality Archive.

The drawings were taken from the Archives of Milan ("Cittadella degli archivi"). Reference was made to the old documents containing designs of the former altar of the city of Milan throughout the ages and all the stages it went through in construction. We were able to arrive to the current state of the new slaughterhouse and of the buildings surrounding it; these are considered as an interconnected whole. Other material was collected from the technical sheets given by the Reinventing Cities Competition, from here it was possible to determine the state of each part of the building: from the structural building materials to the finishes. The conclusion is that the gallery building in the middle was important to be kept and not be demolished like the others. This building has two hudge portals designed as one piece of concrete that has a majestic appearance. The other main feature of the gallery is the roof: It is a metal truss structure, with on top of it two strips of glass and the rest was covered with a laminated sheet.

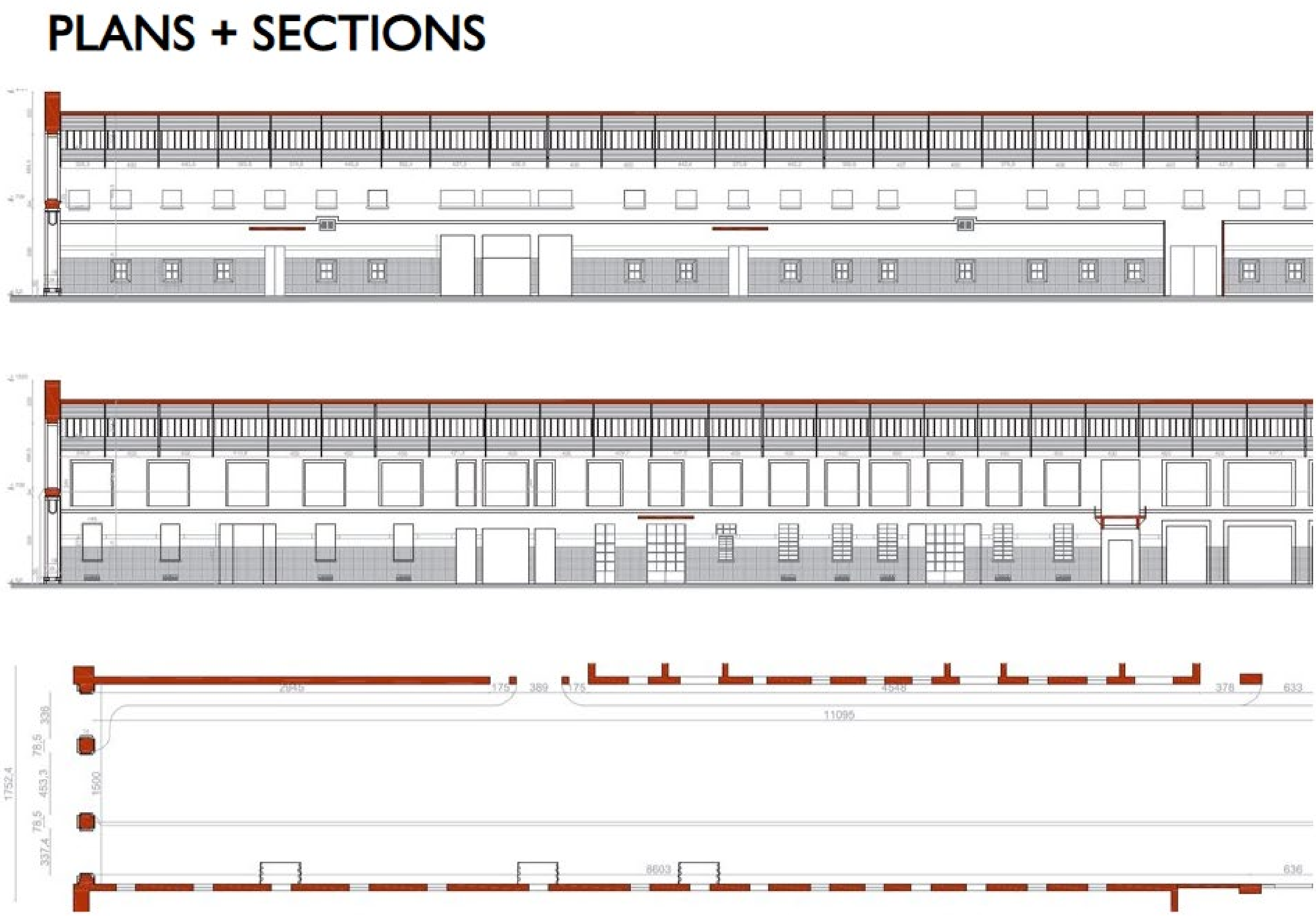


Fig.43:Architectural plan of the main slaughterhouse and two sections showing openings and building mechanism.

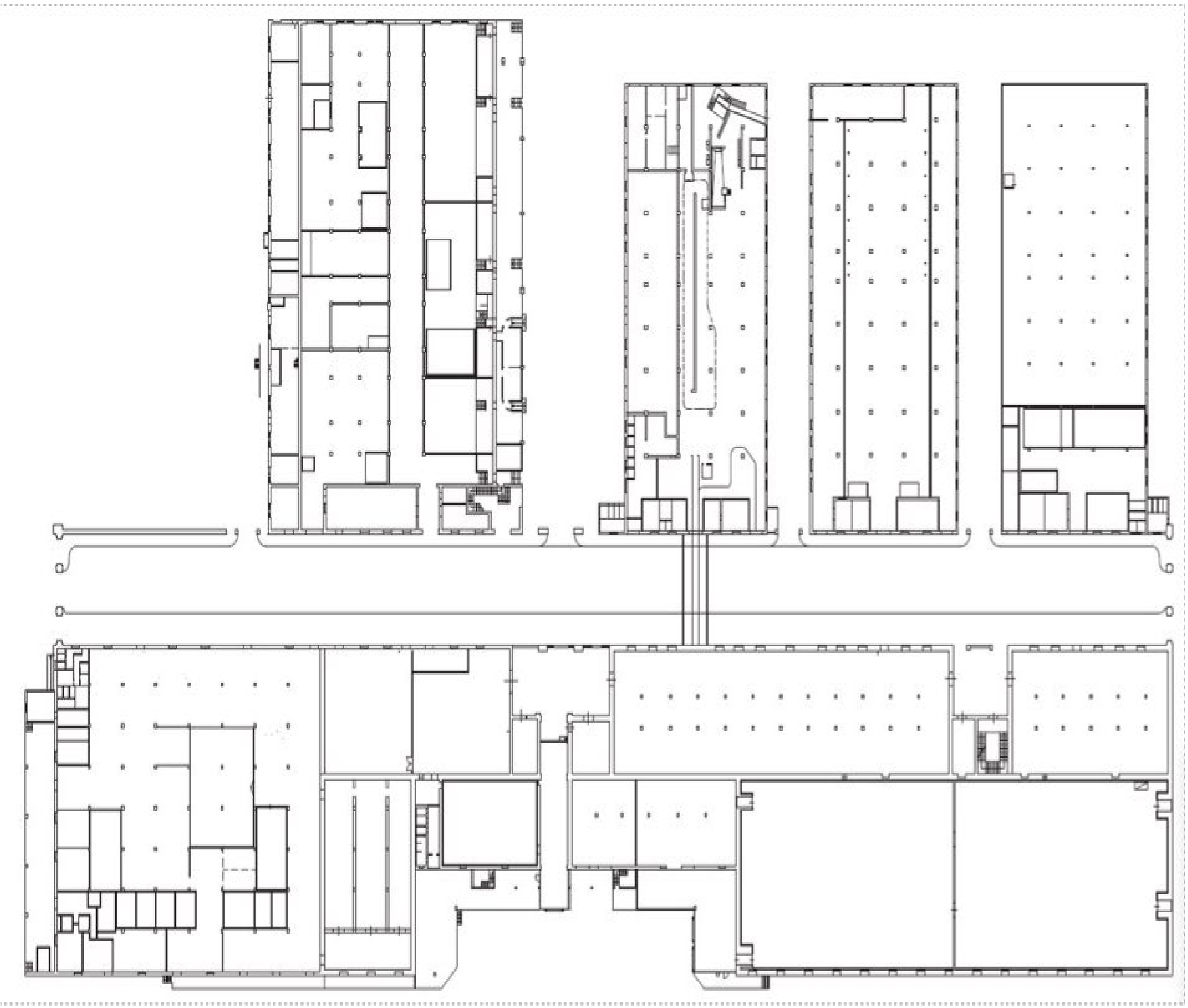
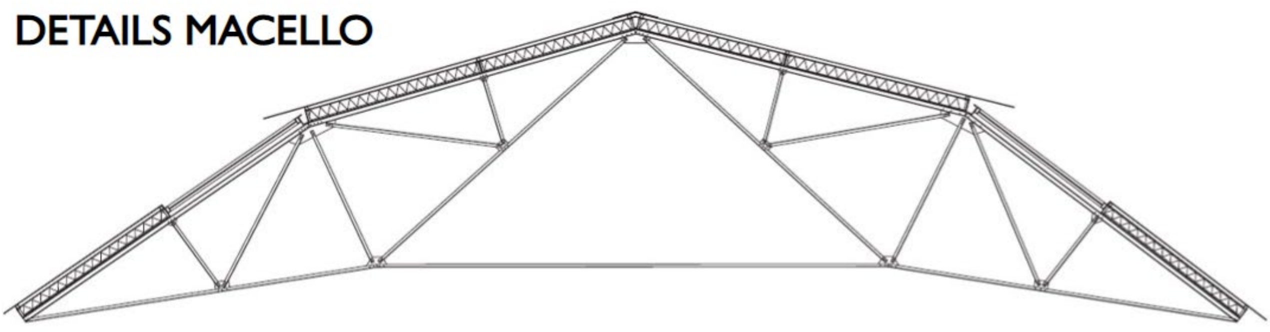


Fig.44:Ground floor plan. Source: Catasto Fabbricati Ufficio provinciale di Milano

DETAILS MACELLO



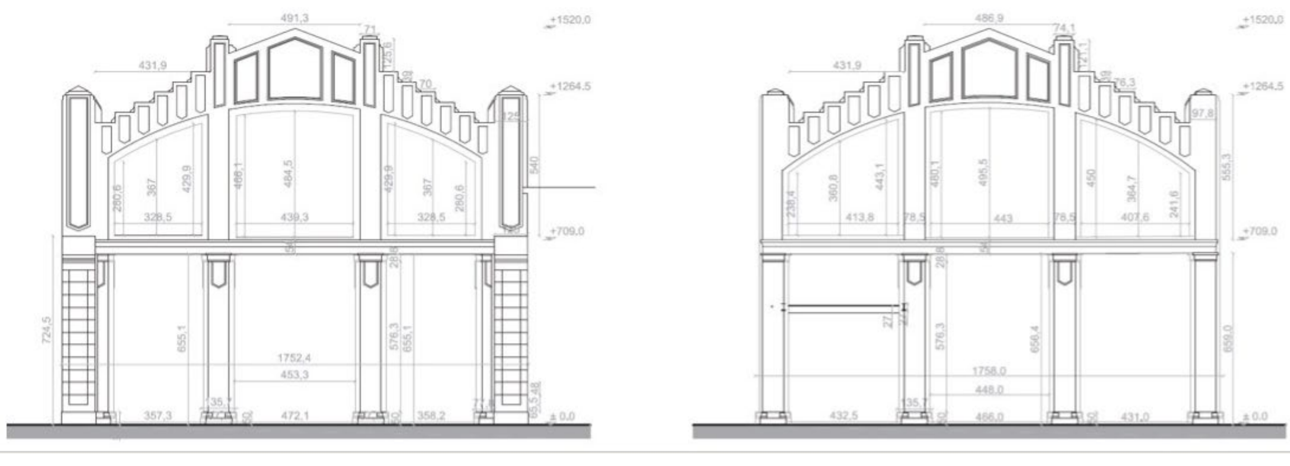


Fig.45:Technological details of the main elements that keeps identity of the slaughterhouse and milan , main gates and roof truss.

Fig.46:Image 1

Fig.47:Image 2

Fig.48:Image 3

Fig.49:Image 4

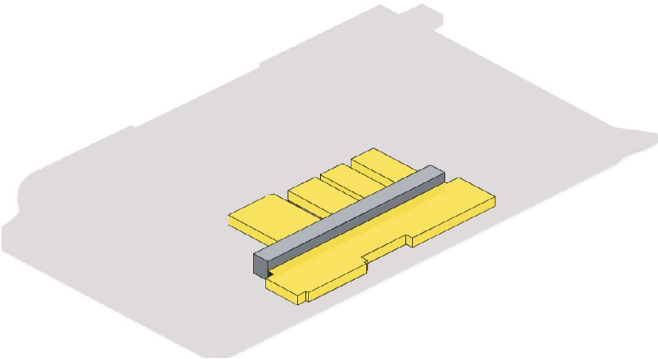
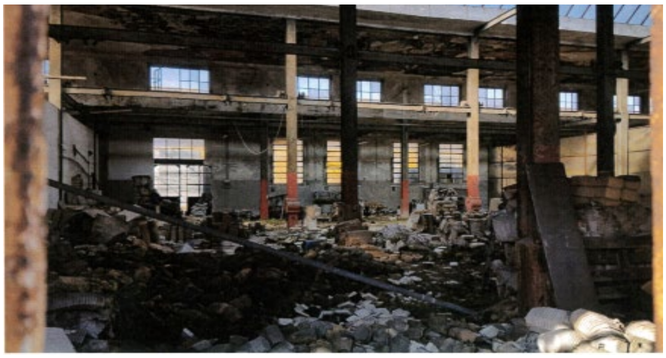


Fig.50:Degraded and parts demolished in yellow.



3.2. Conclusion and reasoning for demolishion based on state.

The area of interest of the project given by Reinventing City has a very strong identity and a big historical interest for its old function.
The importance of the area comes from the function helded by the beginning, the neighbourhood was born as industrial site, and as one of the biggest suppliers of meet of Italy.
Unfortunately with the city expansion the decline of the slaughterhouse started around the 1970s until 2007 when the business was definitively ceased.
The architecture of the buildings is very simple, industrial, with no decoration and no architectural interest.
Since the buildings were abandoned they degraded very quickly, until the actual **state of complete disaster**.
From the pictures is visible the situation of the building, the very simple and poor material used and the state of conservation of the structure.

From the plans shown in the technical sheet it is also visible how the spaces are organized to follow exactly the previous function with a medium **flexibility** to ri-organize it.
One of the concept of the Master-plan is to imagine the area as a sponge to absorb people inside, remove the existing huge barriers formed with the boundary walls and the railway, by creating a permeable space open to the surrounding. The main point of the site is the gallery, that is going to attract every kind of people. Unfortunately, the attached buildings **reduce enormously the permeability** reducing the visibility and creating huge barriers.

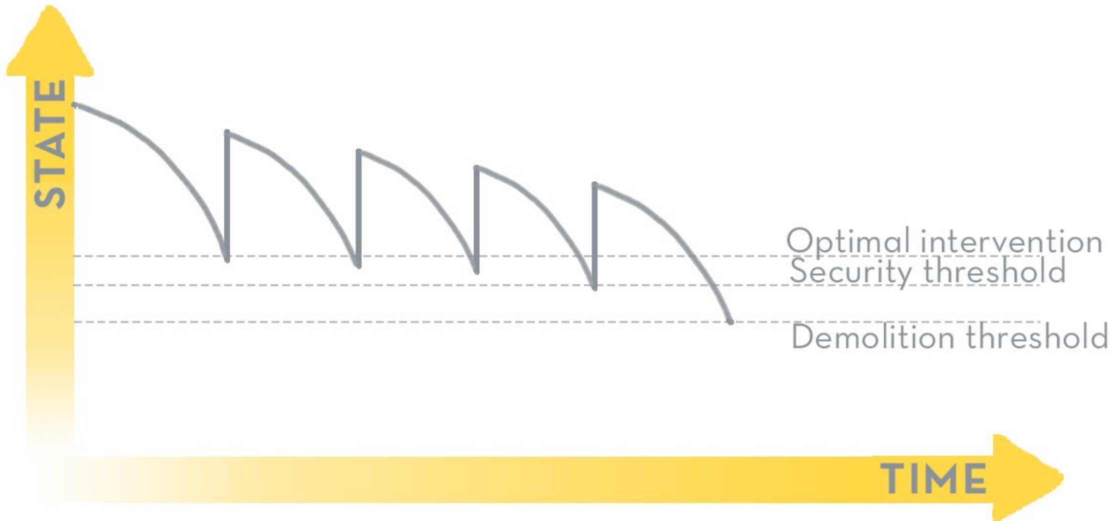


Fig.51:The building renovation rule and relation between time and state .

The graph above shows the state of affair of a building in relation to the time: we have three different threshold and after the last one it's more convenient to demolish the building instead of refurbishing it another time because the **cost of the intervention will be too expensive**. A new building will ensure a duration of 50 years while with a refurbishment of such deteriorated structures will have much shorter life.
The buildings that are going to be demolished have a huge size and can be **substituted by NZeb** with a very low impact on nature and that will reduce the heat island effect.

Deconstruction or demolishment

Another important aspect to consider is that the demolition will happen with the less impact on the environment as possible. One of the possible solution is the deconstruction of the materials that can be recycled completely.
The development of plant and equipment has allowed for the easier segregation of demolition waste types on site and the reuse within the construction of the replacement building. On site crushers allow the demolished concrete to be reused as type 1 crushed aggregate either as a piling mat for ground stabilization or as aggregate in the mixing of concrete.
Timber waste can be shredded using specialist timber shredders and composted, or used to form manufactured timber boards, such as MDF or chipboard.

From the graph below are visible the positive and negative aspects of deconstruction: sustainable because recycle the materials and sometimes it's given to no profit organizations, and because it reduces the landfill waste. But at the same time is more expensive and more time consuming.

Fig.52: Pros and Cons of deconstruction in this case.

4. URBAN ANALYSIS AND IMM

3.3. Introduction: Relation between Milan and site location

The Macello area is located south-east of the city of Milan, due to its slaughtering function, the plant was deliberately built in an area that was outside the city at the time of its construction. Today, however, it is fully inserted in the urban context since the city has undergone great changes since the beginning of 1900, the years in which the slaughterhouse was built. The complex in Viale Molise is therefore inserted in a particular urban conformation as it is closed by the railway system to the east, where the line leading to Rogoredo clearly separates the districts of Santa Giulia and Forlanini from the rest of the city, while of a broad gaze towards the city center to the west where it merges with the existing urban fabric. The main streets that surround me are Viale Molise to the west, where the main access is through the complex of the liberty buildings, via Lombroso to the south, from which the service staff can access and Via Piranesi at Nord. And the whole complex can be divided into four large areas defined by their function. First place the west strip of which the Liberty buildings are part of the year, the only buildings of the slaughterhouse visible and open to the rest of the city; in this wing the administrative and service functions were carried out such as the porter's lodge, the canteen, the stock exchange, etc.

The second area and the one to the south, comprising the gallery and the buildings annexed to it, housed the actual slaughtering function with the various annexed departments. The third area is the one to the east made up of smaller buildings. The live cattle arrived here thanks to a railway track that entered the complex, therefore the functions performed were those of collecting, controlling and maintaining the live cattle. The last part includes the two large pavilions to the north where the Meat Market and the Live Market were located. Most of the buildings are currently abandoned with the exception of the liberty buildings and some minor buildings used as a warehouse for the sellers who work at the fish market in the SoGeMi area. The market area, on the other hand, is used by the Municipality as a deposit for seized cars.

4.1. Mobility and transformation

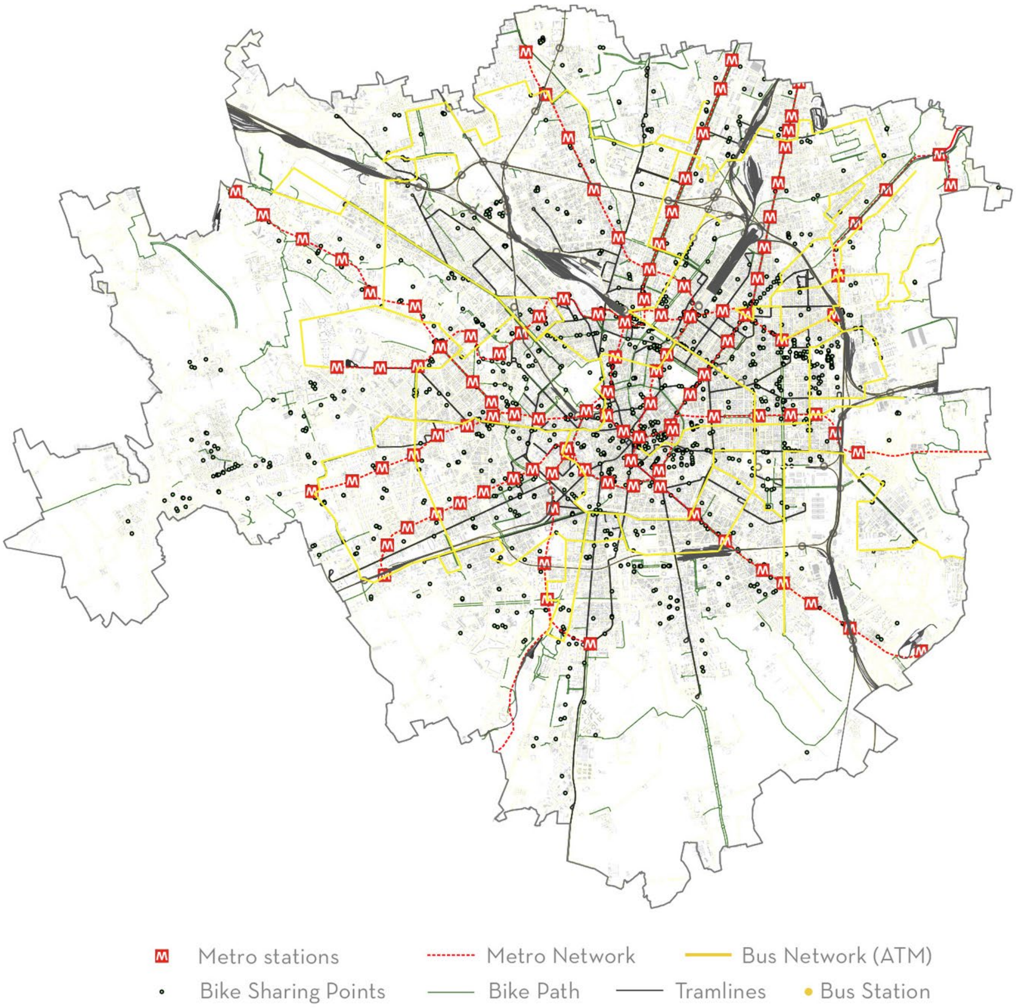


Fig.53:Map scale 1:20000.source : Geoportal SIT - open data source

By performing public transportation and mobility index along with GIS Mapping system using DBT files of regione lombardia. We were able to figure out and overlap all layers expressing public transportation means, number of stations and the ability to reflect them on a city scale in order to show connections between all systems indicated in 113 stations for metro with more for buses and tram. Bar chart below is expressing average percentage of users mostly commuters, With the distance people travel to get to work using public transportation is also expressed in radar diagram showing coverage in kilometres of different systems and networks connected to each other in which are Light Rail, Metro, Train, Bus, Shared cars and bicycles. noting that all numbers used are average time in weekdays including exact numbers of peak times 7.00 am to 9.00 am and 5:00 pm to 8:00 pm.

Coverage in kilometers **Milan statistics of daily users**

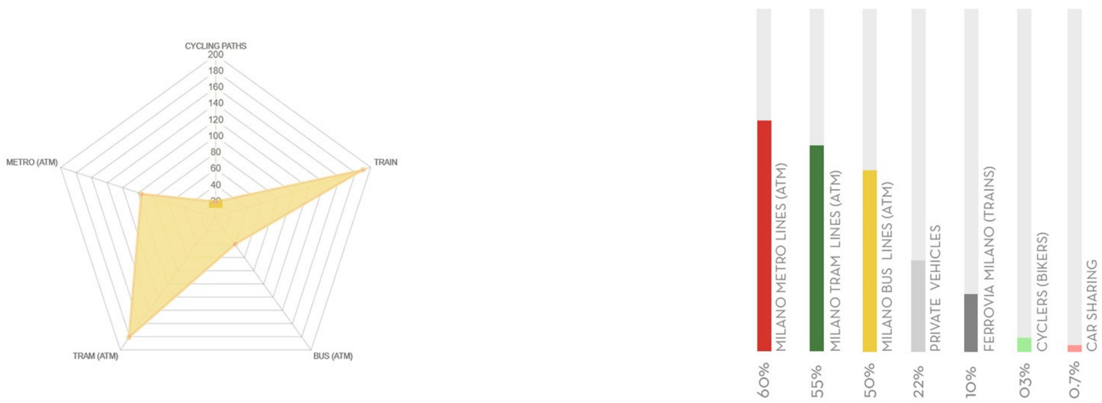


Fig.54:Bar and radar charts of mobility calculations. Source: EU Commission - dept. of urban research.

4.2. Biodiversity and vegetation

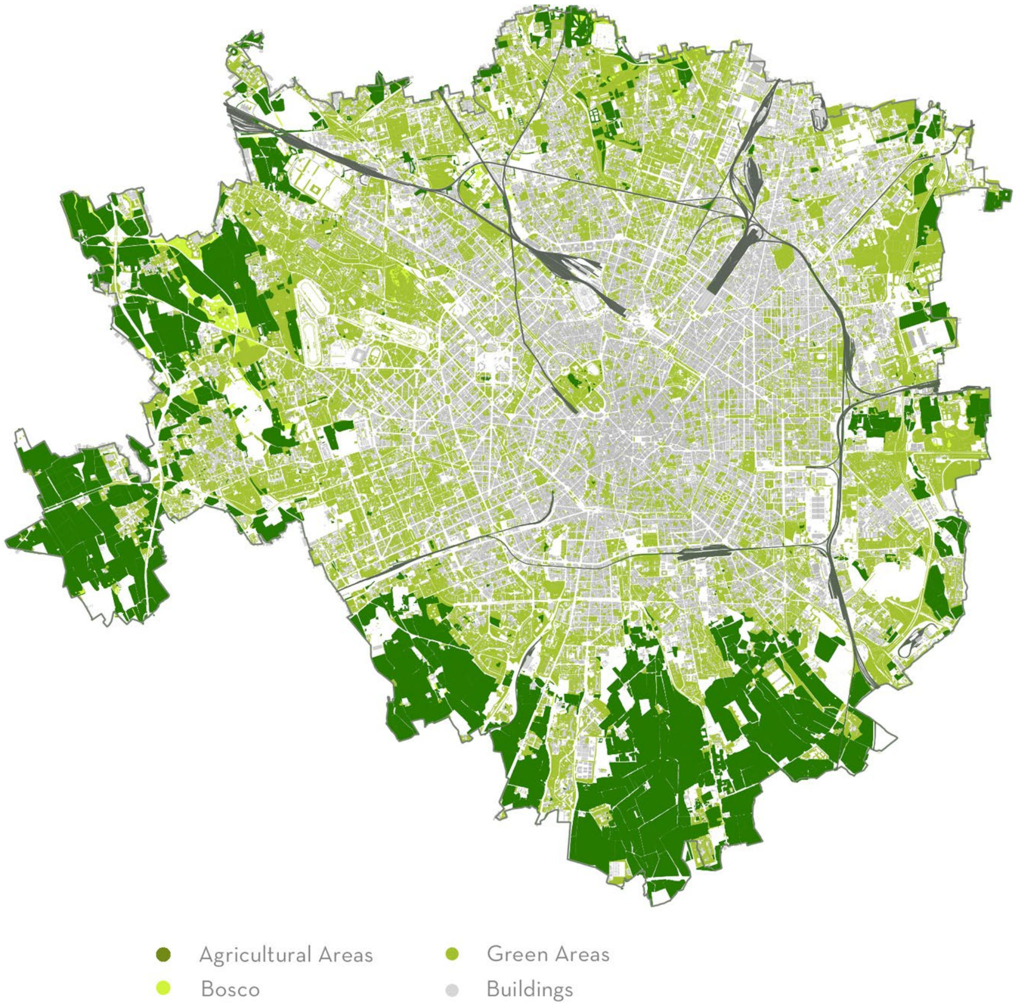
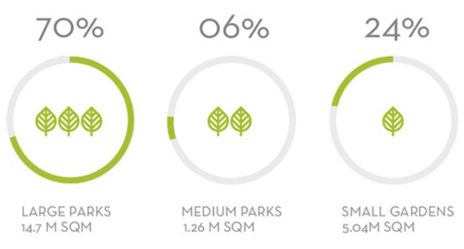


Fig.56:Map scale 1:20000.source : Geoportal SIT - open data source

Biodiversity is incorporated into the urban network in the same way as the constructed city and green areas play host to a vital component of biodiversity that is often over- looked: fauna, consisting of a huge variety of birds, small mammals, amphibians, insects and other organisms.

On the diagram is possible to see green infrastructure and biodiversity plan is a strategic instrument that sets out the long-term actions that are needed to attain green infrastructure that can serve several environmental and social functions, that can bring nature into the city with all the life forms it houses, that can achieve connectivity between the city and the broader territory and, lastly, that can make the city more fertile and resilient. In order to achieve that goal we had to highlight green diversity and categories public green parks and green zones with areas

Public green spaces distribution



Green diversity and vegetation

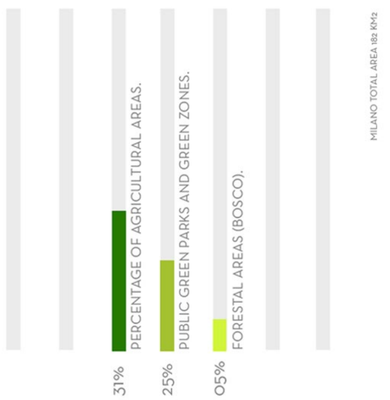


Fig.55:Bar chart and histogram showing percentages of functions and diversity. Source : systematic- research department

4.3. Hydrography

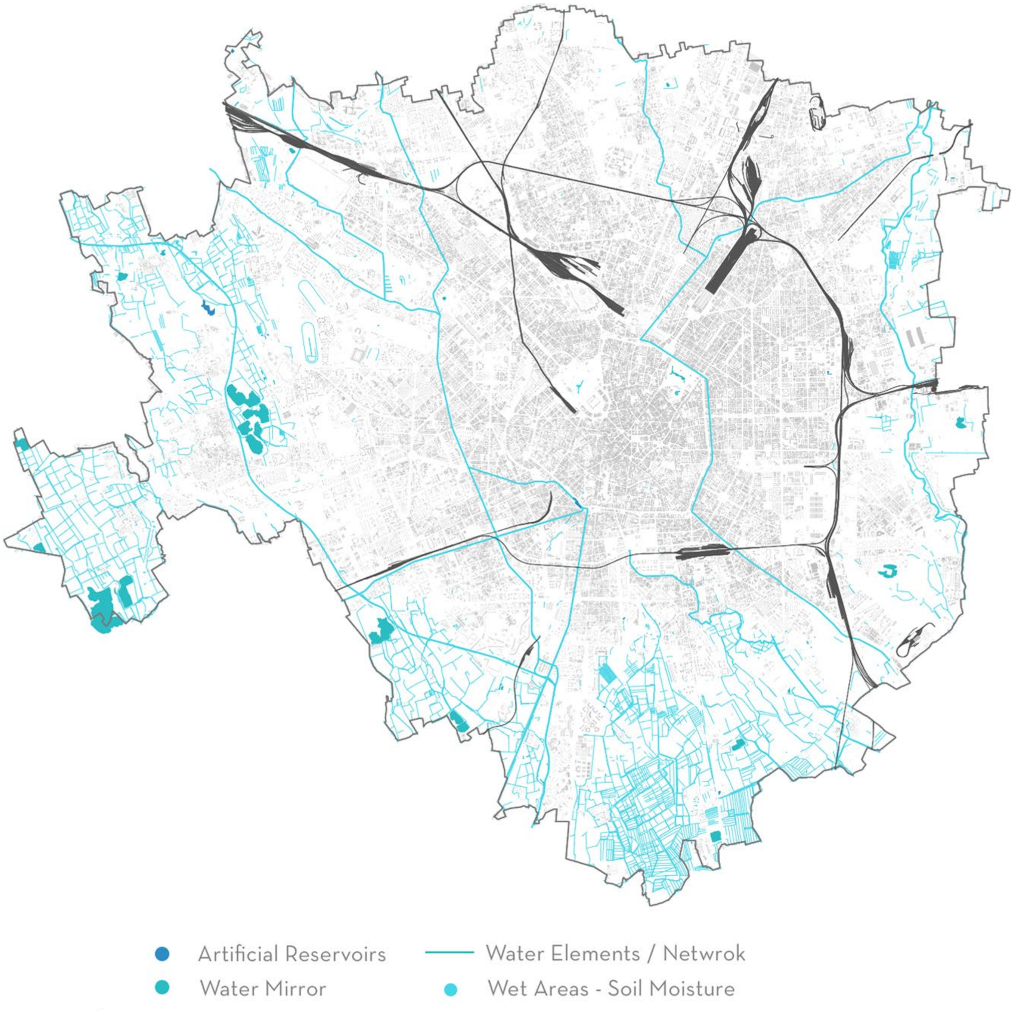
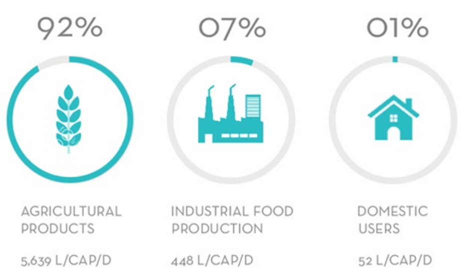


Fig.58:Map scale 1:20000.source : Geoportal SIT - open data source

Geodata is the main key-role in defining artificial reservoirs with function of controlling the rate flow of the stream or to store water for more expedient use. They are the most useful means of controlling the natural character of water flows, instead of depending on nature. While main piping system is the major elements of water network in Milan following topography heading from lakes and streams towards boundaries of the cities providing inhabitants with water then to be directed towards agricultural areas for food productivity and harvesting. Meanwhile beside providing the city with water needs, Water mirrors have specular reflection of reservoirs to create authentic urban nodes to attract people from city center towards the borders. Natural reservoirs-soil based moisture acts as natural supplying point to surroundings. The charts below states percentages of footprint for each element also showing types of uses and rate of consumption.

Water consumption



Water resources

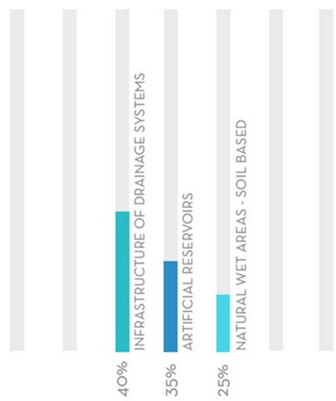


Fig.57:Bar chart and histogram showing percentages of consumption and resources. Source : systematic- research department

4.4. Population

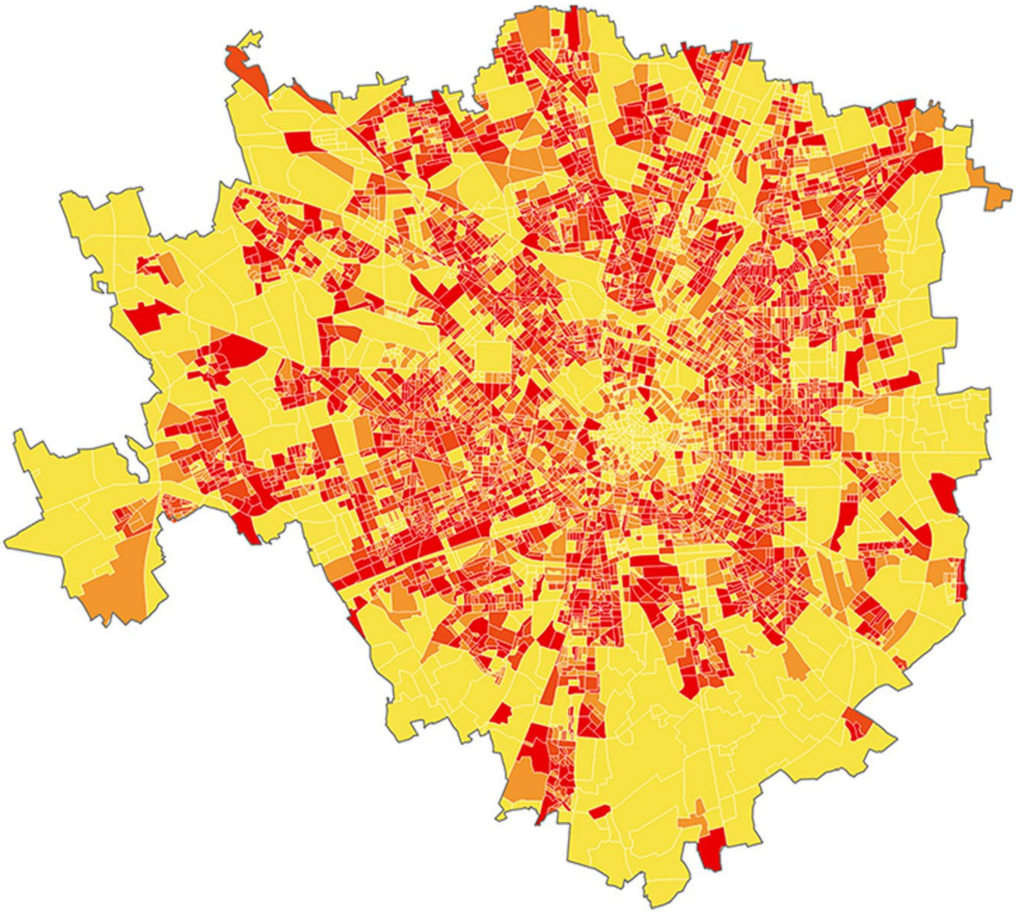
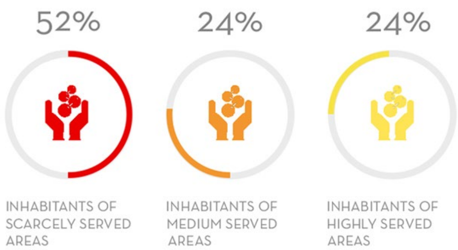


Fig.60:Map scale 1:20000.source : Geoportal SIT - open data source

The map shows the detailed processing of the results obtained through the isochronal analysis. The analytical process starts with the areas of high density going towards boundaries in which has low population density due to increment of agricultural lands in which led to low number of inhabitants and services. Then, information about the residing population is analysed. The methodology allows us to obtain a synthesized reading of the municipal area that compares the population density with the availability of recreational areas within 15 minutes from each census cell. The chromatic scale identifies the total amount of recreational areas available to each resident

Gathering Area Provision



Population density distribution

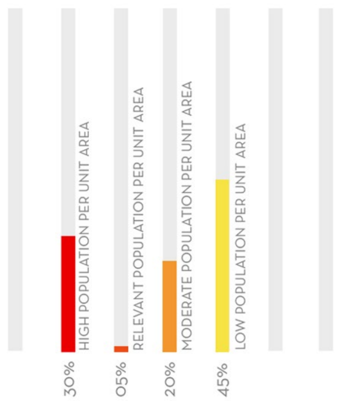


Fig.59:Bar chart and Distribution chart for served people. Source : world population review.

4.5. Integrated Modification Methodology

The main concept of integrated modification methodology is to transform existing urban contexts seen as complex systems into more sustainable, energy efficient forms. It's also a methodology in which analysing complex system and solving wicked problems on different scales whether it's local , intermediate or global scale. We have defined and performed all catalyzers by performing two investigations, horizontal and vertical investigations in which made us highlight the problems of our area when it comes not just to urban problems and running urban morphology but also how to do sustainable design and what exactly we need to develop in order to get key elements of problem solving. We focused on two problems which are permeability and voids that caused us lack of integration, misuse of land areas,distribution of people and heat island effect.

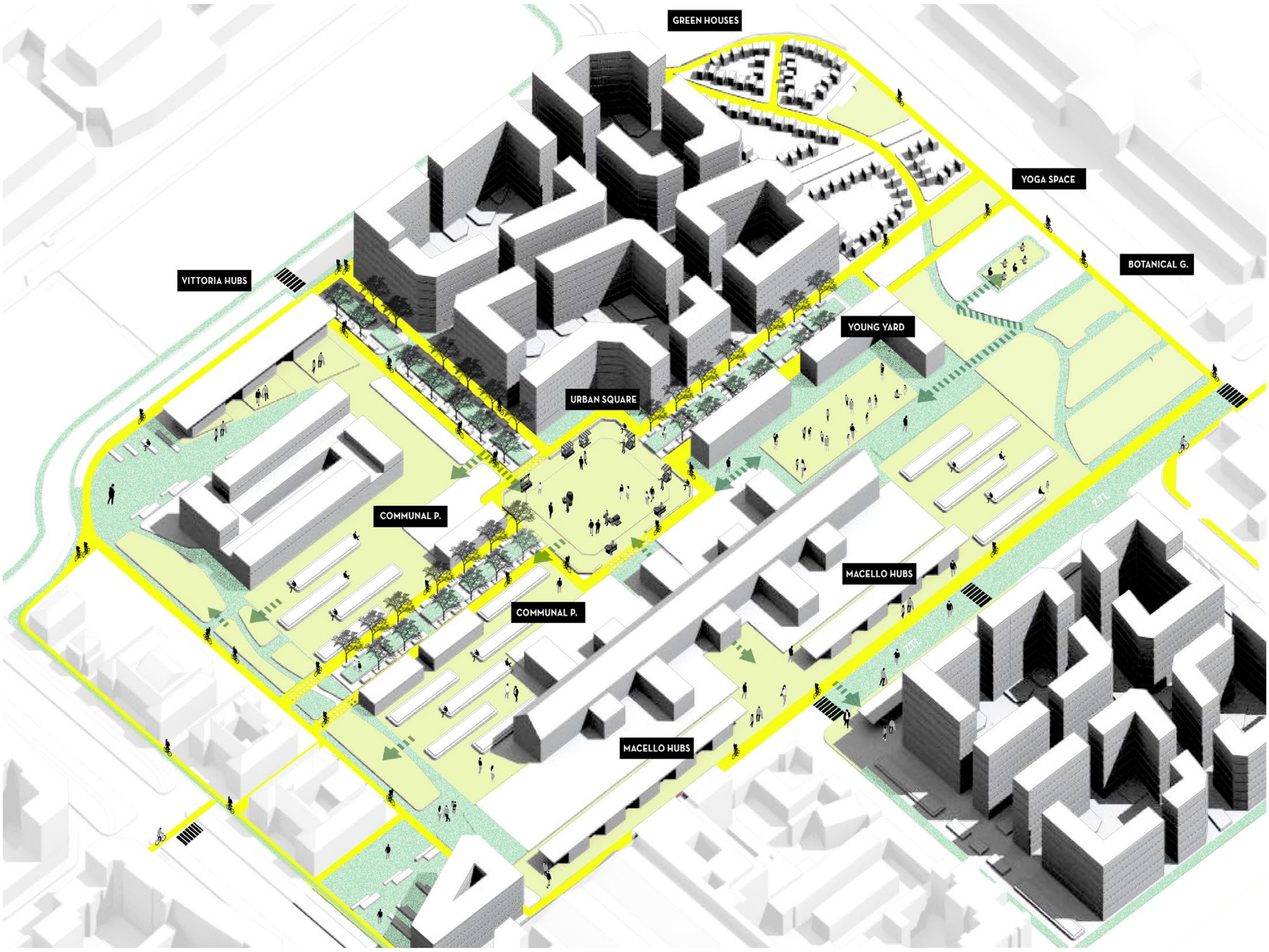


Fig.61:Performed design for the area after solving permeability problem

VERTICAL INVESTIGATION :
We chose permeability based on determining the ability to access or moving to the site considering some important factors and values in order to assure we meet the final results and it would have an effect for it as Street area, Link length, Directness ,topography and contour and also studying how many people flowing into this part of the city and points of attractions. number of public transportation means and number of users.

HORIZONTAL CATALYZER VOIDS

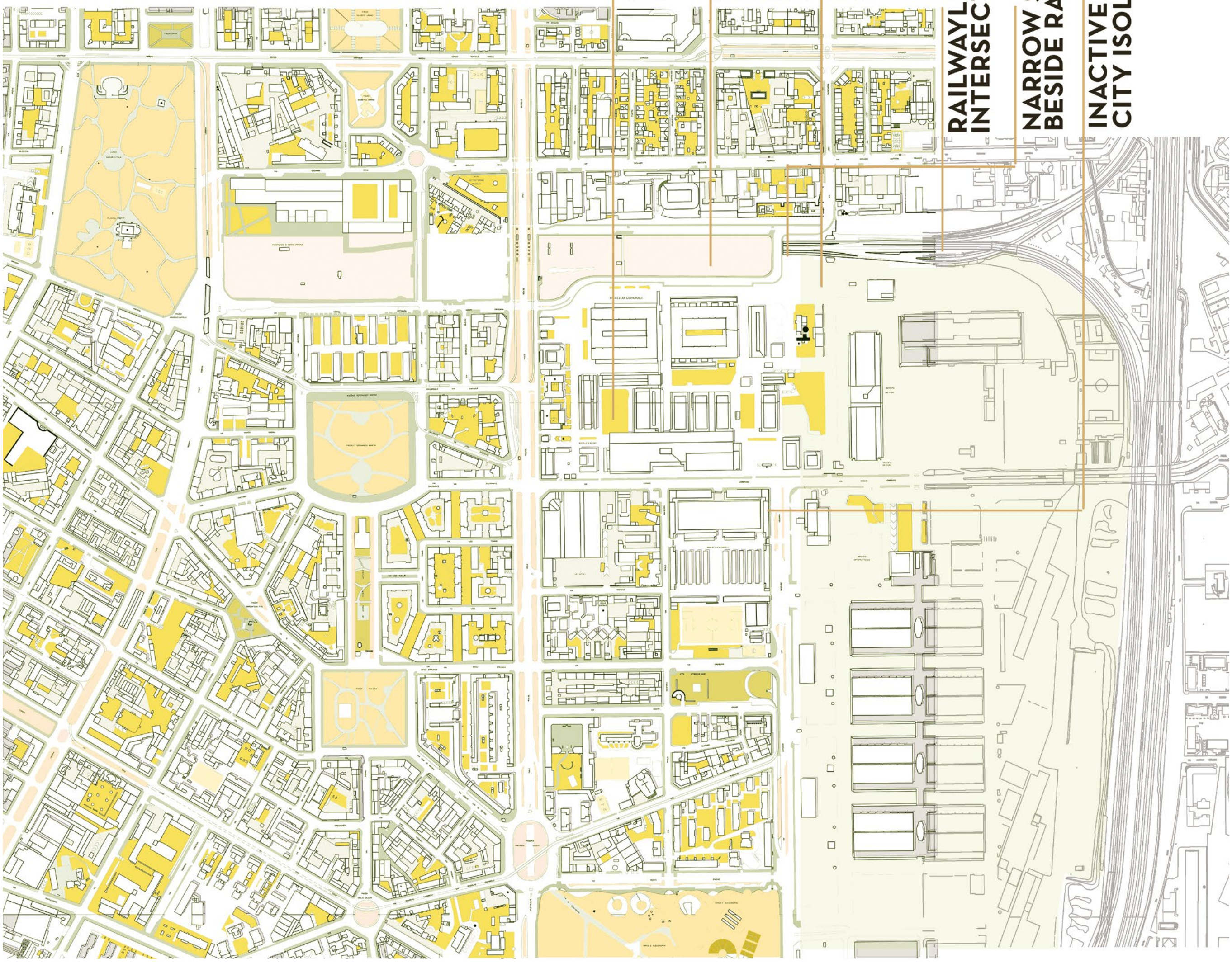


Fig.62:Distribution of land areas and Heirarchy for degrees of abundance from low use to high use.

HORIZONTAL INVESTIGATION :

We chose voids based on the percentage of land areas and hierarchy degrees of abundance from low use to high use. also number of volumes in contrast to these spaces. as we discovered that there are some land and sites resulting from change in urban fabric,Abandoned land areas and underused urban voids,narrow streets beside railways, Inactive roads and city isolation and focusing on integrating our site to the surroundings.

S

STRENGTHS

MOBILITY AND CONNECTION

- Variety of public transportation nearby: bus-line, tram-line, underground
- Porta Vittoria train station at 20 m (S1 Lodi-Saronno/S2/S5/S6/S13)
- Well maintained cycling paths
- Central Station is well connected by the train nearby

SERVICES

- Good accessibility for disabled people
- Proximity to Politecnico di Milano
- Proximity to the ATM storage infrastructure

LANDSCAPE

- Variety of green areas

URBAN FABRIC

- Histroical identity of the neighbourhood (Volumes Map)
- Viale Molise is important connection to Milan keyplaces
- Historical importance of the Liberty buildings

SOCIO-ECONOMIC TRENDS

- Rich History
- High level of social integration

WEAKNESSES

MOBILITY AND CONNECTION

- Lack of bike sharing station
- Absence of electric recharge stations
- High traffic area
- Disconnected cycling paths
- Corvetto (Metro Station) 2 km Yellow line (San Donato- Comasina) FAR

SERVICES

- Low commercial level, just for the locals
- Presence of low-quality industrial building: ATM

LANDSCAPE

- Uncultivated and abandoned greenery
- Noise Pollution on main streets

URBAN FABRIC

- Concentration of industrial structures in the area
- Lack of parking lots in our area
- Unused Building Stock

SOCIAL AND ECONOMIC TREND

- Inadequate spaces for small production/ activities, ex: workshops, warehouses, labs
- Not a touristic neighbourhood
- Lack of cultural and physical activities in the open spaces
- Poor safety for pedestrians in some places
- Distribution of commercial shops
- Crowded Housing

OPPORTUNITIES

MOBILITY AND CONNECTION

- Proximity to Porta Vittoria station
- Existence of wide boulevards that can increase green mobility

SERVICES

- New cultural and gathering buildings
- Create a connection with Mercato Ortofrutticolo nearby

LANDSCAPE

- Design our site as green connector between the parks of the neighbour

URBAN FABRIC

- The neighbouring equipped areas still constitute today the largest wholesale distribution centre in Italy

SOCIAL AND ECONOMIC TREND

- Reinventing cities competition can help finding investors
- Design rules are not strict
- European Library is going to create a cultural pole: the area is increasing interest
- Community nodes
- Greater involvement of Macao Cultular Center

THREATS

MOBILITY AND CONNECTION

- Vehicles overcrowedness Viale Molise
- The cars change the perception of the pedestrian and the way he lives the space

SERVICES

- Presence of drug dealers and low quality life

LANDSCAPE

- Heat island problem (we reach 41 degrees in summer)
- Bad air quality
- Noise pollution due to the railway and to the traffic congested streets

URBAN FABRIC

- The surrounding area is too built up
- The site connects a very dense area and a very porous area

SOCIAL AND ECONOMIC TREND

- Area size big regeneration project addressed by a single operator (SOGEMI)
- Expensive nvestment
- Possible social conflicts due to ethnic and cultural differences 37,3% foreign population

4.6. Vision and Strategies.

Recently the role of strategic visioning and systems of controls gets a special importance as tool for strategic planning. The primary aim of the present research is examining the relation between strategic vision and sustainability base on the case of the city. At the global level, the city of Milan is a member of C40 , a network of cities committed to address climate change. we had succeeded in reducing carbon emissions and reducing heat island effect plus providing a meaningful global impact by reducing greenhouse gas and transforming the abandoned and concrete area to a green paradise that directly affect people health and playing important role in food sector.

Fig.63:Performed design for the area after implementing strategies.

IMPLEMENTED STRATEGIES :

(1) Defining inclusive programmes and polices
(2) Encouraging engagement and participation
(3) Enabling social infrastructure
(4) Promoting proximity
(5) Generate pleasant and functional open public spaces
(6) Designing affordable and adaptable housing
(7) Improving walk-ability and cycling
(8) Developing public transportation
(9) Providing seamless mobility
(10) Increasing connectivity
(11) Increasing biodiversity
(12) Improving food production
(13) Digitalizing the zone

Fig.64:External view

5. MASTERPLAN

5.1. Introduction: Designing master plan and context approach.

A Master Plan deals primarily with the physical development of a municipality, taking into account a wide range of social and economic factors. generally comprises a report or statement and land use and development proposals, with maps, charts, diagrams, and text. Essential to the preparation of a Master Plan are extensive studies of present conditions, development trends, regional factors, and prospects for future growth. These background studies form the basis for establishing a set of policies, standards, and objectives which guide the future physical development of the entire township which, in turn, forms the basis for a general physical design of the community. A Master plan must be comprehensive, including proposals for all major physical elements affecting both public and private property. It must also process a plan regarding land use, circulation, housing , what city needs.
The adoption of an official map more specifically sets forth, engineering terms, those facilities and utilities of a more specific and imminent nature. as we can notice these aspects has to be reflected on functions that serve the goals and vision.

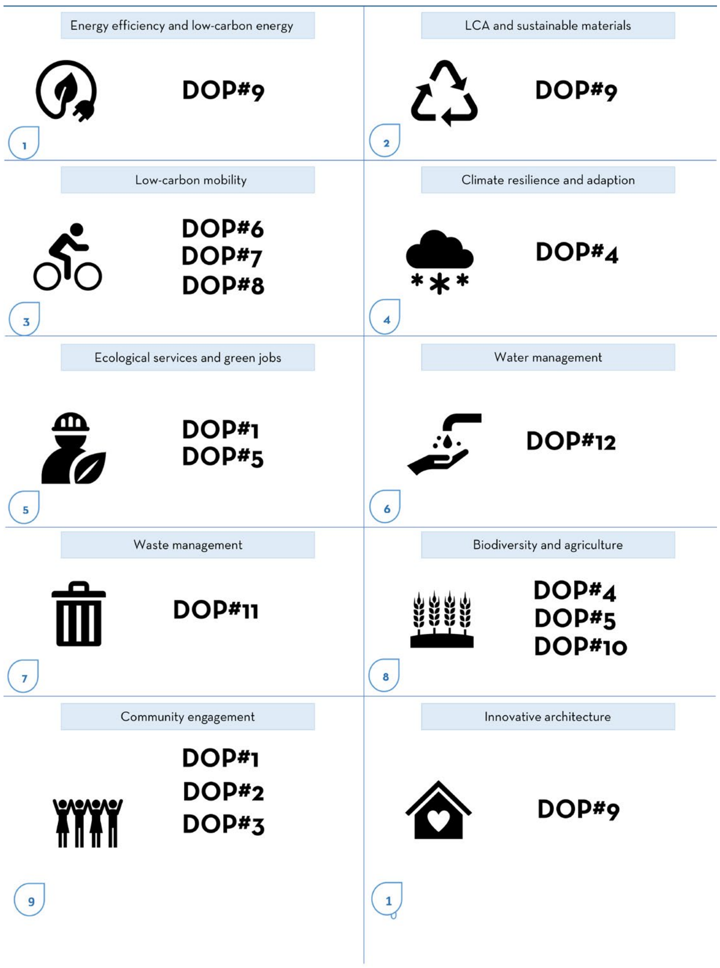


Fig.65:C40 challenges linked to IMM design ordering principles.

5.2. Functions

As preliminary procedure we had to highlight the city approach , municipality regulations , going through realistic sustainable plans that are targeting people needs without city expansions towards the nature and playing an opposite role in integrating the nature with the city instead .In addition to fulfilling the living needs of the people who are going to be moved to our area as it's planned to move almost 60,000 inhabitants to the area and to provide them with all possible services without creating an isolated neighbourhood from the city fabric and infrastructure, as this part has to be integrated with all transportation networks and also provide new functions that are not only serving inhabitants of the area but also serving the neighborhood on local scale basis , city in intermediate scale and to participate in change if it's designed according new goals and vision of sustainability that directly results on global scale basis.

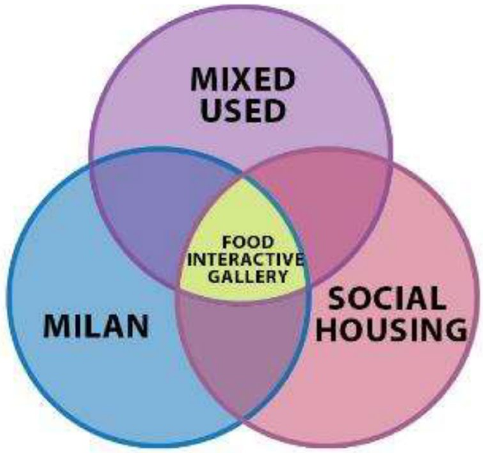


Fig.66:Interconnected circles of design interest

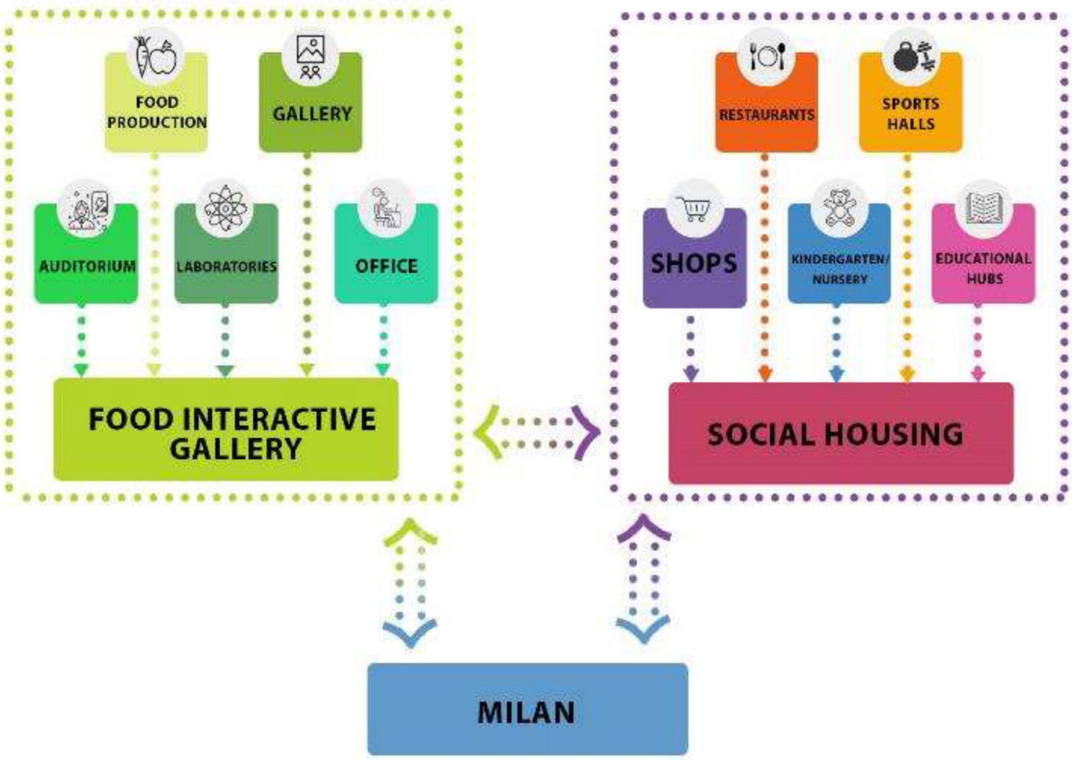


Fig.67:Subdomains following main domain interconnections.

5.3. Residential Focus

Plans

We started to adjust the initial shape taken from the master-plan using a grid of pillars with a distance of 5.6 m each. In this way it was easier to design and think about the disposition of the spaces.
Moreover, we thought about different modules and minimum surface in relation to the request about the type of the apartments that could fit the grid previously created. Because the building is a social house, we also added some common spaces as study rooms, relax living rooms dose to the main corridors. After a solar and radiation analysis that we performed, we decided to add some continuous balconies on the southern façades, to give to the people a common open air space. Moreover, we thought about the right number of the vertical connections (stairs and elevators) that could easily bring the people to their home, in respect to the Italian fire rules.

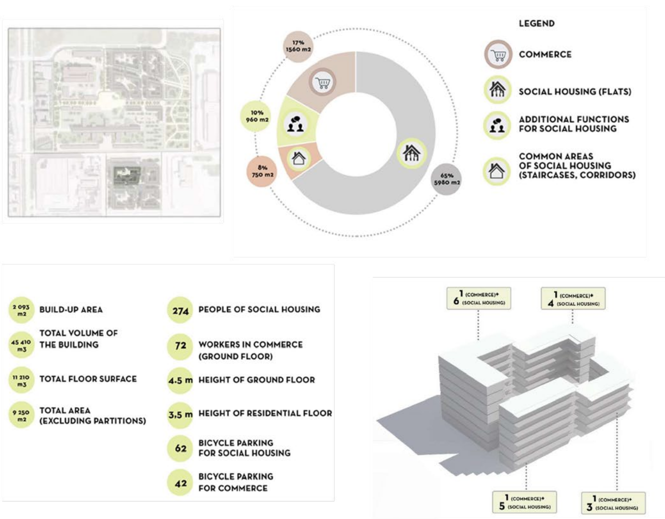


Fig.68:Functional distribution and areas.

Fig.69: Architectural design for commercial and social housing plans.

Elevations

The façade of the building follows a grid that is based on the structural grid of the plan: starting from the 5.6 m, we divided it in four, having a distance of 1.4 m. This measure was used to place the metal cables all along the height of the building to sustain and let the vegetation grow on it to create e natural solar screen to reduce the solar radiation inside the apartments.

Sections

The section is important to understand the vertical connections of the building that allow the people to reach the rooftop that is designed as a green terrace for the residences. It is also visible that each slab sticks out from the perimeter of 40 cm. This space is used to host small vegetation that grow all around the perimeter of the building, to reduce the heat island problem.

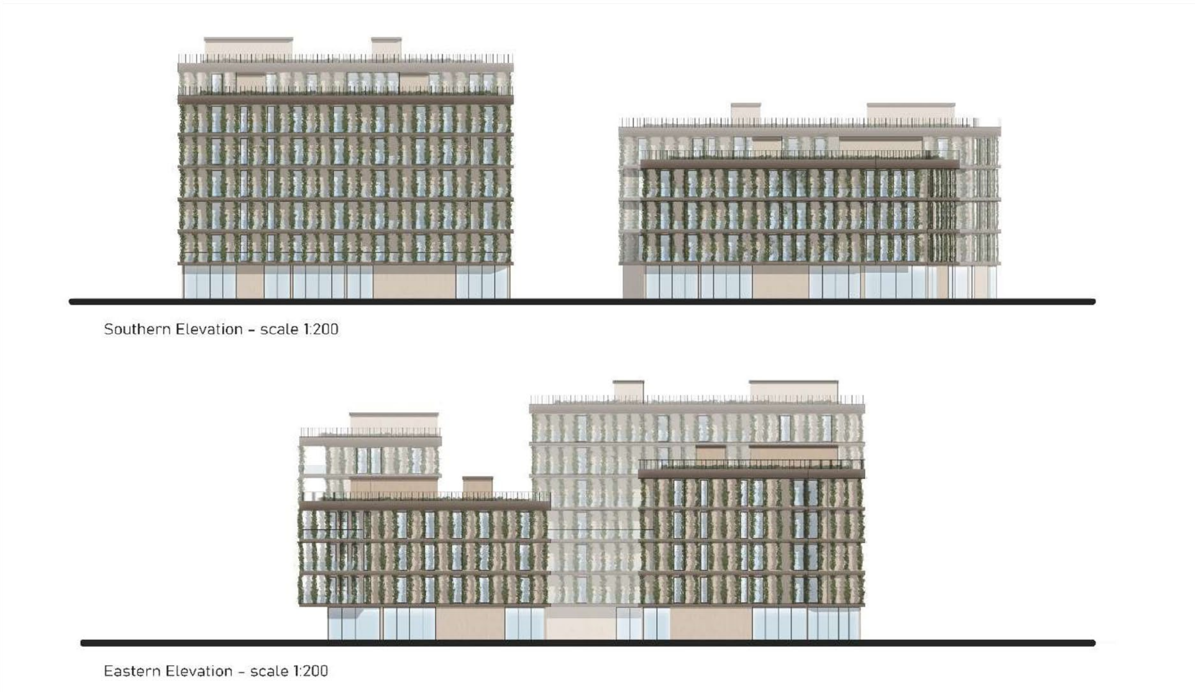


Fig.70:Residential blocks southern and eastern façades. scale 1:200

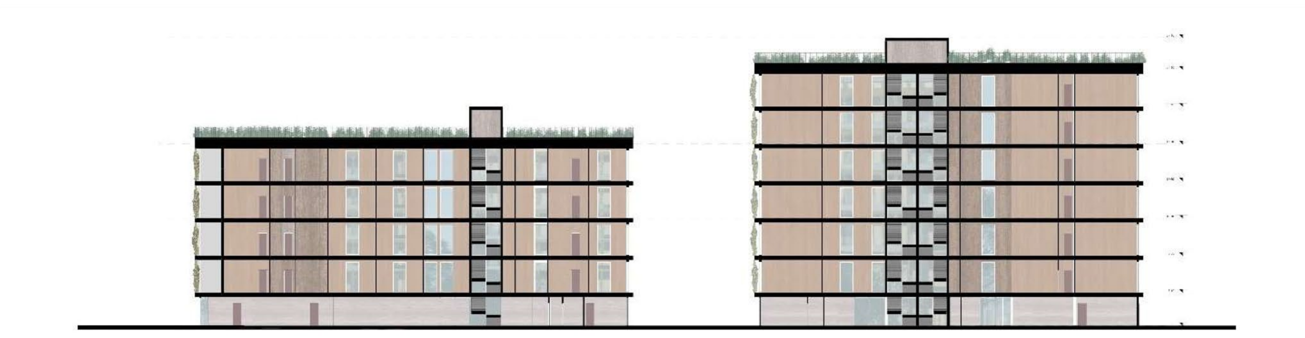


Fig.71:Residential blocks longitudinal section. scale 1:200

Schematic section

In the schematic design we thought about all the improvements related to the energy consumption such as a good insulated envelope, mechanical ventilation to improve the comfort and the energy efficiency of the building, helped also by the natural screens on the balconies to reduce heat gain. Than we focused on the renewable aspect adding a waste management system, a water management system, connected to the green rooftop able to collect the rain water and reuse it in the building. In the end we added solar panels on the roof to increase the energy efficiency of the building.

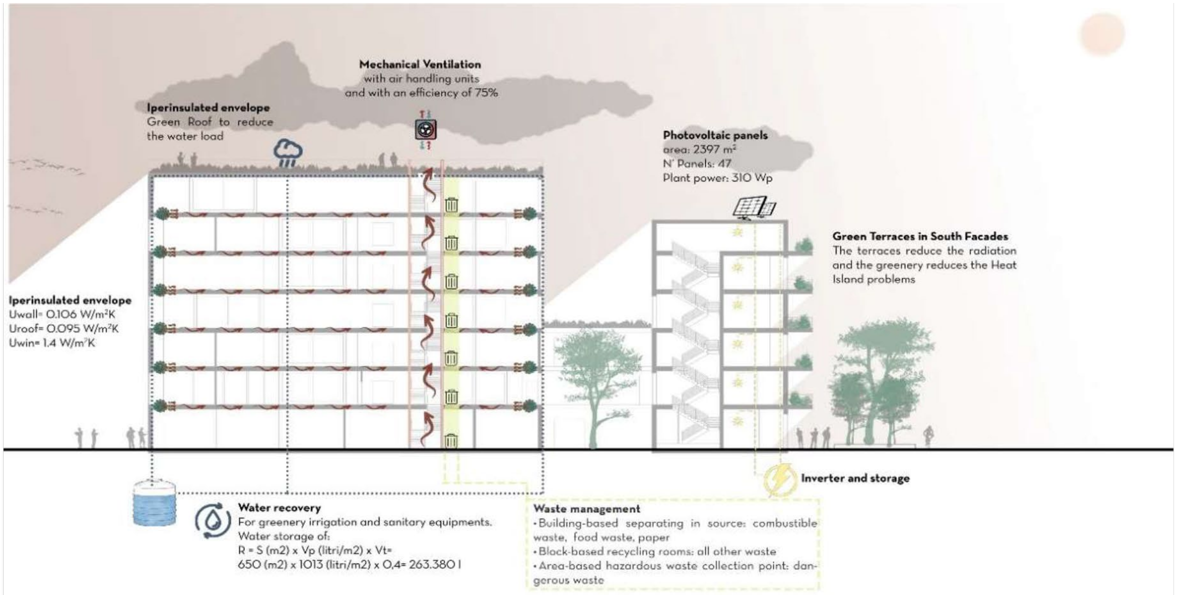


Fig.72:Schematic design section for energy use.

Fig.73: Unreal Engine render representing and evolving the concept of Milans patios / SMDP

5.4. Final masterplan

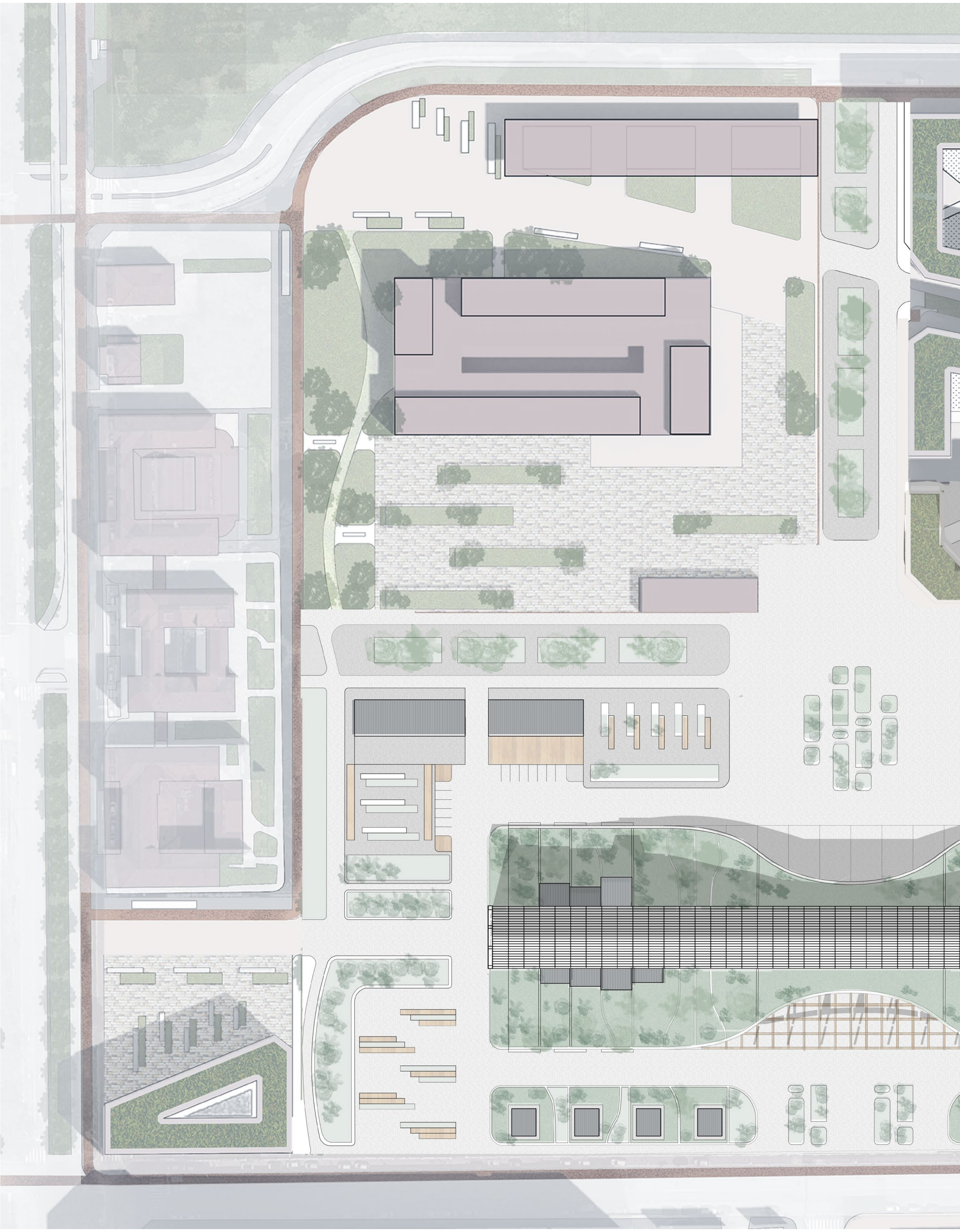


Fig.74:Masterplan final competition design concluding ex slaughterhouse building , residential blo

ocks for inhabitants , public spaces and parks , commercials and cultivation farms. SCALE 1:1000

5.5. Conclusion

The dimensioning analysis made us understand the regulations to follow, gives us some rules that can help us to define the master-plan. We studied the numbers at first, from the PGT of Milan and then we understood also some more qualitative focuses that we MUST follow in the design, the main aspects we must consider, according to Reinventing Cities, in parallel with the functional, spatial and quantitative aspects. According to previous investigations , linking and understanding DOPs plus Re-inventing city rules , hand to hand with regulations and guidelines regarding commune of Milan. We decided to implement and consider important factors as strategic location , surrounding functions and current user categories. According to the latest global trends, researches and the way that Milan has chosen to develop and support the production of food in the city, the implementation of such an important aspect as the production of food is an integral part of the project. It is the new gate of the oppressed side of Milan, A starting point of performing a sustainable district that impact and result to a huge transformation of the city, the district affects surroundings as it will strengthen the connection to the isolated southern agricultural part, spreading green colour into the massive concrete city in which balancing the concrete blocks expansion of city outwards and to perform a strategic, solid vision of the new Milano city.

Fig.75:Internal view of Ex Macello Gallery

6. COVID- 19

5.6. Architecture and pandemics

During pandemic conditions it's difficult not to pay attention to our physical realm with giving the fact that many people are using residential , commercial ,business complexes that contain huge amount of workers and employees that cast the most high percentage of users combined at one place. The first perception or imagination in design community is how to provide social distancing in architecture and led to think about increasing or at least doubling design standards which is something incorrect according to architecture design principles that cause a huge waste of spaces but it's correct to precautions and pandemic protocol and regulations. However, the rapid spread of COVID-19 has caused to re-evaluate design standards, and competitions were run and initiated to perform a large platform of worldwide brainstorming to solve the problem globally. It might mean to design for a world that will never be the same, especially when it comes to how we gather in and use large public spaces, like airports, hotels, hospitals, gyms, and offices.

While social distancing would seem to be a necessary, if temporary, action, it's reasonable to think that concerns about future viruses might encourage architects to design with an eye toward open spaces that enable and encourage people to spread out. but what happens to enclosures and indoor spaces when it comes to design ? Gathering spaces and rest room were taken out of calculations with no equations to solve.

Nowadays,Architecture is going towards transformation in theories and to be mixed with construction solutions using BIM softwares in terms of designing and using technologies when it comes to construction and finishings. Almost everyone predicts that indoor spaces will move toward more automation to mitigate contagion, with COVID-19 speeding up development of all types of touch-less technology—automatic doors, voice-activated elevators, cellphone-controlled hotel room entry, hands-free light switches and temperature controls, automated luggage bag tags, and advanced airport check-in and security is a way to prove that yes we are going in the right way. Although we can't predict how the future would be like when it comes to looking constructively to the COVID-19 pandemic, many architects have turned to what they know best: design and innovation. The new restrictions placed on society have been a catalyst to rethink much of what we take for granted in the built environment. By this we can perform analytical solutions based on studies and statistics of user circulation , atmospheres , distances , how do people interact when it comes to spatial experience and how architecture would achieve such goal and not to lose one of the most aspects that shows importance of design. Finally all designers agreed on common solutions and provided us with some answers and measurements to be taken in consideration.

6.1. Measures to be applied during project phasing.

<u>Shifting from verticality to horizontality</u>

Worldwide, people are working from home due pandemic lock-down measures. In central business districts, large office buildings and skyscrapers have been deserted. Now that work is being done remotely, some are re-evaluating the need for such spacious and expensive spaces. In our project we wanted to merge two concepts as back in time horizontal expansion of building and not going vertically was due to lack of building technologies before skyscrapers and high-rise building , thus during pandemic conditions it showed that it's not the solution to go vertically although it might be good for land-use but it's a disaster in terms of social distancing and construction cost. as no one would think building such marvellous or highrise construction if they cannot occupy 50% out of total area as it will not be feasible. Psychological wise this pandemic period proved that people need to go out of homes and to social interact instead of using media and technology , hence we shifted from vertical to horizontal expansion in order to maximize the efficiency of spaces used and also considering technologies that allows us to use common places and rest rooms instead of cancelling them from functional diagrams. Remote working would cut costs and instead of working in one place , families can work while taking care of their children.

<u>Increase in modular construction</u>

The need to design and build fast in emergency conditions taking healthcare industry as a reference continues to be overwhelmed , there is a big change nowadays in terms of supply and demand. Same applies to any project type whether it's educational , scientific , public space or indoor buildings for events. Temporary lodging and modular construction was one of the previous design applications working on modules , but now the modular construction is going to be designed based on a grid and also it goes towards flexibility and design free for the space. Maybe sometimes in renovation projects it's more challenging to design but prefabricated materials and modules are the current global goals for fast construction to cope with large number of population in parallel to safety and limiting economical and lives losses when it comes to community. As people are the most important key the need to design and build fast in emergency situations has become increasingly common.

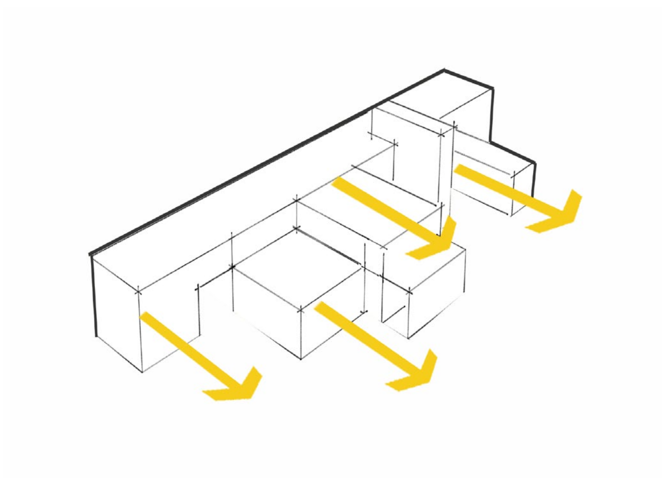


Fig.76:Conceptual Sketch showing horizontal expansion

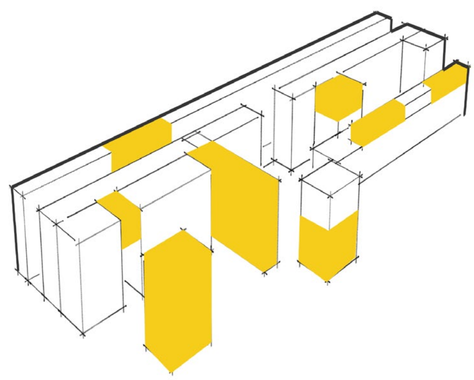


Fig.77:Conceptual sketch: modular construction with flexibility

Concept of Adaptive reuse.

Additional design approach that has been popular during the pandemic is adaptive reuse, the process of using existing structures to serve new purposes. Adaptive reuse is an efficient and sustainable approach to creating new spaces, especially for aging cities or mega cities that suffers from high urban density and has lots of ancient buildings that remained abandoned and with no use , some of them needs to be renovated while the others has more prior historical value that they are listed and cannot be touched . Side by side with modular construction, It's proven to be very effective in creating emergency facilities, multifunctional spaces serving multifunctional purposes with an idea of keeping important elements that reminds community with the past while using the space for current or new functions. For instance the previous ex Macello is having a special structural element shape that we prefer to keep and then to add to it in terms of preserving the past and cost wise according to the current condition. This means that we can reach the ultimate benefit of the building without eliminating it from past.

Lightweight Architecture and combating COVID

The Food and Agriculture Organization (FAO, 2020a) states that COVID-2019 is affecting agriculture in two significant aspects: the supply and demand for food. These two aspects are directly related to food security, so food security is also at risk. Speaking about Milan and food problem in urban and IMM design labs , one of the most important factors that have been into consideration when it comes to urban design. While agricultural labs and greenhouses are considered as main functions in our projects we want to insure that economic allocation equivalent to the cost of food rations of basic necessity and research labs are playing the administrative role in possessing it during pandemic. Architectural wise the idea of lightweight architecture such as new innovations of tent structures , shipping containers converted into bio-containment pods and modular critical care units that can be easily transported from our laboratories to lands that affected by lack of labour , also it could take place in outdoor areas surrounding the sites as portability and ease of assemblage is perfect for disaster and crisis response.

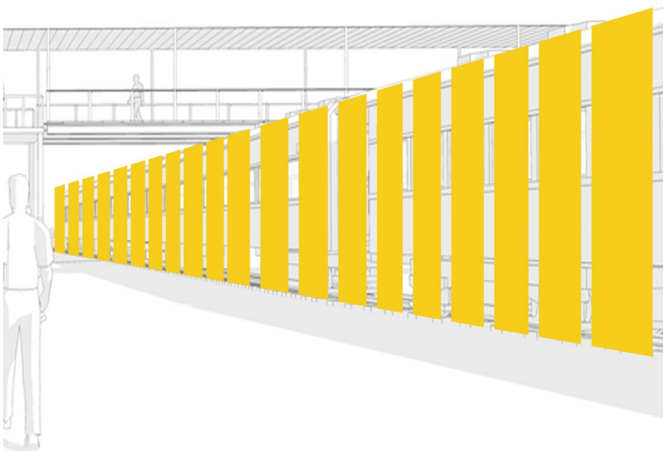


Fig.78:Sketch showing building reuse and transformation

Fig.79:Conceptual figure of sanitized lightweight construction

Fig.80:Eastern facade

7. CASE STUDIES

7.1. Introduction

Doing a case study and documenting information is providing various ideas and lets us peek into the minds of various architects who used their years of experience and dedicated their time to creating such fine structures. The case study helps us study the design philosophy of the architect and do a detailed analysis. By doing so we get a clear picture of the pros and cons of the design that might have an effect on our design as well. We may like or dislike the design but it doesn't go unnoticed. a case study is essentially research or an investigation, essentially giving one a better understanding of examples of executed solutions for a project similar to that one is about to Professional/ Executive Summary, Outline the purpose of the case study, findings. Identify the problems found in the case by: discussion, summarise the major problems,conclusion, Recommendations,
Implementation or references. Case studies also allow a lot of detail to be collected that would not normally be easily obtained by other research designs and tend to be conducted on rare cases where large samples of similar participants are not available.

We found that in order to get the maximum benefit of studying previous cases, we have to understand the value of the building and reasons that made it subjected to renovation projects. Also using regional and local examples would help us to most probably understand the suitable materials to be used during renovation process and best matching building techniques to be applied. as first example we chose a similar case study of Roman slaughterhouse exposing the history of that building , reasons of renovation works , architectural features were studied and the main architectural language of the design. but also we chose another case study of Dutch slaughterhouse as Italian slaughterhouses design were influenced by German and Netherlands engineers back in time when construction technology was depending on steel structures including roofs , Inner columns ,steel beams and also cables/holders of meat transportation into and outside the slaughterhouse. with all German catalogues designing modern slaughterhouses with spaces and aisles , distribution chambers and how circulation happens inside the building , While Italians were using traditional slaughterhouses coming out as historical or ancient buildings expressing identity then shifted to new slaughterhouses across city borders and following the new European trend of design and technology.

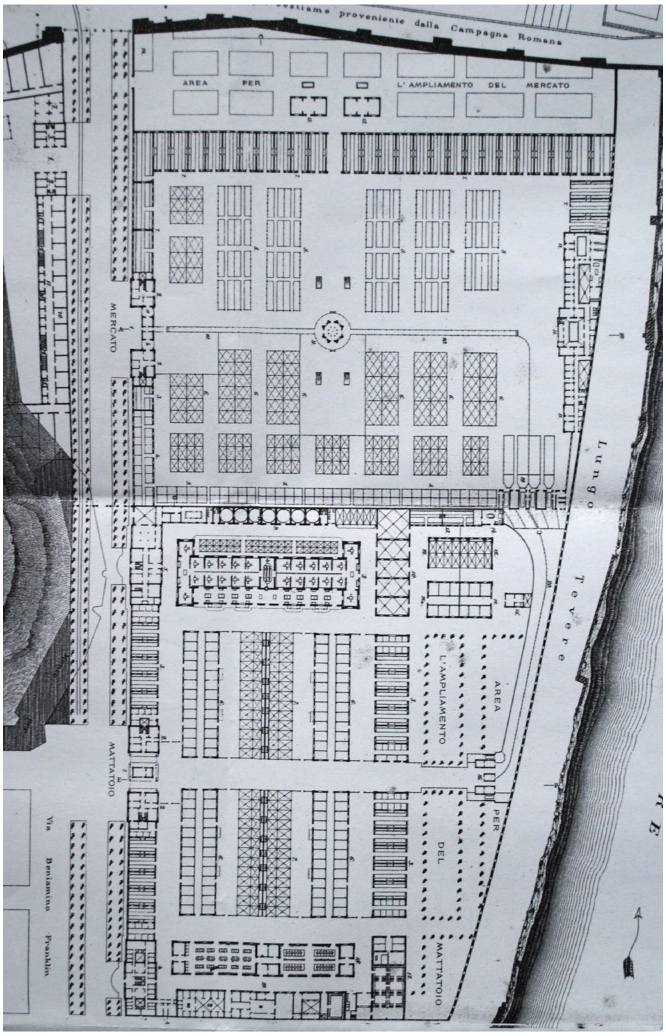


Fig.81:Plan and picture of the site before the Renovation. Source: "CUPELLONI, Luciano. Il mattatoio di Testaccio a Roma. Gangemi Editore, 2001."

