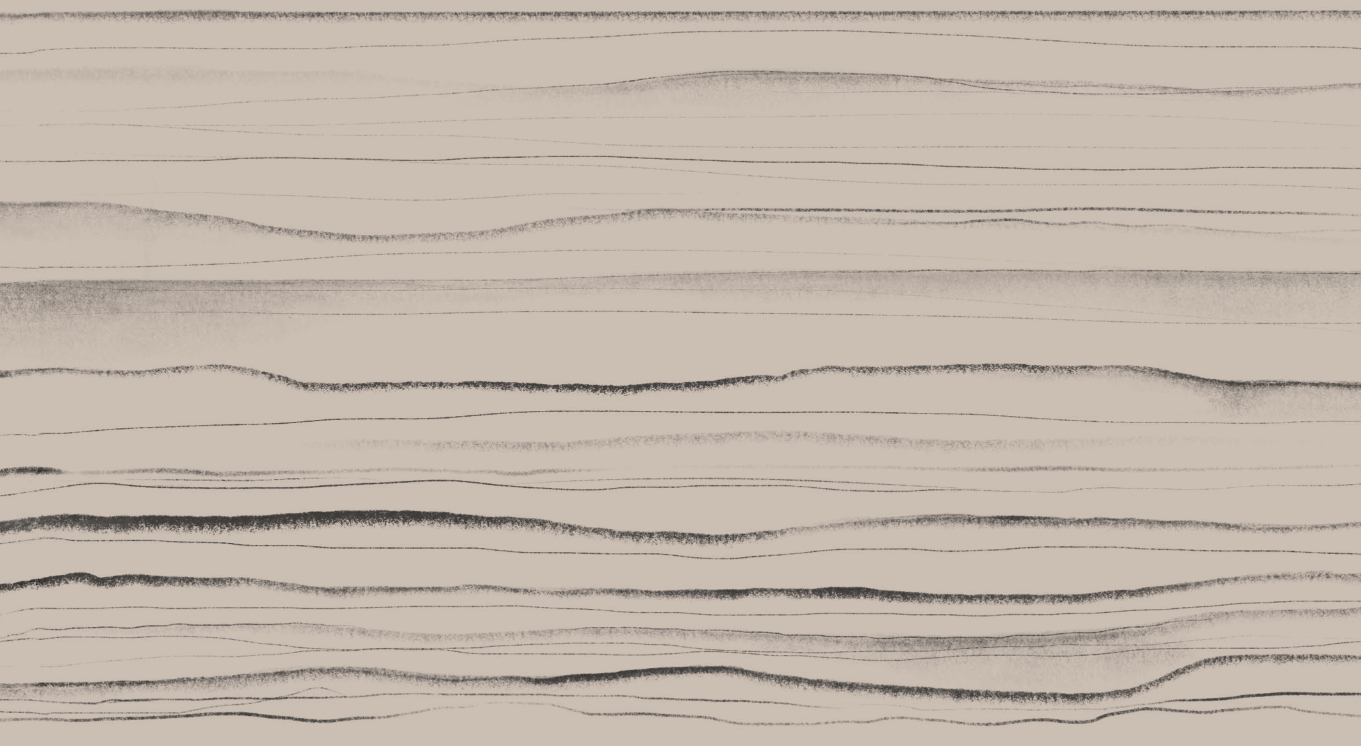
MIRA ACHKOUTY CHRISTELLE AYOUB POLINA RAZZHEVAIKINA

PARIS SACLAY COMMUNITY CENTER

A CROSSROAD TO DIVERSITY



ABSTRACT

Within the framework of Grand Paris, the Saclay plateau undergoes a territorial transformation bound to create a remarkable dynamic base for higher education and innovation. The ensemble of the plateau and the valleys challenges the development of the science and technology cluster. Previously an isolated area limited by an agricultural landscape, it is today a privileged setting characterized by an archipelago of campuses and structured by green open spaces.

As a start, this thesis studies the development of the "Urban Campus" in synergy with its environment. It explores the theoretical and practical importance of a communal civic core, that targets the intermingling of the communities and the strengthening of urban life.

The École Polytechnique finds itself imbedded in a composition of public spaces and clustered volumes. As it opens its historic campus towards the eastern sector, a border between the built environment and the natural landscape unfolds. On this edge is grafted the community center, the ultimate hitch that rounds the boundary between the architectural and the natural context. It generates a demographic flow, merging all users towards a collective sense of belonging.

To carry on, the architectural solution comes in the shape of an "Earth" forum emerging from the ground. It accommodates a library, a scientific center, a recreation center, an event space, and multiple communal functions. Physically linking different ends of the site, it prompts themes of reversibility, re-use, and adaptation: traditional materials are coupled with reinvented construction methods to produce a labyrinth of rammed earth walls supporting a sustainable public platform. This podium is punctuated by individual technological blocks of concrete and steel contributing to the sequence of events along the promenade. Their double outward facades of profiled glass filter the predominant landscape and balance the connections with the surroundings.

In conclusion, this agora is a melting pot of ideas and a puzzle of architectonic manifestations. With its program, composition, and material choices, it reaches into the different corners of the cluster to gather a persistent identity for the region.

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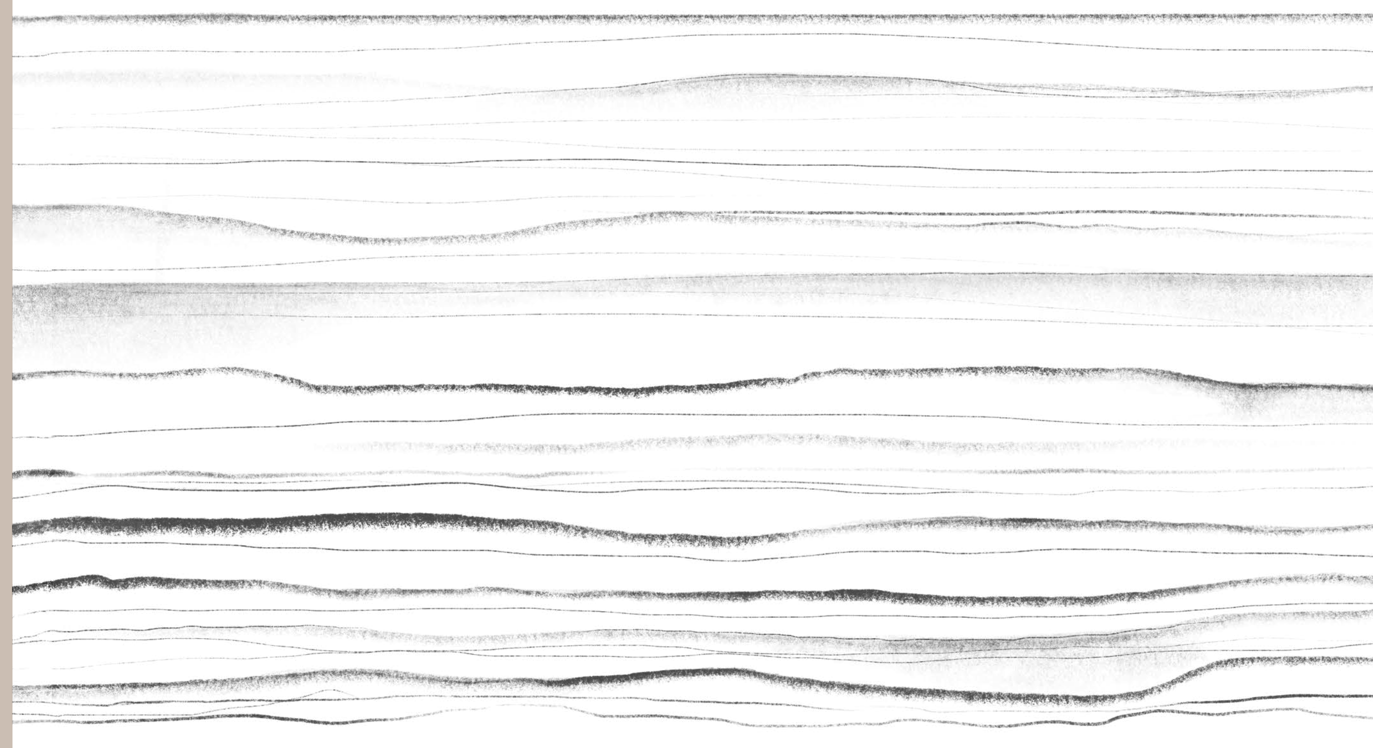

PARIS SACLAY COMMUNITY CENTER

A CROSSROAD TO DIVERSITY

POLITECNICO DI MILANO

School of Architecture Urban Planning & Construction Engineering

Laurea Magistrale (equivalent to Master of Science)

Architecture - Building Architecture

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ABSTRACT

ENG - - ITA

Within the framework of Grand Paris, the Saclay plateau undergoes a territorial transformation bound to create a remarkable dynamic base for higher education and innovation. The ensemble of the plateau and the valleys challenges the development of the science and technology cluster. Previously an isolated area limited by an agricultural landscape, it is today a privileged setting characterized by an archipelago of campuses and structured by green open spaces.

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To carry on, the architectural solution comes in the shape of an "Earth" forum emerging from the ground. It accommodates a library, a scientific center, a recreation center, an event space, and multiple communal functions. Physically linking different ends of the site, it prompts themes of reversibility, re-use, and adaptation: traditional materials are coupled with reinvented construction methods to produce a labyrinth of rammed earth walls supporting a sustainable public platform. This podium is punctuated by individual technological blocks of concrete and steel contributing to the sequence of events along the promenade. Their double outward facades of profiled glass filter the predominant landscape and balance the connections with the surroundings.

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Nell'ambito del progetto Grand Paris, il 'plateau' di Saclay è interessato da una trasformazione territoriale destinata a dar luogo ad un caso esemplare, dinamico e iconico, nell'ambito dei distretti per l'istruzione superiore e l'innovazione. L'insieme del 'plateau' e delle valli costituisce una sfida per lo sviluppo del cluster scientifico e tecnologico. Territorio un tempo isolato e delimitato da un suggestivo paesaggio agrario, il Plateau è oggi un contesto privilegiato, caratterizzato da un arcipelago di campus e strutturato da spazi verdi aperti.

Questa tesi prende l'avvio dallo studio dello sviluppo del "Campus Urbano" in sinergia con il suo ambiente. Esplora l'importanza teorica e pratica di un nucleo civico comunitario, che mira alla mescolanza delle comunità e al rafforzamento della vita urbana.

L'École Polytechnique si inserisce all'interno di una articolata composizione di spazi pubblici e un cluster di volumi costruiti. Con l'apertura del suo storico campus verso il settore orientale, si apre un confine tra l'ambiente costruito e il paesaggio naturale. Su questo bordo si innesta il Centro civico, ultimo anello di congiunzione tra paesaggio urbano, architettura e natura. Genera un flusso di persone che fa confluire tutti i visitatori in verso un senso collettivo di appartenenza.

L'organismo architettonico si presenta nella forma di un Foro "Tellurico" che si erge dal suolo. Ospita una biblioteca, un centro scientifico, un centro ricreativo, uno spazio per eventi e molteplici funzioni pubbliche. Collegando fisicamente le diverse estremità del sito, suggerisce temi di reversibilità, riuso e adattamento: i materiali tradizionali sono accompagnati da metodi di costruzione innovativi per dar luogo a un labirinto di muri di terra battuta che supportano una piattaforma pubblica sostenibile. Questo podio è scandito da blocchi "tecnologici" distinti in cemento e acciaio che contribuiscono alla sequenza degli eventi lungo la passeggiata. Le loro doppie facciate esterne in vetro filtrano la presenza potente del paesaggio e regolano i rapporti con l'ambiente circostante.

In conclusione, questa agorà è un insieme coeso di idee e un puzzle di manifestazioni architettoniche. Con il suo programma, la sua composizione e le sue scelte materiali, raggiunge ogni parte del

KEY WORDS

University campus – Urban campus - Community center – Innovation district – Landscape – Territorial transformation – Technology Campus - Social architecture – Nature - Architecture – Morphology - Urban promenade – Rammed Earth - Earth construction– Circular life Strategy – Prefabrication – Adaptability – Materiality – Natural resources – Sustainability – Reversibility - Public spaces – Synergies.

THEORY OF PROBLEM

How will the Saclay Plateau gain its place within the Grand Paris scheme, and within the world's top innovation districts, as a social, cultural, technological, and economic catalyst?

How can the urban and landscape design, coupled with architecture and tectonics, contribute to an intellectually stimulating environment? What is the role of the campus typology in promoting the region as a higher education and research hub?

Can a program hybridization contribute to territorial and behavioural transformations? How will the introduction of a community center induce this kind of change and synergies within a society?

What are innovative choices within the construction sector that could fulfil environmental goals? How can traditional materials implemented through contemporary methods contribute to a circular life strategy?

INTRODUCTION

The design of a new complex building for the community within the Urban Campus of Paris-Saclay starts from the understanding of the transformation dynamics of this Innovation Science District. This thesis begins with evaluating the importance of the Saclay plateau with all its components, as a key player in the development of the Grand Paris scheme, proceeds to explore the significance of a hybrid community center in a changing urban setting, to finally assess the solution on a technological, social, and ecological level.

In the first two chapters of Part 01, we follow the transformation of the urban landscape of the plateau from a series of disparate clusters to an adequately developed technology and innovation campus. That is through a morphological and territorial analysis, a study of possible and imminent configurations and a layout of the required program, links, and interactions.

Chapter 3 introduces the physical need to a community center that would articulate social interactions, events, behavioural patterns, and cultural happenings in the region; and evaluate the possibilities of crossing the roads to establish a new diverse human dimension. This chapter also introduces the solution in all its technical layers: structural system, materials, constructive details, and service systems.

Specific attention is given to the projects' materiality in Chapter 4, that consists in reintroducing the use of earth as a sustainable construction material and constructing a podium where most public functions are placed. We study rammed earth's past vernacular and patented uses, its development with emphasis on its use on French territory. Responding to the challenges of such a predominately natural site, we organize its life cycle as a reusable material in an adaptable system and design its details and planar configuration to optimize its performance at the scale of the forum.

The rest of the program is developed in the form of four technological glass, concrete, and steel blocks. These volumes are more specifically oriented in terms of program and use. We dive into their typologies, spatial configurations, and façade treatment in Chapter 5.

After explaining the baselines for conception and the architectural design of the Saclay Community Center, we go on to detail the systems that made the configurations and materiality possible. Part 02 gathers all structural calculations, element dimensioning and connection that allowed the erection of the earth and timber podium, and the construction of the elevated, free plan blocks.

Plans, sections, and details can be found, explaining all technical aspects, from foundation laying to façade cladding. We also give importance to material choices as seen in the materials catalog, making sure that products show optimal behaviors and that most producers are in relative proximity to site (Part 03 and 04).

In Part 05 is a technical arrangement of all building services design, from ventilation, cooling, heating to water supply. Attentive consideration to practical details optimizes the projects lifetime, use and present earth qualities.

ACKNOWLEDGEMENTS

Countless wonderful people supported our efforts on this project. We would like to thank Professor Francesca Battisti who has been an ideal teacher, mentor, and thesis supervisor, offering advice and encouragement with a perfect blend of insight, consideration, and appreciation.

Thank you to our co-supervisors, Professor Grigor Angeliu, Giovanni Dotelli, Massimiliano Nastri, and Francesco Romano, this intricate work would not have been possible without you.

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Thank you to our friends and colleagues, whose company and understanding made our days pleasurable and the workload manageable.

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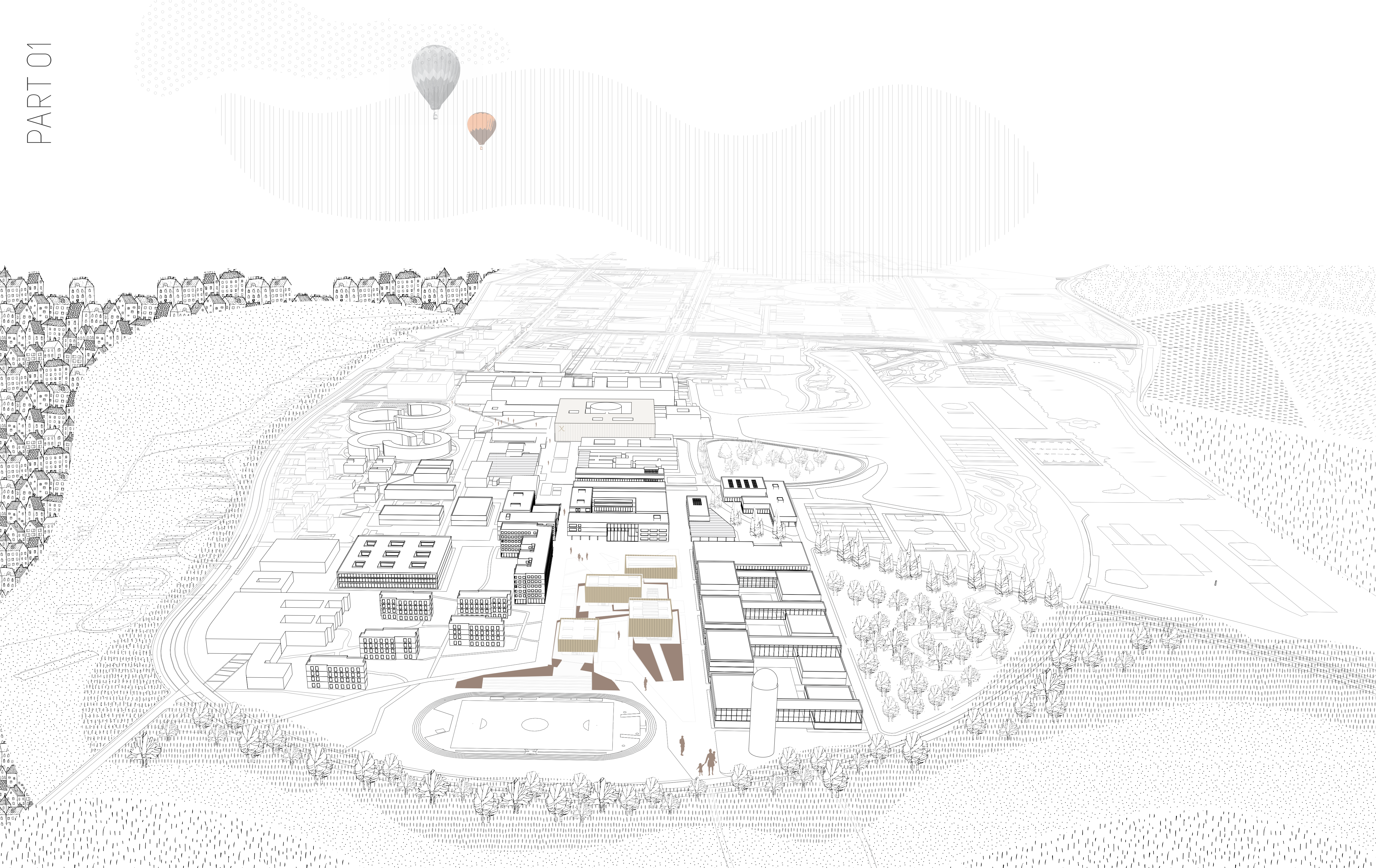
PART 01



"Innovation districts represent the ultimate union of corporate and educational institutions, entrepreneurs and scholars, companies and research facilities, mixed-use development, and technological innovations; all connected by transit and powered by clean energy. Many case studies show how the development of specialized knowledge clusters, and the organized mixture of programs can turn the monofunctional areas into a prosperous and innovative urban science district."

CHAPTER 1

PARIS-SACLAY CLUSTER: BETWEEN NATURE, SCIENCE AND CITY

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Fig. 1

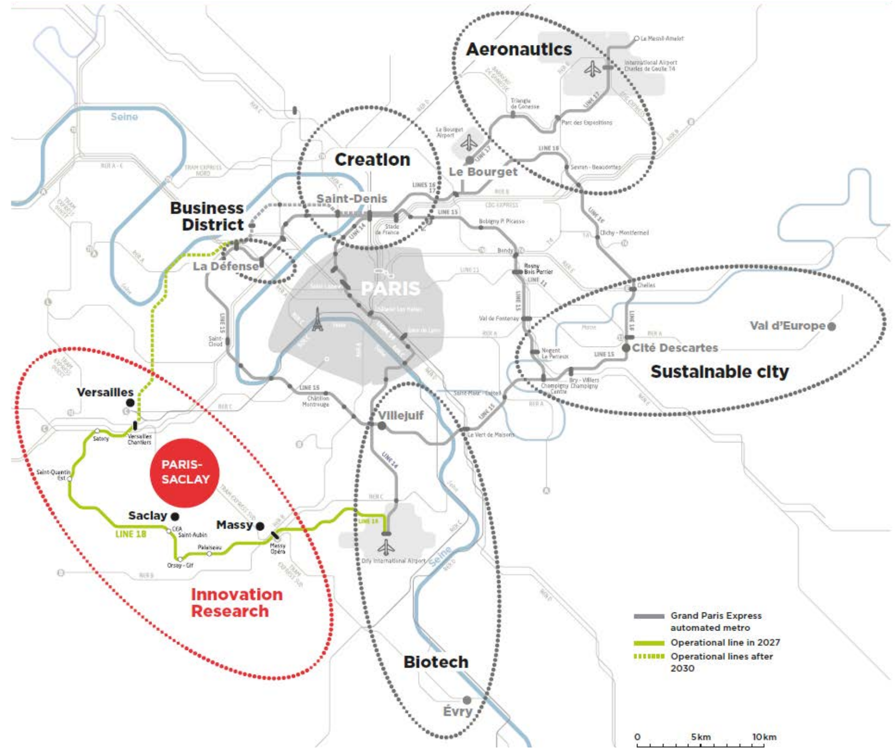


Fig. 2

1.1. Paris-Saclay at a macroscale

A key element for the Grand Paris

For a long time now, the growth of the Parisian metropolis has been thought and organized around the extension of a unique core, the city of Paris. That vision is translated with the Grand Paris project that links and articulates big hubs, while surpassing the old borders of the Parisian suburbs. This is also the vision of the Grand Paris Express, the structure of metros that extends and completes the existing public transport system, connecting the different hubs between each other and with the airports, while opening the urban centers that were badly served in the past.

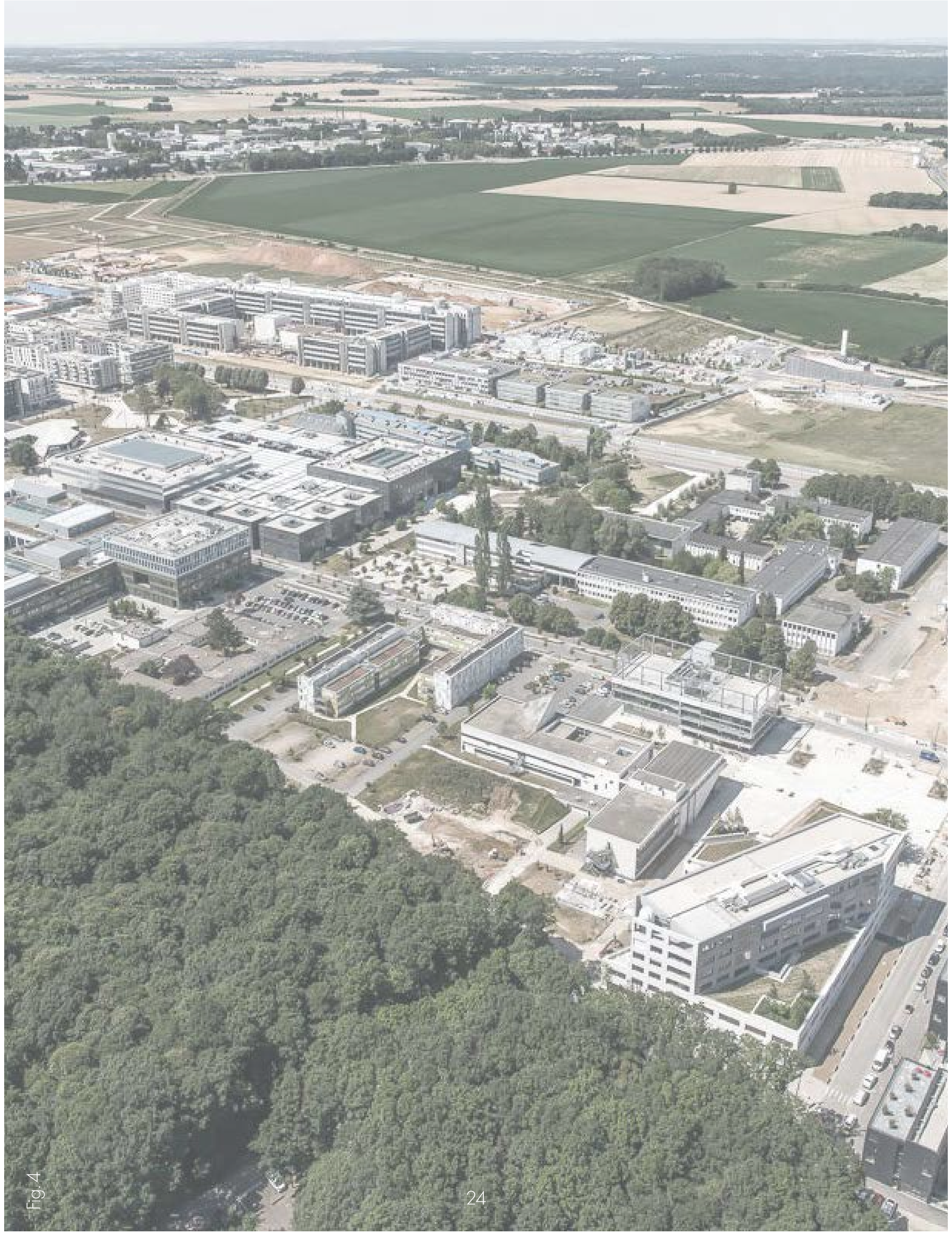
A set of major thematic clusters reinforce the dynamics of Grand Paris while contributing to the regeneration of the economic and urban development of the region as a whole. Interlinked by the Grand Paris Express metro, these constellations support the attraction of metropolitan Paris, emphasizing its ability to welcome well known higher education institutions, public and private research centers, and high-tech industries, all on a large scale.

The Paris-Saclay project is emblematic of the transition to a polycentric vision of this agglomeration. With its incomparable concentration of internationally renowned research and higher education facilities, high-tech corporations, and laboratories, it is empowering the Parisian region with an outstanding drive for innovation.

Fig.1. Aerial view of the Paris-Saclay Urban Campus, side of the Ecole Polytechnique

Fig.2. Map of the Grand Paris clusters with the Grand Paris Express future scheme

Fig. 3



Campus and city: into an urban Science District

Worldwide, the interest in urban and campus design has not ceased to grow. With the changing demands of a knowledge-based society, the relationship between the campus and the city is evolving and transforming urban practices. Many examples can be cited demonstrating strategies, visions and policies that are meant for a changing city, a city worthy of international competitivity. Urban campus models have not disappointed in this area. Today, they are demonstrating more than ever their role in the economic development of cities, in Europe and beyond.

In effect, the development of each of the city and the campus is interconnected. The university provides a solid ground for potential expansion, through the creation of incubators and businesses related to the campus, while the surroundings become more oriented towards the university.

The technology cluster of Paris-Saclay is no stranger to this. Built around historical scientific actors (Paris-Sud University, École Polytechnique, CEA, Supélec, etc.), the urban campus will be a place of attraction, and intellectual and industrial creativity. It will contribute to the economy and the reputation of Paris, consolidating Saclay’s position among the 8 global innovation clusters.

In this thriving modern knowledge society, universities and corporate bodies take on a key role in the cultural, economic, and social development of their host cities. Together, they give rise to what is known as “innovation districts”. As an emerging urban model, these districts provide a strong foundation for a sustainable economic development. They present the potential to encourage denser residential and employment examples and to foster the regeneration of urban or suburban areas.

Innovation districts represent the ultimate union of corporate and educational institutions, entrepreneurs and scholars, companies and research facilities, mixed-use development, and technological innovations; all connected by transit and powered by clean energy. Many case studies show how the development of specialized knowledge clusters, and the organized mixture of programs can turn the monofunctional areas into a prosperous and innovative urban science district.

Technology campuses as catalysts for innovation

Without exception, innovation districts have taken the spotlight, with universities at their central core. Technology campuses have proven to be the motor for innovation and social interactions with the power to respond to the demands of a changing society.

In all these developments, the campus typology serves various aspirations: from spatial organizations stimulating internal knowledge exchange and social mingling, to approaches that promote urbanity or active integration with an existing urban setting. Overall, the target is to create an ecosystem that can best foster the dynamic synergies needed to create sustainable centers for knowledge and learning.

Fig.3. Aerial view of la Défense, one of the Grand Paris hubs

Fig.4. Aerial view of the Paris-Saclay Urban Campus, side of the Moulon district

Technology clusters can differ in type, size, and density. Some are large, allocated quarters that are supported by investment programs and government policies and have the potential to lead internationally. Others are complexes established at proximity to the cities and benefit from good transit system.

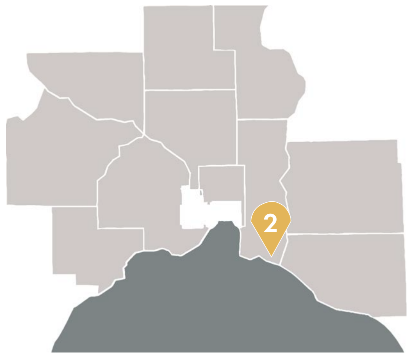
However, in terms of localities and businesses, Bruce Katz and Julie Wagner identify three main types of districts:

1. The "**anchor plus**" model; mainly found in the downtowns and mid-towns of central cities. It is characterized by mixed-use developments on a broad scale, established around major institutions and related anchor firms, businesses and spin-off companies that invest in innovation.

2. The "**re-imagined urban areas**" model; set in former industrial sites that are undergoing physical and/or economic transformation, which can often take advantage of good infrastructural connections, historic building stock and proximity to city centers, where advanced research institutions are located.

3. The "**urbanized science park**" model; often located in suburban areas where traditionally isolated innovation institutions gather, urbanizing entire sites thanks to the increased density of residential and employment patterns and the setting of a diversified program of amenities.

Fig. 5



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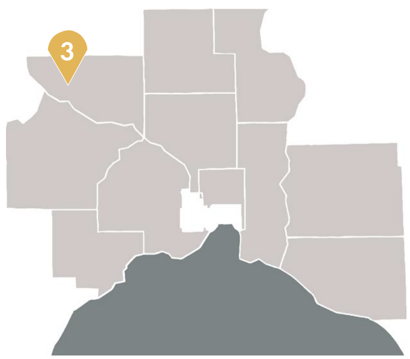


Fig. 7

Fig.5-7. The three types of innovation districts based on their location, edited

Fig.8. Satellite imagery localizing the Saclay Urban Campus according to the center of Paris, google earth

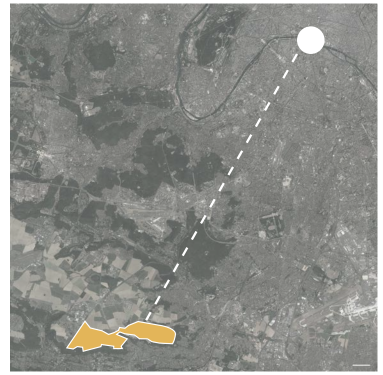


Fig. 8

Fig. 9

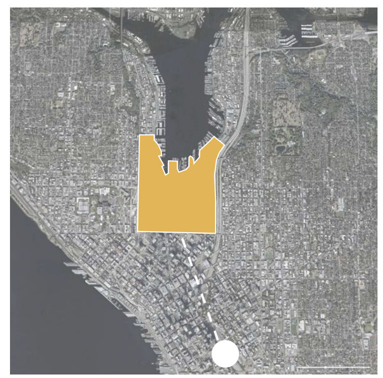


Fig. 10

The "urbanized science park" model proves itself to be the closest to the case of Paris-Saclay technology cluster (urban campus).
In effect, the district, located in the suburbs of Paris, is witnessing transformations on different levels, starting from the densification and urbanization of the area to the investment in the public to create positive synergies in innovative ways.

The most representative example of the "anchor plus" model is that of Kendall Square in Cambridge, Boston, anchored by the MIT, and connected to Harvard, Mass General and other research institutions.
The result was the rise of a sciences and pharmaceutical cluster, around which several firms started to develop, attracting major technology companies as well.

The "re-imagined urban areas" model is best exemplified by the notable redevelopment in Seattle's South Lake Union area that transformed a forgotten industrial neighborhood into a dynamic innovation district.
This resulted in a vibrant mixed-use area with some of the most renowned tech companies, as well as new mixed-income housing, restaurants, retail, hotels, and parks.

Fig.9. Satellite imagery localizing the tech cluster in Kendall Square according to the center of Boston, google earth

Fig.10. Satellite imagery localizing the South Lake Union area according to the center of Seattle, google earth


Fig. 11

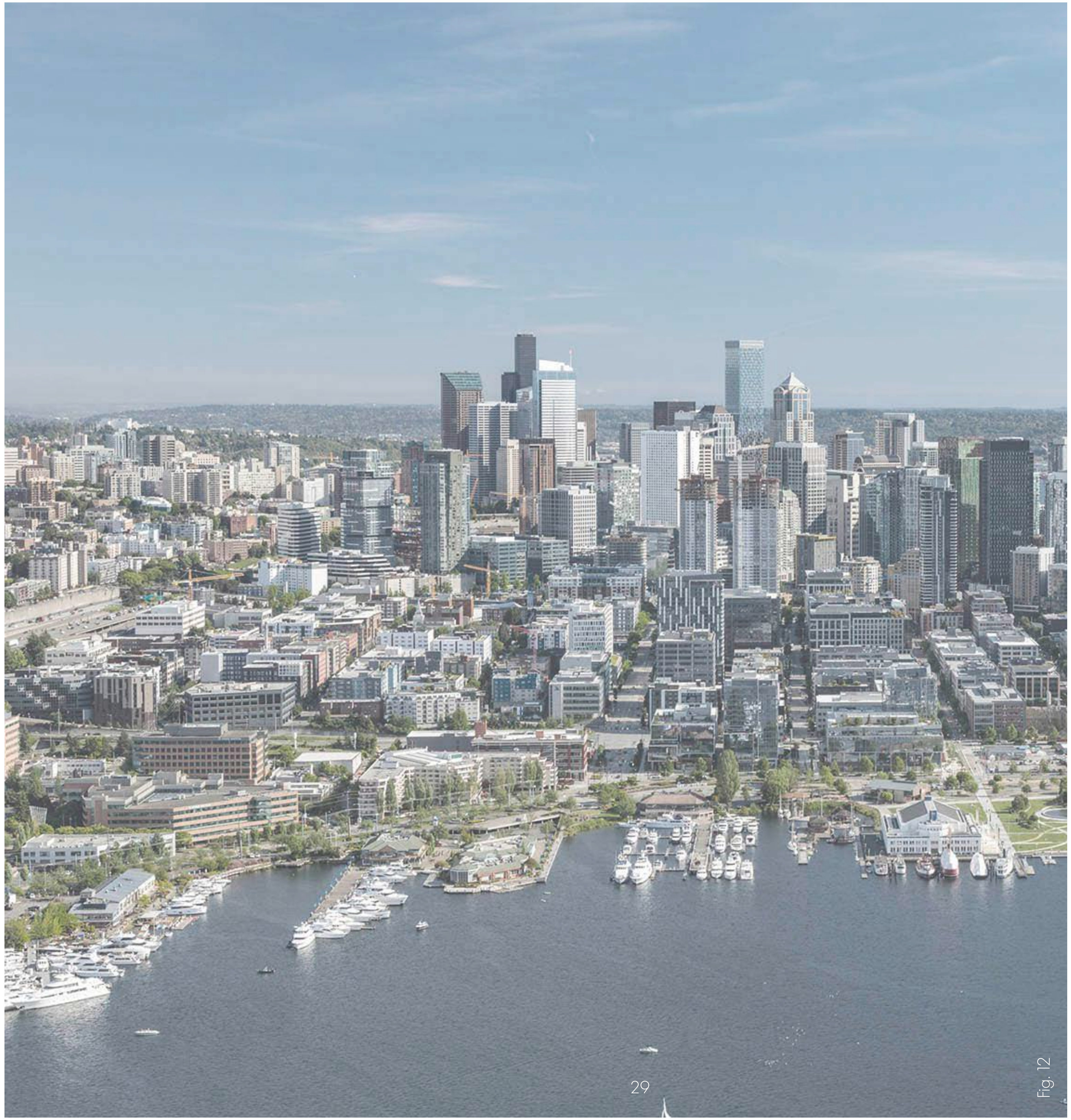


Fig. 12

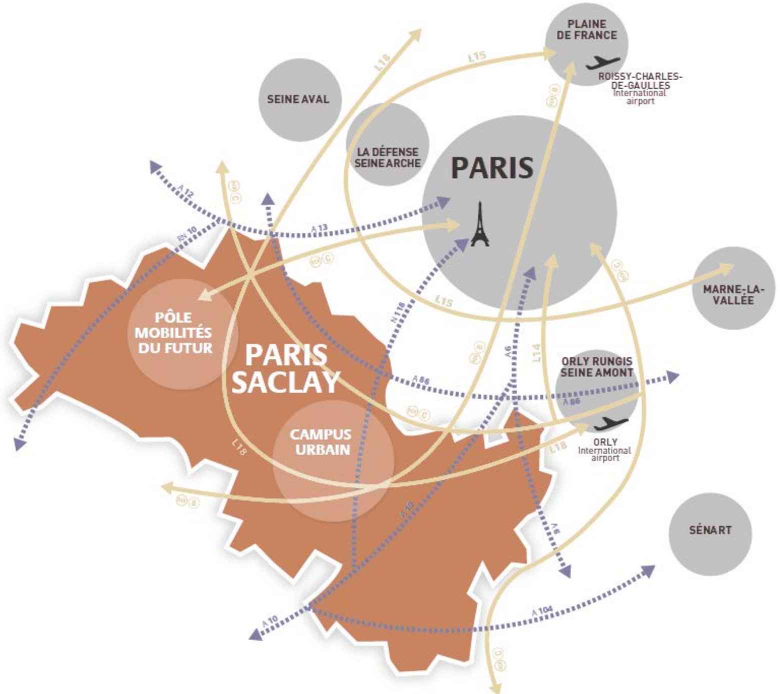


Fig. 13

As it is clear by now, the campus model in the suburbs has the potential to transform far-off areas into booming urban agglomerations that can significantly affect the development of a whole region.

In the ensemble of Greater Paris hubs, the technology cluster occupies a unique place. Around a vast protected open space, agricultural and natural, the urban ensembles of Versailles, Saint-Quentin-en-Yvelines, Massy, Palaiseau-Orsay-Gif-sur-Yvette, bring together a remarkable set of activities in terms of higher education, public and private research (15% of national potential), cultural and natural heritage.

The challenge is in defining the ensemble's strengths for a better organization of its resources, in dialogue with the whole metropolitan area of Paris. This implies a development strategy on two large scales:

- first, the entire **territory**;
- second, specific **centers of force**, the two main ones being the urban campus to the south of the Saclay plateau, and the Versailles-Saint-Quentin-en-Yvelines projects to the northwest.

The landscape, a keystone of the territorial transformation

Strictly protected from urbanization by law, the vast collection of the Saclay plateau constitutes an essential common good, showing the way to new relationships between city and nature, the agricultural world and the urban world.

In effect, agriculture is one of the region's crucial assets and denotes significant potential for innovation and development. Its long-term sustainability is guaranteed by the Grand Paris law: "the Saclay Plateau natural, agricultural and forestry zone protects more than 4,115 hectares of land from urbanization." (EPPS, *Un Projet Scientifique, économique et urbain, Paris*).

With the aim of sustaining vibrant and productive agricultural activity, an action program has been developed by the Authority alongside farming experts. It will contribute to fostering links between towns and agriculture by supporting their productive practices and promoting synergies between researchers.

With the landscape being at the core of the Saclay plateau, it has contributed to defining the characteristics that underpin its identity. As an international consultation took place, the first task was to define a global spatial strategy while being as economical as possible in terms of space consumption, by enhancing and respecting the territory's nature and agricultural activity, and by being at the forefront of innovations in environmental sustainability.

The Paris-Saclay Public Establishment retained the consortium led by landscape architect Michel Desvigne associated with architects and urban planners Xaveer de Geyter (XDGA) and Floris Alkemade (FAA), and the AREP agency. The proposal retained was based on the idea that the landscape structure of the plateau, its valleys and its wooded hillsides, constitute the supporting element and most significant for the development strategy. It should be highlighted and even amplified.

A new quality would thus be conferred on all elements forming the landscape (edges, boundaries, thresholds, hydraulic network, etc.), while integrating transport infrastructure in common and soft mobility. In this reinforced landscape structure would take place a network of park-campus, urbanized sites intended to accommodate mixed programs, preserving the agricultural areas.

In a nutshell, the development strategy aims at amplifying the landscape structure of this immense territory recognized by its geography, its wooded hillsides and valleys that constitute gateways to the urban campus.

Other key players for a stable transformation

This major regional development project serves the growth of businesses and research facilities along with improving the quality of urban and social life of residents, in the ambition of becoming an essential competitive advantage in a highly competitive world. When the operation of national interest was created in the spring of 2009, emphasis was placed very strongly on the idea of creating, at the junction of Yvelines and Essonne, a scientific and innovation center, a world-class cluster.

The State is making an unparalleled financial effort through investments for the future. As the mandate for the development of this territory, the Paris-Saclay Public Development Establishment works closely with local authorities to make this project

Fig.11. Aerial view showing MIT's Kendall Square Initiative

Fig.12. Aerial view of the South Lake Union redevelopment

Fig.13. Paris-Saclay, the innovation cluster of the Grand Paris

Fig.14. Territorial map of the Paris-Saclay technology cluster


Versailles
SATORY
Velizy - Villacoublay
Saint-Quentin
en-Yvelines
LA MINIÈRE
Saclay
Massy
LA BONDE
SUD DU PLATEAU
Palaiseau
COURTABOEUF

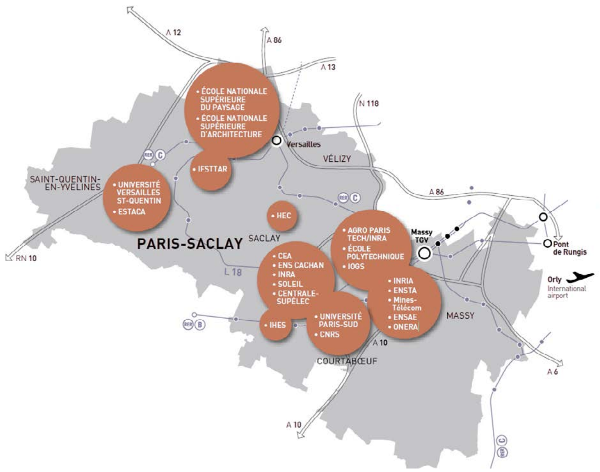


Fig. 15

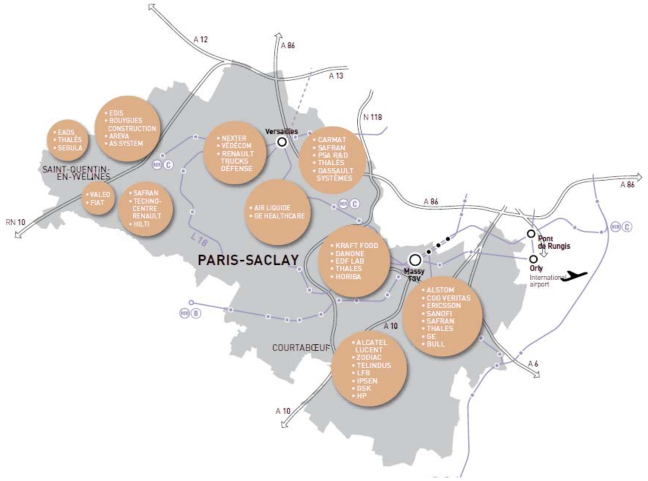


Fig. 16

a balanced territorial transformation. It mobilizes industrial players to stimulate growth around strategic sectors (aerospace – defense – security, energy, mobility, ICT, health).

The 19 establishments of Paris-Saclay, brought together within the University of Paris-Saclay and the Institut Polytechnique of Paris, deploy a training and research offer at the highest international standards. They constitute the scientific engine of the cluster. Built around historical scientific actors (Paris-Sud University, École Polytechnique, CEA, CentraleSupélec...) joined by a new wave of academic and industrial establishments, the Urban Campus will be a place of attraction for intellectual and technological creativity.

To match the diversity of inhabitants and their needs, the Development Authority also plans a wide variety of accommodation types: from dormitory and student housing to hotel residences for investors, visitors, and researchers, along with family housing that will contribute to the stable future of this region. It is thus necessary to provide a wide range of choice, combining both collective and individual housing, for the permanent and the temporary residents. This is where the architectural design of buildings also comes into place. It will play an important role in ensuring the harmonious incorporation of the neighborhoods, and in providing all the necessary elements of a homogeneous multifunctional city.

Fig.15. Higher Education and research facilities on Paris-Saclay

Fig.16. Major corporations and enterprises on Paris-Saclay

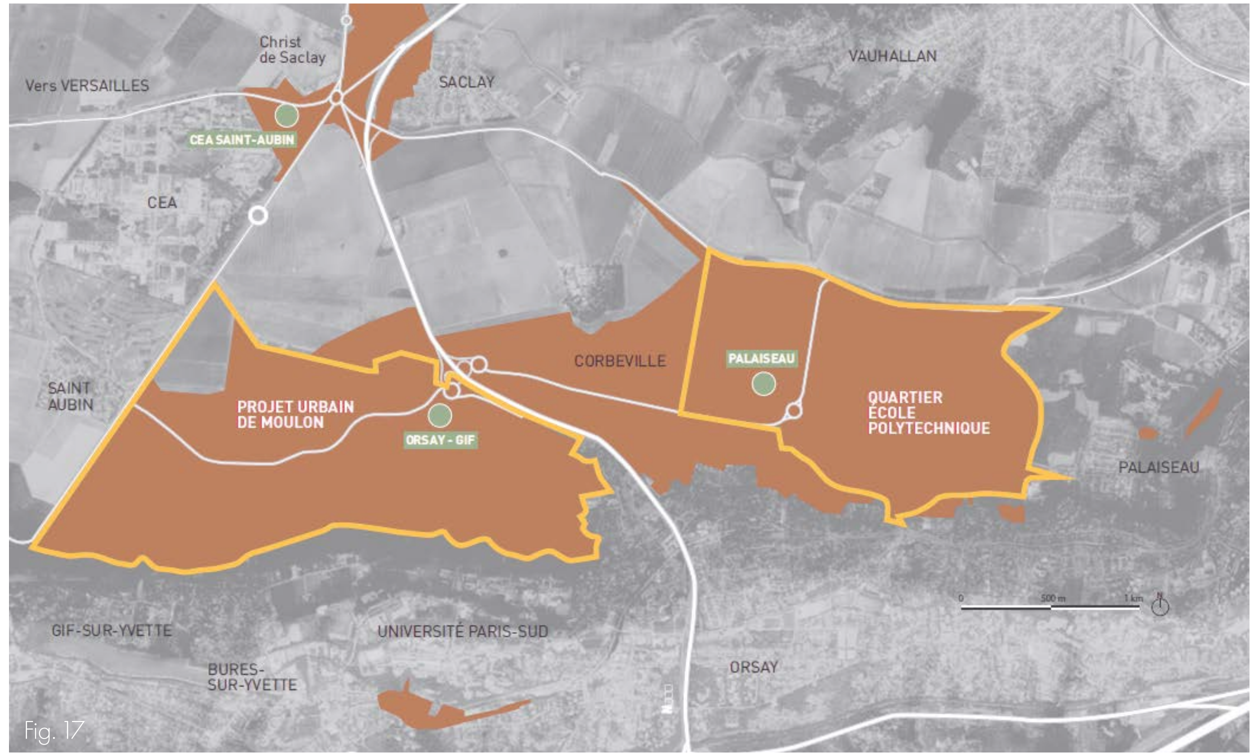


Fig. 17

Fortunately, the site already enjoys many assets that make for an exceptional quality of life both for residents and employees. Soon closely connected to Paris, it will enjoy the city's urban life with its national operas and theatres, numerous cinemas and a wide range of restaurants. Adding to this are the region's most significant cultural and historical assets, on top of them the Château de Versailles.

While in the field of sports the area benefits from the National Golf Course and Velodrome in Saint-Quentin-en-Yvelines and the French national Rugby Center in Marcoussis. To this are added the natural and ecological assets already presents, represented by a wide variation of remarkable landscapes including verdant forests, wooded hills, agricultural lands, and water streams. These resources sustain a wide array of activities, among them walking, running, and biking.

For well-balanced territorial transformation, The Paris-Saclay Public Development Establishment defiened five concerted development zones, the Satory Ouest district in Versailles and the Guyancourt – Saint-Quentin station district in Guyancourt; the École polytechnique district, the Moulon district and the Corbeville district on the Saclay plateau. In this study, we will be focusing on the development of the Saclay plateau as an urban campus.

Fig.17. The quarters of the Urban Campus of Paris-Saclay

Fig.18. CentraleSupélec campus on Paris-Saclay


Gustave EIFFEL
CENTRALESUPELEC

Fig. 18


ÉCOLE NORMALE SUPÉRIEURE PARIS-

Fig. 19

'IF THE CONSTITUTION OF A LANDSCAPE SEEMS, OBVIOUSLY, ONE OF THE MEANS OF ORGANIZING SUCH A VAST TERRITORY, ONLY ITS ROOTING IN THE GEOGRAPHY OF THE SITE CAN GIVE IT ITS RELEVANCE. THE LANDSCAPE IS FOR US THE KEYSTONE OF THE TRANSFORMATION OF THE TERRITORY. AT THIS SCALE, IT MUST BE THE STARTING POINT OF THE DEVICE. IT IS THE MEANS TO GIVE IT AN IDENTITY AND, IN A PRACTICAL WAY, TO BEGIN TO TRANSFORM IT.'

- MICHEL DESVIGNE, EPPS-SDT 2012

"Si la constitution d'un paysage semble, à l'évidence, l'un des moyens d'organiser un territoire aussi vaste, seul son enracinement dans la géographie du site peut lui donner sa pertinence. Le paysage est pour nous la clef de voûte de la transformation du territoire. À cette échelle, il doit être le point de départ du dispositif. Il est le moyen de lui donner une identité et, de façon pratique, de commencer à le transformer."

1.2. Urban Campus: from territory to architecture

The Plateau, a morphology with many opportunities

The heart of the Paris-Saclay project is the Urban Campus extending to the south of the Saclay plateau, between the École Polytechnique and the CEA, encompassing a very large territory with a very large potential of densification.

Through a careful analysis of the site's morphology, there is no doubt that the plateau is enclosed by a natural forested barrier in the south, the valleys, and limited by what is now lands used for agricultural activity in the north. It can be said that the area presents a ratio of 3:2, greenery to built environment. The greenery is split between forestries, agricultural fields and open spaces. This sets a balance and gives way to a sustainable planning of the area while encouraging future collaborations between agriculture and city.

From then on, the edge of the campus is no longer a simple line, a limit of demarcation materializing the temporary stabilization of the urban front. It thickens, enriches itself, until it becomes the place where the reconciliation of two worlds that have long been opposed can be replayed: the city and the countryside.

The plateau in well connected thanks to the existing train lines in proximity and the bus lines that serve the heart of the campus. Luckily, with the new metro line 18 in vision, it will be directly linked to the city of Paris and will allow a large flow of people entering the area everyday. In such a vast territory, the transportation lines take on an important role in defining the space and creating important edges, nodes and links between the districts themselves and their immediate context.

When oberving the built environment in different points of interest on the plateau, the higher education and research facilities seem to be constructed gradually and autonomously, as if to fulfill their own needs in their own parcel. Today, they seem to lack a common ground that would join them together into a common city cluster with its own identity. It is thus necessary to induce urban links and broaden the sense of community to transform this agglomertion into an integrated urban campus capable of competing on an international level.

In order to understand better the morphology of the plateau, **four urban cuts** were chosen:

- two taken from the urban campus,
- and the other two belonging to the city of Paris.

For each of these elements, we analyse the system of greenery, the built environment in opposition to the open spaces, and finally the system of roads and circulation.

Fig.19. Ecole Normale Supérieure campus on Paris-Saclay

Fig.20. Territorial plan of Paris-Saclay


Atomic Cluster
Cluster 1
Cluster 2
Univ. Paris Sud
Ecole Polytechnique
Natural Southern Edge
Intersection
Natural and Forest Areas
Farming and Agronomy Research Areas
Open Spaces - Built Environment
Nuclear Institutions
Public Transport
Primary Vehicular Arteries

Fig. 20

The first two cuts present a predominance of open spaces with a big part of them being natural greenery: some agricultural fields in the Moulon district and the forestries in the valley of the Ecole Polythecnique distrcit.

In the latter, a difference of scale is clear between the facilities on the plateau and the neibourhoods of Orsay and Palaiseau separated by the valley.

A comparison is made with the cuts in the city of Paris to better grasp the morphological identity and geographical characteristics of the territory.

The cuts made are of two kinds: one is in the traditional city and demonstrate the typical morphology present in Paris Intramuros with its compact clusters and typical aligned buildings forming a branched planar typology of clusters; while the second is in a location that witnessed newer developments which can be seen through the different scales of buildings present there presenting a punctual typology like that on the plateau with considerably larger structures.

The pillars of the urban campus

After defining the Plateau's strengths and weaknesses, the next steps were clearer when it comes to the future of this area.

Since 2009, the multidisciplinary team led by landscaper Michel Desvigne Paysagiste with Xaveer de Geyter-Floris Alkemade (architects-urban planners) has been responsible for supporting the Établissement Public d'Aménagement de Paris-Saclay (EPA-PS) in defining a spatial strategy regarding the structuring themes for this territory: the landscape, mobility, and environmental principles. The team is also an urban consultant for the ZAC in the École Polytechnique district.

The development plan designed with the team on the scale of the south plateau offers an innovative response to the urban and landscape situations encountered on the Saclay Plateau, particularly in the treatment of the infrastructure and the urban and agricultural fringes.

It is structured around three orientations: the edges, mixed and compact districts, and a chain of major places:

The edges:

At the scale of the campus, it is a question of designing a system of parks based on all the elements that form the landscape (edges, topography, limits). This system, designed to shape the transition between agricultural areas and future districts, will host a set of contiguous landscape entities such as water management and biodiversity protection systems, technical and sports equipment, recreational areas, agricultural land dedicated to agronomic research.

Mixed and compact districts:

The dispersion of buildings and the lack of dedicated public spaces have led to the converse design of compact districts with a diversity of functions guaranteeing the animation of the campus and its attractiveness while allowing synergies between users. Thus, the neighborhoods will combine university spaces, offices, housing, facilities, and shops.

Fig.21,22. Morphological comparison of four urban cuts within Paris and the Plateau

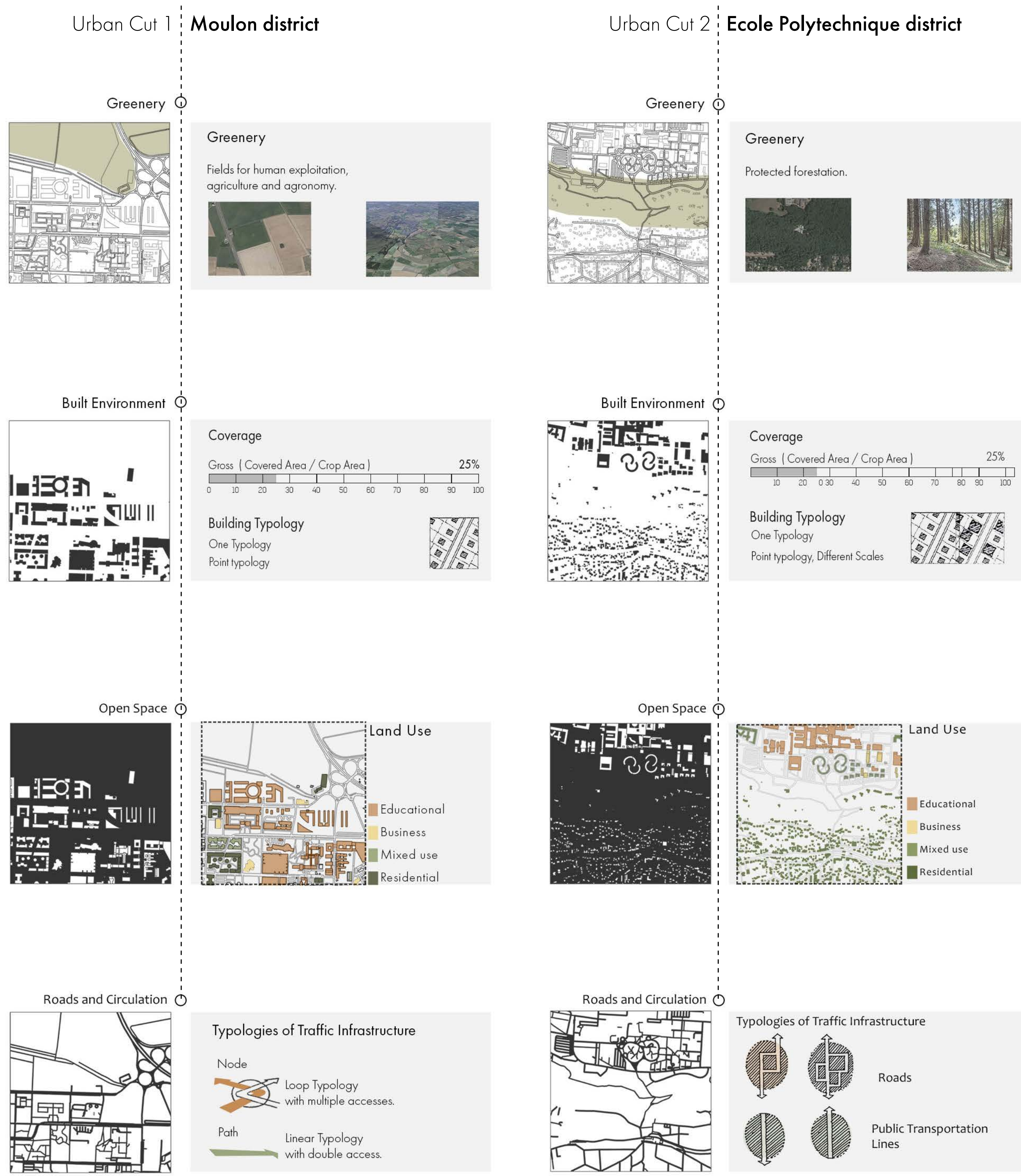


Fig. 21

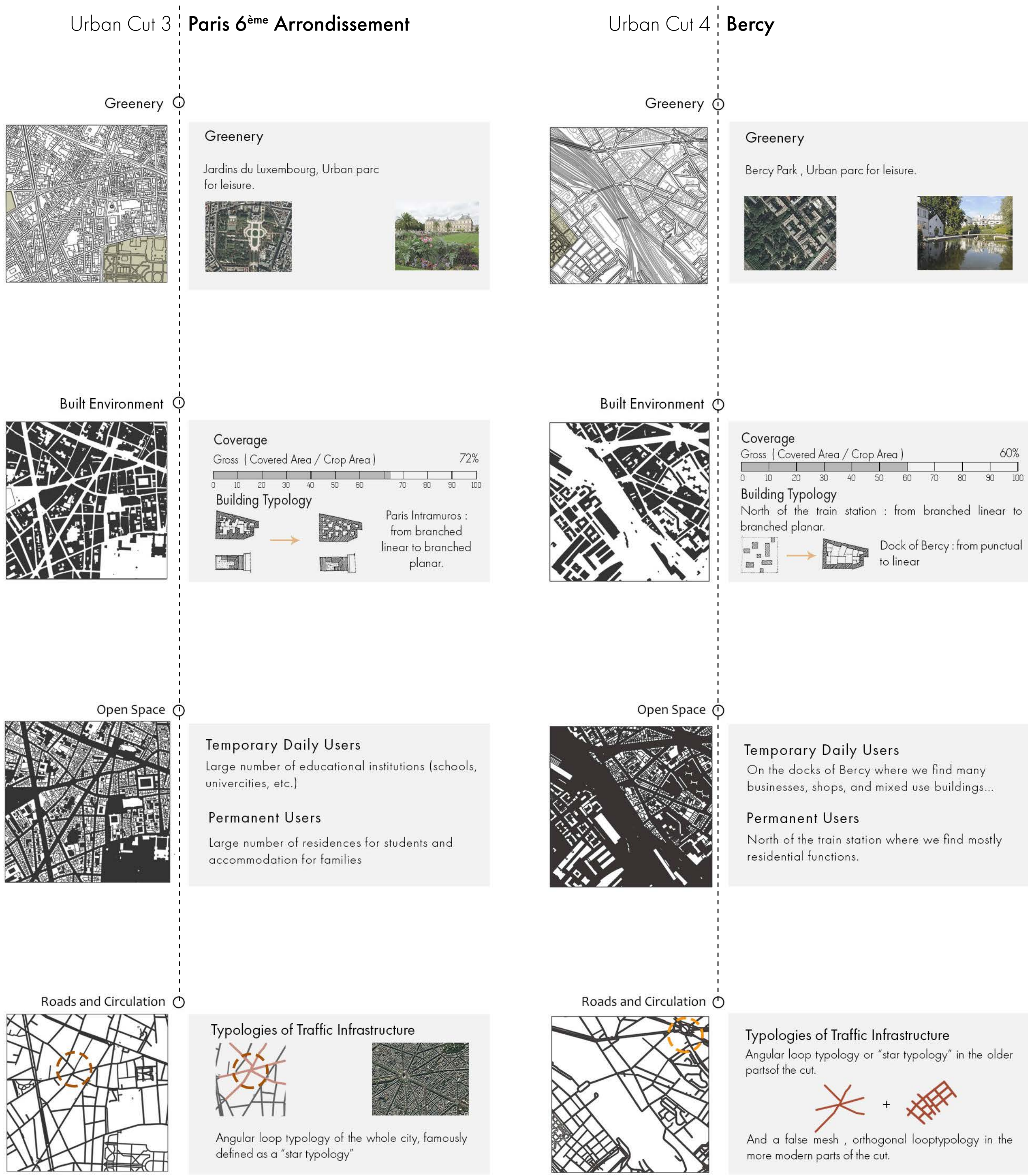
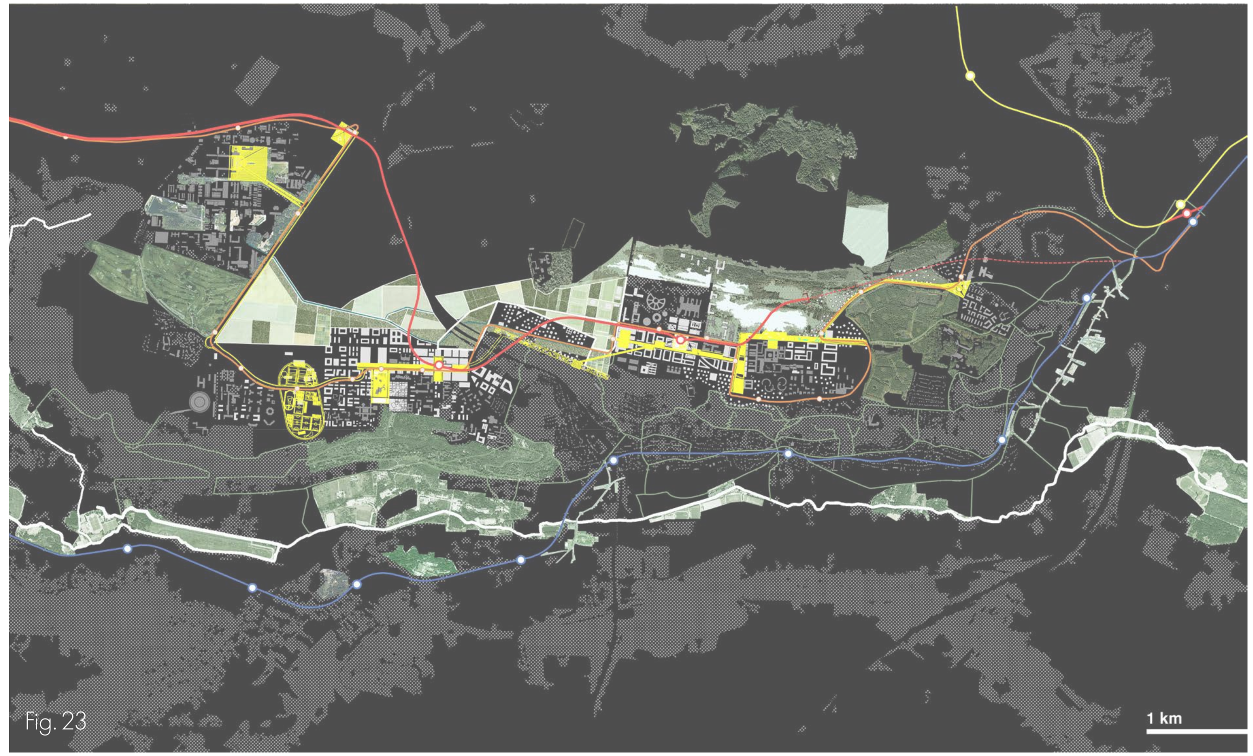


Fig. 22



A chain of major places:

The campus is structured around a linear layout made up of sequences of unique and diverse public places. These spaces have a double function: on a large scale, they constitute a centrality and a spatial reference for the users; and on a close scale, each of the spaces is a place of meetings and exchanges, close to places of density.

At the heart of the development strategy, public transport structures and gives coherence to the territory of the campus.

The improvement of the site's public transport service will allow a real transformation of practices by linking the districts to existing cities and to the centers of Greater Paris.

The development plan is organized around a wide spectrum of mobility, in the forefront of which line 18 of the Grand Paris Express metro, with three stations on the south of the plateau.

In addition, the campus has been served since 2016 by the Express 91-06 bus line and today, soft mobility routes are developed throughout the site, in connection with the valley.

Fig.23. Map showing the edges and the central strip of major places of the Urban Campus

1.3. Institut polytechnique: program, challenges, and aspirations

The setting of the urban project

The campus is now taking shape through the emergence of two districts, that of Moulon and that of the École Polytechnique district. In addition, the ZAC of the Corbeville sector, which is located between the two ZACs, is now launched.

For the rest of this study, we will be focusing on the Ecole Polytechnique district where the community center will be located.

The ZAC of the École Polytechnique is located to the west of the commune of Palaiseau and to the southeast of the commune of Saclay. It covers an area of 232 hectares: 217 hectares in Palaiseau and 15 hectares in Saclay. The site consisted of sparsely populated spaces punctuated by large built-up areas.

The eastern part of the district historically corresponds to the site of the École Polytechnique, which opened its doors in 1976, and includes teaching and research premises and student accommodation. The western part of the district has undergone progressive urbanization.

To the east, the site is bordered by the Palaiseau State Forest, to the south by the wooded hillsides of the plateau and to the west by the ZAC of Corbeville.

Regarding the environment at the time of their creation, each of the establishments was designed independently and anticipated all its needs on its plot.

The master plan, entrusted to the landscapers, architects and urban planners already presented, is based on the opening of the current campus of the École Polytechnique, with the creation of a new network, the establishment of mixed programs and the realization of comfortable public spaces for all.

The objectives of the urban project

Characterized by its academic and scientific vocation with the establishment of numerous higher education and research programs within the framework of the Campus Plan, the ZAC of the École Polytechnique district is intended to become a mixed and lively district with the creation of housing, economic activities, service, and shopping centers.

The orientations for the urban project of the École Polytechnique district are as follows:

- create an open district, linked to the rest of the Sud du Plateau campus and to the existing districts, those being the districts of Joncherettes, Camille Claudel, and the future Corbeville project;

- integrate new and existing programs into a coherent urban whole;

- create a dynamic living environment thanks to the compactness of the facilities, the mix of programs and the development of places of urban intensity;
- allow the reception of higher education and

Fig.24. Aerial view of the Ecole Polytechnique, Palaiseau

ECOLE POLYTECHNIQUE PROFILE

'Since its creation in 1794, École Polytechnique has been producing and sharing multidisciplinary knowledge at the highest level, for its students, for companies and for society, by developing an entrepreneurial spirit, boldness and a sense of general interest in its three fundamental missions of education, research and innovation.

In a globalized higher education and research environment that is both competitive but also open and collaborative, École Polytechnique has inscribed its future within Institut Polytechnique de Paris.

Created in June 2019, Institut Polytechnique de Paris is a public institution of higher education and research, encompassing 5 prestigious French engineering Schools: École Polytechnique, ENSTA Paris, ENSAE Paris, Télécom Paris, Télécom SudParis.

Since its creation, IP Paris has established itself as a world-class institution of higher education and scientific and technological research, capable of attracting the best French and foreign researchers and students, and thus being an essential driving force for France's power and influence.'

- PRESENTATION OF ECOLE POLYTECHNIQUE; EXERPT FROM THE IP WEBSITE

research establishments and companies in good conditions, and thus contribute to developing synergies between public research and private research;

- improve the site's public transport service and restructure the network of road and soft traffic in the district, by redefining public spaces and setting up a landscaped framework to encourage encounters;

- manage the phasing of the project: landscaping prefiguration processes should make it possible to quickly transform the site, avoid the appearance of wasteland and manage the works phase for this large-scale development project;

- carry out an exemplary operation in terms of sustainable development by collectively and innovatively managing issues related to energy and water management.

The Central Axis

The Central Strip is the representative address of the main programs of the district. It crosses the district from East to West and establishes the chain of major places that federates the 7 km of the campus in the south of the plateau.
This public space, approximately 20 meters wide,

Fig.25. Map of the key public spaces of the IP Paris campus with the respective schools

Fig.26,28,31,33. Impressions of the main public spaces structuring the campus

planted in its center and mineral on its sides, connects the École Polytechnique and Le Green to the east with the Corbeville sector to the west, carrying on to the Moulon district.
The execution of the ground floors in the central strip is the subject of particular attention: their animation will be partly guaranteed by the integration of shops and numerous services.

Crossing squares and gardens, it will be primarily reserved for soft mobility with coherent landscape implementation.

The treatment of the facades along this axis is sequenced to participate in the animation of the public space and to illustrate the differences in use of the buildings around it.

The atmosphere is defined by a particular profile which imposes a stepped treatment of the buildings arranged on this axis. These terraces are an opportunity to animate the city on the floors by creating terraces, balconies or by exposing circulations. This brings light to this largely landscaped public space.

IP Paris and its public spaces

Public spaces, the real framework of the district, constitute structuring places on the scale of the district. Of varied scales, they are characterized by their simplicity and their reversibility which must allow a great diversity of uses and leave all their place to pedestrians and soft mobility.

A sequence of key places forms the east-west axis already mentioned and punctuates the IP Paris with large public spaces. Displaying a verdant natural setting, it balances the districts with its green surroundings while structuring the campus with points of interest.
These large public spaces become central locations to which the activities and pedestrian flow converge.

Each IP school benefits from one of the places taking in all the unique advantages it offers:

- Télécom Paris and Télécom sudParis and **Place Marguerite Perey**, the heart of the urban district.
- ENSAE and the **Green**, a lively park with a variety of uses.
- Polytechnique and the **Agora**.
- ENSTA and the **Prairie**, a lively open space with multiple uses, the main location in the eastern sector of the campus.

Connecting the principal hubs of campus life, public places and community services, this urban strip gains a complementary nature in the progression of the spaces shaping it.

A strong coherence is therefore achieved within a wide variety of functions giving the urban campus its identity, its exceptional space. The obtained structure of major places enables green modes of transport and hosts multiple uses.

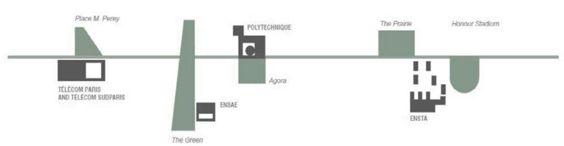
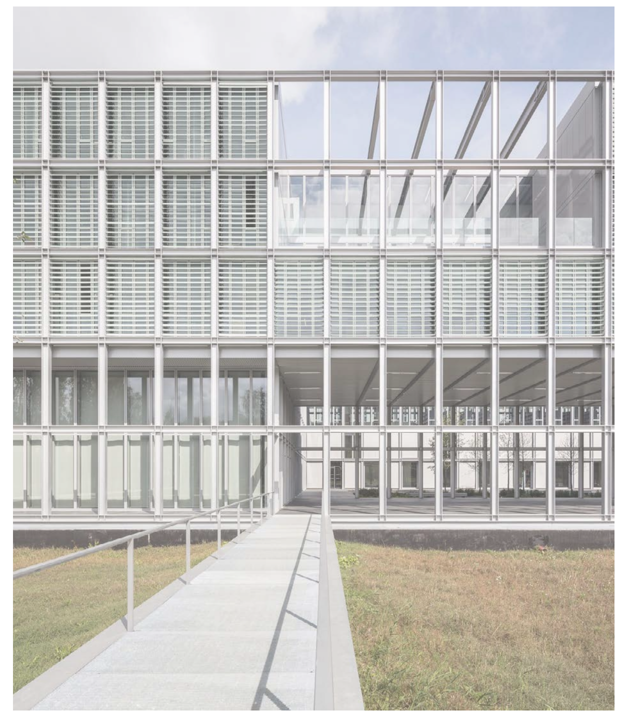


Fig.27,29,30,32. The buildings of the Institut Polytechnique school


Fig. 26 PLACE MARGUERITE PEREY


Télécom Fig. 27


Fig. 28 LE GREEN


ENSAE Fig. 29

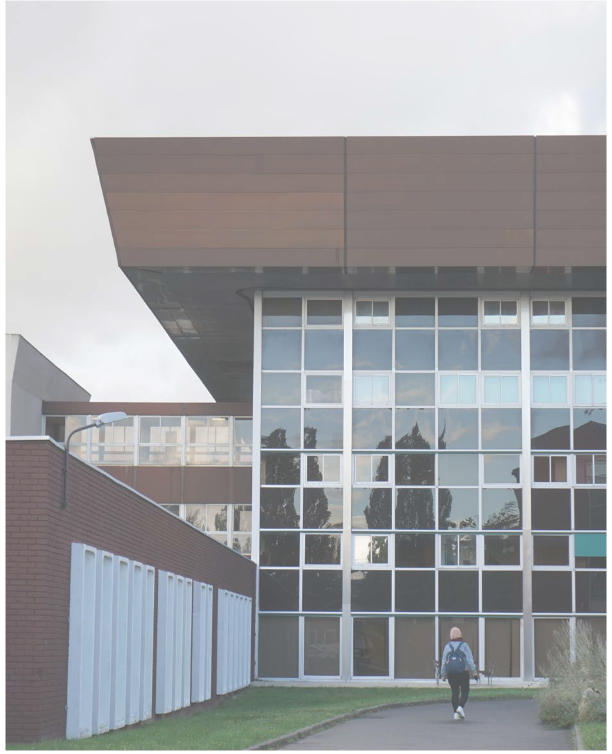


Fig. 30 Ecole Polytechnique


THE AGORA Fig. 31


Fig. 32 ENSTA


THE PRAIRIE Fig. 33

1.4. A Summary

How is the Saclay plateau defined?

- Functionally: An innovation and research cluster that improves the role of Paris as a leading economy in Europe and the world becoming an essential competitive advantage in a highly competitive global environment.
- Geographically: A major regional development project characterized by an important landscape area that holds innovative sustainable possibilities and promising urban development.
- Morphologically: A modern urban tissue presenting a high potential of densification coupled with a natural sustainable setting.

What are the Masterplan's goals?

- Organize the urban and rural expansion of the cluster, in a way to attain a self-sufficient and ecologically healthy innovation zone.
- Respect and promote what makes the territory unique, i.e. its geography and landscape contributing to the characteristics that underpin its identity
- Diversify the users, reinforce social interaction, and induce synergies for a common sense of belonging.
- Help create and maintain an improved microclimate consisting of minimal waste, smart water management, biodiversity and environmental awareness of the city and its inhabitants.

How are the goals achieved?

- Building direct and explicit connections with the natural and urban context present with both public transit systems and soft mobilities.
- Zoning and organizing the growing urbanization while implementing urbanization laws for the protection the agricultural and natural zones.
- Creating public spaces along a common central axis giving the districts a point of reference.
- Grafting micro communities among research and innovation functions for positive synergies.

"The overall goal in this part of the plan is to encourage encounters and synergies between researchers, students, and private and public workers. This will be achieved by creating a shared green and adaptable space, animating the main east-west axis with shops, services, and a shared program (incubators, coworking, startups...), and integrating a sporting dimension into each new building to keep the welcoming image of the campus."

CHAPTER 2

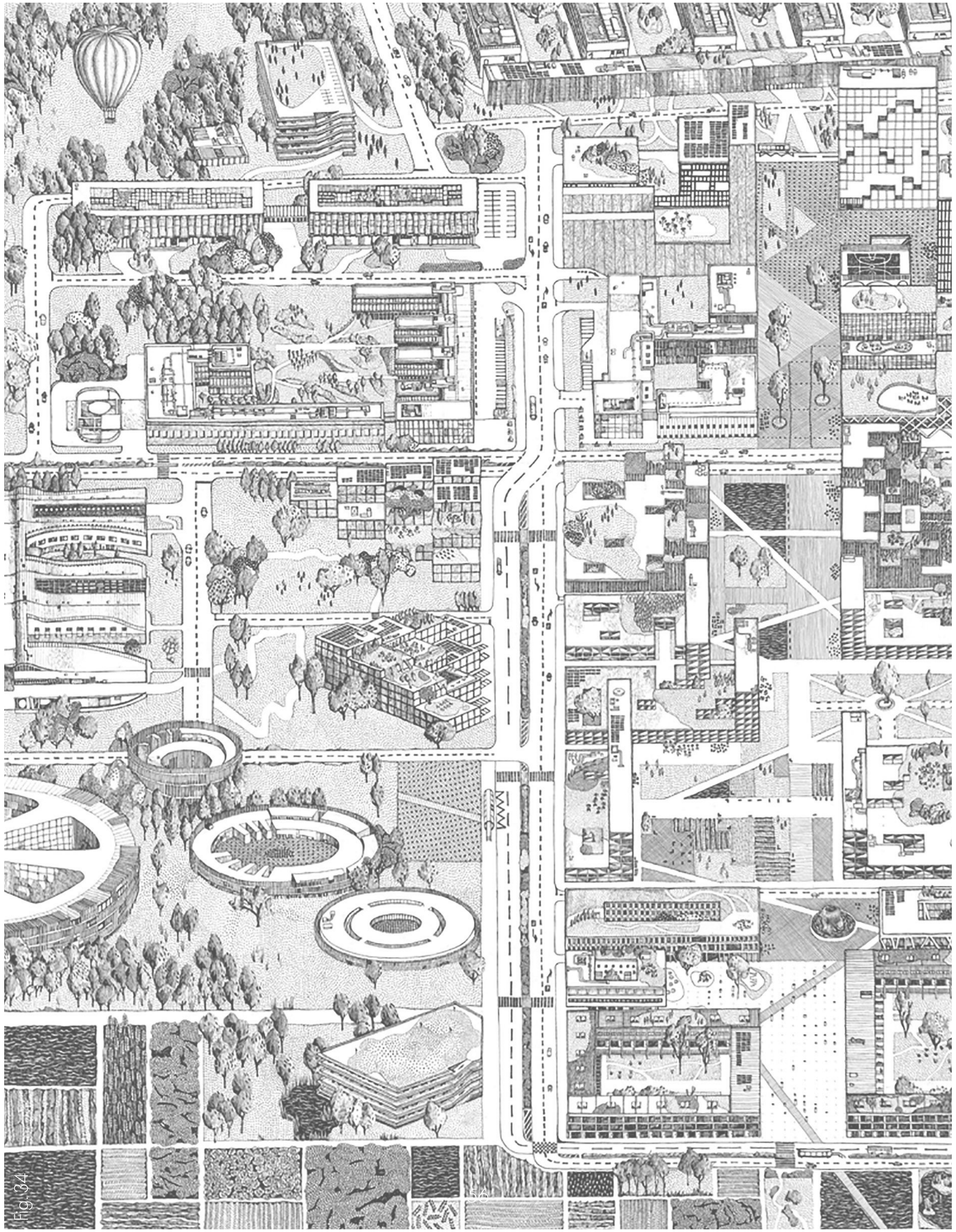
THE EASTERN SECTOR: A PLACE OF SYNERGIES

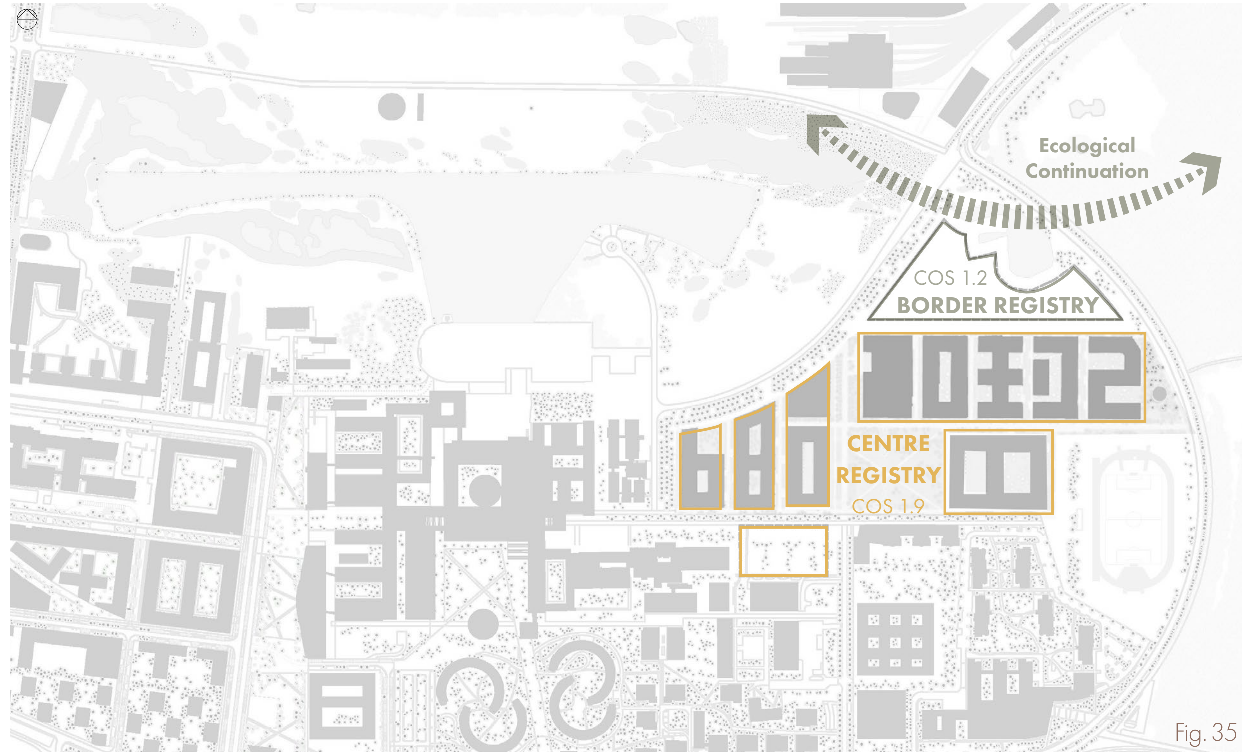
2.1. A flexible and resilient system

2.2. A new layout for new interactions

The densification in form, program, and links

From the Prairie to the Crossroads





2.1. A flexible and resilient system

Within the Paris-Saclay South Campus, the development of the eastern sector, carried out jointly by the Institut Polytechnique (IP) de Paris and the EPA of Paris-Saclay, will host:

- research and innovation centers or public and private teaching centers,
- a museum for the exploration of the IP past and present scientific achievements,
- a recreation center accommodating a wide range of sports facilities and places for the community,
- a set of specialized corporate buildings, and
- a cultural and community center.

The varied program of this sector calls for a diverse range of building shapes, sizes, and functions. To achieve this, the strategic plan proposes a flexible and robust system able to adapt to investors' future needs while ensuring essential urban coherence and enhancing the daily life of those already living on the plateau.

The innovation and research park is structured around the Prairie, punctuated by Avenue Becquerel leading to the Nature Park and the junction with Chemin de la Vauve aux Granges leading to the Camille Claudel district. Building projects in the north-east zone will help meet the building requirements of EPA Paris Saclay and will aim for a

Fig.34. Paris-Saclay straight axonometry showing the ambiances in the urban campus

Fig.35. Paris-Saclay straight axonometry showing the ambiances in the urban campus

design that blends in with the landscape, ultimately one that is not too dense and is in continuity with the Nature Park.

To ensure the coherent urban development of the eastern sector, the different lots will be governed by urban, architectural and landscape guidelines. The lots to the north will be less dense because they are part of the ecological continuity of the park.
While building density is a prerequisite, the heights of the buildings, urban alignment, and qualitative addresses according to the hierarchy of public spaces must also respect certain requirements, such as a maximum height of 25 meters.

The development of the sector will include the creation of shops and services. The edge of the Prairie and the intersection between Avenue Becquerel and the east-west axis have been identified as strategic positions, located at the convergence of areas within walking distance (5 mins) of Ecole Polytechnique and ENSTA.

The creation of the east-west axis is the starting point for the implementation of the project. This axis articulates the major public spaces on the campus, serving as an anchor for the developments to follow. IP Paris's first developments for the Innovation Park will border the east-west axis and bring it to life, in particular by the commercial polarity of the ground floors as identified. This axis will thus provide the constant flow required for the economic balance of the projects. Its main concentration point will be 'The Prairie' providing important visibility from the east and a convergence point for all users.

The creation of gardens and visual openings are encouraged on private plots to provide links to

Fig. 36 Amplified Geography

Fig. 37 Naturalistic Landscape

Fig. 38 Landscape of the Campus' Centre

Fig. 39 Central Major Places

Fig.36-39. Maps showing the hierarchy of the landscape in the neighborhood

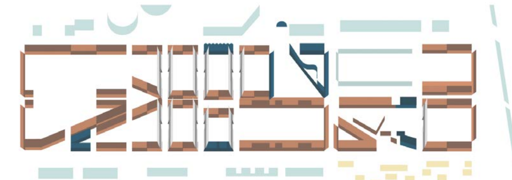


Fig. 40 Materiality guidelines of central strip

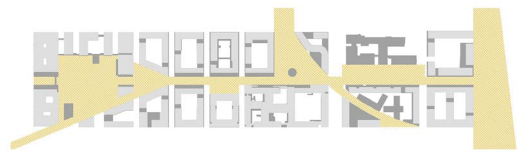


Fig. 41 Urban Campus: between GF and upper floors

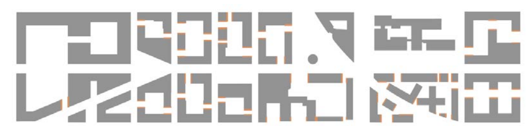


Fig. 42 Lower registry: active bases and porosities

Fig. 43 Higher registry: faults and openings

Fig. 40-43. Some general conditions that shape buildings and spaces along the central strip

the park and the Palaiseau forest. Underground parking and maximum integration of logistics docks and access roads will contribute to the creation of a peaceful campus. EPA will develop the eastern part of the northern section of Becquerel as well as the forest avenue to the north of the Prairie which will benefit newcomers from the eastern sector.

The existing sports facilities play an essential role in life on the Ecole Polytechnique campus. To the north, on the edge the lake, are major sports pitches and an equestrian showground. In the heart of the campus, spread out along Avenue Borotra, are the indoor facilities to the west and the tennis courts and major sports fields to the east, leading to the Honor Stadium. In addition to serving educational purposes, these facilities are also used by staff and external associations. They contribute to creating the image of a welcoming and dynamic campus.

The work on the Nature Park is the starting point for the EPA-PS developments in the eastern sector. The relocation of the football pitches will allow the first developments to begin on the innovation and research park, starting at Avenue Becquerel and working from west to east.

The overall goal in this part of the plan is to encourage encounters and synergies between researchers, students, and private and public workers. This will be achieved by creating a shared green and adaptable space, animating the main east-west axis with shops, services, and a shared program (incubators, coworking, startups...), and integrating a sporting dimension into each new building to keep the welcoming image of the campus.

Fig.44

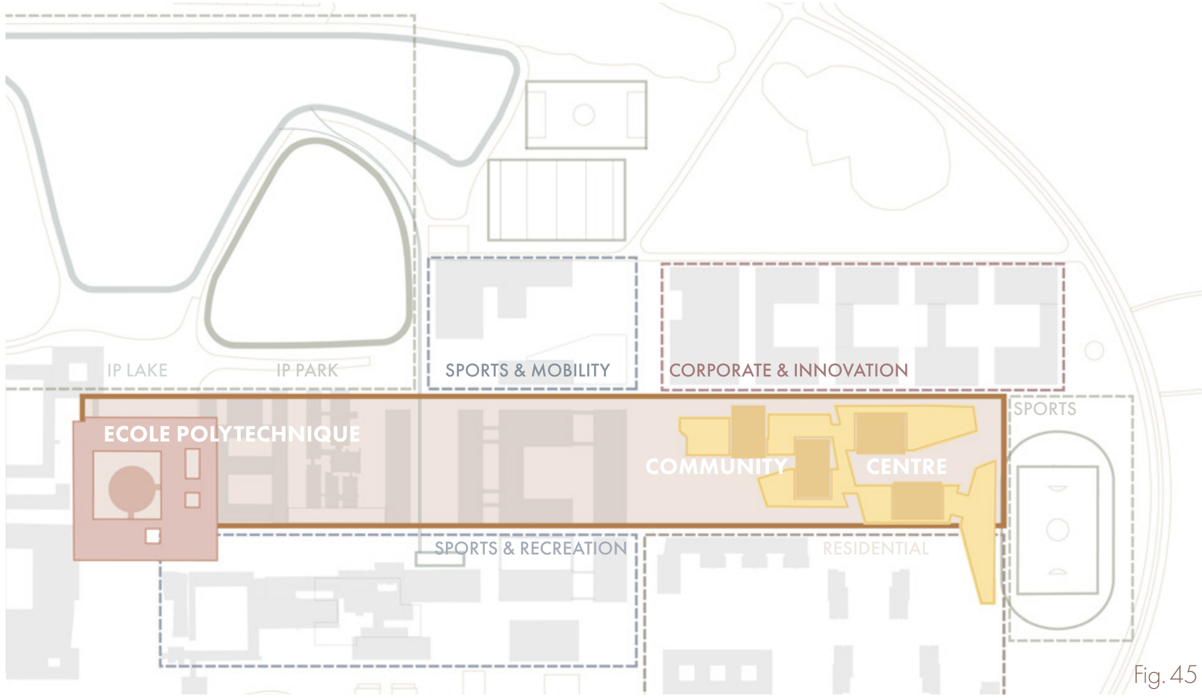


Fig. 45

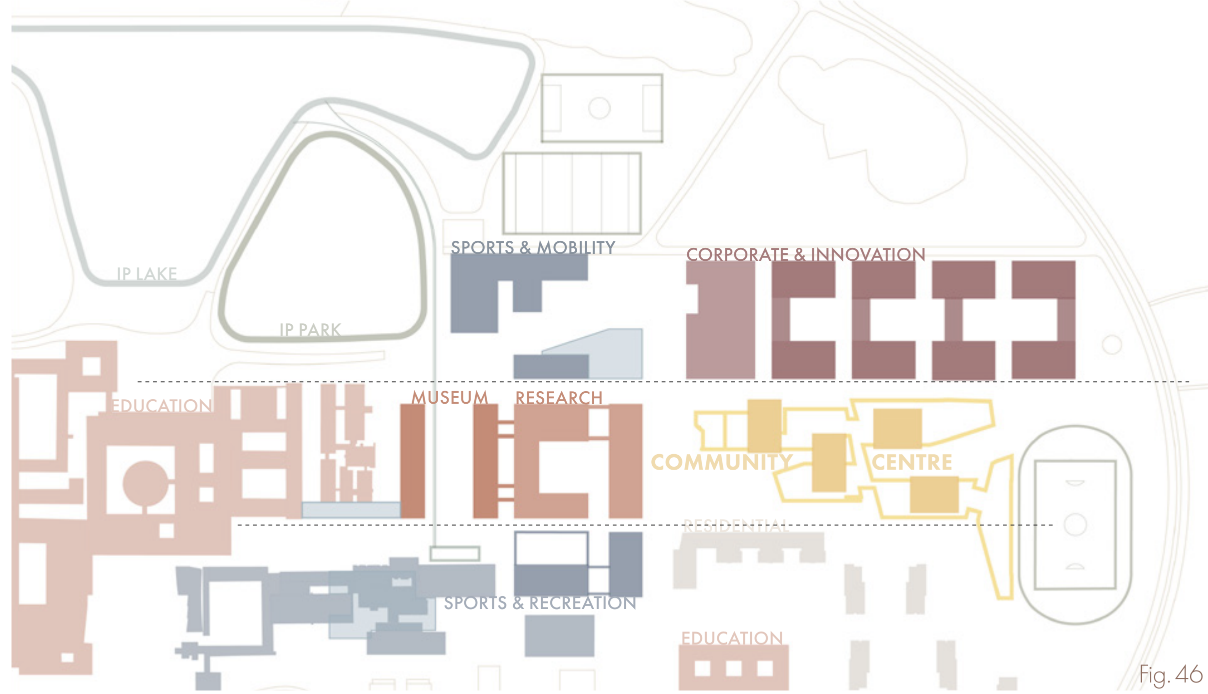


Fig. 46

2.2. A new layout for new interactions

The densification in form, program, and links

For the rest of this study, we will proceed by further developing the cultural and community center for the purpose of this thesis.
Our choice fell directly on this specific part of the program because of the impact it could have on this particular location and territory as an attraction point. It joins so many different users and a wide range of functions in one unique concentration spot. Therefore, this entity could be an explicit demonstration of the junction between a varied collection of consumers and a diversified program, while serving its purpose in producing positive synergies.

Since building density is a requisite for the urban campus, the process initiated by drawing up a central belt of density. Within this belt will be the sector's most significant buildings: the Ecole Polytechnique and the Community Center. In between are the complementary facilities of the Polytechnique, those being the IP Center for Research Excellence in Biomedical Engineering and the X/IP Museum dedicated for the most significant collections of the Institut Polytechnique's research.

To this belt are added supporting structures. Besides achieving the density required along the belt, they help in the process of transferring the different types of landscape that characterize the site. Of course, we are talking about first a formal type which is related to the set of open public spaces defined by the agglomeration of buildings; and another informal type coming from the green natural landscape predominantly spread out in the territory and holds the key to bringing out its identity.

To the west of the Community Center, and on both sides of the belt, an agglomeration of sports and recreation facilities sprawl. In the north, a complex dedicated to large indoor facilities (aquatic sports area, athletic gym...) with spaces reserved for parking for vehicles and bicycles. In fact, at this point of the cluster, access for private vehicles is blocked and reserved only for deliveries. This mediates the physical barrier previously present because of the Avenue René Descartes and allows a more pedestrian-friendly connection between the upper side of the belt and its core.

This building complex benefits from the proximity to the lake and what is now defined as the IP park, a tool that would make this side of the natural landscape more accessible and closer to the human scale. To the other side of the boulevard is an entity dedicated to recreation and social encounters due to its proximity to the research and academic community.

Fig. 44. A physical model made by the architects along the design process

Fig. 45. Diagrammatic map of the initial density loop joining the Polytechnique and the Community Centre

Fig. 46. Diagrammatic map of the new massing and its respective program in the eastern sector

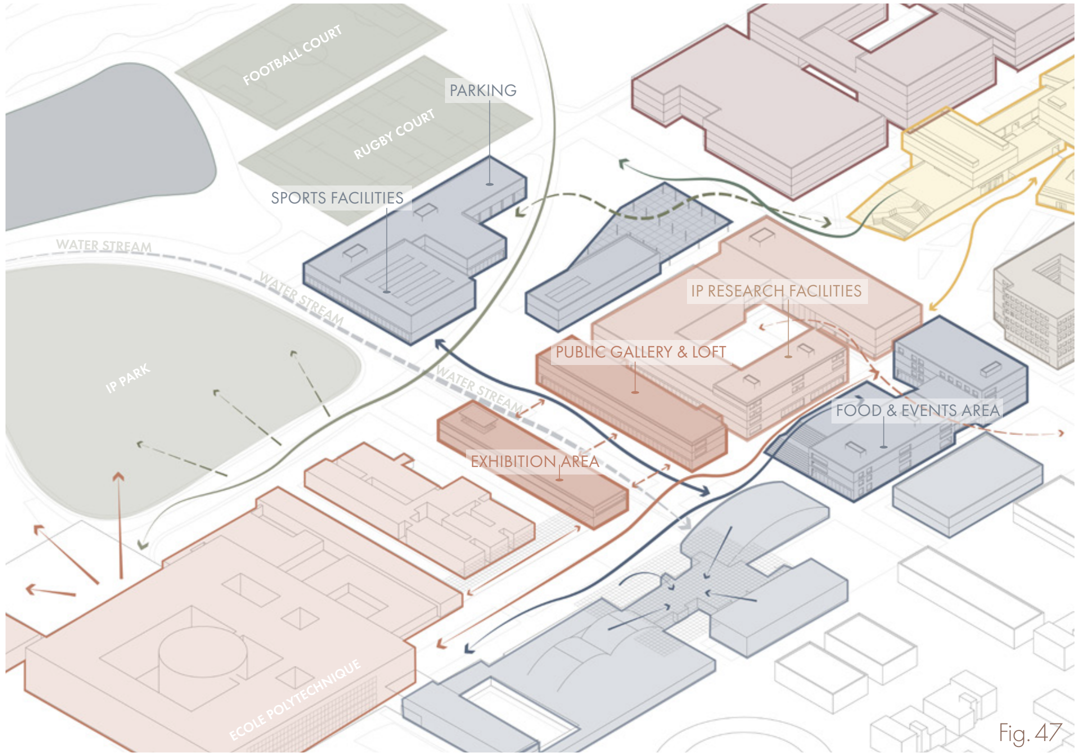


Fig. 47

In the south is a series of mismatched buildings constituting some of the indoor sports equipment which all the staff and students benefit from daily. A canopy could be envisioned bringing together some of these buildings in a way to create a common ground that would homogenize this set. This sequence will also benefit from the now animated Borotra Avenue in the center of the campus which will be turned into a space dedicated to green travel and sport.

Both collections in the north and the south are interconnected through the museum's public square where a water line runs guiding people towards the landscape along the Polytechnique lake. The museum thus plays the role of a lever engaging the public and creating a more dynamic flow for an everyday or occasional crossing. Divided in two blocks, it will host, in the part connected to the IP, the permanent collections introducing X /IP and illustrating key moments of their past, present, and future. While the independent block will be dedicated to the temporary exhibitions and its most public functions (public gallery, event space, museum café...).

Next to the museum is the IP Center for Research in Biomedical Engineering, a flexible research hub for R&D and an accelerator of innovation that combines academic and corporate types.

