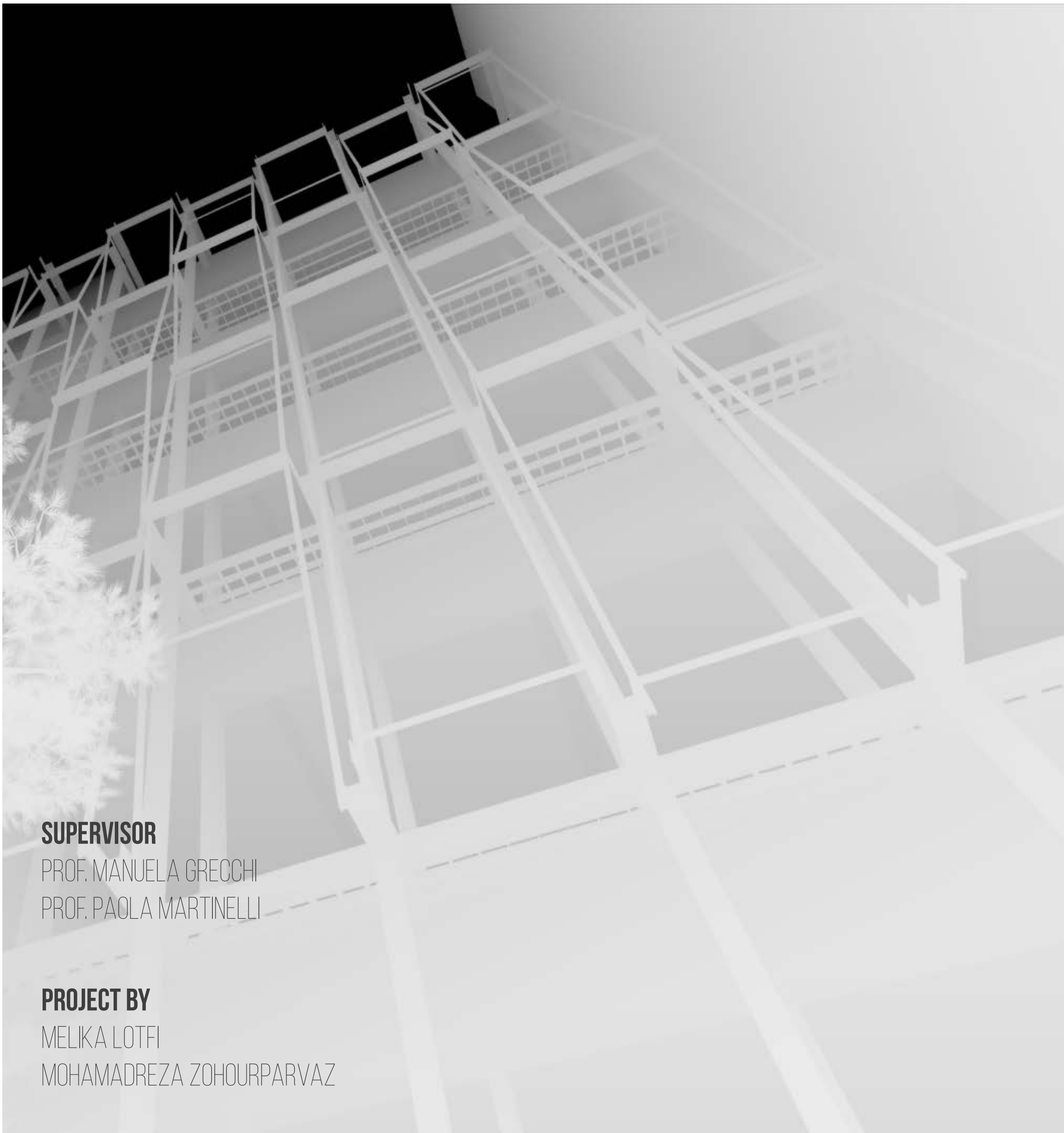
NEW STEPS

LOW CARBON ENERGY RENOVATION RETROFIT DESIGN
The social housing in Via Vertunni ,Roma

APRIL 2022



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“We shape our buildings; thereafter they shape us.”
Winston Churchill

CONTENT

ABSTRACT

The renovation encompasses not just the act of repairing or replacing a broken or obsolete structure, but also the process of reviving anything. Retrofitting, on the other hand, is the modification of a product after it has been created. After its initial construction and occupation, a building can be retrofitted by modifying its components, systems, or structure. This action will increase resident amenities while also improving the building's performance. The thesis intends to restore a two-story school building into social housing and upgrade the building's energy efficiency according to NZEB guidelines.

The project is located in Rome, Italy, on Via Vertunni. The analysis of the current building's energy usage status was the starting point. To improve the building's energy efficiency, several energy retrofit measures were implemented, including increased envelope insulation, the addition of shade panels, and the installation of renewable energy sources. Architectural solutions to improve the quality of the existing building's internal space were also incorporated into the design. These design concepts were shown to be useful in terms of energy efficiency as well.

The present thesis is divided into eight chapters, the first three chapters describe and analyze the building's site, surroundings, and the history of social housing in context. Various architectural ideas are explored and assessed in the next two chapters. The building technologies used in the project were introduced and studied in the sixth chapter, and the findings of the thorough energy and daylight analysis for before and post-retrofit scenarios and restoration strategies were given, debated, and contrasted in the next chapter. Also estimated and displayed is the performance of energy retrofit scenarios to minimize the building's global warming potential to meet the low carbon design targets. In the last chapter, structural analysis and design are completed and presented.

KEYWORDs: social housing, renovation, NZEB

ABSTRACT

La ristrutturazione comprende non solo l'atto di riparare o sostituire una struttura rotta o obsoleta, ma anche il processo di ripristino di qualsiasi cosa.

Il retrofit, invece, è la modifica di un prodotto dopo che è stato creato. Dopo la sua costruzione e occupazione iniziali, un edificio può essere adattato modificando i suoi componenti, sistemi o struttura. Questa azione aumenterà i servizi dei residenti migliorando anche le prestazioni dell'edificio. La tesi intende ripristinare un edificio scolastico a due piani in alloggi sociali e migliorare l'efficienza energetica dell'edificio secondo le linee guida NZEB.

Il progetto si trova a Roma, in Italia, in Via Vertunni. Il punto di partenza è stato l'analisi dello stato di consumo energetico dell'edificio attuale.

Per migliorare l'efficienza energetica dell'edificio, sono state implementate diverse misure di riqualificazione energetica, tra cui un maggiore isolamento dell'involucro, l'aggiunta di pannelli ombreggianti e l'installazione di fonti di energia rinnovabile. Nel progetto sono state incorporate anche soluzioni architettoniche per migliorare la qualità dello spazio interno dell'edificio esistente.

Questi concetti progettuali si sono dimostrati utili anche in termini di efficienza energetica.

La presente tesi è suddivisa in otto capitoli, i primi tre capitoli descrivono e analizzano il sito dell'edificio, i dintorni e la storia dell'edilizia sociale nel contesto. Varie idee architettoniche vengono esplorate e valutate nei prossimi due capitoli.

Le tecnologie edilizie utilizzate nel progetto sono state introdotte e studiate nel sesto capitolo, e i risultati dell'analisi approfondita dell'energia e della luce diurna per gli scenari prima e dopo l'adeguamento e le strategie di ripristino sono stati presentati, dibattuti e confrontati nel capitolo successivo.

Inoltre, vengono stimate e visualizzate le prestazioni degli scenari di retrofit energetico per ridurre al minimo il potenziale di riscaldamento globale dell'edificio per soddisfare gli obiettivi di progettazione a basse emissioni di carbonio. Nell'ultimo capitolo vengono completate e presentate l'analisi strutturale e la progettazione.

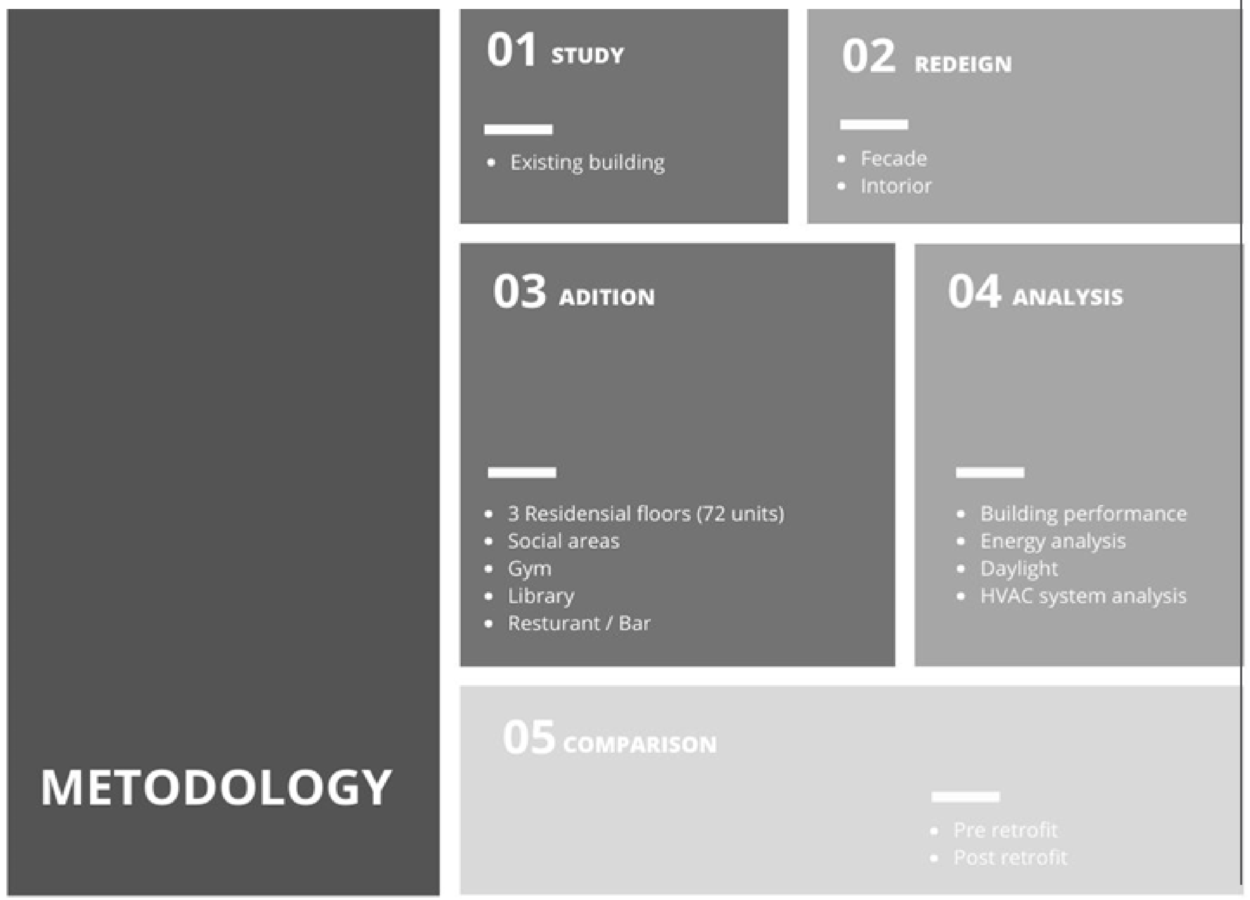
PAROLE CHIAVE: social housing, ristrutturazione, NZEB

1 INTRODUCTION

1.1 INTRODUCTION

The thesis is based on renovating a former school facility located on the eastern outskirts of the city, about 100 meters inside the highway ring, in a marginal area of the residential district The starting point was to analyze the situation of the existing building in terms of architectural point of view, urban context, and energy consumption. The important aspect was to avoid fundamental changes due to financial and structural reasons. Furthermore, there were arrangements to enhance the energy performance of the building; such as increasing the thickness of the insulation layer and addition of the shadings around the building envelope. The architectural aspect was considered in each stage of the project. In addition, it was required to add three residential floors above the building to turn it into high-performance social housing based on the context and the city. Moreover, it was decided to create a restaurant, cafeteria, market, and gathering areas in the ground floor space next to the existing voids. Enhancing the aesthetic values of the building was also an important design goal. Another essential issue was to use the component that was developed by ENI, PV panels, and solar heating elements. PV panels represent an active element in the energy performance of a building, providing a multifunctional contribution in terms of renewable energy production. At the end of the report, different daylight control systems were introduced. In the conclusion, the positive effects of the changes in both aesthetic and energy consumption terms of the building were obtained. The last step was to calculate the energy saving achieved by energy retrofitting during the operation phase of the building. Also, the global warming potential of pre and post-retrofit situations were calculated over the projected building life span, and the environmental advantages of the energy retrofitting are demonstrated. It was realized that the retrofitting of the building is highly effective to reduce the energy consumption and the global warming potential of the building to reach low carbon design targets.

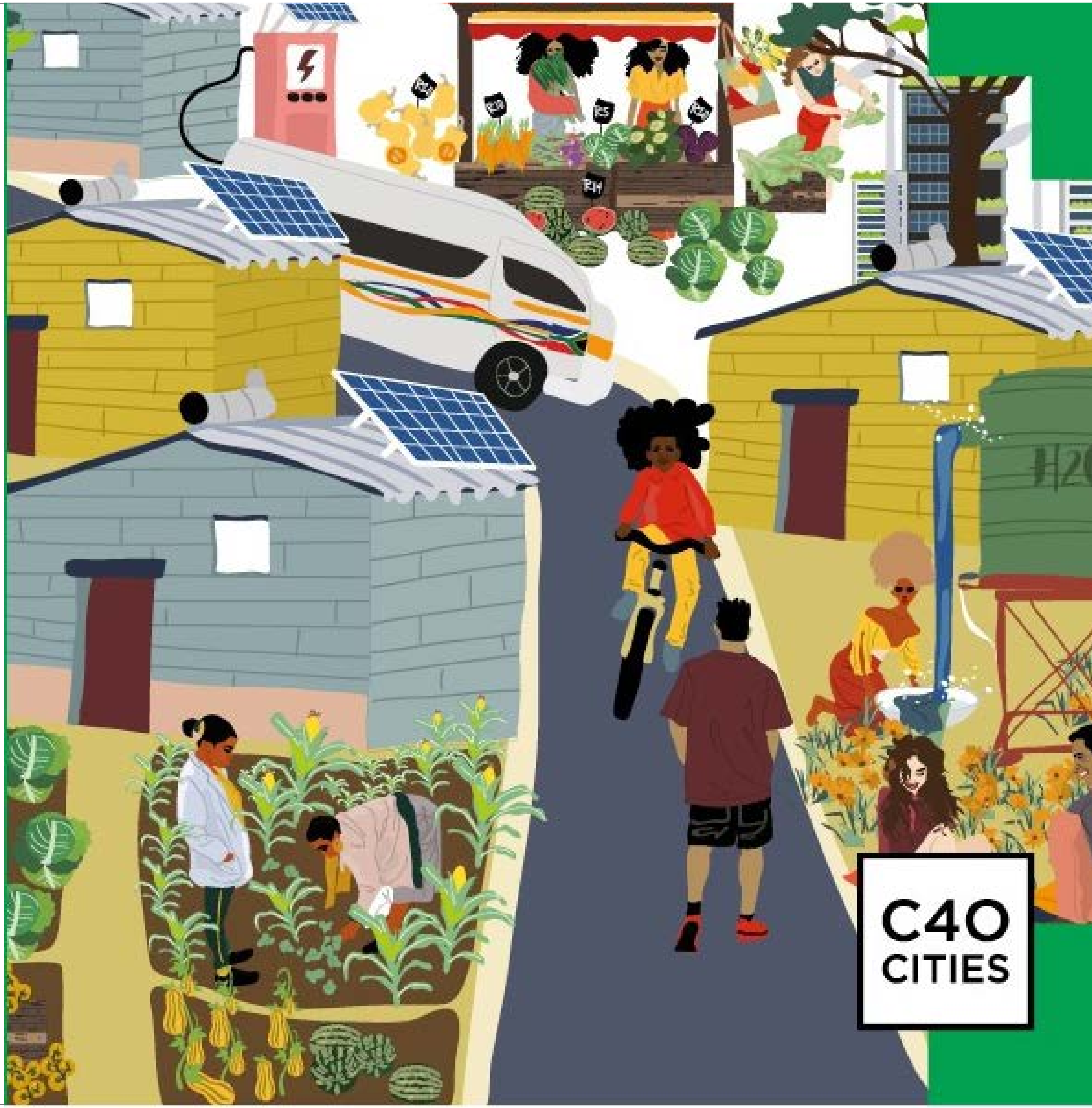
1.2 METODOLOGY



1.3 THE COMPETITION BRIEF

For our Master's thesis we worked on a project from Reinventing Cities Competitions, which is a competition initiated by the C40 .
The competition approache is to address the challenges comply with local and national building and environmental regulations, policies, and standards. Where it should be demonstrated how the use of approved national or international sustainability standards from design to completion will allow the project to address the relevant challenges, for example: NZEB standards, European Energy Performance of Buildings Directive, the Greenhouse Gas (GHG Protocol), ISO standards, etc.
Actually The competition seeks to stimulate the most innovative carbon-neutral developments across the globe, implement the best ideas to transform underutilized sites into beacons of sustainability and resilience, and act as a showcase for future zero-carbon urban developments.
The project we chose to work on is located in Roma ,Italy.
The competition area consists of a former school facility located on the eastern outskirts of the city, about 100 meters inside the Grande Raccordo Anulare (highway ring), in a marginal area of the residential district of La Rustica, not far from via Collatina which runs about 70 meters to the south. The study area is surrounded on the west side by the La Rustica Zone Plan (the school is part of the public spaces), on the south side by the Vittorio De Sica kindergarden; on the east side by via Achille Vertunni, which is also connecting the neighborhood to via Collatina,and it is the access road to the study area; on the north side by an unplanned residential urbanization.

In addition to the residential areas, consisting of the Zone Plan with seven-story buildings and unplanned urbanization with two or three story buildings, the urban context is characterized by the presence of large productive, commercial and business areas along the Via Collatina and close to the G.R.A., and from free residual areas left mostly uncultivated or that preserve the original agricultural use in a small part. Outside the G.R.A., to the east, wide agricultural lands extend mostly flat or with slight slopes and the landscape is characterized by the spring of Virgin water, with the piezometric tower, the only vertical element in this area. The school building has heights ranging from one floor to two floors, it has never been completed and is currently in abandon, with the reinforced concrete structure completed and un-plastered partition walls.



1.4 PRESPECTIVE

This study aimed at applying an integrated approach to design; incorporating multiple disciplines and scales of a project that is architectural, technological, and structural design. The proposed site within via vertunni is 2,853 square meters of which 1,641 square meters is built structure that needs to be renovated and given a new sustainable life. At the Architectural or building scale, the main objective was to arrive at a contemporary and energy-efficient building design that meets the users' needs. The site was built as a school but it left and never got used. We tried to develop an ambitious project, revealing and finding a new role for the site and its built structure. According to the Municipal Plan, the planned function or operation for the proposed site and build structure, via vertunni is residential. The development will be social housing with a mixed-use area. Therefore, the proposal should take into account the existing redevelopment plan for transforming the area. The proposal should also allow for sustainable quality, livability, and diversity. It should emphasize sustainability through cost-effective use of land, green space and ecosystems, transportation, employment, urban integration, and public health. According to the municipal plan, the proposed adjacent site will host a restaurant, gym, and market for the whole community via vertunni area. We developed an ambitious project that is revealing and finds a new role for the site and its built structure. After carefully studying all the existing buildings on the site, we concluded it is best to keep and refurbish most of them for sustainability reasons. According to residential neighbors and roman cultural studies, we redesigned the site to social housing that hosts many activities based on the needs and daily habits of roman people. Our design also improves vegetation and biodiversity as needed.

1.5 DESIGN FRAMEWORK

Our Design choices are tied in with creating aggressive activities that look for new jobs for destinations and engineering structures. We center around maintainability through green space and sustainable power sources, as well as monetarily proficient land use. We are addressing the environmental challenge to design a Low-Carbon, Sustainable and Resilient Project. The way to carry out an NZEB project requires a few arrangements. The decision of such an answer should be made considering the area, arrangement, and how proper is for the climate. We attempted to track down the arrangement of these necessities through the Low-Carbon, Sustainable and Resilient Project description.

Major questions being considered to limit the energy utilization on this undertaking are:

_ Energy effectiveness and low-carbon energy utilization:
it focuce on reduceing the GHG discharges and the ecological effect of energy creation and utilization. The proposed advancement ought to go past current 'The same old thing' energy guidelines to exhibit excellent energy productivity, clean energy utilization, and endeavor to accomplish net zero energy or 'positive energy' status . in this project we were attempting to include: inactive plan and effective structure and texture; energy proficient machines/gear; inhabitant control, observing and assessment of energy utilization; on location and off-site creation and utilization of environmentally friendly power; energy capacity; social advantages connected with manageable energy.
Energy productivity is a high need in the plan and activity of the structures and public spaces. This implies limiting how much energy a structure utilizes for warming, cooling, high temp water, lighting, ventilation, electrical administrations, and so forth Encouraging the creation and utilization of clean energy on location is additionally key.

_ Life cycle appraisal and maintainable development materials :
it accentuation on reduceing the epitomized carbon of the venture, which alludes to the lifecycle ozone harming substance emanations that happen during the production and transport of development materials, as well as the development interaction itself and end-of-life parts of the structure. The undertaking needs fabricating retrofits over wrecking old structures or building new ones. We attempted to pick development materials with lower discharges from the extraction, assembling, transportation, and end-of-life stage .

- Environment flexibility and variation:
we were attempting to foster a task that is strong to current and future environment risks explicit to the area of the site. The venture ought to be strong towards environment perils, for example, temperature climb, expansion in force and recurrence of winds and tempests, flooding. This implies that the undertaking ought to incorporate an environmental change risk evaluation, including the environment dangers that the particular site is presented to and under which environmental change situations/what time skyline. With this appraisal as a beginning stage, undertakings should try to execute variation measures. Versatility should cover two perspectives: (I) Occupant strength, for example, tree planting or concealed regions to shield inhabitants from the hotness island impact. (ii) Building strength, for example, supported establishment where solid breezes could cause harm, thought of what dry spells could mean for building material steadiness or secluded plan.

2

SOCIAL HOUSING OVERWIEW

Fig 2.1
Workers' Housing in the 19th Century

2.1 A HISTORIC OVERVIEW OF THE SOCIAL

2.1.1 THE EARLY TIME(1900-1940): THE WELFARE FOR WORKING CLASS HOUSING POLICIES IN ITALY

History of social housing in European countries began more than a century ago. Although each country has different definition of "social housing", the core of it is similar, which is the housing provided to those who needs them in the lower price. As much of Europe has "a common history of social housing with shared roots, a shared philosophy, and a large variety of experiences", the social housing topic is quite popular around Europe. The word social housing is the key element of the "social welfare" policy that "marked the first stage of industrialization". (1)

"Since the industrial revolution, together with the traditional provision by private and speculative initiatives, industries and companies, as well as the State, initiatives, industries and companies, as well as the State, of housing stock for workers, thus confirming the role of industrial production as a principle of economic, social and spatial organization. Public housing estates were conceived as answers to the relevant housing demand, as well as platforms for social inclusion, for urban integration and control of the working classes that migrated toward the city" (2).

The first Italian law on social housing was declared in the early twentieth century (3). Proposed by MP Luzzati, it was called the "Luzzati Law."

It creates intermediate entities, financial companies and cooperatives, which build wellings to be rented or sold to people in housing need. The resources of banks and mutual aid societies can finance these entities. IACP (Istituto Autonomo per le Case Popolari, Independent Institution for Tenement Building) was established in 1908 in almost all Italian cities. For many decades these entities have been the main actors on the scene of social housing.

The aim of the IACP was to provide housing to lower classes of the population. Luzzati's idea was to give a house to families who could pay mortgages to financial companies and cooperatives; hence to the working class. The law was not intended for the most vulnerable part of the population.

Hence, early in this century, the birth of social housing is not only for the needs of workers, but also for economic and political needs. But anyway, this kind of housing does constitute the main body of the social welfare system.

Social housing is also related to the modern architecture movement, modernism and industrialization were accepted as guiding ideologies of the European countries in the same historical background, and social welfare policies are closely related.

1: Lévy-Vroelant, 2008 / 2: Bricocoli 2010

2.1.2 POST WORLD WAR II RECONSTRUCTION PHASE (1945-1967): PROMOTING THE ECONOMIC RECOVERY

Fig 2.2 A view of a decimated city of Mainz from its cathedral,after world war ll

After the World War II, the national goal was the country's reconstruction, and the real estate sector was chosen as a trigger for economic development. In this phase, subsidised housing was strengthened and specific categories of beneficiaries were identified (1), shifting housing policy's purpose from supporting workers (pre-war period) to economic recovery. This was achieved through Law 43 of 1949, which defined a national housing plan (called "Fanfani Plan," as the Minister of Labor who proposed it). The plan's goal was to increase employment by building social housing for workers (subsidized housing). Financial resources were provided by the national State and by a contribution from all workers (entrepreneurs and employees had a deduction on their income). The funds of the plan were managed by Istituto Nazionale delle Assicurazioni (2); therefore, the housing program was called INA-Casa. This is a public housing project, located mostly in the outskirts of the metropolitan area, providing nearly 355,000 housing for the public. Since then, a large number of immigrants from villages and small towns to large cities, urban suburbs began to be formed.

Law 167/1962, which created a new spatial planning tool for new social housing areas in the cities, this plan was the first planning tool to create a relationship between public authorities, private actors and cooperatives to build new housing Law 60/1963: the State promoted a housing programme, thus replacing INA-Casa, called GEStione Casa Lavoratori (3), management of workers' housing. The funding system was the same as for INA-Casa: contribution from the State, employers and employees. The state's contribution was larger than in the former plan, since it invested the financial resources gained by selling the previously built subsidized houses. GESCAL was a ten-year plan, whose purposes were not only to build new social housing, but also to construct infrastructures and services.

1: Minelli 2004 / 2: INA, National Institute for Insurance /3: GESCAL

2.1.3 PERSISTENCE OF THE HOUSING NEED AND PROTESTING MOVEMENTS (1967-1978) : DECENTRALIZATION OF HOUSING POLICIES AND PUBLIC PRIVATE PARTNERSHIPS

During the 70s a declining trend started. The number of families kept growing but with fewer members than before in Italy one single member can be considered a family) and it has continued so until today. Families' needs started to differentiate thanks to changes in lifestyle (1).

In the end of 1960s and during the 1970s unresolved issues affected the Italian scenario, bursting in protesting movements, violent tensions and terroristic attacks. Housing need was not solved (social housing neighborhoods were not sufficient for the housing demand), and in peripheral areas of cities the real estate sector created low quality housing, without services and parks. In particular, lower classes were expelled from cities' centers, which were left to the richest population. The most vulnerable people and the population who migrated from the countryside gathered in peripheral districts. Under these circumstances, self-organized initiatives bloomed; neighborhood committees were created in the social housing districts to fight for issues about services and infrastructures. These protesting movements were well organized and they proposed changes in the situation: occupation of free areas, spaces and rooms, auto-reductions of rents, promotion of cultural events and public debates. Housing has always been considered also by labor unions as a fundamental right to be provided to every citizen. A new national housing policy was demanded.

The housing reform was introduced in 1971 with Law 865, it organized the public intervention in housing with a clear structure. The housing competences were entrusted from the State to the Regions (public authorities created in 1970). These have the duty to manage the locations and public investments for social housing. The national government plans the financing and the mechanism of fund distribution among the regions, adapting the financial resources to the various regional housing needs. Regarding expropriation, the law introduced the expropriation for public benefit:

municipalities could obtain areas or buildings if they were planning of creating public services in those zones.The economic value of this kind of expropriations was really low, since they were assimilated to rural land (agricultural use) therefore these costs were feasible for the municipalities. In this way, municipalities could begin to control the land revenue's mechanisms. The law clearly states the separation between land property and real estate activity: the municipal master plan is stronger than the landowners' rights. Also the entities who can build and manage social housing are controlled: IACP is the appointed one to partner with municipalities and regions.6 This law was considered as a big achievement, for instance, the law allowed municipalities to partner with private actors.

1: Boeri et al. 1993 /

2.1.4 DECLINING OF SOCIAL HOUSING CONSTRUCTION (1978 - 1990): INITIAL STAGE OF SOCIAL HOUSING REGENERATION AND EFFORTS TO REGULATE THE HOUSING MARKET

The new construction share of social housing estates in whole building construction has been declining from 8 percent at the beginning of the '80s to a less than 2 percent at the beginning of the '90s. At the end of the 1970s in Italy, when two main national acts were promulgated:

Law 392/1978 (Rent Act), which introduced a new form of regulation for the rental sector (not only for housing, but for all uses): the mechanism defined by the law was based on objective criteria related to the dwelling's features and rent prices were raised less than the market ones. Government involvement makes rents relatively reasonable.

And Law 457/1978, which launched the Ten-Year Public Housing Plan. The law defined the entities that managed the plan and their activities (financial management and resources, norms about mortgages, regulations about old buildings and neighborhoods' renewal). The plan financed the social housing sector for ten years; in particular financial resources were assigned not only to subsidized housing, but also to assisted and agreed housing. The focus on renewal became stronger in those years: public-private partnerships could be created to act on urban form and on buildings. The existing degraded building itself and neighborhoods were the objects of this policy, which focused only on the built environment, without any attention toward social and economic dimensions.

The decade of the 70s can be considered as a phase of regulation and attempts of equality: the central State tried to regulate the housing market, correcting alterations and pursuing redistribution. During the 80s, instead, these efforts were neglected and some of the laws and norms enforced in the previous years were cancelled. Both expropriation and fair rent regulations experienced some degree of repeal. In this decade home ownership was promoted through specific norms and financial resources at the same time, selling processes reduced the availability of subsidized housing. The rental market started shrinking and also the middle class was affected by housing problems. Low classes of the population, demanding social housing, were in social distress.