7.2. Ex Slaughter-house Testaccio, Rome

• Location: Rome, Italy
• Year of construction: 1992-2013
•Architects: LucianoCupelloni, Insula, S.Cordeschi.
• Investors: Università degli Studi Roma 3 – DiPSA
• Area: 111.8 m2

Old
The slaughterhouse, designed between 1888 and 1891, was built to replace the existing structures, built under the pontificate of Pope Leo XII, and describes the transition from papal Rome to Rome capital. The project was included in the Rome master plan of 1893, which determined the industrial nature of the Testaccio area, a neighborhood that was supposed to host workers' residences and important production complexes. Located in Testaccio neighbour, the slaughterhouse is the most advanced product of the time: it represents the identity of an era of great changes.

Architectural features
While the composition of the fronts is based on nineteenth-century and neoclassical rules, the interior of the pavilions marks the turning point towards modernity. Ersoch reveals an innovative approach to design: by organizing spaces in a rational and functional way and proposing a new architecture of work, he demonstrates an ordering and social intention; he uses prefabricated structures in iron and cast iron, dedicating a lot of attention to the choice of materials, selected on the basis of their availability, processing, their duration and mechanical characteristics. The monumental entrance to the slaughterhouse, located on via Galvani, is characterized by three arches on columns: the symmetrical side bodies are open, while the central one houses the keeper's rooms. The main parts are organized in the central spine: four identical slaughterhouses define the long sides of the square while the short sides are occupied by the tripe and the goat slaughterhouse on the right, and the pig pelanda and tanks on the left. The activities most connected to the city, in order to be reached more easily from the outside, are arranged along the perimeter.

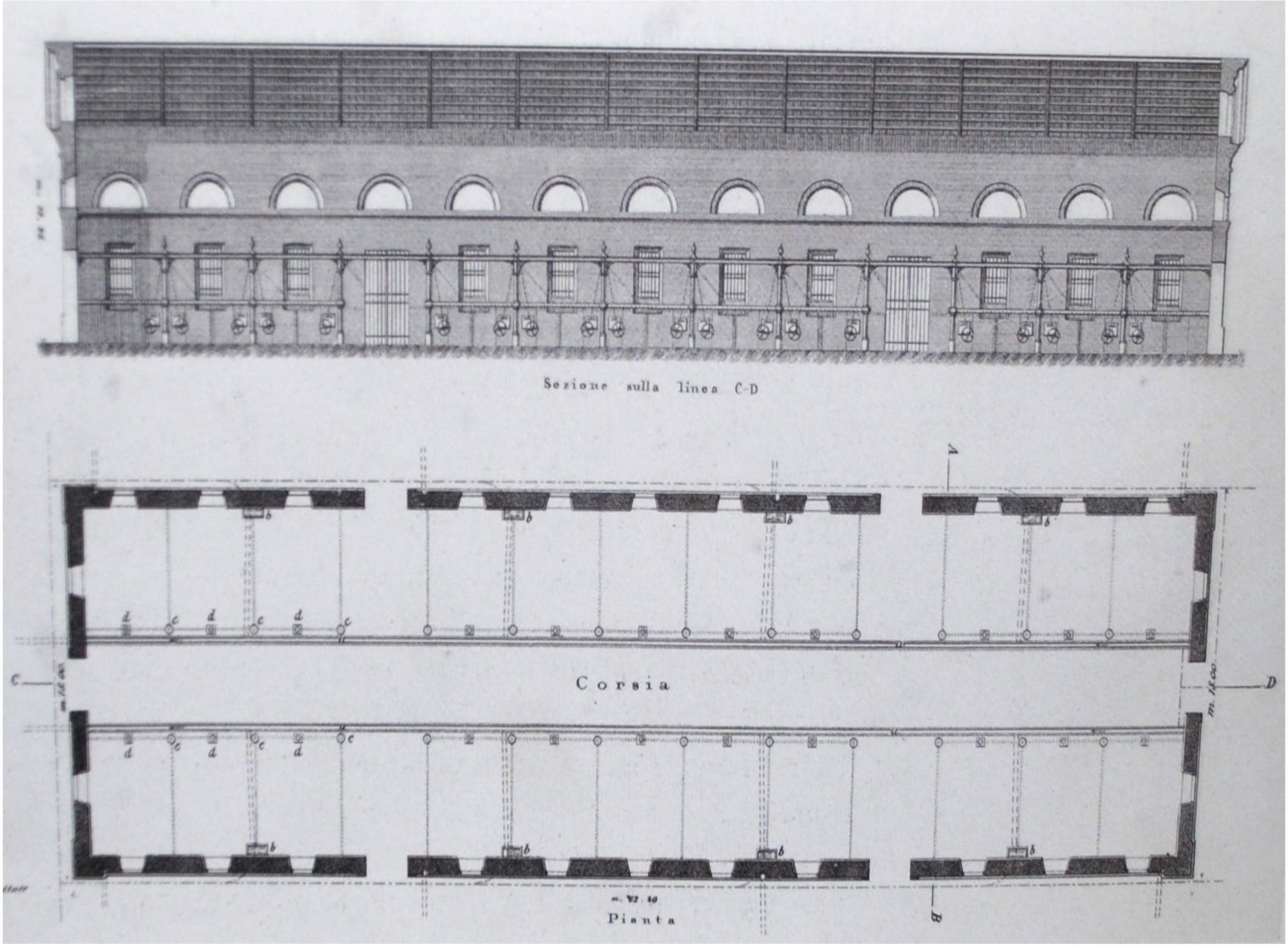


Fig.82:Elaborates slaughterhouse before the Renovation. Source: "CUPELLONI, Luciano. Il mattatoio di Testaccio a Roma. Gangemi Editore, 2001."

Project

The slaughterhouse has not been in operation since 1975. In 2000, the renovation project of the entire complex was approved, resulting in a functional subdivision: the MACRO Future, acronym for the Museum of Contemporary Art in Rome, university activities for the Academy of Art and for the Faculty of Architecture in Rome Three, while the shelters of the Foro Boario, the spaces for the scales and the sheds host the City of the Other Economy. The first intervention (in 2002) concerned pavilions number 6 (toilets and thermal power station) and 7, a large covered area (85 x 15 x 10 meters) illuminated by four large skylights. With the aim of creating three laboratory classrooms and a 260-seat lecture hall, Insula's design choice enhances the industrial body and creates **separate and acoustically isolated areas, through the insertion of three dividing walls with a steel structure**: transverse diaphragms partially transparent, linear,light (made with materials such as iron, wood, glass) and essential colours (white, gray and blue). The large geometric veils and the long hanging perimeter tables re-establish the human scale and accentuate the volume of the building, reaffirming the university use of the place. School and the library. As in the previous intervention, Insula decided to preserve the volume and articulate the large internal space -840 square meters- through mobile partitions, tracing the The project of Pavilion 2B (visible in the scheme in the right) foresaw the recovery of the building to guarantee flexible locations for classes and workshops, together with a collective space as a link between the architecture original division in 7 stables (demolished in 1932).

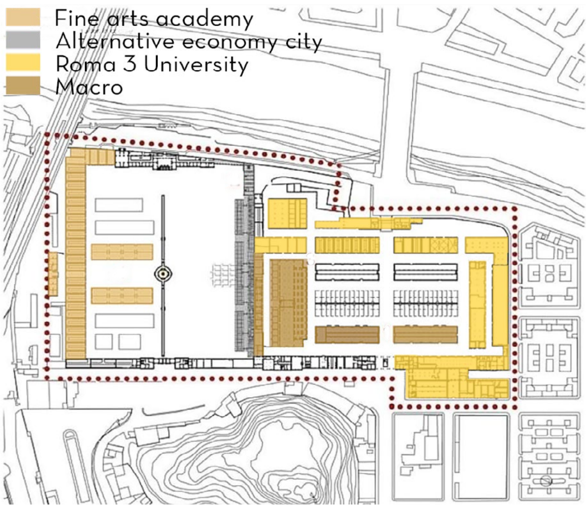


Fig.83:Elaborates building distribution and type of uses.


Fig.84: Mattation pavilion. Source: ArchiDiAP - Foundation reinforcement - Source: ArchiDiAP

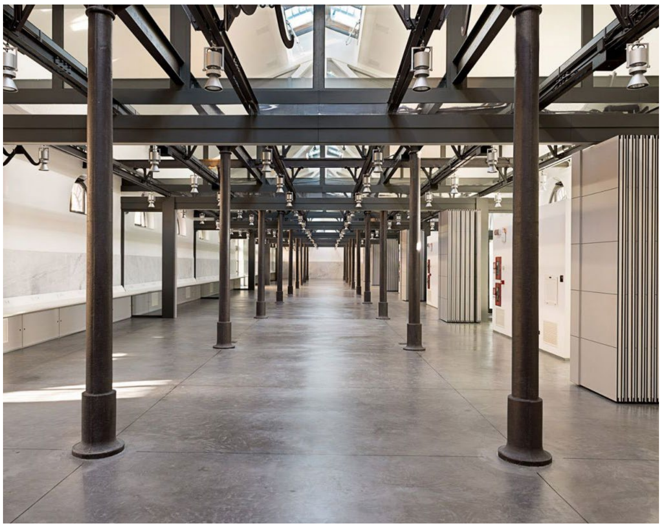



Fig.85: pad.2B, Source: Insulate - pad 2B, Flexible space with movable walls. Source : Idib

Fig.86:Section. Source: Insula

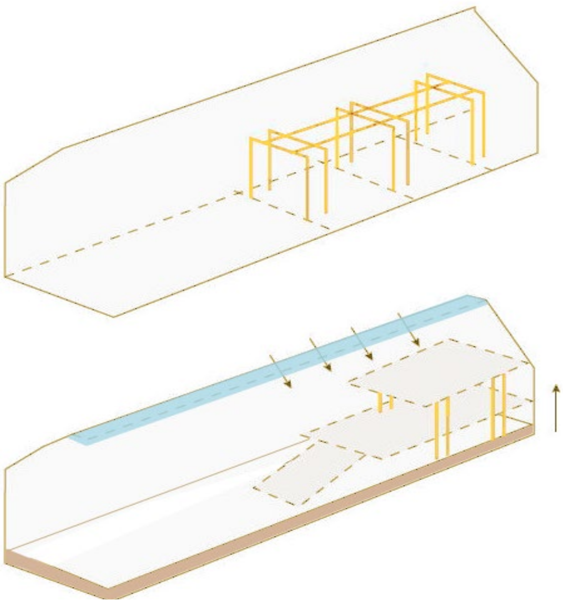


Fig.87: The extension , reflecting percentage of innovative renovation using modern materials in execution.source:Idib

Fig.88: Structual beauty as main component.source:Idib

Fig.89: Post-renovation and adaptive reuse.source:Idib

7.3. Lochall library, Tilburg

- Location: Tilburg, The Netherlands
- Year of construction: 2018
- Architect: Braaksma & Roos architectenbureau, CIVIC architects, Mecanoo
- Investors: Università degli Studi Roma 3 – DiPSA
- Area: 11 200 m2

Old

The building is an instant classic with the people of Tilburg. All of this, in what used to be a locomotive hall in the up-and-coming 'Spoorzone' area. At the beginning of the 21st-century locomotives were built and repaired here. The municipal monument dating back to 1932, has been converted into a modernist epicentre of design filled with glass, stunning wooden staircases and the grand old skeleton from its industrial days.
The construction of the Local catalyses the redevelopment of 75ha railway area in Tilburg. The building will unite and activate public routes and places all around. Its location in the middle of a public transport node and the transparency of its construction will turn the building into an attractive hub for sharing knowledge and information for the entire region.

Architectural features

The main goal of the architects was to refurbish this huge building of 90x60m with a hight of 15m, keeping in consideration the old function. The recovery of memory and history becomes the common thread to imagine a new life for the area.
The building remind a cathedral in steel and glass and was very important in the memory of the locals.. This is why the process followed was to bring back the site to the city , maintain the original structure., the imperfection of the old materials and their maintenance contribute to re-bring the authentic atmosphere.
To lighten the huge steel structure, it has been decided to use a chromatic register with warm shades (red and orange), stairs in wood and soft mobile textile screens to create private and intimate spaces.

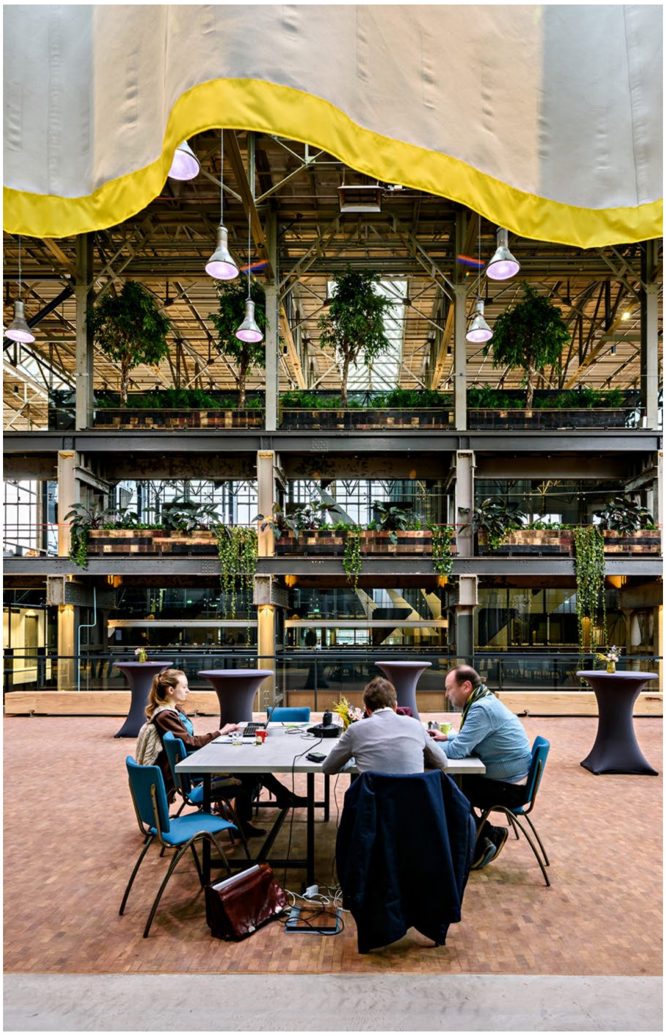


Fig.90: Post-renovation gathering space.source:Idib

Fig.91: Halls after being redesigned,elevated approach.source:Idib

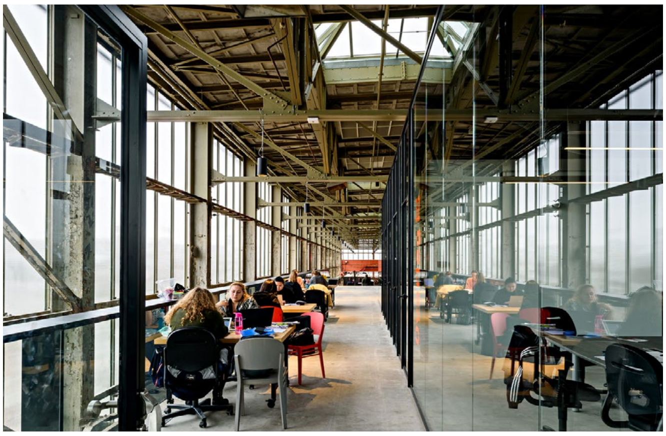


Fig.92: In and Out , terraces and corridors.source:Idib

The project

The building located in Tilburg, was renovated after a competition that made possible the transformation from an industrial deposit built on 1932 into a public library.
The LocHal houses the Midden-Brabant Library, the cultural institutions Kunstloc and Brabant C and the co-working spaces of Seats2meet. The LocHal is a space for both young and old to read, learn, study, meet and gather. It is a place for testing, creating, exhibiting and presenting the latest innovations.
Mecanoo's playful and innovative interior design forms striking contrasts by combining characteristic historical elements with new oak and steel additions. There is a diversity of settings for meeting, collaboration, and concentrated work. The building is locally and adaptively conditioned for mixed use. The open city hall has a climate concept tailored to its role of a roofed forum. Seating on the landscape of stairs will be heated and cooled and offices will have their own sub-climate. This creates a flexible and comfortable climate while preserving the monumental shell.

The halls have been "redesigned", placed in a firmly different perspective with the elevated stepped landscape and the monumental textiles. A harmonious contrast in which the play of incident and filtered light emphasizes and enhances the spherical perspective, the steam of yesteryear, and allows the whole to be admired again. It is a place where the Tilburger can connect with the past, but where he should above all feel at home.

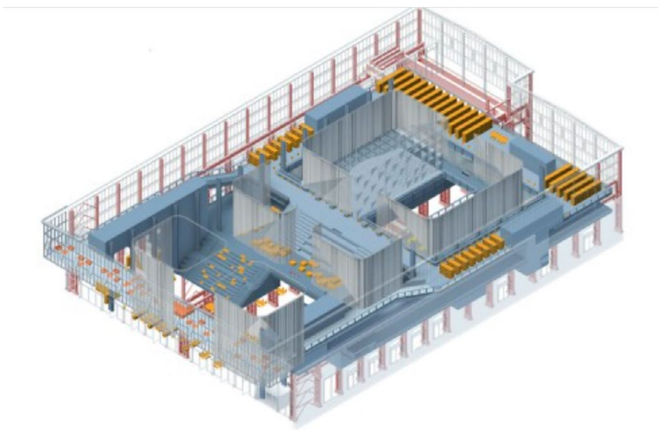


Fig.93: Axonometric redesigned halls and added functions,source:Idib.

8. FUNCTIONAL ANALYSIS

7.4. Introduction

In relation to the built environment, the term 'function' refers to the purpose of a building or structure. It can also relate to the proper operation, process or performance of something and how it works, such as plant, tools, lift, building services. Buildings may have a range of different functions, Products, materials, components and systems, can be assessed in terms of their functionality, that is, the suitability and capability with which they serve a particular purpose or practicality for which they were intended. A Functional Architecture is an architectural model that identifies system function and their interactions. It defines how the functions will operate together to perform the system. There is normally more than one architecture that can satisfy the requirements. Usually, each architecture and its set of associated allocated requirements have different cost, schedule, performance, and risk implications. The two most common architectures a system will have are: functional or physical architecture. As form follows function, this would be another way of stating this position. Architecture is the reflection of the program and the spaces it creates and serves. These elements begin to give the project its form. This faction believes in the notion of form follows function. The functions of the spaces are the priority in the design process.

They represent the primary elements to drive the design and the Form itself. We would go so far as to even state the idea that the programmed spaces are what give this Architecture its meaning. In psychology the term 'function' is defined as 'ability' or 'power'. The dictionary amplifies this definition by adding 'special kind of activity' or 'mode of action'. Various authors have devoted their considerations to the functions of a building. As also we had to respect the economic value of the functions , A building requires investment. It gives added value to raw materials. Maintenance and management form part of the exploitation cost, and must be set against income from rental or sale. It follows that a building, whether property or an investment object, has economic value and so an economic function.

On the other hand it's very important to specify type of users and scope of work if we want to ensure people efficiency in their working environment is going fine when it comes to ergonomics when it's well designed.

8.1. Laboratories function and users

Description

The primary users of this facility will be researchers and employees those who provide services to keep the function working as independent private sector. These users will require laboratory spaces , offices and high-tech equipment. There is an assumption that these individuals would work from 9:00 to 17:00 basis with possibility of late nights. This department also used to inform the general public, We are introducing defined categories also for labs like Food and nutrition in which training and dissemination on food is playing a role in quality and its role in maintaining health and preventing the risk of food-related diseases.
Genomics and Bioinformatics: The research aims to understand how small variations in the DNA sequence and / or proteins determine important crop traits and apply this knowledge to genetic improvement, crop sustainability, traceability of production processes and food safety.

Timeline for users

According to several aspects including relationship matrix we decided to choose a specific timeline to organize users flow and highlighting each function and category separateley in order to have deep understanding and to provide the best functional allocation, spatial and personal experience to them.

As shown at figure below we focused on one specific type of users which is researchers , retrieved info from different types of laboratories and difference in working times. Also as per our goal and vision for achieving sustainable design and also futuristic vision , as per WBDG also it's very important to follow design standards and circulation of users according to the international system.

Fig.95: image showing expermental laboratory and users

Fig.94:image showing specimen lab for running tests.

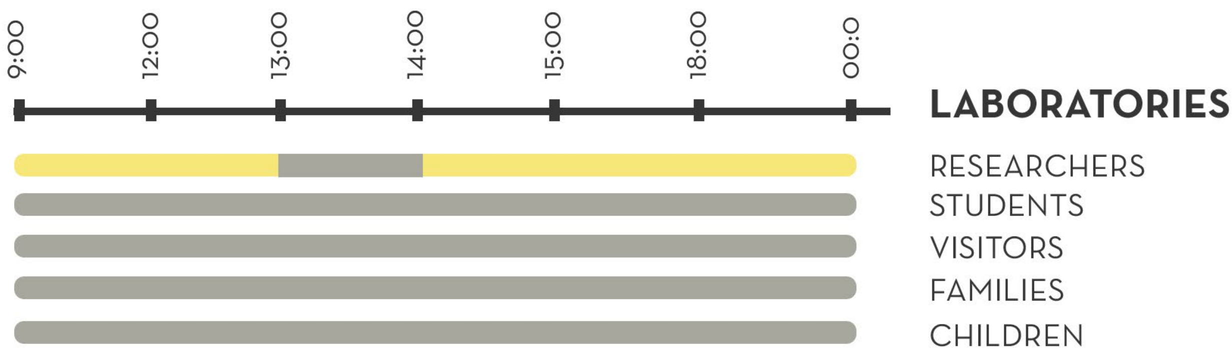


Fig.96: Chart showing timeline and working hours for users / researchers

8.2. Educational function and users

Description

Educational facilities are considered as one of the most challenging functions to design although it has quite clear sub-functions but the way of design and implementation and how to look to it as a whole complex building and interconnected spaces is important as it depends on number of users , circulation and which type of educational complex we are targeting. In our perception and goal we want to provide unique educational experience by introducing families section for participation into educational cycle not just ordinary experience between professors and students. In this section as our aim to provide all needs and requirements for them as matter of involving them in space design when it comes for shared activities , rest rooms to practice their work in parallel using online system as world is going towards digitalization with barrier free spaces.
As in our concept huge space is created then we need to start shaping its smaller and specific areas. in order to maintain the void under the old building, we decided to put these auxiliar spaces to the back so they do not interfere with the main ones. so, all the services-workshops, offices, stairs, and bathrooms- are hidden behind bookshelves or library breakout spaces.

Time-line for users

As we did before in functions category including relationship matrix we assigned the functional allocation to four types of users that are going to use the space most probably at the same time , in working time and interlaced activities we find out that these 4 types of users are the key cores of all functions if they're at indoor spaces or outdoor spaces.

Fig.99: image showing library and studying spaces

Fig.98:educational activities and tours for young generation

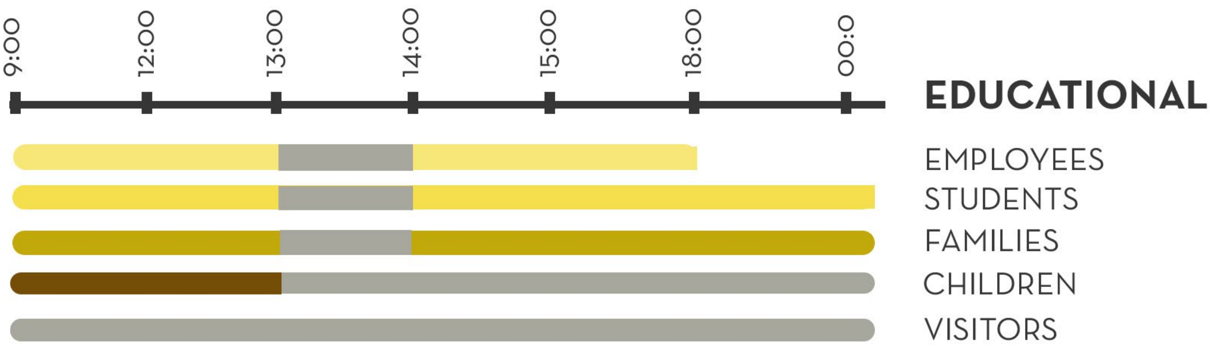


Fig.97:Chart showing timeline and working hours for users

8.3. Gallery And Exhibition Spaces.

Description

The meaning of the exhibition here is not associated with just art it's interchangeable space within a building or boundary so it becomes typically flexible in the way it can be used to present products , plants and decorated showrooms to maximize the impact of the temporary exhibition, and is usually in a prime location within the museum proper. Galleries and temporary exhibition spaces within the fine art world are carefully climate controlled to protect fragile works of art. As in our proposal we do need both of inner and outer spaces to be used in parallel with the idea of movable dry walls to be able to design free spaces according to function and event with a technology using the same idea of movable strings as shown in historical ex Macello along ancient times, instead of carrying meat , we carry partitions.
Food and nutrition: training and dissemination on food, its quality and its role in maintaining health and preventing the risk of food-related diseases.
Genomics and Bioinformatics: The research aims to understand how small variations in the DNA sequence and / or proteins determine important crop traits and apply this knowledge to genetic improvement, crop sustainability, traceability of production processes and food safety.

Time-line for users

Mixed use of the same space is playing a big role in this condition , not just per days and events but it could be possible to increase level of flow and intensity using the space for several events working at same place and same time in parallel by performing sound insulation techniques and common sub mutual activities to be done in breakout spaces. As shown at figure below we included all type of users which are mainly students and performers who could be part of working visitors to perform temporary events and also audience attending those events , meanwhile we have to attain certain number of full time employees just working for the gallery and also number of children who will participate in these performances as they are one of the most valuable assets we target in our showroom and they have to present what they've done in classes our their final output / products as it will give them a chance to deal with open market and public in a very young ages, in which would be promising and serves the community very well.

Fig.101:image showing showroom for figures

Fig.100:image showing flexible partitions gallery showroom

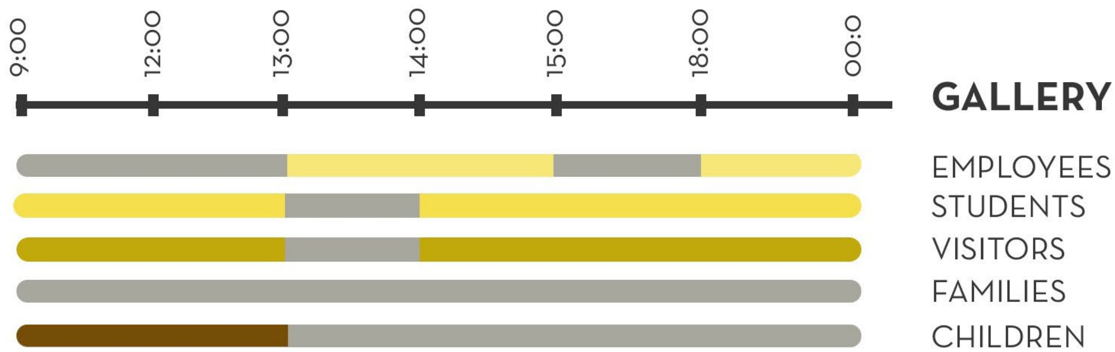


Fig.102:Chart showing time-line and working hours for gallery users and visitors

8.4. Conclusion

At the end of all analytical data according to resources and projecting them to our functional diagram , we wanted to assure that we are going into the right path in order not to design unnecessary spaces and to be realistic to the point of attracting people to the project. Thus, we reached out percentage of users to each type of users according to two factors. the first one is to calculate percentages of people using each zone in specific time line in working days in which provides us the real percentage according to time aspect , then for spaces and it's importance according to bubble diagram or relationship matrix and how they intersect so they can work for more than several functions and not to cause repetitive calculations leads to extra percentage that we will lead us to get deserted or abandoned spaces and more project cost. For example, if we are looking for some specific architectural structure or an architect in relation to spatial experience, more questions might pop up in mind. This could pave the way for the final question you might want to find answers to and based on research and calculations. Also , these percentages are accurate when it comes to express daily users and of course whenever we have flexible design and multifunctional spaces we have almost 20% more or less for each multifunctional zone depending on the event type , how many people will occupy the space in collaboration with event organizers , tools and agreements with administration department that would take place in our functional diagram.

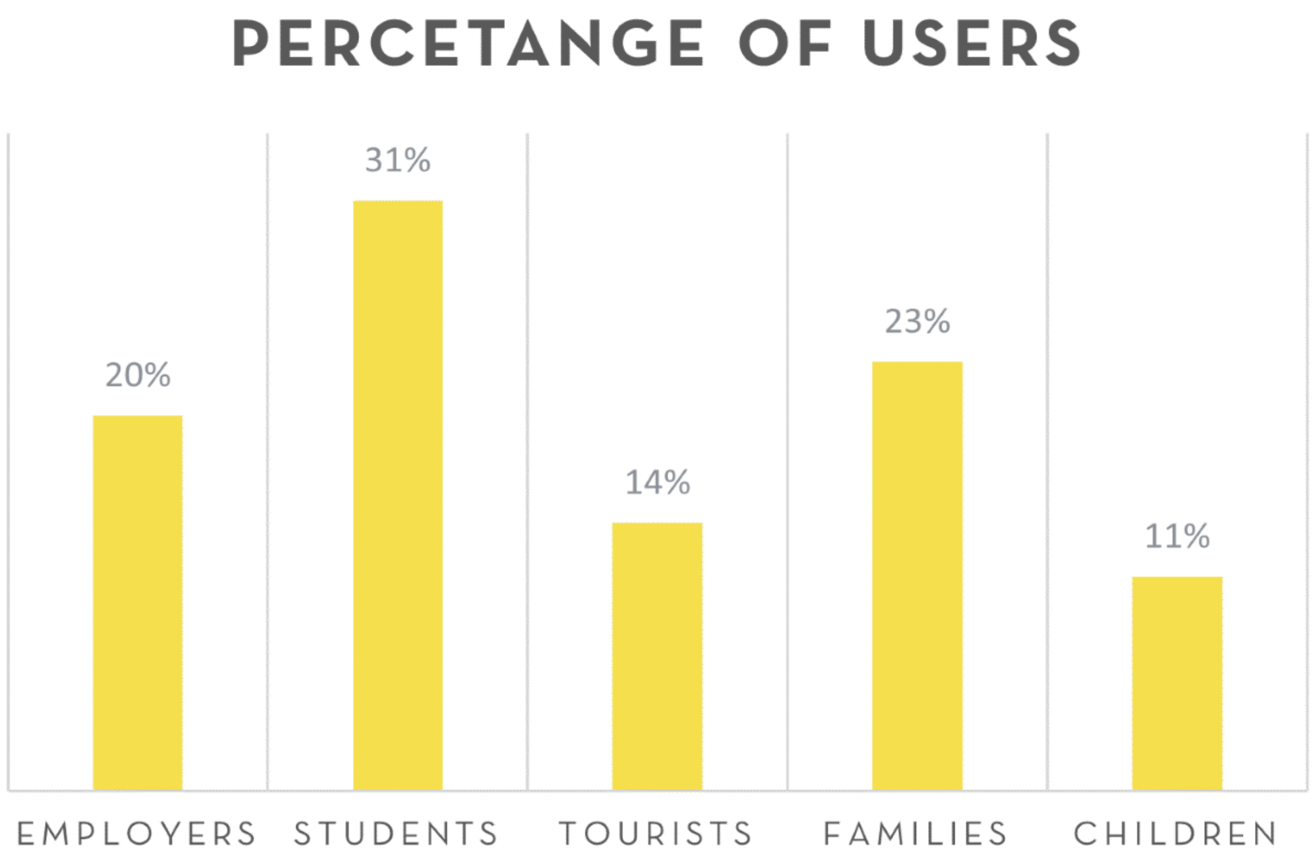


Fig.103: Bar chart expressing percentage of users in all functions according to time-line and occupancy

Fig.104:Laboratory view

9. BUILDING RENOVATION

9.1. Strategies

The ten interrelated renovation strategies :

We believe that renovation of buildings to high energy performance standards could be one of the most cost effective investments a nation can make, given the benefits in terms of job creation, quality of life, economic stimulus, climate change mitigation and energy security that such investments deliver the target as we spoke about the importance of renovation as feasibility study plays big role in it whether it's in construction materials or the way that we renovate. Simplifying the process, we decided to go by continuous steps and working on a logical path of renovation in both engineering and architectural ways. Throughout technical sheets we highlighted buildings to be renovated and by going in details we went for a further look to identify parts of demolition and parts to add as a first step , as for second step we defined the functions needed that matches goals and vision either a renovation or relocation of spaces. then considering whether to build up in or out.

Fourth strategy is to analyse the best use of existing space before renovation takes place, then to consider the building as one major element and how all these functions combined start to integrate with surroundings and masterplan.
Because structural elements are unique and different so we have decided to avoid altering or replacing them as much as possible. When considering the addition of a new space, thought should be given to the existing roof and roof drainage to avoid extensive re-framing of a traditional pitched roof. Where possible, the structure of the roof should be left untouched and the existing roof drainage preserved to avoid expensive work which can often have minimal benefits compared to a more thoughtful approach. Increasing comfort at spaces with ceiling insulation in some functions and involving daylight to play a big role in it, It saved us lots of cost through insulating the ceiling space of existing space. This provides greatly improved thermal comfort and reduces the costs of heating and cooling. After the major decisions have been made about what is to be altered and what is to be added, the final stage is choosing interior finishes and a new colour scheme and brighten up home with larger windows, glass doors and better views.

9.2. Wall Demolition

Dismantling buildings piece by piece to preserve the reusable parts within,keeps materials out of landfills and creates more jobs. In a relatively new concept known as deconstruction, dismantling gallery piece by piece to preserve the abundant reusable components within. So partial demolition are taking place in order to be able to renovate properly. Demolitions are taking part in some construction elements as for an old bearing wall in order to place. New beams strengthen the existing wall by distributing horizontal loads of slabs and transferring them through columns so the connection and the relation between new - old attachments when it comes to structure it is showing that implemented designed structure is supporting old determined structure without affecting it.

9.3. Wall Reinforcements

After demolishing the parts mentioned in digital sketches below in yellow , it was necessary to start reinforcing the old wall with two beams outer and inner and vertical columns for load transfer until completing column and beam steel structure in order to shift load transfer from bearing wall to this structural system. The outer beam attached parallel to bearing wall would be for just fixation time , meanwhile the horizontal one with same wall direction would remain permanently and connected to both columns and secondary beams of the structure. Creating a system support as a whole that allows us to add boxes and slabs of the new building functions and reinforcing the old wall to be able to support multiple loads more than previous condition

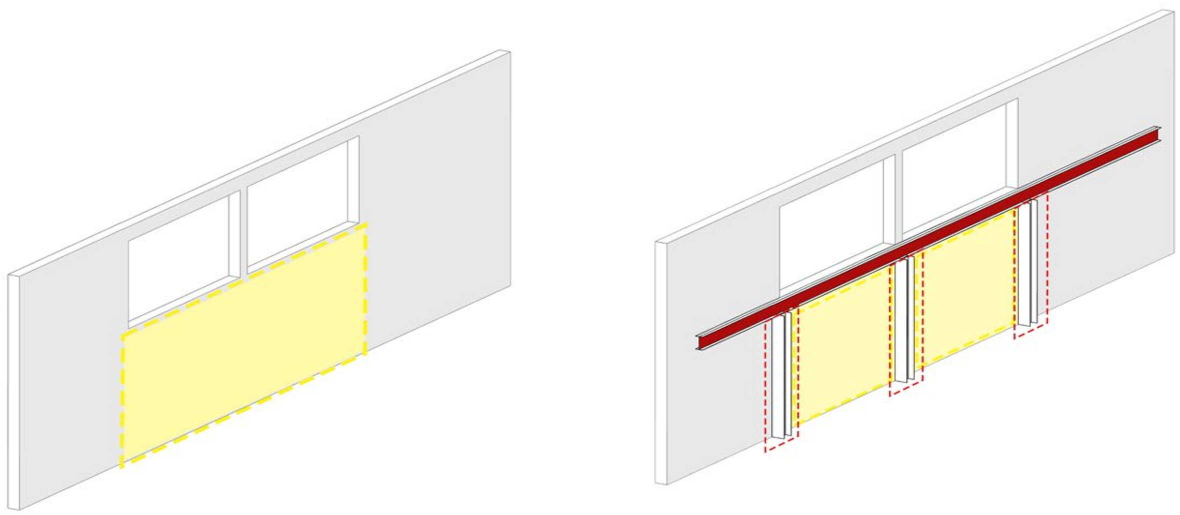


Fig.105: At the figure , yellow parts are highlighting demolished parts and red ones are highlighting added primary beams of support.

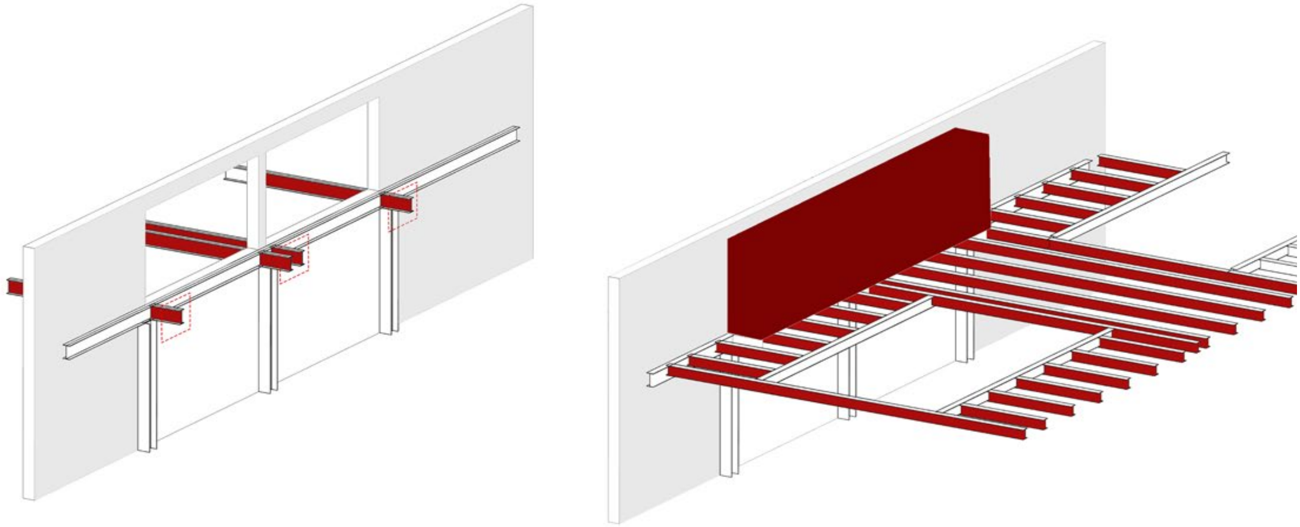


Fig.106:Cantilever intersection with bearing wall to carry the boxes , while on right figure boxes are exact size of openings and carried on both cantilever and secondary beams , thus skylights are opened throughout the slab for visual continuity and daylight.

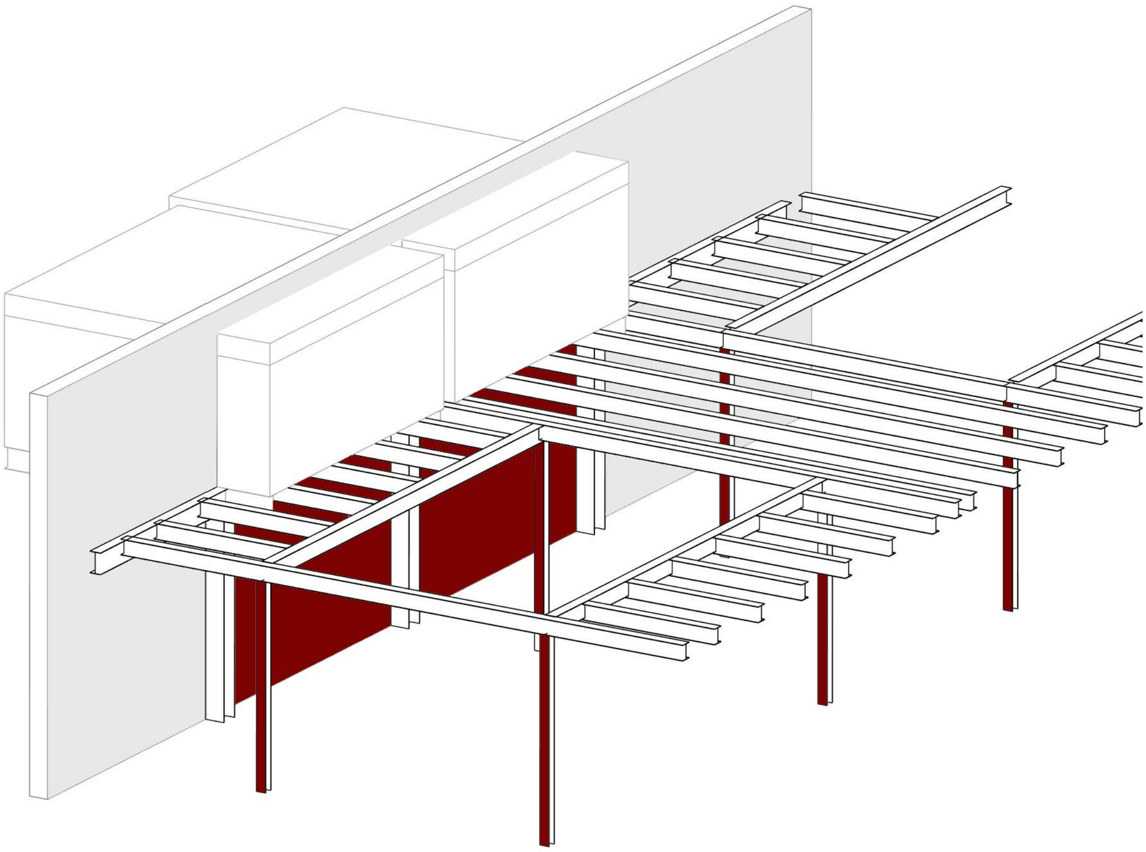


Fig.107: New structure steel columns holding the first floor slab and beam system

9.4. Roof structure and refurbishment

A roof truss serves to help hold up the roof of a building. If they are installed well, roof trusses require minimal truss repair and maintenance. However, it is important to watch roof trusses closely for signs of damage or decline, as broken roof trusses may cause serious problems, including the potential collapse of the roof of the building. Because of this, one of the primary causes of damage to roof trusses is exposure damage. If the roof itself is not completely secure, or if there are leaks in the mortar joints or gutters, moisture may enter the building and collect in and around the roof trusses. Similarly, this exposes the trusses to insect infestation and temperature damage, among other things. Maintaining a properly waterproof and sealed roof is one of the best ways of preventing damage to your roof trusses over time. The loads on the truss were obtained on the basis of initial hypothesized data and from the use of the new stratigraphy. The weights of hedging elements have been calculated and distributed in point loads on the trusses and on the UPN profiles placed at the upper nodes of the truss, to then go to distribute to be unloaded on the ground at the side walls.

For all the structure, just two profiles are not verified, both of them are located in the lower chord and next to the support, it is possible to see the bars in the picture on the left. The aim of the project is to maintain the structure of the roof since it is still in good conditions and because it is an important piece of history.

The solution is to keep the existing structure but at the same time reinforce them was to unload them by inserting pre stressed cables hidden between the profiles, preliminarily reinforcing the support areas and the struts affected by the compression action. While we speak about truss restoration , we have decided to add coatings to protect it from corrosion. Metal plate connected and steel trusses will not perform adequately in most construction environments provided that after permanent installation they are protected with the traditional materials and roofing practices. However, special protection measures may be required when metal plate connected wood trusses are used in adverse conditions. These conditions include exposure to high humidity. Metal connector plates are galvanized for standard use conditions but no exposure to corrosive substances. If the salt storage facility you are designing has free-flowing air throughout the building, it should be fine with no additional steps. If this is not the case, additional steps should be taken in order to resist plate corrosion. For several years, truss plate manufacturers supplied stainless steel truss plates when special protection was required. Stainless steel connector plates were supplied as a substitute when specifications for projects near the ocean or in areas that usually has continuous rainy environment like Milan city , called for metal plates that were "double dip" galvanized. The coating, such as Two-Coat Polyaspartic Urethane , coats the edges of the exposed steel, and provides a tight membrane protection for the plate. Its use has been tested on steel structures subjected to direct salt contact at ocean-front locations on rolled steel members, or exposed metal connector plate joints.

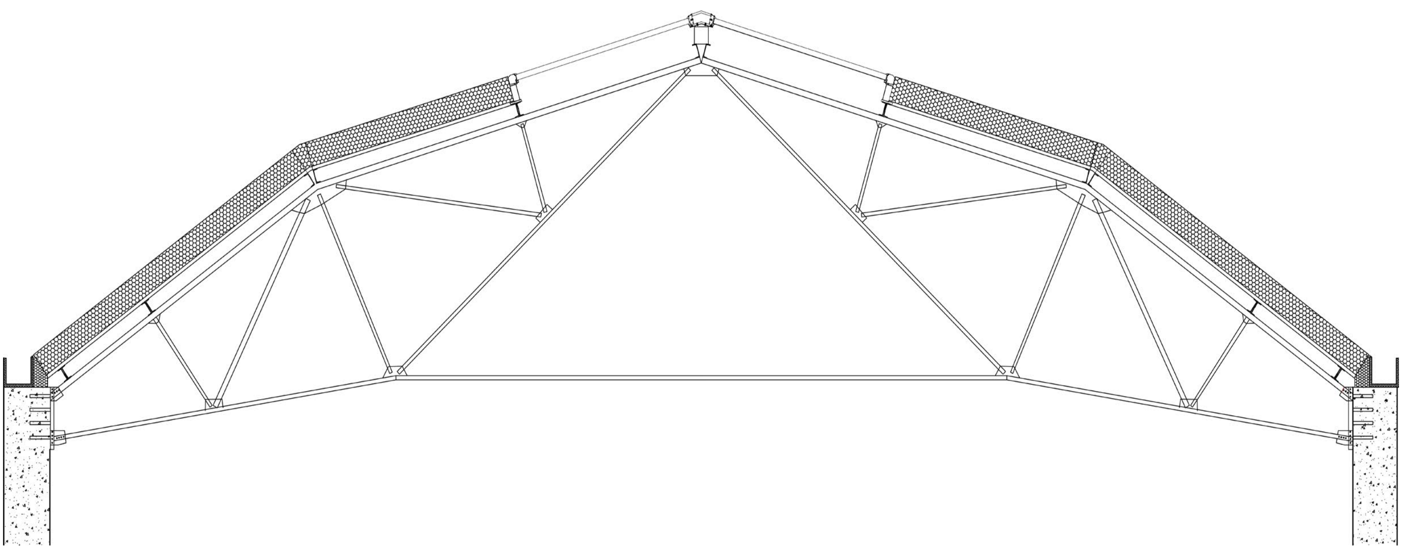


Fig.108: Renovated steel roof structure with connection to bearing walls and holded up by metal plates and bolts.

9.5. Foundations

Most ancient buildings were founded on shallow foundations. Usually they were constructed of stone or brick, and various types of mortar. After medieval period the construction system was changed to be based on bearing soils was to drop rubble or debris into an excavation, equal to or slightly wider than the underground part of the building, and pour poor mortar onto it. Foundation size usually depended more on the available space than on the active loading and bearing capacity. Walls and above ground foundations are among the most important character-defining elements of historic buildings. The design of walls and foundations is influenced by the types of materials used, the location, proportions and scale of openings for doors and windows, massing and rhythm of features such as bays and porches, and details and ornamentation. The exterior walls of most free-standing buildings are also structural, that is they carry the weight of the floors and roof to the foundation. Above ground foundation walls are often visually distinguished from the main wall by a change of plane. For example, brick and stone foundation walls are often visually separated from the wall above by a belt course of molded brick or shaped stone. In other cases, foundation walls are visually distinguished from walls by a change of material. The material used for an exposed foundation wall, how it is finished and how it connects to the wall above, are all distinguishing characteristics. Most historic buildings in Milan have a primary wall and foundation that face a public street. Typically they significantly contribute to the character of the building. The primary walls usually contains the front entrance identified as a gate ,is formally composed and uses high quality materials as we have it in a unique shape made of reinforced concrete. While longitudinal walls are also considered as primary walls because secondary ones where connected to it not carrying the live and dead loads. Thus , we can elaborate that the system acts as one when we identified that only the roof was made from different material rather than reinforced concrete as per walls and foundation.

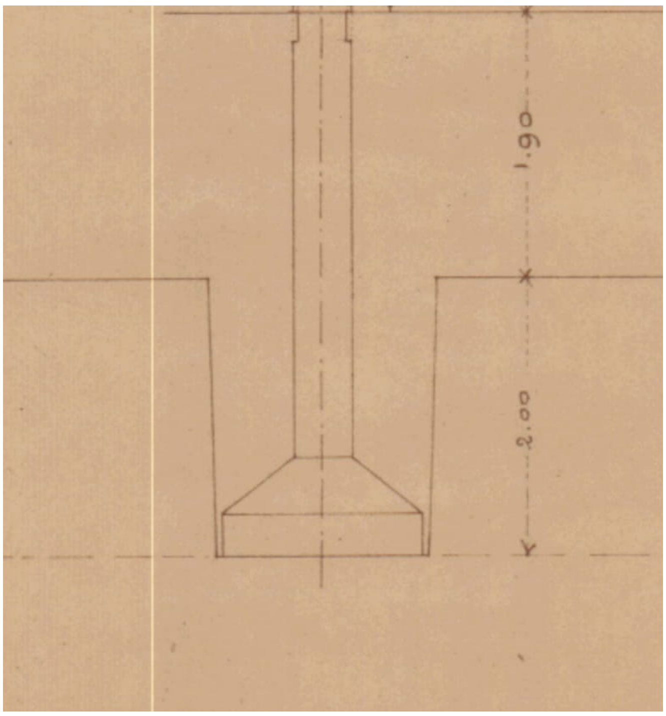


Fig.109:original designed concrete foundation and bearing wall , with two meters depth ,Source: Archivi di municipo di Milano.

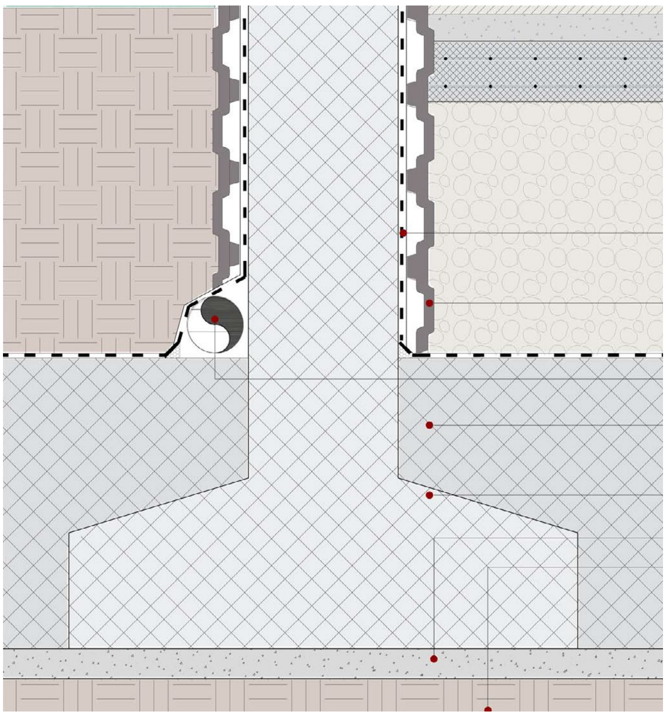


Fig.110: Foundation and bearing wall treatment in post renovation phase considering landfill and level difference.

9.6. Windows

New windows will be many times more energy efficient than the existing windows. And even the efficiency of existing windows can be diminished if we decide to return them to an operating condition. People who repair historic windows are more like artisans than carpenters and there's just not as many of them out there as in years past, not only to get the job done right but also to perform the repairs safely. If you live in a larger community, there may be an organization near you that provides a list of qualified contractors and consultants like Heritage workers especially in mega and historical cities like Milan that they have to understand the value of the building to the community before establishing works. With proper glazing and insulation materials that they were not subjected to energy efficiency concept and it's time to use new building technologies and insulation techniques , not in all spaces we have but in the areas of highlights that require indoor air quality with mechanical ventilation and thermal insulation as studying areas , offices and laboratories in which is different from double height spaces as galleries that it wouldn't require such treatment in order to reduce energy consumption level based on our performed energetic analysis. the frames would be aluminium attached from inside as it would be visible for visitors during indoor circulation or indoor experience , preserving the window opening from outside to keep same language and visual rhythm of façades,

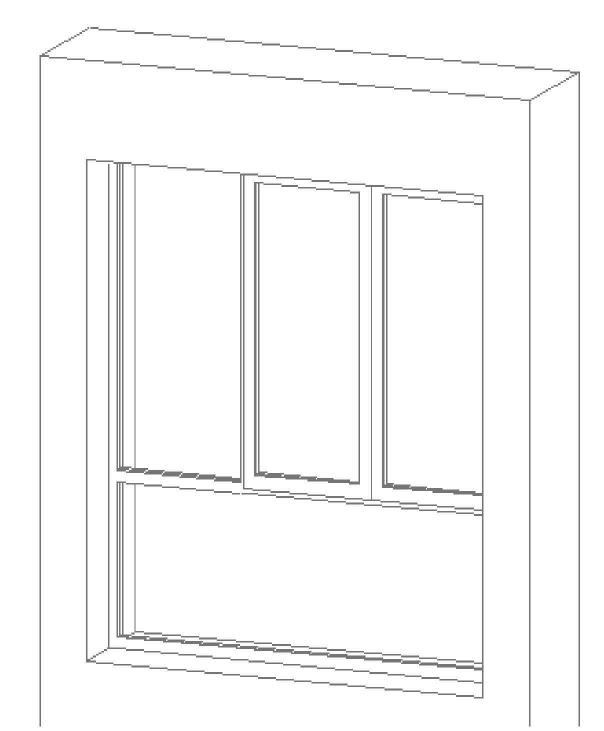


Fig.111:Basic scheme showing window frame shape while looking from exterior .

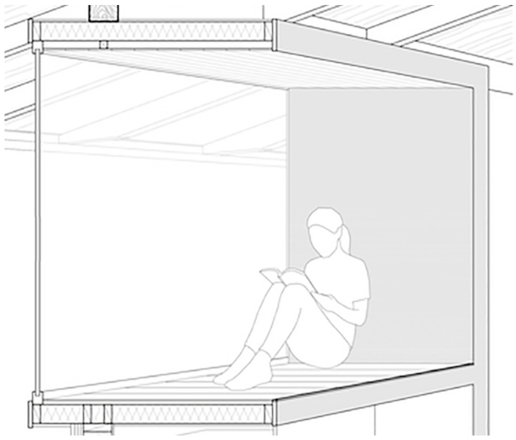


Fig.112:Sketch showing how low E-glazing would perform in attached boxes to main wall.

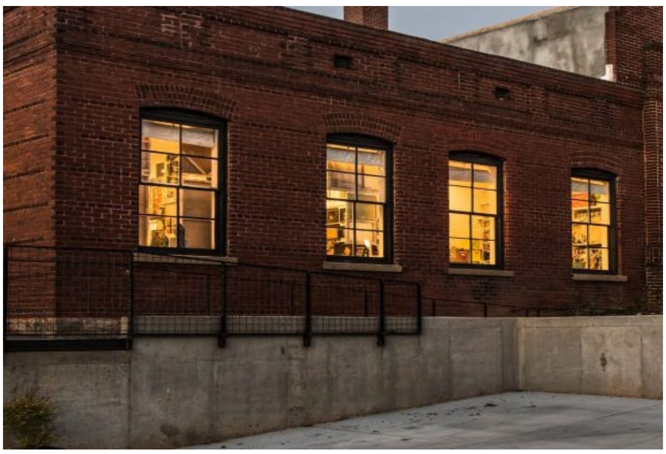


Fig.113: similar example showing windows attached internally during renovation, Source: Archdaily.

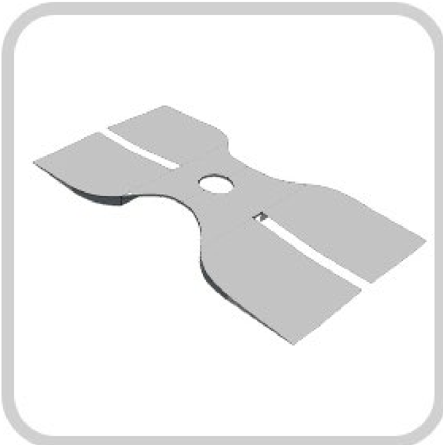
Fig.114:Ground floor entrance

10.ARCHITECTURAL DESIGN

10.1. Concept: Reviving Macello

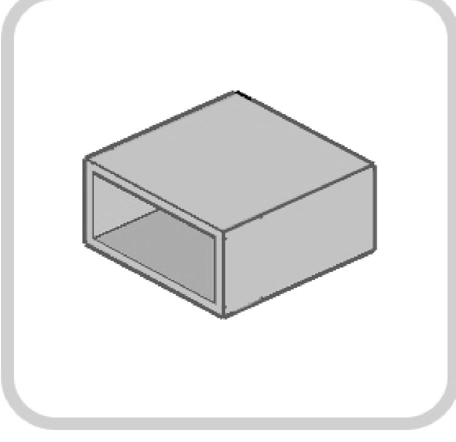
Architectural renovation is the reflection of the past, passage through sense of belonging and direction towards future sustainability. Our concept is to preserve the history as building memory, altering functions for adaptive reuse with technological and educational facility that helps the city to achieve sustainable goals by three divisions:

[1] Permanent – Past.
[2] Interactive Hub – Present.
[3] Innovation and technology – Future.



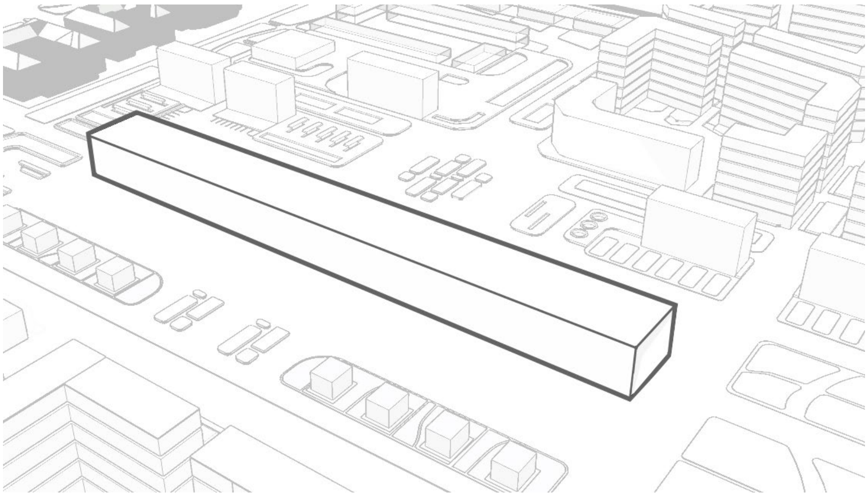
02 PRESENT

01 PAST

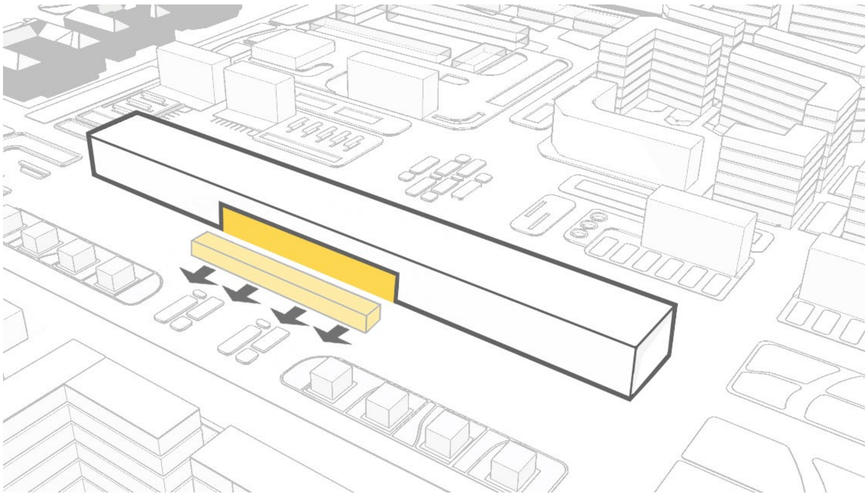


03 FUTURE

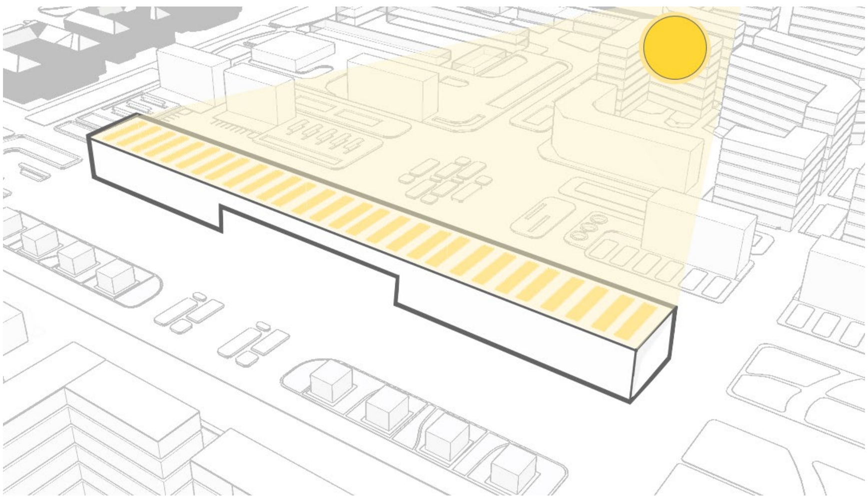
10.2. Architecture conceptual diagrams



1. SELECTION of building mass and main attraction point of the surrounding project area

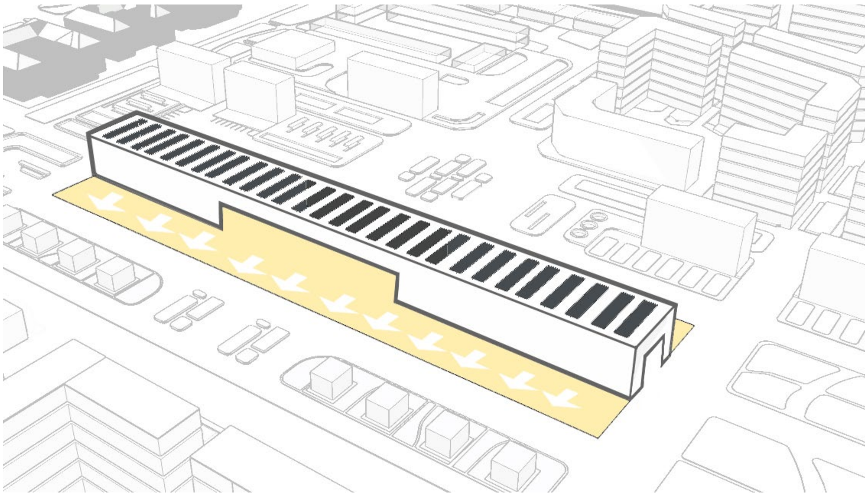


2. SUBTRACTION from building envelop and define prime gallery entrance

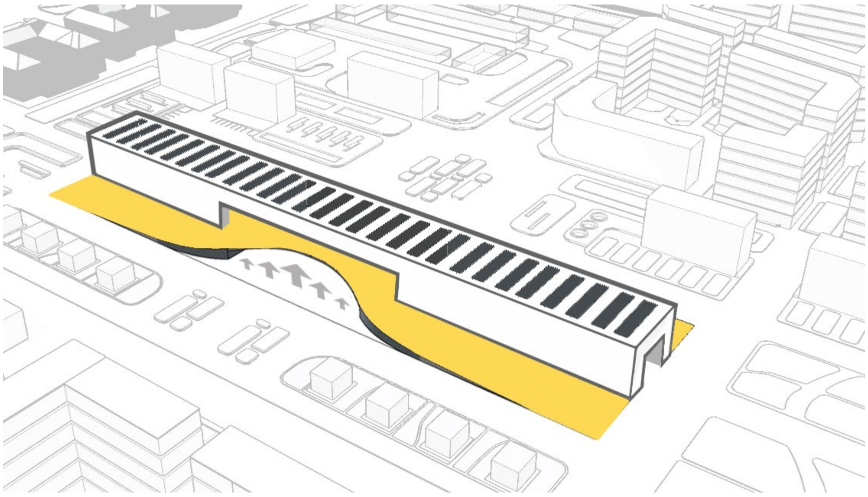


3. ALLOWANCE of sunlight permeability to pass through the existing roof structure

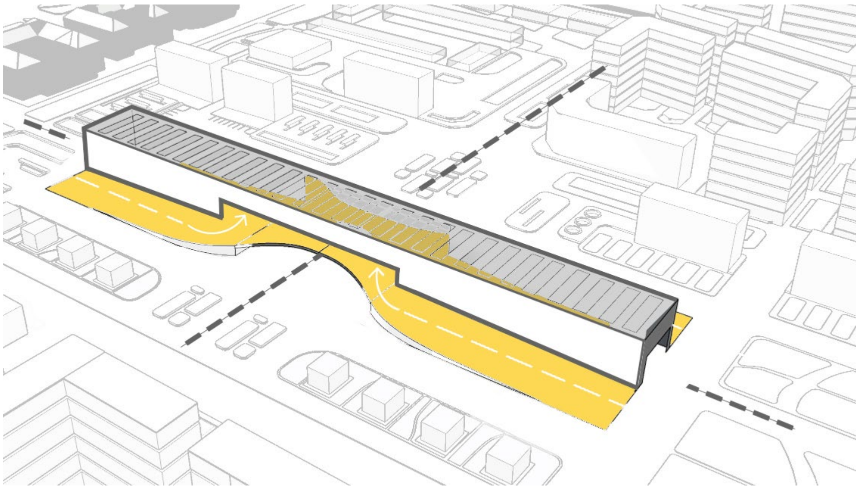
Fig.115: Architecture mass development showing mass transformation following architectural concept.



4. EXPANSION and propagation of functions by integrating them with the surrounding with the greenery



5. CREATION of unique elements and spaces attached to the existing building. Making visible the distinction between old and new



6. INVITATION for passage and social interaction. Creating also two important axis for the masterplan

Fig.116: Architecture mass development showing mass transformation following architectural concept.

10.3. Zoning - bubble diagram for functions distribution

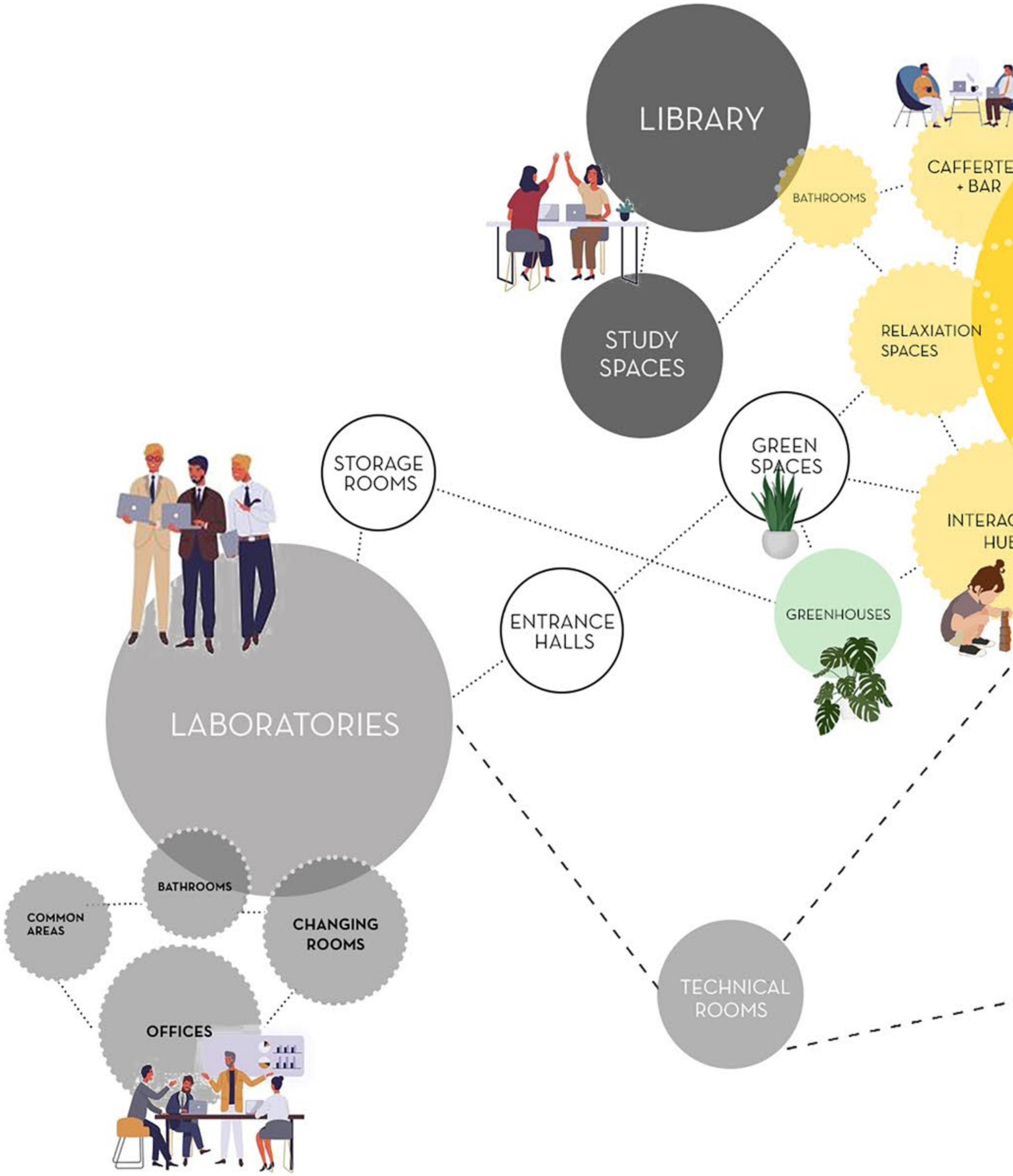
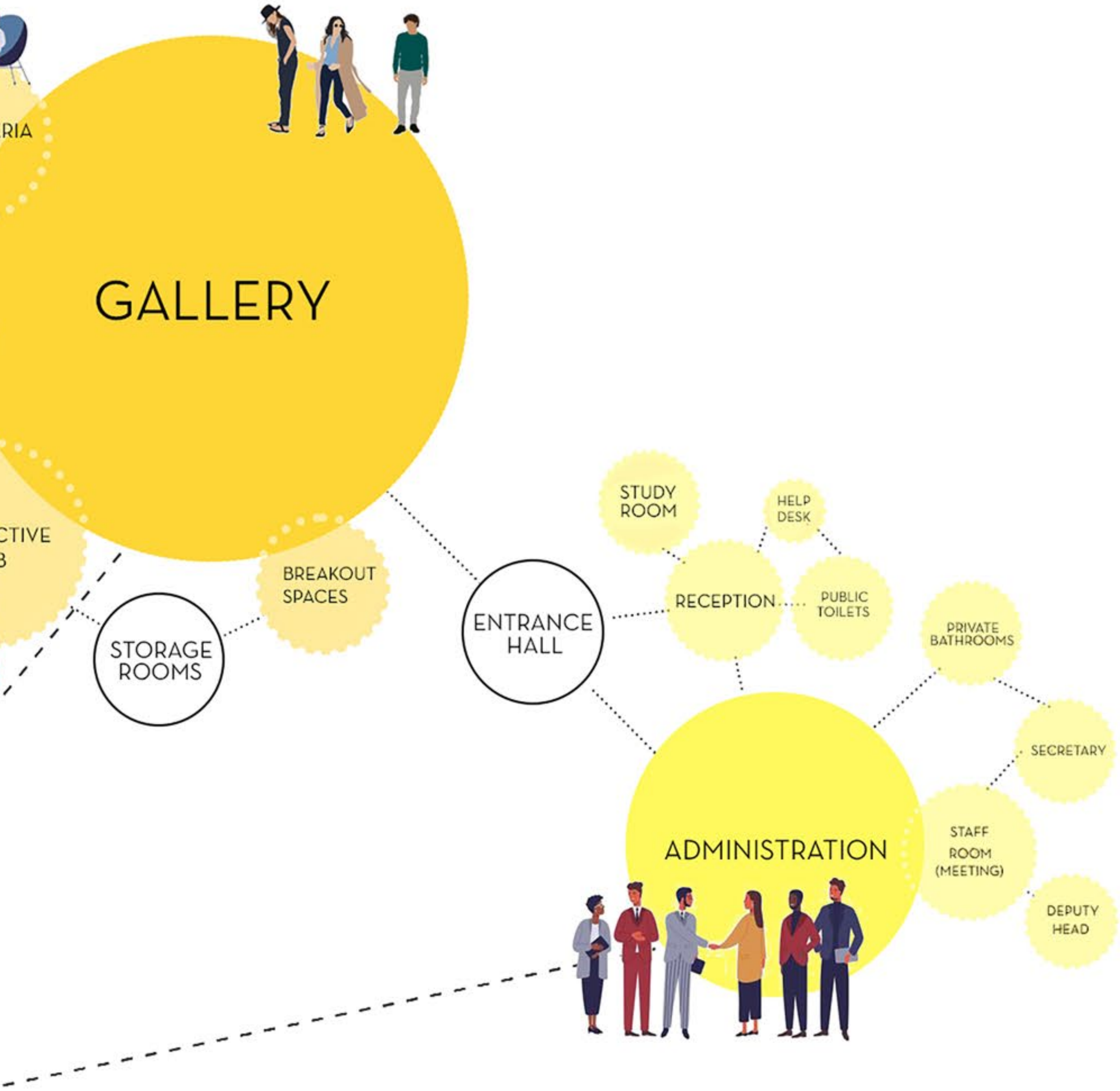


Fig.117:Functional diagram , Main zoning elements and sub functional spaces , with connections and relations between spaces.