In front of it, and across the Borotra Avenue, is a

Fig. 47-48. 3D diagrams of the new massing and its respective program in the eastern sector

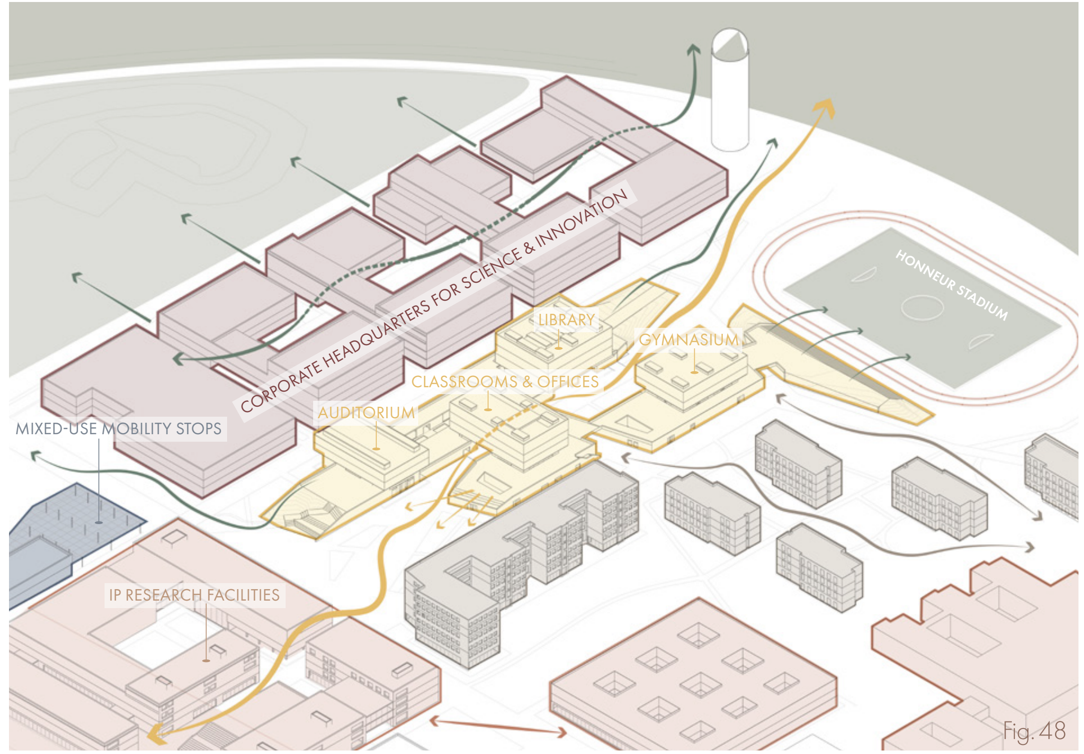


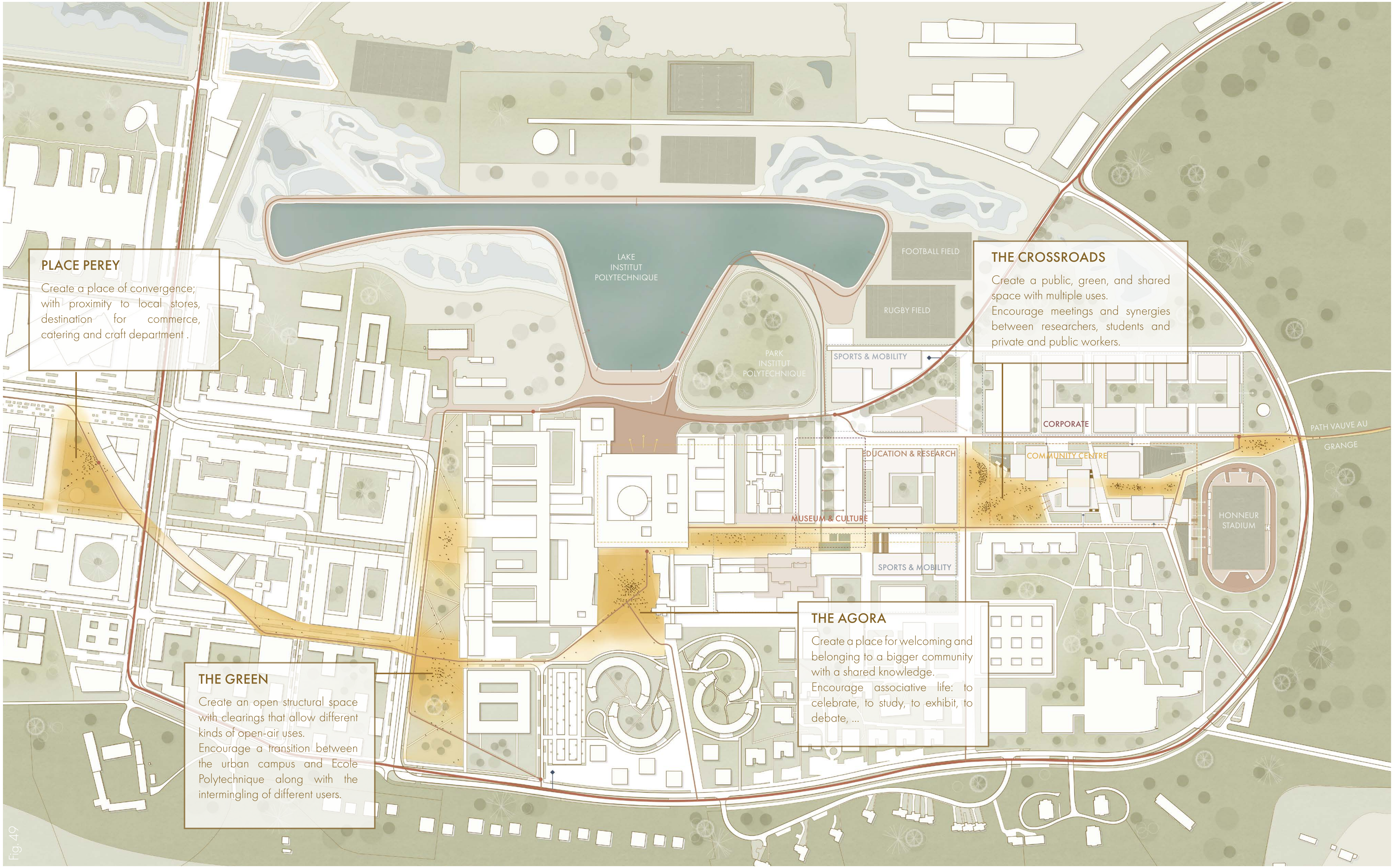
Fig. 48

recreational building forming the hinge between the diversified program at this point of the sector. Housing leisure functions for the socialization and interaction of the community, it completes the sequence of sports facilities along the avenue of Borotra and joins together the different users coming from the Polytechnique, the Research center, ENSTA ...

To the south of the Community Center are some of the sector's housing complexes, while to the north is a cluster fully dedicated to corporate buildings. Within the Research and Innovation Park, this complex is expected to be developed as a flexible research & development incubator, and an innovation accelerator in which academic and business typologies are merged. It must promote synergies between the University's Research Centers and a wide range of leading companies in the high-tech sector, providing shared spaces for entrepreneurial activities and academic research.

In this part of the sector, a smooth transition between the built environment and the nature is sought out to keep a green liaison along the northern edge joining the Palaiseau forest to the landscape around the lake, what is known as the Nature Park. Thus, the corporate buildings must keep their soil occupation to a minimum and maximize planted spaces in a way to form a green strip that joins them together. In this way, the northern edge will be softened, blending into the green landscape.

Fig. 49. New masterplan with emphasis on the central strip of major places


PLACE PEREY
Create a place of convergence; with proximity to local stores, destination for commerce, catering and craft department .
THE CROSSROADS
Create a public, green, and shared space with multiple uses.
Encourage meetings and synergies between researchers, students and private and public workers.
THE AGORA
Create a place for welcoming and belonging to a bigger community with a shared knowledge.
Encourage associative life: to celebrate, to study, to exhibit, to debate, ...
THE GREEN
Create an open structural space with clearings that allow different kinds of open-air uses.
Encourage a transition between the urban campus and Ecole Polytechnique along with the intermingling of different users.
LAKE INSTITUT POLYTECHNIQUE
PARK INSTITUT POLYTECHNIQUE
FOOTBALL FIELD
RUGBY FIELD
SPORTS & MOBILITY
CORPORATE
EDUCATION & RESEARCH
COMMUNITY CENTRE
MUSEUM & CULTURE
SPORTS & MOBILITY
HONNEUR STADIUM
PATH VAUVE AU GRANGE
Fig.49

From the Prairie to the Crossroads

Following the central strip of major spaces conceived by the XDGA, a new major place takes a dynamic shape, representing the end but also the start of this 7km-long axis.

As originally envisioned by the architects, the Prairie(meadow) ought to be a free large space encouraging informal uses. From volleyball and badminton to other forms of outdoor activities, this place is dedicated for sports, recreation, and different events.

The buildings around define the rectangular shape of the space, while fully opening it to the surroundings.

Connected to ENSTA to the south and the Nature Park to the north, the Prairie is also where the central axis joins Chemin de la Vauve aux Grange, the pedestrian connection crossing the Palaiseau forest.

	The Prairie
Shape	Rectangular
Ground treatment	Mostly green
Nature	Static-oriented
Outline	The buildings give the space its form
Function	A large space for sports, recreation, and different events; grounds for volleyball and badminton-type sports and other informal practices

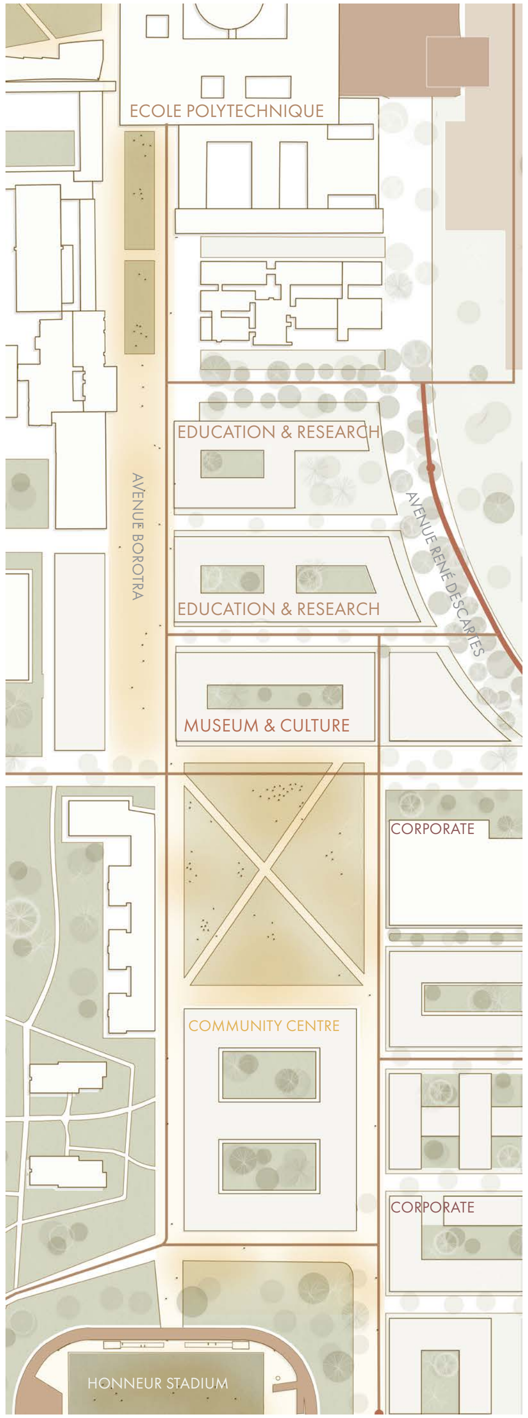


Fig. 50

Fig. 50. Original masterplan of the eastern sector

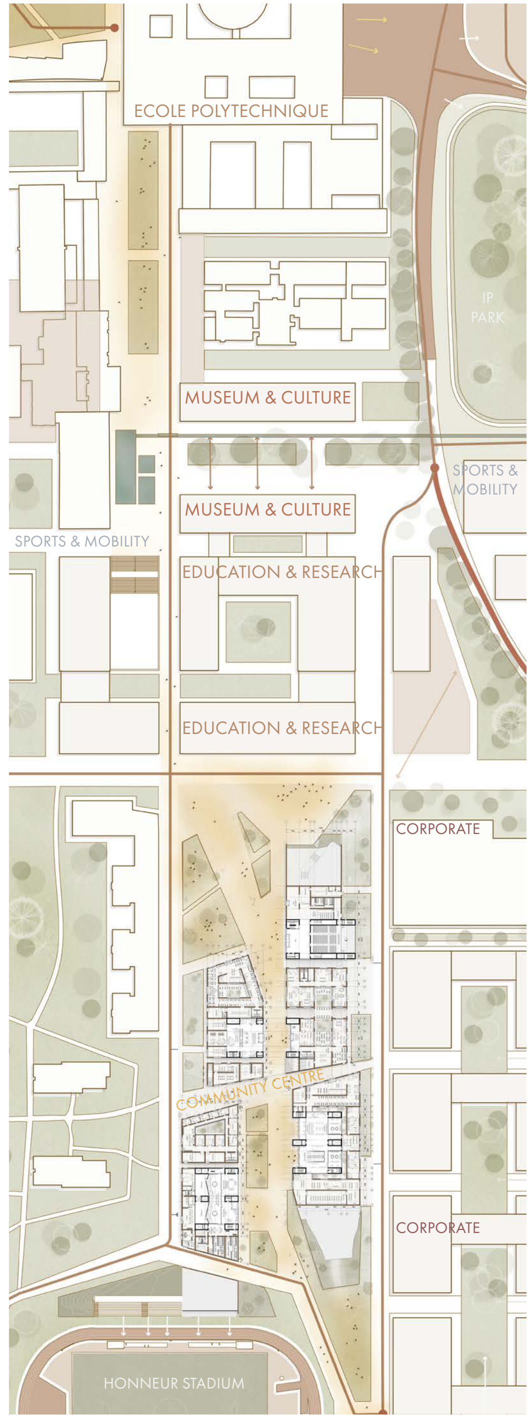


Fig. 51

Fig. 51. New masterplan of the eastern sector

Differing from the original plan of the architects, the new layout of this place consists of a higher ratio of mineral to green treatment on the ground.

Being at the core of the density belt, it must allow a crossing from many directions, blending in all the different users; hence its name: it is a crossroads advocating synergies and encouraging diversity.

The buildings along the edge of this new space, at their front center the community center, are shaped by its main guiding axis.

The latter are generated from the future dominating pedestrian flows that join the various functions and the different corners of the site.

Once the easter sector is achieved, this place will be crossed by such a high number and a big variety of people daily, giving it a dominating dynamic nature.

The Crossroads	
Polygonal	Shape
Mostly mineral	Ground treatment
Dynamic-oriented	Nature
The space shapes the buildings around it	Outline
A multipurpose space for large public gatherings, daily crossing, and different events; can be used by all the buildings around it	Function

"Today, architects have commitments towards their respective communities. Among their responsibilities is to envision the shared space, implement it, and develop it in a way that allows communication, socio-cultural relations, and a revival of community spirit. [...] In designing modern community centers, the main keyword would be multifunctionality. In fact, a multifunctional space is the most concrete representation of the ever changing and multiplying facets of contemporary society."

CHAPTER 3

THE COMMUNITY CENTER: ITS ROLE, COMPONENTS AND SYSTEMS

3.1. A civic core as identity generator

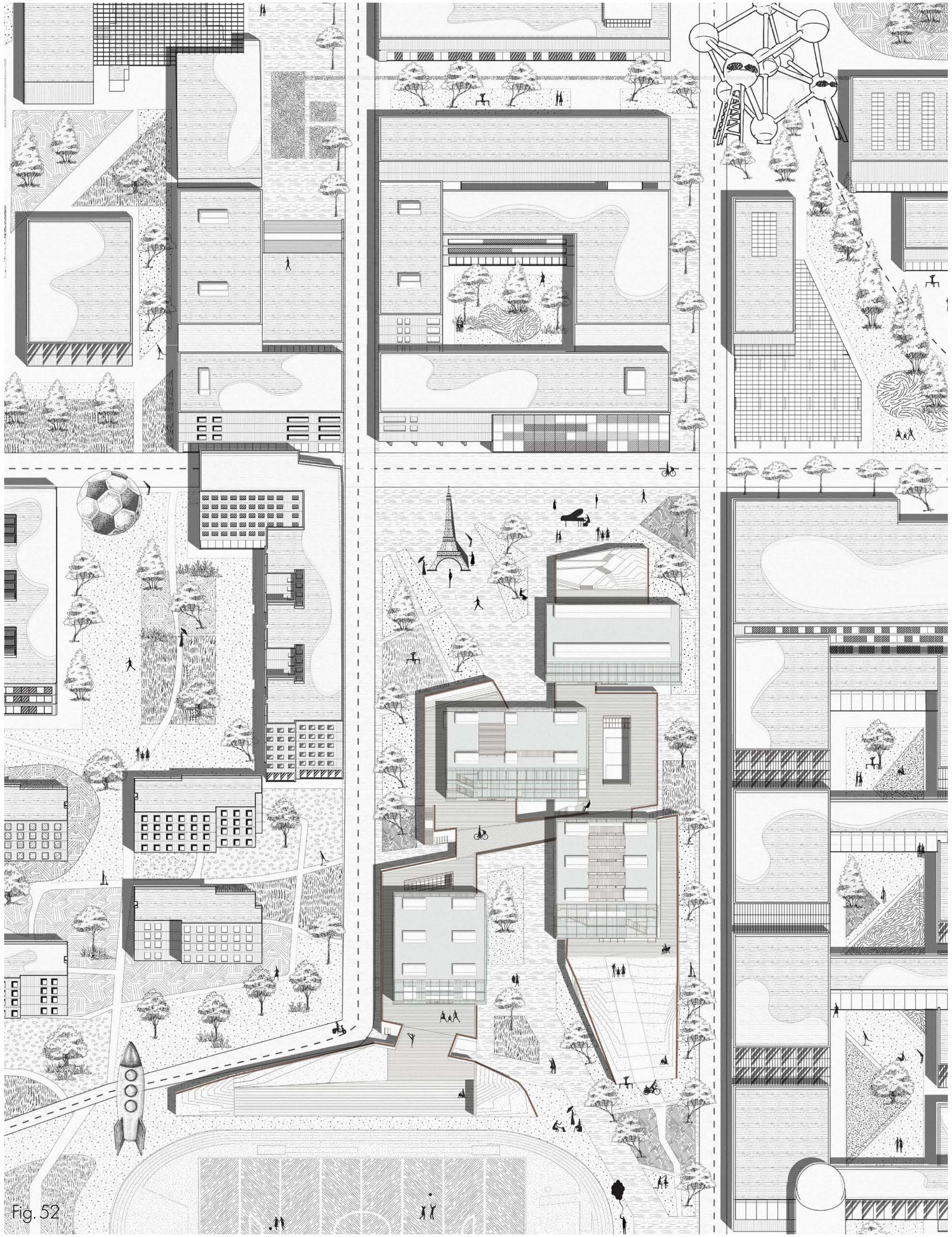
Social patterns as design foundation
Case studies

3.2. The Community Center in form, function, and goals

A multileveled promenade
Functional Interruptions: technology blocks

3.3. An overview of systems

The structure
The technology & materials
The services



3.1. A civic core as identity generator

After exploring the development of the Urban Campus as an innovation hub within the Paris-Saclay initiative, and an exhaustive analysis of the potential of the site in question, there was no doubt in our mind that introducing a cultural and community center in this specific area will have many positive repercussions on the social, economic, and cultural level. With the numerous users and the wide range of functions already present on site, this entity could be an explicit manifestation of the union between a diverse assembly of individuals and a multidimensional program.

In this part of the study, we illustrate the importance of a communal civic core in a multifaceted aggregation. Within a previously excluded area looking to gain a personal identity to attract newcomers, a common nucleus plays a key role in achieving a shared bond within such a varied society.

Social patterns for a design foundation

Man has been classified by many theoreticians and philosophers as a social being. He is the product of previous generations' habitual interactions, present circumstances, and physical environments. He longs to live in complex collectivities and to find a sense of community. Through history, this basic human social behavior has progressed explicitly and actively from nomadic settlements, to fortified cities, homogenous neighborhoods, and thematically distinctive clusters...

It is thus reasonable to expect that the lay of land and volumes in an inhabited zone define and are defined by the density, quality, and frequency of social and behavioral encounters.

To elaborate, the pattern of social interaction should be the basis on which we build and design. The main aim, to serve local communities, should swerve and sprout from the habits upon which it was built. Vice versa, the eventually designed space will be important to the making of new social relations that will enable people to continue living together.

Today, architects have commitments towards their respective communities. Among their responsibilities is to envision the shared space, implement it, and develop it in a way that allows communication, socio-cultural relations, and a revival of community spirit. This physical embodiment could be in any form that, in its role, intensifies links and lifestyles between users, whether it is a public square, a museum, a public building, an event space, and even a well-defined center for the community...

In designing modern community centers, the main keyword would be multifunctionality. In fact, a multifunctional space is the most concrete representation of the ever changing and multiplying facets of contemporary society.

Effectively, and according to Hanson and Hillier in their paper The Architecture of Community (1987), there are three types of multifunctionality:

Merging-concomitant – a principle that assumes the existence of spaces with defined identities and ambiences, where a certain activity or function is carried out strictly and systematically.

Fig. 52

Fig. 52. Straight axonometry showing the ambiances around the Community Center in the eastern sector

Polyvalence-adaptability – a principle where spaces are un-programmed to the extent of them being interchangeable, adaptable, and distributed in a way that serves the momentary needs and requests of the society.

Hybrid solutions – an ultimate principle presenting both types of already stated spaces in one community center, fulfilling an ultimate multifunctional program that requires well-defined spaces as well as morphing zones and areas.

Our take on the Saclay Community Centre should be by adapting a hybridization of spaces and functions to fulfill the complex interrelations and happenings on the plateau and around the Polytechnique. This project is important, not only as a social melting pot for the zone and the many different communities that inhabit it, but also as an outlet for creative and cultural expression.

The users of scientific and technical backgrounds will find in the community center, a tool aiding their academic and professional paths in addition to a leisure escape where they can unwind during the day or when needed.

We achieve the wanted multifunctionality and accomplish the role of the project through a thorough study of the program, its possible distribution and volumetric retaliations, and through researching and understanding impactful communal projects that have set the tone in theorizing relations between society, context and architecture.

Case Studies

Museum of Art of São Paulo, Lina Bo Bardi, 1968

This icon of modern and brutalist architecture is built in the heart of a financial and cultural quarter of the city, making it a standpoint between two different but intermingling communities of users.

The building of glass and concrete starts underground and is then lifted from the street level on four enormous pillars joined by four lateral beams, freeing the ground level where a public piazza unfolds.

This emphasis on the public space dedicates the project to the population, making the museum and its surroundings a place for exhibition and explicit manifestation of cultures.

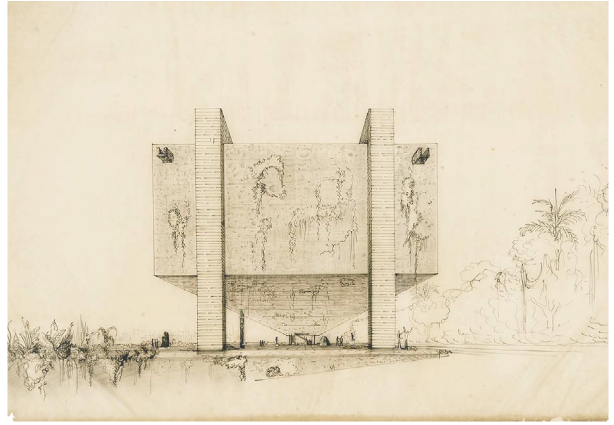


Fig. 53


Fig. 56


Fig. 54

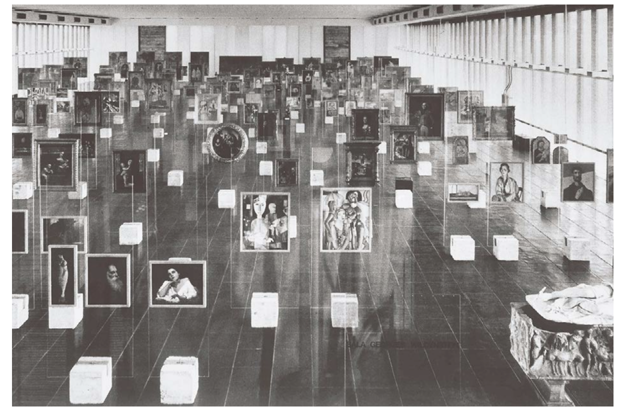


Fig. 57

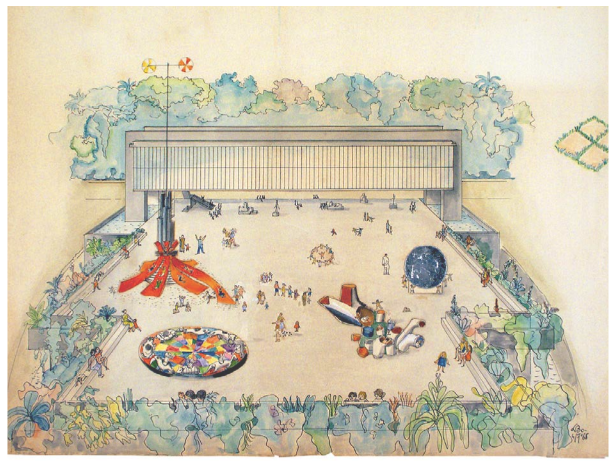


Fig. 55


Fig. 58

Fig. 53-55. Initial sketches demonstrating the impact of the Sao Paulo Museum of Art

Fig. 56-58. Photos of the interior and exterior spaces of the Sao Paulo Museum of Art

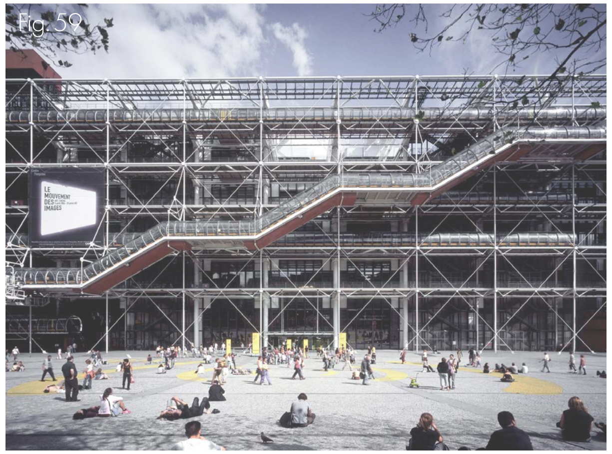
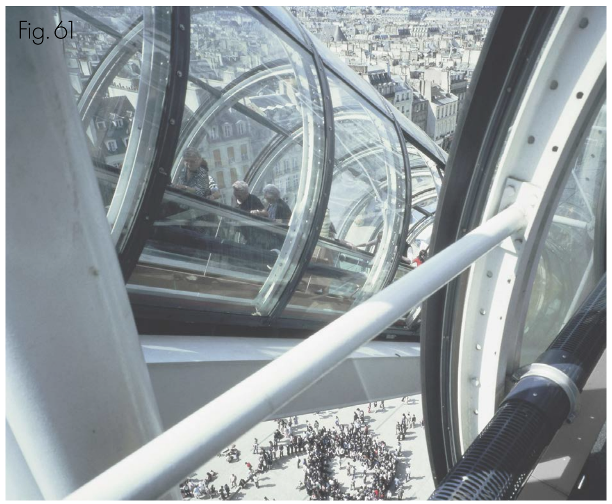
Fig. 59


Fig. 60


Fig. 61


Georges Pompidou Center, Paris, Renzo Piano and Richard Rogers, 1971-77

The winning competition's winning project lies in the dense fabric of Paris as if being from a different world.

The high-tech steel and glass volume occupies only half the site, with the rest being a sloping public square described by Rogers as a "place to meet".

It is a space structured by multifunctional aspects and disciplines. In fact, the interior presents enormous open rooms, made structurally possible by exposing all services and circulation on the exterior facades.

Transparence, versatility, and contrast with the impenetrable neighboring buildings, made the Centre Pompidou a monumental icon of Paris where old meets new and where people join their distinct minds through art, design, literature, music, and cinema...

Fig. 59-61. Photos of the Pompidou center, its public square, and the relation with the city of Paris

Seattle Central Library, OMA, 1999-2004

Situated at a strategic node in the city of Seattle, the library's program unfolds vertically in a scheme of programmatic clusters (parking, staff, meeting, book spiral, HQ).

They are arranged on overlapping and architecturally defined platforms. Between them and on the top of each platform, we find interstitial undedicated spaces that are left un-orchestrated and flexible, to pertain unexpected activities and interactions between users.

This system of programmed and de-programmed spaces, transforms the library from a temple solely dedicated to books and solitary reading to a multimedia and information hub serving a broader community of users who can more easily access, share, and discuss new information.

Studying these examples intensifies our views on the importance of having on the plateau, not only a hybrid program of defined and undefined functions but also a series of indoor and outdoor spaces differing in levels of privacy, tranquility, flow of people and dynamism... Having this plethora of characteristic zones defining a promenade in a horizontal and vertical sense along the project, will improve its richness and aptitude in being a social and cultural catalyst.

Fig. 62

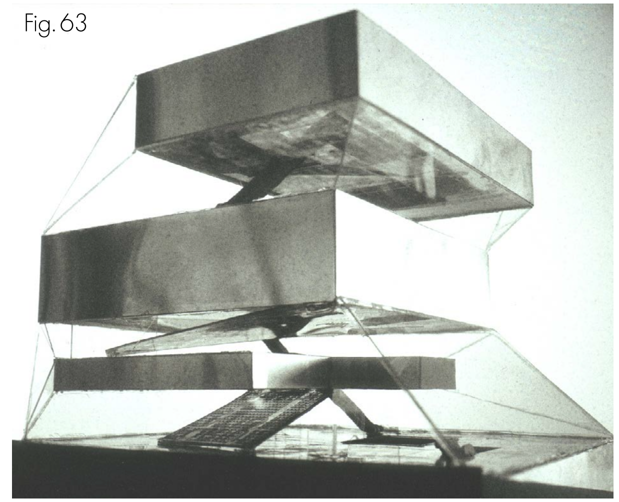

Fig. 63


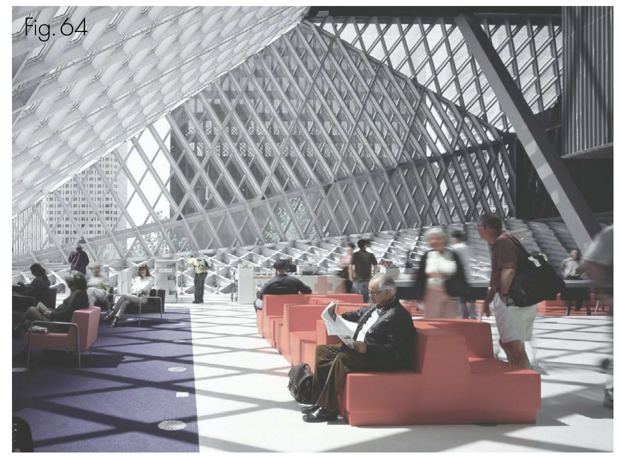
Fig. 64


Fig. 62-64. Photos showing the exterior of the Seattle Central Library, a conceptual model and the interior common space

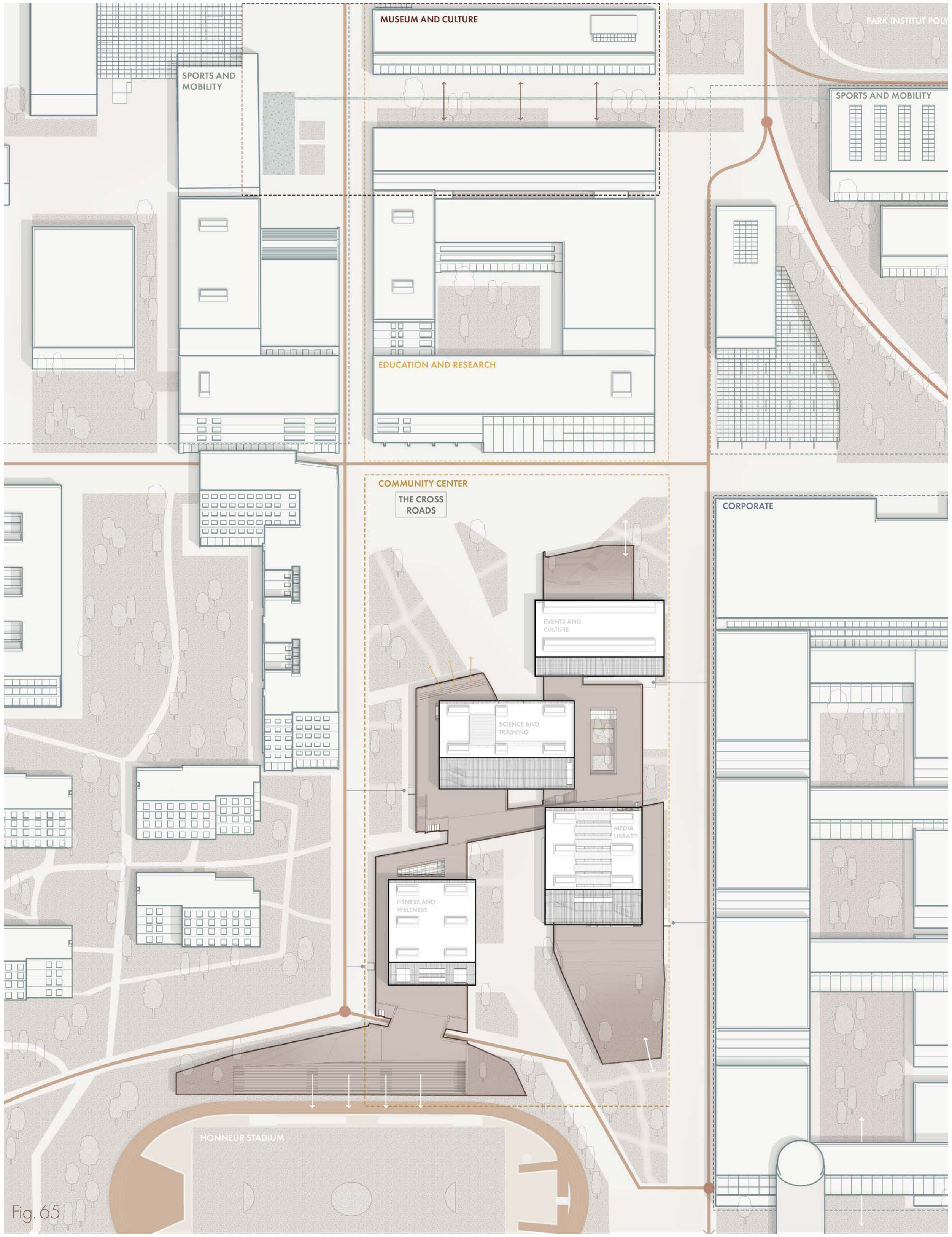


Fig. 65

3.2. The Community Center in form, function and goals

After demonstrating the weight of such a prompting center within the eastern sector of the Urban Campus, analysing its role as a socially mending institution and defining the parts it plays on an urban communal scale, we proceed by defining the Community Centre in form, program, and position. On the edge between the natural and urban world settles this hub, the ultimate stop, or the opening act, of a progression of spaces bound to orient the economic, social, and innovative growth of the campus.

The zone presents different levels of urban density, with the Polytechnique and its annexes defining a rich close-bounded loop ending with our site. Taking part in reaching the compactness intended, the plot is at a crossroads between two types of landscapes: formal and informal, or urban and natural. The architectural solution is thus exhibited through two main components: a one-level podium with a flexible outline shaped by the landscape around it – a promenade of unexpected spaces and activities – coupled with four monofunctional blocks that represent a more rationally defined architecture.

A Multileveled Promenade

When it comes to the ground floor, the podium stretches along the site and is positioned and shaped according to its immediate context. With two communal strips that elongate the plot, it gathers the landscape around it and mutates according to openings and pathways along the urban panorama.

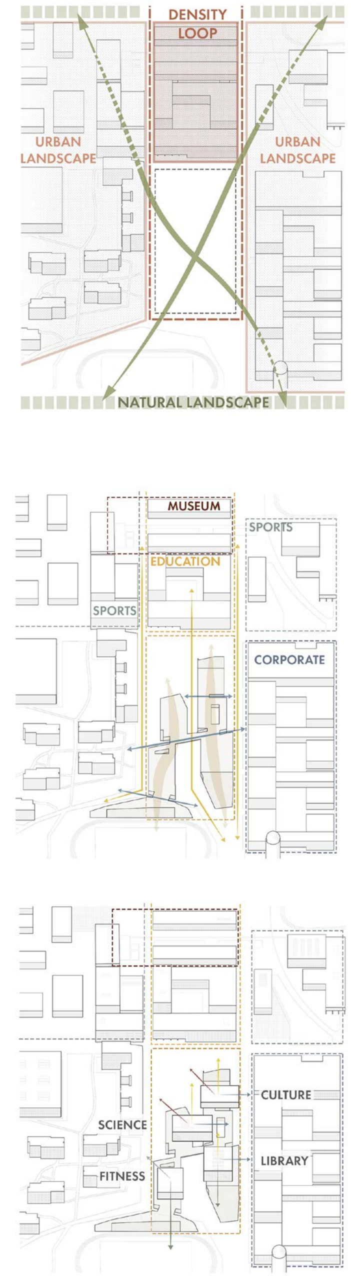


Fig. 66

Fig. 65. Urban axonometry of the Community Center, straight view from the east

Fig. 66.. 3D diagrams of the volumetric and programmatic strategy for the Community Center

From the side of the Honor Stadium, the southern strip takes the shape of a set of bleachers allowing a large audience to enjoy the sports activities. In the northern strip, the north-east end, stretches out as an ascending garden, linking the podium to the Chemin de la Vauve aux Granges into the natural forest. On the north-west end, the platform concretizes the union between the built environment and the natural landscape with a set of green stairs bringing in the Nature Park that spreads at proximity into the project site. From the side of the Ecole Polytechnique, and connecting to the Borotra Avenue, the podium shrinks giving way to a large public space that becomes a central culmination and assembly point in this density loop; on that edge, a lookout is sought to allow a point of view looking towards the urban realm.

As already mentioned, the ground level composition holds everyday-functions that are open to all and are necessarily visited on a typical day on the campus. Walking between the two long one-leveled strips, one can enjoy the main public functions: a restaurant benefiting from a large outdoor space, lounges and living rooms for both the professionals and the students that would like some socializing or leisure time. In addition to a bookstore, a university press, and a cyber café.

Along the continuation of the Borotra Avenue towards the Honour Stadium, the strider can benefit from useful services like a health center, a pharmacy, a bank office... This axis and the one shared with the corporate buildings are thoroughly animated by the communal functions. The site will act as a Superblock celebrating soft mobilities for pedestrians and cyclists. It will be used exceptionally and locally by delivery and emergency vehicles (no common cars).

Moreover, crossing the site along the main central artery allows you to access the four main technological blocks, each housing a specific function with a dedicated program.

As a volumetric entity shaped by its surroundings, the podium takes on different shapes, resulting in a complex collection of rich quality spaces and unique atmospheres. Reaching into the different corners of the site, it inspires themes of reversibility, re-use, and adaptation.

Within such a natural setting coupled with innovative aspirations, the choice of materials was not taken lightly. As the world is going back to traditional materials and processes that decrease ecological loads, earth as a construction material became an obvious choice as it represents an asset in the architectural heritage of France and offers many multidimensional advantages, ranging from environmental and economical to aesthetic and ergonomic. (More about this in chapter04)

In addition to the functional and atmospheric qualities: the earth walls rise from the ground supporting a landscaped garden-terrace. The labyrinthic layout comprising green courtyards expands to the first level as a walkway with a series of dynamic and static spaces where users gather, play, eat, work... These in-between zones, the patios, stairs and terrasses, coupled with the exceptional earthen qualities, form a distinctive microclimate improving the air, temperature, and ambience of the surrounding spaces.

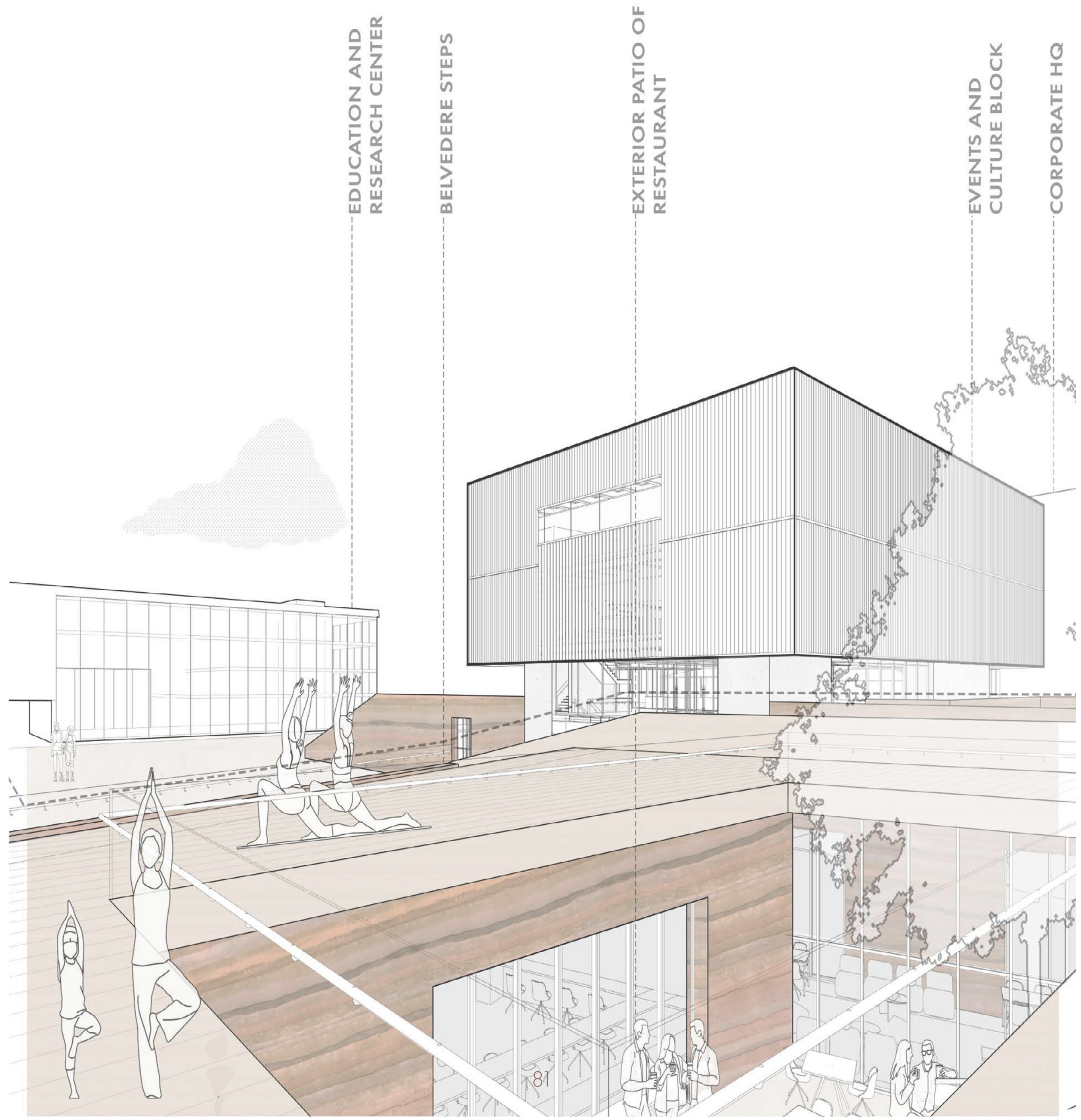


Fig.67. Ground floor plan showing the two main components of the Community Center


AUDITORIUM
STORAGE
KITCHEN
CLOAK ROOM
BAR AREA
CATERING AREA
HALL
STUDENT LOUNGE
SERVING AREA
STUDENT CAFETERIA
CYBER CAFFE
RESEARCH STUDIO
STAFF ROOM
OFFICES
INFORMATION STATIONS
RECEPTION AND ENTRANCE
LIBRARY HALL
RESEARCH QUARTERS
ARCHIVE
BAR AND LOUNGE
UPSCALE RESTAURANT
ENTRANCE HALL AND RECEPTION
UNIVERSITY SPIN-OFFS
MEETING ROOM
BOOKSTORE
UNIVERSITY PRESS
CLINIC
ROOM
HEALTH CENTER
TECHNICAL ROOM
FOOD AND SNACK AREA
GYM RECEPTION
GYMNASIUM AND CLIMBING WALL
SHOWERS AND WC
WELLNESS ZONE
PHARMACY
BANK
OFFICE

Fig. 67

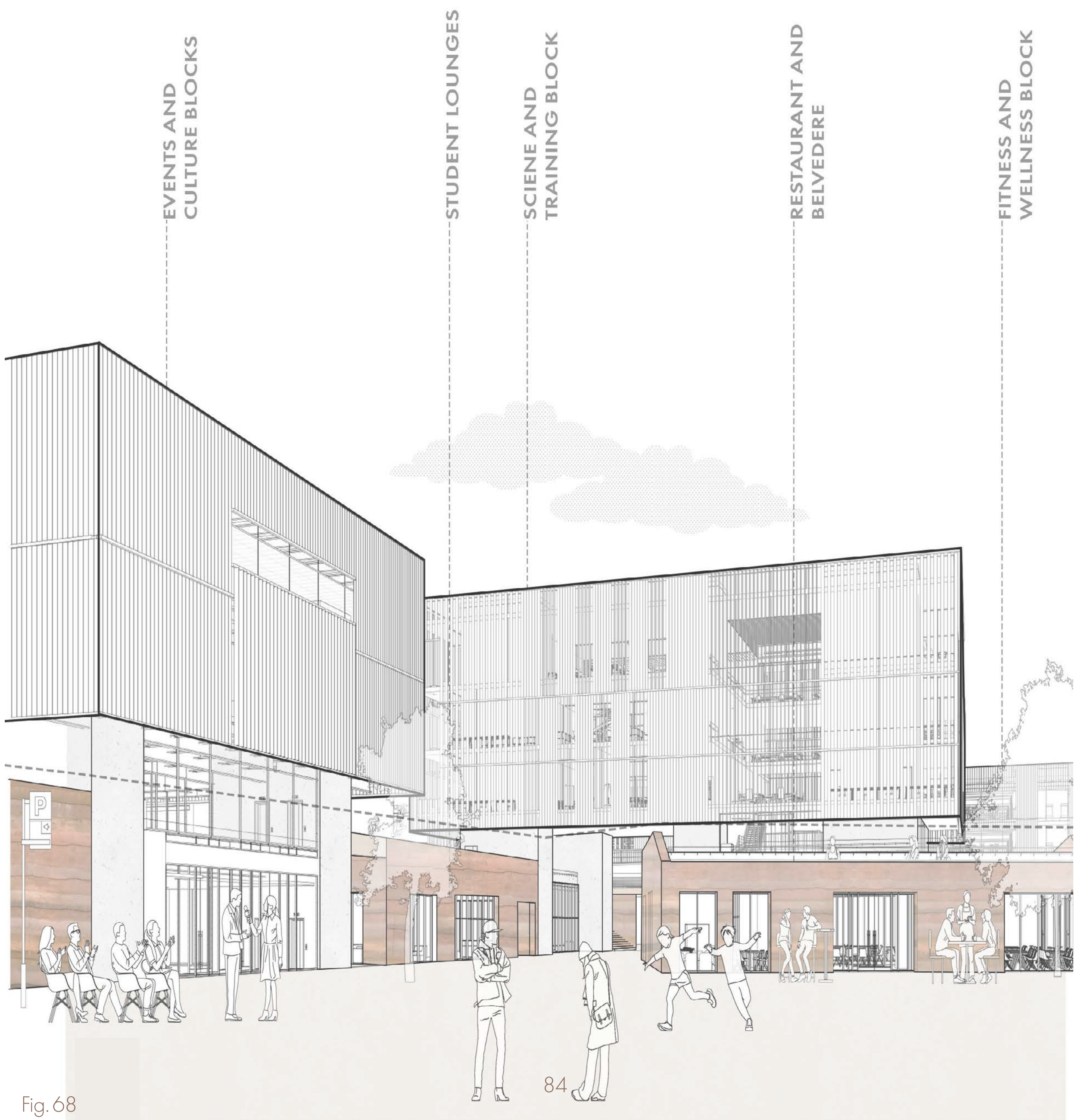


Fig. 68

Functional Interruptions: Technology Blocks

The garden-terrace and earthen platform are penetrated at specific locations by four individual blocks contributing to the richness of the promenade. At the point of contact we find the most interesting and exciting spaces, acting as attraction points along this earth forum. These distinct buildings accommodate a library, a scientific center, a recreation center, and an event space:

Block A: Events and Culture
Block B: Science and Training
Block C: Media Library
Block D: Fitness & Wellness

Each entity is positioned and oriented according to its dedicated function and in relation to the immediate context.

The Events and Culture volume, Block A, houses an auditorium welcoming a large number of people, with above it, a spacious and flexible polyvalent space. It benefits directly from the public piazza linking the community center to the Polytechnique and acting as a funnel for the crowds.

Block B, with a diverse program targeting professionals, students, and entrepreneurs all together, takes a central location within the project. It connects both podium strips and acts as a physical and theoretical bridge between the university, the corporate buildings and science-oriented users or visitors.

The Media Library, Block C, benefits from a position on the north-eastern fringe of the sector, open towards the natural forest of Palaiseau and the Honneur football field. This serene position secures it with views and a calm atmosphere where knowledge and learning are prioritized.

The Fitness & Wellness compound, Block D, occupies the south-eastern edge and presents an adequate proximity to the large Honour Stadium. It caps and corners the site with a sport-oriented program that makes its way to improve wellness and to procure a sense of belonging.

All four volumes are formed of concrete cores and steel beams and follow configurations that allow flexibility and future re-adaptation. As front, they present a double façade treatment that encourages good ventilation and lighting: to the inside, we find layer of transparent glass perforated with openings when needed; to the outside, an outer layer of profiled glass with a translucent finish that is arranged in different compositions, allowing a high flexibility in managing both light and temperature for comfort and energy efficiency.

The façade compositions and openings are a direct result of the functions lying behind them and the site orientation. All blocks may look similar on the outside when seen as a compound but each of them, in the end, demonstrate a unique character and a special ambiance. (More about this in chapter 05)

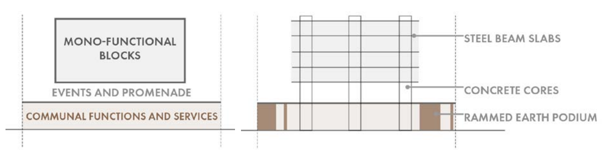


Fig. 69

Fig.69. Diagrams in section of the main guidelines differing the two components of the building, podium and blocks

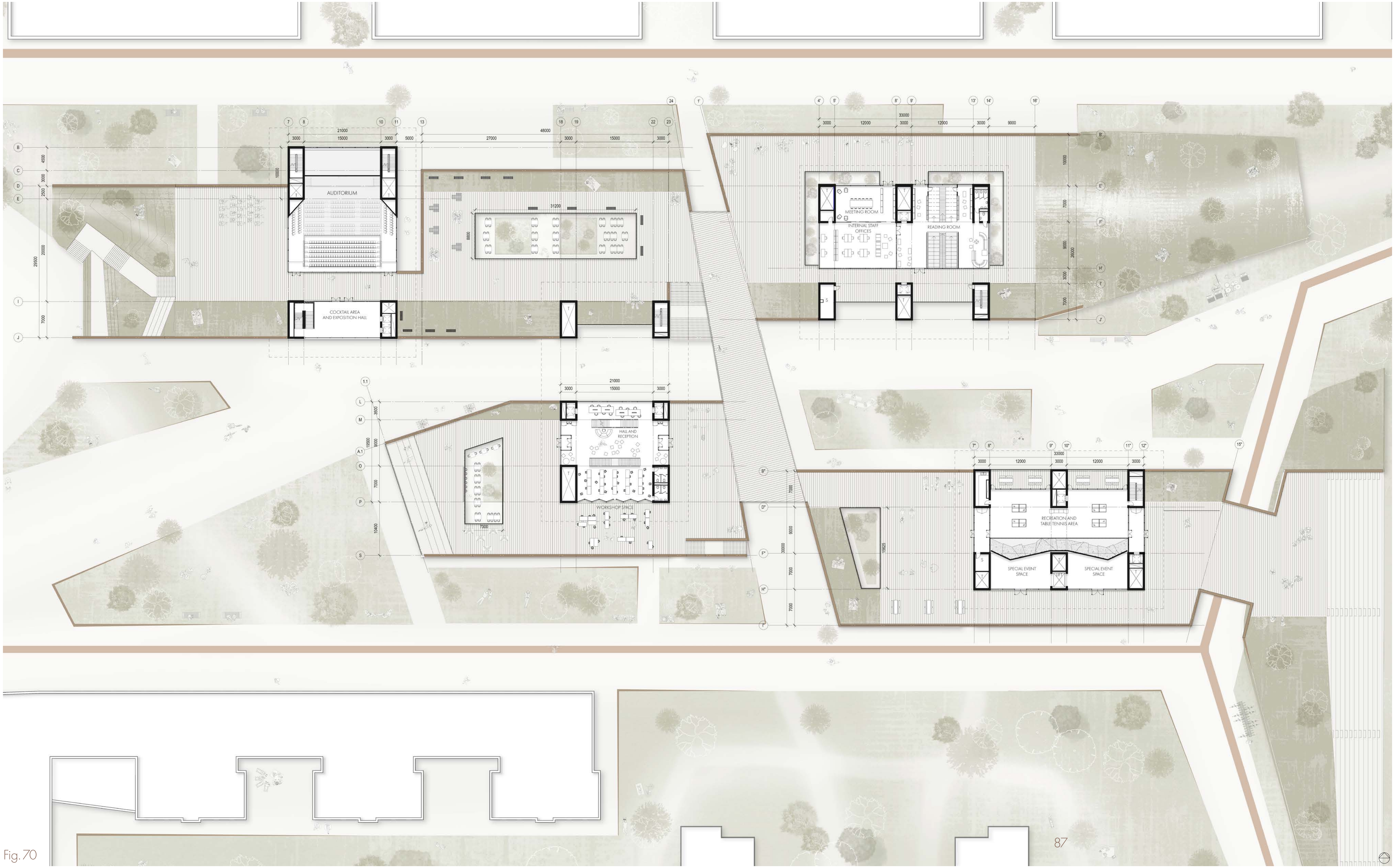

AUDITORIUM
COCKTAIL AREA AND EXPOSITION HALL
MEETING ROOM
INTERNAL STAFF OFFICES
READING ROOM
HALL AND RECEPTION
WORKSHOP SPACE
RECREATION AND TABLE TENNIS AREA
SPECIAL EVENT SPACE
SPECIAL EVENT SPACE

Fig. 70

3.3. An overview of the systems

The Structure

As discussed, the project comprises two main sections that differ in materiality as well as in structural systems:

I- The four edifices (Blocks A to D); all share a common structural system of concrete and steel. They range from a height of two to four levels. Their reinforced concrete cores constitute the only vertical elements, thus permitting a flexible spatial organization. Standard steel beams (IPE, HEB, HEM) connect them together and support the composite slab and finishings on each level.

II- The podium, a green sustainable continuation that consists of one level (5 meters) covering the site with two longitudinal strips, is formed of 50 cm-thick rammed-earth walls prefabricated near the site and assembled as modules. Timber beams transfer the loads from the planks maintaining the floor of the terrace to the load bearing earthen walls.

Under the blocks the foundations are of reinforced concrete, while under the podium the foundations are of stabilized rammed earth with a stone blocks neck. In the dedicated technical part for structures (Part 06), we describe the structural system with its components, connections, and materials while further detailing the calculations.

We start by assessing a typical floor and its beams in the conventional Block C (Media Library). Then, we go on to dimension the Vierendeel trusses of the auditorium in Block A (Events and Culture). Finally, we end the report by estimating the timber beams of the Podium.

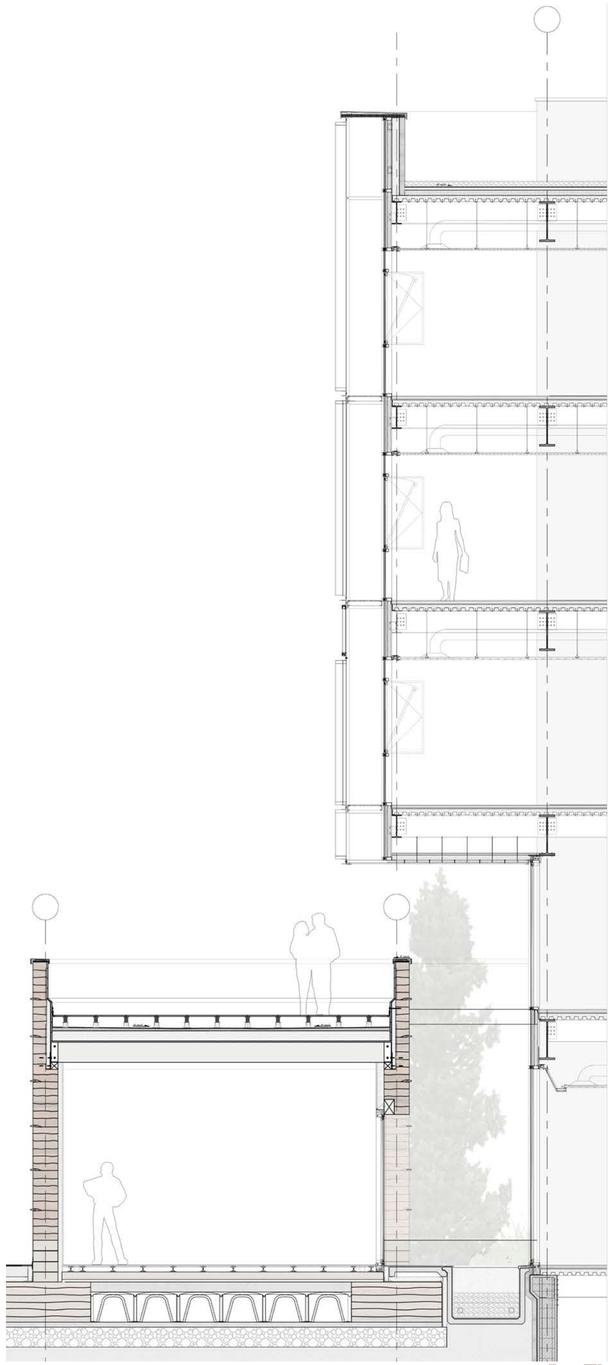


Fig.71

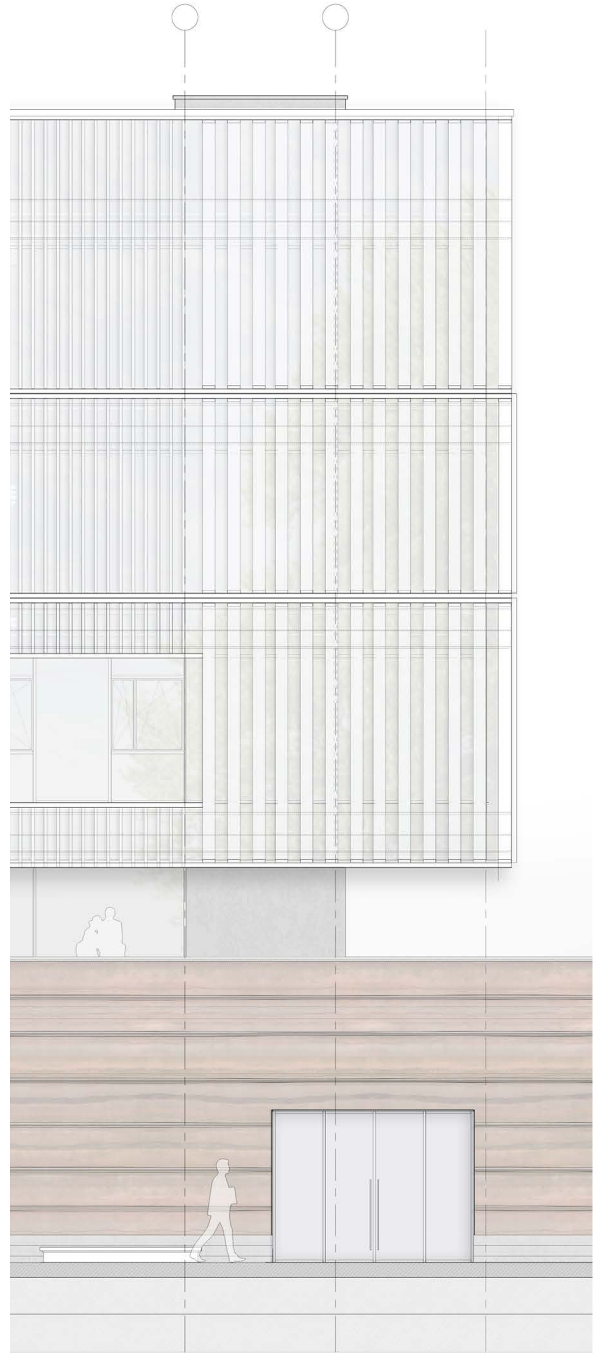


Fig.72

Fig.70. First floor plan showing the intersection of the blocks with the green-terrasse

Fig.71. Wall section made on the block C, Media Library, presenting the two systems

Fig.72. North Façade of the block C, Media Library, showing the two distinct characters

The technology and materials

Similarly to the structural design part, the two distinct project components differ in materiality and building technology:

I- The blocks present a common construction for the envelope: a double façade made of an inner curtain wall and an outer composition of U-glass. The outward layer of profiled glass helps to control the light according to the type of space behind it and the amount needed. It allows a continuous contact with the outdoor landscapes and an immersion of light at the same time. The aim was to homogenize and match the language of the raw and unsophisticated system of the rammed earth podium.

II- The first level exhibits a low-tech, highly sustainable, and crude construction. A layout of earthen walls, made from raw soil with no additives, gives the ensemble a natural look assimilating with the surrounding green landscape. The walls erected at a height of around 5 meters, are left exposed from the outside, showing off their unique patterns. At the interior level, they are covered with insulation and clay mortar panels in a way to keep the same atmosphere and improve ergonomic qualities. The timber beams holding the slab are left uncovered from the inside, thus preserving a tactical aesthetic combination of earth and wood. These elements and material choices allow a circular life cycle for this part of the building (Discussed in part 04).

Overall, the blocks and podium, contrast and complement each other at the same time. One demonstrates a more grounded appeal while the other showcases a rational style, but both fall under the same authentic, simple, and straightforward essence.

The services

The selection and development of HVAC services wasn't an exception to the already established distinction between the podium and blocks. Different solutions are chosen for each part:

I- For the blocks, the most versatile selection was made, equally suitable for offices, exhibitions, classrooms, and concert halls. An all-air system was adopted. It accompanied the established structural system that presented many advantages:

- the presence of a basement, allowing a big space to place large equipment.
- the availability of load-bearing cores distributed in each of the four blocks, giving the opportunity to organize a system of vertical air ducts and evenly distribute the air ducts network on each floor.

Efficiently, air ducts are located internally between the floor slab and the false ceiling. Such a system can be preserved and expanded if the number of technological blocks increases, and the project expands in the future.

II- In the case of the podium, the aesthetic component, the size of the equipment and the ease of implementation were considered as priorities as it was essential for us to keep the natural materials of the walls and ceilings uncovered. All things considered; the most suitable option seemed to be a combined air-water system installed in the floors, with fan coils as ambient units.

The Fan coils are distributed along the inner perimeter of the podium, under the façade windows. The water network and the air conditioning ducts, as well as the air handling units themselves, are located under the raised floor. The use of a 4-pipe system allows the heating and cooling of rooms, thus ensuring a comfortable stay in the different zones and spaces.

Furthermore, an explanation and detailing of the equipment used, calculations made, and schemes presented for distributing the technical gear in the building will be presented in Part 05.

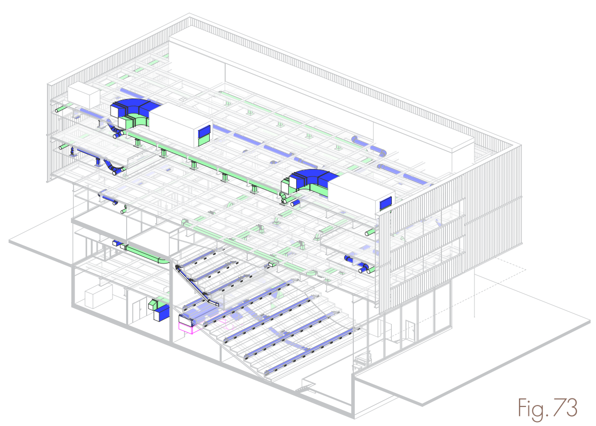


Fig. 73

Fig.73. Sectioned axonometry of Block A, showing the air ventilation network

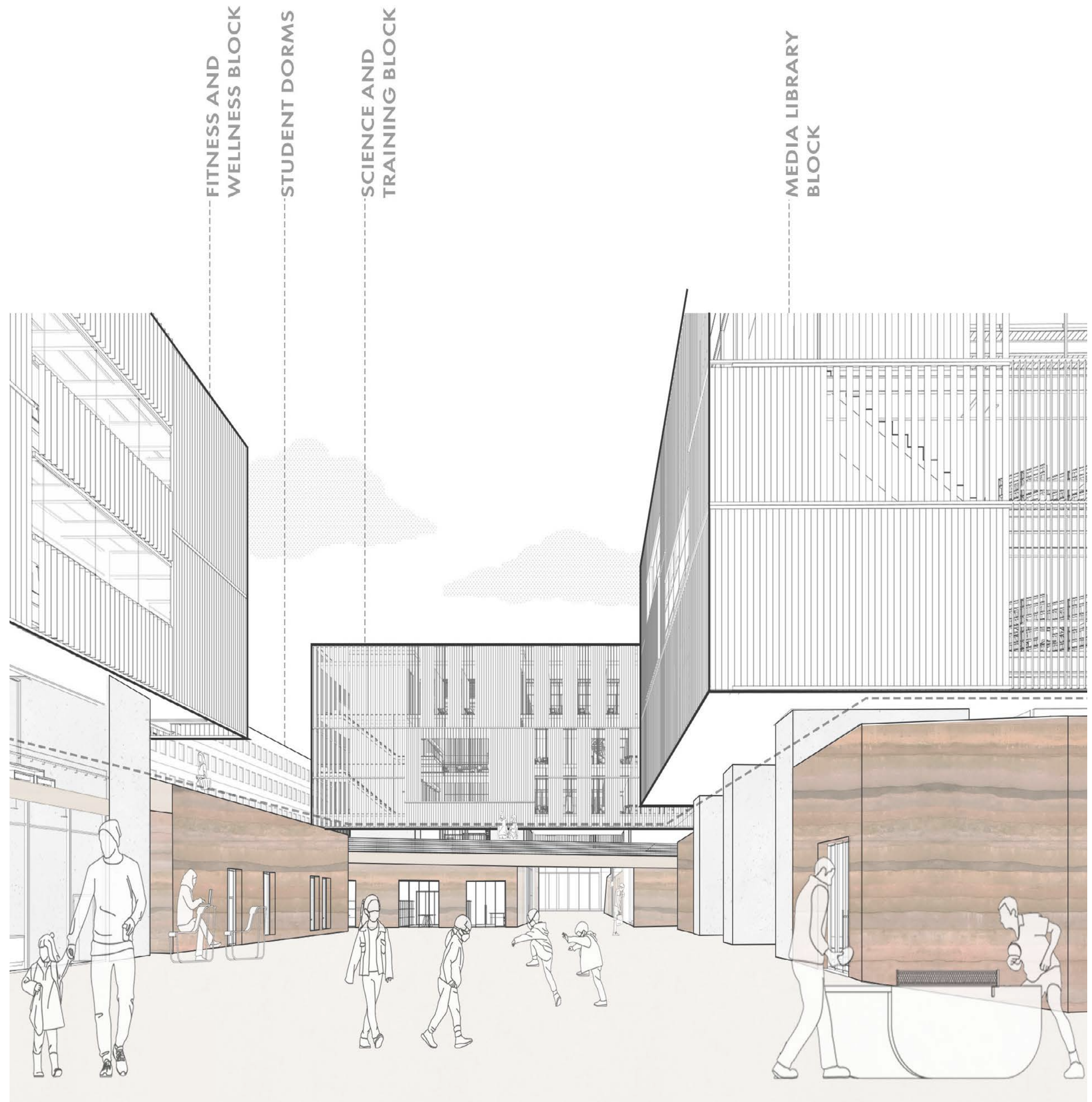


Fig.74. Manifesto cutting through one podium strip and two tech blocks demonstrating materials, construction

FITNESS AND WELLNESS

As sports and physical activities predominate the eastern sector of the area, this center was designed to foster a culture of sustainability, healthy lifestyles, and fitness. Unifying wellness and recreation under one roof, it will ultimately transform the future health of the community.

MEDIA LIBRARY

A gateway to knowledge and culture, the new media library is a rich repository of historically and culturally significant collections. The resources and services it offers help shape the new ideas and perspectives that are central to the science and technology cluster of Paris-Saclay. A storytelling lingers as you enter its doors lending you the freedom to choose the role you'd like to play.

SCIENCE AND TRAINING

Literally bridging gaps between users and disciplines, the Learning Center is meant to seize the imagination of students, scholars and those involved in the pursuit of innovation. It engages the surrounding buildings by spanning the main pedestrian central strip and allowing controlled views on all sides.

EVENTS AND CULTURE

The Cultural Center embraces the radical notion that an exhibition hall could both display culture and serve as a stage for the society. In that sense, it should belong to the people and the city. It serves as a concentrated point for large crowds welcoming the most brilliant artistic events in the region.

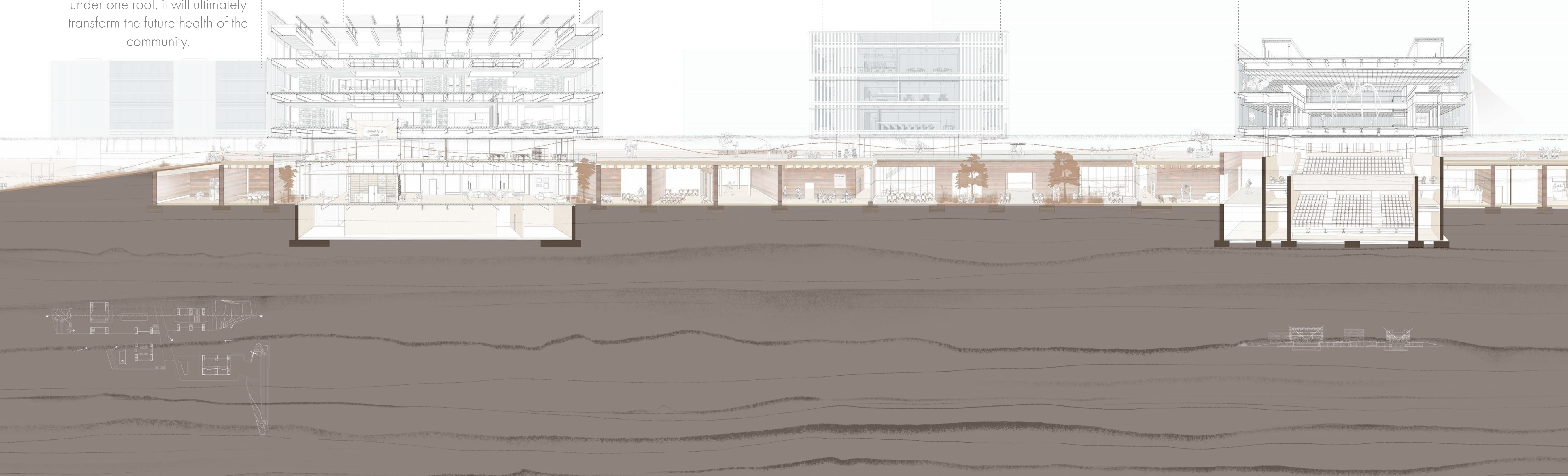


Fig.74

"Rammed Earth use has grown and withered unceasingly in different parts of the world. Many scholars have advocated, investigated, and perfected its methods and techniques, spreading a message of affordability, quickness, and ease of construction. Recently, as awareness for the climate emergency is taking root, earth is witnessing a "revival", flourishing as a sustainable material that supports a circular economy."

CHAPTER 4

EARTH CONSTRUCTION, REVISITED

4.1. A craft through time and space

A brief through history
Earth construction as French heritage
Experimentation in France: From matter to material
Case studies

4.2. Earthen Construction: life, demise, and rejuvenation

The role and the ways of a circular life strategy
The art of prefabrication and assembly
An earth wall under the spotlight: The Use Stage
The Afterlife of a community pedestal

'WOULD IT BE POSSIBLE TO THINK OF THE BUILT ENVIRONMENT AS AN OPPORTUNITY TO DEVELOP NEW SOLUTIONS RATHER THAN AS A PROBLEM THAT NEEDS SOLVING?'

- MARILYNE ANDERSEN & GUILLAUME HABERT, THE MATERIALS BOOK, RUBY I. & RUBY A.

4.1. A craft through time and space

A brief through history

Documentation has proven that, since antiquity, men all over the world have used earth as a building material. The lasting beauty of ancient earth architecture showcases the populations' ability and ingenuity in creating a complete built environment with resources available locally. The result: an ingenious passed-on craftsmanship, and a world heritage of monuments, historic towns, residential homes, and archaeological sites that are transformed into economic, ecological, and cultural assets in their communities.

Previous civilizations experimented and perfected earth construction to what suited their physical and contextual capabilities. This ensued in earth buildings being constructed in different techniques and processes regardless of the composition of the earthen mixture that is almost always sand, silt and clay.

For instance, we notice the use of adobe (sundried or fired) bricks in many regions of north Africa, while Asian peoples relied on compressed earth in wooden formworks or compressed earth bricks made in molds. Other relics demonstrate cob wall (French Bauge) constructions or the employment of the wattle and daub method (French Torchis), a process where wooden stakes and woven branches are covered with an earth clay paste to create wall panels. Nowadays, new experimental high-tech methods exist such as automated 3D extruded earth, robotic in-situ rammed earth, or even remote material deposition.

Fig.75 Adobe Bricks

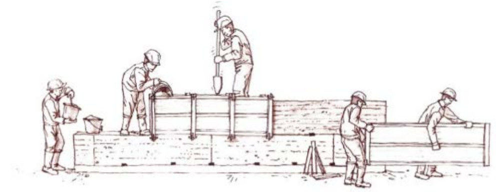


Fig.76 Rammed Earth

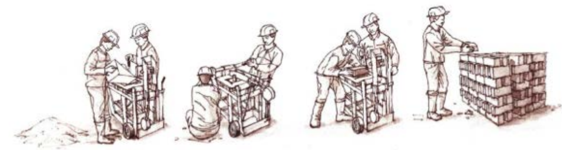


Fig.77 Compressed Earth Blocks

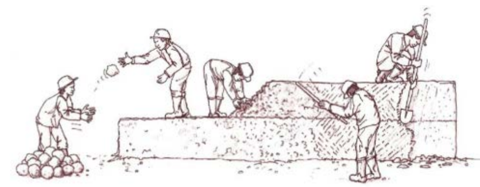


Fig.78 Cob Wall

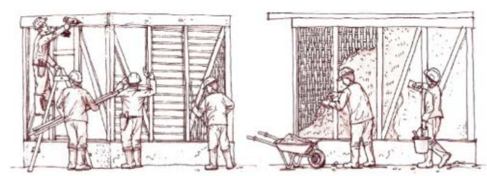


Fig.79 Wattle and Daub

Fig.75-79. Sketches describing the building processes of different kinds of historical earthen construction

Fig.80. UNESCO world heritage site, Draa Valley, Morocco, earthen buildings

Fig. 80

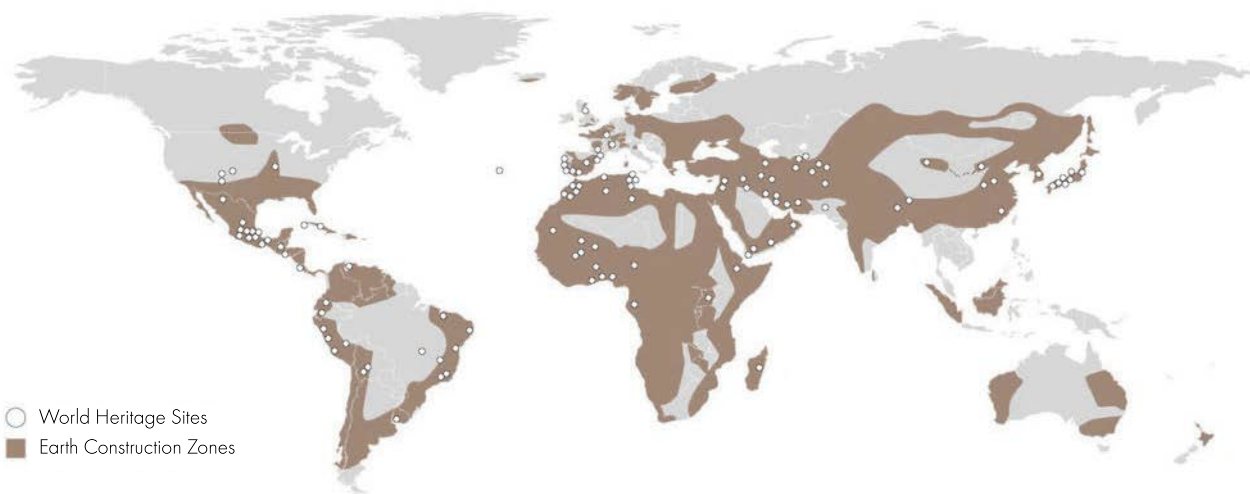


Fig. 81

This chapter focuses on rammed Earth (French Pisé), one of the most ancient construction techniques. It is defined as a dynamic compression of soil between formwork boards, to create a homogenous mass wall. The wall consisting of dense layers of earth, presents thermal, structural, and ergonomic qualities. The use of local resources in their primal nature eliminates any significant costs, which makes the technique relatively economical and extremely ecological. Effectively, rammed earth construction is not merely a know-how associated to small rural habitats, but an architecture of craftsmen, that requires perfect knowledge of the material.

Now, considering that compressed earth is, and will probably remain, the most important resource available to build quality and sustainably sourced architecture, it is important to understand how earthen heritage has traveled and evolved throughout the centuries and the continents.

Historical rammed earth construction unveiled a complex distribution scheme: the oldest evidence was found in antique China, then noticed in central Asia and India. Simultaneously, compressed earth around the Mediterranean was uncovered, it spread towards Europe where it was used in the 8th century by the Muslim caliphates in northern Africa and Spain. Europe caught-on to the process and raised the level of craftmanship in Christian Spain, Lyon, and Marseille. Eventually, the 14th century European migration to the Americas and to Australia spread earth construction into new territory where it flourished incessantly into the 21st century.

Fig.81. CRAterre Diagram: Earth Architecture Distribution Worldwide

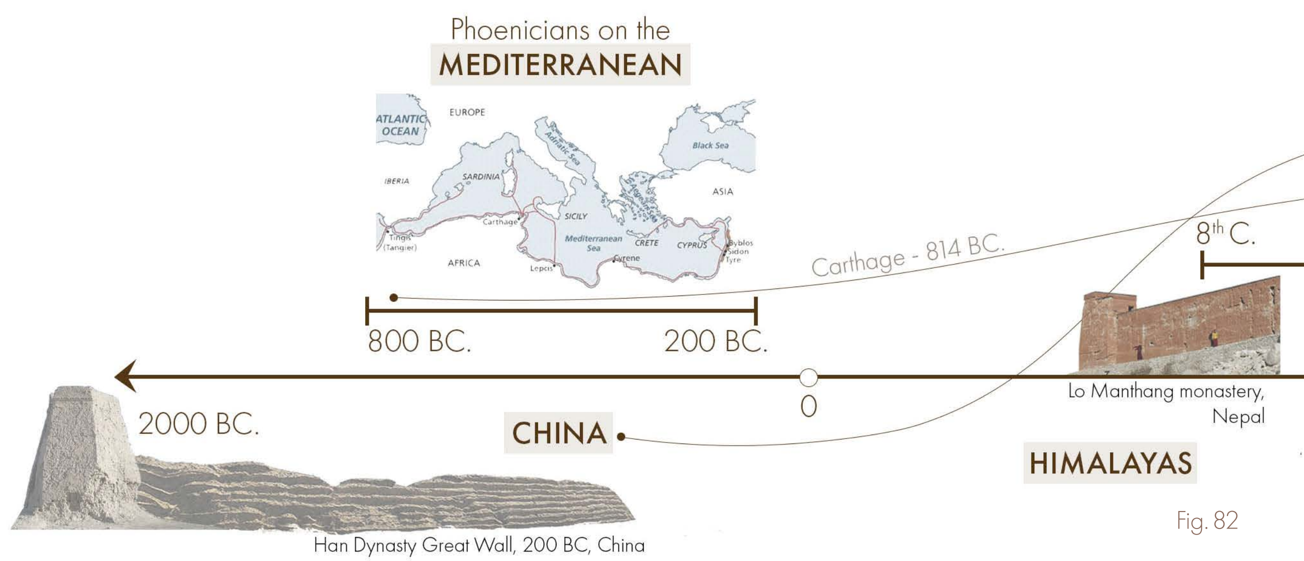


Fig. 82

China: Earth walls are found as early as 2000BC in nomadic settlements. Material transportation was difficult, so soil was easily extracted and used. Rammed earth was typically used, and techniques were developed up until the 14th century, where the Ming dynasty fortified of The Great Wall using stone and fired brick, instead of rammed earth. Nonetheless, the process and material use spread through central Asia towards the Himalayas region.

Mediterranean: Rammed earth appears to have been used in Phoenician settlements around the Mediterranean. The Phoenicians spread from the Levant region of the eastern Mediterranean (modern Lebanon), founding multiple cities such as Carthage (city in modern Tunisia) in 814BC. Excavations of Phoenician settlements suggest the use of rammed earth both in north Africa and in Spain.

Middle East and Central Asia: Due to the fragility of earth construction and to the destruction brought by the Muslim expansion of the 8th century, little to no trace of rammed earth sites remain in the middle east and central Asia. This said, the use of adobe and clay bricks is more evident in these regions, as the timber needed to produce the formwork for compressed earth is scarce.

North Africa, Spain, and Western Asia: Around the 8th to the 16th century, during the reign of the Muslim caliphates, rammed earth construction proliferated. The expansion of Islam was accompanied by an increase of vernacular and monumental earth architecture in Iberia, Persia, Marrakesh (Mo-

Fig.82. Visual timeline following the spread of rammed earth worldwide and through the centuries

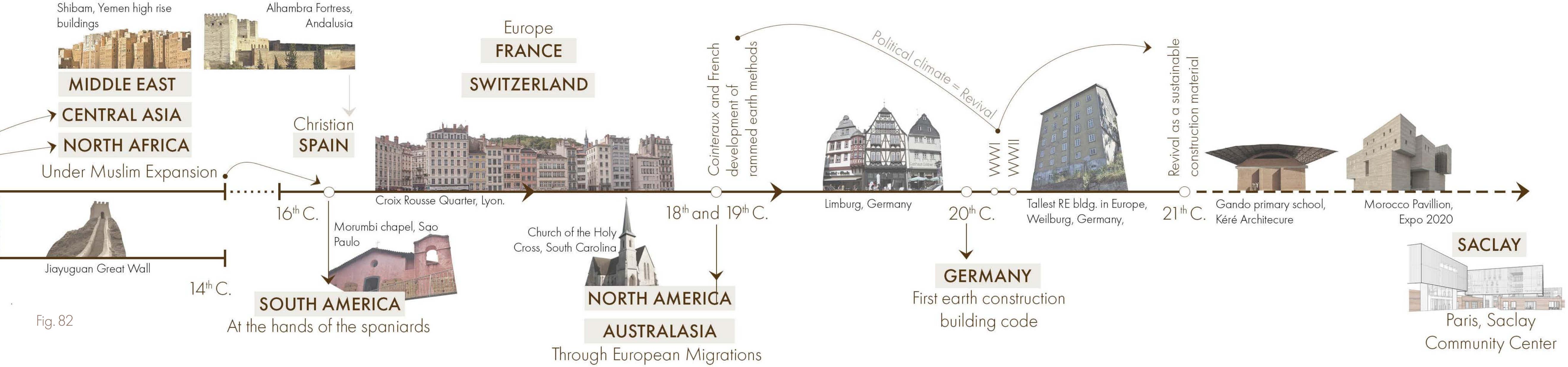


Fig. 82

rocco), Yerevan (Armenia)... The use of this type of construction was rationalized due to its thermal properties and temperature regulating benefits.

Medieval Europe: The Muslim rule in Spain introduced rammed earth to Europe. In Fact, 15th century Christian rulers in emancipated Spain employed the Muslim population as craftsmen and artisans. The techniques spread towards regions in France such as Lyon (whose historical center is home to hundreds of rammed earth structures) and to Switzerland.

South America: Spaniards transported the rammed earth know-how to south America in the 16th century. No evidence of earth construction was found on the continent prior to European settlements.

Europe and Cointeraux: The revolutionary political climate in 18th century Europe and the rise in status of the common worker made rammed earth a well-used, low-cost, owner-builder construction technique. Papers on rammed earth construction were being published at the hands of many French connoisseurs.

North America, Australia, and New Zealand: The late 18th and 19th century observed exodes of peoples toward North America, Australia, and New Zealand. The migrations were accompanied by previously unknown skills and customs such as earth construction. Settlers experimented different techniques of rammed earth.

Germany: In the 20th century, and following the first and second World Wars, rammed earth was again revived as a solution to the housing and labor shortages. It was used for post war reconstruction in East Germany, being a cheap and widely available material. Effectively, Germany was the first country to publish a Building Standards Document covering rammed earth construction (1947-1956).

Rammed Earth use has grown and withered unceasingly in different parts of the world. Many scholars have advocated, investigated, and perfected its methods and techniques, spreading a message of affordability, quickness, and ease of construction. Recently, as awareness for the climate emergency is taking root, earth is witnessing a "revival", flourishing as a sustainable material that supports a circular economy.

Fig.82. Visual timeline following the spread of rammed earth worldwide and through the centuries

Fig.83. Alhambra of Granda, Andalusia, Spain. A fortress constructed in earthen materials

Fig.84. Lyon, Croix Rousse district, high rises constructed in rammed earth

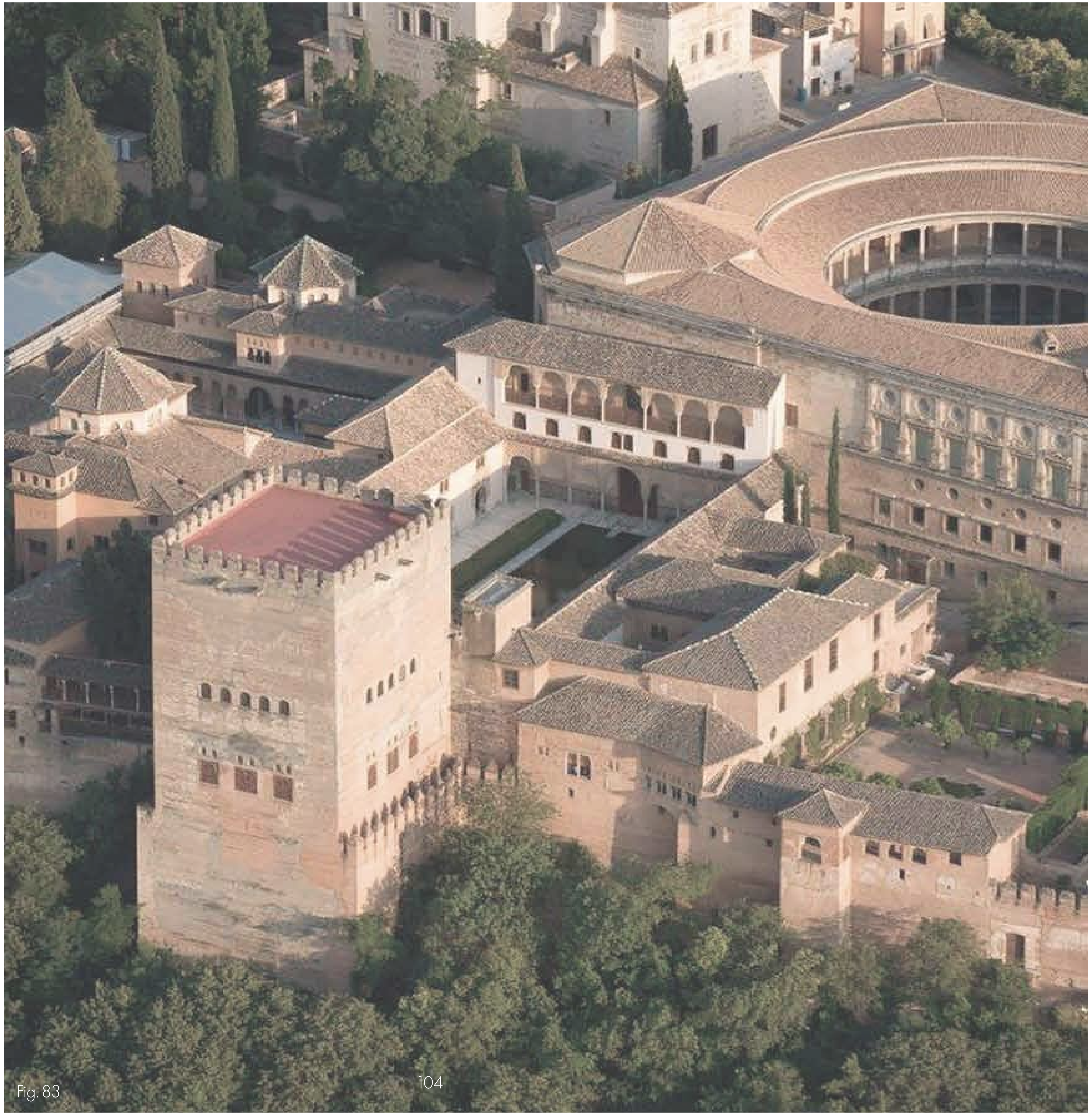


Fig. 83

Fig. 84

Earth construction as French heritage

In France, the age of enlightenment (bookmark: 18th century intellectual movement that dominated Europe) and the French Revolution, put urban expansion and transmission of knowledge under central light. The traditional rammed earth technique saw a strong resurgence of interest in the second half of the 18th century, especially with scholars and builders from Lyon.

Abbé Rozier (a botanist) and the architects Georges-Claude Goiffon, François Boulard and François Cointeraux, theorized and rationalized the technique of rammed earth in their publications. These writings had a considerable impact, with some of Cointeraux's works being translated and sold all over the world.

François Cointeraux (1740-1830) was a laboring class theoretician of rural architecture. He showed great interest in theorizing rammed earth construction and documented its construction process after studying its artistry. His practical and pragmatic observations on the subject came from a craftsman point of view, which put him in closer proximity with his subject.
Moreover, reflecting on the uses of rammed earth, Cointeraux developed a process that he calls the "new pisé": a mass production of mechanically compressed earth blocks, rammed with a patented tool (the crécise) in a timber plank formwork. In 1791, he conducted several practical experiments on rammed earth (French Le Pisé (etymology in bookmark)) and detailed his findings in documents distributed around Europe and America.

Fig. 85

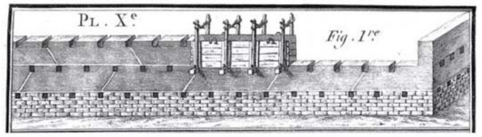


Fig. 86

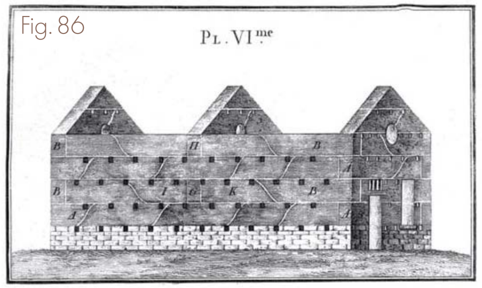


Fig. 87

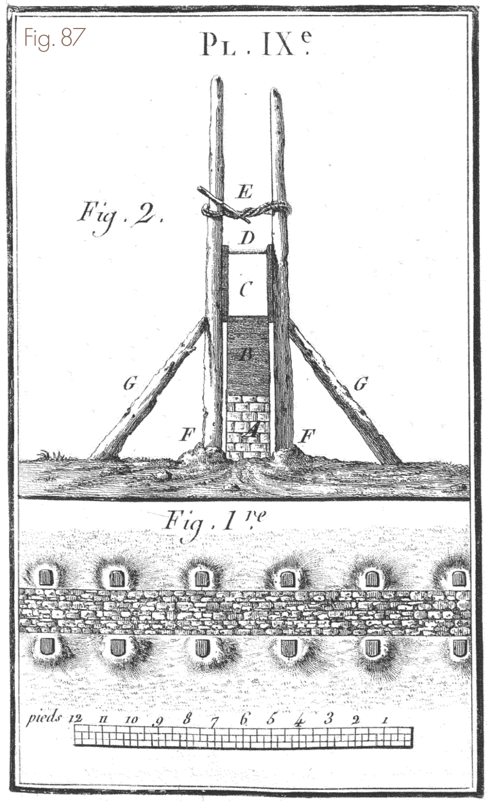


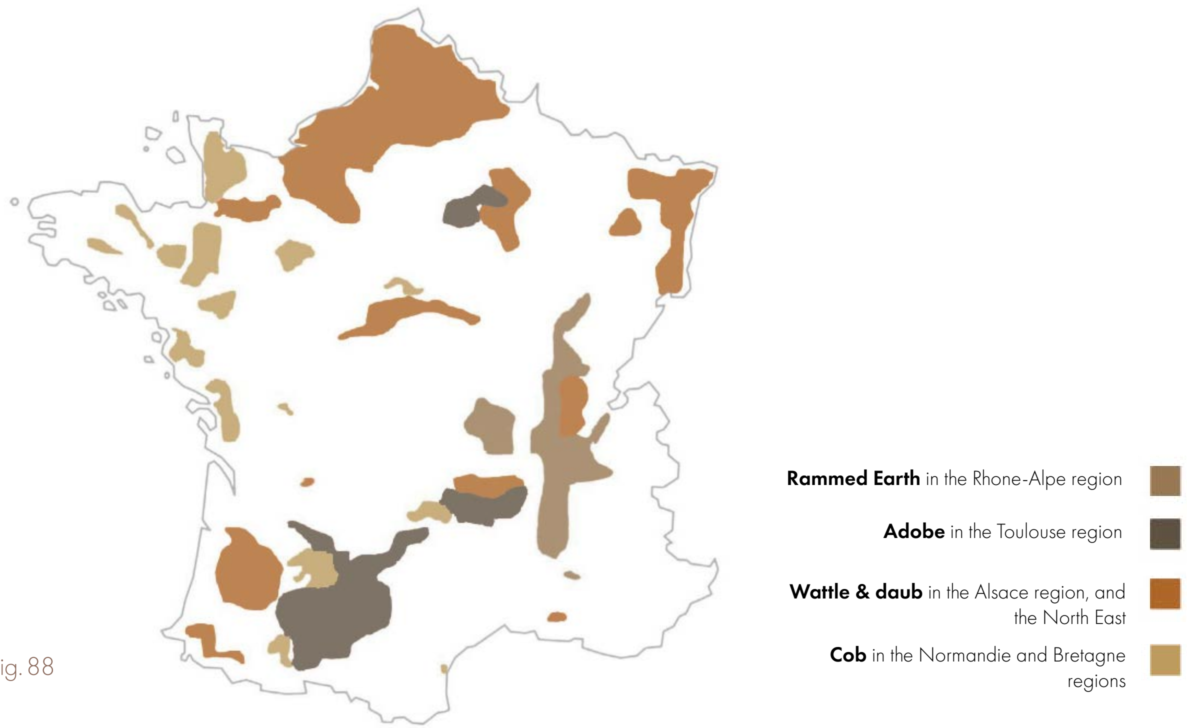
Fig.85-87. F. Cointeraux's illustrations from Cahiers de l'Ecole d'Architecture Rurale (1790)

In his own words **F. Cointeraux** defines rammed earth in his Cahiers de l'Ecole d'Architecture Rurale in 1790 as such:

"Le pisé est un procédé d'après lequel on construit les maisons avec de la terre, sans la soutenir par aucune pièce de bois, et sans la mélanger de paille ni de bourre. Il consiste à battre, lit par lit, entre des planches, à l'épaisseur des murs ordinaires, de la terre préparée à cet effet. Ainsi battue, elle se lie, prend de la consistance et forme un mélange homogène qui peut être élevée à toutes les hauteurs données pour les habitations (...)"

Rammed earth is a process by which houses are built with earth, without the support of wood, and without mixing it with straw or cob. It consists of beating, layer by layer, between formwork boards, to the thickness of ordinary walls, earth mixtures prepared for this purpose. Thus beaten, the matter binds itself, gathers consistency and forms a homogeneous mixture that can be raised to all heights of construction (...)

Fig. 88



Today we see that France has an exceptional raw earth vernacular heritage. Historically, when wood and stone started lacking, earthen construction was developed: this provided that 15% of the entire French architectural heritage be constructed using earth. The country became one of the rare territories where all four of the main construction techniques in raw earth were used.

For example, in the North of France, Normandy, Picardy, Champagne, and Alsace, more than 60% of traditional buildings are half-timbered houses with a cob filling. In the West of France, particularly in Brittany and Vendee, the cob is widespread. In the South-West region, the Gers, and the Toulouse region, the adobe technique is found in abundance. Finally, the rammed earth technique is, by far, the most widely used earth construction technique in the Rhône-Alpes region.

Taking on the case of the Auvergne-Rhône-Alpes region in South-East France, we find rammed earth construction in multitude. It constitutes up to 40% of all buildings and 80% of old buildings (built before 1948). The areas presenting such constructions are both rural and urban, such as Lyon's historical center and its surroundings, now classified as UNESCO world heritage.

This heritage, built up until the 1940s, takes on diverse forms: residential houses, farms, barns, churches, mansions, industrial buildings, castles, etc... In

Fig.88. Construire solidaire map: kinds of earth construction and their distribution on French territory

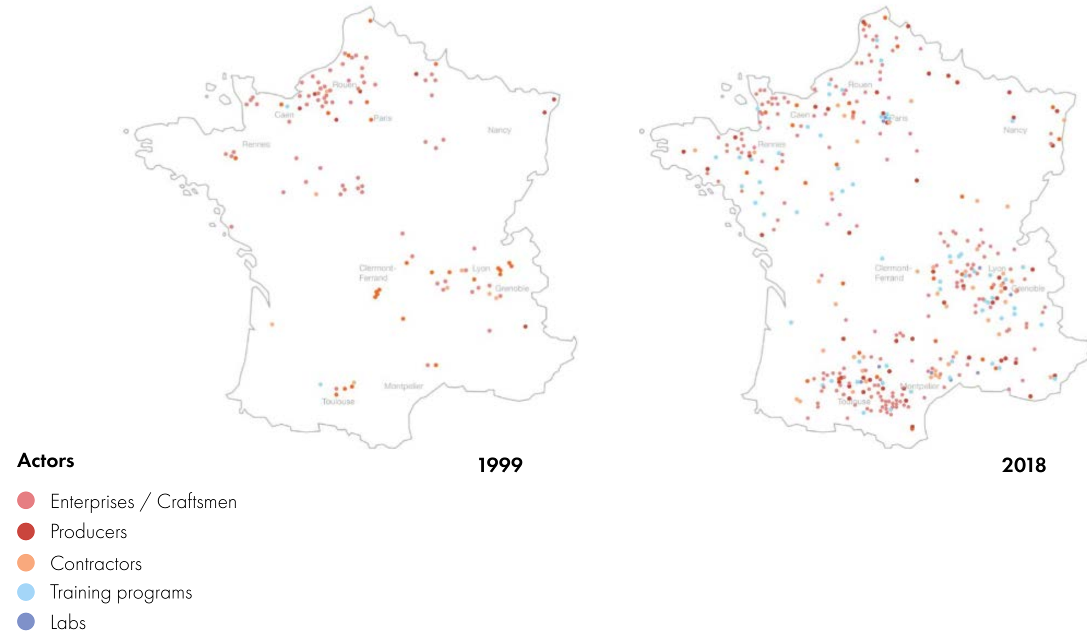


Fig. 89

fact, the built environment represents typologies of traditional architectural features of the region, in addition to the authenticity brought by using earth. The site terrain offers soil rich in great quality clay, silt, sand, and gravel perfectly suitable for compacted earth mixtures. This leaves the region with a remarkable architectural heritage, an expression of a true culture of builders.

Unfortunately, the prevailing of concrete practices after World War I, and the lack of knowledge about rammed earth construction craftsmanship have caused it to dwindle in use over the last few decades.
Today, we know that French territory is no stranger to earth construction and old-time techniques are being revived, trusting that earth construction will be a major step in shifting the climate crisis scales, and that the only resource needed, good quality soil, is still abundantly available.

Experimentation in France: From matter to material

In 1979, CRAterre, Center for research and application in earth (Centre de Recherche et d'Application en terre), was founded. It started as a student association intending to update and promote scientific knowledge on earthen construction, but slowly became a research laboratory and a global reference in the earth architecture domain, publishing books, articles and papers about the use

Fig.89. Actors in the rammed earth sector between 1999 and 2018

Fig. 90

Fig. 91

and techniques of earth construction in France and worldwide.
As interest in the subject grew, many similar organizations and research centers started forming and joining the narrative of earth being a pertinent construction material for present and future generations. Of these organizations, we can name Amàco (founded in 2012), an experimentation laboratory that investigates the transformation of soil and clay matter into effective building materials.

In order to organize and collaborate between all actors in the field of earth construction, the national Association of Raw Earth Professionals was founded in 2006. Recognized as Asterre (Association Nationale des professionnels de la Terre crue), it aspired to create collaborations and activities that joined producers, architects, engineers, and heads of organizations under a mutual apprehension of earth construction and architecture.

Since then, earth construction professionals in France have increased in numbers and the subject has witnessed a slow, but undeniable revival. With specialists in Ile-de-France, situational climate of our study, still proving to be scarce in number, on a national level.