Fig 2.3 le vele di scampia ,naples ,Italy 1970

2.1.5 SOCIO-ECONOMIC CHANGES AND INTEGRATED URBAN PROGRAMS (1990-2000): COMPREHENSIVE REGENERATION POLICY UNDER SOCIAL HOUSING SHORTAGE

Due to the changing of families and social structures, the influence of economic crisis and the pressure of immigrants, the housing demand have become highly fragmented in the last decades. Housing deprivation no longer concerns only traditional low-income families but new, numerous and heterogeneous population segments, which were not previously affected by this problem (1).

Moreover, the changes in post-Fordist societies and the impact of the globalization process, mainly related to labor market flexibility and to the widely feared risk of unemployment (2) has given rise to new forms of social fragility and poverty, which has strong consequences for housing needs.

In terms of subsidized housing, supply conditions have remained the same in the past twenty years. The number and features of dwellings are inadequate and rigid, quite unsuitable for the various housing needs. The most vulnerable people are, therefore, gathered in specific neighborhoods and parts of the cities. Most of the financial support for social housing is now focusing on rehabilitation and regeneration programs, so few buildings are being built and cannot actually improving the existing stocks,

In the 1990s, public investment in housing fell further and the limited public resources that had been allocated to this sector went to the so-called "integrated urban programs", which in Italy fuelled urban renewal and regeneration policy (3).

After more than 50 years from the construction of the first buildings of social housing, it was clear that this real estate sector needed renewal and restructuring. The social housing neighborhood became the symbol of decay and marginalization. In social housing neighborhoods, the grouping of various forms of social distress constitutes a multi-faceted issue.

As a result of the European Union's initiatives (i.e. Urban), these neighborhoods have become part of renewal and regeneration policies. The aim of the regeneration process was to tackle all dimensions of deprivation and distress. Economic and social revitalization entered the framework along with physical interventions. The key aspect of the integrated approach is multidimensional actions designed to achieve social inclusion, focusing on principles like integration, involvement of different actors, and capacity to make agreements among various entities.

1:Tosi 2007 / 2 ; Clapham 2006 / Governa and Saccomani 2004

2.1.6 AFTER 2000: MULITI-SECTOR PARTICIPATION AND PARTNERSHIP

After 2008, the ongoing economic crisis profoundly reduced the social housing construction industry; besides, Italian buildings have an average of about 40 years of history. Generally, urban development was interrupt: geographical isolated, industrial areas abandoned, the value of public building in a loss.

New actors have become visible in the housing sector in this time frame. The tertiary sector and ethical investors are often involved in providing housing services and taking care of vulnerable sectors of the population. It is part of a general trend of planning negotiation, which targets actors and aims at providing social services (1). Bank foundations are often replacing public actors in sustaining welfare policies. They finance social policies when there is no (or scarce) public resource. The ethical goals of these actors influence sectors, such as healthcare, social services,

housing, environment, etc. In the last years, especially in Northern Italy, bank foundations have played a considerable role in integrating local housing initiatives, and have often been financing pilot projects and housing experiments.

The goal of Law 9/2007 is the development of a new housing policy for vulnerable population categories. A negotiating table was created involving ministries, regions, municipalities, Federcasa (IACP's organization), real estate associations and cooperatives. The goal was the design of a national housing plan to develop the new aims and orientations of regions, such as improvement of housing supply, fiscal proposals, measures for better cooperation to deal with housing deprivation, and calculation of financial resources. This negotiation was supposed to be used as a continuous meeting to discuss the national housing conditions. The law also introduced some norms on the suspension of eviction, the allocation of evicted population, and tax reductions for owners renting dwellings at fixed prices and new three-year regional plans for subsidized housing. 3.2.2 A more profound transformation in Italian urban policies in terms of more integrated actions and variety of intervention.

Since the early 1990s Italy has seen a growing trend in institutional innovation and co-operation between public bodies that has generated experimentation in the regeneration process. Partnerships between public and private sectors have been developed in the Welfare system in general as well as in the local re-qualification processes which invested specific urban areas (2).

As Padovani (3) shows, the propensity to try out innovative practices has been facilitated by the fact that, since the early 1990s, Italy has been characterized by institutional innovation and new practices of negotiated co-operation between public bodies.

As the large amount of legislation passed in the past decade shows, there is in Italy the lack of an integrated plan for interventions based on a clearly defined program. A further reason is the fragmentation of responsibility for intervention in urban areas among the various levels of government. As a rough guide we can say that, very schematically speaking, the responsibility as regards policies and interventions in cities and urban areas is divided up between at least three horizontal political-institutional levels: state, regions, local authorities (the latter subdivided into provincial and municipal). And then among numerous 'vertical' sections on each of these levels, which it is not always possible to get to work together in a coordinated and integrated fashion (4).

1:Bricocoli and Coppola 2011 / 2: Ombuen, 2001 / 3: 2000, pp. 4-7; 2002 / 4: Enzo Mingione 2013

2.2 MULTI-SECTOR COLLABORATION IN ITALIAN SOCIAL HOUSING REGENERATION

Urban regeneration policies in Italy have been traditionally characterized by fragmented, sectorial, non coordinated and voluntary actions and, for a long time, mainly oriented towards improving housing conditions without paying attention to urban factors linked with social exclusion in the more deprived neighborhoods. Nevertheless, following the European example, the last two decades have witnessed a profound transformation in Italian urban policies in terms of more integrated actions and variety of interventions. The general improvement in housing and infrastructures in Italian cities has also determined the necessity to promote a territorially concentrated policy for tackling specific socio-residential problems in specific urban contexts.

In terms of regional policies, much effort has been focused on public and third sector rental supply, on the search for greater synergy among the public sector, the social/private sector, the credit system and entrepreneurs and on the search for a greater link between housing policies and social policies.

The certain critical point is that the need to involve different operators and resources means there must be a partnership and negotiation among the public, private and third sectors. In a broad sense, the social role of the state implies its capacity to interact with private and associative action. Innovation requires the identification of local subjects able to combine and manage different resources and create flexible supply suitable for the new complexity of demand. The search for a local subject is the difficult task undertaken by public and private players, and it is also an opportunity being evaluated by the old and new players - IACP (Autonomous Public Housing Institute), cooperatives, associations - of social housing in their search for new roles and opportunities. The search for a role for - or the wager on - a third housing sector is gaining ground and is taking on an increasingly essential role.

Regions are responsible for defining requirements for accessing social housing, as well as rules for setting rents.

In 1992 some special schemes were established in the framework of a social housing program. Such schemes, soon named "integrated programs" were initially aimed at the improvement of the overall housing quality. In fact, soon after the eighties the prevailing opinion was that dwelling shortage was definitely resolved, and that housing needs were to be confined to an issue of affordability limited to the largest metropolitan areas. However, it was thought that they were no longer a problem of poverty, but an issue confined to some distinct, marginalized social groups. As such, broad housing schemes were no longer needed, while a number of local actions devoted to the renovation and change of limited areas were rather thought as more effective. (1)

There is a need to develop strategic frameworks at the urban region level (2). This consensus is based on the premise that successful urban regeneration requires a strategically designed, locally based, multi-sector, multi-agency partnership approach.

Strategic planning is an important tool for enabling communities to identify advantages in relation to the external environment - local, regional, national and international. This emphasis on external factors allows the process to incorporate a wide range of organizations and individuals from the public, private, voluntary and community sectors. Clearly the partnership approach is a critical element in adopting a strategic approach to urban regeneration.

1:Tosi 2008 / 2: Healey, 1997

2.2.1 NATIONAL LEVEL

At the Ministry of public works, a general direction is in charge of Housing Affairs for the whole countries. The DG for Housing, former Housing Committee (1), was appointed by the 1978 Construction Ten years Plan for establishing and coordinating a national program aimed to the construction of a consistent amount of new housing units, to the renovation and refurbishment of existing stock an to the experimentation of new housing programs.

However, the national level has lost most of its functions. The financial provision and planning responsibilities have been gradually devolved to the Regions, together with the functions concerning social housing. The devolution process has lasted more than a decade, and has been accomplished only recently in 1998. The main change occurred concerns the end of the special channel of funding exclusively devoted to housing, and of the central power role in redistributing the resources among the regions. They are not that effective. Apart from several modest measures, such as Law 21/2001 and several tax concessions for the construction of low-rent housing, the rent policies are those that implement the provisions of Law 431/1998.

The law eliminated residual limitations carried over from the previous rent regulation system and, at the same time, introduced a set of measures aimed at pursuing social objectives. It provides incentives for expanding the market and renting vacant space, as well as support in reducing costs. The tools involved are tax and contractual incentives to bring vacant space back onto the market, consisting of tax benefits for tenants and landlords who sign special landlord/ tenant agreements. In addition, financial support for rent is provided for low-income families, a measure carried out in Italy on a national scale for the first time and, to this end, a special Social Fund for rent has been established.

The central levels maintain some powers over general regulation and planning, particularly in the field of social housing and in providing the legislative frame for private rental sector. The central government is responsible for macroprogramming and co-financing projects through housing allowances, co-funding of urban renewal programs and programs to support social rental housing. The State should give Regions financial resources to accomplish their local competences, which consists in financing the sector.

2.2.2 REGIONAL AND LOCAL LEVEL

Regions were assigned formal functions in the early seventies, and later the full responsibility for housing. The State retained most of the financial resources until 1998, and the power to distribute them; the Regions had the responsibility to approve regulations and to establish the programs for housing construction and support. The regional government is responsible for determining the eligibility of access to social housing and the provision for rent.

Municipalities have become more and more concerned with housing. They have been given exclusive responsibility for the outcome of social housing policies and for the politically sensitive selection of applicants for social housing. In the past this was the task of special independent bodies in charge of the design, building and maintenance of social housing (IACPS: Autonomous Institutes for Social housing). With the transfer of responsibilities to the regional/ local level, IACPs have lost their special place and have been partially reorganized by regions.

The regional/local context has seen interesting initiatives over the last few years, reflecting the responsibilities gained with the aforementioned decentralization as well as the requirement to compensate for the shortcomings in national policies. Various regions and municipalities have taken steps to handle, at times with significant innovation, the structural complications inherent in the construction of new social housing:

How to direct private resources to social uses; How to set up a robust non-profit sector;

How to redefine the role of the local public body in this new context.

1:CER: Comitato per l'edilizia residenziale

2.3 ITALIAN CONDITION
SOCIAL HOUSING IN URGENT NEED

As for the social concern of housing policies, problems of poverty and exclusion have mixed up with a widespread problem of affordability, especially in urban areas.(1) The general problems can be divided into the following aspects::

Fig 2.4 % of population owning or renting their home, 2019, source elaboration on Eurostat data

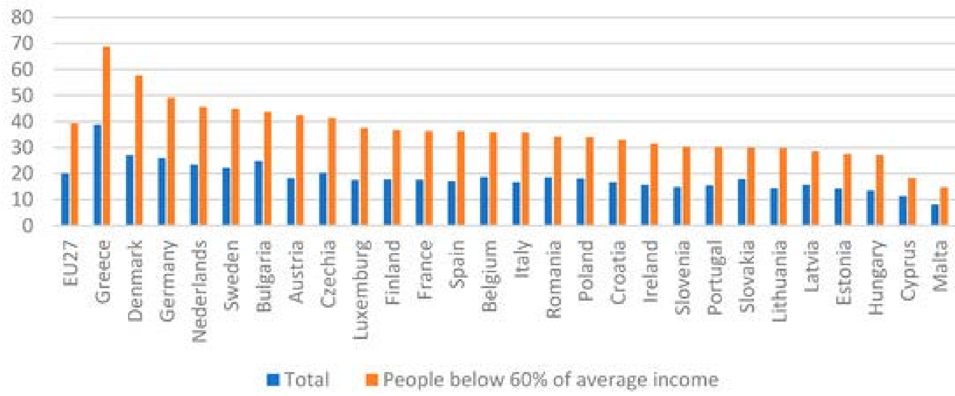


Fig 2.5 % of income spent in housing costs, 2019, source elaboration on Eurostat data

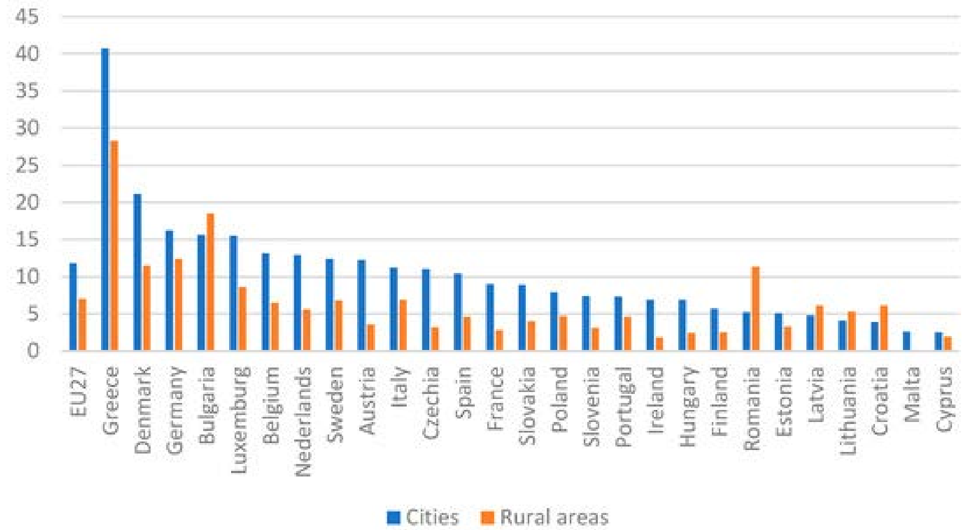


Fig 2.6 Share of population living in a household where total housing costs represent more than 40% of disposable income, 2019. Source elaboration on Eurostat data

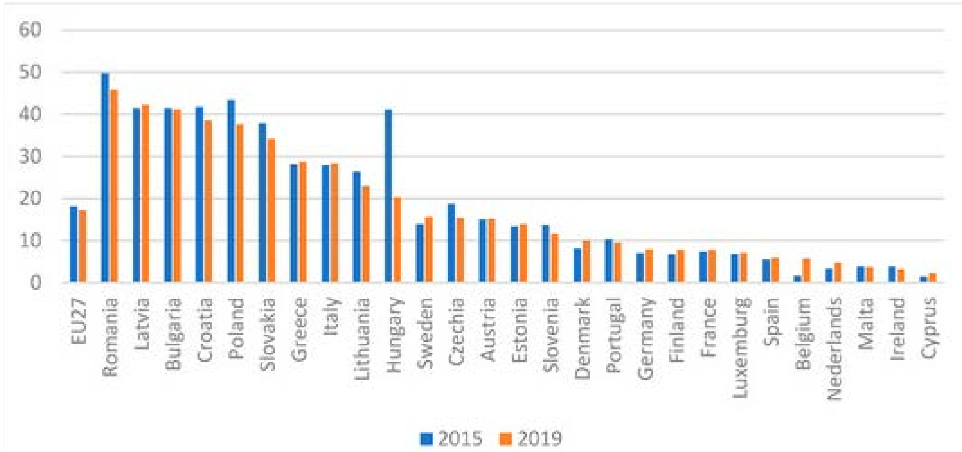


Fig 2.7 % of people with an income below 60% of the average living in overcrowded houses, source elaboration on Eurostat data

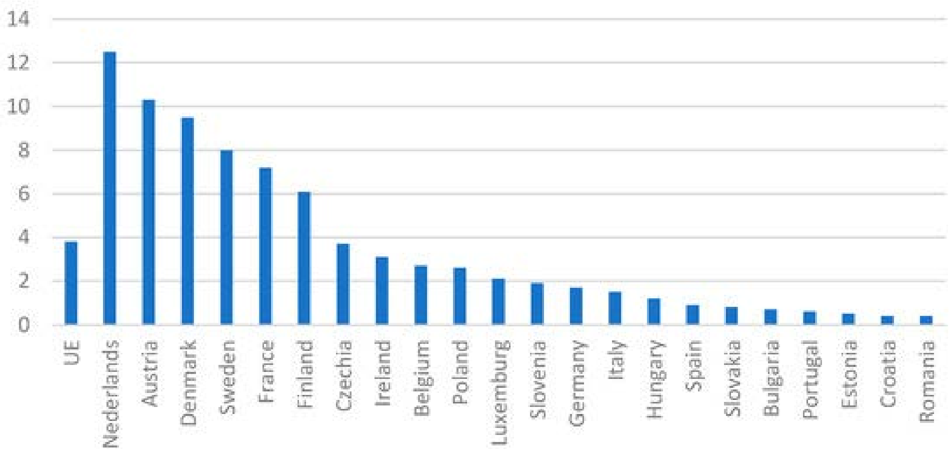


Fig 2.8 Social housing units per 100 inhabitants, 2019, source elaboration on Eurostat data

2.3.1 INSUFFICIENT SOCIAL HOUSING STOCK AND THE PRIVATIZATION

The public housing stock in Milan is just 5% of all the dwellings, similar with the average percentage of Italy, which is 4%.(Pittini et al. 2015). This number is very low compared with other countries, such as Netherlands (36%), Great Britain (22%), and France (20%), which shows Italy is actually a country lack of social housing stock.

However, under such a premise, Italy still is not in a good process of social housing privatization. from 1971 to 2011, the country's housing privatization rate continues to rise, which means that the proportion of social housing in the total number of buildings has been declining. Most of this is due to economic reasons, that the government or relevant institutions were unable to afford the repairing cost for the social housing, and thus they put them into

1 : Tosi, 1998

2.3.2 CHANGING OF FAMILY STRUCTURE RAISES NEW DEMANDS OF HOUSING

After WWII, the classic model of Italian family changes from 4 to 5 people to smaller units consisting only 1 to 2 people, so more compact housing types as well as units have been needed in Italian housing stock. However, from the table3 in the last few decades, the average number of rooms in residential buildings is still increasing in Italy. The smart housing units are still rare, in a state of urgency.

Compared to 2001, single-parent households, single parent households, unmarried and non-conjugated couples, and the classical mononuclear family in decline are growing significantly. Families with at least one foreign resident, especially one-person, are also greatly increased .

The family resources are coping with the problems of younger generations, while the public subsidies are helpful for elderly workers. The young population, compared to the older one, is lacking in various sectors (housing, labor, salaries, lifestyle), and this condition is much more widespread than in the past years.

2.3.3 THE INCREASING NUMBER OF IMMIGRANTS HAS EXACERBATED THE PRESSURE ON THE HOUSING MARKET

According to the Italian National Bureau of Statistics (ISTAT), the number of immigrants living in Italy has been going up all the time. Ten years (2001) and 20 years ago (1991), the number of foreign immigrants was only 1.3 million and 350,000 (1). As of January 2011, it has reached 4,570,317, an increase of 7.9% (335,000 people) from the previous year. The immigration flow naturally exacerbated the housing market's pressure.

Fig 2.9 people

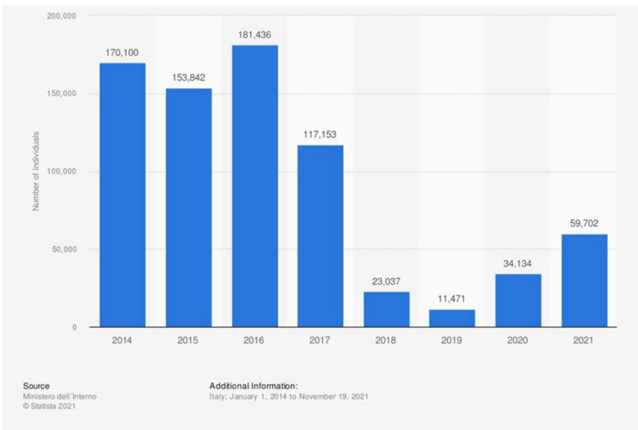
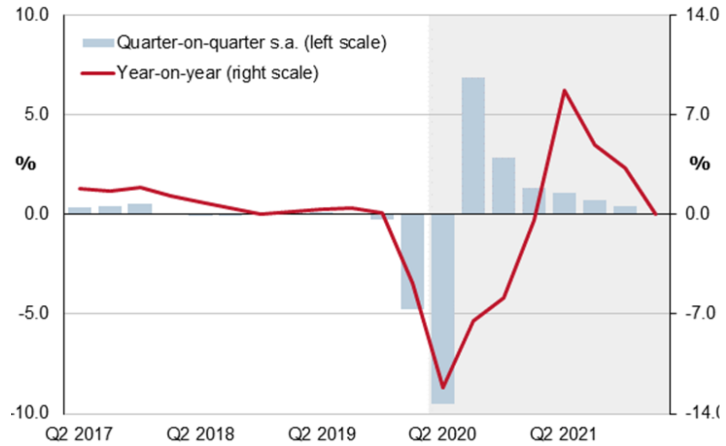


Fig 2.10 Number of immigrants arrived by sea in italy from 2014 to 2021

1 : ISTAT, 1991 & 2001

Fig 2.11 increasing due to a process of widespread poverty



2.3.4 ECONOMIC CRISIS HAS CAUSED URGENT DEMAND FOR RENTAL HOUSING OF LOW-INCOMES AND EVEN OF THE MIDDLE CLASS

In fact, due to the negative influence of the financial crisis in 2008, the Italian economy growth turned negative for the first time in many years, the national final consumption fell by 0.5%; household consumption fell by 0.9% (1). The employment market is deteriorating, and even those who had stable jobs in the private or public sectors were faced by the threaten of unemployment. In the economic crisis, one-third of working-age Italians faces a certain degree of economic loss or unemployment (2). This means that not only low-income groups, people who were belonging to the so-called "middle class" are also at risk of home ownership and entering into the rental market . To sum up, there exists a large need to lease lower-cost houses, but at a time when supplies are declining.

In 2015, 60 % of families are looking for housing in the rental market (3). Another sign of national housing distress is the incidence of housing costs on the income of families. According to Federcasa data (4), nearly 2 million people live in subsidized homes(most of them in northern Italy, 44%), and 650,000 households that meet the access criteria are waiting for their homes. and this figure is increasing due to a process of widespread poverty. (Federcasa, 2015)

In addition to the recorded needs of these people, there is a "hidden" demand that is not insignificant and that is represented by those who cannot reach the official channels (some of the foreign population, discouraged people who after various failed attempts stop applying; categories that due to their social-cultural and economic condition do not have the possibility of accessing institutional channels- mentally disables, ex-convicts etc., and also people who earn too much to match the allocation economic criteria and at the same time cannot afford a house in the private market) (5).

Since the primary housing need of traditionally weak social groups is still not completely satisfied, a new additional demand is emerging, expressed by a diversified low income population, such as the elderly, young couples, students, immigrants, temporary workers.

So not only the marginalized segments of society are involved, but also large portion of the middle class, that has swiftly grown poor and it is looking for a housing affordable to their income levels; which doesn't allow the access even to the large surplus of 5.5 million unoccupied homes on the market.

1 : ISTAT, 2009 / 2 : ANSA, 2014 / 3: Censis and Nomisma 2015 / 4: Federcasa, 2015 / 5: Cela, 2011

3 CONTEX ANALYSIS

Fig 3.1
Rome, Italy

3.1 LOCATION DESCRIPTION _ROME

Rome, historic city and capital of Roma province of Lazio region, is located in the central portion of the Italian peninsula, on the Tiber River about 15 miles (24 km) inland from the Tyrrhenian Sea. Once the capital of an ancient republic and empire whose armies and polity defined the Western world in antiquity and left seemingly indelible imprints thereafter, the spiritual and physical seat of the Roman Catholic Church, and the site of major pinnacles of artistic and intellectual achievement, Rome is the Eternal City, remaining today a political capital, a religious centre, and a memorial to the creative imagination of the past. Area city, 496 square miles (1,285 square km); province, 2,066 square miles (5,352 square km). Pop. (2011) city, 2,617,175; province, 3,997,465; (2007 est.) urban agglom., 3,339,000; (2016 est.) city, 2,873,494; province, 4,353,738.

3.1.1 CHARACTER OF THE CITY

For well over a millennium, Rome controlled the destiny of all civilization known to Europe, but then it fell into dissolution and disrepair. Physically mutilated, economically paralyzed, politically senile, and militarily impotent by the late Middle Ages, Rome nevertheless remained a world power—as an idea.

The force of Rome the lawgiver, teacher, and builder continued to radiate throughout Europe. Although the situation of the popes from the 6th to the 15th century was often precarious, Rome knew glory as the fountainhead of Christianity and eventually won back its power and wealth and reestablished itself as a place of beauty, a source of learning, and a capital of the arts.

Rome's contemporary history reflects the long-standing tension between the spiritual power of the papacy and the political power of the Italian state capital. Rome was the last city-state to become part of a unified Italy, and it did so only under duress, after the invasion of Italian troops in 1870. The pope took refuge in the Vatican thereafter. Rome was made the capital of Italy (not without protests from Florence, which had been the capital since 1865), and the new state filled the city with ministries and barracks. Yet the Catholic church continued to reject Italian authority until a compromise was reached with Fascist dictator Benito Mussolini in 1929, when both Italy and Vatican City recognized the sovereignty of the other. Mussolini, meanwhile, created a cult of personality that challenged that of the pope himself, and his Fascist Party tried to re-create the glories of Rome's imperial past through a massive public works program.

Since Mussolini's fall and the traumas of World War II, when the city was occupied by Germans, politics have continued to dominate Rome's agenda—although regionalism began, in the 1980s, to devolve some political power away from the capital. Lagging behind Milan and Turin economically, Rome has maintained a peripheral place within the Italian and European economies. It also has been plagued with perennial housing shortages and traffic congestion. However, the late 20th and early 21st centuries brought increased efforts to resolve Rome's infrastructural problems and to foster a Roman cultural revival.

3.2 CLIMATE IN ROME

In Rome, the summers are short, hot, humid, dry, and mostly clear and the winters are long, cold, wet, and partly cloudy. Over the course of the year, the temperature typically varies from 37°F to 89°F and is rarely below 28°F or above 95°F.

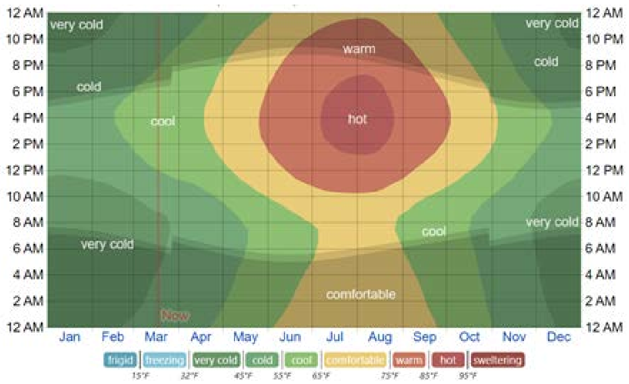


Fig 3.2 year_hourly average temperatures characterization

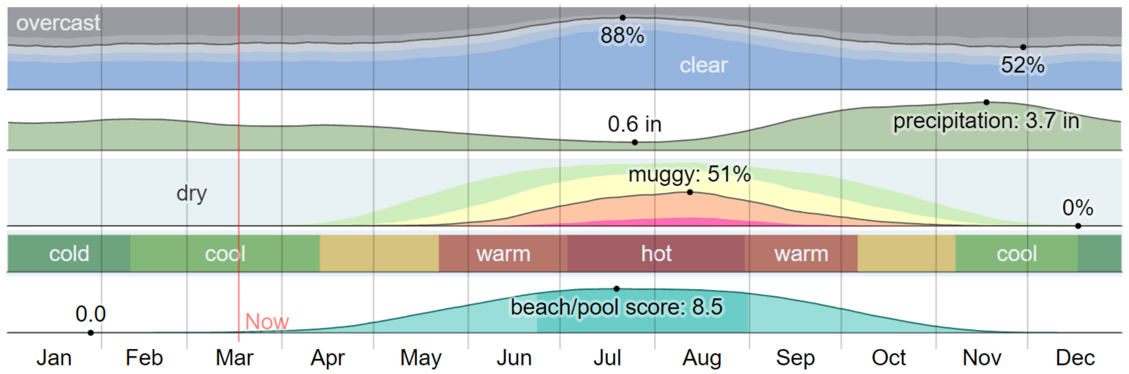


Fig 3.3 Rome weather by

3.2.1 AVERAGE TEMPERATURE

The hot season lasts for 2.8 months, from June 17 to September 10, with an average daily high temperature above 82°F. The hottest month of the year in Rome is August, with an average high of 87°F and low of 65°F.
The cool season lasts for 3.9 months, from November 20 to March 17, with an average daily high temperature below 60°F. The coldest month of the year in Rome is January, with an average low of 37°F and high of 54°F.

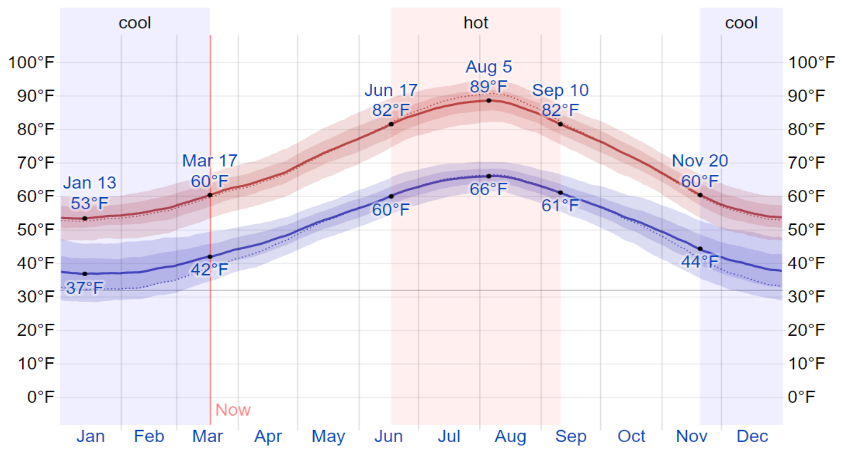


Fig 3.4 Average High and Low Temperature

Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	54°F	56°F	60°F	66°F	74°F	81°F	87°F	87°F	80°F	72°F	62°F	55°F
Temp.	45°F	46°F	51°F	56°F	64°F	71°F	76°F	77°F	70°F	62°F	53°F	46°F
Low	37°F	38°F	42°F	47°F	54°F	60°F	65°F	65°F	60°F	53°F	45°F	39°F

3.2.2 CLOUDS

In Rome, the average percentage of the sky covered by clouds experiences significant seasonal variation over the course of the year.
The clearer part of the year in Rome begins around June 10 and lasts for 3.1 months, ending around September 12.
The clearest month of the year in Rome is July, during which on average the sky is clear, mostly clear, or partly cloudy 87% of the time.
The cloudier part of the year begins around September 12 and lasts for 8.9 months, ending around June 10.
The cloudiest month of the year in Rome is November, during which on average the sky is overcast or mostly cloudy 47% of the time.