RIA
GALLERY
CTIVE
B
BREAKOUT SPACES
STORAGE ROOMS
ENTRANCE HALL
STUDY ROOM
HELP DESK
RECEPTION
PUBLIC TOILETS
PRIVATE BATHROOMS
SECRETARY
ADMINISTRATION
STAFF ROOM (MEETING)
DEPUTY HEAD

10.4. Architectural plans

Ground floor plan Scale 1:500. Level + 3.0 m

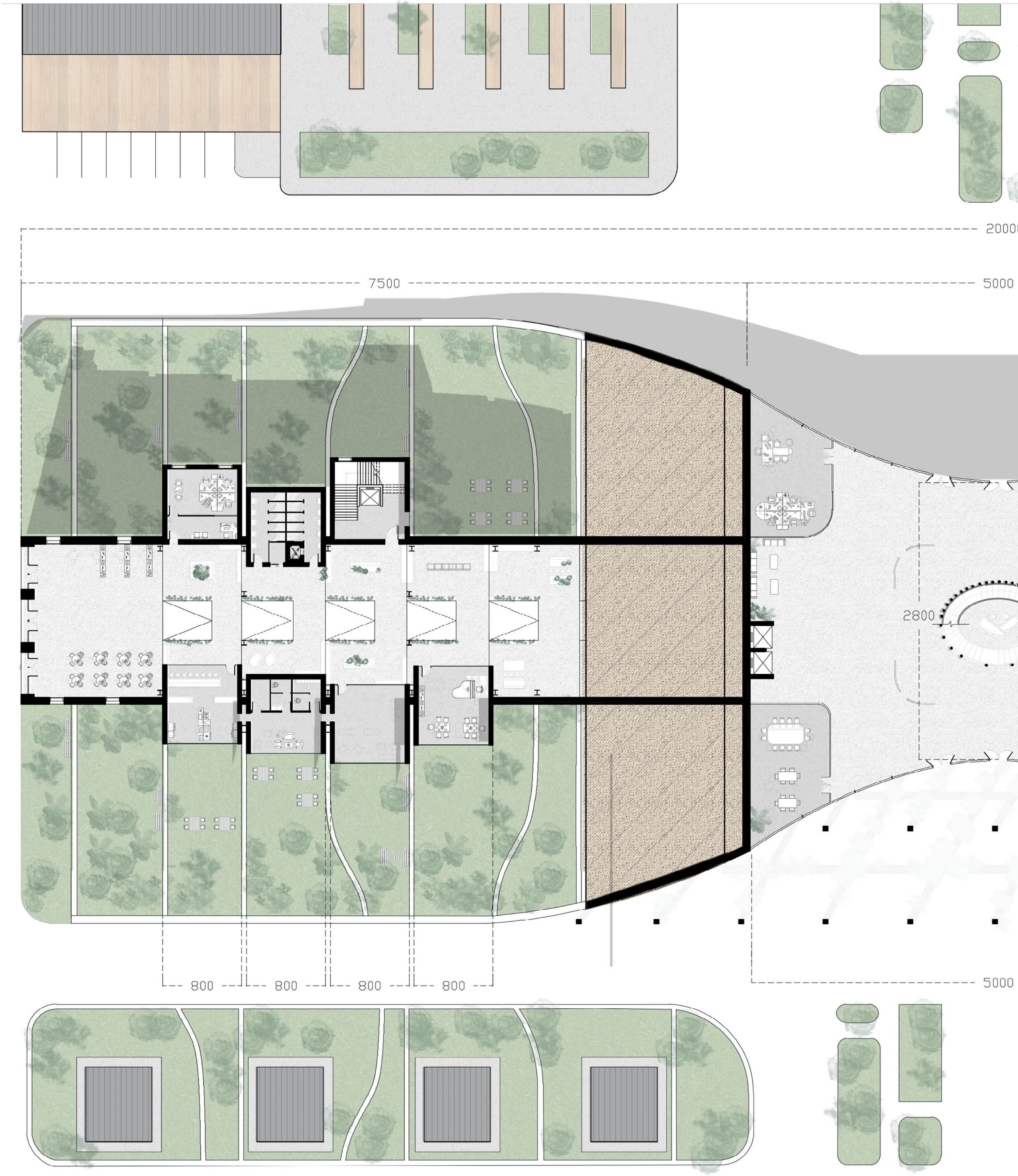
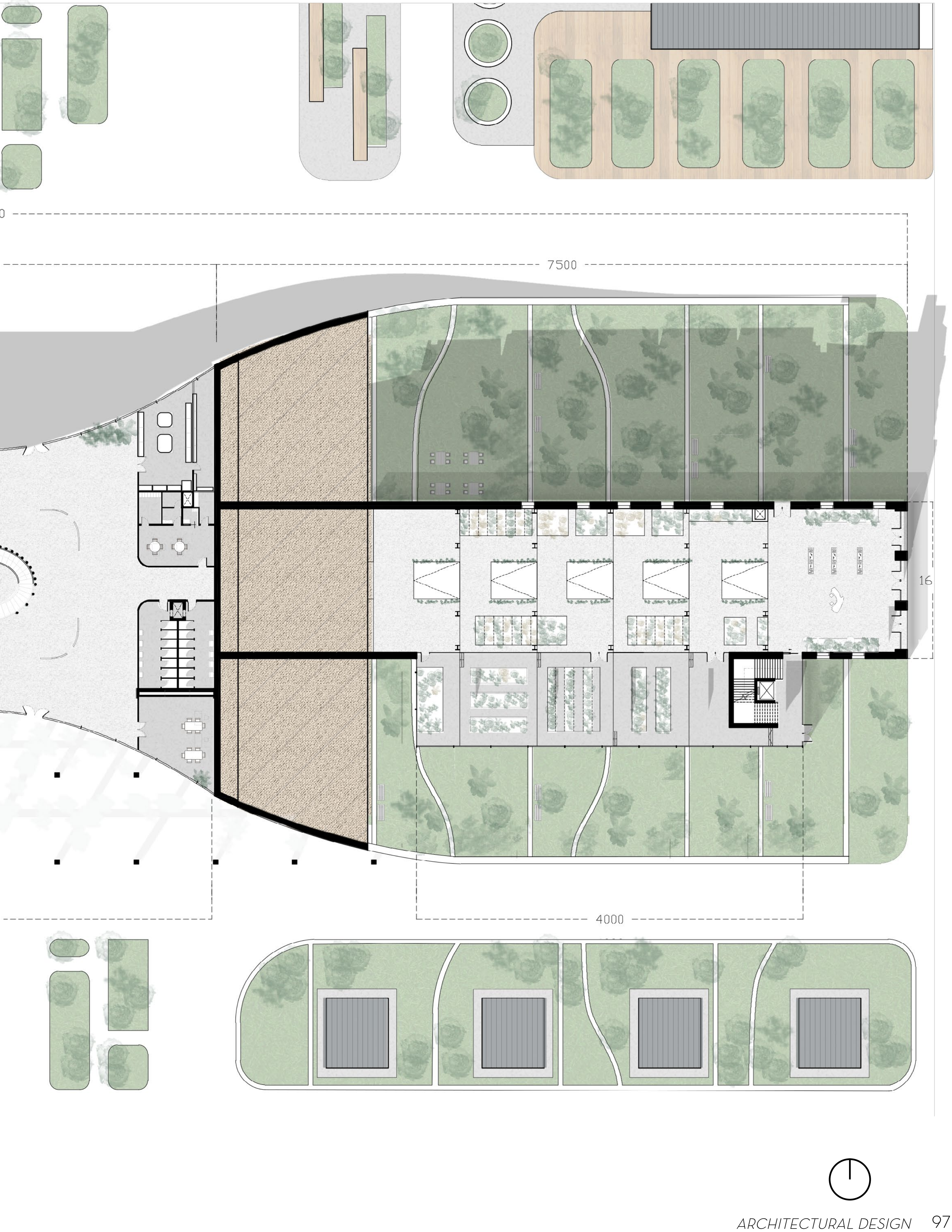


Fig.118:Ground floor plan Scale 1:500. Level +3.0 m


7500
16
4000

First floor plan Scale 1:500. Level + 5.7 m

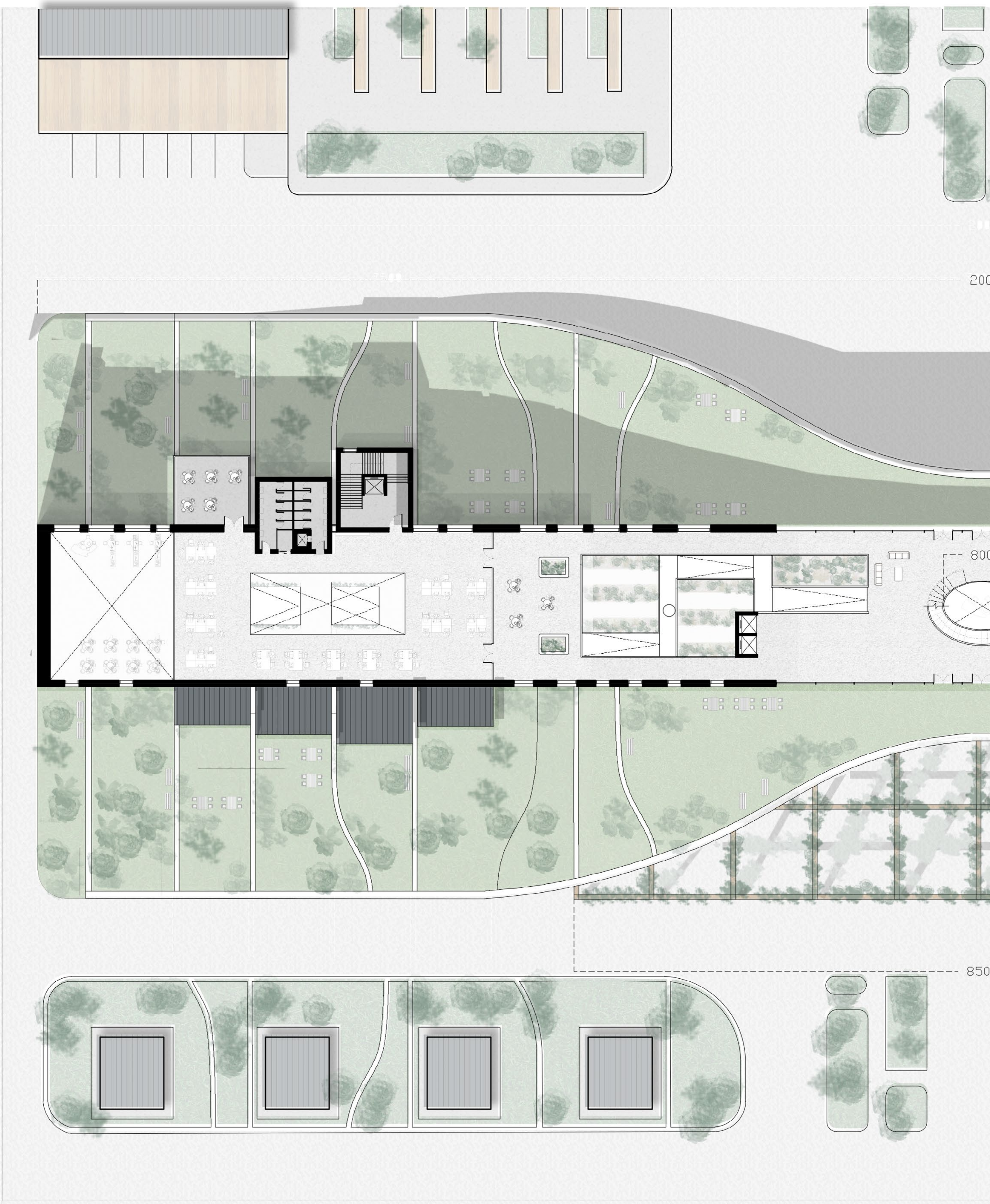
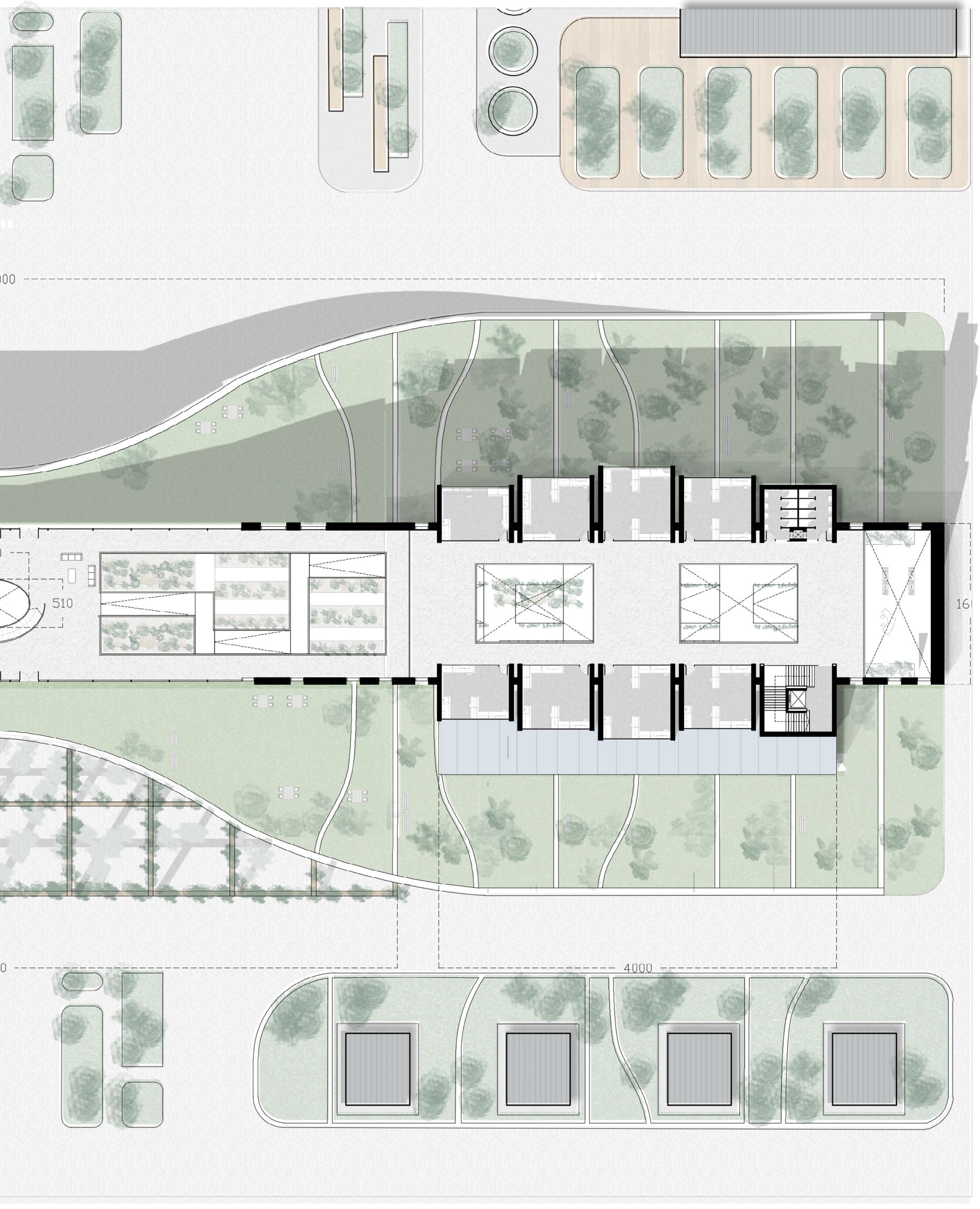
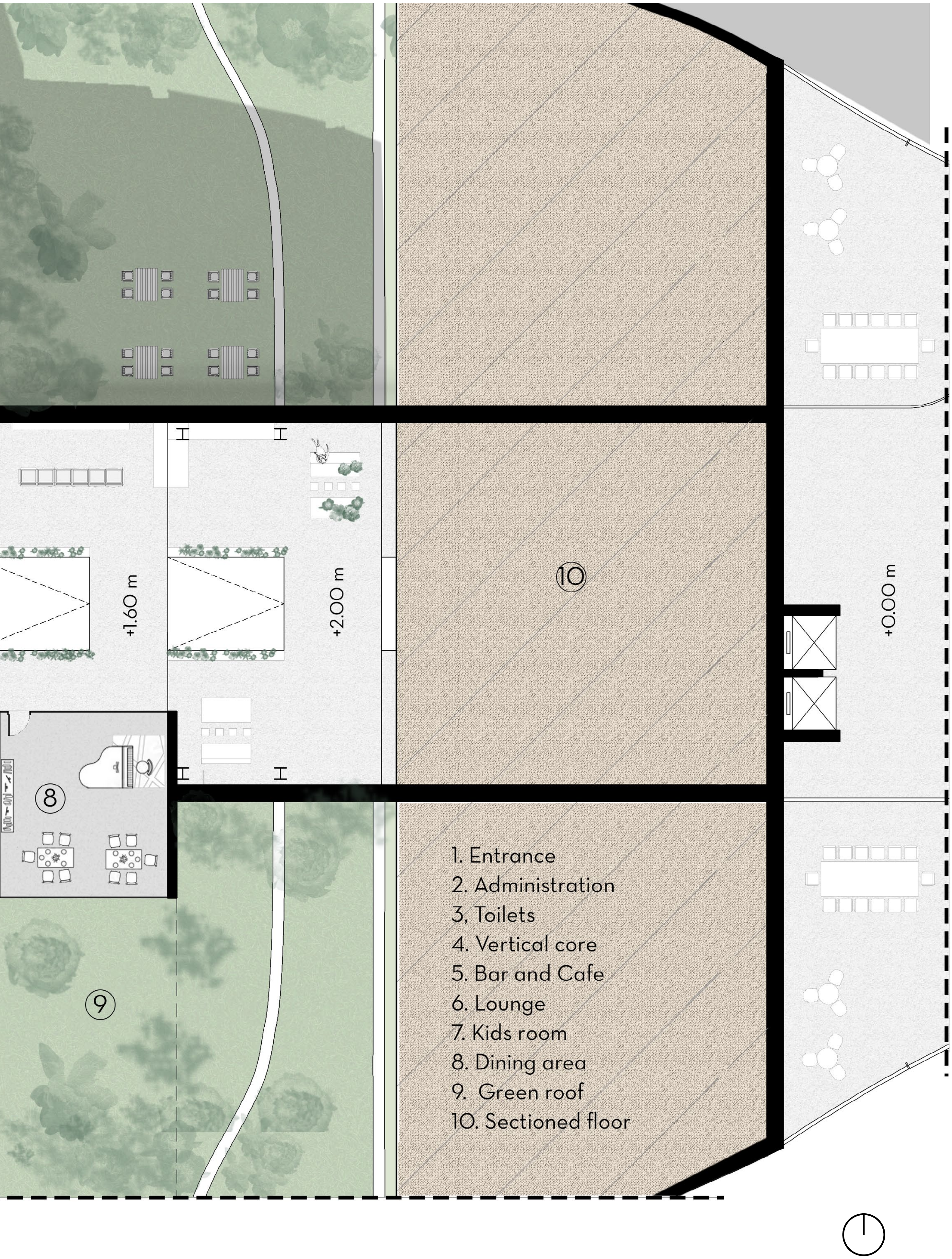


Fig.119:First floor plan Scale 1:500. Level + 5.7 m


510
4000

Ground floor plan Scale 1:500. Level +3.0m

Fig.120: Ground floor plan focus on the commercial zone. Scale 1:200



+1.60 m
+2.00 m
10
+0.00 m
8
9
1. Entrance
2. Administration
3, Toilets
4. Vertical core
5. Bar and Cafe
6. Lounge
7. Kids room
8. Dining area
9. Green roof
10. Sectioned floor

Ground floor plan Scale 1:500. Level +3.0m

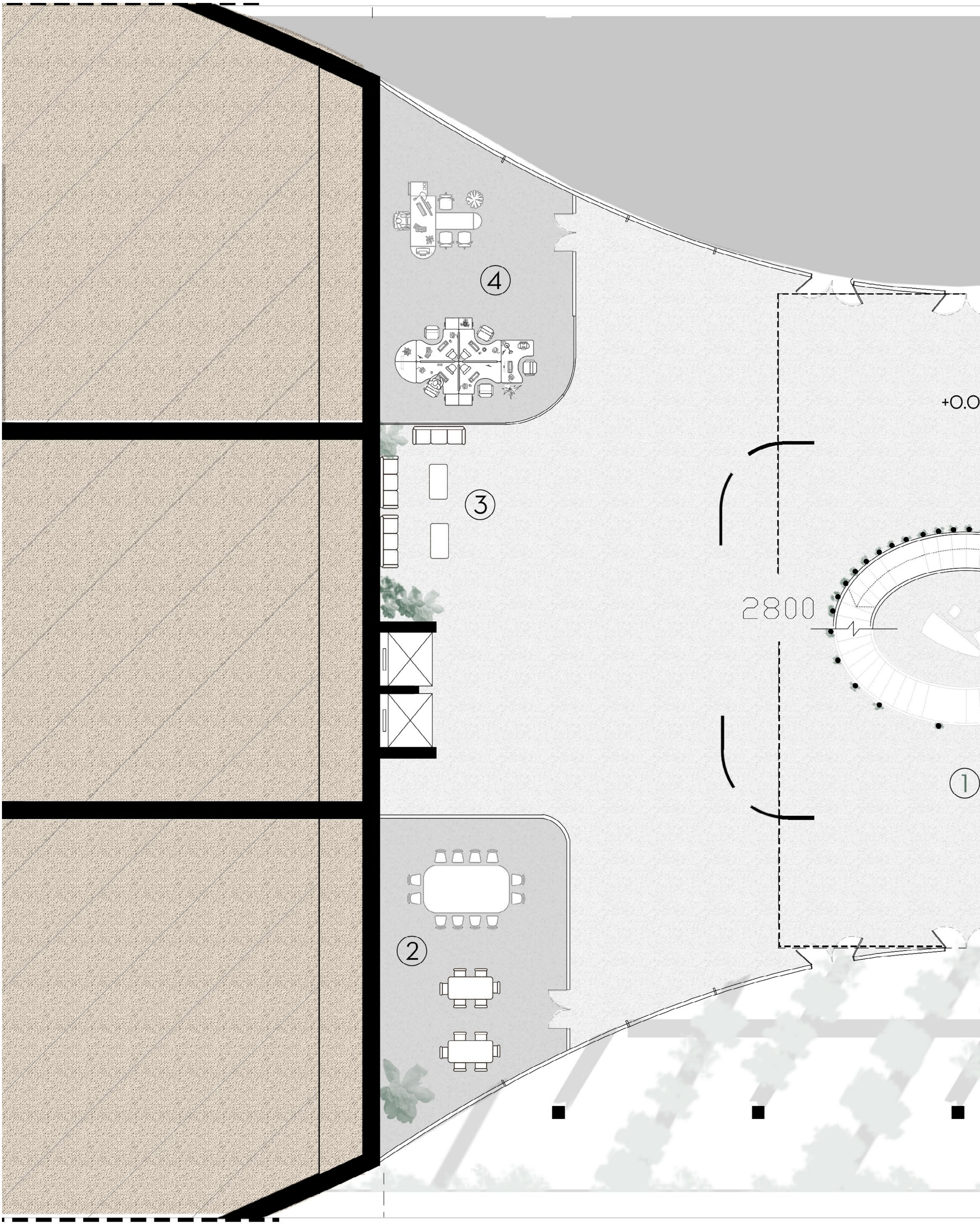
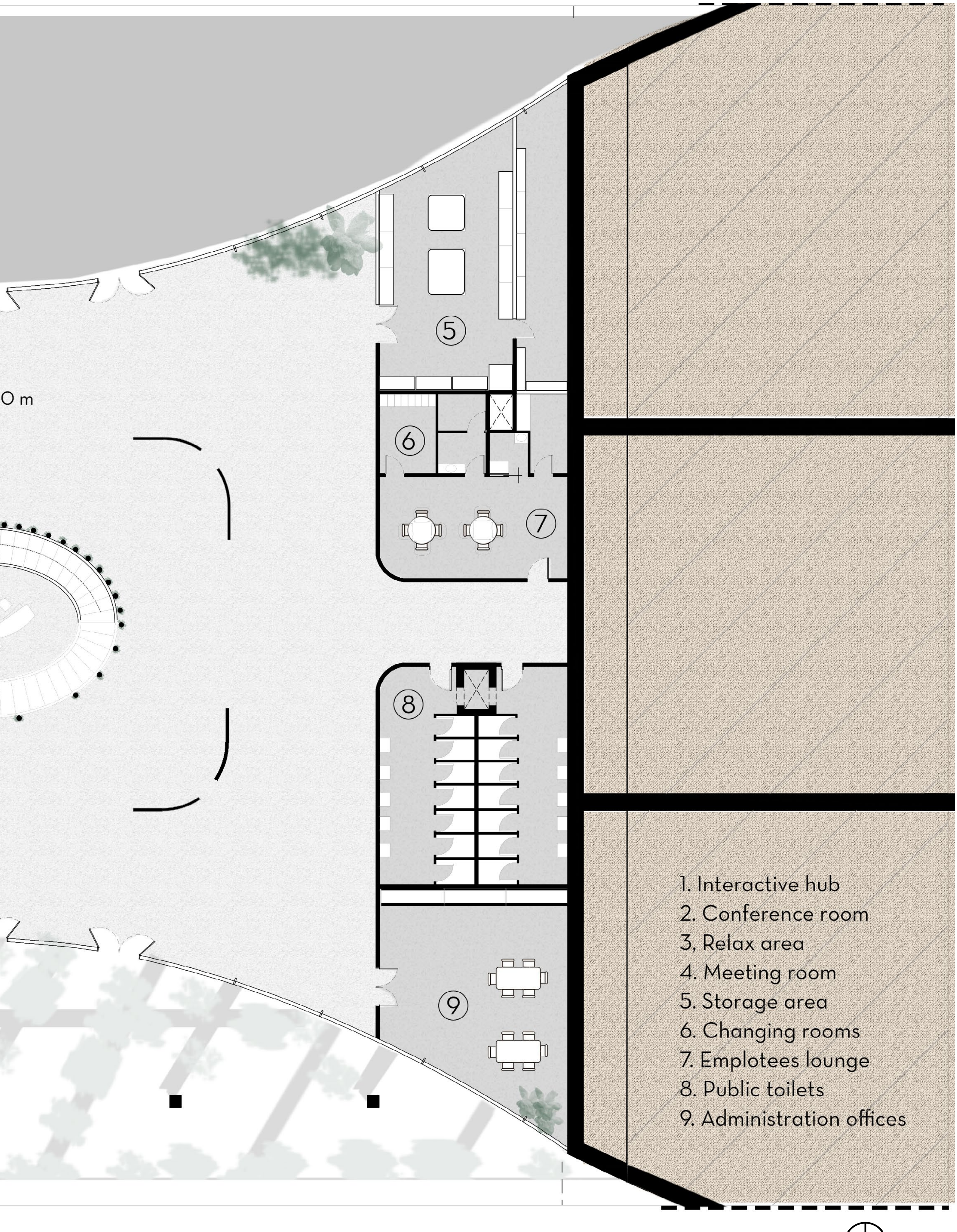


Fig.121: Ground floor plan focus on the entrance. Scale 1:200



0 m
5
6
7
8
9
1. Interactive hub
2. Conference room
3, Relax area
4. Meeting room
5. Storage area
6. Changing rooms
7. Emplotees lounge
8. Public toilets
9. Administration offices

Ground floor plan Scale 1:500. Level +3.0m

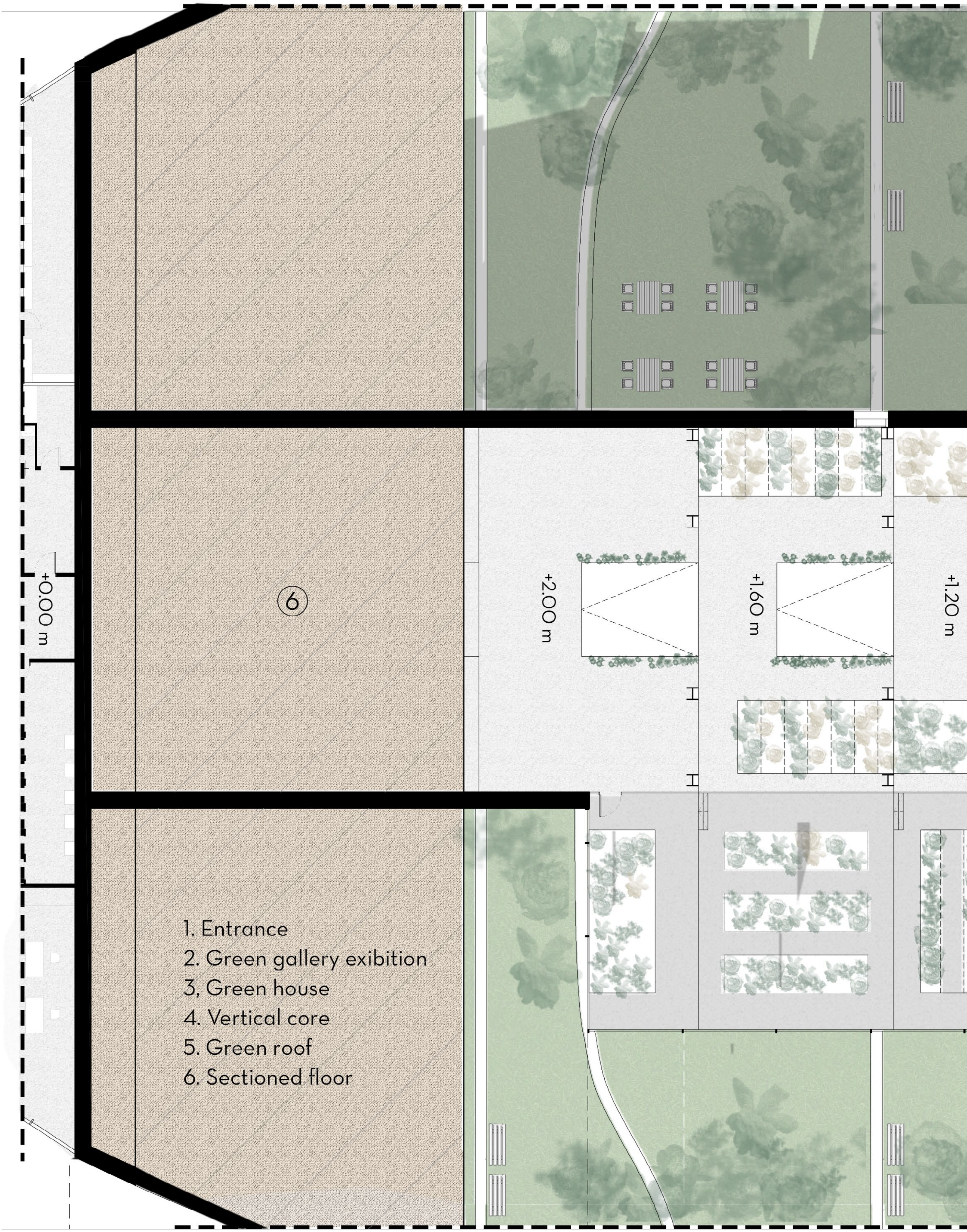


Fig.122: Ground floor plan focus on the greenn gallery. Scale 1:200


+0.80 m
+0.40 m
+0.00 m
1600
1
2
3
4
5

First floor plan Scale 1:500. Level +5.7 m

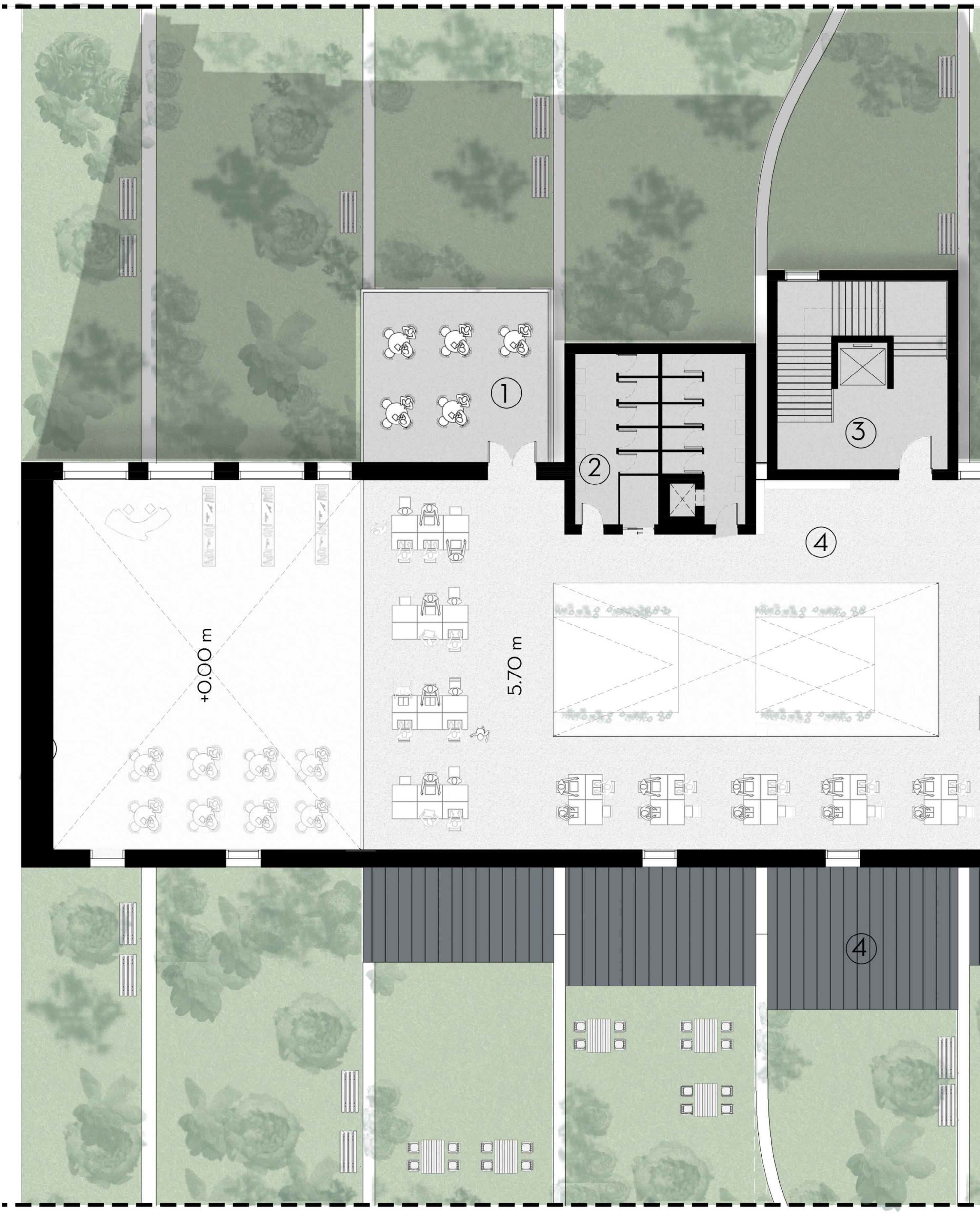
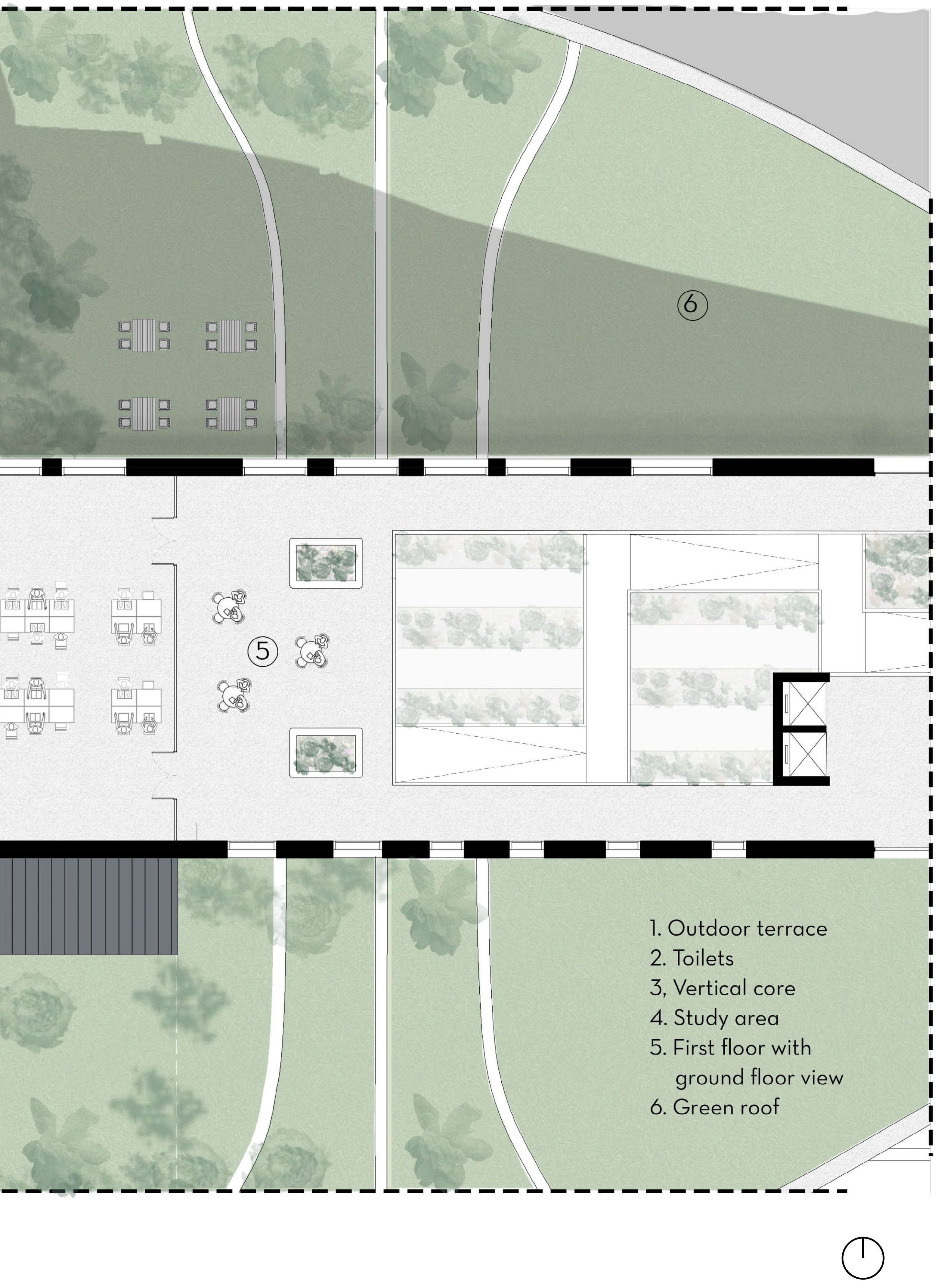


Fig.123: First floor plan focus on the study area. Scale 1:200


6
5
1. Outdoor terrace
2. Toilets
3, Vertical core
4. Study area
5. First floor with
ground floor view
6. Green roof

First floor plan Scale 1:500. Level +5.7 m

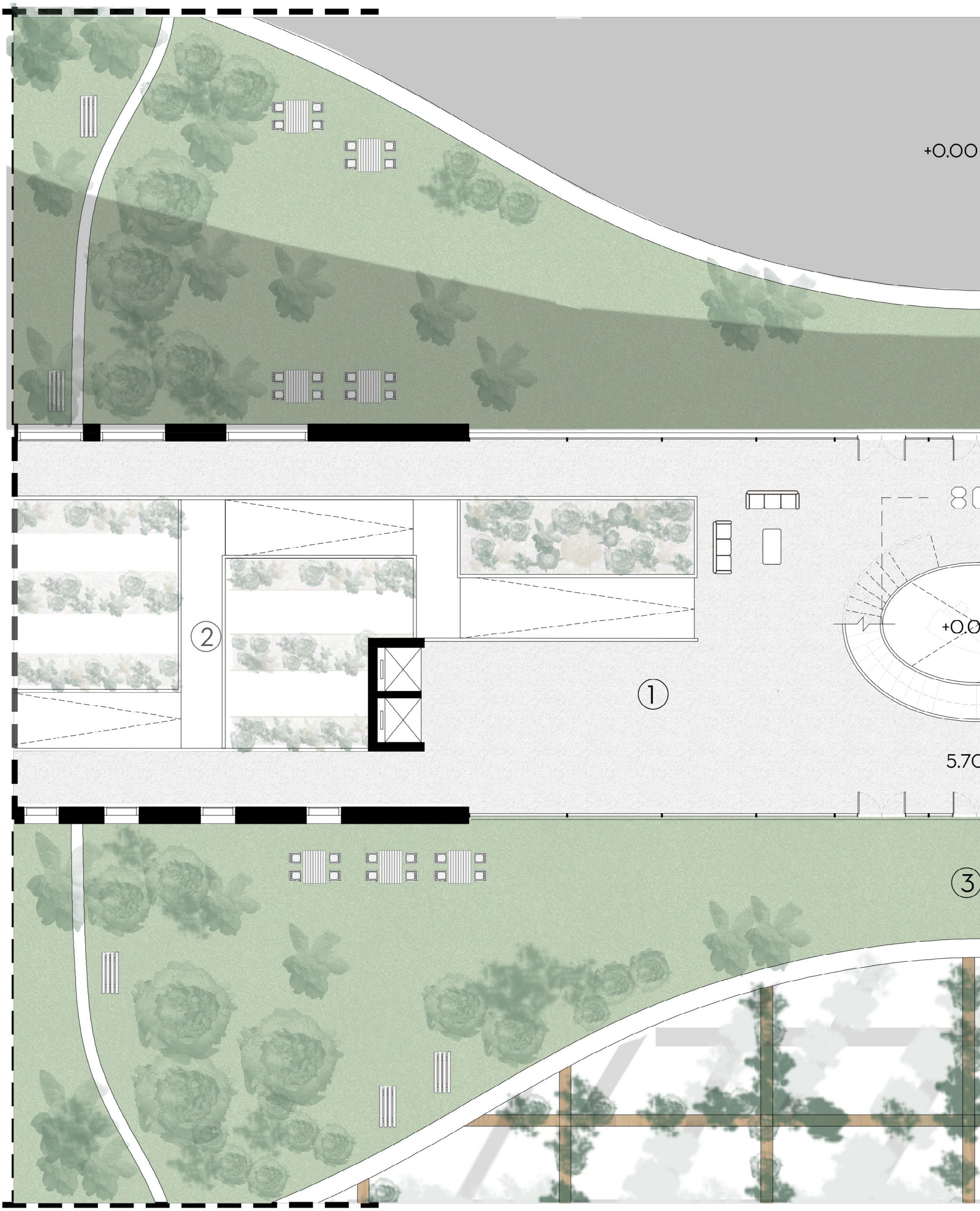
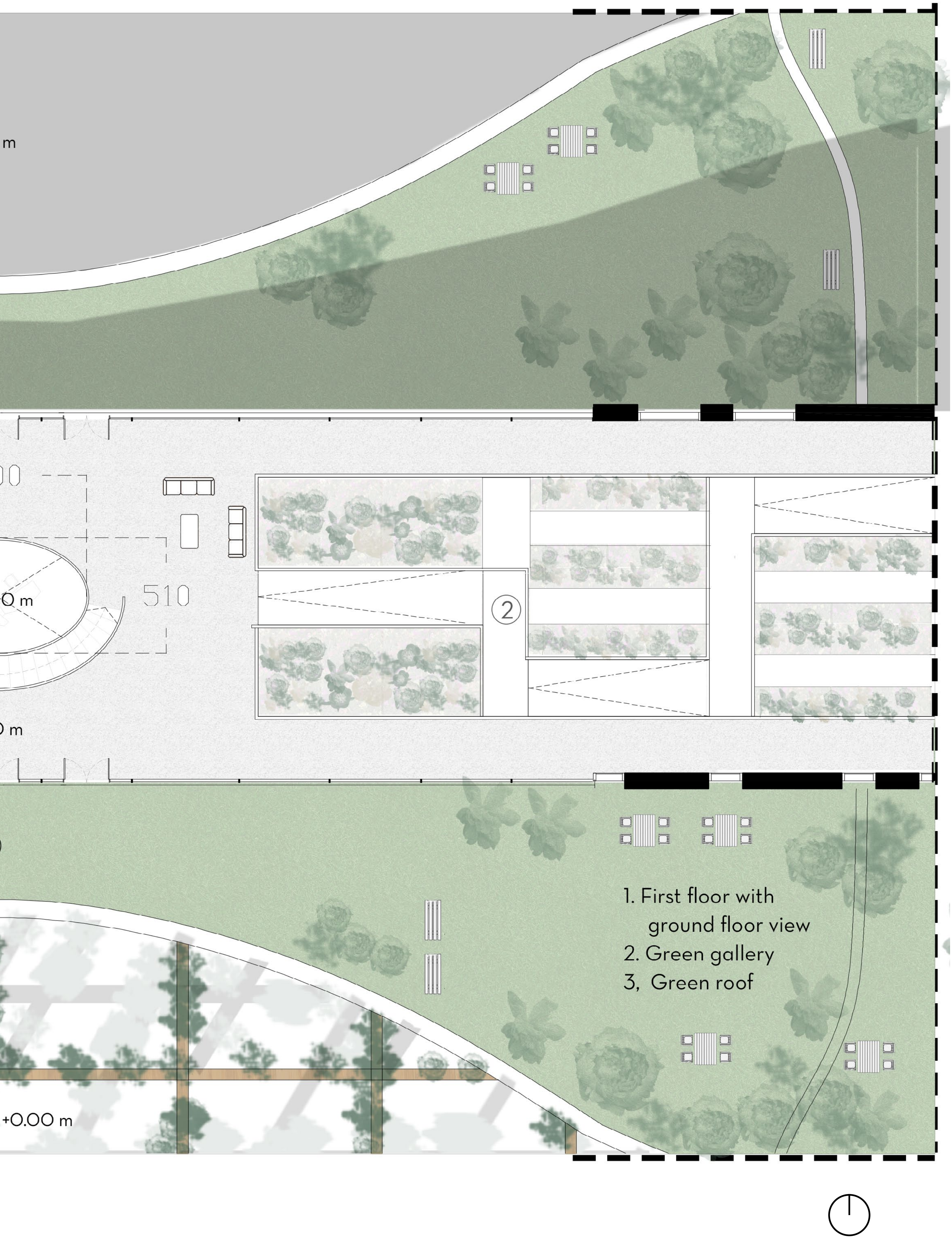


Fig.124: First floor plan focus on the upepr floor entrance end the green expositions. Scale 1:200

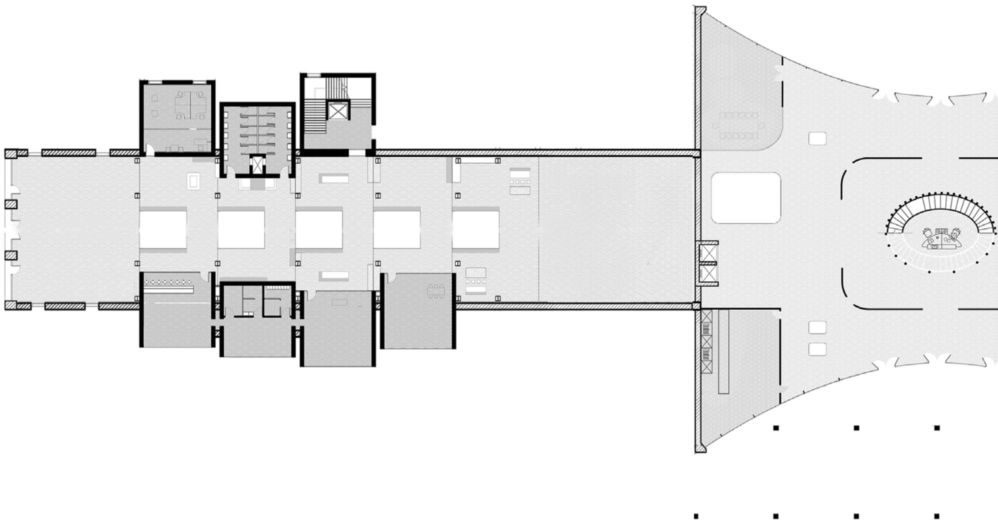

m
510
0 m
2
0 m
1. First floor with
ground floor view
2. Green gallery
3, Green roof
+0.00 m

First floor plan Scale 1:500. Level +5.7 m

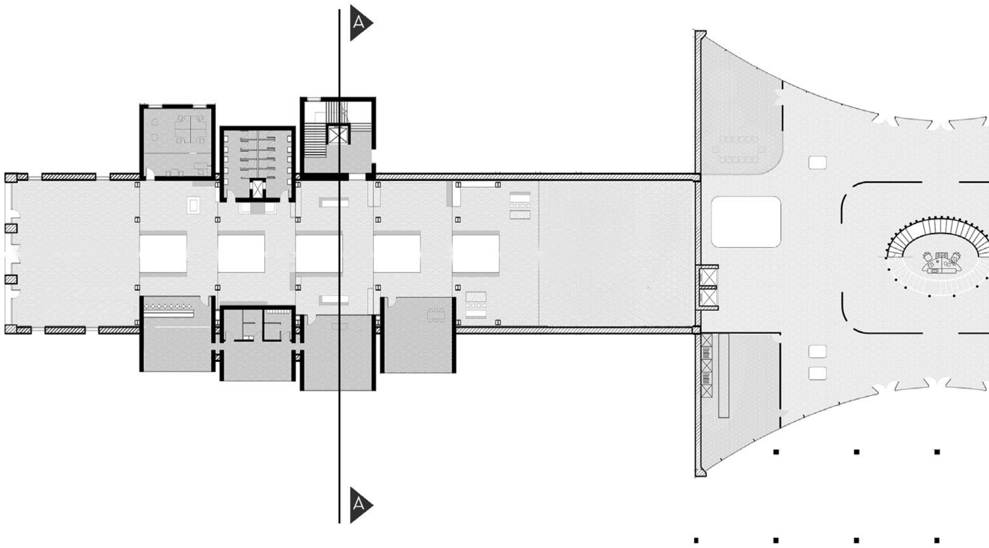
Fig.125: First floor plan focus on the slaboratories. Scale 1:200

3
5
+5.70 m
1
+0.00 m
3
4
6

Section A-A'
Commercial



Section B-B'
Laboratories



Section C-C'
Entrance

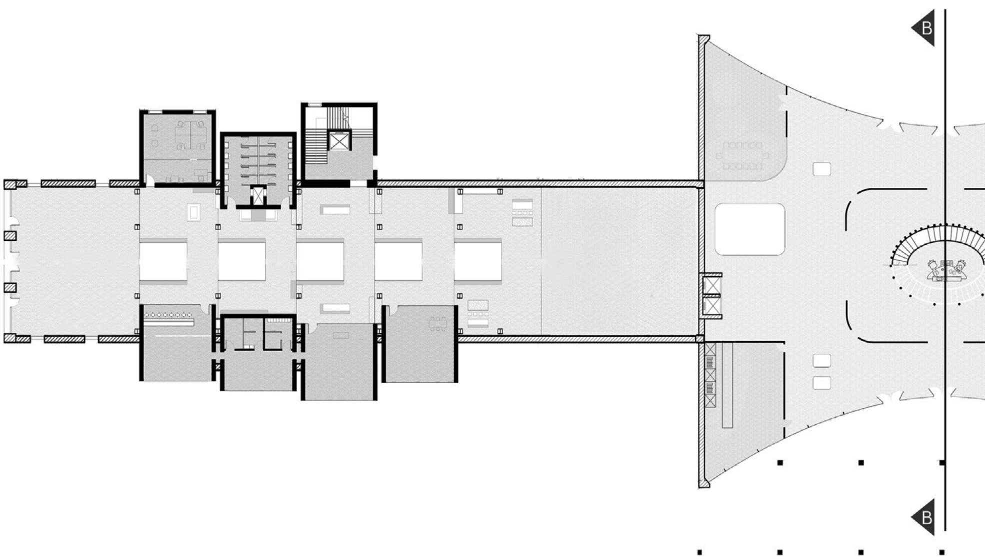
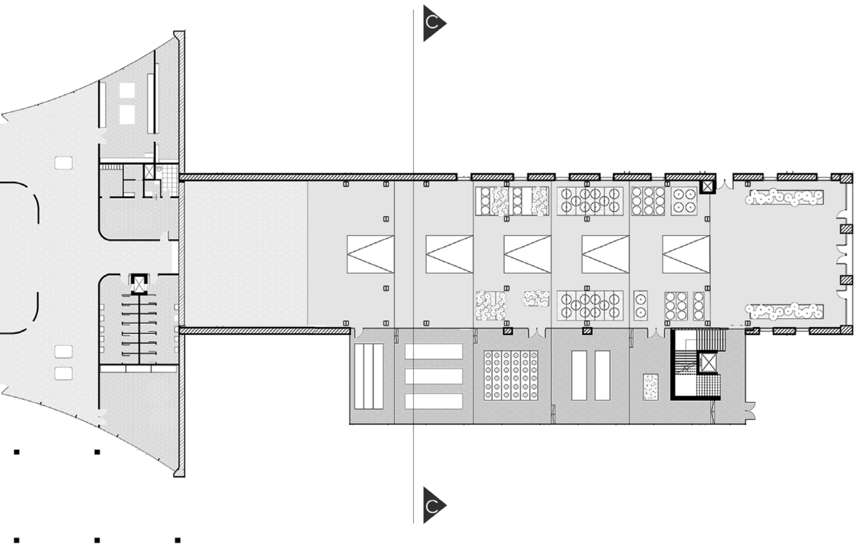
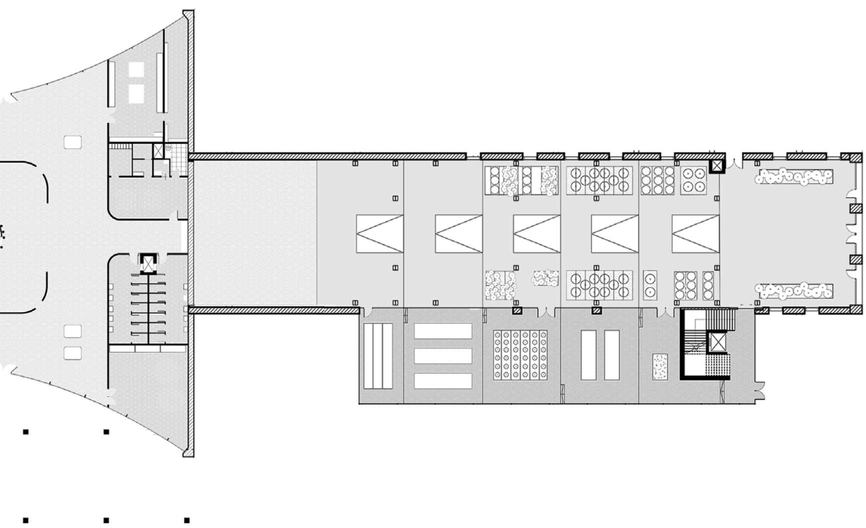
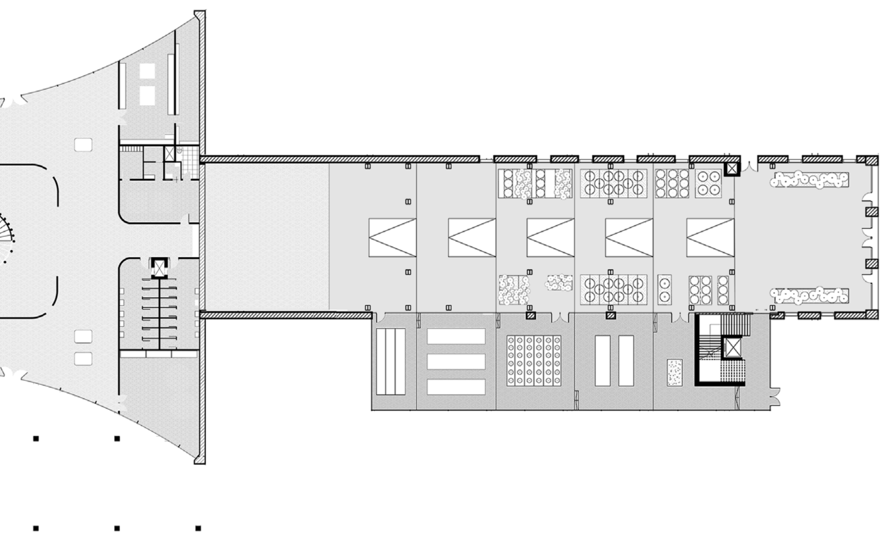
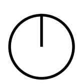


Fig.126:Points where the transveral sections were done


C
C







10.5. Transversal sections

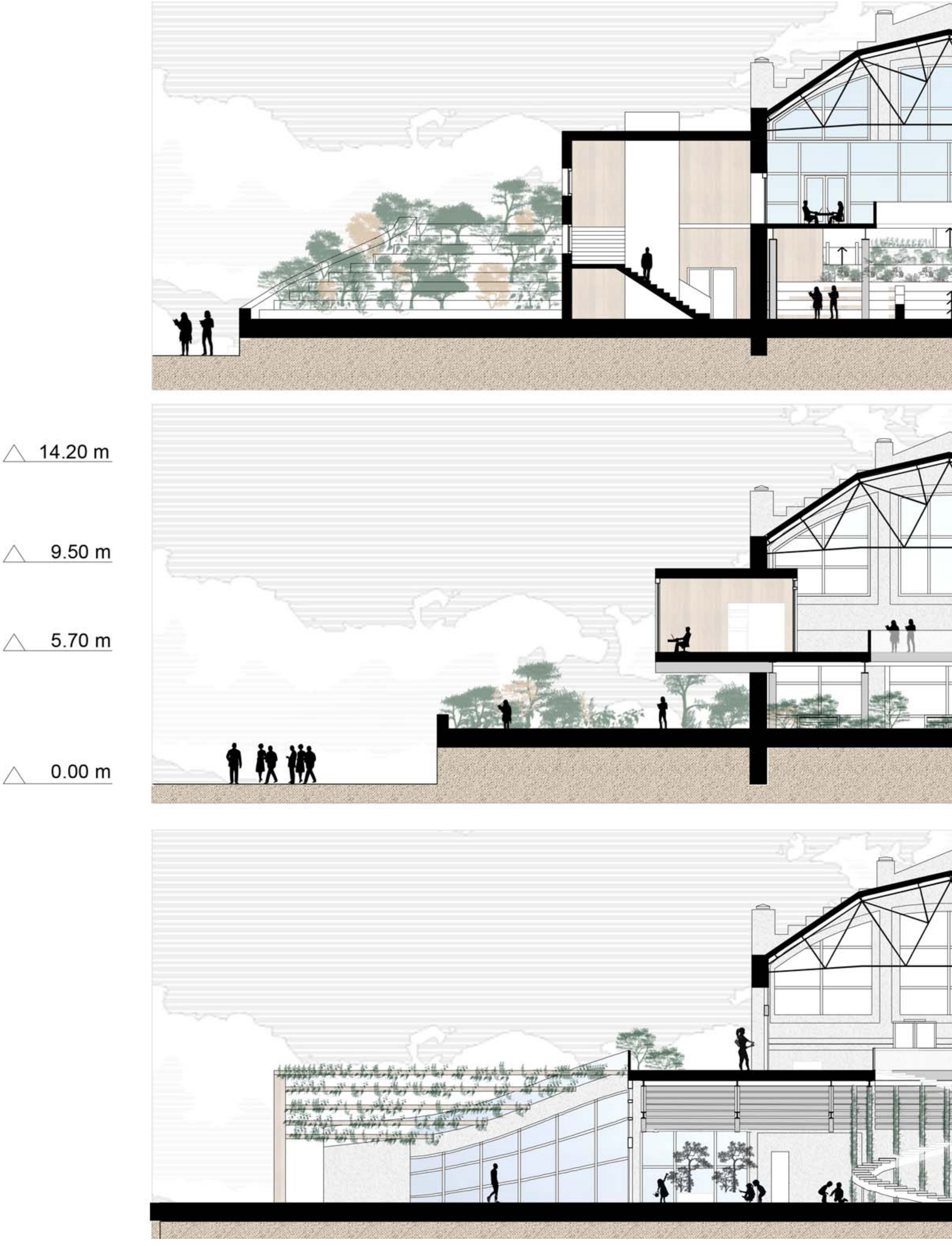
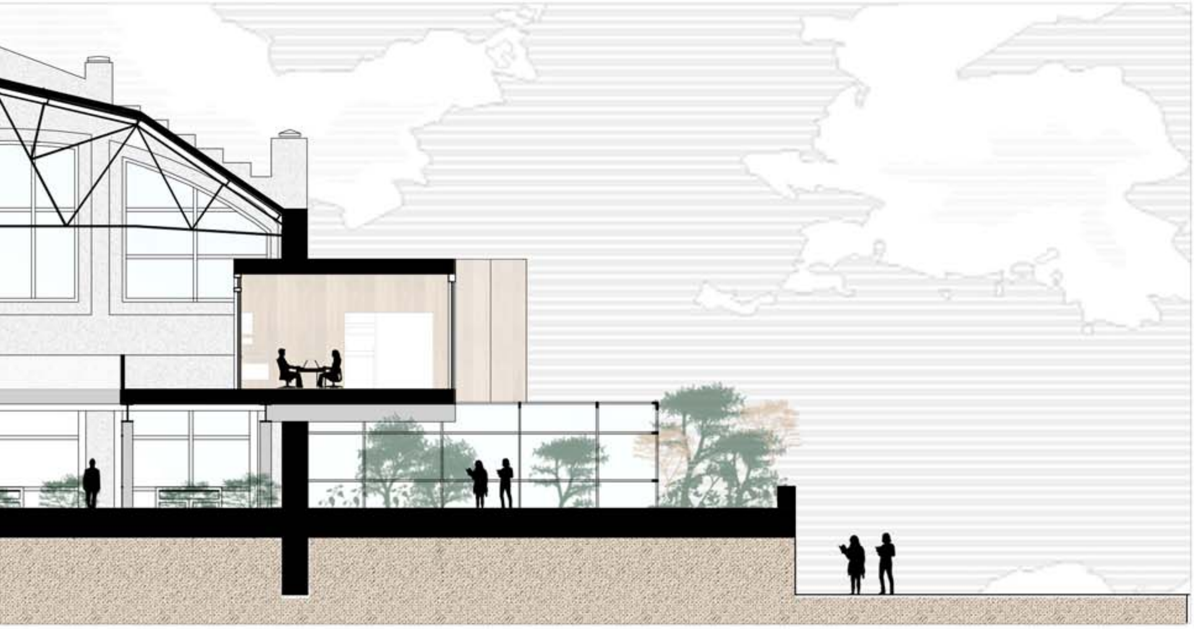


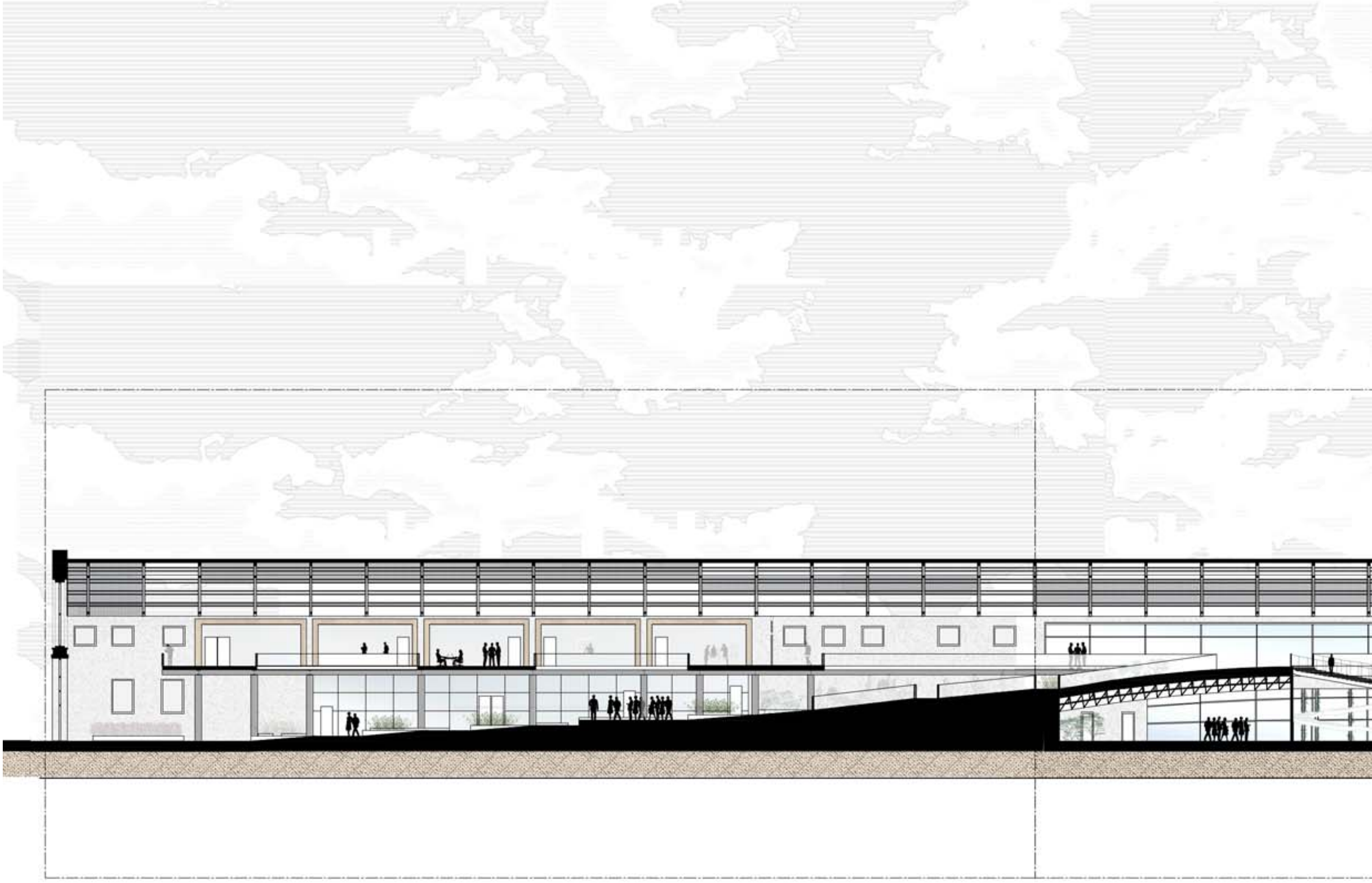
Fig.127:Transversal section. Scale 1:200


14.20 m
9.50 m
5.70 m
1.20 m
0.00 m




14.20 m
9.50 m
5.70 m
0.00 m

10.6. Longitudinal sections



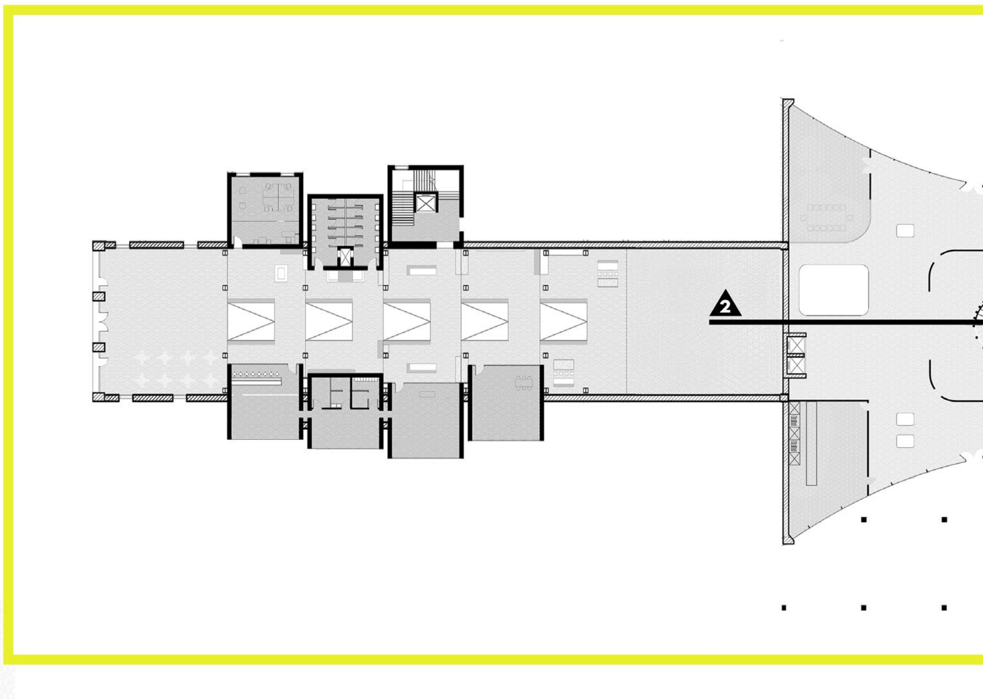
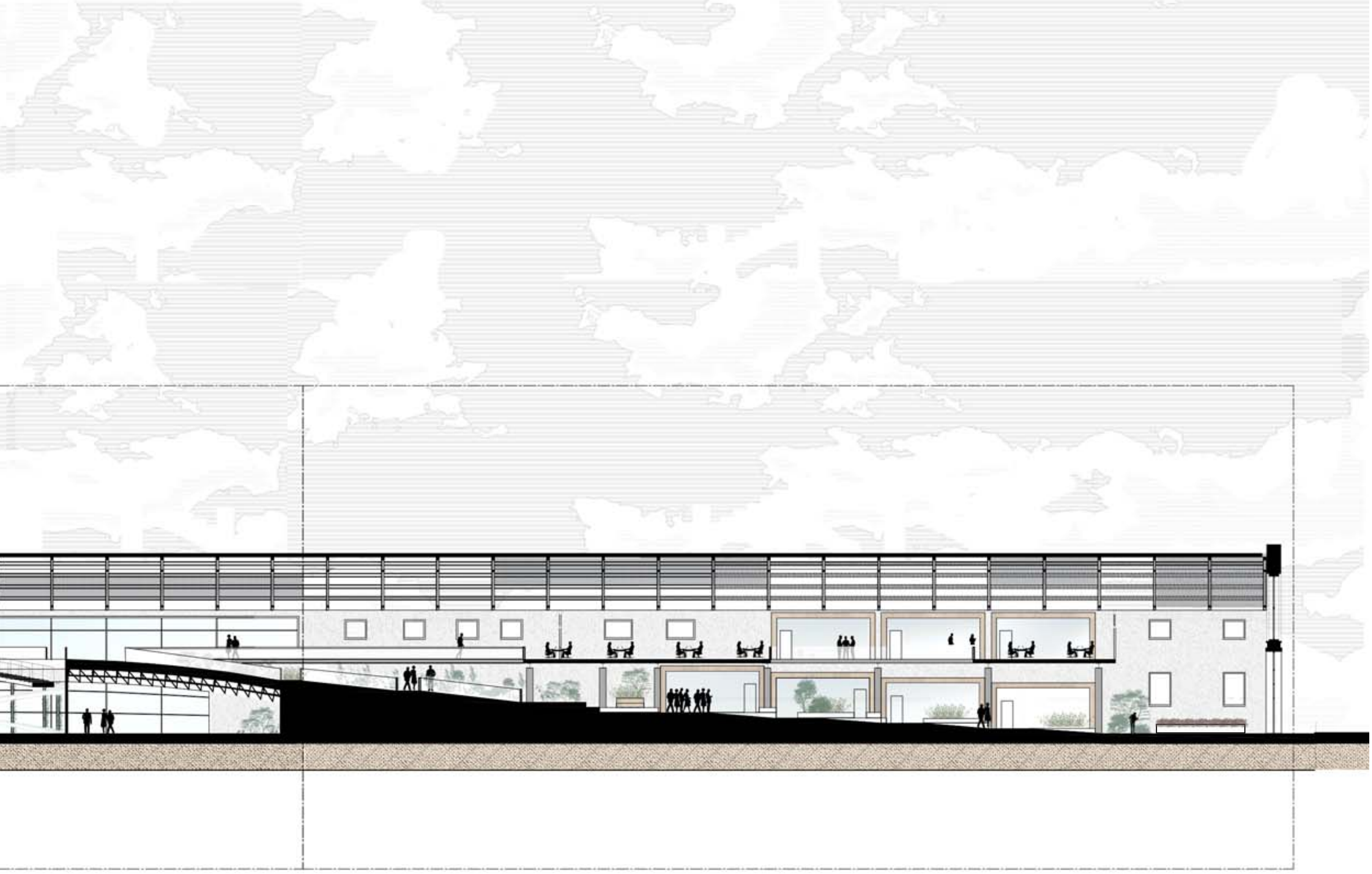
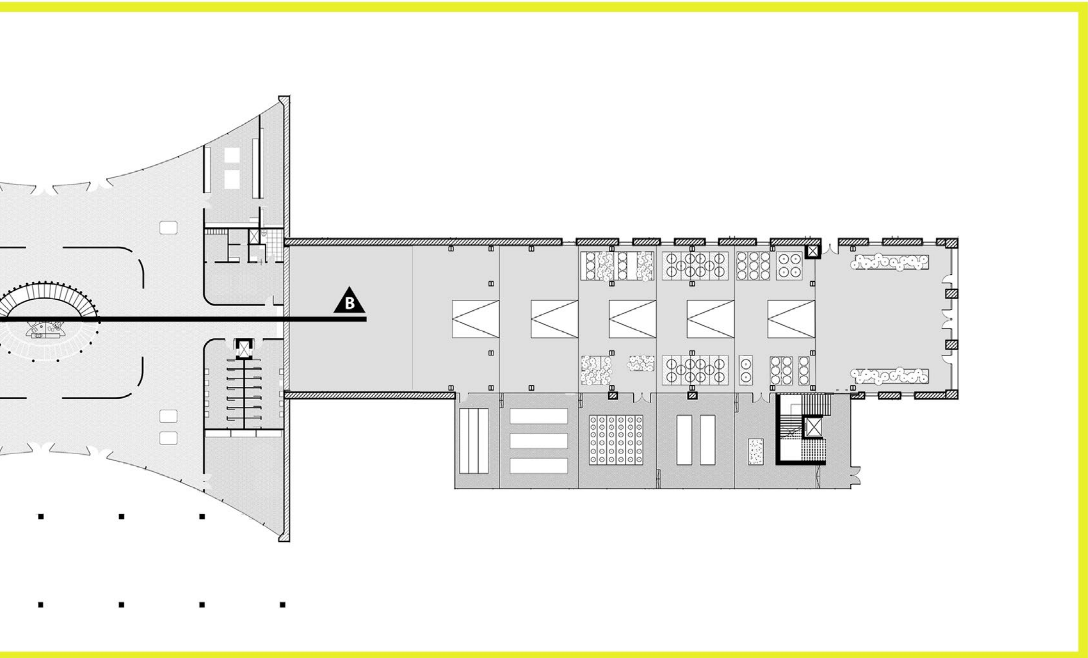


Fig.128:Longitudinal section in the middle of the building. Scale 1:500




B

Longitudinal section: Commercial area. Scale 1:200.

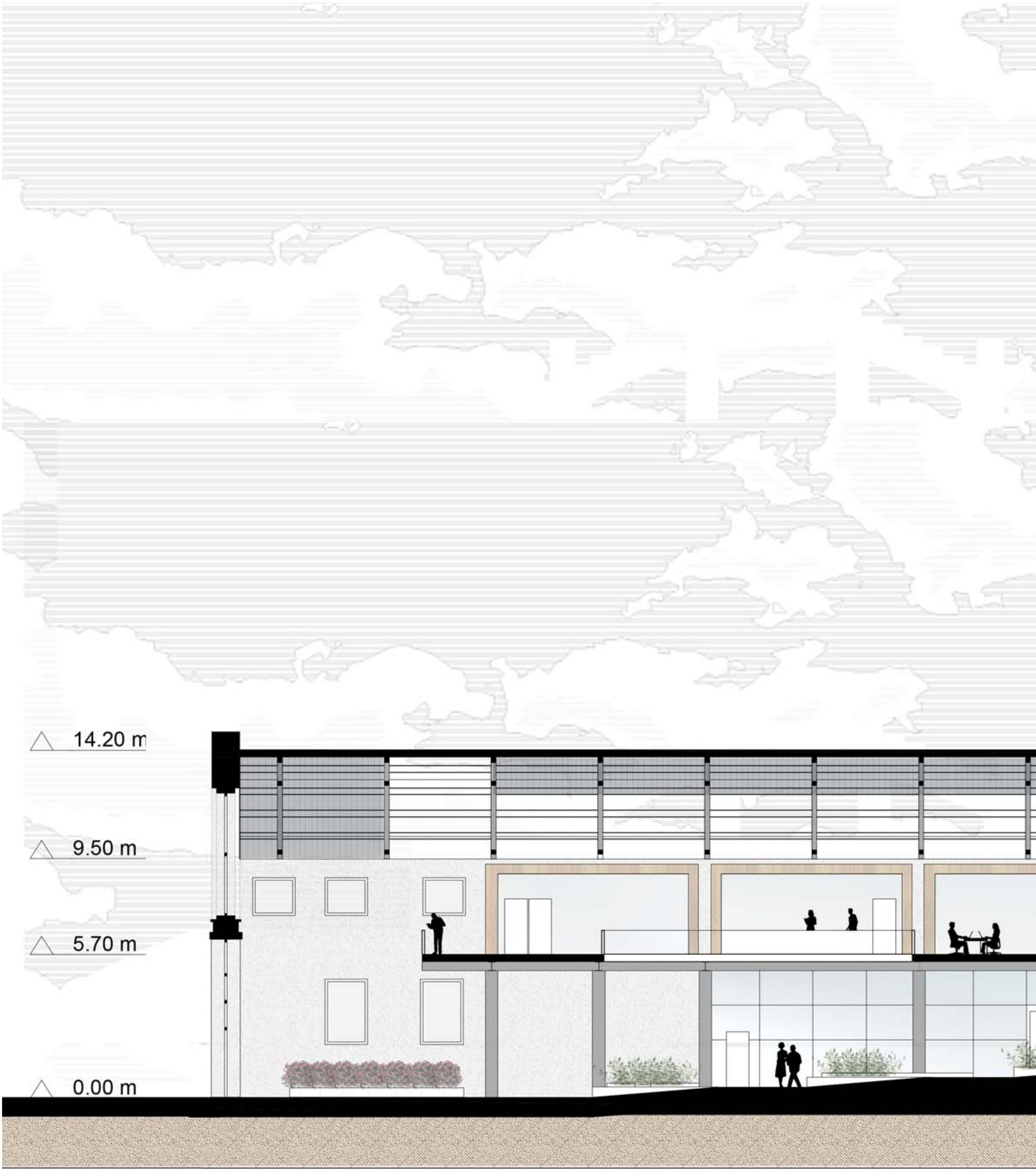
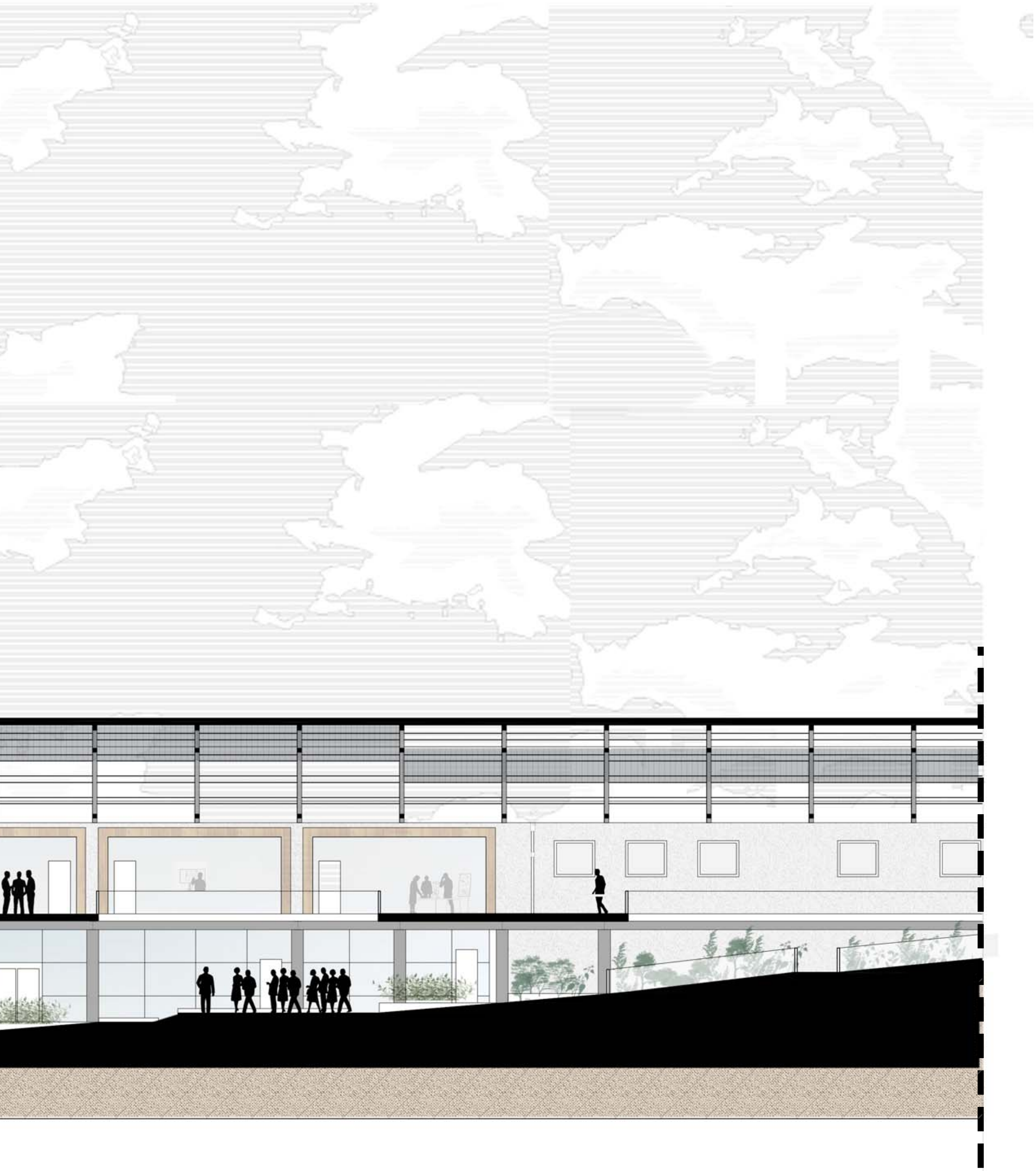


Fig.129:Longitudinal section, focus on the Commercial part. Scale 1:200



Longitudinal section: Central entrance. Scale 1:200.

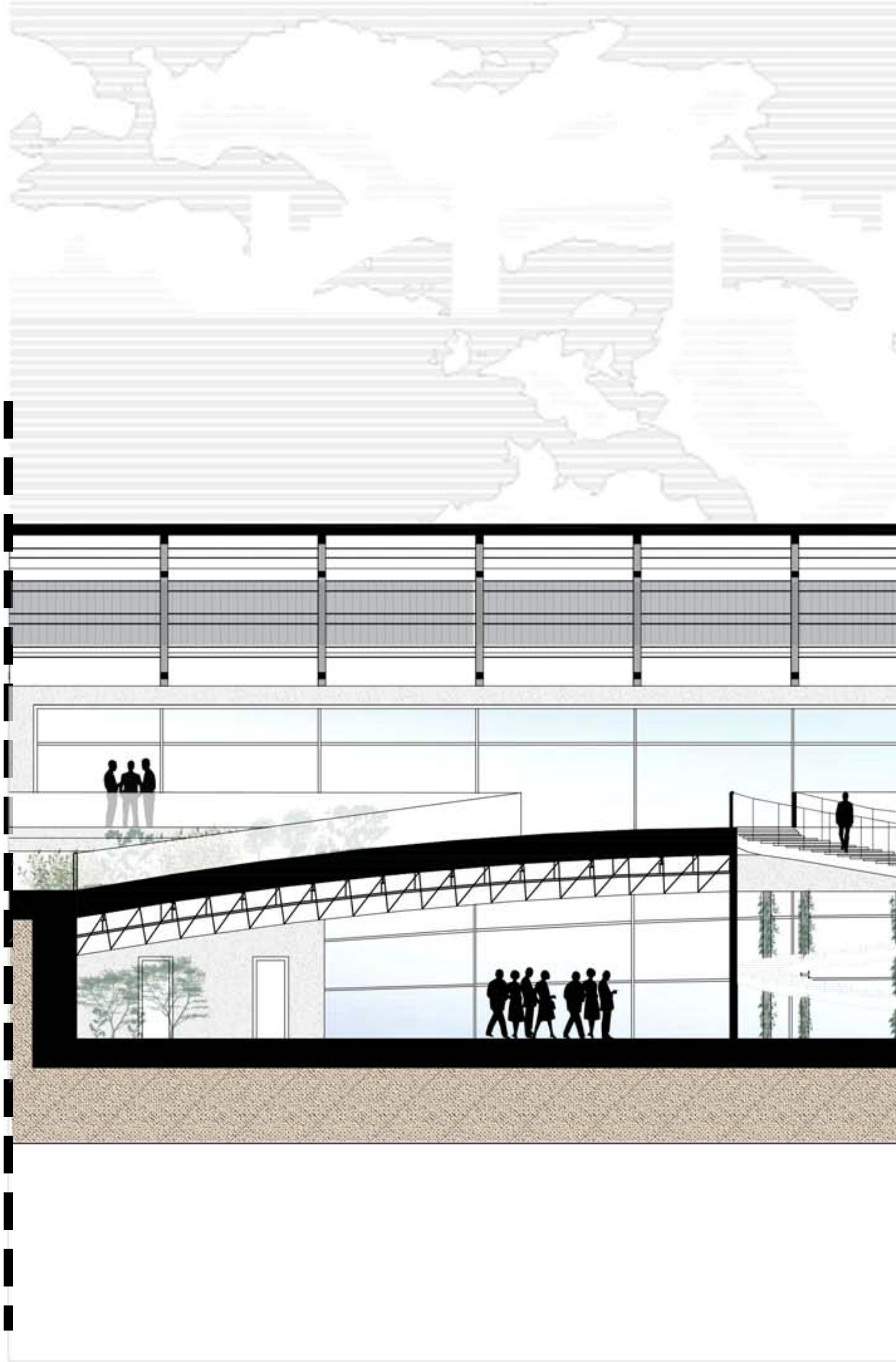
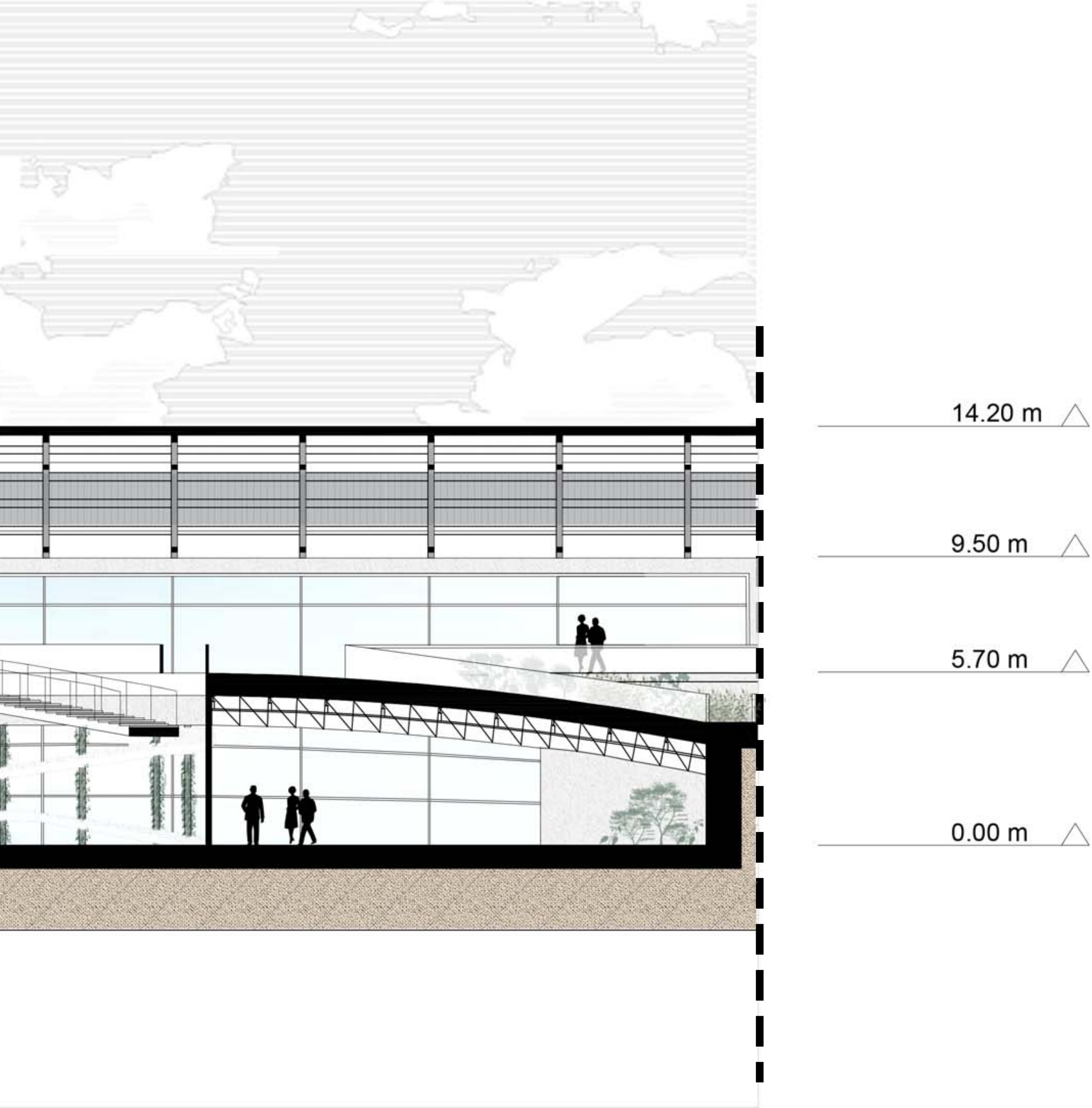


Fig.130:Longitudinal section, focus on the entrances. Scale 1:200


14.20 m
9.50 m
5.70 m
0.00 m

Longitudinal section: Laboratoriesl area. Scale 1:200.