In 2016, in the context of France, and more specifically of Ile-de-France, architects Paul-Emmanuel Loiret and Serge Joly, in collaboration with amàco and CRAterre, carried out experiments

Fig.90,91,94,95. Earth samples for the exposition *Terres de Paris*

Fig. 92

Fig. 93

Fig. 94

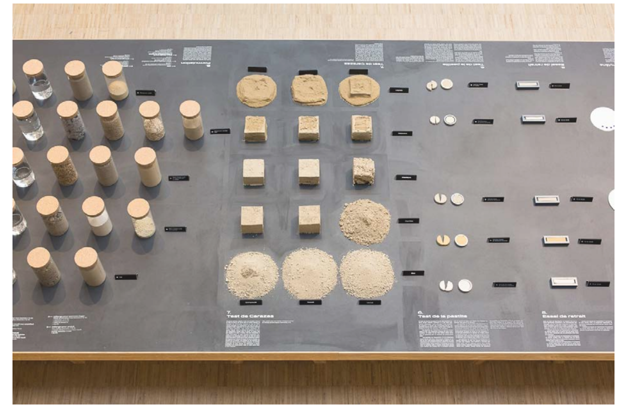


Fig. 95

on Parisian soil extracted on construction sites. An exhibition named "Terres de Paris" took place at the Pavillon de l'Arsenal. They explored plausible earth construction techniques after observing and processing several earth samples extracted from metropolitan construction sites. From matter to material, they elevated Parisian clay aggregates to showcase the potential of the 20 million tons of soil removed in the greater Paris area to make room for the metro network plans of the Grand Paris Scheme. This underground expansion offers a rare opportunity to exploit earth as an innovative, sustainable material that would reduce waste and pollution in the metropole.

The Saclay plateau presents a similar opportunity. Construction sites along the urban campus and the works carried out to urbanize and densify the region are resulting in a bulk of unused soil. One of our projects' aims would be to find another future for this substance considered a debris, knowing that its benefits expand fully beyond mere matter recycling...

The project discussed in this thesis brings forward the use of traditional rammed earth to construct a set of walls that bears the load of an extensive garden terrace. The soil used is extracted from the project terrain and from neighboring construction sites in Saclay. Modules are then prefabricated in an on-site lab before being assembled to form the "podium", ground level of the project.

Fig.92,93.Excavation Process for exposition *Terres de Paris*

Case Studies

To manage fulfilling our aspirations in constructing a functional rammed earth podium in our project, we dedicate ourselves to analyzing three case studies. These examples will help us refine different aspects of the construction process in parallel to understanding the many retaliations that come with using earth as construction material.

The Rauch Family Home – 2008, Austria, Martin Rauch in collaboration with Roger Bolthauser.

This house is the culmination and physical embodiment of Martin Rauch's theoretical work. Embedded in a hillside, it is entirely made of earth excavated from the site on which it stands. It takes on the shape of shifting blocks with generous openings.

The load bearing façades are striped with clay bricks inserted between compressed earth layers to stop the waterflow along the walls. The interior serves the same haptic and earthy aesthetic with the many rooms being individualized and articulated using an organic stairway along the different levels.

The small building's materiality and form reflect Rauch's narrative that stands to build contemporary forms with vernacular and sustainable techniques.

From this case study we adopt the reuse of excavated soil, the façade treatments, and the rawness of the architectural language.


Fig. 96


Fig. 97


Fig. 98

Fig.96-98. The Rauch Family Home, 2008, Austria, Martin Rauch in collaboration with Roger Bolthauser


Fig. 99

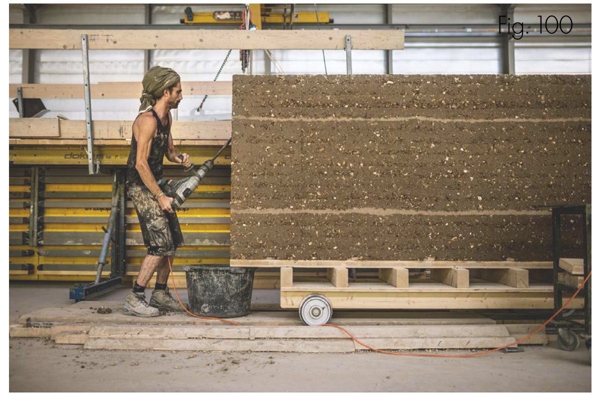


Fig. 100


Fig. 101

The Ricola Factory - 2014, Switzerland, Herzog & de Meuron with Martin Rauch as rammed earth specialist.

In a now rural context, the project comes in the form of a singular massive rectangular volume built with locally soured earth.

The material choice merges the block with the greenery around it and conceptually satisfies the concept of it being a factory for organic herb sorting and mixing.

The earth walls are assembled earth modules that were prefabricated on site using compacted loam in formwork.

During production, after each few layers of soil, a volcanic trass and lime mortar is compacted to delay erosion and strengthen the wall blocks. Following assembly, the seams are retouched using an earth mortar to give a homogenous appearance.

The project focuses on including sustainable choices since its conception, giving ample attention to interior humidity control thanks to the earthen techniques and to energy saving methods.

From this example, we take on the concept of prefabrication and the inclusion of volcanic mortar layers between the compressed earth beds.

Fig.99-102. The Ricola Factory, 2014, Switzerland, Herzog & de Meuron with Martin Rauch as rammed earth specialist

Fig. 102

Fig. 103

îlot B2 – 2015 to 2021, Lyon, Diener & Diener Architekten and Michel Desvigne, with Le Pisé as contractor company.

A series of buildings, each individually designed, form the project of Block B2 in Lyon, capital of earthen construction in France.

The B05 office building strikes the eye, having the role of urban activity stimulator, it is constructed using prefabricated rammed earth modules.

The assembled walls, positioned on elevated footings of concrete, display large arcades of transparent and traversing windows. And the interior open plan system presents a courtyard.

This configuration is made possible with the use of timber beams, walls and slabs that are sustained on corbels sculpted into the rammed earth load bearing facades.

We acquire from this project the in-situ prefabrication of modules, the elevation of walls on footings to eliminate water flooding, the use of corbels to connect structural elements and transfer loads, and the hybrid structural system of rammed earth walls and timber slab.

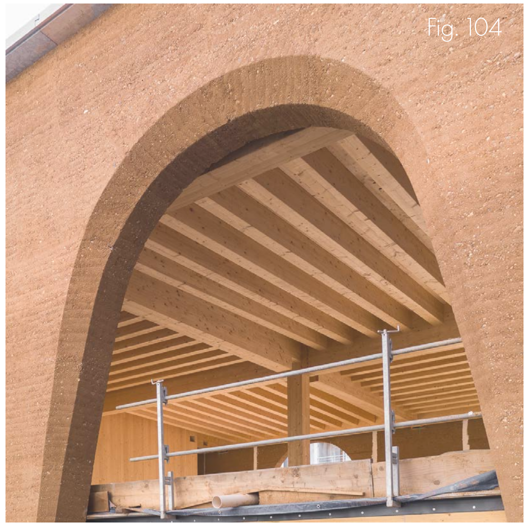


Fig. 104

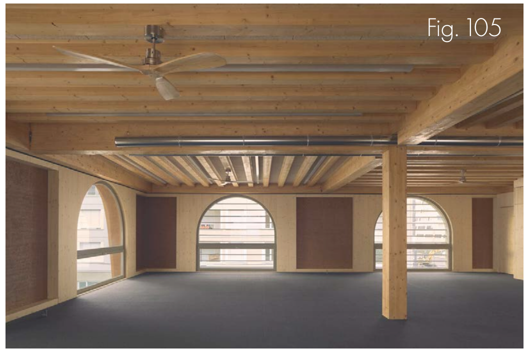


Fig. 105

Fig. 106

Fig.103-106, 110. îlot B2 – 2015 to 2021, Lyon, Diener & Diener Architekten and Michel Desvigne

TO SPEAK ABOUT THE MATERIALS OF CONSTRUCTION, AS A DESIGNER, IS TO TAKE INTO ACCOUNT THE CONTEXT OF THE MATERIALS. STARTING WITH HISTORY: IT'S BEEN SAID THAT IF YOU WANT TO LOOK FAR INTO THE FUTURE, FIRST LOOK FAR INTO THE PAST. HISTORY IS INSEPARABLE FROM PLACE. SUSTAINABILITY, SIMILARLY, IS INSEPARABLE FROM NATURE.

- LORD NORMAN FOSTER,
THE MATERIALS BOOK, RUBY I.
& RUBY A.

4.2. Earthen Construction: life, demise, and rejuvenation

The role and the ways of a circular life strategy

The ever-growing construction sector is one of the largest sectors on the stage of world economy today. It has proven to be extremely energy intensive, weighing immensely on the environment. Today, construction waste constitutes more than 30% of the world's landfills. This is due to the standardization of building materials, most of which are non-recyclable and have high carbon footprints.

While the world is realizing that the sustainability paradigm must shift, we notice a return to vernacular materials that have low embodied energy. Earthen construction resurfaces as a sustainable global value that should be raised to compete with other types of standardized building products and methods.

Although this low-tech construction method is recognized to have many advantages in comparison with conventional procedures, it has yet to be standardized and assessed in a way to procure for the builders detailed quantitative data about its environmental performance. The reason would be its dependance on the specific climatic and contextual conditions of each site and the different composition of each earth mixture depending on the region of sourcing...

Nonetheless, the carbon balance of raw earth can be roughly estimated as being between 100 and 200 kWh per ton of soil. This value is significantly lower than that of cement (330 kWh), and about four times lower than that of reinforced concrete (850 kWh).

Obtaining comprehensive data on the stages of life of a building constructed using the rammed earth method is essential. For our project, a schematic life cycle briefing is put in place to attempt a closing of the loop in production. We try to ensure that a cradle-to-cradle strategy is effective in reducing waste.

Non-renewable energy consumed by one ton of material	
- Raw Earth	**100 to 200 kWh**
- Concrete	170 kWh
- Ciment	330 kWh
- Reinforced Concrete	850 kWh
- Steel	3560 kWh

Table: the energy consumption of 1 ton of rammed earth in comparison with concrete and other materials

As a start, we elaborate targeted concepts that are put in place to develop the community center. They help devising the lifecycle of the entire project.

Building the landscape: The idea, as stated previously in chapter ... is to gather all different kinds of landscapes into one concentrated high point: the community center. This concept physically materializes into two distinct compounds: four monofunctional blocks and a podium. The latter rises from the ground as an integral part of it and of the context that surrounds it.

Reversibility: Creating one entity between landscape and podium meant taking thorough choices regarding techniques and materials this is when building with rammed earth became evident.

Regarding the project life cycle, the material use of un-stabilized earth mixtures meant total reversibility of the intervention. The end of life of the building can have two sustainable outcomes: a recovery of the earth towards the ground or its recycling for a future re-use. The environmental impact is minimized, especially knowing that the materials were sourced in-situ since the beginning.

Adaptability: In the case of a dismantle of the podium, the proposed structural and architectural systems would allow a flexible and adaptable spatial organization. The blocks can witness additions, expansions or a total interior and exterior reconfiguration. The goal is to have the project respond and adapt according to the needs of the next generations.

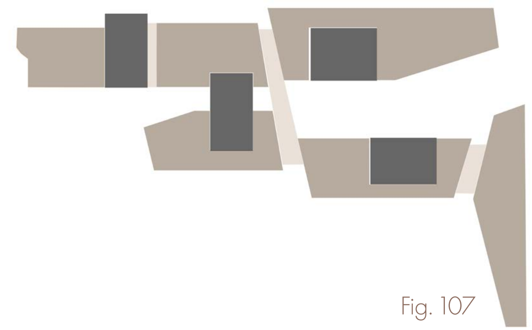


Fig. 107

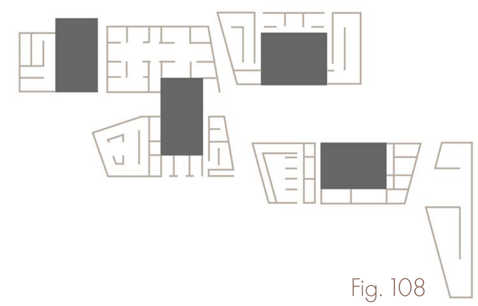


Fig. 108

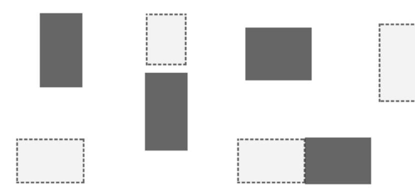


Fig. 109

Fig.107-109. Diagrams illustrating the reversibility and adaptability of the earth podium

Fig. 110

Fig. 111

The end-product of the reasoning process comes in the shape of a labyrinthic ground floor, housing all communal functions serving the adjoining masterplan's edifices. The walls' disposition helps them define spans and accomplish their load bearing roles while dividing the spaces. As an aesthetic finish and to maximize ergonomic qualities (explained in page ...), raw, earthy, and unvarnished facades are maintained, they hint to an approach calling back craftsmanship and vernacular processes.

Effectively, a sustainable environment is created through understanding the ecological impact of the different lifecycle stages of such a project. At the end-of-service term, the used materials most often become an environmental burden. The perfect scenario is to aspire towards a positive impact consisting of feeding them back to the production stage. This way, the extraction of new virgin matter for manufacturing purposes is reduced and a circular construction process is created.

This life loop can be summarized in three ideally repeating phases.

A – Production and Construction Stage:

- Extraction of soil from the site and nearby on-going projects on the Saclay plateau.
- Production of transportable rammed earth wall in an on-site workshop: mix the components to reach the desired composition – construct the formwork – compress earth layers into formwork with pneumatic tamper – lift the formwork and wait for curing.
- Erection of walls by moving modules into place and by connecting them using clay mortar.
- Filling of joints between the modules using clay mortar to create a seamless finish.

Fig.111. GF Plan (unscaled) showing a diagrammatic layout of the rammed-earth walls

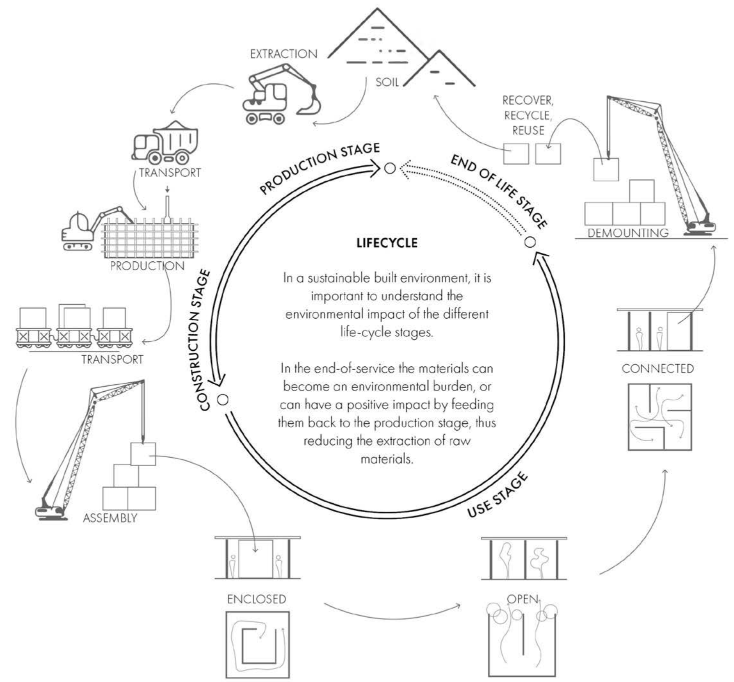


Fig. 112

B – Use Stage:

Assembly of different wall configurations that allows several distinct uses of space throughout the project. Achievement of high thermal performance of the ensemble through good maintenance, repair, and management of energy use.

C – End of Life Stage:

Demounting of modules with possible benefits and scenarios:

- total return of the earth matter to the ground
- reuse or recycling of the earth for new purposes (new modules, land infills...)
- keeping of the podium walls to create a planted labyrinth that serves as a garden for the surrounding blocks...

We proceed by diving into the details of each of these stages, emphasizing the structural and thermal roles of the rammed earth walls, their construction process, the challenges faced and the solutions that were implemented.

Fig.112. Diagram of the rammed-earth wall lifecycle; from production to end of life

Fig.113,116. Rammed earth wall modules assembly in the Ricola factory project by Herzog and de Meuron

Fig. 113

The art of prefabrication and assembly

The Paris – Saclay plateau is in the process of welcoming 400 ha of neighborhoods in a 900 ha urban park. All projects will require an extraction of raw earth that will amount to waste if not put to good use.

In our project, we aspire to built rammed earth wall units in a lab, close to the construction site. The modules will then be assembled to form the podium. This ensures waste management for the extracted soil, and energy saving in terms of transportation.

The production and construction process can be summarized with these following steps:

Production

1 – Raw material extraction
2 –Soil composition mixing
3 – Formwork assembly
4 – Earth ramming
5 – Curing

Construction

6 – Foundation building
7 – Walls Assembly
8 –Joints treatment
9 – Slab construction

1 – Raw material extraction

Operations begin with the extraction of subsoil (Bookmark subsoil definition) from the site of Saclay itself: the volume of earth extracted to make room for underground basements and foundations of the project and the quantity extracted from nearby on-going construction in the area will be used to produce the rammed earth units. Subsoil is one of the deeper soil layers, or loam soil, it is defined by its plasticity and should be found below the topsoil and the humus layers.

The most energy efficient extraction procedure would be to sieve the soil during its extraction, rejecting rough particles such as rocks and pebbles. The waste from the sieving process will be organically returned to the site.

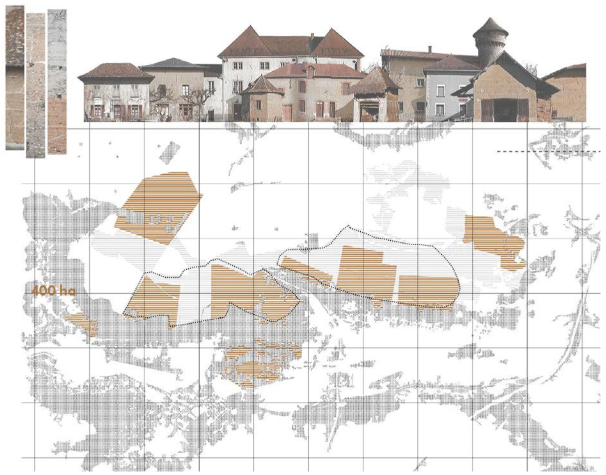


Fig. 114

2 – Soil composition mixing

The loam's composition type and properties differ from site to site. Therefore, an analysis proving the exact components of the mixture should be done. Particle distribution and percentages of materials might need adjusting, even when the site's soil is adequate for rammed earth construction.

An appropriate constitution would be 67% sand, 30 % clay, 3% lime, combined with water to create a plastic mixture that will eventually be compressed and dried (cured). The mixing of the combination is an essential operation, guaranteeing the homogeneity of the soil used and consequently a good structural integrity and a smooth architectural finish.

3-4 – Formwork assembly & earth ramming

Following this, planks and panels of either wood or aluminum are assembled using nails, into a sort of open lid box, making up a standardized mold for the wall units. Soil is dropped into these formworks in layers of around 15 to 20 centimeters. Layer after layer, they are compacted using a heavy pneumatic rammer, until the formwork is full.

Layers of volcanic trass lime and clay tiles are inserted every 6 to 7 layers with aim to reduce erosion and stop water flow (see page ... for further explanation).

Fig.114. Map of Paris, Saclay, highlighting the possible earth extraction zones

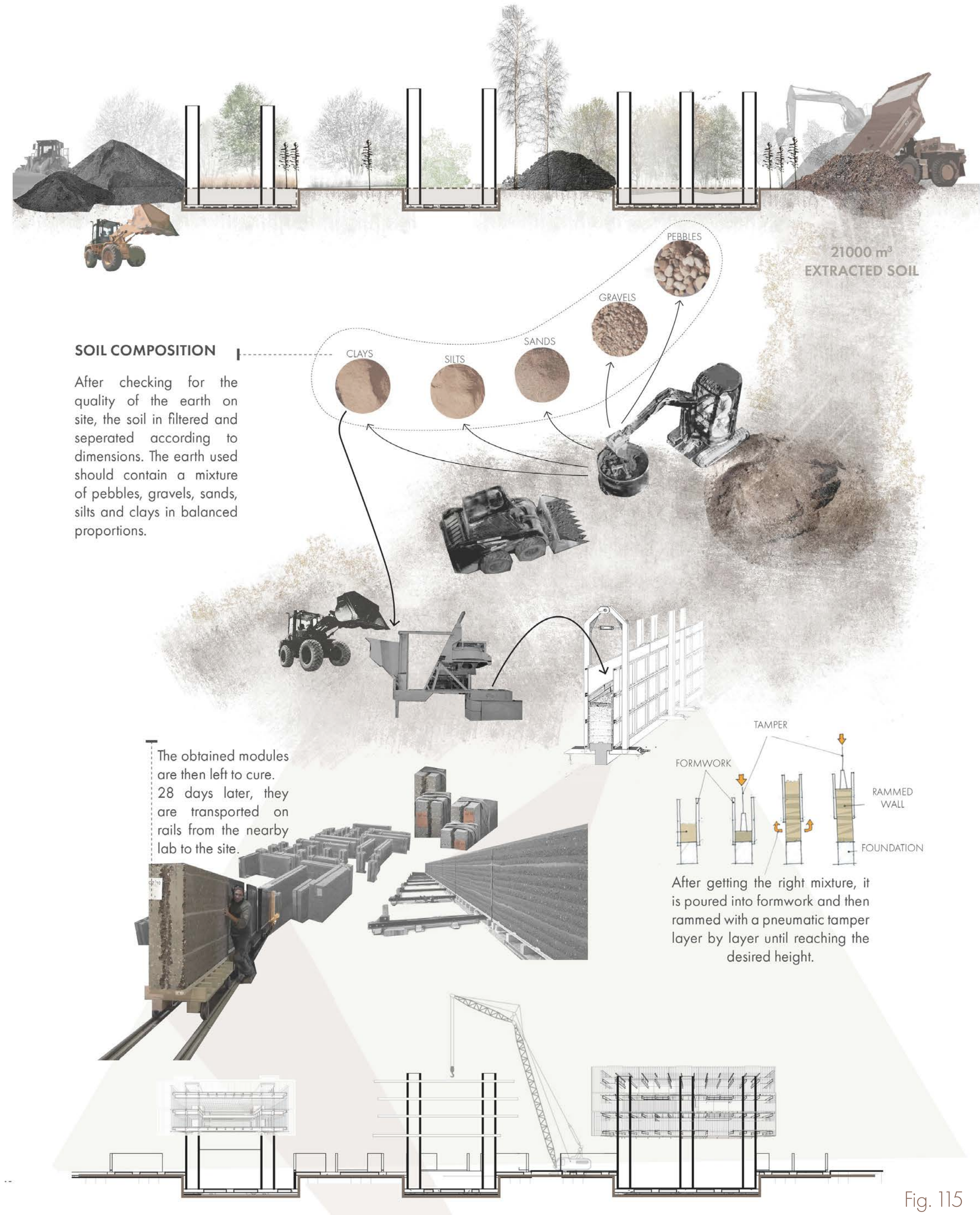


Fig. 115

Fig.115. Collage timeline of the earth modules production and construction process

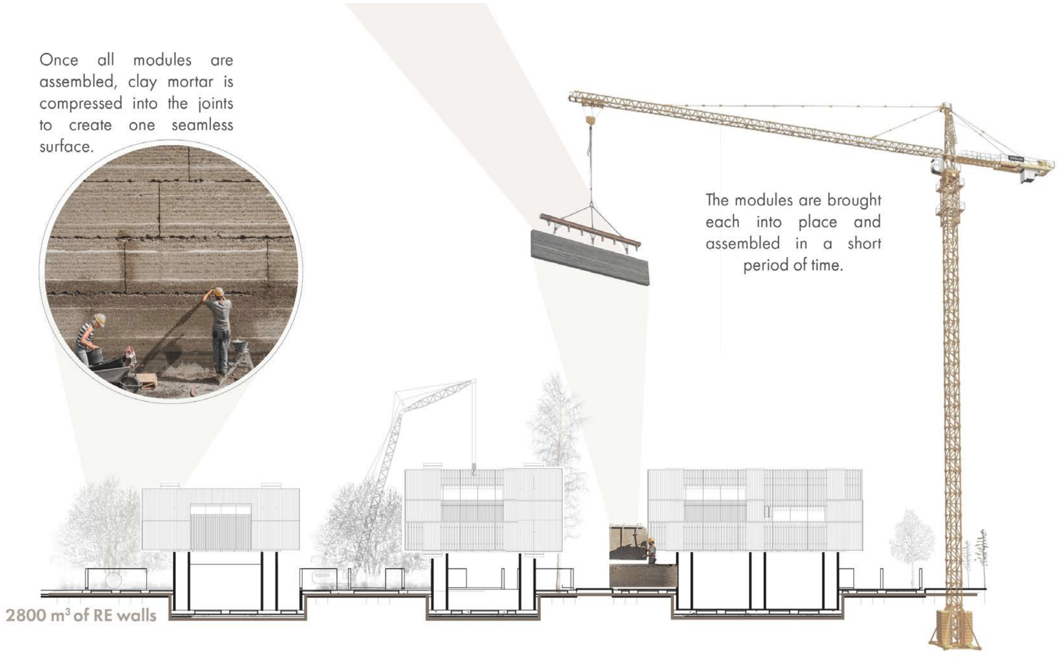


Fig. 115

5 – Curing
The mold is then immediately demounted (facilitating rapid re-use), and the rammed earth block is left to cure naturally, ideally for around 28 days to a month.

6 – Foundation building
The foundation footings for the one-level earth podium are made of stabilized rammed earth. In this case, cement is used as an artificial stabilizer to improve the structural capabilities of the foundations. This provides higher security as the strength of the walls increase, but the stabilized mixture cannot be recycled. On the footings stand necks of natural stone blocks that will extend above ground level and serve as preventors of capillary rise (see page...).

7 – Walls assembly
The cured modules are transported on rails from the lab to the nearby site, where the prefabricated stabilized earth footings are already positioned in the excavated trenches. The rammed earth wall units are brought into place and assembled above the stone necks in short period of time.

8 – Joints treatment
The joints between the blocks are treated using an earth mortar. Thanks to the plasticity of the loam, the seams disappear, and a homogenous appearance is achieved.

Fig. 116

Fig. 117

9 – Slab construction

Walls of rammed earth now form the first level of the project. The labyrinth of load bearing facades is topped with timber beams, timber planks and finishing layers: an elevated urban promenade takes place over the new terrace.

An advantage of the configuration of the project, and the differing materials and building processes between blocks and podium, is that both construction types can be undergone independently and simultaneously: while the earth modules are being produced nearby, the construction of the tech-blocks can already be underway.

After the main structural elements of the blocks are built, the assembly of the stabilized earth foundations for the podium can start, leaving only the time necessary to assemble the cured modules for the walls. This time can be considered very minimal considering the advantages of the prefabrication process in minimizing the total length of the construction period.

Fig.117. Rammed earth modules assembly for the Orangerie building of ilot B2 by Clement Vergely architectes

An earth wall under the spotlight: The Use Stage.

Challenges & solutions

The rammed earth podium now erected; we can dive into explaining all construction details from capping of the walls to footings. These features were designed while thinking of the in-use phase of the project, in relation to the exterior and interior factors such as erosion, rain, ergonomic comfort... We therefore discuss along the way, the challenges faced and the methods that came into play to solve them.

At the level of the roof slab, the wall thins from 500 mm to 270 mm, forming a parapet and a corbel where the timber beams will rest. The top of the wall is covered by a sloping coping system of titanium-zinc sheeting (1 mm, pre-patinated). This will prevent ponding and water infiltration through capillary flow unto the top of the wall.

In fact, when the evaporation of the water from the wall is slower than the flow of water into it, the moisture content inside the wall increases, and this causes a reduction in the compressive strength and an increase in the ductility of the wall.

The inner part of the wall is further protected from water by bringing the timber planks and waterproofing membrane of the slab all the way up towards the coping mechanism and securing them with a flashing.

Fig. 118

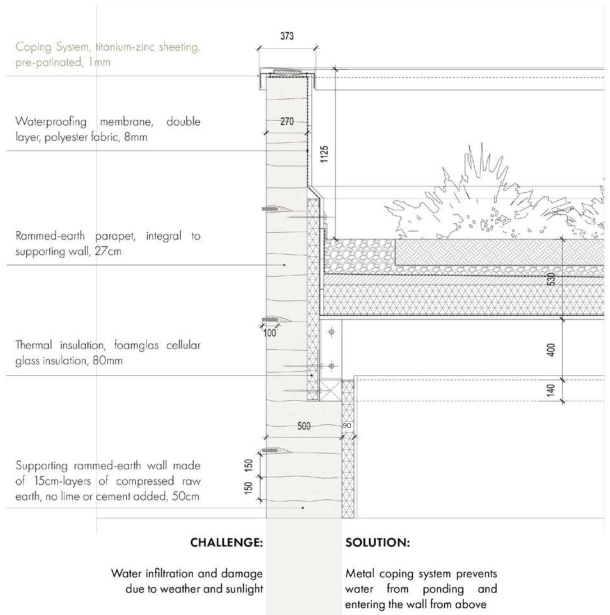


Fig.118,121,122. Details focused on the caping, middle and base of a rammed earth wall in the project podium. Scale 1:20

The length of the wall presents layers of fired clay tiles and trass lime mortar placed every 6 to 7 layers of compressed earth.
The mortar, mixed with extra volcanic tuff and lime, stiffens the outer layer of the wall against wind and water erosion.

The fired clay tiles, in addition to slowing erosion, interrupt water flow along the façade. Water absorbed into the outer skin of the rammed earth wall can cause it to saturate, swell and disintegrate.

In all cases, fine earth particles on the façade will dissolve, leaving the mortar, tiles and the bigger and stronger particles of the wall exposed: erosion lessens after a few years when the wall has completely settled and toughened, the outer skin becomes a barrier.

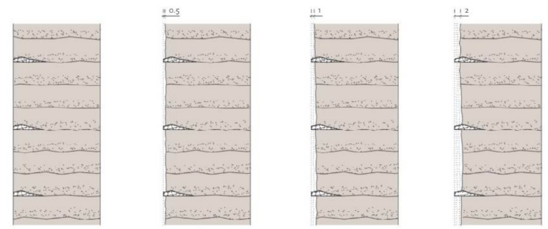


Fig. 119

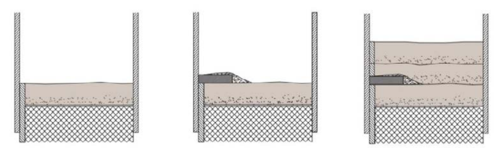


Fig. 120

Fig. 121

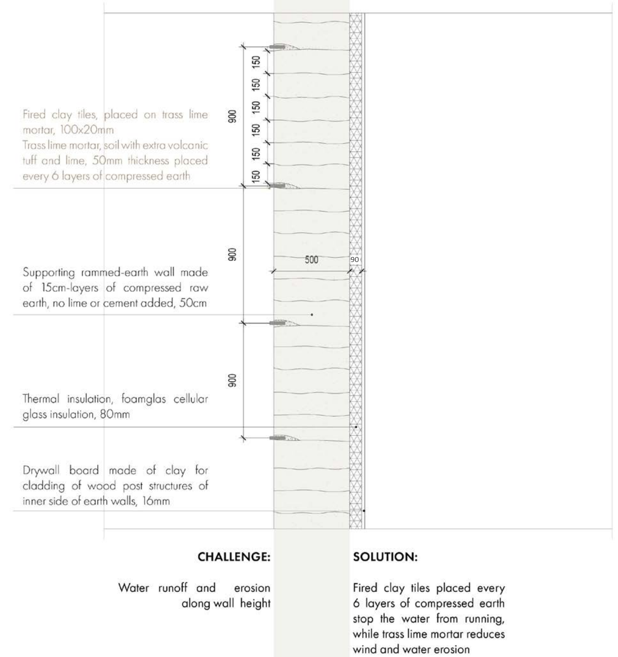


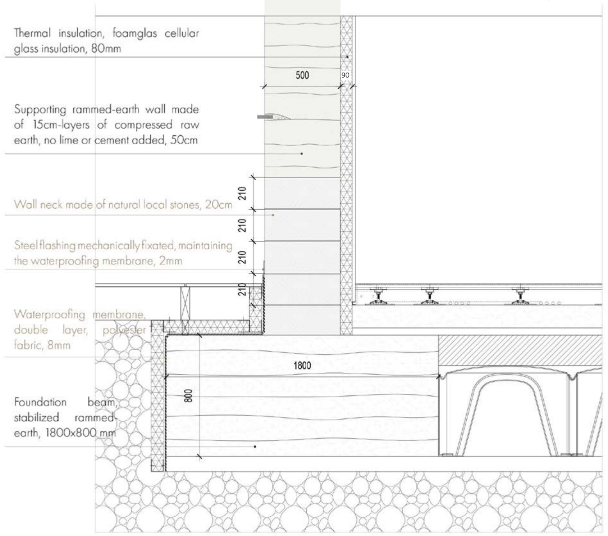
Fig.119. Impact of the insertion of tuff mortar between the earth layers of a wall on the integrity of the wall against erosion

Fig.120. Insertion process of fired clay tiles between earth layers of a wall

The base of the wall, consisting of the stabilized earth footing and the natural stone foundation neck, is encased in a waterproofing membrane and a Foamglas insulation layer to prevent water infiltration and thermal bridges.
The stone neck rises around 630 mm above ground level to prevent water splash and water flow. Contact with water at the base is dangerous, as it causes the wall to saturate and overturn, which leads to thinning and eventually, to compressive failure.

The interior face of the wall is covered with an 80 mm Foamglas cellular glass thermal insulation and a clay plasterboard as finish (from producer CLAYTEC). The insulation is necessary as the rammed earth walls regulate temperature in summer, better than they do in winter (further elaboration in next few paragraphs)
As for the openings, the podium on the ground floor, is perforated continuously with doorways and windows of 2 to 4 meters in width and around 2.2 m in height. The orifices are made structurally possible through laminated timber lintels that cover the spans and are positioned towards the interior face of the wall. They act in bending, to distribute the load above the opening to the structural wall on each side of it. The sliding double glass windows and doors have well-insulating, hybrid frames of timber (inner layer) and aluminum (outer layer) from French producer MINCO.

Fig. 122



CHALLENGE:

Capillary rise, moisture and rainwater splashback

SOLUTION:

Waterproofing membrane protects the stabilized footings. 60cm-high-wall neck made of natural stones protects earth walls from water splashback

Fig.123.Horizontal pattern of tiles and earth on the walls of the Rauch family house

Fig.124. Main stairwell in the Rauch family house

Fig. 123

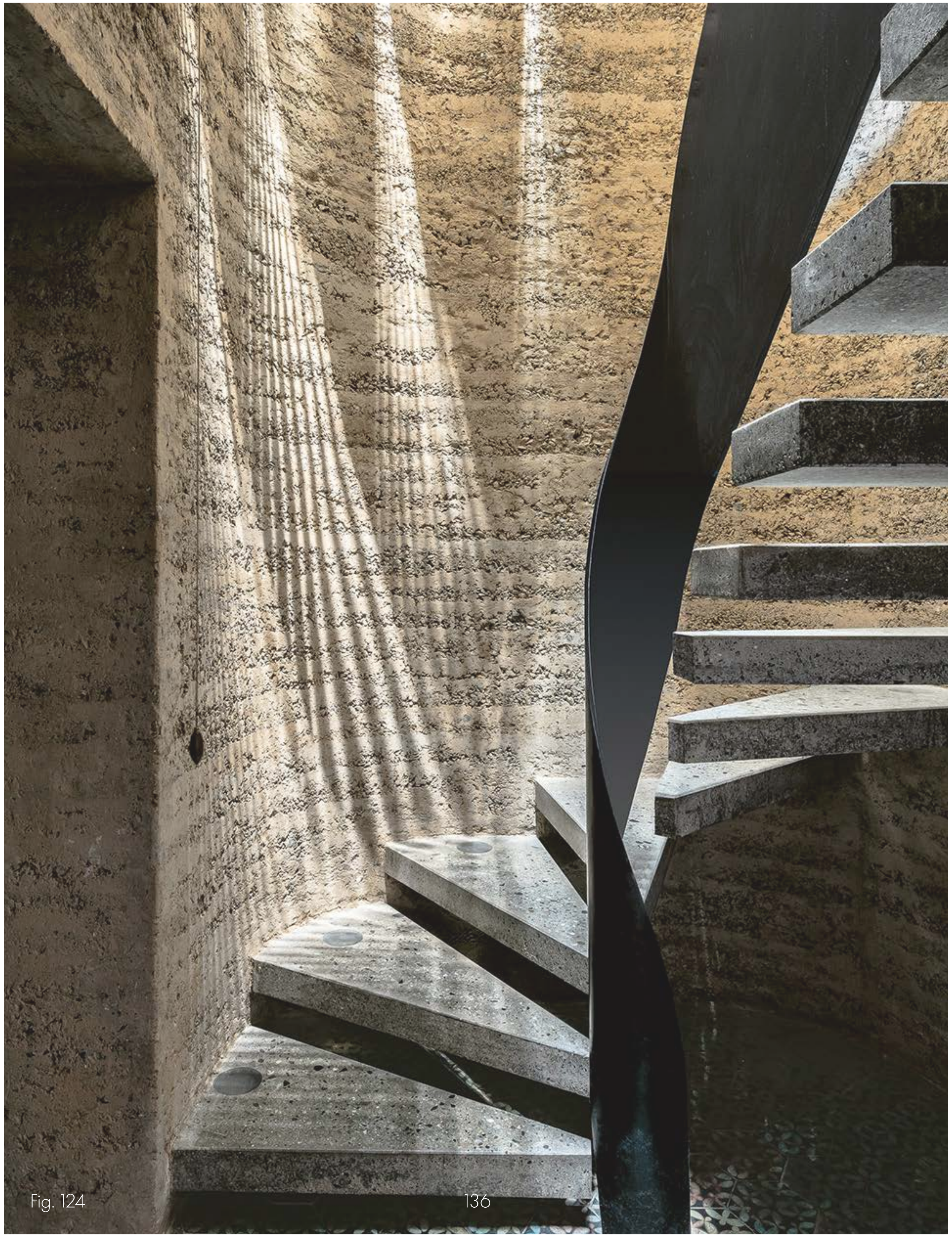


Fig. 124

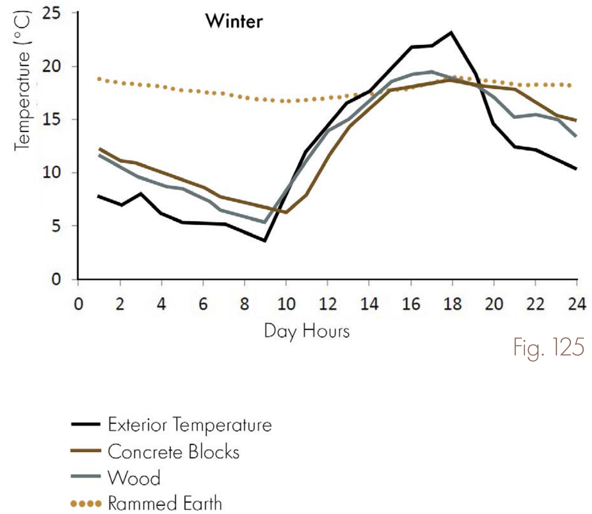


Fig. 125

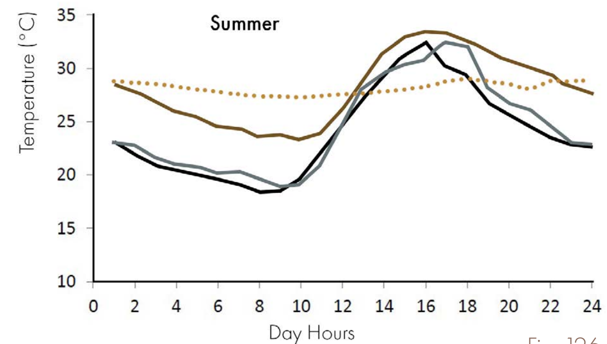


Fig. 126

Physical properties & interior comfort

The increase in energy needs in standardized construction has raised awareness about the importance of earth as a construction material.
The European Union, with its 2050 goal to reduce gas house emissions by 80 to 95%, turns towards exponentially increasing the number of zero-net energy buildings. Rammed earth construction is being redeveloped for its spectrum of sustainable features and for its passive thermal and hygric performance, in addition to its capability in limiting the proliferation of toxic molds and particles.

Thick earth walls are climate-responsive, they play an important and active role in temperature and humidity regulating inside the building, thus reducing the need for mechanical heating and cooling to achieve comfort conditions.

Earthen materials, being porous in nature, can store great amounts of thermal energy in comparison with conventional materials and can provide a relative thermal stability to the building. In fact, when the outside temperature increases, the water contained in the walls evaporates. This change in the state of matter of the water consumes energy and cools off the wall. Inversely, when the outside temperature decreases, the water vapor condenses, and heat is emanated.

Fig.125. Thermal efficacity of a rammed earth wall in winter in the Atacama desert (Chili, Morel, 2014)

Fig.126. Thermal efficacity of a rammed earth wall in summer in the Atacama desert (Chili, Morel, 2014)

Although characteristics of rammed earth walls differ from site to site when it comes to the context and the loam composition, some qualities can be approximately defined.

In technical terms, the **thermal storage** of a rammed earth wall, which is its specific heat capacity, is around 1830 J/m3_C (Houben & Guillaud, 1994).

Its **thermal resistance or R-values**, a measure of the opposition to heat transfer offered by a building element of specified thickness, is between 0.35-0.70 m2K/W for a wall of 300 mm (Standards Australia, 2002).

A measure of the overall rate of heat transfer, by all mechanisms under standard conditions, the **thermal transmittance or U-values** is around 1.9-2.0 W/m2K for a wall of 300 mm.

Studies on rammed earth construction's ergonomic qualities have proven that high summer temperatures are always mitigated, ensuring a good summer thermal performance by passive means only, reducing the energy demands for HVAC.
During winter season, the buildings show a poorer performance, proving that heating is necessary.

Therefore, the only downside in using rammed earth, is its poor insulating properties in winter season during very low temperatures. An insulation using Foamglas on the interior face is necessary to satisfy regional regulations.

Fig.129. Exterior view of the project from the North-western podium strip end

THE ENVELOPE THAT SURROUNDS US SHOULD BE ABLE TO BREATHE AND DIFFUSE IN THE SAME WAY AS OUR BODIES.

- MARTIN RAUCH, THE RAUCH HOUSE: A MODEL OF ADVANCED EARTH ARCHITECTURE.

The afterlife of a community pedestal

Buildings and constructions, regardless of their materiality and construction methods, have a period of use and a lifetime. At the end of said period, either a refurbishment or a decapitation happens, resulting in a massive percentage of materials being dumped into landfills and contributing further to the climate crisis. It is thus imperative to find solutions, where the materials used and disposed of, do not weight on the environment and do not exode energy in the process of them being eliminated. Therefore, planning, analyzing, and projecting end-of-life scenarios can better the choices made during the conception and construction process. We start, by evaluating quantities and comparing material impact.

The configuration and material distribution of the project on site shows a rammed earth podium coverage of 7000 m2 and a concrete cores coverage of only around 460 m2.
In a total demolition and disposal scenario, the rammed earth walls will be 90% returned to the earth and recovered without any environmental impact, while the concrete cores will be landfill deposited.
The larger site coverage in earth and lower coverage in concrete warrants less punctual damage to the site surface. Steel beams, timber beams, and glass panels are easily demounted for further reuse or recycling.

To further understand the possible retaliations of the project's choices, we project ourselves towards two imagined but possible scenarios.

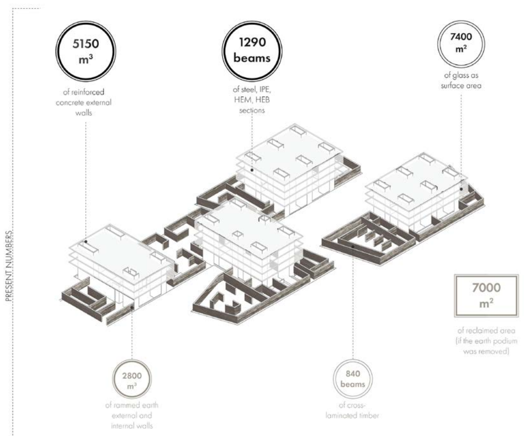


Fig. 127

The project in numbers

Most environmentally impactful:
5150 m3 of reinforced concrete external walls
1290 steel beams (HEM and HEB)
7400 m2 of glass covered area

Less environmentally impactful:
840 beams of laminated timber
2800 m3 of rammed earth walls

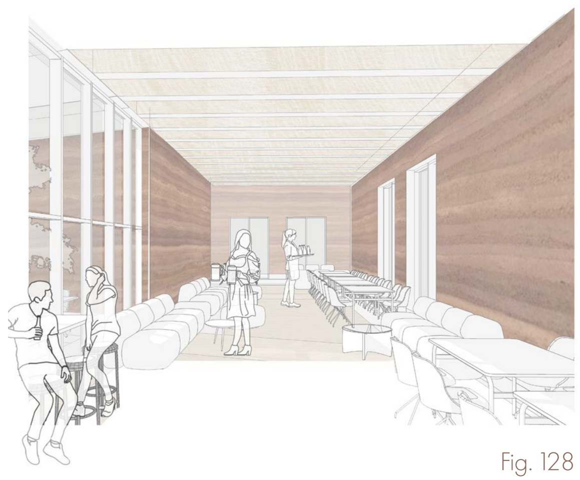


Fig. 128

Fig.127. Axonometry of the community center indicating numbers of structural elements

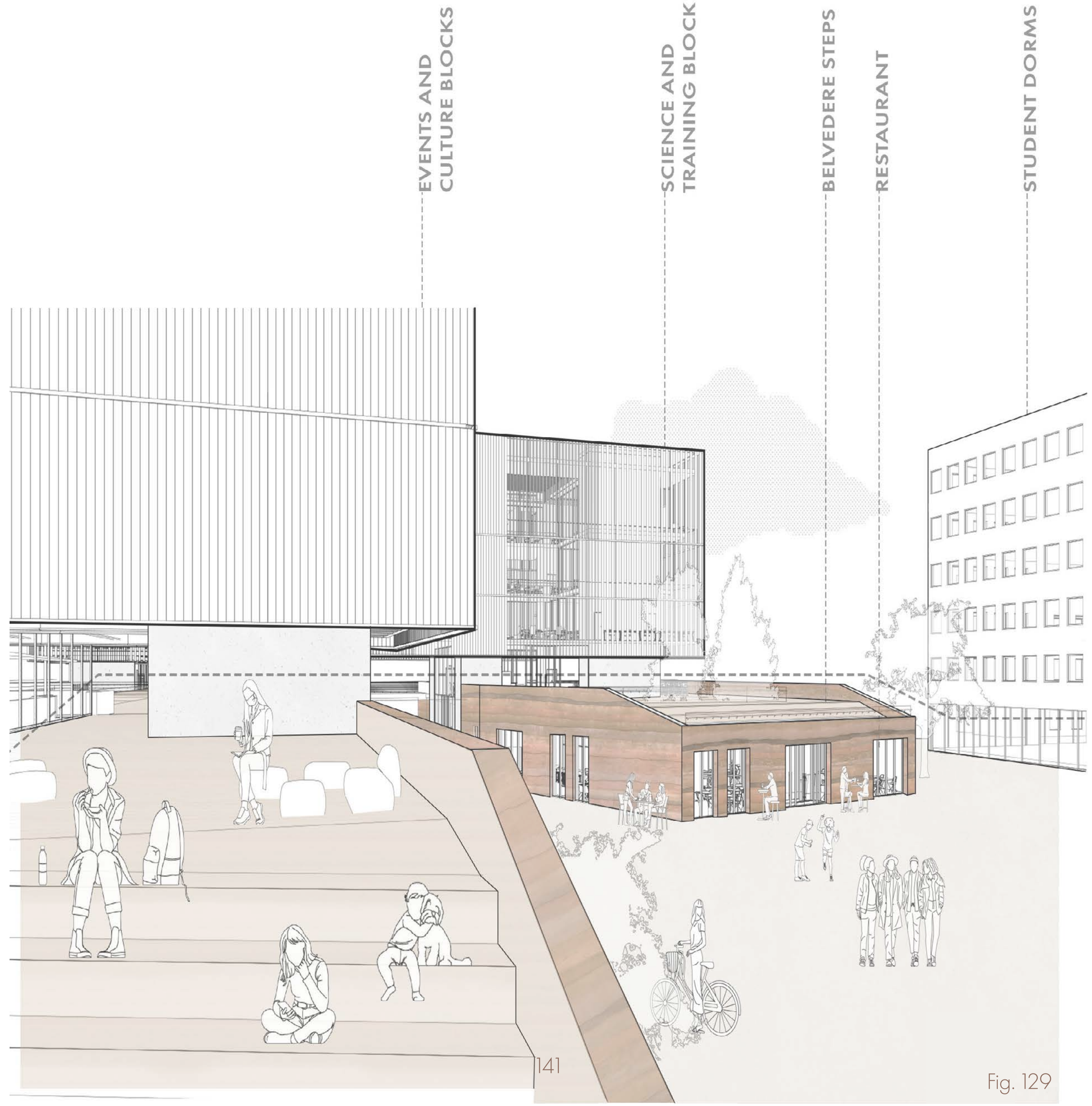


Fig. 129

A dystopian scenario where the rammed earth walls are disposed of and returned to the earth completely to make place for a densification in the form of concrete cores and steel and glass blocks.

Fig. 130

A utopian scenario where functions in the rammed earth podium are diminished and the walls are planted and transformed into a labyrinthic garden in consistency with the contextual parks and forests.

In both plots, the use of rammed earth proves itself as a prolific step in environmentally oriented strategies.

Fig. 131

The destruction and disposal which is almost completely waste free, can be done on site, reducing the transportation energy needs. No further impact is weighing on either the podium's removal or its decay into a landscape garden. It is safe to say that the lifetime and end-of-life of the rammed earth volume have highly positive impacts on socio-economy and the environment.

Fig.130. Axonometry of the project depicting a dystopian urban expansion

Fig.131. Axonometry of the project depicting a utopian reuse of the podium as a garden

AND IT'S IMPORTANT, YOU SEE, THAT YOU HONOUR THE MATERIAL YOU USE.

- LOUIS KAHN

"The project is intended as being a complete urban promenade, full of pleasant happenings that spark interest and participation in the user, prompting him to keep coming back and to be actively involved in the present community."

CHAPTER 5

A COMPLEX OF GLASS AND STEEL

5.1. Guidelines for adaptability

Between conneecting and animating
Case studies: from structure to envelope
Resulting schemes and guidelines

5.2. The Blocks: unique typologies

General analysis
Block A: Culture and events
Block B: Science and training
Block C: Media library
Block D: Fitness and wellness

5.3. Façade system design

Light-gathering lenses
Performance and practical details

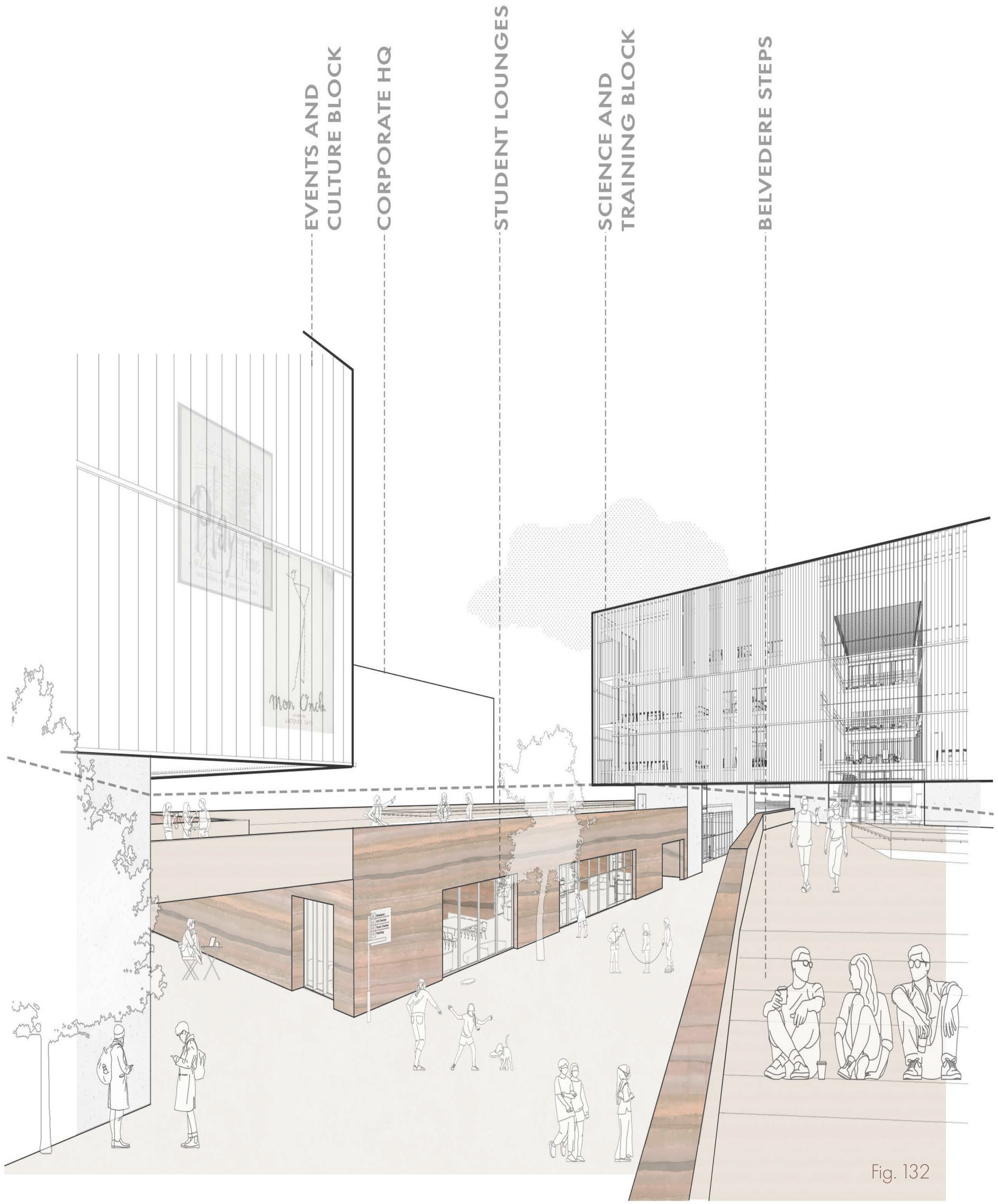


Fig. 132

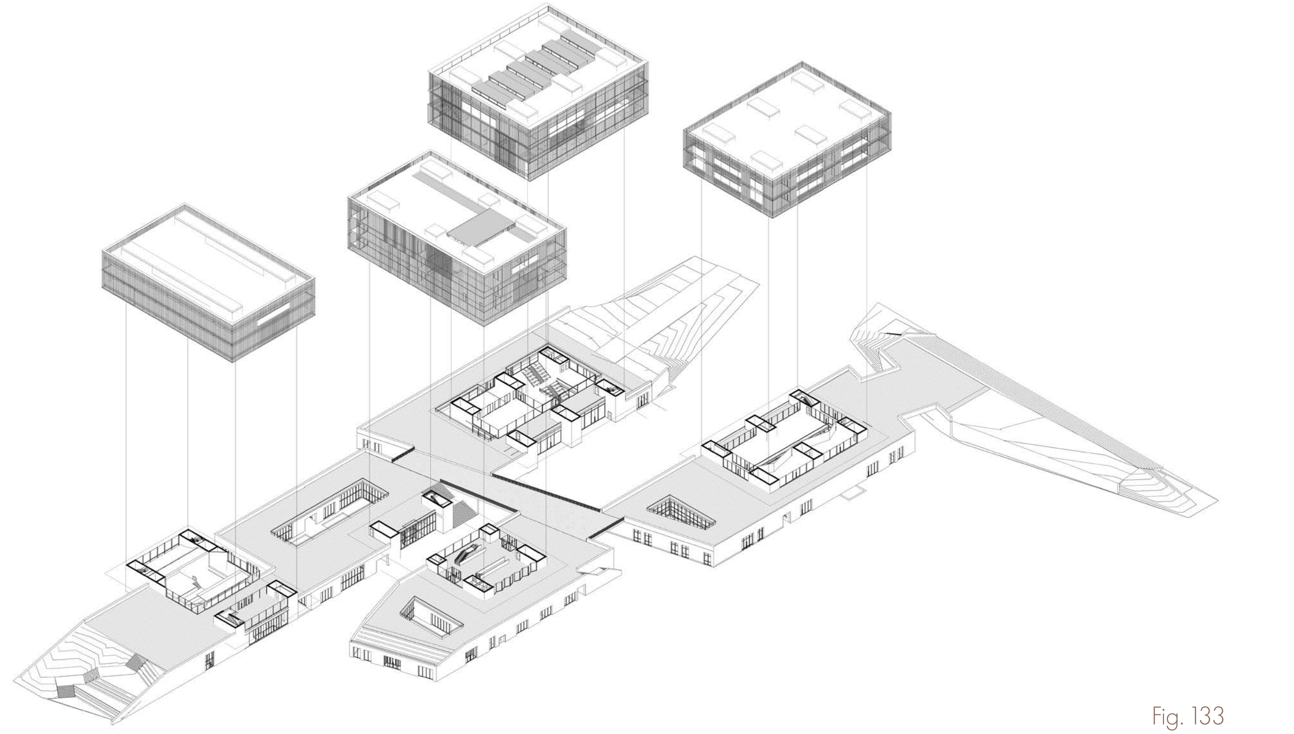


Fig. 133

5.1. Guidelines for adaptability

Between connecting and animating

As discussed in Chapter 3 of this thesis, the community center comprises of two very distinct parts: first, the podium made of rammed earth walls and timber slab, and second, the four monofunctional technological blocks puncturing its continuation.

Both entities function independently on the level of systems and circulation, and seem to have, at first glance, distinct atmospheric spirits. In this chapter, we delve into the interior typology of each block to understand the choices behind their situation, orientations, cladding, finishing, and spatiality.

The project is intended as being a complete urban promenade, full of pleasant happenings that spark interest and participation in the user, prompting him to keep coming back and to be actively involved in the present community.

These events, at times, are sowed along the promenade in the form of dedicated outdoor spaces such as exterior cinemas or playgrounds, and at other times, come in the form of programmatic interruptions where the technological blocks penetrate the earth forum and sprout upwards.

The hybrid multifunctionality of the project (see Chapter 3), is intensified through the insertion of

Fig.132. Exterior view of the project from the northern podium strip, overlooking Block B

Fig.133. Exploded axonometry of the community center

Fig. 134

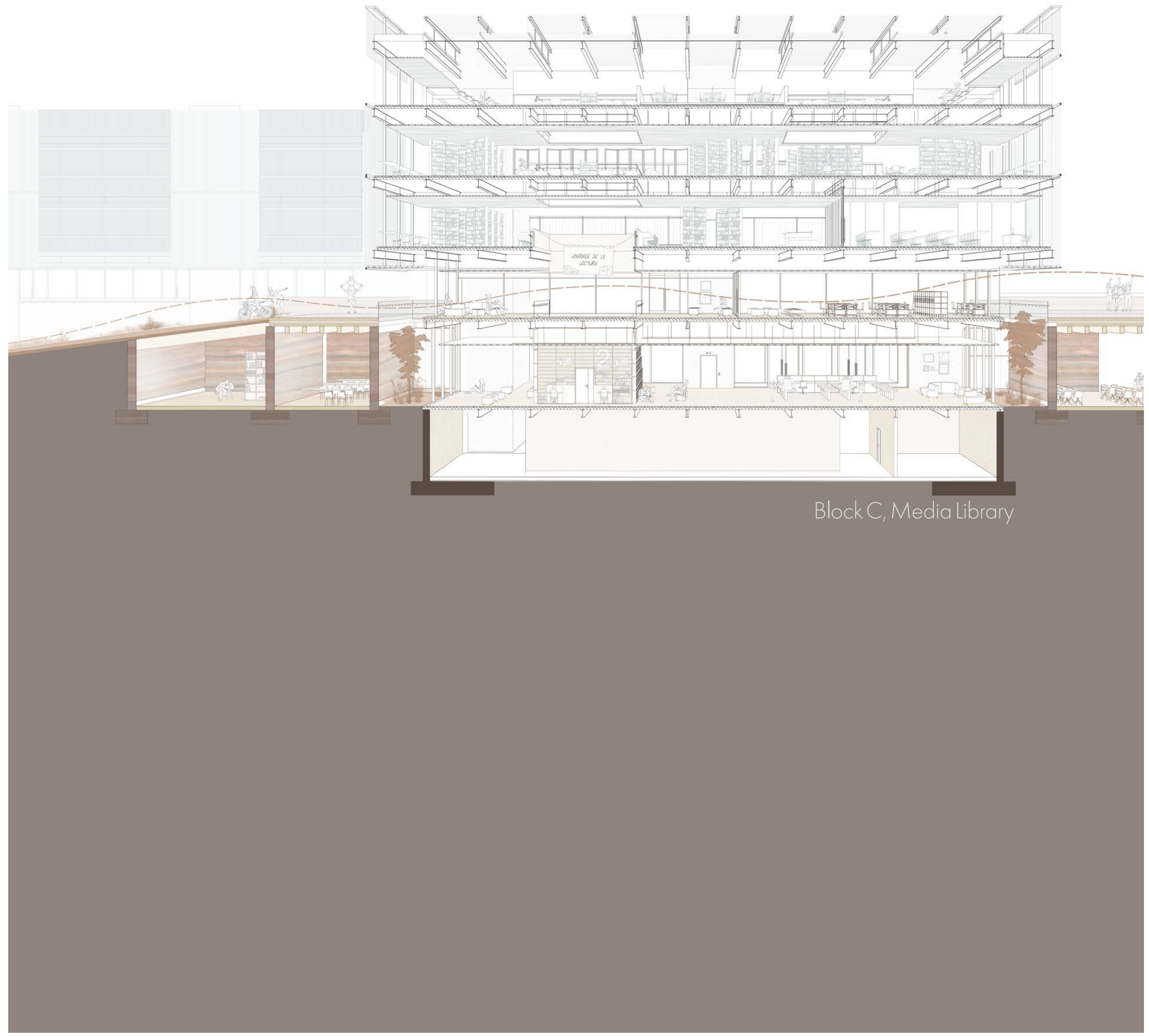
these "element of surprise" linking spaces.
Essentially, the community center is born with the construction of the four blocks. They are elevated from the ground floor on concrete cores, freeing the space between the ground and the second floor, making them able to accommodate the functions needed in an autonomous way. This space is crucial as a connection between podium and block.

Architecturally, the spaces are injected with an eye-catching function that serves as an attractor, buffer zone, and foyer between the blocks and the outside. Present at the base of each of the four volumes, they become a sort of repetitive zoning system that takes on different characters when in contact with different programs.

Eventually, passing through this transitional area, the user arrives inside each of the blocks and makes his way across the levels. Within, the trajectory becomes more guided and resolute, the visitor has a destination and purpose to achieve in regards of the functions presented in a specific volume.

Whether it is a desire for fitness, entertainment, education, research..., all utilities are at his disposition. The typology of each of the blocks is designed to drive him towards this purpose, while still giving the freedom to achieve it through his own mind and means.

Fig.134. GF +1 plan with emphasis on contact points between podium and blocks



Block C, Media Library

Fig. 135

Fig. 136

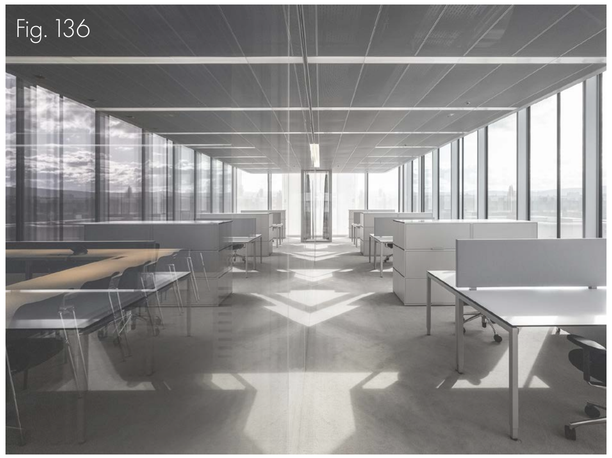


Fig. 137

Fig.135-137. Taniguchi building, Novartis campus, Basel, 2009

Case studies: from structure to envelope

To better understand and attain our desire for autonomous hybridization, we analyze some examples where similar programs and typologies have been employed.

Taniguchi Building, Novartis Campus, Basel, Yoshio Taniguchi, 2005-09

Described as a floating white cube, the project joins scientific laboratory facilities with contemporary office workplaces.

The program, in addition to the extensive need for technical equipment and services, mandated a flexible floor layout that allows adaptation to future requirements and technologies. This is achieved through the suspension of the glazed levels on four concrete cores, liberating the spaces between them.

Trusses on the top level hold the system together when combined with vertical tendons. This structural system creates at the bottom a space free of constraints and triggering the curiosity of the stroller.

Pure transparency and clearness of vision fill the spaces, creating a serene, objective environment for academic professionalism.

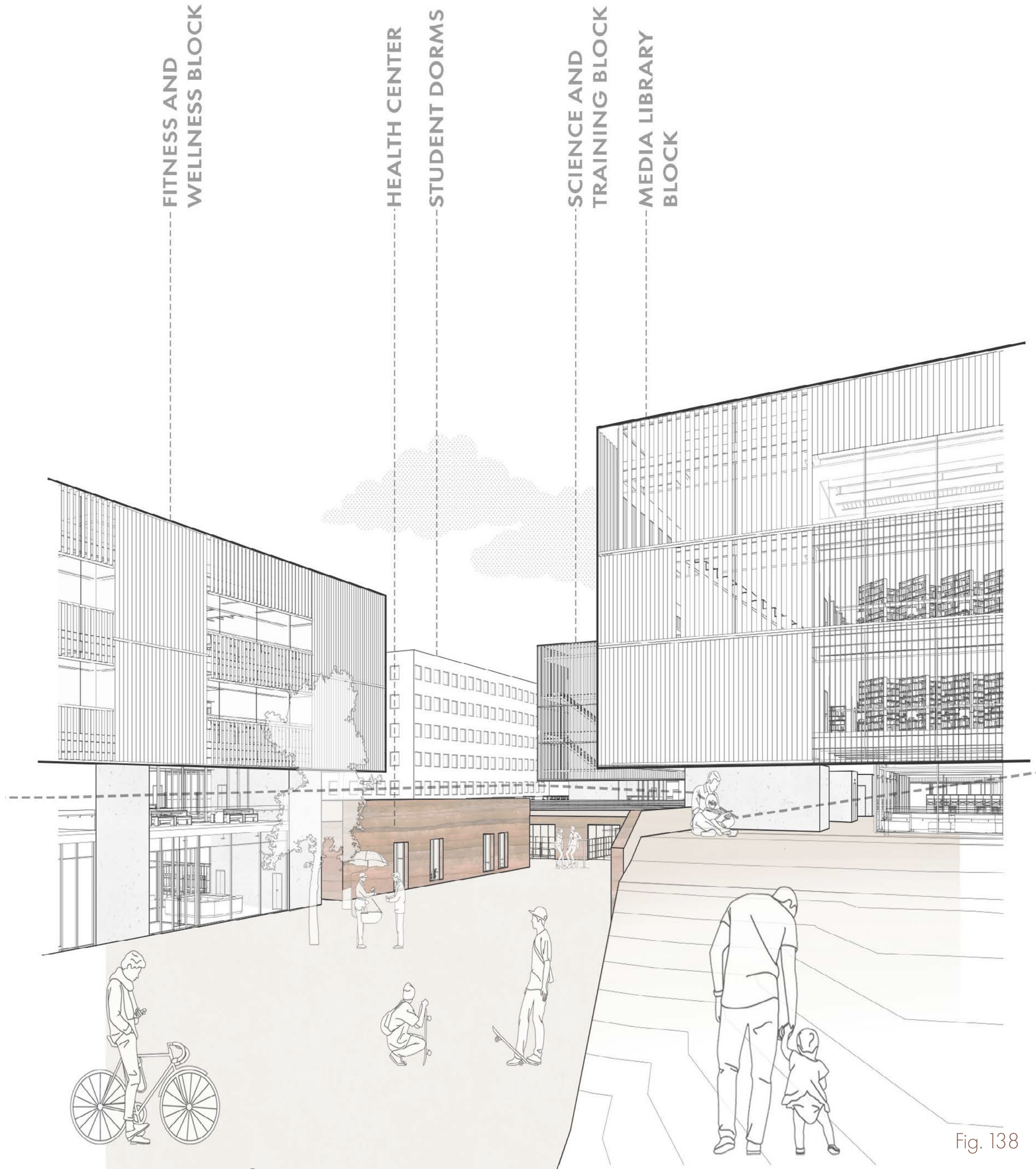
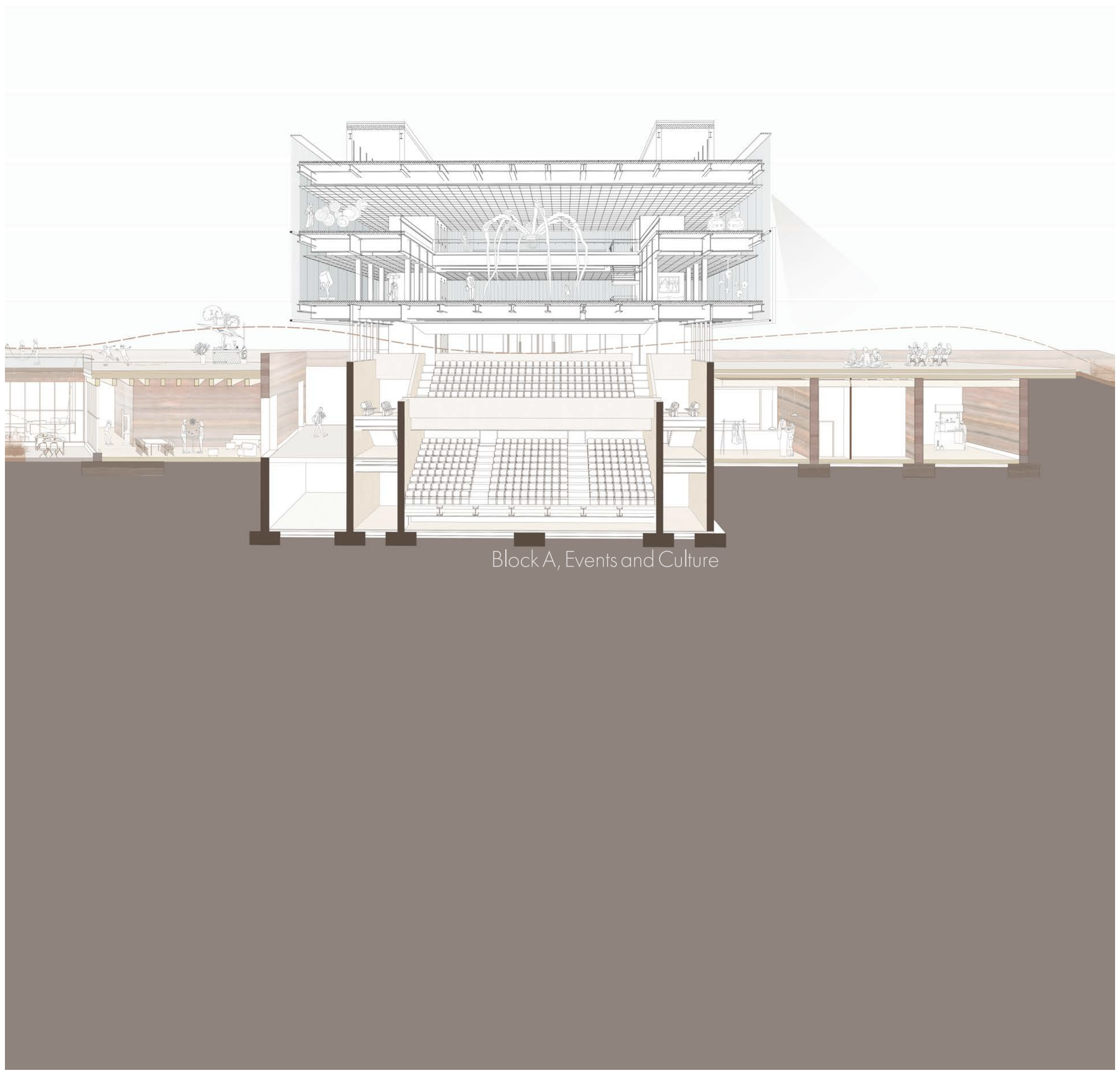


Fig. 138

Fig.138. Exterior view of the project from the North-eastern podium strip end



Visual Arts Building at the university of Iowa, USA, Steven Holl Architects, 2016

The art faculty is a composition of porous and deconstructed volumes, evoking the essence of cubism in art.

The architecture, in form and materiality, focuses on allowing visual and physical connections and crossovers between users to induce artistic behavior and creation.

To further inspire, special attention is given to the use of light. The facades are a collage of shifting plates, made of transparent glass, translucent glazed panels, and steel perforated meshes.

They modulate and moderate the natural sunlight intake in accordance with the functions behind them.


Fig. 139

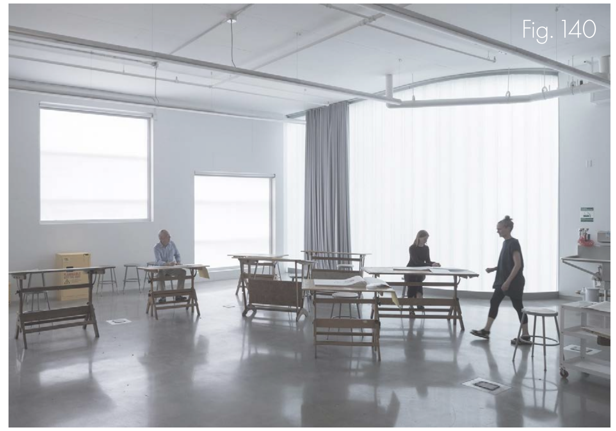


Fig. 140

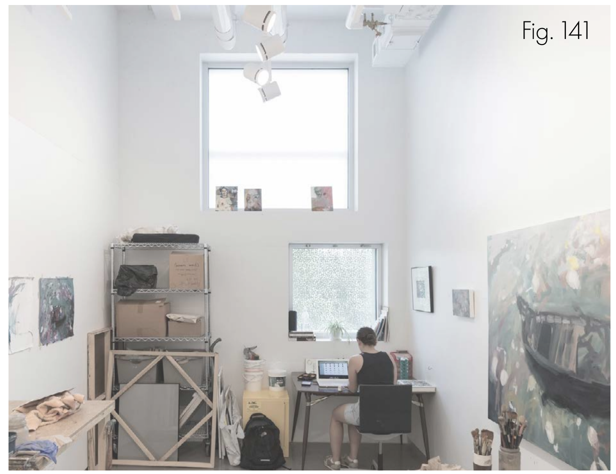


Fig. 141

Fig.139-141. Visual Arts Building at the university of Iowa, USA, Steven Holl Architects, 2016

Fig.142. GF+1 plan of the community center

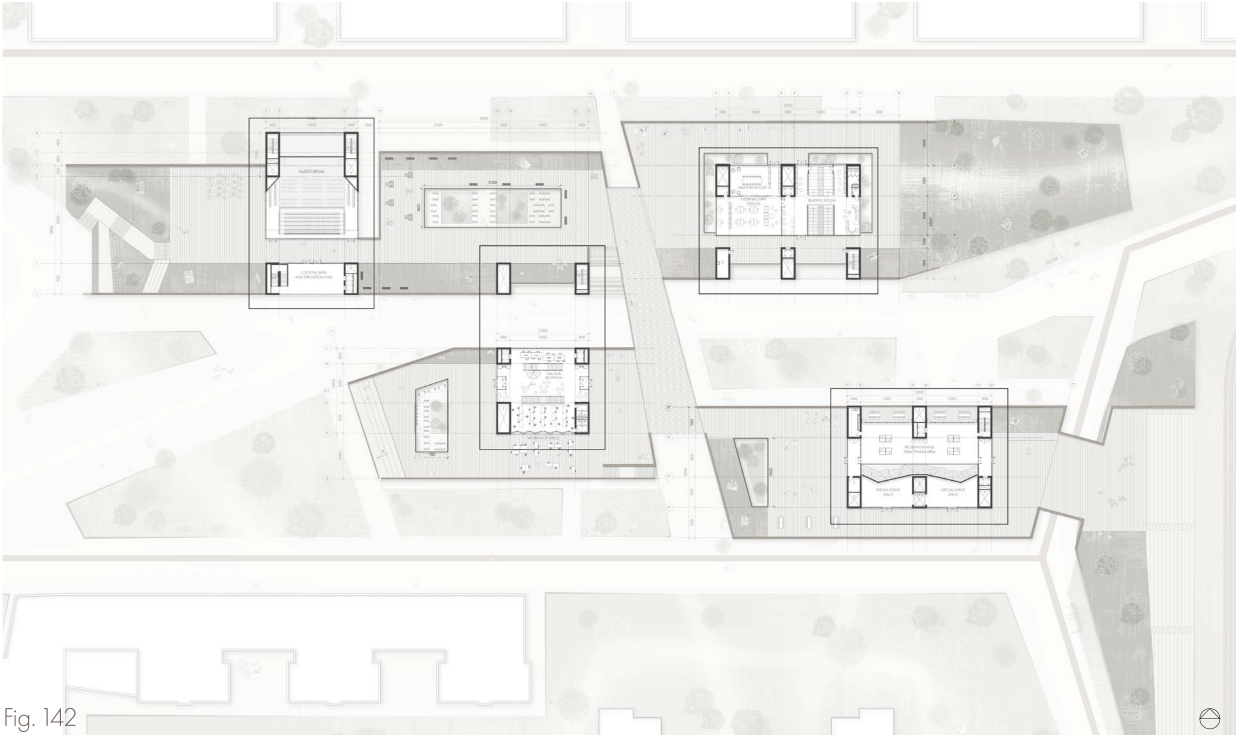


Fig. 142

Resulting Schemes and Guidelines

Our first aim was to adopt a structural scheme like the one in the Taniguchi building: a system that would allow a flexible yet coordinated interior for the blocks.

Our second aim, was to convey the interior functions to the exterior, subconsciously guiding the user, but also allowing a play with light that challenges transparency and opacity and serves the functions.

Consequently, the project blocks score a footprint of six concrete cores each, the only vertical connections to the ground, unto which the beams and slabs are connected.

We clad their facades with a double-glazed system of transparent glass as inner layer and U-glass units in different patterns and rotations as outer layer.

In each volume, between the cores and façades a world of educational or cultural nature unfolds in more personalized plans.

Fig.143. GF+2 plan of Block D: Fitness and Wellness. Scale 1:500

Fig.144. Distribution of spaces in accordance with privacy level in GF+2 plan of Block D

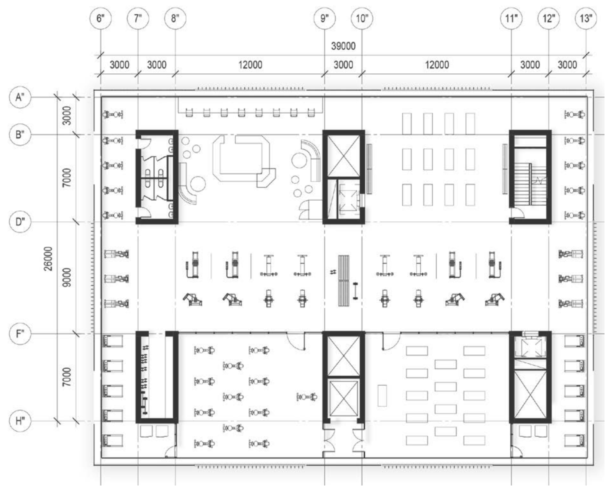


Fig. 143

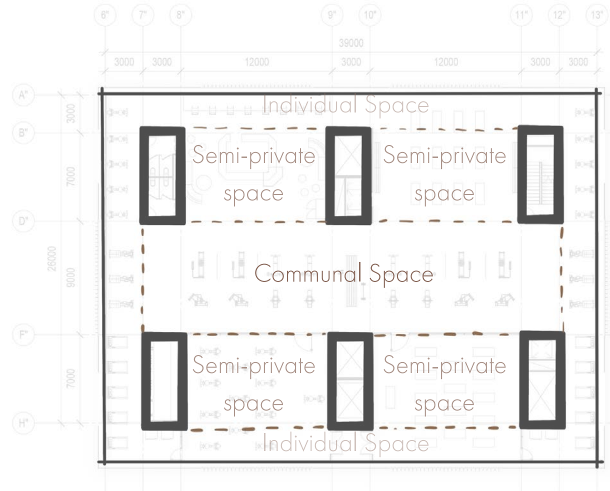


Fig. 144

5.2. The blocks: unique typologies

General analysis

By isolating a typical plan of a block, for instance the second level of the Fitness and Wellness center (figure 1), we can analyze the cause-and-effect relationship between the building and the construction system.

The desire to induce and maximize social interactions in the community center influences and directs the conception of space and, effectively, the development of the construction principle.

When it comes to the spatial organization, we have a plethora of hybrid spaces where communication and sharing happen. Varying in size, these spaces connect differently between each other and with the outside. The concrete cores and their disposition help provide zones with differing degrees of transparency and privacy.

The hollow vertical structures are conceived as programmatic spaces: they are used for vertical circulation, situation of HVAC units and ducts, water supply...
Moreover, being the only opaque barriers in the volume, their disposition proves prominent in providing a central communal agora where most socialization happen, and in providing in-between spaces where the user's individuality is expressed and respected.

Fig.145. Diagrammatic Hypostyle plan of the hypostyle hall at Persepolis

Fig.146. Diagrammatic Basilica plan, Basilica of Maxentius, Rome

Fig. 145 Hypostyle Plan

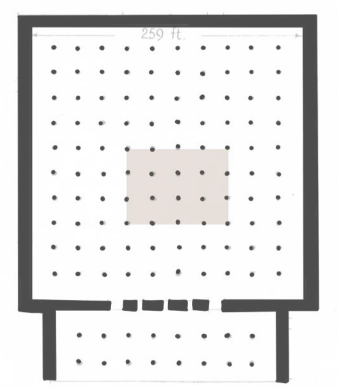


Fig. 146 Basilica Plan

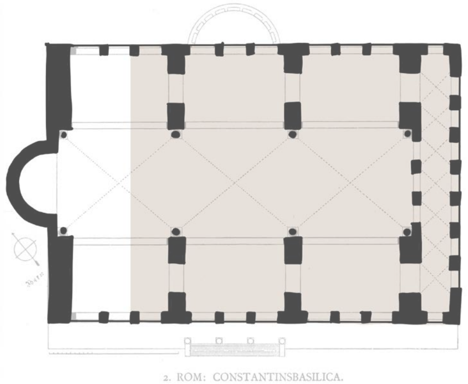
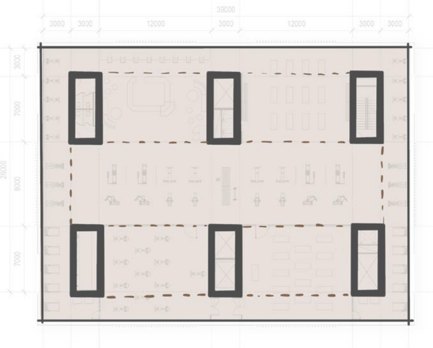


Fig. 147 Block D Plan



In addition, the type of distribution system can be described as presenting a coincidence and overlapping between the inhabited spaces and circulation system.

The distribution scheme melts, in part, into the work and leisure spaces. Each block maintains a defined unique entrance: the autonomous freed space between ground floor and glass box, that intensifies the relationship between interior and exterior.

Effectively, to analyze its architectural type, the plan can be brought to a recognizable form when compared with a hypostyle or basilica plan.

The cores and spaces are repetitive and recurring, not only on the scale of one block's plan but also on the scale of the complete project plan.

The monumental, temple-like style configuration establishes logical connections between the parts. These connections unite the spatial, technical, structural, and linguistic elements.

Therefore, the project can be considered to sprout from a logical-syntactic type that transformed and varied when put in contact with the urban, social, cultural, and economic needs of the context.

Fig.147. Diagrammatic GF+2 plan of Block D: Fitness and Wellness. Scale 1:500

Fig.148. Exterior view of the project from the South-eastern podium strip end

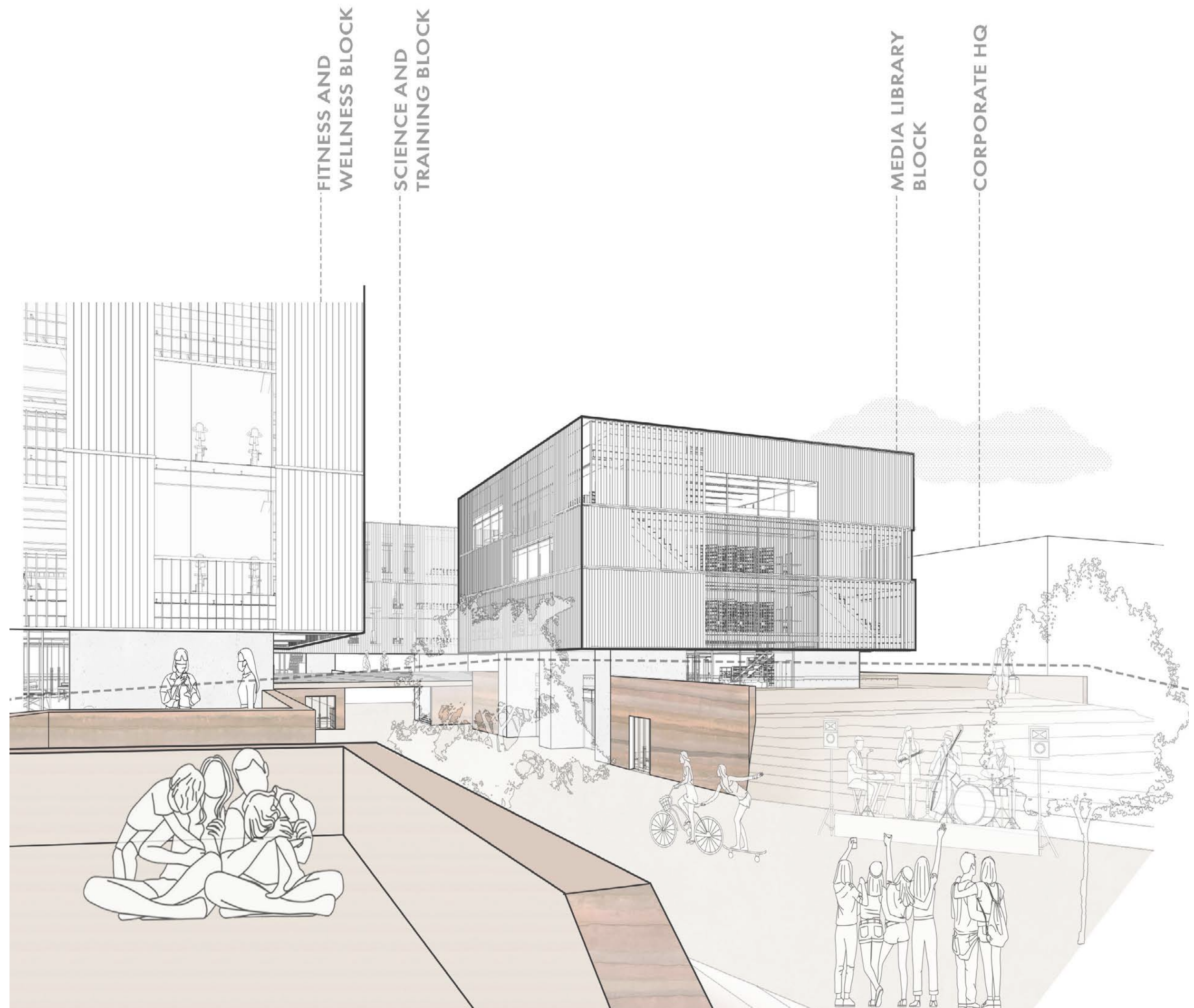
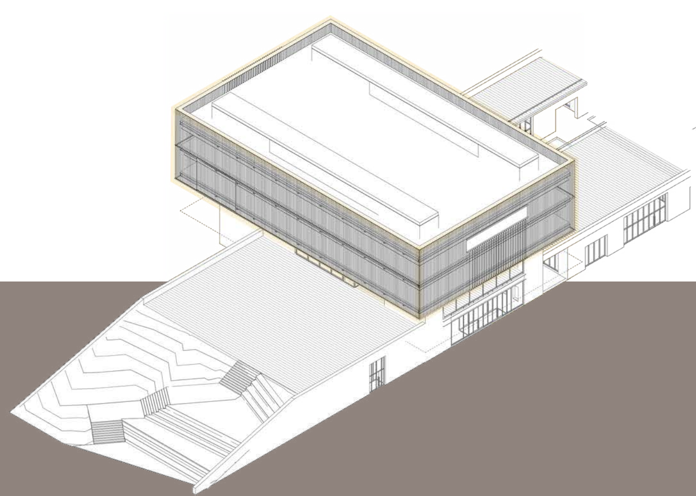


Fig. 148

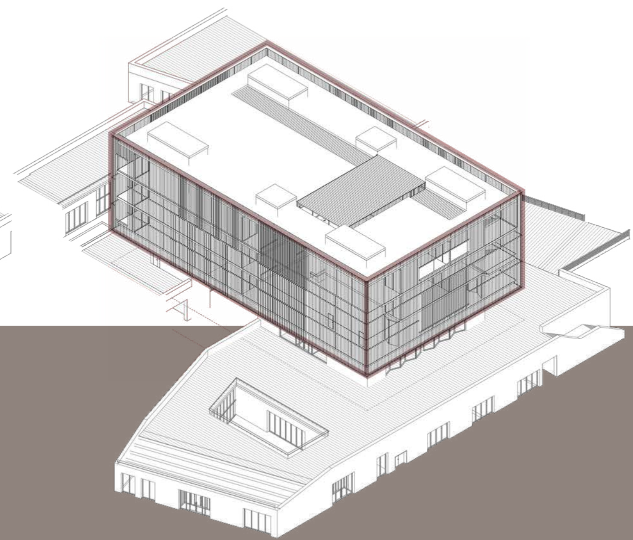
BLOCK A



Events and Culture

4 Floors
27 x 43 m
4600 m^2

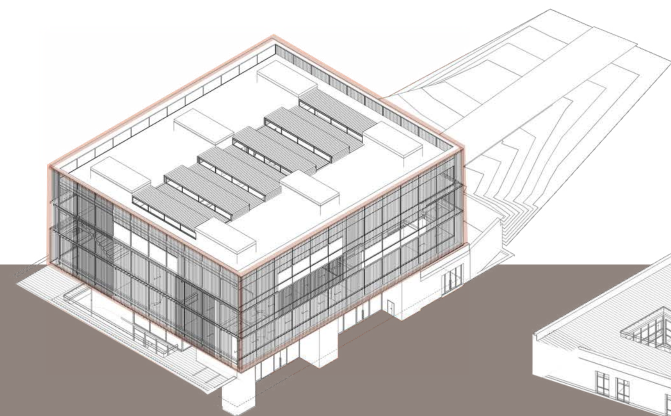
BLOCK B



Science and Training

5 Floors
27 x 45 m
6100 m^2

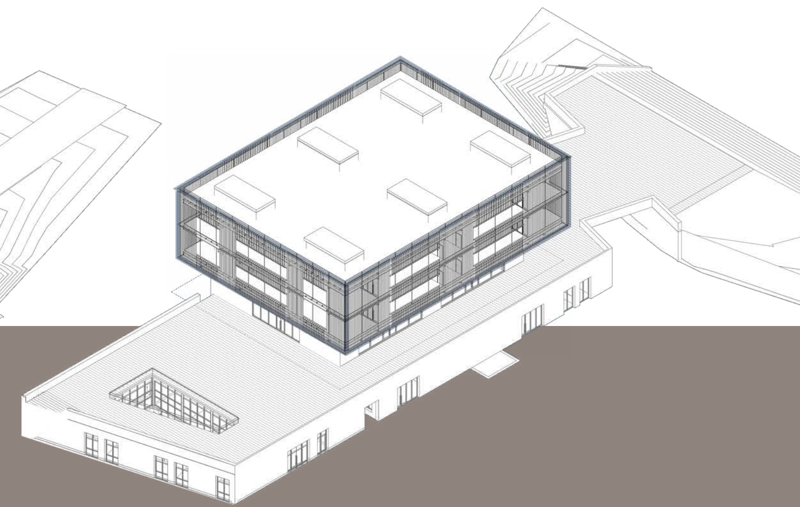
BLOCK C



Media Library

5 Floors
39 x 32 m
6200 m^2

BLOCK D



Fitness and Wellness

4 Floors
39 x 29 m
4500 m^2

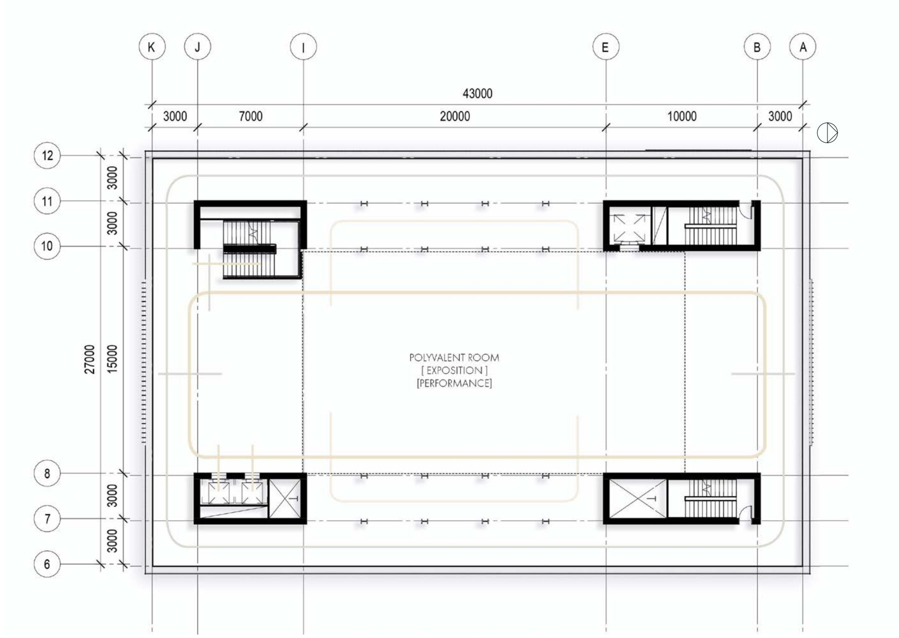


Fig. 149

Fig. 150

Fig.149. GF+2 of Block A: Events and Culture. Scale 1:500

Fig.150. Sectioned axonometry of Block A: Events and Culture

Block A: Events and Culture

Welcoming the most brilliant artistic events in the region, the Cultural Center is conceived for the people and the city.
It embraces the fundamental notion that an exhibition hall could both display culture and serve as a stage for the community. Its modernist open-floor plan radically redefines the hierarchies between works of art and releases visitors into an unmediated field of experiences.

Unconventionally open to the urban and natural interfaces, a triple-height auditorium constitutes the foundation of this building.
As the stroller crosses the green-terrasse on the first level, his attention is taken by the hall that spreads inside a glass volume.

When looking from the inside, the view is uninterrupted and a strong connection to the outside is achieved. Open to the public, it is the most spectacular and intriguing space positioned on the intersection between the upper block and the earth forum.

On the first level, and in front of the auditorium, we find a cocktail area that can be opened to the public on a day of performance, creating a strong connection between the great hall, the people, and the city.
This continuous level separates the base from the top box, which houses a double-heighted multifunctional space. It occupies the upper block on the second and third level where the structural choices permitted a large volume of a 15x26m-imprint.

The inner space offers many opportunities: from performances to exhibitions or even sporting events... it is a multipurpose room. This was made possible by the scheme of only four concrete cores and the addition of Vierendeel trusses spanning twenty meters between them.

Coordinated with standard steel beams and a composite slab, they take on the full height of one level (4meters), supporting the floor of the second story in addition to a broad corniche-like walkway on the third level. Smaller Vierendeel trusses of two meters high hold the roof level with all its finishings and technical equipment.

Following a technology common with the other blocks, the envelope of the higher block has two layers, a transparent glass wall on the inside and a profiled glass wall on the outside.

This permits the exhibition or event space to be entirely immersed in beautifully diffused natural light. This barrier also becomes a canvas where the city can exhibit the art that makes it most proud. From illustrations to posters, it can also function as a projection screen, serving as a stage and communicating with the urban life that is yet to flourish within the community center and the district.

Fig.151. Interior view and ambience of the Block A auditorium

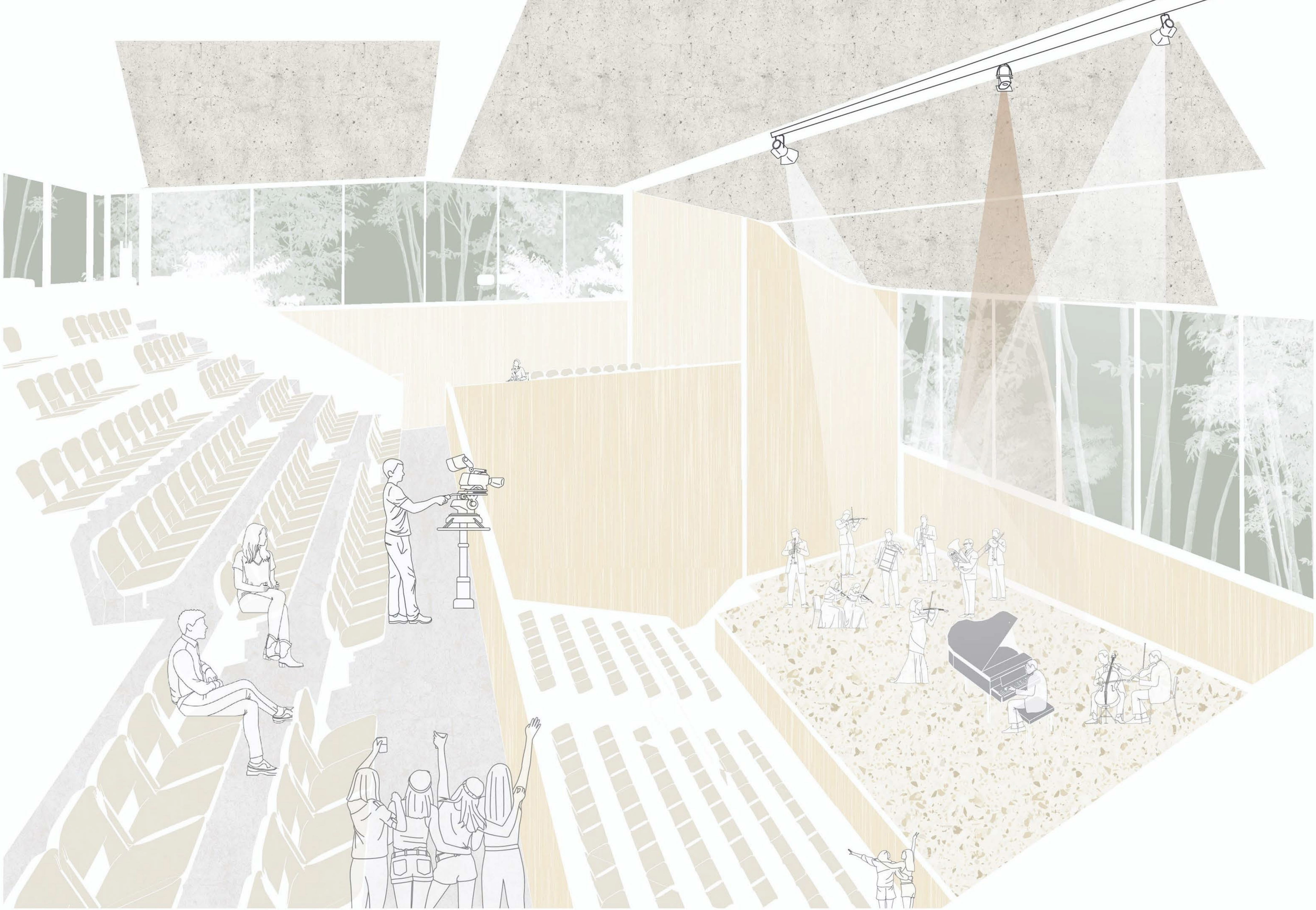


Fig. 151

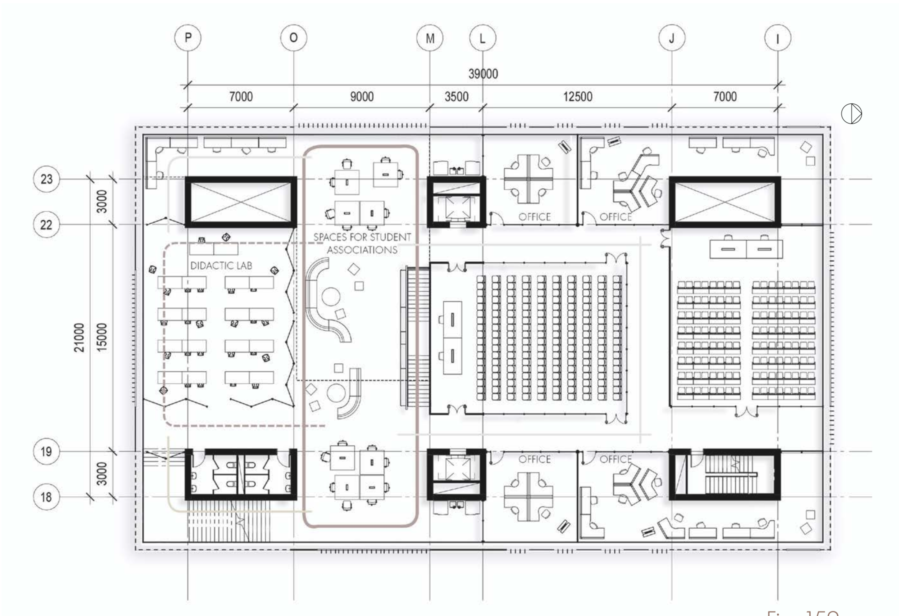


Fig. 152

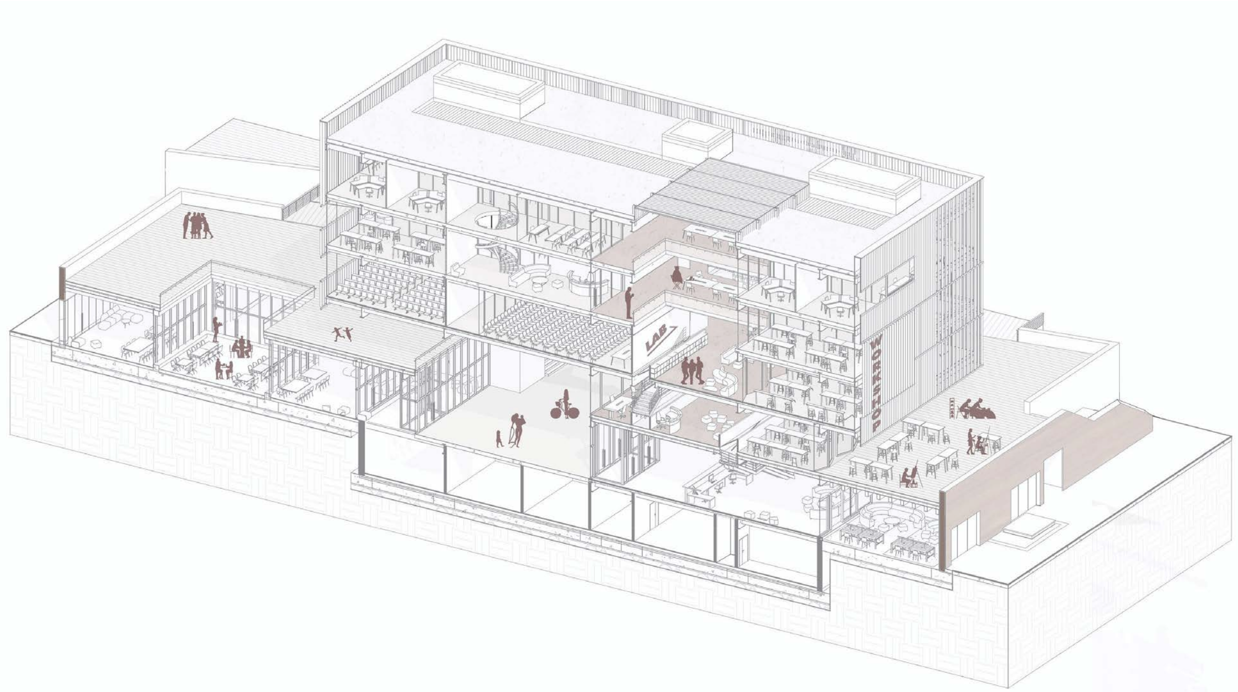


Fig. 153

Fig.152. GF+2 of Block B: Science and Training. Scale 1:500

Fig.153. Sectioned axonometry of Block B: Science and Training

Block B: Science and Training

Literally bridging gaps between users and disciplines, the Learning Center is meant to seize the imagination of students, scholars and those involved in the pursuit of innovation.