Fraction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cloudier	47%	44%	44%	43%	39%	25%	13%	18%	32%	43%	47%	46%
Clearer	53%	56%	56%	57%	61%	75%	87%	82%	68%	57%	53%	54%

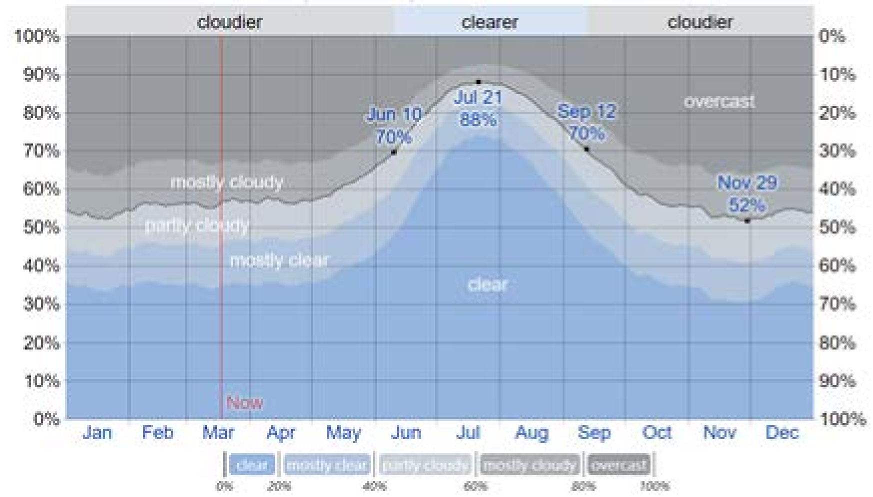


Fig 3.5 Cloud Cover Categories in

Days of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain	6.8d	7.2d	6.8d	7.0d	5.9d	4.1d	2.6d	3.2d	6.9d	8.6d	9.5d	7.7d

Fig 3.6 Daily Chance of Precipitation in Rome

3.2.3 PRECIPITATION

A wet day is one with at least 0.04 inches of liquid or liquid-equivalent precipitation. The chance of wet days in Rome varies throughout the year.
The wetter season lasts 8.1 months, from September 8 to May 11, with a greater than 20% chance of a given day being a wet day. The month with the most wet days in Rome is November, with an average of 9.5 days with at least 0.04 inches of precipitation.
The drier season lasts 3.9 months, from May 11 to September 8. The month with the fewest wet days in Rome is July, with an average of 2.6 days with at least 0.04 inches of precipitation.

3.2.4 RAINFALL

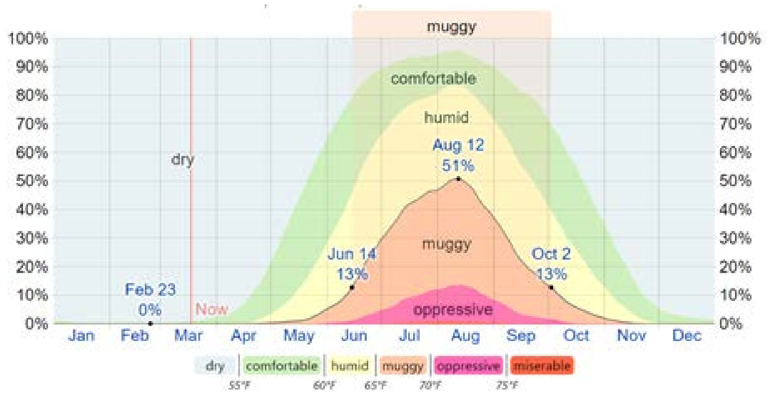
To show variation within the months and not just the monthly totals, we show the rainfall accumulated over a sliding 31-day period centered around each day of the year. Rome experiences significant seasonal variation in monthly rainfall.

Rain falls throughout the year in Rome. The month with the most rain in Rome is November, with an average rainfall of 3.7 inches.

The month with the least rain in Rome is July, with an average rainfall of 0.7 inches.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	2.1"	2.4"	1.9"	1.9"	1.5"	1.0"	0.7"	0.9"	2.4"	3.4"	3.7"	2.8"

Fig 3.7 Average Monthly Rainfall in Rome



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Muggy days	0.0d	0.0d	0.0d	0.0d	0.5d	4.9d	12.7d	14.3d	6.9d	1.9d	0.1d	0.0d

Fig 3.8 Humidity Comfort Levels in Rome

3.2.5 HUMIDITY

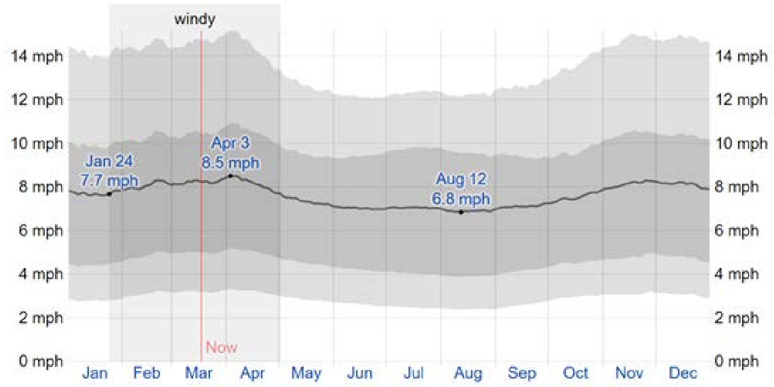
We base the humidity comfort level on the dew point, as it determines whether perspiration will evaporate from the skin, thereby cooling the body. Lower dew points feel drier and higher dew points feel more humid. Unlike temperature, which typically varies significantly between night and day, dew point tends to change more slowly, so while the temperature may drop at night, a muggy day is typically followed by a muggy night.
Rome experiences extreme seasonal variation in the perceived humidity.
The muggier period of the year lasts for 3.6 months, from June 14 to October 2, during which the comfort level is muggy, oppressive, or miserable at least 13% of the time. The month with the most muggy days in Rome is August, with 14.3 days that are muggy or worse.
The least muggy day of the year is February 23, when muggy conditions are essentially unheard of

3.2.6 WIND

this section discusses the wide-area hourly average wind vector (speed and direction) at 10 meters above the ground. The wind experienced at any given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages.

The average hourly wind speed in Rome experiences mild seasonal variation over the course of the year.

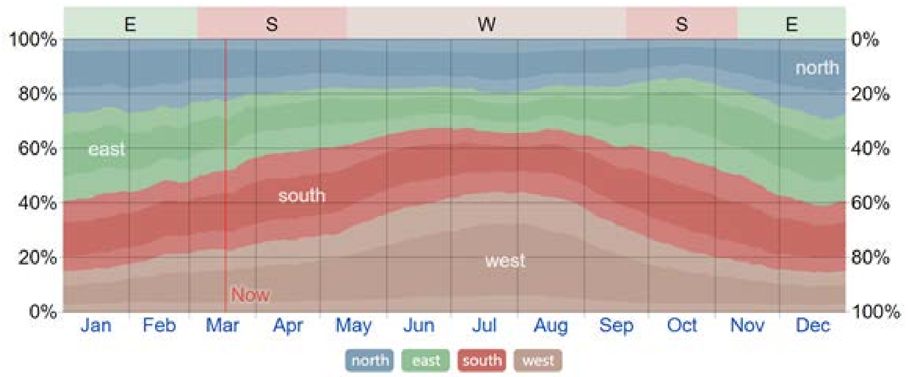
The windier part of the year lasts for 3.3 months, from January 24 to May 1, with average wind speeds of more than 7.7 miles per hour. The windiest month of the year in Rome is March, with an average hourly wind speed of 8.2 miles per hour.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (mph)	7.7	8.1	8.2	8.1	7.3	7.0	7.0	6.9	7.1	7.6	8.1	8.1

Fig 3.9 Average Wind Speed in Rome

Fig 3.10 Wind Direction in Rome



The predominant average hourly wind direction in Rome varies throughout the year.
The wind is most often from the south for 2.3 months, from March 4 to May 13 and for 1.7 months, from September 20 to November 11, with a peak percentage of 34% on October 18. The wind is most often from the west for 4.2 months, from May 13 to September 20, with a peak percentage of 44% on July 23. The wind is most often from the east for 3.8 months, from November 11 to March 4, with a peak percentage of 32% on January 1.

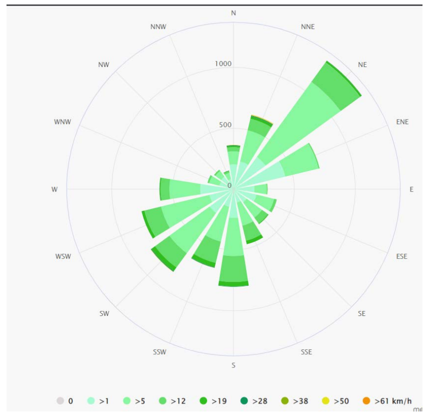


Fig 3.11 wind rose roma

The percentage of hours in which the mean wind direction is from each of the four cardinal wind directions, excluding hours in which the mean wind speed is less than 1.0 mph. The lightly tinted areas at the boundaries are the percentage of hours spent in the implied intermediate directions (northeast, southeast, southwest, and northwest).

3.2.7 SUN

The length of the day in Rome varies significantly over the course of the year. In 2022, the shortest day is December 21, with 9 hours, 8 minutes of daylight; the longest day is June 21, with 15 hours, 14 minutes of daylight.

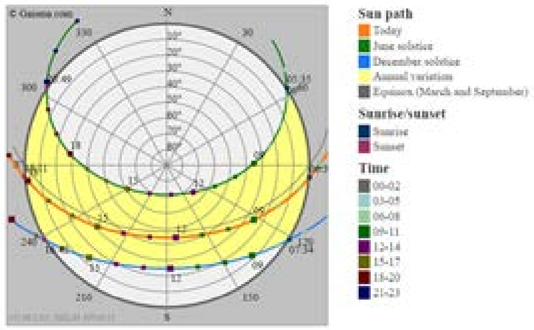


Fig 3.12 Sun path .Rome ,italy

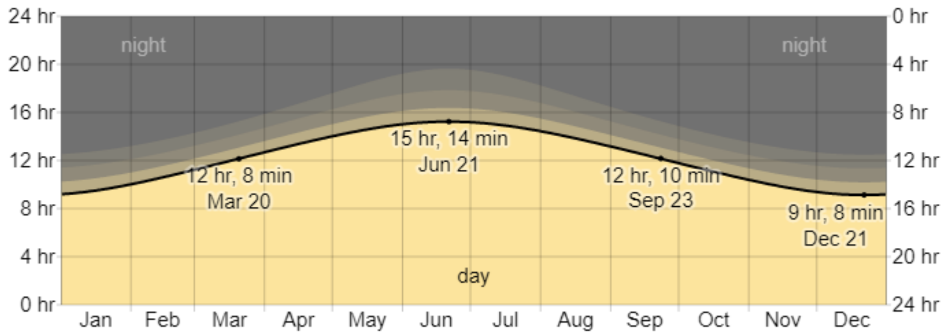


Fig 3.13 Hours of Daylight and Twilight in Rome

Hours of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daylight	9.5h	10.6h	12.0h	13.4h	14.6h	15.2h	14.8h	13.8h	12.4h	11.0h	9.8h	9.2h

The earliest sunrise is at 5:34 AM on June 15, and the latest sunrise is 2 hours, 4 minutes later at 7:38 AM on October 29. The earliest sunset is at 4:38 PM on December 9, and the latest sunset is 4 hours, 11 minutes later at 8:49 PM on June 27.

Daylight saving time (DST) is observed in Rome during 2022, starting in the spring on March 27, lasting 7.1 months, and ending in the fall on October 30.

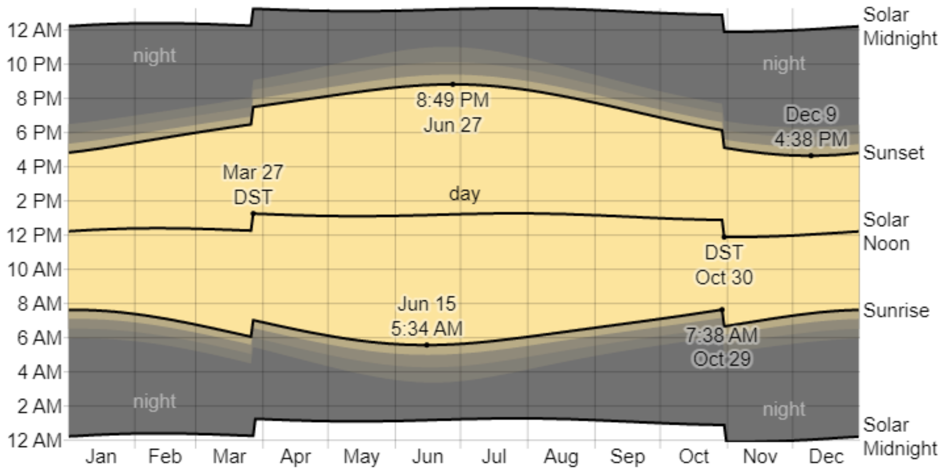


Fig 3.14 Sunrise & Sun set with Twilight and Daylight Saving Time in Rome

3.2.8 SOLAR ENERGY

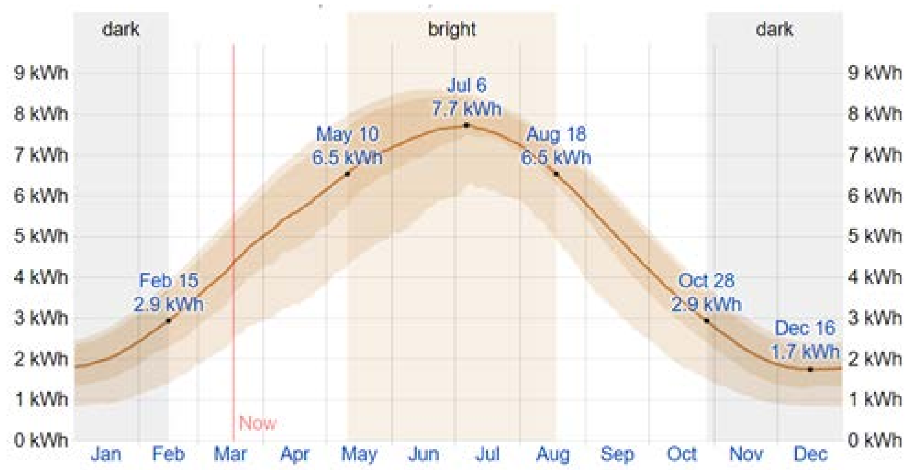
This section discusses the total daily incident shortwave solar energy reaching the surface of the ground over a wide area, taking full account of seasonal variations in the length of the day, the elevation of the Sun above the horizon, and absorption by clouds and other atmospheric constituents. Shortwave radiation includes visible light and ultraviolet radiation.

The average daily incident shortwave solar energy experiences extreme seasonal variation over the course of the year.

The brighter period of the year lasts for 3.2 months, from May 10 to August 18, with an average daily incident shortwave energy per square meter above 6.5 kWh. The brightest month of the year in Rome is July, with an average of 7.5 kWh.

The darker period of the year lasts for 3.5 months, from October 28 to February 15, with an average daily incident shortwave energy per square meter below 2.9 kWh. The darkest month of the year in Rome is December, with an average of 1.8 kWh.

Fig 3.15 Average Daily Incident Shortwave Solar Energy in Rome



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Solar Energy (kWh)	2.0	3.0	4.3	5.6	6.8	7.5	7.5	6.5	4.9	3.4	2.2	1.8

3.3 SITE OVERVIEW

The study area consists of a former school facility located on the eastern outskirts of the city, about 100 meters inside the Grande Raccordo Anulare (highway ring), in a marginal area of the residential district of La Rustica, not far from via Collatina, which runs about 70 meters to the south. The study area is surrounded on the west side by the La Rustica Zone Plan (the school is part of the public spaces), on the south side by the Vittorio De Sica kindergarten; on the east side by via Achille Vertunni, which also connects the neighborhood to via Collatina,and is the access road to the study area; and on the north side by an unplanned residential urbanization. In addition to the residential areas, consisting of the Zone Plan with seven-storey buildings and unplanned urbanization with two or three-storystorey buildings, the urban context is characterized by the presence of large productive, commercial, and business areas along the Via Collatina and close to the G.R.A., and of free residual areas left mostly uncultivated or that preserve the original agricultural use in a small part. Outside the G.R.A., to the east, wide agricultural lands extend mostly flat or with slight slopes, and the landscape is characterized by the spring of virgin water, with the piezometric tower, the only vertical element in this area. The school building has heights ranging from one floor to two floors. It has never been completed and is currently abandoned, with the reinforced concrete structure completed and unplastered partition walls. Even outdoor spaces are in a state of high degradation, resulting from the general state of abandonment.

3.3.1 ENVIROMENTAL SUMMARY OF THE SITE

The outdoor areas of the study area have some isolated tree species and are rich in spontaneous weed vegetation, among which can be distinguished dense cane groves that highlight the presence of humidity in the soil, also given the proximity of the Fosso di Torre Agnola which flows at about 130 meters to the south, close to via Collatina and which flows into the Fosso di Tor Sapienza or del Cervaro. The Tiber River Basin Authority, in the PAI - Hydrogeological Assessment Plan updated in June 2015 - Tav. PB83 - Bands and hydraulic risk on secondary and minor reticle Tor Sapienza - Pratolungo, identifies part of the area of the PdZ La Rustica affected by the residential buildings (which are raised from the ground using pilotis on the ground floor), as risk area R3 and R2, a short distance from the school area that by the way is not affected by this issue. Furthermore, the area does not fall within the Potential Hydraulic Hazard Areas for Accumulation, Runoff, and Subdivision, areas in which, depending on the conformation of the land and/or the characteristics of the surface runoff, there may be critical flooding issues, identified by the Project of Update of the Tiber Basin Plan for the metropolitan section of the Tiber from Castel Giubileo at mouth PS5 - Potential hydraulic hazard Table P3- Bi (sheet 24 of 33); there are not present minor hydrographic reticles directly affecting the area. From the air quality point of view, the potentially critical element is the emissions from car traffic on the nearby G.R.A. and via Collatina below; it should be noted that the air quality monitoring units closest to the area (Cinecittà e Cavaliere of urban and suburban background respectively) are however quite distant and representative of contexts with different characteristics. Concerning noise pollution, the area is currently classified by the Plan of Acoustic Zoning of the Municipality of Rome in Class IV, as an area of intense human activity, with limitations emission equal to daytime 65Db (A), nighttime 50Db (A). The potentially critical element is represented also in this case by the G.R.A., which in this stretch has no barriers and vehicular traffic on the Via Collatina.

3.3.2 BUILDING CONSISTENCIES AND CONSERVATION STATUS SUMMARY

GENARAL DATA Plot Area = 8.370 sqm

GFA = 4.330 sqm

Volume = 15.350 cbm

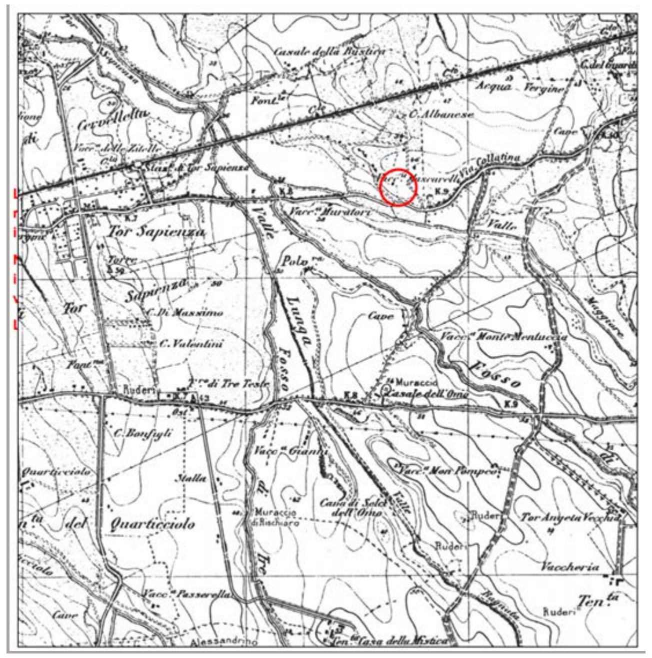
Virtual Area = 4.800 sqm

The building, with a rather articulated shape, consists of the main floor, a mezzanine floor, and two other floors of the same height but with a significantly smaller surface area, in the basement, and on the upper level. The flat roof covers a surface of about 2,200 square meters and the maximum height above ground is about 10 m. The architectural ensemble can be divided into three aggregations characterized by different functions related to the exercise of the school activity: along the southern front (a body rotated by about 12 degrees on the north-south axis) there are three equal volumes of two floors above ground, shifted in façade, containing the classrooms; along the opposite front there is a rather articulated one-floor building, with the same module of the opposite front, containing secondary functions (offices, refectory, atrium, and library); the connection space between these two functional units is interrupted on one side by the gym building, for the width of the first module and two stories high, followed by two identical inner courtyards. The building is incomplete, with a fully constructed reinforced concrete framed structure but with incomplete cladding, without windows, installations, and finishes.

The roof has been covered with a waterproo membrane. It has been In a state of total neglect for many years, thus a significant degradation of structures can be expected as a result of exposure to the atmospheric agents (carbonation of concrete), as well as vandalism (prolonged exposure of structures to high temperatures due to the setting of fires). The entire fenced surrounding area appears cluttered with dense wild vegetation. On the northern side is also located a small masonry structure probably used as a dwelling.

Fig 3.16 via vertunni project

1: Boeri et al. 1993



The construction of the elementary school and the adjacent kindergarten in Via Vertunni is part of the public spaces planned in Zone Plan 16/a of the 1st Plan for Economic and Popular Construction (PEEP). Construction works on the elementary school began in the early 1980s following the Deliberation C.C. 1691 of 17/06/1977 approving the project and the works tender for the construction of the building for primary school (15 classes) in via Vertunni (La Rustica) ex via Castelli according to law 5/08/1975 n. 412 and variation P.Z. 16/a bis ex art. 10 law.

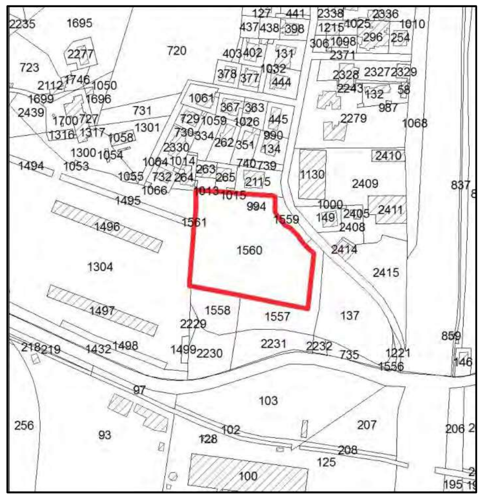
The building school has not been completed.

3.3.3 INTERVENTION AREA CLASSIFICATION

The school is located in a marginal area e degraded area of the residential area of La Rustica near the G.R.A.
In addition to the residential areas, the urban context is characterized by presence of large production, commercial and management areas that yes they alternate along Collatina street and close to the Grande Raccordo Annular.
The property is accessible from a local road network (via Achille Vertunni) which also acts as a link between the neighborhood and the Collatina street.
The land on which the building stands is part of the public spaces within the La Rustica Zone Plan and adjoins the relative residential settlement and with the Vittorio De Kindergarten School Sica.
The building is currently in a rustic state with the structure in c.a. completed and the infills and partitions without plaster.
All the existing structures are in a state of high decay resulting from the state of abandonment of the property.

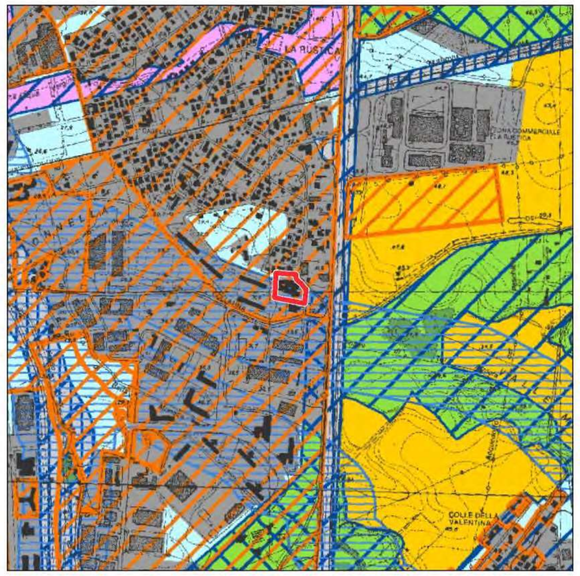
location: town hall Roma V, La Rustica, via Achille Vertunni, 15
accessibility: La Rustica Città railway station (1 km); public transport lines via Collatina (210 m)

3.3.4 INTERVENTION AREA CLASSIFICATION

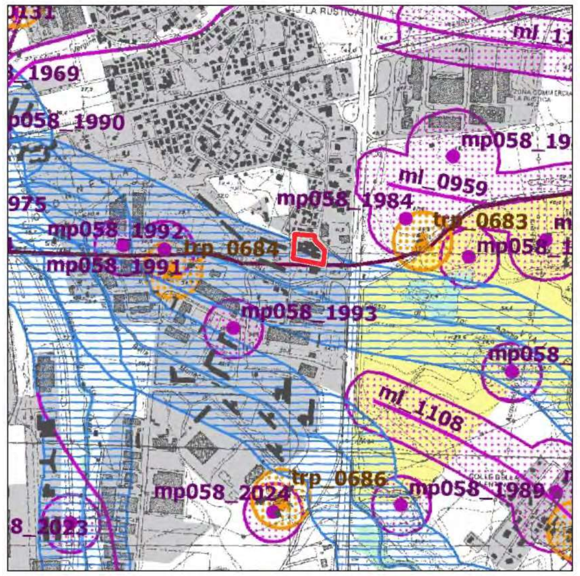


Proprietà	Roma Capitale
Verifica Interesse Culturale (artt. 10,12 D.lgs 42/2004)	Inizio lavori 1977 edificio non completato
Provenienza	Atto di ricognizione e di individuazione catastale n. 2019 del 13/11/2017
Dati Catastali	Terreni: F. 659 p. 1560
Superficie Fondiaria	8.370 mq
Consistenza Edilizia	SUL = 4.330 mq Volume = 15.350 mc; Suv = 4.800 mq Fonte: aggiornamento progetto esecutivo, 1993
IBU	46705
Valore Immobile	€ 2.277.182,39
Categoria Inventariale	B patrimonio INDISPONIBILE
Utilizzo precedente	Scuola elementare
Stato di conservazione	Fatiscente

3.4 URBAN ANALYSIS
3.4.1 SUPERORDINATE URBAN PLANNING DISCIPLINE



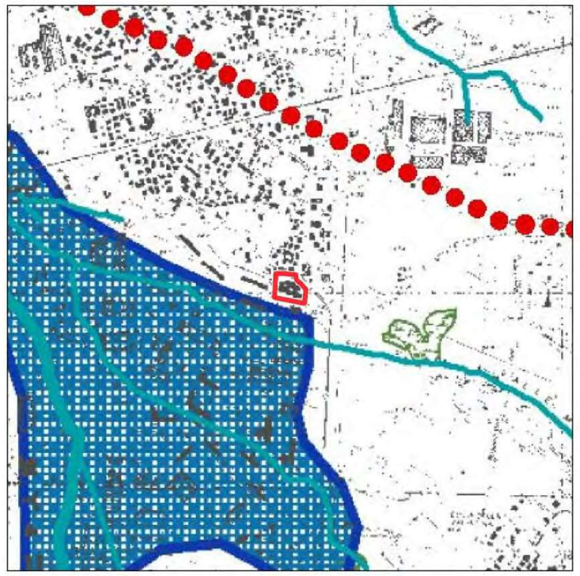
PTPR - Landscape systems and domains.
- Natural Landscape System Watercourse buffer zone
- Settlement Landscape System, Urban settlement landscape
- Municipal proposals to modify the PTPs in force



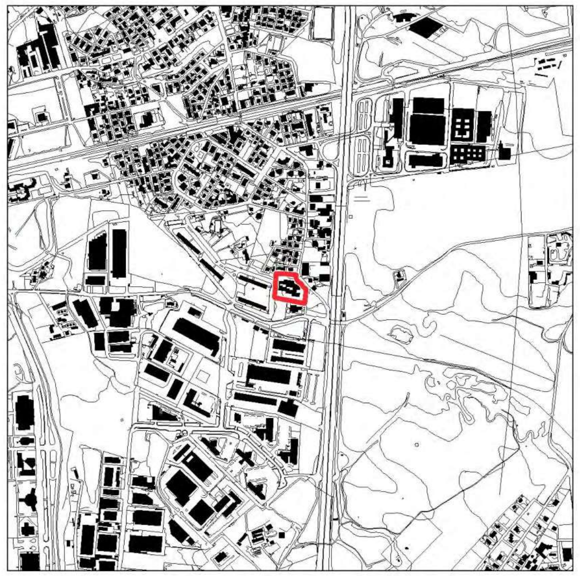
PTPR - Landscape assets.
- Legal Recognition Constraints