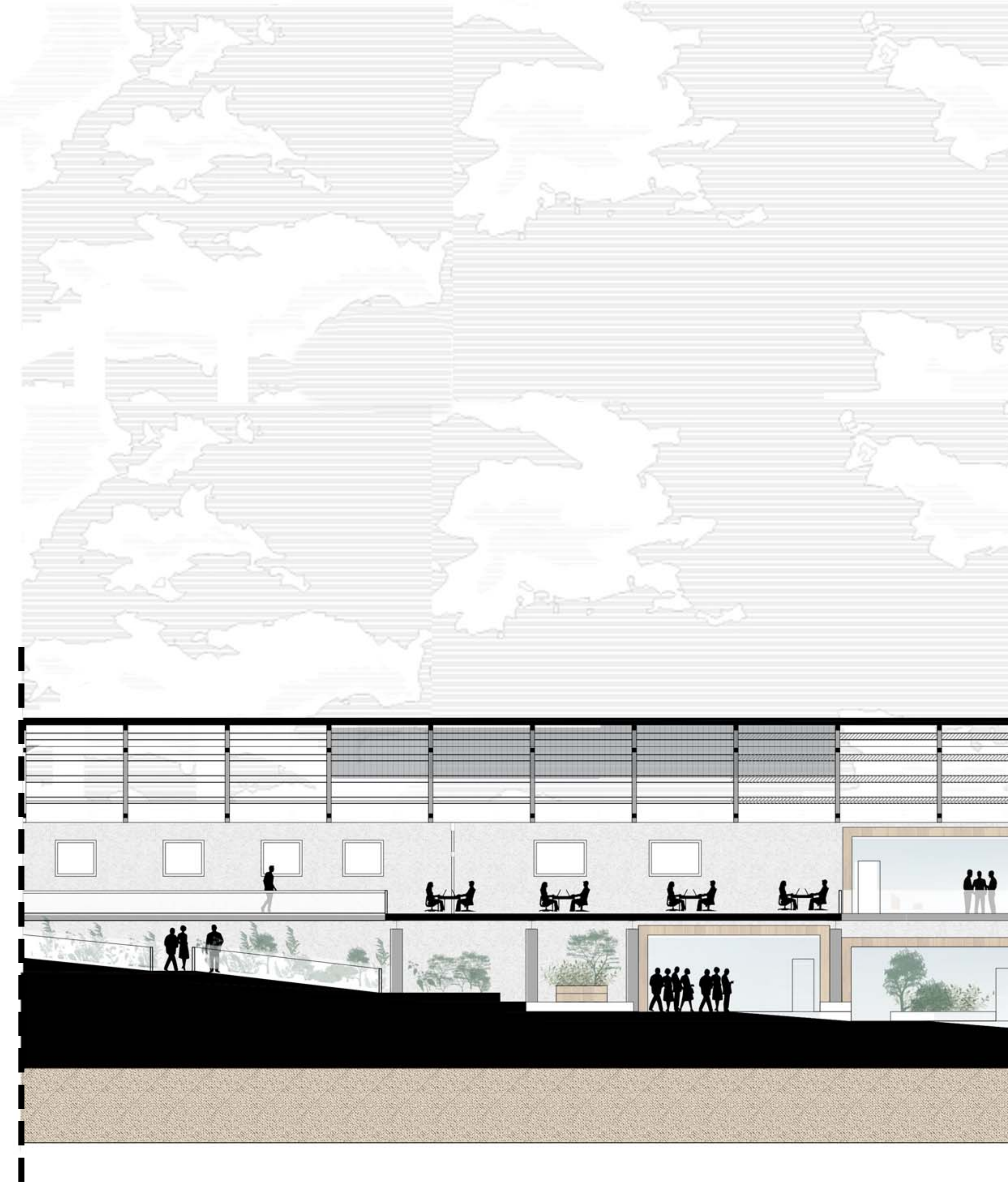


Fig.131:Longitudinal section, focus on the laboratories part. Scale 1:200


14.20 m
9.50 m
5.70 m
0.00 m

10.7. Elevations

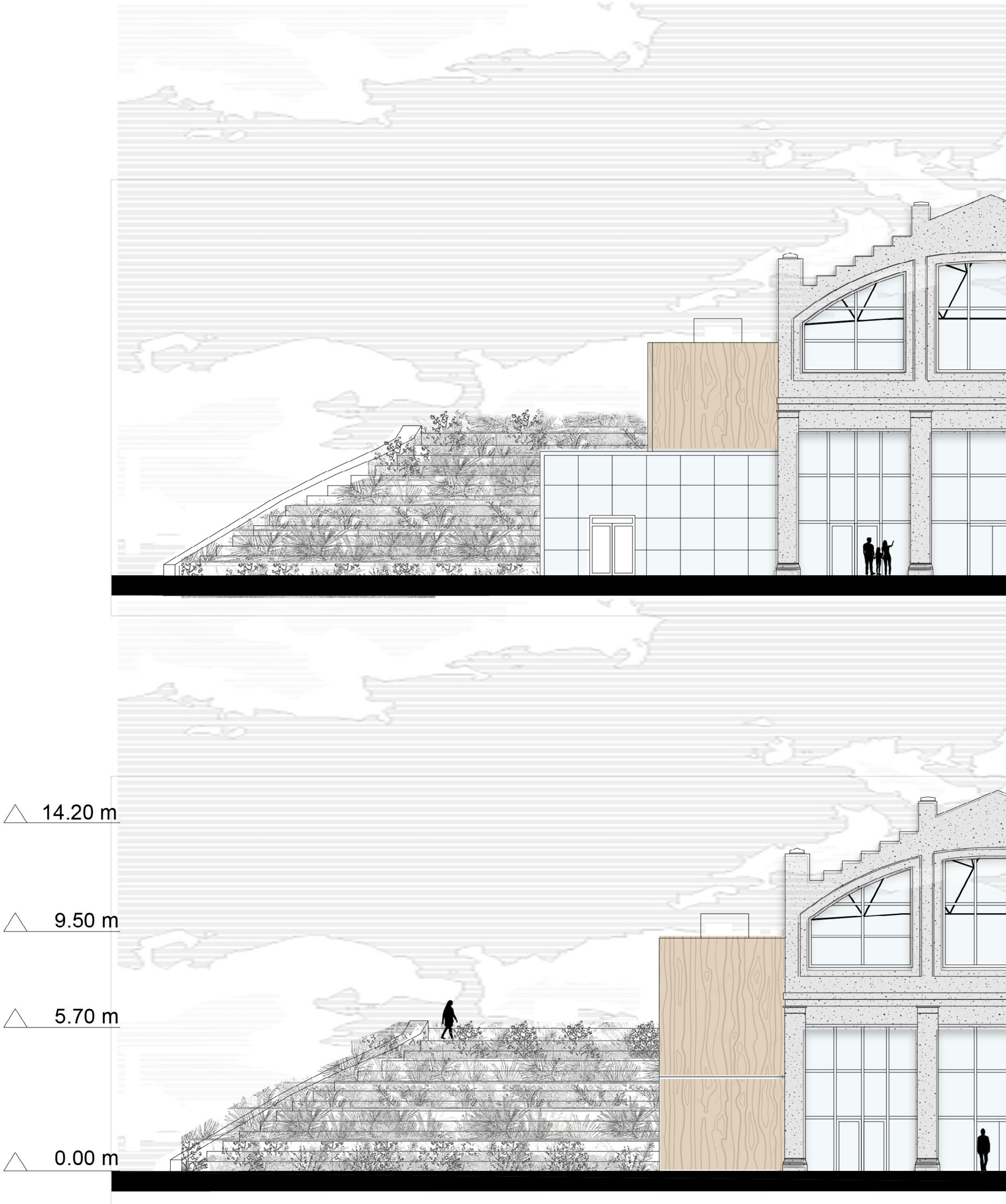
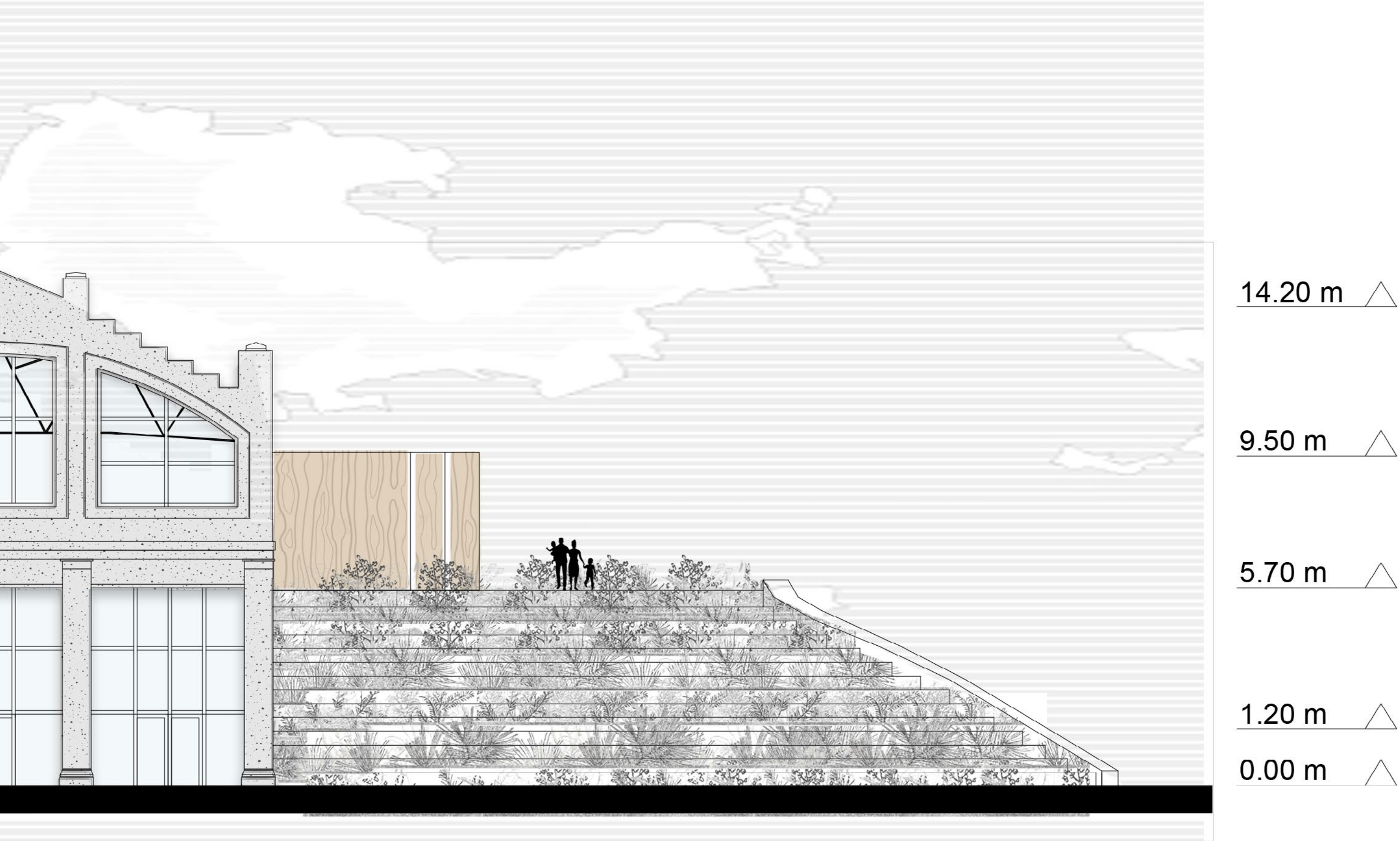
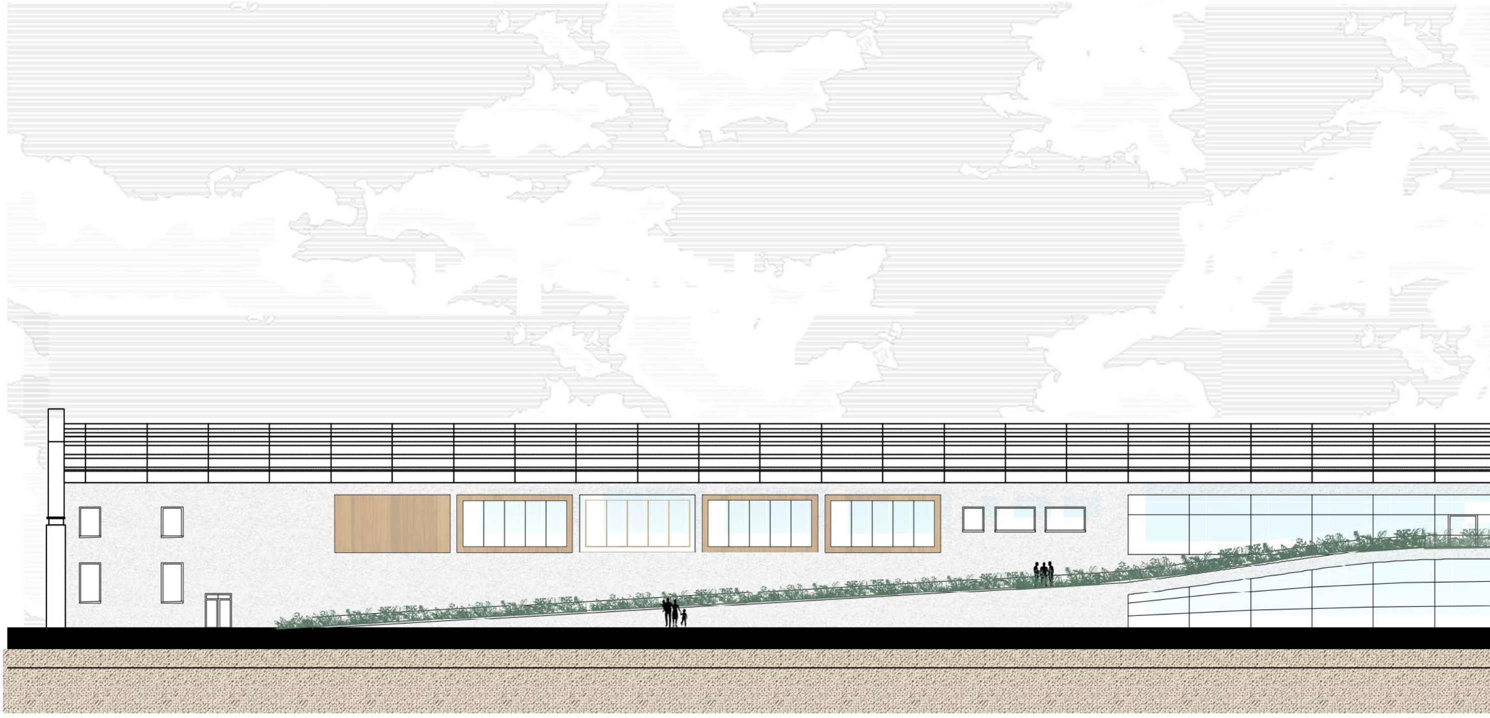


Fig.132:Eastern and West elevations. Scale 1:200


14.20 m
9.50 m
5.70 m
1.20 m
0.00 m



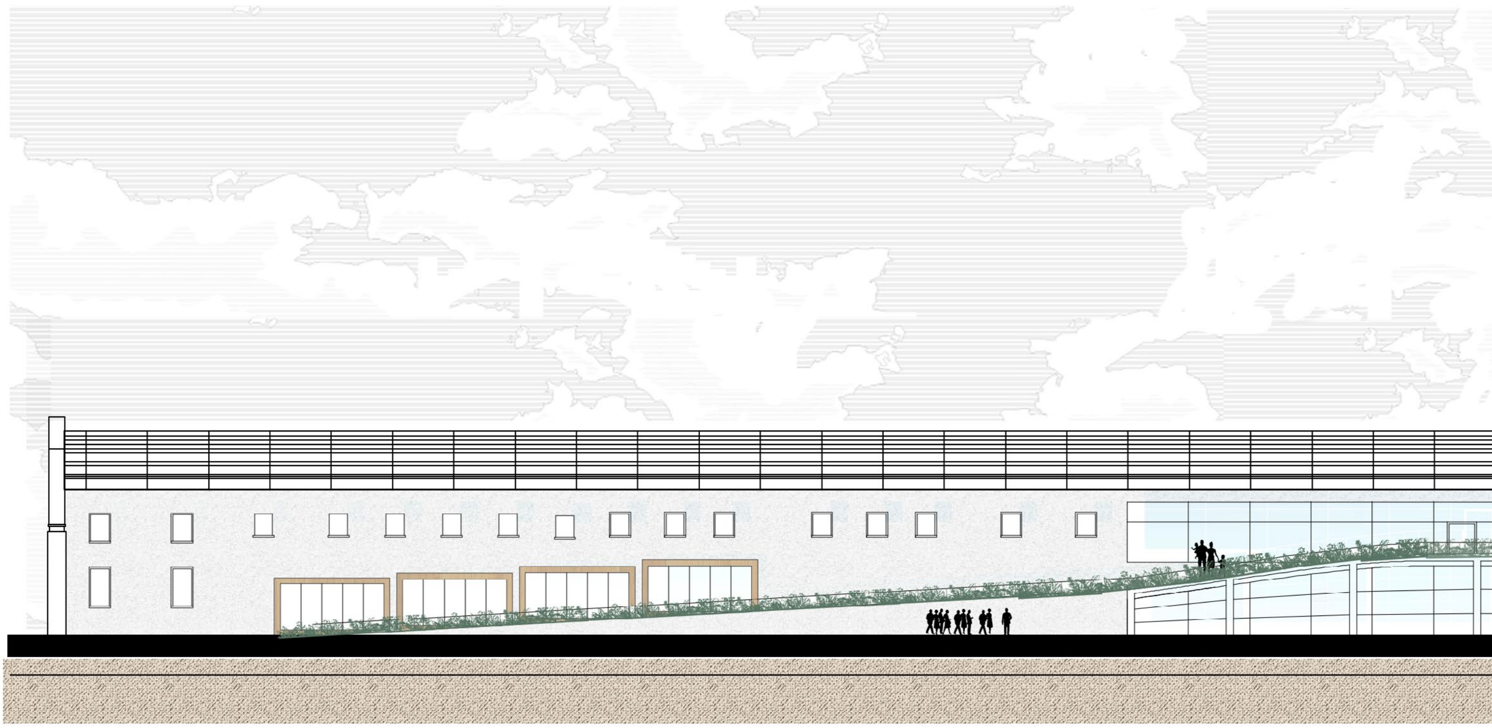
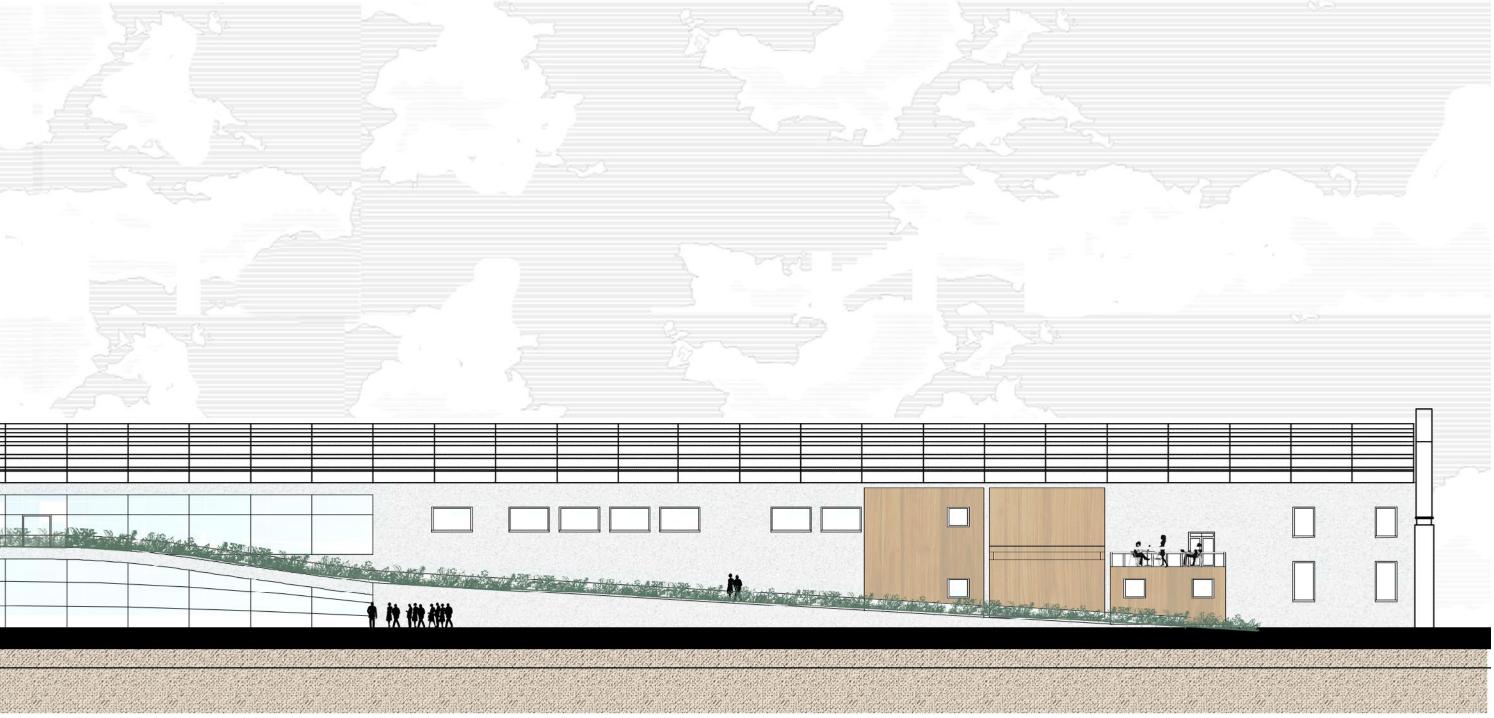
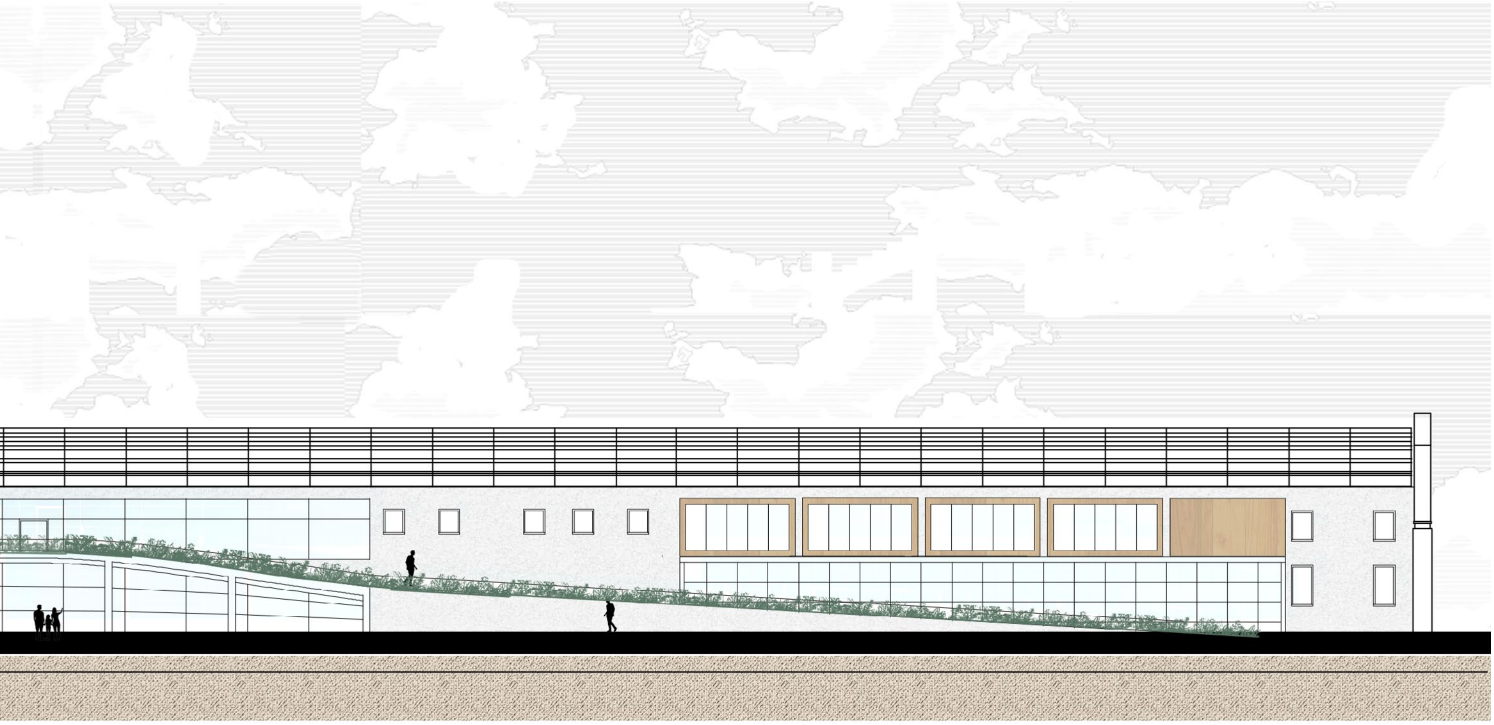


Fig.133:Northern and south elevation. Scale 1:200





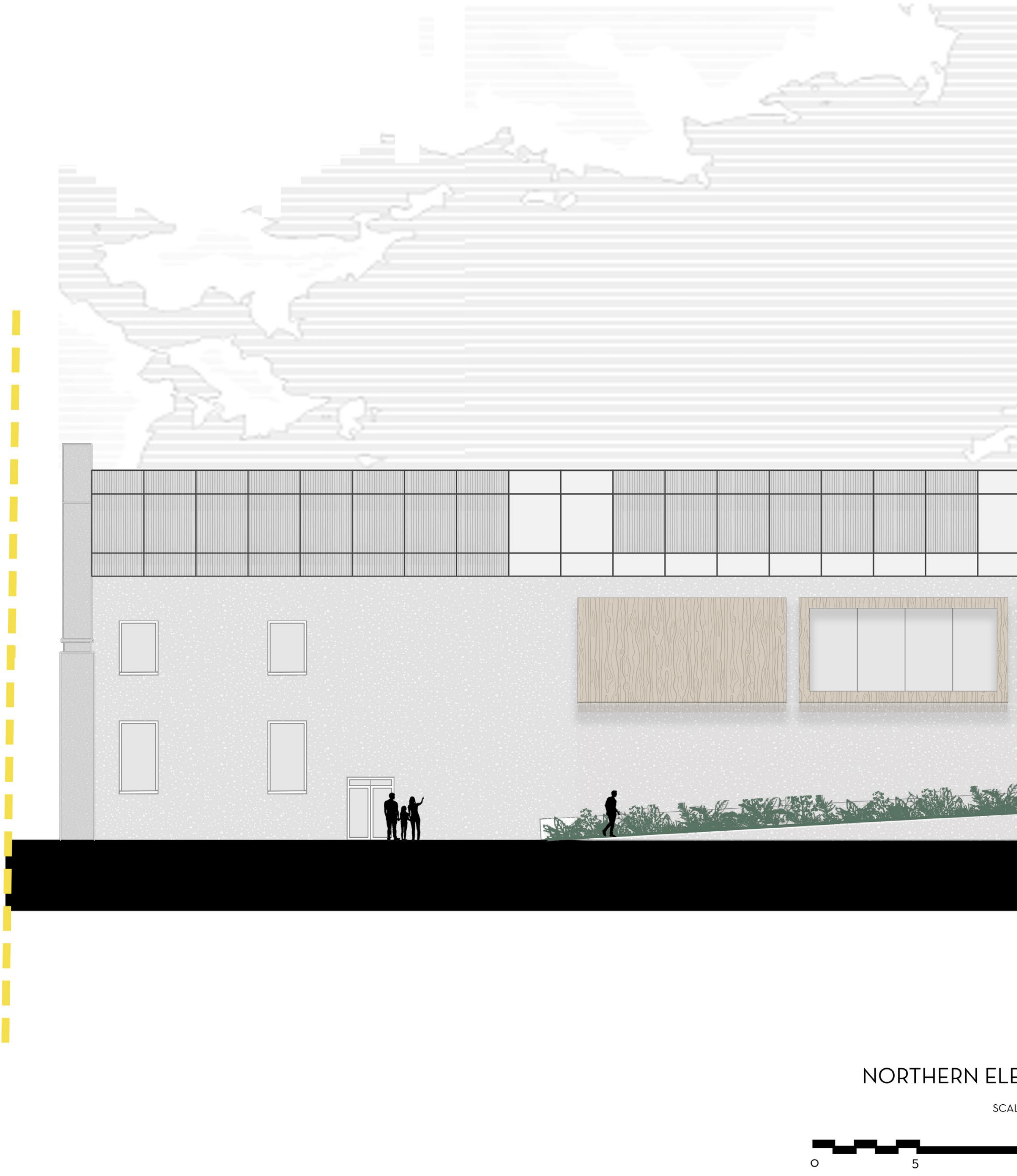


Fig.134:Northern elevation Scale 1:200

EVATION DIVISION 1

LE 1:200

10 20

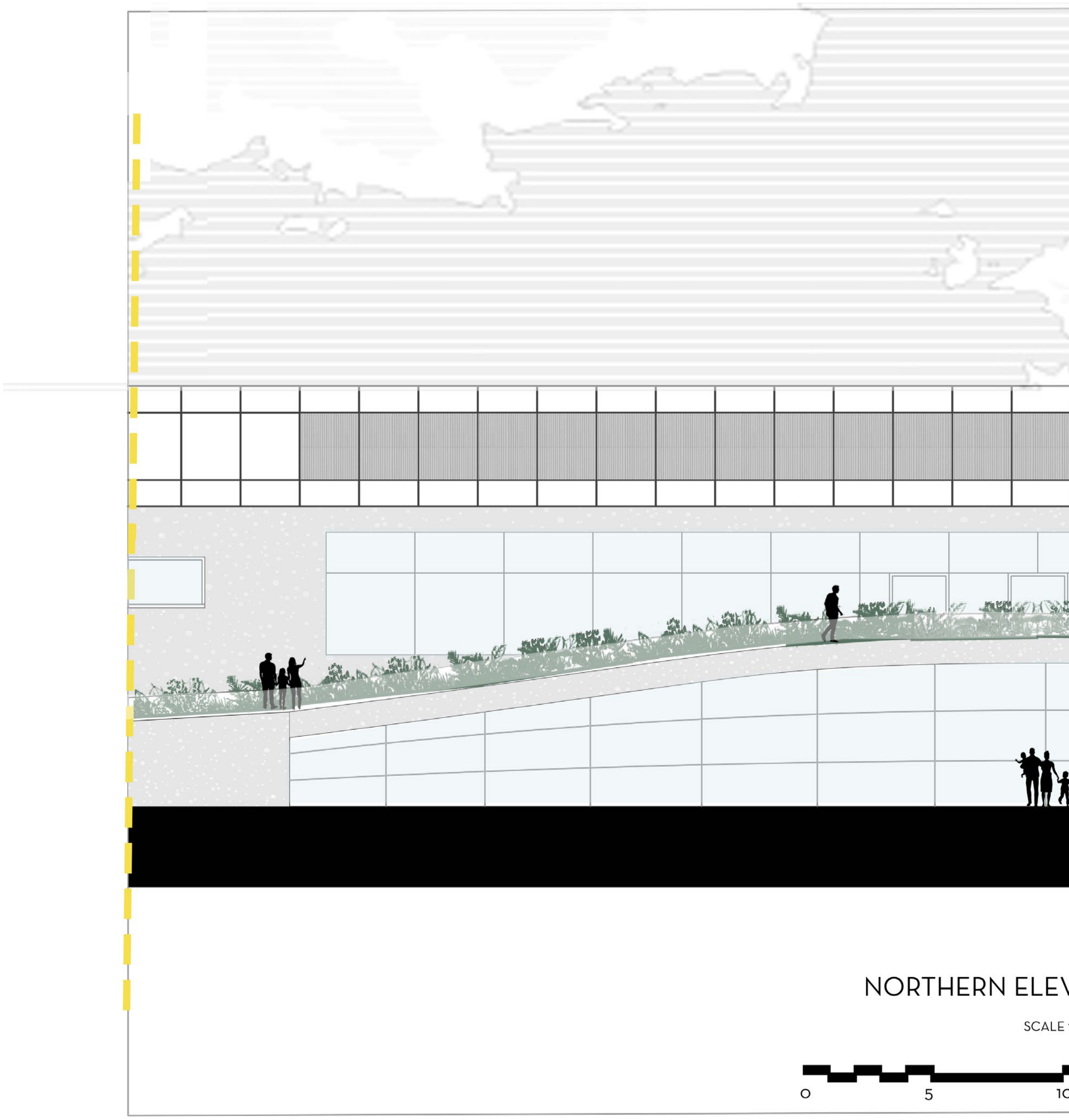
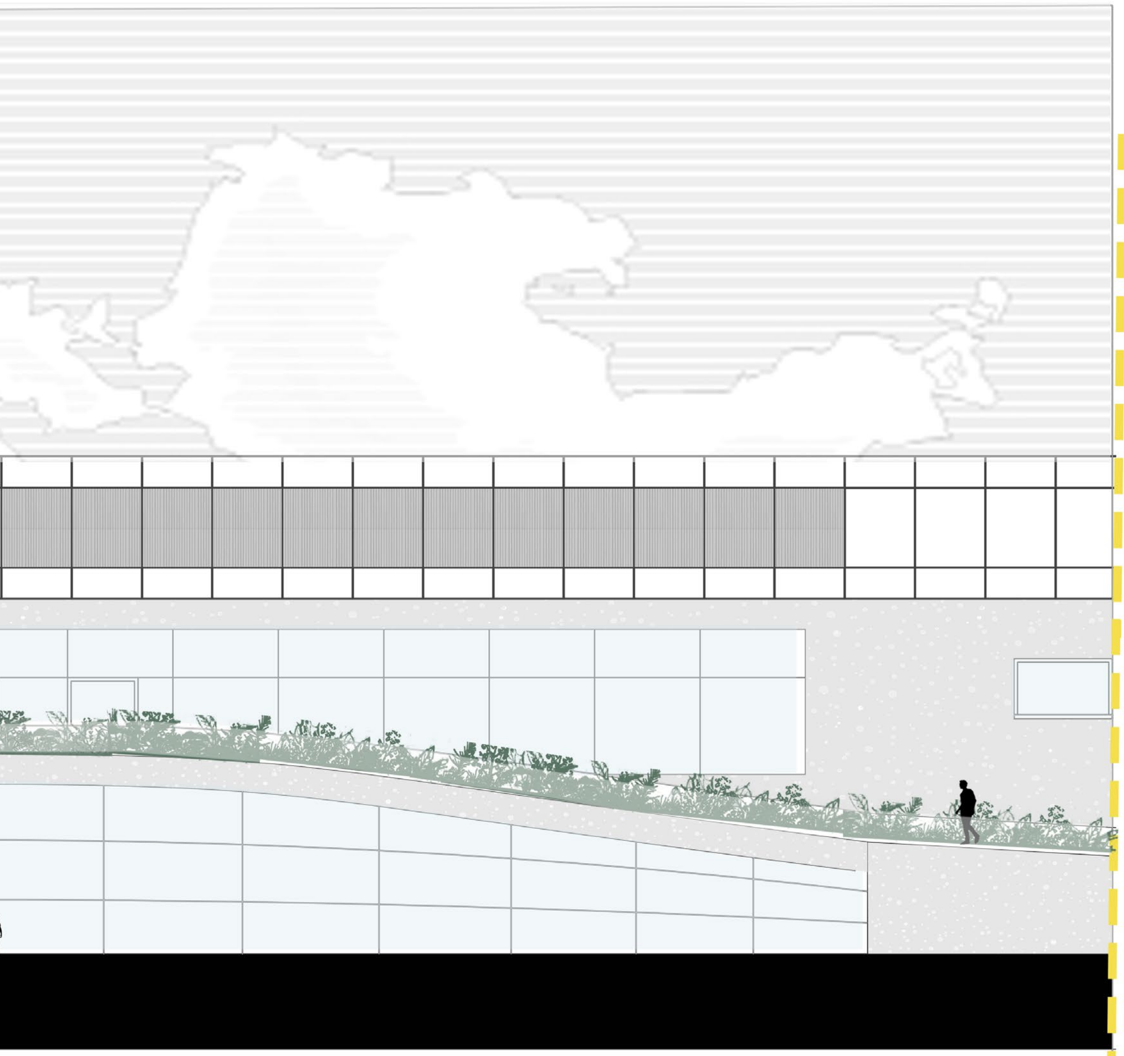


Fig.135:Northern elevation Scale 1:200



VATION DIVISION 2

1:200

0 20

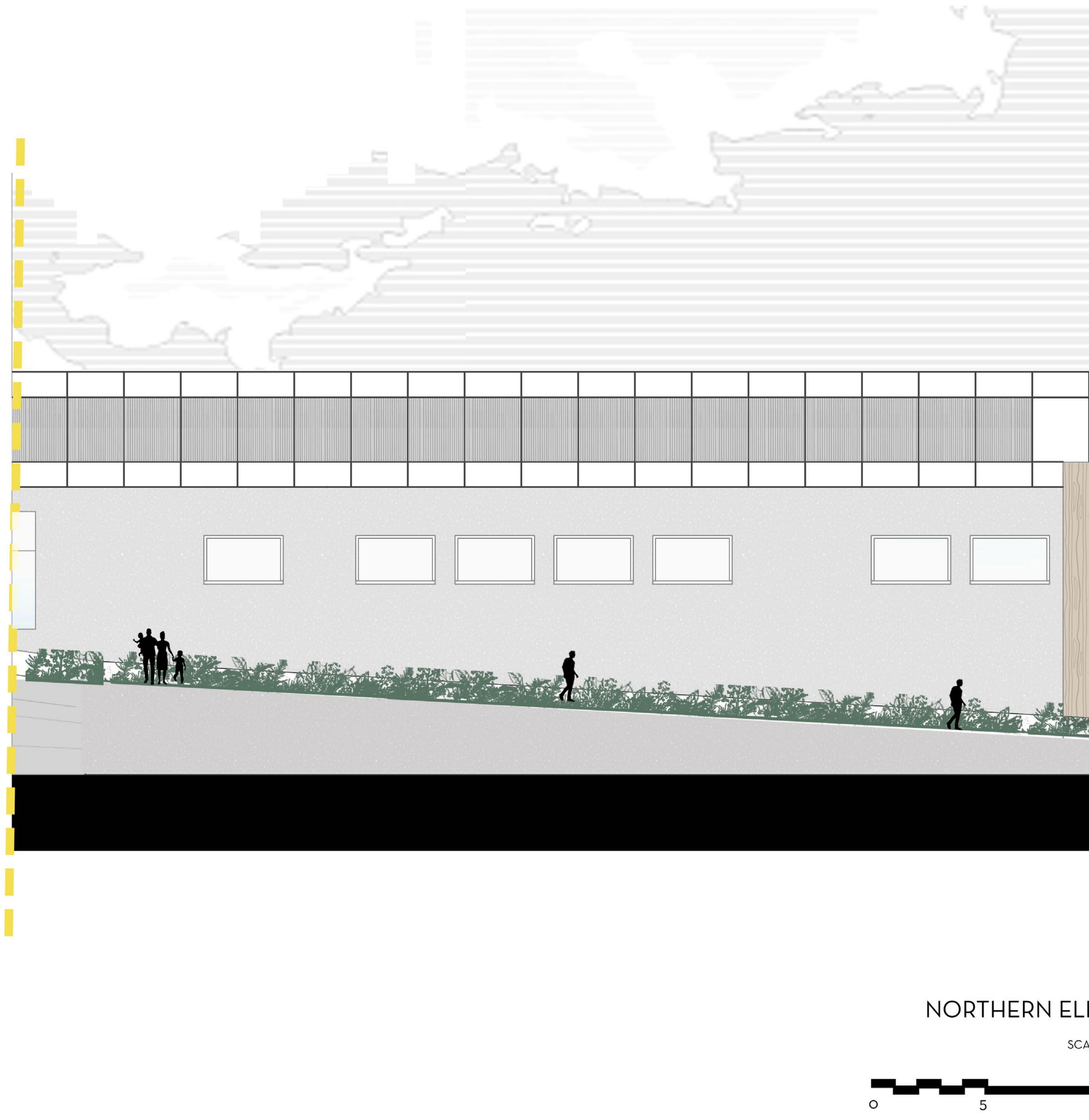
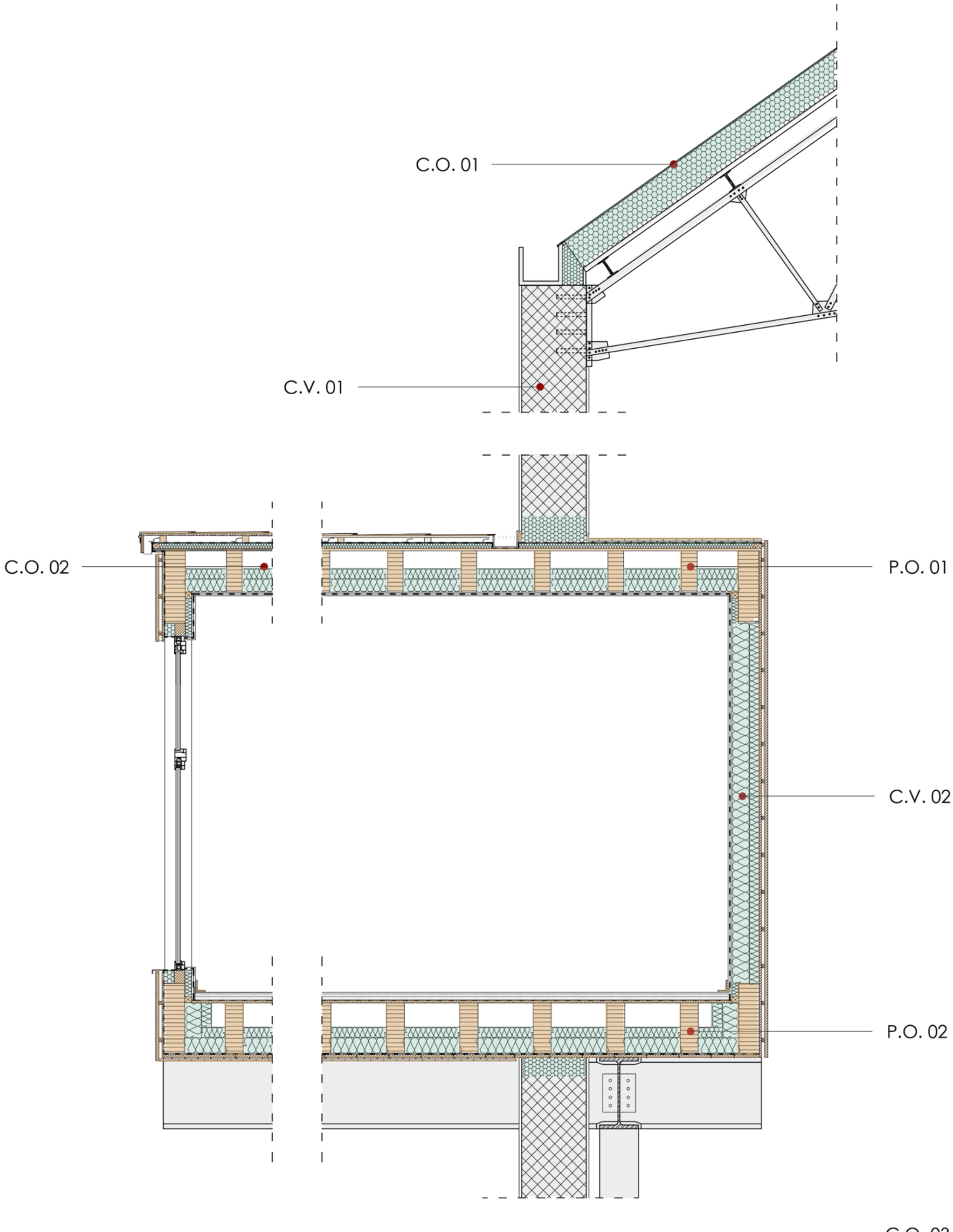
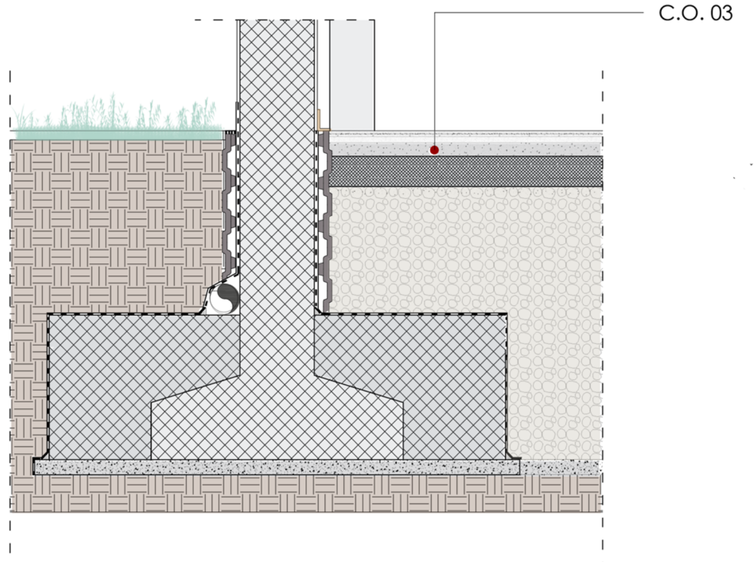


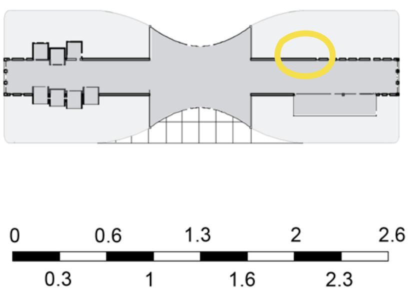
Fig.136:Northern elevation Scale 1:200

EVATION DIVISION 3

LE 1:200


C.O. 01
C.V. 01
C.O. 02
P.O. 01
C.V. 02
P.O. 02


C.O. 03

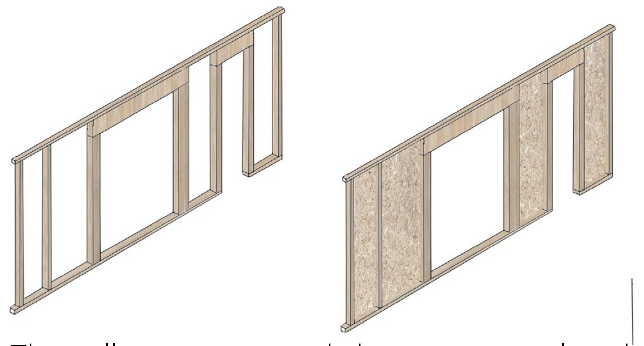

0
0.6
1.3
2
2.6
0.3
1
1.6
2.3

11. CONSTRUCTION TECHNOLOGIES

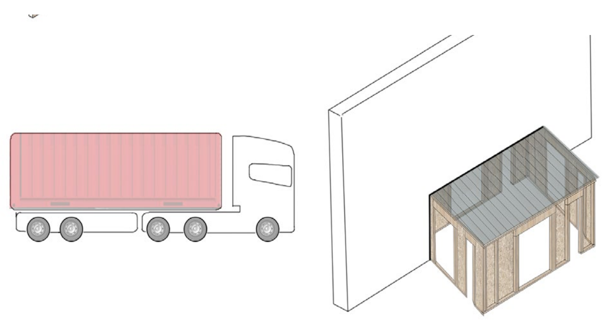
11.1. Introduction

The term 'construction technology' refers to the technical processes and methods used in the constructing buildings. Buildings have moved from being evolutions of standard types to becoming one-off prototypes, building performance requirements have become more demanding, and the number of products and specialist suppliers has increased.

The project uses different types of materials and technologies, both for the diversity of study that allowed us to study different materials and technologies, and because of the size of the building that has very different functions and spaces, so to require different solutions. Starting from the existing building we find, as previously described in the technical data sheets, a 1920s masonry and foundations in reinforced concrete, and steel trusses. These two elements have been maintained as they are still in good condition and due to their historical importance.
The boxes added with the intervention are made of wood, with the construction technique of the timber-frame construction. This choice is given by the flexibility of the spaces we wanted to create, to allow the quick removal, reduction or enlargement of these. In fact, this type of construction made possible to have boxes with prefabricated walls to be mounted on site, as dry systems.

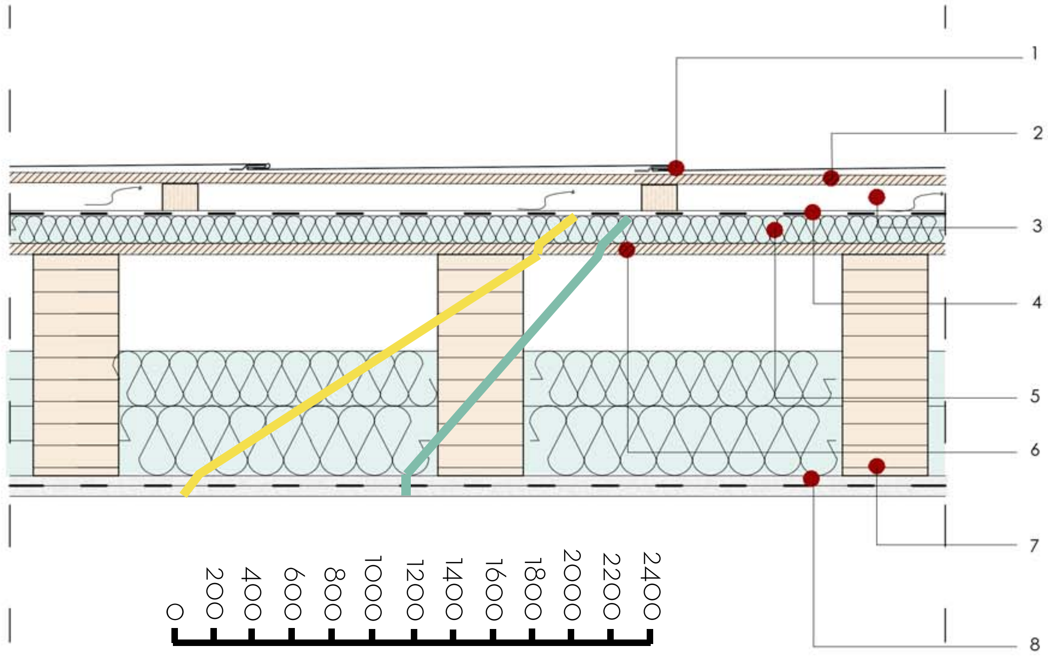


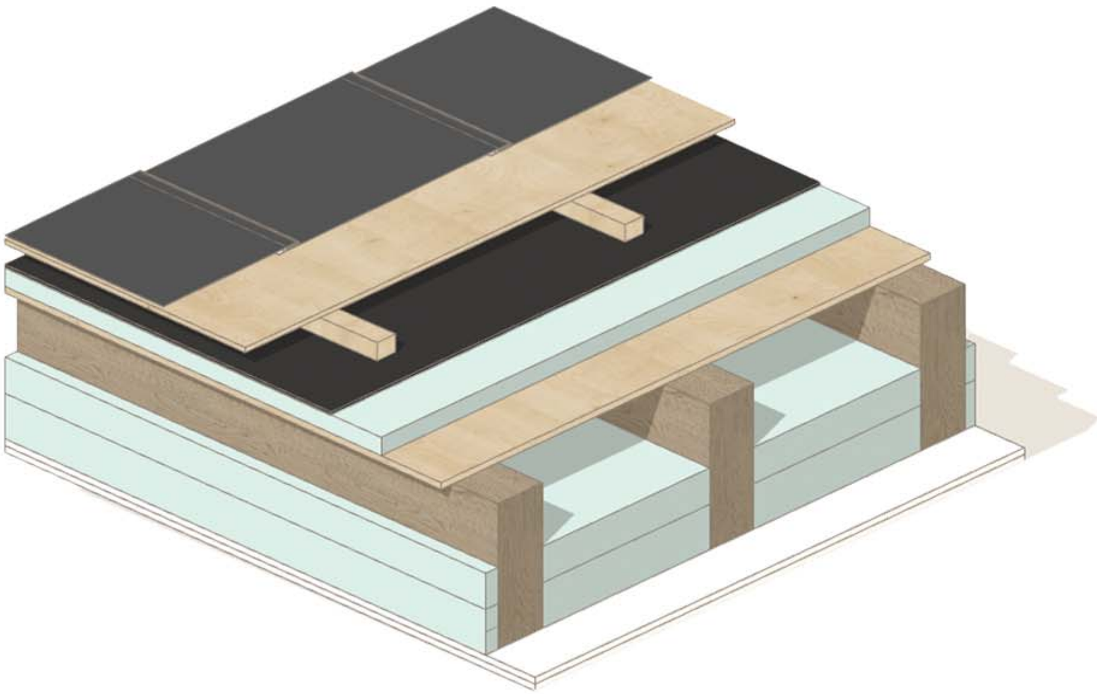
1. The wall structure is made by many vertical studs close together and they are prefabricated
2. Always in the prefabrication moment, the osb panels are inserted, they have bracing function.



3. The single façades are then transported in site
4. Finally the box is assembled in site and inserted in the existing wall.

11.2. Ceiling stratigraphy





Partial vapour pressure

Vapour saturation pressure

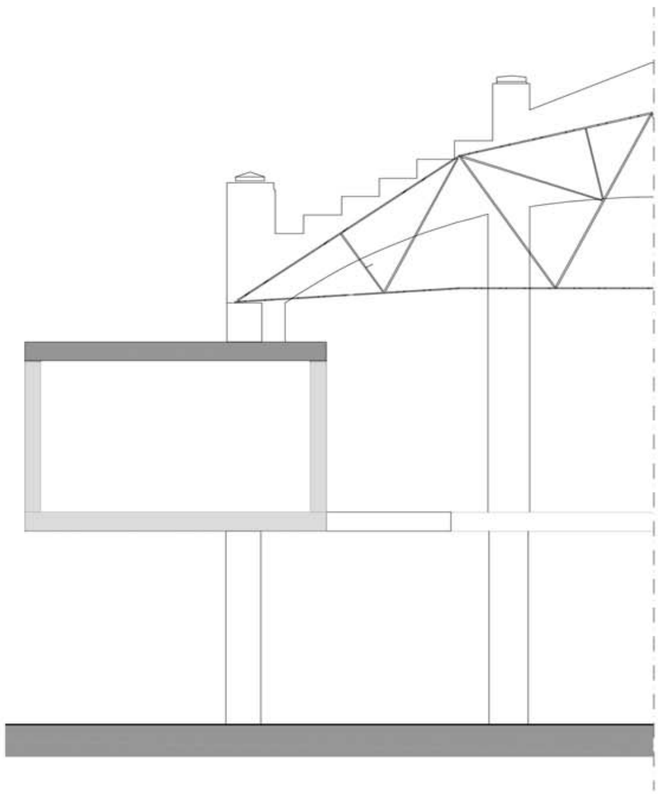
1. FINISH: Pre-patinated zinc sheet with double angular crimping, th. 0.8 mm, Zintec type Conductivity λ [W / mK]:109
2. SUPPORT: Wooden plank as a structure for finishing, th. 10 mm
3. IVENTILATION: Ventilation layer. Th. 50 mm
4. MEMEBRANE: Breathable membranes ROOF TRASPIR Rothoblaas. Th. 0.4 mm
5. INSULATION: Insulated material XPS. Th. 50 mm. Thermal transmittance equal to ψ = 0.034 W /mK
6. INFILL: infill panels in OSB panels, Th. 15 mm
7. STRUCTURE: Platform frame in lamellar wood beams. Inside there are 2 layers of Rockwool insulation. Density 40 Kg/mc. Th. 80 + 100 mm
8. FINISH LAYER: Double plasterboard coated with vapor barrier, type "Knauf GKB + Kasa"

Climate informations

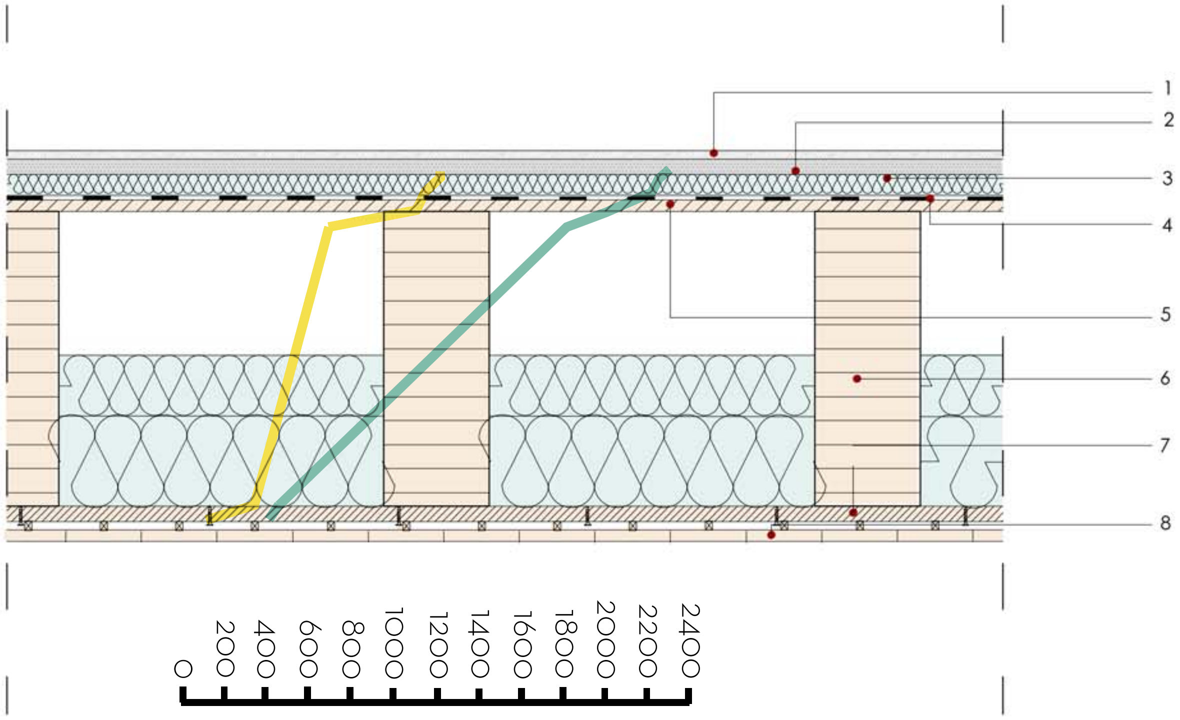
The municipality of Milan
Climate Zone: E, Degrees Day 2404
Indoor T (° C): 20.0
Outdoor T (° C): -5.0
Internal U (%): 52.0
External U (%): 38.7

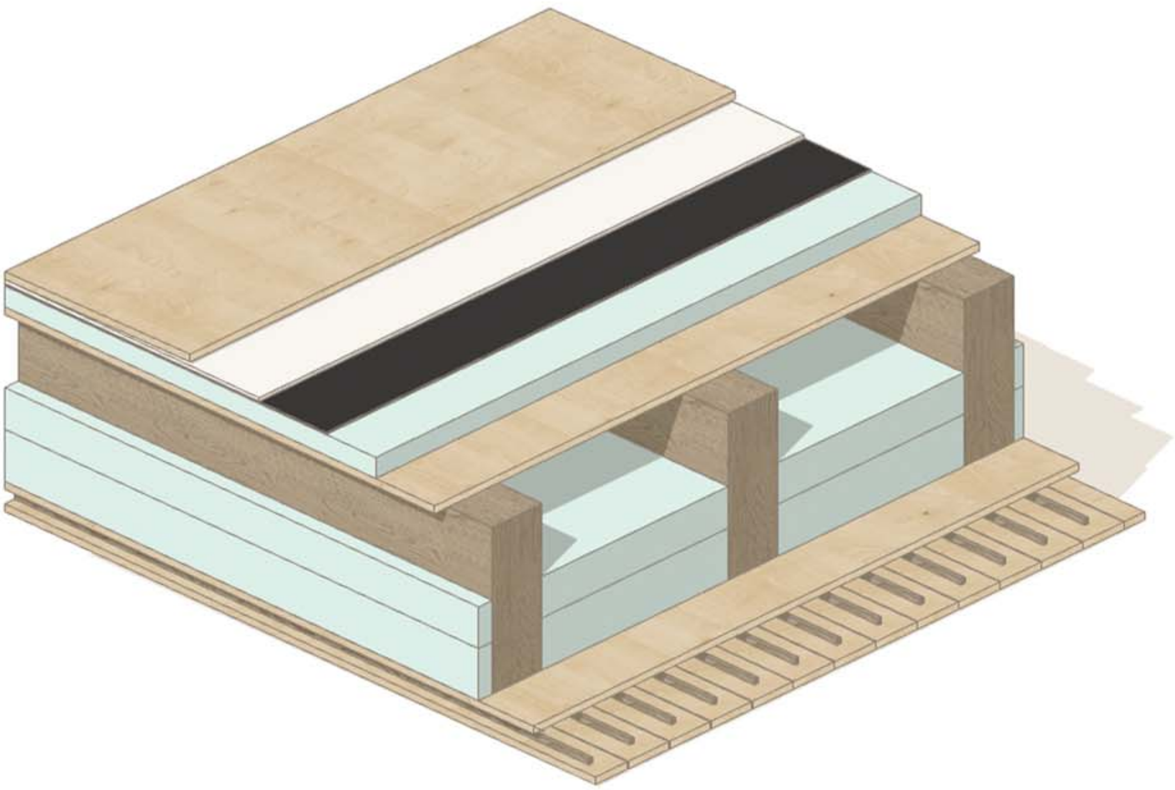
Surface mass (Kg / m2): 42
Thermal resistance (m2K / W): 6.854
Total thickness (mm): 264

Transmittance: 0.146 W / m2K
Law value 0.3 W / m2K



11.3. Slab stratigraphy





Partial vapour pressure

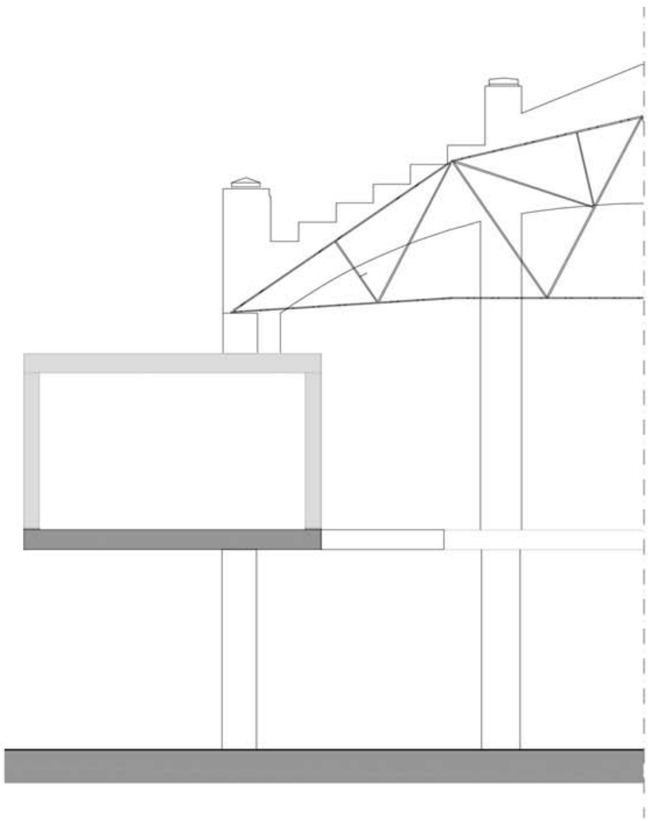
Vapour saturation pressure

1. FINISH: resin for interiors, light gray "Resinfloor" type. Composition: 200 m2 transparent, opaque protective paint layer, 1500 m gray epoxy self-leveling resin layer, 350 m epoxy resin smoothing layer
2. DRY LAYING LAYER: gypsum-fiber slab with rabbeted edge for continuous laying, size 1200 x 600 mm, thickness 18 mm, type "F145 Knauf"
3. INSULATION: Insulated material XPS. Th. 50 mm. Thermal transmittance equal to ψ = 0.034 W /mK
4. VAPOR RESISTANT: polyethylene impermeable to water vapor, thickness 2 mm, R98 series. Specific for the "Giacomini Dry" package
5. INFILL: infill panels in OSB panels, Th. 15 mm
6. STRUCTURE: Platform frame in lamellar wood beams. Inside there are 2 layers of Rockwool insulation. Density
7. INFILL: infill panels in OSB panels, Th. 15 mm
8. FINISH LAYER: Wood cladding, weather board larch. 25 mm

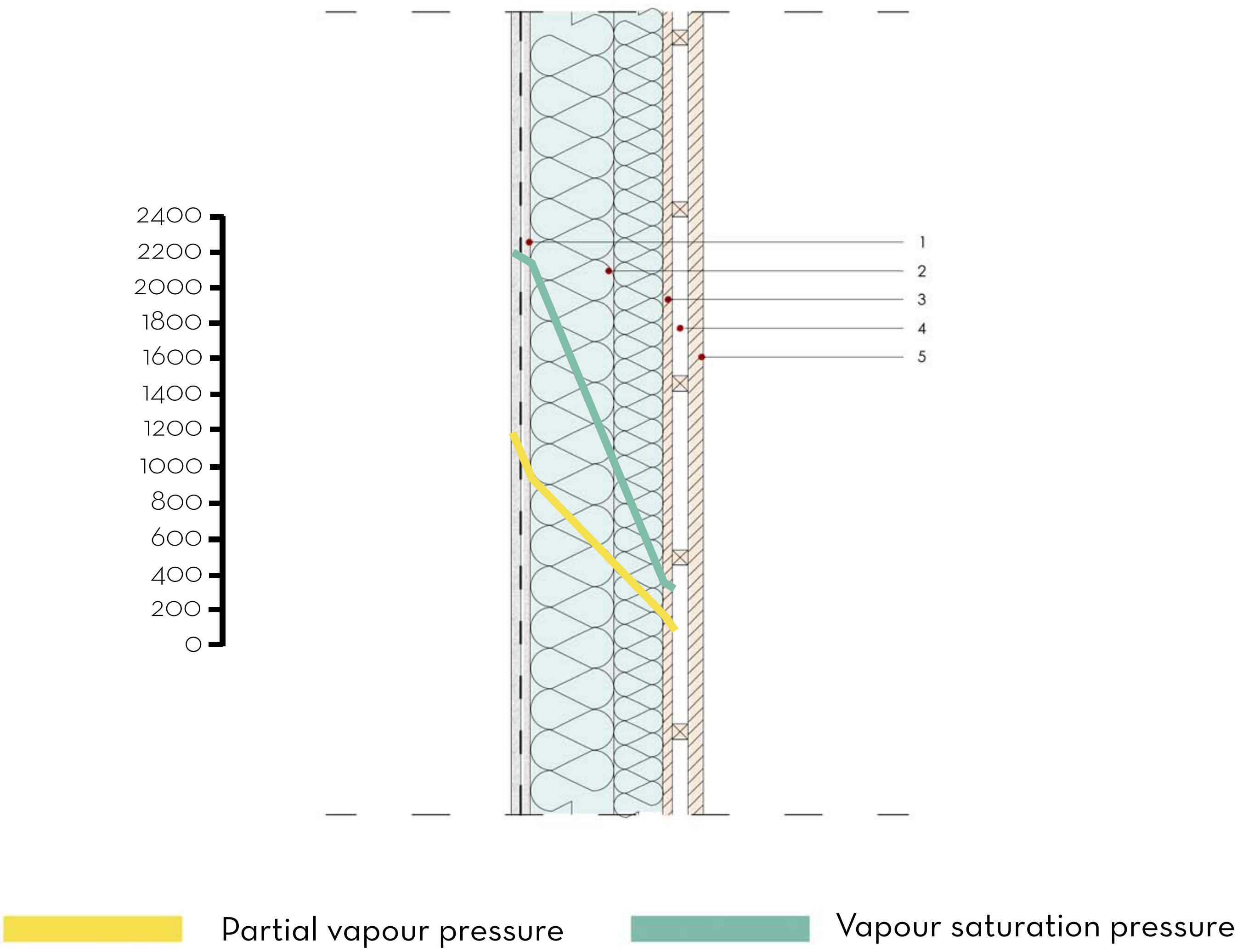
Climate informations
The municipality of Milan
Climate Zone: E, Degrees Day 2404
Indoor T (° C): 20.0
Outdoor T (° C): -5.0
Internal U (%): 52.0
External U (%): 38.7

Surface mass (Kg / m2): 49
Thermal resistance (m2K / W): 5.856
Total thickness (mm): 258

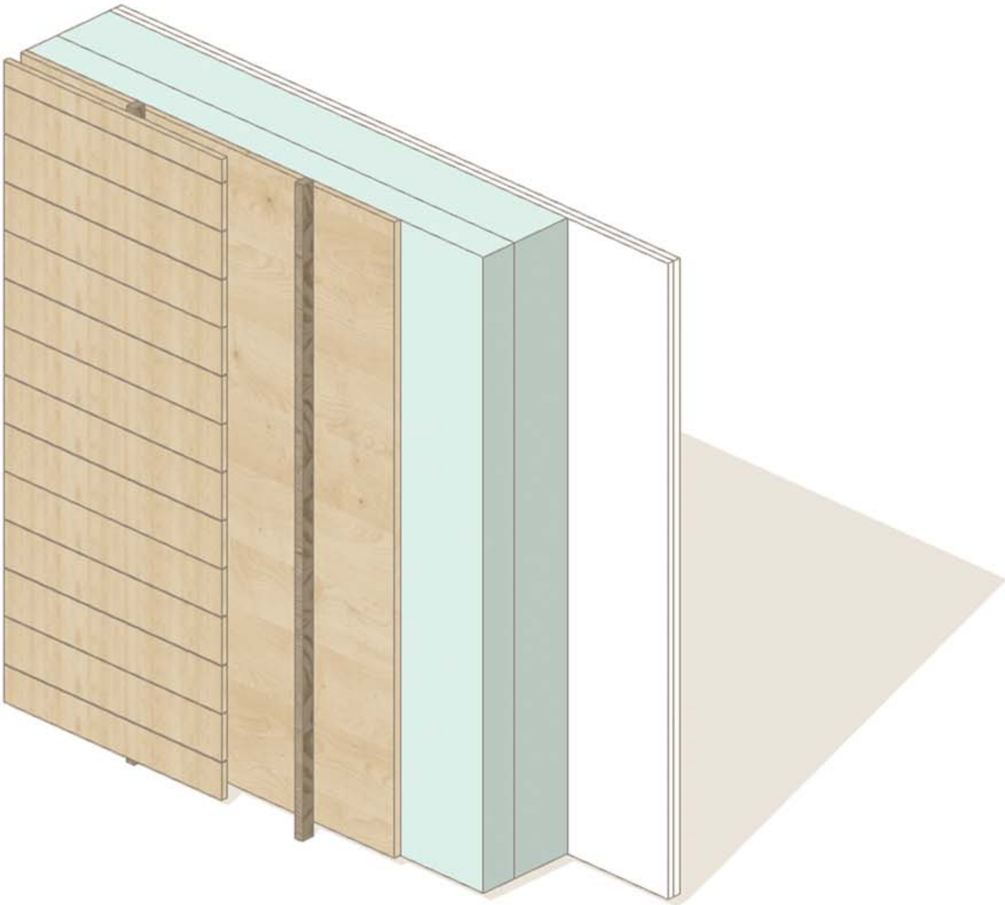
Transmittance: 0.171 W / m2K
Law value 0.3 W / m2K



11.4. Wall stratigraphy



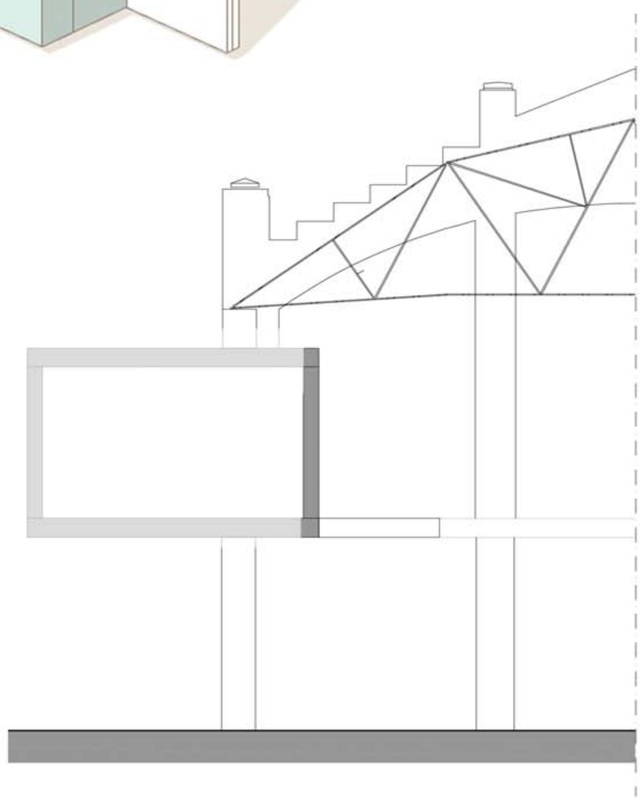
1. FINISH: double plasterboard coated with vapor barrier, type "Knauf GKB + Kasa"
2. STRUCTURE: load-bearing structure consisting of a frame made of wooden uprights (8x20cm) with a center distance of 62.5 cm. With two layers of thermal-acoustic panel insulation Rockwool panels (density 40 kg / mc)
3. INFILL: infill panels in OSB panels, Th. 15 mm
4. SUPPORT LAYER: Wood support structure 2,5 x 2,5 cm every 30 cm
5. FINISH LAYER: Wood cladding, weather board larch. 25 mm



Climate informations

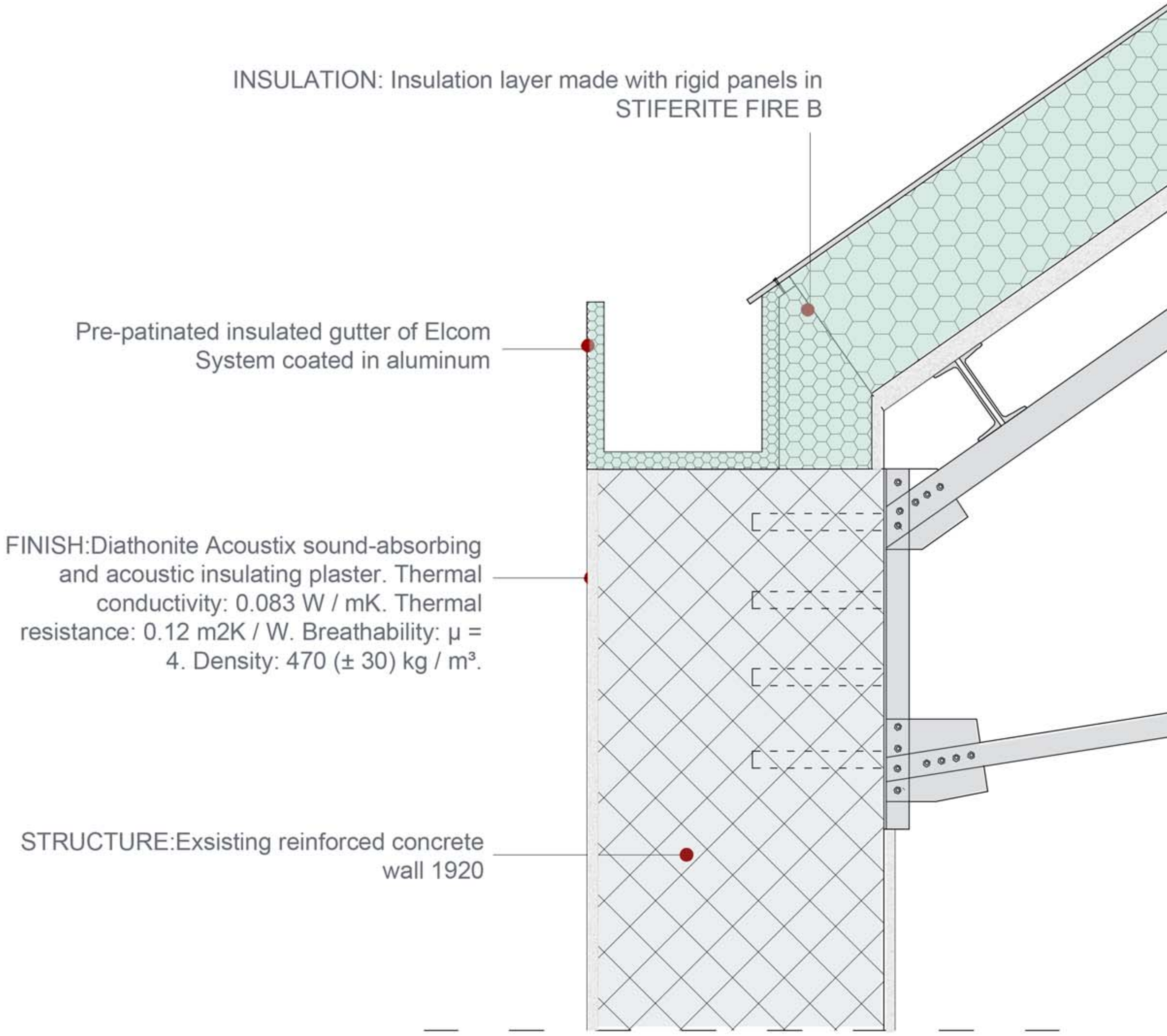
The municipality of Milan
Climate Zone: E, Degrees Day 2404
Indoor T (° C): 20.0
Outdoor T (° C): -5.0
Internal U (%): 52.0
External U (%): 38.7

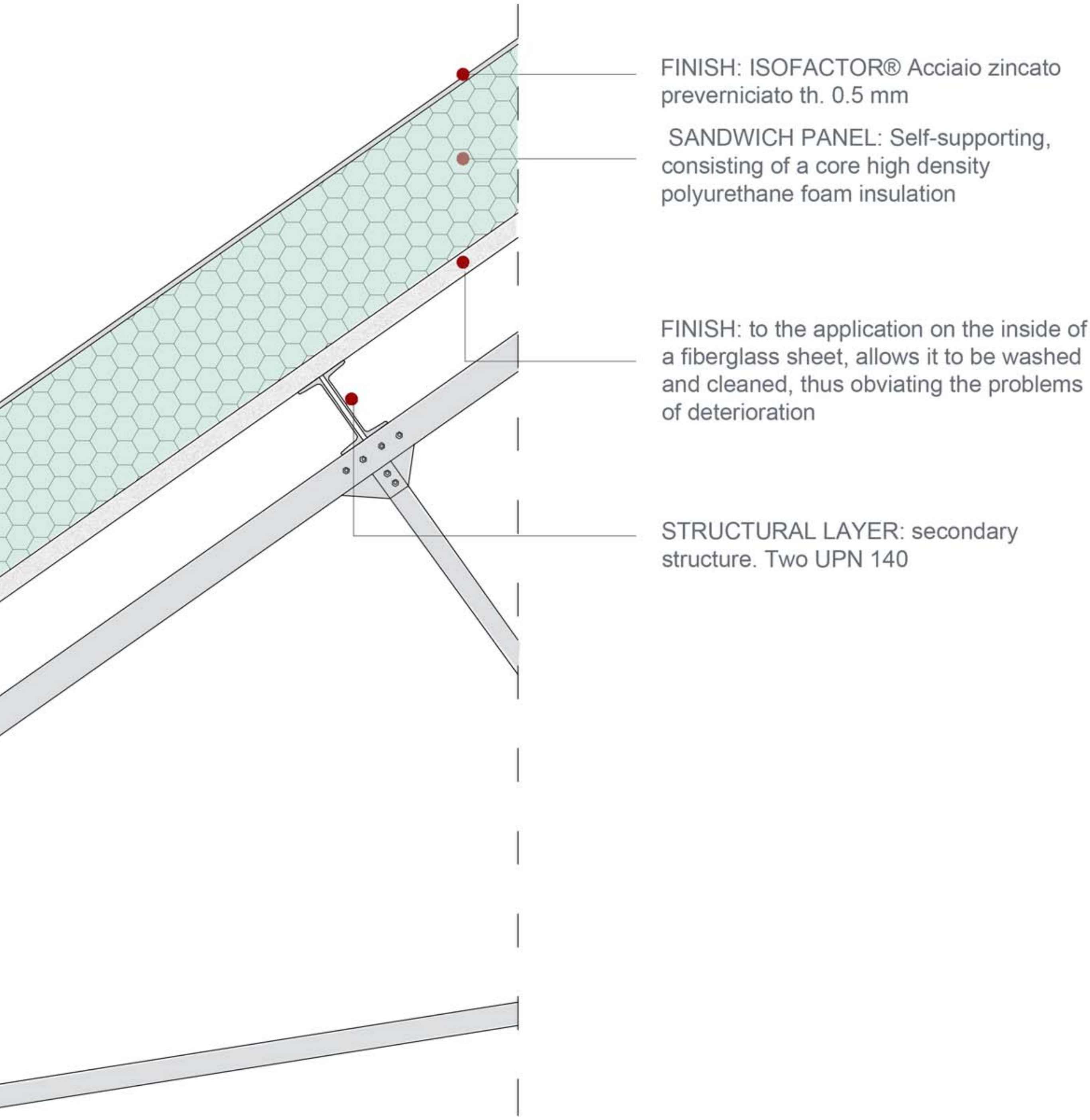
Surface mass (Kg / m2): 33
Thermal resistance (m2K / W): 6.08
Total thickness (mm): 227.5

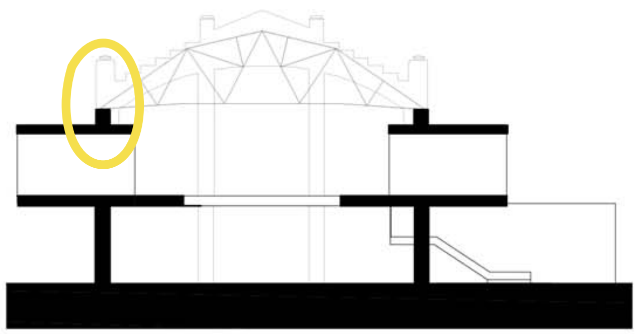


Transmittance: 0.164 W / m2K
Law value 0.3 W / m2K

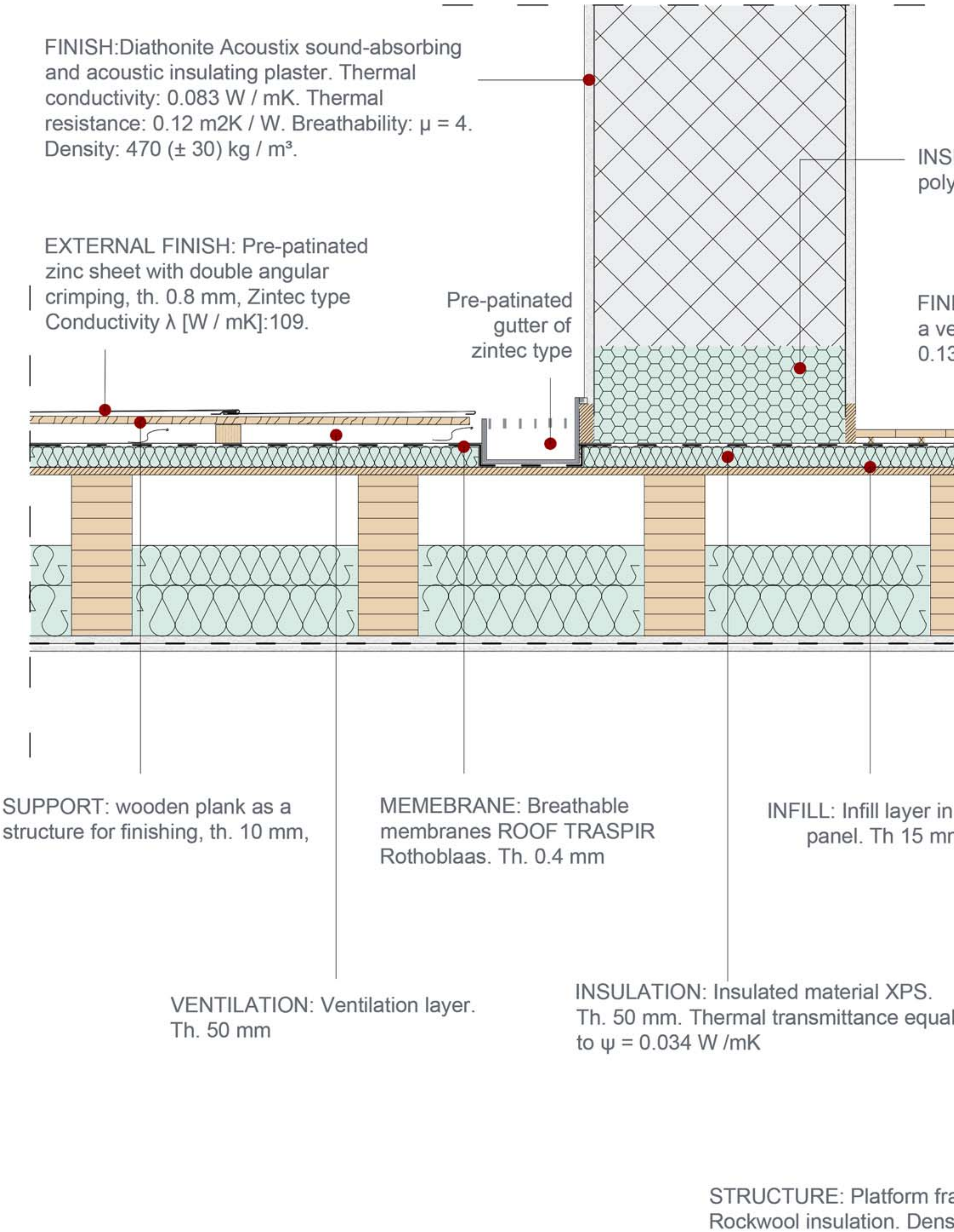
11.5. D01 - Roof and bearing wall



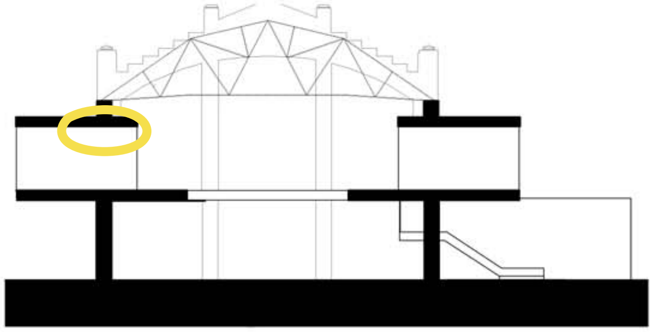

FINISH: ISOFACTOR® Acciaio zincato preverniciato th. 0.5 mm
SANDWICH PANEL: Self-supporting, consisting of a core high density polyurethane foam insulation
FINISH: to the application on the inside of a fiberglass sheet, allows it to be washed and cleaned, thus obviating the problems of deterioration
STRUCTURAL LAYER: secondary structure. Two UPN 140



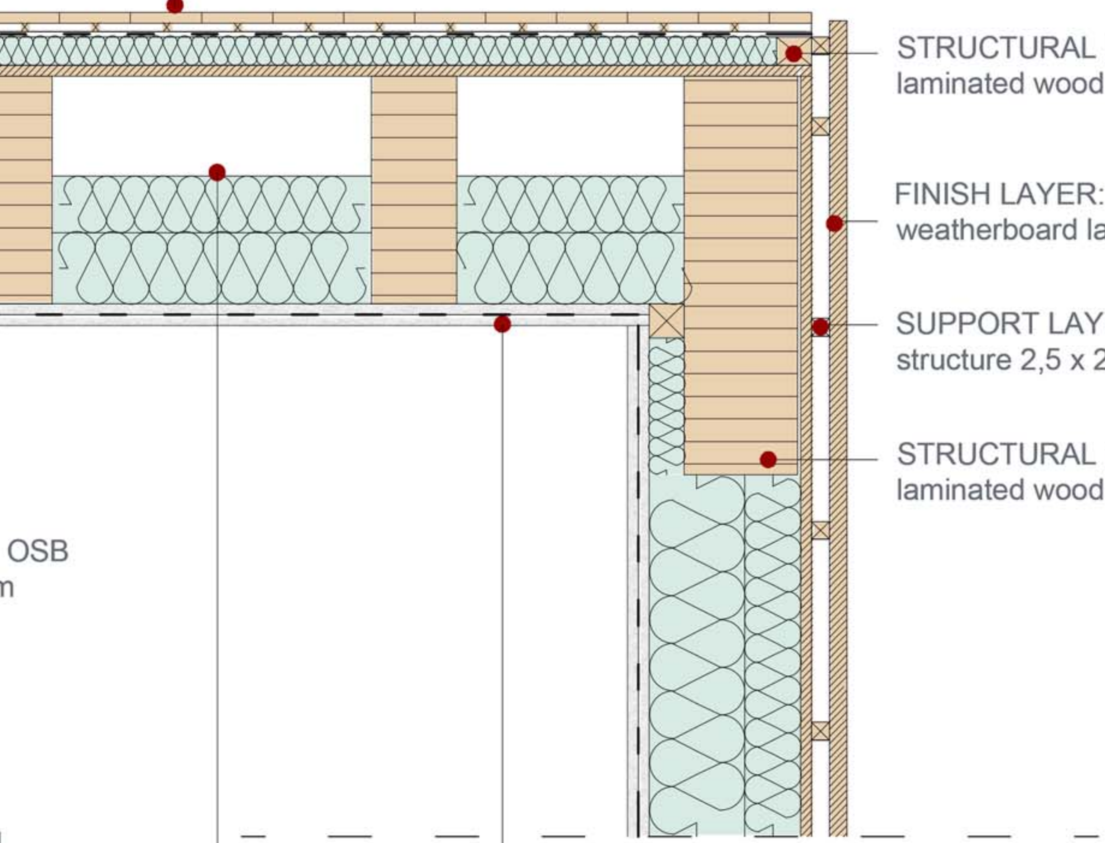
11.6. D02 - Lab ceiling box



ULATION :Alpac monobloc in XPS extruded expanded
ystyrene. Thermal transmittance equal to ψ = 0.044 W /mK



ISH: external cladding in larch strips on
entilated cavity. Conductivity λ [W / mK]:
3. Density ρ: 475 Kg\m3. Th. 15 mm



STRUCTURAL LAYER: 16 X 56 cm
laminated wood beam

FINISH LAYER: Wood cladding,
weatherboard larch. 25 mm

SUPPORT LAYER: Wood support
structure 2,5 x 2,5 cm every 30 cm

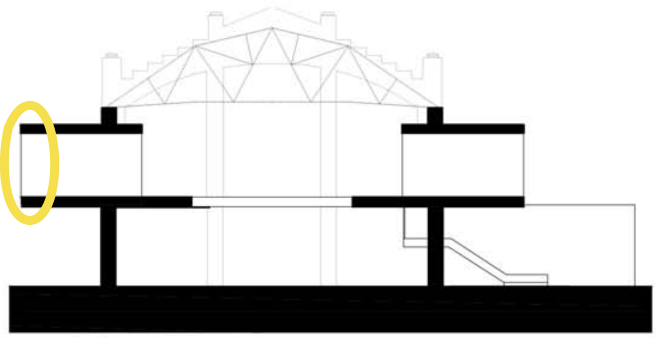
STRUCTURAL LAYER: 16 X 56 cm
laminated wood beam

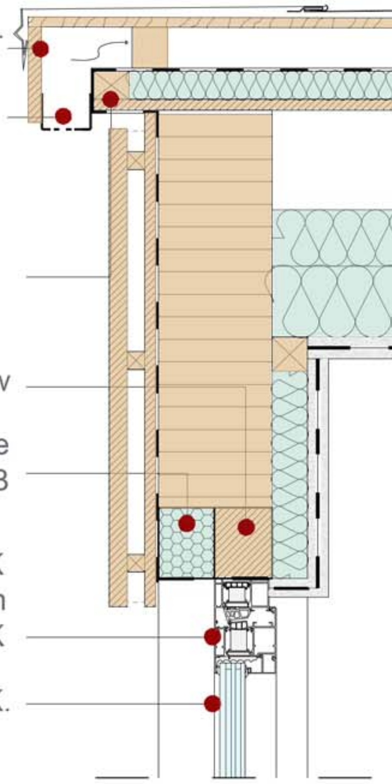
OSB
m

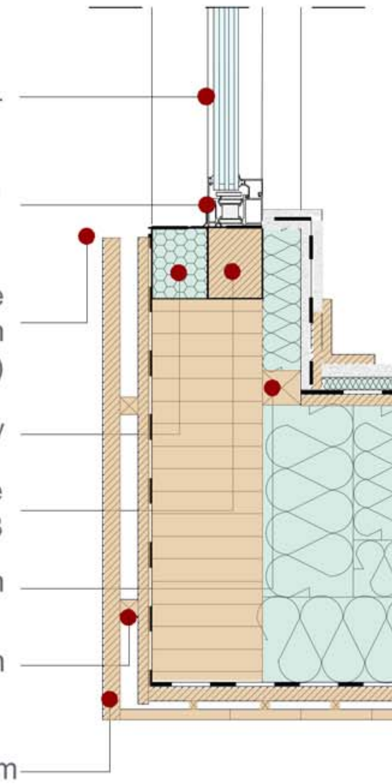
FINISH LAYER: double plasterboard coated with vapor
barrier, type "Knauf GKB + Kasa"

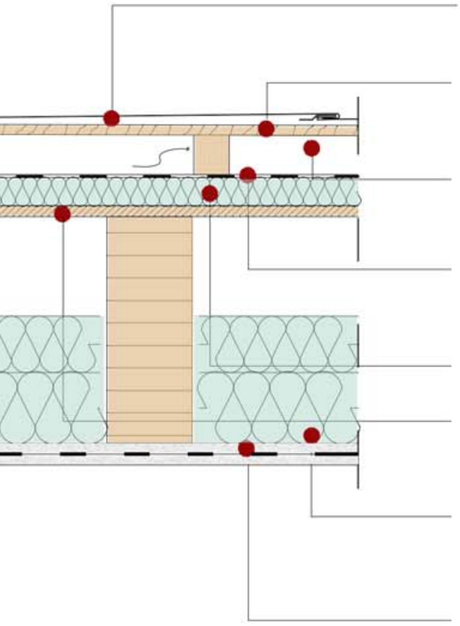
ame in lamellar wood beams. Inside there are 2 layers of
ity 40 Kg/mc. Th. 80 + 100 mm

11.7. D03 - Transparent glass and box









EXTERNAL FINISH: Pre-patinated zinc sheet with double angular crimping, th. 0.8 mm, Zintec type Conductivity λ [W / mK]:109.