Located at the focal point for access, the building exhibits a sense of arrival and forms an inviting interface to the public by hosting lectures and other events.

Engaging the surroundings, this block is all about the importance of interdisciplinary learning. Physically joining the two communal strips of the first level, it is also inspiring intellectual exchange within the scientific community.

The spatial organization allows crosspollination between the users, demonstrated by an open working space that flourishes on all levels, in various shapes, sizes, and heights.

Visual connection with the upper floors is achieved through a triple-height space immersed in zenithal light, and through the wide corridors that also double as working areas between the rooms.
A wide range of proportionated spaces is envisioned in order to accommodate functions with diverse natures of learning and groups of people.

This substantial, shared working space benefits from an excellent location spanning over the main pedestrian central strip and allowing controlled views on all sides.

When experiencing the building, the visitor crosses a number of lounges on the ground floor, then, a polyvalent laboratory on the first level. This lab can additionally host public workshops on the green-terrasse and can open and extended to participate in the urban sequence along the promenade. Upwards, the visitor arrives to the free-plan working place submerged in light and facing the public square and the central pedestrian strip of events.

The six RC cores of assorted proportions that support this building, house various sizes of opaque rooms. Along the plans, we find spaces ranging from big classrooms to smaller individual units, this proves the flexibility of the implemented structural system in fulfilling the needs of a disparate community.

Fig.154. Interior view and ambience of the Block B common space

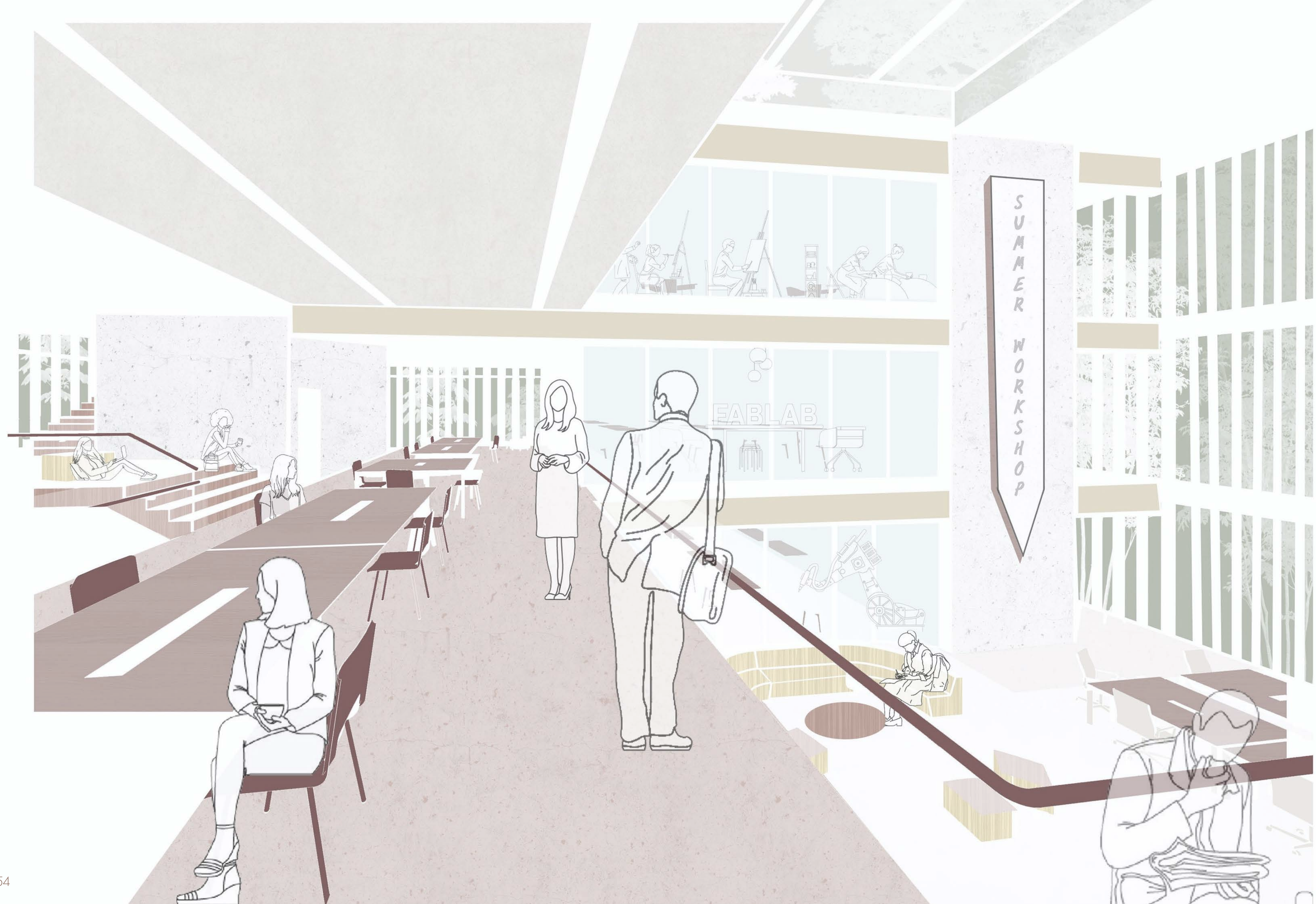


Fig. 154

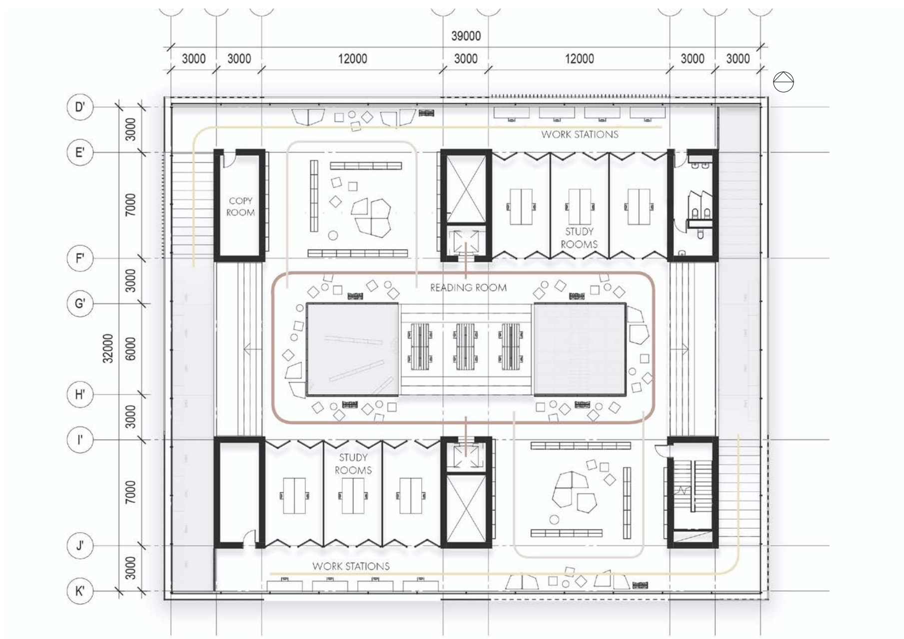


Fig. 155

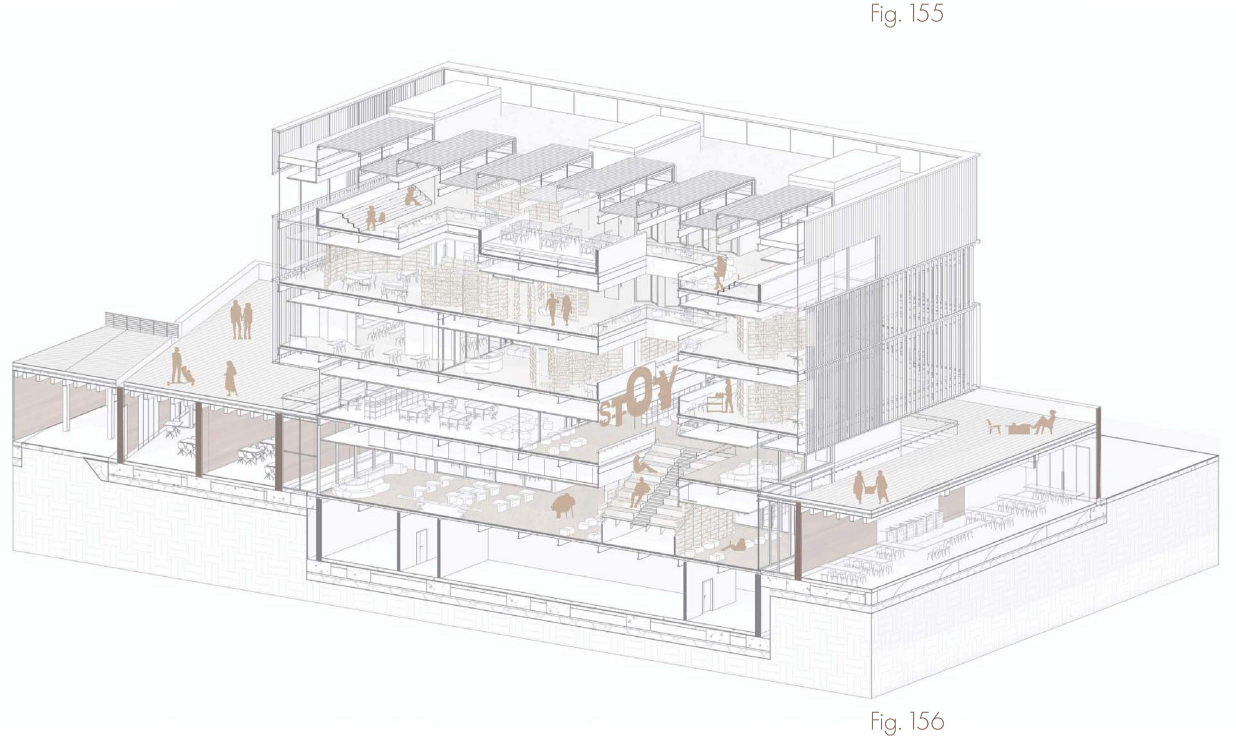


Fig. 156

Fig.155. GF+2 of Block C: Media Library. Scale 1:500

Fig.156. Sectioned axonometry of Block C: Media Library

Block C: Media Library

A gateway to knowledge and culture, the new media library is a rich repository of historically and culturally significant collections.

The resources and services it offers help shape new ideas and perspectives that are central to the development of the science and technology cluster of Paris-Saclay.

A storytelling lingers as you enter its doors lending you the freedom to choose the role you'd like to play. As you progress, the unfolding of the outer envelope accentuates the library's relation to the surrounding landscape. There is no definite reading of the space; the perception one has of it reveals a complexity, an unexpected richness, and a strong connection to the outside.

A prolonged reading room takes the visitor from the entrance to the top glass roof, sprawling on all the levels, taking different shapes, always connecting and joining the spaces together.

On the ground level, a small garden surrounds the block separating it from the podium. There, a large space is devoted for archives with a calm area for researchers and professionals that stimulates good thoughts and academic intelligence. A set of wide monumental stairs pierces and connects the first two floors, constituting a major space for reading and for social and cultural exchange.

The configuration of the six cores separated from the façade with a 3m-gap permits diverse levels of privacy: from a general, public learning zone to an intimate reading spot, the user is offered many options, depending on the purpose of his visit. Between these cores, flexible rooms have the possibility to merge or separate according to the number of people and the use type.

At the edge, the building enjoys interesting connections with the nature outside. Therefore, the choice of locating wide stairs in the interstitial space between the core and the façade allows to have a dynamic meeting place with maximum interfaces.

In the last level, the user can experience a sort of detachment from the outer world as he finds himself floating in a bright area with an interesting complexity and quality. The top level is partly separated from the façade benefiting from a higher level of intimacy within various offered platforms that follow the deconstructed glass roof.

If you're either studying for an exam with friends by sharing a table in the big open space, enjoying a book in tranquility on a set of stairs that overlooks the forestry, or researching in silence between earthen walls and green courtyards, you'll find that the Paris-Saclay Media Library has a lot to offer.

Fig.157. Interior view and ambience of a Block C reading room

Fig. 157

Fig. 158

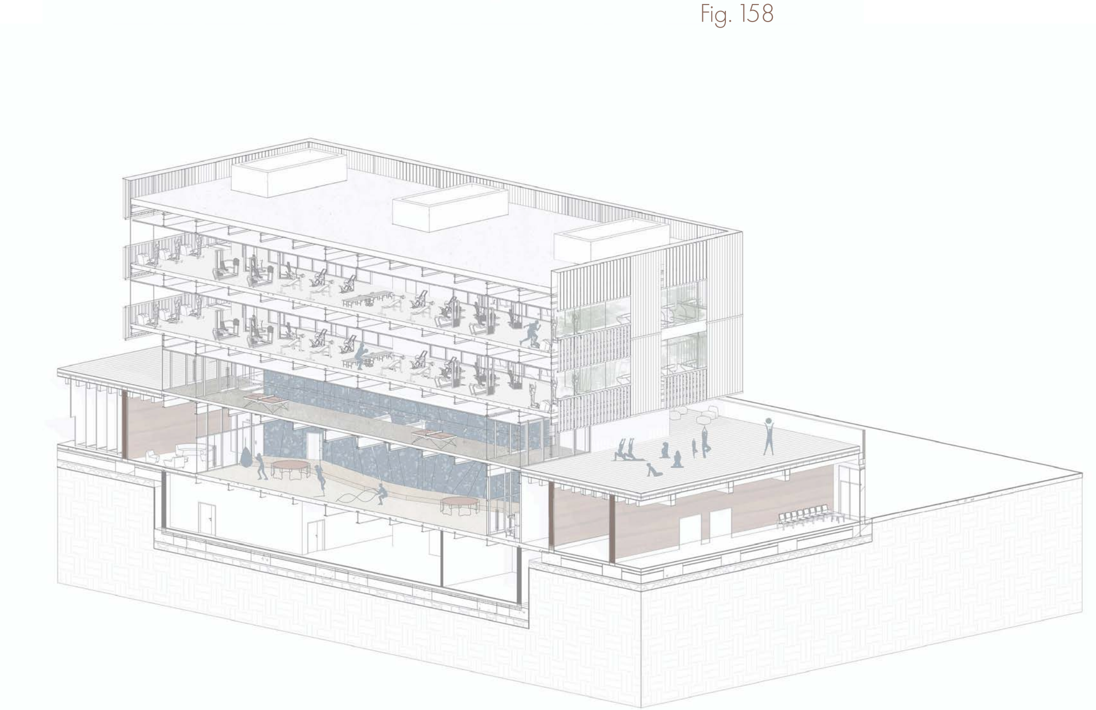


Fig. 159

Fig.158. GF+2 of Block D: Fitness and Wellness. Scale 1:500

Fig.159. Sectioned axonometry of Block D: Fitness and Wellness

Block D: Fitness and Wellness

As sports and physical activities already predominate the eastern sector of the area, this center was designed and situated to further foster a culture of sustainability, healthy lifestyle, and fitness.

Unifying wellness and recreation under one roof, is in the best interest of the society's long-term comfort. This strategy will help students and locals realize their greatest potential and achieve lifelong wellness, ultimately ameliorating the overall health of the community.

At the point of intersection between the block and the podium is a two-level area welcoming physical activities with a large climbing wall connecting the ground level to the first. There, a crossing platform allows the stroller, jogger or visitor to experience the energy that characterizes the eastern sector. This stimulates the people and fosters a wellbeing among the community.

This building will be crossed by people on a daily basis. They will enjoy its vivacity culminating in a set of stairs that gives access to the Honour Stadium. From there, one can enjoy some sporting events or continue working out.

The top box is a two-leveled gym relishing the view from the four different sides. One can enjoy the view while running on the treadmill making this a wonderful stimulating experience. The six cores allow a flexible spatial organization following the numerous categories of workouts – cardio, stretching, weightlifting... - they also delimit rooms for group classes.

The functions in the podium complete the vocation of the building with a health centre, a pharmacy and rooms that serve the decent functioning of the gym as a center dedicated to rest and welfare (showers, lockers, washing rooms, storages...).

Fig.160. Interior view and ambience of Block D 's hall

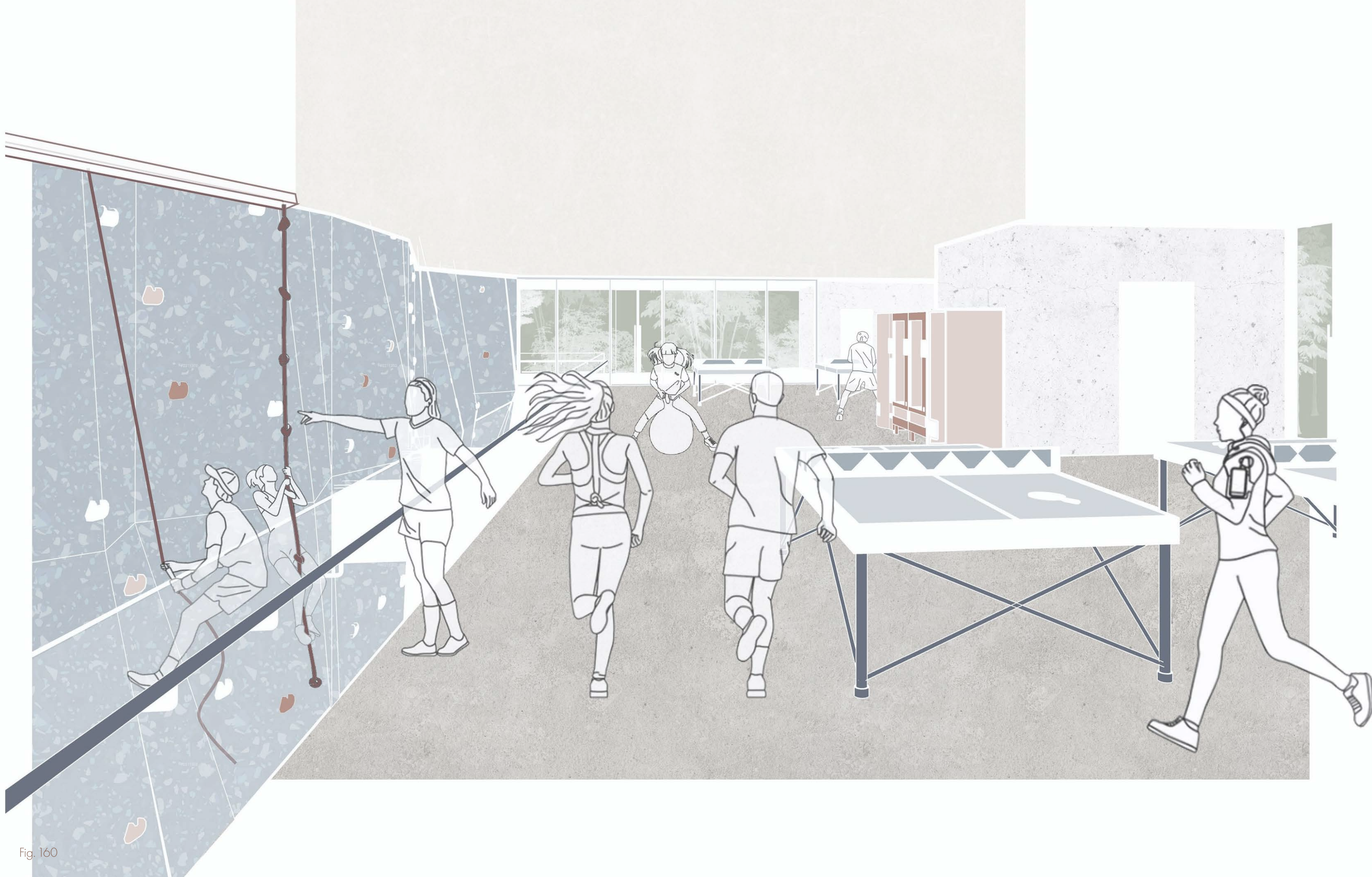


Fig. 160

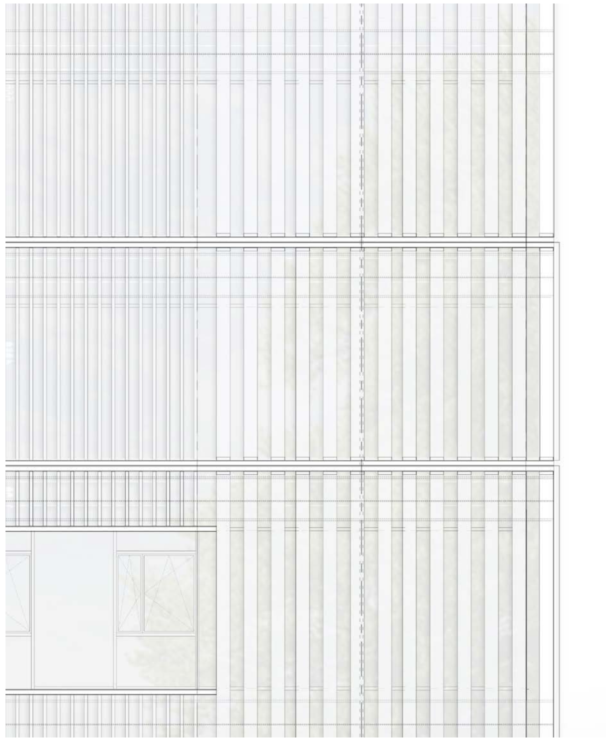


Fig. 161

Fig. 162

5.3. Façade system design

Light-gathering lenses

With all the differences that distinguish the blocks and the podium, these two components ought to share some common grounds in order to harmonize and unify the whole. Even with such disparate structural systems and distinct materials and construction methods, both parts fall under the same authentic, raw, and straightforward principles.

The envelope of the upper blocks speaks for itself. With a modern but unsophisticated look, it employs conventional materials and techniques to form what is now quite widespread under the environmental obligations: the double façade.

alternated with gaps of the same length allowing a balanced light and relation with the context, or a full glass wall still permitting a diffused light to penetrate but concealing the view with the surroundings.

Performance and practical details

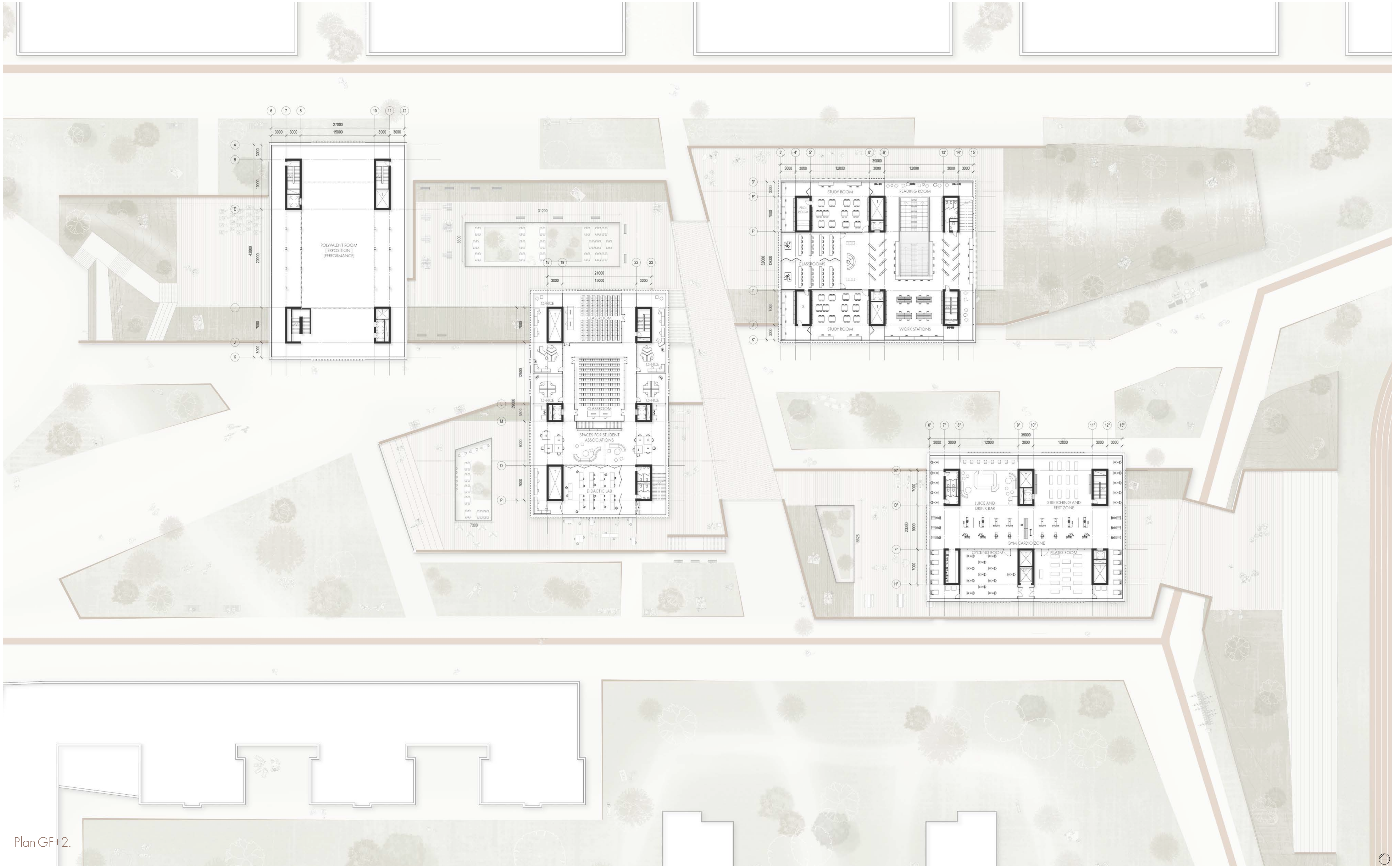
With the ecological requirements of today, a careful selection of sustainable materials as first step is becoming a necessity, with the challenge of creating a unique and pleasant architectural esthetic.
This is one of the reasons why channel or profiled glass features prominently in new constructions. Its linear, translucent appearance creates a signature esthetic.

Fig.161. Rendered Facade detail

Fig.162. Translucent U-Glass facade

Fig. 163

Fig.163. Block A South Facade. Scale 1:200



POLYVALENT ROOM
[EXPOSITION]
[PERFORMANCE]
STUDY ROOM
READING ROOM
CLASSROOMS
STUDY ROOM
WORK STATIONS
OFFICE
CLASSROOM
SPACES FOR STUDENT ASSOCIATIONS
DIDACTIC LAB
JUICE AND DRINK BAR
STRETCHING AND REST ZONE
GYM CARDIO ZONE
CYCLING ROOM
PILATES ROOM

Plan GF+2.

Fig. 164

Fig.164. Block B West Facade. Scale 1:200


Fig. 165

Profiled glass is a sustainable solution going beyond its eco-friendly manufacturing. It provides a robust layer of protection to the building for decades to come. The durable glass envelope reaches continuous vertical spans of up to 7 m (depending on the producer), and features glass-to-glass corners in a variety of angles. Since it is a resilient material, its use can extend to cover both interior and exterior applications.

For exterior use, it's typically installed in a double-glazed configuration, with one interior facing and one exterior facing channel. Many of the standard limitations of plate glass regarding size and span capabilities don't apply to channel glass, because of the structural qualities.

Because of its manufacturing process, translucent channel glass provides interiors with an evenly diffused light without shadows or hotspots.

Special treatments on the glass on the exterior walls inhibit the transmission of damaging UV rays to the interior spaces and ensure an evenly diffused white light naturally illuminating the spaces. This type of glare free, diffused natural light is an excellent fit for many uses.

In fact, the day lighting properties of profiled glass were one of the main reasons it was selected by **Steven Holl** for the **Nelson-Atkins Museum of Art.**

Fig.165. Nelson-Atkins Museum of Art by Steven Holl

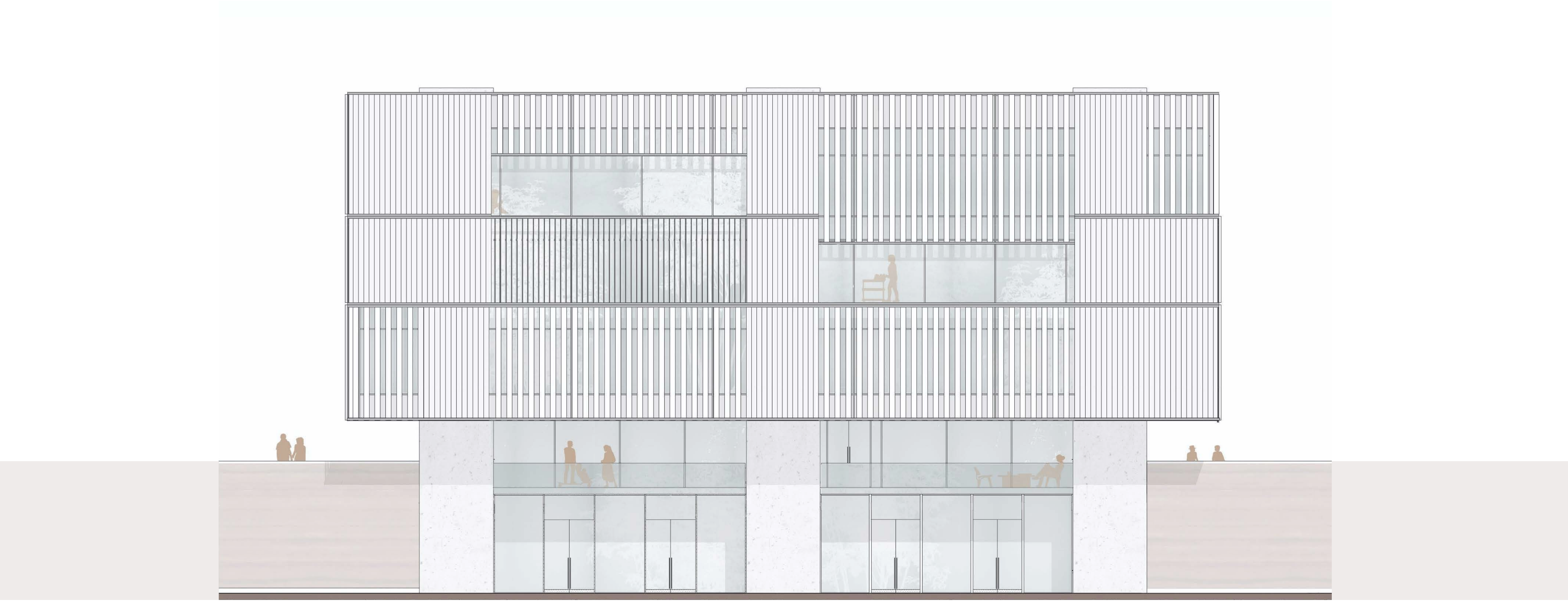


Fig. 166

Fig.166. Block C South Facade. Scale 1:200

In the aforementioned project, the glass channels reach continuous heights up to 7 meters while the U-shape of the tiles lends strength to the glass, allowing it to create relatively lightweight facades of grand proportions, with minimal horizontal framing and virtually no visible vertical framing.
During the day, the channel glass fills the interior with diffused natural light, while at night the insulated, sandblasted glass structures glow from within like lanterns.
Sandblasting and a translucent white insulation material, inserted in the cavity of the double-glazed channel glass wall, create structures that react with light for an ever-changing appearance. When daylight hits, they can appear solid and brilliant white or blend into the sky.

The glass is continuously reacting with the light to create unpredictable phenomena: diffusion, diffraction, refraction, reflection, and absorption, creating a myriad of kinetic visual effects.


Fig. 167


Fig. 168


Fig. 169

Fig.167-169. Nelson-Atkins Museum of Art by Steven Holl

Fig.170. Nelson-Atkins Museum of Art by Steven Holl


Fig. 170

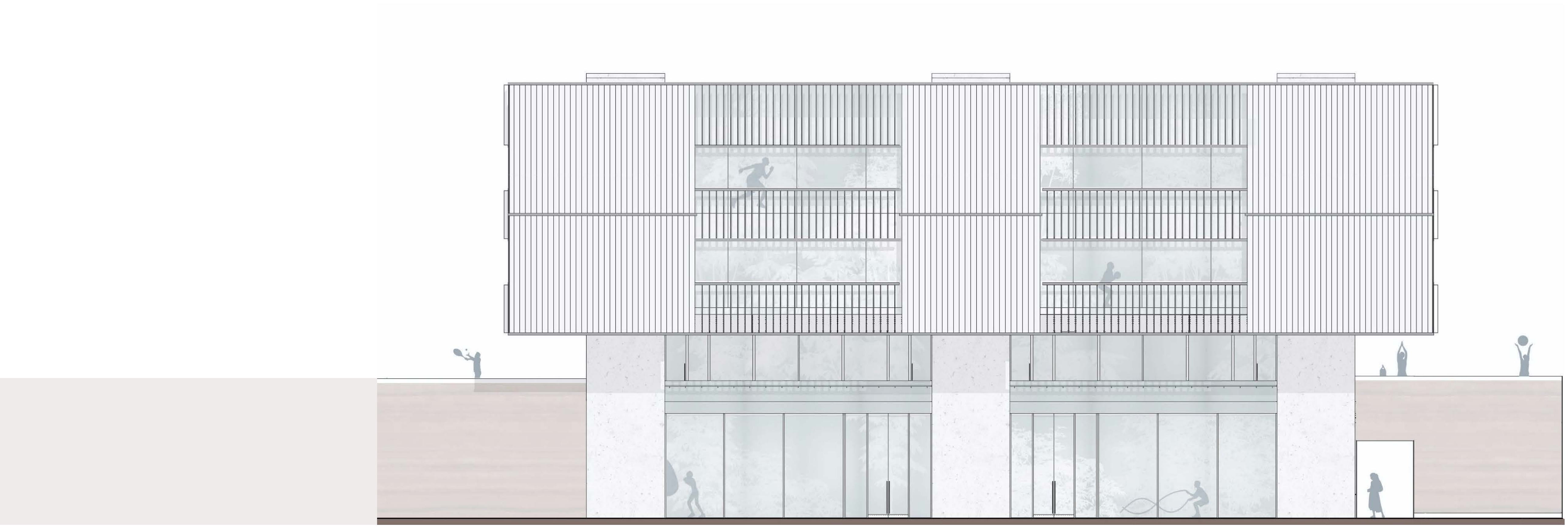


Fig. 171

Fig.171. Block D North Facade. Scale 1:200

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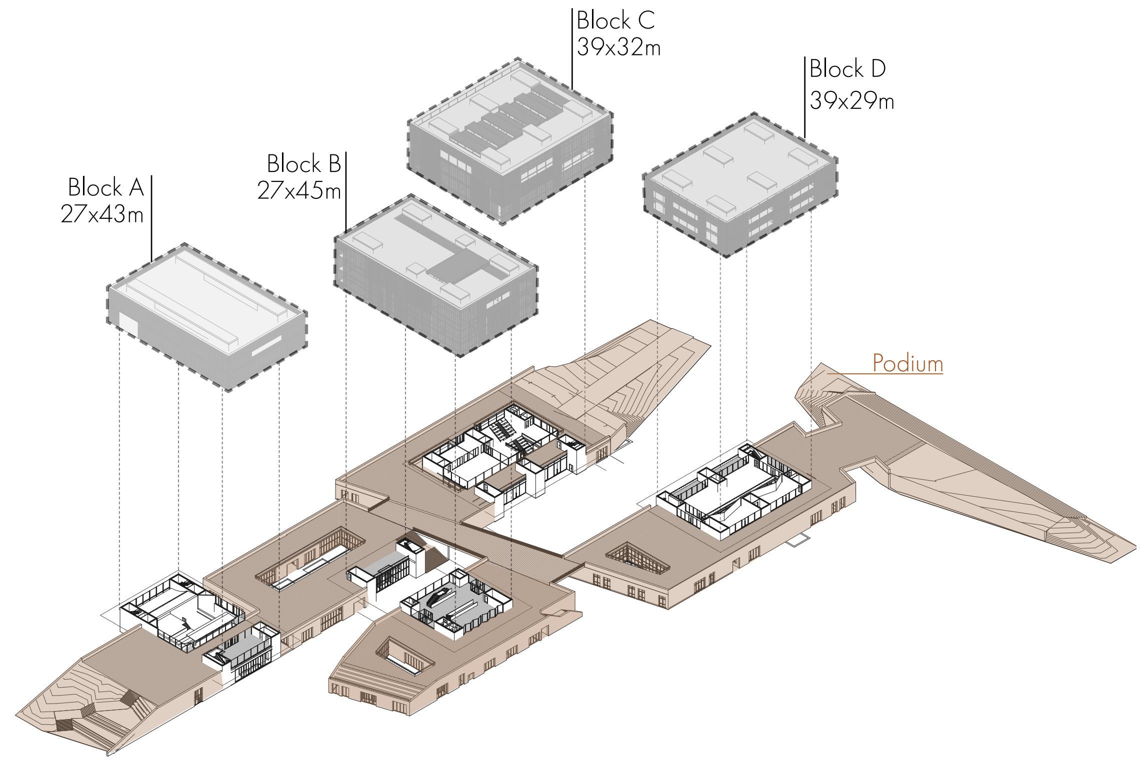
PART 02

STRUCTURAL DESIGN

CHAPTER 01

PROJECT DESCRIPTION

Project layout: Podium and Blocks



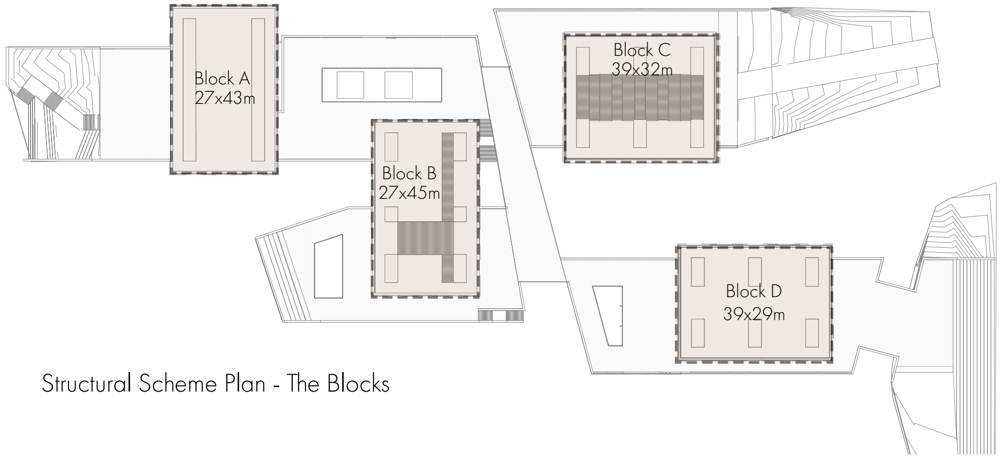
Project layout

The project is made up of two main parts, they differ in materiality and in structural systems:

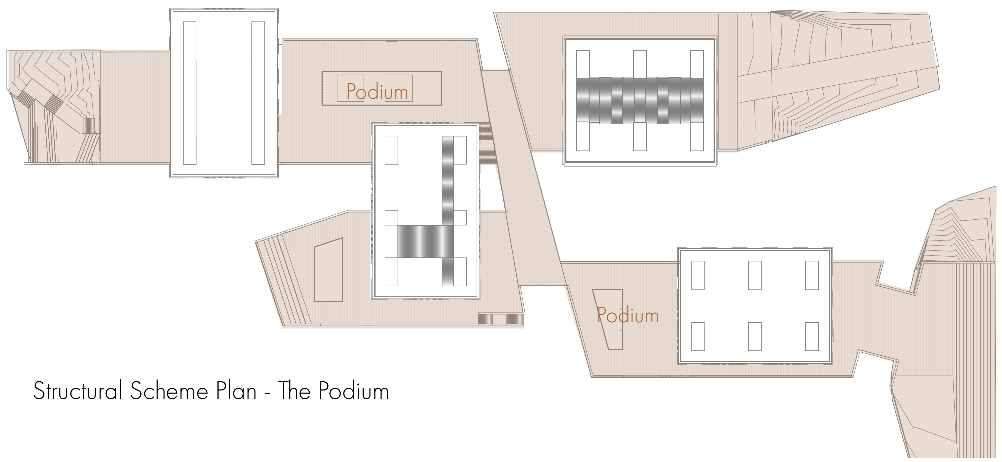
I - The Blocks, four singular architectural functions, have a mixed structure of concrete cores as vertical elements and steel beams with composite slabs as horizontal elements. They range from a height of 4 to 5 levels (17 to 25 meters), with one underground level each, serving as technical basement.

Block A -	Events and Culture.
Block B -	Science and Training.
Block C -	Media Library.
Block D -	Fitness and Wellness.

II - The Podium, a landscape continuation, consists of two longitudinal strips of one level height (5 meters) running through the site. This part consists of a labyrinth of rammed earth supporting walls and timber beams and slabs. Its roof is a landscaped garden-terrace.



Structural Scheme Plan - The Blocks

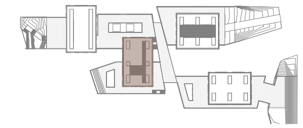


Structural Scheme Plan - The Podium

We start by calculating a typical floor and its beams in one of the Typical Blocks, which are blocks B,C and D (with the beams and spans calculated being in Block C: Media Library).
We go on by calculating and dimensioning the steel trusses of the auditorium in block A: Events and Culture.
Finally, we end the report by calculating the timber beams of the Podium.

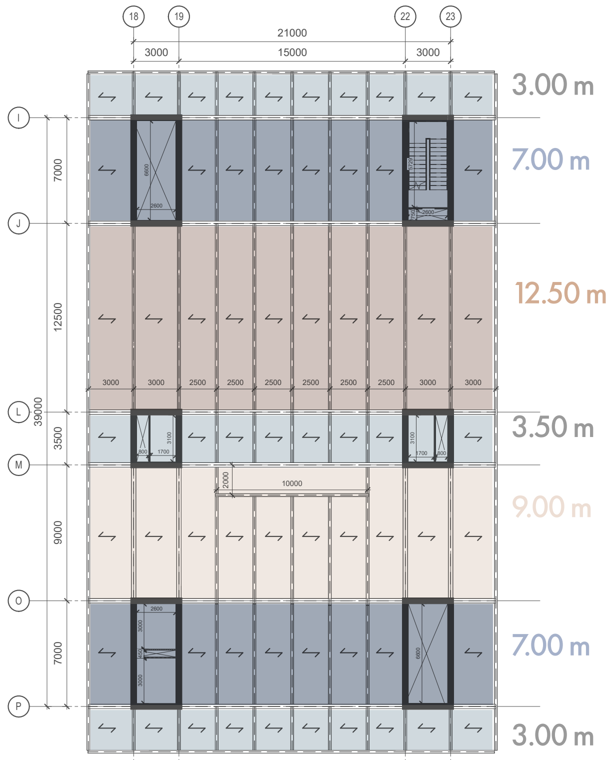
CHAPTER 02

TYPICAL BLOCKS



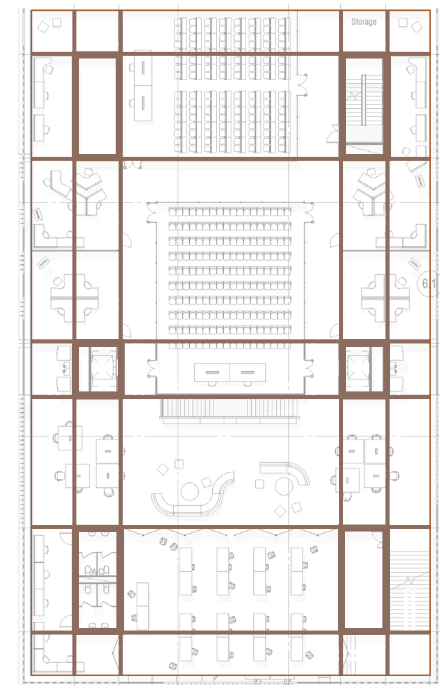
Dimensions, heights and relation with architecture:

Block B - Science and Training.

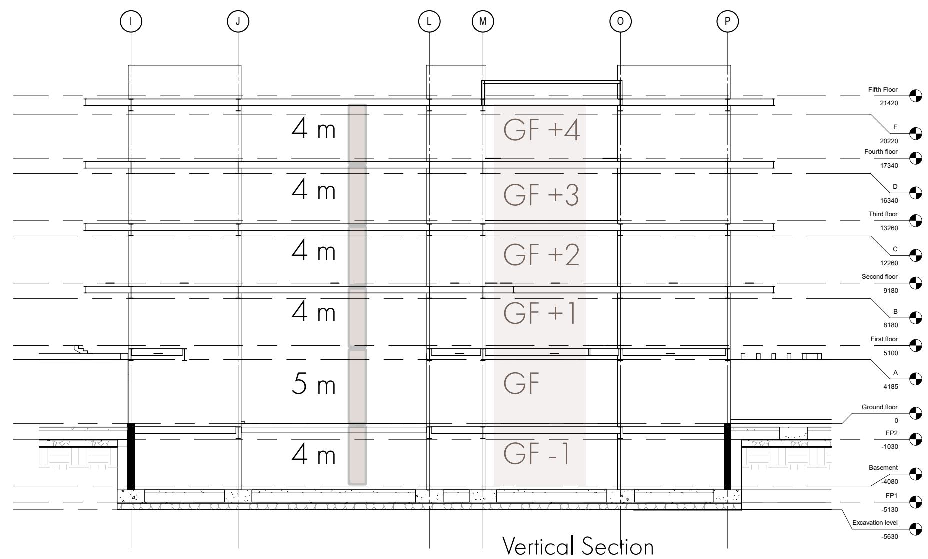


Horizontal Spans and Axis Distribution
Level GF+2 | Scale 1:500

Vertical Spans and Axis Distribution
Level GF+2 | Scale 1:500



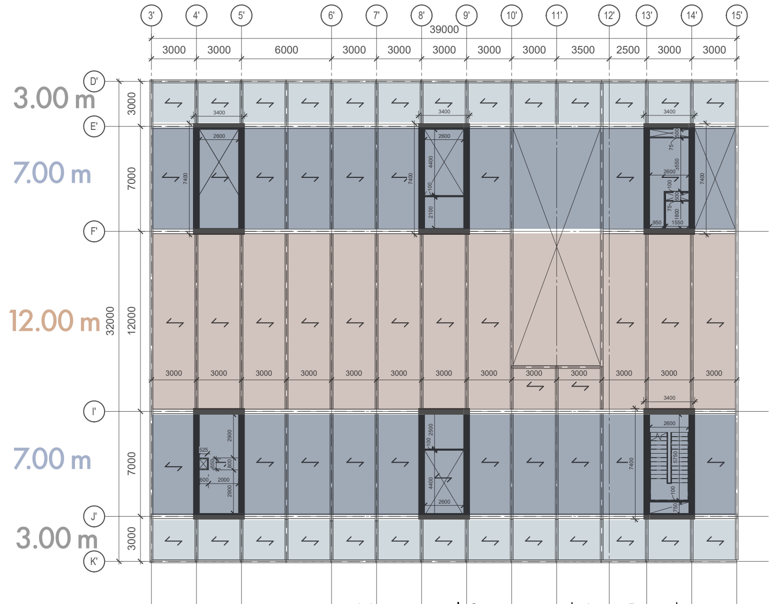
Ovelapping of Structure and Architecture
Level GF+2 | Scale 1:500



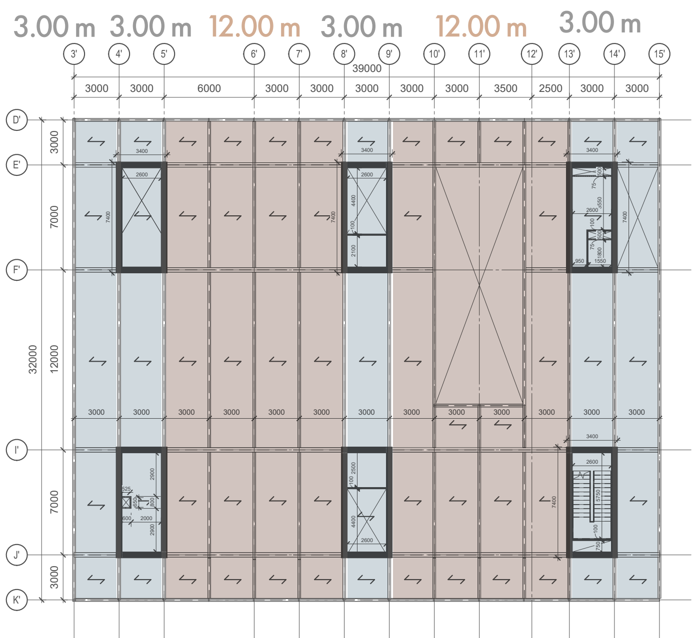
Vertical Section
Scale 1:500

A large span (15 meters, with voids) crosses the block vertically allowing to house a large gathering space, vertical and horizontal circulation, and large flexible classrooms.
The cores and facades define a 3 meter peripheral cantelever.
Horizontally, the volume presents spans of 9 and 12 meters between the cores, with the latter covering a pedestrian passage on the ground floor of the project.

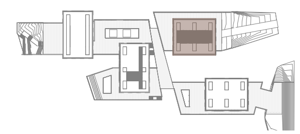
Block C - Media Library.

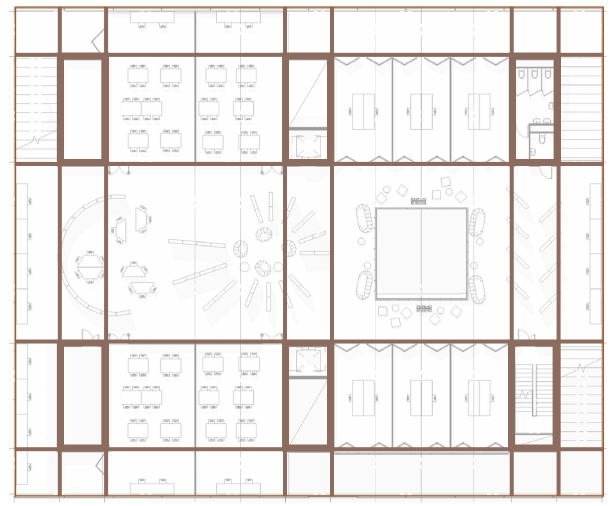


Horizontal Spans and Axis Distribution
Level GF+2 | Scale 1:500



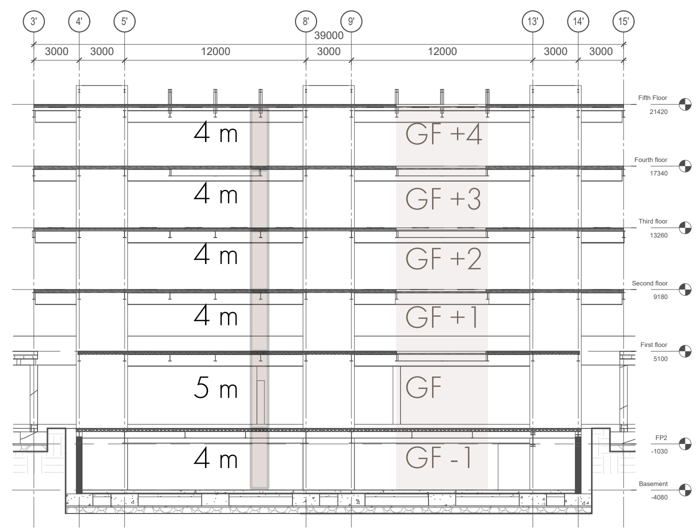
Vertical Spans and Axis Distribution
Level GF+2 | Scale 1:500





Ovelapping of Structure and Architecture
Level GF+3 | Scale 1:500

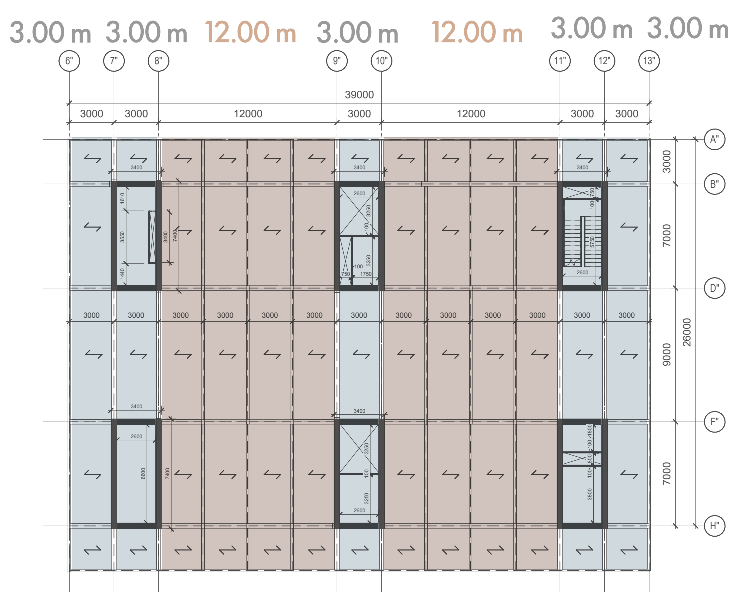
A large span (12 meters, with voids) crosses the block horizontally allowing to house the main reading room of the library and vertical and horizontal circulation.
The cores and facades define a 3 meter peripheral cantelever where we find semi-private individual work stations. Vertically, the volume presents two spans of 12 meters between the cores, where flexible study rooms are set.



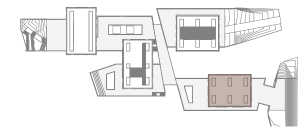
Horizontal Section
Scale 1:500

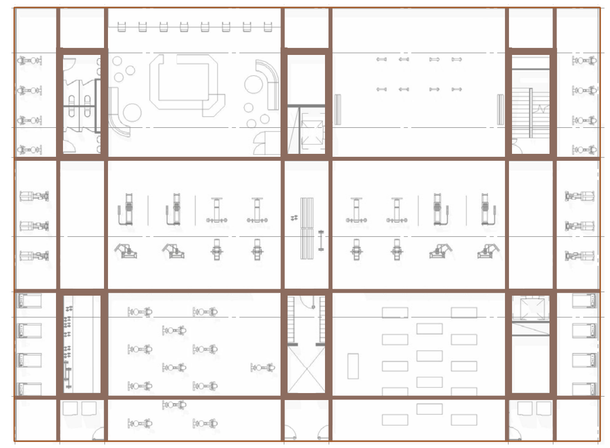
Block D - Fitness and Wellness,

Horizontal Spans and Axis Distribution
Level GF+2 | Scale 1:500



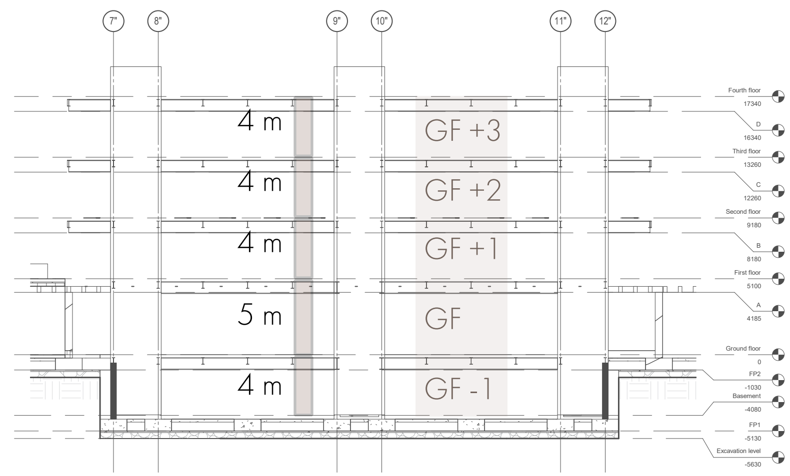
Vertical Spans and Axis Distribution
Level GF+2 | Scale 1:500





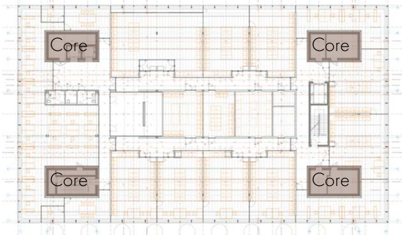
Ovelapping of Structure and Architecture
Level GF+2 | Scale 1:500

A large span (9 meters) crosses the block horizontally allowing to house the main gym and weight training space of the block. The cores and facades define a 3 meter peripheral cantelever where we find machinery facing the exterior view. Vertically, the volume presents two spans of 12 meters between the cores, where flexible music rooms are set.

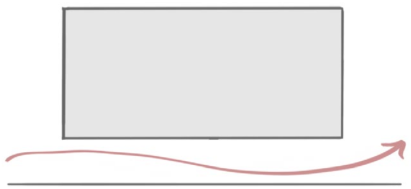


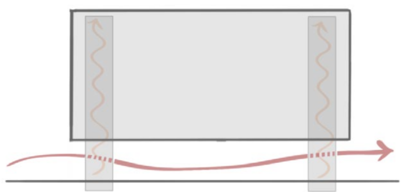
Horizontal Section
Scale 1:500

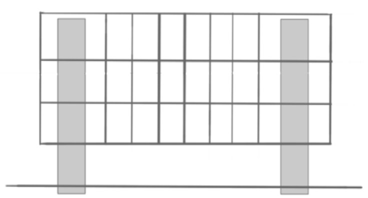
Case study: the Blocks



Plan of common floor





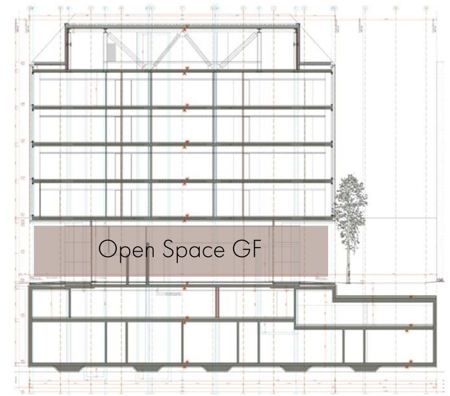


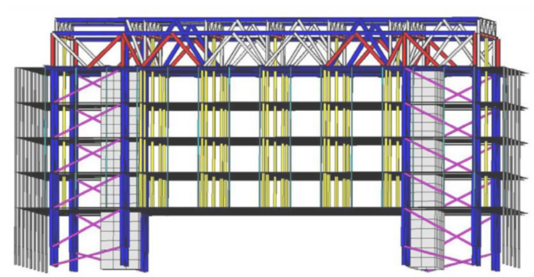
Taniguchi Building, Novartis Campyus, Basel, A floating white cube, 2005-09 - The laboratory building by Yoshio Taniguchi is in the form of a floating box. To create a void ground floor, its structural system is designed as having four concrete cores that are the only structural point of contact with the ground. The cores are combined with metallic trusses that span between them and hold up the upper floors, with the help of vertical elements and beams. The cores encapsule the service and technical spaces, leaving the rest of the building with an open plan configuration. They also help completely freeing up the ground floor, that is left as an exterior gathering space.

Our projects' technological individual blocks have a similar structural system to this project. Their structural system consists of concrete cores as vertical elements and of metallic beams to support the corrugated steel slab. This configuration aids in designing an open plan typology with a free ground floor.

What differenciates both projects are the cores, more often in the number of 6, which are closer together with smaller spans. This permits us to eliminate any other kind of vertical connectors and to diminish the size of horizontal elements, thus replacing the trusses by smaller primary and secondary steel beams.

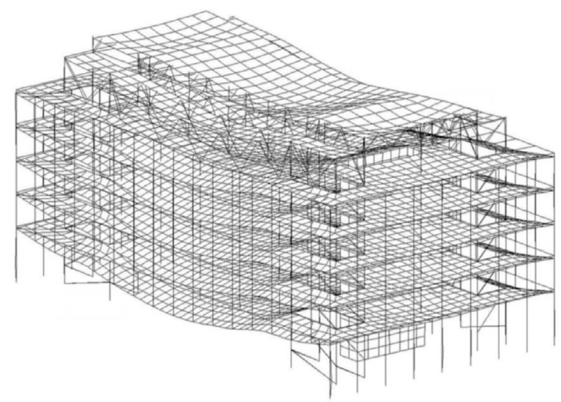
Facade





Structural System and Elements

Ground Floor free of structure - Concrete cores are the only

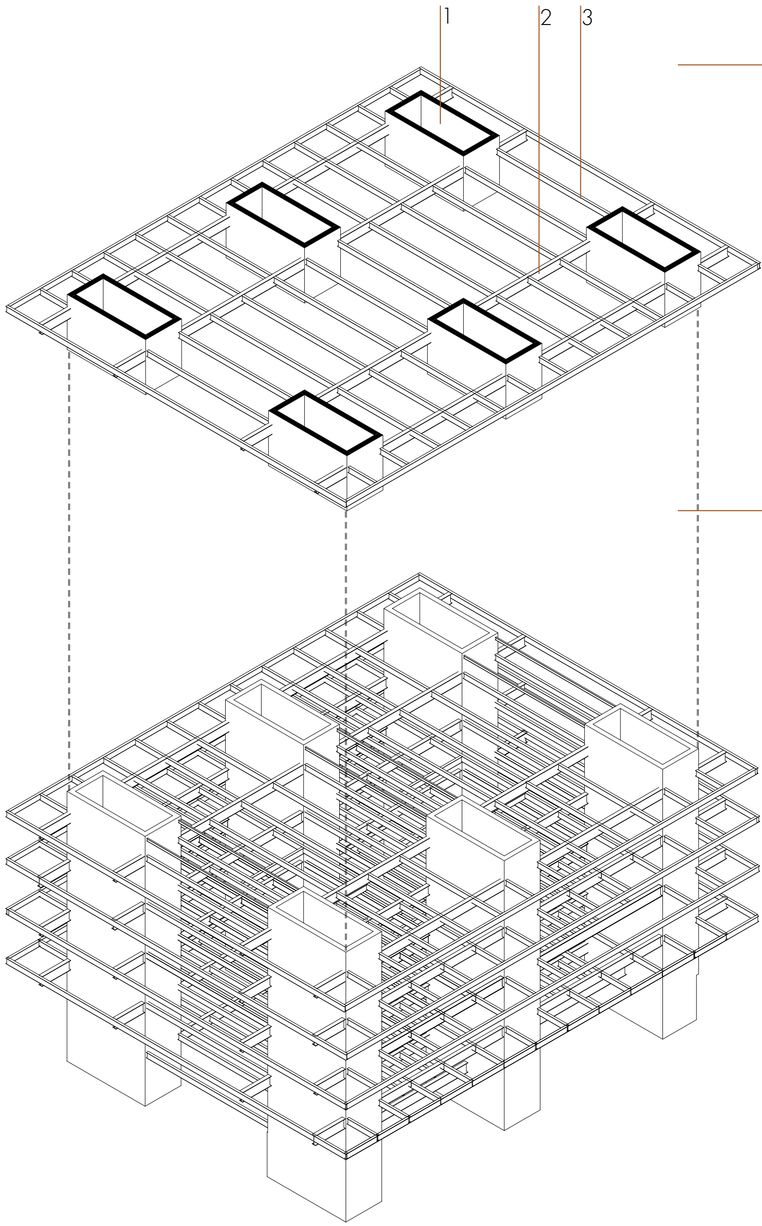


Structural Simulation

2.1. Structural load calculations

Structure hierarchy

For the upcoming structural calculations, we proceed by isolating and studying the block C - Media Library.
We calculate the primary and secondary at the biggest span (12 meters).



Typical floor full structure and connections:

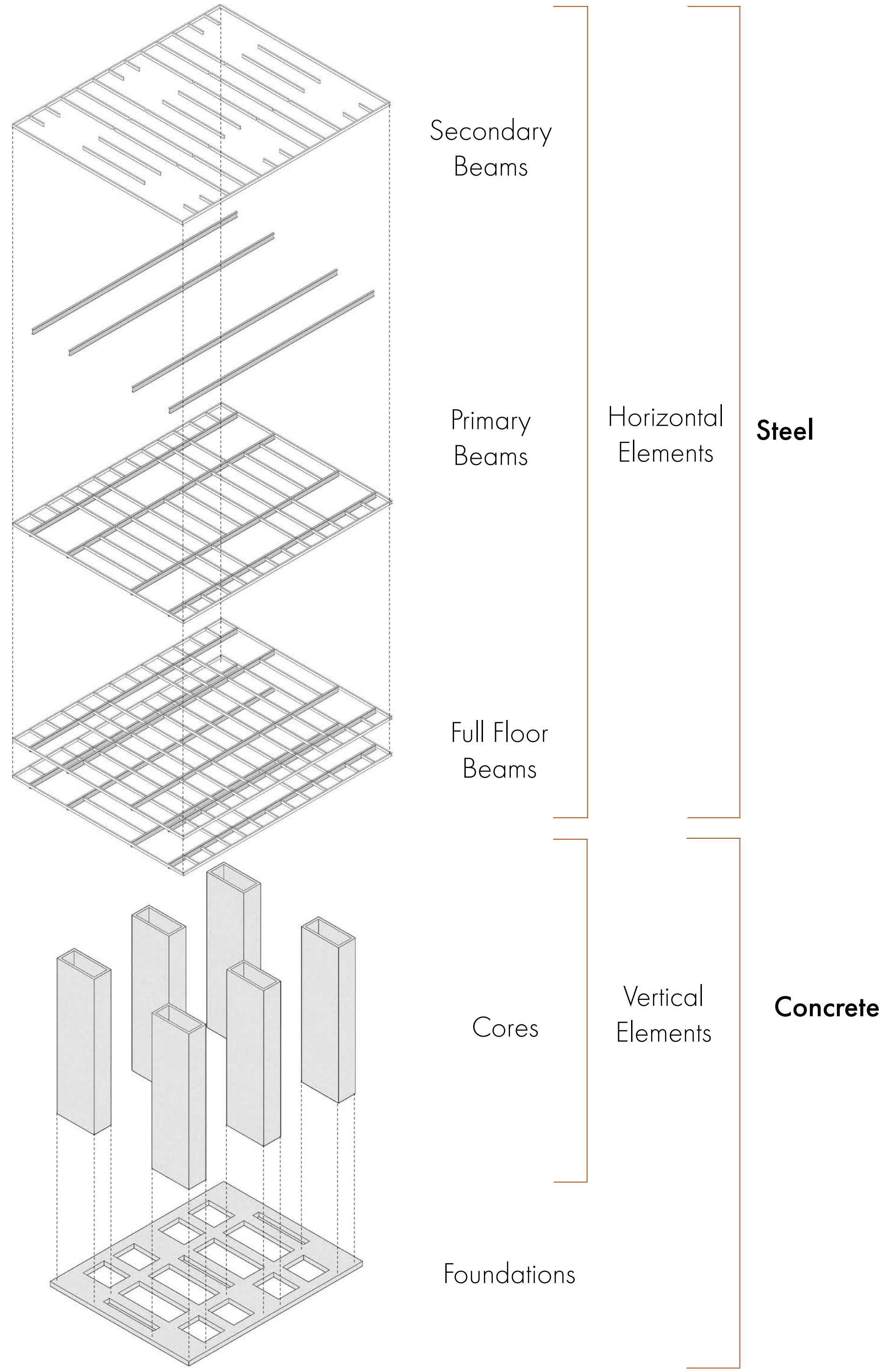
1-Concrete cores, contact with foundations.

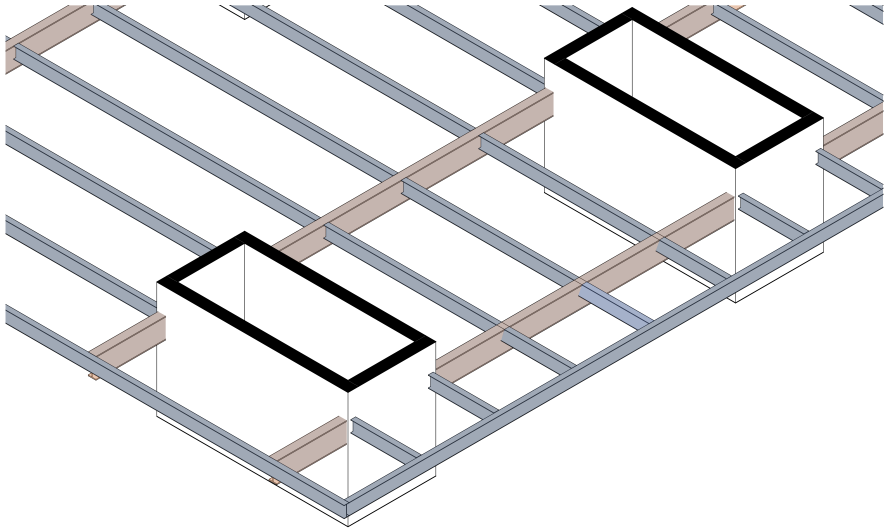
2-Primary beams in one direction, between cores on 12m span.

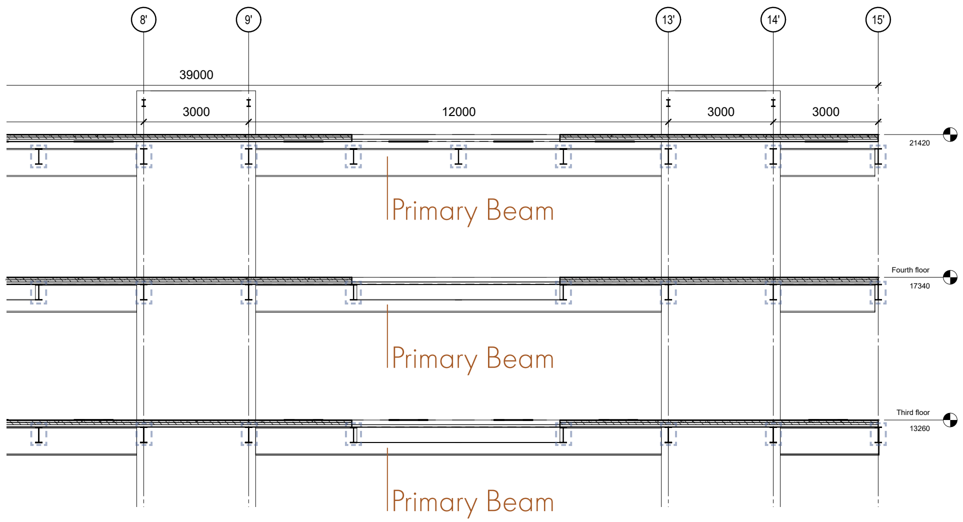
3-Secondary beams in opposite direction + ring beams.

Axonometry of Block B's upper floors structural system

Exploded axonometry of Block B's structural system







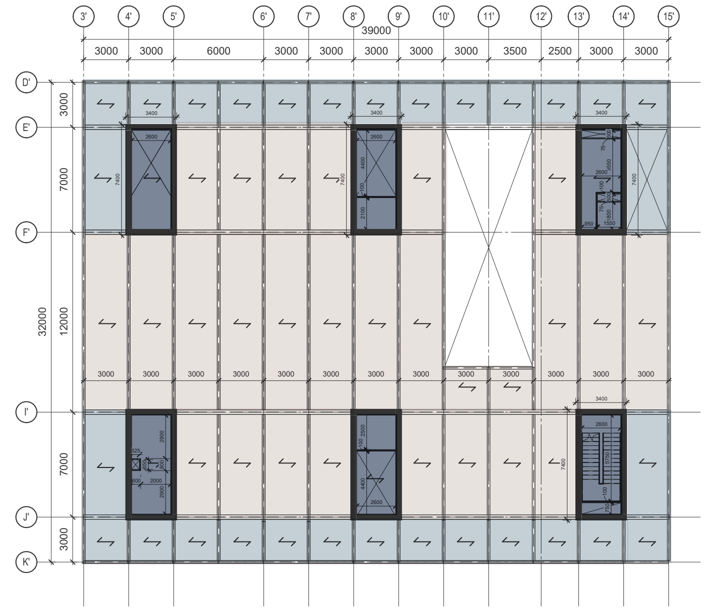
Concrete Cores, the only point of contact with the ground, the only vertical elements.

Primary Beams, mechanically fixated on cores, through metallic plates and bolts.

Secondary Beams, mechanically fixated on Primary Beams, through metallic plates and bolts.

Composite Slab, Fixated on Tertiary Beams

Ring Beam, to support the facade load.



Distribution of Live Loads on a Plan
Block C | Level GF+2 | Scale 1:500

Live loads distribution scheme

As a first step for structural load calculation, we define the different live loads present in one typical floor plan, based on the use of the defined areas.

Spaces equipped with tables (classrooms, lecture rooms, reception, meeting room...): 3 kN/m.

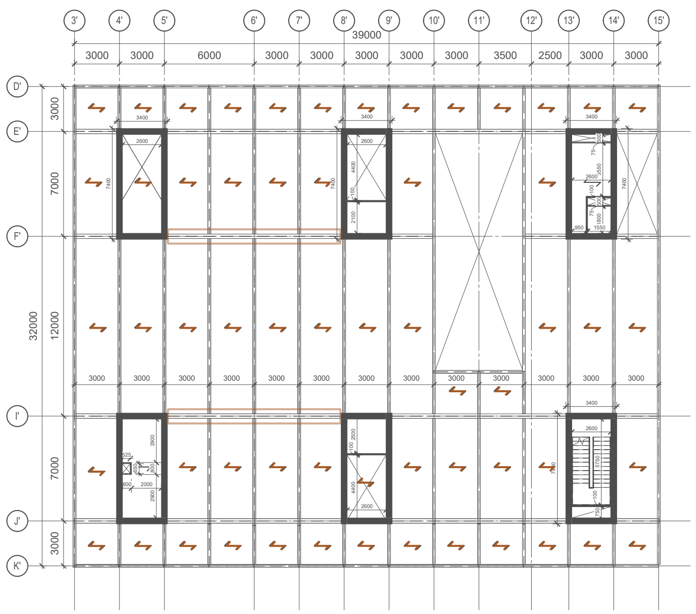
Small Offices: 2 kN/m

Technical and Emergency Stairs: 4 kN/m

With also, not present on this plan:

- Technical Inaccessible Roof: 2 kN/m
- Spaces with no obstacles and major spaces of assembly: 4 kN/m.

N.B: The partitions are also included in the live loads.



Typical Floor Loads Distribution
Block C | Level GF+2 | Scale 1:500

Dead loads distribution scheme

As second step for structural load calculation, we define the load bearing direction of each slab. They are predefined as being unidirectional slabs.

The spans, proportions, and axis configuration help define a unidirectional system of slabs.

This system consists of steel primary beams holding their self weight, the weight of the secondary beams, the weight of composite slabs, and the live loads in each area. They then transfer this load onto the vertical cores that act as the sole vertical elements.

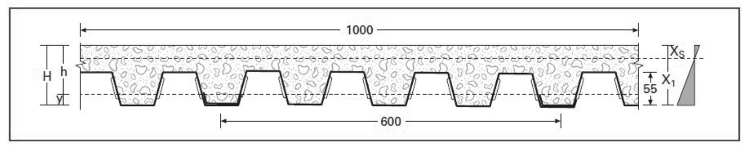
The loads are mostly distributed along an East to West direction, perpendicular to the secondary beams. In this plan of Block C, the beams with a span of 12 meters hold most of the loads and will be calculated and dimensioned in the rest of this report.

Slabtype and loads

The project is designed as having a composite aluminum sheet slab. This slab of a height of 12 cm weights as the G1" floor self weight. It is present at all levels of the blocks and is held by the primary and secondary beams. It is covered by a set of finishing layers that count as the G2 dead weight.

DEAD LOAD - FLOOR SELF WEIGHT - G1"										
Layer	Length		Width		Height		Volumetric weight		Weight	
Concrete layer	1.0	m	1.0	m	0.09	m	24	kN/m3	2.2	kN/m2
Area load G1"									**2.2**	**kN/m2**

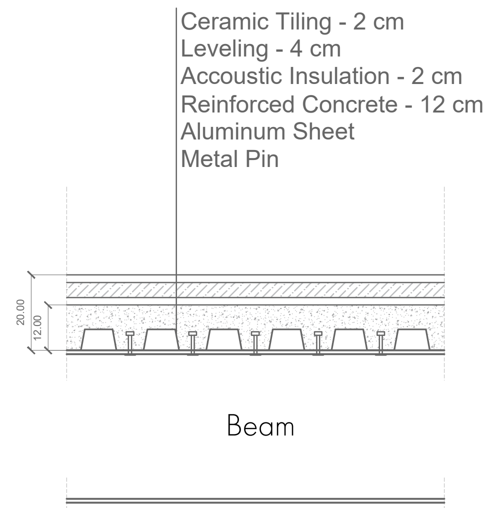
DEAD LOAD - COMPOSITE SLAB WEIGHT- G2										
Layer	Length		Width		Height		Volumetric weight		Weight	
Ceramic	1.0	m	1.0	m	0.02	m	20	kN/m3	0.4	kN/m2
Levelling	1.0	m	1.0	m	0.04	m	10	kN/m3	0.4	kN/m2
Accoustic Layer	1.0	m	1.0	m	0.02	m	0	kN/m3	0.0	kN/m3
Aluminum Sheet	1.0	m	1.0	m	0.01	m	25	kN/m3	0.1	kN/m2
Area load G2									**0.9**	**kN/m2**



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	

We consider 9.25 cm out of the height of 12 cm of slab to be in concrete.



Composite slab and finishing layers | Scale 1:20

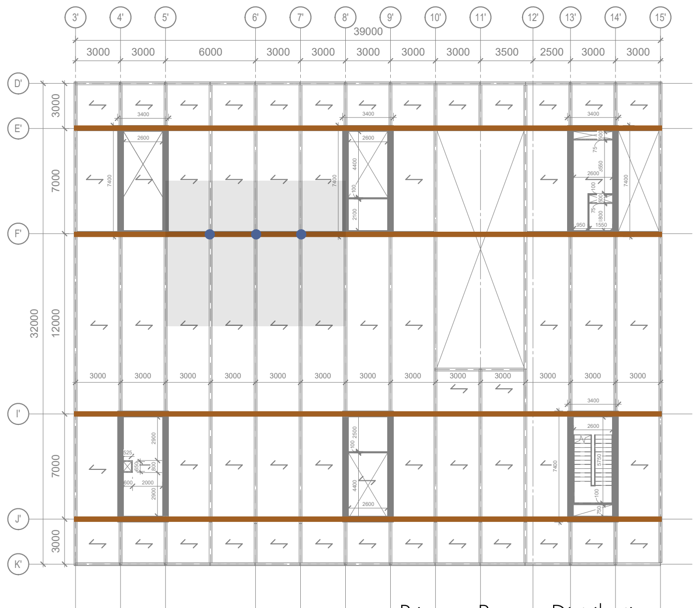
2.2. Beam design

Beam loading system

The system presents a hierarchy of primary and secondary beams that span from core to core or from extremity to extremity of the block.

The primary and secondary beams are fixated mechanically together, through metallic plates. In spans, we assign a Live Load of 3 kN/m, them being spaces equipped with tables (see Live Load distribution page ...)

The primary beam supports, its self weight, and the punctual load transferred to it by the secondary beams (that consists of the secondary beams self weight, the live loads, and the area slab loads). In the following calculations, the slabs held by the beams are all considered to be unidirectional slabs, performing in the same direction (East - West).

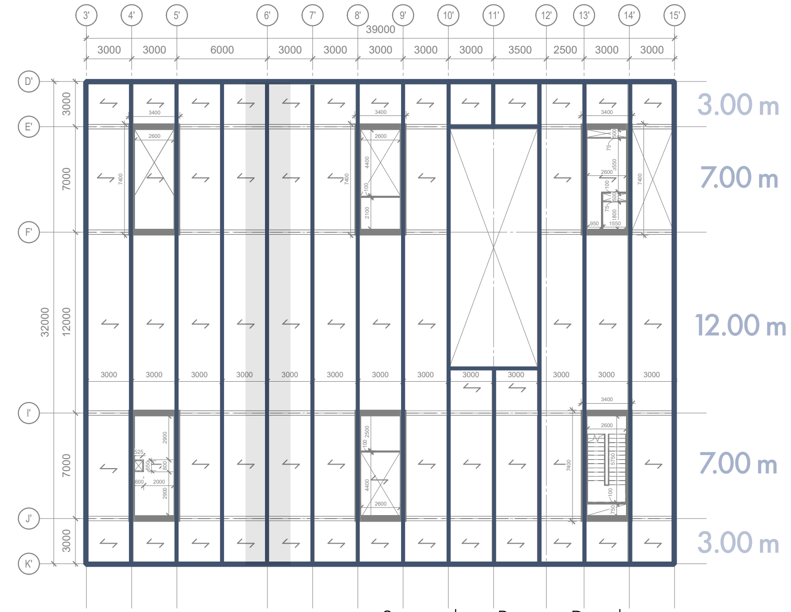


Primary Beams Distribution
Level GF+2 | Scale 1:500

Secondary Beams Distribution
Level GF+2 | Scale 1:500

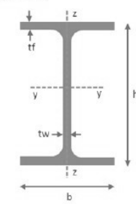
Secondary beam pre-dimensioning and loads

This beam is calculated as being continuous, it spans two 3m cantilevers, two 7m spans and one middle 12 m span.
It has an influence area width of 3 meters. We predimention it as being an IPE 450.



Secondary Beams Distribution
Level GF+2 | Scale 1:500

Profili IPE



LEGENDA

- A = area
- Iy = momento d'inerzia
- Wy = moduli di resistenza elastico
- Wpl,y = modulo di resistenza plastico
- iy = raggio d'inerzia
- Iz = momento d'inerzia
- Wz = moduli di resistenza elastico
- Wpl,z = modulo di resistenza plastico
- iz = raggio d'inerzia
- JT = fattore di rigidezza torsionale
- Iw = momento d'inerzia settoriale

Profilo	g (Kg/m)	h (mm)	b (mm)	tw (mm)	tf (mm)	r1 (mm)	r2 (mm)	A (cm2)	Iy (cm4)	Wy (cm3)	Wpl,y (cm3)	iy (cm)	Iz (cm4)	Wz (cm3)	Wpl,z (cm3)	iz (cm)	JT (cm4)	Iw (cm6)
IPE 400	66.3	400	180	8.6	13.5	21	0	84.46	23130	1156	1307	16.55	1318	146.4	229	3.95	51.08	490000
IPE 450	77.6	450	190	9.4	14.6	21	0	98.82	33740	1500	1702	18.48	1676	176.4	276.4	4.12	66.87	791000
IPE 500	90.7	500	200	10.2	16	21	0	115.5	48200	1928	2194	20.43	2142	214.2	335.9	4.31	89.29	1249000
IPE 550	106	550	210	11.1	17.2	24	0	134.4	67120	2441	2787	22.35	2668	254.1	400.5	4.45	123.2	1884000
IPE 600	122	600	220	12	19	24	0	156	92080	3069	3512	24.3	3387	307.9	485.6	4.66	165.4	2846000

DEAD LOAD - STEEL BEAM SELF WEIGHT - G1'				
TYPE	IPE 450			
B	19	cm	0.19	m
H	45	cm	0.45	m
Material density	9000	kg/m3	90	kN/m3
Linear load G1'			**7.7**	**kN/m**

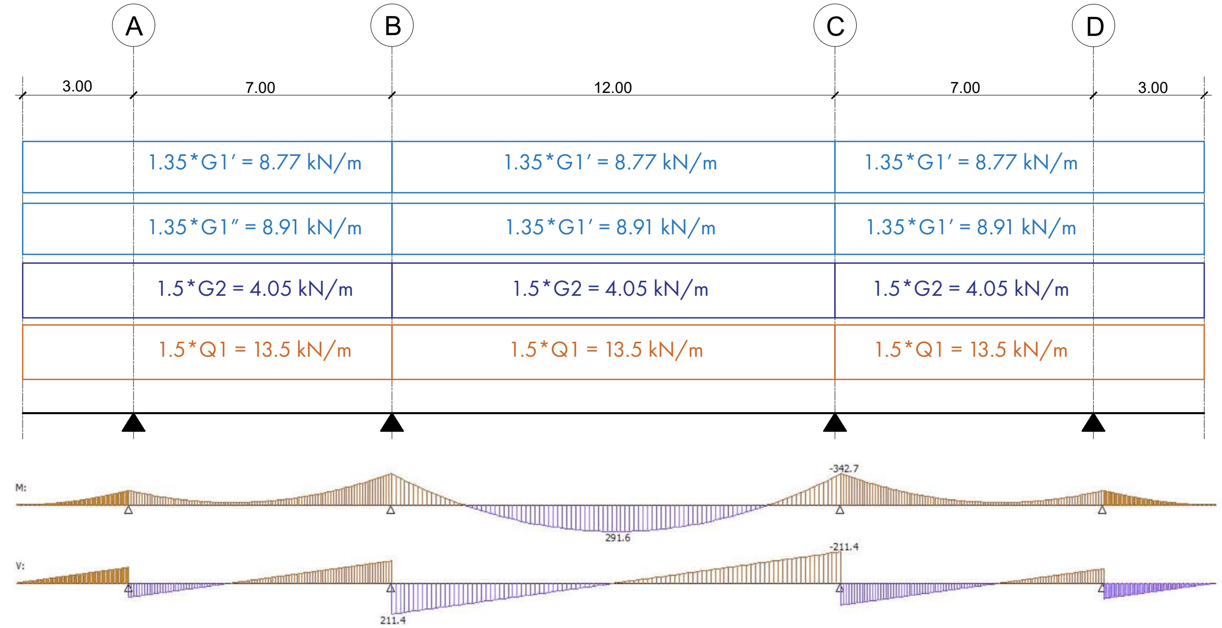
Secondary beam design and checks

We find the Total Beam Load by multiplying the results with the respective coefficients. Using the influence area width as being 3 meters, we input the beam loads after multiplication with the coefficients into the software, to check the maximal bending moment, the maximal shear force, and the maximal displacement (at the longest span of 12 meters).

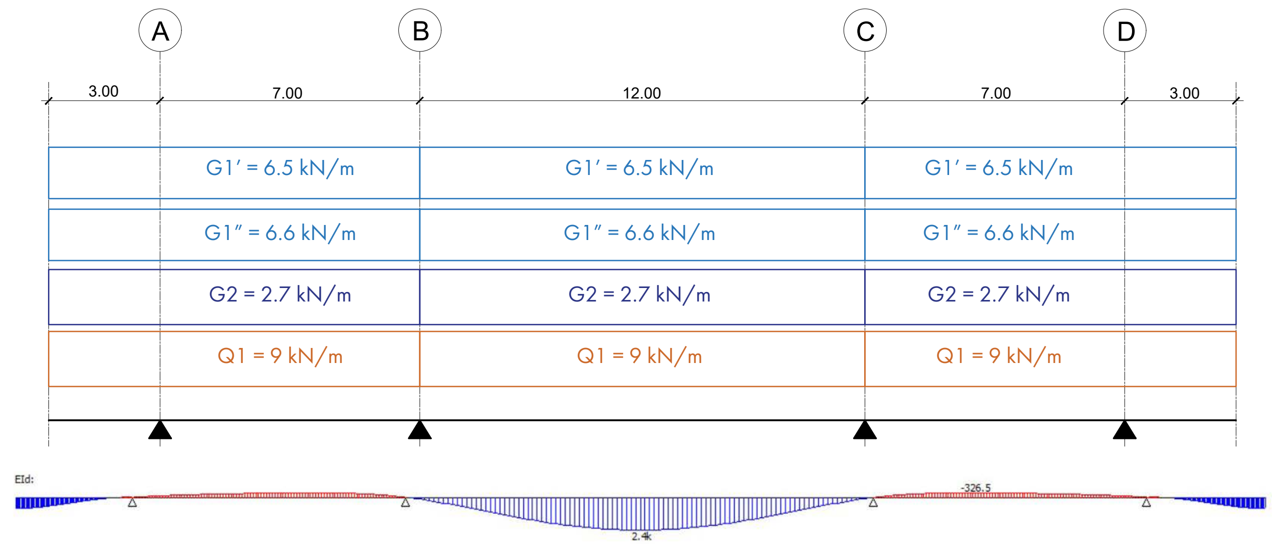
SECONDARY BEAMS LOAD CALCULATION			
	Influence area width	3.0	m
Dead load: Floor self weight	Linear load G1"	2.2	kN/m2
		6.6	kN/m
Dead load: Beam self weight	Linear load G1'	6.5	kN/m
Dead load	G1'+G1"	13.1	kN/m
	Area load G2	0.9	kN/m2
Dead load: Floor Self weight	Linear load G2	2.7	kN/m
	Area load Q1	3.0	kN/m2
Live load: Space with tables	Linear load Q1	9.0	kN/m
Dead load: Beam self weight	Linear load G1	13.1	kN/m
Dead load: Floor Self weight	Linear load G2	2.7	kN/m
Live load: Residential	Linear load Q1	9.0	kN/m
	Coefficient for G1	1.35	-
	Coefficient for G2	1.50	-
	Coefficient for Q1	1.50	-
	TOTAL BEAM LOAD Quls	35.2	kN/m

SECONDARY STEEL BEAM SYSTEM				
Beam Type	IPE 450			
Beam Lenght L	12	m	12000	mm
Influence area width	3	m		
Linear load G1'	6.5	kN/m		
Linear load G1"	2.2	kN/m2		
	6.6	kN/m		
G1' + G1"	13.1	kN/m		
Area load G2	0.9	kN/m2		
Linear load G2	2.7	kN/m		
Area load Q1	3	kN/m2		
Linear load Q1	9.0	kN/m		

EXTERNAL BENDING MOMENT CAFLCULATIONS				
Load_ULS COMB	35.24	kN/m		
Load_RARA COMB	24.80	kN/m		
Load_LIVE COMB	9	kN/m		
M_ED_ULS	291.30	kNm	291300000 Nmm	SOFTWARE



ULS - Bending Moment and Shear Force Diagram from the Software



SLS - Displacement Diagram from the Software

After chosing the steel class and calculating, the checks confirm a proper predimensioning: Secondary beam as IPE 450.

STEEL CLASS				
Steel class	275			
fyk	275	MPa		
γs	1.05			
fyd	262	MPa		
Wpl	1466182	mm3	1466	10^3 mm3
Wpl chosen	1702	10^3 mm3	OK	
Iy chosen	33740	10^4 mm4		
E	206000	MPa		

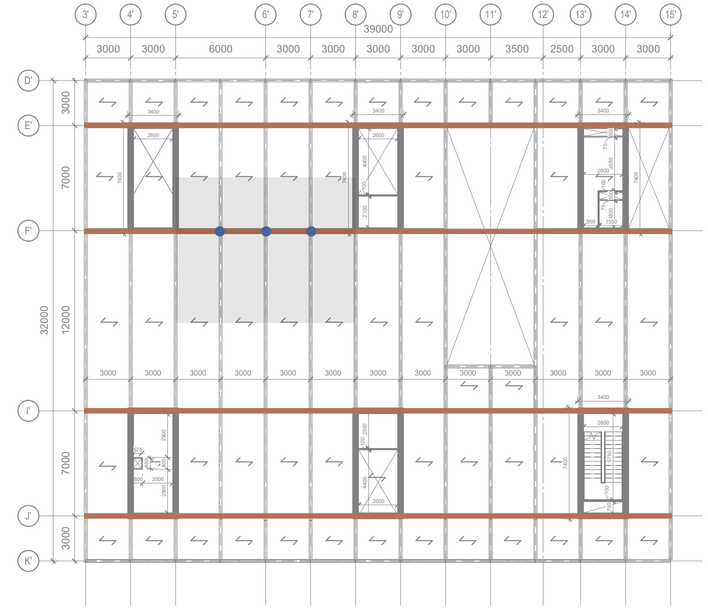
CHECK - MAXIMAL DISPLACEMENTS FOR RARA COMB (D + L)		
Delta Max L/200	60	mm

Delta Software	$EI\delta_{span}$ =	2354.00	
	δ =	33.87	OK

CHECK - SHEAR ULS COMB			
	IPE 450		
h_section	450	mm	
tw_section	9.4	mm	
r_section	21	mm	
tf_section	14.6	mm	
Av (area resisting shear)	5456.40	mm2	
V_Ed_ULS	211.41	kN	
Software Value	211.2	kN	
V_Rd	825.07	kN	OK

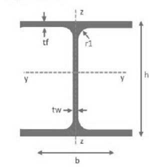
Primary beam pre-dimensioning and loads

The primary beam linking and supporting the three secondary beams and spanning from core to core (12 meters) is predimensioned as being an HEB 800.



Primary Beams Distribution
Level GF+2 | Scale 1:500

Profili HEB



LEGENDA

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- iy = raggio d'inerzia
- Iz = momento d'inerzia
- Wz = moduli di resistenza elastico
- Wpl,z = modulo di resistenza plastico
- iz = raggio d'inerzia
- JT = fattore di rigidezza torsionale
- Iw = momento d'inerzia settoriale

Profilo	g (Kg/m)	h (mm)	b (mm)	tw (mm)	tf (mm)	r1 (mm)	r2 (mm)	A (cm2)	Iy (cm4)	Wy (cm3)	Wpl,y (cm3)	iy (cm)	Iz (cm4)	Wz (cm3)	Wpl,z (cm3)	iz (cm)	JT (cm4)	Iw (cm6)
HE 360 B	142	360	300	12.5	22.5	27	0	180.6	43190	2400	2683	15.46	10140	676.1	1032	7.49	292.5	2883000
HE 400 B	155	400	300	13.5	24	27	0	197.8	57680	2884	3232	17.08	10820	721.3	1104	7.4	355.7	3817000
HE 450 B	171	450	300	14	26	27	0	218	79890	3551	3982	19.14	11720	781.4	1198	7.33	440.5	5258000
HE 500 B	187	500	300	14.5	28	27	0	238.6	107200	4287	4815	21.19	12620	841.6	1292	7.27	538.4	7018000
HE 550 B	199	550	300	15	29	27	0	254.1	136700	4971	5591	23.2	13080	871.8	1341	7.17	600.3	8856000
HE 600 B	212	600	300	15.5	30	27	0	270	171000	5701	6425	25.17	13530	902	1391	7.08	667.2	10970000
HE 650 B	225	650	300	16	31	27	0	286.3	210600	6480	7320	27.12	13980	932.3	1441	6.99	739.2	13360000
HE 700 B	241	700	300	17	32	27	0	306.4	256900	7340	8327	28.96	14440	962.7	1495	6.87	830.9	16060000
HE 800 B	262	800	300	17.5	33	30	0	334.2	359100	8977	10230	32.78	14900	993.6	1553	6.68	946	21840000
HE 900 B	291	900	300	18.5	35	30	0	371.3	494100	10980	12580	36.48	15820	1054	1658	6.53	1137	29460000
HE 1000 B	314	1000	300	19	36	30	0	400	644700	12890	14860	40.15	16280	1085	1716	6.38	1254	37640000

DEAD LOAD - STEEL BEAM SELF WEIGHT - G1'				
TYPE	HEB 800			
B	30	cm	0.3	m
H	80	cm	0.8	m
Material density	9000	kg/m3	90	kN/m3
Linear load G1'			**21.6**	**kN/m**

Primary beam design and checks

The beam holds its own self weight and the loads of the secondary beams (G1+G2+Q1) as point loads along its length (one secondary beam each 3 meters) . The system of loads is computed into the software to calculate the maximum bending moment of the beam.

For the supports, in order to take account of the effect of the continuity of the beam along the concrete cores, we add a cantilever of 3 meters on each side. This results in a negative bending moment of 245 kNm, and in decreasing the maximal bending moment for the main 12 m span.