Public water courses - Fosso di Torre Agnola
- Plan Recognition Constraints

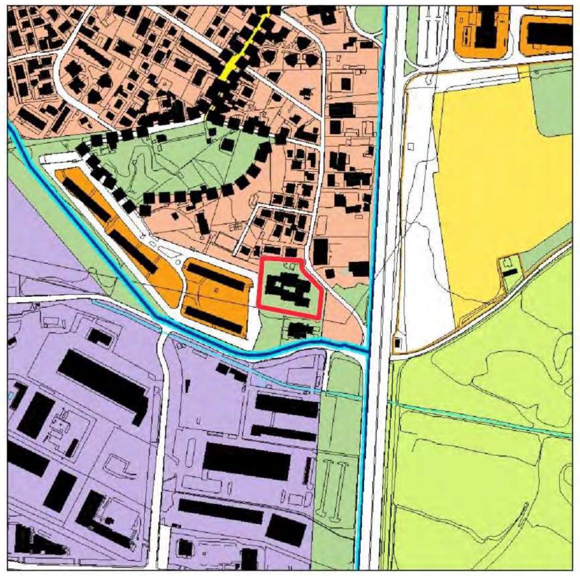
Linear assets, testimony of archaeological and historical identity characteristics
- Urbanized areas of the PTPR



- Tiber river basin plan - Extract plan for the metropolitan stretch of the Tiber from Castel Giubileo to the mouth. Environmental corridors



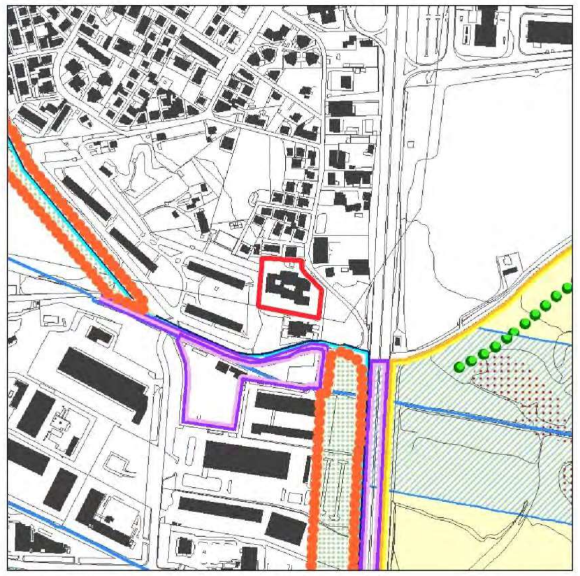
metropolitan of del Tevere da Castel Giubileo alla foce.
Hydraulic structure - River strips and areas at risk
The area does not fall within the cartography of the plan



PRG - Systems and rules - 1: 10,000
- Settlement system

City to be restored - Mainly residential integrated program
- System of services and infrastructures

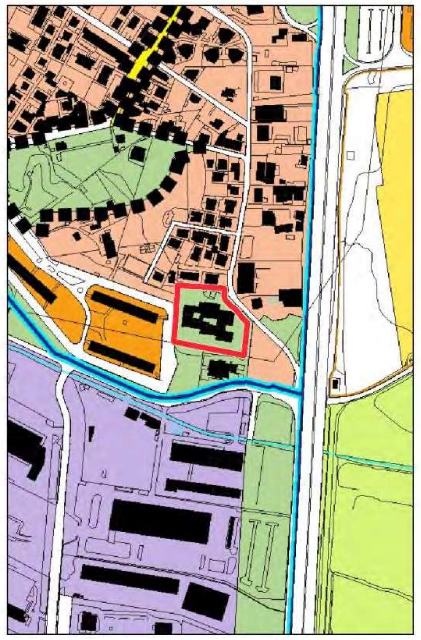
Public green and local public services



PRG - Ecological network - 1: 10,000

PRG - Quality Paper - 1: 10.000

Constraints
excerpt from: Charter of Cultural and Landscape Heritage - Charter for Quality
- Landscape respect band pursuant to Legislative

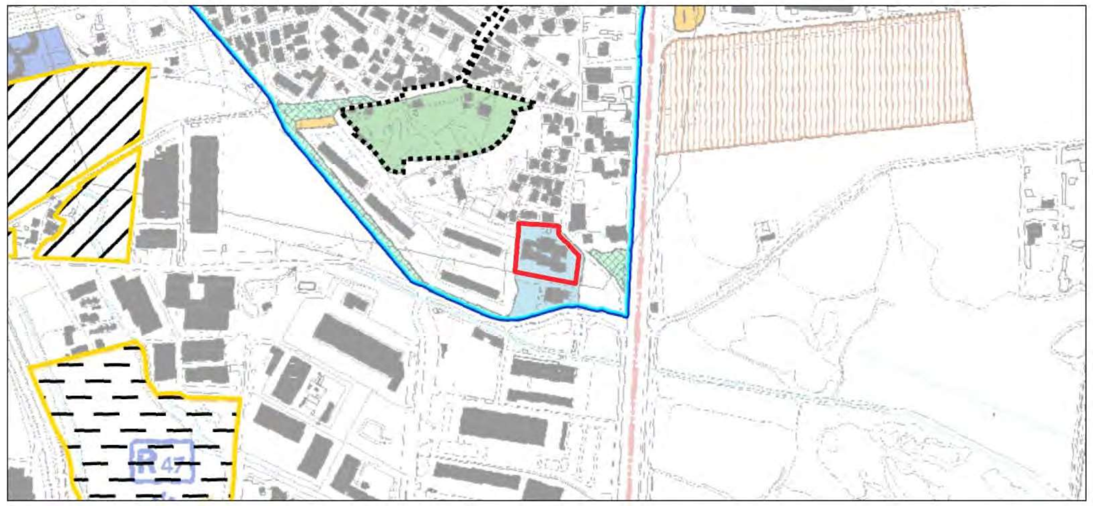


Approved PRG - P3 Systems and rules

3.4.2 PRELIMINARY VERIFICATION OF URBAN PLANNING

Standard del nuovo PRG (mq e mq/ab) per Municipio									
Municipio	Popolazione teorica ad esito	Verde		Servizi		Parcheggi		Totale	
		mq	mq/ab	mq	mq/ab	mq	mq/ab	mq	mq/ab
I	130.880	1.460.070	11,2	230.121	1,8	8.462	0,1	1.698.653	13,0
II	129.458	4.126.558	31,9	189.760	1,5	57.886	0,4	4.374.204	33,8
III	61.141	270.532	4,4	90.200	1,5	10.146	0,2	370.878	6,1
IV	249.005	6.431.914	25,8	1.594.140	6,4	746.214	3,0	8.772.268	35,2
V	219.946	6.826.893	31,0	1.865.459	8,5	705.216	3,2	9.397.568	42,7
VI	140.027	1.467.443	10,5	567.019	4,0	122.504	0,9	2.156.966	15,4
VII	142.302	4.529.047	31,8	1.146.396	8,1	391.967	2,8	6.067.410	42,6
VIII	276.457	9.007.111	32,6	4.042.791	14,6	1.808.406	6,5	14.858.308	53,7
IX	140.216	399.626	2,9	338.081	2,4	51.505	0,4	789.212	5,6
X	211.856	5.184.074	24,5	1.819.747	8,6	564.372	2,7	7.568.193	35,7
XI	151.513	4.187.008	27,6	829.035	5,5	331.324	2,2	5.347.367	35,3
XII	242.876	12.051.667	49,6	2.878.585	11,9	1.545.436	6,4	16.475.688	67,8
XIII	272.465	8.067.618	29,6	2.478.713	9,1	928.099	3,4	11.474.430	42,1
XV	188.857	4.275.968	22,6	1.168.997	6,2	405.794	2,1	5.850.759	31,0
XVI	173.138	3.570.373	20,6	876.447	5,1	338.256	2,0	4.785.076	27,6
XVII	80.040	291.490	3,6	90.042	1,1	19.624	0,2	401.156	5,0
XVIII	164.078	2.678.940	16,3	1.154.892	7,0	357.985	2,2	4.191.817	25,5
XIX	230.893	3.536.938	15,3	1.673.215	7,2	635.740	2,8	5.845.893	25,3
XX	179.943	7.653.479	42,5	1.637.812	9,1	546.079	3,0	9.837.370	54,7
Totale 1	**3.385.092**	**86.016.749**	**25,41**	**24.671.452**	**7,29**	**9.575.015**	**2,83**	**120.263.216**	**35,53**
Totale 2*	**3.394.914**		**25,34**		**7,27**		**2,82**		**35,42**

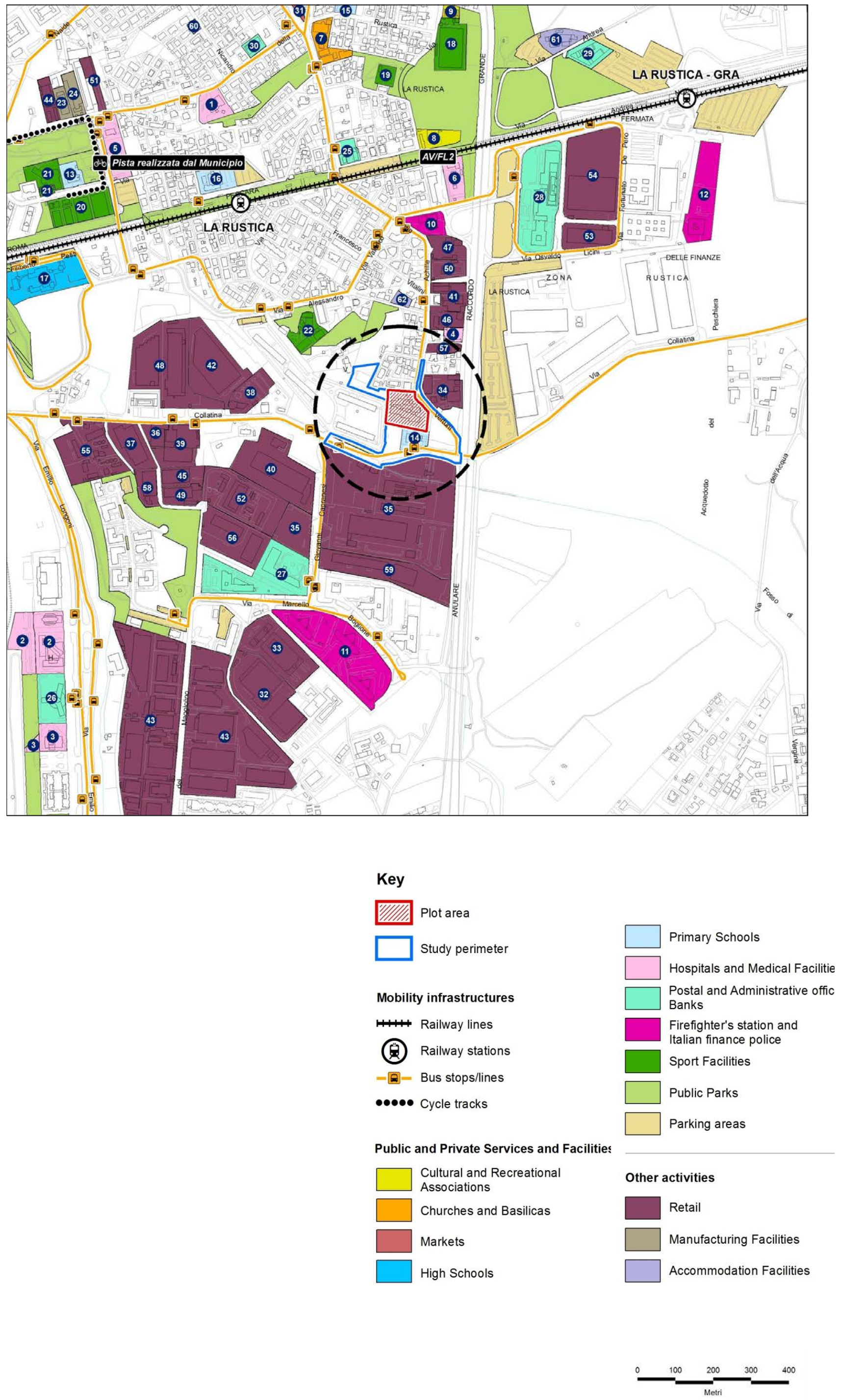
Taken from:
COP1AN CONFERENCE FL CATION - GB c / d * 1
Draft of amendments and additions.
Components of urban planning standards sizing.



As highlighted in Table attached to the Report approving the Town Plan, in Municipio V (formerly VI and VII) the total endowment of areas for urban planning standards, calculated on a theoretical outcome population equal to 282,329 inhabitants, is equal to 29.13 sq m / inhabitant, a value considerably higher than 22 sqm / inhabitant provided for by the NTA of the PRG. By subtracting the area relating to the property in question (8,370 square meters) from the area of 8,224,376 square meters of areas for urban planning standards in Municipality V, the endowment of public spaces per inhabitant is equal to 8,216,006 m2 corresponding to 29.1 m2 / inhabitant.

As highlighted in the draft of PRG G8 Urban planning standards, the area is inserted in a reference context that has a considerable amount of areas for urban planning standards existing and planned and therefore the removal of the property from the system of services and infrastructures of the PRG results quantitatively irrelevant and qualitatively sustainable.

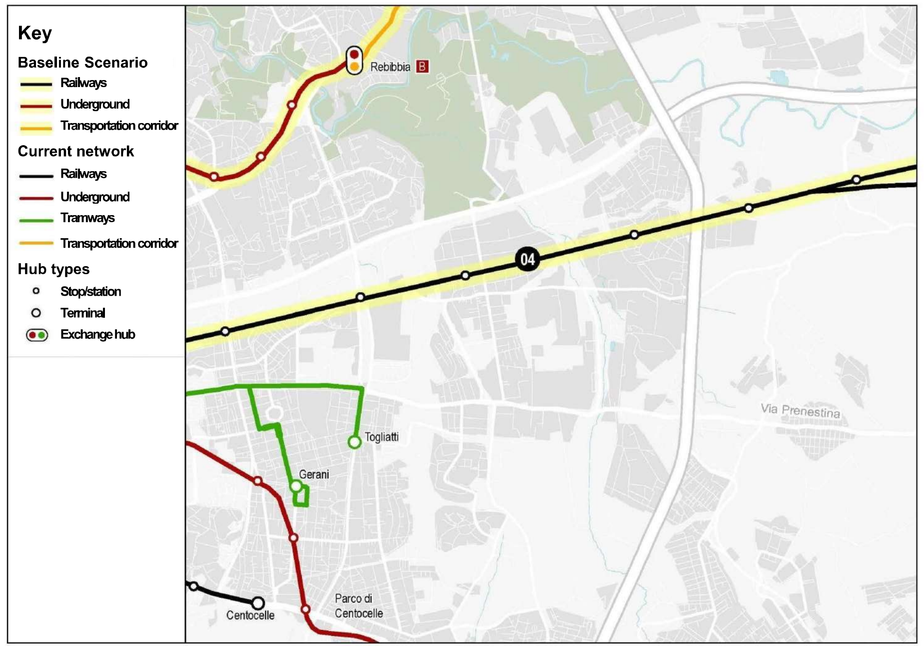
3.4.3 INTERVENTION AREA PUBLIC TRANSPORT AND SERVICES



Existing Places of Interest

1 Presidio Sanitario *La Rustica*
2 Rome American Hospital
3 Campus Biomedico
4 Istituto Bioterapico Nazionale
5 Poliambulatorio Veterinario
6 Associazione *Il Raggio di Sole*
7 Parrocchia *Nostra Signora di Czestochowa*
8 Centro Anziani *La Rustica*
9 C.B. La Rustica *Q. Mancinelli*
10 Vigili del Fuoco
11 Guardia di Finanza - Nucleo Speciale Polizia Valutaria e Frodi Tecnologiche
12 Guardia di Finanza - Comando Unità Speciali
13 Scuola Infanzia *Fabio Montagna*
14 IC Via Aretusa - Scuola Infanzia *Vittorio De Sica*
15 IC Via Aretusa - Scuola Primaria *Loredana D'Alessandro*
16 IC Via Aretusa - Plesso *Massimo Troisi*
17 Istituto Tecnico per il Turismo *Livia Bottardi*
18 Campo Sportivo *Renato Fiorentini*
19 Polisportiva *La Rustica*
20 A.S.D. *Rosati Calcio*
21 Physical Village
22 Centro Sportivo *La Mimosa*
23 Emili Teglie
24 Co.Ri.Ma. S.R.L.
25 Ufficio Postale Roma 134
26 Uffici INPS Casilino Prenestino
27 Agenzia delle Entrate
28 IGCG - Ministero dell'economia e delle Finanze
29 UNINDUSTRIA - Unione degli Industriali di Roma e Provincia
30 Credito Cooperativo di Roma
31 Mercato *La Rustica*
32 Heineken Italia
33 MIR - Medical International Research S.R.L.
34 Non Identificata
35 Romana Diesel
36 Arredando Casa
37 Benetton Retail Italia S.R.L.
38 Big S.R.L.
39 Bricofer
40 BRT - Corriere Espresso
41 Carrelli Elevatori Omia
42 C.E.F. - Cooperativa Farmacisti
43 Complesso Industriale
44 Curcio Grandi Opere S.R.L.
45 Ecologylab S.R.L.
46 Edilmaco S.R.L.
47 Europont Ponteggi S.R.L.
48 Gruppo Novelli S.R.L.
49 Happy Gel S.R.L.
50 Intermorm Roma
51 Lidl
52 Linde Medicale S.R.L.
53 Log&Service
54 Metro
55 Rossetti S.P.A.
56 Soc. Coop. Freccia Traslochi
57 Spa Group S.R.L. Roma
58 Teknowool Roma S.R.L.
59 Volvo Roma Car Room
60 Ielasi Camere
61 Hotel Novotel Roma Est
62 Alloggio Turistico *Casa Francesca*

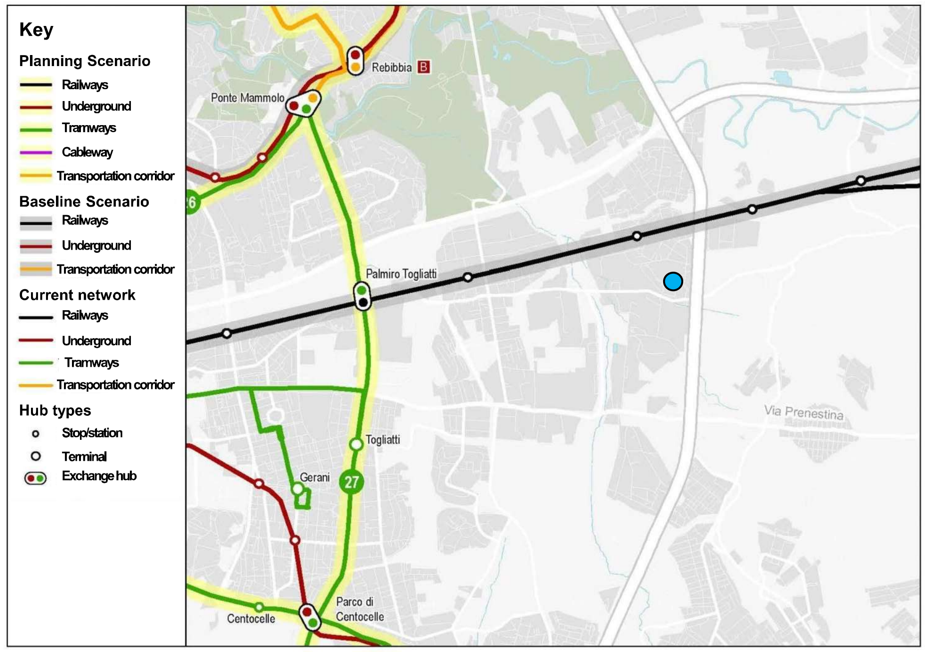
3.4.4 URBAN PLAN FOR SUSTAINABLE MOBILITY DEPLOYMENT OF COLLECTIVE MOBILITY SYSTEMS PUBLIC TRANSPORT NETWORK



Baseline scenario

2.1.4 Imediate surroundings of the Vertunni School the Baseline Scenario

the PUMS includes the following interventions :
Railway Network
- M1-04 Upgrading the capacity of the railway lines

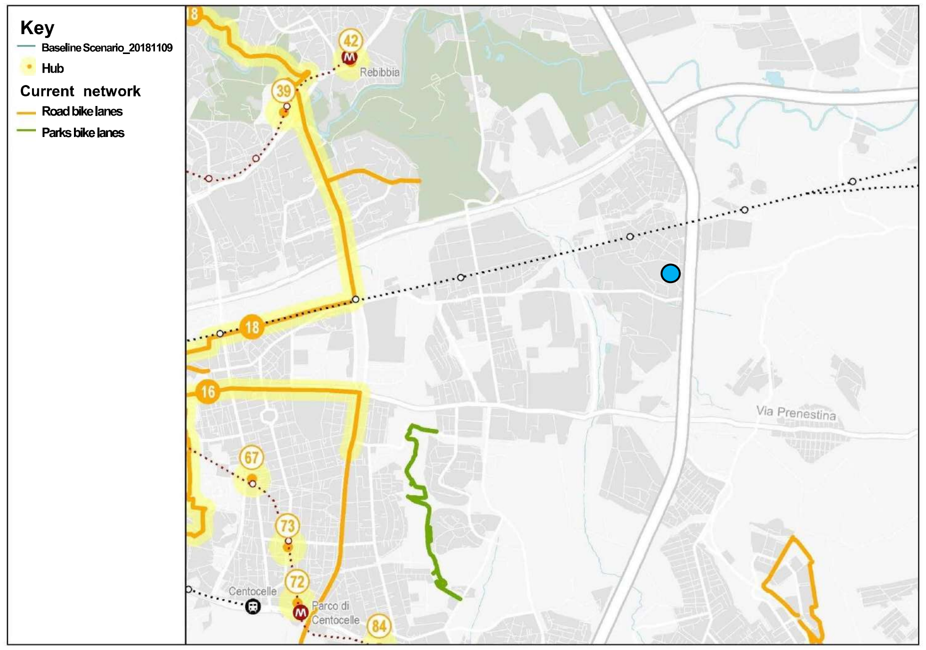


Planning scenario

2.1.4 Imediate surroundings of the Vertunni School the Baseline Scenario

In the reference urban context of the PUMS Plan Scenario does not include the implementation of new measures on the public mobility system

3.4.5 URBAN PLAN FOR SUSTAINABLE MOBILITY DEPLOYMENT OF CYCLE MOBILITY SYSTEMS



Baseline scenario

In the reference urban context of the PUMS Plan Scenario does not include

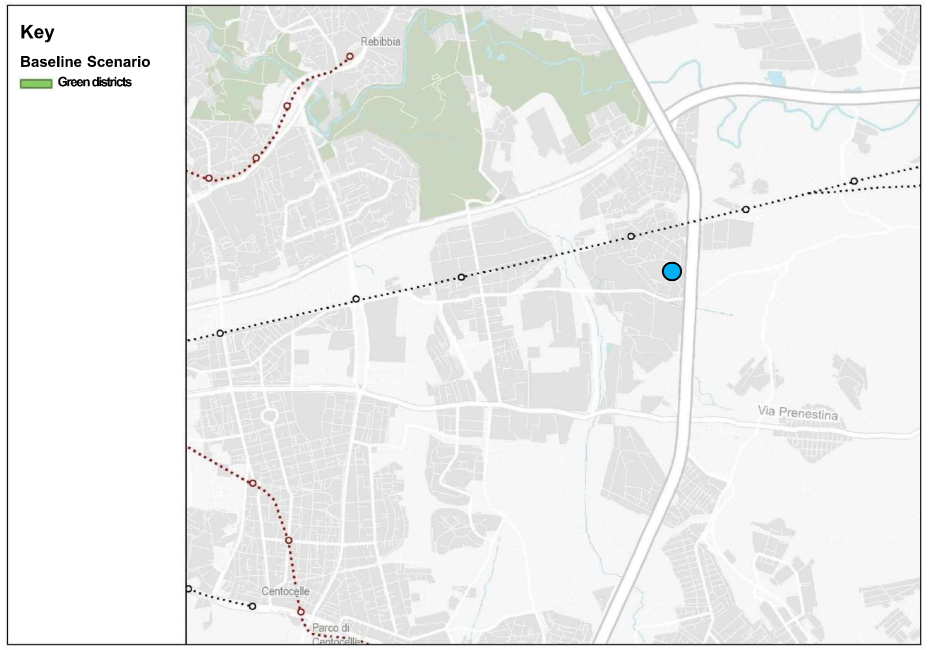
the implementation of new measures on the cycle mobility systems.

Baseline scenario

In the reference urban context the PUMS Plan Scenario includes the implementation of the following measures:

- Cycle tracks • C2-69 Part of the project «Parco lineare dell'Antica via Collatina da Porta Maggiore a Gabii»

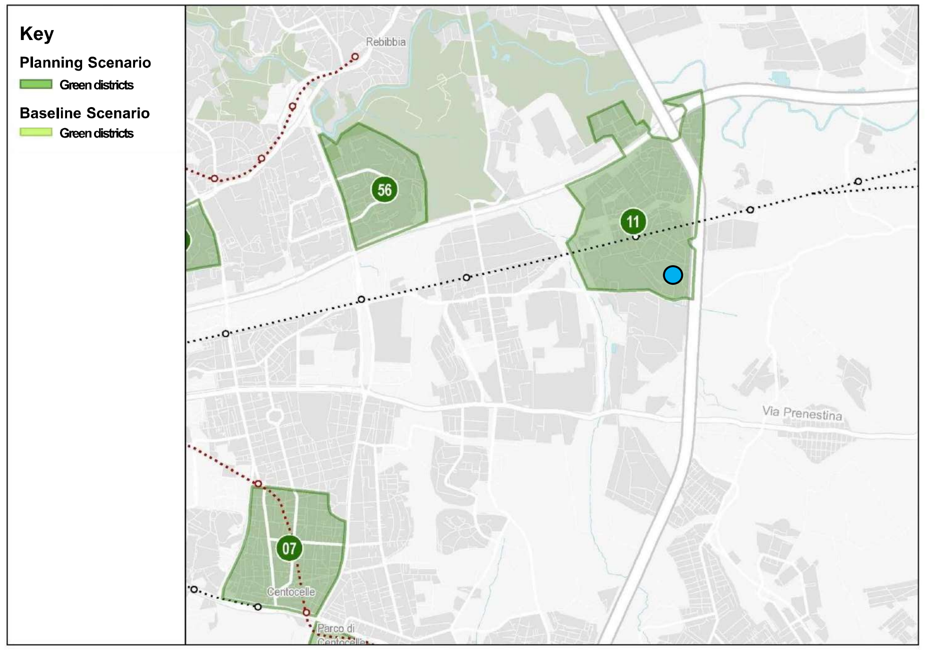
3.4.6 URBAN PLAN FOR SUSTAINABLE MOBILITY DEPLOYMENT OF PEDESTRIAN MOBILITY SYSTEMS



Baseline scenario

The PUMS Baseline Scenario does not plan Green districts in the immediate

surroundings of school Vertunni



Planning scenario

The site of the Vertunni school is located inside the "P2-11 Green District La Rustica" included in the PUMS Plan Scenario.

3.5 SWOT ANALYSIS

The aim of the SWOT analysis is to provide an instrument to characterize the context phenomena and to support the construction of strategic vision.
As the result of analysis, there is a positive potential in the district, especially for the complex under study.

4

RENOVATION CONCEPT

Fig 4.1 project top view, via vertunni,roma

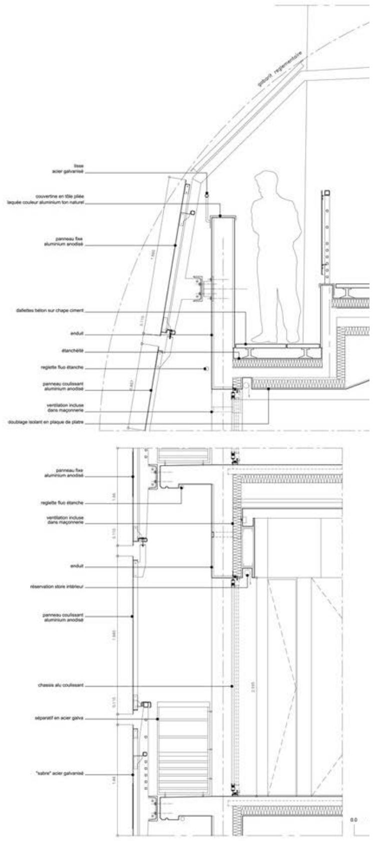
4.1 RENOVATION CHALLENGE

The fundamental challenge of the project is to discover a modern part of the location and its encompassed range in a sustainable way. In addition, the other challenge was the existed structure and its re-development in a way that the location and its construct structure still stay imperative points of interest and an update of the past. The advancement will be inside a private and mixed-use range so the proposition ought to take under consideration the current redevelopment arranges of transformation within the range, to make an economical quality, livability and differences.

In like manner, we were trying to figure out what we need to do with the current building with the new function and how we need to renovate, relive and retrofit it in a mentioned sustainable way according to the NZEB standards.

4.2 RENOVATION CASE STUDIES

We considered numerous renovated projects-considers around the world and summarized distinctive techniques connected for the renovation and restoration . Among the studied cases, we clarified the more important and motivating for our plan.