SUPPORT: wooden plank as a structure for finishing, th. 10 mm,

VENTILATION: Ventilation layer. Th. 50 mm

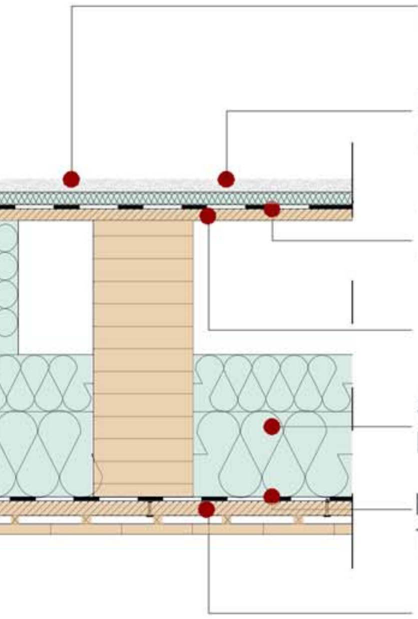
MEMEBRANE: Breathable membranes ROOF TRASPIR Rothoblaas. Th. 0.4 mm

INSULATION: Insulated material XPS. Th. 50 mm. Thermal transmittance equal to ψ = 0.034 W /mK

INFILL: infill panels in OSB panels, Th. 15 mm

STRUCTURE: Platform frame in lamellar wood beams. Inside there are 2 layers of Rockwool insulation. Density 40 Kg/mc. Th. 80 + 100 mm

FINISH LAYER: double plasterboard coated with vapor barrier, type "Knauf GKB + Kasa"



FINISH: resin for interiors, light gray "Resinfloor" type. Composition: 200 m2 transparent, opaque protective paint layer, 1500 m gray epoxy self-leveling resin layer, 350 m epoxy resin smoothing layer.

DRY LAYING LAYER: gypsum-fiber slab with rabbeted edge for continuous laying, size 1200 x 600 mm, thickness 18 mm, type "F145 Knauf"

VAPOR RESISTANT: polyethylene impermeable to water vapor, thickness 2 mm, R98 series. Specific for the "Giacomini Dry" package

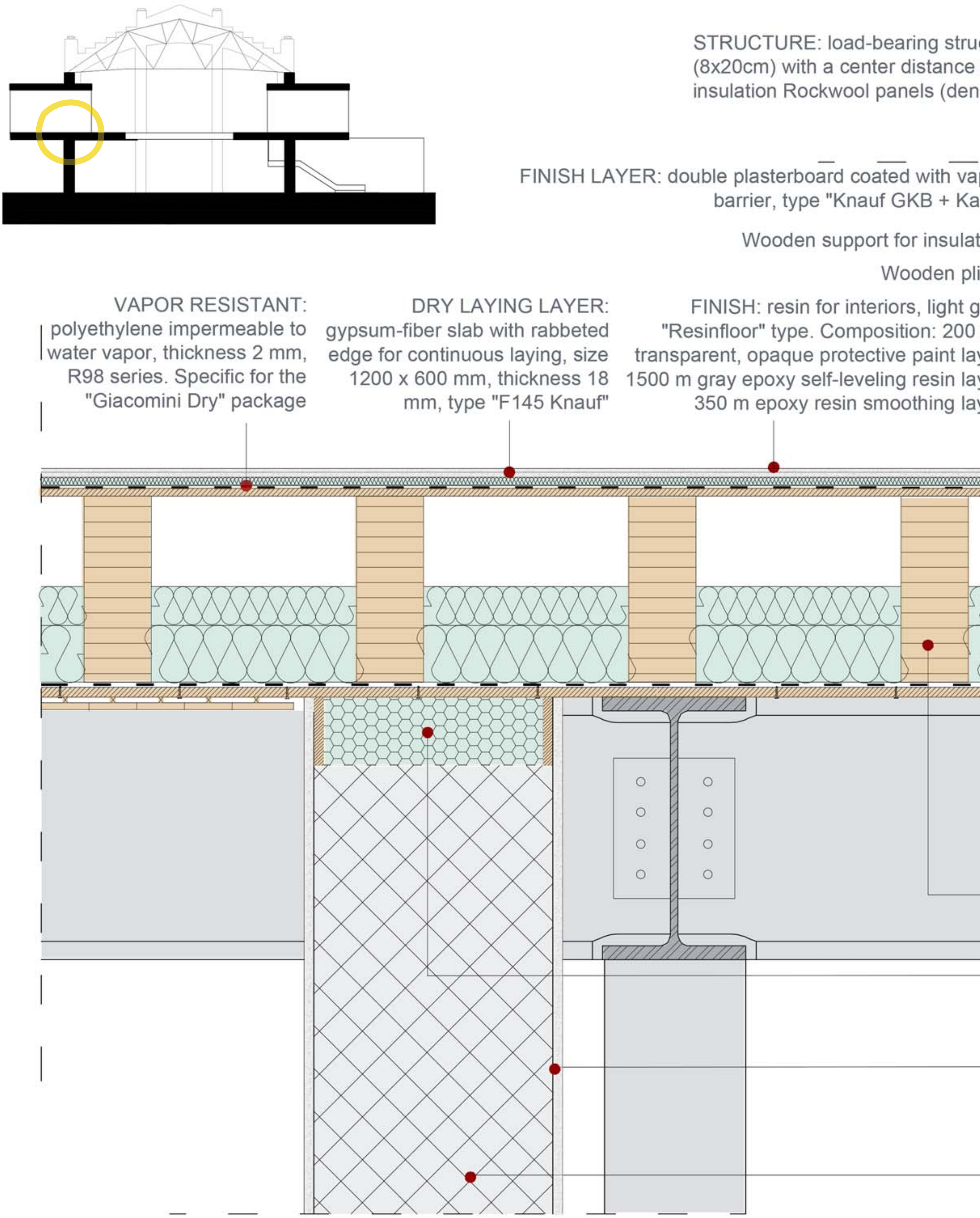
INFILL: infill panels in OSB panels, Th. 15 mm

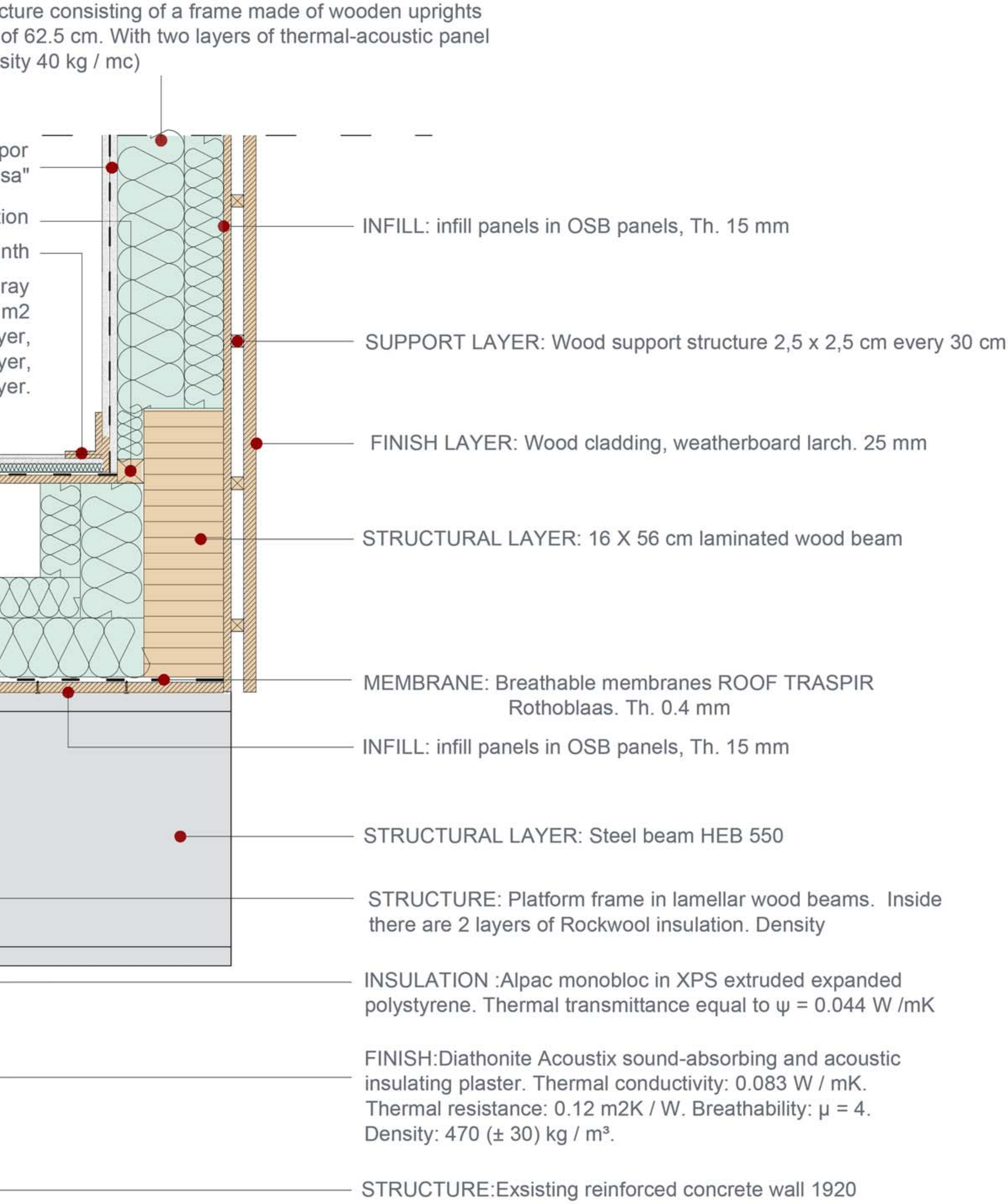
STRUCTURE: Platform frame in lamellar wood beams. Inside there are 2 layers of Rockwool insulation. Density

MEMBRANE: Breathable membranes ROOF TRASPIR Rothoblaas. Th. 0.4 mm

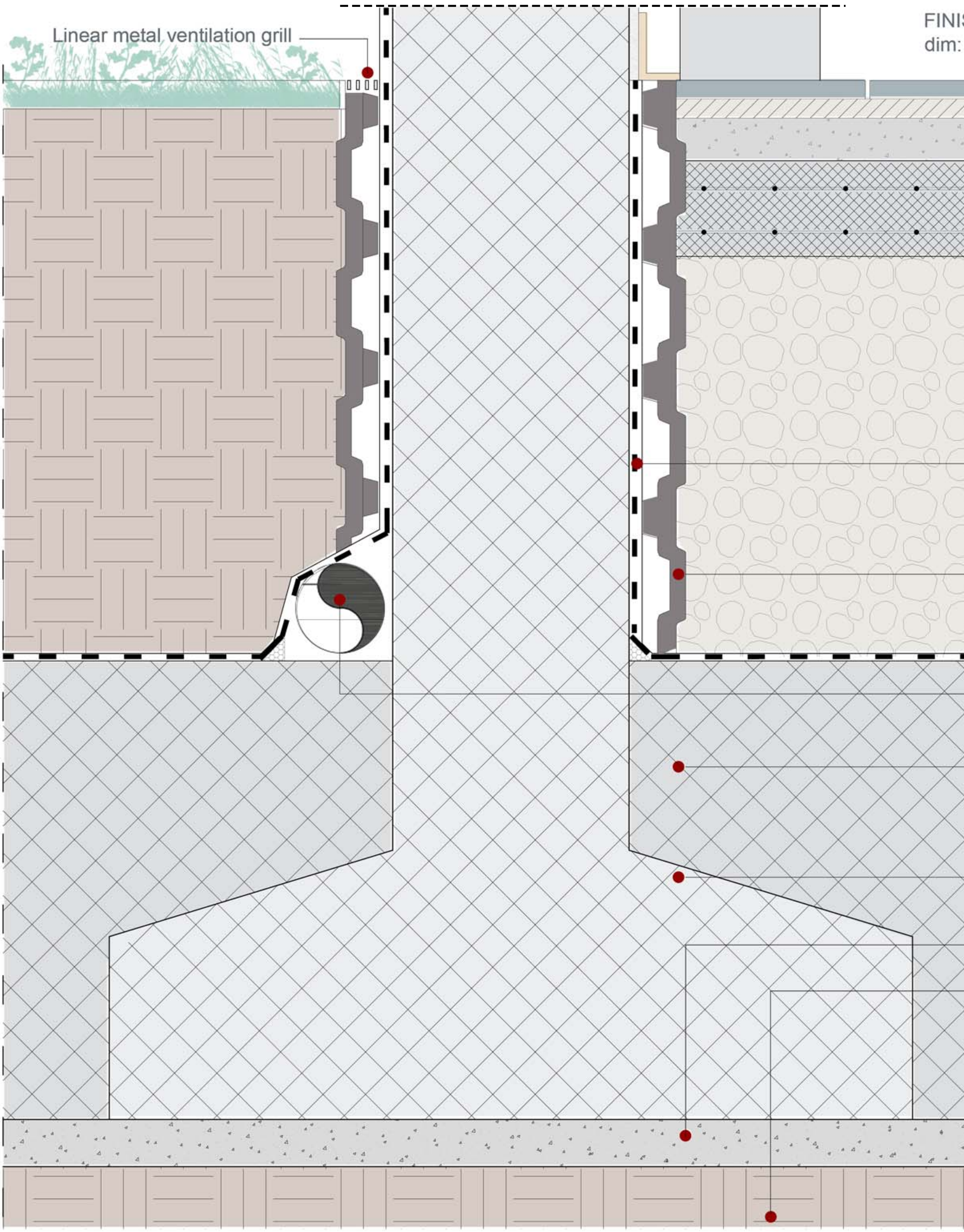
INFILL: infill panels in OSB panels, Th. 15 mm

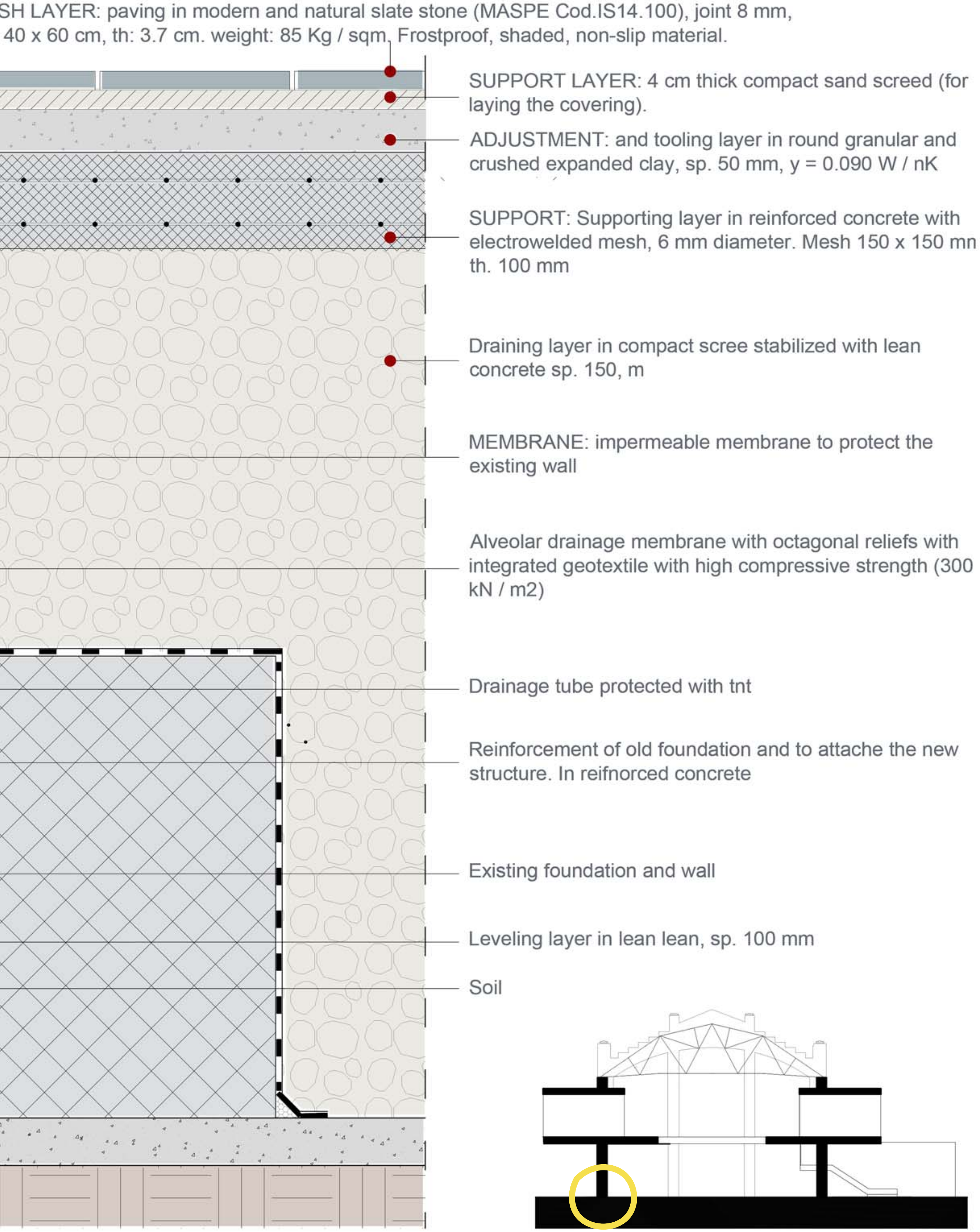
11.8. D04 - Lab flooring box

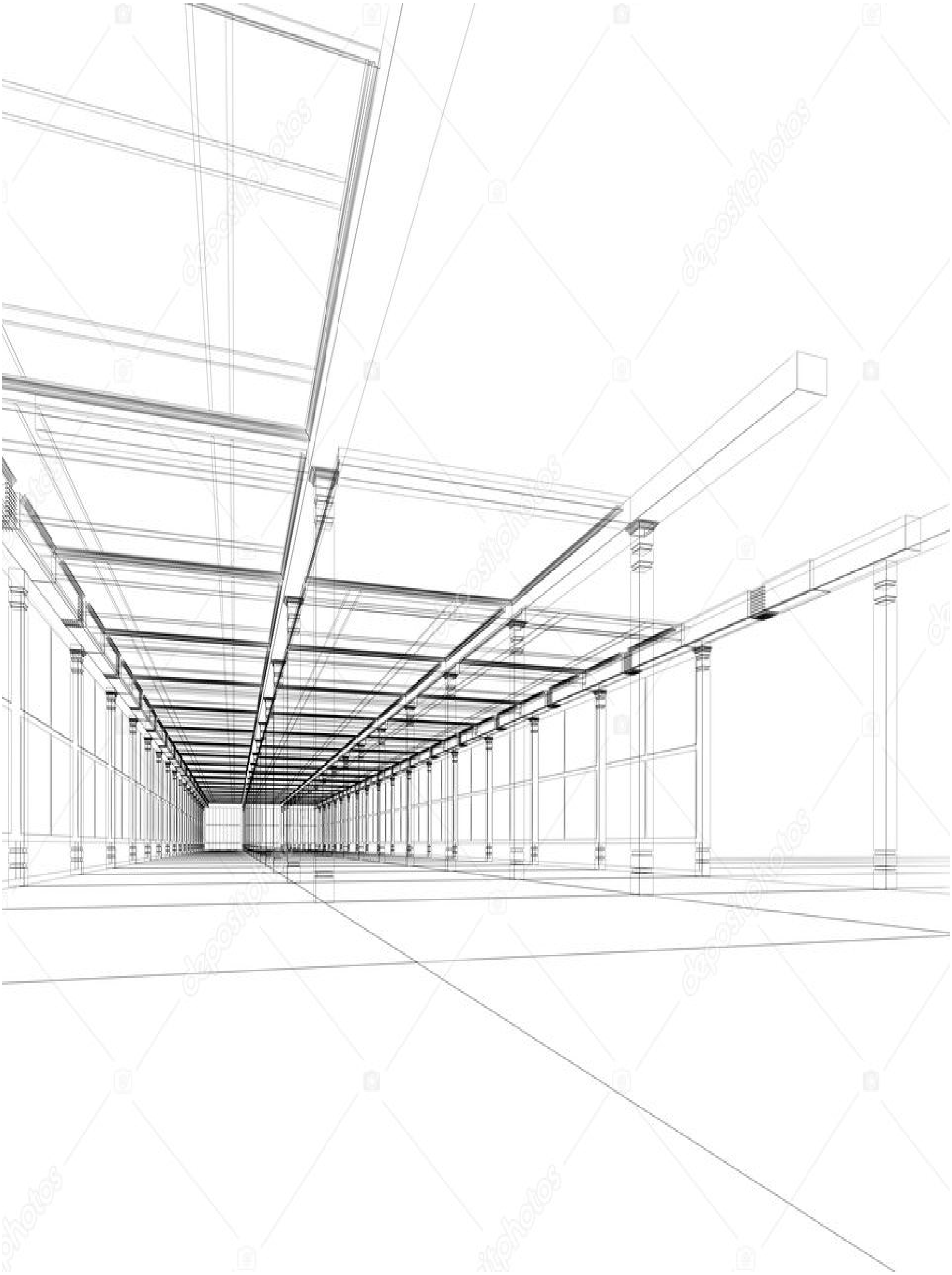



cture consisting of a frame made of wooden uprights
of 62.5 cm. With two layers of thermal-acoustic panel
sity 40 kg / mc)
por
sa"
ion
nth
ray
m2
yer,
yer,
yer.
INFILL: infill panels in OSB panels, Th. 15 mm
SUPPORT LAYER: Wood support structure 2,5 x 2,5 cm every 30 cm
FINISH LAYER: Wood cladding, weatherboard larch. 25 mm
STRUCTURAL LAYER: 16 X 56 cm laminated wood beam
MEMBRANE: Breathable membranes ROOF TRASPIR Rothoblaas. Th. 0.4 mm
INFILL: infill panels in OSB panels, Th. 15 mm
STRUCTURAL LAYER: Steel beam HEB 550
STRUCTURE: Platform frame in lamellar wood beams. Inside there are 2 layers of Rockwool insulation. Density
INSULATION :Alpac monobloc in XPS extruded expanded polystyrene. Thermal transmittance equal to ψ = 0.044 W /mK
FINISH:Diathonite Acoustix sound-absorbing and acoustic insulating plaster. Thermal conductivity: 0.083 W / mK. Thermal resistance: 0.12 m2K / W. Breathability: μ = 4. Density: 470 (± 30) kg / m³.
STRUCTURE:Exsisting reinforced concrete wall 1920

11.9. D05 - Foundations




SH LAYER: paving in modern and natural slate stone (MASPE Cod.IS14.100), joint 8 mm,
40 x 60 cm, th: 3.7 cm. weight: 85 Kg / sqm, Frostproof, shaded, non-slip material.
SUPPORT LAYER: 4 cm thick compact sand screed (for laying the covering).
ADJUSTMENT: and tooling layer in round granular and crushed expanded clay, sp. 50 mm, y = 0.090 W / nK
SUPPORT: Supporting layer in reinforced concrete with electrowelded mesh, 6 mm diameter. Mesh 150 x 150 mn th. 100 mm
Draining layer in compact scree stabilized with lean concrete sp. 150, m
MEMBRANE: impermeable membrane to protect the existing wall
Alveolar drainage membrane with octagonal reliefs with integrated geotextile with high compressive strength (300 kN / m2)
Drainage tube protected with tnt
Reinforcement of old foundation and to attache the new structure. In reifnorced concrete
Existing foundation and wall
Leveling layer in lean lean, sp. 100 mm
Soil



12. STRUCTURAL DESIGN

12.1. Introduction

The structural analysis of the building has been divided in two parts. The firs one is about the curvilinear entrance of the gallery, chose because of the innovative technique used to cover the 50 meters span. The other analysis were done on the laboratory side of the building, the calculation of the steel structure of the new slab and the timber frame boxes on top of it.

1.1 Site analysis
The case study building is located in Milan, therefore, the climatic data relating to this area were used where required. Below is a summary table of the values taken into consideration for the design.

LOCATION	Milan
PROVINCE	Mi
LATITUDE	122 m s.l.m.
SNOW ZONE	1
COORDINATES	45°27 50.98" N 9°11" 25.21" E

Tab.1:Project location

Fig.137:Map projection.

12.2. Building description

The building taken in consideration is a mixed used building in the centre of Milan, near Porta Vittoria. We are going to analyse three different parts of the whole system: the timber-frame boxes with laboratories and commercial functions; the catwalk at level 5,7 m and the curvilinear beams in the middle entrance.
The new structure is going to be entirely in wood to have a natural environment in the building, to use a sustainable material that is not to expensive.

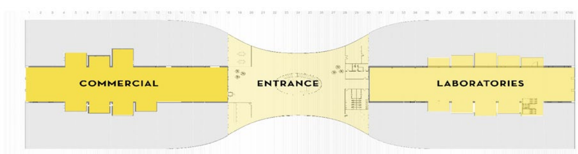


Fig.138:Building divadants according to main functional zones.

12.3. Reference code used

This report was drawn up in relation to current legislation, in particular:
- D. M. 17/01/2018: "Update of technical standards for construction" (Norme tecniche per le costruzioni)
- Eurocode 1 (UNI EN 1991)
- Eurocode 2 (UNI EN 1992-1-1: 2015)

The technical standards for constructions define the principles for the design, execution and testing of buildings, with regard to the performance required of them in terms of essential requirements of mechanical strength and stability, even in the event of fire, and durability.
They therefore provide the general safety criteria, specify the actions to be used in the project, define the characteristics of the materials and products and, more generally, deal with the aspects relating to the structural safety of the works.
The Eurocode 1 was taken in consideration for the Actions on structures, the densities, self-weight, imposed loads. While the Eurocode 2 for the design of concrete structures.

1.3.1 Design life

The designed life of a building is the number of years in which it is expected that the work, as long as it is subject to the necessary maintenance, maintain specific performance levels.
The minimum values to be adopted for the different types of construction are shown in table 1.4.I These values can also be used to define time-dependent actions.

The 50 year selection, as is also explained in the EN1990 Basis of Structural Design, is chosen for the indicative design working life of building structures and other common structures.
The design service life should be used to determine the time-dependent performance of the structure.
NOTE :Examples of time-dependent performance include durability, fatigue, and deformation due to consolidation of the ground". It's clear that this parameter doesn't depend on climate factors.

1.3.2 Classes of use

Referring to the paragraph § 2.4.2 of the NTC, the classes of use divide the construction in 4 with reference to the consequences of an interruption of operations or a possible collapse.

Class I Buildings with only occasional presence of people, agricultural buildings.

Class II Buildings whose use involves normal crowding, without dangerous contents for the environment and without essential public and social functions. Industries with activities that are not dangerous for the environment. Bridges, infrastructural works, road networks not falling under Class of Use III or Class of Use IV, railway networks whose interruption does not cause emergency situations. Dams whose collapse does not cause significant consequences.
Class III/Buildings whose use involves significant crowding. Industries with dangerous activities for the environment. Extra-urban road networks that do not fall under Class of Use IV. Bridges and railway networks whose interruption leads to emergency situations.Dams relevant to the consequences of their eventual collapse.

Classe IV Buildings with important public or strategic functions, also with reference to the management of civil protection in case of disaster. Industries with activities that are particularly dangerous for the environment. Road networks of type A or B, as per Ministerial Decree 5/11/2001, n. 6792, "Functional and geometric rules for the construction of roads", and type C when belonging to connecting routes between provincial capitals not also served by type A or B roads. Bridges and railway networks of critical importance for the maintenance of routes of communication, especially after a seismic event. Dams connected to the operation of aqueducts and to electricity production plants.

	TYPES OF CONSTRUCTIONS	Number of years
1	Temporary constructions	10
2	**Constructions with ordinary levels of performance**	**50**
3	Construction with high performance levels	100

Tab.2:Construction types

1.3.3 Classes of services

The structures (or parts of them) must be assigned to one of the 3 service classes listed in Tab. 4.4.II. The service class system has the purpose of defining the dependence of the design resistances and the elastic modules of the wood e materials derived from it from environmental conditions.

Class I It is characterized by a humidity of the material in equilibrium with the environment at one temperature of 20 ° C and a relative humidity of the surrounding air that does not exceed 65%, if not for a few weeks a year.

Class II It is characterized by the humidity of the material in equilibrium with the environment at a temperature of 20 ° C and a relative humidity of the surrounding air that exceeds 85% only for a few weeks a year.

Class III It is characterized by higher humidity than that of service class 2.

1.3.4 Resistance of the project

The duration of the load and the humidity of the wood affect the resistant properties of the wood. The design values for the material properties from the characteristic values are then assigned with combined reference to service classes and load duration classes.
The design value Xd of a property of the material (or of the resistance of a connection) is calculated using the relation:

Xd = “kmod Xk” /”m”

where is it:

- Xk is the characteristic value of the material property, or of the strength of the connection. The value characteristic Xk can also be determined by experimental tests on the basis of tests carried out under defined conditions the applicable European standards;
- yM is the partial safety factor relating to the material, the values of which are shown in the Tab. 3;
- kmod is a correction coefficient that takes into account the effect, on the resistance parameters, of both the duration of the load and humidity of the structure. The kmod values are given in Tab. 4.

ULS	COLUMN A yM	COLUMN B yM
Fundamental combinations		
Solid wood	1,5	1,45
Gluelam	1,45	1,35
Xlam	1,45	1,35

Tab.3:Partial safety factors for wood

Kmod	Xk	M
0.7	To calculate	1.5

Tab.4:Correction coefficient value

12.4. Load Analysis

Actions shall be classified by their variation in time as follows:
Permanent actions (G):
Self-weight of structures, fixed equipment and road surfacing, and indirect actions caused by shrinkage and uneven settlements
Variable actions (Q):
Imposed loads on building floors, beams and roofs, wind actions or snow loads
Accidental actions (AJ):
Explosions, or impact from vehicles.

12.1.1 Dead structural loads (G1)

Wood
Actions that act throughout the nominal design life of the building, which change in intensity over time is very slow and modest:
The weight of the structure is, in fact, the result of a sizing carried out according to the actions exercised on it. In this chapter these loads are only assumed. The permanent structural load in this case is the OSB panel on top pf the secondary beams.

MATERIAL	QUANTITY	Th. (m)	WEIGHT (kN/ m3)	G1 (kN/ m2)
OSB panel	1	0,015	6,5	0.09

12.1.2 Dead NON-structural loads (G2)

With reference to NTC § 3.1.3, the loads present on the building during its normal operation are considered permanent non-structural loads, such as those relating to external cladding, internal partitions, screeds, insulation, floors and floor coverings, plasters, false ceilings, systems and more, although in some cases it is necessary to consider transitory situations in which they are not present. The permanent gravitational actions associated with the own weights of non-structural materials are derived from the geometric dimensions and the weights of the volume unit of the materials with which the non-structural parts of the construction are made. but with transversal distribution capacity, the permanent non-structural loads can be assumed, for the overall checks, as uniformly distributed. If not, the actual distributions must be assessed. Partitions and light systems of residential and office buildings can generally be assumed as equivalent distributed loads, provided that the floors have adequate transversal distribution capacity.

12.1.3 Box horizontal closure- External\Internal

H.C. ROOF - INSULATED				
MATERIAL	QUANTITY	Th. (m)	WEIGHT (kN/ m3)	G2 (kN/ m2)
Bituminous impermeable membrane	1	0.0004	1.3	0.1
Plywood plank	1	0.020	4,5	0.009
XPS	1	0.050	0,34	0.017
Rock-wool insulation	1	0,180	1,47	0.2646
Plasterboard sheet	1	0,030	10	0.3
TOTAL (kN/ m·)				0.6906

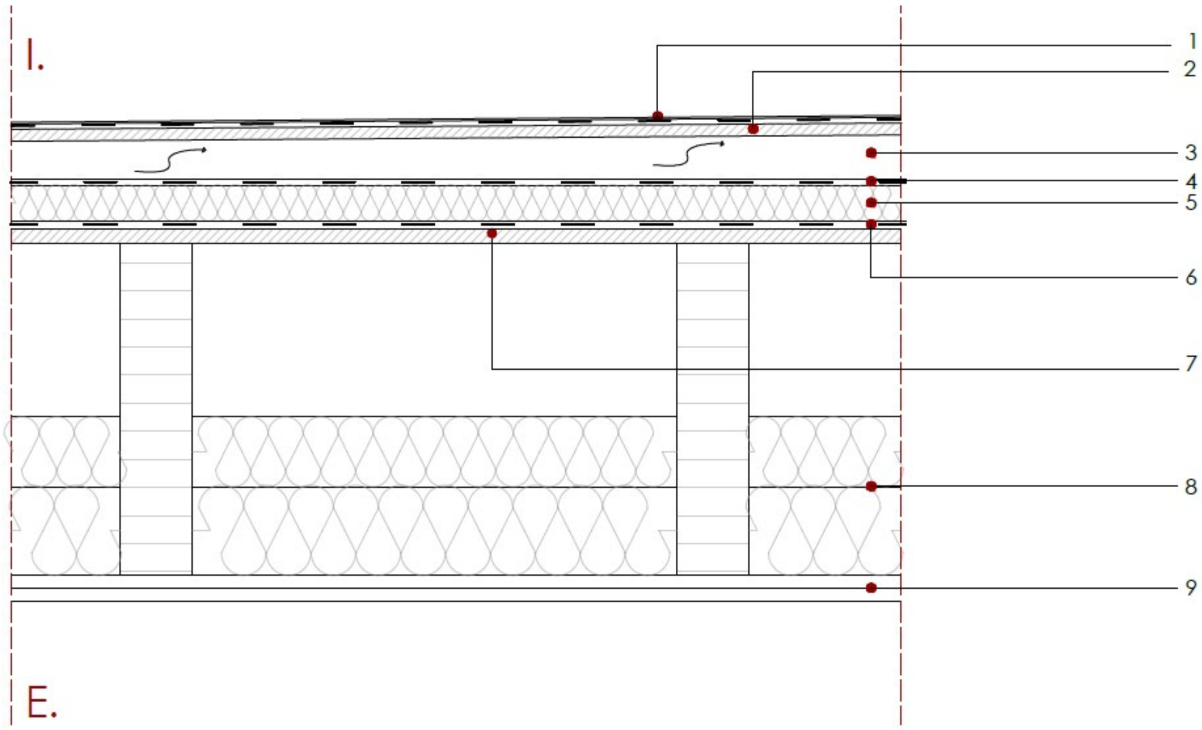


Fig.139:Box horizontal enclosure - internal to external

MEMBRANE: Bituminous impermeable membranes ROOF BYTUM Rothoblaas Th. 0.4 mm
FINISH: Waterproof plywood plank. Th. 20 mm
VENTILATION: Ventilation layer. Th. 50 mm
MEMBRANE: Breathable membranes ROOF TRASPIR Rothoblaas. Th. 0.4 mm
INSULATION: Insulated material XPS. Th. 50 mm
MEMBRANE: Vapour barrier USB Elegant - Riwega. Th. 0.4 mm
INFILL: Infill layer in OSB panel. Th 15 mm
STRUCTURE: Platform frame in lamellar wood beams. Inside there are 2 layers of Rock-wool insulation. Density 40 Kg/mc. Th. 80 + 100 mm
FINISH: Double layer of plasterboard. Th. 15 mm each

12.1.4 Box Vertical closure- External\Internal

V.C. 1.01 PLATFORM FRAME CLOSURE- INSULATED				
MATERIAL	QUANTITY	Th. (m)	WEIGHT (kN/ m3)	G2 (kN/ m2)
Plasterboard sheet	1	0.0125	10	0.125
Rock-wool insulation	1	0,200	1,47	0.294
OSB panel	1	0,015	6.5	0.09
Wood support	1	0.025	4,9 x 30%	0.036
Weatherboard larch	1	0.025	4,9	0.1
TOTAL (kN/ m·)				0.645

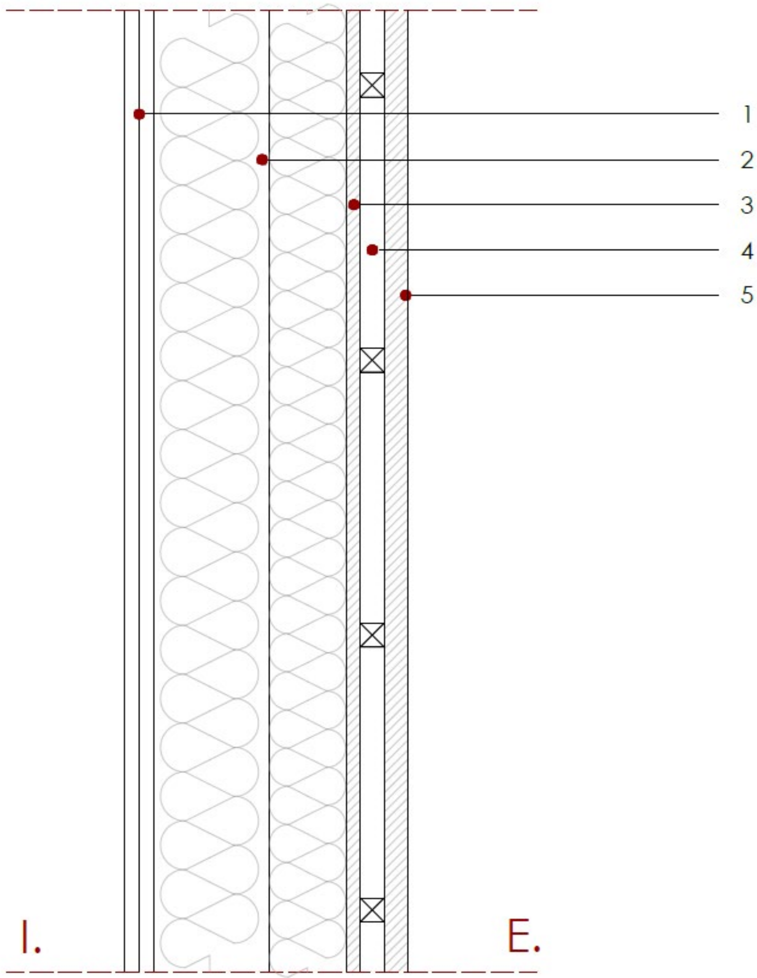


Fig.140:Box vertical closure External to internal

1. FINISH: interior painting with MAPEI Dursilite washable water-based paint. Single plasterboard Knauf GKF th.12.5 mm, fasten with self-drilling screws to the wooden supporting structure
2. STRUCTURE: load-bearing structure consisting of a frame made of wooden uprights (8x20cm) with a center distance of 62.5 cm. With two layers of thermal-acoustic panel insulation Rockwool panels (density 40 kg / mc) + polyethylene vapor barrier
3. INFILL: infill panels in OSB panels, Th. 15 mm
4. SUPPORT: Wood support structure 2,5 x 2,5 cm every 30 cm.
5. FINISH: Wood cladding, weatherboard larch. 25 mm

12.1.5 Box slab- External / Internal

H.C. SLAB- EXT/INT- INSULATED				
MATERIAL	QUANTITY	Th. (m)	WEIGHT (kN/ m3)	G2 (kN/ m2)
Resin-floor	1	0.01	1,25	0.0343
Gypsum-fiber	2	0.018		0.1274
Galvanized steel	1	0.001		0.0769
Polystyrene foam	1	0.028	0.32	0.0096
Rock-wool insulation	1	0,180	1,47	0.2646
OSB panel	1	0,015	6.5	0.09
Weatherboard larch	1	0.025	4,7	0.1
TOTAL (kN/ m2)				0.7024

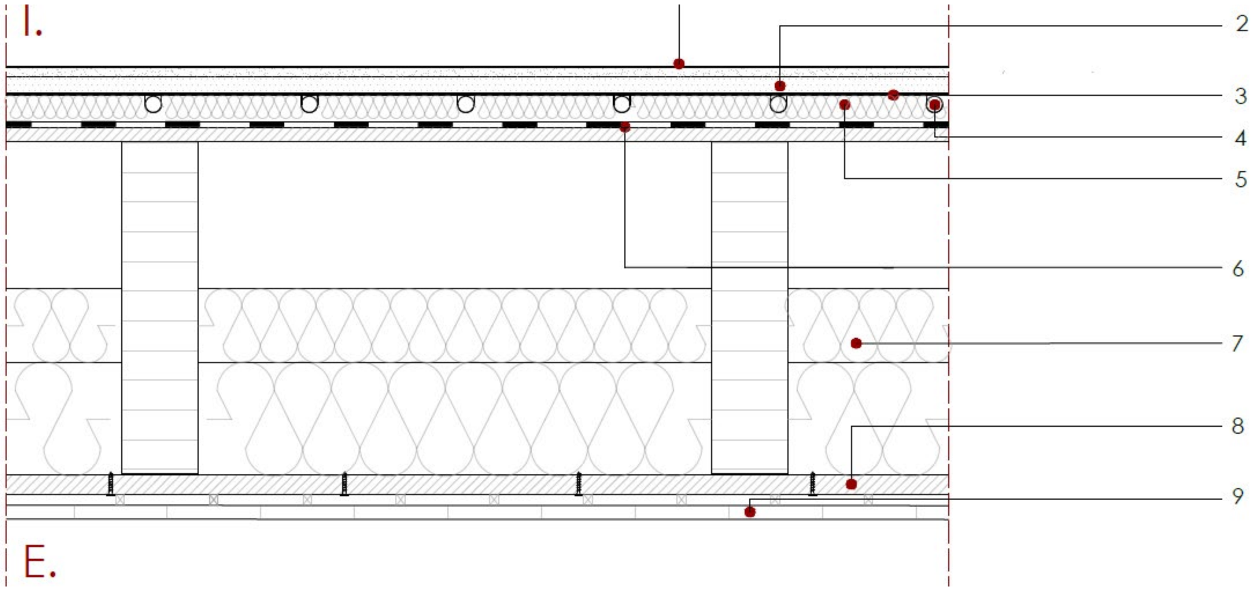


Fig.141:Box slab illustrated relation between external to internal.

1. FINISH: resin for interiors, light gray "Resinfloor" type. Composition: 200 m2 transparent, opaque protective paint layer, 1500 m gray epoxy self-leveling resin layer, 350 m epoxy resin smoothing layer.
2. DRY LAYING LAYER: gypsum-fiber slab with rabbeted edge for continuous laying, size 1200 x 600 mm, thickness 18 mm, type "F145 Knauf"
3. LOAD DISTRIBUTION LAYER: double layer of galvanized steel plates 1 mm thick with dimensions 600x300 mm, K805P series. The second layer, equipped with double-sided adhesive, K805P-1 series, is offset from the first one to close the joints. Specific for the "Giacomini Dry" package.
4. RADIANT ELEMENT: plastic tubing, diameter 17 mm, R999 series. Fixed to the insulating panel with fixing clips, K809 series. Specific for the "Giacomini Dry" package.
5. SUPPORT LAYER FOR RADIANT FLOOR: expanded polystyrene insulation panel (EPS200), R883-1 series. Dim 1200x600 mm, density 30 kg/ m2, thermal resistance 0.65 m2K/ W. Allows the passage of pipes. Total sp. 28 mm.
6. PROTECTION LAYER, VAPOR RESISTANT: polyethylene impermeable to water vapor, thickness 2 mm, R98 series. Specific for the "Giacomini Dry" package.
7. STRUCTURE: Platform frame in lamellar wood beams. Inside there are 2 layers of Rockwool insulation. Density 40 Kg/mc. Th. 80 + 100 mm
8. REINFORCEMENT LAYER: OSB wood plank with support function dimensions 25 x 50 cm th. 1,5 cm type "DATAHOLZ"
9. FINISH: external cladding in larch strips on a ventilated cavity. Conductivity y [W / mK]: 0.13. Density p: 475 Kg\m3. Th. 15 mm

12.1.6 Catwalk- Internal - Internal

H.C. SLAB- EXT/INT- INSULATED				
MATERIAL	QUANTITY	Th. (m)	WEIGHT (kN/ m3)	G2 (kN/ m2)
Parquet	1	0,022	7.06	0.15
Natural cork	1	0.001	1.96	0.0002
OSB panel	2	0,015	6.5	0.18
Galvanized steel	1	0.001		0.0769
TOTAL (kN/ m2)				0.407

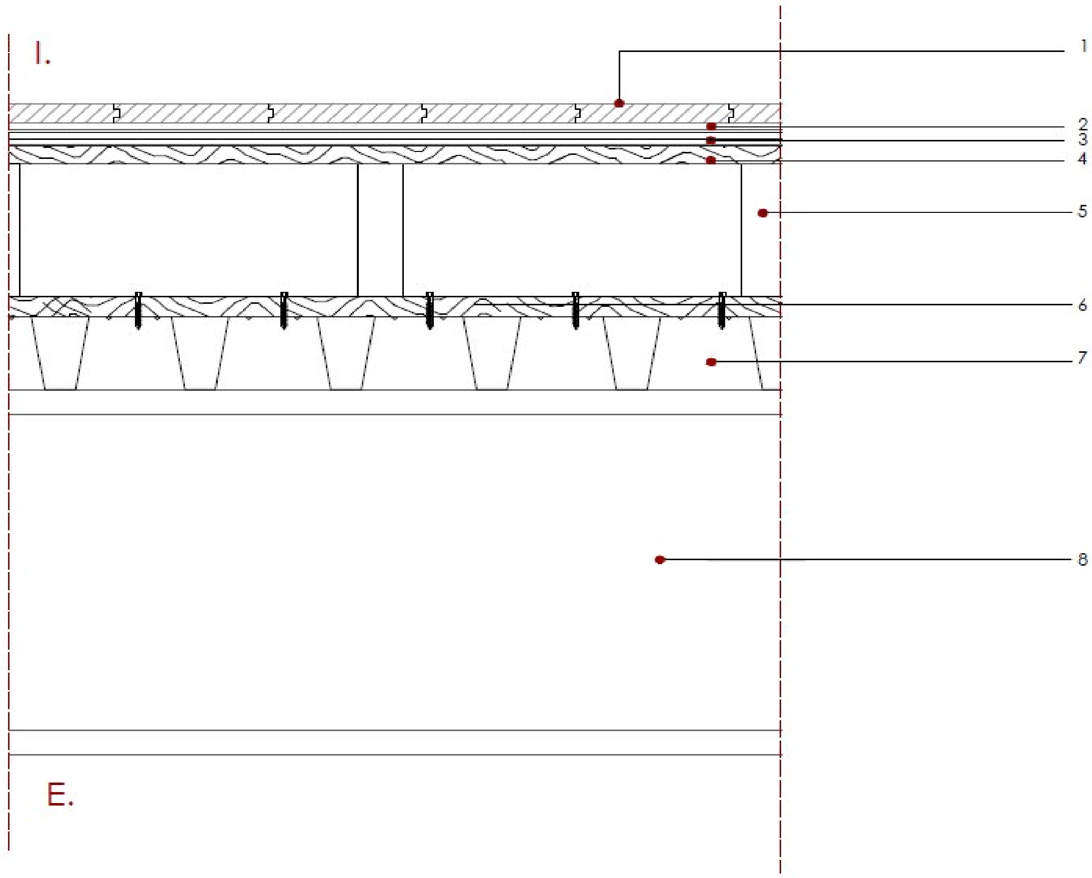


Fig.142:Catwalks Internal - Internal relation

1. FINISH: parquet 22 mm thick, with a layer of noble oak wood
2. FIXING LAYER: through glue. thickness 3 mm
3. SOUND INSULATION LAYER: in natural cork, self-expanded, self-glued, th. 1 cm
4. REINFORCEMENT LAYER: OSB wood plank with support function dimensions 25 x 50 cm th. 1,5 cm type "DATAHOLZ"
5. SUPPORT: Timber joists and support battens 6x 20 cm.
6. REINFORCEMENT LAYER: OSB wood plank with support function dimensions 25 x 50 cm th. 1,5 cm type "DATAHOLZ
7. SUPPORT LAYER: non-cooperating corrugated sheet in galvanized steel, height 7.5 cm, th. 0.12 cm, type "EXPAN - EPS 75/570"
8. STRUCTURAL LAYER: Steel structure HEB 550

12.1.7 Green roof- Ext/int

H.C. SLAB- EXT/INT- INSULATED				
MATERIAL	**QUANTITY**	**THICKNESS (m)**	**WEIGHT/UNIT VOLUME (kN/m3)**	**G2 (kN/m²)**
Peat moss + Perlite	1	0.25	6.5	1.6
Anti-root Membrane	1	0.04		0.06
Gravel	1	0.06	15	0.9
Polypropylene Geotextile	1	0.004		0.04
Expanded Polystyrene	1	0.047	0.32	0.015
Double Waterproof Membrane	2	0.004		0.06
Thermal Insulation – Cellular Glass	1	0.1	1.2	0.12
Baffle Ceiling System	20	-	-	0.35
Total				3.14

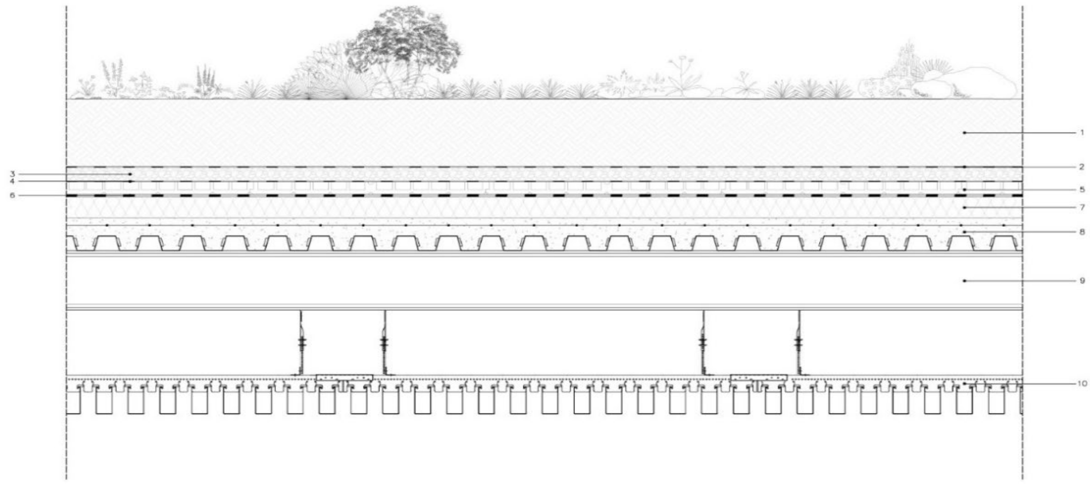


Fig.143:Greenroof detail and layering external to internal surfaces.

1. FINISH: 250 mm vegetation layer, horticultural perlite and peat moss mixture for lightweight rooftop plating systems
2. ROOT BARRIER: 5 mm protection layer WSB 100-PO, by ZinCo. Excellently weldable sheet made of flexible polyolefin (FPO), polyester scrim reinforced, resistant to bitumen, flexible at low temperatures.
3. WATER DRAINAGE LAYER: 50 mm gravel.
4. WATER PERMEABLE PROTECTION LAYER: 0.5 mm geotextile with needled and thermo-stabilized polypropylene fibers, type "Daku stabilfilter SFE"
5. DRAINAGE AND WATER DEPOSIT LAYER: 47 mm sintered expanded polystyrene, type "Daku SDF 30"
6. WATER RESISTANCE LAYER: 4 + 4 mm two crossed layers of bituminous self-adhesive waterproofing sheath, "INDEX type"
7. THERMAL INSULATION LAYER: 100 mm PUR waterproof cellular glass
8. LOAD BEARING LAYER: 55 mm corrugated sheet in galvanized steel with 55 mm collaborating casting in concrete, type "MARCEGAGLIA - EGB 210"
9. STRUCTURE: IPE 220 steel beam
10. FALSE CEILING: Straight baffle ceiling system, a lightweight floating ceiling of 50 x 100 mm aluminium box-shaped panels.

12.1.8 Live loads

In this case, as variable loads, we are going to consider just the snow because we can neglect the horizontal loads (wind).

Snow loads
With reference to NTC § 3.1.4 The load caused by snow on the roofs will be evaluated using the following expression:
qs = ·1 · qsk · CE · Ct
where is it:
·1: Coefficient of the shape of the roof
qsk: is the reference characteristic value of the snow load on the ground [kN / m2]
CE: Esposition coefficient
Ct: Thermal coefficient
In the next paragraph , the individual parameters will be analysed and the methods of calculation and the value in the specific case will be presented.

Roof shape coefficient (µ 1)

The shape coefficients of the roofs depend on the shape of the roof itself and on the horizontal inclination of its component parts and on the local climatic conditions of the site where the construction is located.

SHAPE COEFFICIENT	0°· α · 30°	30°< α < 60°	Α · 60°
µ	0.8	0.8 · (60-α)/30	0.0

Tab.5:Roof shape coefficient

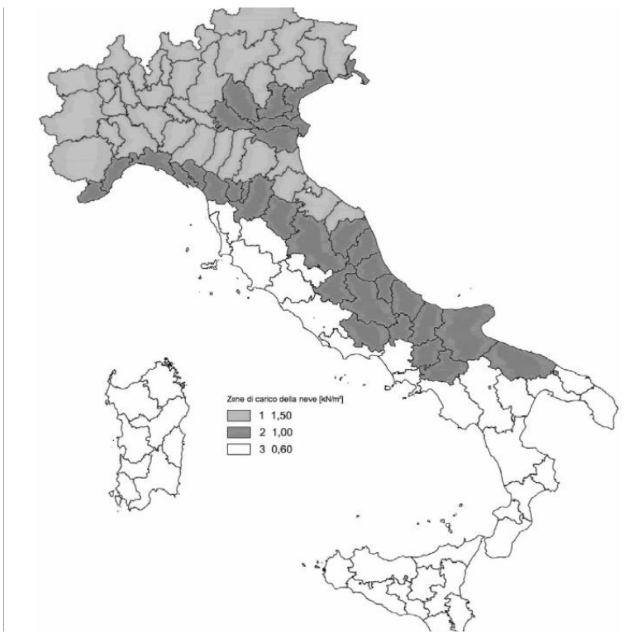


Fig.144:IX load zones of the snow.

In our case we choose 0.8 because we have a flat roof, so an angle that is less than 30°.

Reference characteristic value of the snow load on the ground (QSK)

The snow load on the ground depends on the local climate and exposure conditions, considering the variability of snowfall from area to area.
In our case study we are in zone 1:

Zone I - Mediterranean
Alessandria, Ancona, Asti, Bologna, Cremona, Forlì-Cesena, Lodi, Milano, Modena, Monza Brianza, Novara, Parma, Pavia, Pesaro e Urbino, Piacenza, Ravenna, Reggio Emilia, Rimini, Treviso, Varese:
qsk = 1.50 kN/m2 as · 200 m
qsk = 1.35 · [1 + (as/602) ·] kN/m2 as > 200 m

Exposition coefficient (Ce)

The EC exposure coefficient considers the specific characteristics of the area in which the work stands. Recommended values of this coefficient are given in table 2.1.XII for different exposure classes. Unless otherwise indicated, CE = 1 will be assumed.

TOPOGRAPHY	DIFFERENT VALUES OF Ce FOR DIFF. CLASSES	Ce
With wind	Unobstructed flat areas exposed on all sides, with no buildings or taller trees.	0.9
Normal	Areas where there is no significant snow removal on the construction produced by the wind, due to the terrain, other buildings, or trees.	1.0
Repaired	Areas where the construction considered is significantly lower than the surrounding land or surrounded by taller buildings or trees.	1.1

Tab.6:Exposition coefficient

Thermal coefficient (Ct)

The thermal coefficient considers the reduction of the snow load, due to the snow melting, caused by the heat loss of the building. This coefficient depends on the thermal insulation properties of the material used in the roof. In the absence of a specific and documented study, Ct = 1 must be set.
The snow load results: 1.2 kN/m2

Loads due to intended use

With reference to NTC §3.1.4, variable loads include loads related to the intended use of the work; the models of these actions can consist of:
- uniformly distributed vertical loads qk
- concentrated vertical loads Qk
- linear horizontal loads Hk
- The nominal and / or characteristic values of qk,
- Qk and Hk are reported in the Tab7..

These values include ordinary dynamic effects, if there is no risk of significant dynamic amplifications of the response of the structures.

CATEGORY	ENVIRONMENT	qk [kN/m2]	Qk [kN]	Hk [kN/m]
A	Residential use			
	Areas for domestic and residential activities	2.0	2.0	1.0
	Common stairs, balconies, galleries	4.0	4.0	2.0
B	Offices			
	Cat.B1 Offices not open to the public	2.0	2.0	1.0
	Cat.B2 Offices open to the public	3.0	2.0	1.0
	Common stairs, balconies, galleries	4.0	4.0	2.0
D	Commercial use			
	Cat.D1 Shops	4.0	4.0	2.0
	Cat.D2 Shopping centres, markets, department stores	5.0	5.0	2.0
	Common stairs, balconies, galleries	category due to use served		
E	Areas for storage and commercial use and industrial use			
	Cat. E1 Areas for accumulation of goods and related areas access, such as libraries, archives, warehouses, manufacturing workshops	> 6.00	7.00	1.0
	Cat. E2 Environments for industrial use	to be evaluated case by case		
F	Garages and areas for vehicle traffic (excluding bridges)			
	Garages, areas for traffic, parking and parking of light vehicles (full load weight up to 30 kN)	2.5	2 x 10	1.0
H	Roof			
	Roofs accessible for maintenance and repair only	0.5	1.2	1.0

Tab.7:Loads due to intended use

Since our different functions, we will have 5 different values for the imposed load.

Summary of the loads

LOADS	
G2 Roof	0.7806 kN/ m2
qk (category H)	0,5 kN/ m2
G2 Slab	0.7024 kN/ m2
qk (category E1)	6 kN/ m2
G2 Vertical closure	0,645 kN/ m2

The values G1 will be calculated in the next step because they are the result of the stratigraphy and the other loads.

12.5. Curved truss

The most interesting part of the building is related to the central one, where, as already shown, we decided to create a curved green roof that simulates a hill as the main attraction of the research centre. That was the most challenging part of the project. In fact, we had to face different problematic related to the geometry, the loads of the slab and the verification of the structural elements.

Semi - intensive roof garden

The main aim of the roof is to support a layer of soil to host a semi-intensive green roof that allows small bushes and vegetation to grow, creating an attractive biodiversity of different species.
It is mainly composed by a layer of 25 cm height of a mixture of peat moss and horticultural perlite, a lightweight planting mix system for rooftop gardens that helps to reduce the planter weight by at least 60% of the common soil, in fact it weighs just 6.5 kN/m^3.Then, we added, an anti-root membrane on a gravel layer to avoid the penetration of the roots through the slab, damaging the other layers, especially the drainage system and the waterproof membrane that keep isolated the soil humidity from the thermal insulation and the steel structural elements, avoiding corrosion. This all system is supported by a collaborating corrugated steel sheet that spans 2 m on the secondary steel beams.

First of all, we will start defining the permanent structural loads (G_1).
For the determination of the structural own weights of the most common materials, the weight values of the volume unit shown in the table below can be assumed. If any materials are not specified in the standard,reference can be made to the unit weight indicated in the manufacturer's technical sheet.

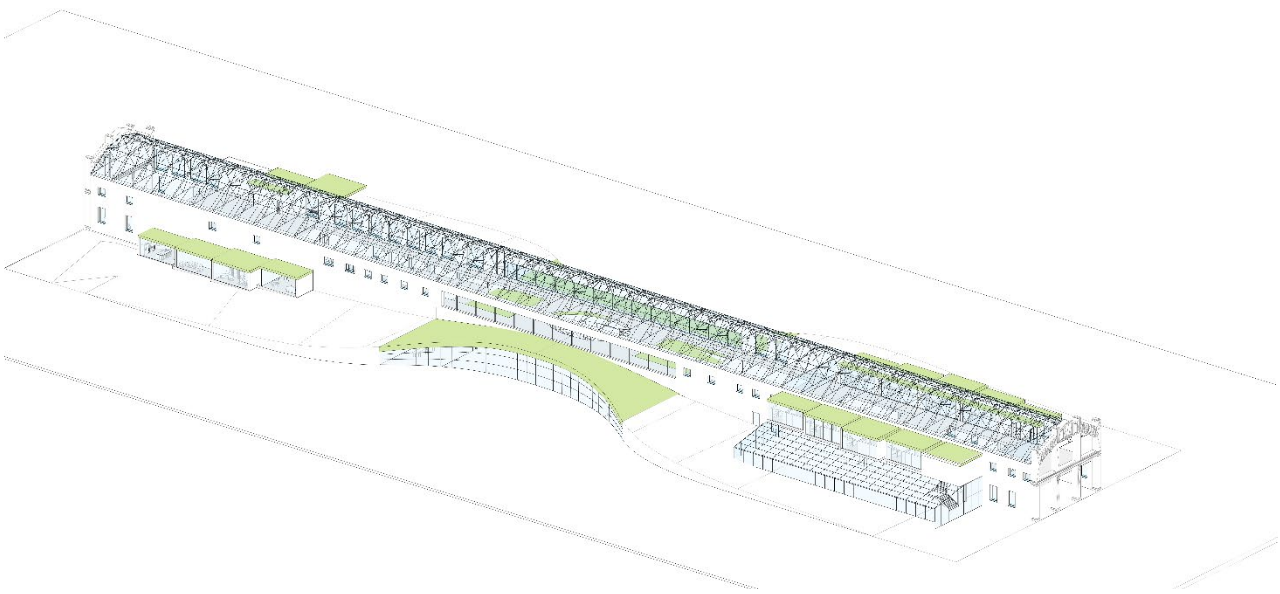


Fig.145:Curvilinirar truss design.

MATERIALS	WEIGHT PER UNIT OF VOLUME (kN / m3)
Cementitious concrete and mortars	
Ordinary concrete	24.0
Reinforced concrete (and / or prestressed)	25.0
“Light” concretes: case by case	14.0 · 20.0
“Heavy” concretes: case by case	28 · 50.0
Lime mortar	18.0
Cement mortar	21.0
Lime powder	10.0
Powdered cement	14.0
Sand	17.0
Metals and alloys	
Steel	78.5
Cast iron	72.5
Aluminum	27.0
Stone material	
Volcanic tuff	17.0
Compact limestone	26.0
Soft limestone	22.0
Plaster	13.0
Granite	27.0
Brick (solid)	18.0
Timber	
Conifers and poplar	4.0 · 6.0
Hardwood (except poplar)	6.0 · 8.0
Various substances	
Fresh water (clear)	9.81
Paper	10.0
Glass	25.0

Tab.8: Specific weight materials

12.2.1 Steel characteristics

In the design phase, the following nominal values of the properties of the material steel type S275 can be conventionally assumed:

Elastic modulus (E): 210 000 N/mm2
Transversal modulus of elasticity (G): E / [2 (1 + ν)]
Poisson coefficient (ν): 0,3
Linear thermal expansion coefficient (α) (for temp. up to 100 ° C): 12x10-6 per ° C-1
Density (ρ): 7850 kg/m3

12.2.2 Corrugated sheet design

For the choice of the corrugated sheet which, combined with the collaborating casting and the beams that support it, will form the load-bearing part of the floors, the loads on the bearing layer were analysed. Among these loads we find:
The permanent loads carried by the horizontal partition and by the internal vertical partition, G2, expressed in kN / m··;
The variable load due to the category of use to which the building belongs, qk, in kN / m·.
The snow load related to the local climate and exposure conditions, considering the variability of snowfall from area to area, "q (snow)", in kN /m·

Once the total overload was obtained, obtained through the sum of the different unit weights, it was possible to size the corrugated sheet, resting on the secondary beams, and the height of the resulting concrete casting, using the tables provided in the manufacturer's technical data sheets.
We choose a corrugated sheet HI- BOND TYPE 55/ P600
Since the total unit weight is 9.34 kN/m· that means 952 kg/m², we are going to choose a right span for sheet member that can carry the total load previously calculated, using the table below. So, the corrugated sheet will have a maximum span of 2,21 m, a hight of 1,1 cm and a thickness of 0.7 mm.

After the thickness of the corrugated sheet, it is possible to calculate its weight from the table below:
having a thickness of 1.2, the load bearing element will weigh 16.53 kg/m².

Regulation and quality	Nominal thickness "t" of the element			
	t · 40 mm		40 mm< t · 80 mm	
UNI EN10025-2	fyk (N/mm2)	ftk (N/mm2)	fyk (N/mm2)	ftk (N/mm2)
S275	**275**	**430**	**255**	**410**

Tab.9:Steel characteristics

OVERLOADS	UNIT WEIGHT (kN / m²)
Stratigraphy load (G2)	3.14
qk (roof for maintenance)	5
q (snow)	1.2
TOTAL	9.34

Tab.10:Loads on the laminated sheet

H Soletta Slab Dalle Decke mm	Spessore Thickness Epaisseur Stärke mm	Sovraccarico utile uniformemente distribuito KN/m² - Useful overload evenly distribuited KN/m² Surcharge utile uniformement repartie KN/m² - Nutzlast gleichmassig verteilt KN/m² 1,50	2,00	2,50	3,00	3,50	4,00	4,50	5,00	5,50	6,00	7,00	8,00	10,00
10	0,70	3,30	3,18	3,07	2,97	2,88	2,79	2,72	2,64	2,58	2,52	2,41	2,31	2,15
	0,80	3,55	3,42	3,29	3,18	3,08	2,99	2,91	2,83	2,76	2,69	2,56	2,44	2,26
	1,00	4,01	3,85	3,70	3,57	3,39	3,24	3,12	3,01	2,91	2,83	2,69	2,57	2,26
	1,20	4,41	4,23	3,94	3,71	3,53	3,37	3,24	3,13	3,03	2,95	2,80	2,68	2,26
11	0,70	3,20	3,10	3,01	2,93	2,85	2,78	2,72	2,65	2,60	2,54	2,44	2,36	2,21
	0,80	3,44	3,34	3,24	3,15	3,06	2,98	2,91	2,85	2,78	2,73	2,62	2,52	2,36
	1,00	3,89	3,76	3,64	3,54	3,44	3,35	3,27	3,19	3,12	3,05	2,93	2,80	2,50
	1,20	4,29	4,14	4,01	3,89	3,78	3,67	3,53	3,41	3,30	3,21	3,04	2,91	2,50
12	0,70	3,09	3,02	2,94	2,87	2,81	2,75	2,70	2,64	2,59	2,55	2,46	2,38	2,24
	0,80	3,33	3,25	3,17	3,09	3,02	2,96	2,89	2,84	2,78	2,73	2,64	2,55	2,40
	1,00	3,77	3,66	3,57	3,48	3,40	3,33	3,25	3,19	3,13	3,07	2,96	2,86	2,69
	1,20	4,15	4,04	3,93	3,83	3,74	3,65	3,57	3,50	3,43	3,36	3,24	3,13	2,72
13	0,70	2,99	2,93	2,87	2,81	2,76	2,71	2,66	2,62	2,58	2,53	2,46	2,39	2,27
	0,80	3,22	3,15	3,09	3,03	2,91	2,91	2,86	2,81	2,77	2,72	2,64	2,56	2,43
	1,00	3,65	3,56	3,49	3,41	3,35	3,28	3,22	3,16	3,11	3,06	2,96	2,88	2,72
	1,20	4,03	3,93	3,84	3,76	3,68	3,61	3,54	3,48	3,42	3,36	3,25	3,15	2,92

Since the total unit weight is 9.34 kN / m2, we are going to choose as a useful overload 10.00 in the table below.

By choosing a floor solution positioned on the secondary beams, a static scheme with several supports is taken into account. A 0.7 mm thick sheet with a collaborating casting is chosen for a total height of 5.5 + 5.5 = 11 cm (to have a concrete casting> 5 cm) which covers a maximum span of 2.81 m.

2.81 m> 2.5 m (light between the secondary ones)

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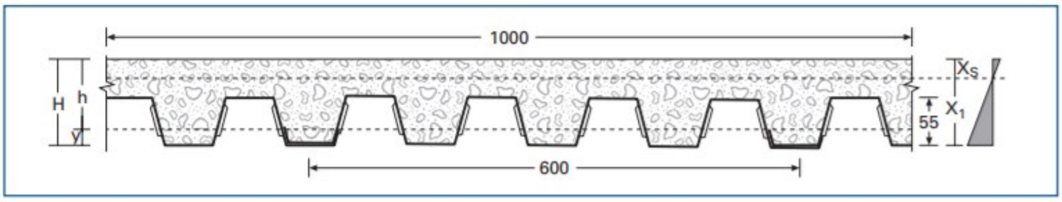


Caratteristiche statiche della soletta - Properties of the slab - Caracteristiques statiques de la dalle - Statische eingenschaften der decke

H cm	Peso soletta - Slab weight Poids de la dalle - Gewicht der Decke kg/m²	Spessore lamiera- Sheet thickness Epaisseur de la tôle - Blechstärke mm	Xs cm	J tot. cm⁴/m	Ws cm³/m	Wi cm³/m	T Kg/m
10	190	0,70	3,61	329,49	1368,98	51,57	1130
		0,80	3,79	362,35	1435,63	58,31	
		1,00	4,08	422,25	1550,71	71,38	
		1,20	4,33	475,79	1648,72	83,90	
11	215	0,70	3,92	424,00	1624,49	59,85	1250
		0,80	4,11	466,42	1701,96	67,70	
		1,00	4,44	543,66	1834,79	82,93	
		1,20	4,72	612,43	1946,55	97,51	
12	240	0,70	4,20	533,98	1905,23	68,50	1360
		0,80	4,42	587,80	1995,33	77,53	
		1,00	4,79	685,83	2149,20	95,08	
		1,20	5,09	773,00	2277,62	111,88	
13	265	0,70	4,48	659,76	2209,28	77,43	1460
		0,80	4,71	726,89	2313,67	87,71	
		1,00	5,11	849,32	2491,55	107,69	
		1,20	5,45	958,20	2639,26	126,84	

Extraction from the catalogue of HI-BOND design solutions

Note the dimensions of the floor, referring to the technical data sheet, it is possible to check the structural weight G1, which is equal to 215 Kg / m2 or

G1: 2.15 KN

Secondary beam sizing

12.2.3 Secondary beam

Predimentioning

In determining the loads on the secondary beams, the following loads were considered in the Operating Limit State (SLS):

Sheet metal loading with collaborating casting, G1;

Loads that constitute the technological package of the adjacent internal floor G2

An influence length Li equal to the sum of the two halves of the centre distance between the analysed secondary beam and the adjacent one;

Variable load due to the category of use to which the building belongs, qk

The snow load since we are operating in the roof, q (kN / m·)

Ptot is the total load applied on the structure that has to be transformed in kN/m so we multiply the result for the influence length. Calculated in Tab. 11.

Ptot= (G1+G2+ qk) x Li

Reference was made to a support-support static scheme, because of the constraints that bind the secondary beams to the main ones, with uniformly distributed load over the entire length of the profile, carried by the floor.

G1 (kN / m·) CORRUGATED SHEET	G2 (kN / m·)	qk (kN / m·)	q (kN / m·) SNOW	Li (m) interax	P(tot) kN/m
2.15	3.14	5	1.2	2	22.98

Tab.11: Total load applied on the structure

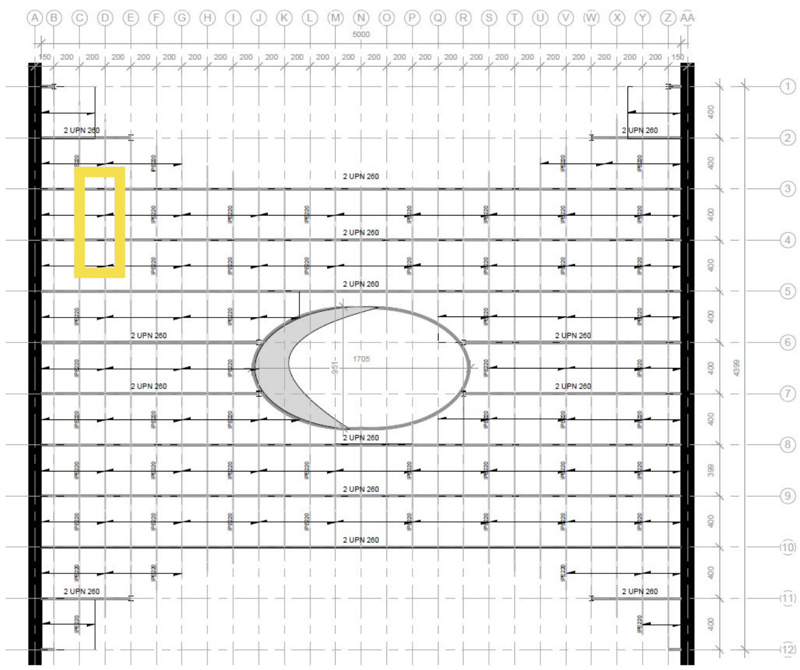


Fig.146:Level 0.0m structural plan of the gallery hall highlighting secondary beam design.

Carico uniforme su tutta la trave	Reazioni
	$V_A = V_B = \frac{pl}{2}$; $H_A = 0$
	Taglio
	$T_{Ad} = V_A = \frac{pl}{2}$; $T_{Bs} = V_B = -\frac{pl}{2}$
	$T_x = +\frac{p \cdot l}{2} - px = p\left(\frac{l}{2} - x\right)$
	Momenti
	$M_A = M_B = 0$
	$M_{l/2} = M_{max} = +\frac{pl^2}{8}$
	$M_x = +\frac{plx}{2} - \frac{px^2}{2}$ (parabolico)
	Spostamenti
	$f_{max} = \frac{5}{384}\frac{pl^4}{EJ}$; $\alpha = \frac{pl^3}{24EJ}$
	$f_x = \frac{1}{24}\frac{pl^4}{EJ}\frac{ab}{l^2}\left(1 + \frac{ab}{l^2}\right)$

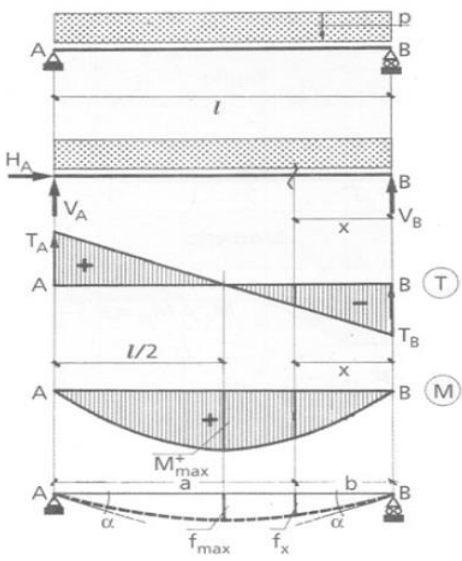


Fig.147:Uniform distributed load diagrams with reactions calculations.

From the diagram shown here it is possible to go back to the formulations for the calculation of the static quantities that characterize the project situation, both in terms of actions on the section and in reference to the displacement components.

Uniform distributed load Reactions

The fmax value is the maximum deflection, needed to calculate the inertia of the beam so that I can find the correct dimensions.

f= fmax

f= l/250 fmax= 5 /384 “pl”^”4”/”EI”

Imax= 5/384 (pl^4/EI) = (5/384)*((22.98x(4^4)) / ((2,1) x(10^8)(0.016)) = 0.00002279 m^4= 2279.76 cm^4 = 0.00002279 = 2279.76

It is assumed that the secondary central intermediate beam with an IPE 220 profile in hot rolled steel S-275JR characterized by a maximum inertia of Ix = 2772 cm4, has a length of 4 m and a centre distance of 2 m.

The designation of steel, in accordance with UNI EN 10027/1 refers to the following properties:
S indicates that we are referring to a steel for structural use (metal carpentry);
275 is representative of the yield stress (fyk);
JR indicates the resilience class of steel, aimed at avoiding brittleness at low temperatures.

l (Pitch of secondary beam)	fmax l/250	E kN/m2	P kN/m	I max 250 cm^4	IPE Profile
4	0.016	2,1 x	22.98	2935.5	220

Tab.12:Secondary beam predimentioning

h	b	a	e	r	Peso	Sezione	Momenti di inerzia		Moduli di resistenza		Raggi di inerzia	
							Jx	Jy	Wx	Wy	ix	iy
mm	mm	mm	mm	mm	kg/m	cm^2	cm^4	cm^4	cm^3	cm^3	cm	cm
80	46	3,8	5,2	5	6,0	7,64	80,14	8,49	20,03	3,69	3,24	1,05
100	55	4,1	5,7	7	8,1	10,32	171,0	15,92	34,20	5,79	4,07	1,24
120	64	4,4	6,3	7	10,4	13,21	317,8	27,67	52,96	8,65	4,90	1,45
140	73	4.7	6,9	7	12,9	16,43	541,2	44,92	77,32	12,31	5,74	1,65
160	82	5,0	7,4	9	15,8	20,09	869,3	68,31	108,7	16,66	6,58	1,84
180	91	5,3	8,0	9	18,8	23,95	1.317	100,9	146,3	22,16	7,42	2,05
200	100	5,6	8,5	12	22,4	28,48	1.943	142,4	194,3	28,47	8,26	2,24
220	110	5,9	9,2	12	26,2	33,37	2.772	204,9	252,0	37,25	9,11	2,48
240	120	6,2	9,8	15	30,7	39,12	3.892	283,6	324,3	47,27	9,97	2,69
270	135	6,6	10,2	15	36,1	45,95	5.790	419,9	428,9	62,20	11,23	3,02
300	150	7,1	10,7	15	42,2	53,81	8.356	603,8	557,1	80,50	12,46	3,35
330	160	7,5	11,5	18	49,1	62,61	11.770	788,1	713,1	98,52	13,71	3,55
360	170	8,0	12,7	18	57,1	72,73	16.270	1.043	903,6	122,8	14,95	3,79
400	180	8,6	13,5	21	66,3	84,46	23.130	1.318	1.156	146,4	16,55	3,95
450	190	9,4	14,6	21	77,6	98,82	33.740	1.676	1.500	176,4	18,48	4,12
500	200	10,2	16,0	21	90,7	115,5	48.200	2.142	1.928	214,2	20,43	4,31
550	210	11,1	17,2	24	106	134,4	67.120	2.668	2.441	254,1	22,35	4,45
600	220	12,0	19,0	24	122	156,0	92.080	3.387	3.069	307,9	24,30	4,66

Tab.13:IPE 220 selection

$$G_{1\ \text{secondary beam}}\ \text{IPE220} = 0.262\ (kN / m)$$

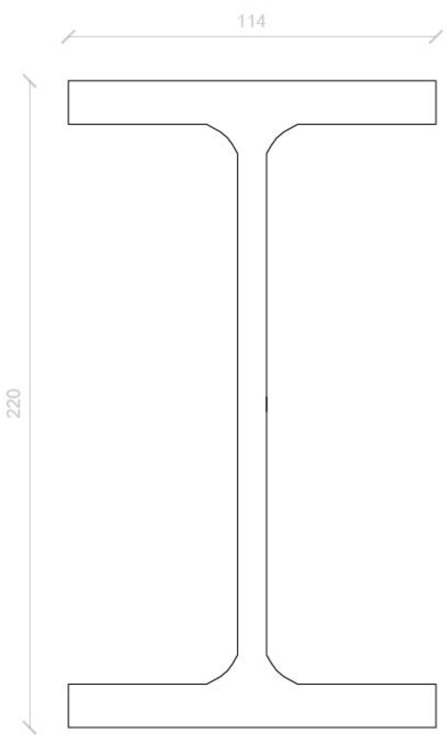


Fig.148:Seoncary beam dimensioning.