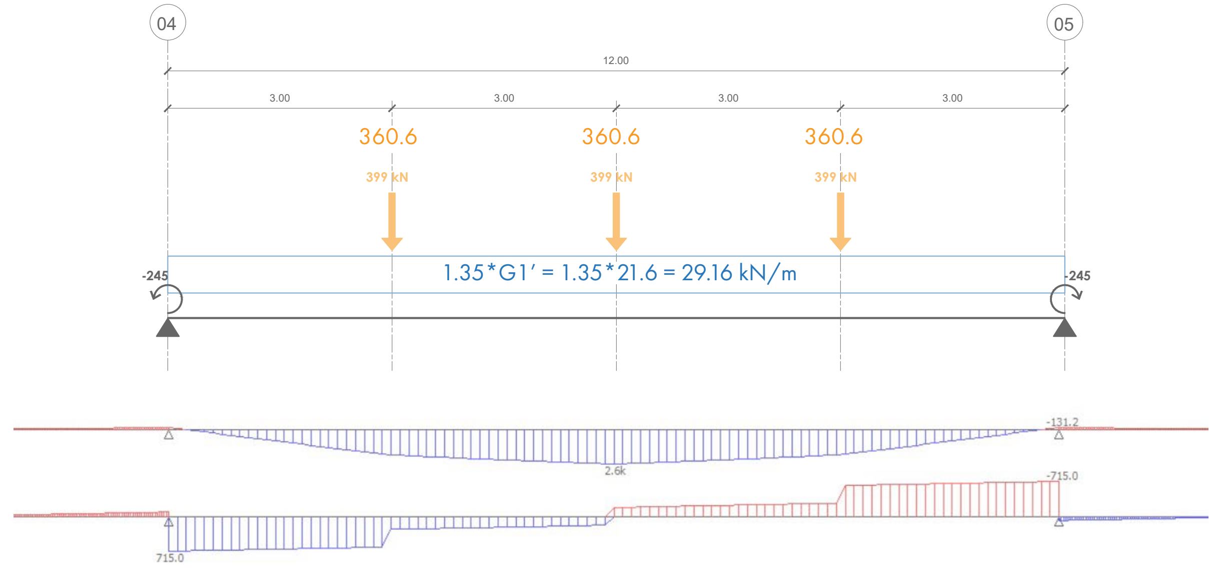
PRIMARY BEAM				
Beam Type	HEB 800			
Beam Lenght L	12	m	12000	mm

Influence area width	9.5	m

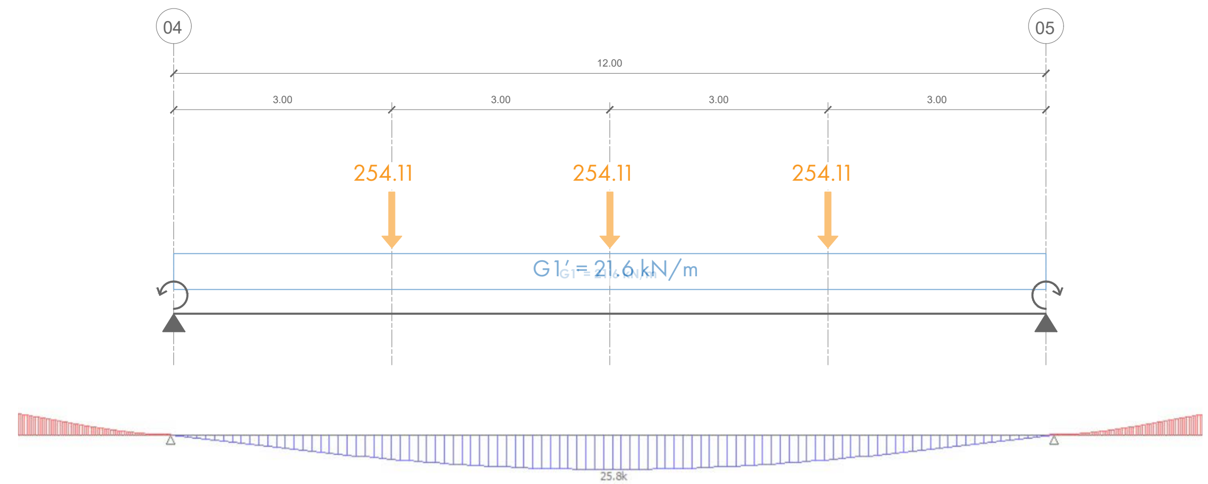
SHEAR FORCE OF THE SECONDARY BEAMS					
Vmax:	0	96.93	211.2	149.47	105.6
Vmin:	-105.6	-149.47	-211.2	-96.93	0

RESULTANT REACTION FORCES		
x=10	360.67	kN

CONTINUOUS STEEL BEAM - 1 SPAN				
L	12			
PERMANENT LOADS				
G1'	21.6	x 1.35 =	29.16	kN/m
POINT LOADS				
x = 3	360.67	kN		
x = 6	360.67	kN		
x = 9	360.67	kN		
RESULTS FOR MAIN SPAN				
Mmax:	2553	kNm		
Mmin:	-131.22	kNm		
Vmax:	715	kN		
Vmin:	-715	kN		



ULS - Bending Moment and Shear Force Diagram from the Software



SLS - Displacement Diagram from the Software

After chosing the steel class and calculating, the checks confirm a proper predimensioning: Primary beam as HEB 800.

CHECKS FOR CONTINUOUS STEEL BEAM			
M_ED_ULS	2553.00	kNm	2553000000 Nmm

STEEL CLASS				
Steel class	275			
fyk	275	MPa		
γs	1.05			
fyd	262	MPa		
Wpl	9747818	mm3		
Wpl chosen	10230	10^3 mm3	9748	10^3 mm3
Iy chosen	359100	10^4 mm4		
E	206000	MPa	OK	

CHECK - SHEAR ULS COMB			
	HEB 800		
h_section	800	mm	
tw_section	17.5	mm	
r_section	30	mm	
tf_section	33	mm	
Av (area resisting shear)	17960.00	mm2	
V_Ed_ULS			
Software Value	715	kN	
V_Rd	2715.75	kN	OK

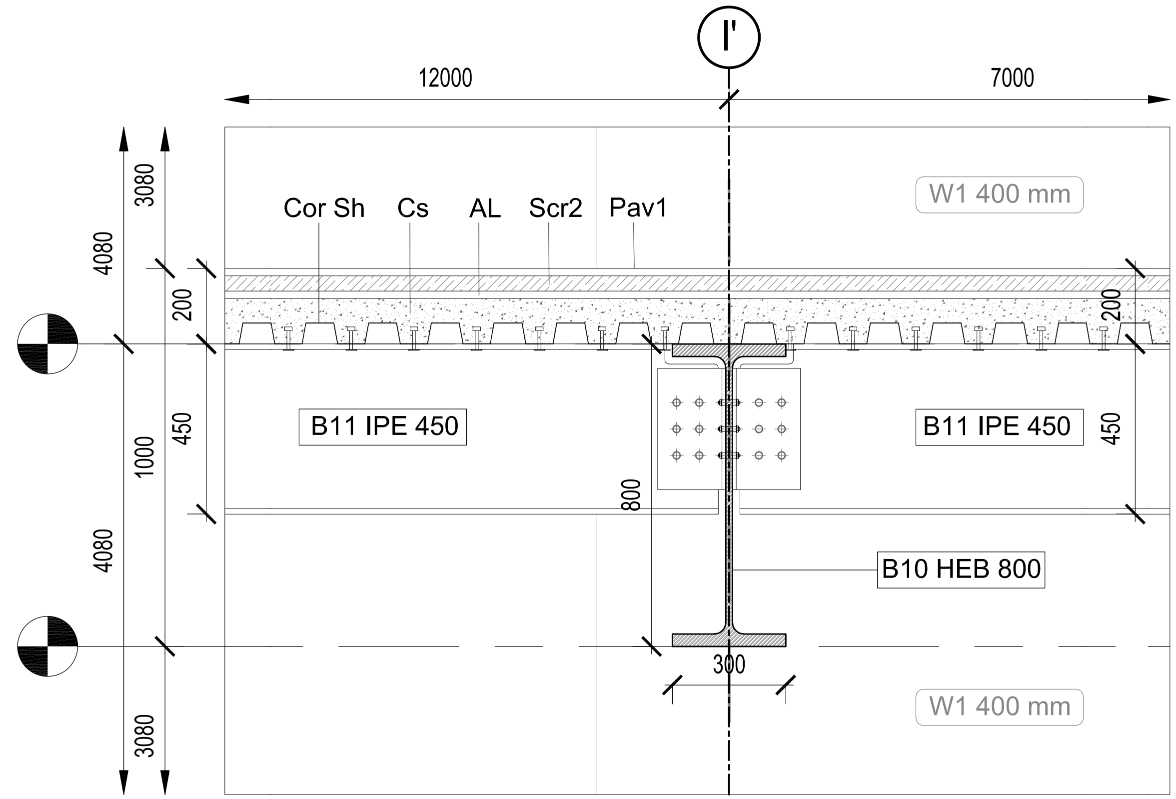
CHECK - MAXIMAL DISPLACEMENTS FOR RARA COMB (D + L)					
SHEAR FORCE OF THE SECONDARY BEAMS (NO COEFF)					
Vmax:	0	68.29	148.8	105.31	74.4
Vmin:	-74.4	-105.31	-148.8	-68.29	0

RESULTANT REACTION FORCES		
x=10	254.11	kN

CONTINUOUS STEEL BEAM - 1 SPAN		
L	12	
PERMANENT LOADS		
G1'	21.6	
POINT LOADS		
x = 3	254.11	kN
x = 6	254.11	kN
x = 9	254.11	kN
Delta Max L/200	60	mm

Delta Software	$EI\delta_{span} =$	25808.00	
	$\delta =$	34.89	OK

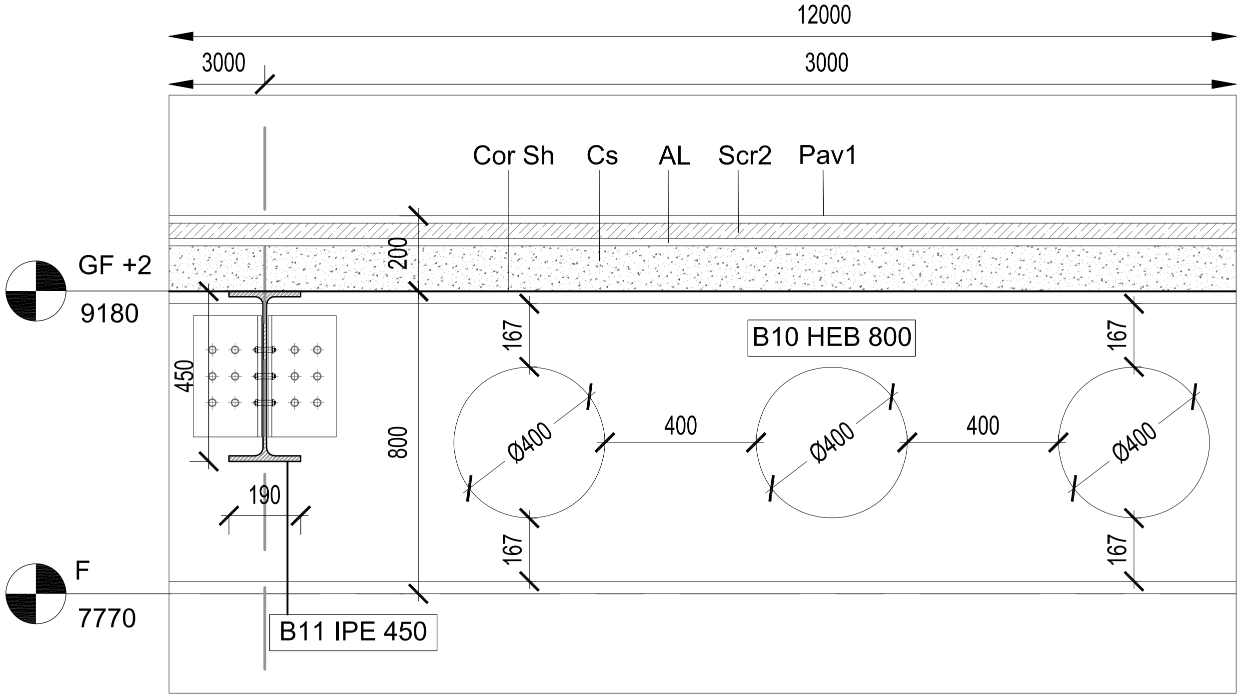
Beams and slabs details and connections



Composite Slab, Finishing Layers and Beams
Detail | Scale 1:20

Technical Description

W1 |	-	; 400	mm	; reinforced concrete
B10 |	HEB 800	; 800 x 300	mm	; steel
B11 |	IPE 450	; 450 x 119	mm	; steel
Cor Sh |	Corrugated Sheet	; 1	mm	; Galvanised steel
Cs |	Concrete System	; 120	mm	; Reinforced Concrete
AL |	Acoustic Layer	; 20	mm	; Cork Fibers
Scr2 |	Screed	; 40	mm	; Concrete
Pav1 |	Pavement	; 20	mm	; Ceramic



Composite Slab, Finishing Layers and Beams

Detail| Scale 1:20

Technical Description

W1 |	-	; 400	mm	; reinforced concrete
B10 |	HEB 800	; 800 x 300	mm	; steel
B11 |	IPE 450	; 450 x 119	mm	; steel
Cor Sh |	Corrugated Sheet	; 1	mm	; Galvanised steel
Cs |	Concrete System	; 120	mm	; Reinforced Concrete
AL |	Acoustic Layer	; 20	mm	; Cork Fibers
Scr2 |	Screed	; 40	mm	; Concrete
Pav1 |	Pavement	; 20	mm	; Ceramic

Elements identification on typical plan: Block C - Media Library

Structural Plan

Level GF +2 | Scale 1:500

Elements identification on typical plan: Block D - Fitness and Wellness

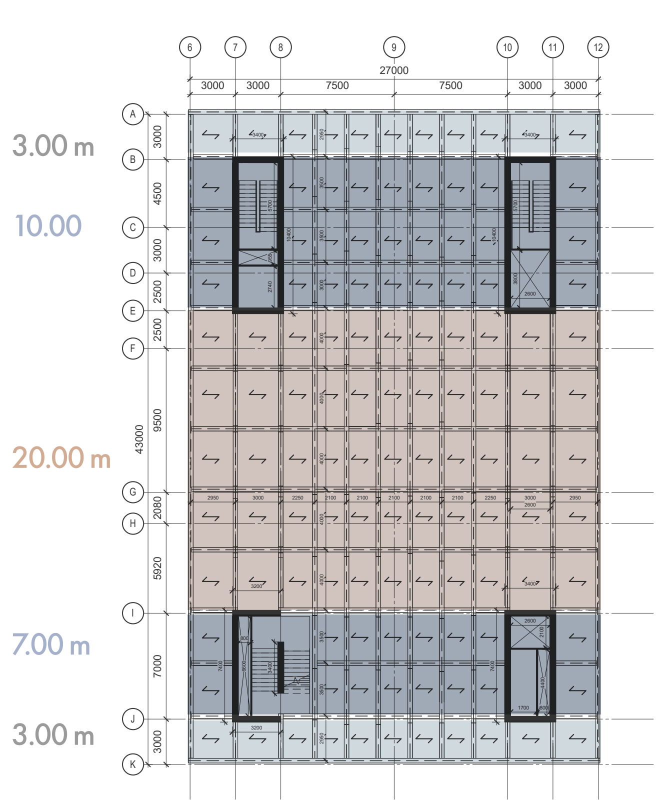
Structural Plan

Level GF +2 | Scale 1:500

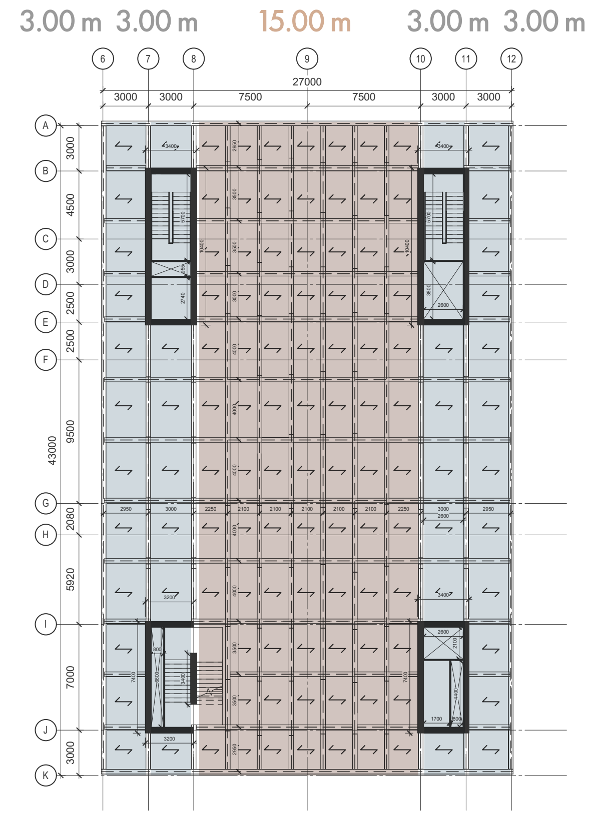
CHAPTER 03

SPECIAL STRUCTURE: BLOCK A

Dimensions, heights and relation with architecture



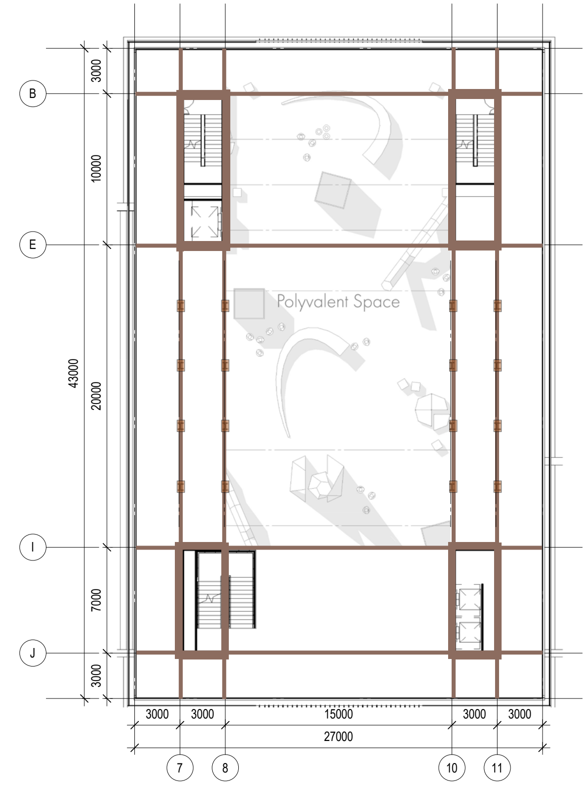
Horizontal Spans and Axis Distribution
Level GF+2 | Scale 1:500



Vertical Spans and Axis Distribution
Level GF+2 | Scale 1:500

A large span (20 m) crosses the block horizontally , and another smaller one (15 m) vertically, allowing to house a big auditorium for 600 people (GF-1,GF,GF+1); and a big polyvalent space (GF+2) for exhibitions, shows,events ...

The cores are mainly used for circulation, both for day-to-day movements and evacuation for safety reasons. On the last level, balconies are defined on the large span of 20 m overlooking the large event space beneath.

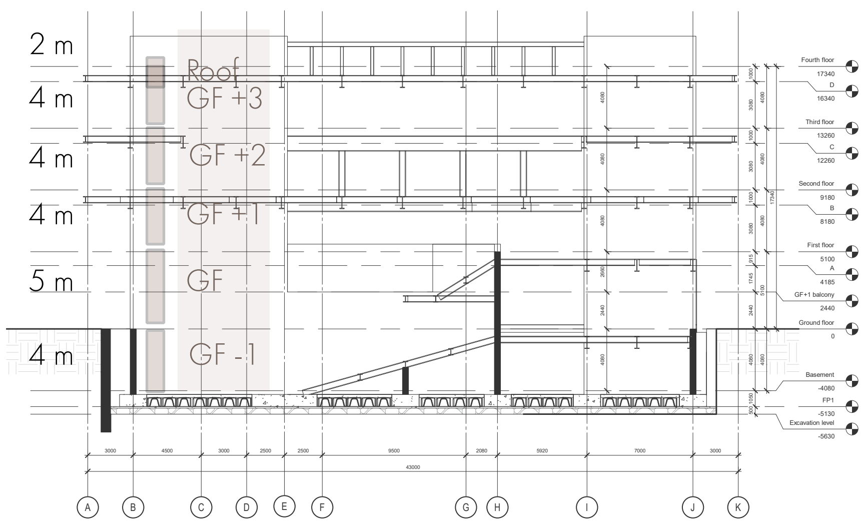


Ovelapping of Structure and Architecture
Level GF+2 | Scale 1:500

For the special part of this project, we will focus on block A, Culture and events; more specifically, the design and calculation of the virendeel truss spanning horizontally the 20 meters.

To the right is an exploded axonometry of Block A's structural system showing the different levels and the 20 m large span.

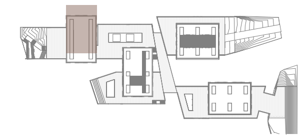
We will start by developping the upper block, consisting of the levels GF+2, GF+3 and GF+4(roof).

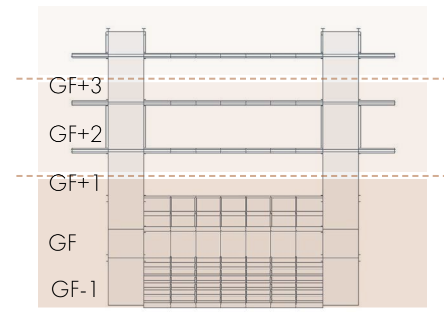


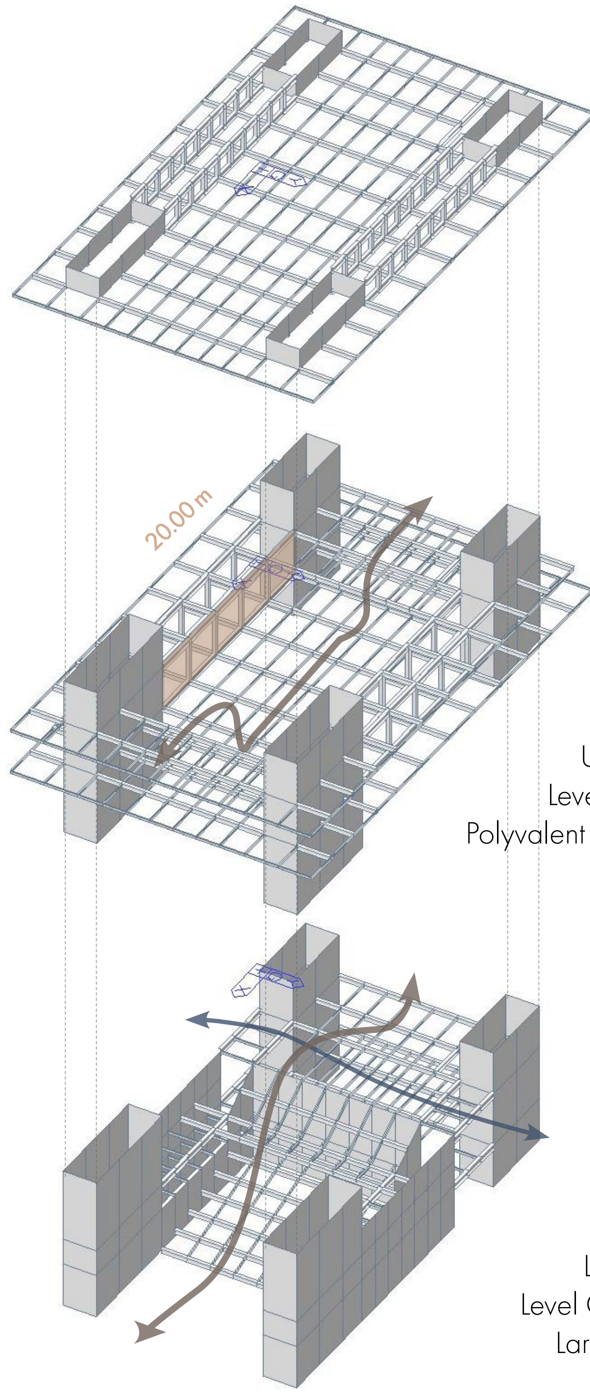
Vertical Section
Scale 1:500

3.1. Structural load calculations

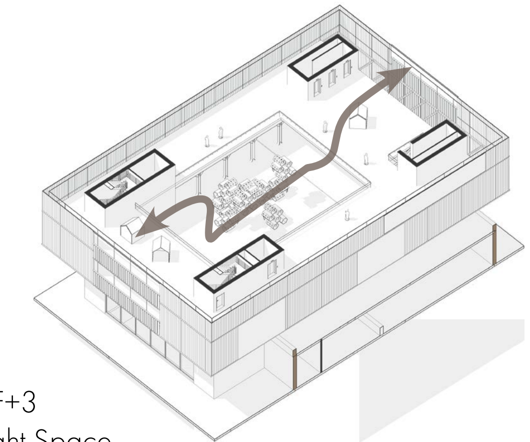
Structural concept



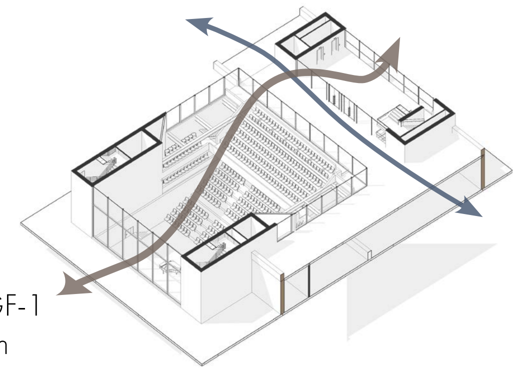




Roof
Level GF+4



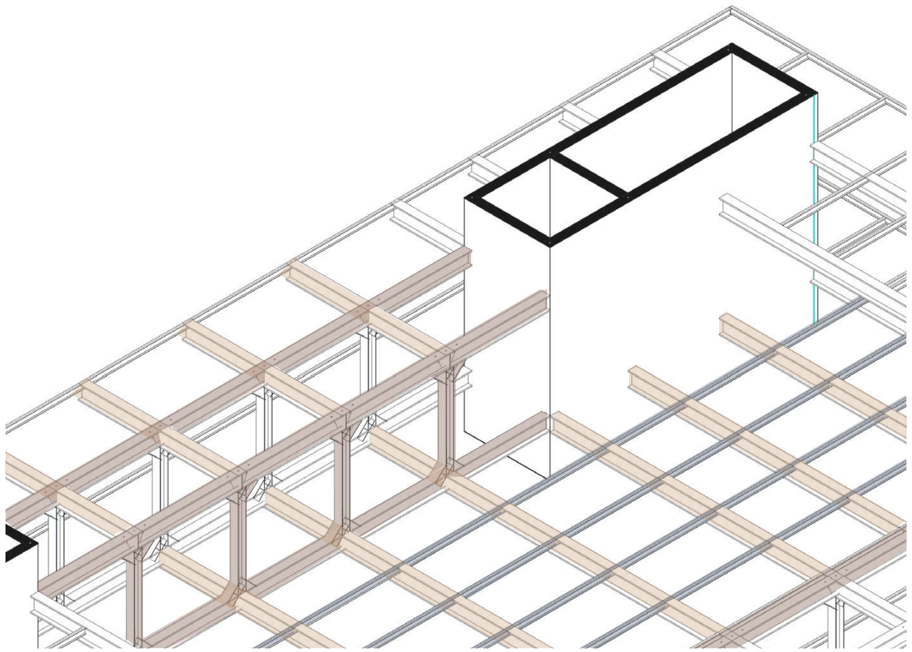
Upper Block
Level GF+2_GF+3
Polyvalent double-height Space

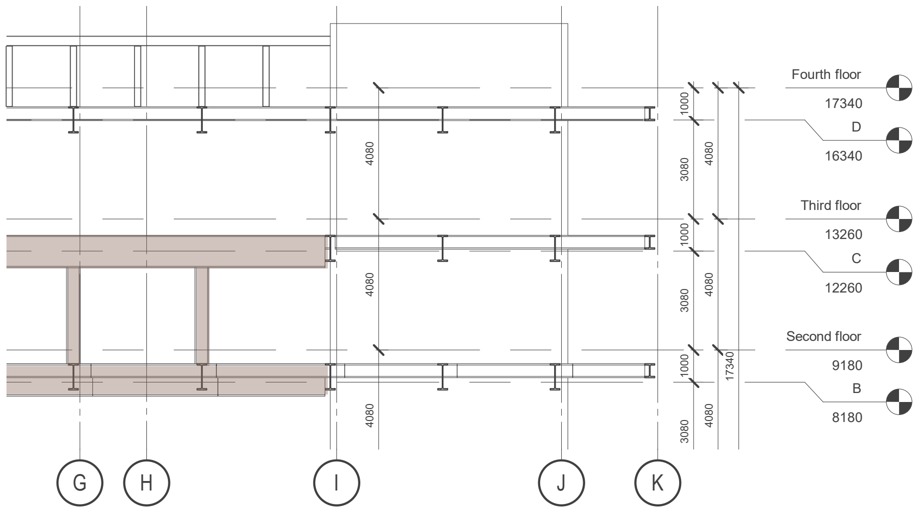


Lower block
Level GF+1_GF_GF-1
Large Auditorium

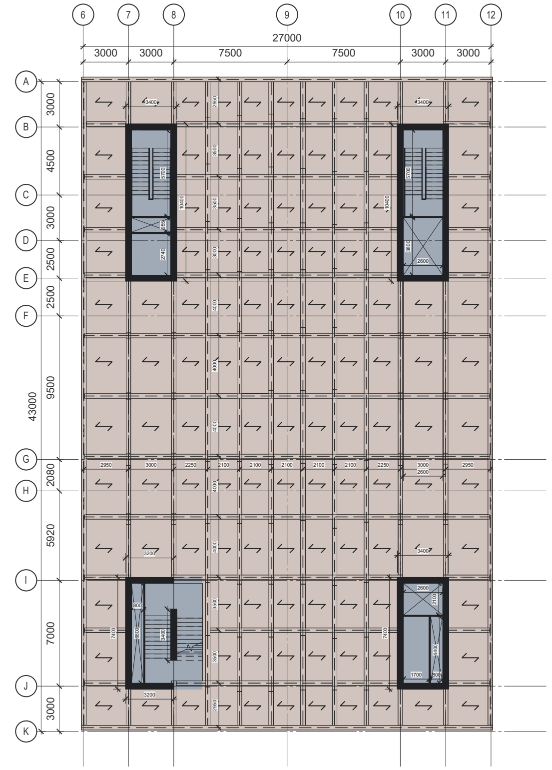
Structure hierarchy

- Concrete Cores, the only point of contact with the ground.
- Virendeel Truss, full floor 4m height, mechanically fixated on the concrete cores.
- Primary Beams, mechanically fixated on the virendeel truss, max span of 15m.
- Secondary Beams, mechanically fixated on Primary Beams, through metallic plates and bolts.
- Composite Slab, supported by the Secondary Beams





Live loads distribution scheme



Distribution of Live Loads on a Plan
Block A | Level GF+2 | Scale 1:500

- Spaces with no obstacles and major spaces of assembly LL= 4 kN/m.
- Stairs and Emergency Stairs 4 kN/m

With also, not present on this plan:

- Technical Inaccessible Roof 2 kN/m
- Small Offices 2 kN/m
- Spaces equipped with tables (classrooms, lecture rooms, reception, meeting room...) 3 kN/m.

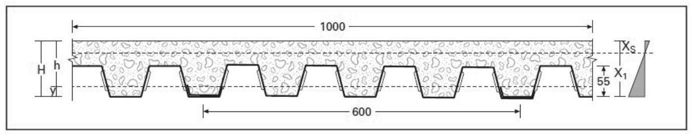
N.B: The partitions are also added to the live loads as being equal to 2 kN/m

Slab type and loads

The project is designed as having a composite aluminum sheet slab. This slab of a height of 12 cm weights as the G1" floor self weight. It is present at all levels of the blocks and is held by the primary and secondary beams. It is covered by a set of finishing layers that count as the G2 dead weight.

DEAD LOAD - FLOOR SELF WEIGHT - G1"										
Layer	Length		Width		Height		Volumetric weight		Weight	
Concrete layer	1.0	m	1.0	m	0.09	m	24	kN/m3	2.2	kN/m2
Area load G1"									**2.2**	**kN/m2**

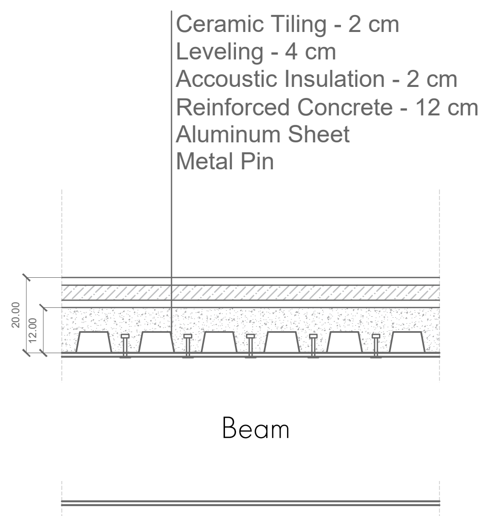
DEAD LOAD - COMPOSITE SLAB WEIGHT- G2										
Layer	Length		Width		Height		Volumetric weight		Weight	
Ceramic	1.0	m	1.0	m	0.02	m	20	kN/m3	0.4	kN/m2
Levelling	1.0	m	1.0	m	0.04	m	10	kN/m3	0.4	kN/m2
Accoustic Layer	1.0	m	1.0	m	0.02	m	0	kN/m3	0.0	kN/m3
Aluminum Sheet	1.0	m	1.0	m	0.01	m	25	kN/m3	0.1	kN/m2
Area load G2									**0.9**	**kN/m2**



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	

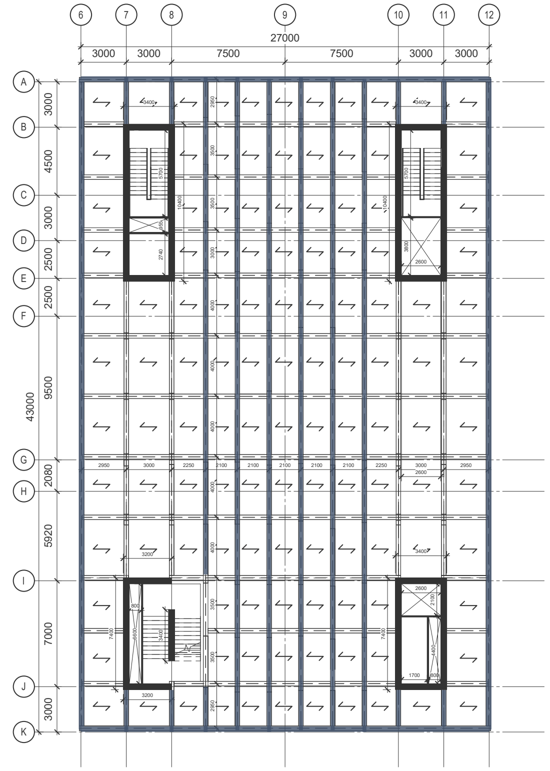
We consider 9.25 cm out of the height of 12 cm of slab to be in concrete.



Composite slab and finishing layers | Scale 1:20

3.2. Beam design

Beam loading system



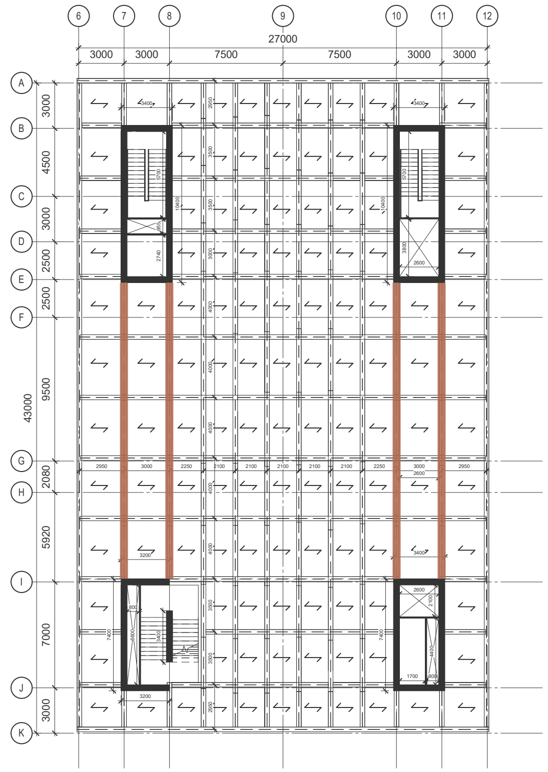
Secondary Beams Distribution
Level GF+2 | Scale 1:500

The system presents a hierarchy of primary and secondary beams that span from core to core or from extremity to extremity of the block, on which a composite slab rests. Four Vierendeel beams join the cores together on the large span of 20 meters.

The secondary beams hold the composite slab and its finishing layers. The primary and secondary beams are fixated mechanically together, through metallic plates. The primary beams transfer all the loads to the vierendeel beams as nodal loads.

The vierendeel beam supports its self weight and the loads transferred to it by the primary beams (that consists of the self-weight of the primary and secondary beams, the live load, and the floor load).

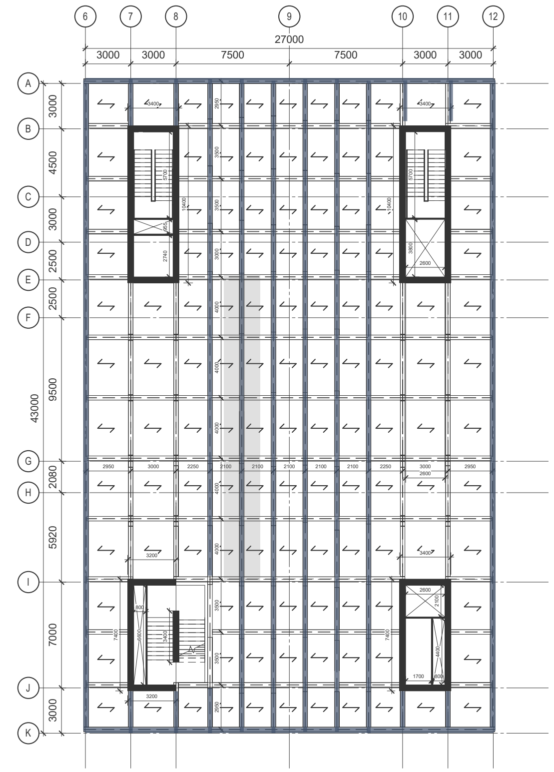
Primary Beams Distribution
Level GF+2 | Scale 1:500



Vierendeel Beams Distribution
Level GF+2 | Scale 1:500

In the following calculations, the slabs held by the beams are all considered to be unidirectional slabs, performing in the same direction (East-West).
In spans, we assign a Live Load of 4 kN/m, them being major spaces of assembly (see LL distribution p.16)

Secondary beam predimensioning and loads



Secondary Beams Distribution
Level GF+2 | Scale 1:500

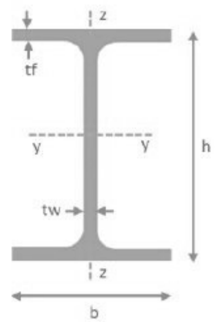
For this block, we assume the same type of composite slab, with the same set of finishing layers, consequently the same dead load.
This slab is supported directly by the secondary beams.

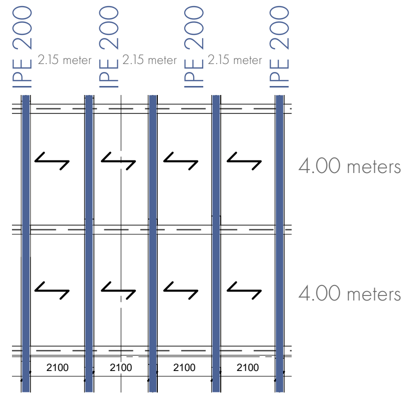
This beam is calculated as being continuous, it spans five 4m spans, crossing six primary beams. It has an influence area width of 2.18 meters. We predimention it as being an IPE 200.

LEGENDA

- A = area
- Iy = momento d'inerzia
- Wy = moduli di resistenza elastico
- Wpl,y = modulo di resistenza plastico
- iy = raggio d'inerzia
- Iz = momento d'inerzia
- Wz = moduli di resistenza elastico
- Wpl,z = modulo di resistenza plastico
- iz = raggio d'inerzia
- JT = fattore di rigidezza torsionale
- Iw = momento d'inerzia settoriale

Profili IPE





Profilo	g (Kg/m)	h (mm)	b (mm)	tw (mm)	tf (mm)	r1 (mm)	r2 (mm)	A (cm2)	Iy (cm4)	Wy (cm3)	Wpl,y (cm3)
IPE 80	6	80	46	3.8	5.2	5	0	7.64	80.14	20.03	23.22
IPE 100	8.1	100	55	4.1	5.7	7	0	10.32	171	34.2	39.41
IPE 120	10.4	120	64	4.4	6.3	7	0	13.21	317.8	52.96	60.73
IPE 140	12.9	140	73	4.7	6.9	7	0	16.43	541.2	77.32	88.34
IPE 160	15.8	160	82	5	7.4	9	0	20.09	869.3	108.7	123.9
IPE 180	18.8	180	91	5.3	8	9	0	23.95	1317	146.3	166.4
IPE 200	22.4	200	100	5.6	8.5	12	0	28.48	1943	194.3	220.6
IPE 220	26.2	220	110	5.9	9.2	12	0	33.37	2772	252	285.4
IPE 240	30.7	240	120	6.2	9.8	15	0	39.12	3892	324.3	366.6

DEAD LOAD - STEEL BEAM SELF WEIGHT - G1'				
TYPE	IPE 200			
B	10	cm	0.1	m
H	20	cm	0.2	m
Material density	9000	kg/m3	90	kN/m3
Linear load G1'			**1.8**	**kN/m**

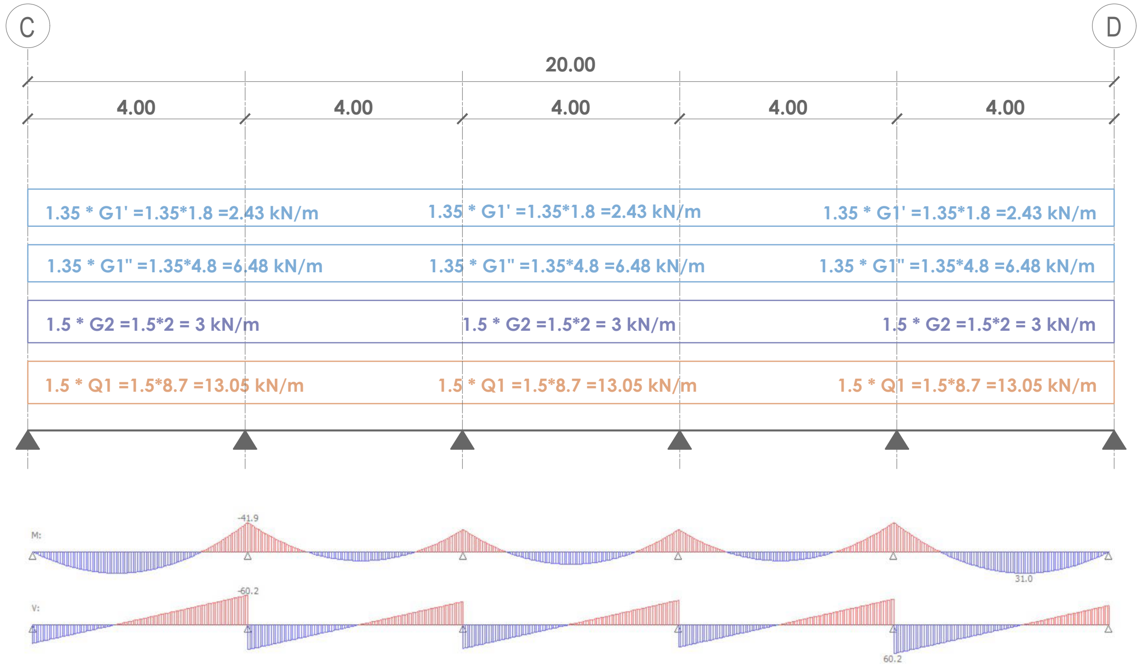
Secondary beam design and checks

We find the Total Beam Load by multiplying the results with the respective coefficients.
We use the Influence area width as being 2.18 meters. We input the beam loads after multiplication with the coefficients into the software, to check the maximal bending moment, the maximal shear force, and the maximal displacement.

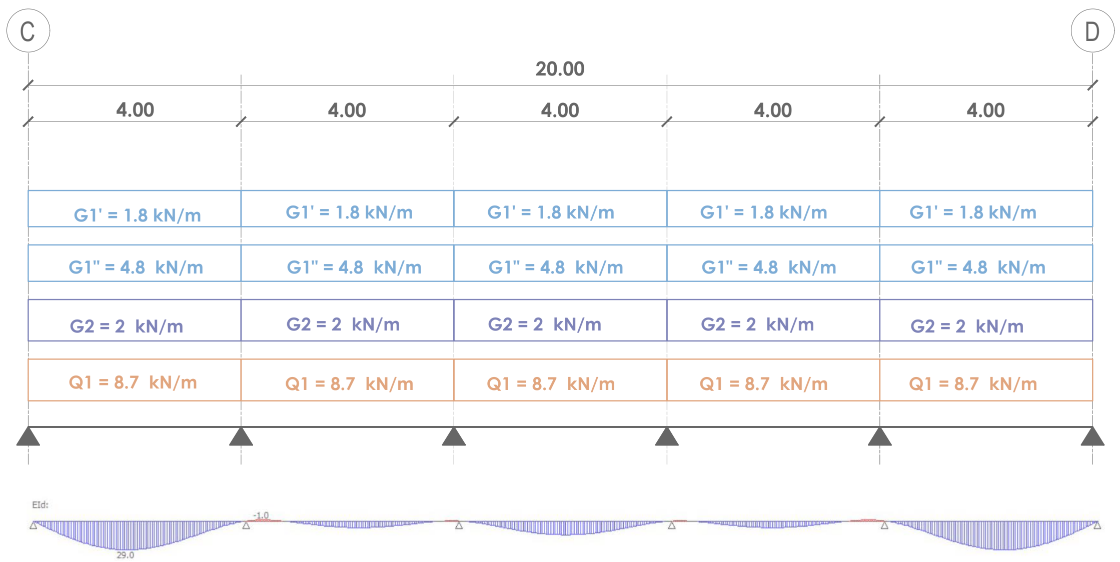
SECONDARY BEAMS LOAD CALCULATION			
	Influence area width	2.18	m
Dead load: Floor self weight	Linear load G1"	2.2	kN/m2
		4.8	kN/m
Dead load: Beam self weight	Linear load G1'	1.8	kN/m
Dead load	G1'+G1"	6.6	kN/m
	Area load G2	0.9	kN/m2
Dead load: Floor Self weight	Linear load G2	2.0	kN/m
	Area load Q1	4.0	kN/m2
Live load: Major Assembly	Linear load Q1	8.7	kN/m
Dead load: Beam self weight	Linear load G1	6.6	kN/m
Dead load: Floor Self weight	Linear load G2	2.0	kN/m
Live load: Residential	Linear load Q1	8.7	kN/m
	Coefficient for G1	1.35	-
	Coefficient for G2	1.50	-
	Coefficient for Q1	1.50	-

EXTERNAL BENDING MOMENT CAFLCULATIONS		
Load_ULS COMB	24.88	kN/m
Load_RARA COMB	17.24	kN/m
Load_LIVE COMB	8.7	kN/m

** These checks serve only a preliminary design because they are not quite accurate as the supports modelled are not really fixed this way and the secondary beam will in fact be affected by the primary beams. Therefore, the forces, moments and displacements will also be affected, and they will be rechecked on MIDAS.*



ULS - Bending Moment and Shear Force Diagram from the Software



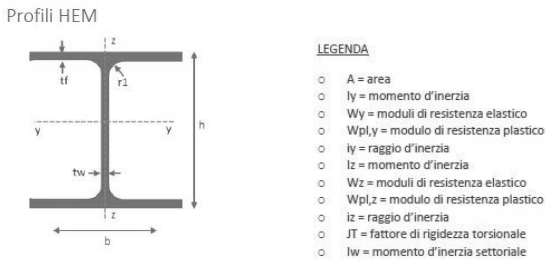
SLS - Displacement Diagram from the Software

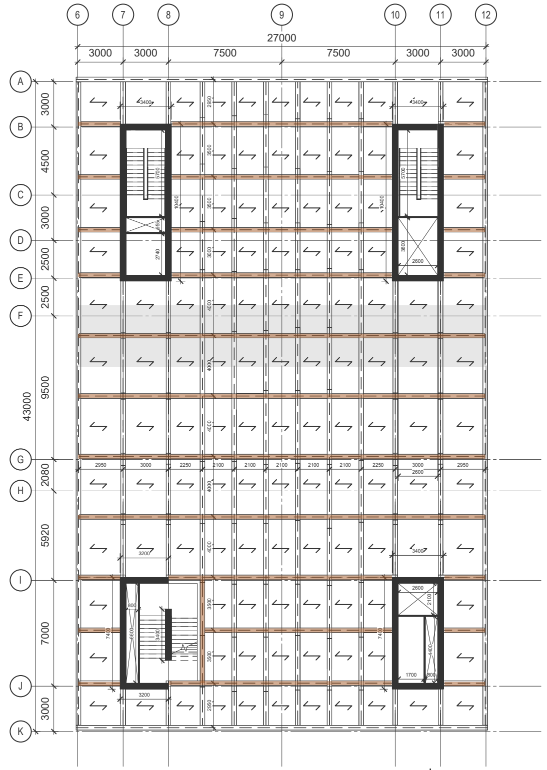
After chosing the steel class and calculating, the checks confirm a proper predimensioning: Secondary beam as IPE200.

SECONDARY STEEL BEAM SYSTEM					
Beam Type	IPE 200				
Beam Lenght L	4.00	m	4000	mm	
Influence area width	2.18	m			
Linear load G1'	1.80	kN/m			
Linear load G1"	2.20	kN/m2			
	4.79	kN/m			
G1' + G1"	6.59	kN/m			
Area load G2	0.90	kN/m2			
Linear load G2	1.96	kN/m			
Area load Q1	4.00	kN/m2			
Linear load Q1	8.70	kN/m			
EXTERNAL BENDING MOMENT CAFLCULATIONS					
Load_ULS COMB	24.88	kN/m			
Load_RARA COMB	17.24	kN/m			
Load_LIVE COMB	8.7	kN/m			
M_ED_ULS	41.90	kNm	41900000 Nmm		SOFTWARE
STEEL CLASS					
Steel class	355				
fyk	355	MPa			
ys	1.05				
fyd	338	MPa			
Wpl	123930	mm3	124	10^3 mm3	
Wpl chosen	220.6	10^3 mm3	OK		
Iy chosen	1943	10^4 mm4			
E	206000	MPa			
CHECK - MAXIMAL DISPLACEMENTS FOR RARA COMB (D + L)					
Delta Max L/200	20	mm			
Delta Simple Beam	$\delta = \frac{5}{384}\frac{ql^4}{EI} =$	14.36	OK		
Delta Software	$EI\delta_{span} =$	29.00			
	$\delta =$	7.25	OK		
CHECK - SHEAR ULS COMB					
	IPE 200				
h_section	200	mm			
tw_section	5.6	mm			
r_section	12	mm			
tf_section	8.5	mm			
Av (area resisting shear)	1528.00	mm2			
V_Ed_ULS	49.75	kN			
Software Value	60.2	kN			
V_Rd	298.26	kN	OK		

Primary beam predimensioning and loads

This beam is calculated as being continuous, it spans two 3m cantilevers, two intermediate 3m spans and one middle 15 m span.
It links 6 secondary beams and 4 vierendeel beams with an influence area width of 4 meters. It is predimensioned as being an HEM 340.





Primary Beams Distribution
Level GF+2 | Scale 1:500

Profilo	g (Kg/m)	h (mm)	b (mm)	tw (mm)	tf (mm)	r1 (mm)	r2 (mm)	A (cm2)	Iy (cm4)	Wy (cm3)	Wpl,y (cm3)
HE 280 M	189	310	288	18.5	33	24	0	240.2	39550	2551	2966
HE 300 M	238	340	310	21	39	27	0	303.1	59200	3482	4078
HE 320 M	245	359	309	21	40	27	0	312	68130	3796	4435
HE 340 M	248	377	309	21	40	27	0	315.8	76370	4052	4718

DEAD LOAD - STEEL BEAM SELF WEIGHT - G1'				
TYPE	HEM 340			
B	30.9	cm	0.309	m
H	37.7	cm	0.377	m
Material density	9000	kg/m3	90	kN/m3
Linear load G1'			**10.5**	**kN/m**

Primary beam design and checks

The beam holds its own self weight as uniform load, and the loads transferred from the secondary beams (G1+G2+Q1) as point loads along its length (one secondary beam each 2.1-2.2 meters). The nodal loads of the primary beam, transferred from the secondary beams, are deducted from the reaction forces of these secondary beams at the point of crossing (x=4). It is equal to 112.62 kN. The nodes span from 2.25 to 2.15m with a total number of 5 spans (L=15m is the max middle span).

We input the beam loads after multiplication with the coefficients into the software, to check the maximal bending moment, the maximal shear force, and the maximal displacement.

SHEAR FORCE OF THE SECONDARY BEAMS					
Vmax:	39.28	52.38	49.76	47.14	60.24
Vmin:	-60.24	-47.14	-49.76	-52.38	-39.28

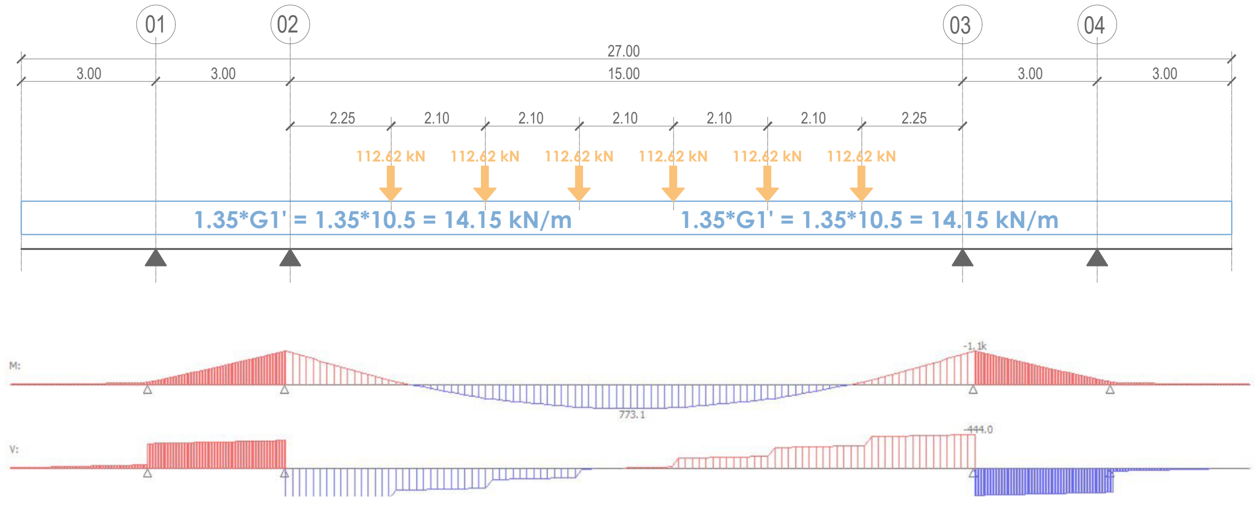
RESULTANT REACTION FORCES		
x=4	**112.62**	kN

CONTINUOUS PRIMARY BEAM				
Beam Type	HEM 340			
Beam Total Lenght L	15	m	15000	mm

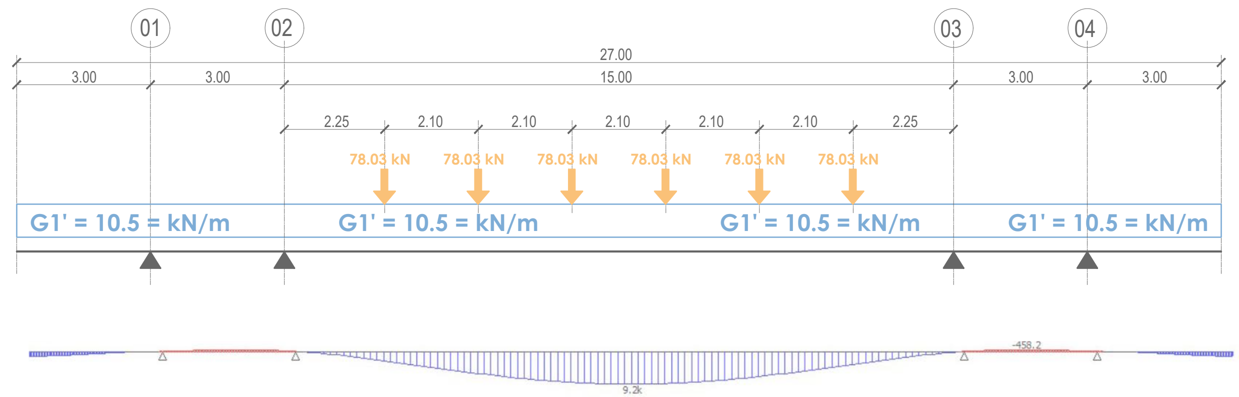
PERMANENT LOADS				
G1'	10.5	* 1.35 =	14.15	kN/m
POINT LOADS				
x' = 2.25	112.6	kN		
x' = 4.35	112.6	kN		
x' = 6.45	112.6	kN		
x' = 8.55	112.6	kN		
x' = 10.65	112.6	kN		
x' = 12.75	112.6	kN		

RESULTS FOR MAIN SPAN		
Mmax:	1094.51	kNm
Vmax:	443.99	kN

** These checks serve only a preliminary design because they are not quite accurate as the supports modelled are not really fixed this way and the secondary beam will in fact be affected by the primary beams. Therefore, the forces, moments and displacements will also be affected, and they will be rechecked on MIDAS.*



ULS - Bending Moment and Shear Force Diagram from the Software



SLS - Displacement Diagram from the Software

After chosing the steel class and calculating, the checks confirm a proper predimensioning: Primary beam as HEM 340.

CHECKS FOR CONTINUOUS STEEL BEAM			
M_ED_ULS	1094.51	kNm	1094510000 Nmm

STEEL CLASS				
Steel class	355			
fyk	355	MPa		
γs	1.05			
fyd	338	MPa		
Wpl	3237283	mm3	3237	10^3 mm3
Wpl chosen	4718	10^3 mm3		
Iy chosen	76370	10^4 mm4		
E	206000	MPa	OK	

CHECK - SHEAR ULS COMB			
	HEM 340		
h_section	377	mm	
tw_section	21	mm	
r_section	27	mm	
tf_section	40	mm	
Av (area resisting shear)	12237.00	mm2	
V_Ed_ULS			
Software Value	443.99	kN	
V_Rd	2388.65	kN	OK

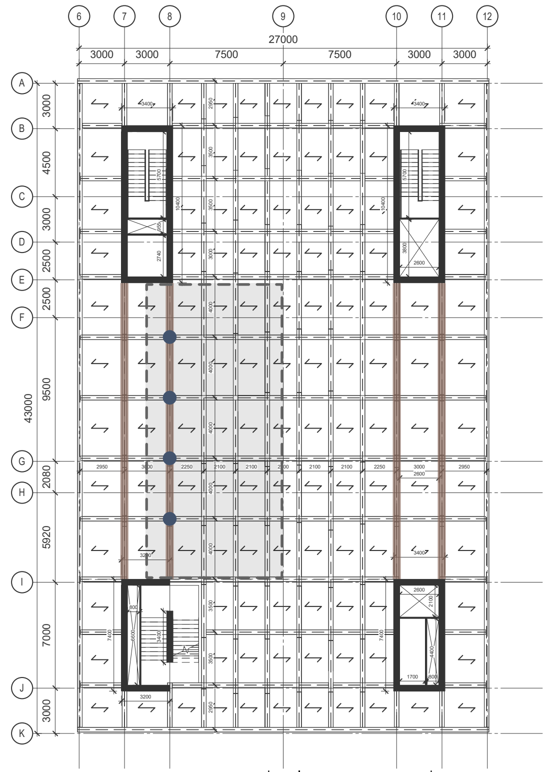
CHECK - MAXIMAL DISPLACEMENTS FOR RARA COMB (D + L)					
SHEAR FORCE OF THE SECONDARY BEAMS (NO COEFF)					
Vmax:	27.22	36.29	34.48	32.67	41.74
Vmin:	-41.74	-32.67	-34.48	-36.29	-27.22

RESULTANT REACTION FORCES		
x=10	**78.03**	kN

CONTINUOUS STEEL BEAM - 1 SPAN			
L		15	
PERMANENT LOADS			
G1'		10.5	
POINT LOADS			
x = 3		78.03	kN
x = 6		78.03	kN
x = 9		78.03	kN
Delta Max L/200		75	mm
Delta Software	$EI\delta_{span}$ =	9200.00	
	δ =	58.48	OK

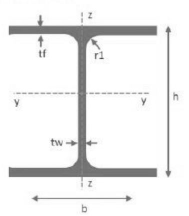
Vierendeel beam predimensioning and loads

The beam holds its own self weight and the loads transferred from the primary beams , (one primary beam each 4 meters).
It spans 20 m between two concrete cores.
It is predimensioned as being an HEM 500 for the horizontal elements.
For the design of this truss, we will resort to modelling this block in MIDAS, imputting the necessary floor loads, and deducting the beam stresses, bending moment, shear force, vertical displacement.. for the final checks.



Vierendeel Beams Distribution
Level GF+2 | Scale 1:500

Profili HEM



LEGENDA

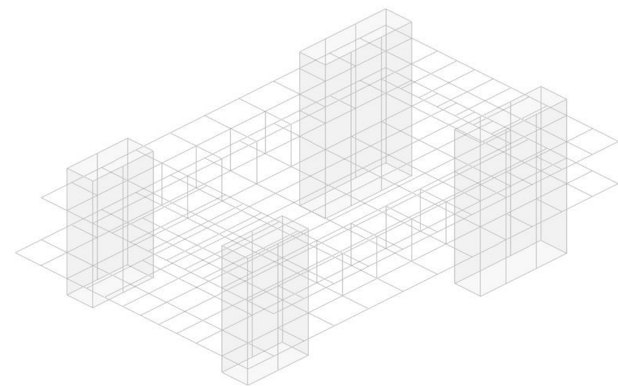
- A = area
- Iy = momento d'inerzia
- Wy = moduli di resistenza elastico
- Wpl,y = modulo di resistenza plastico
- iy = raggio d'inerzia
- Iz = momento d'inerzia
- Wz = moduli di resistenza elastico
- Wpl,z = modulo di resistenza plastico
- iz = raggio d'inerzia
- JT = fattore di rigidezza torsionale
- Iw = momento d'inerzia settoriale

Profilo	g (Kg/m)	h (mm)	b (mm)	tw (mm)	tf (mm)	r1 (mm)	r2 (mm)	A (cm2)	Iy (cm4)	Wy (cm3)	Wpl,y (cm3)
HE 360 M	250	395	308	21	40	27	0	318.8	84870	4297	4989
HE 400 M	256	432	307	21	40	27	0	325.8	104100	4820	5571
HE 450 M	263	478	307	21	40	27	0	335.4	131500	5501	6331
HE 500 M	270	524	306	21	40	27	0	344.3	161900	6180	7094
HE 550 M	278	572	306	21	40	27	0	354.4	198000	6923	7933
HE 600 M	285	620	305	21	40	27	0	363.7	237400	7660	8772

MIDAS analysis | Steps

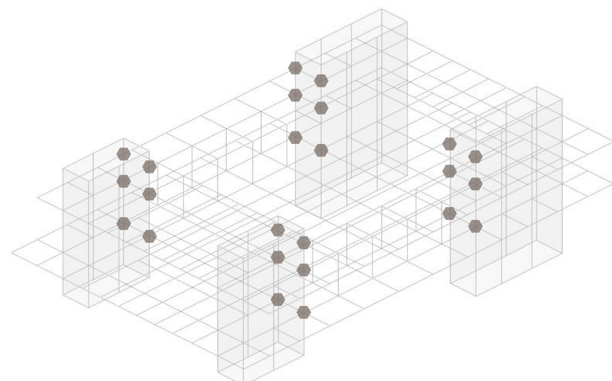
1- Modeling on Midas

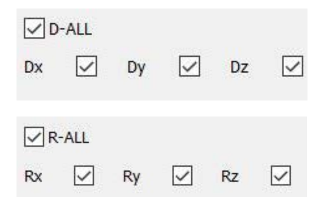
Only the two floors supported by the truss are modelled (GF+2; GF+3); those being one full floor supported on the lower level, and two smaller portions supported on the upper level.

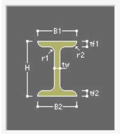


2- Supports

The vierendeel trusses are fixated on concrete cores. Therefore, all displacement and rotational degrees-of-freedom are restrained.



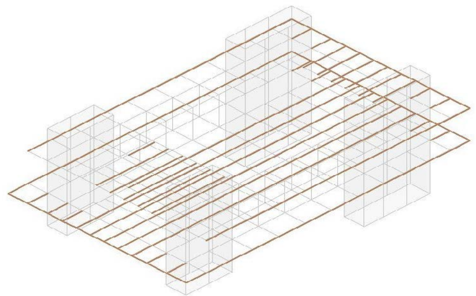




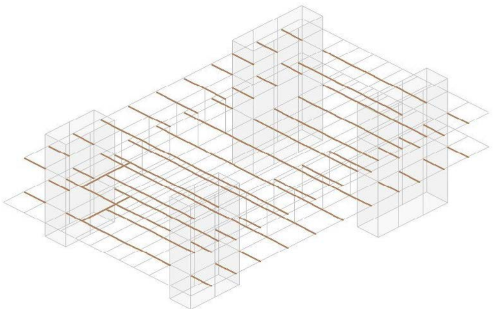
3- Materials & sections

The assigned material for these sections is S355

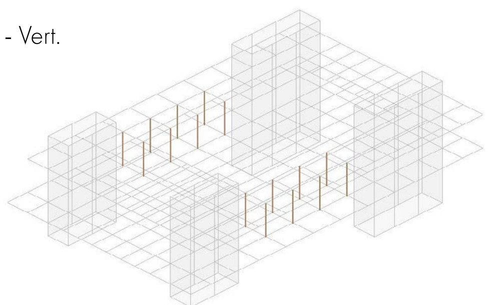
Secondary beams
IPE200



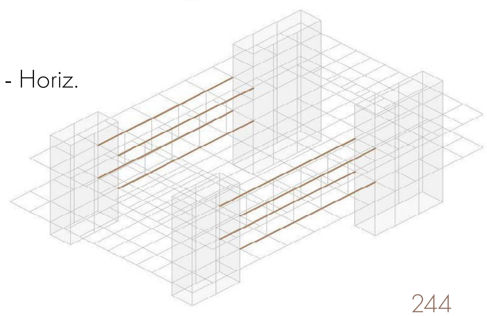
Primary beams
HEM 340



Vierendeel beams - Vert.
HEM 300



Vierendeel beams - Horiz.
HEM 500



4- Loads

The dead loads assigned to each floor are relative to the components and layers of the slab. To this is added the self weight of all the elements. The slabs held by the beams are all considered to be unidirectional slabs.

The system of loads is computed into the MIDAS software to check the maximal beam stress, bending moment, the maximal shear force, and the maximal displacement of each element constituting this vierendeel beam.

	No	Name	Type	Description
▶	1	Q1	Live Load (L)	Floor Live Load
	2	G1"	Dead Load (D)	Floor Structural Load
	3	G2	Dead Load (D)	Floor Non-structural Load
	4	G1'	Dead Load (D)	Beam Self-weight
*				

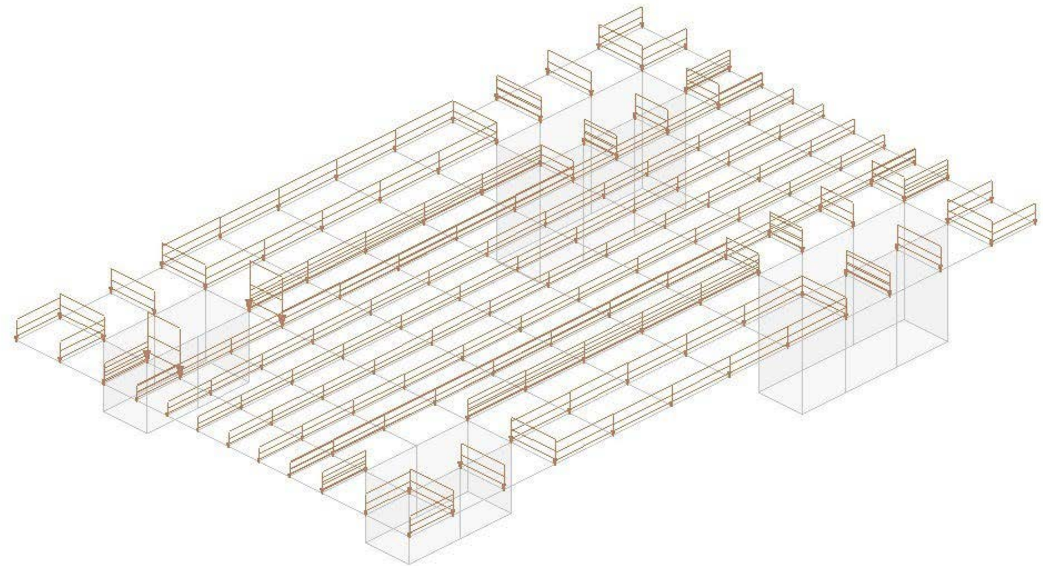
Floor Load Type Name & Description

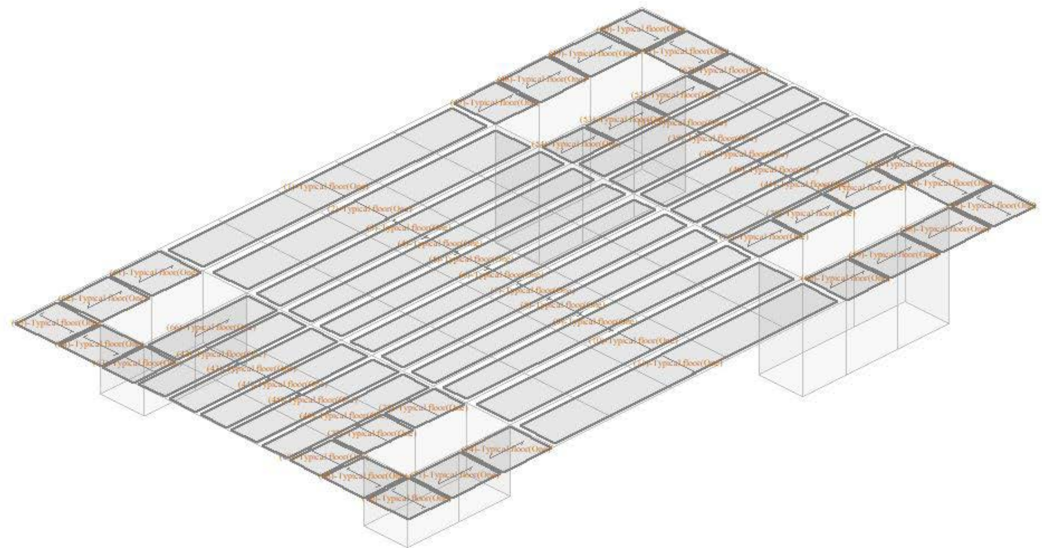
Name : Typical floor

Description : G1" + G2 + Q1

Floor Load & Load Case

	Load Case	Floor Load		
1.	Q1	-4	...	kN/m^2
2.	G1"	-2.2	...	kN/m^2
3.	G2	-0.9	...	kN/m^2

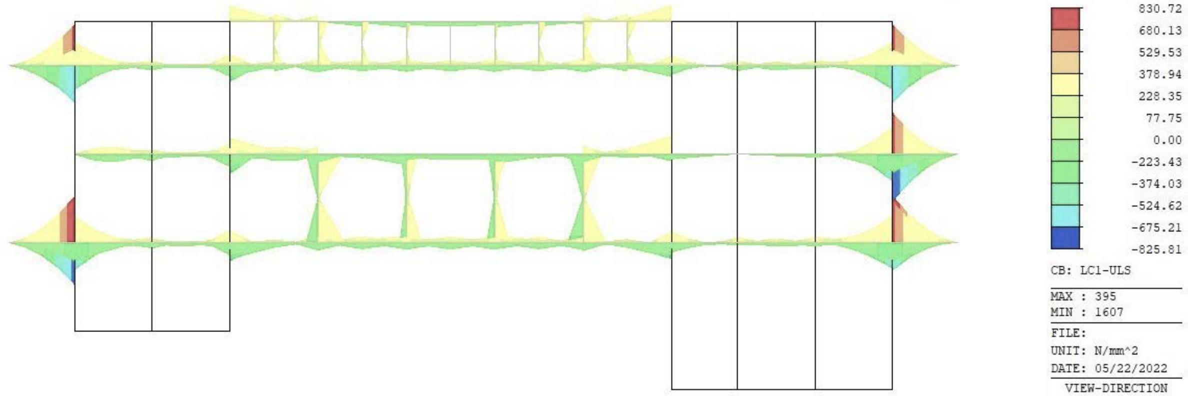




Floor Loads | Level GF+2

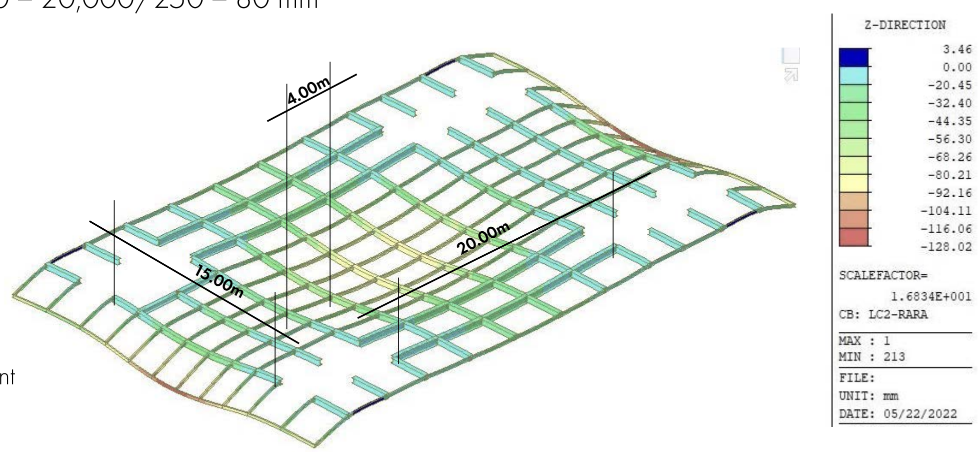
MIDAS analysis | First results

A - Results of Combined Load case - max. min. **Beams Stress**
Load Combination (ULS): 1.35*G1"+1.35*G1'+1.5*Q1+1.5*G2
Using steel of S355, the stress should be less than: 355/1.15= 308.70



As the results showed, the beam stress are much higher than the tolerated value 308.70.
Therefore, an increase of the sections is needed.

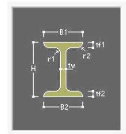
B - Results of Combined Load case - max. min. **Vertical Displacement**
Load Combination (SLS): G1"+ G1'+ Q1+ G2; The max. allowed displacement for each of the beams is:
Secondary: L/200 = 4,000/200 = 20 mm
Primary: L/250 = 15,000/250 = 60 mm
Virendeel: L/250 = 20,000/250 = 80 mm



Vertical Displacement
Level GF+2

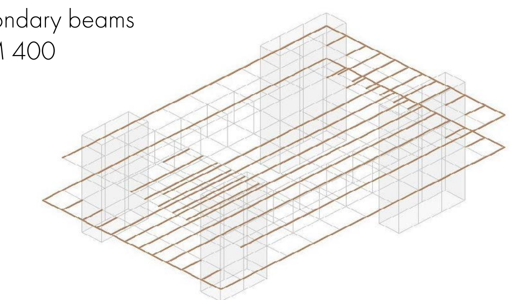
As the results showed, the vertical displacements are much higher than the tolerated values.
Therefore, an increase of the sections is needed.

MIDAS analysis | Final results

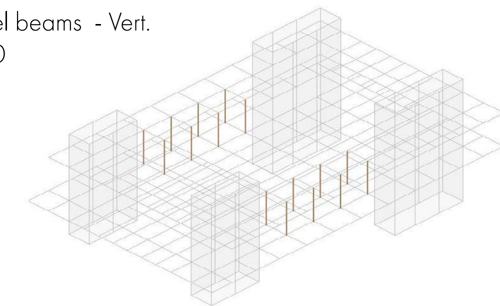


1- Materials & sections
The assigned material for these sections is S355

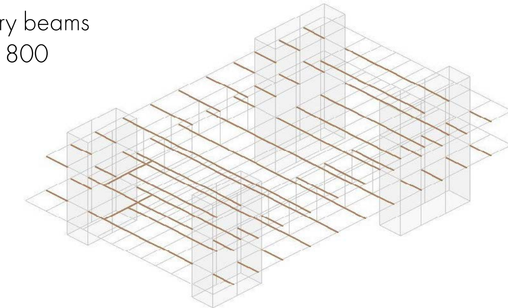
Secondary beams
HEM 400



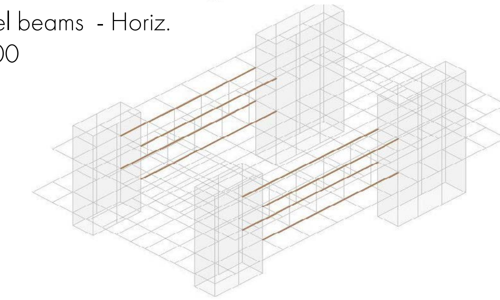
Vierendeel beams - Vert.
HEM 400



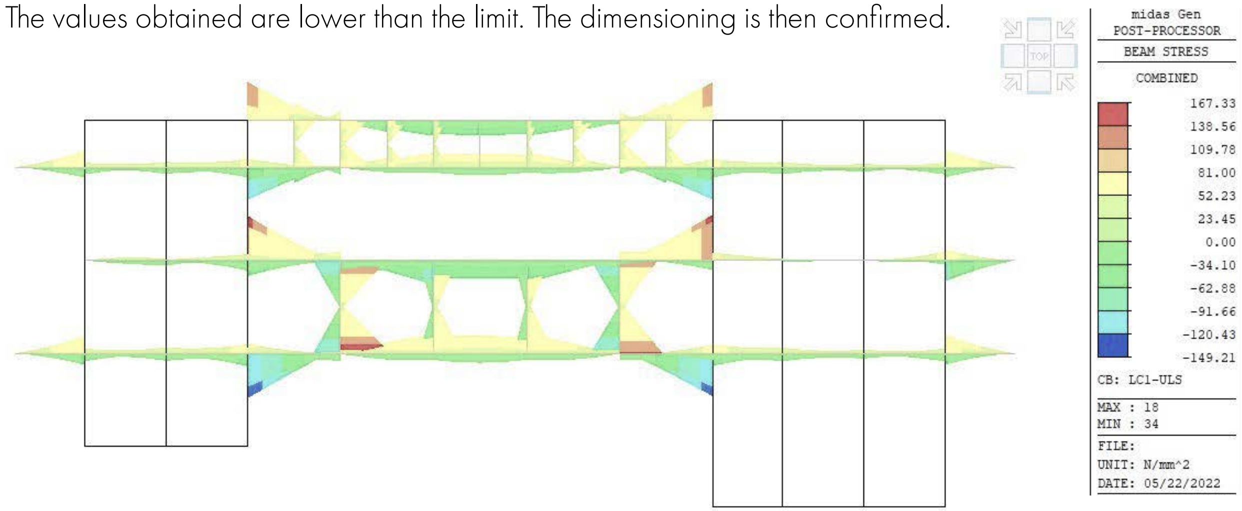
Primary beams
HEM 800



Vierendeel beams - Horiz.
HEM 1000



2 - Results of Combined Load case - max. min. **Beams Stress**
Load Combination (ULS): 1.35*G1"+1.35*G1'+1.5*Q1+1.5*G2
Using steel of S355, the stress should be less than: 355/1.15= 308.70.
The values obtained are lower than the limit. The dimensioning is then confirmed.



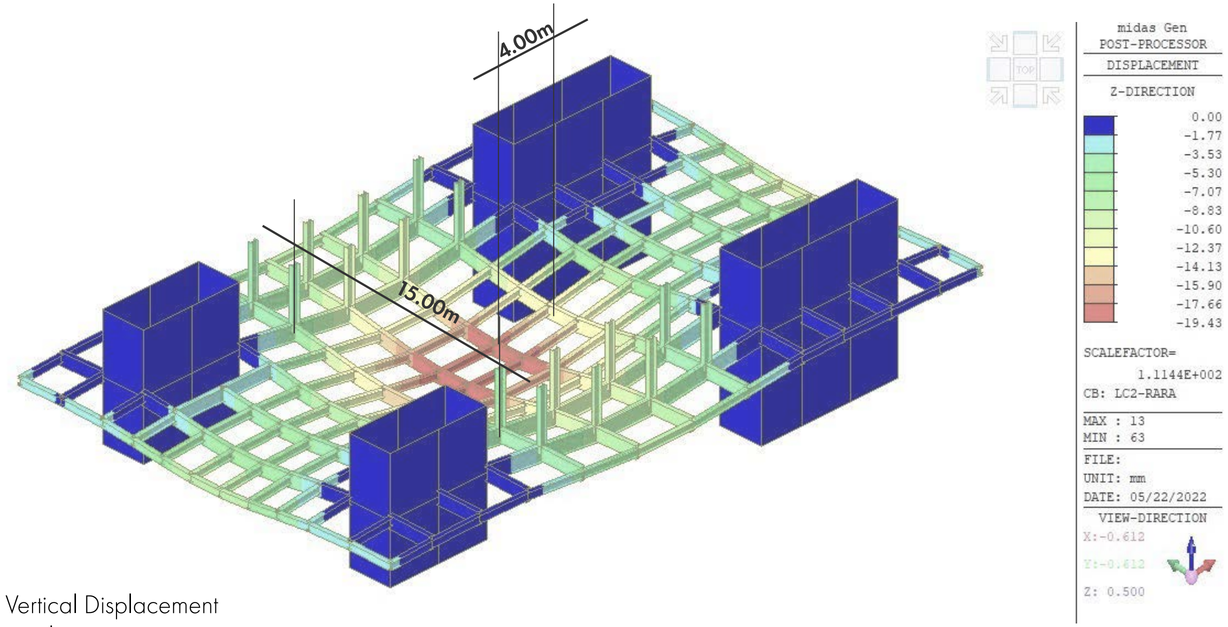
3 - Results of Combined Load case - max. min. **Vertical Displacement**

Load Combination (SLS): G1"+ G1'+ Q1+ G2; The max. allowed displacement for each of the beams is:

Secondary: L/200 = 4,000/200 = 20 mm

Primary: L/250 = 15,000/250 = 60 mm

Virendeel: L/250 = 20,000/250 = 80 mm

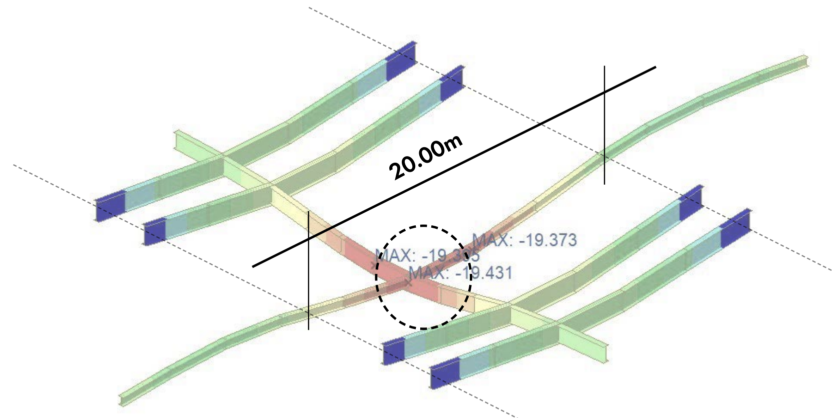


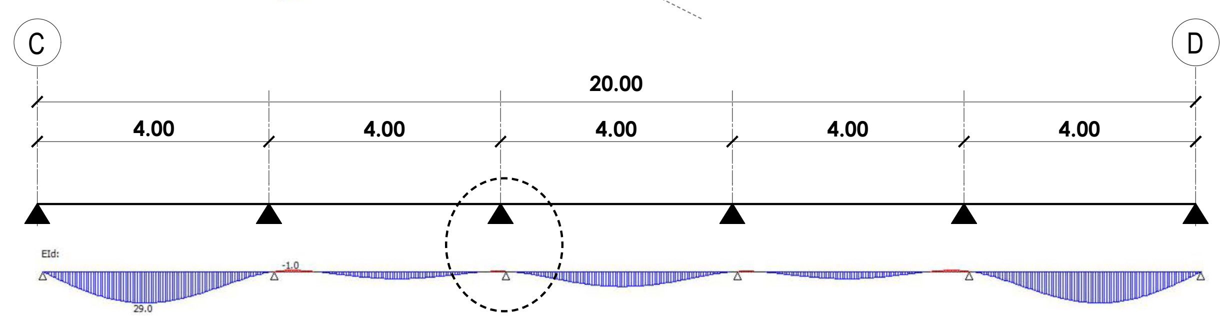
Vertical Displacement
Level GF+2

The max. value obtained (19.43mm) is lower than the limit. The dimensioning is then confirmed.

* As already stated, the preliminary checks were not quite accurate as the supports modelled on the intersection with the primary beams do not give a null displacement. In fact, at this point of crossing we get the max. displacement because it is directly affected by the displacement of the primary beam, and the latter by that of the virendeel truss.

To achieve the adequate dimensioning, the process was to change the sections following the structural hierarchy; so starting with the truss and reaching the secondary beams.



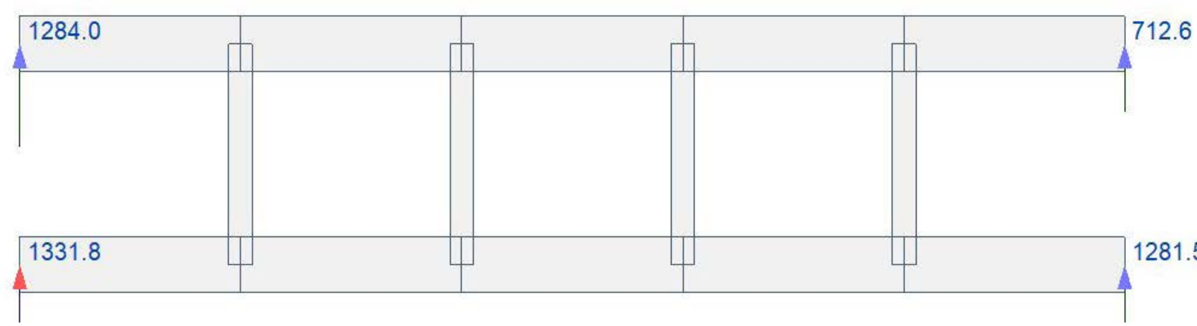


SLS - Displacement Diagram from the CBA Software (preliminary)

MIDAS analysis | Vierendeel beam

4- Results of Combined Load case - **Reaction Forces**

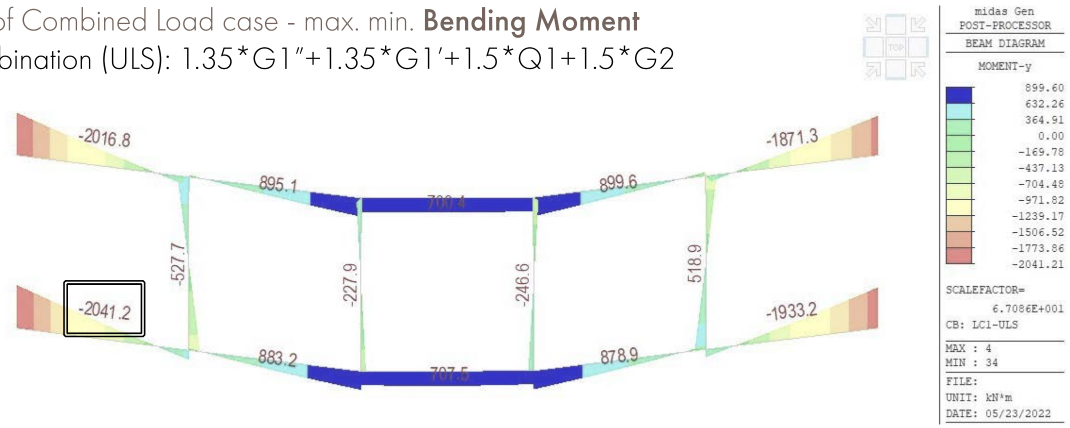
Load Combination (ULS): 1.35*G1"+1.35*G1'+1.5*Q1+1.5*G2



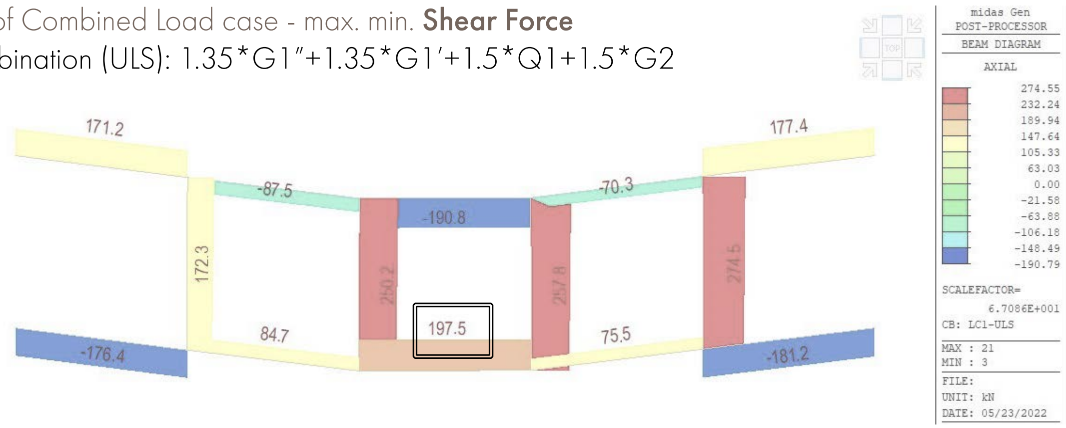
Resultant reaction forces

After chosing the steel class and calculating, the checks confirm a proper predimensioning: Horizontal elements as HEM1000

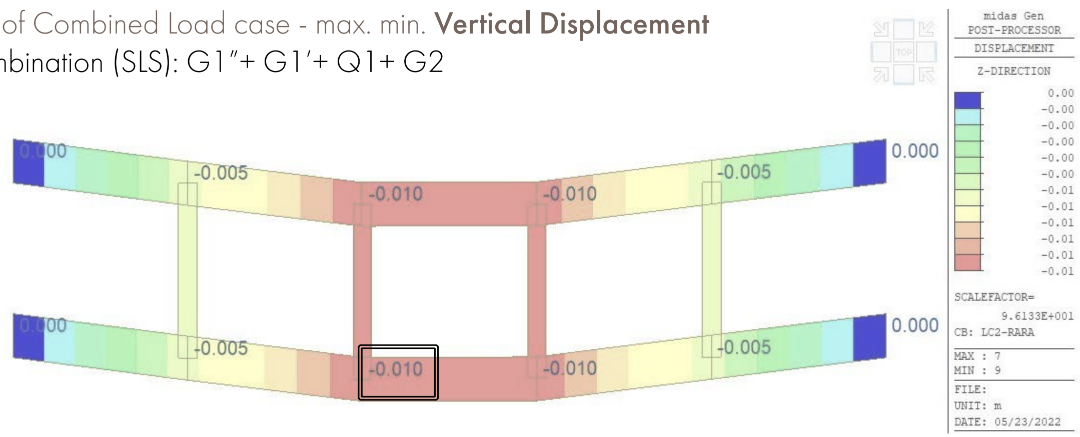
5- Results of Combined Load case - max. min. **Bending Moment**
Load Combination (ULS): 1.35*G1"+1.35*G1'+1.5*Q1+1.5*G2



6- Results of Combined Load case - max. min. **Shear Force**
Load Combination (ULS): 1.35*G1"+1.35*G1'+1.5*Q1+1.5*G2



7- Results of Combined Load case - max. min. **Vertical Displacement**
Load Combination (SLS): G1"+ G1'+ Q1+ G2



CONTINUOUS VIRENDEEL BEAM				
Beam Type	HEM 1000			
Beam Total Lenght L	20	m	20000	mm

RESULTS FOR MAIN SPAN		
Mmax:	2041.2	kNm
Vmax:	197.5	kN

CHECKS FOR CONTINUOUS STEEL BEAM			
M_ED_ULS	2041.20	kNm	2041200000 Nmm

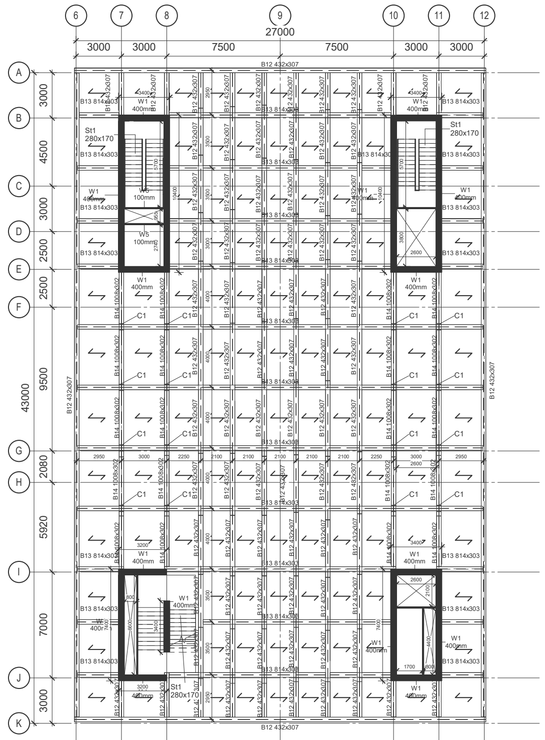
STEEL CLASS				
Steel class	355			
fyk	355	MPa		
γs	1.05			
fyd	338	MPa		
Wpl	6037352	mm3	6037	10^3 mm3
Wpl chosen	16570	10^3 mm3		
Iy chosen	722300	10^4 mm4		
E	206000	MPa	OK	

CHECK - SHEAR ULS COMB			
	HEM 1000		
h_section	1008	mm	
tw_section	21	mm	
r_section	30	mm	
tf_section	40	mm	
Av (area resisting shear)	25968.00	mm2	
V_Ed_ULS			
Software Value	197.5	kN	
V_Rd	5068.94	kN	OK

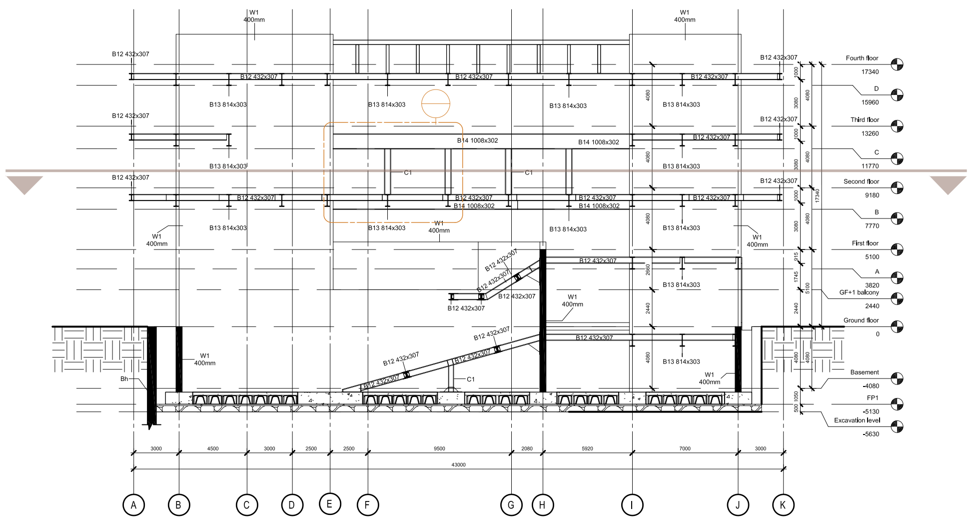
CHECK - MAXIMAL DISPLACEMENTS FOR RARA COMB (D + L)			
Delta Max L/250	80.00	mm	
Delta Software $\delta =$	10.00	mm	OK

3.3. Structural drawings

Elements identification on typical plan and section: Block A - Events and Culture

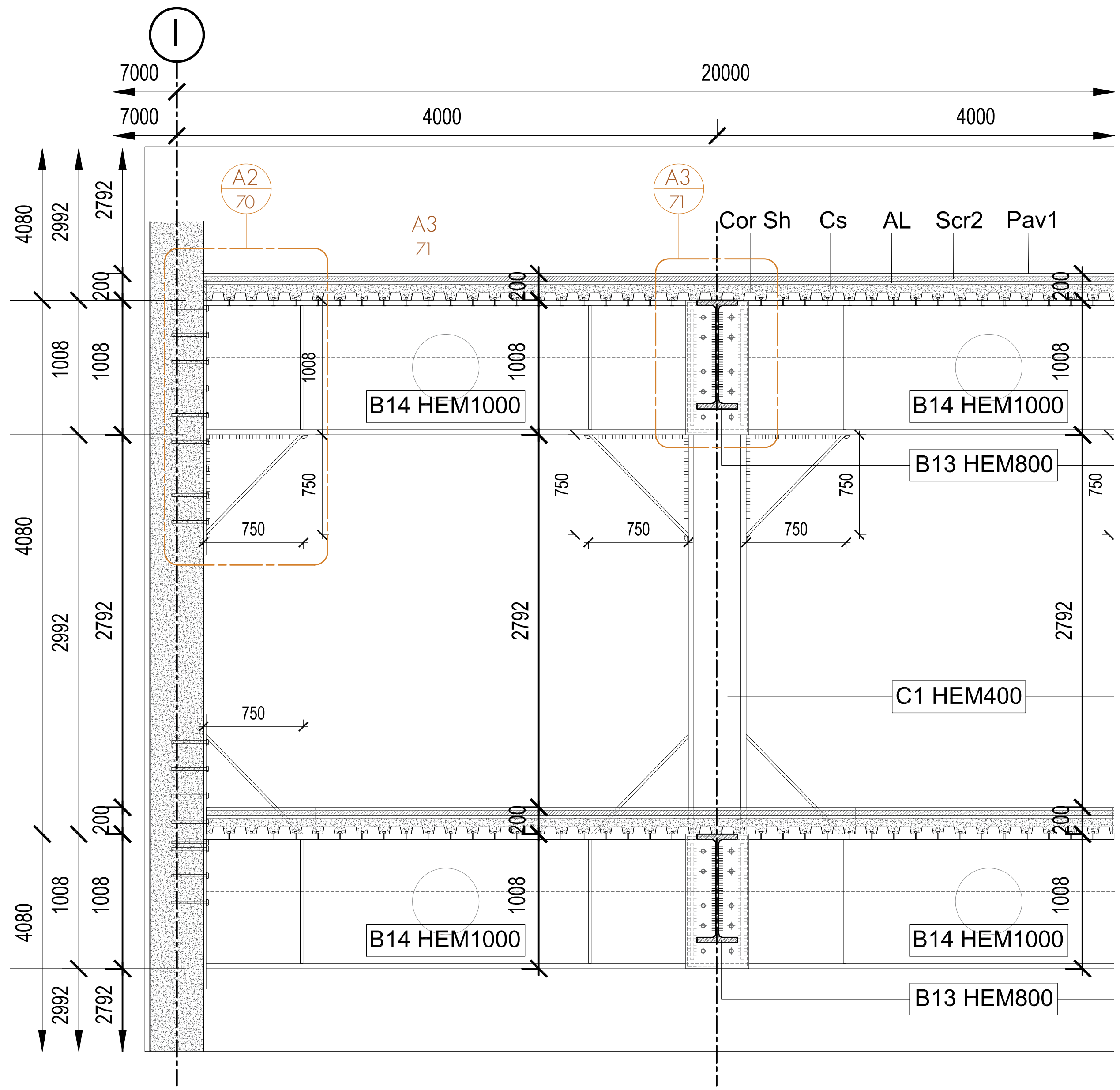


Block A | Level GF+2 | Scale 1:500

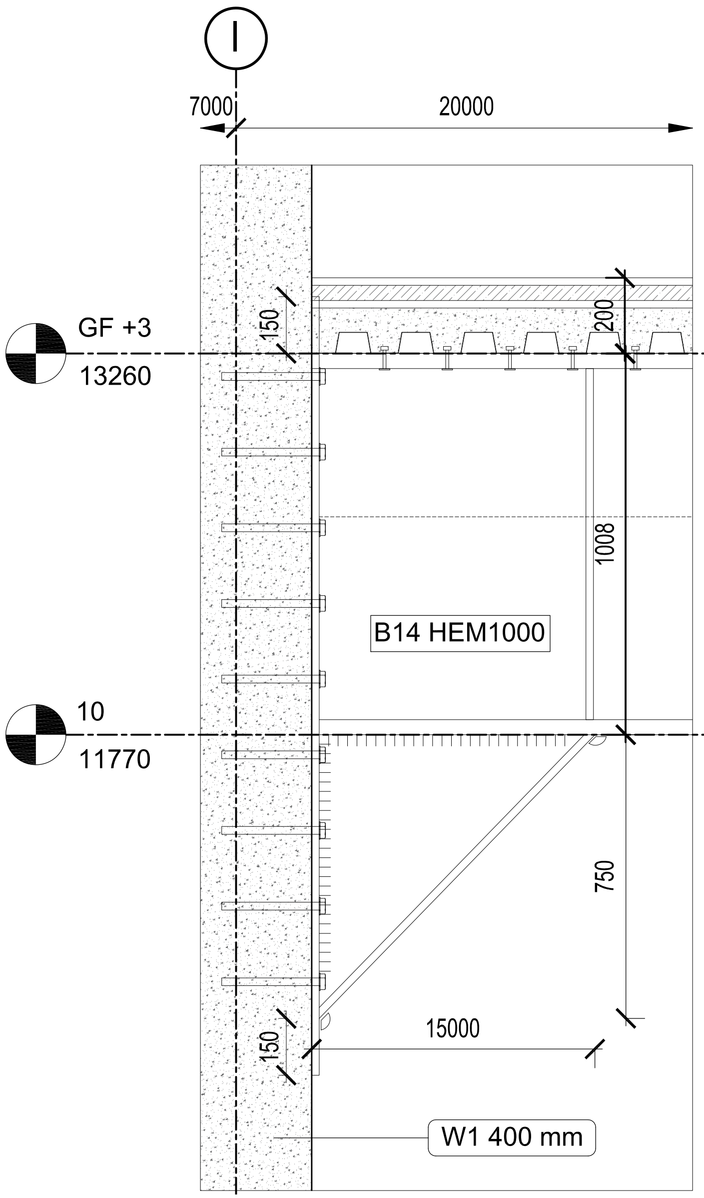


Block A | Section | Scale 1:500

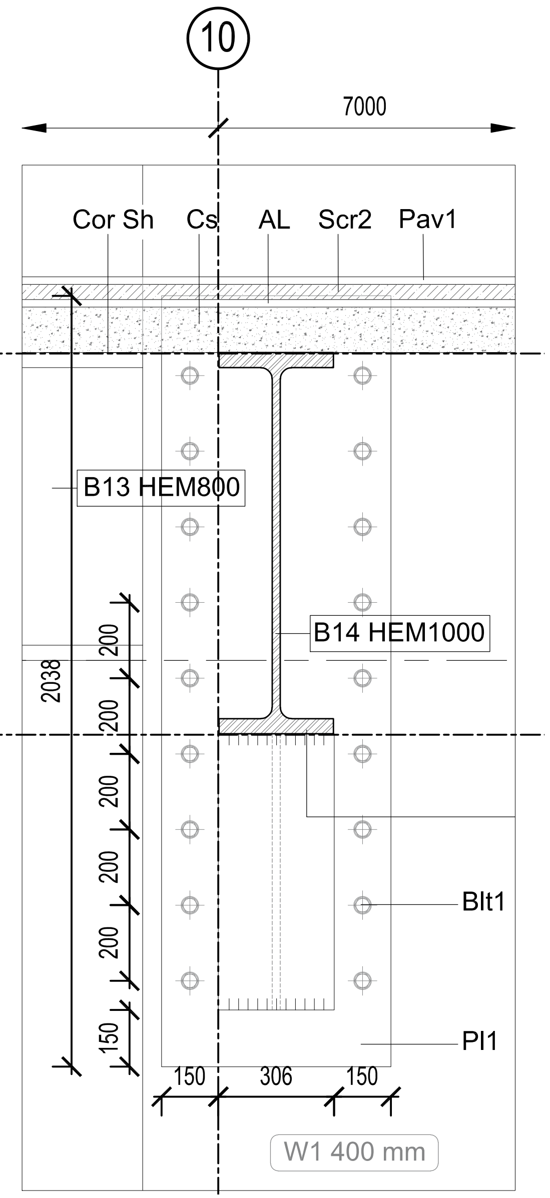
Connection details



Main Construction Drawing (longitudinal) showing the virendeel truss | Scale 1:50 A1 70