4.2.1 SOCIAL HOUSING / CHARTIER - CORBASSON

Architects: Chartier - Corbasson

Area : 900 m²

Year : 2009

This project located in the heart of the Marais district comprises the rehabilitation of the building 76, Rue Saint-Antoine and the adjoining plot at 1, Rue de Turenne. Dating back to the seventeenth century, the existing building is built on a very narrow site. The project will complete the block and create a new façade for the gable-end that currently bears the traces of a building that was demolished to make way for Rue de Turenne.

The existing building has been preserved and refurbished. The upper stories have been enlarged by the addition of extra space to the existing area of each floor, creating more spacious accommodations facing Rue de Turenne. The gable has been opened out to provide the best possible views.

An exterior skin has been added to protect the newly created spaces and give them a certain coherence. The general aspect matches the officially sanctioned proportions for the area. The housing units created are two- and four-room flats and loft-style studios.

They are accessed by open-air staircases leading up from the interior courtyard. Each unit has a terrace or a balcony. All rooms open onto a central living room, reducing the need for corridors.

Fig 4.2 social housing , chartier, corbasson

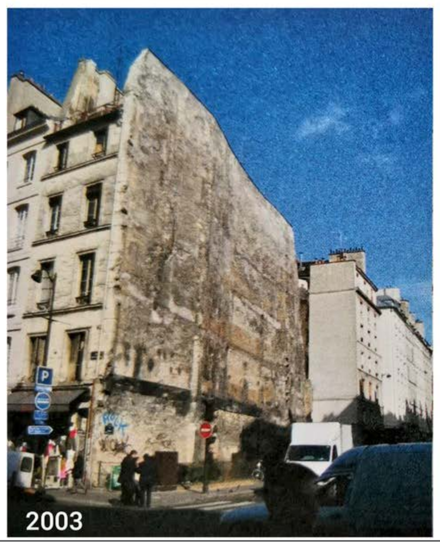


Fig 4.3 Tapetfabriken hotel

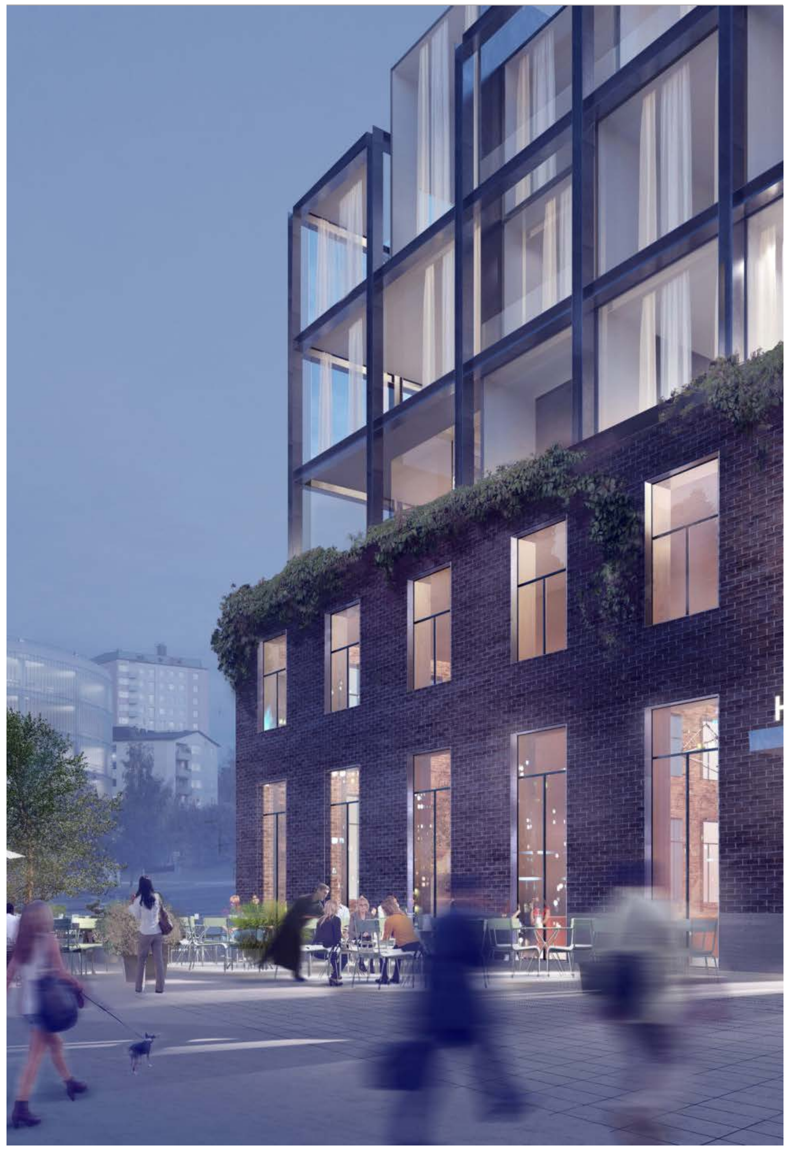


Fig Tapetfabriken hotel

4.2.2 TAPETFABRIKEN HOTEL

The Clarion Collection Tapetfabriken, in the Sickla district of Nacka, southeastern Stockholm, is a hotel named after the Swedish wallpaper manufacturer Kåbergs, active in the old factory building already in 1906. A century later, after having functioned several years as a service building for Swedish industrial company Atlas Copco and as an office, developer Atrium Ljungberg proposed a repurposing of the building to add another urban layer to the old industrial area. The idea was to build off of the local industrial history by keeping the existing brick façade and then create a new interior and a modern extension on top. In 2021, the Tapetfabriken hotel opened its doors and began a new vibrant chapter in the life of this historical building. Tapetfabriken comprises 236 hotel rooms, four conference rooms, a lobby, bar and restaurant. In keeping with Sickla's historical industrial, red brick buildings, the façade of the two lower floors mixes 100-year-old original bricks with new ones to create a beautiful variation. To this historic, grounded lower part is added a more lightweight three-story extension, covered with a white semi-transparent glass lamella structure and integrated façade lighting. Underground, over two floors, there is a garage, technical room and storage. Located at Marcusplatsen, a park in direct connection with retail, offices, restaurants and other services, The Wallpaper Factory takes advantage of its potential as a central hub in Sickla. At the heart of this hub is the hotel lobby, an attractive place for business travelers, tourists, workers and residents alike. From the morning coffee to the late-night drink, the hotel is bustling around the clock. With the upcoming expansion of the Stockholm metro to Sickla, where traffic is expected to commence in 2030, the district will have an even greater development potential in the future. One which The Tapetfabriken stands ready to embrace. Initiated as a parallel commission, the winner White Arkitekter designed the building through project planning documents. HMXV Arkitekter then acted as architect for the construction documents. The hotel is run by Nordic Choice Hotels and developed by property owner Atrium Ljungberg with Arcona as the contractor.

4.2.3 PARK HILL / HAWKINS BROWN WITH STUDIO EGRET WEST

Architects: Hawkins Brown with Studio Egret West, Hawkins Brown with Studio Egret West; : Grant Associates; Grant Associates

Area : 130000 m^2

Year : 2011

Architects Hawkins\Brown and urban designers Studio Egret West were commissioned by property developer Urban Splash to take on the renovation of the notorious social housing estate, which is one of the most famous examples of the “streets in the sky” typology that typified many post-war UK developments in the 1960s and 70s.
Influenced by projects such as Le Corbusier’s Unité d’Habitation, architects at that time thought large housing blocks with communal open-air walkways would foster communities, but they instead became associated with antisocial behaviour, vandalism and crime.

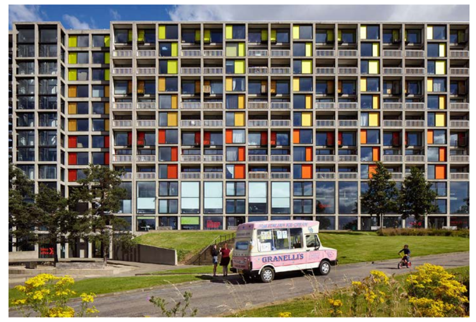
In spite of its problems, the complex was Grade II* listed in 1998 for its architectural significance, as well as for its role as part of the city’s identity. This prompted Urban Splash to embark on a redevelopment to create a mix of social housing and private apartments, alongside offices, shops, restaurants and bars.

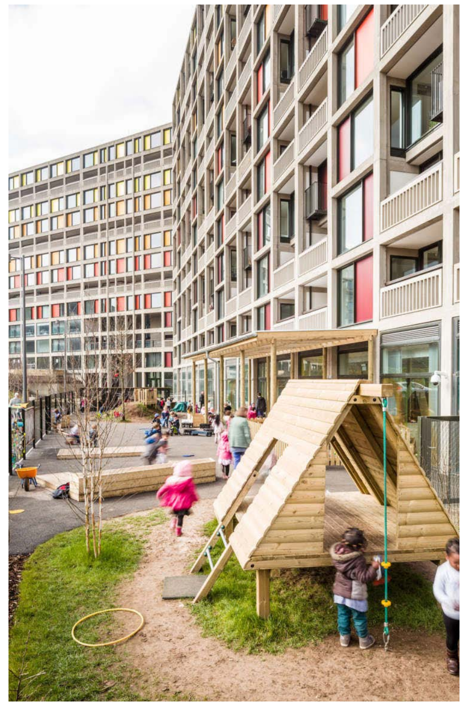
The design team began by stripping the building back to its gridded concrete framework. They then added a new facade made of simple glazing and brightly coloured panels.

By reducing the width of the “streets”, the architects were able to extend the size of the apartments, creating new street-facing windows and much-needed additional storage.
Giving residents a sense of ownership was an important part of the project, so patterned floor tiles and stained plywood details were added around the entrances to each home to provide a more domestic appearance. These details also vary between different clusters of homes, helping residents to orientate themselves.
Landscape architecture studio Grant Associates also worked on the project, designing gardens, courtyards and a large public square.

Fig 4.4 Park hill,hawkins brown

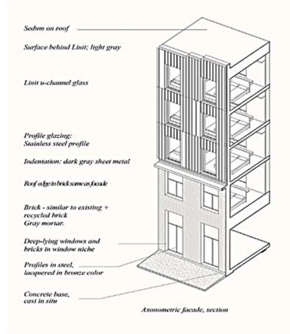
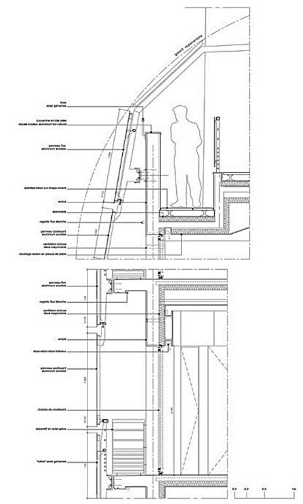
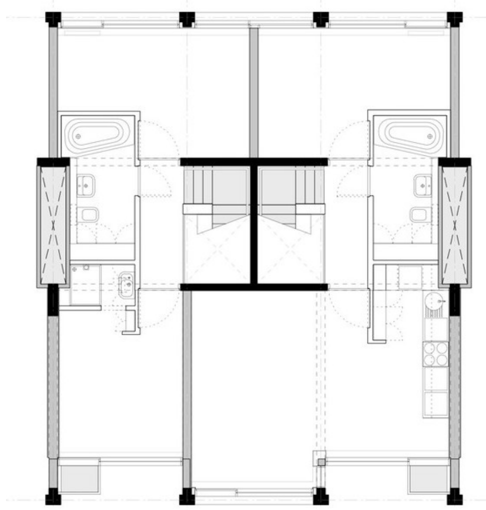
Fig Park hill,hawkins brown





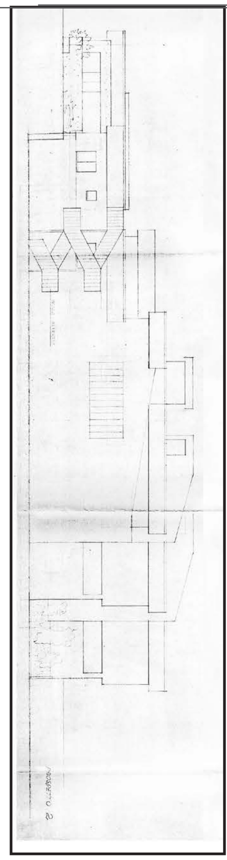
4.3 CASE STUDIES SUMMERY

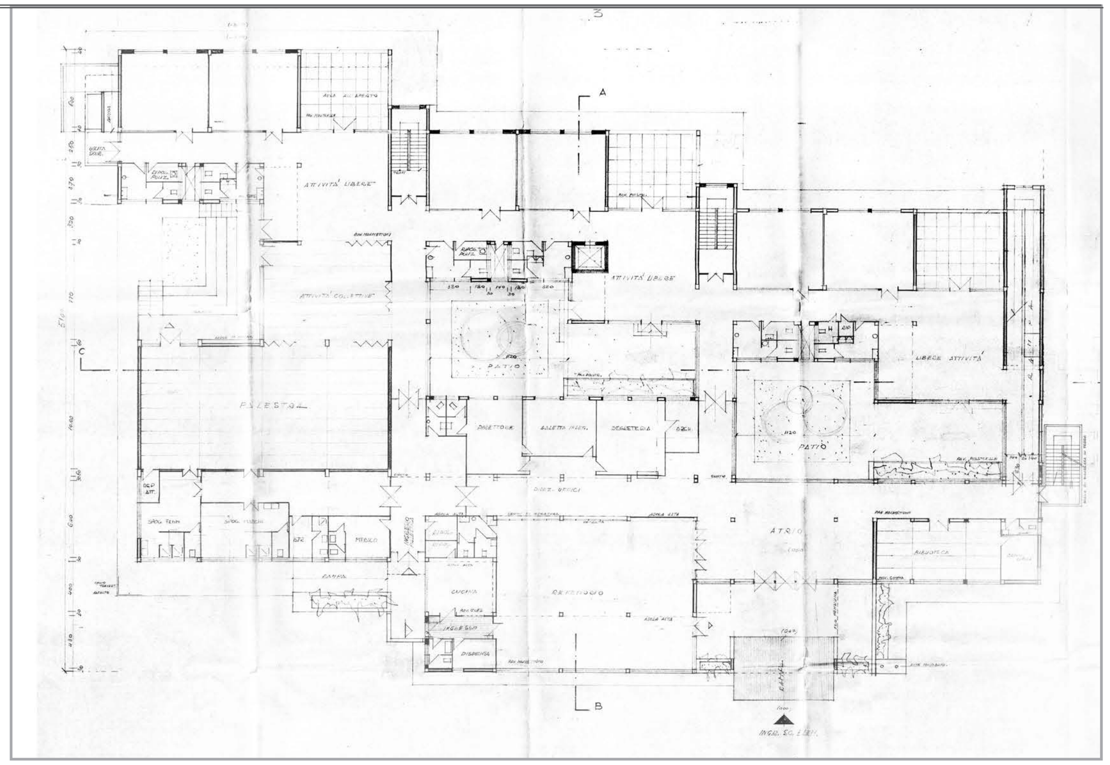
in the table bew we summarized renovation case studies with the ideas ,that inspired us in our way in designing and renovating the project .

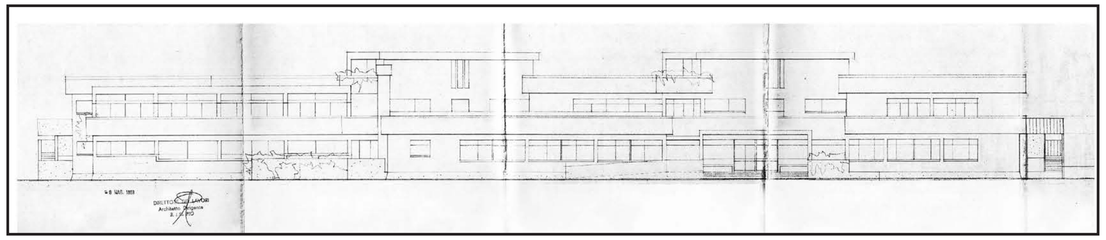
Name	Location	Year	Area	Architecture	Former Function	New Function	Renovation Strategy	Details	Explanations
Tapetfabriken Hotel	NACKA, SWEDEN	2021	15000 m2	White Arkitekter	Factory	Hotel			- Holding the brick facade of the building - Add three floors to the building - Use of semi-transparent glass material in the facade - Reconstruction of green space - Has the ability to develop
Social Housing	PARIS, FRANCE	2009	900 m2	Chartier - Corbasson	Residential Building	Social Housing			- Enlarge space - Opening the gable - Add outer shell for extra protection - Modern style design - Change access to the building
Park Hill	Britain	2011	130000 m2	Hawkins Brown with Studio Egret West	Apartment	Social Housing			- Use of concrete fences in the facade - Change the facade using bricks, paints and panels - Reconstruction of green space - Modern style design - Preserving the original identity of the building - Change the interior plan - Add a private balcony for each apartment - Use of natural ventilation and regional heating

4.4 RENOVATION STRATEGIES
CURRENT BUILDING STUDY

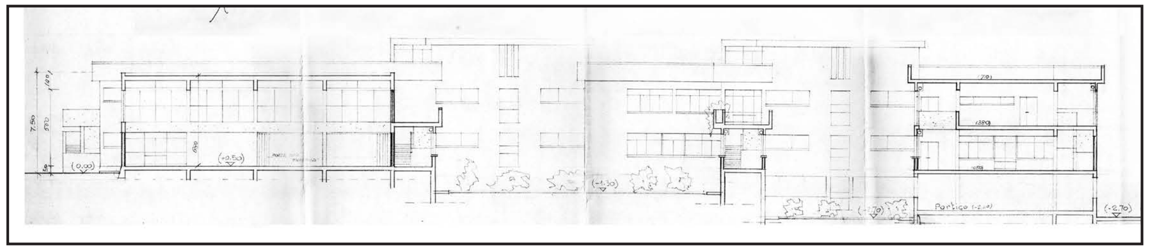
First we analysied the current situation of the building, to understand what we need to do for redevelopment.
this analysis started with diffrent plan layouts of the current building and the way we can use the opportunities and fix the problrms in orther to change its function to turn it into a suitable social housing.
in the next figures you can see the the current building plans, sections and elevation. in the next steps we are going to show the way we inspired by the case studies in our renovation concept in volume,facade and the way of interaction with the context according to the curent site analysis.

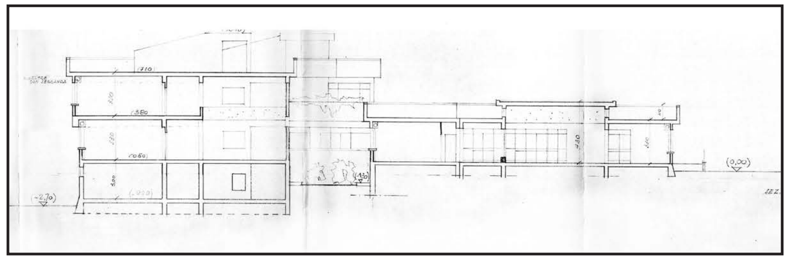


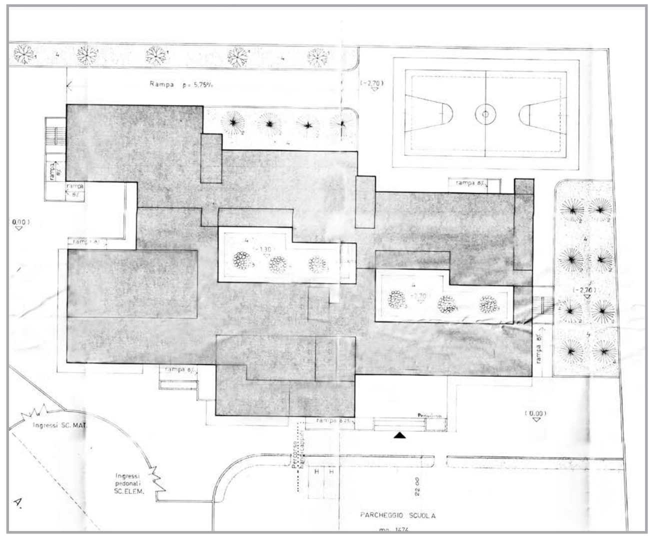


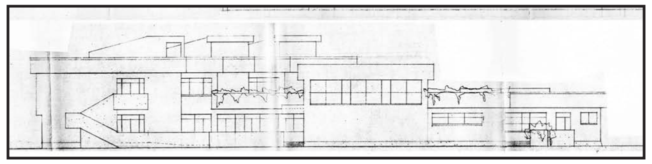


north_west elevation
south_west elevation
ground_floor plan









section A_A
section B_B
Roof plan

5

ARCHITECTURAL DESIGN

Accessory Dwelling

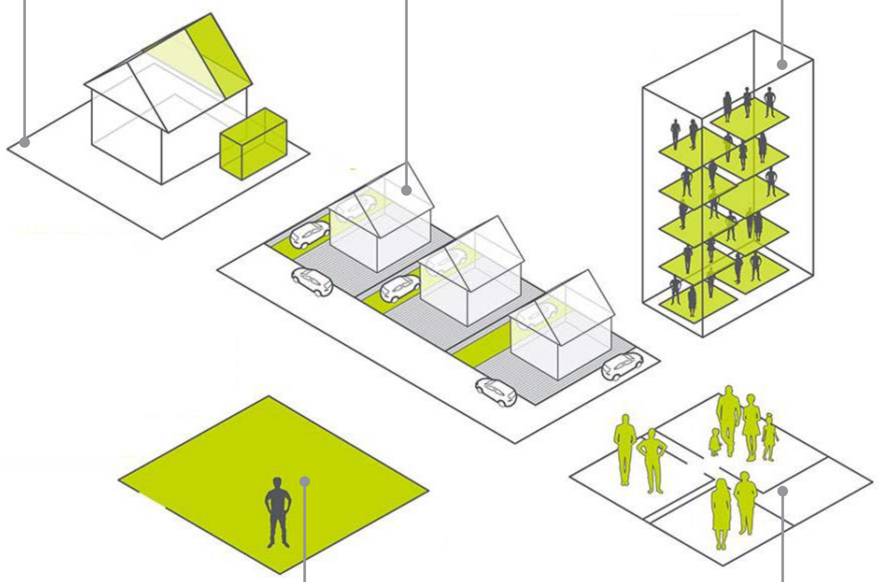
Many zoning codes make it difficult to create legal accessory dwellings. Where permitted, these secondary units share the lot with a primary dwelling and can be either attached or separate-such as a basement or garage apartment.

Occupancy

Occupancy standards regulate the total number of people who can live in a housing unit and/or the number of unrelated adults who can share a unit-often no more than three.
These rules favor the traditional nuclear family and limit construction of shared living spaces.

Density

refers to the maximum number of residential units that can be built on a particular lot.



Minimum Unit Size

Minimum unit size refers to the smallest residential unit permitted.

Accessory Dwelling

Many zoning codes make it difficult to create legal accessory dwellings. Where permitted, these secondary units share the lot with a primary dwelling and can be either attached or separate-such as a basement or garage apartment.

5.1 ATCHITECTURAL TYPOLOGY

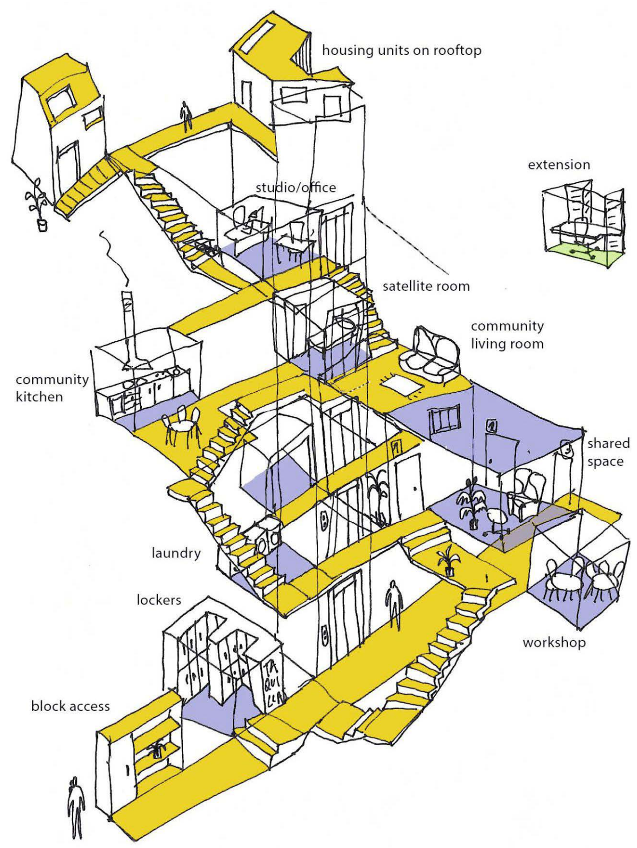
As well as architecture in general, in this typology design is based on its users. It is all about human scale and vast common spaces dedicated for residensial and social interaction.
By analyzing several case studies, we choose three representative ones and we listed couple of design aspects that we found important for consideration.

5.1.1 VOLUME

As said before, geometry is one of the main features that characterize italian architecture. although In the last years, we've seen plenty examples with strong irregular shapes, still for Buildings for residential purposes more regular shapes speak in a better way. However, there are some repetitive regularities regarding this typology.
actually, we strongly belive in the idea of "form follows the-function"

5.1.2 FUNCTIONAL LAYOUT

In terms of internal space organization, the common thing is spreading functions from the inside out. Circulation and common areas are placed at the central axis, while the rest of the functions are perimetrically distributed. Similar functions like residential units are grouped and designed together, but market and entertainment spaces are not necessarily separated from restaurants and bars. Diversity of users and activities is often promoted. Speaking about vertical distribution, major functions and ones meant to serve the public, are located on the ground floor and while more private ones are on the upper floors. If there are several floors of repetitive functions (residential units) usually a discontinuity is introduced by adding some common or sitting areas.



5.1.3 CONNECTIONS

typical italian buildings are designed to meet people needs and to advance social engagement. This usually happens in spaces without certain functions, like stairways, circulation corridors. They are meant only to connect main build.
schemes of social housings functions but they are also more than that. They are designed to accommodate relaxation and common areas, to accommodate bouth people that will liveor spend their free time within these spaces. In a matter of fact, circulation areas take up to 40-50% of total surface area! If there are more separated volumes within buildings, they are often connected with skywalks. Light Influx of daylight is another crucial feature that affects architecture to a large extent. Large openings and glazed surfaces are essential.
Because of the large variations of sunlight duration over the year, openings on vertical surfaces are often not sufficient. Use of skylight is really often present, designed in such way to provide the best natural light inflow. Design is dealing with proper angles and reflective materials as well.
although the Competition brief did not gave us list of required functions and activities and approximate number of occupants, but acording to the analysis context and the needs of roma we decide about the functions and required areas. actually,This gave us an opportunity to go deeper in this aspect and to produce analysis for the major spaces of the social housing.

General goal is to achieve flexibility within space, so some rooms can extend or be divided if needed. exept the apartments and units,Functions occupying the space are often overlapping, allowing different activities to occur.

5.1.4 FUNCTIONAL REQUIREMENTS

- **RESIDENTIAL**

Regarding the project typology, this is the most important activity. the spaces where people suposed to live and spend the most of their time, is essential space.

Architectural experimentation and alive spaces where exchange of information would easily flow are fostered. These spaces imply the biggest degree of flexibility. They have to be flexible areas that could extend or shrink for the days and nights life,in addition could be split in smaller subareas if needed .

This social housing accommodate almost 152 people (indviduals or family members) that are living eigther in short or long term, with possible changes in families population.

residencial area is held in three type of units:

• studio

• 1 bedroom unit

• 2 bedroom unit

- **LIBRARY**

It is the main meeting space between the students and public.

Place for in-depth studying, but as well place for meetings, exhibitions, performances. It is open and inviting , dropin place. It contains several sub functions, like reading area, books/shelves area. Also it contains a multifunctional room for bigger meetings.One of the proposals is to spread functions of the library over the three foors, following the German library model.

Reading area is taken as an reference for determining of all the areas required.

- **SOCIAL AREA**

All commons spaces located in

the project on multiple scales are the main core of "Engaging through Architecture".

the common spaces inside the

social housing have been considered on multiple scale, levels and

locations. Primarily, the whole

complex was designed to dismantle the program according to different users' functions yet to connect them where they can engage, interact, socialize, and

exchange experiences!

Due to the base concept of social housing, various users from different domains have the opportunity to interact together and share different thoughts & ideas through the outdoor spaces, courtyard, bar, library zone.. etc Nevertheless, the residential main functions where the people live in.

On a different scale inside the project different zones, common spaces were distributed between the main functions to connect them togehter and let both residences and people from outside interact together and share their experiences, the common spaces acting as an inbetween area was very useful to locate services and lounge zones, on a different level where terraces are configured

by the volume.