Core verification

The section of the profile is defined in class 1.
In the part subjected to bending, the relation is required:

$$ct < 72\varepsilon$$

where $\varepsilon =\cdot(235/fyk)$

In the case of the hypothesized profile (IPE 220), taking into account that f_{yk} = 275 kN / mm2, there will be a value of ε equal to 0.92. Considering the geometric dimensions from the profile (c = 190.4 mm, t = 6.2 mm), we will have:

$$ct = 30.10 \cdot 72\varepsilon = 66.24$$

The verification is therefore satisfied and the core results in CLASS 1.

WINGS

As above it is necessary that the slenderness does not exceed a limit value:

$$((b/2-a/2)/tf)\cdot 9$$

where $\varepsilon =\cdot(235/fyk)$

a= 6.2 mm
b=120 mm
Tf= 9.8 mm

$$()= \cdot 5.8\ \varepsilon= 8.28$$

The verification is therefore satisfied, and the wings result in CLASS 1.

It can therefore be concluded that the entire profile is in CLASS 1.

12.2.4 Truss primary beam dimensioning

In order to have a space without the presence of pillars inside the plant, the use of a reticular beam covering the entire span of 50 m was envisaged, thus keeping only the pillars on the external perimeter and at the end of the cantilever beams.
It has been analysed the longest beam, the one more suggested to axial stress and deformation.
Structural plan (+0.0 m)

The concentrated loads due to the two constraint reactions of the secondary beams weigh on the main central beam on the roof, whose connection, obtained by joining the cores of the two different frames, allows the exchange of only share actions.
For the sizing, therefore, a static support-support scheme loaded uniformly is used again as for the secondary ones, but a combination of the two schemes represented on the following page must be considered by exploiting the principle of superimposition of the effects, thus also considering the distributed load due to the own weight of the beam.

The calculation of the truss system was done carrying out the following steps:
- Choice of the thickness of the floor in relation to the maximum span
- Definition of structural loads
- Calculation and verification of displacements
- Sizing of the profiles
- Checks

Pre-sizing

For the pre-sizing it is considered that a truss of the chosen type will have a minimum thickness equal to 1/50 of the maximum span, in the case of the project of 50 m.
hmin = 1/50 * 50 m = 1 m

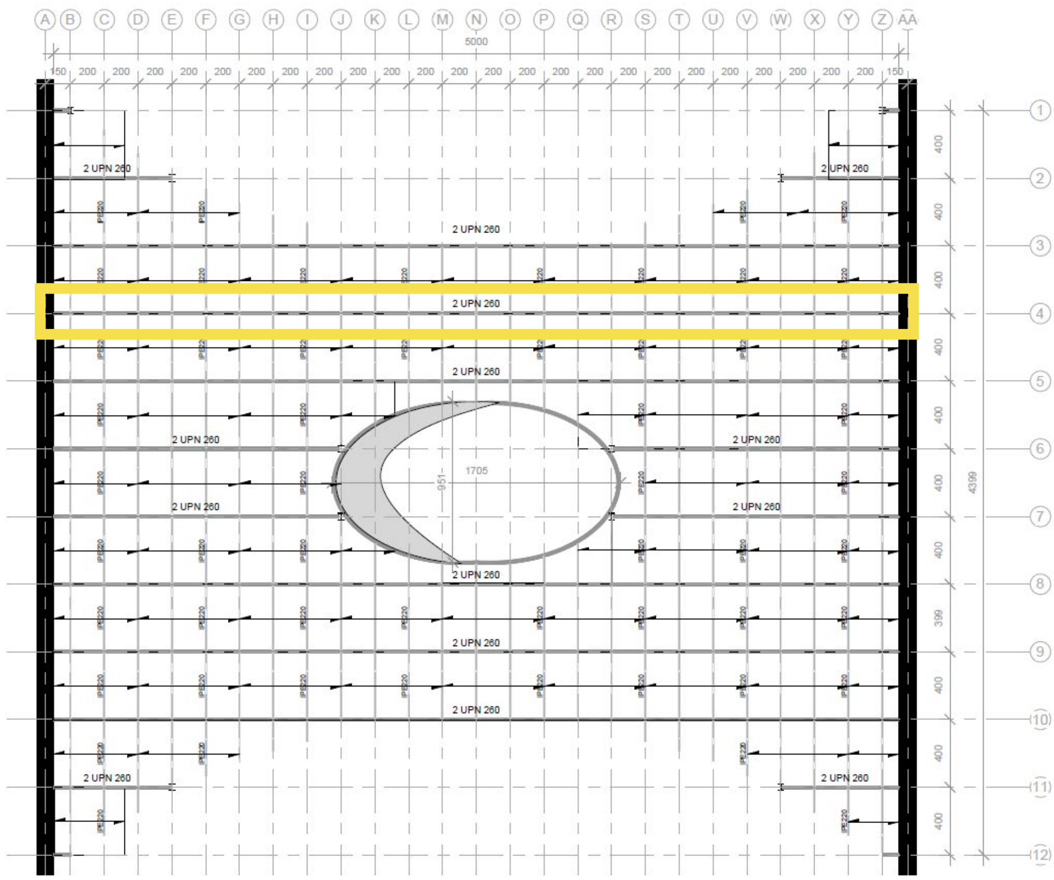


Fig.149:Seoncary beam dimensioning.

PRIMARY BEAMS

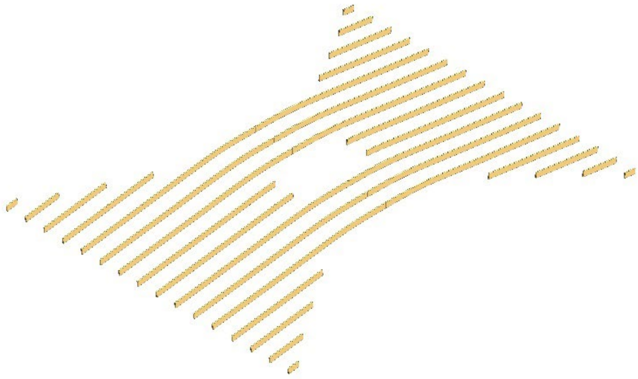


Fig.150:Primary beam distribution among the hall.

SECONDARY BEAMS

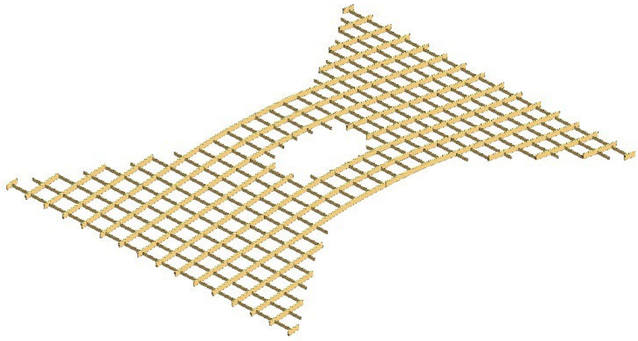


Fig.151:Seoncary beam distribution among the hall.

PILLARS AND BEARING WALL

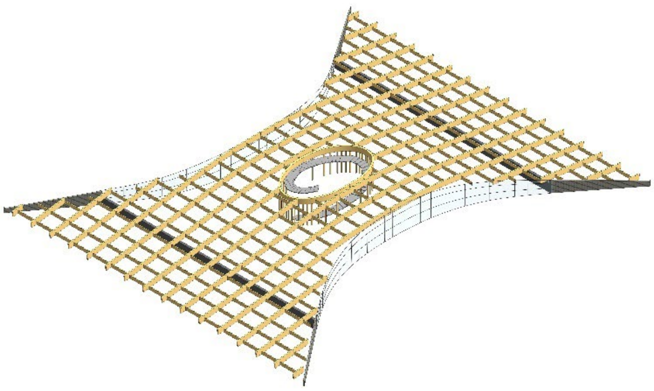


Fig.152:Pillars projection and main staircase along with bearing wall on sides.

ROOF ON TOP

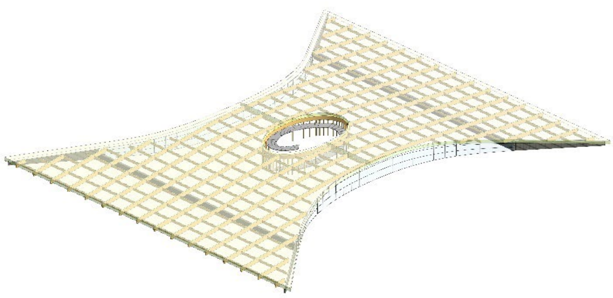


Fig.153:Pillars projection and main staircase along with bearing wall on sides.

Before calculating the primary beams, it is necessary to find the constrain reaction from the secondary beams. These loads are applied every 2 meters in the truss and they need to be summed to the dead load of the primary truss.

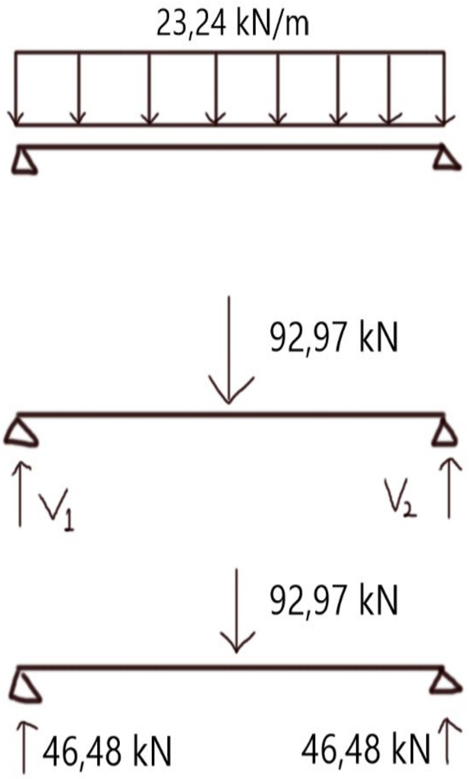


Fig.154:Reactions secondary beam

Since we are doing the pre-dimensioning, we will use for the shear, the value obtained from the Characteristic combination (SLS)

L= 4m we multiply the distributed load for L to obtain a concentrated load

Dividing the value for 2 we obtain the constrain reactions

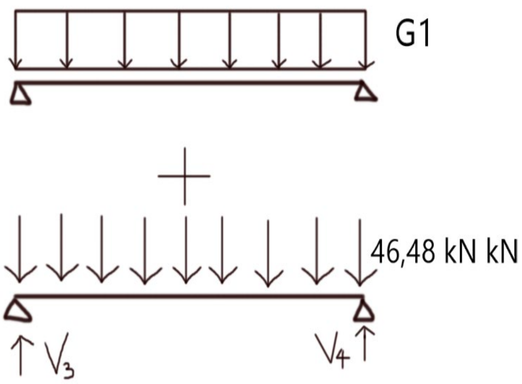


Fig.155:Loads on the truss

The distributed load is given by the weight of the primary beam analised

The concentrated load is the constrain reaction found in the secondary beam.

The truss, as anticipated earlier, has a span of 50 meters and the highest point is 5,7 meters from the level 0 m. But since the arch is elevated from the floor, the rise is just 3,9 m.

The structure is made with UPN coupled profiles for the upper and lower beams and coupled L profiles for the wall beams. The connections between the various components are made by bolting. For the dimensioning of the beam it is necessary to know the internal actions. As already said, each component works like an unloaded connecting rod, consequently, at the equilibrium of each node, there will be only the positive or negative axial action.The model chosen is that of a beam simply resting on the edge bearing walls, the static diagram referred to is shown below.

In order to dimension the beams, in compliance with the provisions of the NTC. 18 § 4.2 - STEEL CONSTRUCTIONS, two different checks must be met, one at the Service Limit State (SLE) and the other at the Ultimate Limit State (ULS).

The operating procedure is briefly divided into the following phases:
- Predimensioning of beams and verification of the classification of the section;
- Verification of the deformability of the beams in a limited service state (SLS)
- Verification of the profile with maximum axial action values for each component (ULS)

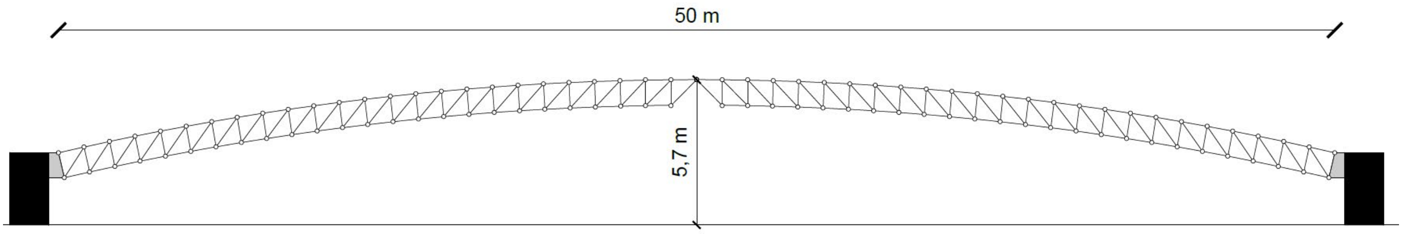


Fig.156:Truss span and height

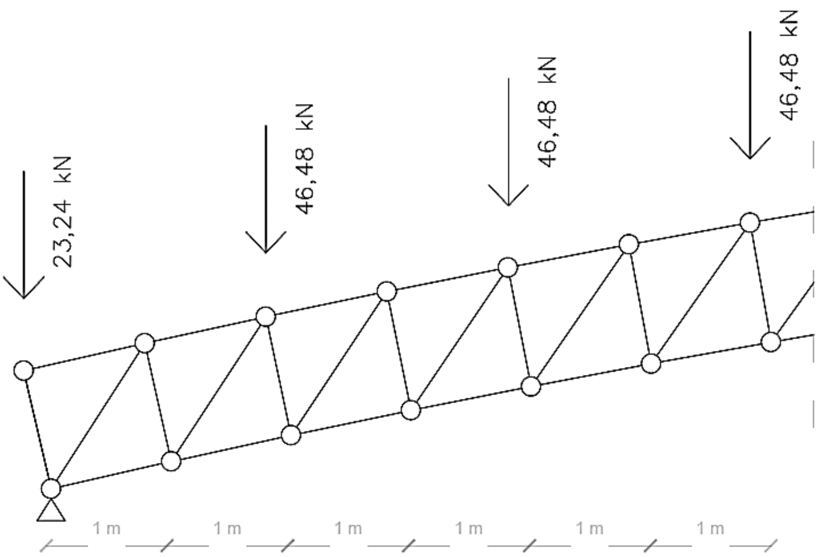


Fig.157:Truss staticscheme

Safety check at the serviceability limit state

To carry out this verification, the values obtained with the SLS RARE are taken into consideration.
The total value of the orthogonal displacement to the element axis is defined as:

$\delta_{max} = \delta_1 + \delta_2$

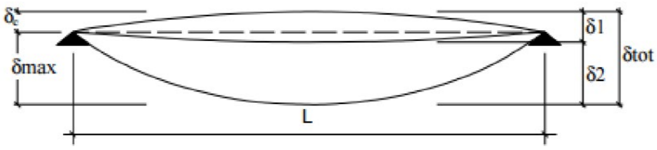


Fig.158:Displacement

Where:
δ_c the initial mount of the beam;
δ_1 the elastic displacement due to permanent loads;
δ_2 the elastic displacement due to variable loads;
δ_{max} the displacement in the final state, without the initial mount = $\delta_{tot} - \delta_c$

In the case of roofs, floors and beams of ordinary buildings, the limit values of δ_{max} and δ_2, referred to the characteristic combinations of the actions, are expressed as a function of the light L of the element.

The values of these limits are to be defined according to:
- the effects on the supported elements
- the quality of the comfort required for construction
- the characteristics of the structural and non-structural elements weighing on the element considered
- the possible implications of an excessive de formability on the value of the loads acting

In the absence of more precise indications, the limits indicated in Tab. 14 can be adopted, where L is the span of the element or, in the case of shelves, double the overhang.

In our case:
l= 50
δ_{max}= 50/250= 0.2 m

12.2.5 First dimensioning

The first analysis was done using a simply supported arched beam high 1 m and 50 m span.
The displacement was too elevated (=10.96 m) because of the strong horizontal stress given by the arched form.
These first analysis were done with Ftool, a 2D software that immediately showed us how to proceed with the calculations.

STRUCTURAL ELEMENTS	LIMITS FOR THE VERTICAL DISPLACEMENTS	
	δ_{max}/l	δ_2/l
	1/200	1/250

Tab.14:Max deflection

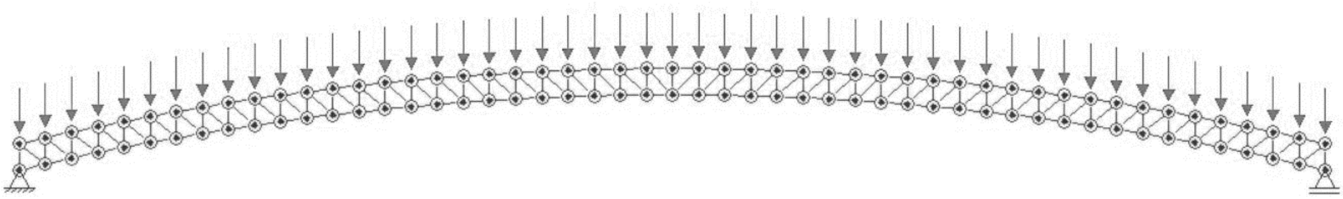


Fig.159:Loads on the truss

10.96 m

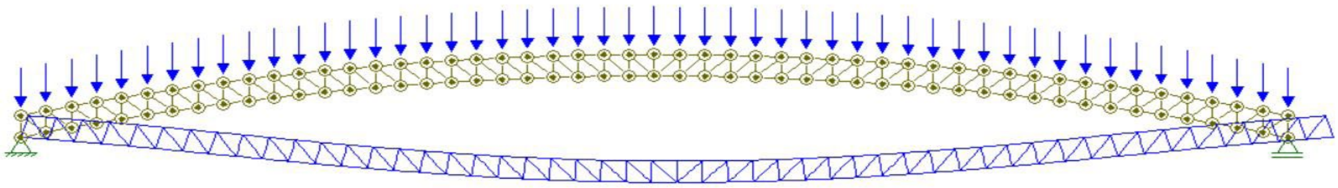


Fig.160:Deflection of the truss

10.96m

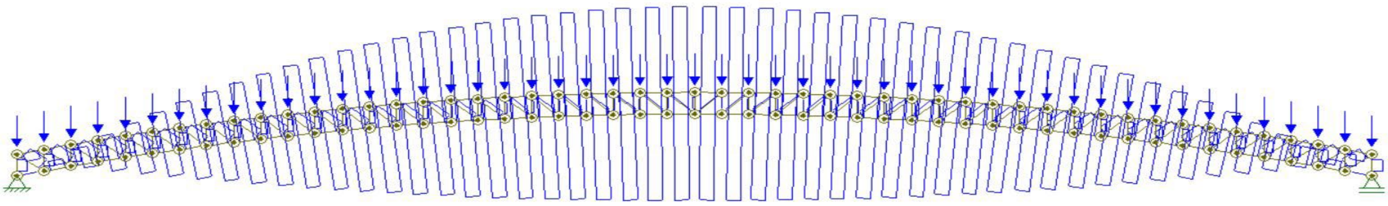


Fig.161:Axial forces of the truss

-14408 kN

12.2.5 Second dimensioning

As second step we decided to use a similar isostatic system: three-hinged arch. Solution used usually for very big structures, like bridges or the famous Stazione Centrale in Milan.
As base point to star the analysis with Robot Structural analysis some elements were defined:
Material: steel S275

Profiles: 2UPN for all members
H= 1.25 m
.With a displacement of 1.8 m it still exceed the maximum limit acceptable. It was therefore decided to proceed with the analysis by gradually increasing each profile until reaching a value that would verify the maximum deflection.
Once the Ultimate Limit State deflection was verified, the Ultimate Limit State analysis were performed to verify the upper and lower chords, the diagonal and vertical members.
Final dimensioning
Thanks to the help of Robot Structural Analysis we performed simulations until the profiles were all verified and these are the final properties of the members defined:

- Material steel S275
- Profiles: 2 UPN 260 for the chords and 2 LUP 80 x 80 x 7 for the diagonal and vertical members
- H= 1.25 m

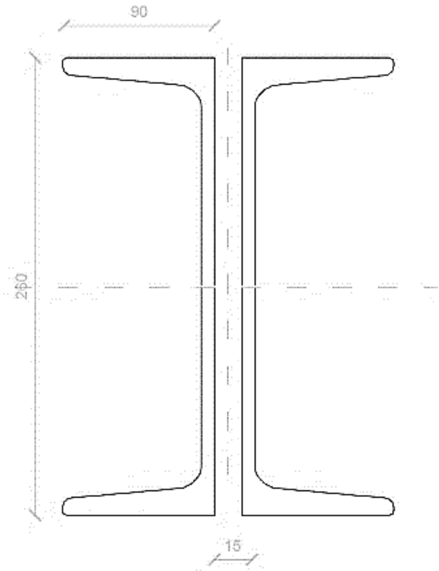


Fig.162:Final dimensioning for chords.

UPN	Dimensions		Weight	Area	Inertia
	h	b	G	A	I_y
Units	mm	mm	kg/m	cm²	cm⁴
UPN 260	260	90	37.9	48.3	4820

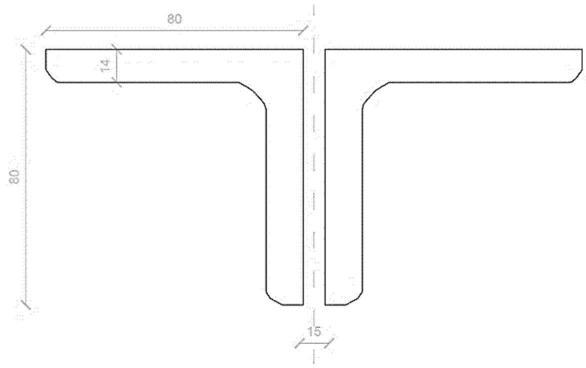


Fig.163:Final dimensioning for the diagonal and vertical members

LUP	Dimensions			Area	Inertia
	h	b	G	A	I_y
Units	mm	mm	kg/m	cm²	cm⁴
L 80 x 80 x 7	80	80	7.36	9.38	59

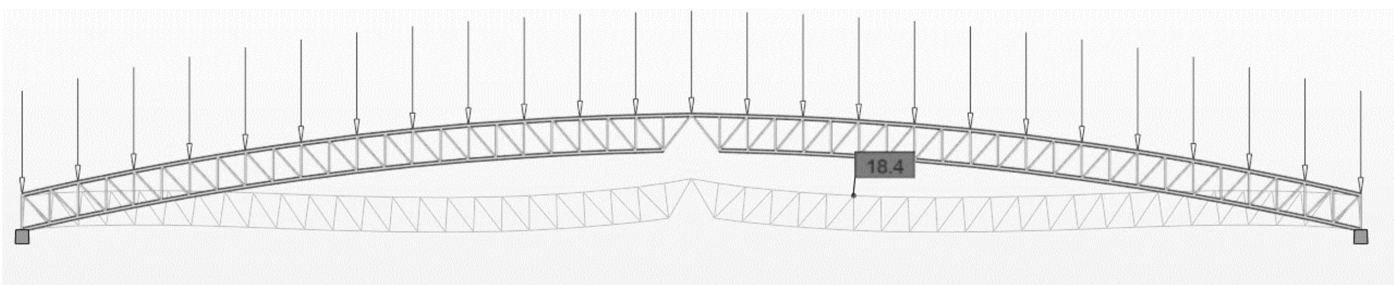


Fig.164:Max deflection of the truss with the second option

After the profiles definition it was verified the whole structure.
In order to dimension the truss ant its critical points, to simplify the process, the research was supported once again by Robot Structural Analysis Professional software and in the pictures below is visible the schematic structure designed.

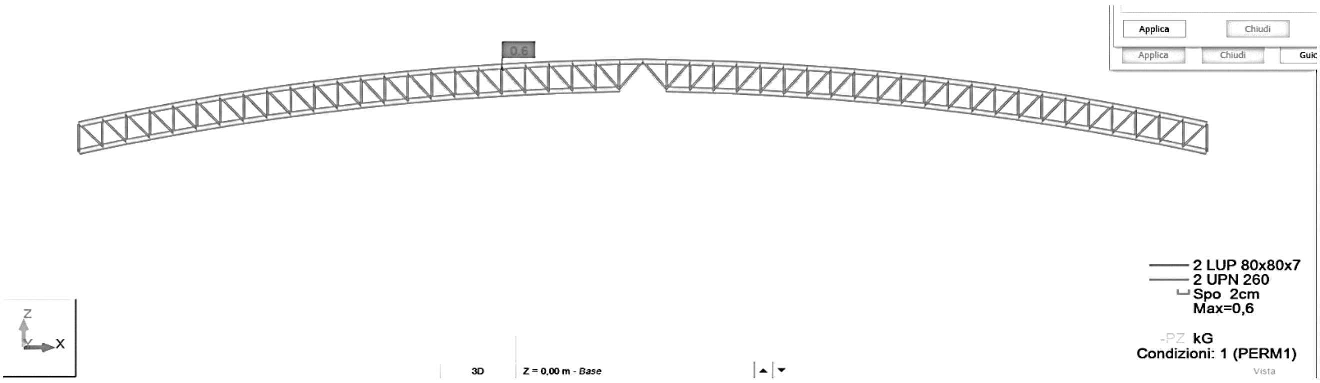


Fig.165:Max deflection

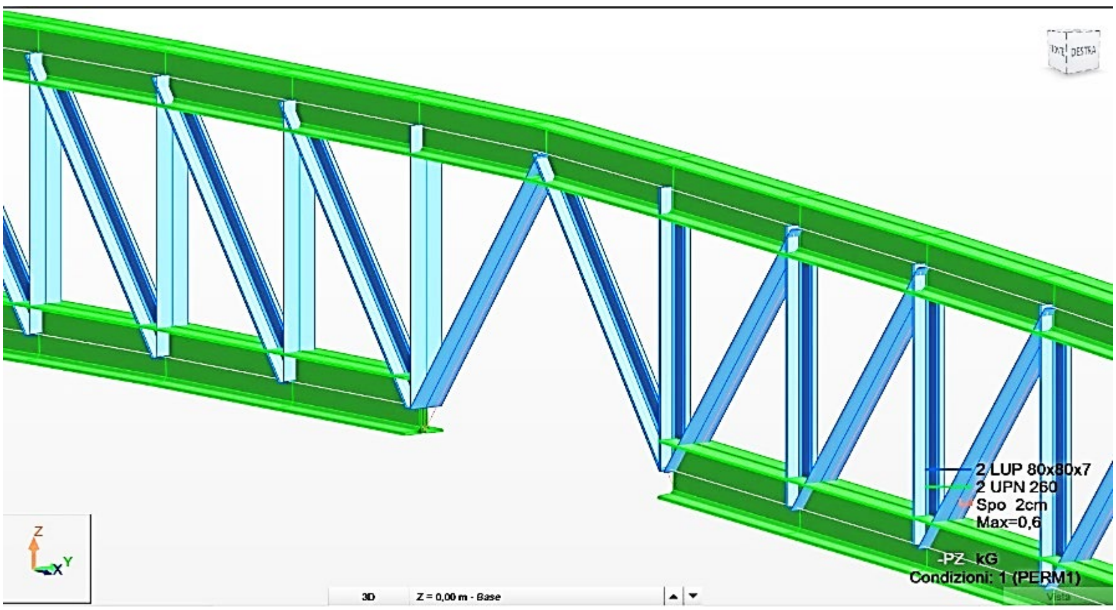


Fig.166:UPN and LUP profiles

12.2.5 Verification at serviceability limit state

As mentioned before, the first verification to do was at SLS: it was carried out the verification of deformability at the limit state of exercise, we calculate the deflection following the static diagram of a three-hinged arch.

Max deflection: 0.08 m

As calculated before, the max deflection has to be max= 50/250= 0.2 m. And finally with a three hinged structure height 1,25 m and with the correct profiles it was reached a good result.

δ=0.06 m < δmax= 0.2 m

12.2.5 Verification at ultimate limit state

Before starting the ULS verifications, it was studied the axial loads on the truss, so that the maximum value of tension and compression for the chords and for the diagonal and vertical members.

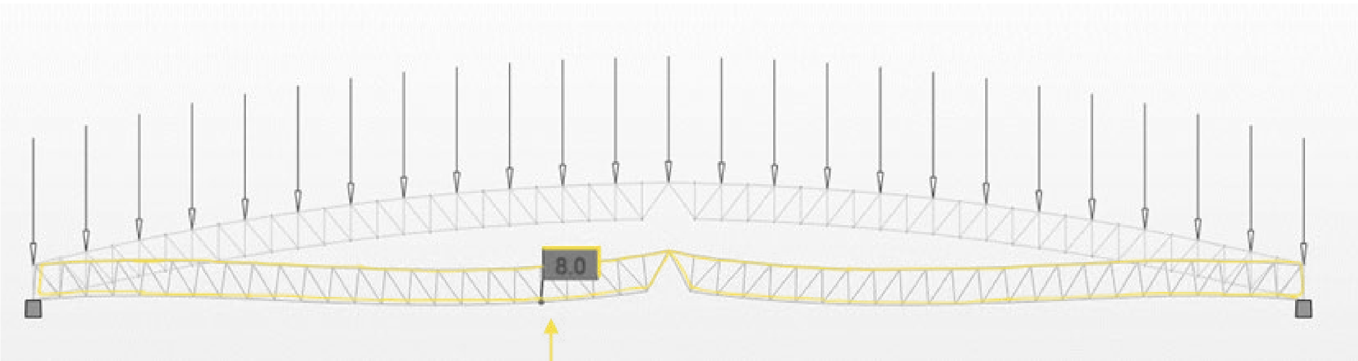


Fig.167:Max deflection and truss deformation

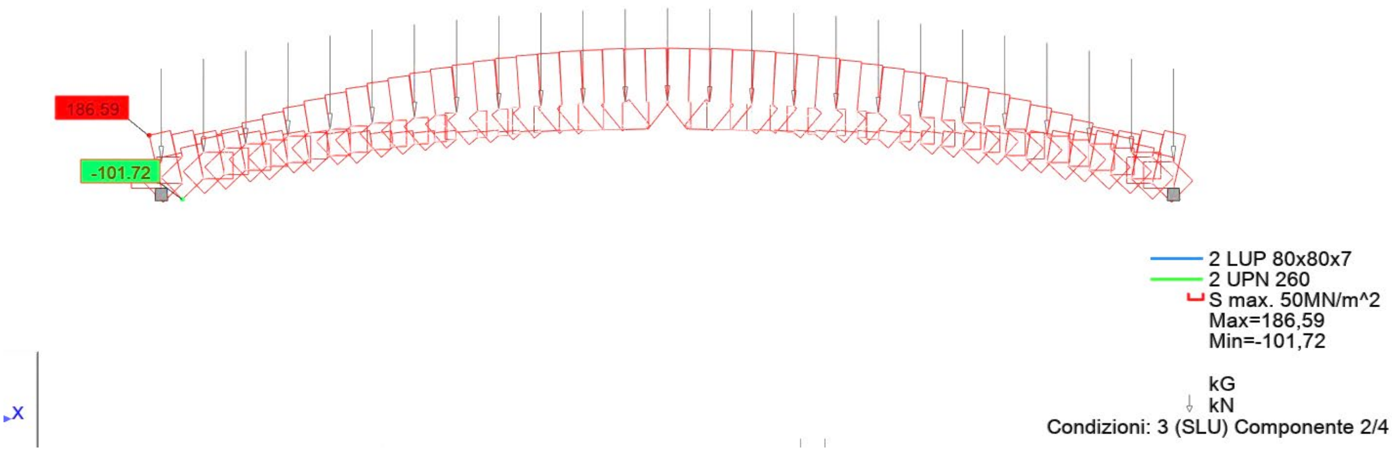


Fig.168:Axial forces truss

TENSION	NAME	FX (Kn)	SECTION	LENGTH	AREA
Chord	Barra_6	2343.24	2 UPN 260	1.03	96.6
Diagonal and vertical	Barra_3	289.64	2 LUP 80x80x7	1.25	21.6

COMPRESSION	NAME	FX (Kn)	SECTION	LENGTH	AREA
Chord	Barra_81	-285.63	2 LUP 80x80x7	1.44	21.6
Diagonal and vertical	Barra_103	-40.32	2 UPN 260	1	96.6

Elements in compression

From § 4.2.4.1.3.1 of NTC 18: the stability check of a rod is carried out in the hypothesis that the cross section is uniformly compressed, that is:

$N_{ed} < N_{b,Rd}$ or $N_{ed} = N_{b,Rd}$

Where is it:
Ned: is the maximum compressive action
Nb,rd: is the resistance to instability in the compressed shaft, given by:

$N_{b,rd} = XAf_{yk} / \gamma_{Mo}$

$$\chi = \frac{1}{\Phi+\sqrt{\Phi^2-\lambda^2}} \leq 1$$ ":

x depends on the type of section and the type of steel used; it is deduced, as a function of appropriate values of the dimensionless slenderness, from the following formula:

phy: is given by the following formula:

$$\Phi = 0.5\,[1 + \alpha(\bar{\lambda}-0.2) + \bar{\lambda}^2]$$

"alfa: is the is the imperfection factor, obtained from Tab. 4.2.VIII of the D.M. 20/02/18. In the case in question " = 0.49;

$$\lambda = \sqrt{A\frac{f_{yk}}{N_{cr}}}$$ "

Lambda: is the dimensionless slenderness equal to:

Ncr: indicates the Eulerian critical load and is expressed by the following equation:

$$N_{cr} = \pi^2 \cdot E \cdot \frac{I}{l_0^2}$$

l_0: is the free deflection length equal to l_0 = 1 m ,
I: is the moment of inertia of the profile.

	Ned kN	α	lo m	Ncr kN	λ	Φ	X	Nb,rd kN	Ned / Nb,rd
2 UPN260	-40.32	0.49	1	1.9 *	0.11	0.48	1.04	2718.08	0.014

VERIFIED

Tab.15:Verification values for the more compressed elements UPN

	Ned kN	α	lo m	Ncr kN	λ	Φ	X	Nb,rd kN	Ned / Nb,rd
2 LUP 80X80	-285.63	0.49	1.4	1284.4	0.69	0.85	0.73	425.8	0.67

VERIFIED

Tab.16:Verification values for the more compressed elements LUP

ELEMENTS IN TENSION

From § 4.2.4.1.3.1 of NTC 18: the stability check of a rod is carried out in the hypothesis that the cross section is uniformly compressed, that is:

$N_{ed} <= N_{b, Rd}$

Where the design tensile strength Nt, Rd of members with sections weakened by holes for bolted connections studded must be assumed equal to the lower of the following values:

-

- the design plastic resistance of the gross section, A:

$$N_{pl,Rd} = \frac{Af_{yk}}{\Phi_{M0}}$$

- the design resistance at break of the net section, A_{net}, in correspondence with the holes for the connections:

$$N_{u,Rd} = \frac{0.9\ A_{net}\ f_{tk}}{\Phi_{M2}}$$

	Ned	Nu,Rd	Npl,Rd	Nt,rd	Ned/ Nt,rd
2 UPN260	2343.24	3075.01	2605.9	2605.9	0.89

VERIFIED

Tab.17:Verification values for the more compressed elements UPN

	Ned	Nu,Rd	Npl,Rd	Nt,rd	Ned/ Nt,rd
2 LUP 80X80	289.64	684.59	582.69	582.69	0.49

VERIFIED

Tab.18:Verification values for the more compressed elements LUP

12.2.6 Column sizing

The column verification was done for a beam long 17.5 meters where the reticular beam it is interrupted by the double height hole. Here we find the process flow followed.

1. The correct loads were inserted.
2. Every load was multiplied for the correct area of interest (of primary or secondary beam)
3. From the drawing we can see the selected column.
4. We see that in the pillar are going to burden one primary beam and two secondary
5. Adding these loads, we found the final shear that is going to act on the column

Check the stability of the HEB 180 pillar

The stability check of the pillar was performed, according to the NTC 2018 standard. The stability check was carried out with respect to both the z-z axis and the y-y axis.
The stability check of a rod is carried out in the hypothesis that the cross section is uniformly compressed (Ref. NTC §4.2.4.1.3). It must be:

G1 corrugated (kN / m2)	G1 primary (kN / m2)	G1 secondary (kN / m2)	G2 (kN / m2)	qk (kN / m2)	P(tot) kN/m
2.15	1.9	0.26	3.14	5	19.86

Tab.19:Loads that weigh on the column

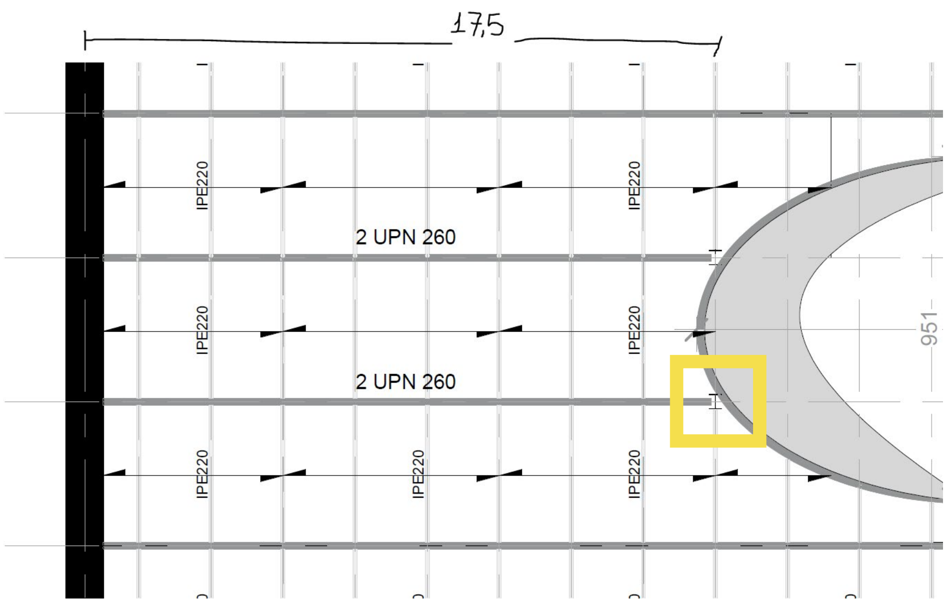


Fig.169:UPN load and shear acting no columns.

P (tot) kN/m	P *L (tot) kN	V1 and V2 kN	Ned
19.86	337.62	168.81	184.96

Tab.20:Final share acting on the column

AXIS Z-Z	AXIS Y-Y
Ncr = (π2 · EI)/ = 1534.97 kN Dove: E = 210 · kN/m2 I = 1,363 · m4 l0 = 4,29 m A = 0,00653 m2 α = 0,34 HEB 180 appears to have an instability curve c, since we are evaluating the deflection around the short axis of a profile with ratio h/b = 1 · 1.2 with a wing thickness · 100 mm.	Ncr = (π2 · EI)/ = 4314.362 kN Dove: E = 210 · kN/m2 I = 3,831 · m4 l0 = 4,29 m A = 0,00653 m2 α = 0,34 HEB 180 appears to have an instability curve c, since we are evaluating the deflection around the short axis of a profile with ratio h/b = 1 · 1.2 with a wing thickness · 100 mm.
λ= = 1.08 Φ = 0,5 • (1+ α · (λ · 0,2) + λ2) = 1.23 χ= 0.546 Nb, Rd = χ • A • = 933.9908609	λ= = 0.64 Φ = 0,5 • (1+ α · (λ · 0,2) + λ2) = 0.78 χ= 0.814 Nb, Rd = χ • A • = 1390.870118
Resistance check by standard: Ned / Nb, Rd = 0.19 < 1	Resistance check by standard: Ned / Nb, Rd = = 0.13 < 1
VERIFIED	**VERIFIED**

In conclusion, it was decided to use HEB 180 pillars on the entire structure.

Structural plan (+0.0 m)

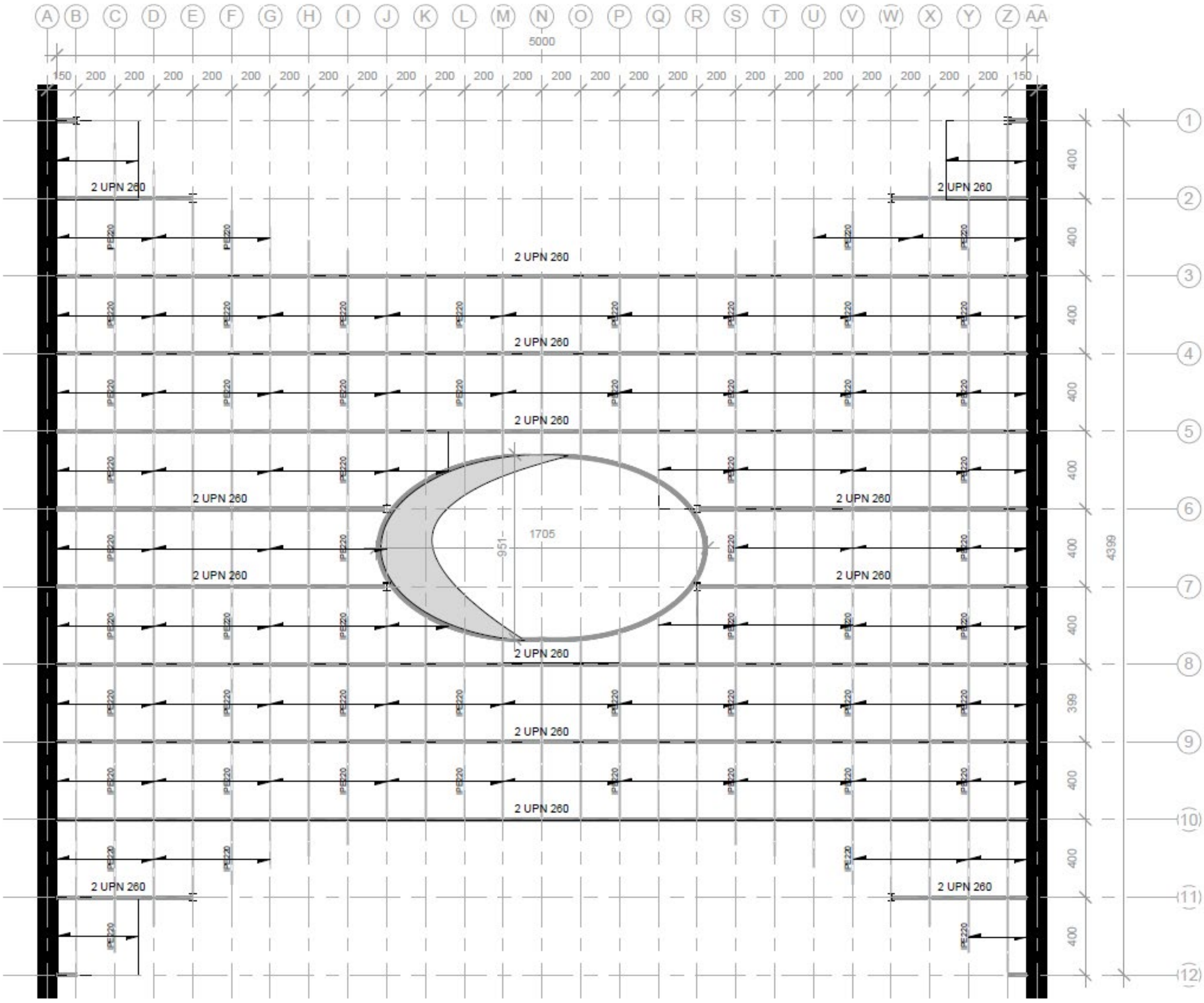
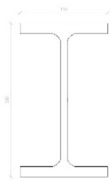
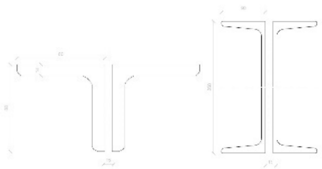


Fig.171:UPN load and shear acting no columns.

BEAMS		
IPE 220	Secondary beam roof	
2 UPN260 2LUP 80X80	Primary beam roof	
COLUMN		
HEB 180	Steel profile Vertical element	

Tab.21:Beam profiles

12.6. Box pre-dimentioning

First of all, we will start defining the permanent structural loads (G1).

For the determination of the structural own weights of the most common materials, the weight values of the volume unit shown in the table below can be assumed. If any materials are not specified in the standard, reference can be made to the unit weight indicated in the manufacturer's technical sheet.

MATERIALS	WEIGHT PER UNIT OF VOLUME (kN / m3)
Cementitious concrete and mortars	
Ordinary concrete	24.0
Reinforced concrete (and / or prestressed)	25.0
"Light" concretes: case by case	14.0 · 20.0
"Heavy" concretes: case by case	28 · 50.0
Lime mortar	18.0
Cement mortar	21.0
Lime powder	10.0
Powdered cement	14.0
Sand	17.0
Metals and alloys	
Steel	78.5
Cast iron	72.5
Aluminum	27.0
Stone material	
Volcanic tuff	17.0
Compact limestone	26.0
Soft limestone	22.0
Plaster	13.0
Granite	27.0
Brick (solid)	18.0
Timber	
Conifers and poplar	4.0 · 6.0
Hardwood (except poplar)	6.0 · 8.0
Various substances	
Fresh water (clear)	9.81
Paper	10.0
Glass	25.0

Tab.22:Specific weight for different materials

12.3.1 Platform frame construction

The “box” is one of the key concepts of the project, these are entirely prefabricated, brought on site, assembled and inserted directly inside the existing windows.

The system used it the Platform frame, quick to assemble and that can create a flexible architecture, necessary for the new conception of spaces after Covid19.

The platform frame method of building timber frame structures is suited to both low-rise and medium-rise buildings. Many buildings up to six and seven storeys in height have been constructed over recent years typically for residential, institutional and hotel uses.

The term ‘platform frame’ derives from the method of construction where floor structures bear onto load-bearing wall panels, thereby creating a ‘platform’ for construction of the next level of wall
There are a number of different conditions that need to be satisfied by the structural engineer during the engineering of a multi-storey timber frame building, including:

- The adequacy of vertical load paths
- The strength and stiffness of the individual framing members
- Overall building stability and stability of the individual elements
- Robustness of the framing and connections
- Disproportionate collapse design

12.3.2 Glue-lam wood characteristics

According to EN 1194 expressing nominal value of laminated wood

Strength classes for homogeneous and combined softwood glulam (EN1194)									
Characteristic values of strength and elastic modulus			GL24c	GL28h	GL28c	GL32h	GL32c	GL36h	GL36c
Resistances (MPa)									
flexion	fm,g,k	24		28		32		36	
tension parallel to grain	ft, 0, g, k	16.5	14.0	19.5	16.5	22.5	19.5	26	22.5
traction perpendicular to the grain	ft, 90, g, k	0.40	0.35	0.45	0.40	0.50	0.45	0.60	0.50
compression parallel to grain	fc, 0, g, k	24.0	21.0	26.5	24.0	29.0	26.5	31.0	29.0
compression perpendicular to the grain	fc, 90, g, k	2.7	2.4	3.0	2.7	3.3	3.0	3.6	3.3
Elastic modulus (GPa)									
mean elastic modulus parallel to the fibers	E0, g, mean	11.6	11.6	12.6	12.6	13.7	13.7	14.7	14.7
characteristic elastic modulus parallel to the fibers	E0, g, 05	9.4	9.4	10.2	10.2	11.1	11.1	11.9	11.9
mean elastic modulus perpendicular to the fibers	E90, g, mean	0.39	0.32	0.42	0.39	0.46	0.42	0.49	0.46
mean shear modulus	Gg, mean	0.72	0.59	0.78	0.72	0.85	0.78	0.91	0.85
Density (kg / m3)									
Characteristic density	ρg, k	380	250	410	380	430	410	450	430

Tab.23:Characteristics of different types of Gluelam

The choice of the material was very important to us, it was important to have a strong but sustainable material that could be assembled. Secondary beam roof sizing.

The process that is going to be followed now is to dimension the beams of the roof and of the slab, to understand the thickness of the elements. Important aspect to understand if the height of the boxes is enough to permit the easy positioning through the existing wall of the gallery.

12.3.3 Secondary beam roof sizing

Pre-dimentioning

In determining the loads on the secondary beams, the following loads were considered in the Operating Limit State (SLS):

- OSB loading, G_1;
- Loads that constitute the technological package of the adjacent internal floor G_2
- An influence length Li equal to the sum of the two halves of the centre distance between the analysed secondary beam and the adjacent one;
- Variable load due to the category of use to which the building belongs, qk
- The snow load since we are operating in the roof, q (kN / m·)
- Ptot is the total load applied on the structure that has to be transformed in kN/m so we multiply the result for the influence length.

$$Ptot= (G_1+ G_2+ qk) \times Li$$

The structural plan is shown below in which the secondary beam analysed is highlighted.
Reference was made to a support-support static scheme, because of the constraints that bind the secondary beams to the main ones, with uniformly distributed load over the entire length of the profile, carried by the floor.
From the diagram shown here it is possible to go back to the formulations for the calculation of the static quantities that characterize the project situation, both in terms of actions on the section and in reference to the displacement components.
Structural plan (+5.7 m)

Pitch l= 8 m

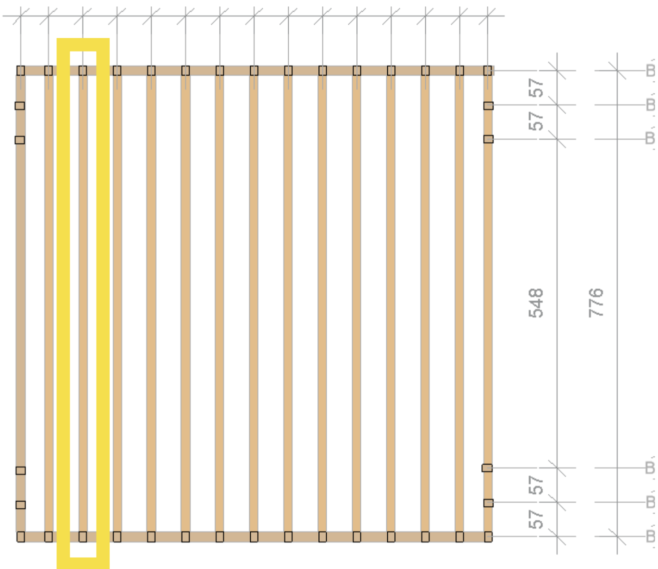
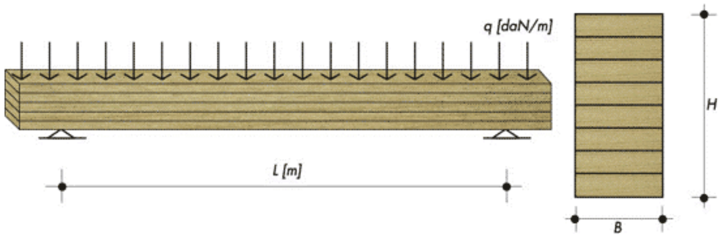


Fig.172:Secondary beam roof selection for the analysis

G1 (kN / m2)	G2 (kN / m2)	qk (kN / m2)	q (kN / m2) SNOW	Li (m) infuence	P(tot) kN/m
0.09	0.6906	0.5	1.2	0.57	1.41

Tab.24:Loads weights on the secondary beam

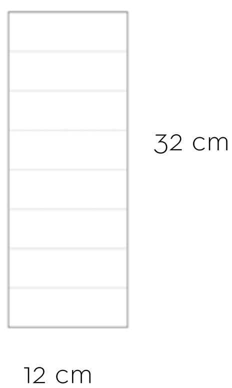
To choose an approximate dimension for the secondary beams we are going to use the table below that compares the weight per unit length and the pitch of the beam.



Luce di calcolo (m)	Carico q (kN/m) 1,0	1,5	2,0	2,5	3,0	4,0	5,0	6,0	7,0	8,0	9,0	10,0	12,0	15,0	18,0
3,0	8/12	8/12	8/12	8/16	8/16	8/16	8/19	8/19	10/19	10/19	10/22	10/22	10/26	10/29	12/29
3,5	8/12	8/16	8/16	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/26	12/26	12/29	12/32
4,0	8/12	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/29	10/29	12/29	12/32	12/39	12/39
4,5	8/16	8/19	8/19	10/22	10/22	10/22	10/26	10/26	10/29	12/29	12/29	12/32	12/36	12/39	14/39
5,0	8/16	10/19	10/19	10/22	10/22	10/26	10/29	12/29	12/29	12/32	12/32	12/36	12/39	14/42	14/46
5,5	8/19	10/22	10/22	10/26	10/26	10/29	12/29	12/32	12/32	12/36	12/39	12/39	14/39	14/46	14/49
6,0	10/19	10/26	10/26	10/29	10/29	12/29	12/32	12/36	12/36	12/39	14/39	14/39	14/49	14/49	16/55
6,5	10/22	10/26	10/26	12/29	12/29	12/32	12/36	12/36	12/39	14/39	14/42	14/42	14/49	16/49	16/55
7,0	10/22	10/29	12/26	12/32	12/32	12/36	12/39	14/39	14/39	14/42	14/46	14/46	14/52	16/55	16/59
7,5	10/26	[illegible]	2/29	12/32	12/32	12/42	14/39	14/42	14/42	14/46	14/49	14/49	16/52	16/59	16/65
8,0	10/26	12/32	2/32	12/36	12/36	14/39	14/46	14/42	14/46	14/49	14/52	16/49	16/56	16/52	18/65
9,0	12/29	[illegible]	2/36	12/39	14/39	14/42	14/46	14/49	16/49	16/52	16/59	16/55	16/62	18/65	18/72
10,0	12/32	12/39	14/42	14/42	14/42	14/49	14/52	16/52	16/55	16/59	16/59	16/62	18/65	18/72	18/82
11,0	12/36	14/39	14/42	14/46	14/49	16/49	16/55	16/59	16/62	16/69	18/69	18/65	18/72	18/82	20/85
12,0	12/39	14/42	14/46	14/52	16/49	16/55	16/59	16/62	18/65	18/72	18/69	18/72	18/78	20/85	20/92
15,0	14/45	14/52	16/55	16/59	16/62	18/55	18/72	18/75	18/82	20/82	20/85	20/88	20/88	20/105	20/115

Tab.25:Pre-dimentioning of a gluelam beam

On top of the table the tot load applied is listed; on the left there is the max pitch of the beam, and all the rest of the table is the size of the glue-laminated beam to use according to the given data.



Now that we found the dimension of the secondary beams of the roof, we can calculate his permanent load G1:

$G_1 = (b \times h \times g_{,k} / l) = 0.12 \times 0.32 \times 4.5 / 0.57 = 0.303$ kN/m2

Where:
- b is the thickness of the beam
- h is the height of the beam
- is the characteristic density
- l is the influence length

12.3.4 Primary beam roof sizing

The primary beam of these boxes is just in the borders, in the parts where we find the vertical elements and were the secondary beams apply their load. This are also called Headbinders or 'header plates' which connect together adjacent wall panels to enable them to function as a continuous wall diagram and, in combination with the top wall panel rails, act as 'spreader' beams to distribute floor joist loads to the wall studs where the joists are not aligned (noded) with the studs. Head-binders are usually site-fitted.

The primary beam of the roof has 15 pointed loads that can be considered distributed, taking in consideration the small wheelbase between the loads of the secondary beams.
The load analysis is the same as the secondary beams but adding their G1.

Also in this case, to find the load on 1 linear meter of beam, I multiply the distributed load by the area of influence of the beam (s):

P(tot) = (G1 + G1 + G2 + qk + qk) x Li [kN/m]

Structural plan (+5.7 m)

Pitch l= 8 m

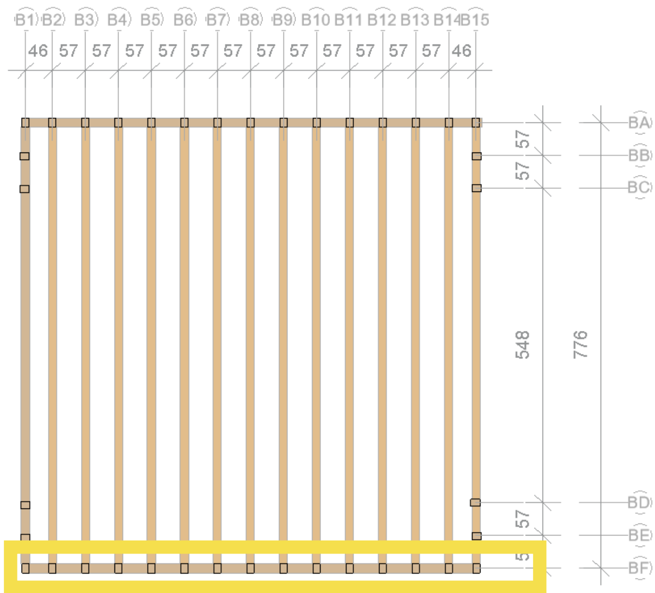


Fig.173:Primary beam roof selection for the analysis

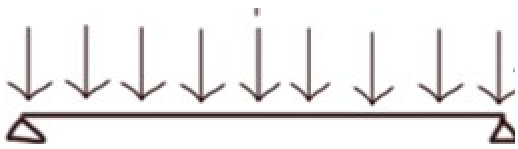


Fig.174:Static scheme for the primary beam

G1 (kN/ m2) OSB	G1 (kN/ m2) Secondary	G2 (kN/ m2)	qk (kN/ m2)	q (kN/ m2) SNOW	Li (m) infuence	P(tot) kN/m
0.09	0.303	0.6906	0.5	1.2	4	11.13

Tab.26:Loads weights on the primary beam

As before, from the table we can extrapolate the beam dimension having the given load and the pitch of the beam in consideration.
The load found in the previous table is 11.5 so we so we round up and choose 12 kn / m to be in favour of safety. After finding the latter I also choose the value of the beam span and at the point where they meet it is possible to choose the correct beam for the case in question.

Luce di calcolo (m)	Carico q (kN/m) 1,0	1,5	2,0	2,5	3,0	4,0	5,0	6,0	7,0	8,0	9,0	10,0	12,0	15,0	18,0
3,0	8/12	8/12	8/12	8/16	8/16	8/16	8/19	8/19	10/19	10/19	10/22	10/22	10/26	10/29	12/29
3,5	8/12	8/16	8/16	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/26	12/26	12/29	12/32
4,0	8/12	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/29	10/29	12/29	12/32	12/39	12/39
4,5	8/16	8/19	8/19	10/22	10/22	10/22	10/26	10/26	10/29	12/29	12/29	12/32	12/36	12/39	14/39
5,0	8/16	10/19	10/19	10/22	10/22	10/26	10/29	12/29	12/29	12/32	12/32	12/36	12/39	14/42	14/46
5,5	8/19	10/22	10/22	10/26	10/26	10/29	12/29	12/32	12/32	12/36	12/39	12/39	14/39	14/46	14/49
6,0	10/19	10/26	10/26	10/29	10/29	12/29	12/32	12/36	12/36	12/39	14/39	14/39	14/49	14/49	16/55
6,5	10/22	10/26	10/26	12/29	12/29	12/32	12/36	12/36	12/39	14/39	14/42	14/42	14/49	16/49	16/55
7,0	10/22	10/29	12/26	12/32	12/32	12/36	12/39	14/39	14/39	14/42	14/46	14/46	14/52	16/55	16/59
7,5	10/26	12/29	12/29	12/32	12/32	12/42	14/39	14/42	14/42	14/46	14/49	14/49	[illegible]	6/59	16/65
8,0	10/26	12/32	12/32	12/36	12/36	14/39	14/46	14/42	14/46	14/49	14/52	16/49	16/56	6/52	18/65
9,0	12/29	12/36	12/36	12/39	14/39	14/42	14/46	14/49	16/49	16/52	16/59	16/55	[illegible]	8/65	18/72
10,0	12/32	12/39	14/42	14/42	14/42	14/49	14/52	16/52	16/55	16/59	16/59	16/62	18/65	18/72	18/82
11,0	12/36	14/39	14/42	14/46	14/49	16/49	16/55	16/59	16/62	16/69	18/69	18/65	18/72	18/82	20/85
12,0	12/39	14/42	14/46	14/52	16/49	16/55	16/59	16/62	18/65	18/72	18/69	18/72	18/78	20/85	20/92
15,0	14/45	14/52	16/55	16/59	16/62	18/55	18/72	18/75	18/82	20/82	20/85	20/88	20/88	20/105	20/115

Tab.27:Pre-dimentioning of a gluelam beam

Now that we found the dimension of the secondary beams of the roof, we can calculate his permanent load G1:

G1=(b x h x g,k /l) = 0.16x 0.56x 4.5 /4 = 0.1008 kN/m2

Where:

- b is the thickness of the beam
- h is the height of the beam
- is the characteristic density
- l is the influence length

12.3.5 Secondary beam roof sizing

Pre-dimentioning

In determining the loads on the secondary beams, the following loads were considered in the Operating Limit State (SLS):

- OSB loading, G1;
- Loads that constitute the technological package of the adjacent internal floor G2
- An influence length Li equal to the sum of the two halves of the centre distance between the analysed secondary beam and the adjacent one;
- Variable load due to the category of use to which the building belongs, qk
- Ptot is the total load applied on the structure that has to be transformed in kN/m so we multiply the result for the influence length.

$$P_{tot} = (G_1 + G_2 + q_k) \times L_i$$

The structural plan is shown below in which the secondary beam analysed is highlighted.
Reference was made to a support-support static scheme, because of the constraints that bind the secondary beams to the main ones, with uniformly distributed load over the entire length of the profile, carried by the floor. From the diagram shown here it is possible to go back to the formulations for the calculation of the static quantities that characterize the project situation, both in terms of actions on the section and in reference to the displacement components.

Structural plan (+5.7 m)

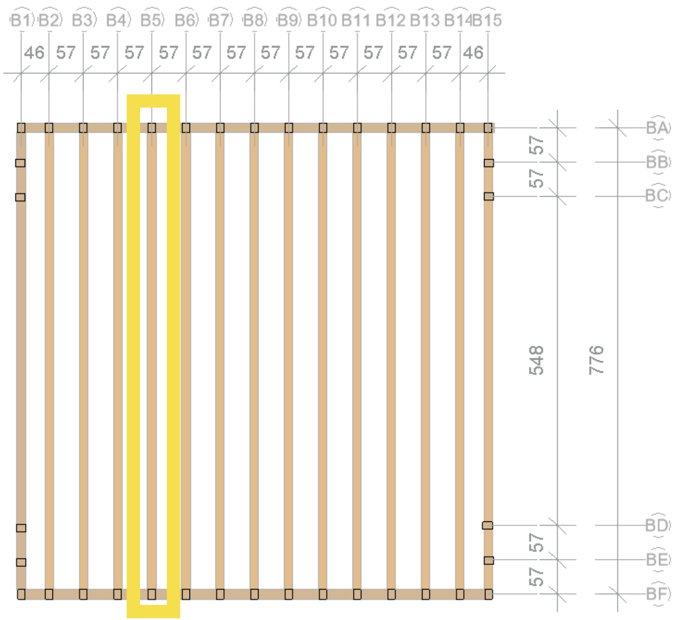


Fig.175:Secondary beam sl selection for the analysis

G1 (kN / m2)	G2 (kN / m2)	qk (kN/m2)	Li (m) influence	P(tot) kN/m
0.09	0.7024	6	0.57	3.87

Tab.28:Loads weights on the secondary beam

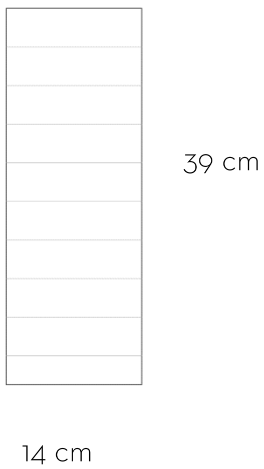
As before, from the table we can estrapolate the beam dimension having the given load and the pitch of the beam in consideration.
The load found in the previous table is 11.5 so we so we round up and choose 12 kn / m to be in favour of safety. After finding the latter I also choose the value of the beam span and at the point where they meet it is possible to choose the correct beam for the case in question.

Luce di calcolo (m)	Carico q (kN/m) 1,0	1,5	2,0	2,5	3,0	4,0	5,0	6,0	7,0	8,0	9,0	10,0	12,0	15,0	18,0
3,0	8/12	8/12	8/12	8/16	8/16	8/16	8/19	8/19	10/19	10/19	10/22	10/22	10/26	10/29	12/29
3,5	8/12	8/16	8/16	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/26	12/26	12/29	12/32
4,0	8/12	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/29	10/29	12/29	12/32	12/39	12/39
4,5	8/16	8/19	8/19	10/22	10/22	10/22	10/26	10/26	10/29	12/29	12/29	12/32	12/36	12/39	14/39
5,0	8/16	10/19	10/19	10/22	10/22	10/26	10/29	12/29	12/29	12/32	12/32	12/36	12/39	14/42	14/46
5,5	8/19	10/22	10/22	10/26	10/26	10/29	12/29	12/32	12/32	12/36	12/39	12/39	14/39	14/46	14/49
6,0	10/19	10/26	10/26	10/29	10/29	12/29	12/32	12/36	12/36	12/39	14/39	14/39	14/49	14/49	16/55
6,5	10/22	10/26	10/26	12/29	12/29	12/32	12/36	12/36	12/39	14/39	14/42	14/42	14/49	16/49	16/55
7,0	10/22	10/29	12/26	12/32	12/32	12/36	12/39	14/39	14/39	14/42	14/46	14/46	14/52	16/55	16/59
7,5	10/26	12/29	12/29	12/32	12/32	12/42	14/39	14/42	14/42	14/46	14/49	14/49	[illegible]	6/59	16/65
8,0	10/26	12/32	12/32	12/36	12/36	14/39	14/46	14/42	14/46	14/49	14/52	16/49	16/56	6/52	18/65
9,0	12/29	12/36	12/36	12/39	14/39	14/42	14/46	14/49	16/49	16/52	16/59	16/55	[illegible]	8/65	18/72
10,0	12/32	12/39	14/42	14/42	14/42	14/49	14/52	16/52	16/55	16/59	16/59	16/62	18/65	18/72	18/82
11,0	12/36	14/39	14/42	14/46	14/49	16/49	16/55	16/59	16/62	16/69	18/69	18/65	18/72	18/82	20/85
12,0	12/39	14/42	14/46	14/52	16/49	16/55	16/59	16/62	18/65	18/72	18/69	18/72	18/78	20/85	20/92
15,0	14/45	14/52	16/55	16/59	16/62	18/55	18/72	18/75	18/82	20/82	20/85	20/88	20/88	20/105	20/115

Tab.29:Predimentioning of a gluelam beam

Now that we found the dimension of the secondary beams of the roof, we can calculate his permanent load G1:

G1=(b x h x g,k /l) = 0.16x 0.56x 4.5 /4 = 0.1008 kN/m2



Where:

- b is the thickness of the beam
- h is the height of the beam
- is the characteristic density
- l is the influence length

12.3.6 Primary beam roof sizing

Predimentioning

In determining the loads on the secondary beams, the following loads were considered in the Operating Limit State (SLS):

- OSB loading, G1;
- Loads that constitute the technological package of the adjacent internal floor G2
- An influence length Li equal to the sum of the two halves of the centre distance between the analysed secondary beam and the adjacent one;
- Variable load due to the category of use to which the building belongs, qk
- Ptot is the total load applied on the structure that has to be transformed in kN/m so we multiply the result for the influence length.

$$P_{tot} = (G_1 + G_2 + q_k) \times L_i$$

The structural plan is shown below in which the secondary beam analysed is highlighted.
Reference was made to a support-support static scheme, because of the constraints that bind the secondary beams to the main ones, with uniformly distributed load over the entire length of the profile, carried by the floor. From the diagram shown here it is possible to go back to the formulations for the calculation of the static quantities that characterize the project situation, both in terms of actions on the section and in reference to the displacement components.

Structural plan (+5.7 m)

Pitch l= 8 m

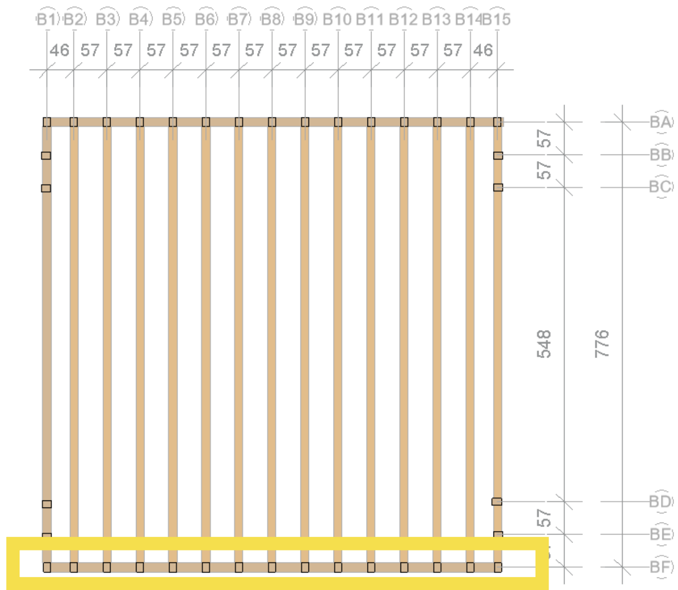


Fig.176:Primary beam roof selection for the analysis

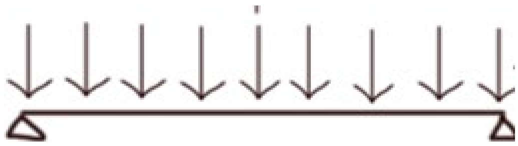


Fig.177:Static scheme for the primary beam

G1 (kN/ m2) OSB	G1 (kN/ m2) Secondary	G2 (kN/ m2)	qk (kN/ m2)	Li (m) influence	P(tot) kN/m
0.09	0.431	0.7024	6	4	28.89

Tab.30:Loads weights on the primary beam

Also in this case, to find the load on 1 linear meter of beam, I multiply the distributed load by the area of influence of the beam (s):
P(tot) = (G1 + G1 + G2 + qk + qk) x Li [kN/m]

Luce di calcolo (m)	Carico q (kN/m)														
	1,0	1,5	2,0	2,5	3,0	4,0	5,0	6,0	7,0	8,0	9,0	10,0	12,0	15,0	18,0
3,0	8/12	8/12	8/12	8/16	8/16	8/16	8/19	8/19	10/19	10/19	10/22	10/22	10/26	10/29	12/29
3,5	8/12	8/16	8/16	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/26	12/26	12/29	12/32
4,0	8/12	8/16	8/16	8/19	10/19	10/19	10/22	10/22	10/26	10/29	10/29	12/29	12/32	12/39	12/39
4,5	8/16	8/19	8/19	10/22	10/22	10/22	10/26	10/26	10/29	12/29	12/29	12/32	12/36	12/39	14/39
5,0	8/16	10/19	10/19	10/22	10/22	10/26	10/29	12/29	12/29	12/32	12/32	12/36	12/39	14/42	14/46
5,5	8/19	10/22	10/22	10/26	10/26	10/29	12/29	12/32	12/32	12/36	12/39	12/39	14/39	14/46	14/49
6,0	10/19	10/26	10/26	10/29	10/29	12/29	12/32	12/36	12/36	12/39	14/39	14/39	14/49	14/49	16/55
6,5	10/22	10/26	10/26	12/29	12/29	12/32	12/36	12/36	12/39	14/39	14/42	14/42	14/49	16/49	16/55
7,0	10/22	10/29	12/26	12/32	12/32	12/36	12/39	14/39	14/39	14/42	14/46	14/46	14/52	16/55	16/59
7,5	10/26	12/29	12/29	12/32	12/32	12/42	14/39	14/42	14/42	14/46	14/49	14/49	16/52	16/59	16/65
8,0	10/26	12/32	12/32	12/36	12/36	14/39	14/46	14/42	14/46	14/49	14/52	16/49	16/56	16/52	18/65
9,0	12/29	12/36	12/36	12/39	14/39	14/42	14/46	14/49	16/49	16/52	16/59	16/55	16/62	18/65	18/72
10,0	12/32	12/39	14/42	14/42	14/42	14/49	14/52	16/52	16/55	16/59	16/59	16/62	18/65	18/72	18/82
11,0	12/36	14/39	14/42	14/46	14/49	16/49	16/55	16/59	16/62	16/69	18/69	18/65	18/72	18/82	20/85
12,0	12/39	14/42	14/46	14/52	16/49	16/55	16/59	16/62	18/65	18/72	18/69	18/72	18/78	20/85	20/92
15,0	14/45	14/52	16/55	16/59	16/62	18/55	18/72	18/75	18/82	20/82	20/85	20/88	20/88	20/105	20/115

Tab.31:Predimentioning of a gluelam beam

Now that we found the dimension of the secondary beams of the slab we can calculate his permanent load G1:
G1== = 0.1008 kN/m2
Where:
b is the thickness of the beam
h is the height of the beam
 is the characteristic density
I is the interaxis

56 cm

16 cm

Now, the box structure is completed, and as a next step it will be shown where the laboratories are going to be inserted in the building and how they will be hold by the Steel structure.

12.7. Cantilever beam dimensioning

Analysed beam

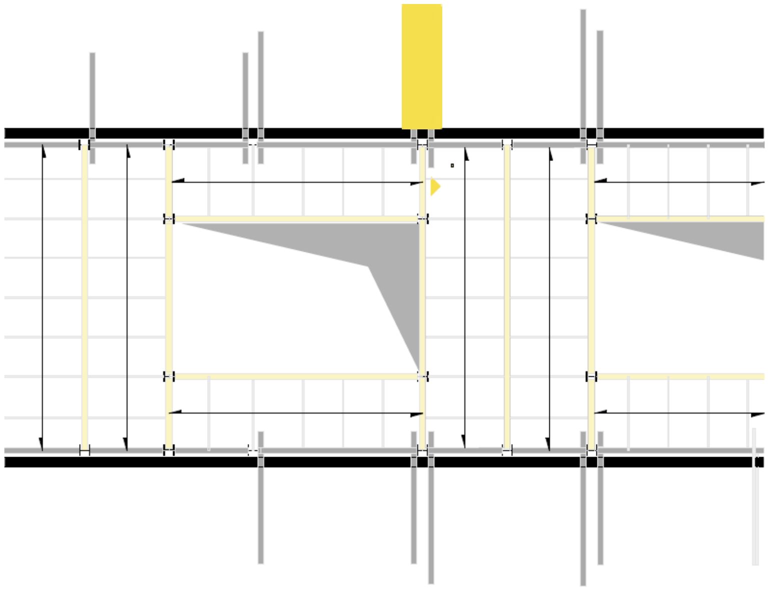


Fig.178:Analysed cantilever beam

Proceeding to analyse the cantilever beam holding the wood box. This decision was made in order to have a new structure that will totally hold the new elements.

Next to the wall we find a steel beam that reinforces the existing concrete masonry through the many connections between the two. These create a sort of chain around the building, internally, avoiding the formation of cracks and detachments in case of horizontal forces. This is necessary because in the period of construction of the old building (1920),
there was no regulation that added the horizontal loads given by seismic actions.

This steel jacket that runs through the entire building is also interrupted every 50 meters due to possible thermal expansion and supports most of the loads on the first floor of the building. in fact, the edge steel beams not only support the secondary beams of the floor but also the primary cantilever beams that support the wooden boxes. This choice was made to have a more flexible building, so that the boxes can be added and removed with great ease.

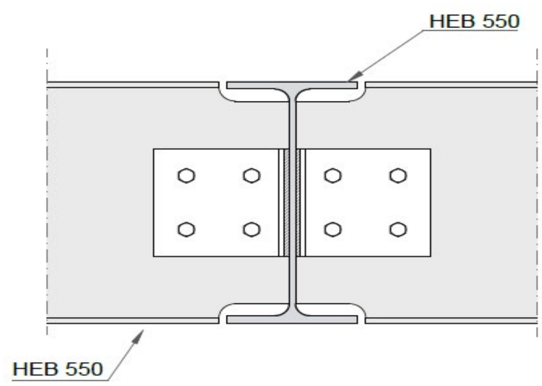


Fig.179:Elevation: connection between two primary beams

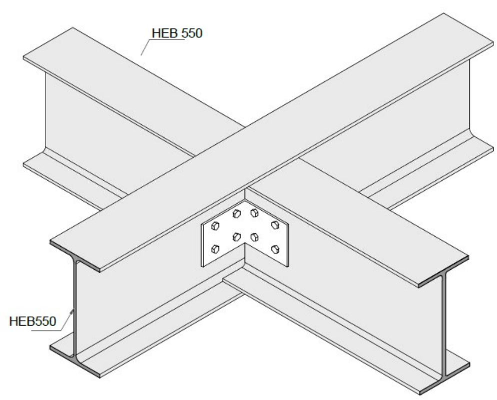
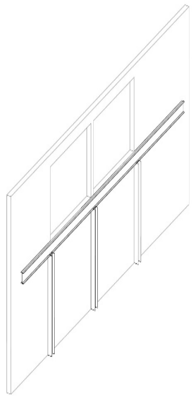
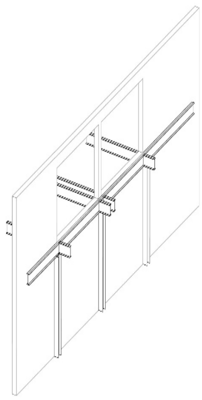


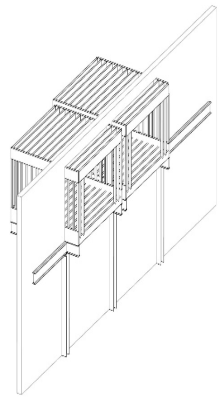
Fig.180:3D view: connection between two primary beams



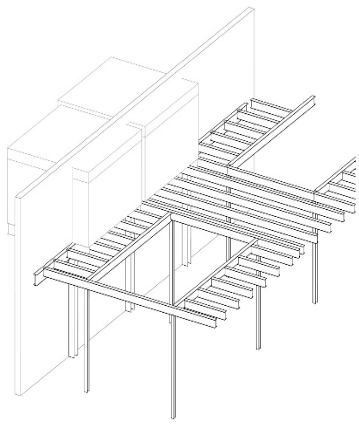
1. The existing wall in concrete is strengthened by the steel beams and the connection every 40 cm to create a unique structure that could work simultaneously.



2. To the primary beams along the wall, the cantilever beams going out the building are hold. Every eight meters there are two adjacent beams and a pillar below to hold the whole



3. On top of the steel new structure, the platform frame boxes are positioned. To have a more flexible building, it was decided to use two different materials that work perfectly together. It also gives us the opportunity to study more topics.



4. At the same level of the boxes we have the non insulated slab. This is just a passage between the closed laboratories.

Fig.181:Box structure and first floor slabs - laboratories illustration.

The primary steel beams are going all along the gallery both for reinforce the existing concrete wall by bearing the horizontal loads, and works as primary beam for the first floor.

This beam that was more complicated to calculate was the cantilever one holding the boxes: will be a primary beam attached to another primary as shown in the detail below.

The load is given by the load transferred do the primary beam of the bearing box in wood, plus the G1 of the wood beam.

Li (m) interax	P(tot) kN/m
4	28.89

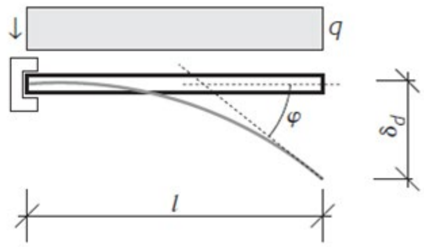
Tab.33:Interax and Load on wood beam

The fmax value is the maximum deflection, needed to calculate the inertia of the beam so that I can find the correct dimensions.

f= fmax

f=1/250 fmax=pl^4/8EI

Imax = 0.001351777= 135177.6857



$$M_{max} = \frac{ql^2}{2}$$

$$V_{max} = ql$$

$$\varphi = +\frac{ql^3}{6EI}$$

$$\delta_d = \frac{ql^4}{8EI}$$

Fig.182:Diagrams table , axial , shear and moment diagrams.

(Pitch of second-ary beam)	fmax l/250	E kN/m2	P kN/m	I max 250	HEB Profile
6.8	0.0272	2,1 x	28.89	135177.7	550

Tab.32:Predimentioning of the steel beam from the deflection

12.8. First floor dimensioning

Corrugated sheet design

For the choice of the corrugated sheet which, combined with the beams that support it, will form the load-bearing part of the floors, the loads on the bearing layer were analysed. Among these loads we find:
The permanent loads carried by the horizontal partition and by the internal vertical partition, G2, expressed in kN / m·
The variable load due to the category of use to which the building belongs, qk, in kN / m·.

OVERLOADS	UNIT WEIGHT (kN / m²)
Stratigraphy load (G2)	0.407
qk (Offices)	4
TOTAL	4.4

Tab.35:Total weight on corrugated sheet

Once the total overload was obtained through the sum of the different unit weights, it was possible to size the corrugated sheet, resting on the secondary beams, and the height of the resulting concrete casting, using the tables provided in the manufacturer's technical data sheets.
We choose a corrugated sheet non-cooperating in galvanized steel, type EXPAN - EPS 75/570
Since the total unit weight is 4.4 kN/m· that means 400 kg/m², we are going to choose a right span for sheet member that can carry the total load previously calculated, using the table below.
Since the total unit weight is 4.4 kN / m2, we are going to choose as a useful overload 4. 95 in the table above.

CARATTERISTICHE STATICHE GEOMETRICHE					
Spessore	0,6	0,7	0,8	1	1,2
Peso Kg/m²	8,26	9,64	11,02	13,77	16,53
Peso Kg/m	4,71	5,5	6,28	7,85	9,42
J cm⁴/m	85,87	100,18	114,5	143,12	171,75
W cm³/m	18	21	24	30	36

Tab.34:Geometric characteristics of the choosen laminated sheet

Extract from the catalogue of EXPAN - EPS 75/570 the weight

Note the dimensions of the floor, referring to the technical data sheet, it is possible to check the structural weight G1, which is equal to 8.26 Kg/m2

G1: 0.081 KN / m2

Spessore mm.	DISTANZA FRA GLI APPOGGI IN METRI																
	1,5	1,75	2	2,25	2,5	2,75	3	3,25	3,5	3,75	4	4,25	4,5	4,75	5	5,5	6
	sovraccarico di esercizio utile uniformemente distribuito kN/m² (per trasformare i KN/m² in kgf/m² si deve moltiplicare per 102)																
0,6	7,04	5,17	3,96	3,13	2,54	2,1	1,76	1,5	1,29	1,13	0,99	0,88	0,78 **0,77**	0,7 **0,66**	0,63 **0,56**	0,52 **0,42**	0,44 **0,33**
0,7	8,77	6,45	4,94	3,9	3,16	2,61	2,19	1,87	1,61	1,4	1,23	1,09 **1,07**	0,97 **0,9**	0,88 **0,77**	0,79 **0,66**	0,65 **0,5**	0,55 **0,38**
0,8	10,57	7,77	5,95	4,7	3,81	3,14	2,64	2,25	1,94	1,69	1,49 **1,47**	1,32 **1,23**	1,17 **1,03**	1,05 **0,88**	0,95 **0,75**	0,79 **0,57**	0,66 **0,44**
1	14,25	10,47	8,01	6,33	5,13	4,24	3,56	3,03	2,62	2,28 **2,23**	2 **1,84**	1,77 **1,53**	1,58 **1,29**	1,42 **1,1**	1,28 **0,94**	1,06 **0,71**	0,89 **0,54**
1,2	17,87	13,13	10,05	7,94	6,43	5,32	4,47	3,81	3,28	2,86 **2,68**	2,51 **2,21**	2,23 **1,84**	1,99 **1,55**	1,78 **1,32**	1,61 **1,13**	1,33 **0,85**	1,12 **0,65**
Freccia cm.	0,25	0,34	0,45	0,57	0,7	0,85	1,01	1,19	1,37	1,58	1,8	2,03	2,25	2,38	2,5	2,75	3
0.6	8.8	6.47	4.95	3,91	3,17	2,62	2,2	1,88	1,62	1,41	1,24	1,1	0,98	0,88	0,79	0,65	0,55
0,7	10,97	8,06	6,17	4,87	3,95	3,26	2,74	2,34	2,01	1,75	1,54	1,37	1,22	1,09	0,99	0,82	0,69
0,8	13,21	9,71	7,43	5,87	4,76	3,93	3,3	2,81	2,43	2,11	1,86	1,65	1,47	1,32	1,19	0,98	0,83
1	17,81	13,08	10,02	7,91	6,41	5,3	4,45	3,79	3,27	2,85	2,5	2,22	1,98	1,78	1,6	1,32	1,11 **1,05**
1,2	22,34	16,41	12,57	9,93	8,04	6,65	5,59	4,76	4,1	3,57	3,14	2,78	2,48	2,23	2,01	1,66 **1,63**	1,4 **1,26**
Freccia cm.	0,16	0,22	0,29	0,37	0,46	0,55	0,66	0,77	0,89	1,03	1,17	1,32	1,48	1,65	1,82	2,21	2,63

Tab.36:Definition of the thickness of the laminated sheet

12.5.1 Secondary beam sizing

Pre-dimentioning

In determining the loads on the secondary beams, the following loads were considered in the Operating Limit State (SLS):
Sheet metal loading G1;
Loads that constitute the technological package of the adjacent internal floor G2
An influence length Li equal to the sum of the two halves of the centre distance between the analysed secondary beam and the adjacent one;
Variable load due to the category of use to which the building belongs, qk
Ptot is the total load applied on the structure that has to be transformed in kN/m so we multiply the result for the influence length.