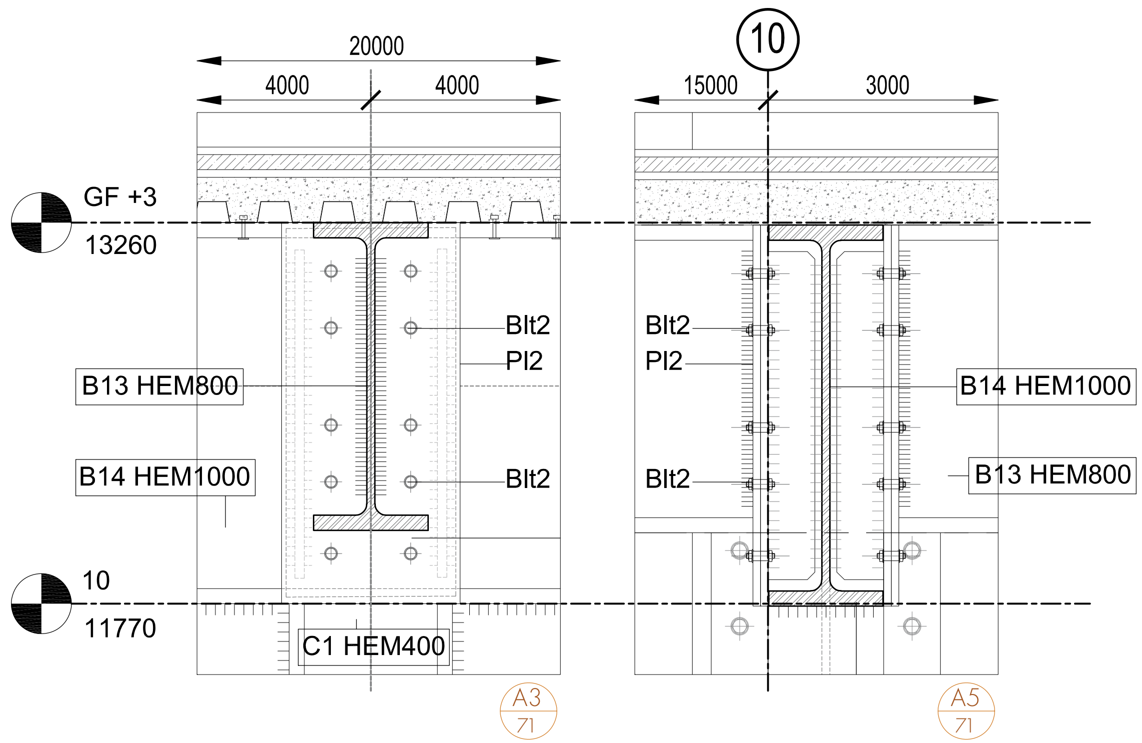
Construction Drawing (longitudinal) showing the connection to the RC wall | Scale 1:20 A2 70



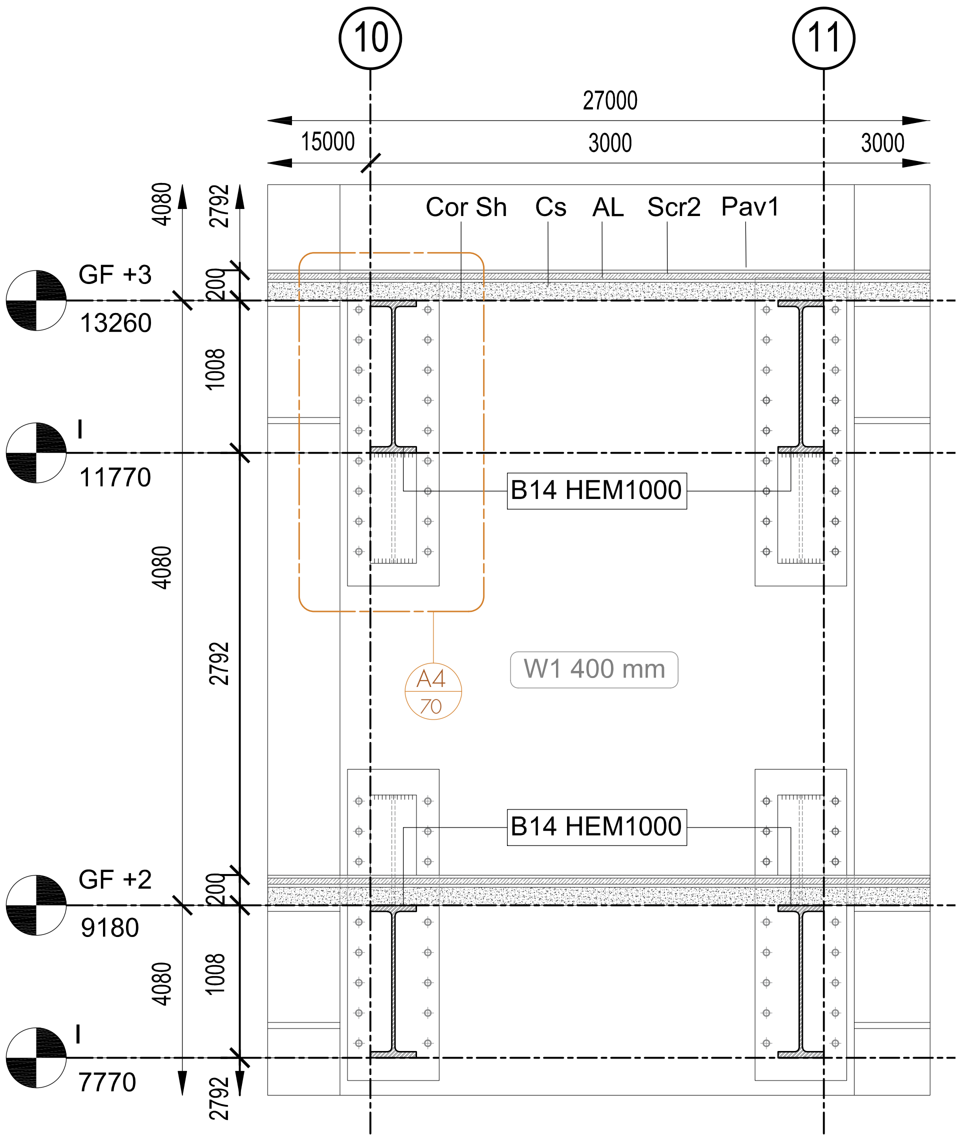
Construction Drawing (transversal) showing the connection to the RC wall | Scale 1:20 A4 70

Technical Description

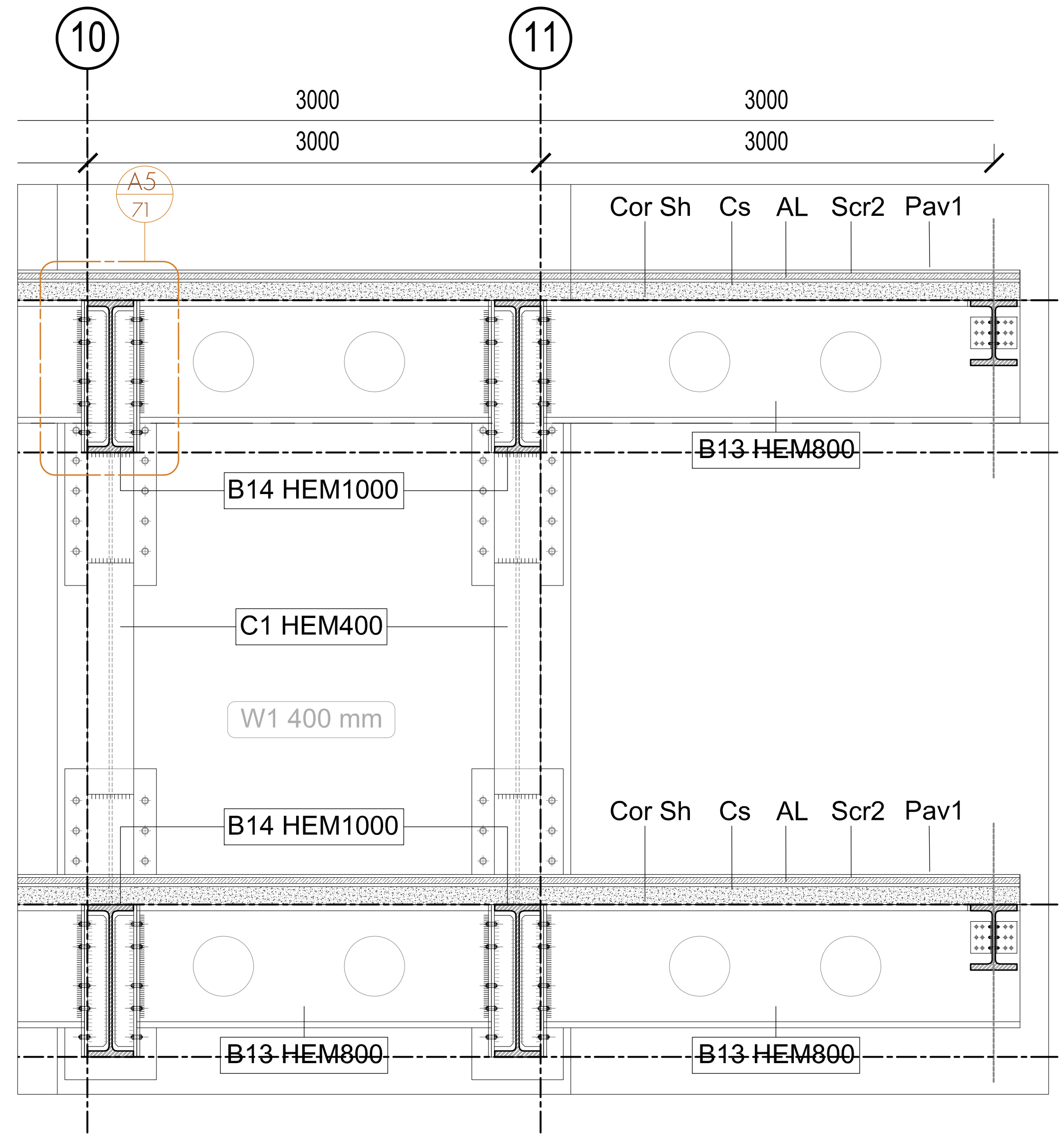
W1 |	-	;400	mm ;	reinforced concrete
C1 |	HEM 400	;432 x 307	mm ;	steel
B12 |	HEM 400	;432 x 307	mm ;	steel
B13 |	HEM 800	;814 x 303	mm ;	steel
B14 |	HEM 1000	; 1008 x 302	mm ;	steel
Pl1 |	Plate	;20	mm ;	steel
Blt1 |	Bolt	;M32	mm ;	steel
Pl2 |	Plate	; 15	mm ;	steel
Blt2 |	Bolt	;M22	mm ;	steel



Construction Drawings showing connection of primary beam to virendeel truss left (longitudinal); right (transversal) | Scale 1:20



Construction Drawing (transversal) showing connection to the RC wall
| Scale 1:50

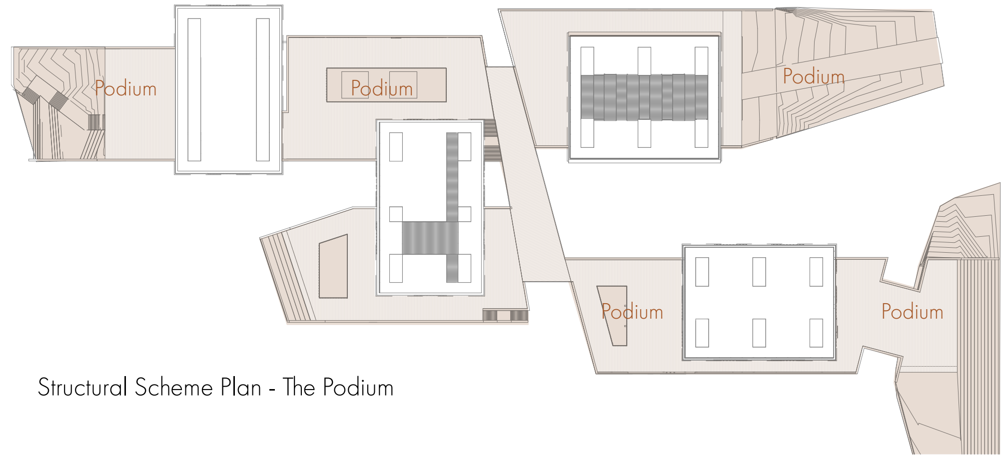


Main Construction Drawing (transversal)
| Scale 1:50

CHAPTER 04

SPECIAL STRUCTURE: THE PODIUM

General configuration and chosen materiality

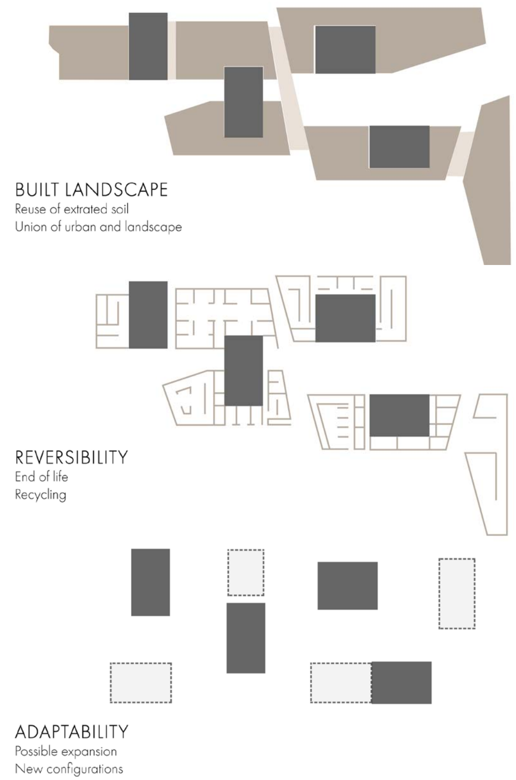


Structural Scheme Plan - The Podium

The Ground floor of the community center houses the most common and most accessible functions. It spans from end to end of the site in the form of two large strips, connecting the different kinds of landscapes in the context and the independant monofunctional blocks.

We have taken the decision to construct this podium entirely with rammed earth walls, supporting a timber structural slab. It will be structurally independant from the concrete, steel and glass blocks.

This system, combined with the chosen materials represent a continuation of the landscape in a way that not only provides a certain reversibility and recyclability, thus improving the life cycle of the project, but also a sort of adaptability in configuration depending on present and future needs.



Case study: the Podium

Ilot B2, Office Building, Lyon, France, Le Pisé Constructions, 2019.

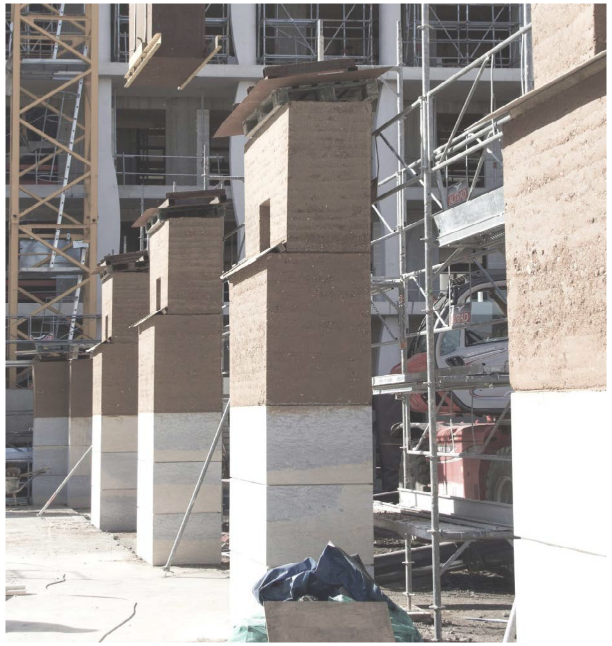
The facade of the building is of around 1000 m2 and is entirely realised using biomaterials: Stone, Timber, Rammed Earth. The building's structure consists of:

- Prefabricated rammed earth walls.
- Timber elements (beams, slabs, columns).
- Concrete blocks footings.

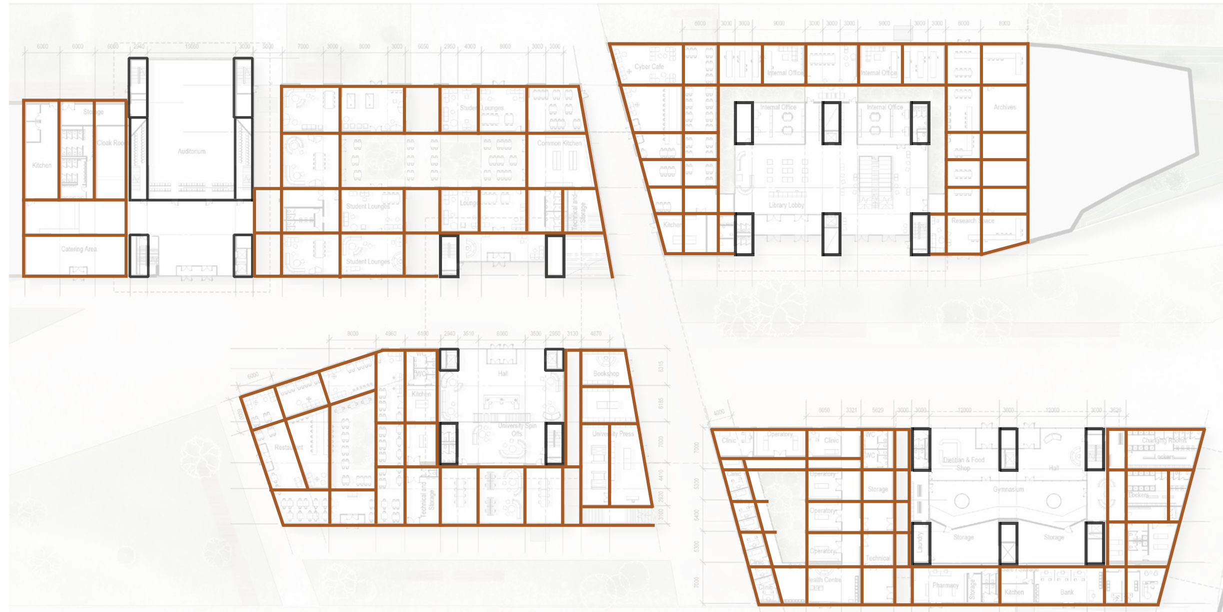
The rammed earth modules are fabricated in a small on-site lab, where the earth is compressed into steel molds. The resulting block of earth is left to cure for a period of time.
The weight of the blocks go up to around 2.5 tons, with a thickness of about 40-80 cm. A total of 280 blocks is used.

The Podium of our Community Center will consist of a similar system of structure and materials: rammed earth walls and a timber system of beams and slab. It will have a height of 5 m and is independent from the concrete and steel monofunctional blocks.

The blocks are assembled one by one using an earthen mortar. Level by level, the structure of the slab is added, the timber structure is connected to the facade by resting lightly on earthen corbels.



Podium plan: relation with architecture



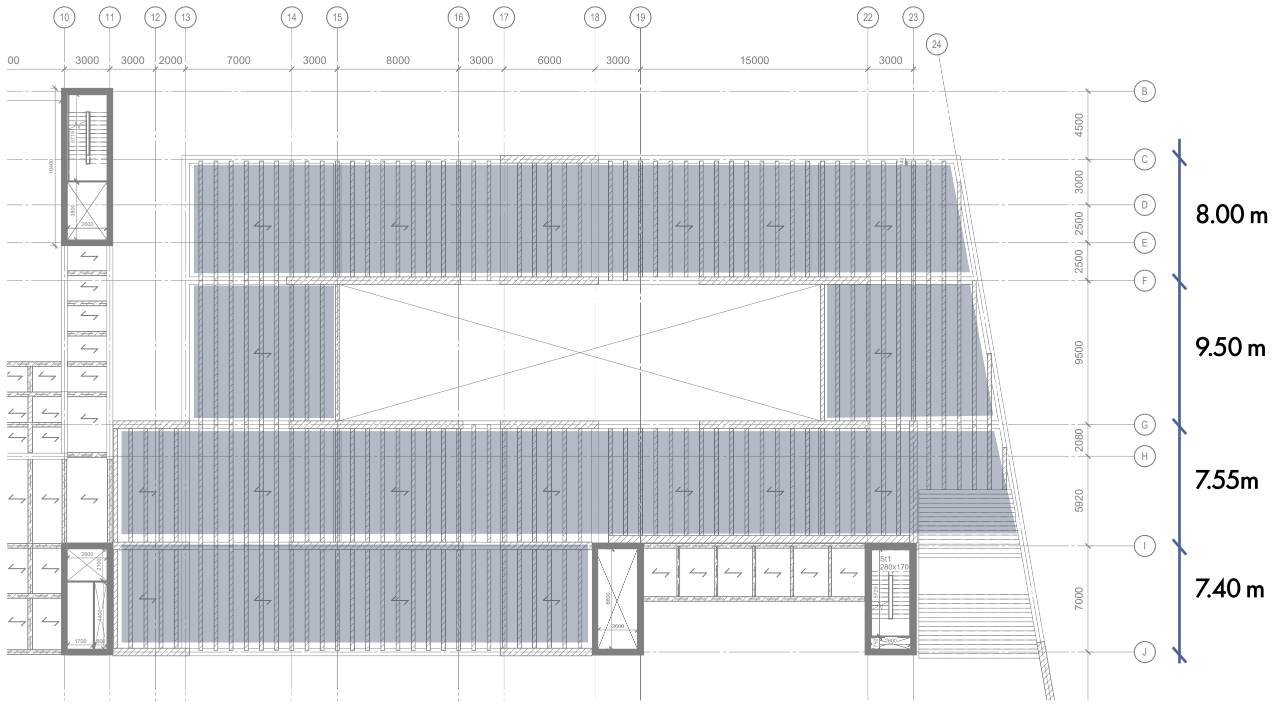
Structural Plan
Level GF | Scale 1:500

The rammed earth walls create a labyrinthic pattern around the concrete cores, this defines the different spaces and functions.

The facades are entirely of ramed earth.
The volumes serpent in a way to present open air courtyards.

The configuration allows the supperposition of a grid of timber beams that will support the roof slab.

Dimensions and grids

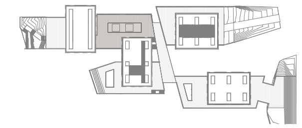


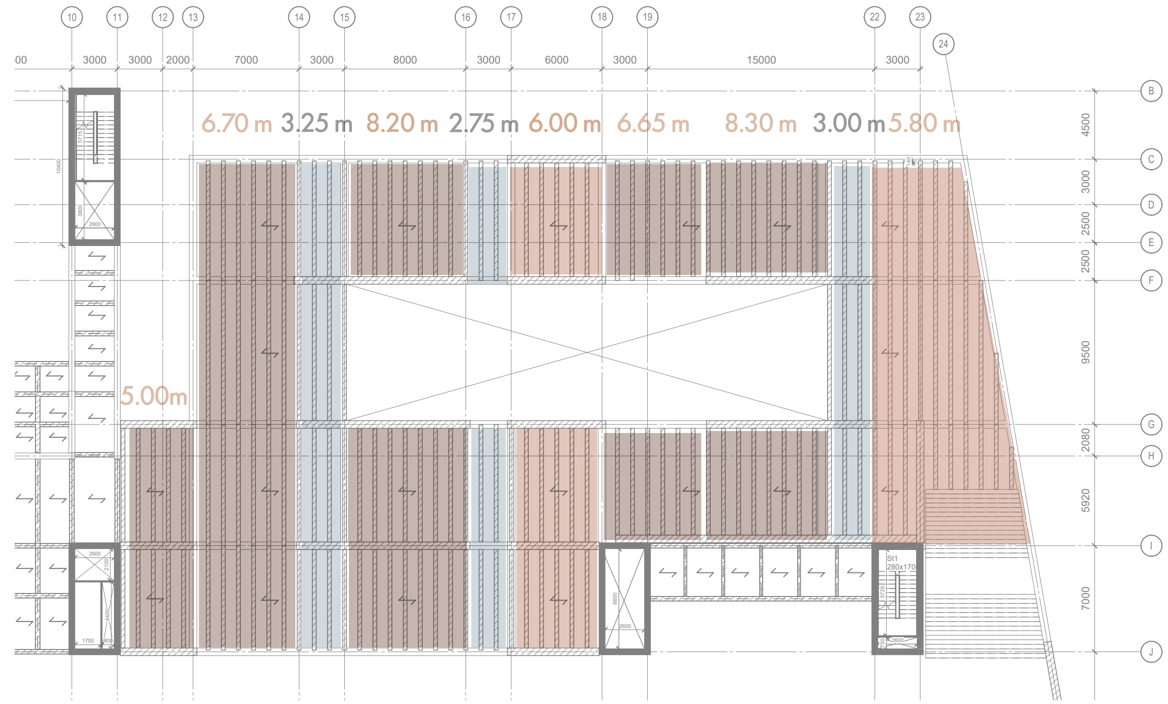
Horizontal Spans and Axis Distribution
Level GF+1 | Scale 1:500

For the study of this special part, we isolate a north-eastern zone of the podium that houses some student lounges. The horizontal spans are somehow homogenous with an average of 8 meters. A 9.5 meters large patio crosses one of them.
Vertically, the volume presents spans of 6 to 8 meters in average between the walls, some spans are of around 3 meters, they house the circulation and the passages.

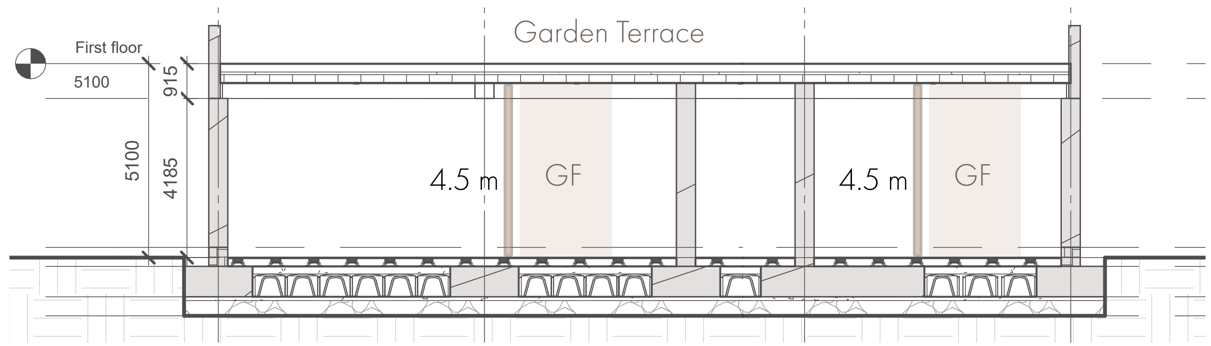
The podium stretches in its entirety on the ground floor, it is therefore of one level, 5.10 meters in gross height.
After constructing the structural system and the slab with its finishing layers, a free height of almost 4.20 meters is maintained on the inside.

It houses communal fuctions such as student lounges, restaurants, coffee shops, a health center...
Its roof is a garden terrace that composes a contextual promenade along the site, linking different ends and landscapes present in the zone.





Vertical Spans and Axis Distribution
Level GF | Scale 1:500

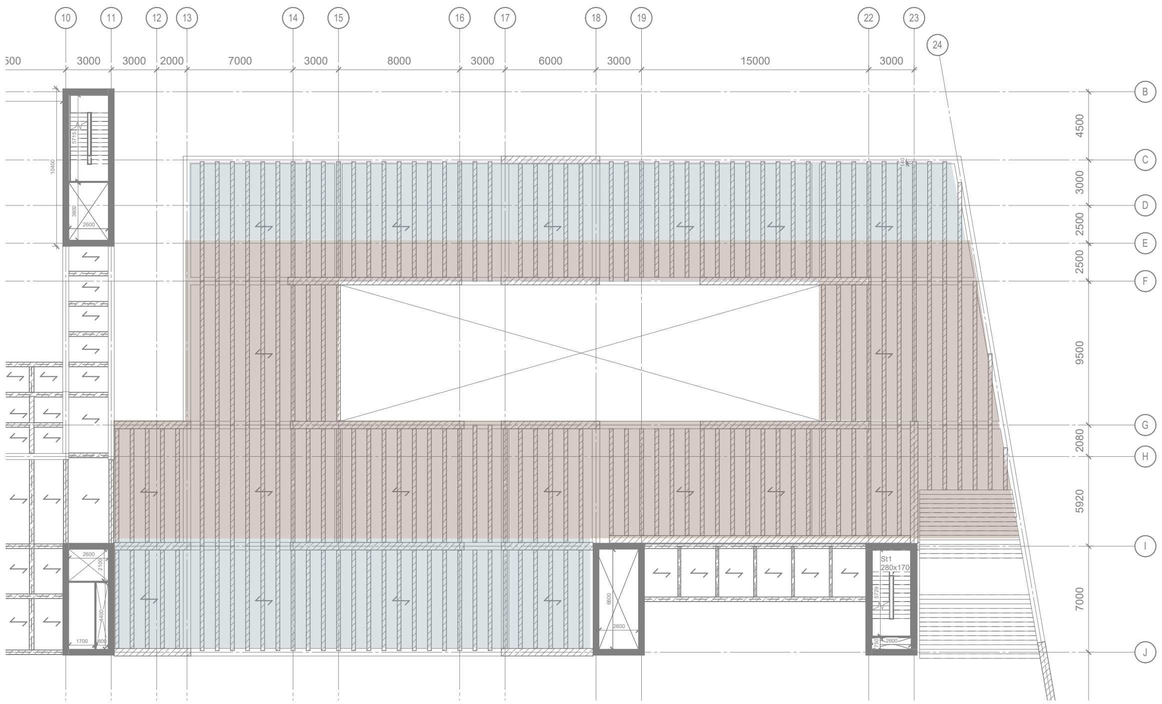


Section showing levels and heights
Scale 1:200

4.1. Structural load calculations

Live loads distribution scheme

Before the structural load calculations, we define the different live loads present in this section of the floor plan, based on the use of the defined areas. In fact, the podium is used as an elevated terrace and garden where multiple events and gatherings can occur, whether they are public, communal, or related to the neighbooring functions in the monofunctional blocks.

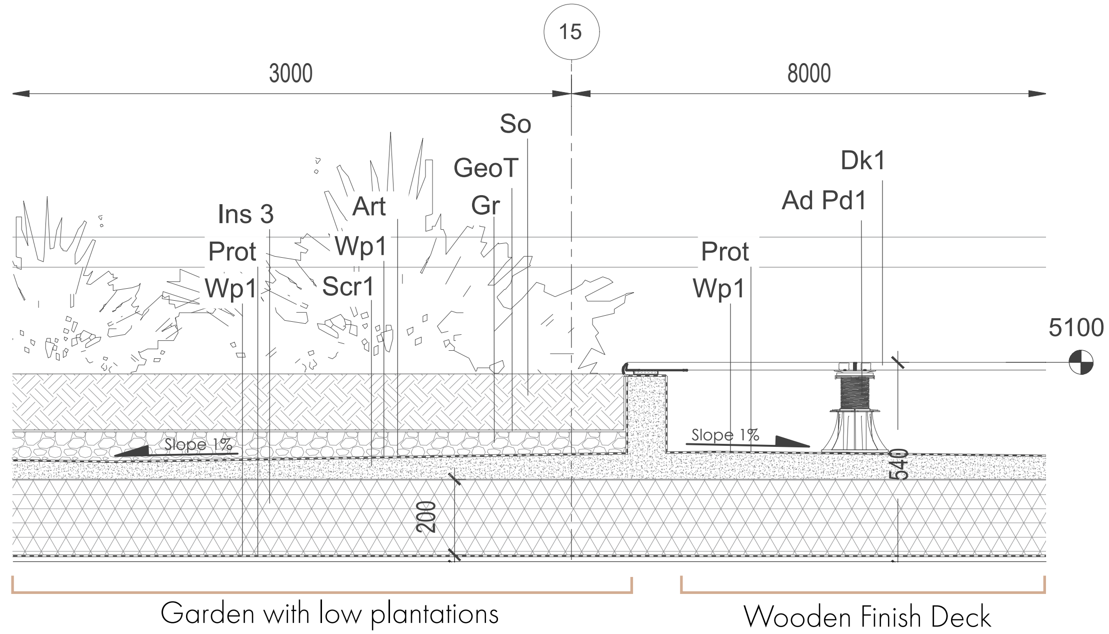


Distribution of Live Loads on a Plan
Level GF | Scale 1:500

Major spaces of assembly: 4 kN/m.

Roof Garden: 4 kN/m

Slab design and finishing layers



Timber slab and finishing layers | Scale 1:20

DEAD LOAD - FLOOR SELF WEIGHT- G										
Layer	Length		Width		Height		Volumetric weight		Weight	
Soil Substrate	1.0	m	1.0	m	0.2	m	18	kN/m3	3.6	kN/m2
Gravel	1.0	m	1.0	m	0.07	m	15	kN/m3	1.1	kN/m2
Screed Levelling	1.0	m	1.0	m	0.07	m	10	kN/m3	0.7	kN/m2
Thermal Insulation	1.0	m	1.0	m	0.2	m	0.3	kN/m3	0.1	kN/m2
Laminated Timber Planks	1.0	m	1.0	m	0.025	m	3.5	kN/m3	0.1	kN/m2
Area load G									**5.5**	**kN/m2**

LIVE LOAD - Q1			
Area load Q1	**4.0**	**kN/m2**	Planted Roof or Place of Assembly

The podium has a timber slab consisting of timber C22 planks of 25 mm thickness and 200 mm in width. It is present in all sections of the podium terrace and is supported by the earth walls and by the primary and secondary beams. It is covered by a set of finishing layers. The planks and the layers count as the G - floor self weight.

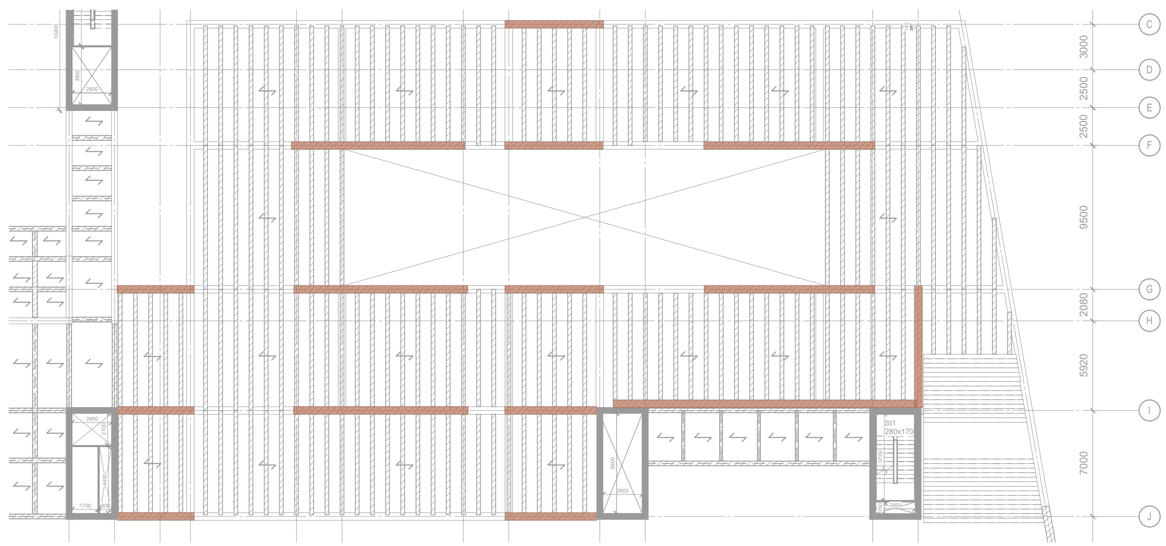
Technical description

So |	Soil Layer	; 200 mm	; Top-Soil
Gr |	Gravel	; 70 mm	; Stone
Scr1 |	Screed	; 60 mm	; Concrete
Ins3 |	Insulation	; 20 mm	; Foam Glass
Tb Plk |	Timber Planks	; 25 mm	; Laminated Timber C22

4.2. Beam design

Structure hierarchy and beam loading system

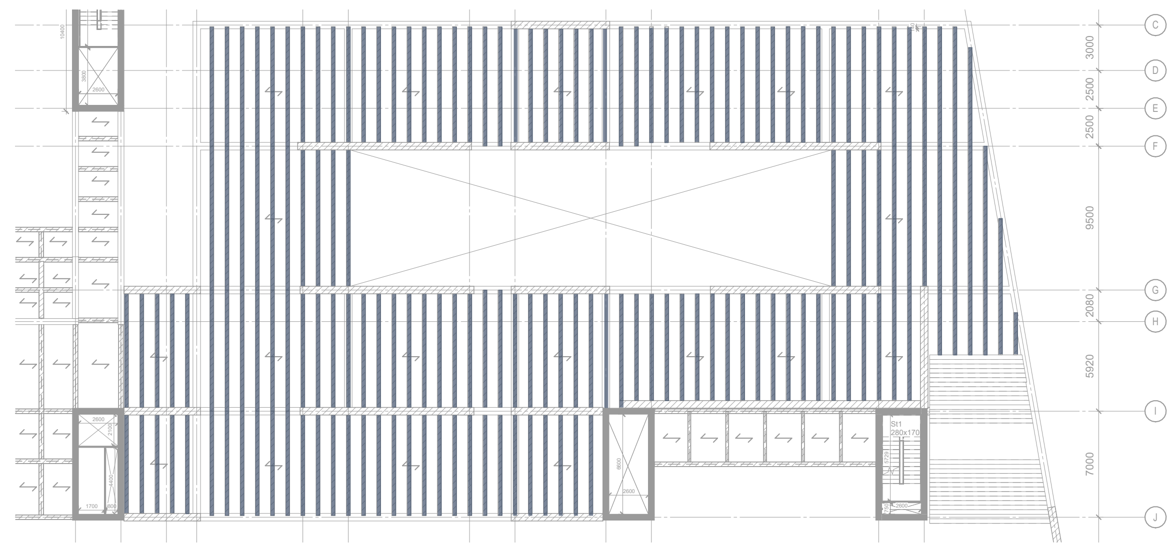
Rammed Earth Walls Distribution
Level GF | Scale 1:500



Primary Beams Distribution
Level GF | Scale 1:500

The system presents a hierarchy of primary and secondary beams that span from wall to wall or from concrete core to wall. The primary and secondary beams are fixated mechanically together, through metallic plates.
N.B: The primary beams are used to span between two earth walls. When support is presented in the form of a wall, no primary beam is needed and the slab is suported on the secondary beams.

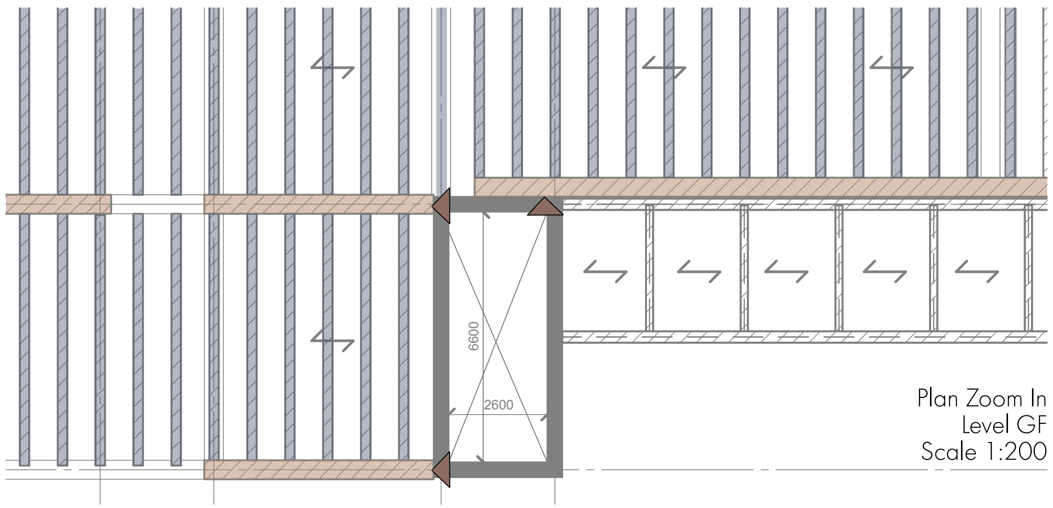
On this system, lies the slab and its finishing layers. We assign on it a Live Load of 4 kN/m, it being a roof garden or a great space of assembly.



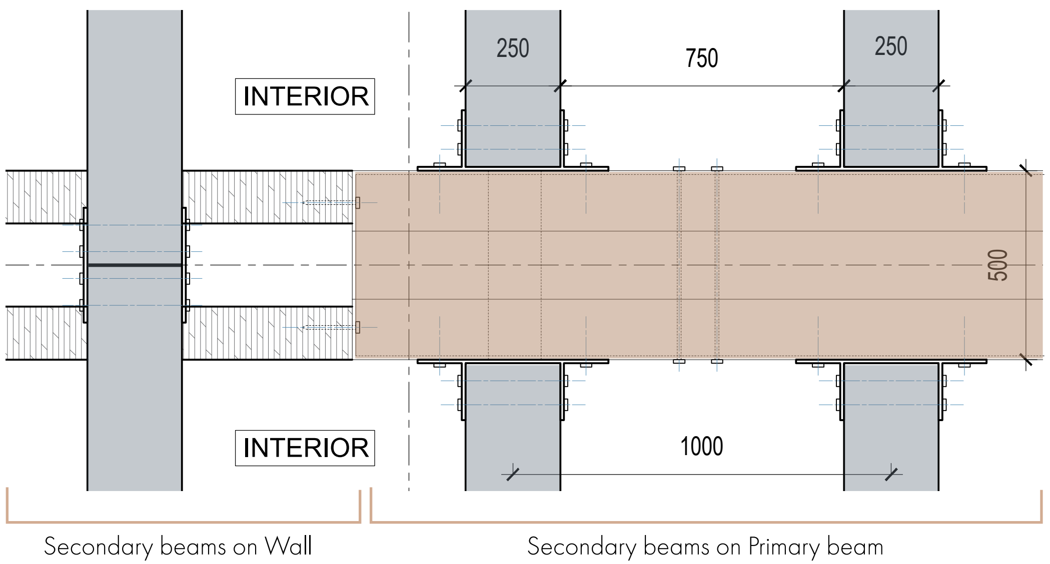
Secondary Beams Distribution
Level GF | Scale 1:500

Structural Hierarchy

- Concrete Cores, the only point of contact with the ground, part of the blocks' structure, present few connections with the podium's beams. It supports the timber beams thanks to concrete corbels.
- Primary Beams, positioned on top of load bearing rammed earth walls or spanning from support to support.
- Secondary Beams, mechanically fixated on Primary Beams, through metallic plates, bolts and nails.
- Timber Slab 25 mm, positioned on primary and secondary beams, with finishing layers.
- Concrete corbel on cores to support the timber beam

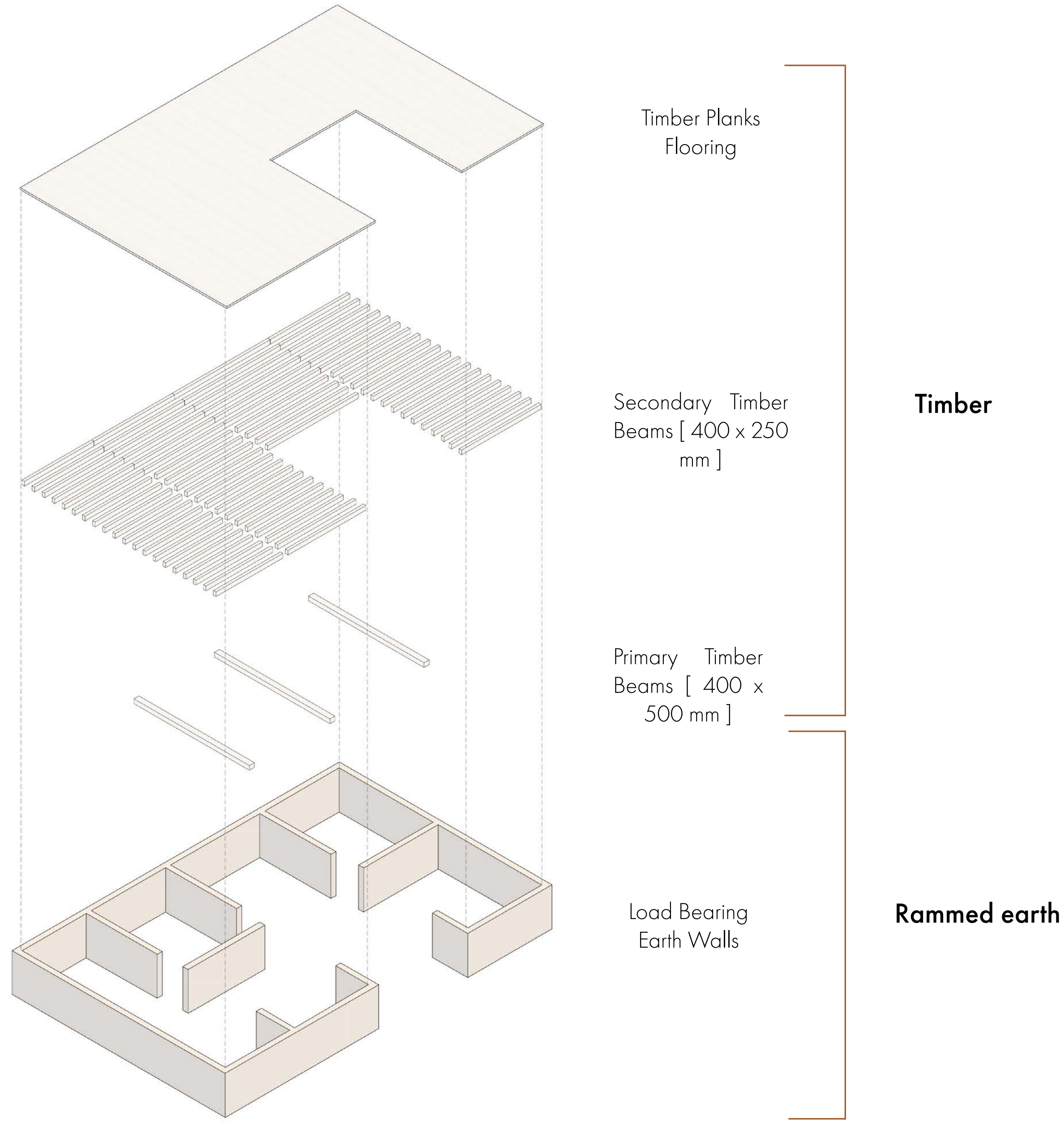


Plan Zoom In
Level GF
Scale 1:200

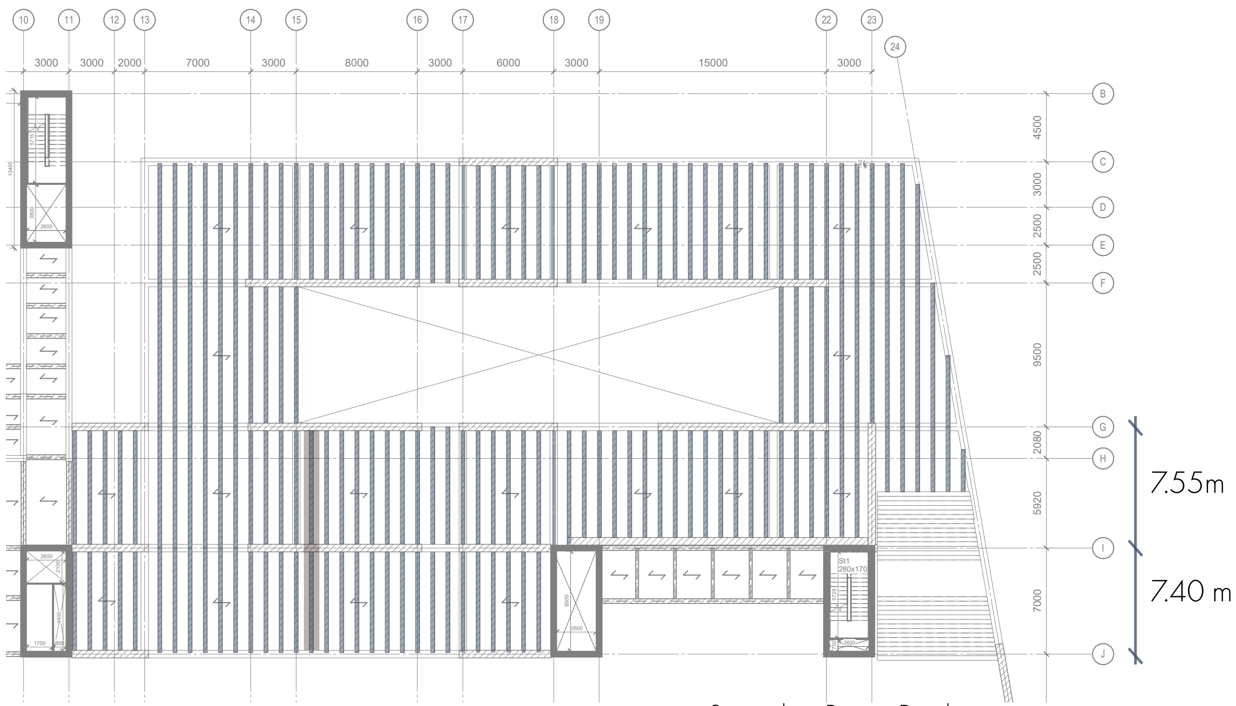


Connection and Hierarchy Detail
Level GF | Scale 1:20

The secondary beam calculated [400 x 250 mm] supports, its self weight, the floor weight and the live loads. It transfers all loads unto the walls and/or the primary beams. At the levels of the cores, a concrete corbel supports the timber beam.
In the following calculations, the slabs held by the beams are all considered to be unidirectional slabs, performing in the same direction (East - West).



Secondary beam predimensioning and loads



Secondary Beams Distribution
Level GF | Scale 1:500

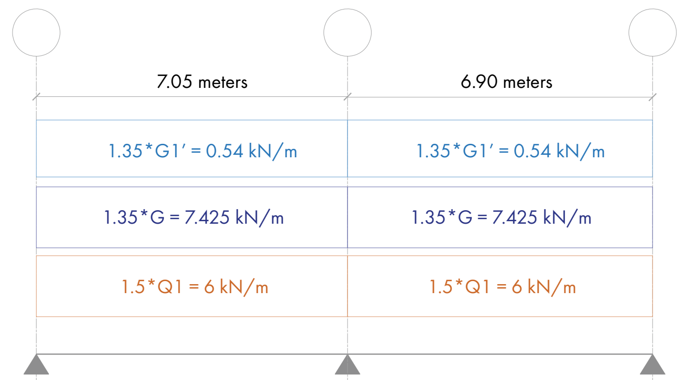
DEAD LOAD - BEAM SELF WEIGHT - G1'				
TYPE	C35 Timber Beam			
B	25	cm	0.25	m
H	40	cm	0.4	m
Material density	440	kg/m3	4.4	kN/m3
Linear load G1'			**0.4**	**kN/m**

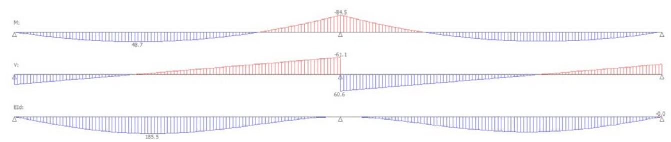
This beam is calculated as being continuous, it spans two spans of 7.55m and 7.40 m. It has an influence area width of 1 meter. We predimention it as being a C45 timber beam of 40 X 25 cm.

Secondary beam design and checks

We find the Total Beam Load by multiplying the results with the respective coefficients. We use the Influence area width as being 1 meter. We input the beam loads after multiplication with the coefficients into the software, to check the maximal bending moment, the maximal shear force, and the maximal displacement.
It is done on the beam being continuous, with two spans of 7.05 m and 6.90 m (substractingt the supports' thickness).

TIMBER SECONDARY BEAMS LOAD CALCULATION			
	Influence area width	1.0	m
Dead load: Beam self weight G1'	Linear load G1'	0.4	kN/m
	Area load G	5.5	kN/m2
Dead load: Floor Self weight G	Linear load G	5.5	kN/m
	Area load Q1	4.0	kN/m2
Live load: Residential Q1	Linear load Q1	4.0	kN/m
Dead load: Beam self weight	Linear load G1'	0.4	kN/m
Dead load: Floor Self weight	Linear load G	5.5	kN/m
Live load: Residential	Linear load Q1	4.0	kN/m
	Coefficient for G1'	1.35	-
	Coefficient for G	1.35	-
	Coefficient for Q1	1.50	-
	TOTAL BEAM LOAD Quls	14.0	kN/m





Bending Moment, Shear Force, and Displacement Diagram from the Software

After calculating, the checks confirm a proper predimensioning: Secondary Timber beam as C45 - 40 x 25 cm. The Primary Beams are constructed as being 40 x 50 cm, covered with two mechanically fixed steel C brackets.

TIMBER SECONDARY BEAMS DIMENSIONING AND CHECKS

Beam Lenght L	7	m		7000 mm
Influence area width "a"	1	m		
Linear load g1'	0.400	kN/m	Dead load: Beam self weight	
Area Dead Load G	5.5	kN/m2	Dead load: Floor Self weight	
Linear dead load g	5.5	kN/m		
Area load Q1	4	kN/m2		
Linear load q1	4.0	kN/m	Live load: Planted Roof or Place of Assembly	
Load_ULS COMB	13.97	kN/m		
Load_RARA COMB	9.90	kN/m		
M_ED_ULS	84.50	kNm	84500000	Nmm

TIMBER CLASS: C	45	
fm,k	45	MPa
γM	1.3	
fm,d	27.7	MPa
fv,k	3.8	MPa
γM	1.3	
fv,d	2.34	MPa

CROSS SECTION		
h	400	mm
b	250	mm
W	6,666,667	mm3
Iy	1,333,333,333	mm4
E0,05	10000	MPa

BENDING STRESS CHECK		
12.83	< fm, d	OK

MAX INSTANTANEOUS DISPLACEMENTS FOR RARA COMBINATION CHECK

delta_max L/300 $\delta = \frac{5}{384}\frac{ql^4}{EI} =$	23.33	mm	
delta simple beam	23.2	mm	OK

SHEAR ULS COMB CHECK

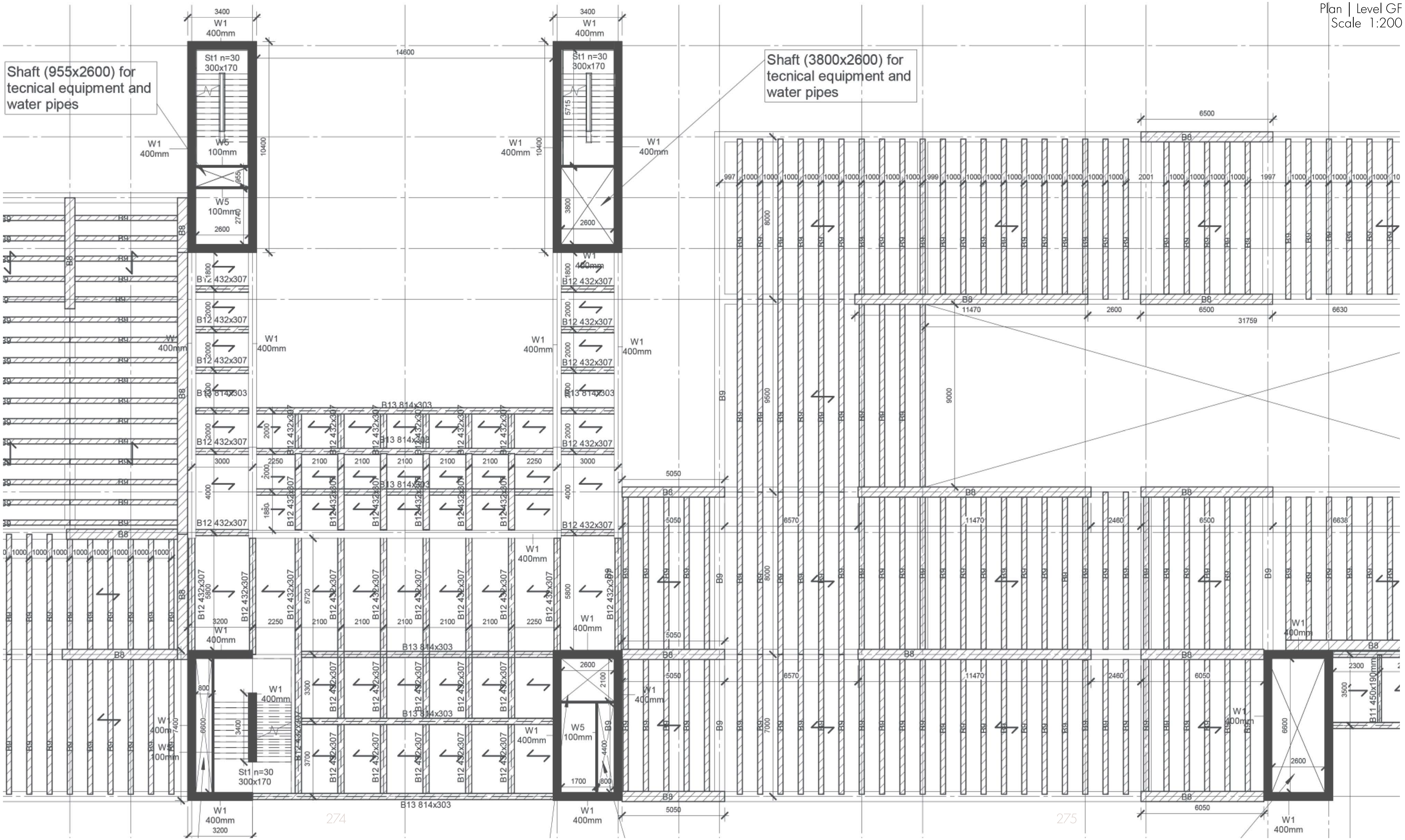
Av (area resisting in shear) $k_{cr} \cdot f_{v,d}$	10000	mm2	
V_Ed_ULS	48878	N	
=0.67 * fv,d	1.57	MPa	$\tau_{v,d} \le k_{cr} \cdot f_{v,d}$
$\tau_{v,d} = \frac{3V_d}{2A}$ =	0.73	MPa	OK

4.2. Structural drawings

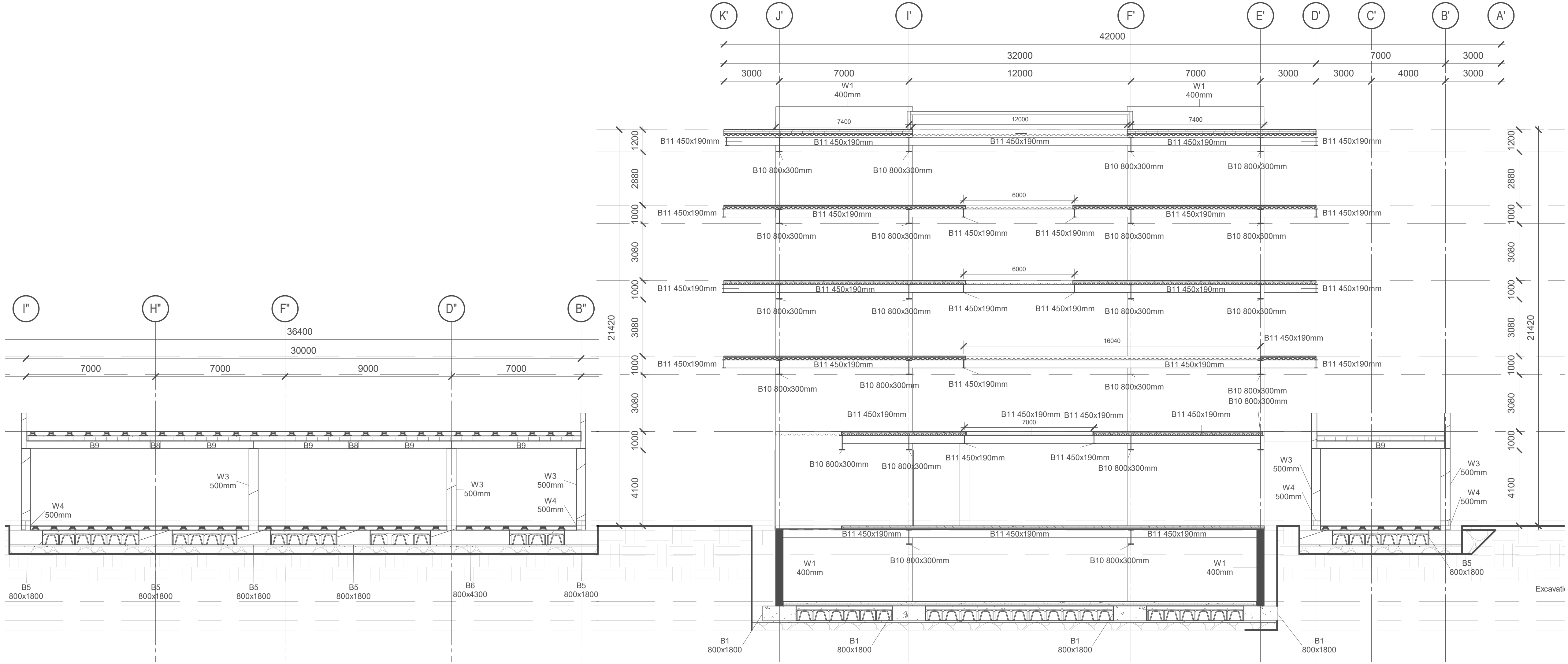
Elements identification on typical plan: Podium and Blocks

W1	wall	400	mm	reinforced concrete
W3	wall	500	mm	rammed earth
W4	wall	500	mm	stone
B1	foundation beam	800 x 1800	mm	reinforced concrete
B5	foundation beam	800 x 1800	mm	stabilized rammed earth
B6	foundation beam	800 x 4300	mm	stabilized rammed earth
B8	primary beam	500 x 400	mm	Laminated Timber C45
B9	secondary beam	400 x 250	mm	Laminated Timber C45
B10	HEB 800	800 x 300	mm	steel
B11	IPE 450	450 x 119	mm	steel
W2	Supporting Wall	500	mm	Rammed Earth
B15	Tie Beam	140 x 140	mm	Laminated Timber C22
P4	C Profile	200 x 150	mm	Steel
Bo1	M14 Bolts	8.8	mm	Alloy Steel
Wp1	Waterproof Membrane	8	mm	Polyester Fabric
Prot	Protection Layer	4	mm	Polyurethane-rubber
Dk1	Deck-Dry System	20	mm	Wood
Ad Pd1	Adjustable Pedestals	-	mm	Zinc-Coated Steel
So	Soil Layer	200	mm	Top-Soil
GeoT	GeoTextile	5	mm	
Gr	Gravel	70	mm	Stone
Scr1	Screed	60	mm	Concrete
Ins3	Insulation	20	mm	Foam Glass
ArC	Architectural Concrete	50	mm	Cement mix
Tb Plk	Timber Planks	25	mm	Laminated Timber C22
Ej	Expansion Joint	20	mm	Rubber
Pla	Interior Plaster	20	mm	Cement Mix

Plan | Level GF
Scale 1:200

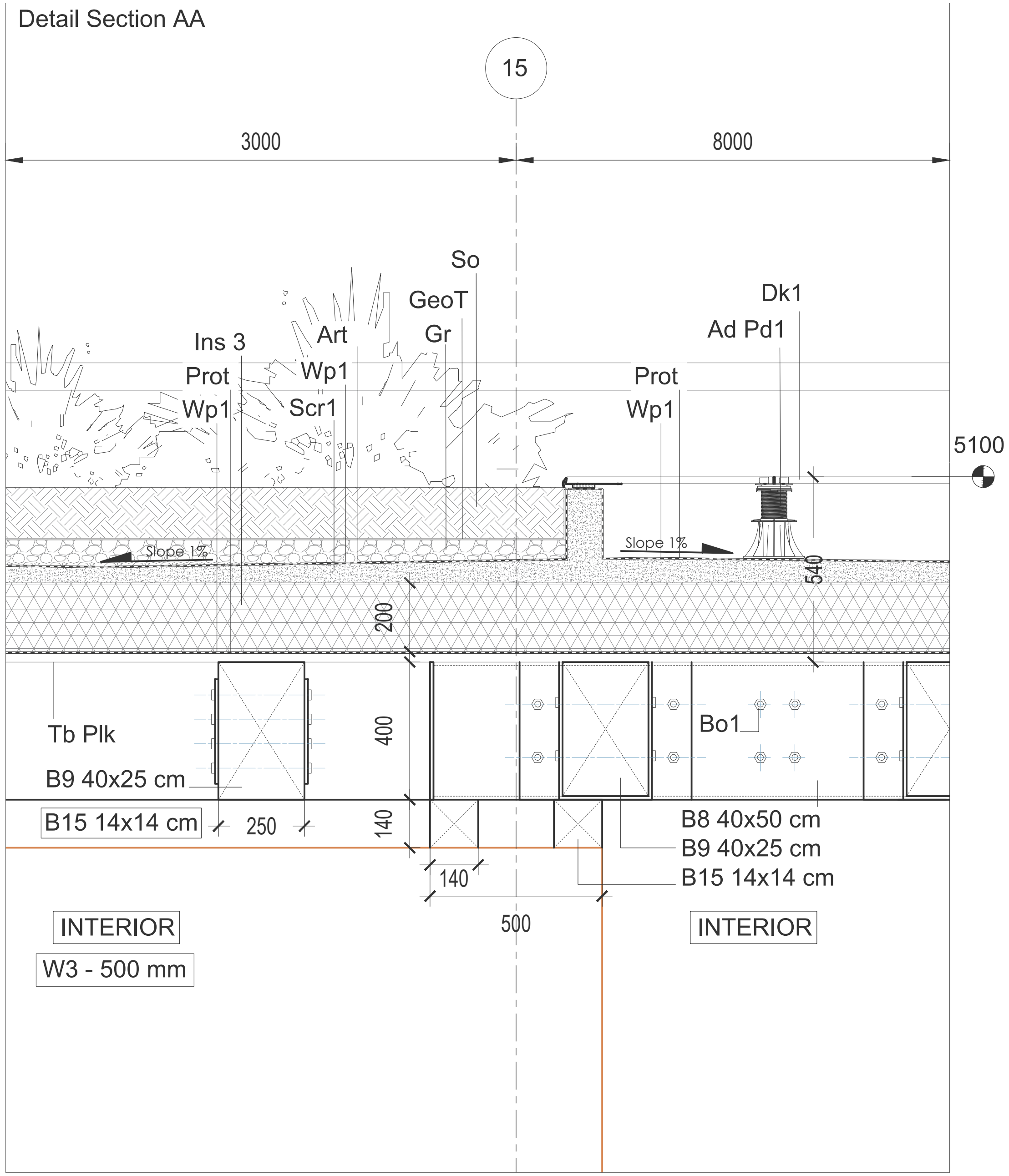


Elements identification on typical section: Podium and Blocks

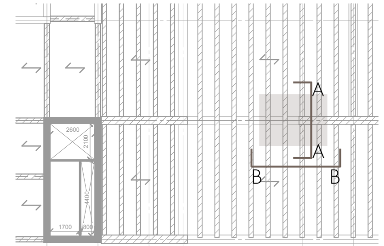


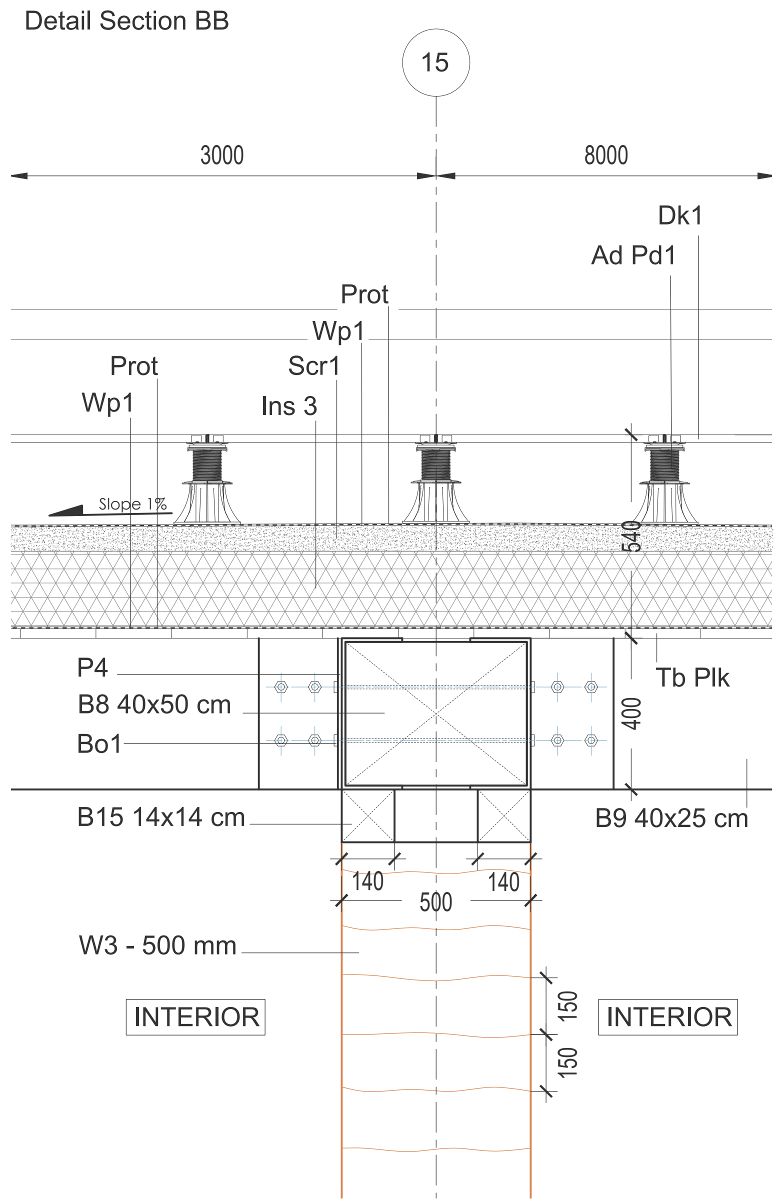
Section on Block and Podium
| Scale 1:250

Connections and details

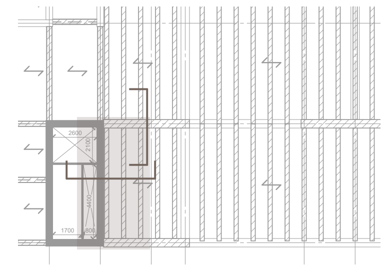


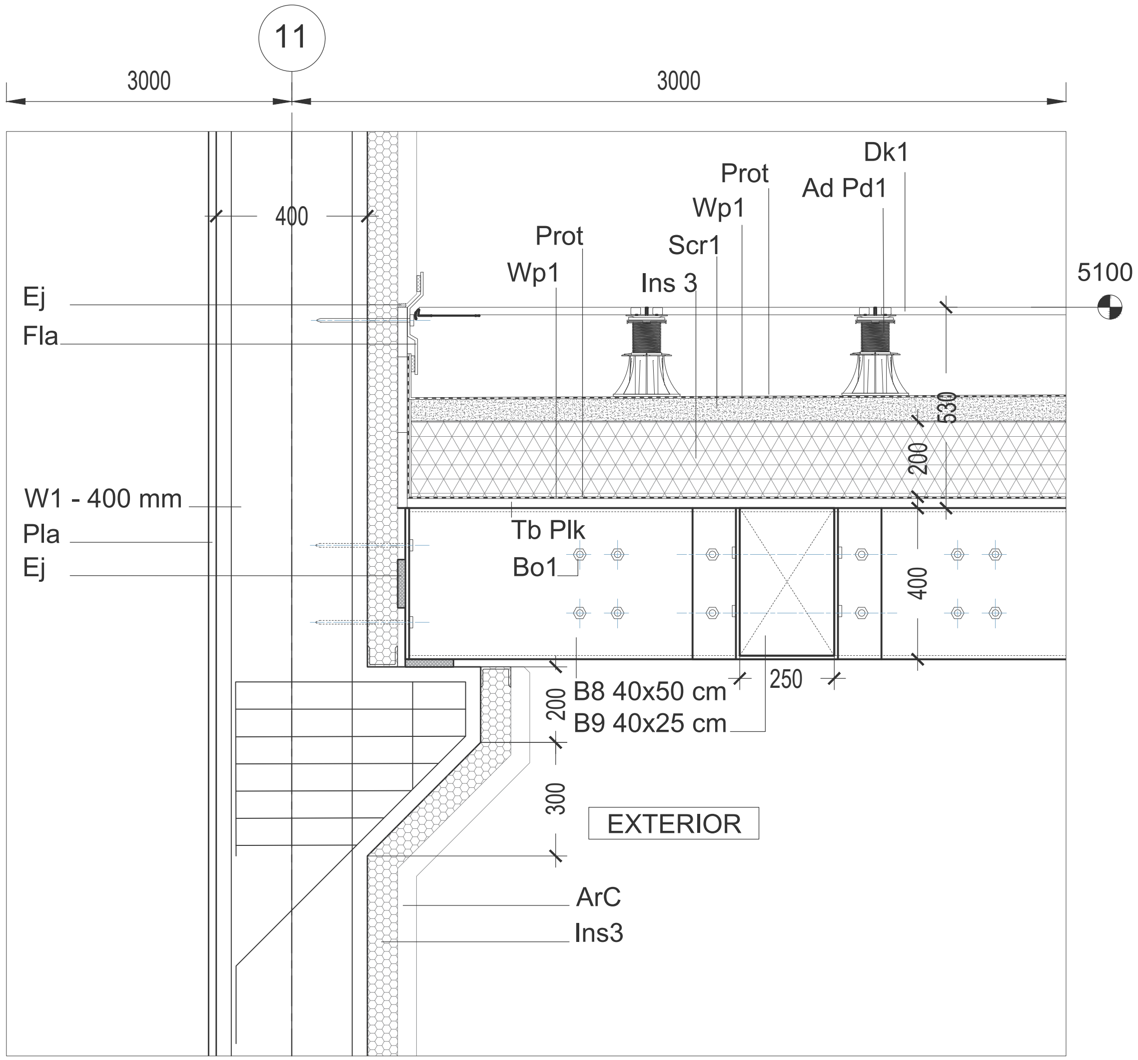
Structural Details, timber beams and earth walls
Level GF | Scale 1:200



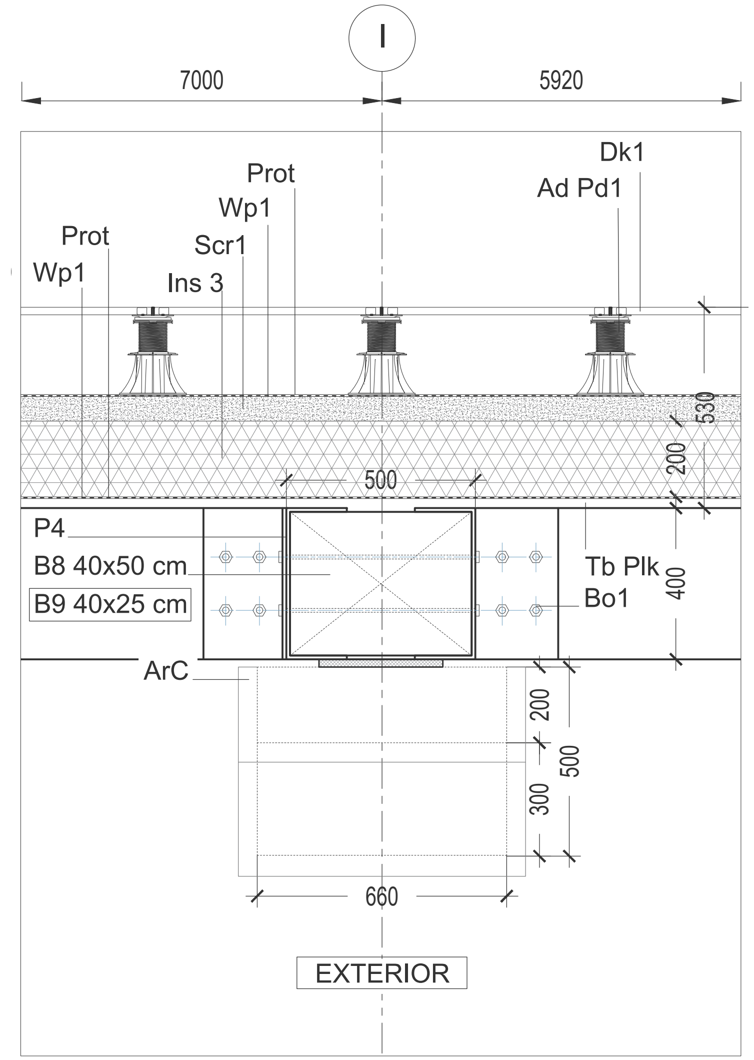


Structural Details, timber beams and earth walls
Level GF | Scale 1:200





Structural Details, timber beams and concrete corbel
Level GF | Scale 1:200



Structural Details, timber beams and concrete corbel
Level GF | Scale 1:200

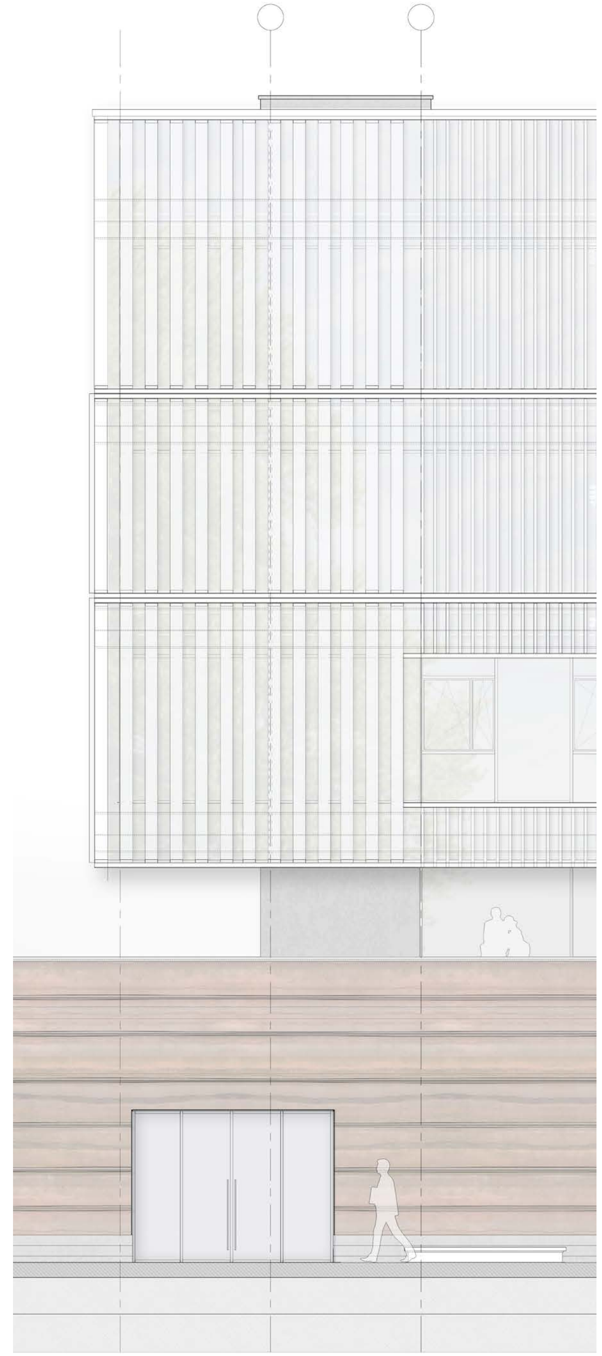
PART 03

MATERIALS CATALOG

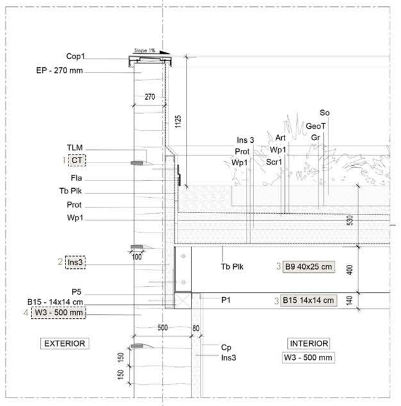
Diving more in details in each layer forming this complex, a careful selection of sustainable materials is made keeping in mind the environmental responsibilities we have today. Similarly to the structural design part, the two distinct project components differ in materiality, each showcasing a unique character:

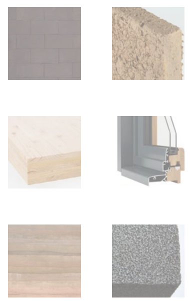
I- The blocks benefit from a common full glass façade: an inner layer of transparent curtain wall, assembled with an outer layer of channel glass. Ecological conditions, coupled with architectural esthetic aspirations, make the profiled glass a great choice. This outward layer allows a continuous contact with the outdoor landscapes and ensures an evenly diffused white light naturally illuminating the spaces. This makes it an excellent choice for many uses within such a hybrid program. The aim was also to homogenize and match the language of the raw and unsophisticated system of the rammed earth podium.

II- The first level exhibits a low-tech, highly sustainable, and crude construction. A layout of earthen walls, made from raw soil with no additives, gives the ensemble a natural look assimilating with the surrounding green landscape. The walls erected at a height of around 5 meters, are left exposed from the outside, showing off their unique patterns. At the interior level, they are covered with insulation and clay mortar panels in a way to keep the same atmosphere and improve ergonomic qualities. The timber beams holding the slab are left uncovered from the inside, thus preserving a tactical aesthetic combination of earth and wood. These elements and material choices allow a circular life cycle for this part of the building, as discussed in chapter 04.

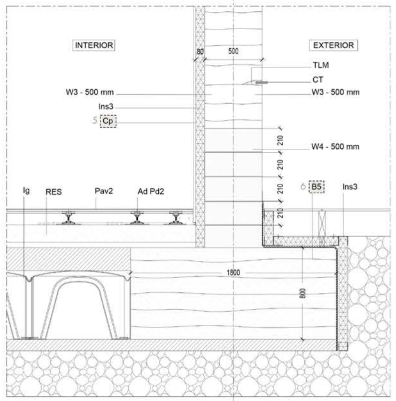


DETAIL I

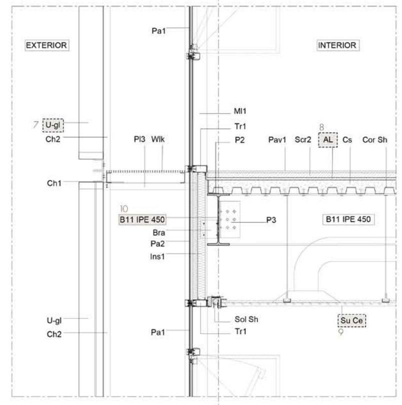


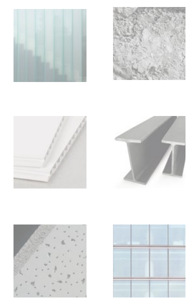


DETAIL II

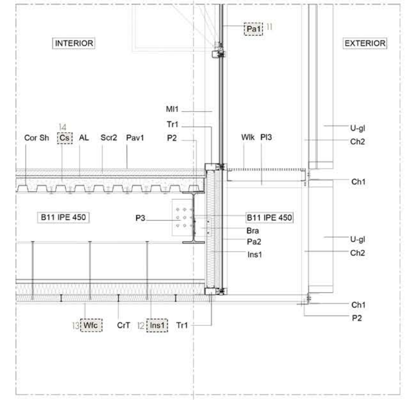


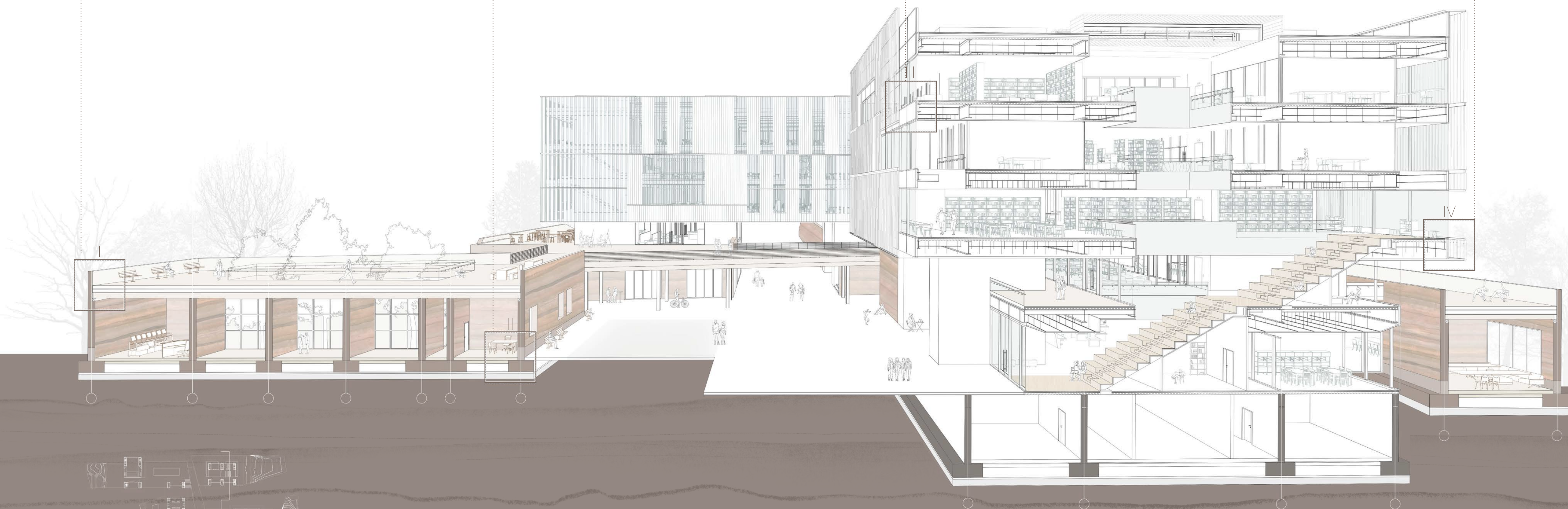
DETAIL III

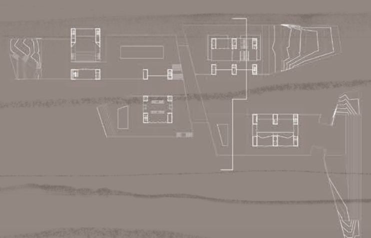




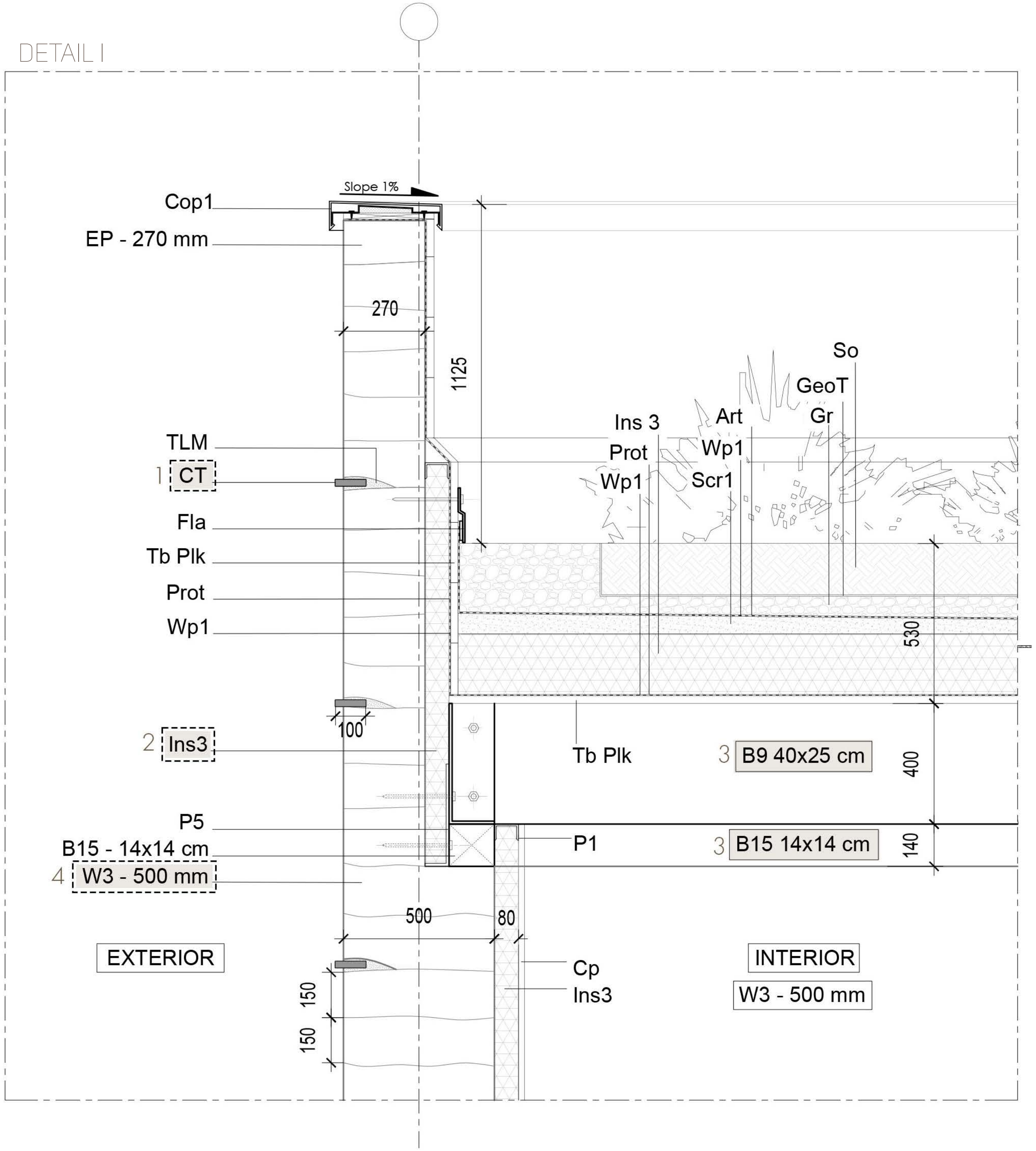
DETAIL IV







DETAIL I

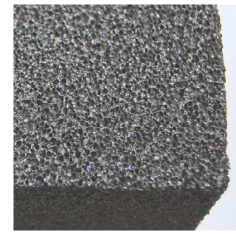


Sienna Clay Tiles on Earth Walls Facade

1. CT

Glass Foam Insulation for Podium

2. INS3



3. B9, B15

Laminated Timber Beams

4. W3

Rammed Earth Walls of Podium

1. CL - Sienna Clay Tiles on Earth Walls Façade

Product Name: **PLAQUETTE DE PAREMENT SIENNE**

Producer: **Terres Cuites de Roujolles**

Location: **France**

Composition: **Fired Clay**

Dimensions: **2 x 10 x 20 cm**

Weight: **800 g**

Coverage: **48 units/m2**

2. INS3 - Glass Foam Insulation for Podium

Product Name: **FOAMGLAS® T3+**

Producer: **FOAMGLAS**

Location: **France**

Dimensions: **600 x 450 mm**

Thickness: **80 mm**

Fusion Point **> 1000 °C**

3. B9, B15 - Laminated Timber Beams

Product Name: **CLT - Cross Laminated Timber**

Producer-Contractor: **STORA ENSO**

Location: **Paris, France**

Working Life: **50 years**

Moisture of wood: **6 to 15%**

4. W3 - Rammed Earth Walls of Podium

Product Name: **Pisé Préfabriqué**

Producer-Contractor: **Le Pisé**

Location: **France**

Thickness: **50 cm**

Density Dry **2.2**

Volumetric mass **2200 Kg.m-3**

Resistance to Compression **1.7 MPa**

Modulus of Elasticity: **800 MPa**

Thermal Conductivity: **0.81 W.m-1.K-1**

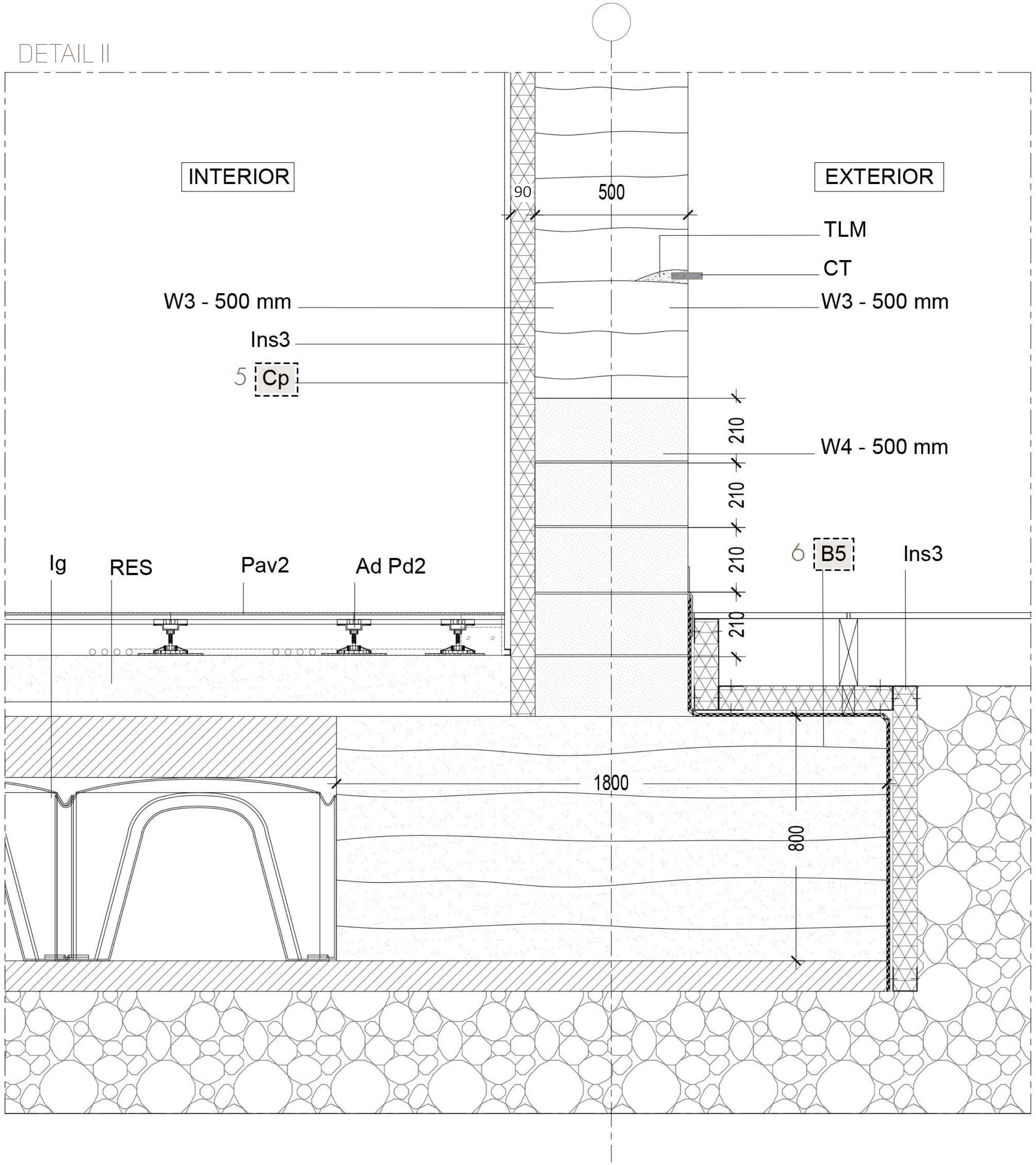
Vapour Diffusion Resistance: **10**

Water Absorption Coeff: **13 kg.m-².h0,5**

Fig.1 Unt fugia dolenet, con non conLocri, orei fue rem, furnihilifero Catquem, utes co meres huideffre forbemus

Fig.1 Unt fugia dolenet, con non conLocri, orei fue rem, furnihilifero Catquem, utes co meres huideffre forbemus

DETAIL II



Clay Plaster-Board as Interior Wall Finish

5. CP

Cement used to Stabilize Rammed Earth

6. B5, FOUNDATION BEAM

6. B5, FOUNDATION BEAM

Rammed Earth Foundation beams

FOR OPENINGS

Podium Sliding Doors and Windows

5. CP - Clay Plaster-Board as Interior Wall Finish

Product Name:	LEMIX Clayboard
Producer:	CLAYTEC
Location:	Belgium, Luxembourg, Germany
Composition:	Clay, earth, wood fibre, starch, jute
Thickness:	22 mm
Surface hardness:	≤ 15 mm
Bending tensile strength	≥ 0.8 N/mm2
Surface Tensile Strength	≥ 0.1 N/mm2
Thermal Conductivity:	0.353 W/mK
Heat storage	35.1 kJ/m2K

6. B5, FOUNDATION BEAM - Cement used to Stabilize Rammed Earth

Product Name:	PLANET cement
Producer:	LaFarge (HOLCIM group)
Location:	France
Code:	CEM III/B 42,5 N – LH/SR CE PM NF
Compression Resistance:	5 MPa (day 1), 15 MPa (day 15), 56 MPa (day 28)
Start of Setting:	3 hours
Composition:	66% recycled materials

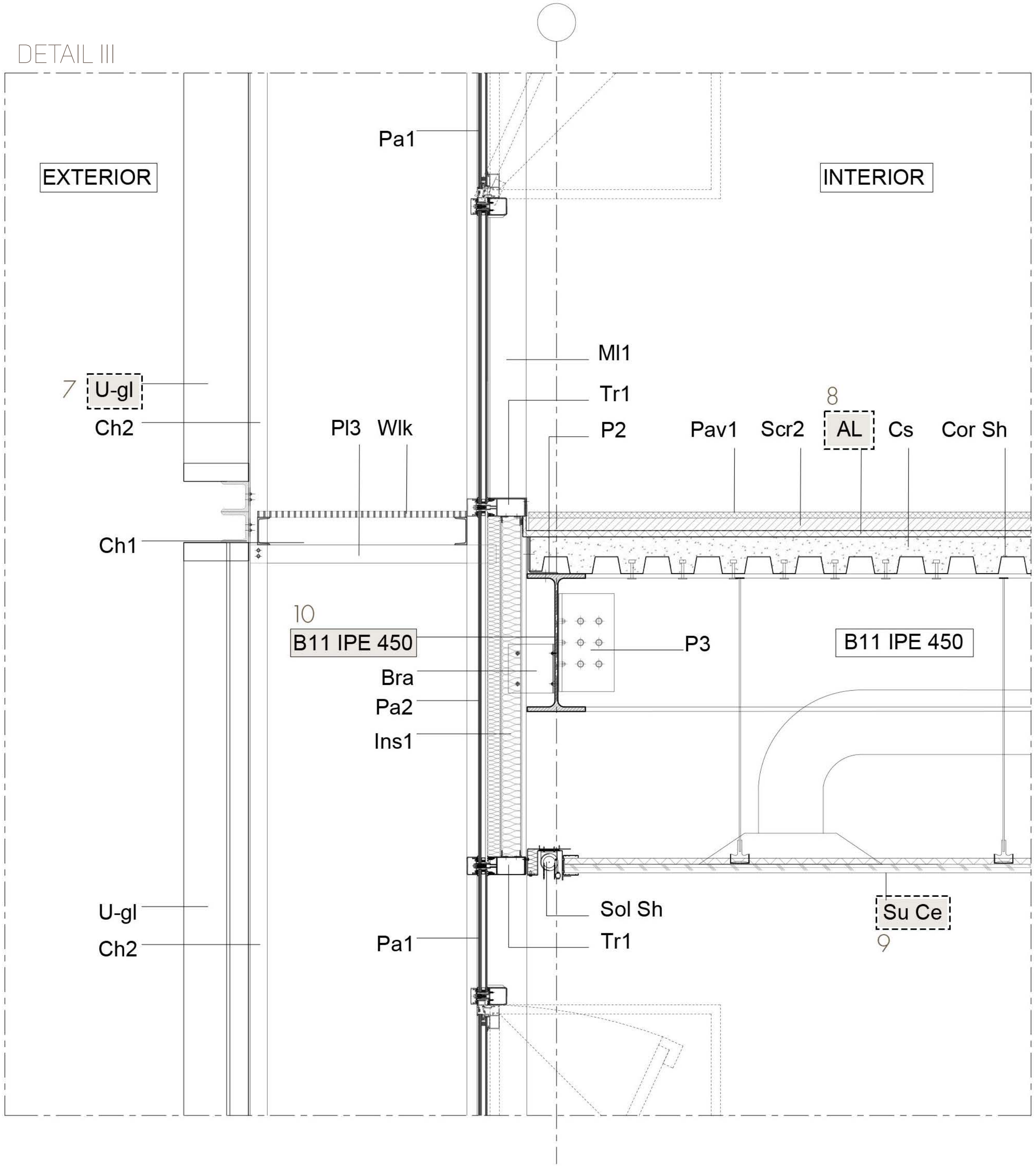
6. B5, FOUNDATION BEAM - Rammed Earth Foundation beams

Product Name:	Pisé Préfabriqué
Producer:	Le Pisé
Location:	France
Dimensions:	1800 x 800 mm
...	[See material 4]

FOR OPENINGS - Podium Sliding Doors and Windows

Product Name:	Fenetres et Portes-Fenetres Mixtes Bois-Aluminium Double Vitrage
Producer:	MINCO
Location:	France
Dimensions:	235 x 218 cm
U-value:	1.3 W/(m² .K)
Acoustic Performance:	31 dB
Wind and Rain Permeability:	A*4 E*9A V*C2

DETAIL III

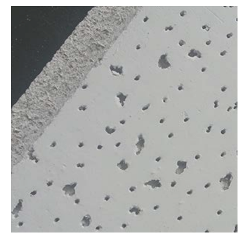


U Glass as second skin

7. U-GL

Cork Fibers Layer for Floor Acoustic and Thermal Insulation

8. AL



9. SU CE

Suspended Ceiling with Mineral Binder

10. B11 & OTHER

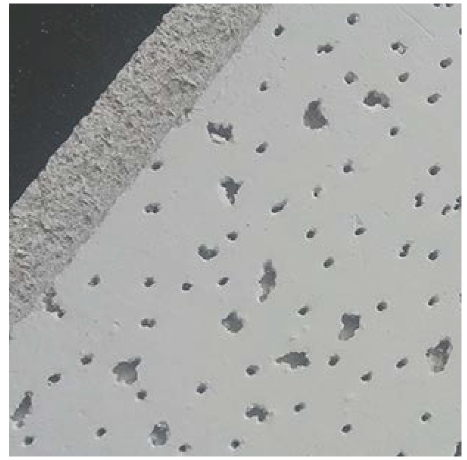
HEB and IPE Steel Beams

7. U-GL - U Glass as second skin

Product Name:	Lamberts LINIT - Chord finish
Producer:	Glasfabrik Lamberts
Location:	Germany
Dimensions:	250 x 60 x 60 mm
Type:	LINIT P 23/60/7, 504
Load resistance:	7

8. AL - Cork Fibers Layer for Floor Acoustic and Thermal Insulation

Product Name:	Sous-Couche NATURE
Producer:	Kenzaï
Location:	France
Dimensions:	1 x 10 m
Thickness:	2 mm
Noise Reduction:	20 dB
Compression Resistance:	90 KPa
Thermal Resistance:	0.052 m2.º C/W



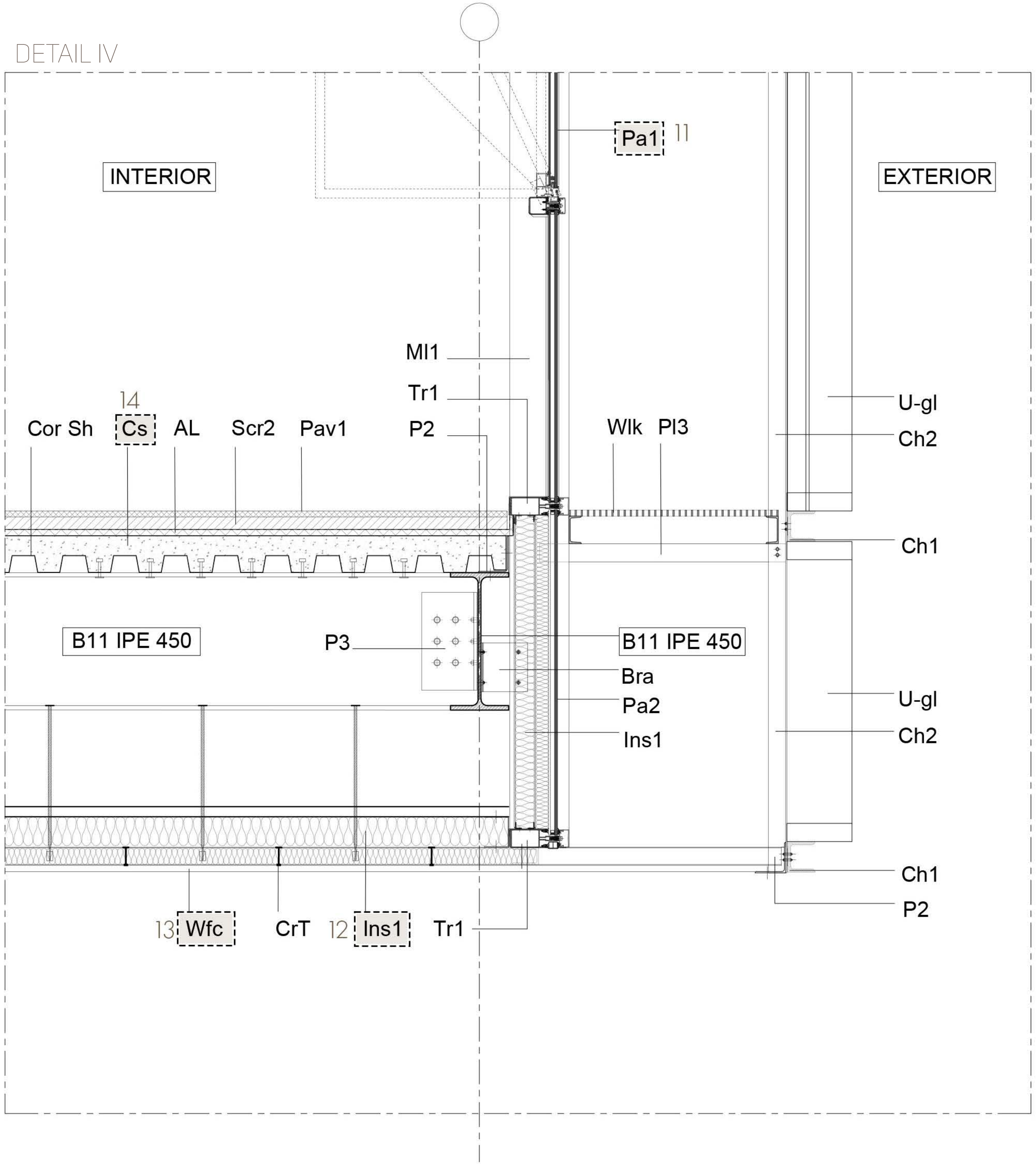
9. SU CE - Suspended Ceiling with Mineral Binder

Product Name:	ADAGIO Acoustic+
Producer:	Knauf Ceiling Solutions
Location:	France
Dimensions:	600 x 600 mm
Sound Reduction:	22 dB
Light Reflectance:	90%
Fire Reaction:	Euroclass A2-s1, d0
Weight:	5.0 kg / m²
Thermal Conductivity:	0.060 W/mK

10. B11 & OTHER - HEB and IPE Steel Beams

Product Name:	IPE/HEB - European beams with parallel flanges or wide flange
Producer:	STAD
Location:	France
Reference Code:	EN-10025/S355J2
Dimensions:	Specific to each beam

DETAIL IV



Glass Panels for Curtain Wall

11. PA1

Rock-Wool Facade Thermal Insulation

12. INS1

13. WFC

PVC Waterproof Exterior False Ceiling

14. CS & OTHER

Concrete for Slabs and Core walls

11. PA1 - Glass Panels for Curtain Wall

Product Name: DIAMANT - Extra clear, low iron glass

Producer: Saint - Gobain

Location: France

Dimensions: 1500 x 2900 mm

Thickness: 6 mm

Light Transmission: 91%

External Reflexion: 8%

g-value: 90%

Energy Transmmission: 89%

Energy Absorption: 3%

12. INS1 - Rock-Wool Facade Thermal Insulation

Product Name: Rockmur nu

Producer: ROCKWOOL

Location: France

Dimensions: 1350 x 600 mm

Code: AMO-CORKT61-3-25

Noise Reduction: 20 dB

Volumetric Mass: 32 to 36 Kg/m3

Thermal Conductivity: 0.05 W/m.K

13. WFC - PVC Waterproof Exterior False Ceiling

Product Name: DumaClip PVC Panels

Producer: DumaPlast

Location: Belgium

Thermal Conductivity: 0.0669 W/m.K

Thermal Dilatation Coeff.: 0.08 mm/m/ºC

Softening Temperature: 80 ºC

Density: 1.51 g/ml

14. CS & OTHER - Concrete for Slabs and Core walls

Product Name: Agilia Architectural Concrete

Producer: LaFarge (HOLCIM group)

Location: France

Density: 2.3

Description: Auto-placing concrete for exposed architectural concrete facades.