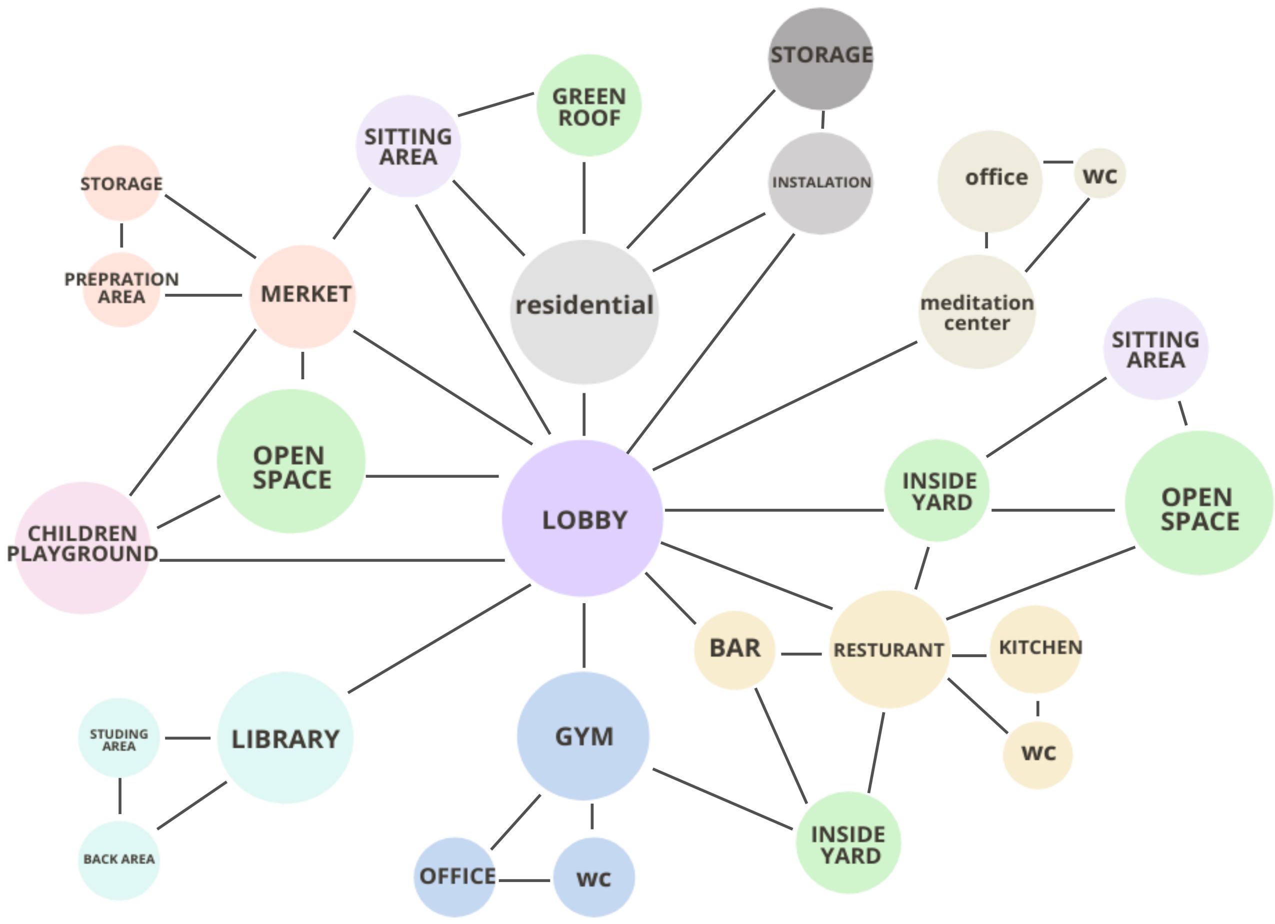
These several groups of functions that are described

and represented through schemes are major social housing function and for that reason they are analysed in details.

Besides these, a social housing project contain several other functions (like students association office, storage, serves...) which are necessary as well, but not relevant for further analysis.

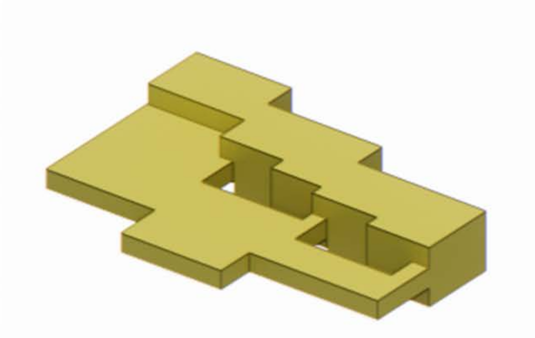
Instead, they are schematically represented together with major ones in the following diagram.

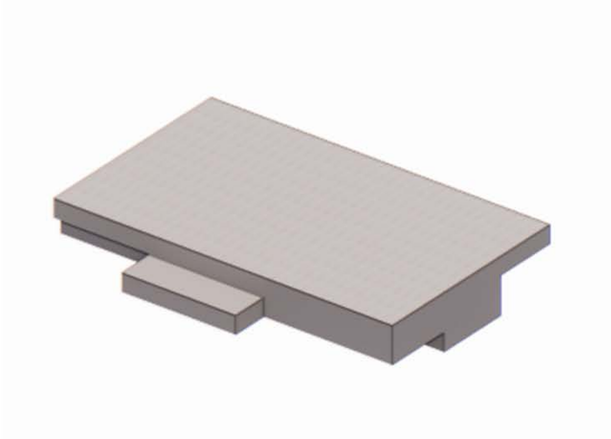
This diagram shows all the functions proposed, as well as connections in between them and clusters or zones that they form. This will be important input for further development of the volume.

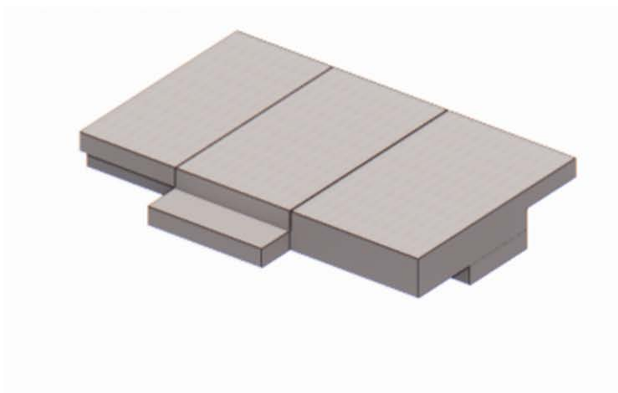


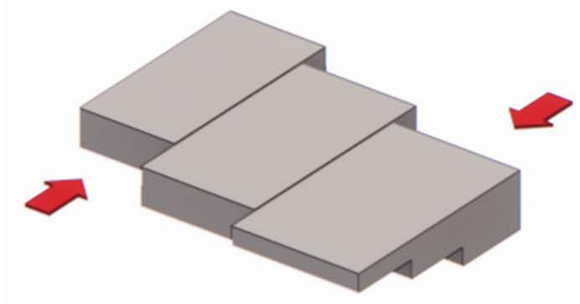
5.1.5 VOLUME DIAGRAM

In the renovation phase of the via vertunni social housing it has been considered to combine the campus together with their immediate surroundings, the fundamental decision taken for the project was to avoid the boundary that would form between them.
The building would thus blend into the public spaces surrounding it, by splitting the whole volumetric form according to the program divisions providing open spaces in between the three main clusters of the campus, interconnected with the surrounding public spaces.
Every stage of the designing process was dealt with according to its own potentials and this was the method used in reaching the whole volumes through locating each program according to the surrounding potentials and functions. Thanks to this, the conception that emerged is a fluid one into which the users can blend as well.
Through this approach, the project becomes an interface in which definite boundaries are eliminated.
The building establishes a relationship with its location and its essential state is determined by the references it draws from its location and surroundings.

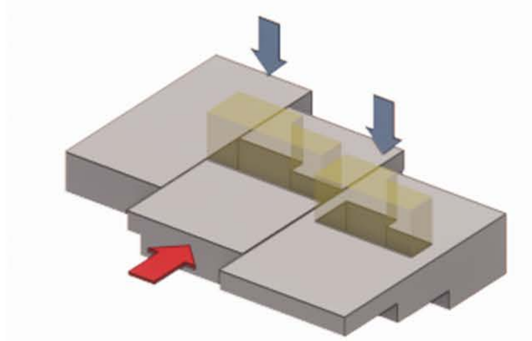


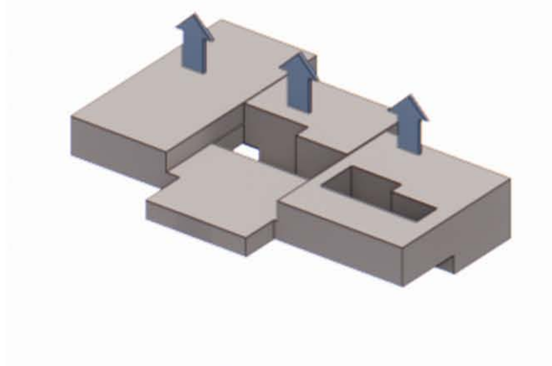


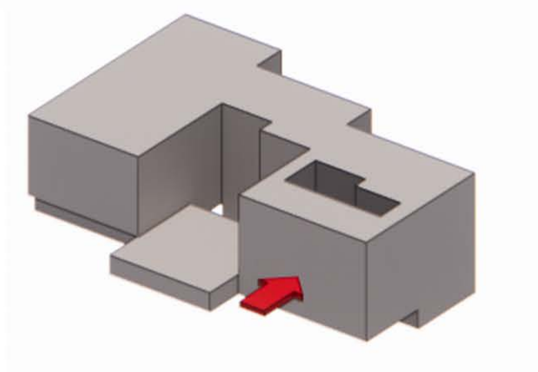


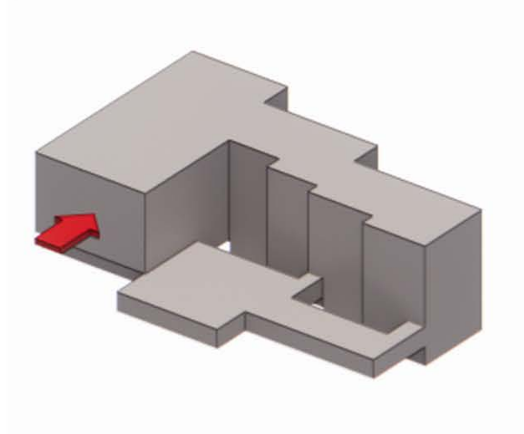


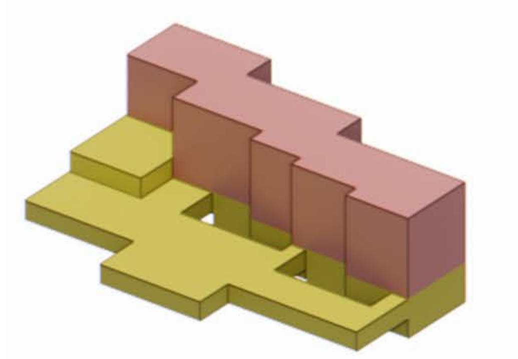
When establishing the spatial organization inside, at the same time, exterior spaces are produced in which many vistas take shape and which enable possibilities for alternative spaces.
The part of the building located in the middle has been rotated to provide more open spaces that could be used by different users, in addition a gateway has been implemented to provide a fulltime access from both ways.
During the volume development the solar path according to the building orientation has been taken into account to maintain the maximum amount of natural lighting to the main educational spaces and facilities keeping in consideration the amount of sun exposure to avoid and kind glare that may affect the studios and class rooms.
Furthermore, the volume extrusions were developed to provide a sort of overhangs to the open spaces activities located in the periphery of the building to maximize area available for semipublic activities along with an outdoor comfort existence to diversify the assigned conditions of the green spaces surrounding the main building.











5.1.6 SKIN DESIGN

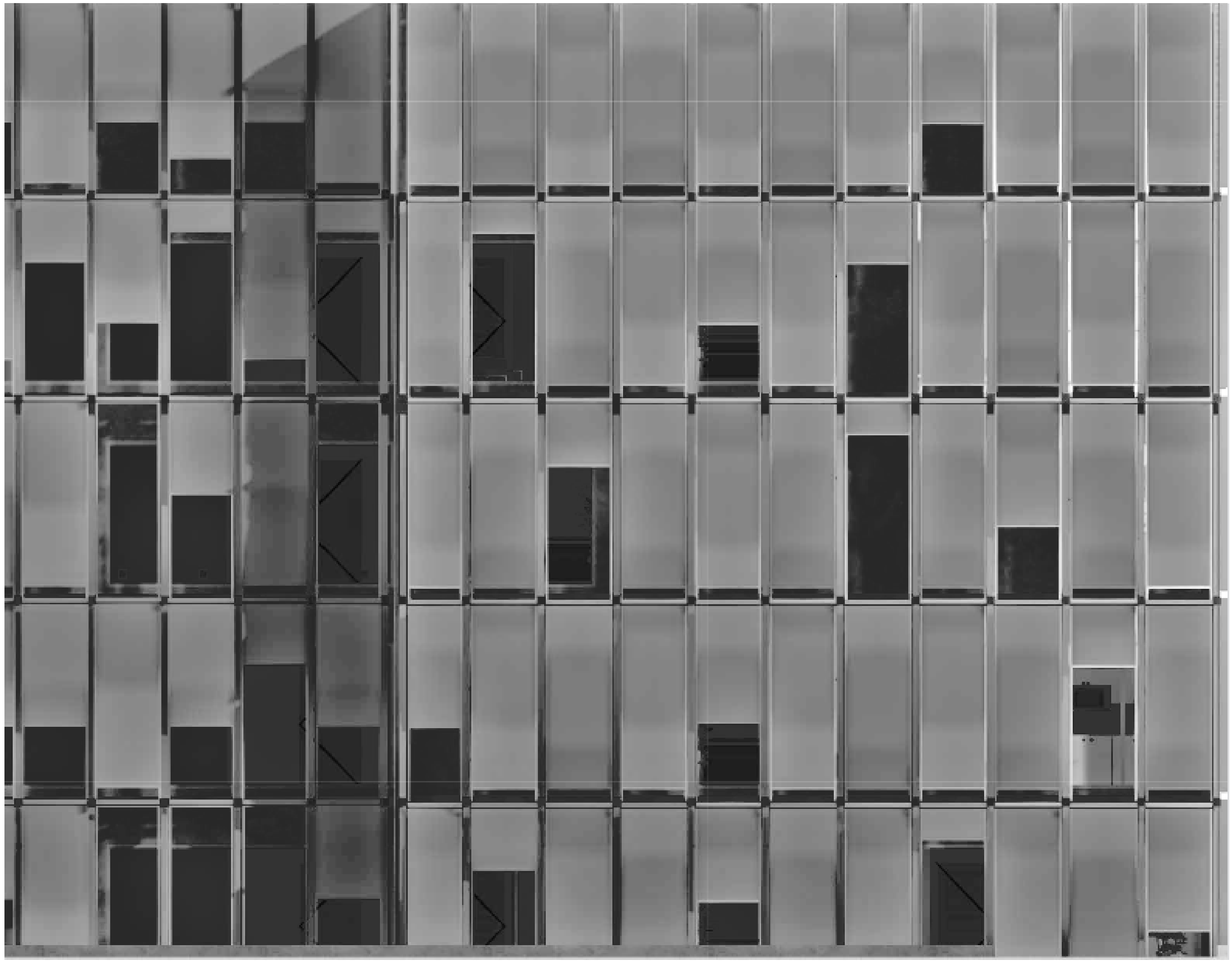
We researched extensively fin sectional and species profiles that would span long distances enough to cover the height of the facade at each floor that would not require further secondary lateral support in the form so as to receive transparency in a delicate way.

Accordingly, a research has been made to choose different materials and colors that involved in providing different prototypes into comparison, the idea was to provide a color match with the darker opaque envelope behind and create a
neutral color within the whole composition.
The composition pattern was meant to have two different skin typologies merging between the different material surfaces, manipulating between the layering of these layers has produced multiple options and finishes.
The flexibility of the facade design optioneering was so helpful to have a reliable decision making for differentspaces and activities in all the facade.
in addition of balancing the facade and aesthetic poin of view ,this pattern help us in shading and daylight controling in the rome climet.

Consequently, the solid and void relation of fins and shadings along with glazing and opaque finishing behind developed a coherent scheme between all the facades of the buildings.

Fig 5.2 designed facade

During the design development of the facade, as you will see in advamce in the daylight chapter,different simulations has been carried out to evaluate the natural lighting performance inside the different spaces and functions, to make sure that all the functions like residential,social areas,library ,gym that need natural sufficient light, are well lit and receive the adequate amount of natural lighting needed.
Many design options were developed to estimate the differences between fins thickness, depth, and separation to have sutable daylight without restricted view.
All the results were evaluated to determine and choose the most applicable dimensions for different locations and interior organization since some of the areas contain internal cores for vertical circulation and services.



5.1.8 TRANSPARENCY

In general physical terms, transparency is considered as an architectural property defined by the amount of light passing through a the outer envelope.
It is also, the capability of seeing through an otherwise solid object behind the building edges. In the genaral, transparency can be used to perceive different spaces simultaneously, creating different perceptions and sensations in-between inside or outside the space.

To achieve transparency through the building which is made out of applying an inner transparent envelope

and an outer layer made of thin fins and the shaders, it was important to consider the amount of permeability allowed by the facade composition to avoid any kind of confusion ,locking or view restriction, it was a convenient solution to create a porous elements.

In the skin design, it was meant to create virtual boundaries that function as filters rather than solid confines; or openings that permit things to pass through or to be seen through.

This concept permits persons within and outside a space to perceive the immediate physical activities inside different spaces and functions to give the sense of engagement and livability wich is important in the social housing designing.

Fig 5.2 designed facade

5.2 FUNCTIONAL LAYOUT

The functional organization of the building has been carried out to focus on interaction between people in the complex,actually we tried our best to relate the residensial part with the gathering areas.
in addition the other idea of functional organization was to promote a dialogue between the landscape and the architecture of the project as a semi-public place .
This approach has led on developing many outdoor public mediums that could facilitate and improve the connectivity between the two domains relation. next to the meditation center as a social gathering area an open space with greenary is located to provide a gathering area for the ewsidents and other users surrounding the social housingl complex.
In addition, a service area and the storages has been located in the basment floor next to each other ,because they are two related function.
in order not to mix these functions with meditation center the entrance elevator and stairs are totally seperated .

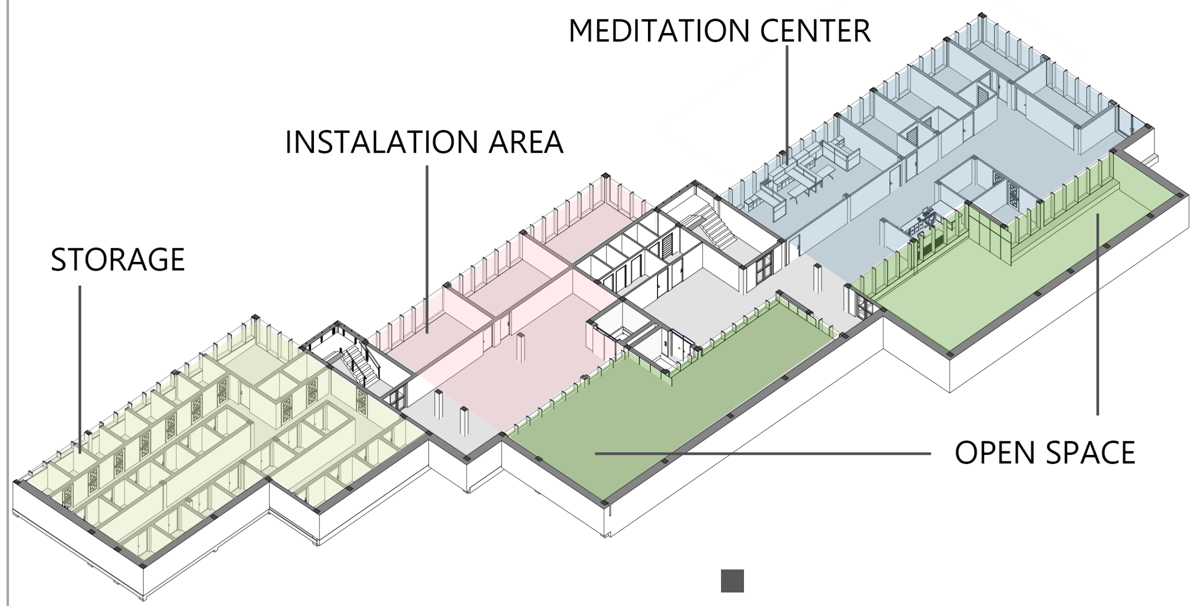
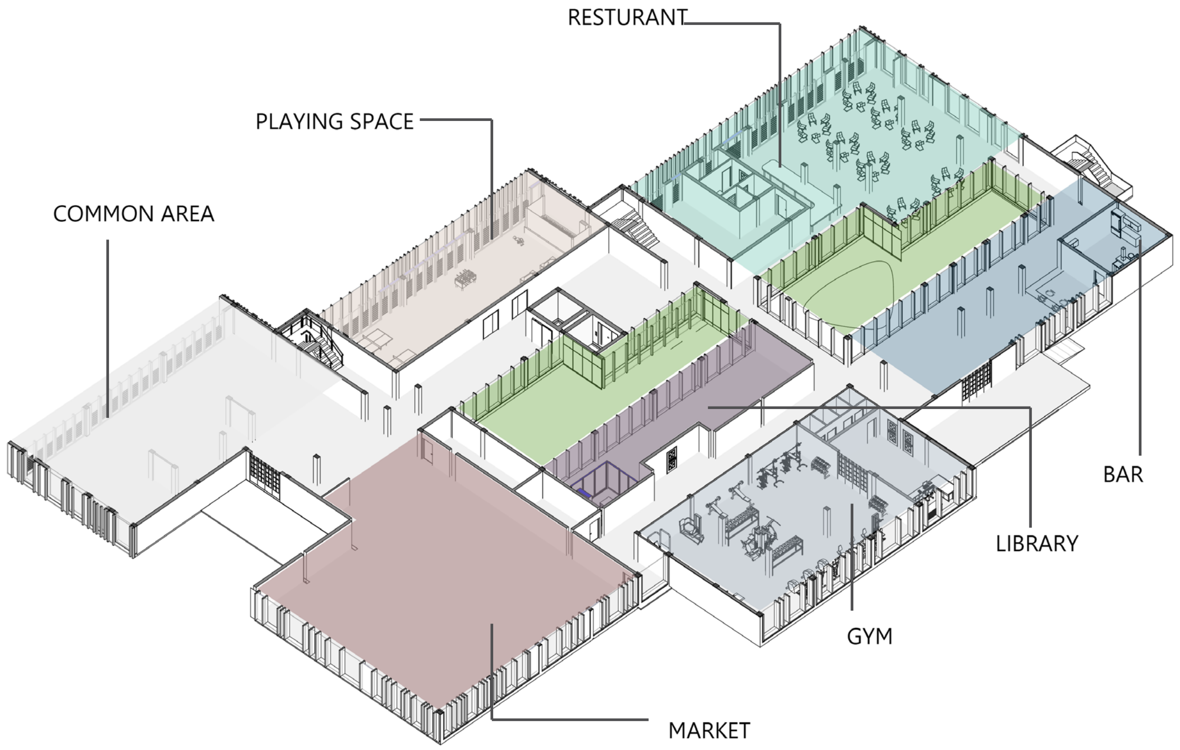


Fig 5.3
Basmebt floor functional layout

Fig 5.4
Ground floor functional layout



As the main theme and philosophy of the social housing is to develop a kind of engagement to the environment through architecture, gathering spaces are designed to be related to the landscape of the district urban , encouraging people to get involved with the building context and allowing the cultural district different users to observe the interior of the building through the envelope with facade of ribs.
In general physical terms,the multiple relation between different functions of the social faculties helped so much to have diversity of functions connected in a programmatic way to create a flexible residential environment merged with the secondary spaces like the library, market, gym and bar and resturant.

5.2 FUNCTIONAL LAYOUT

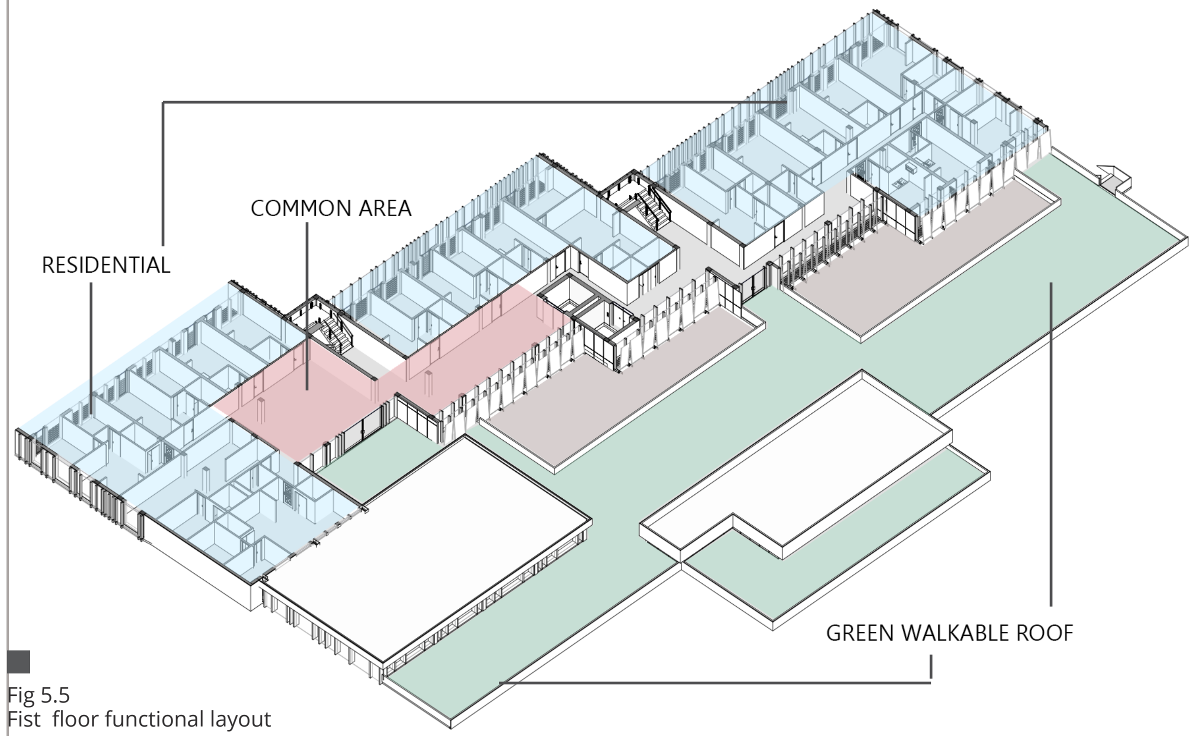


Fig 5.5
Fist floor functional layout

As the main theme and philosophy of the New Aarch is to develop a kind of engagement to the environment through architecture, teaching spaces are designed to be related to the landscape of the district urban , encouraging students to get involved with the building context and allowing the cultural district different users to observe the interior of the building through the envelope with facade of ribs.In general physical terms,the multiple relation between different functions of the educational faculties helped so much to have diversity of functions connected in a programmatic way to create a flexible educational environment merged with the secondary spaces like the library, canteen, internship and graduates building.

the residential parts as the main function of the project is trying to promot a kind of engagement to the context through architecture by the means of the traces and green roof.
the units are designed in a way to be related to each others and gathering spaces which are in between ,encouraging residences to get involved with the other people living in the project .
In general physical terms,the multiple relation between different units of the residential faculties helped so much to have conectivity of functions ,connected in a programmatic way to create a flexible environment merged with the other spaces by the means of vertical and horisontal conections .

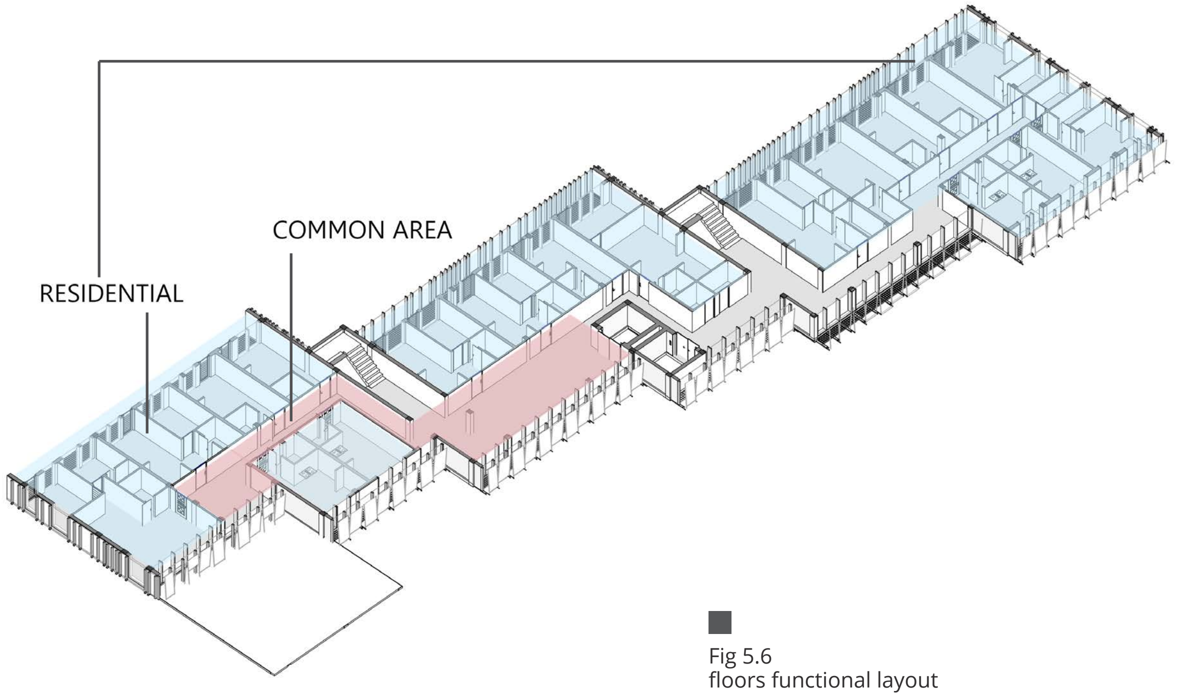


Fig 5.6
floors functional layout

5.3 ACCESSIBILITY AND CIRCULATION

The accessibility was an important issue to be considered due to the mixed functionality of some spaces that could have the opportunity to invite different users, that's why the functions of the project has been splited initially to the building floors, where the residence have their own space, and public can access the ground floor where some function of the program are common between residence and public.
The next upper floors which is fully dedicated fully for the people living in the units has multiple entrances while the servicing for the multipurpose spaces in ground floor and independent entrances for students which lead directly to the workshops and studios. However, market and gym, the entrance is a sort of primary patio where users can access directly or indirectly from the main entrance.