Ptot= (G1+G2+ qk) x Li

G1 (kN / m2) CORRUGATED SHEET	G2 (kN / m2)
0.082	0.407

qk (kN / m2)	Li (m) interax	P(tot) kN/m
4	2	8.978

Tab.37:Total weight on the secondary beam

The structural plan next shows the highlighted secondary beam analysed.
Reference was made to a support-support static scheme, because of the constraints that bind the secondary beams to the main ones, with uniformly distributed load over the entire length of the profile, carried by the floor. From the diagram shown in the next page it is possible to go back to the formulations for the calculation of the static quantities that characterize the project situation, both in terms of actions on the section and in reference to the displacement components.

Analysed beam

Structural plan of the slab (+5.7

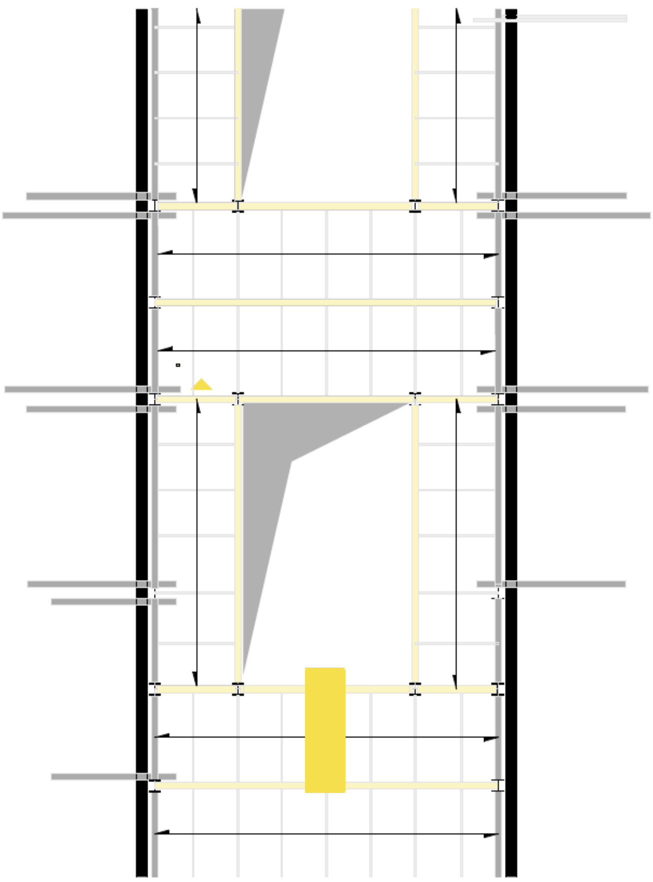


Fig.183:Structure showing secondary beams highlighted.

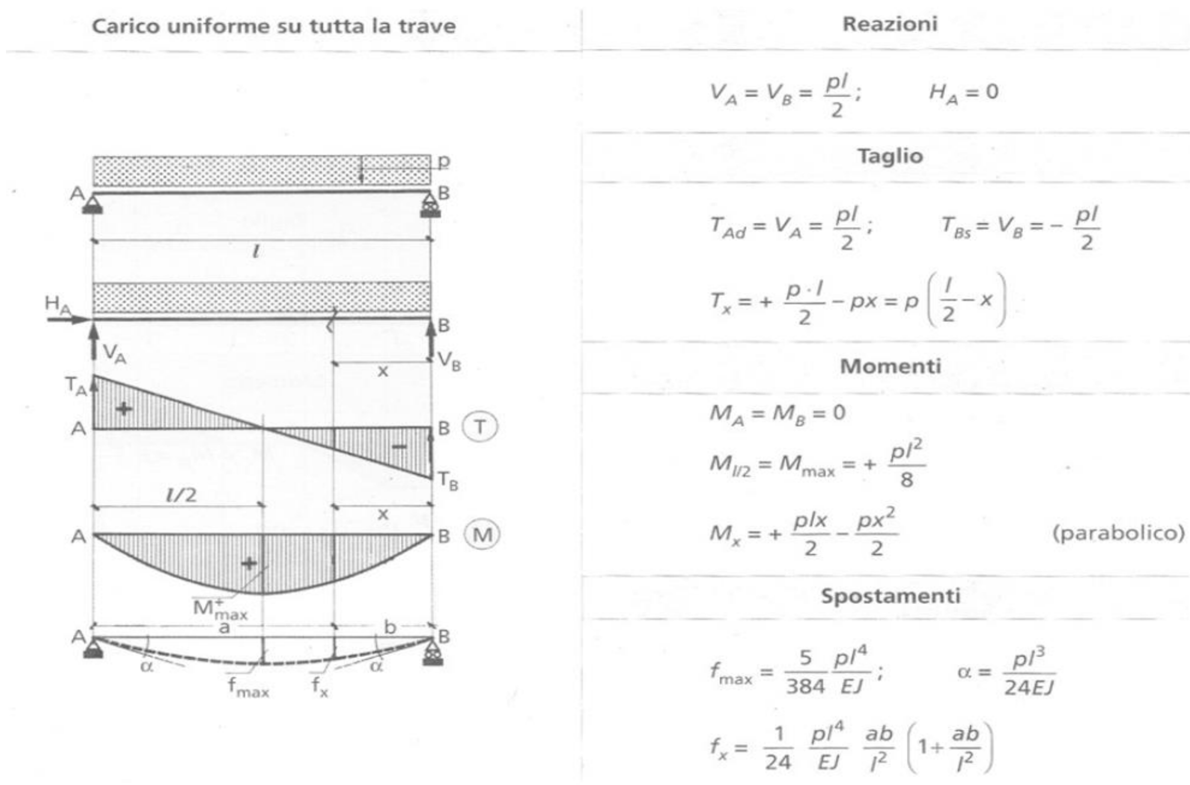


Fig.184:Diagrams table , axial , shear and moment diagrams.

The fmax value is the maximum deflection, needed to calculate the inertia of the beam so that I can find the correct dimensions.

f= fmax

f=1/250 f_{max}= 5/384 (p)(l^4)/EI

I_{max} = 0.00002279 = 7-4.92

It is assumed that the secondary central intermediate beam with an IPE 220 profile in hot rolled steel S-275JR characterized by a maximum inertia of Ix = 2772 cm4, has a length of 4 m and a centre distance of 2 m.

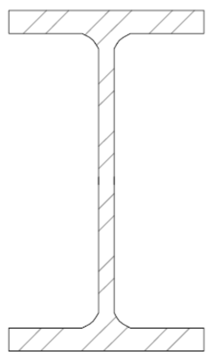
The designation of steel, in accordance with UNI EN 10027/1 refers to the following properties:
S indicates that we are referring to a steel for structural use (metal carpentry);
275 is representative of the yield stress (fyk);
JR indicates the resilience class of steel, aimed at avoiding brittleness at low temperatures.

G_1 secondary beam IPE 160= 0.154 (kN / m)

(Pitch of secondary beam)	fmax l/250	E kN/m2
3.7	0.0148	2,1 x

P kN/m	I max 250	IPE Profile
8.978	704.92	160

Tab.38:Pre-dimentioning of the steel profile from the Inertia



160 cm

82 cm

12.5.2 Primary beam catwalk sizing

The primary beam of the roof has 7 pointed loads that can be considered distributed, taking in consideration the small wheelbase between the loads of the secondary beams.

G1 (kN/ m2) Laminated sheet	G1 (kN/ m2) Secondary	G2 (kN/ m2)
0.4	0.154	0.082

qk (kN/ m2)	Li (m) influence	P(tot) kN/m
4	4	18.544

Tab.39:Total weight on the primary beam

Also in this case, to find the load on 1 linear meter of beam, I multiply the distributed load by the area of influence of the beam (s):

P(tot) = (G1 + G1 + G2 + qk) x Li [kN/m]

The fmax value is the maximum deflection, needed to calculate the inertia of the beam so that I can find the correct dimensions.

f= fmax

f=1/250 f_{max}= 5/384 (p)(l^4)/EI

I_{max}= 97160.99

(Pitch of secondary beam)	fmax l/250	E kN/m2
3.7	0.06	2,1 x

P kN/m	I max 250	IPE Profile
18.572	97160.99	500

Tab.40:Pre-dimentioning of the steel profile from the Inertia

It is assumed that the secondary central intermediate beam with an HEB 500 profile in hot rolled steel S-275JR characterized by a maximum inertia of Ix = 107.2 cm4.

$G_{1\ primary\ beam}$ HEB 500= 1.83 (kN / m)

Analysed beam

Pitch l= 15 m

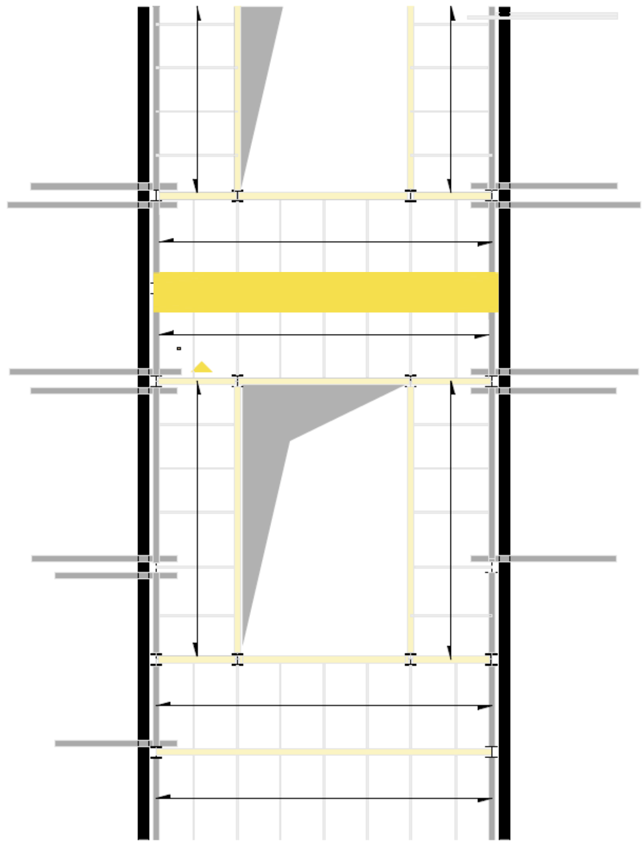
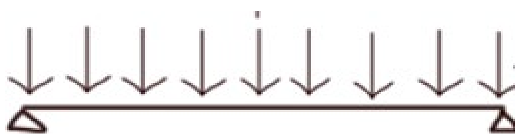


Fig.185:Structure showing secondary beams highlighted.



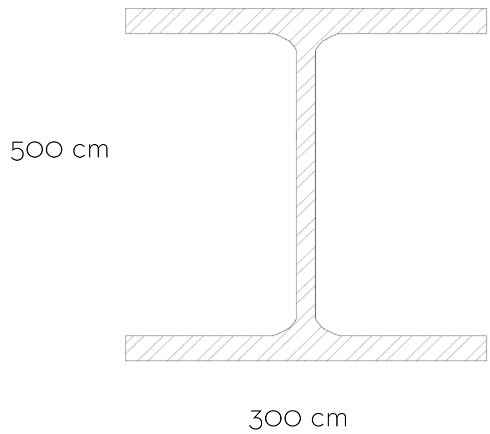


Fig.186:Commercial entrance

13. ENERGY ANALYSIS

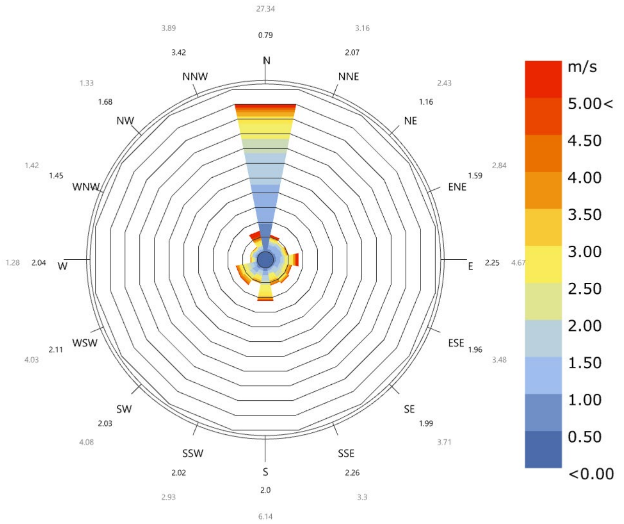
13.1. Introduction

Energy analysis is always one of the most important part of an architectural project, especially nowadays where the main attention is shifted on the climate changing and to find sustainable solution to reduce the impact of the human activities.

13.2. Climate Analysis

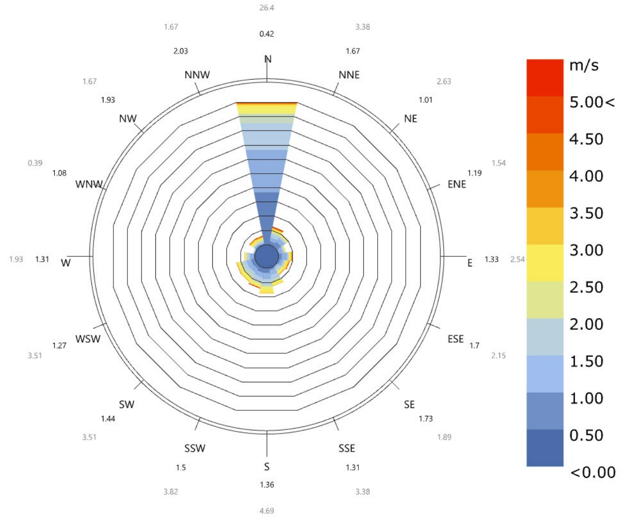
Using climate files we handle values for every 8760 hour of the year, obtaining a huge amount of output. We decided to start analysing three main index and the relationship between them: air temperature; relative humidity; solar radiation. We analysed the annual hourly trend of external air temperature finding that the climate in which we are going to develop our project. Furthermore we had to understand the current state of affair and the environmental effect throughout several broken down analysis as a start of implementing energy effeciency solutions and optioneering.

Wind rose



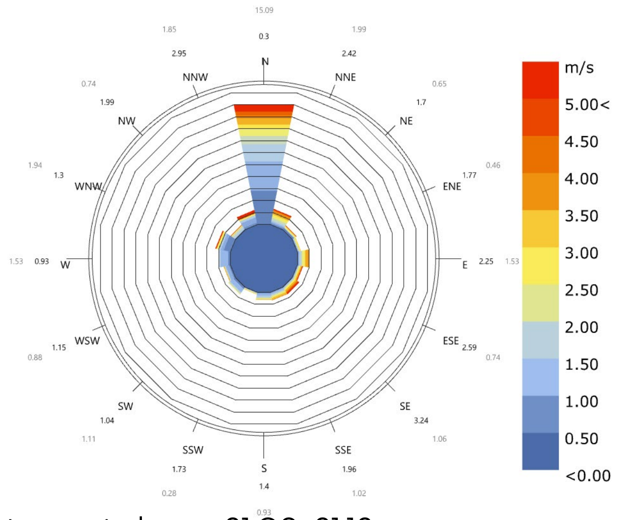
Spring wind rose: 21.03- 21.06

In this period of time we have the highest number of hours of wind coming from all the directions. It's also the period in which the speed close to zero is minimum.
At the same time the maximum values coming from the north direction, arrive to 10 m\s.



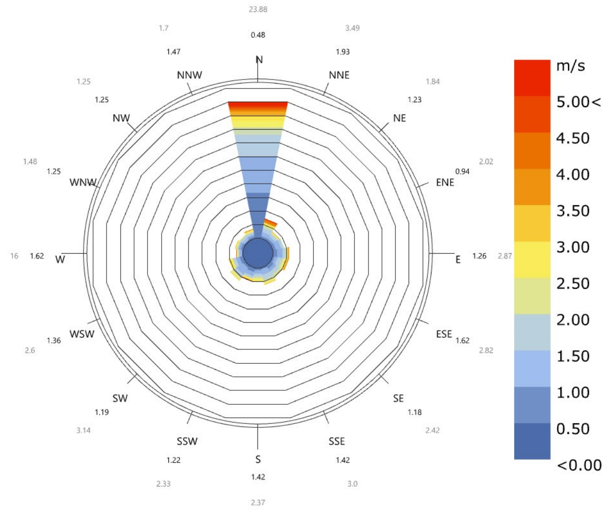
Summer wind rose: 21.06-21.09

The wind in summer has as maximum frequency in the North direction with 26,4 hours of wind. But the maximum velocity of the wind is around 5 m/s and just for a very small period of time.
The second part from where the wind blows is from the south but with 4,69 hours in three months.



Autumn wind rose: 21.09- 21.12

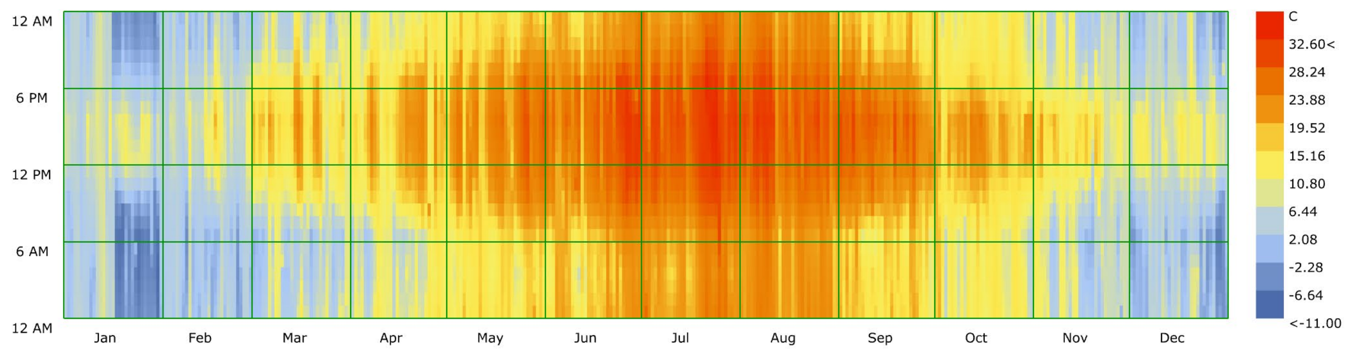
In this months there is a great amount of days without wind or with very low velocity, distributed uniformly from every direction. But from the north direction the wind arrives for 15 h along the period and with picks of velocity that arrives to 15 m\s.



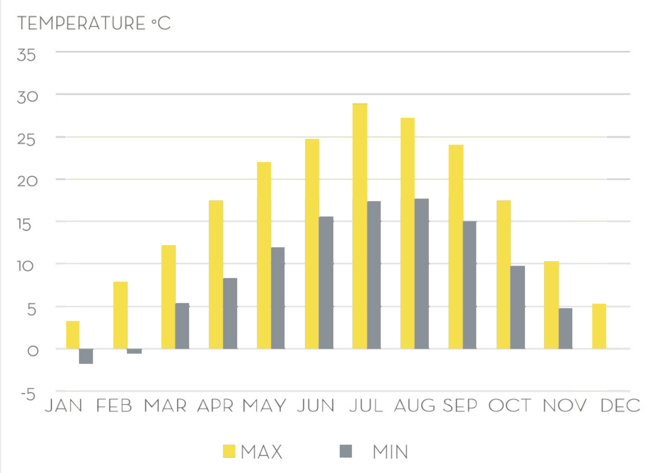
Winter wind rose: 21.12- 21.03

Here the values are similar to the winter ones, but the values with velocity close to zero are much less; the average speed is higher.
Here the maximum value reaches more or less 12 m\s always from the North direction.

Dry bulb temperature

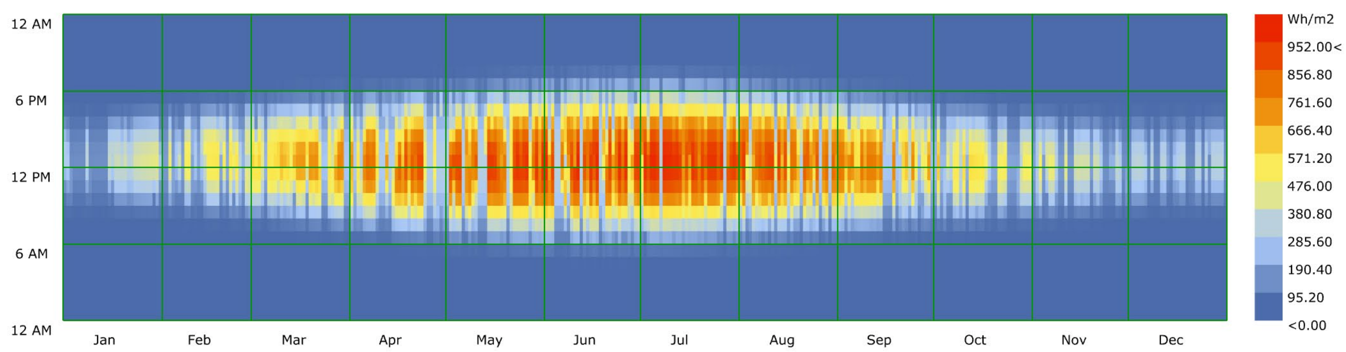


Dry Bulb Temperature (C) - Hourly
MILAN_ITA
1 JAN 1:00 - 31 DEC 24:00

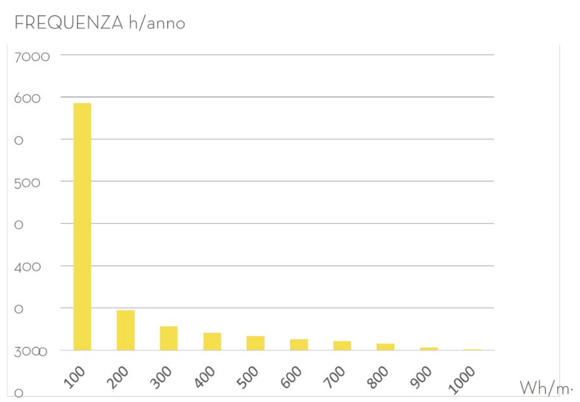


The graph shows the temperature trend: shades of blue are associated with low temperatures, vice versa red refers to high temperatures. There is an insistence of red in the summer months, where temperatures rise with peaks of up to 35 ° C. The graph is asymmetrical as autumn temperatures are higher than spring temperatures.

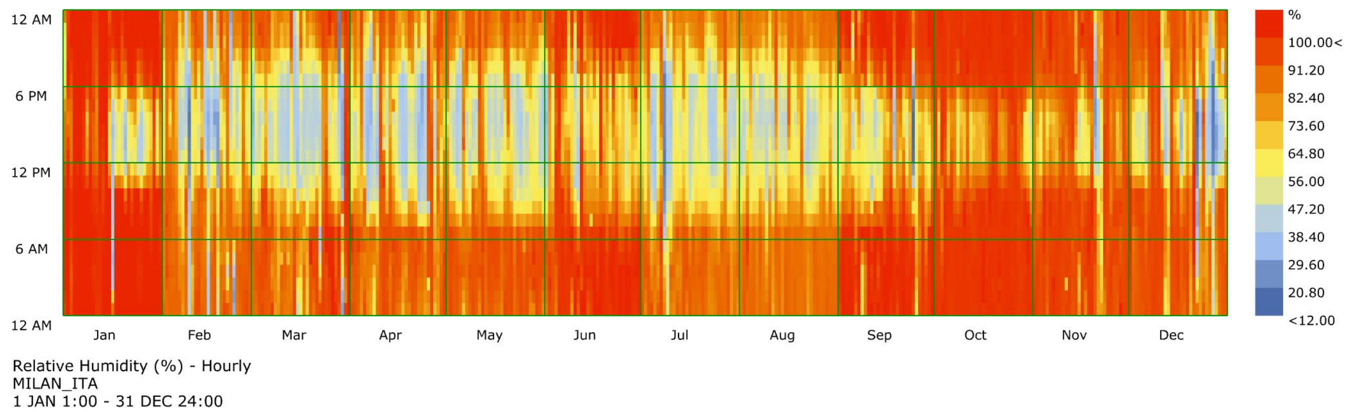
Global horizontal radiation

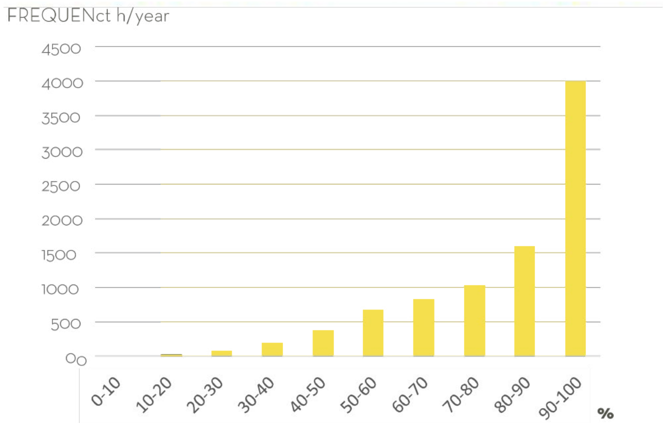


Global Horizontal Radiation (Wh/m2) - Hourly
MILAN_ITA
1 JAN 1:00 - 31 DEC 24:00



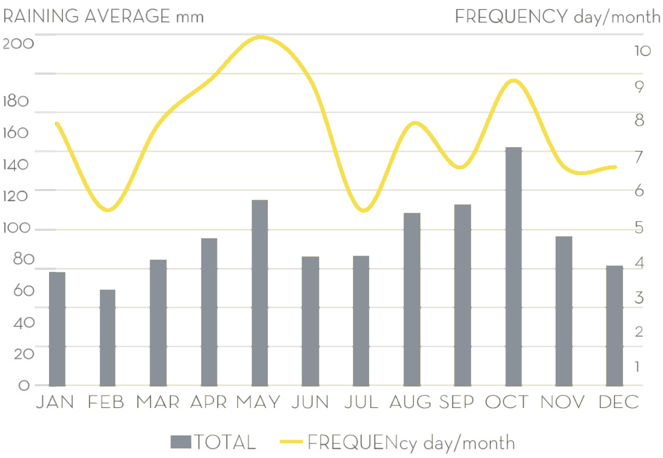
The greater the total daily irradiation, the greater the carpet is in favor of red. Global irradiation occurs predominantly in the central hours of the day, with a slight difference in the summer months, in which the most consistent irradiations also occupy the late morning and early afternoon. From the analysis of the graphs, an initial analysis can be developed on the need for shading systems both in summer and in winter; in the summer, the need for solar shading is greater. It will be useful to design and develop a shading system suited to the needs and requests for comfort related to the visual task and the intended use of the premises.



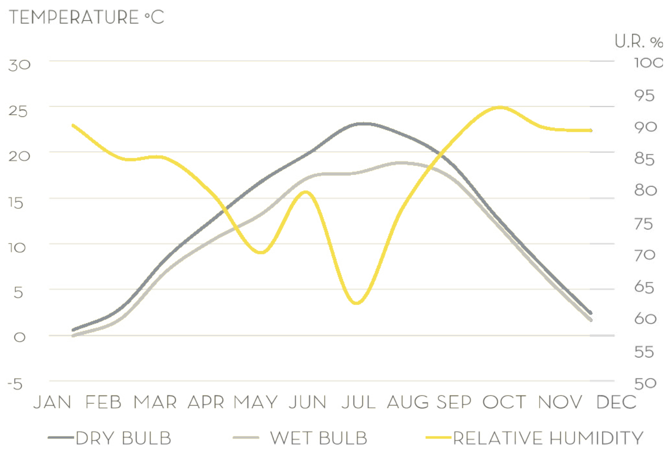


The lowest humidity is associated with red, while the days with higher humidity are highlighted in blue. It is noted that the hours with the highest humidity are morning and evening, while the afternoon hours have a drier climate. The annual average relative humidity records the value of 75.5% with a minimum of 70% in March and July and a minimum of 84% in December; on average there are 93 days a year with foggyepisodes. In summer, however, the values on average are quite high and due to the poor ventilation the heat is sultry.

13.3. Comparisons

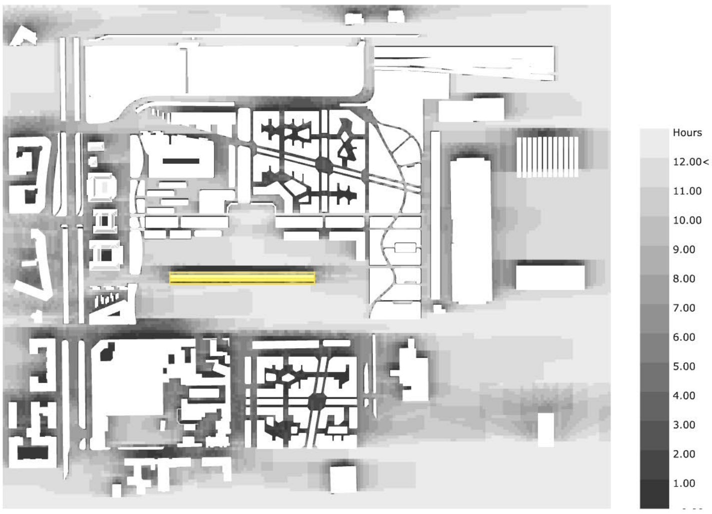


It is noted that the rains are more frequent in mid-seasons and in summer, correlated with thunderstorms and hail falls, especially in the afternoon and evening hours, due to the contrast of different types of air masses. It can be seen that in winter the mm of rain are less due to the snow fall.



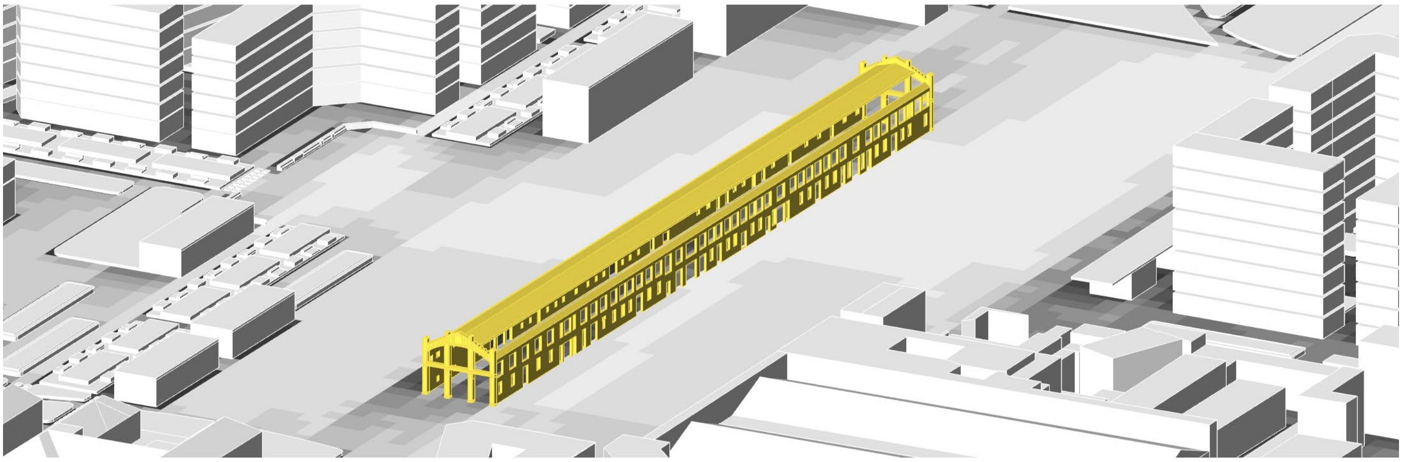
The graph shows the trend of the two curves concerning temperature and relative humidity. The temperature has a sweet and bell-shaped graph, regular with respect to the trend of the months. The humidity is irregular and follows an autonomous trend; temperature and relative humidity are not correlated.

13.4. Shadows Analysis

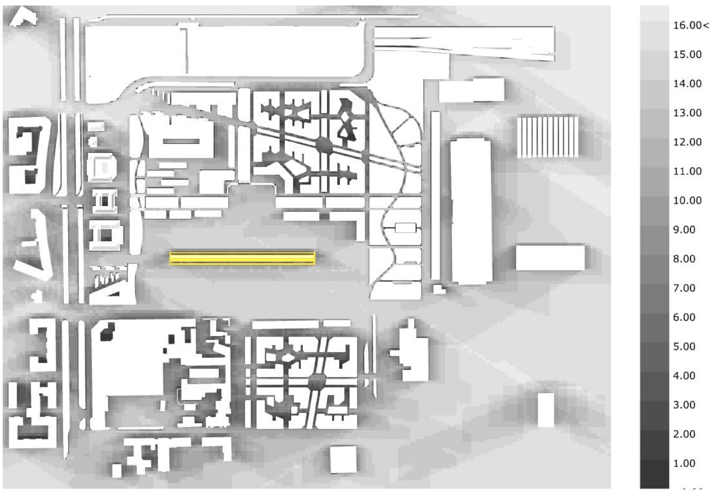


Spring equinox 03.21

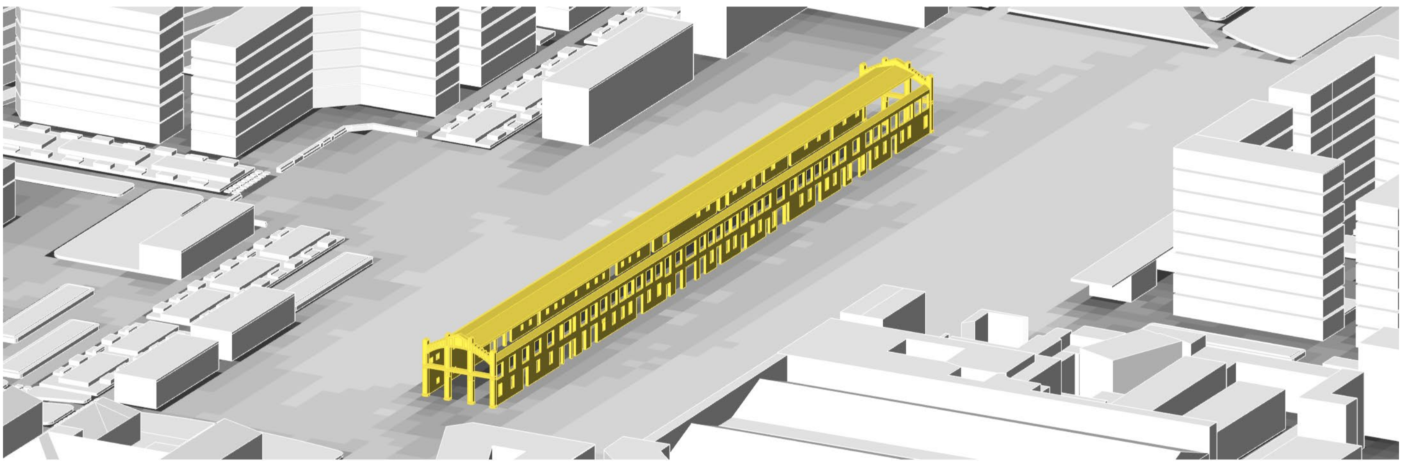
In the intermediate seasons the results are similar. The maximum value reached is 10 hours of sun and the area has a good amount of sun all day long. Another important feature is that no shadows arrive to the Gallery of our interest.

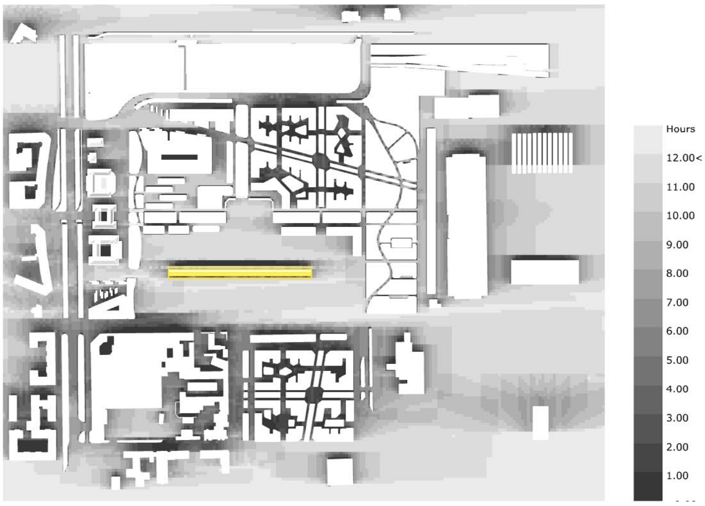


Summer solstice 06.21



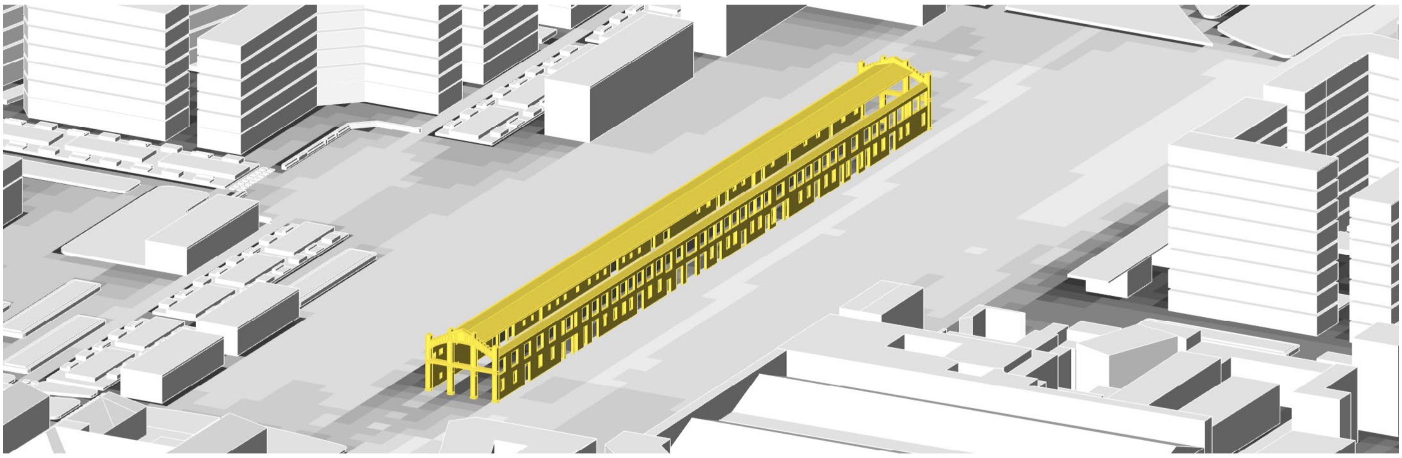
On summer the hours of sun arrive to 16 and the area is not well shaded so this is one of the factors that increase the heat island problem, bringing the temperature to 40 degrees. In the plaza and next to the Galley there are no shadows nearly all day.

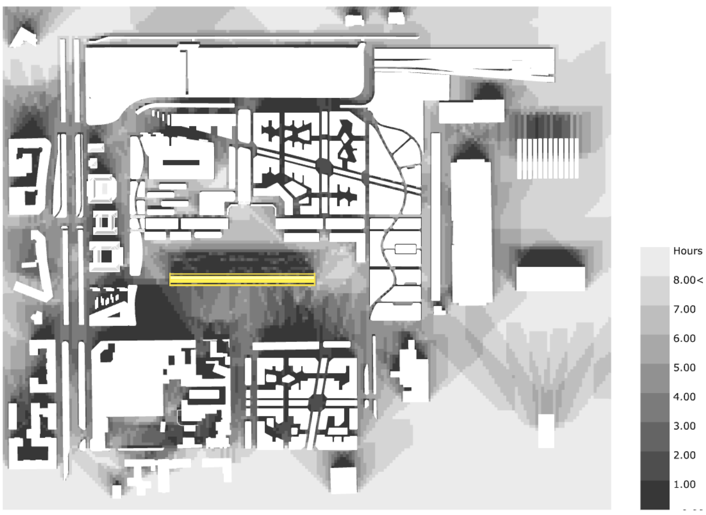




Autumn equinox 09.21

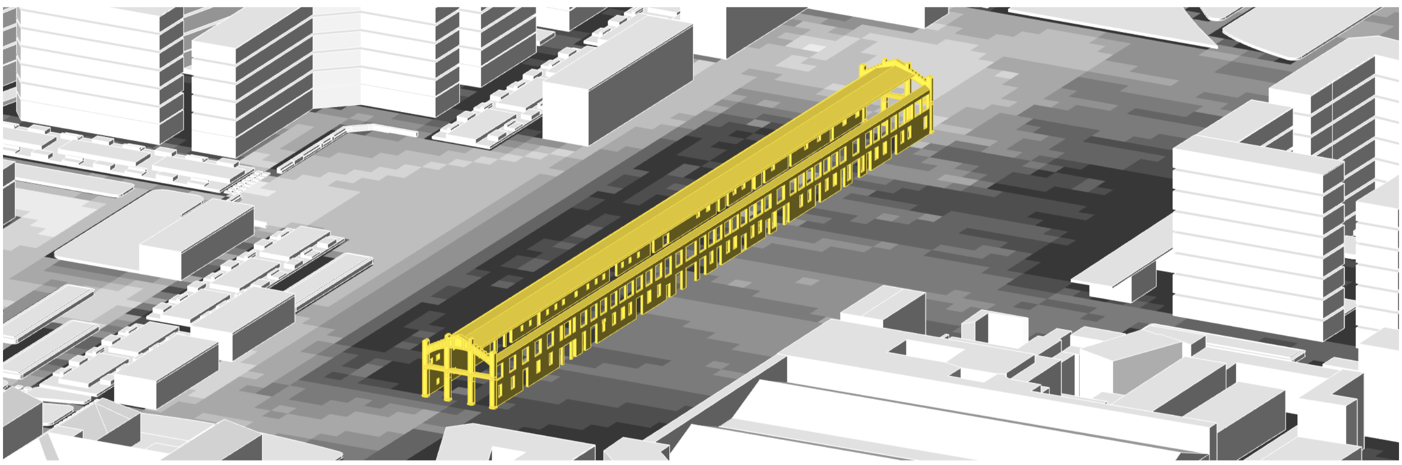
Here we have similar values as spring with very few shadows more next to the highest buildings.
Also if the sun is a bit lower than in spring, the maximum value reached is 12 hours of sun along the day, having so a good amount of sun all day long.
Next to the gallery there are shadows just in the northern facade.





Winter solstice 12.21

In winter the hours of sun decrease enormously arriving to maximum value of 8 hours per day. The problem increase in the south part of the project where the buildings are higher, but fortunately decrease in the centre, where the plaza is located.



13.5. Schematic section design

As the first step of the energy analysis, we thought about a schematic design of the laboratory area, the part of the building in which we were more interested in to analyse. This step is foundametal in each project path because it allows the designer to think about the building as an element that has to blend in the place where it is rising. The view is mostly related to the possible energy behaviours of the building and the strategies that could be used to reduce the negative impact of the building to the eco-system such as the the increasing of the heat island effect, the CO_2 production and the too high energy consumption.

In the picture below we can see different strategies for the Green Hill Research Centre such as:

- the re-use of the rain through a collective system that absorbs water from the green roof and the soil around the building and it allows the water to recirculate to be used expecially for the activities of the labs, the irrigation of the greenhouse and the public bathrooms.
- the greenhouse on the South facade acts as a natural green shading system that reduce the radiation energy avoiding it to go inside the building, keeping under control the rise of the temperatures and saving energy for cooling purposes.
- an horizontal shading system for the laboratories that reduce the radiation on the facade and keep a good amount of daylight factor for the working space, increasing the comfort of the space in terms of temperature and visibility (glare reduction).
- a good choice of the construction materials for the building envelope that reduce the U value of the wall, the floor, the roof and the windows of the laboratories.
- a system of photovoltaic panels that is able to produce energy to be used in the system to safe a great amount of energy, expecially for the light system and the technical equipment of the laboratories, thanks to the southern orientation of the building.
- a use of natural ventilation through various openings at the ground floor to favor the passage of outdoor air in the building, expecially during Spring and Autumn, seasons with good outdoor temperatures for the climate of Milan.

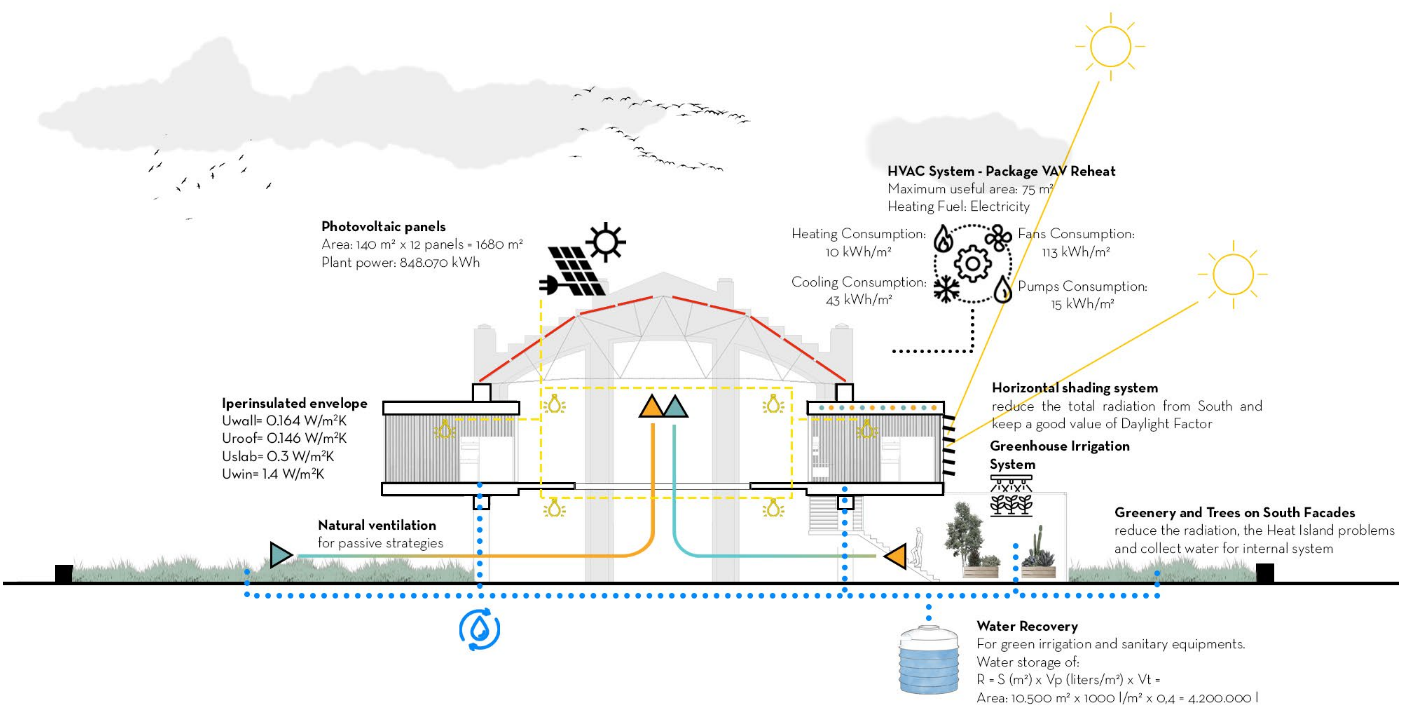


Fig.187:Schematic design section - Energetic strategies

13.6. Outdoor Comfort Analysis

We decided to start performing an analysis on the project site with a focus on the creation of a comfortable microclimate that mitigates especially the hot summer climate. The evaluation of thermal comfort is complex as it involves many parameters: air temperature, radiant temperature from surrounding objects, relative humidity, wind speed, clothing level and activity level. The material choice can impact the thermal sensation in areas with a high direct sunlight exposure. The amount of solar radiation (heat) that is reflected by the material is higher with lighter materials. Trees are used to reduce the direct sunlight radiation on the surfaces, having a significant impact in pedestrian thermal sensation. These values are translated in an "apparent temperature", which is the "felt" temperature and it is measured according to the Universal Thermal Climate Index (UTCI) that takes in consideration different parameters such as air temperature, Mean Radiant Temperature (MRT), relative humidity, air velocity, clothing level or metabolic rate (activity level). According to ASHRAE, the "thermal comfort" is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation. Good outdoor thermal comfort is encourage people to spend time outdoors in urban environments, which is beneficial for both physical and social well-being and the local economy. A wholistic methodology to evaluate outdoor thermal comfort is needed to inform urban planners and urban designers on the best way to make the best design choices. The impact of urban design on outdoor thermal comfort hasn't been completely understood yet, due to the lack of wholistic tools. There is a lack of human perspective focused on the microclimate of outdoor spaces.

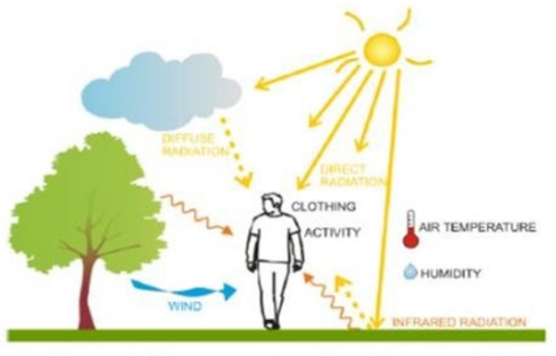


Fig.188:Outdoor Thermal comfort variables

UTCI (°C)	Stress category
UTCI > 46	extreme heat stress
38 < UTCI < 46	very strong heat stress
32 < UTCI < 38	strong heat stress
26 < UTCI < 32	moderate heat stress
9 < UTCI < 26	no thermal stress
0 < UTCI < 9	slight cold stress
-13 < UTCI < 0	moderate cold stress
-27 < UTCI < -13	strong cold stress
-40 < UTCI < -27	very strong cold stress
UTCI < -40	extreme cold stress

Fig.190: UTCI comfort index scale

To perform the energy analysis we decided to use a component of Grasshopper that is called "Ladybug", that allowed us, through a Wheater Data file (.epw), of the city of Milan downloaded from the EnergyPlus website, to study the weather condition of the site, all over the year.

Fig.189: Softwares used for the energetic analysis, Grasshopper, Ladybug and Honeybee

Moreover, we had to recreate a simpler version of the 3D model of the real one, using just surfaces without a thickness to reduce the time of the analysis.
The Outdoor Comfort Analysis is divided in two parts:

1. The analysis with an empty surroundings around the old Macello Gallery, that was our starting point for the project
2. The analysis with the renovated building and the presence of the surroundings: greenery, shading elements and trees.

Trees as natural heating mitigator

To improve the pedestrian comfort we used green areas and trees as shading elements that can reduce the impact of the solar radiation on the surfaces. Trees and other plants help cool the environment, making vegetation a simple and effective way to reduce urban heat islands.
Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, 11–25°C cooler than the peak temperatures of unshaded materials. Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 1–5°C.
Trees and vegetation are most useful as a mitigation strategy when planted in strategic locations around buildings or to shade pavement in parking lots and on streets. Researchers have found that planting deciduous trees or vines to the west is typically most effective for cooling a building, especially if they shade windows and part of the building's roof.
The use of trees and vegetation in the urban environment brings benefits beyond mitigating urban heat islands including:

- Reduced energy use: Trees and vegetation that directly shade buildings decrease demand for air conditioning.
- Improved air quality and lower greenhouse gas emissions: By reducing energy demand, trees and vegetation decrease the production of associated air pollution and greenhouse gas emissions. They also remove air pollutants and store and sequester carbon dioxide.
- Enhanced stormwater management and water quality: Vegetation reduces runoff and improves water quality by absorbing and filtering rainwater.
- Reduced pavement maintenance: Tree shade can slow deterioration of street pavement, decreasing the amount of maintenance needed.
- Improved quality of life: Trees and vegetation provide aesthetic value, habitat for many species, and can reduce noise.

From the image we can easily see the differences of the perception of the thermal comfort thanks the presence of the trees

Because of this fact, we decided to design our landscape using mostly green natural elements and then, we analysed the whole surrounding with two scenarios, that represent the worst weeks of the year in Milan: the Extreme Hot Week and the Extreme Cold Week that go respectively from the 6 to 12 of July and from 13 to 19 of January.

13.7. Sunlight hours analysis.

As we already shown in the schematic design section, the longer parts of our building are oriented on South and North, because of that, we have to understand how to the sunlight and the amount of hours that, during a certain period, hit the building surface because it could be one of the first most important aspects to start with for an energy analysis.
We set two different analysis periods to simplify the calculations: June, the month with the higher number of sun hours and December, the month with the lower number of sun hours.

June sunlight hours

State of affairs

Using the color gradient from the legend, we can easily observe the most exposed surfaces of the building such as the roof and the southern walls while the entrance on the western side is low exposed. In particular the problem is related mostly to the surrounding, that receive the highest amount of sunlight, increaseasing the level of discomort for the people living the space outside.

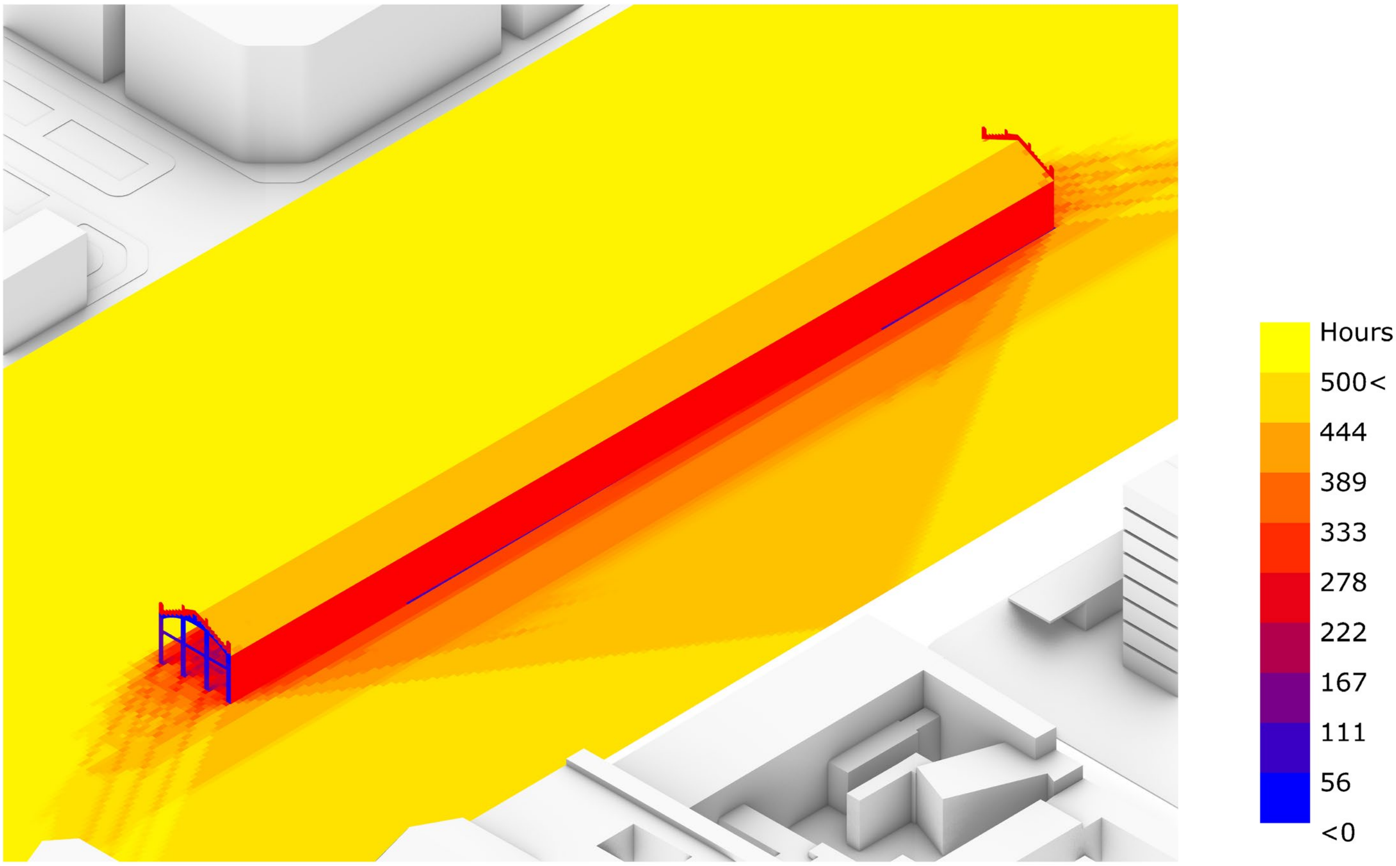


Fig.191: Axonometric view of sunlight hours study

Fig.192: Top view of sunlight hours study

State after the project

After the initial analysis we decided to reduce the sunlight hours hitting the surfaces, adding shading elements such as the trees, the curved green roof of the gallery and the small buildings around. In fact we can observe how the gradient colors change in proximity of the added elements having a less number of hours and improving the microclimate condition. Trees as a natural shading system, are really important in the design process of a project but sometimes they are not used so frequently.

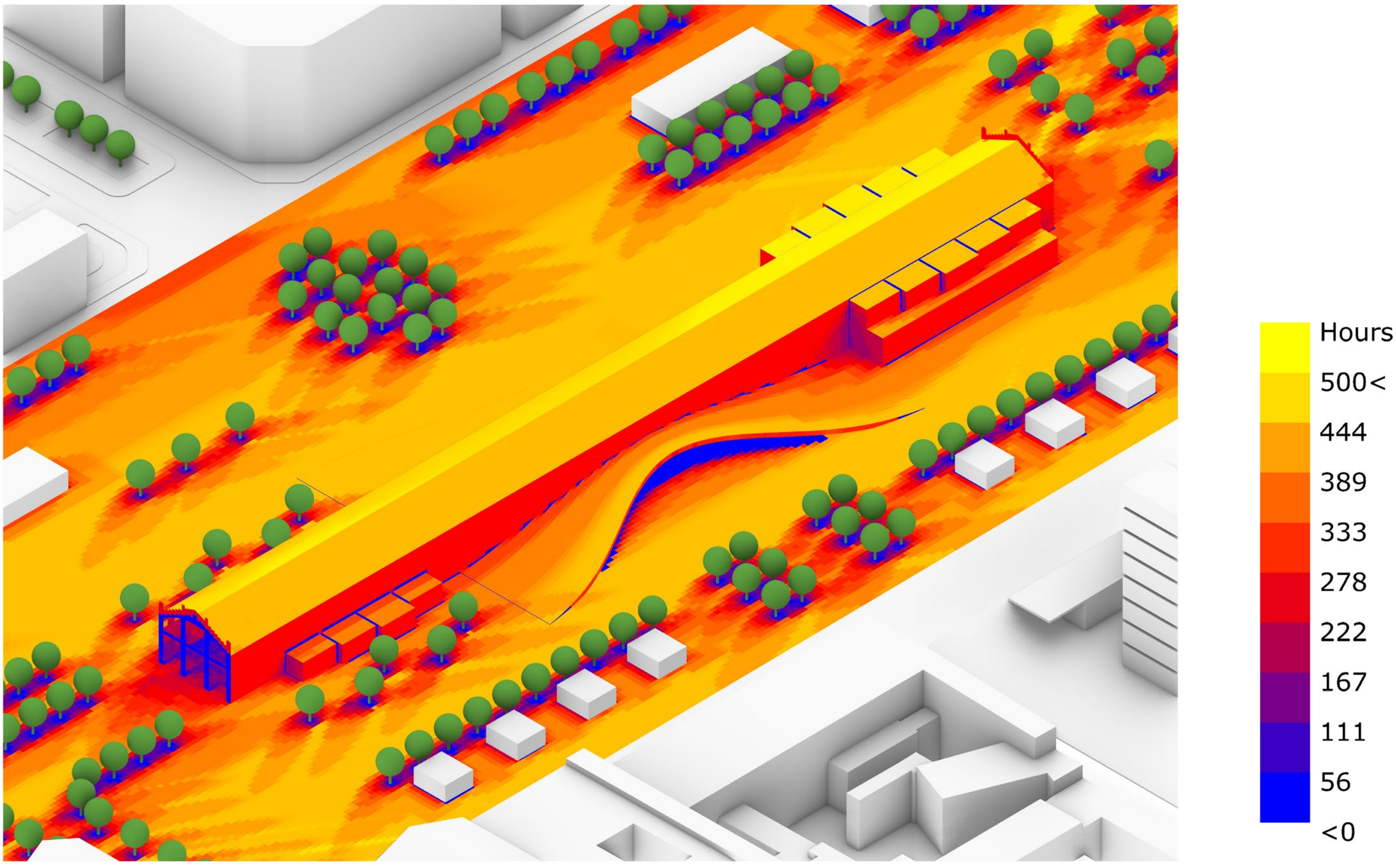


Fig.193: Axonometric view of sunlight hours study

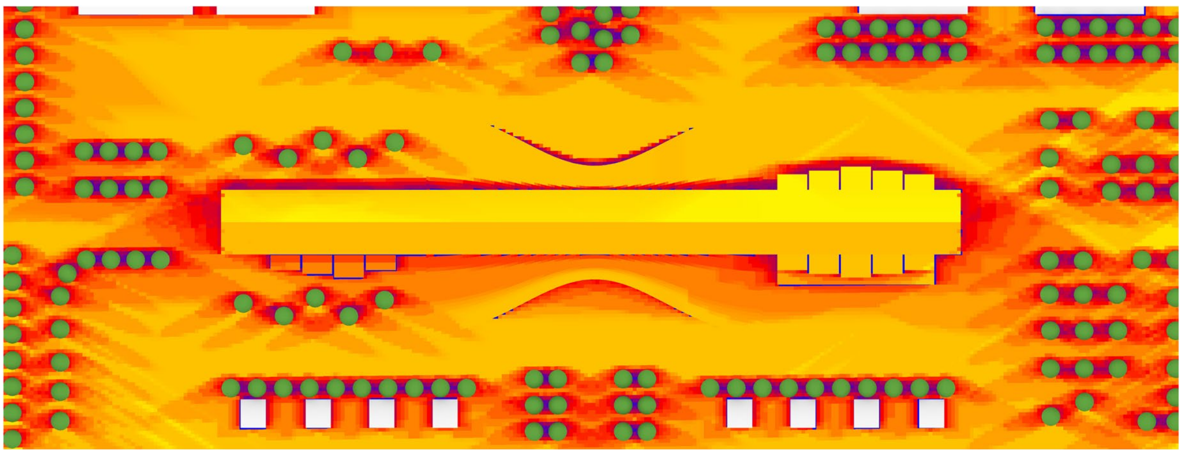


Fig.194: Top view of sunlight hours study

December sunlight hours

State of affairs

During the shortest month of the year we can observe, from the monthly analysis, how the site was affected by the sunlight in the previous state with an empty surroundings. We can clearly see that the building itself is the only shading element of the site in fact only the part on the back and the western facade have just few hours of sun during the month of December. Anyway this situation isn't problematic during winter but will give some problems expecially in summer, as we already seen. Using the color gradient from the legend, we can easily observe the most exposed surfaces of the building such as the roof and the southern walls while the entrance on the western side is low exposed.

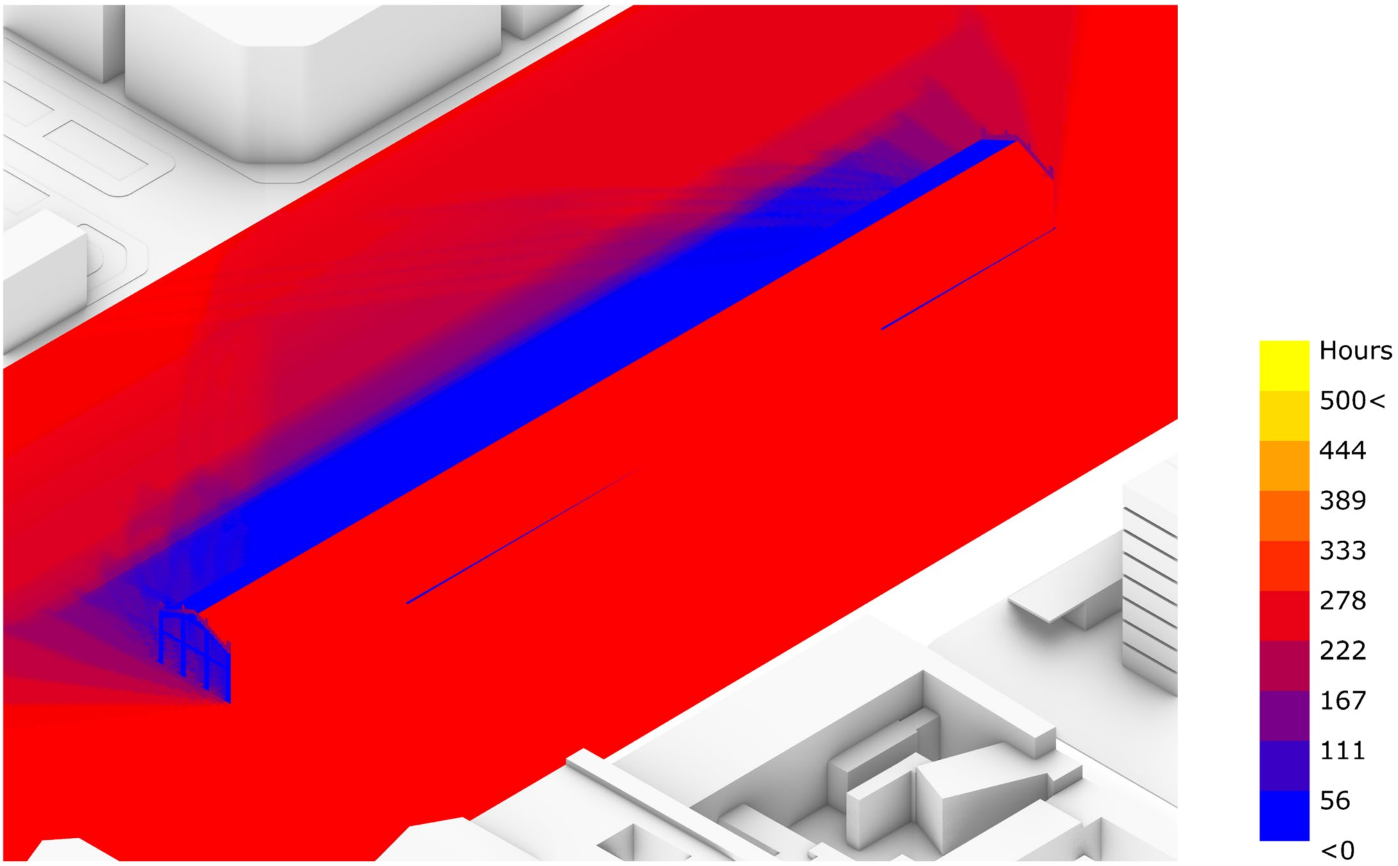


Fig.195: Axonometric view of sunlight hours study

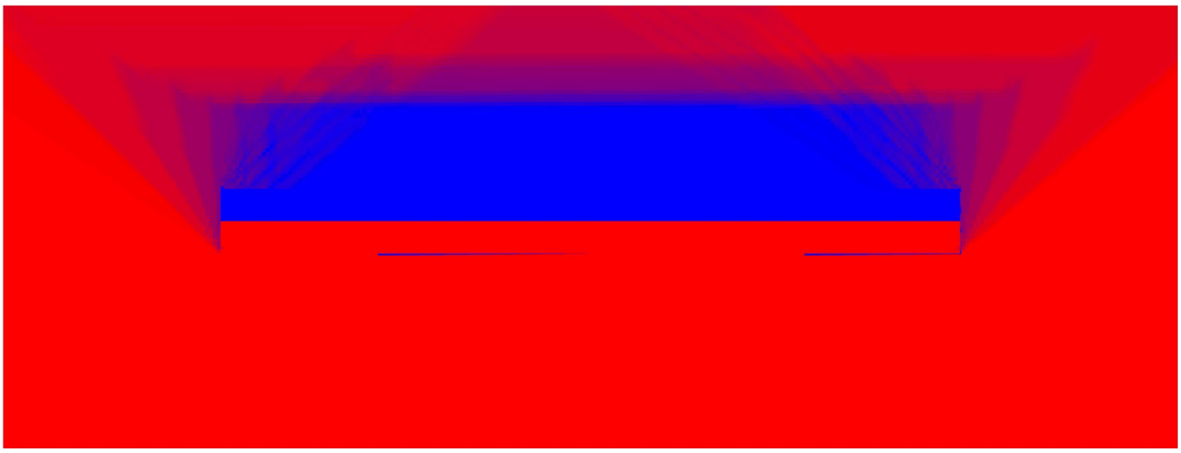


Fig.197: Top view of sunlight hours study

State after the project

The winter analysis is interesting just in the comparison to understand the amount of hours that the surfaces receive. We can easely observe that the shadowed areas that in June receive about 400 hours of sun, in December just receive about 60 hours and this will obviously affect the outdoor thermal perception but anyway, this result is negligible due to the fact that we are speaking about an external part.

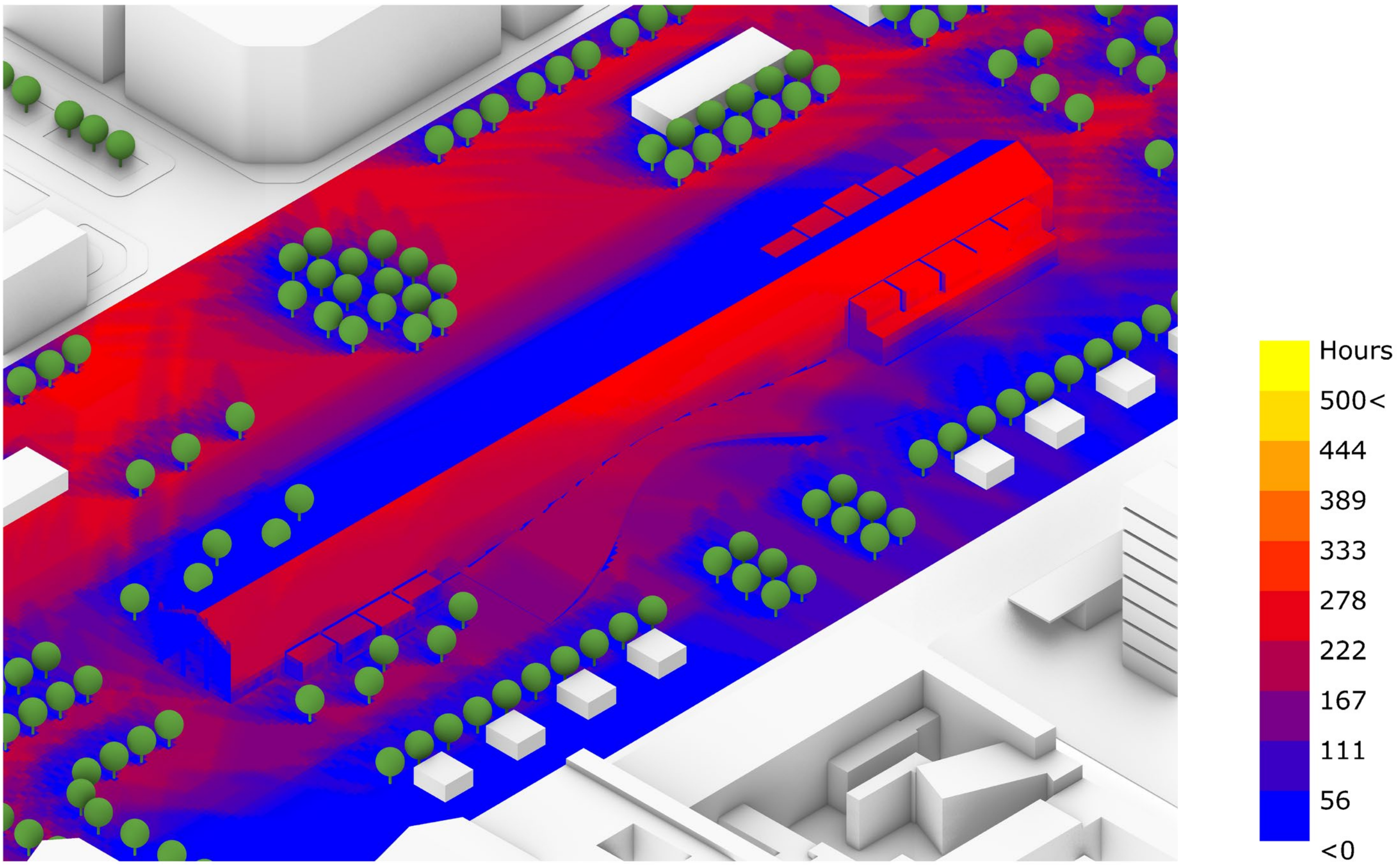


Fig.198: Axonometric view of sunlight hours study

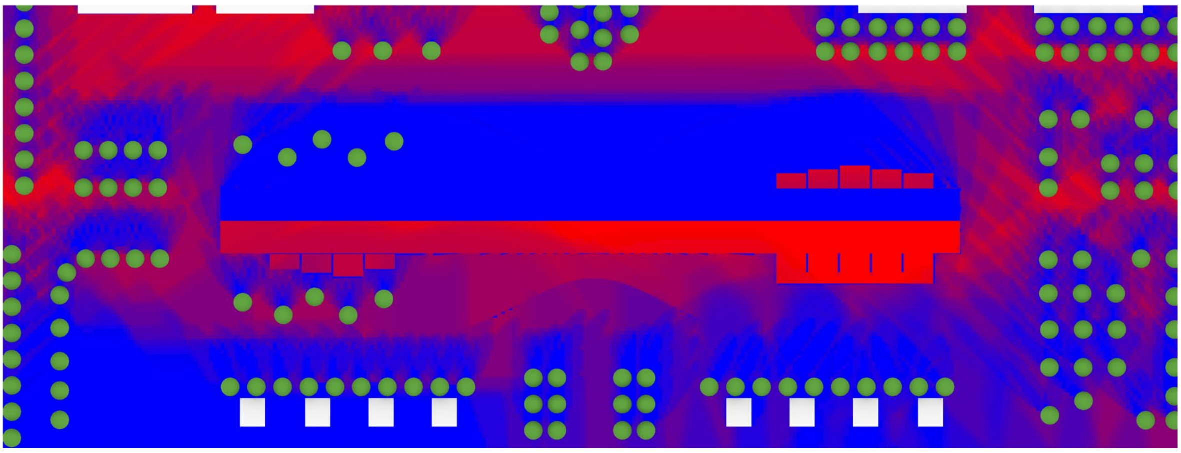


Fig.200: Top view of sunlight hours study

Thermal Comfort Analysis - Hottest week of the year

State of affairs

The outdoor comfort during the hottest week of the year reaches critical levels on our project site expecially because of the amount of the sunlight hours and the absence of shading element that are necessary to decrease the UTCI index.

In fact we can see that quite all the area has no shadows and the red color shows an UTCI index value close to 32 that means “strong heat stress”.

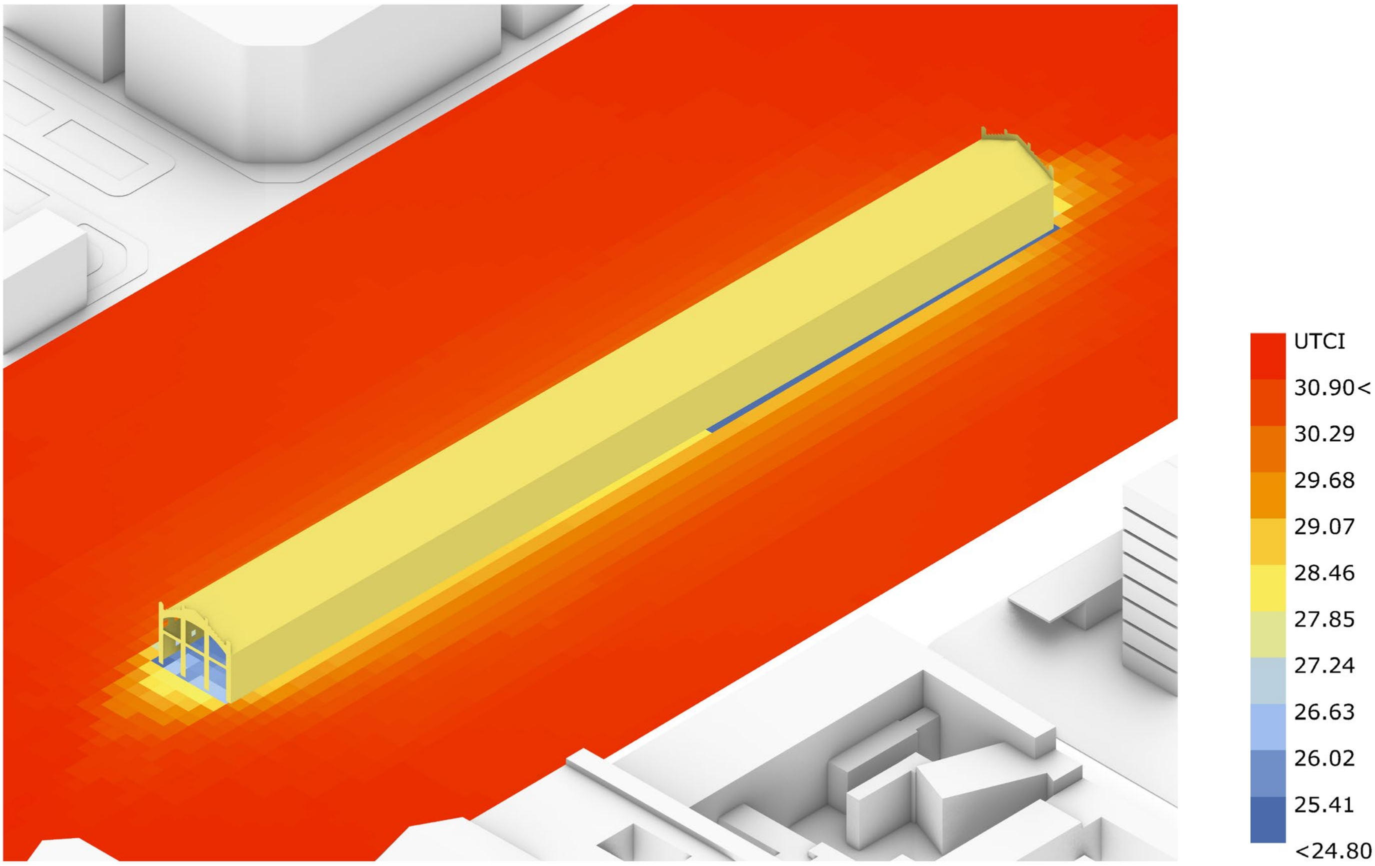


Fig.201: Axonometric view of sunlight hours study

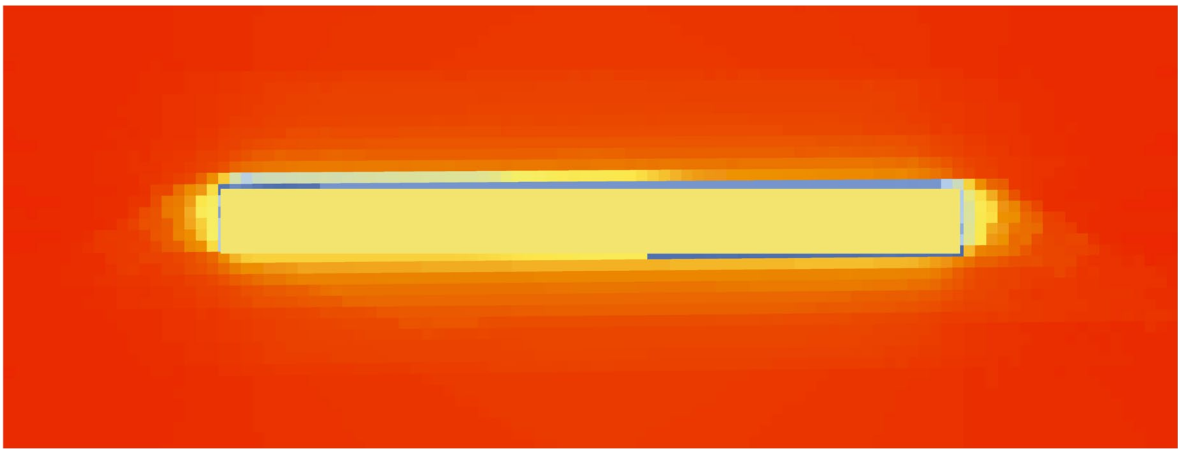


Fig.202: Top view of sunlight hours study

State of project

The outdoor design choices are mostly related to the improvement of the outdoor comfort. The natural elements are used reduce the UTCI index locally with the help of the green areas thanks to the evaportranspiration of the soil.