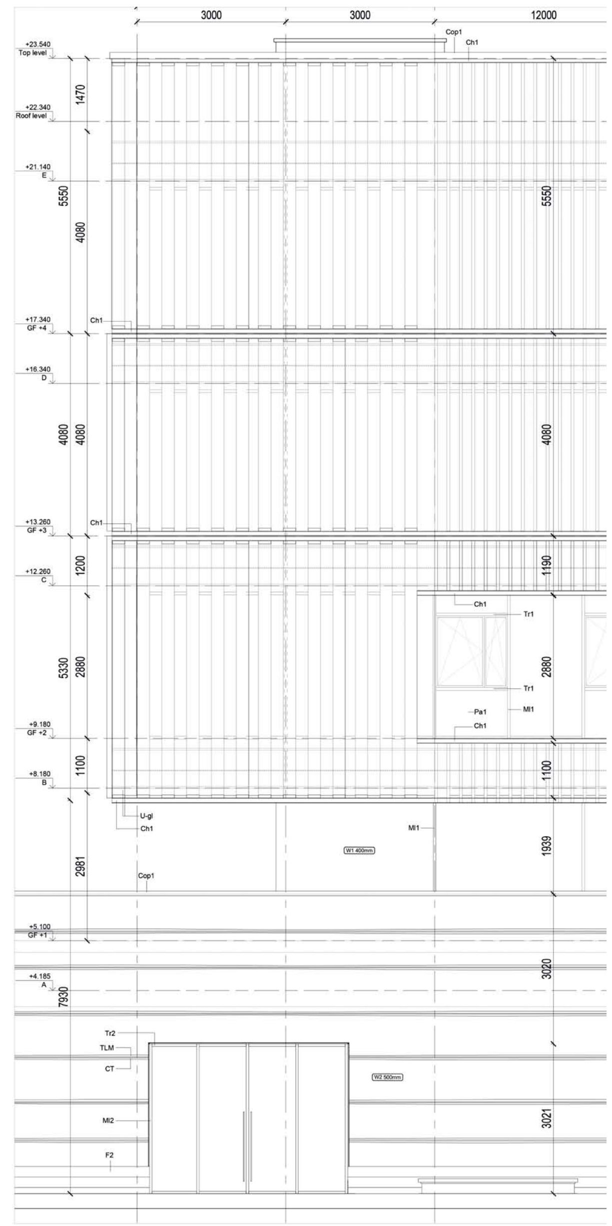
PART 04

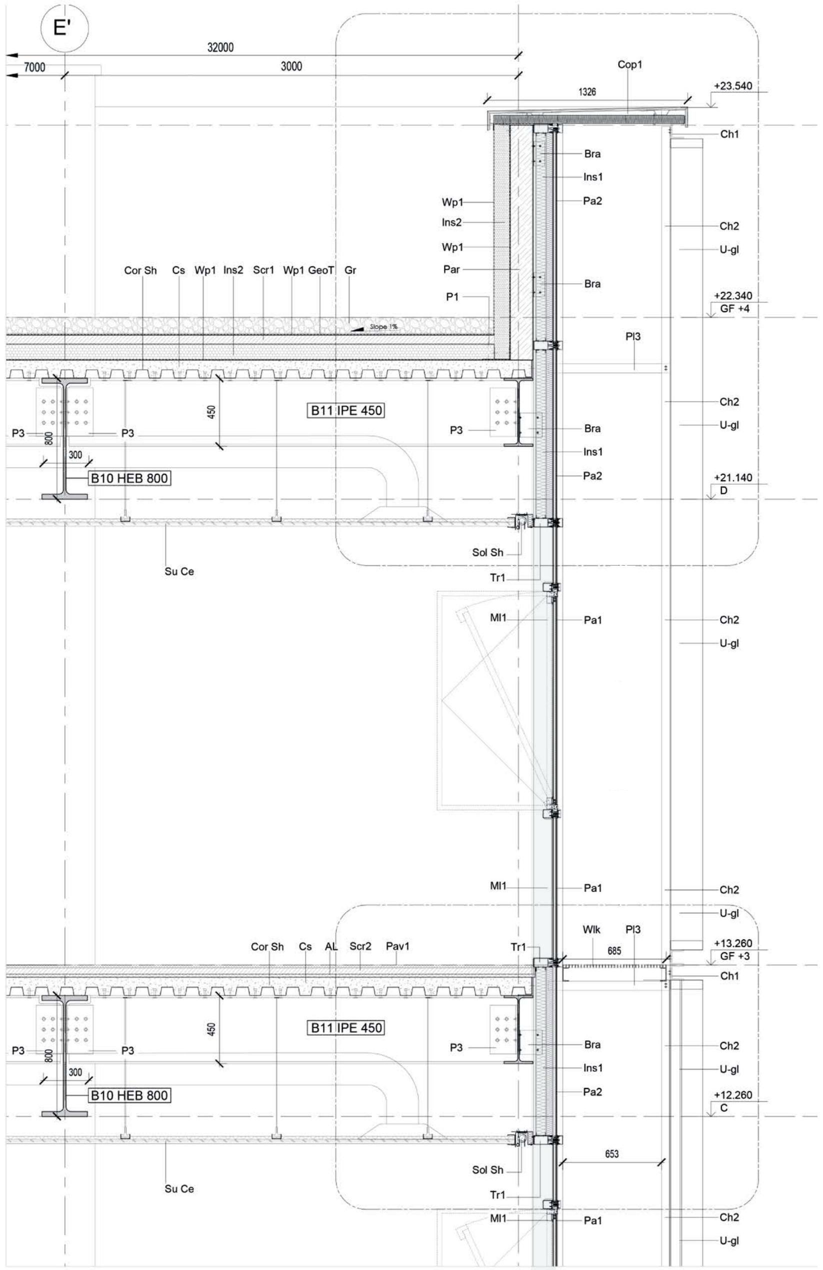
TECHNOLOGY

Following the sequence, it is important to understand how each system is constructed enabling the full functioning of the whole. As we proceeded in the other modules, the building technology also demonstrates two separate systems:

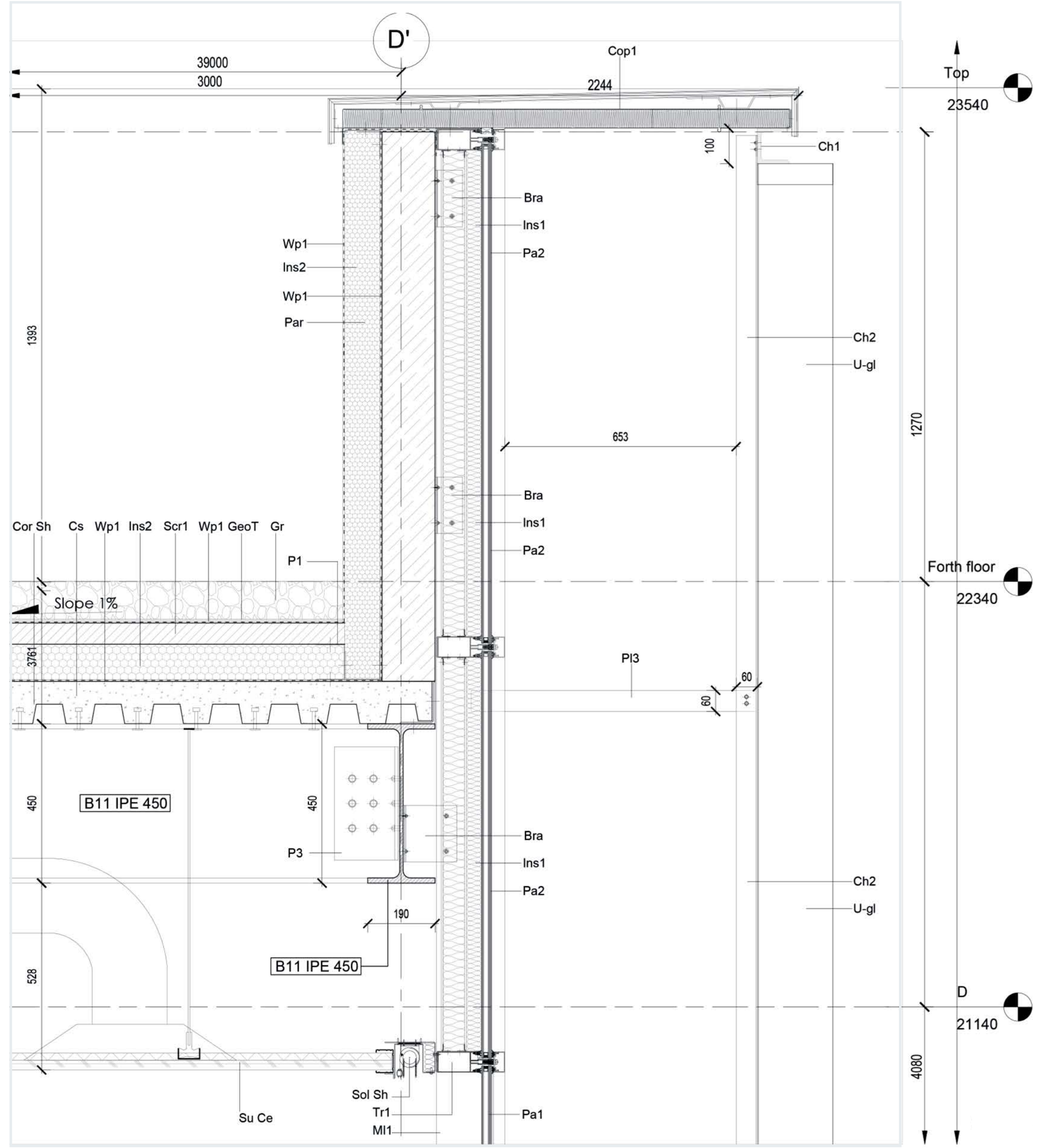
I- The blocks present a common construction for the envelope: a double façade made of an inner curtain wall and an outer composition of U-glass. Both layers are attached together through vertical and horizontal steel channels allowing their stability and resistance. Then, these channels are connected directly to the structural of the building, mostly to the steel beams. The outer resilient material provides a robust layer of protection to the building for decades to come. The durable glass envelope reaches continuous vertical spans of up to 7 m, and features glass-to-glass corners in a variety of angles.

I- The podium exhibits a low-tech, natural, and unsophisticated construction. Earthen walls, made from raw soil with no additives, carries the green sustainable platform. A hierarchy of timber beams that are connected together with many configurations allow the loads transfer to the walls. Particular attention is given to the outer rammed-earth walls as they are exposed to wind, water and temperature. Stone necks shape their footings and fired clay tiles run along the surface preventing water runoff and the decay of the material.





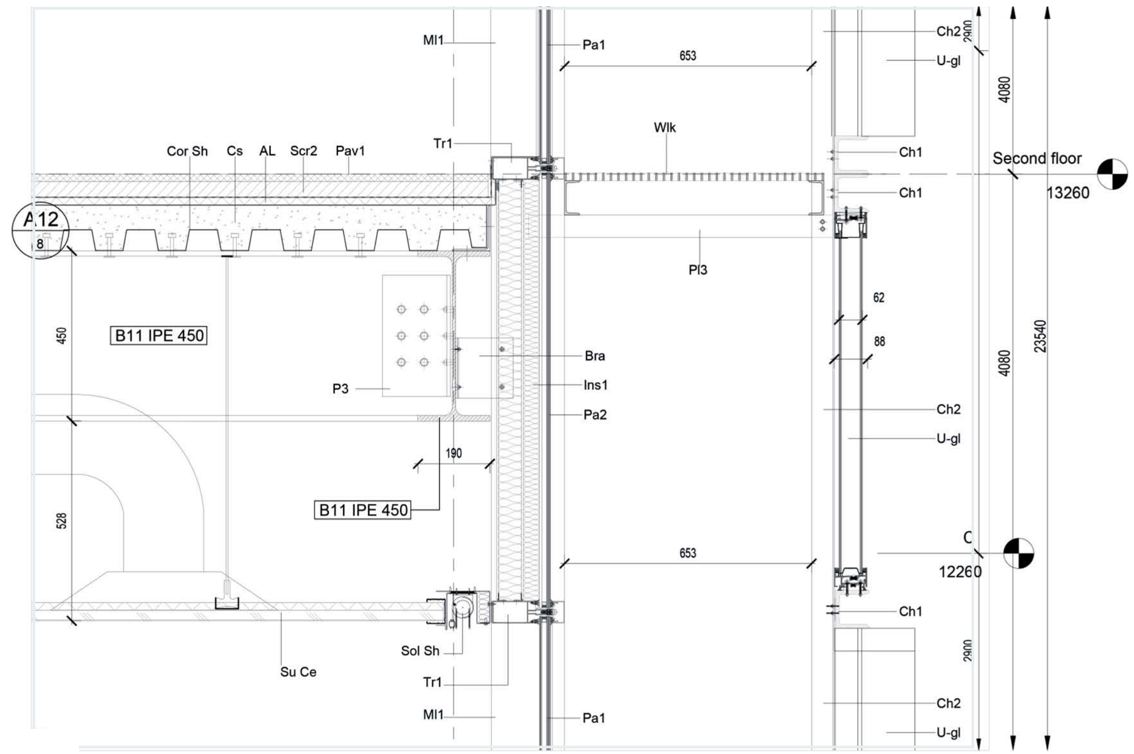
Construction drawing of vertical section showing the top coping system of the blocks | Scale 1:50



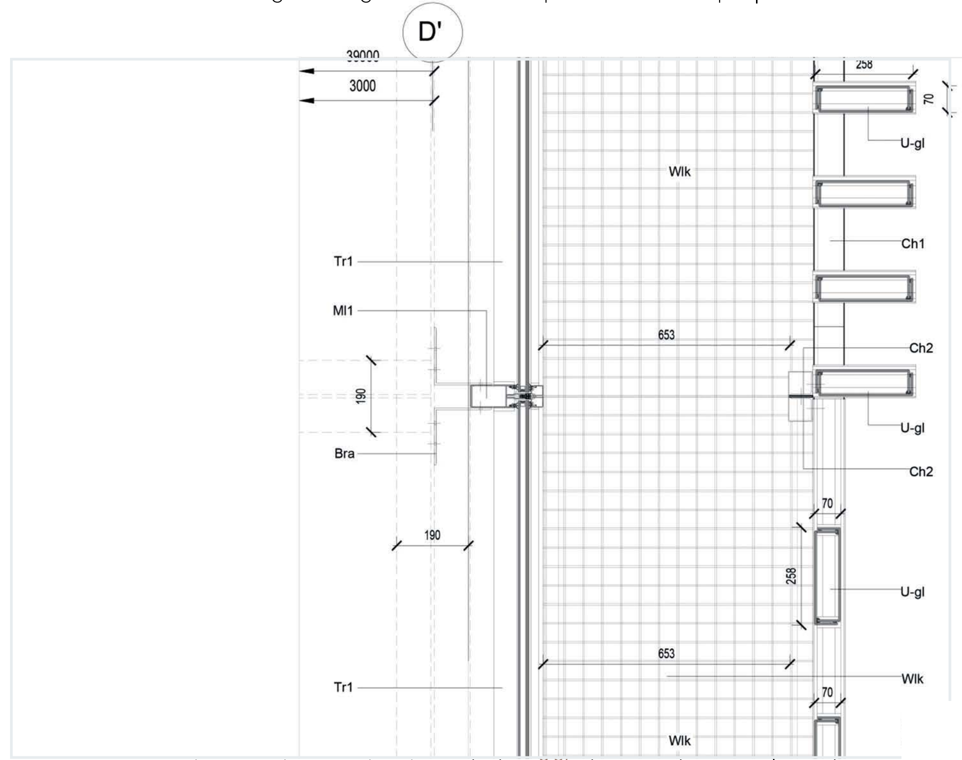
Construction drawing showing the top coping system of the blocks | Scale 1:20

TECHNICAL DESCRIPTION

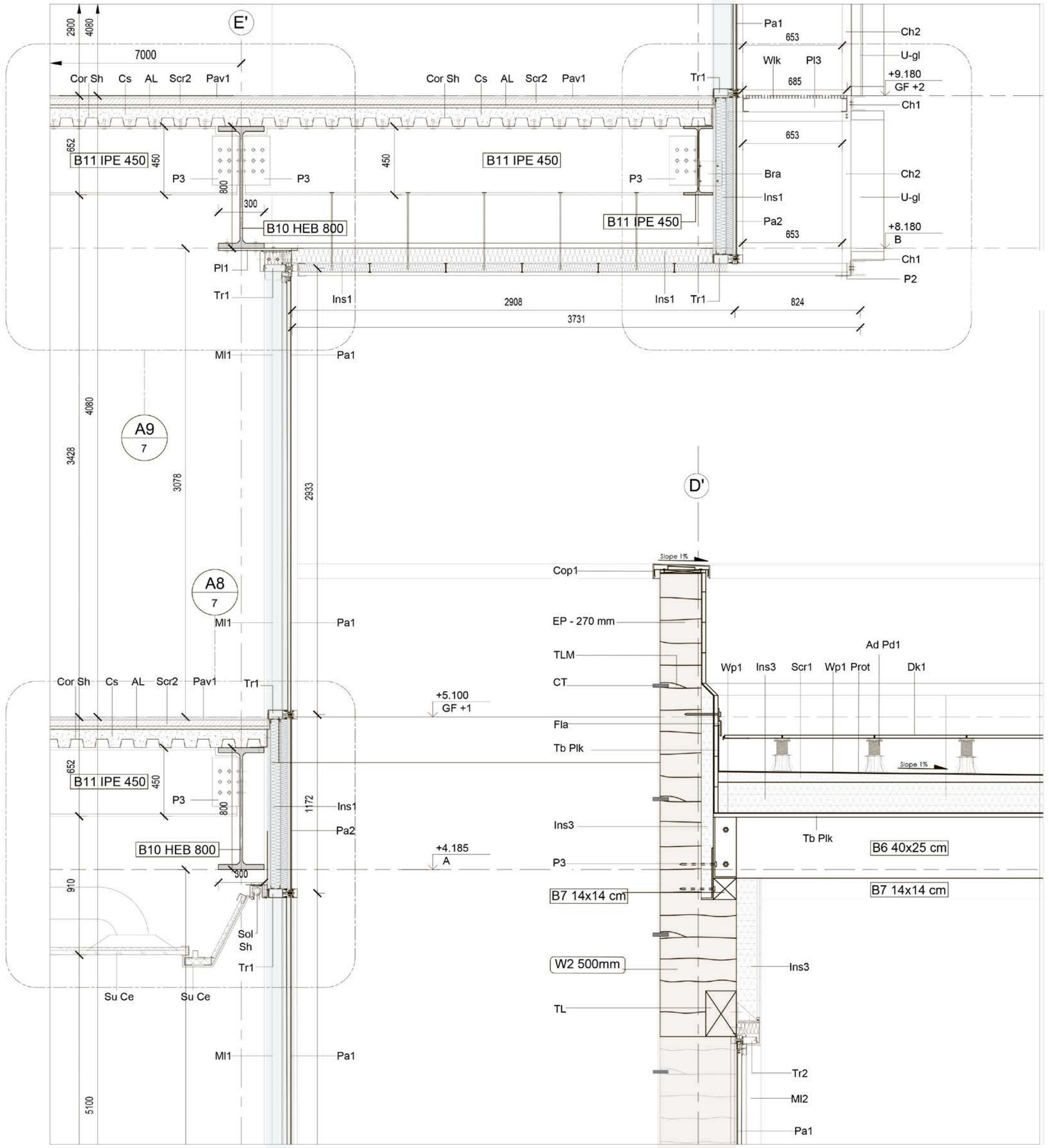
Code	Element	Dimensions	Material
B8	Beam	400x500mm	Timber C35
B9	Beam	400x250mm	Timber C45
B10	Beam	800x300mm	Steel
B11	Beam	450x190mm	Steel
B12	Beam	432x307mm	Steel
B13	Beam	814x303mm	Steel
W1	Wall	400mm	Concrete
W2	Wall	500mm	Concrete
W3	Wall	500mm	Rammed earth
W5	Wall	75mm	Gypsum plasterboard
St1	Staircase		Concrete
St2	Staircase		Concrete
St3	Staircase		Concrete
C1	Column	432x307mm	Steel
B15	Tie beam	140x140mm	Timber C22
Scr 1	Screed	60mm	Concrete
P1	C shaped profile	80x50x2mm	Steel
P2	Angle profile	120x100x4mm	Steel
P3	L shaped profile	340x80x2mm	Steel
P4	C shaped profile	400x150x2mm	Steel
ArC	Architectural concrete	50mm	Cement
Ej	Expansion joint	20mm	Rubber
Pla	Interior plaster	20mm	Cement
Ins3	Thermal insulation	Varies	Glass foam
AL	Acoustic layer	20mm	Cork fibers
Gr	Gravel	80mm	Stone
Port	Protection layer	4mm	Polyurethane-rubber
Wp1	Waterproofing membrane	8mm	Polyuester fabric
TLM	Trass-lime mortar	-	Trass-lime mix
CT	Tiles	100x120mm	Fired clay
GeoT	Geotextile	5mm	Polyuester fabric
Art	Anti-root membrane	5mm	Bitumen
So	Soil layer	150mm	Top-soil
Cp	Clay internal plaster	20mm	Earth clay
EP	Parapet	270mm	Rammed earth
Dk1	Deck-dry system	20mm	Wood
Ad Pd	Adjustable pedestals	-	Zinc-coated steel
Tb Plk	Laminated timber planks	25mm	Timber C22
Bo1	M 14 Bolts	8.8mm	Alloy steel
Fla	Roof flashing	180mm	Metal sheet
Cop1	Coping system	6mm	Metal sheet
RES	Slab	150mm	Rammed earth



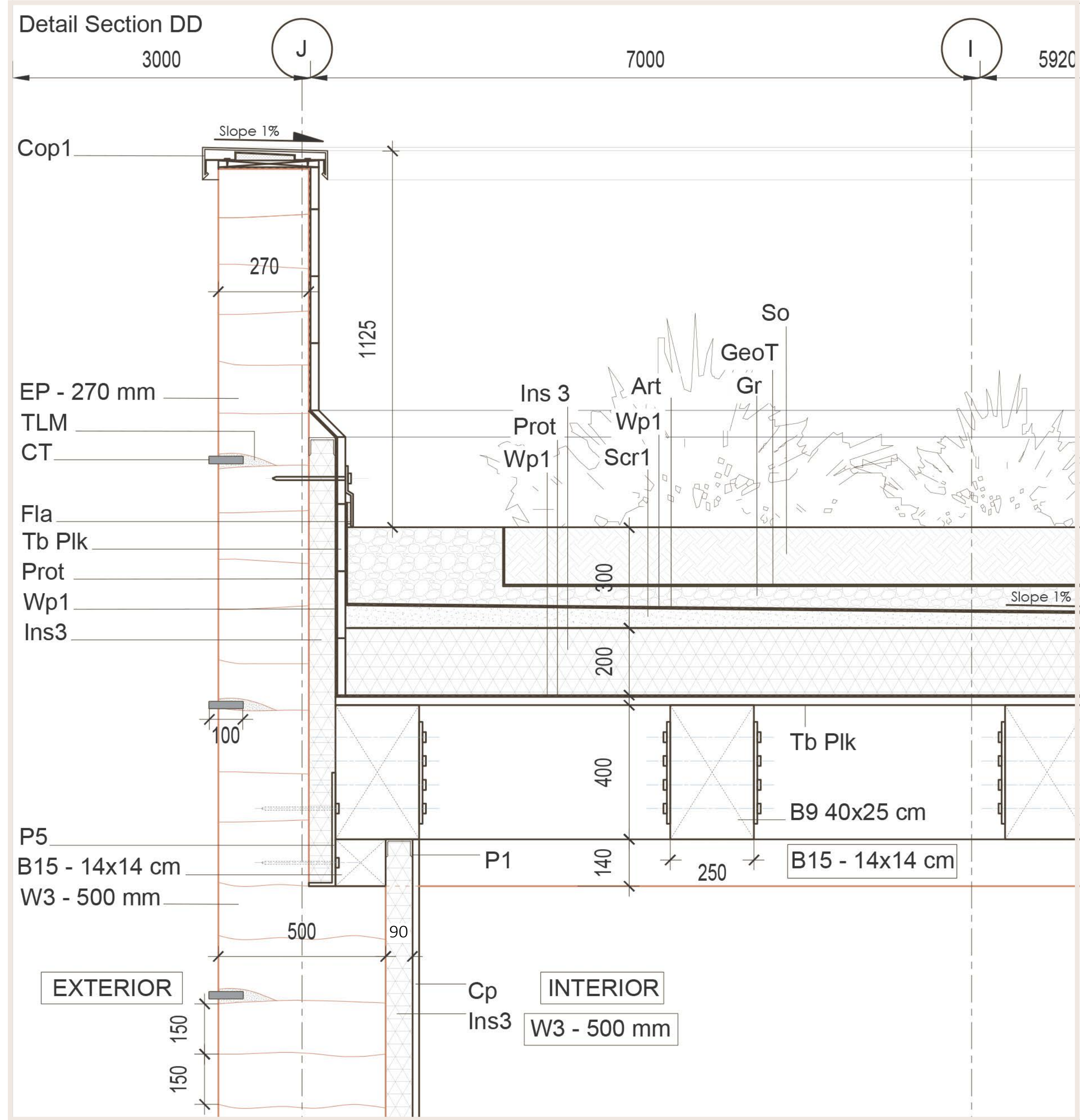
Construction drawing showing the intermediate part of the envelope | Scale 1:20



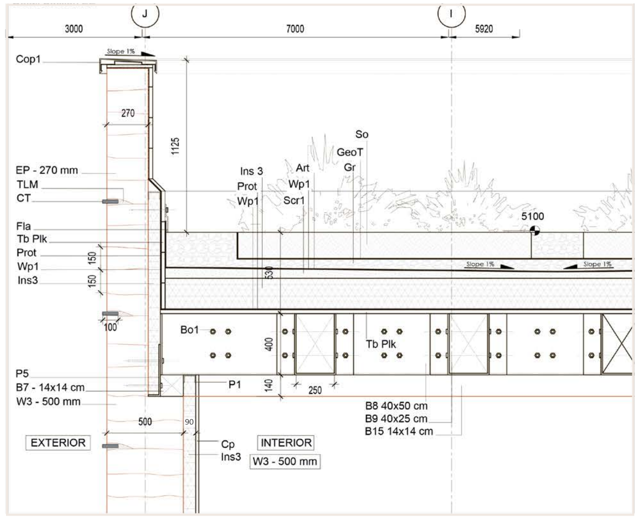
Construction drawing showing the channel-glass-envelope in plan view | Scale 1:20

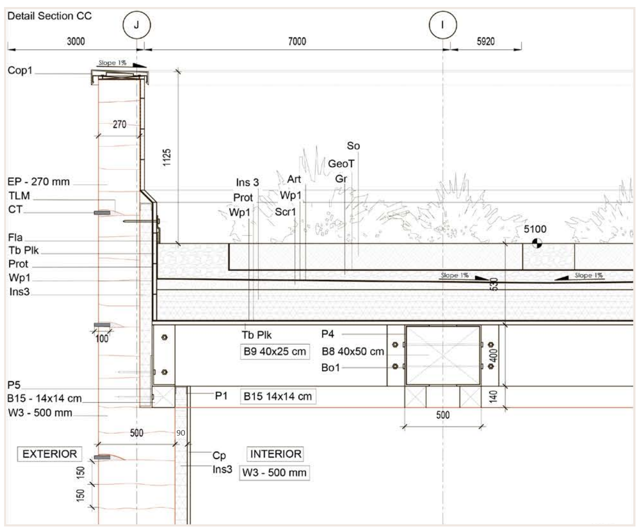


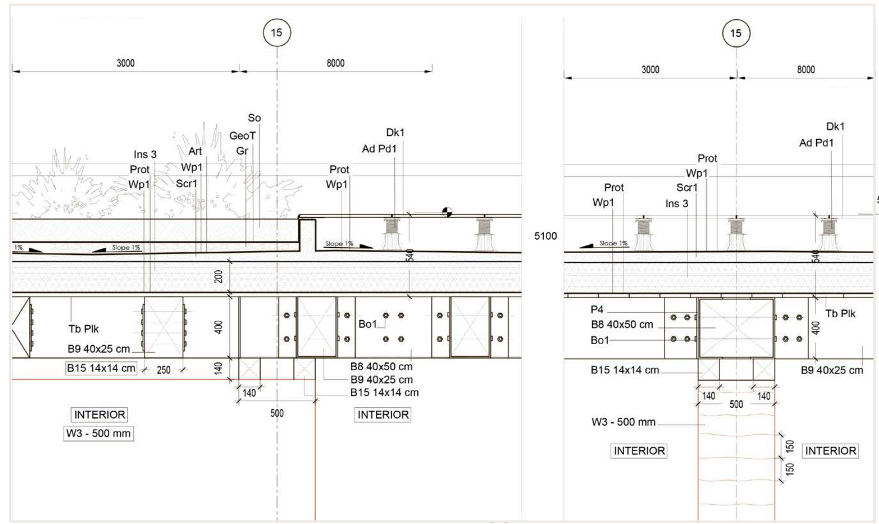
Construction drawingof vertical section showing the envelope, part2 | Scale 1:50



Construction drawings of a vertical section showing the timber beams and earthen wall connections | Scale 1:20





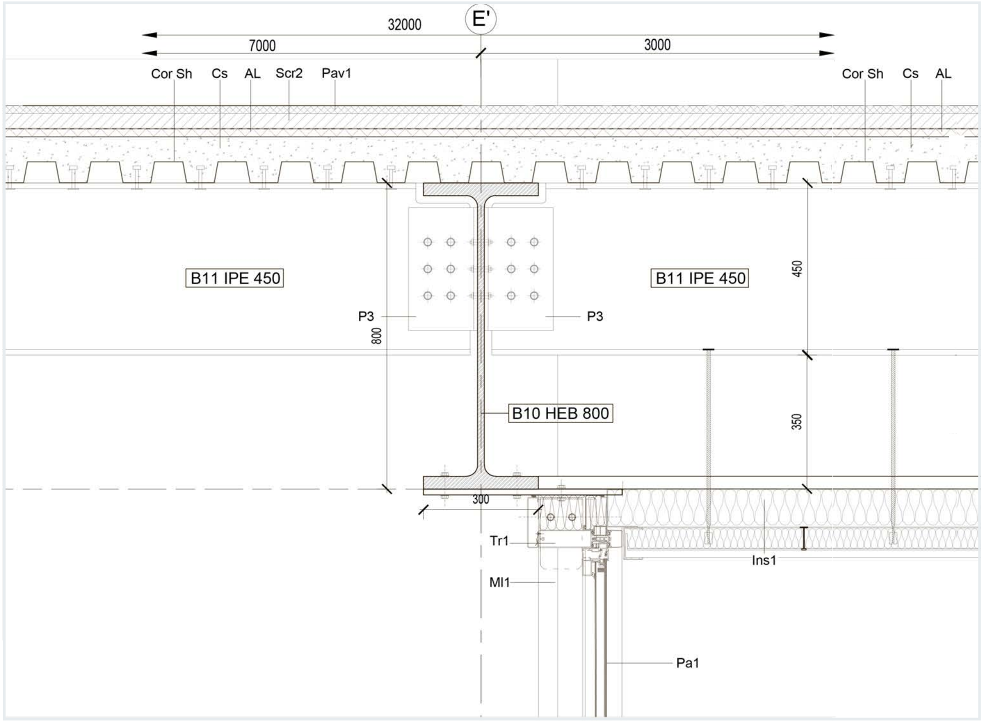


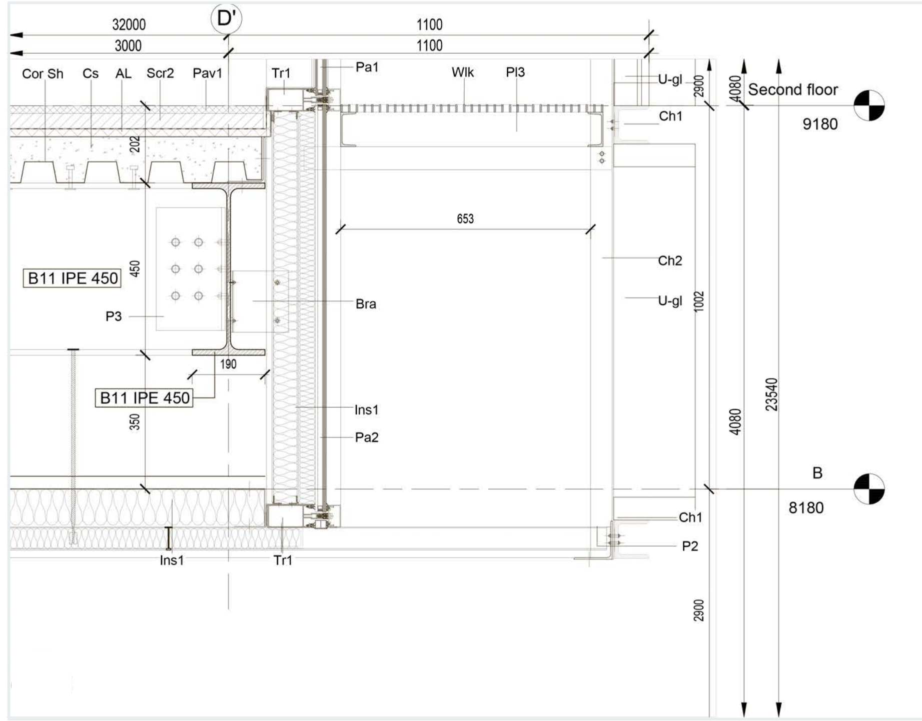
Construction drawings of detail vertical sections showing the timber beams and earthen wall connections, within different configurations | Scale 1:50

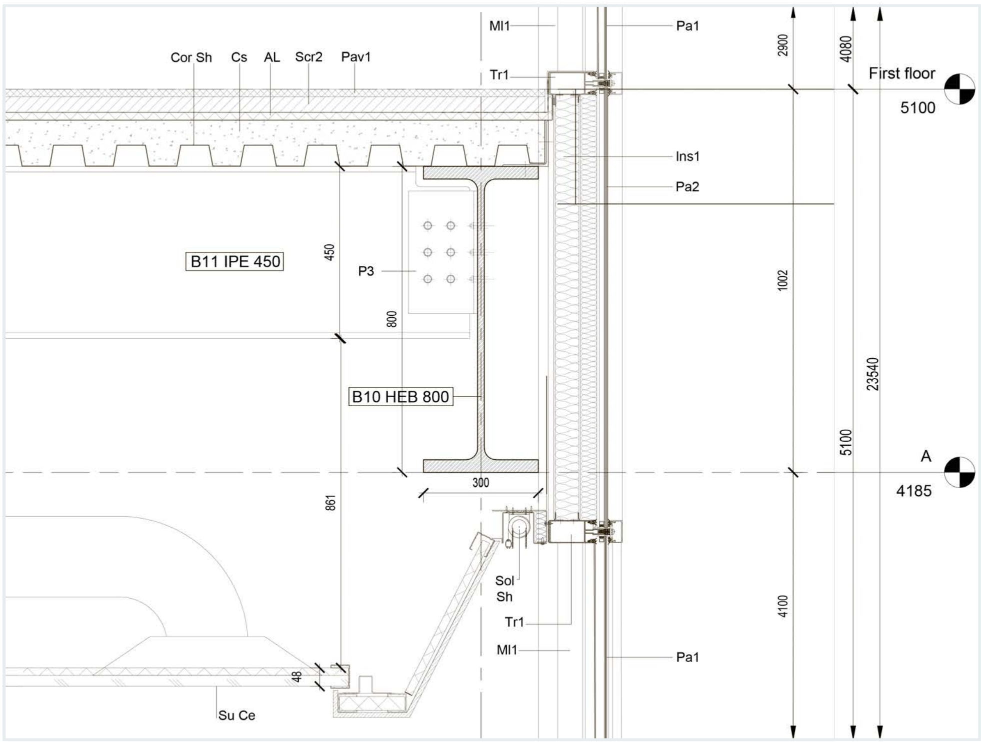
The assembly of the first-level platform is made possible thanks to a hierarchy of primary and secondary timber beams that transfer the floor loads to the rammed-earth walls (W3).

In fig.a, we see a set of secondary beams (B9) connected to the primary one (B8) in projection that rests on the supporting wall; while in fig.b it's the opposite.

In fig. c-d, the connection with the earthen walls is clearer: two beams of 14x14cm (B15) run along the walls to ensure a more stable and secure timber-earth relation.







Construction drawings of a detail vertical section showing the structural system along with the envelope sonstruction system that make up the four technological blocks

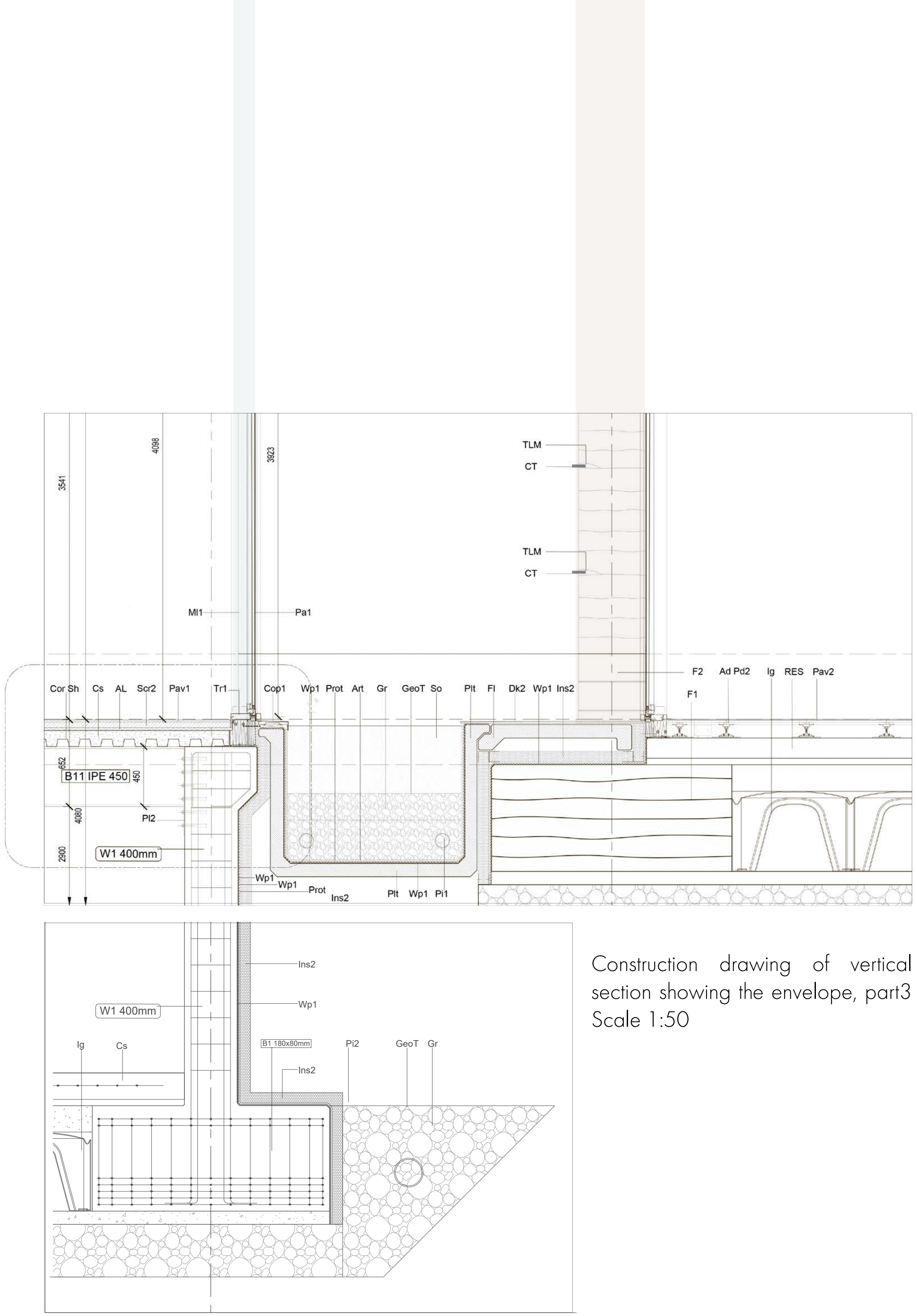
Scale 1:20

When it comes to the blocks, the 3-meter cantilever around the concrete cores allows the envelope to be completely independent of structural elements, therefore permitting a full glass screen for an amplification of natural light.

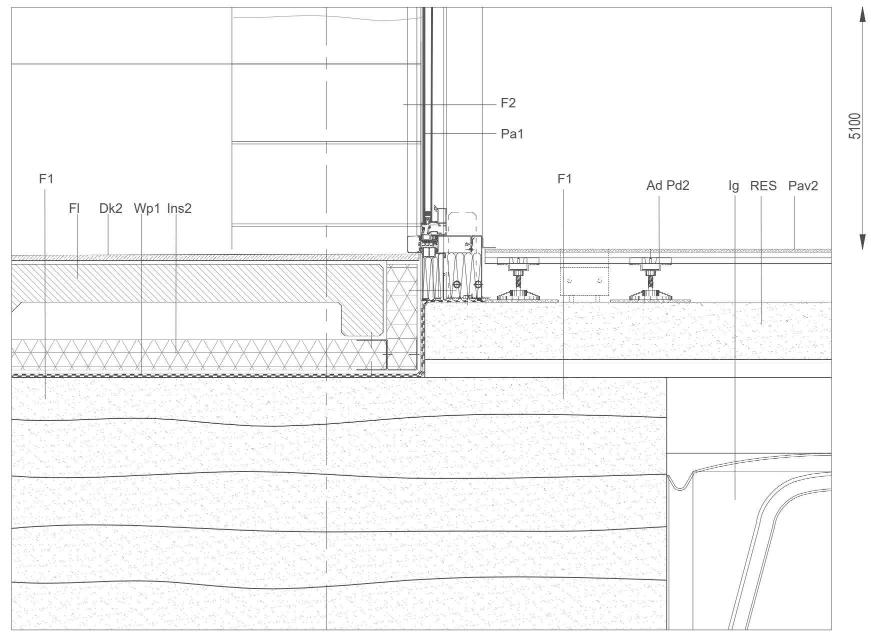
The first level envelope is made of a simple curtain wall glass going up to a 5-meter height.

While the upper floors of the hanging blocks showcase a double façade arrangement with a collection of channel glass elements on the outer layer.

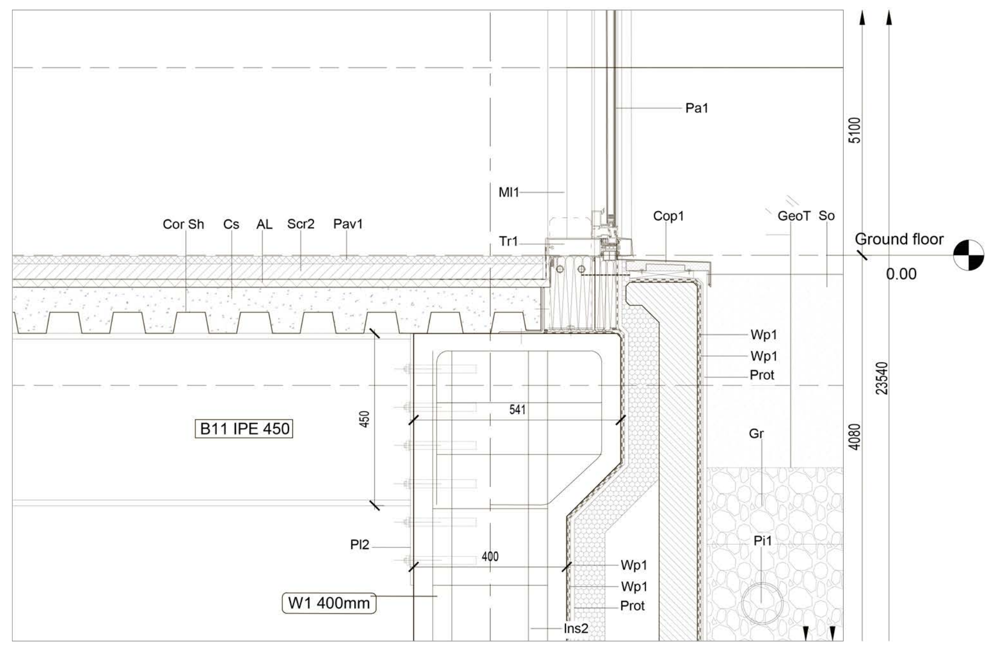
The system is holding on a set of vertical and horizontal steel channels that are connected to the main structure of the blocks.



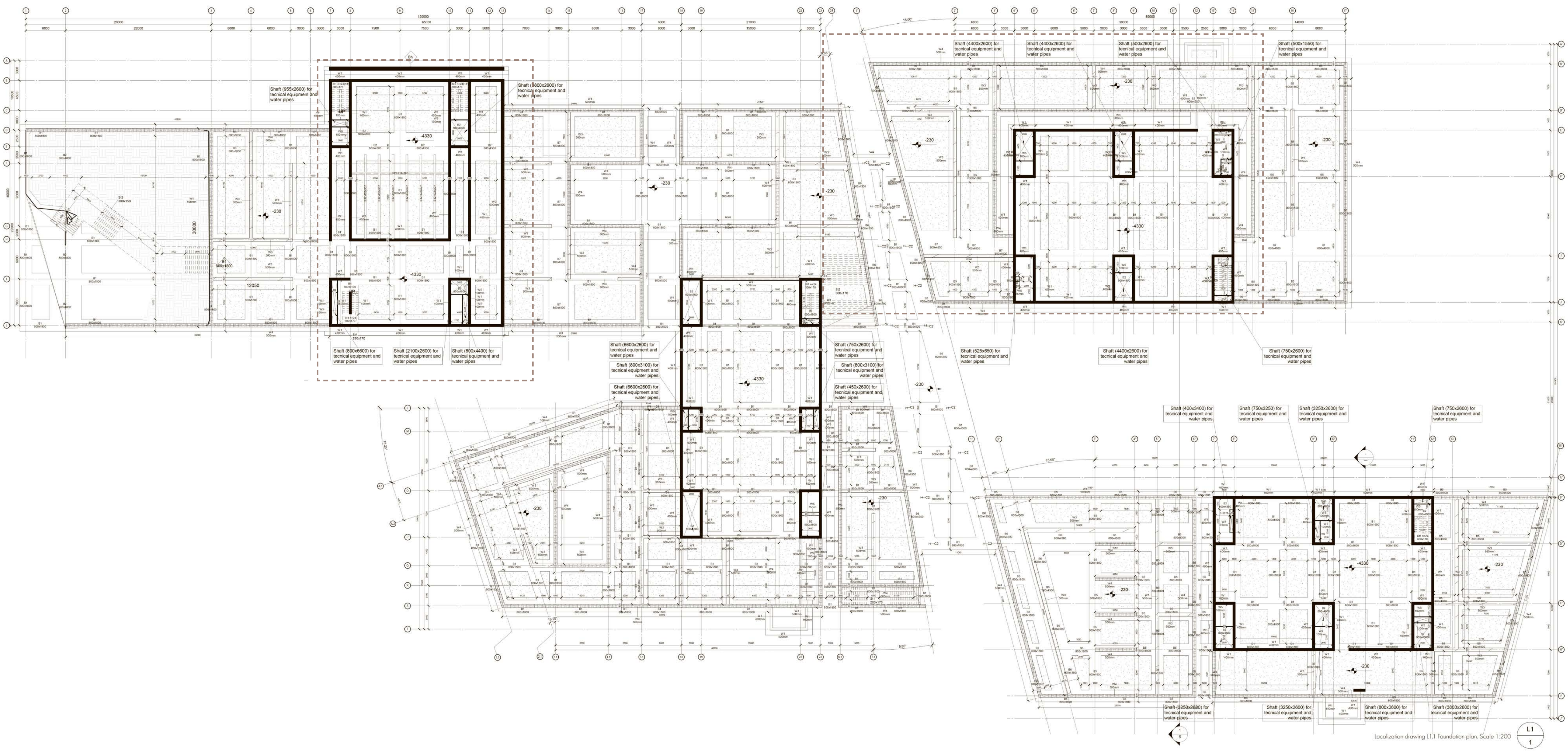
Construction drawing of vertical section showing the envelope, part3 Scale 1:50



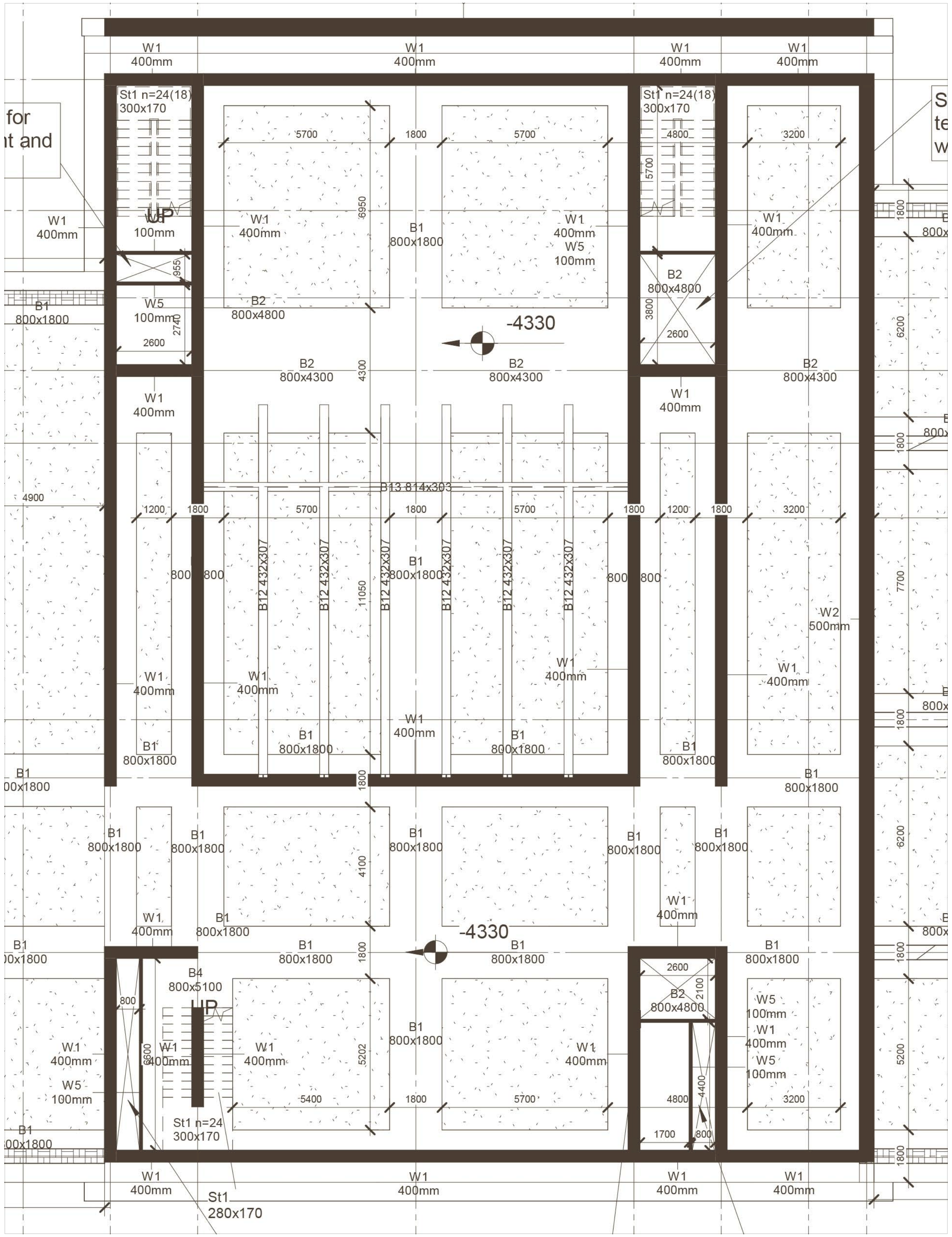
Construction drawing of vertical section showing the base of the podium, Scale 1:20



Construction drawing of vertical section showing the base of the blocks, Scale 1:20



Localization drawing of foundation plan



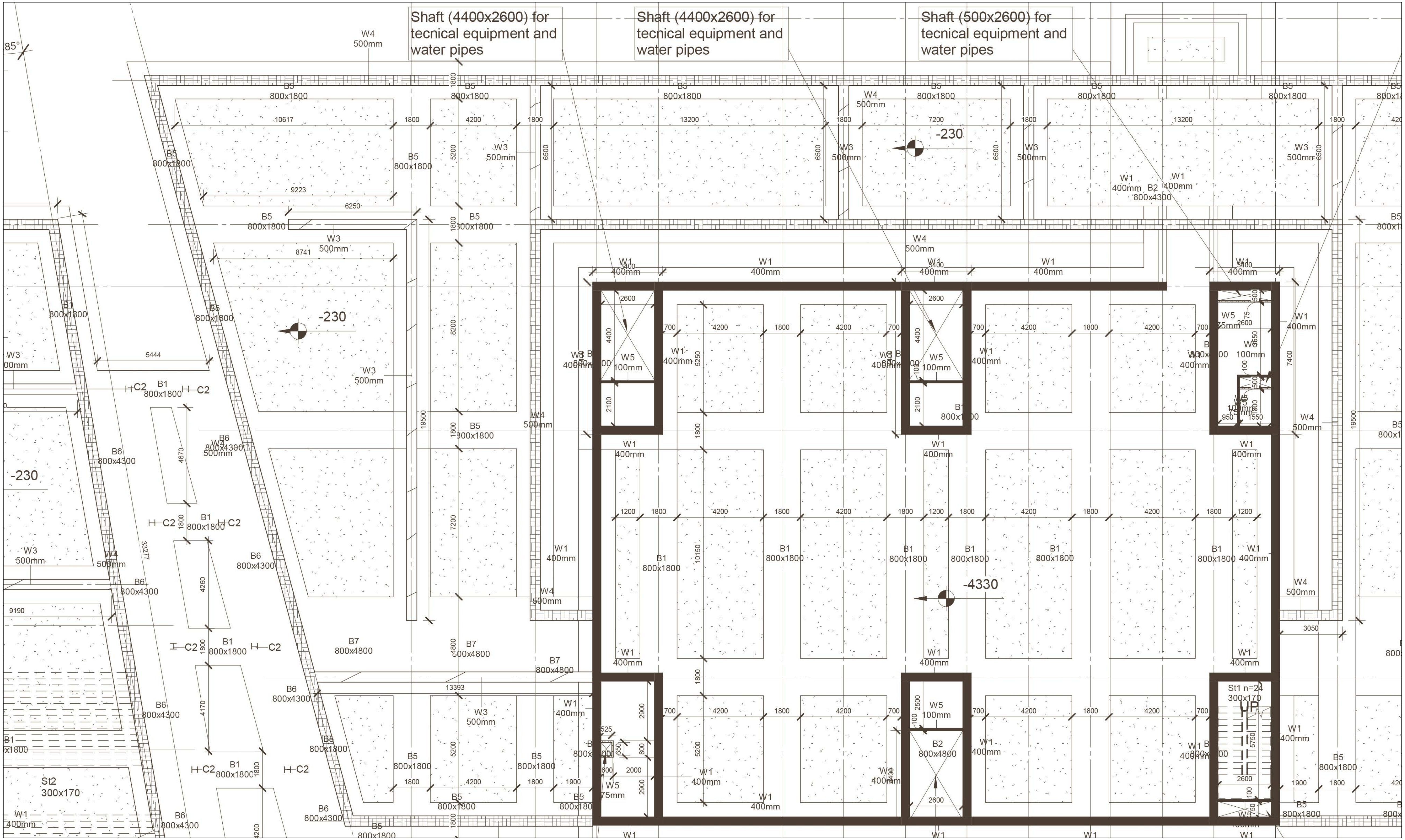
Technical Description

W1 |	wall ;	400	mm	; reinforced concrete
W3 |	wall ;	500	mm	; rammed earth
W4 |	wall ;	500	mm	; stone
B1 |	foundation beam ;	800 x 1800	mm	; reinforced concrete
B5 |	foundation beam ;	800 x 1800	mm	; stabilized rammed earth
B6 |	foundation beam ;	800 x 4300	mm	; stabilized rammed earth
B8 |	primary beam ;	500 x 400	mm	; Laminated Timber C45
B9 |	secondary beam ;	400 x 250	mm	; Laminated Timber C45
B10 |	HEB 800 ;	800 x 300	mm	; steel
B11 |	IPE 450 ;	450 x 119	mm	; steel
B15 |	Tie Beam ;	140 x 140	mm	; Laminated Timber C22
P4 |	C Profile ;	200 x 150	mm	; Steel
Bo1 |	M14 Bolts ;	8.8	mm	; Alloy Steel
Wp1 |	Waterproof Membrane ;	8	mm	; Polyester Fabric
Prot |	Protection Layer ;	4	mm	; Polyurethane-rubber
Dk1 |	Deck-Dry System ;	20	mm	; Wood
Ad Pd1 |	Adjustable Pedestals ;	-	mm	; Zinc-Coated Steel
So |	Soil Layer ;	200	mm	; Top-Soil
GeoT |	GeoTextile ;	5	mm	
Gr |	Gravel ;	70	mm	; Stone
Scr1 |	Screed ;	60	mm	; Concrete
Ins3 |	Insulation ;	20	mm	; Foam Glass
Tb Plk |	Timber Planks ;	25	mm	; Laminated Timber C22

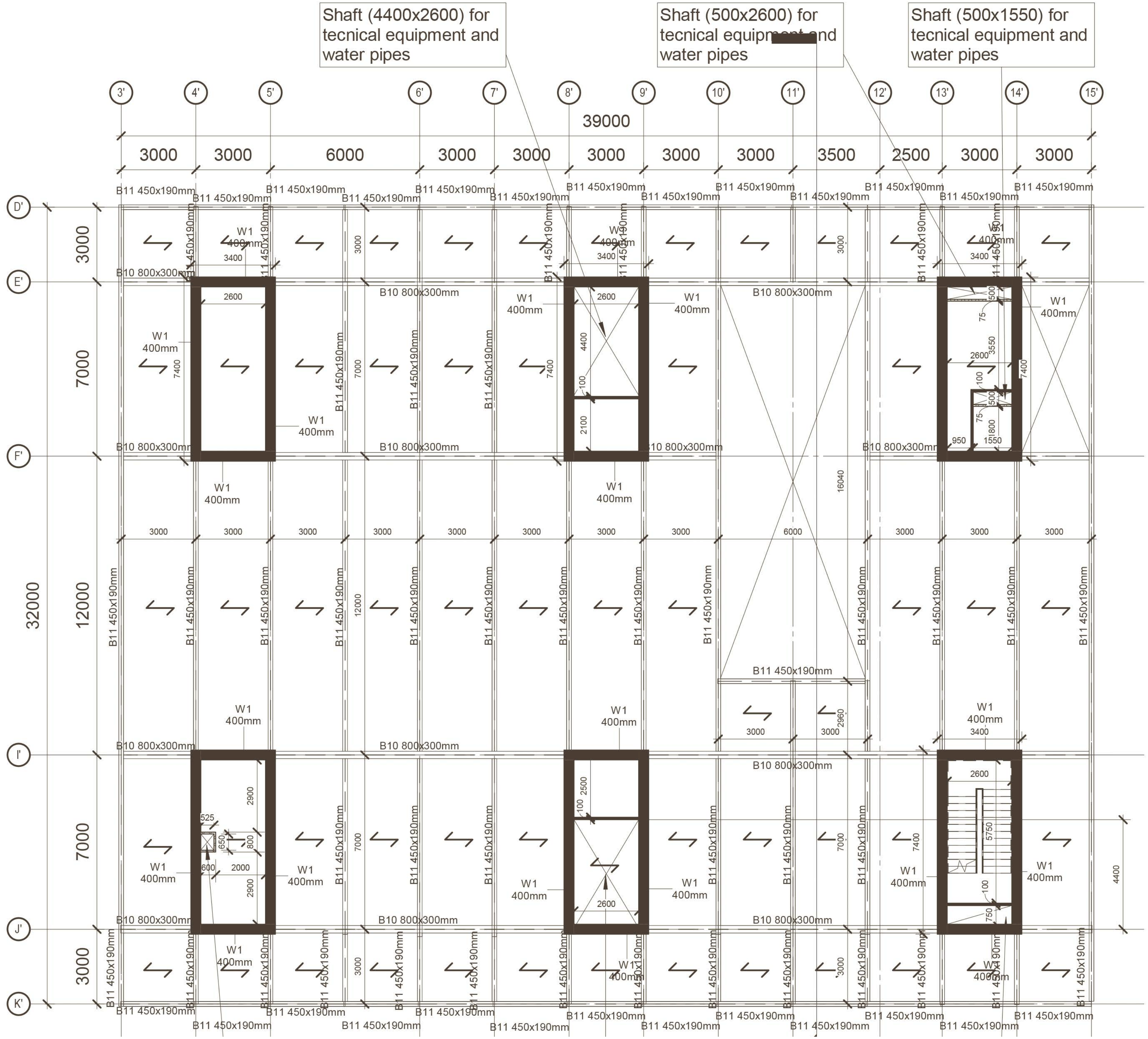
Localization drawing of foundation plan

Block A

Scale 1:200



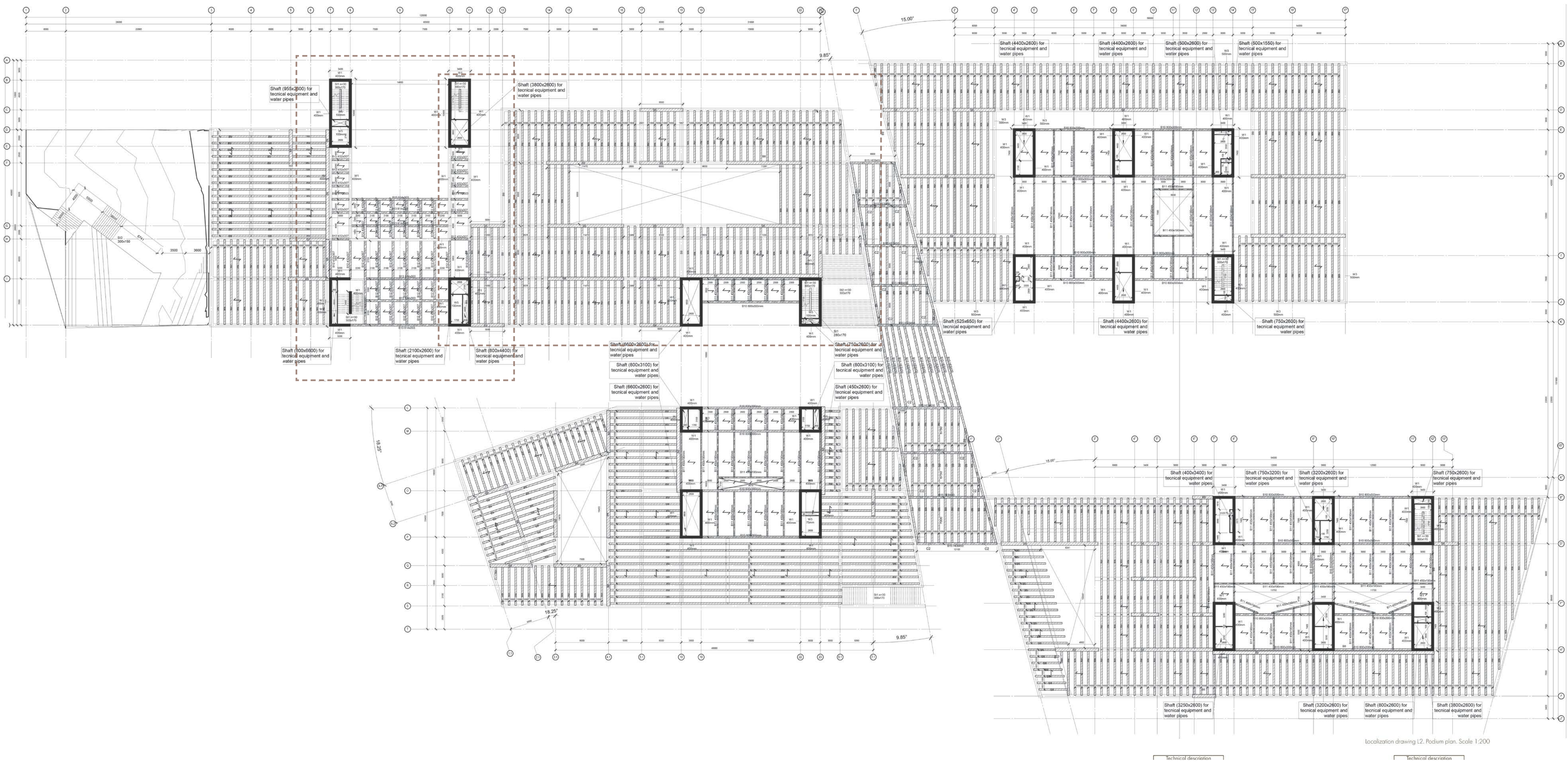
Localization drawing of foundation plan, Block C, Scale 1:200



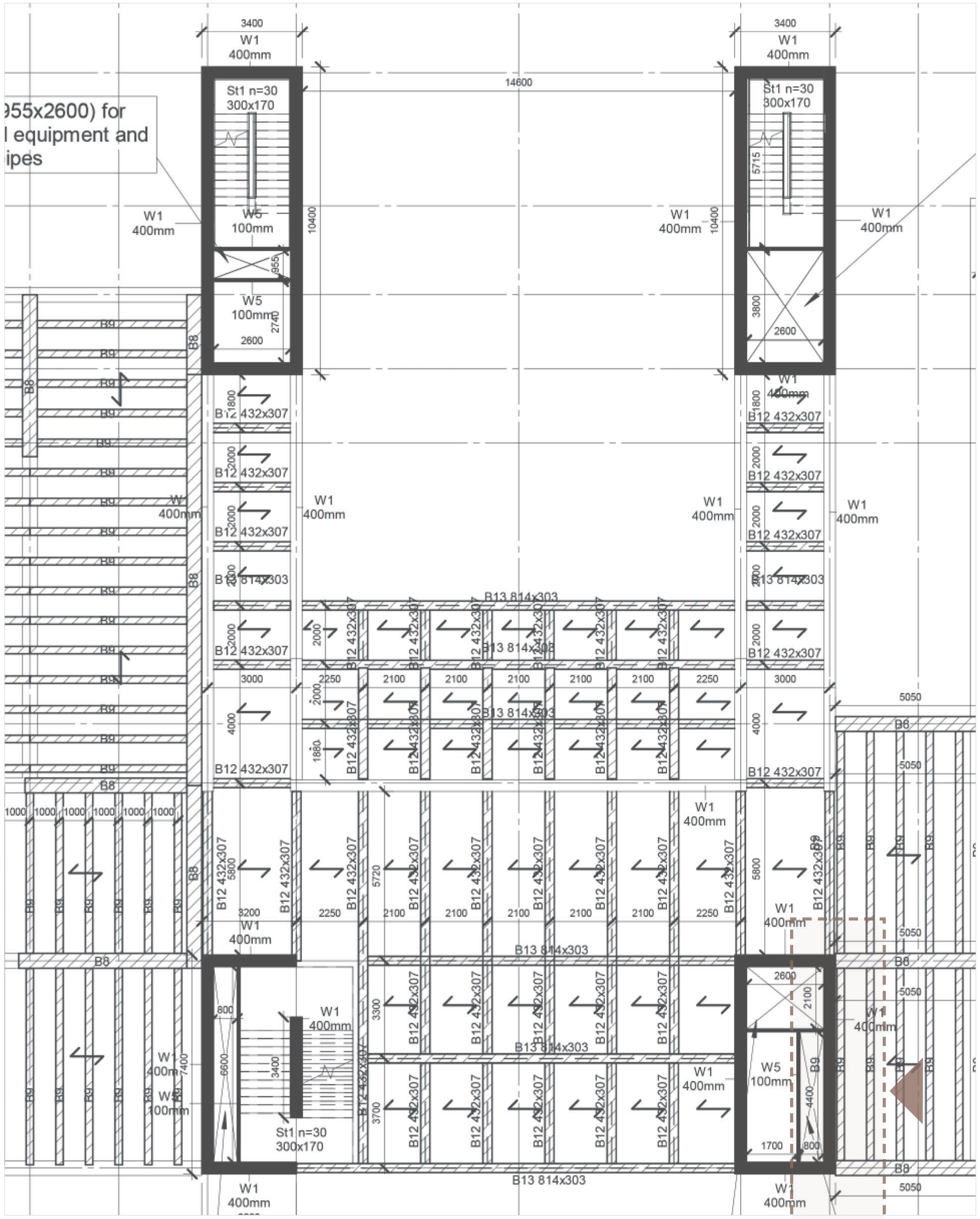
Localization drawing, plan ground floor +2

Block C

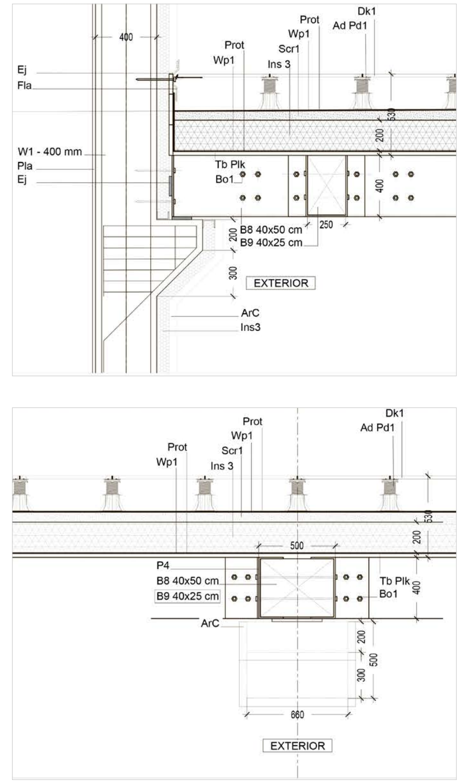
Scale 1:200



Localization drawing of plan ground floor +1



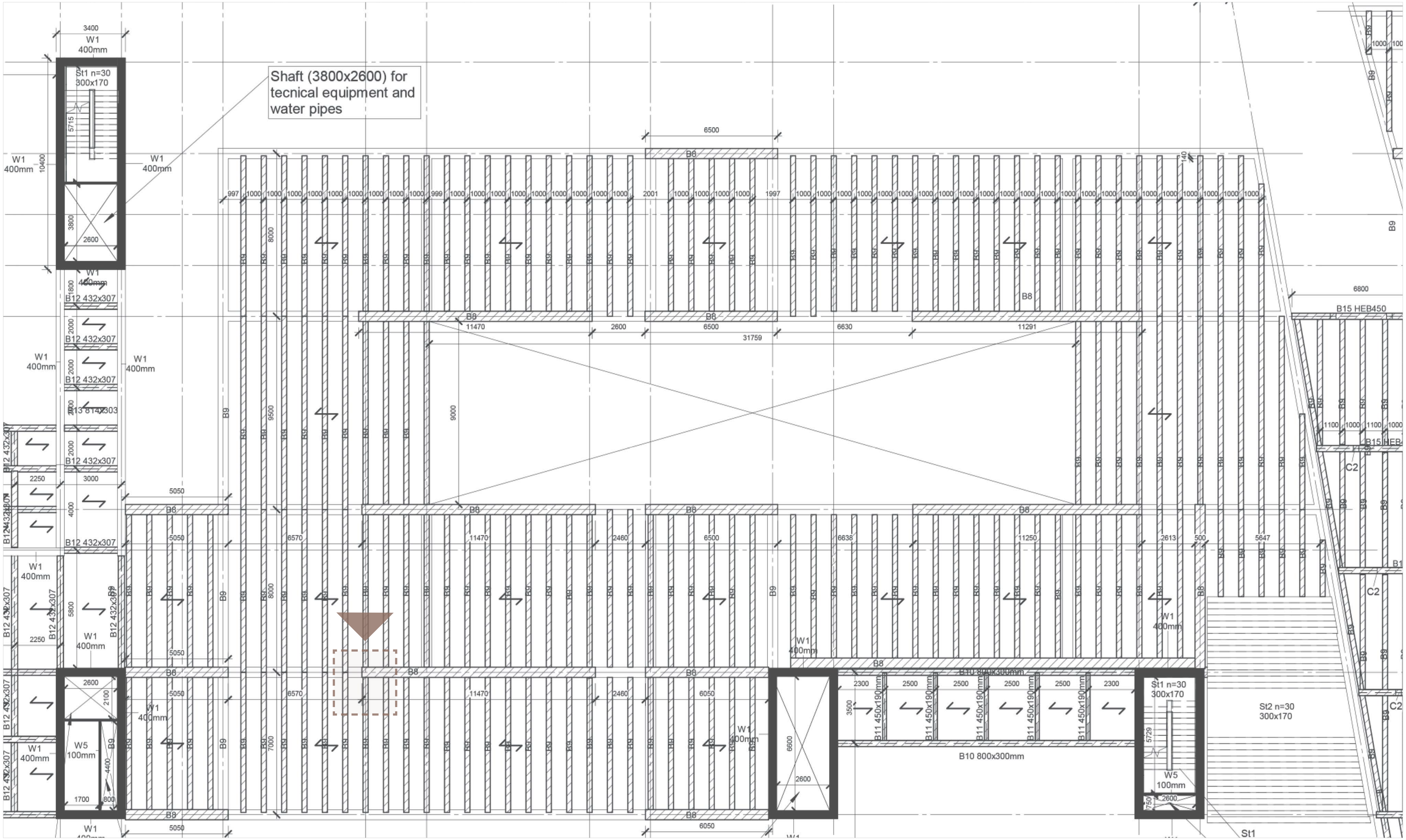
Localization drawing of plan ground floor +1 showing the Block A | Scale 1:200



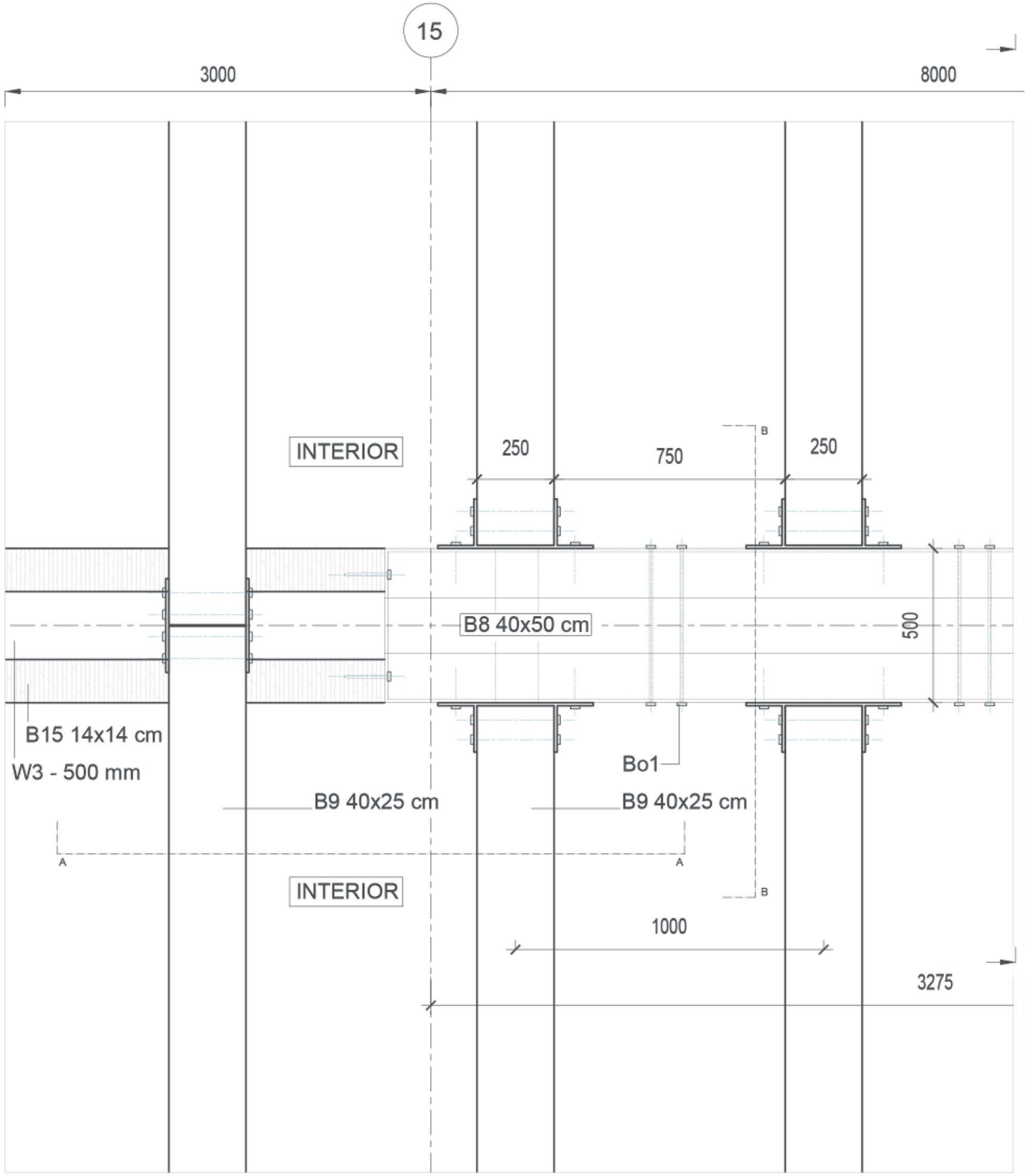
Construction drawings showing the point of contact of concrete cores and timber beams
Scale 1:50

On the point of contact between the blocks and the podium is a new detail allowing the stability of the complex and, more importantly, forming a construction joint between two different systems.

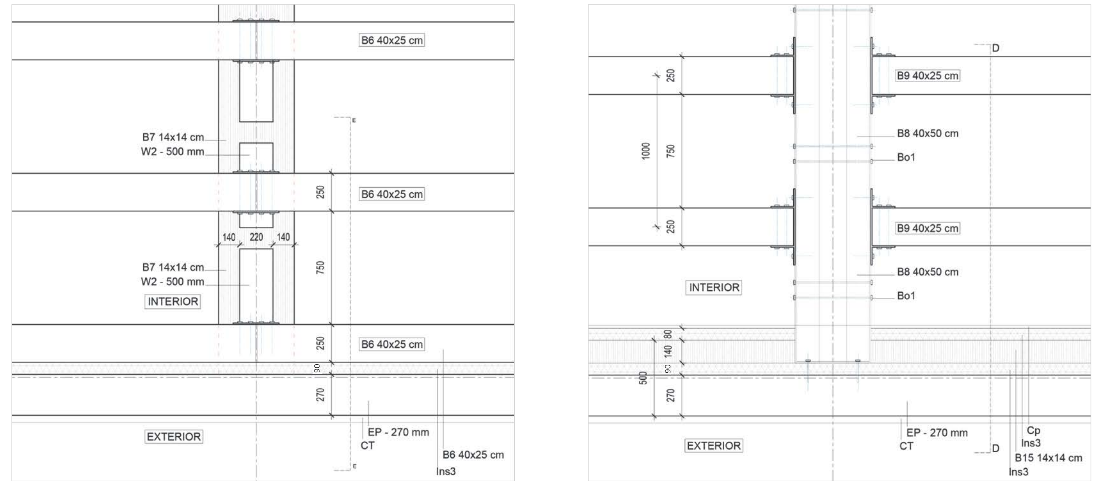
A concrete corbel is conceived on some edges of the RC cores to allow some timber beams to rest without the need of doubling the vertical structural elements there.



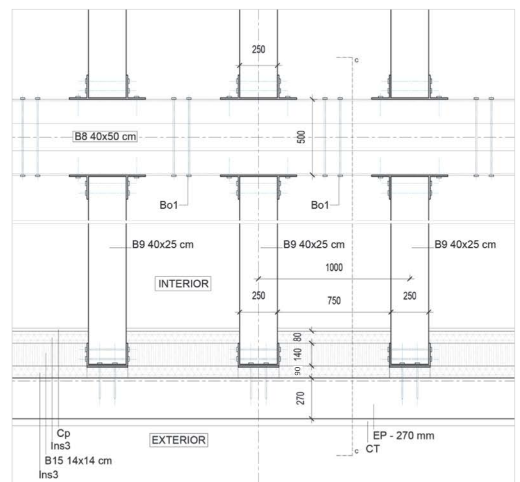
Localization drawing of plan ground floor +1 showing part of the podium between block A and B | Scale 1:200



Construction drawing of a detail horixontal section showing the different timber beams connections | Scale 1:20



Construction drawings of a detail horixontal section showing the timber beams and earthen wall connections, within different configurations | Scale 1:50

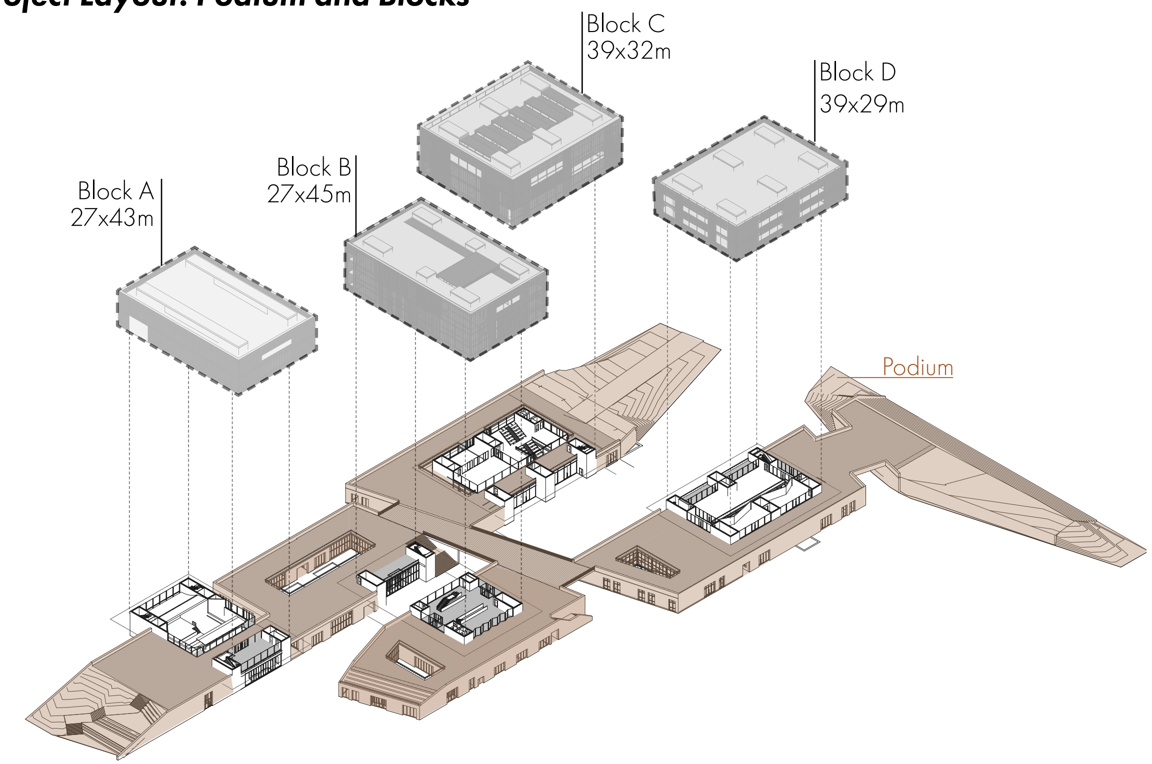


The hierarchy of timber beams and rammed-earth walls is also showcased in plan view.

Fig.a shows the connections of the different beams: secondary beams placed every one meter transfer the loads of the green-terrasse to the primary beams that are laid on the largest spans of the plan; other times, secondary beams rest directly on the 14x14 beams that run along the walls.
In fig.b-d we see some details of the beam connections to the exterior walls.

PART 05
SERVICES DESIGN
CHAPTER 01
PROJECT DESCRIPTION

Project Layout: Podium and Blocks



Project Layout

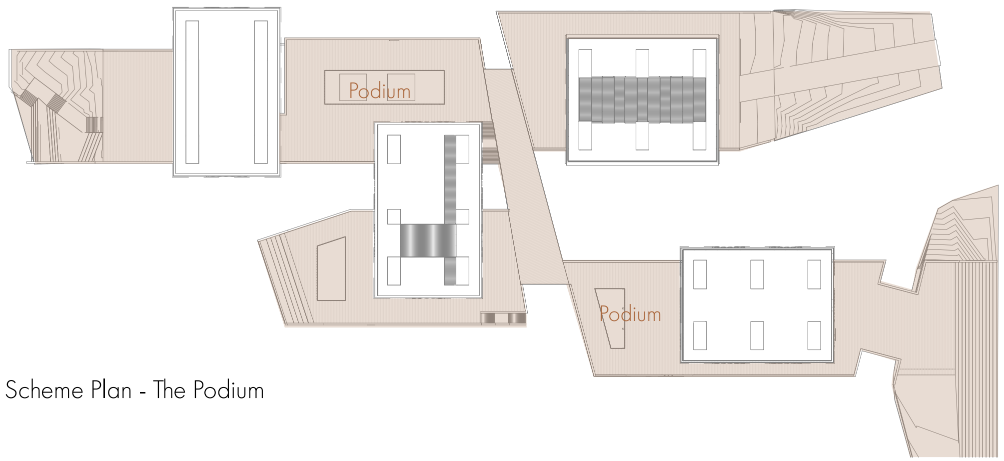
The project is made up of two main parts, they differ in materiality and in structural systems:

I - The Blocks, four singular architectural functions. They range from a height of 4 to 6 levels (17 to 25 meters), with one underground level each, serving as technical basement. All air HVAC system is used in all blocks for heating, cooling and air conditioning.

Block A - Events and Culture.
Block B - Science and Training.
Block C - Media Library.
Block D - Fitness and Wellness.

II - The Podium, a landscape continuation, consists of two longitudinal strips of one level height (5 meters) running through the site. This part consists of a labyrinth of rammed earth supporting walls. Floor mounted fan coil units are used for cooling and heating and ventilation.

Scheme Plan - The Blocks



Scheme Plan - The Podium

We start by creating a BIM model for determination winter and summer loads. The model was build using following paramiters of materials:

U-values of blocks materials

Wall:
Opaque components:
Rock-Wool Facade Thermal Insulation:
thickness = 150mm
thermal condurtivity =0.05 W/(mK)
thermal resistance = 3 m^{2}K/W
PVC Waterproof Exterior False Ceiling:
thickness = 20mm
thermal condurtivity =0.07 W/(mK)
thermal resistance = 0.29m^{2}K/W
U-value = 0.28 W/(m^{2}K)
Transparent components:
Glass Panels for Curtain Wall
U-value(16mm argon combination) =1.0W/(m^{2}K)

Roof:
Extruded polystyrene insulation
thickness = 200mm
thermal condurtivity =0.035 W/(mK)
thermal resistance = 5.714 m^{2}K/W
Screed
thickness = 60mm
thermal condurtivity =0,189 W/(mK)
thermal resistance = 0.317 m^{2}K/W
Concrete slab
thickness = 120mm
thermal condurtivity =0,189 W/(mK)
thermal resistance = 0.635 m2K/W
U-value = 0.145 W/(m^{2}K)

U-values of podium materials

Wall:
Opaque components:
Rammed earth
thickness = 500mm
thermal condurtivity =0.80 W/(mK)
thermal resistance = 0.63 m^{2}K/W
Glass foam insulation
thickness = 90mm
thermal condurtivity =0,036 W/(mK)
thermal resistance = 2.22 m^{2}K/W
U-value = 0.30W/(m^{2}K)
Transparent components:
Podium Sliding Doors and Windows
U-value = 1.3 W/(m^{2}K)

Roof:
Screed
thickness = 60mm
thermal condurtivity =0,189 W/(mK)
thermal resistance = 0.317 m^{2}K/W
Glass foam insulation
thickness = 200mm
thermal condurtivity =0,036 W/(mK)
thermal resistance = 5.56 m^{2}K/W
Timber plank
thickness = 200mm
thermal condurtivity =0.13 W/(mK)
thermal resistance = 5.56 m^{2}K/W
U-value = 0.131W/(m^{2}K)

$R_t = R_{si} + R1 + R2 + R3 + ... + R_n + R_{se}$
$U = 1/R_t$
R_{si} = 0.13 and R_{se}= 0.04 (for horizontal air flow)are the interior and exterior surface resistances [(m2K)/W]
R_{si} = 0.17 and R_{se}= 0.04 (for vertical air flow)(m2K)/W]

Current and future maximum U-values for envelope elements in the Regulation by Building Components

Component	Climatic zone	Maximum U-Value (W/m².K)		
		2016	2018	2023
External opaque walls	H1, H2	U = 0.44	U = 0.35	U = 0.31
	H3	U = 0.5	U = 0.45	U = 0.45
Terrace roof	H1	U=0.4	U=0.3	U=0.22
	H2	U=0.4	U=0.3	U=0.23
	H3	U=0.4	U=0.3	U=0.25
Attic floor	H1, H2, H3	U=0.22	U=0.21	U=0.19
Roof	H1	U=0.25	U=0.22	U=0.19
	H2	U=0.25	U=0.23	U=0.22
	H3	U=0.25	U=0.25	U=0.25
Windows	H1, H2, H3	Uw=2.6	Uw=1.9	Uw=1.9

France is divided in 3 climatic zones from the coldest H1, to the warmest H3. Paris is in the zone H1.

Fig.1

With respect to current regulations on U-values for envelope elements in France, all our building components meet the requirements for 2023 year.

Based on the calculations obtained, we selected the appropriate equipment, first for each of the standard blocks, then for the podium.

Then we continued by calculating the diameters of the pipes for supplying the building with cold and hot water. Finally, we end the report by calculating loads on drinage system and dimentioning relevant pipes.