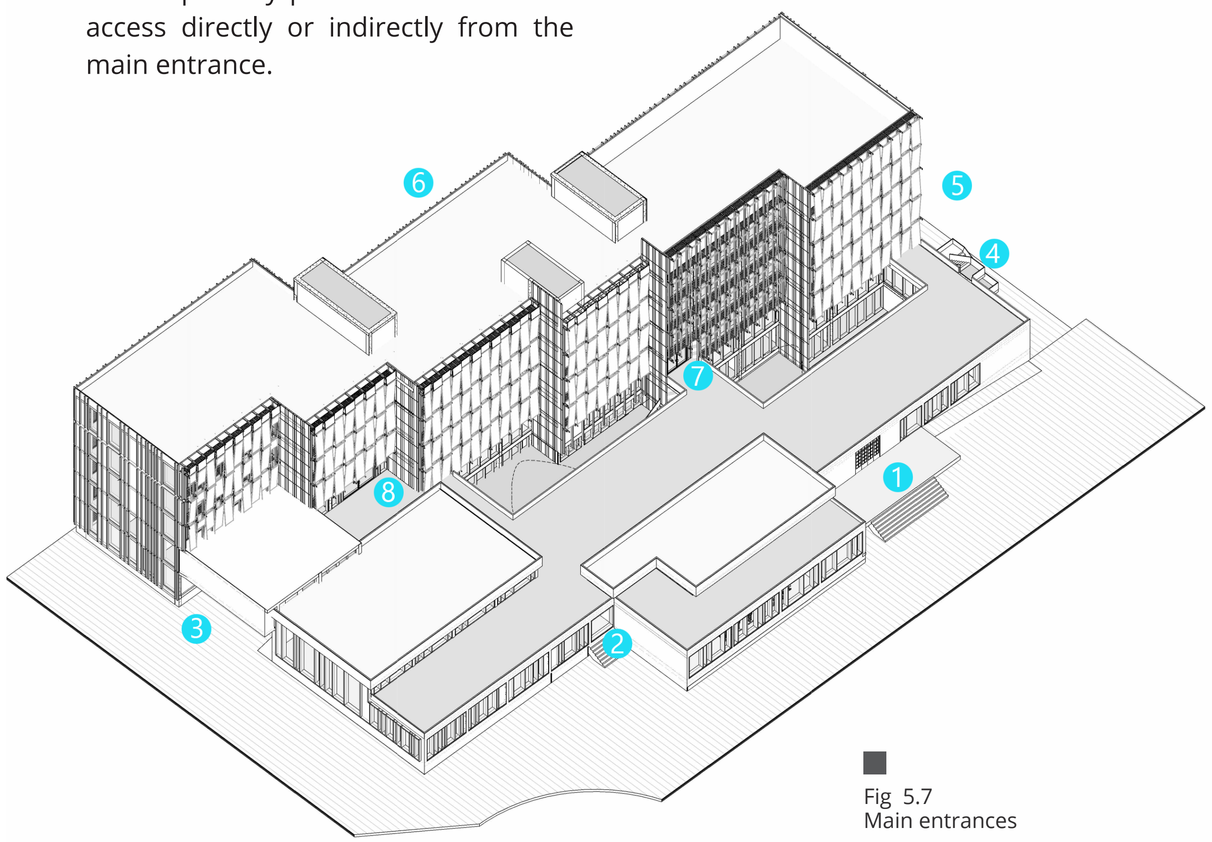


Fig 5.7
Main entrances

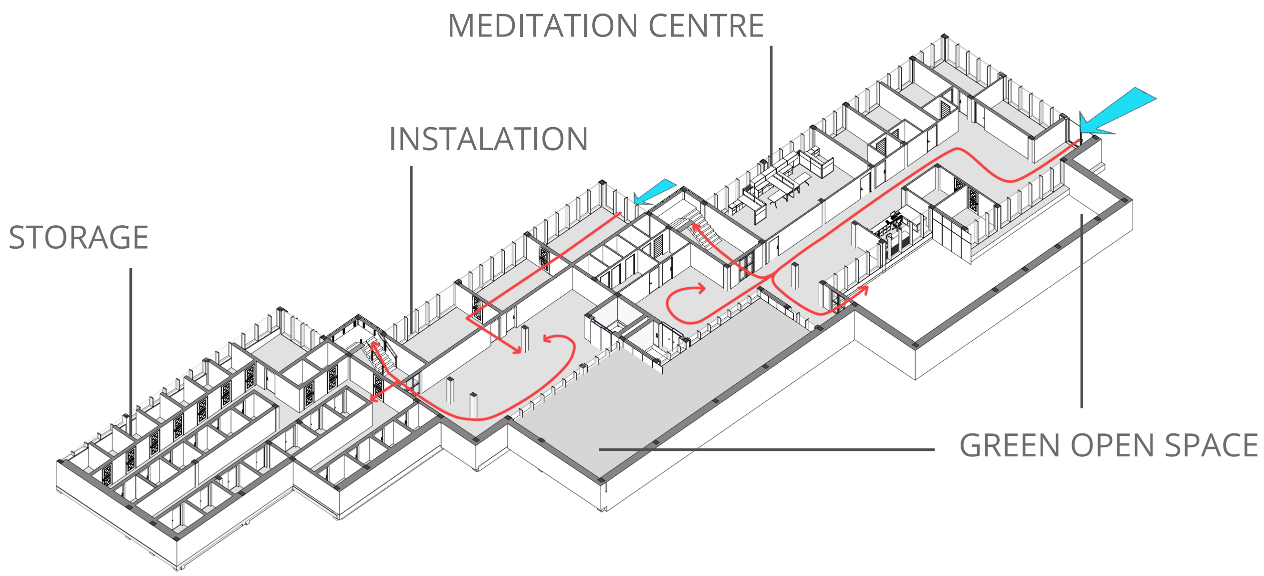


Fig 5.8
Basmebt floor circulation layout

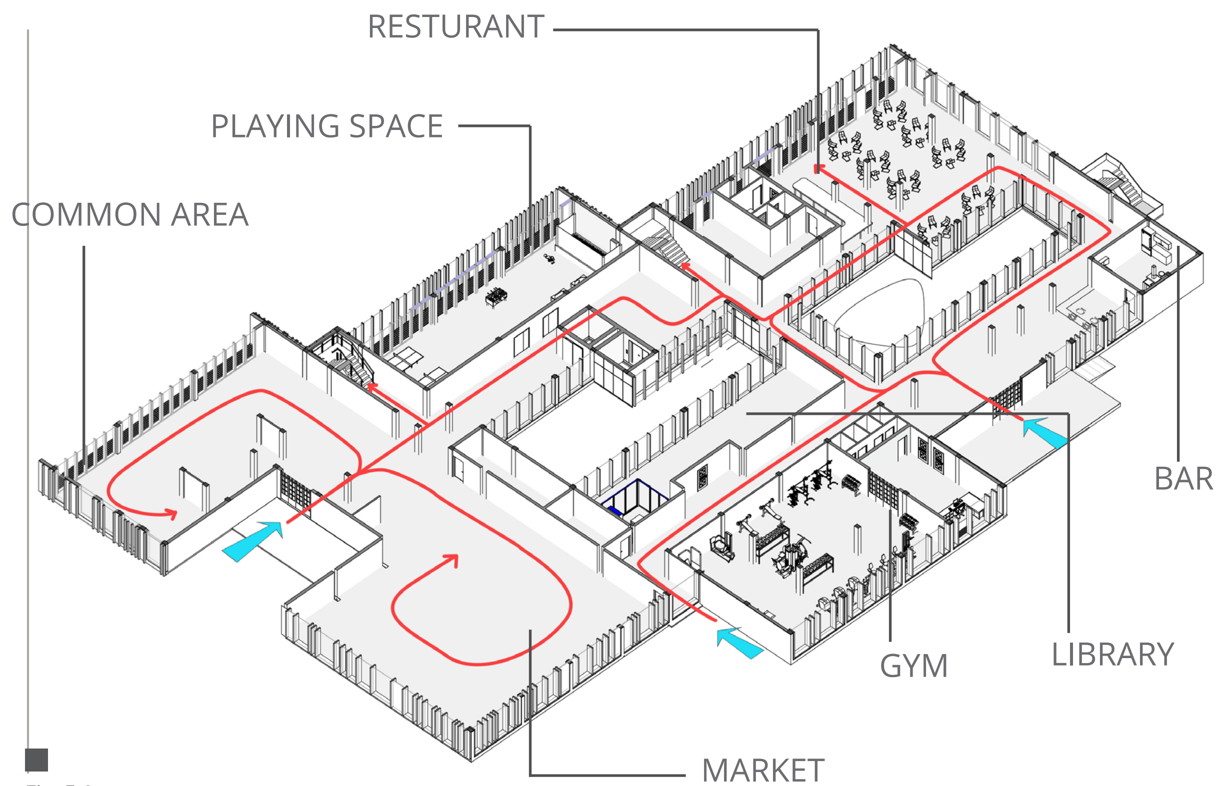


Fig 5.9
First floor circulation layout

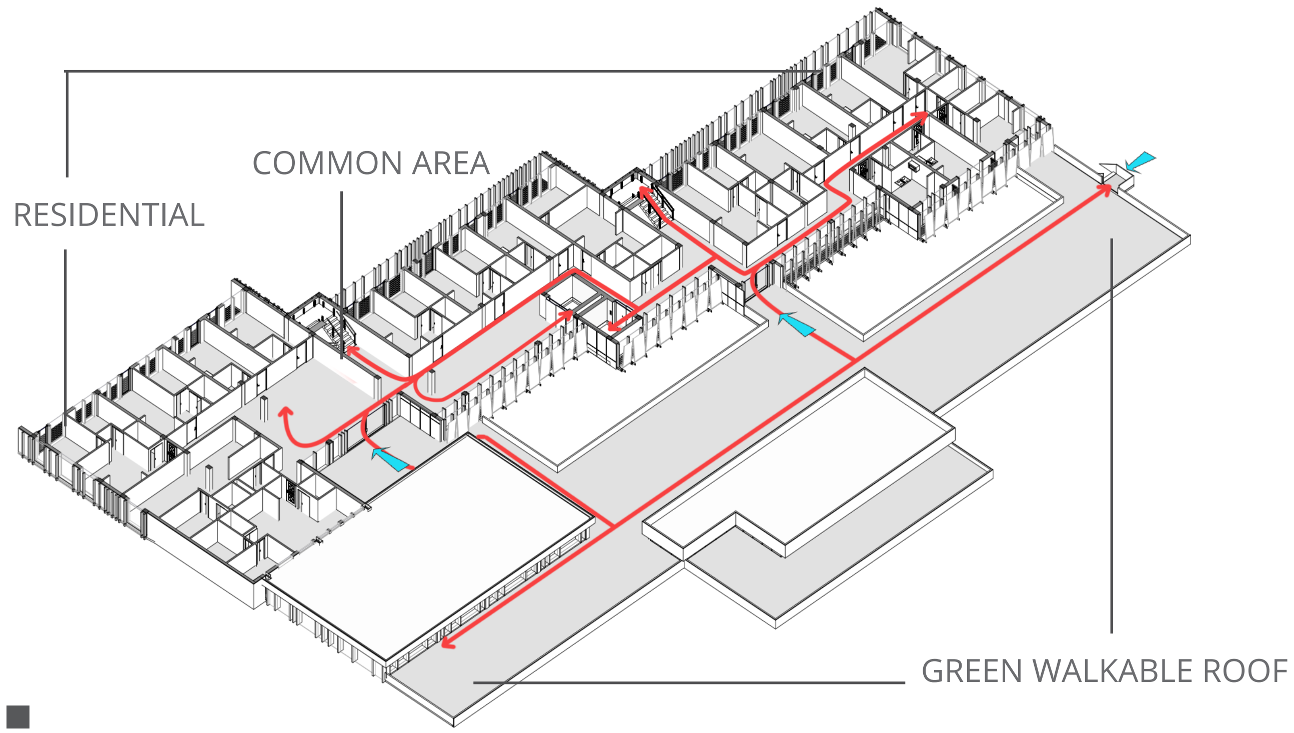


Fig 5.10
First floor circulation layout

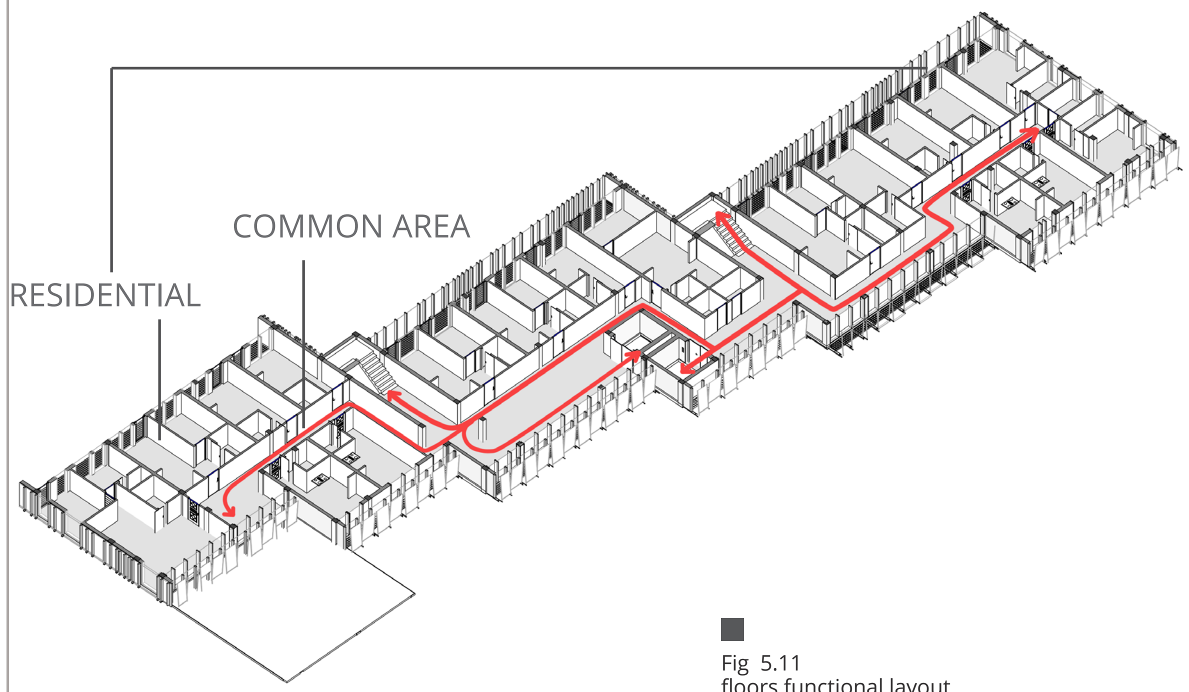


Fig 5.11
floors functional layout

5.4 VERTICAL CIRCULATION

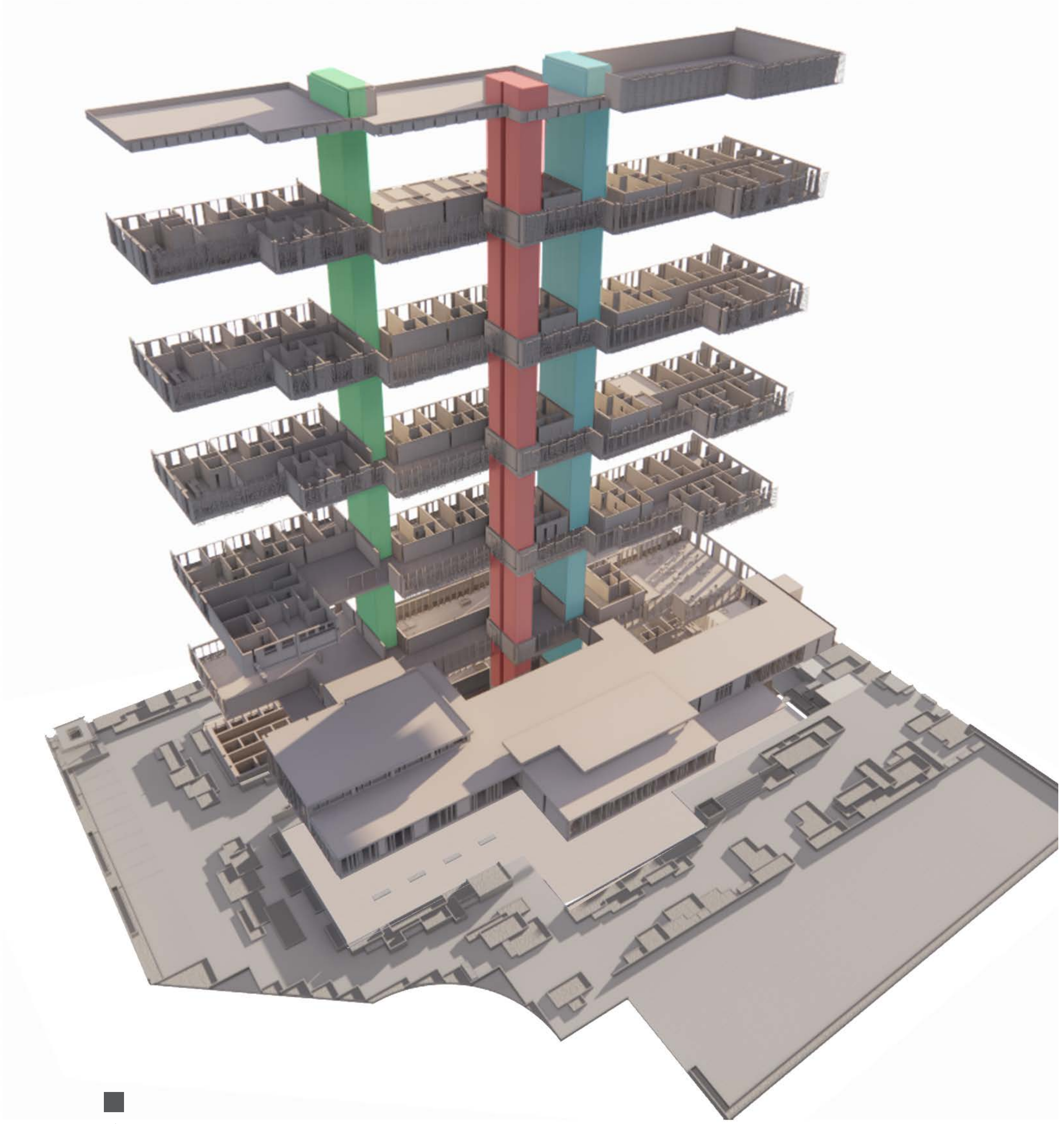


Fig 5.12
vertical circulation

5.5 INTERIOR DESIGN _RESIDENTIAL UNITS
5.5.1 UNIT 1 _ STUDIO

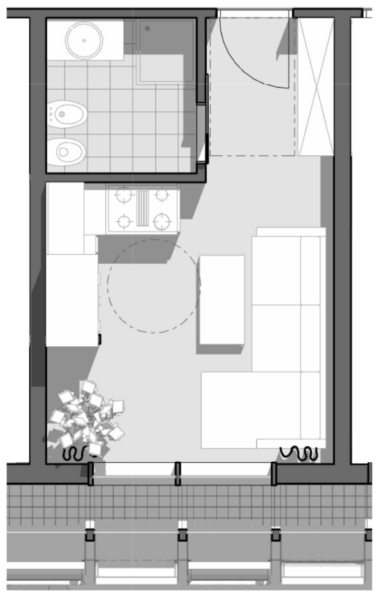


Fig 5.15
floors functional layout

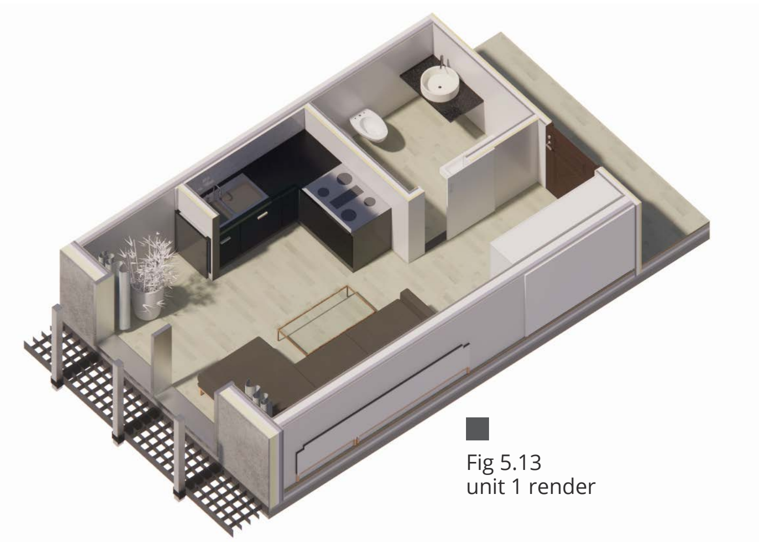


Fig 5.13
unit 1 render

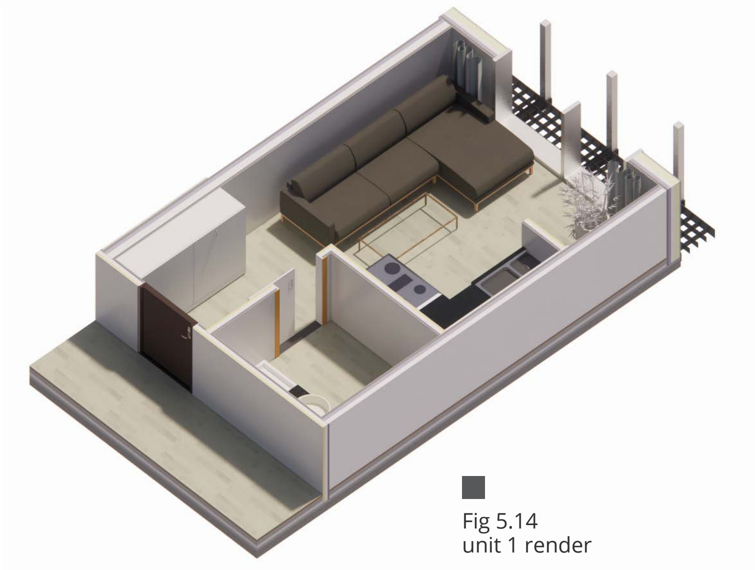


Fig 5.14
unit 1 render

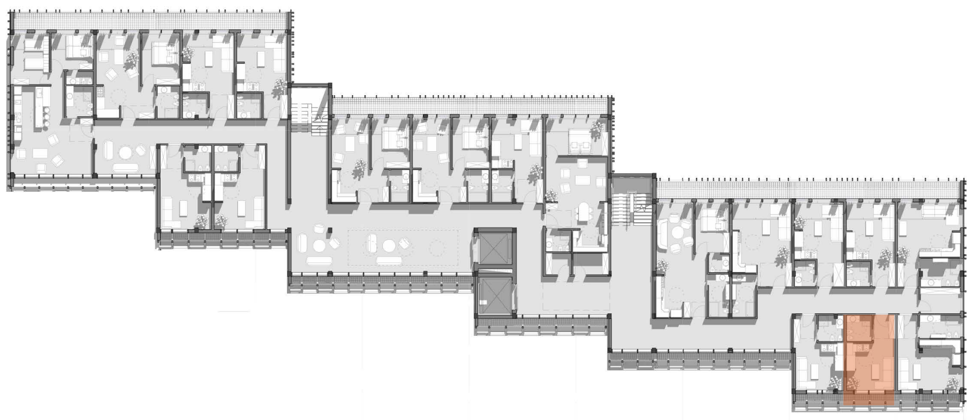


Fig 5.16
unit location in floors plan

5.5.2 UNIT 2 _ ONE BEDROOM UNIT

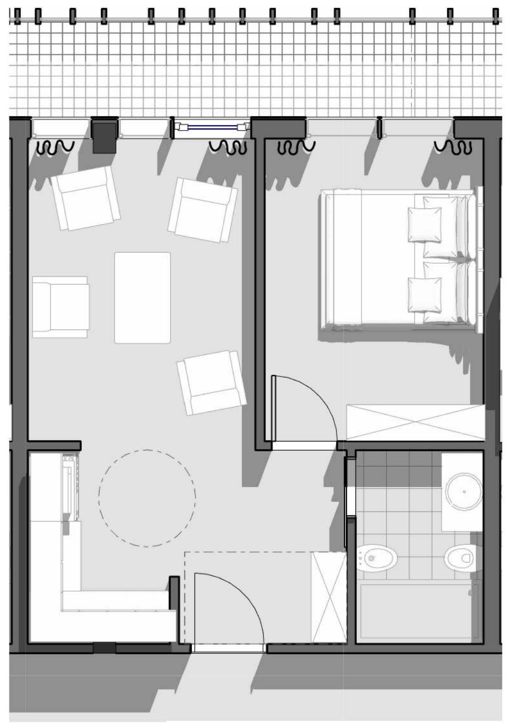


Fig 5.17
unit 2 plan

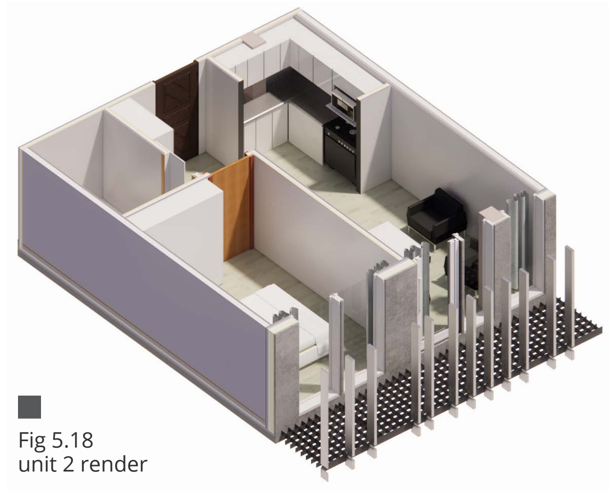


Fig 5.18
unit 2 render

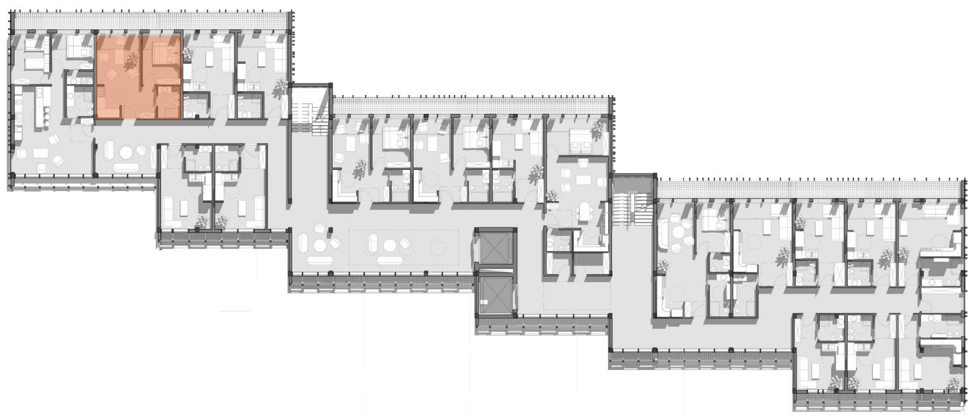


Fig 5.19
unit location in floors plan

Fig 5.20
unit 2 render

5.5.3 UNIT 3 _TWO BEDROOM UNIT

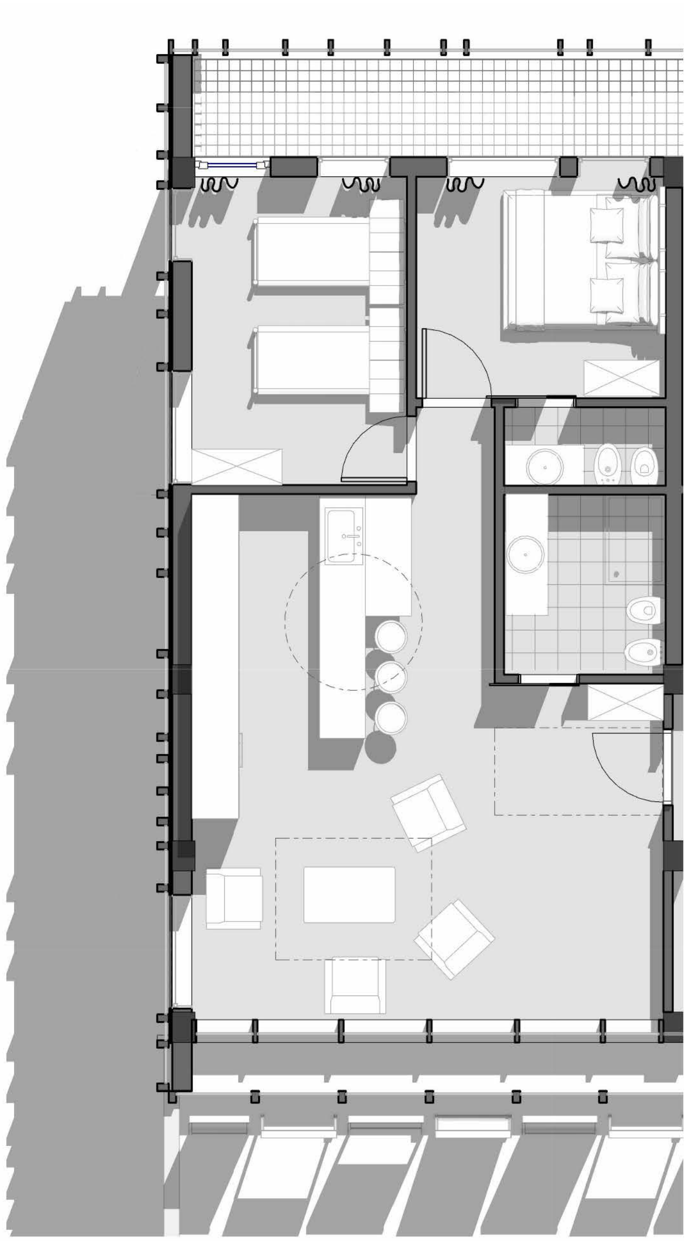
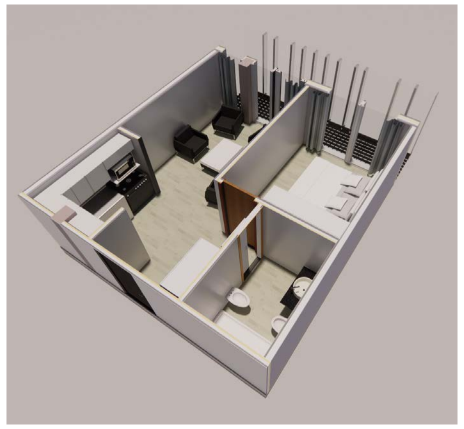