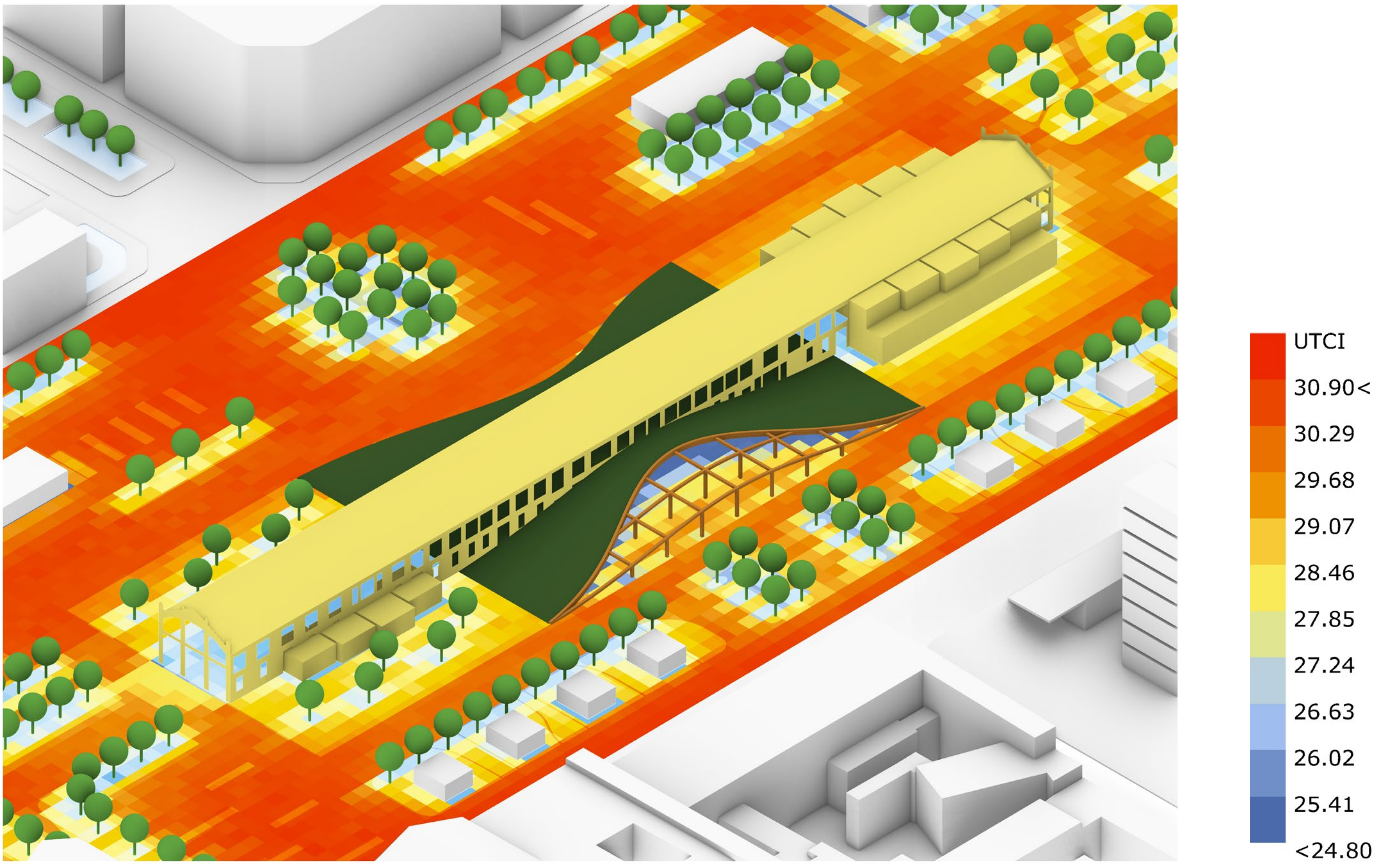


Fig.203: Axonometric view of sunlight hours study

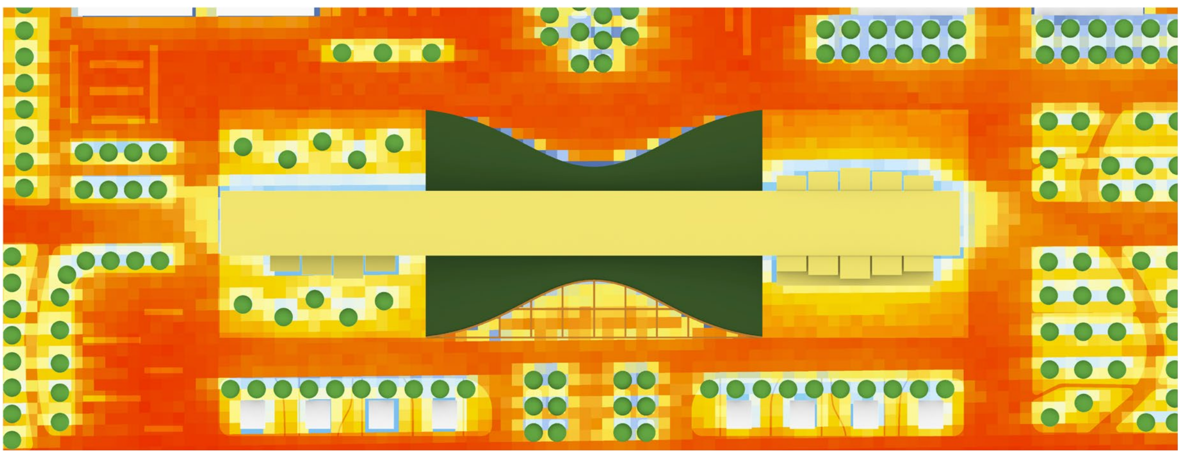


Fig.204: Top view of sunlight hours study

Thermal Comfort Analysis - Coldest week of the year

State of affairs

In coldest week of the year we can observe a drastical reduction of the UTCI index due to the outdoor temperatures. Expecially the part on the northern side of the building that is overshadowed has a value of -5.38, while the highest one is 3.92 that is spread all over the surrounding.

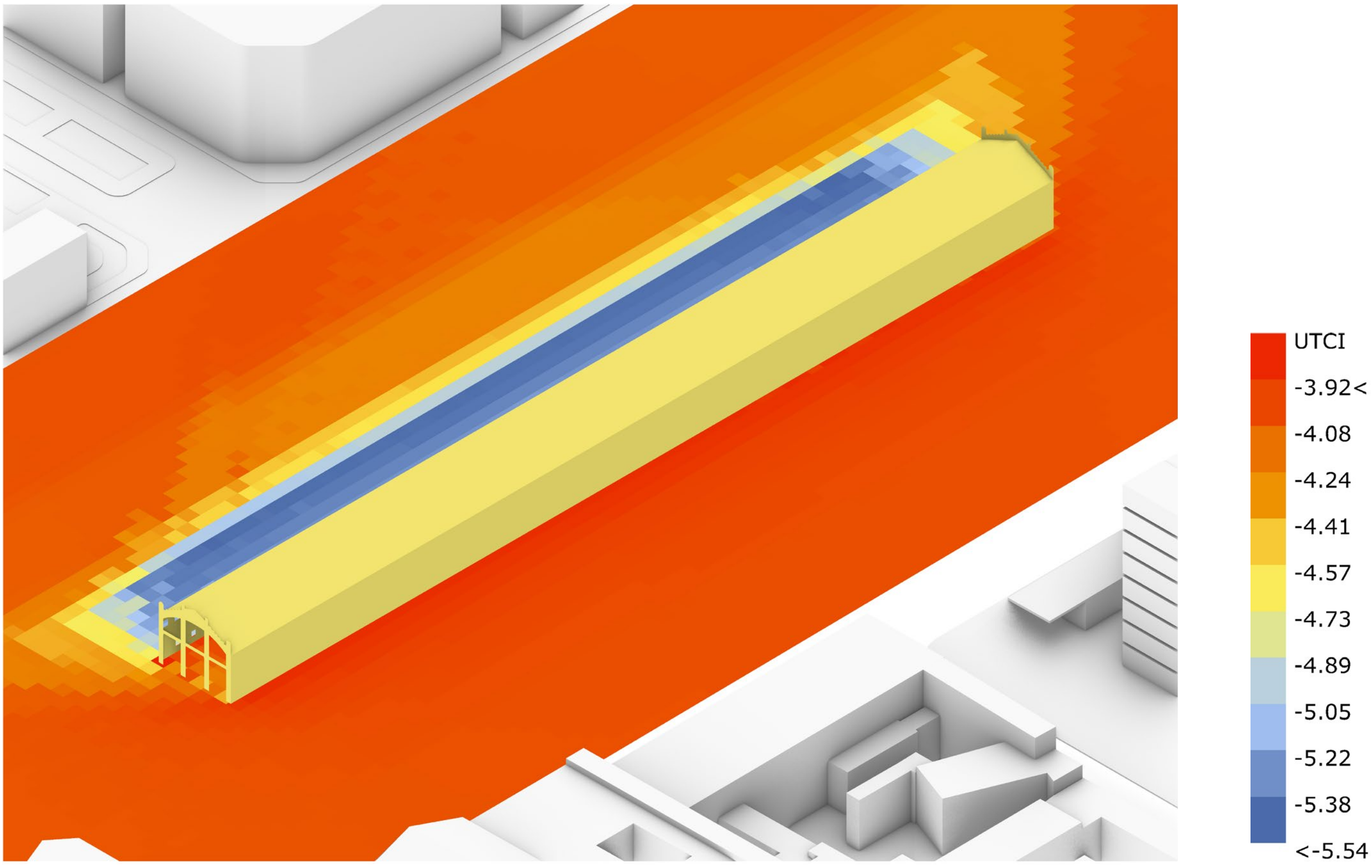


Fig.205: Axonometric view of sunlight hours study

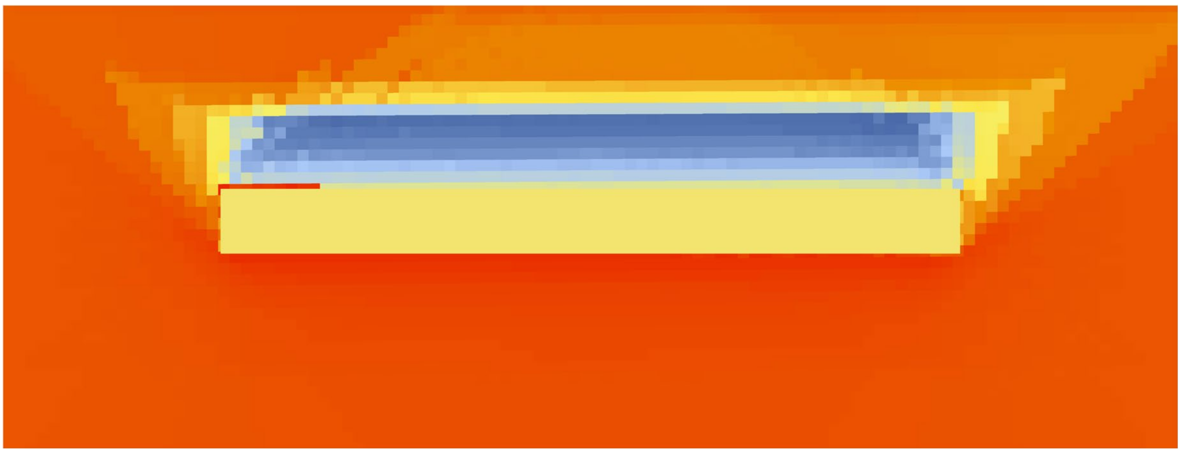


Fig.206: Top view of sunlight hours study

The addition of the shading elements, such as trees, the curved green roof, the parts of the building itself and the greenery are not so effective during winter time because it reduces the UTCI index. Anyway this change is negligible because it is mostly related to winter climate conditions.
This image is just for comparison purposes.

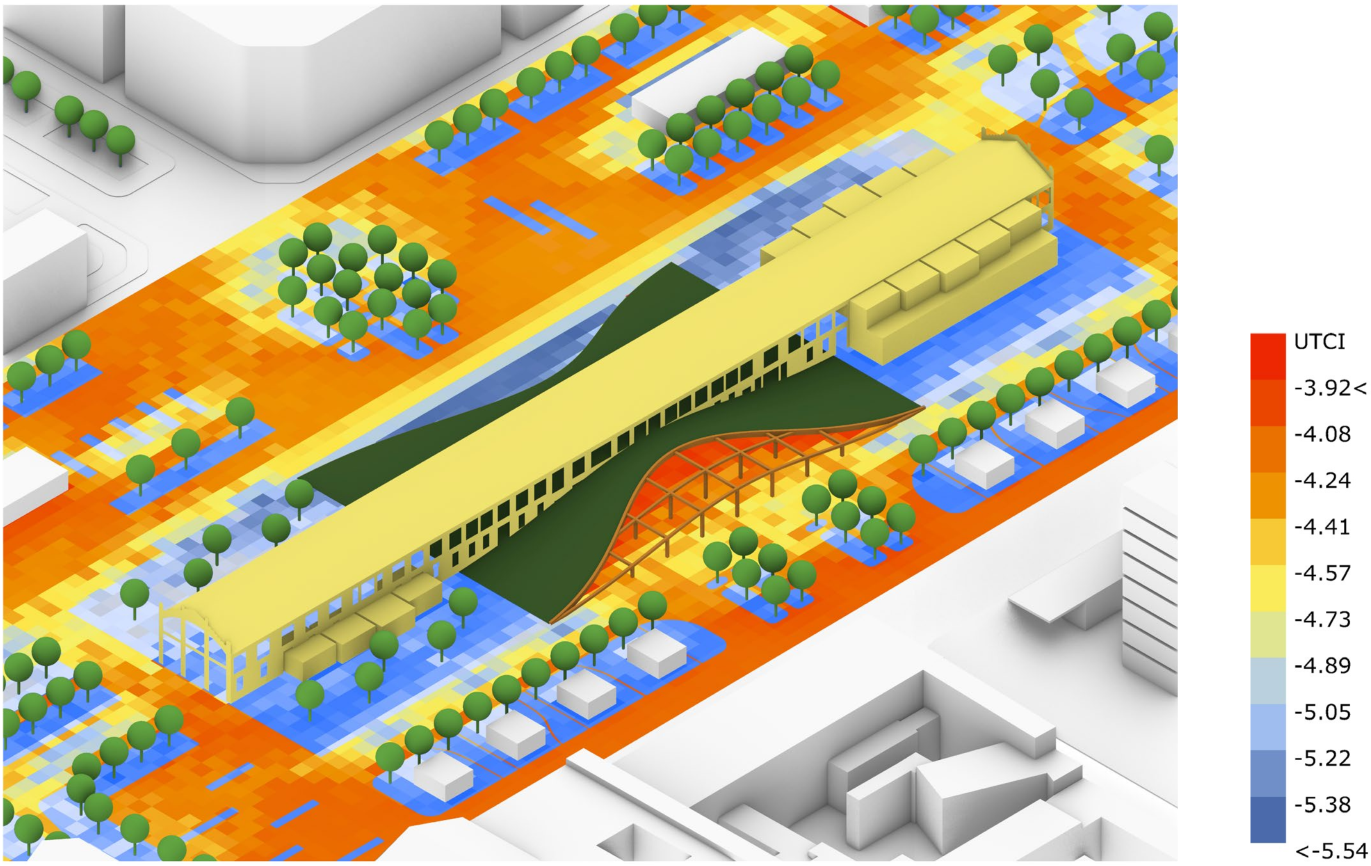


Fig.207: Axonometric view of sunlight hours study

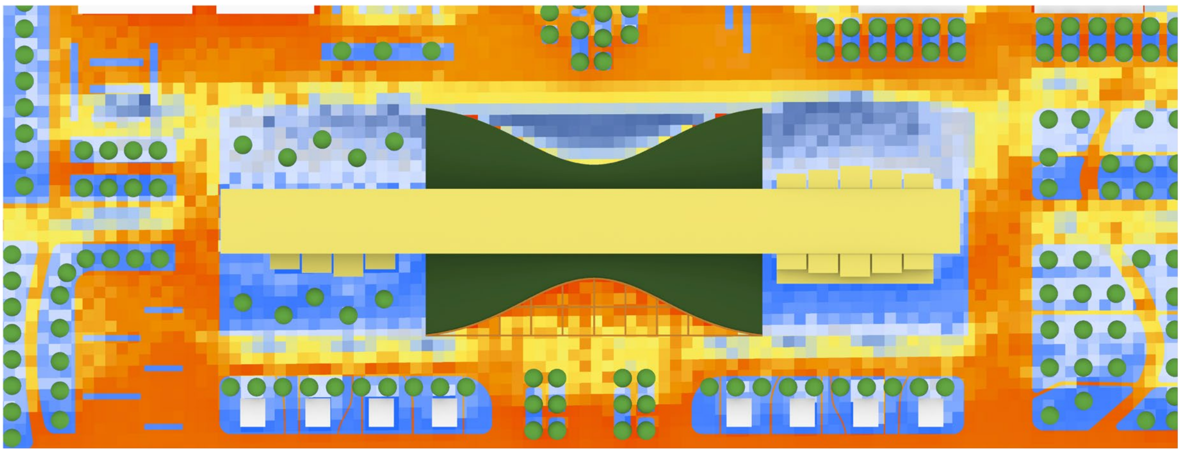


Fig.208: Top view of sunlight hours study

Designing with light

One of the fundamental aspects for the design of quality environments is certainly the light. In fact, if well designed, it guarantees visual comfort and the "pleasantness of being in a place". Light is one of the main tools to facilitate orientation and to define interior spaces based on the functions that will take place there, defining the importance of one environment over another. In a research center also designed to accommodate other functions, such as study rooms and commercial activities, designing the light according to functional needs helps to characterize the environments. Furthermore, the quality of light is a fundamental factor in guaranteeing the psychophysical well-being of those who use the space, especially in the case of reading or study environments, careful management of light increases concentration and comfort and encourages users to stop by.

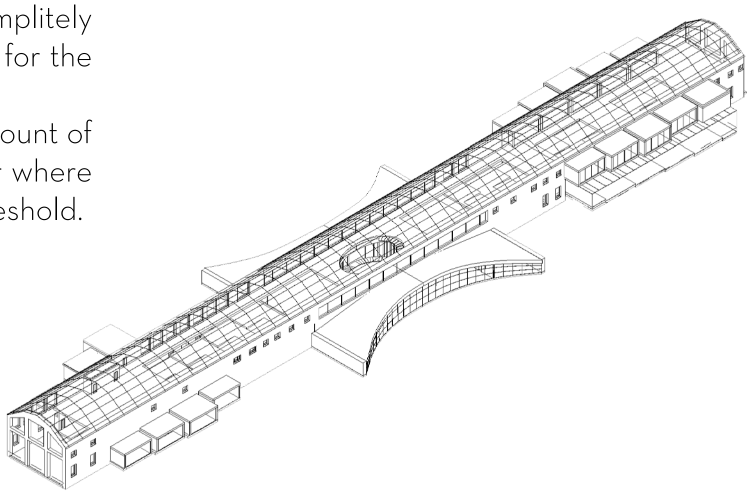
Preliminary architectural choices

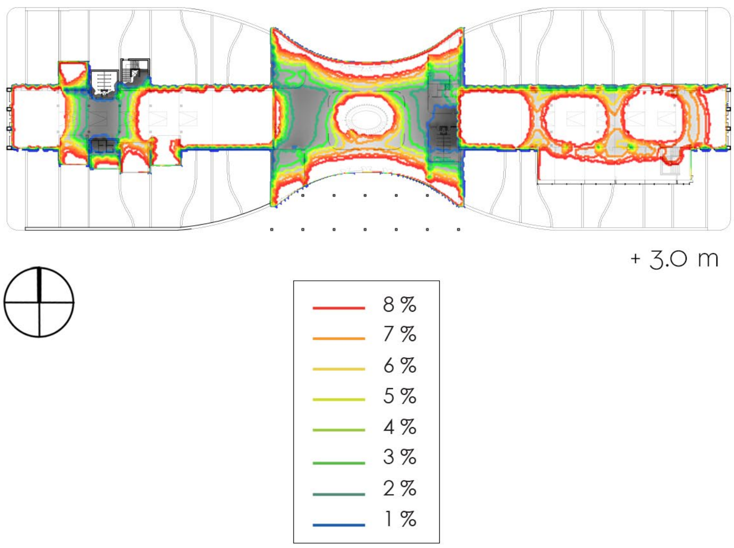
Natural light plays an essential role in the project. Starting from the entrance, the large full-height windows constitute an extension of the external spaces, both physical and visual, and make the gallery on the ground floor, a real public square inside the building, a so-called " urban interior ". Visual contact with the outside is also allowed on the entire perimeter of the building and on the roof, thanks to the large percentage of glazed surface, shielded by the presence of light horizontal sunshades in correspondence with the south boxes and shading strips on the roof. This choice also derives from the fact that the variability of natural light over time, a quality that distinguishes it from artificial light, allows the stimulus to persist over time, an important requirement for keeping the perceptual system efficient and reducing visual fatigue. The lighting and distribution themes are two closely related aspects, they are responsible for the main architectural choices regarding the internal layout of the furniture and functional areas. After carrying out some preliminary lighting analysis evaluating the daylight factor and the illuminance in the worst moments of the year and considering a totally transparent casing, it was clear to us how to make the most of the areas of the building that benefit most of the entry of natural light.

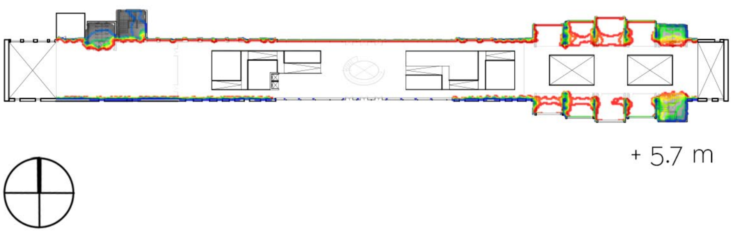
13.8. Daylight factor comparison between three options.

Complitely glazed roof

The first attempt was done on a roof complitely glazed to facilitate the entry of natural light for the greenery.
From the plans it is visible the excessive amount of daylight hours especially on the upper floor where all the has Daylight factor is all above the treshold.

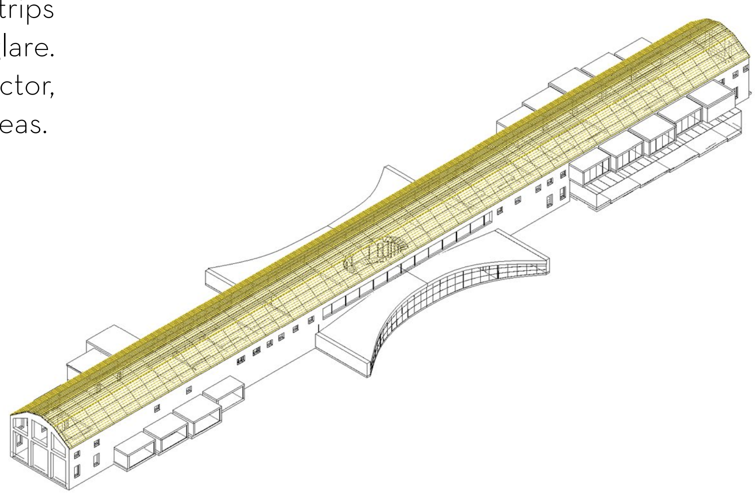


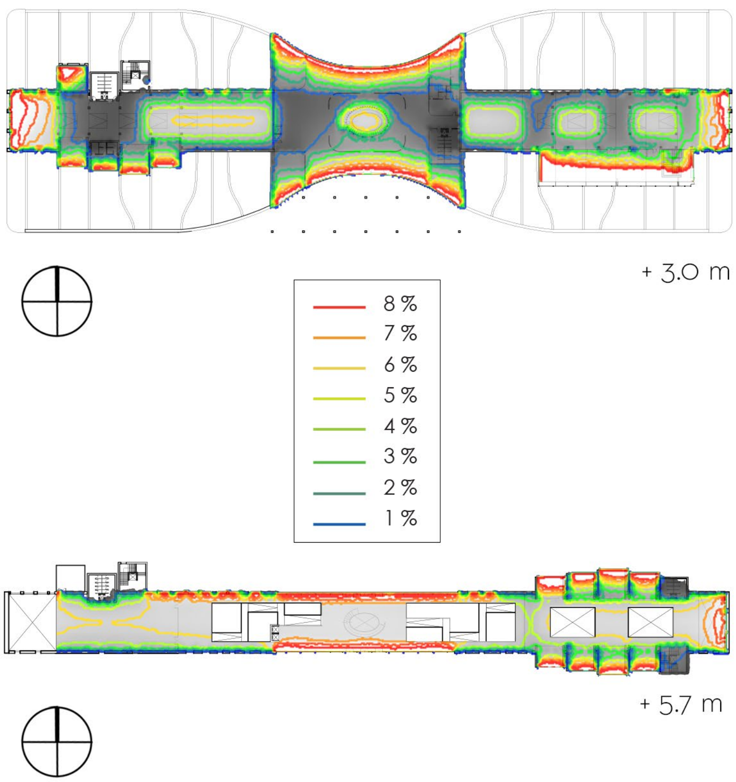




Shading strips on the roof

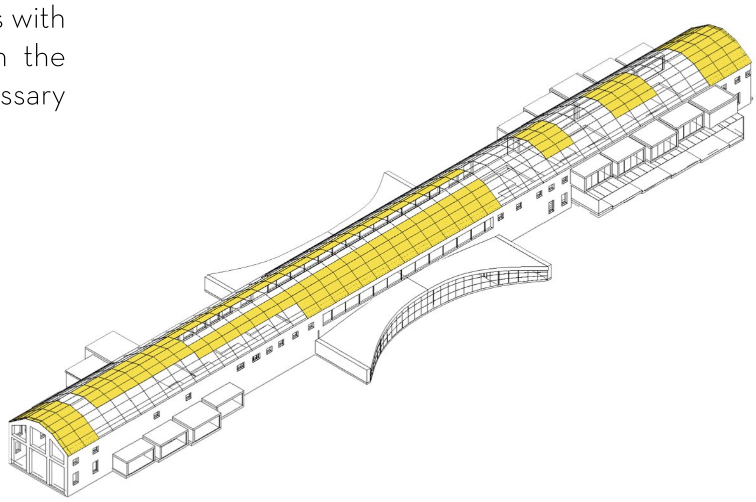
Since the values were to high, some shading strips were added all along the roof to reduce the glare. Here we can see a big reduction of Daylight factor, reaching accettable values, exept for some areas.

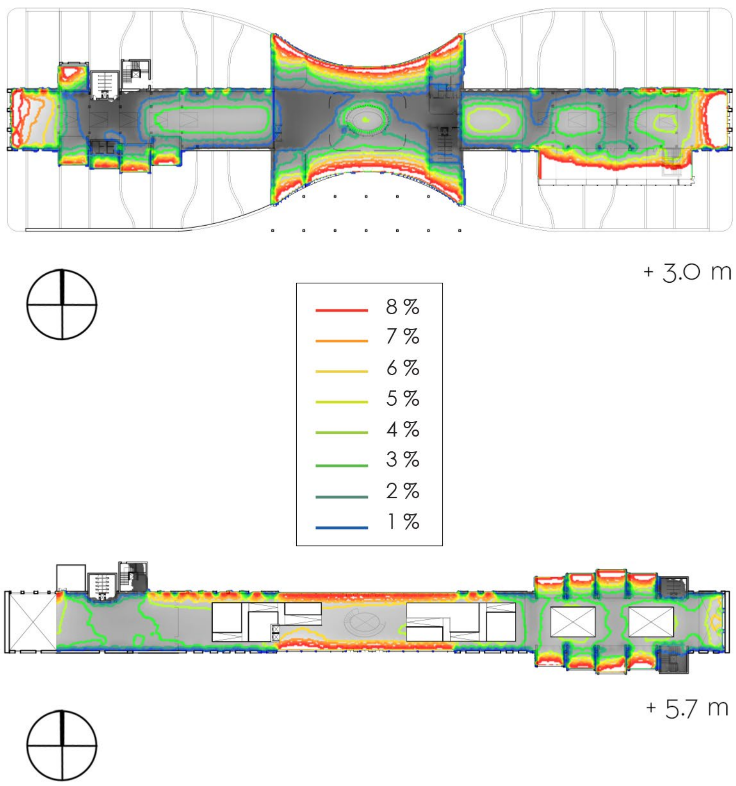




Addition of opaque panels

The last step was to replace some glass panels with opaque, sandwich panels. This was done in the areas where, due to the function, it was necessary to reduce eaven more the value.

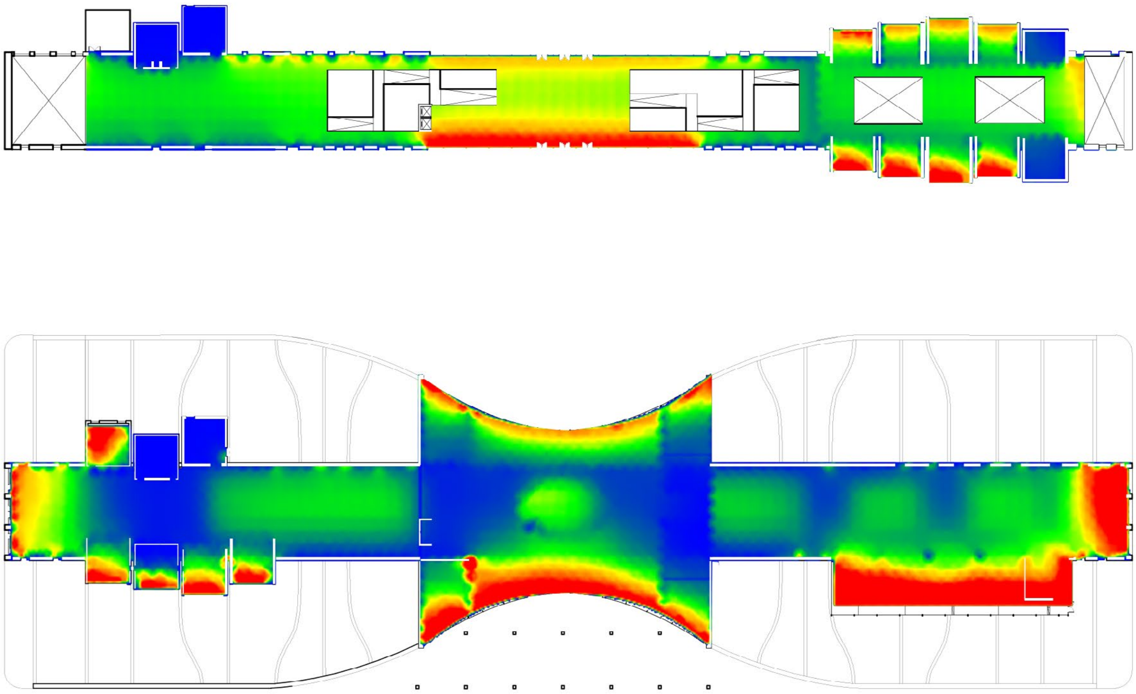


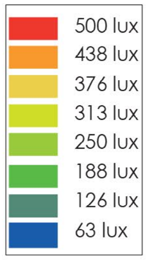


Natural light: illuminance and Daylight factor

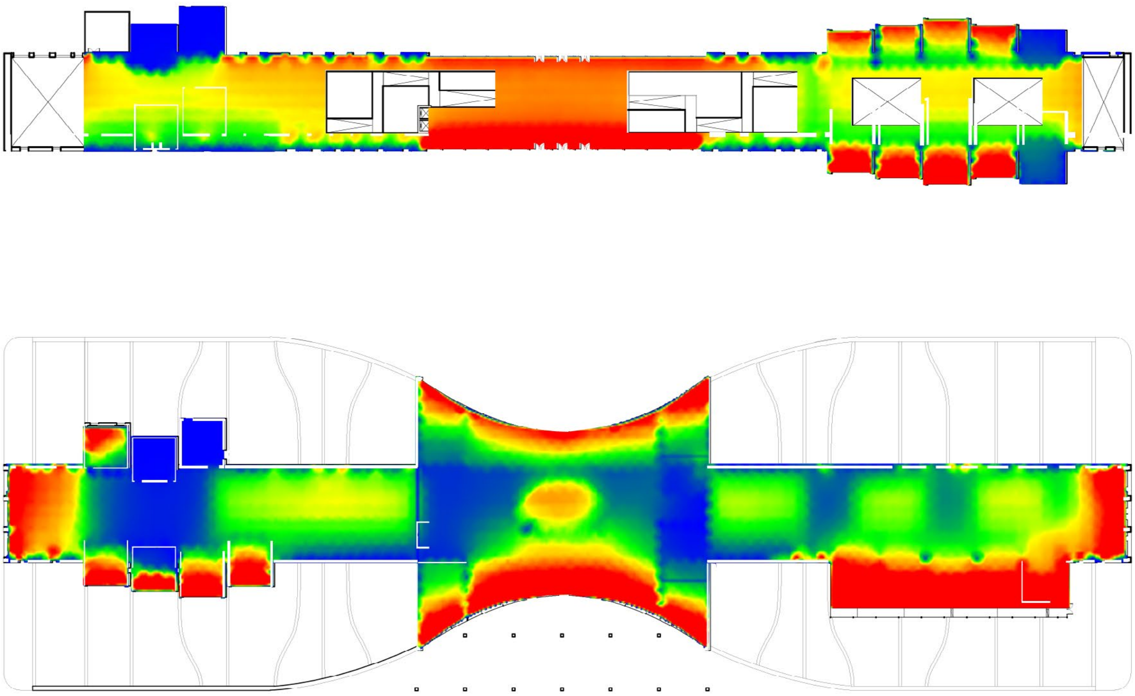
The daylighting project must allow the achievement of illuminance values adequate to the visual performance required for the performance of the activities characteristic of the various environments. After carrying out the first indicative lighting analyzes to support the functional organization of the plants, the same analyzes were carried out which then led to the determination of the final building envelope. The analyzes were carried out on the illuminance by choosing the worst times of the year in terms of the incidence of sunlight, evaluating them at 9:00, 12:00 and 15:00. In the summer months, the solar angle is very high, while in the winter months there is a lower inclination of the sun's rays. For this reason, arguments have been made that lead to solar gains in the cold periods of the year and to screen correctly in the hot months to avoid internal overheating, since we know that the lighting aspects are closely related to those of energy and internal comfort. The benchmark used to define the availability of natural light in the environment was the daylight factor. The effectiveness of this indicator depends mainly on the transparent parts and specifically on their sizing, positioning and optical characteristics of the glazed surface.

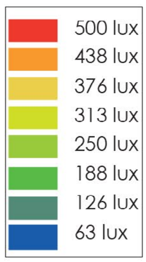
13.9. Illuminance on March with shadings



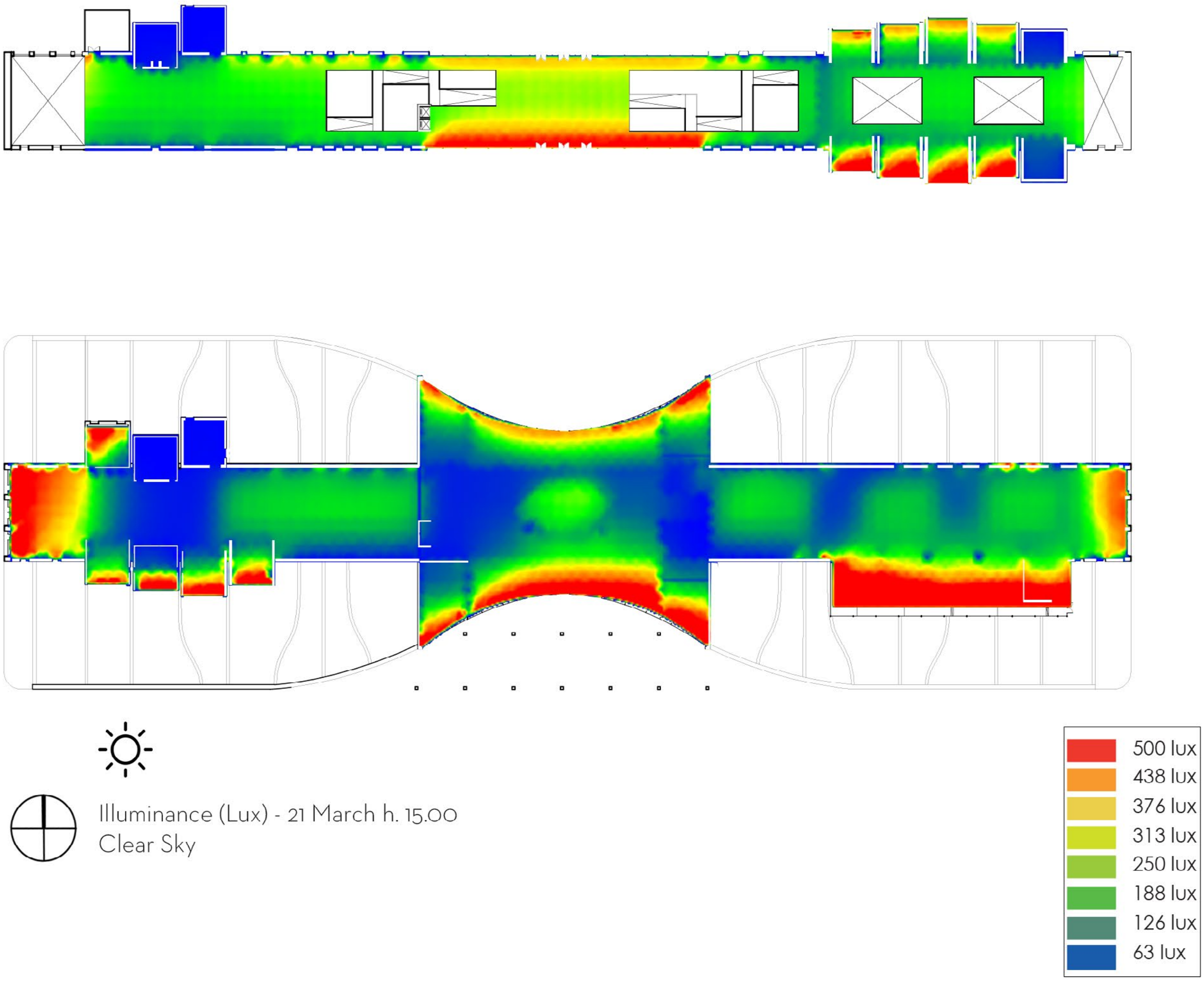


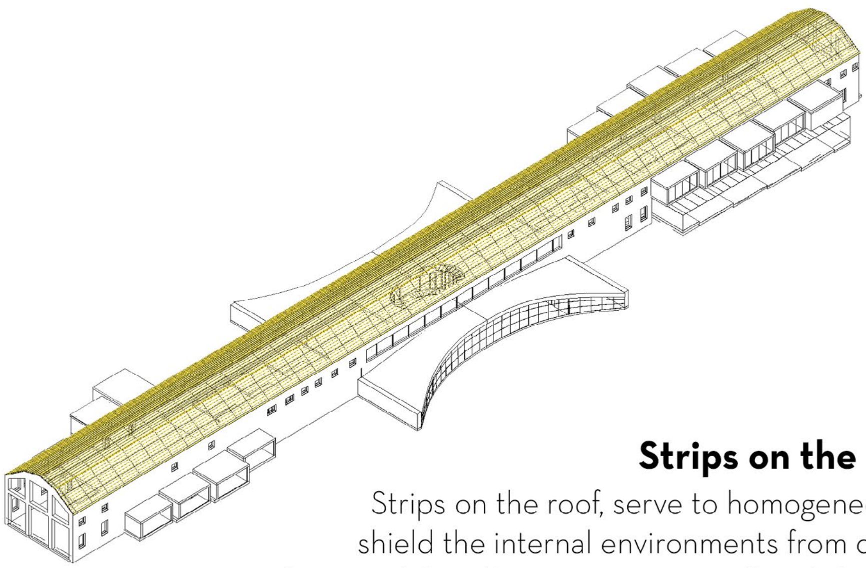
Illuminance (Lux) - 21 March h. 09.00
Clear Sky





Illuminance (Lux) - 21 March h. 12.00
Clear Sky

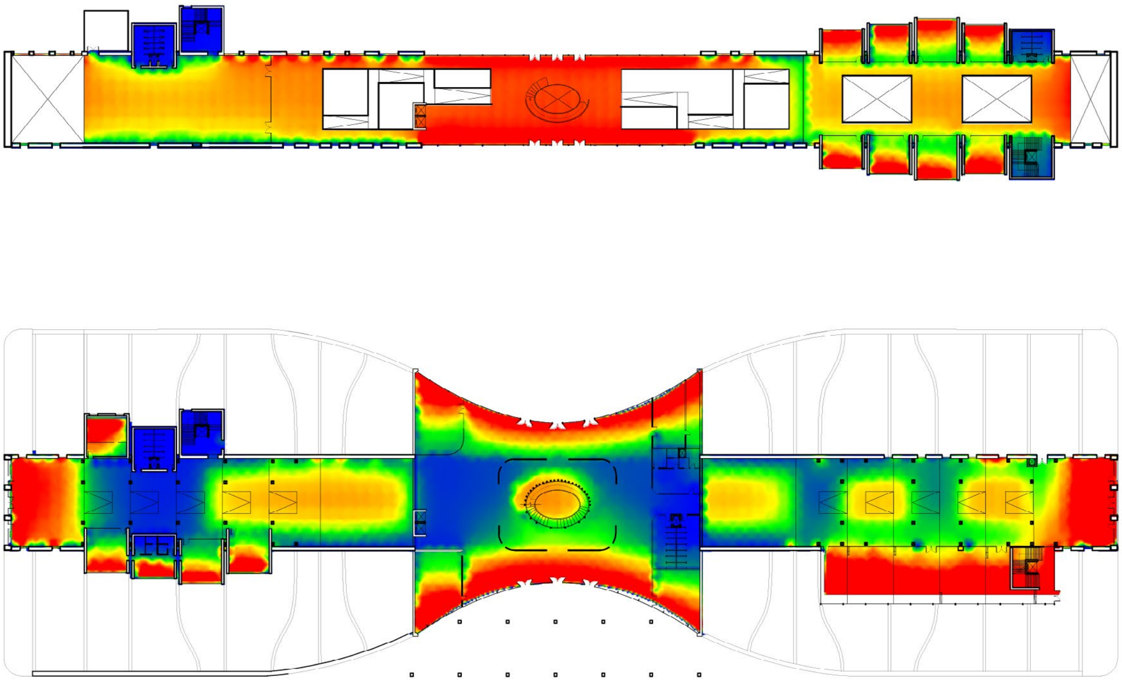




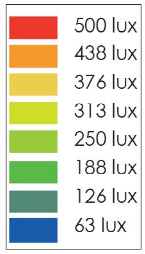
Strips on the roof

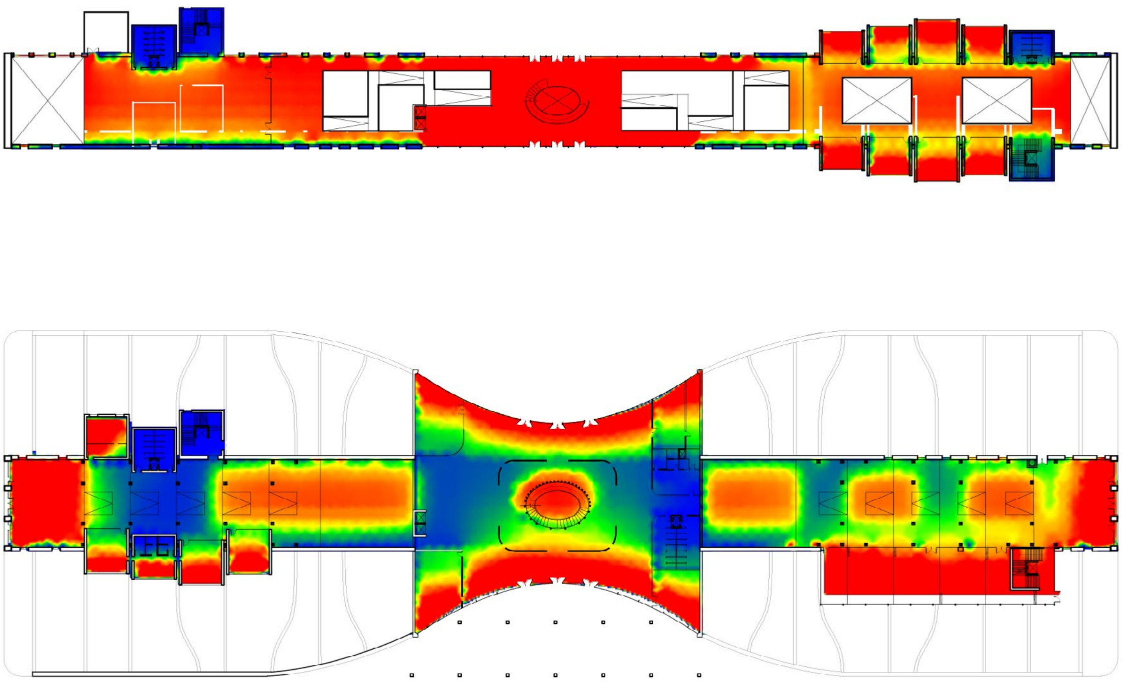
Strips on the roof, serve to homogeneously shield the internal environments from direct radiation, while still guaranteeing excellent light entry

13.10. Illuminance on june with shadings

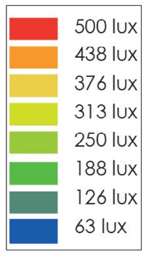


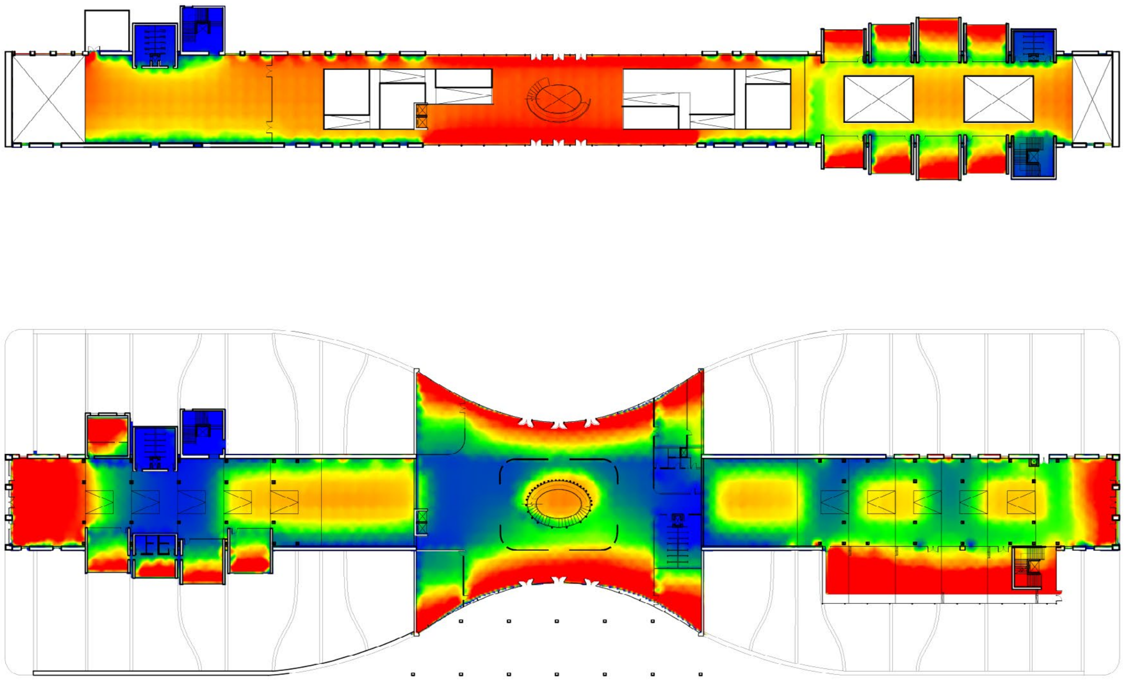
Illuminance (Lux) - 21 June h. 09.00
Clear Sky



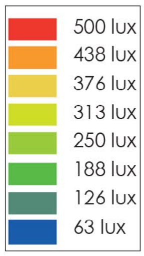


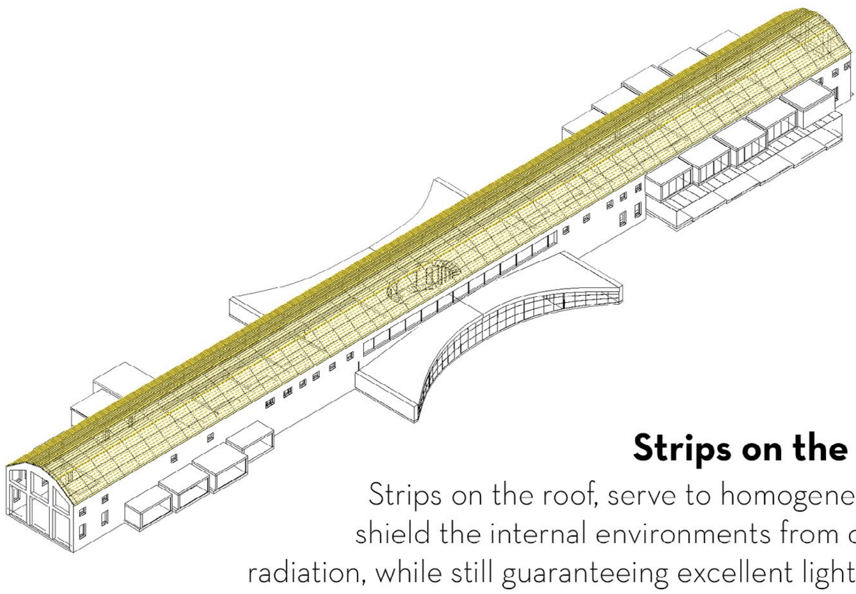
Illuminance (Lux) - 21 June h. 12.00
Clear Sky





Illuminance (Lux) - 21 June h. 15.00
Clear Sky

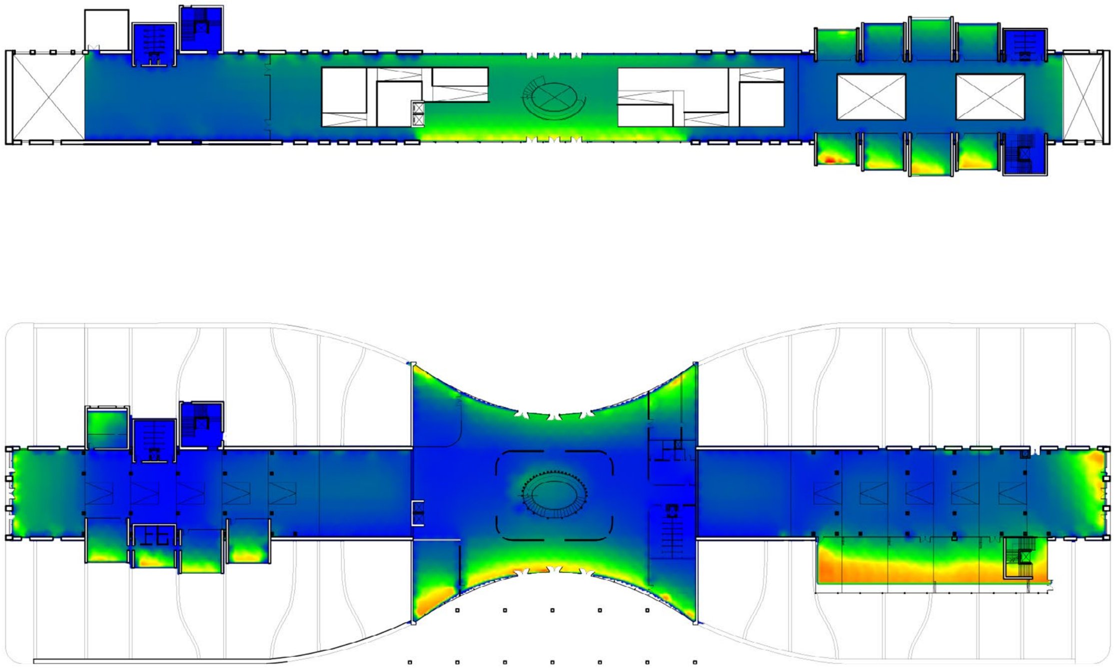


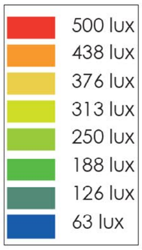


Strips on the roof

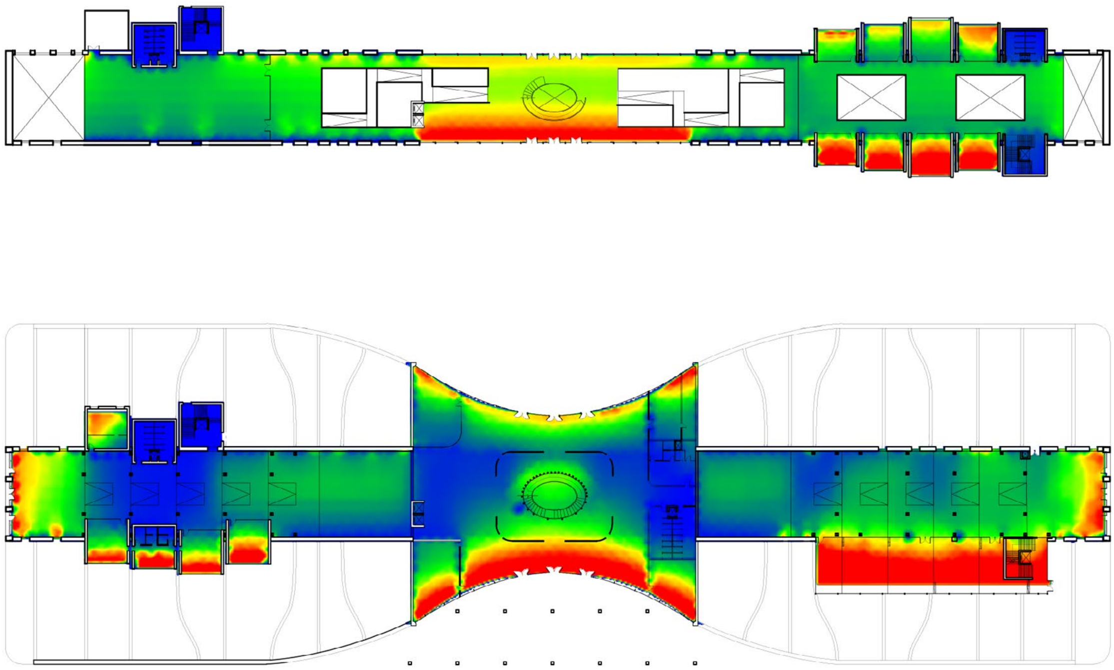
Strips on the roof, serve to homogeneously shield the internal environments from direct radiation, while still guaranteeing excellent light entry

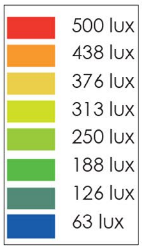
13.11. Illuminance on December with shadings



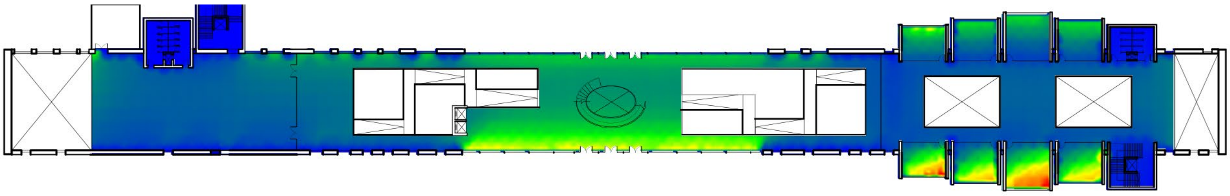


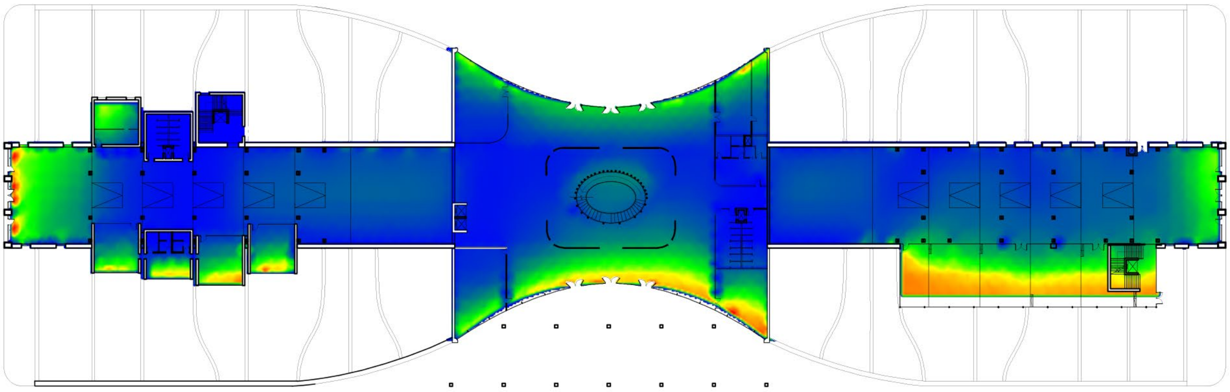
Illuminance (Lux) - 21 December h. 09.00
Clear Sky



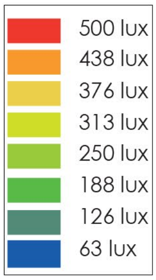


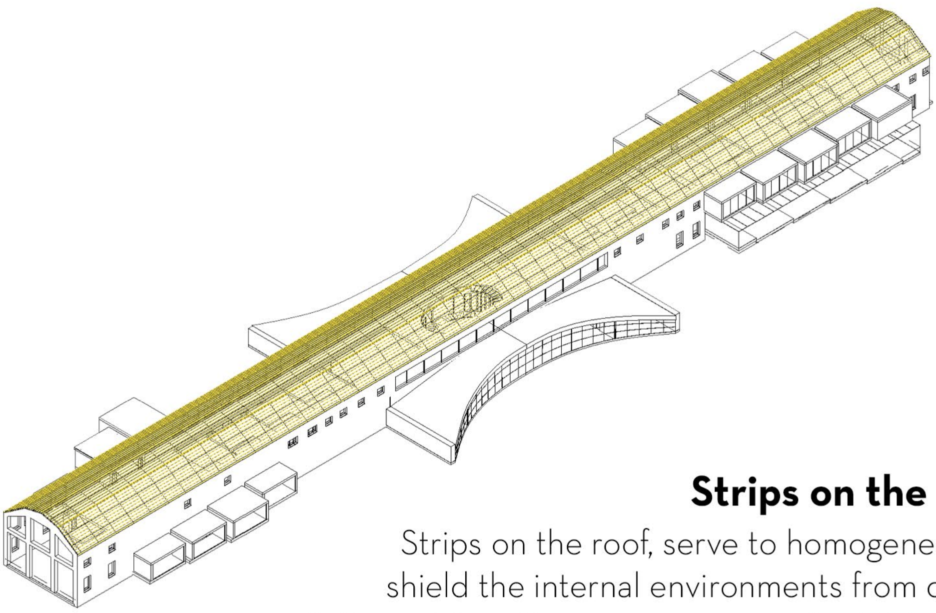
Illuminance (Lux) - 21 December h. 12.00
Clear Sky





Illuminance (Lux) - 21 December h. 15.00
Clear Sky





Strips on the roof

Strips on the roof, serve to homogeneously shield the internal environments from direct radiation, while still guaranteeing excellent light entry

13.12. Conclusions

From the lighting simulations, it can be seen that the elevation of the floor that is being analyzed has a strong impact on the results obtained. The ground floor presents some problems in terms of insufficient light in the winter period; this could involve the use of artificial lighting. These unfavorable areas, however, are limited to spaces where study activity is not the main one; these are areas in correspondence with passages or elevators, where users do not stay for a long time. It is noted that in all the perimeter portions of the various floors the value of the FD clearly exceeds 3%, a threshold suitable for study and reading spaces. The upper floor has FDs that are highly superior to those required by law, thanks to the fully glazed roof. In the points where there were excessive values, opaque panels were placed alternating with glazed ones to obtain values within the standard. As regards the analyzes carried out on the illuminance, during the summer months, the minimum average lux values required are respected in all areas.

13.13. Laboratories - Daylight analysis and shading optimization

Going more in deep with the analysis, we decided to study and optimize the shading system of the laboratories on the southern façade that is the most critical one because of the orientation and the amount of total radiation.For the fact that the orientation of the shading system is on South, we decided to use horizontal shading elements that are suggested for this orientation. The purpose of this analysis is the optimization of the Daylight factor to keep it at 2% on the 80% of the surface at least, as it is written in the BREEAM certification, the world's leading sustainability assessment method for masterplanning projects, infrastructure and buildings.

The shading system of the laboratory boxes on the southern facade was designed through an operation of optimization based on the annual dayligth factor (DF).
We printed 1842 different solution combining the number of the elements, the thickness, the depth and the degree of the rotation.
The purpose was to find a DF close to 2% for more than the 80% of the surface of the lab.
Here are reported just some example that synthetize the process until the perfect solution suitable for our needs.

Fig.209: Softwares used for the design optioneering study

We plotted 1842 different solutions mixing all these parameters and we explored the different possibilities with Design Explorer 2 trying to find the best coupling. Starting from the step 0, where we have just the box without a shading element to the final step where we have 6 elements, with a thickness of 10 cm,a depth of 30 cm and a rotation of 10°.

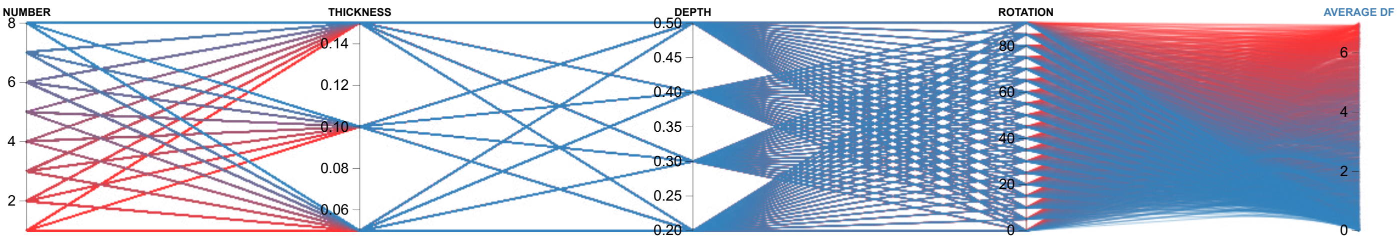


Fig.210: Design explorer Optioneering Graphic

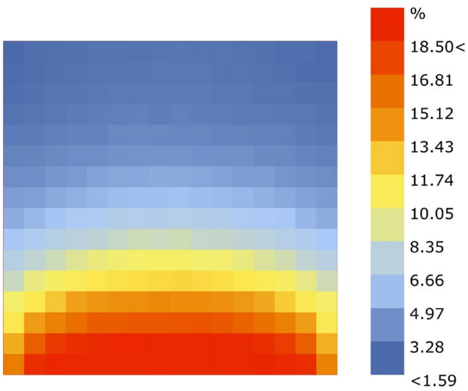


Fig.211: Initial step: no shading elements

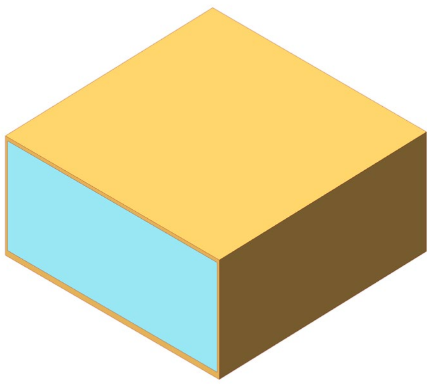


Fig.212: Axonometric view of the laboratory box

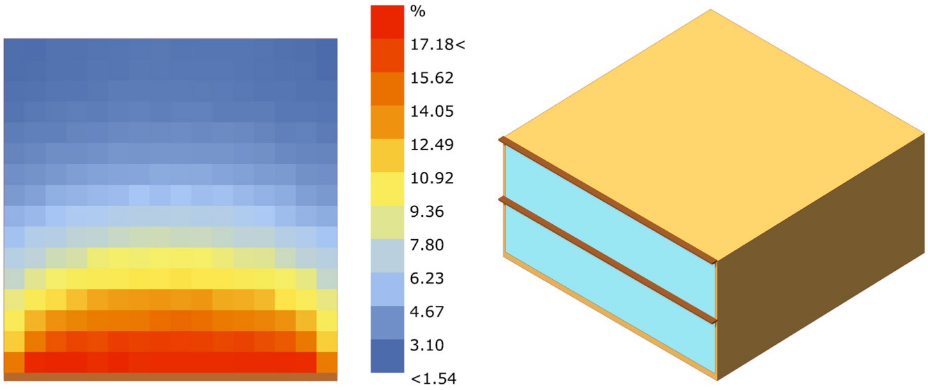


Fig.213: Elements Number 2 - Thickness 5 cm - Depth 20 cm - Rotation 0°

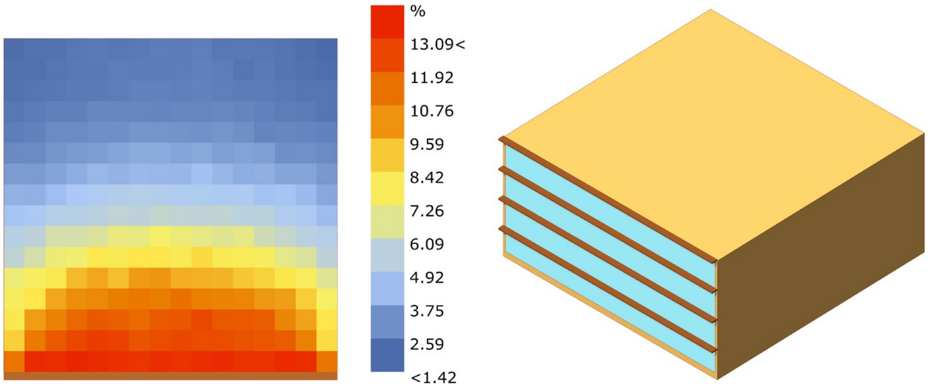


Fig.214: Elements Number 4 - Thickness 5 cm - Depth 20 cm - Rotation 0°

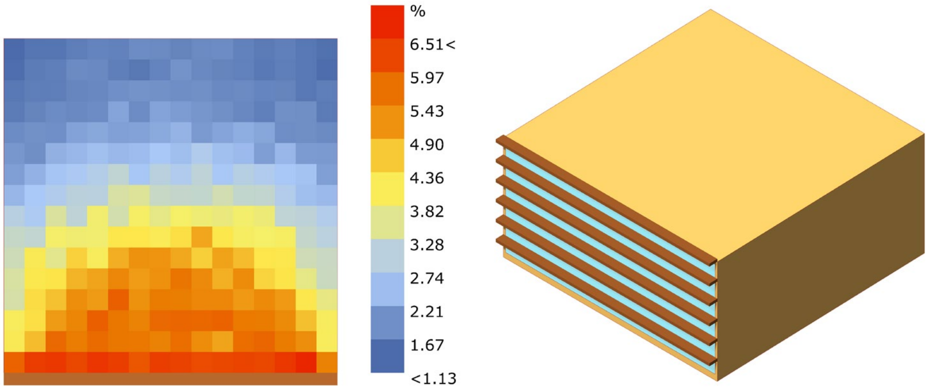


Fig.215: Elements Number 6 - Thickness 10 cm - Depth 30 cm - Rotation 0°

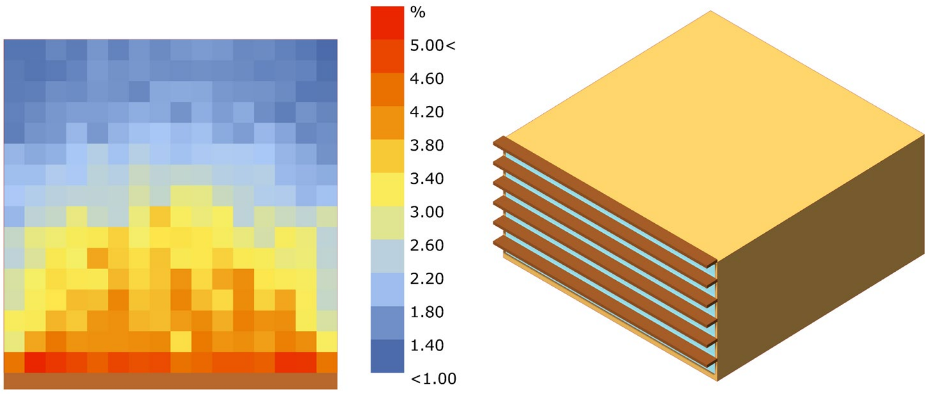


Fig.216: Elements Number 6 - Thickness 10 cm - Depth 40 cm - Rotation 0°

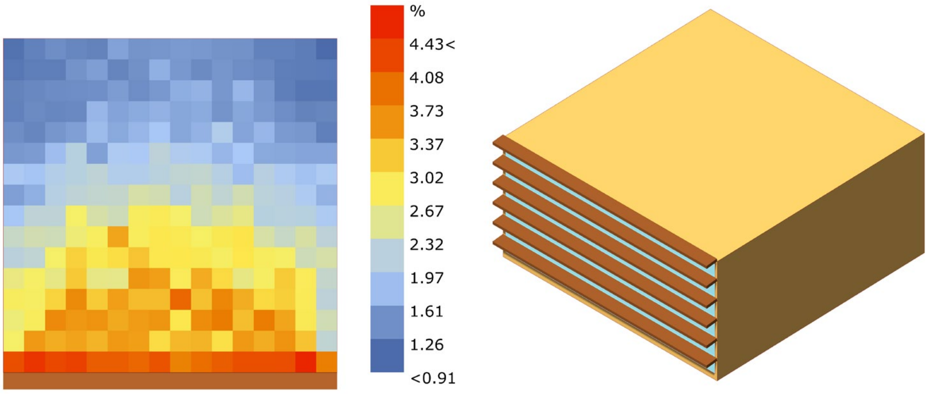


Fig.217: Elements Number 6 - Thickness 10 cm - Depth 40 cm - Rotation 5°

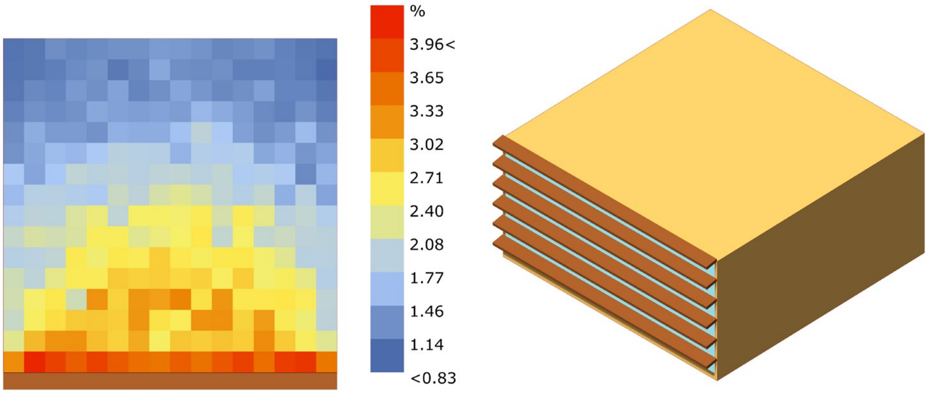


Fig.218: Elements Number 8 - Thickness 10 cm - Depth 30 cm - Rotation 10°

Final Solution

13.14. Building Energy Potential

The second step was to translate the total amount of sunlight hours in radiation potential to be converted in useful energy by a system of photovoltaics (PV) panels installed on the roof to reduce the total energy consumption of the building. A solar panel, or photo-voltaic (PV) module, is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy to generate direct current electricity. A collection of PV modules is called a PV panel, and a system of panels is an array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.
We decided to use a shading elements integrated with pv cells with a 22% of efficiency that could produce 848080 kWh per year.

Photovoltaic shading system

The installation of shading system with an integration of photovoltaics cells all along the roof of the building allow us to produce a huge amount of green energy to use for heating and cooling purposes, as well as, reducing the amount of electric consumes due to the artificial ligths and expecially the technological equipment of the laboratories.

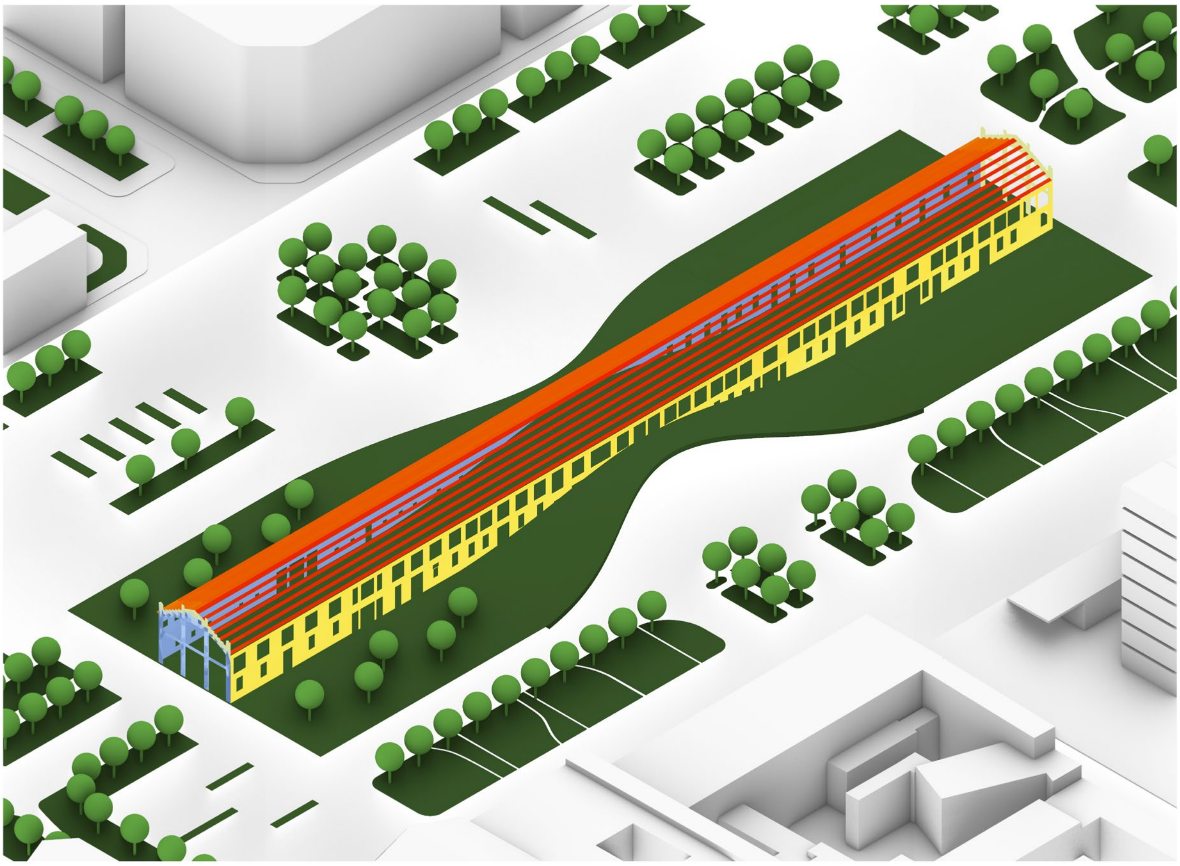


Fig.219:Axonometric View - Concept of the roof shading system with PV

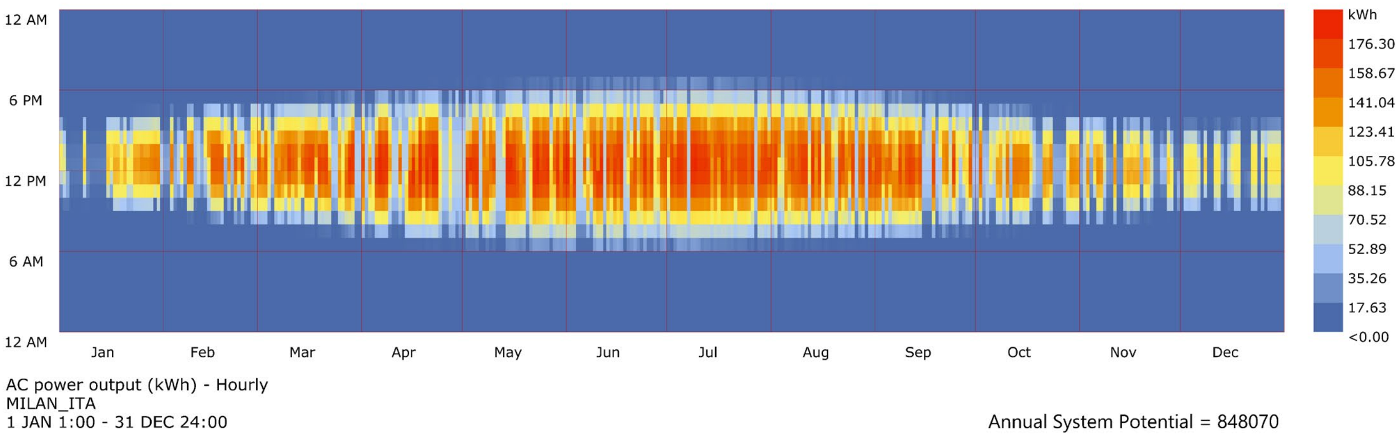


Fig.220: Graphical rapresentation of the annual solar energy production

13.15. Laboratory Energy Consumption

At the end we analysed the amount of energy consumption related to the laboratory boxes that we chose because of the fact that they have different energetic needs despite of the whole building.

We produced a graph that shows the energy consumptions related to the HVAC system, using a packed vav reheated system powered by electricity. This system is suggested for small buildings of 80 m² as maximum, so it fits perfectly the area of the laboratories that it is of 64 m².

Through this system the boxes consume yearly: 10 kWh/m² for heating, 43 kWh/m² for cooling and 113 kWh/m² to recirculate air.

The higher consumption amounts are related to the light system and to the technical machines that are quite constant all over the year because of the function of the space, consuming respectively 47 kWh/m² and 185 kWh/m².

All these energy consumption will be reduced in the end, with the energy produced by the solar systems on the roof.

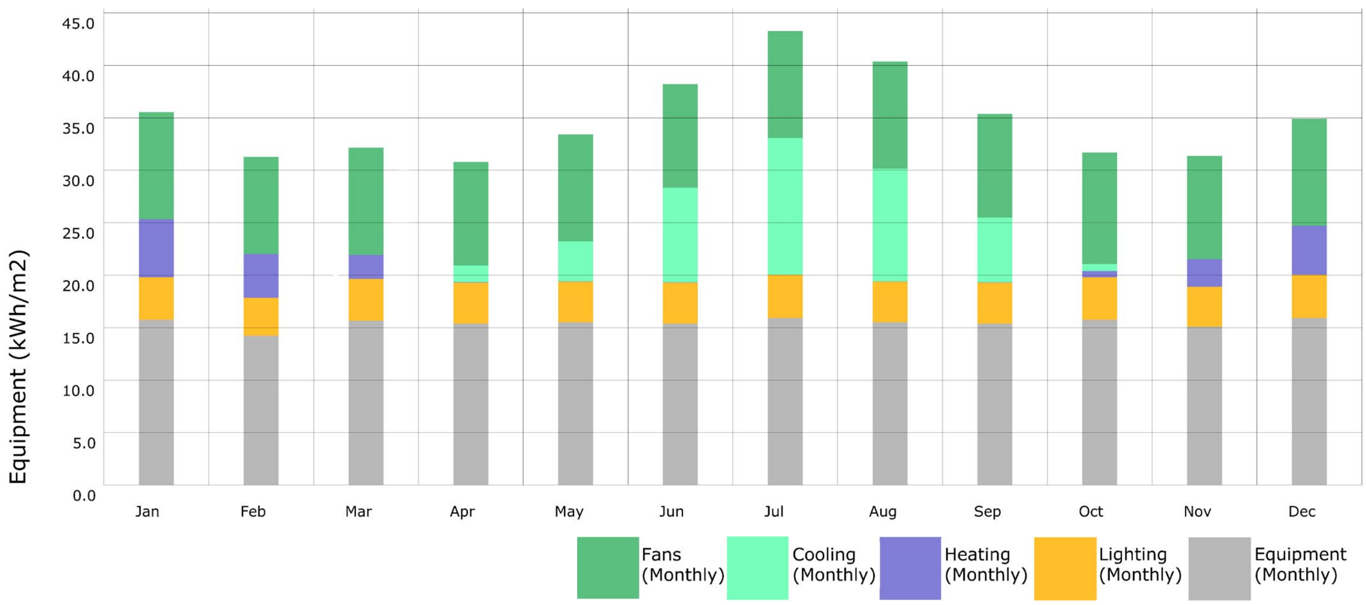


Fig.221:Annual Energetic consumes

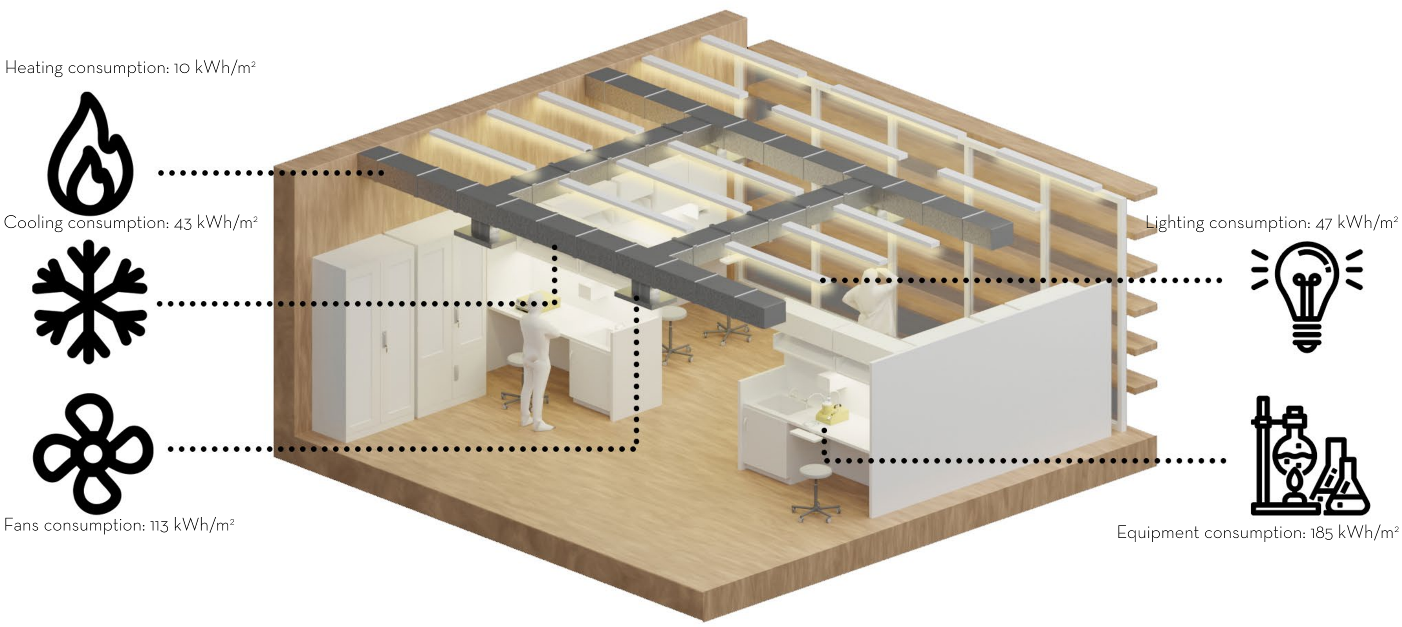


Fig.222:Laboratory consumption - Axonometric view

Conclusions

The study carried out in this thesis allowed us to learn several topics not previously addressed, it concluded our university education in the best way allowing us to work in a group despite the distance given by this difficult year of Covid.

An integrated modification was carried out with the project to transform existing urban contexts seen as complex systems into more sustainable and energy-efficient forms. A methodology was used that analyzed complex systems, and solved problems on different scales: local, intermediate, and global. It began by studying the state of affairs and understanding the historical transformation of the building from the initial construction phase to its use as the most important slaughterhouse in Milan, up to its abandonment. From these analyses it was concluded which parts needed to be renovated and which were demolished to keep the iconicity of the gallery and its historical importance intact.

Together with the historical and urban planning analysis, the study of the structure was deepened, implementing the existing bearing walls in reinforced concrete with a structural steel mesh, chosen to recreate that industrial context that existed during the period of use of the slaughterhouse. This was in fact left totally exposed and coupled with the wood finishes that create warmer environments instead. With the structural analysis, our design approach was innovative and reckless but at the same time tried to work according to the existing structure, reinforcing it to preserve and maintain it in the long term.

At the end of this process, construction technologies have been determined that will help achieve the objectives of the C40 challenge and integrate more sustainable construction materials. Thanks to the technological and energy study, the building has achieved the set goal of reducing CO_2 production and heat island thanks to the large amount of greenery both in the building and in the Masterplan.

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VALENTINA

Belli ziiiii ho finitoo!!

E chi lo avrebbe mai detto di poter arrivare alla fine. Terminare questo percoso è una soddisfazione immensa, troppo grande da descrivere, un traguardo che mi ha fatto imparare tanto non solo a livello universitario ma è stata soprattutto una crescita personale grazie a tutte le persone che mi sono sempre state vicine.

Dedico questo traguardo alla mia famiglia. Ai miei genitori che mi hanno supportato in ogni scelta, mi hanno cresciuta con dei obiettivi da seguire, mi danno ogni giorno tutto l'amore che si possa desiderare e non mi hanno mai fatto mancare niente. Ai miei fratelli che leggendo queste righe probabilmente mi prenderanno in giro fino alla fine dei giorni ma ai quali voglio un bene dell'anima. Ai nonni più dolci e affettuosi che mi hanno reso una nipotina tanto fortunata. Agli zietti e cuginetti che fanno passare ogni momento in famiglia leggero e spensierato. Alla famiglia migliore del mondo.

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Thesis in general requires very hard work. It was even harder to commit and work along with medical treatment. It was a challenge that made me really proud of myself for never quitting and giving up my dream easily. For this I have to thank all my family members, my parents, my sister, my brother. Who really supported me since the first day and were the backbone and foundation to what I have reached today. Thanks to my friends who supported me while I was abroad and motivated me towards successful results and an exciting journey.

No matter what you do or when you do it, hard work always pays off in the end. Hard work is what we have to do if we plan on going or doing anything in this life. A dream doesn't become reality through key factors such as intelligence, opportunity It is about investing in these capabilities with sweat, determination, dedicating effort and time for our goals to be achieved. Well done is better than well said.

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Eccoci qua, finalmente arrivati al fatidico e tanto atteso momento che segna la fine di un capitolo enorme per la mia vita, che chiude per sempre un periodo di gioia e sofferenza.

Durante questi ultimi due anni ho vissuto a Lecco e, per quanto mi è stato possibile, tra Covid e lockdown vari, ho affrontato la mia prima esperienza fuori casa che è andata meglio di quanto potessi pensare.

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