Fig.1. Table showing U-values in France

CHAPTER 02

HEATING AND COOLING LOADS ANALYSIS. MECHANICAL EQUIPMENT

2.1. Systems for typical blocks

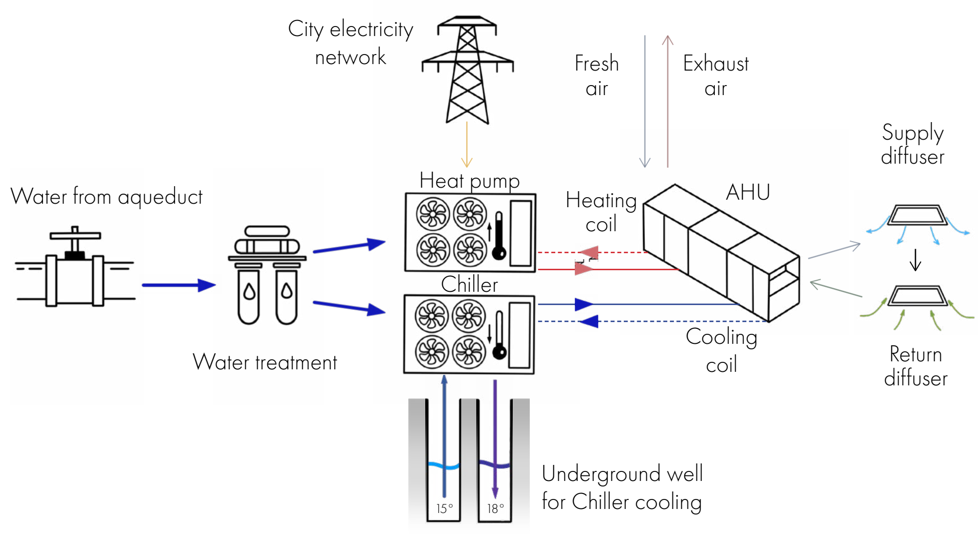
A BIM model of Community Center was made in Revit in order to determin winter & summer heat loads. Tool of Heating and Cooling loads analysis in Revit automatically sets the conditions based on choice of building type, type of service (radiator, convector, fan coil, etc) and other building elements. Some of default conditions like working hours of number of people were corrected to bring calculations closer real project data.

Calculations were made separately for Blocks and Podium parts due to the fact that they use different types of service systems, besides two specific zones (Block A (auditorium hall) and Block B (fitness changing rooms)) because they work as one area with the main block part.

Main project information

Location and Weather	
Project	Community Center of Paris-Saclay
Address	Saclay, France
Latitude	48.73°
Longitude	2.17°
Summer Dry Bulb	33 °C
Summer Wet Bulb	22 °C
Winter Dry Bulb	-3 °C
Mean Daily Range	14 °C

Heating, cooling and vientilating scheme for All Air system.



Block A - Events and Culture

Analysis conditions

Inputs	
Building Type	Office
Area (m^2)	3 987
Volume (m^3)	15 250

Block A Summary

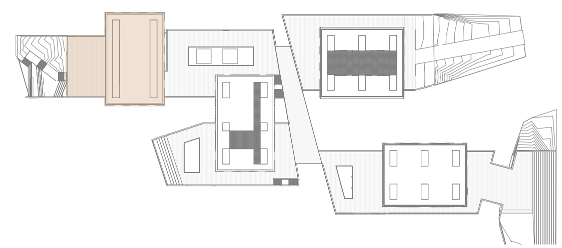
Calculated Results	
Peak Cooling Total Load (W)	449 248
Peak Cooling Month and Hour	July 15:00
Peak Cooling Sensible Load (W)	337 483
Peak Cooling Latent Load (W)	107 234
Maximum Cooling Capacity (W)	435 126
Peak Cooling Airflow (L/s)	28 630
Peak Heating Load (W)	346 672
Peak Heating Airflow (L/s)	12 117

Zone Summary - Auditorium

Calculated Results	
Peak Cooling Load (W)	120,289
Peak Cooling Month and Hour	July 15:00
Peak Cooling Sensible Load (W)	87 595
Peak Cooling Latent Load (W)	32 694
Peak Cooling Airflow (L/s)	5 333
Peak Heating Load (W)	96 851
Peak Heating Airflow (L/s)	3 098

Zone Summary - Exhibition space

Calculated Results	
Peak Cooling Load (W)	328,960
Peak Cooling Month and Hour	July 15:00
Peak Cooling Sensible Load (W)	249 888
Peak Cooling Latent Load (W)	79 071
Peak Cooling Airflow (L/s)	22 596
Peak Heating Load (W)	249 821
Peak Heating Airflow (L/s)	9 062



In The Block A we have 2 main different HVAC zones - Auditorium and Exhibition space. Basing on cooling and heating air flow rates we got after calculations choose 1 AHU for Auditorium zone and 2 equel AHUs for Exhibition space.

Make convertation of air flow rates from L/s into m^3/h in order to match suitable size of Air Handling Units.

<u>Zone Summary - Auditorium</u>

Peak Cooling Airflow: 5 333 (L/s) = <u>19,201.68 (m^3/h)</u>

Peak Heating Airflow: 3 098 (L/s) = 11 154 (m^3/h)

<u>Zone Summary - Exhibition space</u>

Peak Cooling Airflow: 22 596 (L/s) = <u>81345(m^3/h)</u>

Peak Heating Airflow: 9 062 (L/s) = 32623 (m^3/h)

The equipments used in this project are produced by Daikin.

Daikin Professional Air handling units variable dimensioning

Size	Airflow (m³/h)	Height - mm	Width - mm
1	1,800	640	720
2	2,200	640	810
3	3,500	740	980
4	5,400	840	1,190
5	6,600	840	1,390
6	7,600	940	1,390
7	9,000	1,090	1,380
8	11,000	1,150	1,550
9	14,000	1,270	1,720
10	18,300	1,390	1,970
11	23,800	1,570	2,190
12	29,800	1,690	2,480
13	33,800	1,870	2,510
14	43,200	1,990	2,940
15	51,000	2,110	3,230
16	63,000	2,290	3,620
17	68,000	2,290	3,890
18	77,000	2,290	4,410

Fig.2

Fig.3

Fig.2. Size chart for air handling units

Fig.3. Air handling unit

Supply side

1 - Damper section including ventilation grilles, factory-mounted actuators.
2 - Bag filter with factory-mounted differential pressure manometer and hinged door.
3 - Heat recovery system (plate heat exchanger or rotation heat exchanger).
4 - Mixing box with damper and factorymounted actuators.
5 - R-410A with heat recovery system with galvanised condensate tray and drip protection.
6 - Supply air fan (with hinged door, opening, drive monitoring, mounted and cabled lighting and ON/OFF switch).

Return side

7 - Bag filter with factory-mounted differential pressure manometer and hinged door.
8 - Exhaust air fan (with hinged door, opening, drive monitoring, mounted and cabled lighting and ON/OFF switch).
9 - Mixing box with damper and factory-mounted actuators.
10 - Heat recovery system (plate heat exchanger or rotation exchanger).
11 - Damper section including ventilation grilles, factory-mounted actuators.

Fig.4

Fig.4. Air handling unit section

Chillers and Heat pumps

Auditorium zone

The decision was made to choose different heat pumps and chillers for Auditorium and Exhibition zone. To save space in the basement for Auditorium zone was selected Water cooled scroll heat pump EWWP-KBW1N by Daikin - one of the most compact solutions with simultenious heating and cooling.

Heating only & Cooling only			**EWWP-KBW1N**	**014**	**022**	**028**	**035**	**045**	**055**	**065**	**090**	**100**	**110**	**120**	**130**	**145**	**155**	**165**	**175**	**185**	**195**
Cooling capacity	Nom.		kW	12.9	21.4	27.8	32.3	42.8	55.7	64.7	85.7	98.6	112.0	121.0	130.0	141.0	154.0	167.0	176.0	185.0	194.0
Heating capacity	Nom.		kW	16.7	27.5	35.6	41.5	55.0	71.7	83.0	110.0	127.0	143.0	155.0	166.0	182.0	198.0	215.0	226.0	237.0	249.0
Power input	Cooling	Nom.	kW	3.8	6.1	7.8	9.1	12.2	16.0	18.2	24.2	28.0	31.9	34.0	36.2	40.2	43.9	47.7	49.8	52.0	54.1
	Heating	Nom.	kW	3.8	6.1	7.8	9.1	12.2	16.0	18.2	24.2	28.0	31.9	34.0	36.2	40.2	43.9	47.7	49.8	52.0	54.1
	EER			3.44	3.49	3.54		3.51	3.48	3.55	3.54	3.52	3.51	3.56	3.59	3.51		3.50	3.53	3.56	3.59
	COP			4.45	4.49	4.54	4.55	4.51	4.48	4.56	4.55	4.54	4.48	4.56	4.59	4.53	4.51		4.54	4.56	4.60
Dimensions	Unit	Height	mm	600							1,200					1,800					
		Width	mm	600																	
		Depth	mm	600				1,200													

Fig.5

Exhibition zone

For Exhibition zone was choosen Air cooled multi-scroll heat pump EWYQ-F-XS/XL by Daikin because this equipment installed on the roof.
To find suitable equipment we sum up loads of exhibition area of the block A and loads of alumni area of the part of the podium (will se later) because this part of the podium system uses the same heat pump.

Heating & Cooling			**EWYQ-F-XS/XL**	**160**	**190**	**210**	**230**	**310**	**340**	**380**	**400**	**430**	**510**	**570**	**630**
Cooling capacity	Nom.		kW	164	184	205	231	304	335	376	401	427	502	565	624
Heating capacity	Nom.		kW	173	197	227	254	329	362	404	429	463	535	607	674
Power input	Cooling	Nom.	kW	57.6	63.3	70.3	79.3	102	114	129	138	145	172	195	214
	Heating	Nom.	kW	54.0	61.6	70.5	79.2	101	113	126	133	140	167	190	210
EER				2.84	2.91	2.92		2.99	2.93	2.91	2.90	2.94	2.92	2.90	2.91
ESEER				3.73	3.89	3.81	3.71	4.07	4.19	3.99	3.96	4.14	4.20	3.98	4.06
COP				3.20		3.22	3.21	3.24	3.21		3.23	3.30	3.21	3.20	3.21
Dimensions	Unit	Height	mm	2,270				2,220							
		Width	mm	1,200				2,258							
		Depth	mm	4,370		5,270		4,125			5,025		5,925		6,825

Fig.5

Fig.5. Chiller and heat pump data

Duct Friction Chart

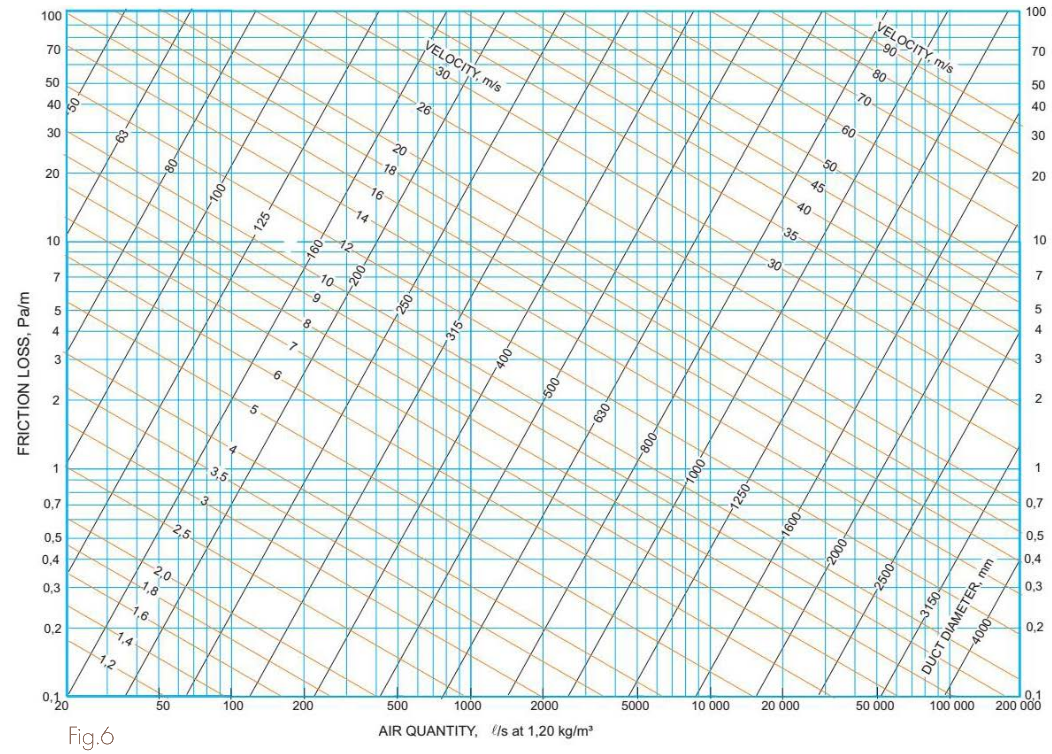


Fig.6

Auditorium zone

Peak Cooling Airflow (L/s) = 5 333

Suggested air velocity for auditoriums and theatres for primary duct = 4 m/s

Material - metal sheet
Air temperature - 20 °C
Ait density - 1,2 kg/m3
Duct roughness =0,09

=> diamiter of the main supply duct = 1250 mm - approximately 1650x750 mm for rectangular duct.

Exhibition zone

Peak Cooling Airflow (L/s) = 22 596
Two equivalent AHUs, so per each air flow 11 298L/s
Suggested air velocity for exhibition spaces for primary duct = 5-6 m/s

Material - metal sheet
Air temperature - 20 °C
Ait density - 1,2 kg/m3
Duct roughness =0,09

> diameter of the main supply duct = 1400 mm - approximately 1250x1250 mm for rectangular duct.

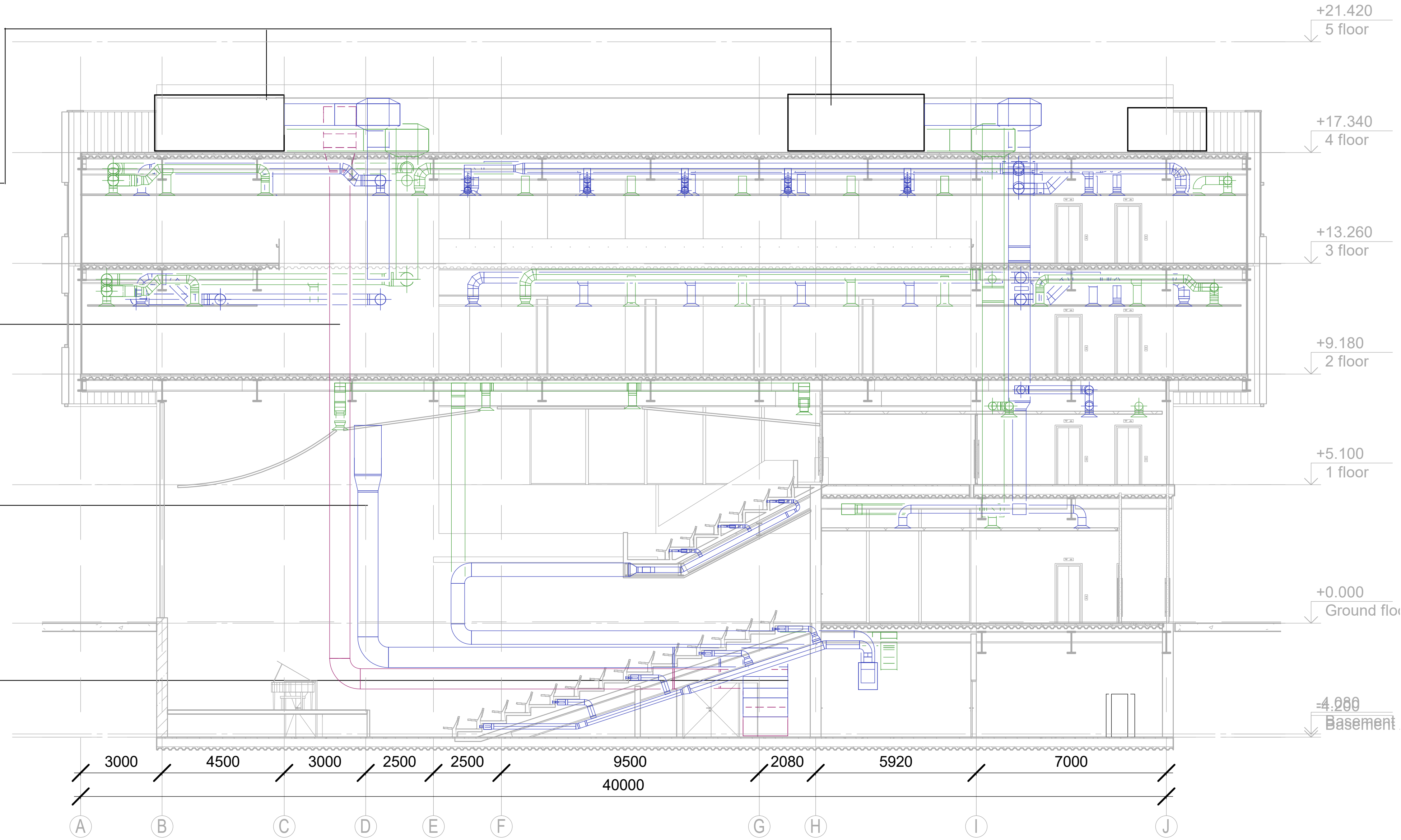
Fig.6. Duct friction chart

Air Handling Unit 2.1 and 2.2
(Located on the roof)

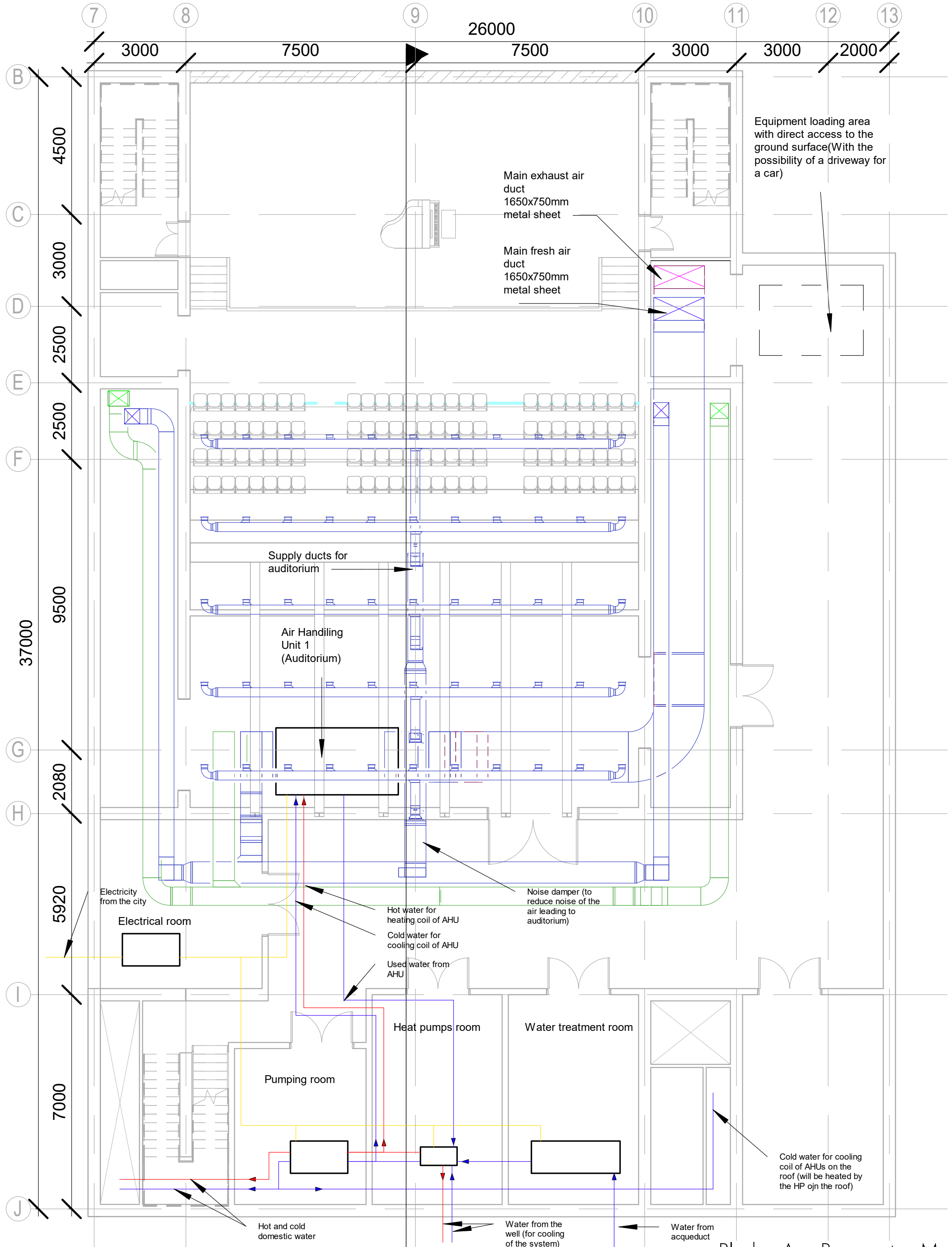
Main Exhaust Duct for AHU1
metal sheet 1650x750
(Located in the shaft. Exhaust grill is on the roof (+18.000m))

Main Fresh Air Duct AHU1
metal sheet 1650x750
(Located in the shaft. Intake grill in on the hight +7.900m from the GF)

Air Handling Unit 1
(Located on the basement)



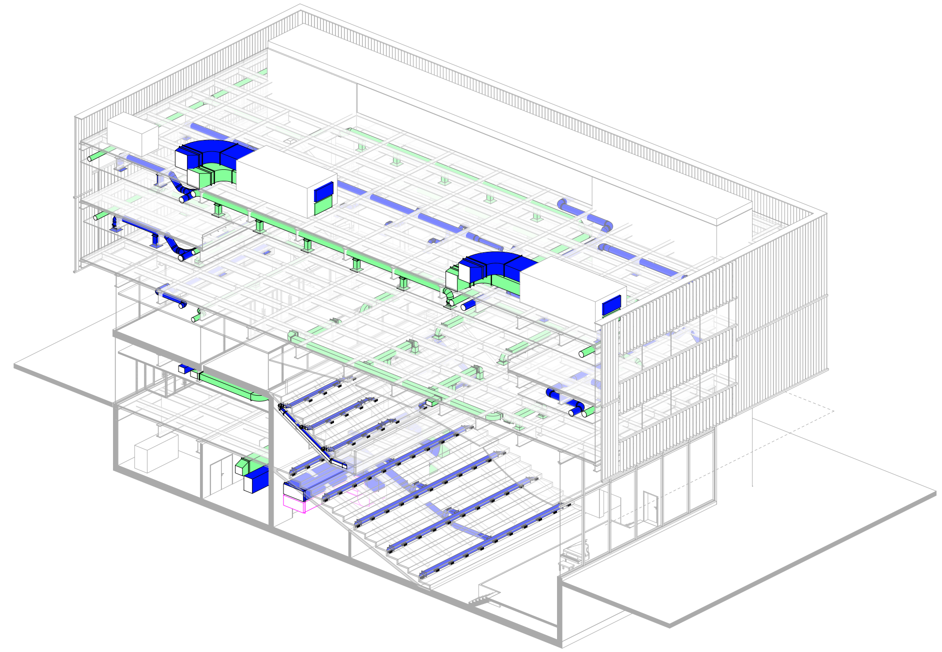
Block A. Air ducts layout section A-A
Scale 1:200



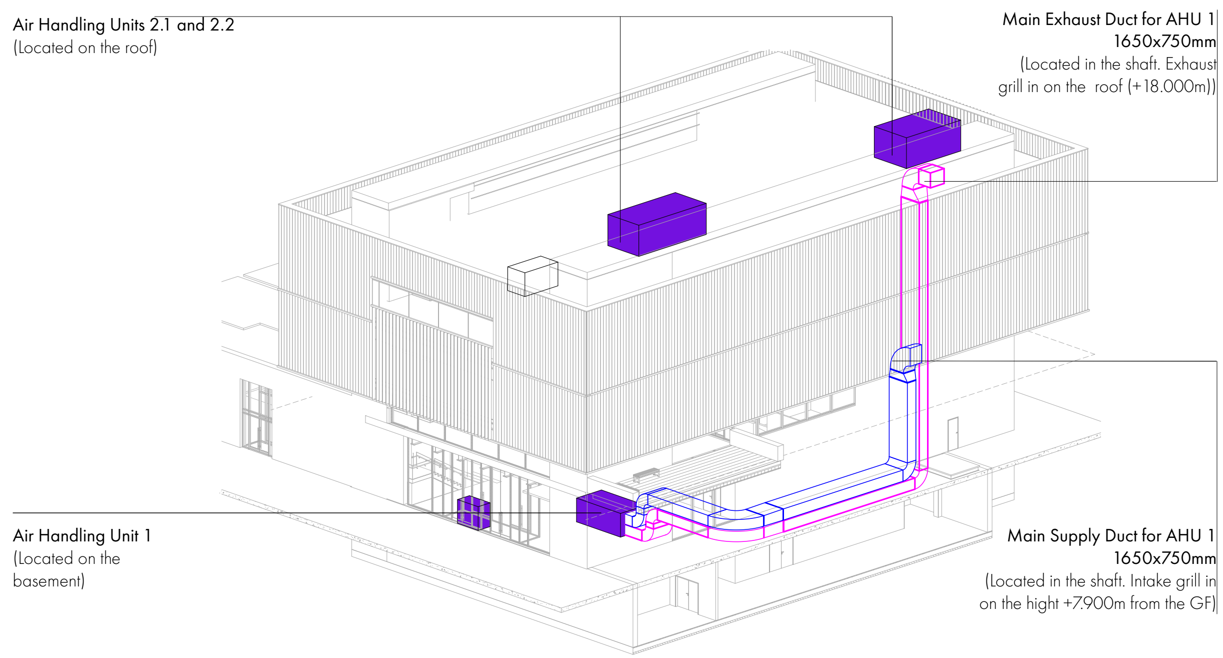
Block A. Basement. Mechanical equipment layout plan | Scale 1:200

Block A. Events and Culture.

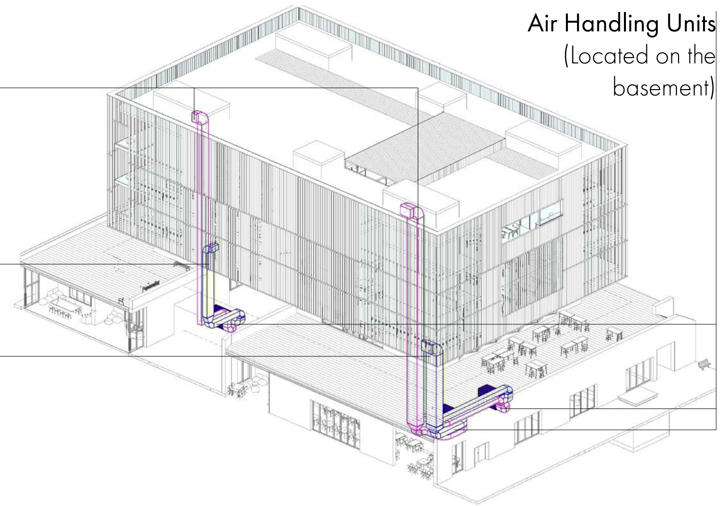
Sectioned axonometry, showing the systems network



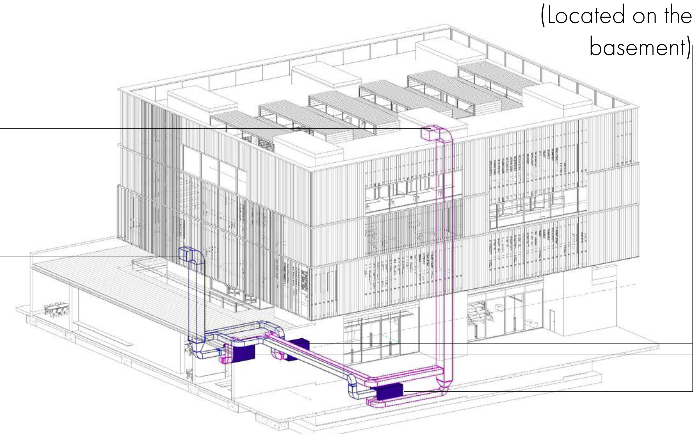
AHU and Heat Pump for Auditorium zone located in tecnical spaces in the basement.
AHUs and Heat Pump for exhibition spaces located on the roof.



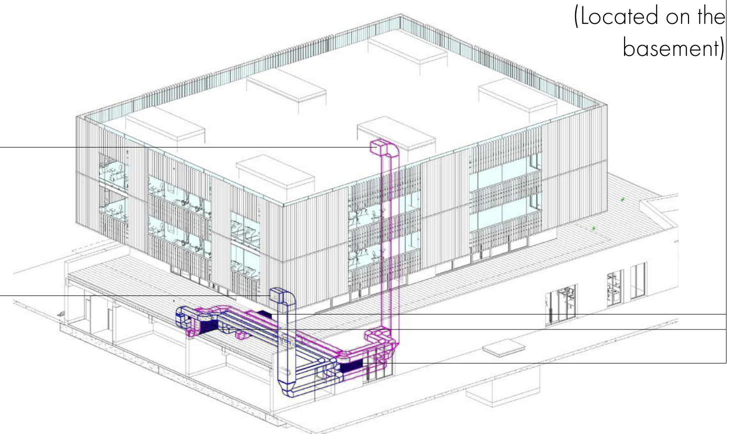
Block B. Science and Training.



Block C. Media Library.



Block D. Fitness andWellness.

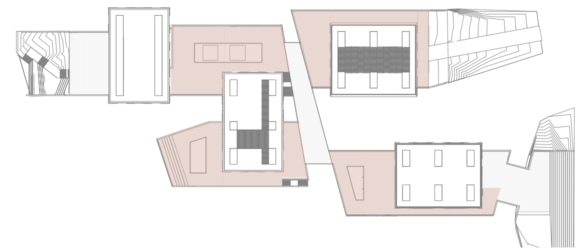


2.2. Systems for podium

In the case of the podium mixed air-water system was used. Fan coils with oppotunity of ventilation were choosen as ambient units. Such cofiguratuon has several advantages over the system used for heating, cooling and ventilation in blocks:

- size of the equipment
- ease of implementation and dismantling
- possibility of equipment installation

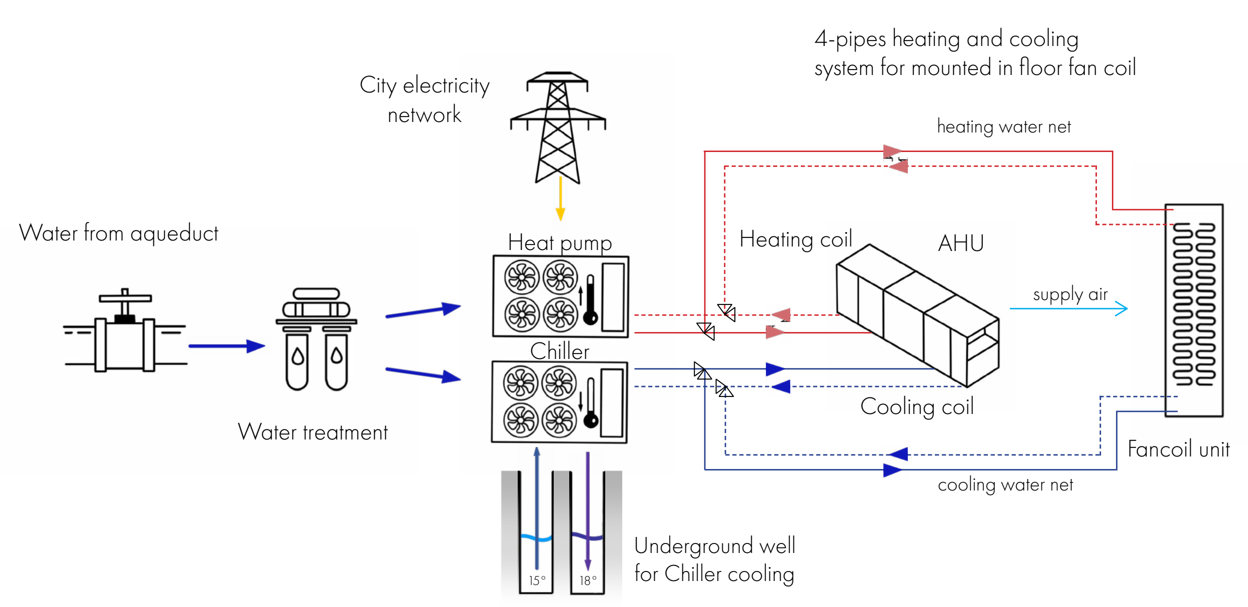
These advantages allow us to keep the natural materials of the walls and ceilings uncovered, which was very important for us in this part of the building.



Analysis conditions

Inputs	
Building Type	Office
Area (m²)	4 319
Volume (m³)	20 412

Heating, cooling and vientilating scheme for air-water mixed system.



Podium Summary

Calculated Results	
Peak Cooling Total Load (W)	318 621
Peak Cooling Month and Hour	July 16:00
Peak Cooling Sensible Load (W)	288 924
Peak Cooling Latent Load (W)	85 996
Maximum Cooling Capacity (W)	306 483
Peak Cooling Airflow (L/s)	28 558
Peak Heating Load (W)	379 532
Peak Heating Airflow (L/s)	13 585

Since we heat the space in winter and want to cool it in summer, we choose a modification with a 4-pipe system.
Trench fan coil units by Konveika were choosen for the project.
In total in all podium rooms we can place up to 90 ambient units with a length of 3000mm. So we select incoming equipment from the catalog, focusing on cooling and heating capacity.

Dimentions of unit

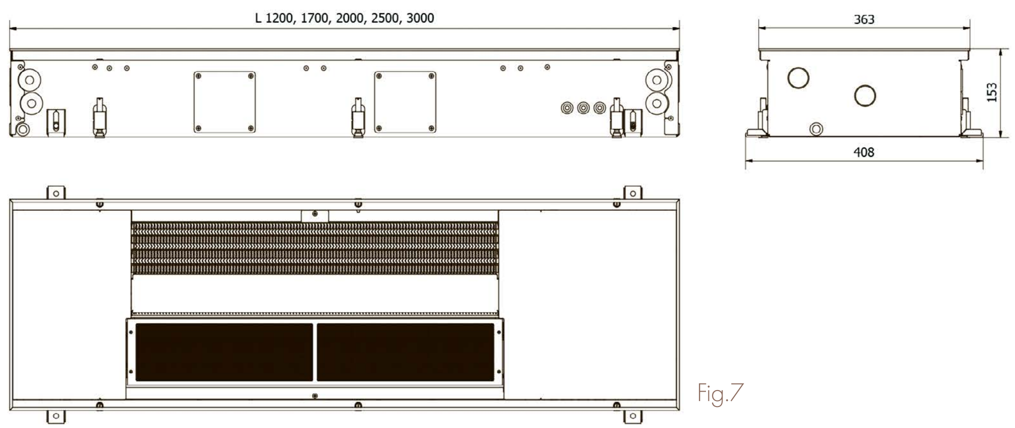


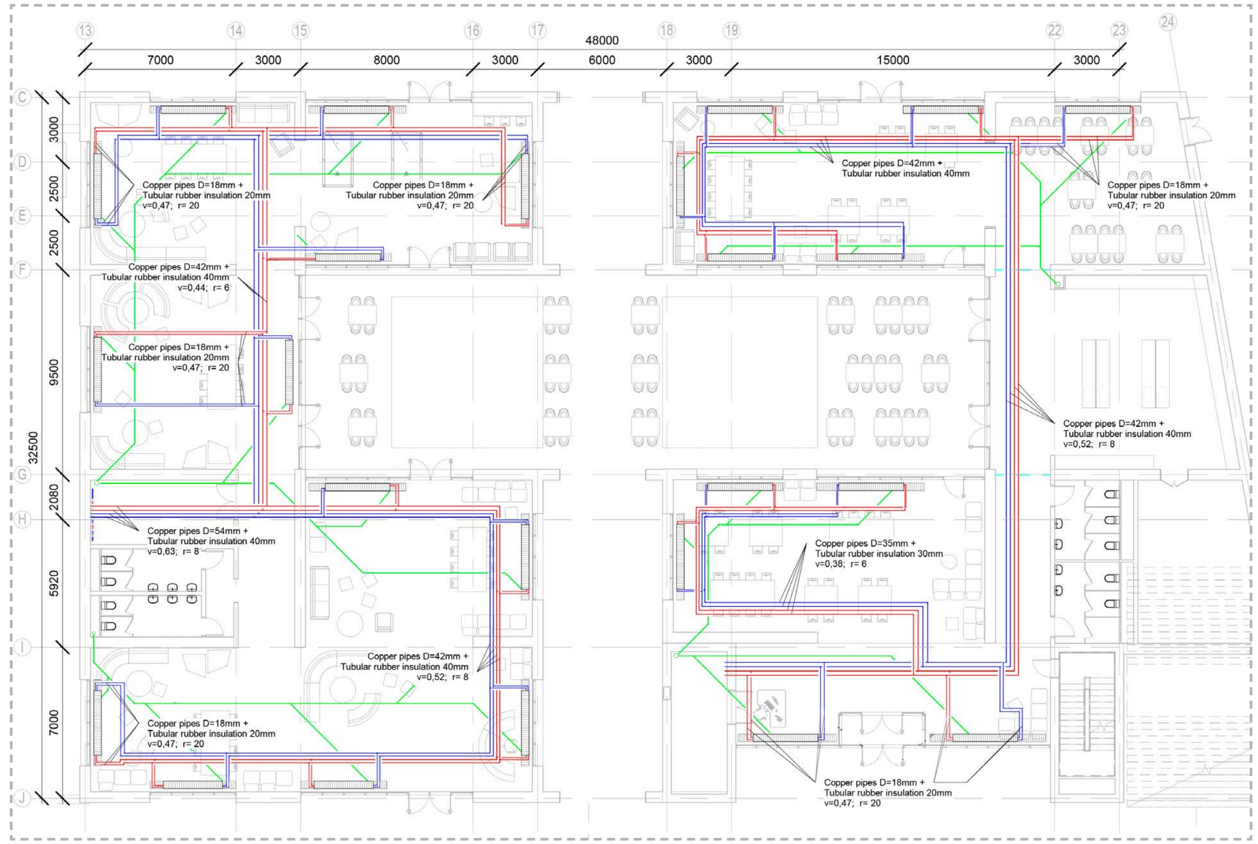
Fig.7

Fan coil paramiters

s d	Heat outputs, W			Sensible cooling outputs, W			Sound levels		Air flow m³/h	Inlet fresh air flow rate, m³/h
	75/65/20°C Δt = 50°C	55/45/20°C Δt = 30°C	35/30/20°C Δt = 12,5°C	7/12/27°C Δt = 17,5°C	**7/12/25°C Δt = 15,5°C**	14/17/25°C Δt = 9,5°C	Sound pressure level, dB(A)	Sound power level, dB(A)		
FCHV4 300										
100%	**7 248**	4 304	1 762	3 456	**3 084**	1 958	43	54	0 - 1 040	320
80%	**6 694**	3 976	1 628	2 908	**2 598**	1 648	42	53		
60%	**5 978**	3 550	1 454	2 330	**2 080**	1 320	33	44		
40%	**4 970**	2 952	1 208	1 704	**1 522**	964	27	38		
20%	**3 246**	1 928	790	998	**890**	566	24	35		

Fig.7. Fan coil drawing and table

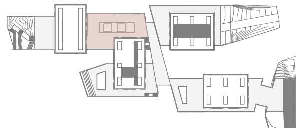
Podium. Ground Floor. Fan coils and water pipes layout plan | Scale 1:350

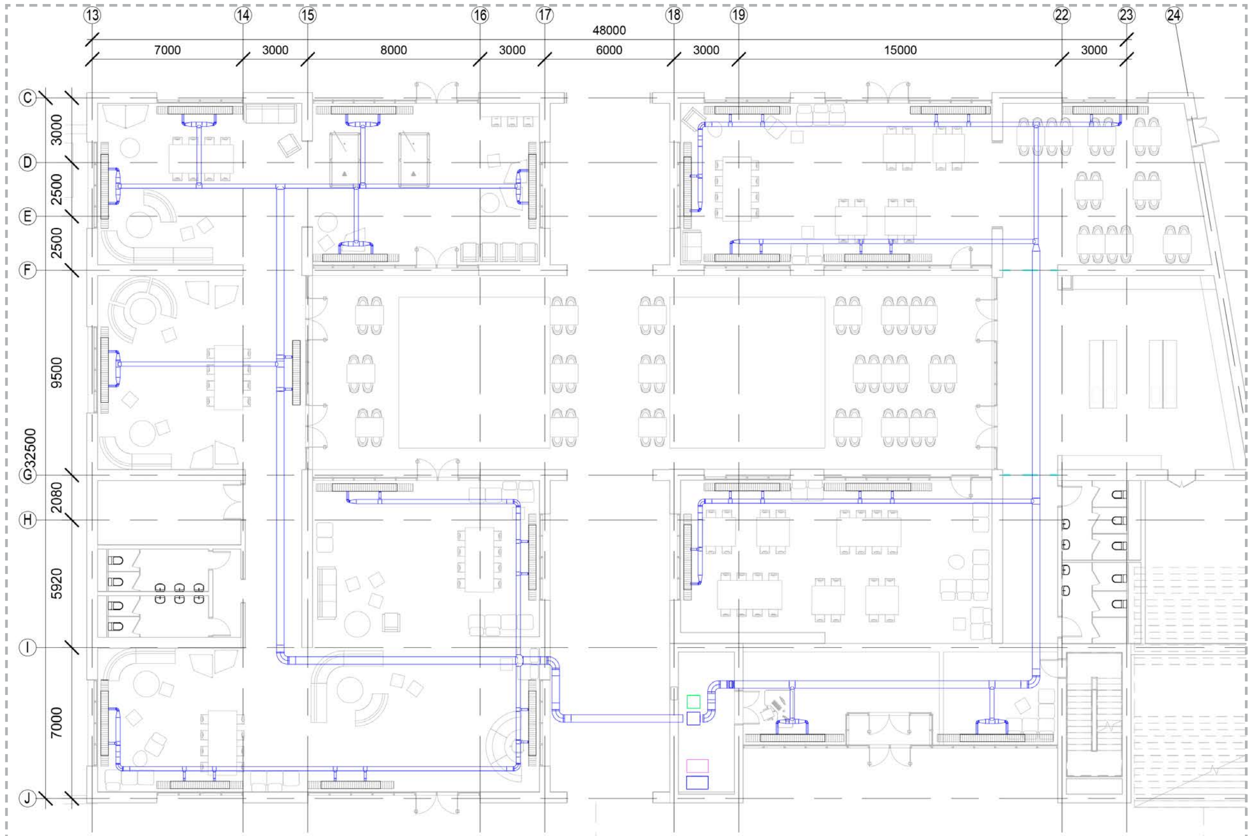


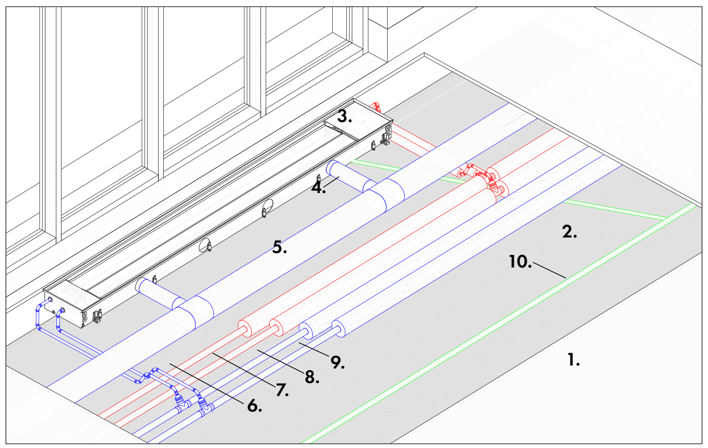
Legend for the air and water network

- Sypply air duct
- Return air duct
- Exhaust air duct
- Hot water pipes
- Cold water pipes
- Fan coil unit

Podium. Ground Floor. Fan coils and air ducts layout plan | Scale 1:350







Legend for fan coil connections

1 - Raised floor (top surface)
2 - Rammed Earth slab
3 - Fan coil unit (300x153x363cm)
4 - Air duct connection (D=10cm)
5 - Main air duct network
6 - Hot warer supply pipe
7 - Hot water return pipe
8 - Cold warer supply pipe
9 - Cold water return pipe
10 - Condensation discharge pipe

Alumni zone summary

Calculated Results	
Peak Cooling Total Load (W)	130 607
Peak Cooling Month and Hour	July 16:00
Peak Cooling Sensible Load (W)	99 507
Peak Cooling Latent Load (W)	31 100
Peak Cooling Airflow (L/s)	8 043
Peak Heating Load (W)	91 848
Peak Heating Airflow (L/s)	3 463

System consists of cuper pipes and tubular rubber insulation with e thermal conductivity of =0.04 W/m/K

Winter conditions for alumni area
Tair = 20 °
dT = 50°
T inlet = 75°
T outlet = 65°

Calculations:

Winter design heat load for alumni area 91 848W
model choosen FCHV4 300
dimentions =3000x368x150
number of units in anumni area = 24 (13 in zone 1 and 11 in zone 2)
91 848W/24 = 3 827 W => im winter fans can work on 20%

To define all water flow for the area 1 we use the formula:
$Q=m_w c_p (T_{w\,in} - T_{w\,out})$ => $m_w = Q/(c_p (T_{w\,in} - T_{w\,out}))$

m_w=(13x 3 827)/4186(75-65))= 1,189(L/s)
1,189 (L/s)x3600 (s/h) = 4 228 (L/h) =>

we define diamiter using the table =>
Paramiters of the biggest pipe of the area 1:
D=54mm
v=0,63 m/s
r=8 mm c.a./m
insulation thickness 40mm

Summer conditions for alumni area
Tair = 27°
dT = 17,5°
T inlet = 7°
T outlet = 12°
Cooling sensible load for alumni area 99 507W, it is almost the same as winter loads, so we will use the same pipe paramiters as calculated for winter.

Branch A pipe sizing (number of units connected =5):
m_w=3 827x5/4186(75-65))= 0,457 (L/s)
0,457(L/s)x3600 (s/h) = 1645 (L/h) =>

Paramiters of the Branch A pipes:
D=42mm
v=0,44 m/s
r=6 mm c.a./m
insulation thickness 40mm

Unit connection pipe sizing:
m_w= 3 827/4186(75-65))= 0,091 (L/s)
0,091 (L/s)x3600 (s/h) = 328 (L/h) =>

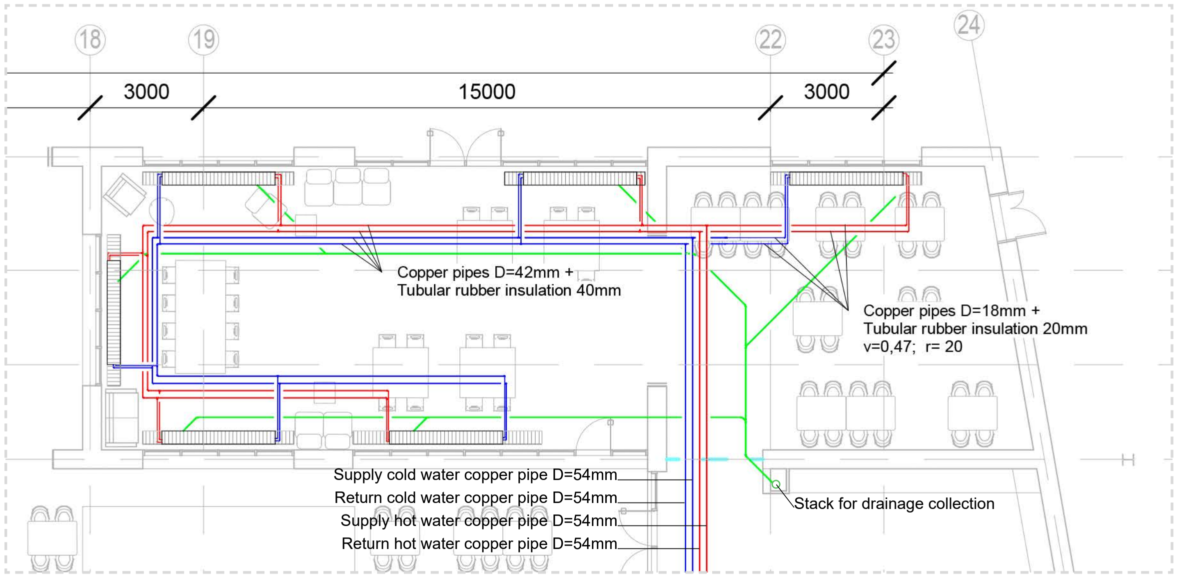
Paramiters of the connection pipes:
D=18mm (maximum possible for this model)
v=0,47 m/s
r=20 mm c.a./m
insulation thickness 20mm

Distributed pressure drops copper pipes - Water temperature = 50 ° C

r = perdite di carico continue, mm c.a./m — G = portate, l/h — v = velocità, m/s

r	Øe	10	12	14	15	16	18	22	22	28	35	42	54	76,1	88,9	108	Øe	r
	Øi	8	10	12	13	14	16	20	19	25	32	39	51	72,1	84,9	103	Øi	
2	G	14	25	42	52	63	91	166	145	304	595	1018	2108	5395	8407	14205	G	2
	v	0,08	0,09	0,10	0,11	0,11	0,13	0,15	0,14	0,17	0,21	0,24	0,29	0,37	0,41	0,47	v	
4	G	21	38	62	77	94	135	247	215	452	884	1512	3132	8017	12492	21108	G	4
	v	0,11	0,13	0,15	0,16	0,17	0,19	0,22	0,21	0,26	0,31	0,35	0,43	0,55	0,61	0,70	v	
6	G	26	47	78	97	118	170	311	271	570	1114	1907	3949	10107	15750	26612	G	6
	v	0,14	0,17	0,19	0,20	0,21	0,23	0,28	0,27	0,32	0,38	0,44	0,54	0,69	0,77	0,89	v	
8	G	30	56	92	114	139	200	367	319	672	1314	2247	4655	11913	18564	31367	G	8
	v	0,17	0,20	0,23	0,24	0,25	0,28	0,32	0,31	0,38	0,45	0,52	0,63	0,81	0,91	1,05	v	
10	G	35	63	104	129	158	227	417	363	764	1492	2553	5288	13533	21088	35633	G	10
	v	0,19	0,22	0,26	0,27	0,29	0,31	0,37	0,36	0,43	0,52	0,59	0,72	0,92	1,03	1,19	v	
12	G	38	70	116	144	176	252	462	402	847	1656	2833	5868	15019	23404	39545	G	12
	v	0,21	0,25	0,28	0,30	0,32	0,35	0,41	0,39	0,48	0,57	0,66	0,80	1,02	1,15	1,32	v	
14	G	42	77	126	157	192	276	505	439	925	1809	3094	6409	16402	25559	43187	G	14
	v	0,23	0,27	0,31	0,33	0,35	0,38	0,45	0,43	0,52	0,62	0,72	0,87	1,12	1,25	1,44	v	
16	G	45	83	136	169	207	297	545	474	999	1952	3339	6917	17703	27585	46611	G	16
	v	0,25	0,29	0,33	0,35	0,37	0,41	0,48	0,46	0,57	0,67	0,78	0,94	1,20	1,35	1,55	v	
18	G	48	89	146	181	221	318	583	507	1068	2088	3572	7398	18935	29506	49856	G	18
	v	0,27	0,31	0,36	0,38	0,40	0,44	0,52	0,50	0,60	0,72	0,83	1,01	1,29	1,45	1,66	v	
20	G	51	94	155	192	235	338	619	539	1135	2217	3794	7857	20110	31337	52950	G	20
	v	0,28	0,33	0,38	0,40	0,42	0,47	0,55	0,53	0,64	0,77	0,88	1,07	1,37	1,54	1,77	v	
22	G	54	100	163	203	248	357	654	569	1198	2342	4006	8297	21236	33091	55914	G	22
	v	0,30	0,35	0,40	0,42	0,45	0,49	0,58	0,56	0,68	0,81	0,93	1,13	1,44	1,62	1,86	v	
24	G	57	105	172	213	261	375	687	598	1259	2461	4210	8720	22318	34778	58764	G	24
	v	0,32	0,37	0,42	0,45	0,47	0,52	0,61	0,59	0,71	0,85	0,98	1,19	1,52	1,71	1,96	v	
26	G	60	110	180	223	273	393	719	626	1318	2576	4407	9128	23363	36405	61514	G	26
	v	0,33	0,39	0,44	0,47	0,49	0,54	0,64	0,61	0,75	0,89	1,02	1,24	1,59	1,79	2,05	v	
28	G	62	114	188	233	285	410	750	653	1375	2688	4598	9523	24374	37980	64175	G	28
	v	0,34	0,40	0,46	0,49	0,51	0,57	0,66	0,64	0,78	0,93	1,07	1,29	1,66	1,86	2,14	v	
30	G	65	119	195	242	296	426	781	679	1430	2796	4783	9906	25354	39508	66756	G	30
	v	0,36	0,42	0,48	0,51	0,53	0,59	0,69	0,67	0,81	0,97	1,11	1,35	1,72	1,94	2,23	v	
35	G	71	130	213	265	324	465	853	742	1562	3053	5223	10818	27688	43145	72903	G	35
	v	0,39	0,46	0,52	0,55	0,58	0,64	0,75	0,73	0,88	1,05	1,21	1,47	1,88	2,12	2,43	v	
40	G	77	140	230	286	349	502	920	801	1686	3295	5637	11676	29884	46566	78683	G	40
	v	0,42	0,50	0,56	0,60	0,63	0,69	0,81	0,78	0,95	1,14	1,31	1,59	2,03	2,28	2,62	v	
45	G	82	150	246	306	374	537	984	856	1803	3525	6030	12489	31964	49808	84161	G	45
	v	0,45	0,53	0,60	0,64	0,67	0,74	0,87	0,84	1,02	1,22	1,40	1,70	2,17	2,44	2,81	v	
50	G	87	159	261	325	397	570	1045	909	1915	3743	6404	13264	33948	52899	89384	G	50
	v	0,48	0,56	0,64	0,68	0,72	0,79	0,92	0,89	1,08	1,29	1,49	1,80	2,31	2,60	2,98	v	
60	G	96	177	290	360	441	633	1160	1009	2126	4154	7107	14721	37675	58708	99199	G	60
	v	0,53	0,63	0,71	0,75	0,79	0,87	1,03	0,99	1,20	1,43	1,65	2,00	2,56	2,88	3,31	v	
70	G	105	193	317	393	481	691	1267	1102	2321	4537	7762	16076	41145	64114	108333	G	70
	v	0,58	0,68	0,78	0,82	0,87	0,96	1,12	1,08	1,31	1,57	1,80	2,19	2,80	3,15	3,61	v	
80	G	114	208	342	425	519	746	1367	1190	2505	4897	8377	17351	44407	69198	116923	G	80
	v	0,63	0,74	0,84	0,89	0,94	1,03	1,21	1,17	1,42	1,69	1,95	2,36	3,02	3,40	3,90	v	
90	G	122	223	366	454	555	798	1462	1272	2680	5237	8960	18559	47499	74015	125063	G	90
	v	0,67	0,79	0,90	0,95	1,00	1,10	1,29	1,25	1,52	1,81	2,08	2,52	3,23	3,63	4,17	v	
100	G	129	237	388	482	590	848	1553	1351	2846	5562	9516	19710	50446	78608	132824	G	100
	v	0,71	0,84	0,95	1,01	1,06	1,17	1,37	1,32	1,61	1,92	2,21	2,68	3,43	3,86	4,43	v	

Fig.8



Podium. Ground Floor. Fan coils and water pipes layout plan | Scale 1:100

Fig.8. Pipes table

CHAPTER 03

COLD AND HOT WATER SUPPLY NETWORK

General description and standarts

Hot and cold water network of the buildong consists of copper pipes and mechanical press fittings. Flow rates and temperature limits are calculated according to UN EN 806-3.

Beginning at the last draw-off point, the loading units for each section of the installation have to be determined. The loading units must be added. Resulting from this calculation the size of that part of the pipe can be determined.

Loading units

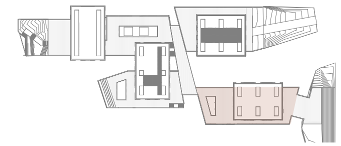
Draw-off point	QA	Qmin	LU
	l/s	l/s	
Washbasin, handbasin, bidet, WC-cistern	0,1	0,1	1
Domestic kitchen sink, - washing machine [a], dish washing machine, sink, shower head	0,2	0,15	2
Urinal flush valve	0,3	0,15	3
Bath domestic	0,4	0,3	4
Taps /garden/garage)	0,5	0,4	5
Non domestic kitchen sink DN 20, bath non domestic	0,8	0,8	8
Flush valve DN 20	1,5	1,0	15

[a] For non domestic appliances check with manufacturer.

Copper pipes sizing

Max. load	LU	1	2	3	3	4	6	10	20	50	165	430	1 050	2 100
Highest value	LU			2			4	5	8					
da x s	mm	12 x 1,0			15 x 1,0			18 x 1,0	22 x 1,0	28 x 1,5	35 x 1,5	42 x 1,5	54 x 2	76,1 x 2
di	mm	10,0			13,0			16,0	20,0	25	32	39	50	72,1
Max length of pipe	m	20	7	5	15	9	7							

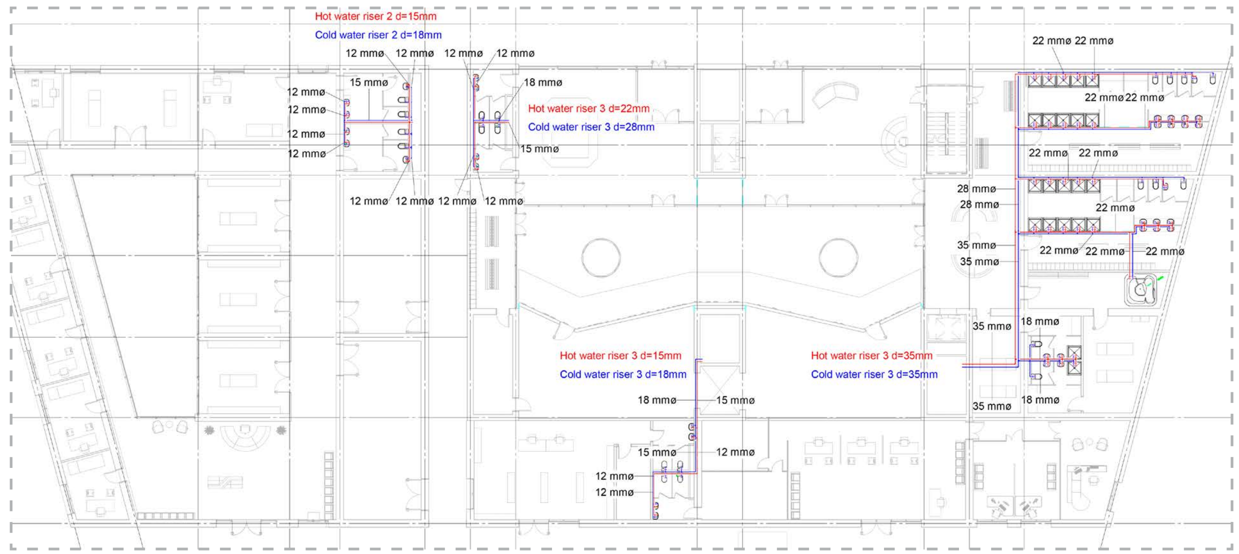
3.1. Water suply network in podium



Typical podium layout and calculations

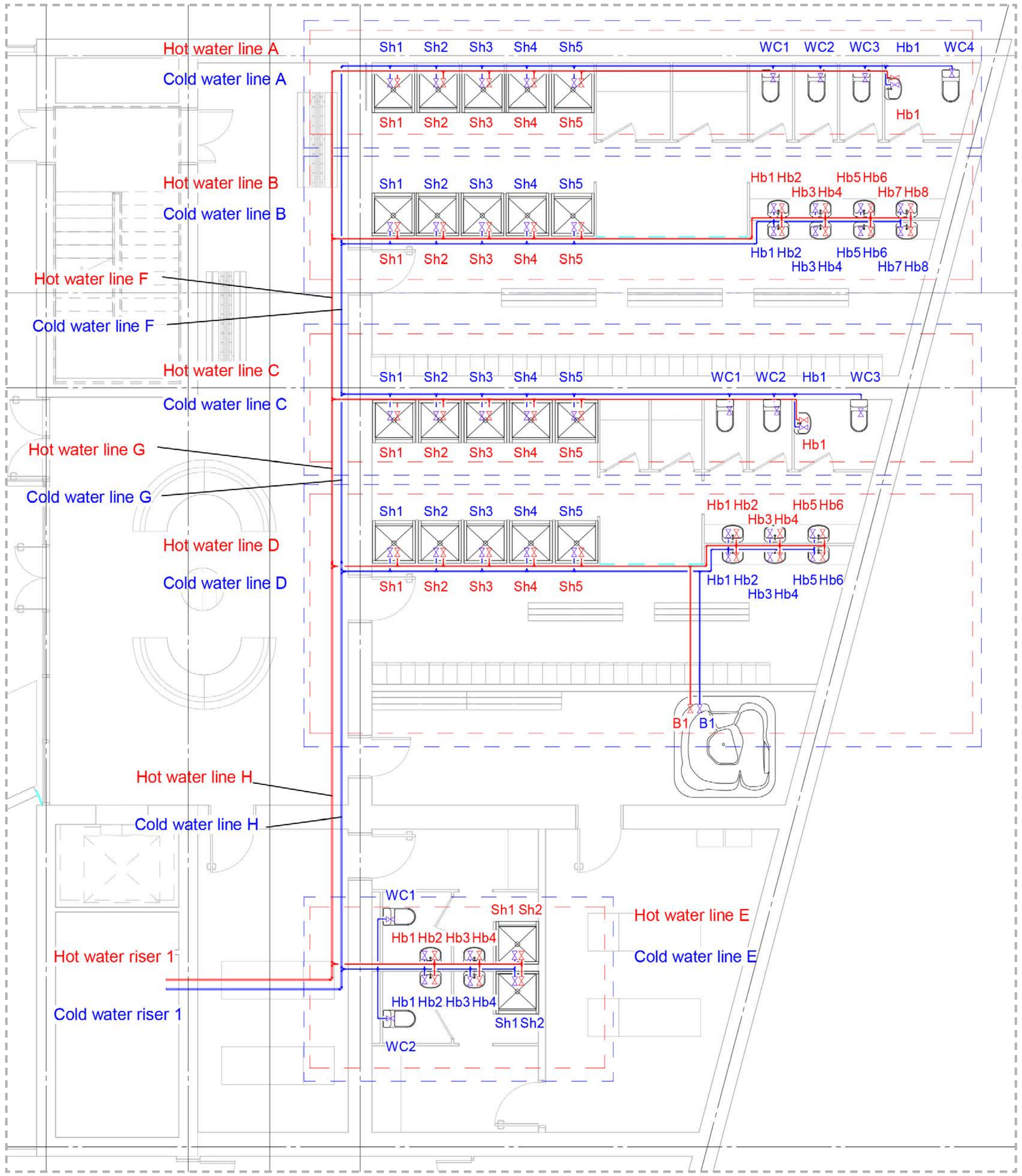
In the podium parts of the building hot and cold water pipes are installed in the space of raised floor. Vertical risers are located in the tecnical shafts.

Podium. Ground Floor. Block B hot and cold water pipes layout plan | Scale 1:500



Legend of hot and cold water networks

Hot domestic water copper pipes		Diamiter and thickness indicated in mm
Cold domestic water copper pipes		Diamiter and thickness indicated in mm
Valve		
Sh	Shower head	2 Loading units
WC	WC-cistern	1 Loading unit
Hb	Hand basin	1 Loading unit
B	Bath non domestic	8 Loading units



Podium. Ground Floor. Block B hot and cold water pipes layout plan | Scale 1:150

Hot water calculations

Hot water line A = Sh1+Sh2+Sh3+Sh4+Sh5+Hb1 = 2+2+2+2+2+1 =11 (LU)

Highest value - 2 >>> D=22x1,0

Hot water line B = Sh1+Sh2+Sh3+Sh4+Sh5+Hb1+Hb2+Hb3+Hb4+Hb5+Hb6+Hb7+Hb8 = =2+2+2+2+2+1+1+1+1+1+1+1+1 =18 (LU)

Highest value - 2 >>> D=22x1,0

Hot water line F = A+B = 11+18 = 29 (LU) >>> D=28x1,5

Hot water line C = Sh1+Sh2+Sh3+Sh4+Sh5+Hb1 = 2+2+2+2+2+1 =11 (LU)

Highest value - 2 >>> D=22x1,0

Hot water line G = F+C = 29+11 = 40 (LU) >>> D=28x1,5

Hot water line D = Sh1+Sh2+Sh3+Sh4+Sh5+B1+Hb1+Hb2+Hb3+Hb4+Hb5+Hb6 = =2+2+2+2+2+8+1+1+1+1+1+1 = 24 (LU)

Highest value - 8 >>> D=28x1,5

Hot water line H = D+G = 24+40 = 64 (LU) >>> D=35x1,5

Hot water line E = Sh1+Sh2+Hb1+Hb2+Hb3+Hb4 = 2+2+1+1+1+1 =8 (LU)

Highest value - 2 >>> D=18x1,0

<u>Hot water riser 1 = E+H = 8+64 = 72 >>> D=35x1,5</u>

Cold water calculations

Cold water line A = Sh1+Sh2+Sh3+Sh4+Sh5+Hb1+WC1+WC2+WC3+WC4= 2+2+2+2+2+1+1+1+1+1=15 (LU)

Highest value - 2 >>> D=22x1,0

Cold water line B = Sh1+Sh2+Sh3+Sh4+Sh5+Hb1+Hb2+Hb3+Hb4+Hb5+Hb6+Hb7+Hb8 = =2+2+2+2+2+1+1+1+1+1+1+1+1 =18 (LU)

Highest value - 2 >>> D=22x1,0

Cold water line F = A+B = 15+18 = 33 (LU) >>> D=28x1,5

Cold water line C = Sh1+Sh2+Sh3+Sh4+Sh5+Hb1+WC1+WC2+WC3 = 2+2+2+2+2+1+1+1+1= =14 (LU)

Highest value - 2 >>> D=22x1,0

Cold water line G = F+C = 33+14 = 47 (LU) >>> D=28x1,5

Cold water line D = Sh1+Sh2+Sh3+Sh4+Sh5+B1+Hb1+Hb2+Hb3+Hb4+Hb5+Hb6 = =2+2+2+2+2+8+1+1+1+1+1+1 =24 (LU)

Highest value - 8 >>> D=28x1,5

Cold water line H = D+G = 24+47 = 71 (LU) >>> D=35x1,5

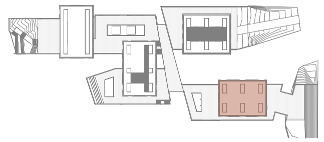
Cold water line E = WC1+WC2+Sh1+Sh2+Hb1+Hb2+Hb3+Hb4 = 1+1+2+2+1+1+1+1 =10 (LU)

Highest value - 2 >>> D=18x1,0

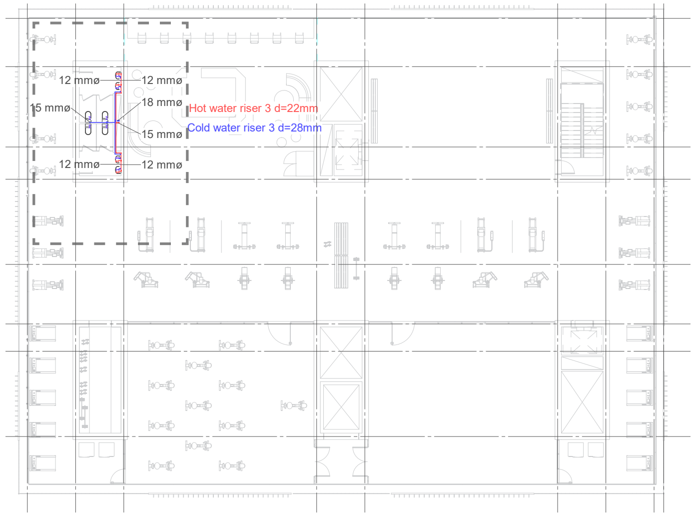
<u>Cold water riser 1 = E+H = 10+71 = 81 >>> D=35x1,5</u>

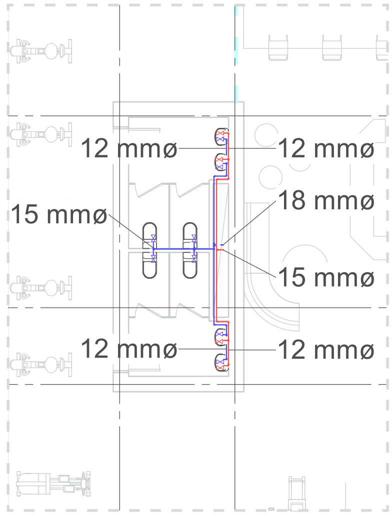
3.2. Water supply network in blocks

Typical block layout and calculations



Block B hot and cold water pipes layout plan





Hot water calculations

Hot water line = Hbx4 = 4 (LU)

Highest value - 1 >>> D=15x1,0

Same configuration on levels: GF, 2,3 so >>> Hbx4x3=12 (LU)

On the level 1 we have only one Domestic kitchen sink 2 (LU)

Highest value - 2 >>> D=12x1,0

<u>Hot water riser 3 = 12+2 = 14 (LU) >>> D=22x1,0</u>

Cold water calculations

Cold water line A = Hbx4+WCx4= 1x4+1x4=8 (LU)

Highest value - 1 >>> D=18x1,0

Same configuration on levels: GF, 2,3 so >>> (Hbx4+ WCx4)x3=24 (LU)

On the level 1 we have only one Domestic kitchen sink 2 (LU)

Highest value - 2 >>> D=12x1,0

<u>Cold water riser 3 =24+2 = 26 (LU) >>> D=28x1,5</u>

CHAPTER 04

DRAINAGE NETWORK

General description and standarts

Consumption and modernity in accordance with UNI EN 12056/02. Creation of an internal drainage and ventilation network in accordance with UNI EN 12056/02 DE LED. Drainage system consisting of pipes and fittings for draining inside buildings made of self-extinguishing polypropylene in accordance with the UNI EN 1451 standard. Minimum slope of drainage and ventilation networks 1%.

Discharge units

Appliance	System I	System II	System III	System IV
	DU (l/s)	DU (l/s)	DU (l/s)	DU (l/s)
Wash basin, bidet	0,5	0,3	0,3	0,3
Shower without plug	0,6	0,4	0,4	0,4
Shower with plug	0,8	0,5	1,3	0,5
Single urinal with cistern	0,8	0,5	0,4	0,5
Urinal with flushing valve	0,5	0,3	-	0,3
Slab urinal	0,2*	0,2*	0,2*	0,2*
Bath	0,8	0,6	1,3	0,5
Kitchen sink	0,8	0,6	1,3	0,5
Dishwasher (household)	0,8	0,6	0,2	0,5
Washing machine up to 6 kg	0,8	0,6	0,6	0,5
Washing machine up to 12 kg	1,5	1,2	1,2	1,0
WC with 4,0 l cistern	**	1,8	**	**
WC with 6,0 l cistern	2,0	1,8	1,2 to 1,7***	2,0
WC with 7,5 l cistern	2,0	1,8	1,4 to 1,8***	2,0
WC with 9,0 l cistern	2,5	2,0	1,6 to 2,0***	2,5
Floor gully DN 50	0,8	0,9	-	0,6
Floor gully DN 70	1,5	0,9	-	1,0
Floor gully DN 100	2,0	1,2	-	1,3

* Per person.

** Not permitted.

*** Depending upon type (valid for WC's with siphon flush cistern only).

\- Not used or no data.

Primary ventilated discharge stacks Hydraulic capacity (Qmax) and nominal diameter (DN)

Stack and vent stack	System I, II, III, IV Qmax (l/s)	
DN	Square entries	Swept entries
60	0,5	0,7
70	1,5	2,0
80*	2,0	2,6
90	2,7	3,5
100**	4,0	5,2
125	5,8	7,6
150	9,5	12,4
200	16,0	21,0

*Minimum size where WC's are connected in system II.
**Minimum size where WC's are connected in system I, III, IV.

Typical frequency factors (K)

Usage of appliances	K
Intermittent use, e.g. in dwelling, guesthouse, office	0,5
Frequent use, e.g. in hospital, school, restaurant, hotel	0,7
Congested use, e.g. in toilets and/or showers open to public	1,0
Special use, e.g. laboratory	1,2

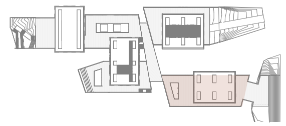
Capacity of drains, filling degree 70 %, (h/d = 0,7)

Slope	DN 100		DN 125		DN 150		DN 200		DN 225		DN 250		DN 300	
i	Qmax	v	Qmax	v	Qmax	v	Qmax	v	Qmax	v	Qmax	v	Qmax	v
cm/m	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s
0,50	2,9	0,5	4,8	0,6	9,0	0,7	16,7	0,8	26,5	0,9	31,6	1,0	56,8	1,1
1,00	4,2	0,8	6,8	0,9	12,8	1,0	23,7	1,2	37,6	1,3	44,9	1,4	80,6	1,6
1,50	5,1	1,0	8,3	1,1	15,7	1,3	29,1	1,5	46,2	1,6	55,0	1,7	98,8	2,0
2,00	5,9	1,1	9,6	1,2	18,2	1,5	33,6	1,7	53,3	1,9	63,6	2,0	114,2	2,3
2,50	6,7	1,2	10,8	1,4	20,3	1,6	37,6	1,9	59,7	2,1	71,1	2,2	127,7	2,6
3,00	7,3	1,3	11,8	1,5	22,3	1,8	41,2	2,1	65,4	2,3	77,9	2,4	140,0	2,8
3,50	7,9	1,5	12,8	1,6	24,1	1,9	44,5	2,2	70,6	2,5	84,2	2,6	151,2	3,0
4,00	8,4	1,6	13,7	1,8	25,8	2,1	47,6	2,4	75,5	2,7	90,0	2,8	161,7	3,2
4,50	8,9	1,7	14,5	1,9	27,3	2,2	50,5	2,5	80,1	2,8	95,5	3,0	171,5	3,4
5,00	9,4	1,7	15,3	2,0	28,8	2,3	53,3	2,7	84,5	3,0	100,7	3,1	180,8	3,6

Capacity of drains, filling degree 50 %, (h/d = 0,5)

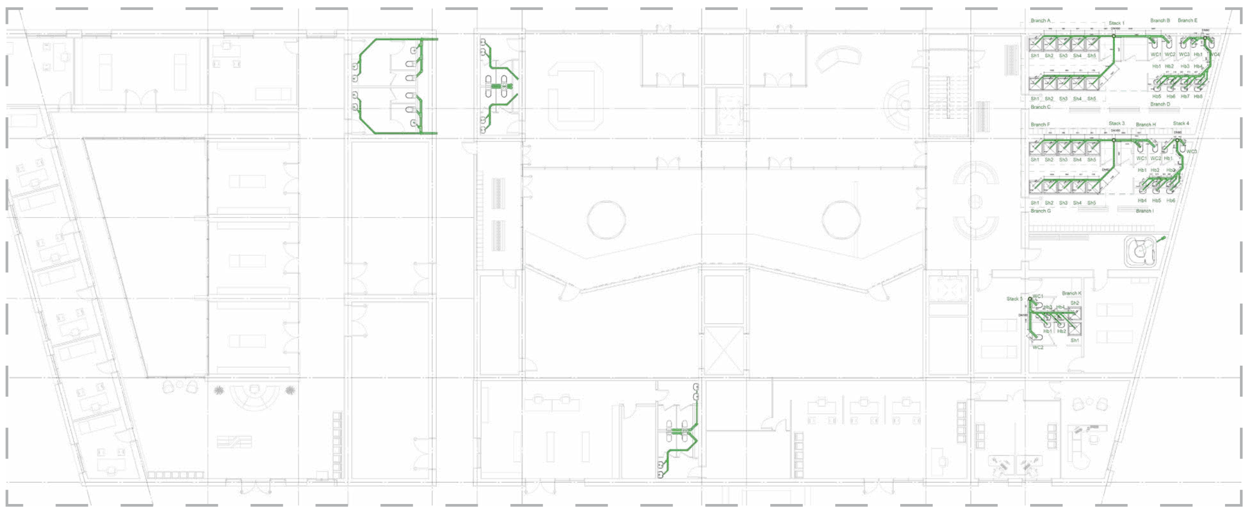
Slope	DN 100		DN 125		DM 150		DM 200		DM 225		DM 250		DM 300	
i	Qmax	v	Qmax	v	Qmax	v	Qmax	v	Qmax	v	Qmax	v	Qmax	v
cm/m	L/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s
0,50	1,8	0,5	2,8	0,5	5,4	0,6	10,0	0,8	15,9	0,8	18,9	0,9	34,1	1,0
1,00	2,5	0,7	4,1	0,8	7,7	0,9	14,2	1,1	22,5	1,2	26,9	1,2	48,3	1,4
1,50	3,1	0,8	5,0	1,0	9,4	1,1	17,4	1,3	27,6	1,5	32,9	1,5	59,2	1,8
2,00	3,5	1,0	5,7	1,1	10,9	1,3	20,1	1,5	31,9	1,7	38,1	1,8	68,4	2,0
2,50	4,0	1,1	6,4	1,2	12,2	1,5	22,5	1,7	35,7	1,9	42,6	2,0	76,6	2,3
3,00	4,4	1,2	7,1	1,4	13,3	1,6	24,7	1,9	389,2	2,1	46,7	2,2	83,9	2,5
3,50	4,7	1,3	7,6	1,5	14,4	1,7	26,6	2,0	42,3	2,2	50,4	2,3	90,7	2,7
4,00	5,0	1,4	8,2	1,6	15,4	1,8	28,5	2,1	45,2	2,4	53,9	2,5	96,9	2,9
4,50	5,3	1,5	8,7	1,7	16,3	2,0	30,2	2,3	48,0	2,5	57,2	2,7	102,8	3,1
5,00	5,6	1,6	9,1	1,8	17,2	2,1	31,9	2,4	50,6	2,7	60,3	2,8	108,4	3,2

4.1. Drainage network in podium



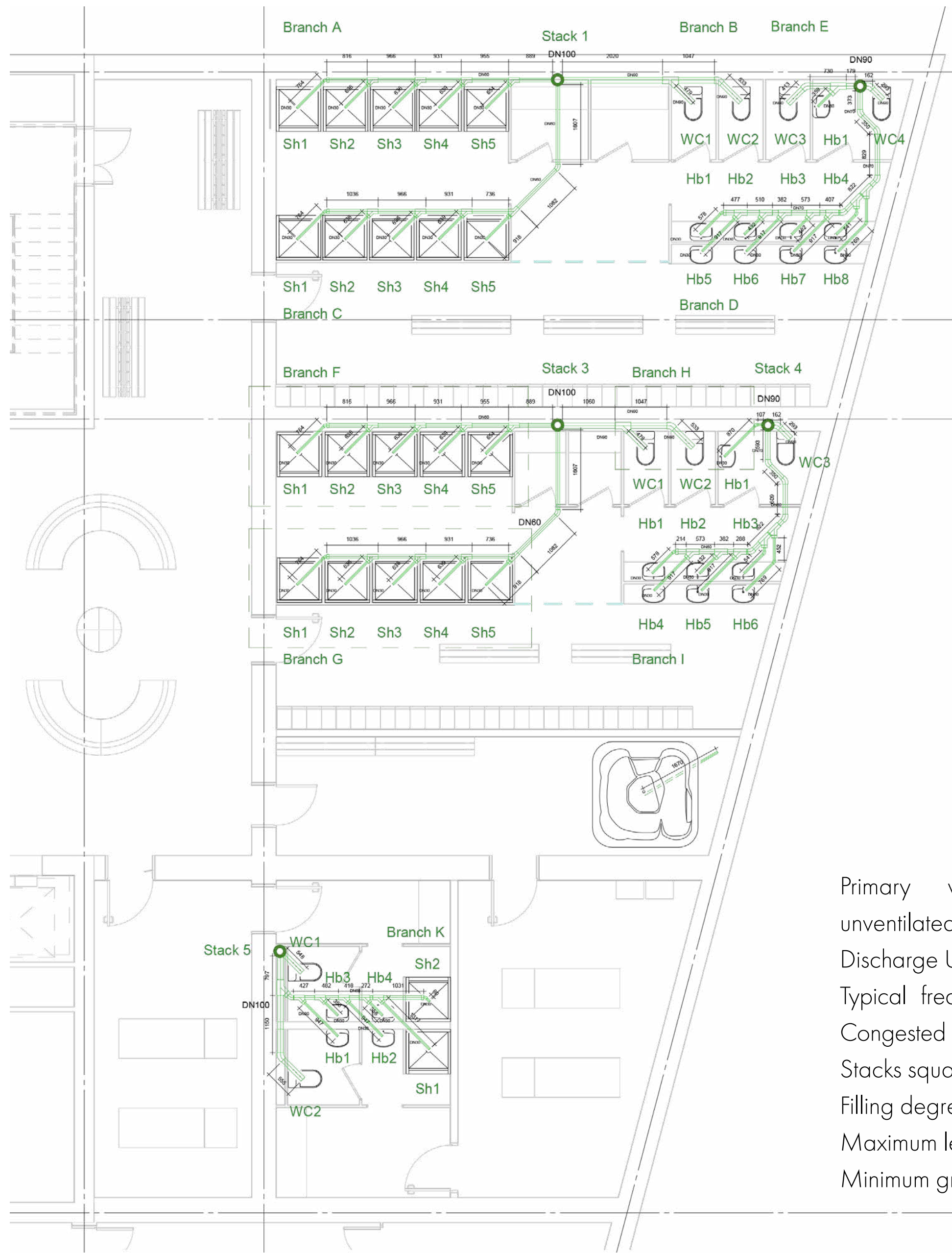
Typical podium layout and calculations

Podium. Ground Floor. Block B discharge pipes layout plan | Scale 1:500



Legend of discharge networks for black water

(green line)	Large diameter polypropylene pipes	Diamiter and thickness indicated in mm
(green circle)	Large diameter polypropylene drainage column	Diamiter and thickness indicated in mm
Sh	Shower without plug	
WC	WC with 6,0 l cistern	2 Loading units
Hb	Hand basin	1 Loading unit
B	Bath non domestic	1 Loading unit
		8 Loading units



Podium. Ground Floor. Block B discharge pipes layout plan | Scale 1:150

Primary ventilated system with unventilated discharge pipe
Discharge Units: System II
Typical frequency factor (K) - 1,0 - Congested use
Stacks square-entries
Filling degree of 0.7 (70 %)
Maximum length (L) of pipe - 10,0 m
Minimum gradient - 1,5 %

Calculations

Branch A = Sh1+Sh2+Sh3+Sh4+Sh5= 0,4+0,4+0,4+0,4+0,4=2 (DU)
DU 2 >>> Qww = 1x(2)$^{0.5}$ = 1.4 >>> DN=60
Branch B = WC1+WC2=1,8+1,8=3,6 (DU)
DU 3,6 >>> Qww = 1x(3.6)$^{0.5}$ = 1.9 >>> DN=90
Branch C = Sh1+Sh2+Sh3+Sh4+Sh5= 0,4+0,4+0,4+0,4+0,4=2 (DU)
DU 2 >>> Qww = 1x(2)$^{0.5}$ = 1.4 >>> DN=60
Stack and stack vent (1) >>> 2+3,6+2= 7.6 DU >>> Qww = 1x(7,6)$^{0.5}$=2,8 >>> DN=100

Branch D =Hb1+Hb2+Hb3+Hb4+Hb5+Hb6+Hb7+Hb8=0,3+0,3+0,3+0,3+0,3+0,3+0,3+0,3= =2,4 (DU)
DU 2,4 >>> Qww = 1x(2,4)$^{0.5}$ = 1.6 >>> DN=70
Branch E = Hb1+WC3+WC4= 0,3+1,8+1,8=3,9 (DU)
DU 3.9 >>> Qww = 1x(3,9)$^{0.5}$ = 2.0 >>> DN=90
Stack and stack vent (2) >>> 2,4+3,9 = 6,3 DU >>> Qww = 1x(6,3)$^{0.5}$=2,5 >>> DN=90

Branch F = Sh1+Sh2+Sh3+Sh4+Sh5= 0,4+0,4+0,4+0,4+0,4=2 (DU)
DU 2 >>> Qww = 1x(2)$^{0.5}$ = 1.4 >>> DN=60
Branch H = WC1+WC2=1,8+1,8=3,6 (DU)
DU 3,6 >>> Qww = 1x(3.6)$^{0.5}$ = 1.9 >>> DN=90
Branch G = Sh1+Sh2+Sh3+Sh4+Sh5= 0,4+0,4+0,4+0,4+0,4=2 (DU)
DU 2 >>> Qww = 1x(2)$^{0.5}$ = 1.4 >>> DN=60
Stack and stack vent (3) >>> 2+3,6+2= 7.6 DU >>> Qww = 1x(7,6)$^{0.5}$=2,8 >>> DN=100

Branch I =Hb1+Hb2+Hb3+Hb4+Hb5+Hb6 = 0,3+0,3+0,3+0,3+0,3+0,3 =1,8 (DU)
DU 1,8 >>> Qww = 1x(1,8)$^{0.5}$ = 1.7 >>> DN=60
Branch J= Hb1+WC3= 0,3+1,8=1,1 (DU)
DU 1.1 >>> Qww = 1x(1,1)$^{0.5}$ = 1.0 >>> DN=90
Stack and stack vent (4) >>> 2,4+3,9 = 6,3 DU >>> Qww = 1x(6,3)$^{0.5}$=2,5 >>> DN=90

Branch K = WC1+WC2+Hb1+Hb2+Hb3+Hb4+Sh1+Sh2=1,8+1,8+0,3+0,3+0,3+0,3+0,4+0,4= = 5,6 (DU)
DU 5,6 >>> Qww = 1x(5.6)$^{0.5}$ = 2.4 >>> DN=90
Stack and stack vent (5) >>> 5,6 DU >>> Qww = 1x(5,6)$^{0.5}$= 2.4>>> DN=100

Stack and stack vent (6) >>> 0,6 DU >>> Qww = 1x(0,6)$^{0.5}$= 0,8>>> DN=70

Drains

Section A >>> 7.6 DU >>> Qww = 1x(7,6)$^{0.5}$=2,8 >>> DN=100 Slope 0,50

Section B >>> 6,3 DU >>> Qww = 1x(6,3)$^{0.5}$=2,5 >>> DN=90 Slope 0,50

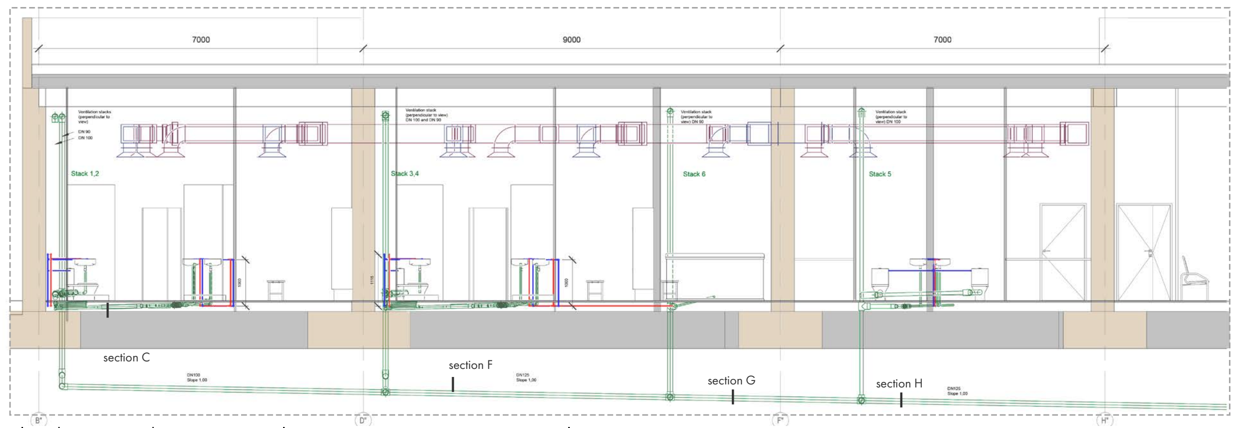
Section C >>> Qww = 1x(6,3+7,6)$^{0.5}$=3,7 >>> DN=100 Slope 1,00

Section D >>> 7.6 DU >>> Qww = 1x(7,6)$^{0.5}$=2,8 >>> DN=100 Slope 0,50

Section E >>> 6,3 DU >>> Qww = 1x(6,3)$^{0.5}$=2,5 >>> DN=90 Slope 0,50

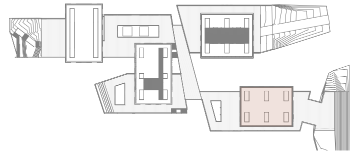
Section F >>> Qww = 1x(6,3+7,6+6,3+7,6+0,6)$^{0.5}$ =5.33 >>> DN=125 Slope 1,00

Section H >>> Qww = 1x(6,3+7,6+6,3+7,6+5,6+0,6)$^{0.5}$ =5.85 >>> DN=125 Slope 1,00

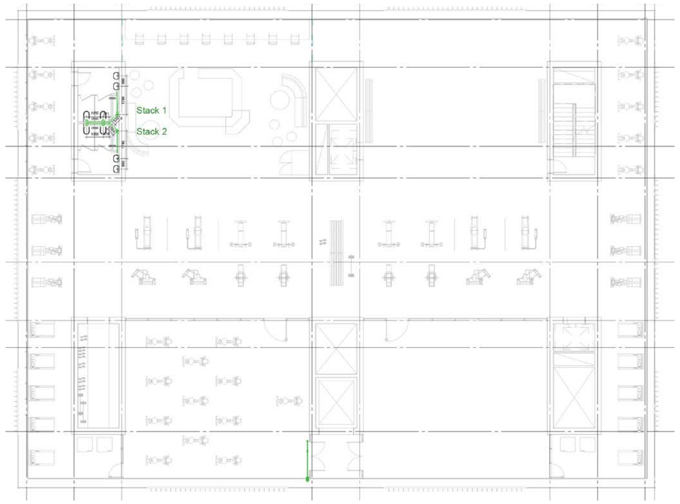


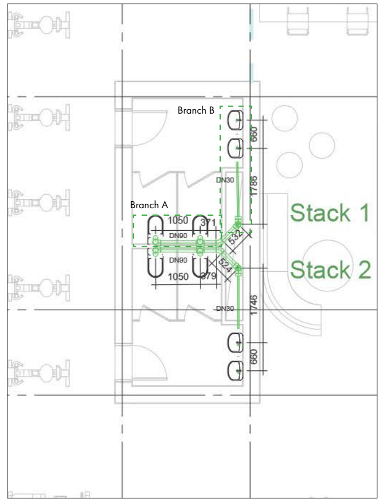
Block D. Podium. Pipes layout section C-C. Scale 1:50

4.2. Drainage network in blocks



Typical block layout and calculations





Primary ventilated system with unventilated discharge pipe.Discharge Units: System I. Typical frequency factor (K) - 1,0 - Congested use. Stacks square-entries. Filling degree of 0.5 (50 %). Maximum length (L) of pipe - 4 m. Minimum gradient - 1 %

Calculations:
Branch A = <u>WCx2</u>=2,0x2=4,0 (DU)
DU 4,0 >>> Qww = 1x$(4,0)^{0.5}$ = 2,0 >>> DN=90
Branch B = Hbx2= 0,5x2=1,0 (DU)
DU 1,0 >>> Qww = 1x$(1,0)^{0.5}$ = 1,0 >>> DN=60
Sum of discharge units on one typical floor >>> 4,0+1,0= 5,0 DU
On the 1st floor we have only one Kitchen sink 0,8 DU
DU 0,8 >>> DN=50
Sum of discharge units on the 1st floor >>> 0,8 DU
3 floors with 5,0 DU each and one with 0,8 DU >>> 5,8 DU
Stack and stack vent (1) >>> DU 5,8x3= 17,4 >>> Qww = 1x$(17,4)^{0.5}$ =
= 4.2 L/s >>> DN=100
System of the block consists of 2 stacks of the same size

<u>Drains</u>
Section A >>> 17,4 DU >>> Qww = 1x$(17,4)^{0.5}$= 4.2 >>> DN=125 Slope 1,00
Section B >>> Qww = 1x$(17,4+17,4)^{0.5}$=5,9 >>> DN=150 Slope 1,00

CONCLUSION

This study aimed to investigate the role of a community center as one of the structuring elements in the Paris-Saclay technology and innovation cluster.

The territorial transformation of Saclay demonstrated to be strongly founded on the site's geography. More closely, the Urban Campus development relies on a landscape hierarchy culminating in a central strip of major places where the most significant and participatory buildings are placed.

We have argued throughout this work the implications of introducing a community center within this strip on a social, cultural, and psychological level.

The results indicate that humans desire to live in complex companies and long to find a sense of belonging. This implies that their social patterns are the basis on which we build and design and eventually also become the ultimate goal for the revival of a community spirit. Following these conclusions, the Paris-Saclay Community Center takes its place as a common nucleus that contributes to a shared connection within a disparate society.

Additionally, this thesis challenged conventional ideas about the relationship between the natural and urban world. Within such a natural setting, flanked by the Palaiseau forest, the agricultural fields and the valleys, the project proved to be a tool with which the built environment and the landscape are combined. The end result came in the shape of an earth forum innovating ancient materials with contemporary processes. In doing so, the study revises the ways in which traditional practices can respond to some of the most crucial goals of the contemporary construction, mainly related to environmental responsibilities.

Following the rules that make up the civic core, we demonstrated that multifunctionality is a representation of the complex and everchanging human nature and eventually can fulfil the intricate relations and experiences on the Saclay Plateau. This statement shaped four technological blocks that penetrate the earthen green platform and contribute to a structured, programmed and unprogrammed urban promenade.

To better understand the implications of these results, future studies could address the technological solution of the podium erected with earth. On the site in question, experimenting with earthen specimens and conducting a quantitative approach could contribute to the assessment of the ecological impact of rammed earth construction.

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Source: Establishment Public Paris-Saclay. (n.d.). Investing for the disruptive economy. Paris.
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Source: Katz, B., & Wagner, J. (n.d.). The Rise of Innovation Districts: A new Geography of Innovation in America. Brookings.
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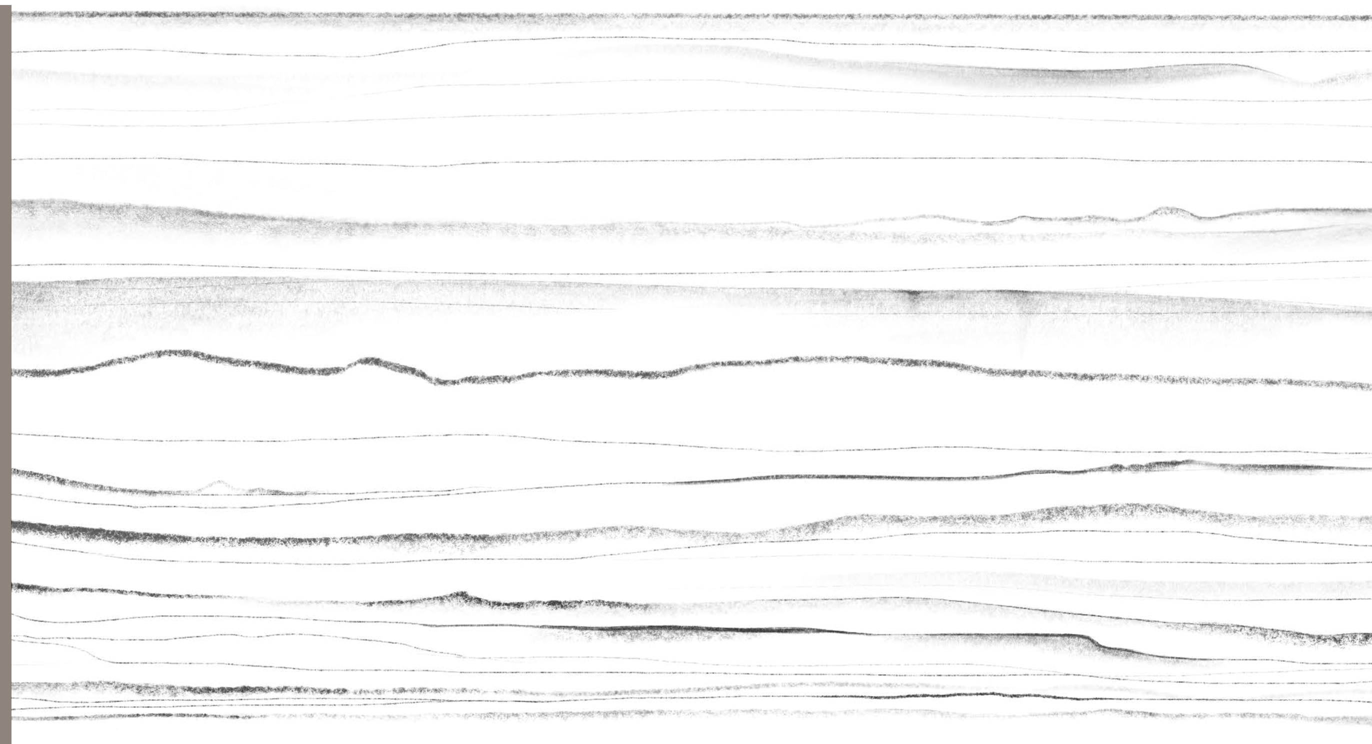

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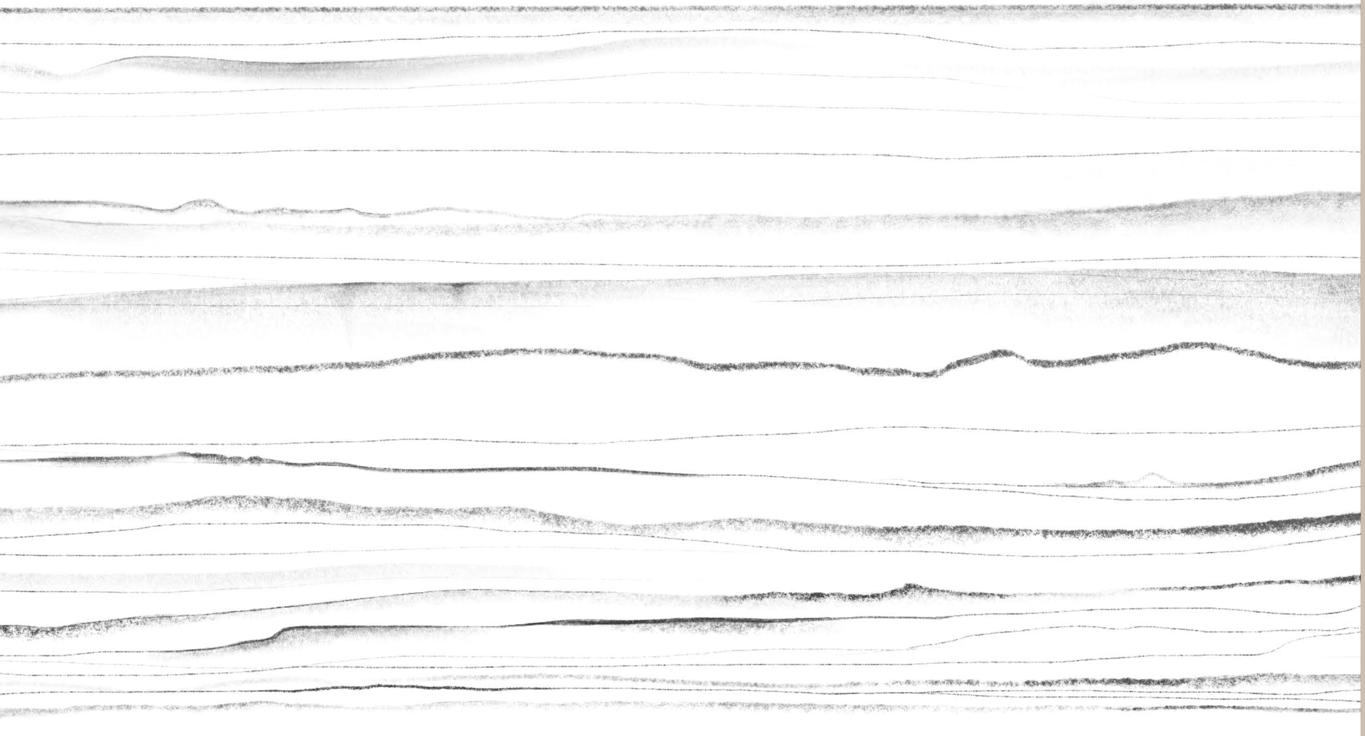

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