Fig 5.21
floors functional layout



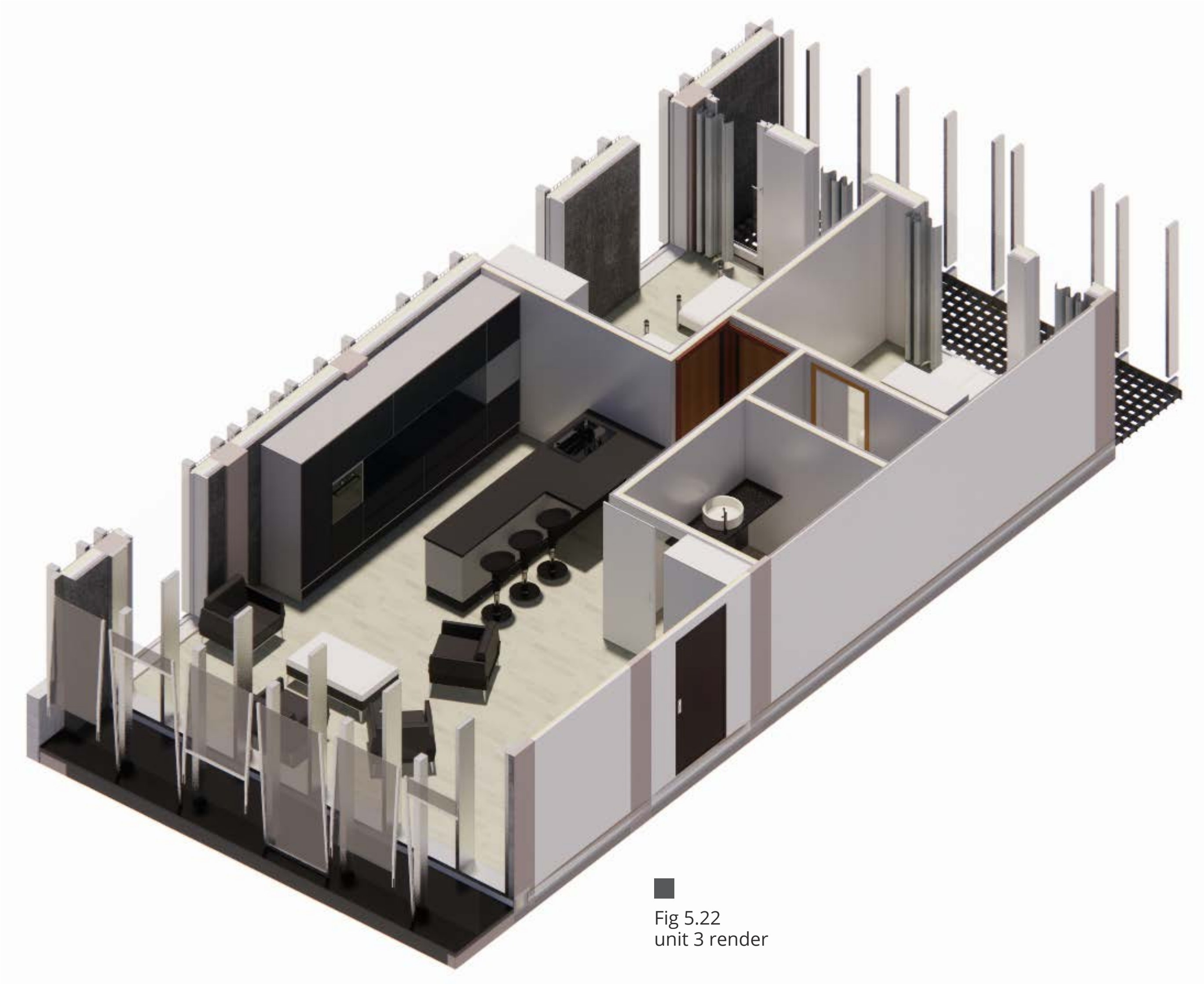


Fig 5.22
unit 3 render

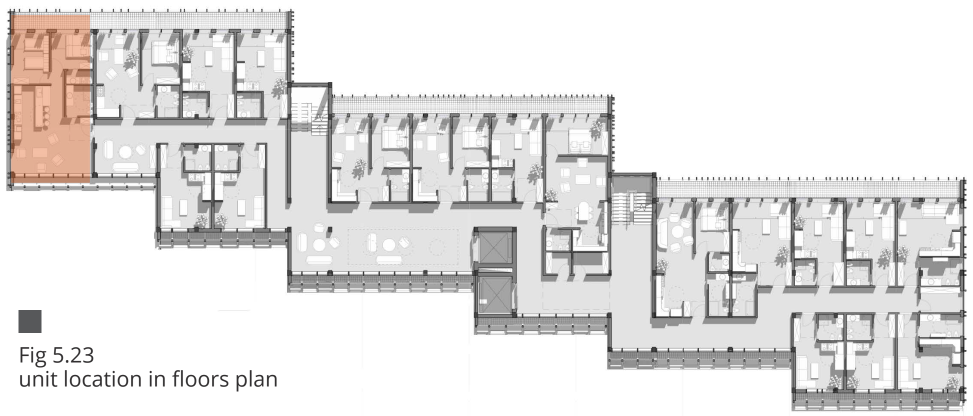


Fig 5.23
unit location in floors plan

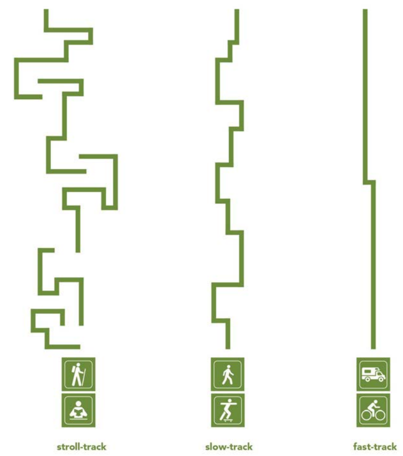
5.6 LANDSCAPE DESIGN

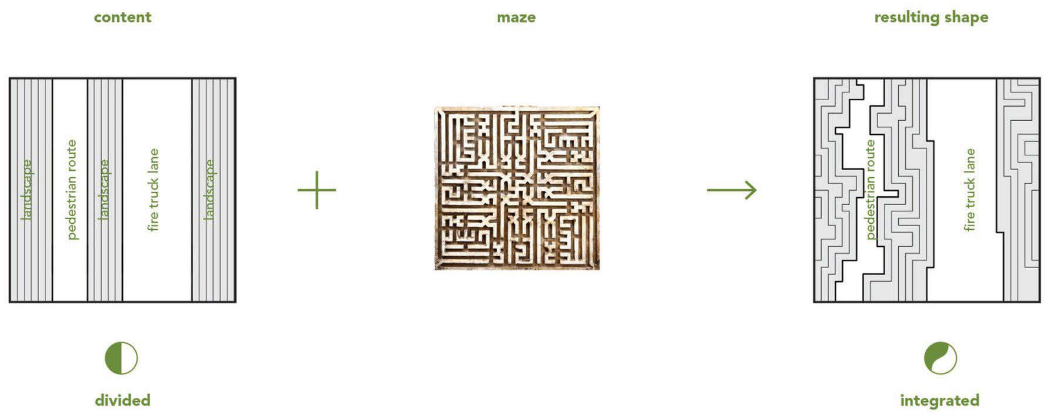
5.6.1 LANDSCAPE CASE STUDY : MAGIC BREEZE LANDSCAPE

- Interiors Designer : penda
- Location : Hyderabad, Telangana, India
- Project Team : Chris Precht, Sun Dayong, Zi Zhi, Xue Bai, Anna Andronova Project Year 2016
- Photographs : Courtesy of penda
- Architects : penda

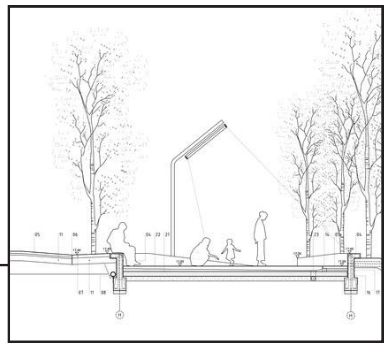
Penda has designed a landscape for Hyderabad, India, inspired by the country's stepwells and water mazes. When completed, the 8,000 square meter (85,000 square foot) Magic Breeze Landscape will serve 145 apartments in a development by Pooja Crafted Homes. Some of the landscape's signature features will be its bamboo coves, flower gardens, water displays, and built-in benches. The steps found throughout the landscape will double as planters for flowers, herbs, and grasses, that will serve as a communal garden for residents.

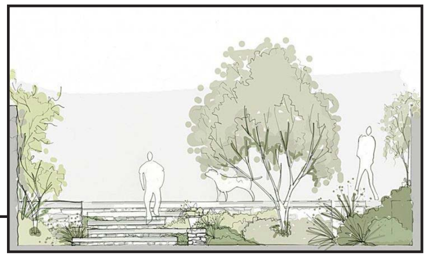
The landscape's maze-like characteristics allow for different experiences of the environment depending on the speed and purpose of the users: a wide, straight road is for runners, fast walkers, and emergency vehicles, a narrower walking path accommodates residents who want to quickly arrive at their apartments, and a third path takes more itinerant visitors onto the steps and through gardens in a more leisurely and transportive manner. The parks stepped and rectilinear appearance may for some recall the mid-century modern landscapes of Lawrence Halprin, or Dan Kiley's roof gardens for the Oakland Museum; building by Kevin Roche and John Dinkeloo.





5.6.2 LANDSCAPE PLAN

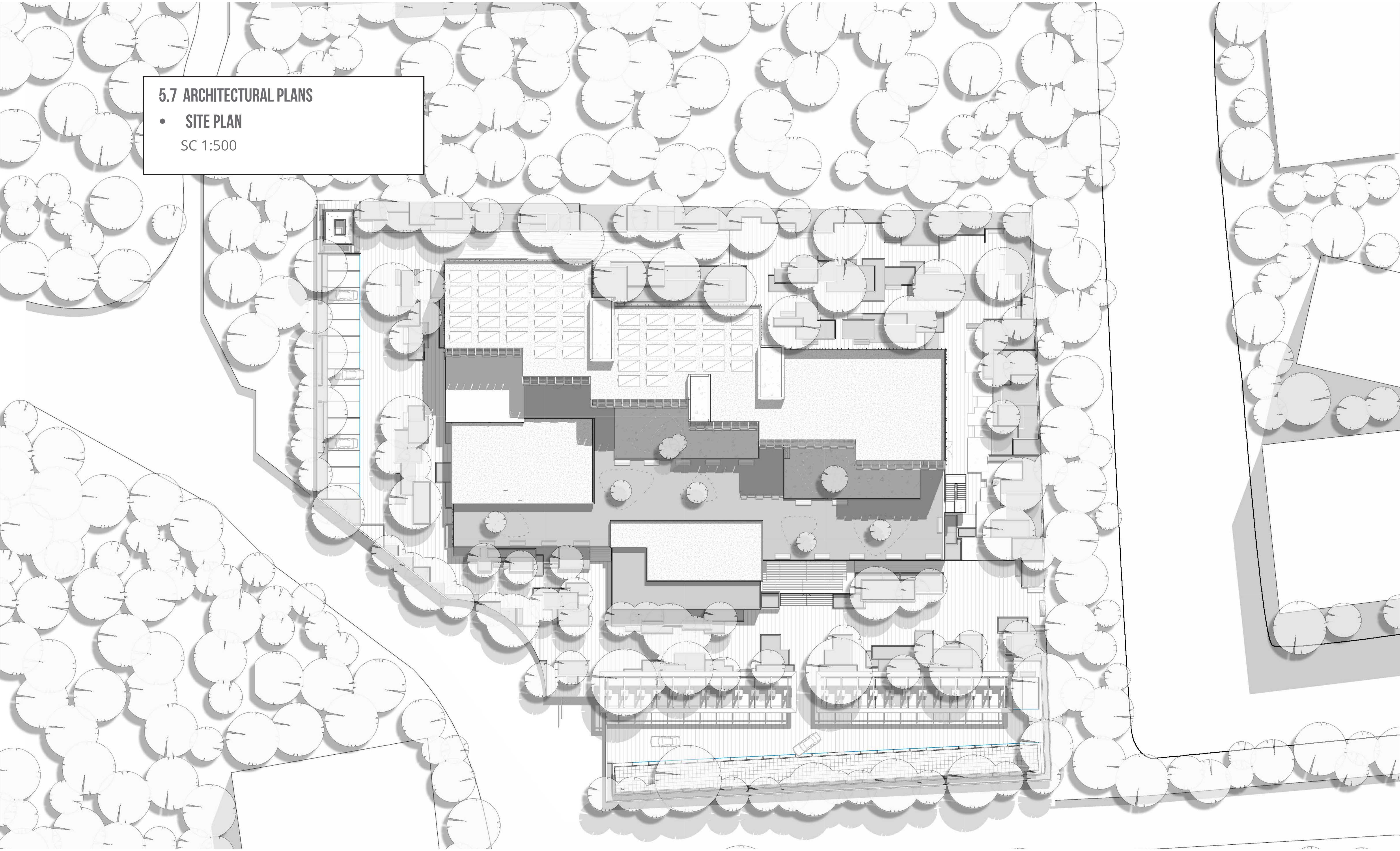


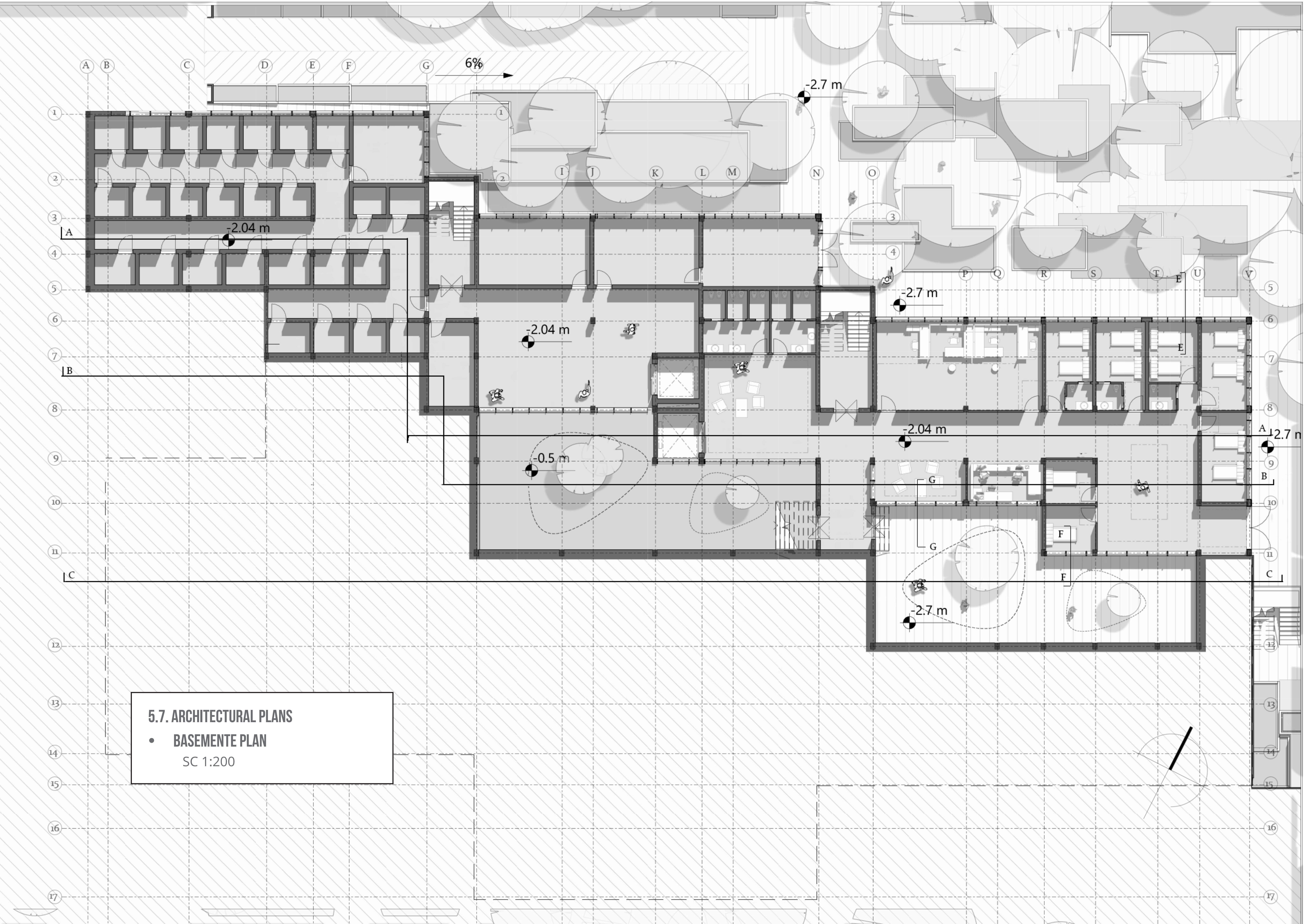


5.7 ARCHITECTURAL PLANS

- **SITE PLAN**

SC 1:500

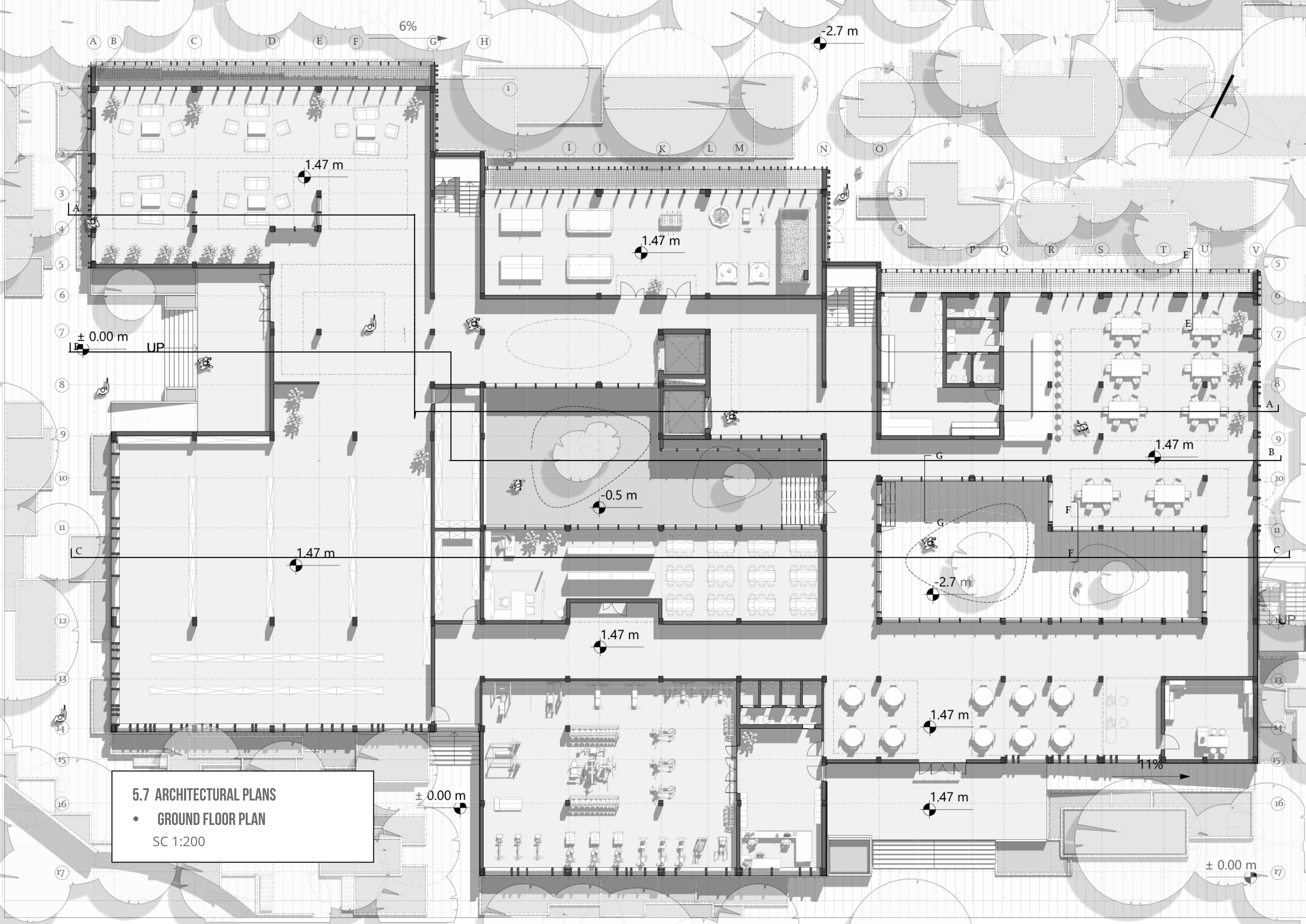




5.7. ARCHITECTURAL PLANS

- **BASEMENTE PLAN**

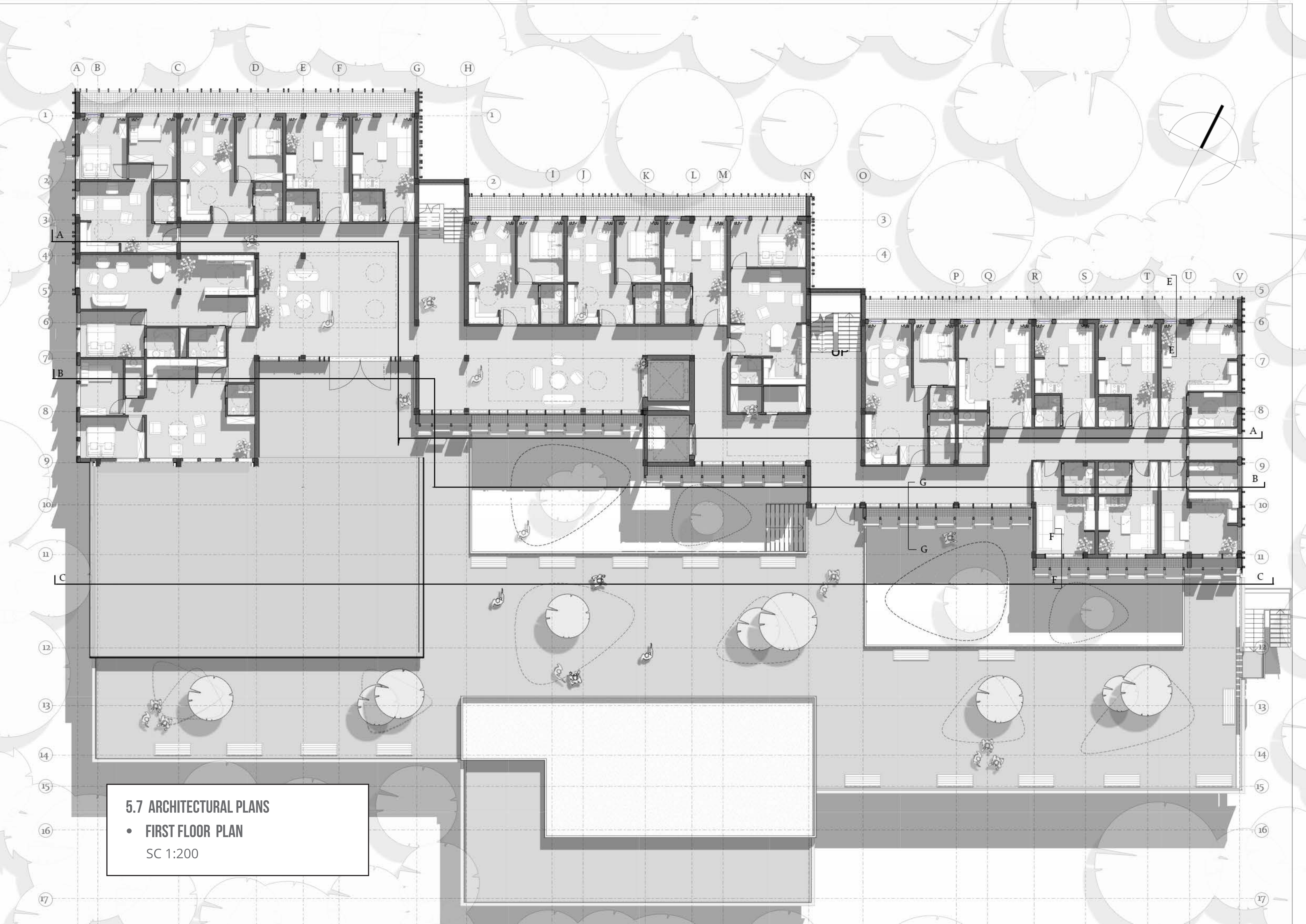
  SC 1:200



5.7 ARCHITECTURAL PLANS

- GROUND FLOOR PLAN

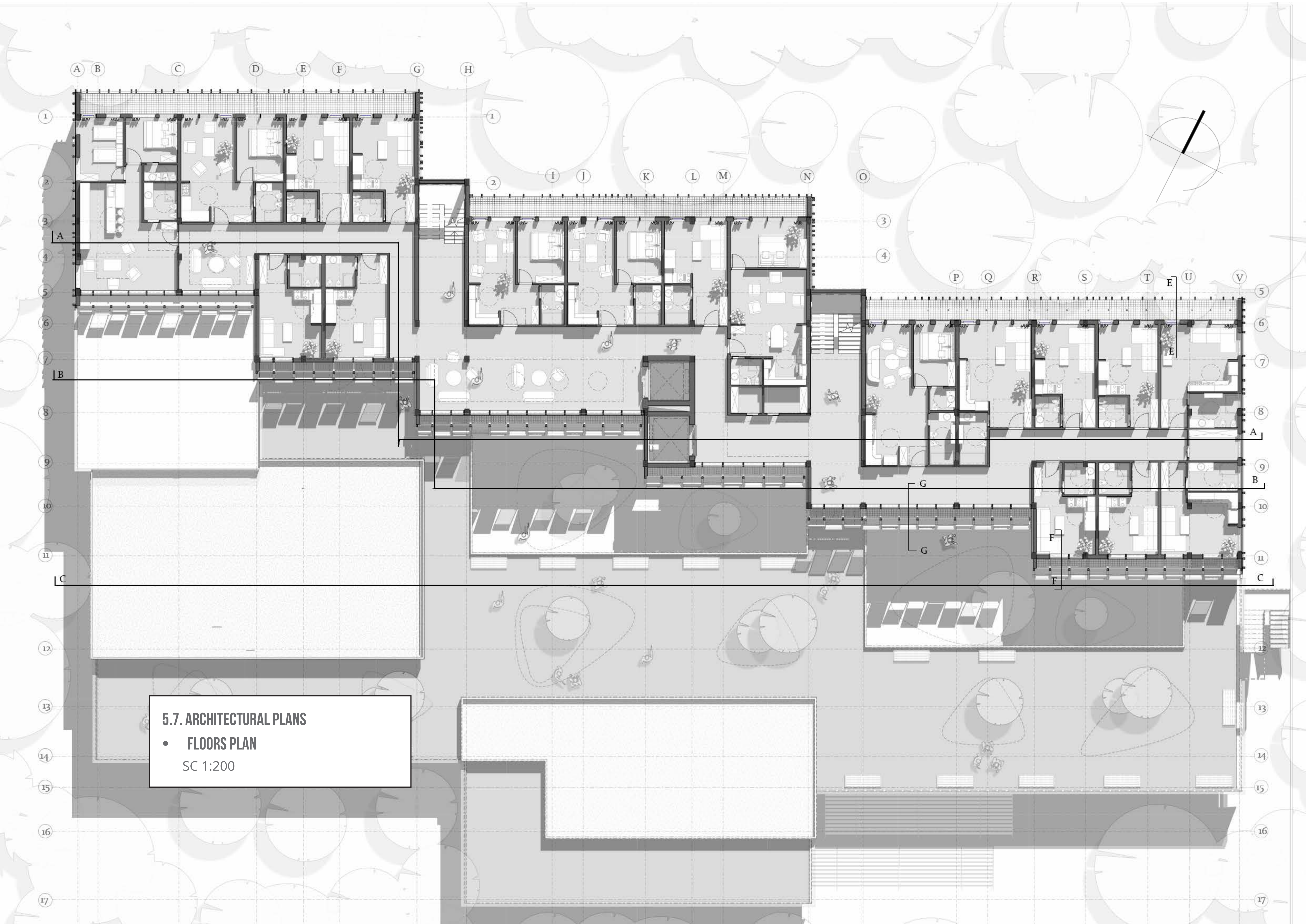
SC 1:200



5.7 ARCHITECTURAL PLANS

- **FIRST FLOOR PLAN**

SC 1:200



5.7. ARCHITECTURAL PLANS

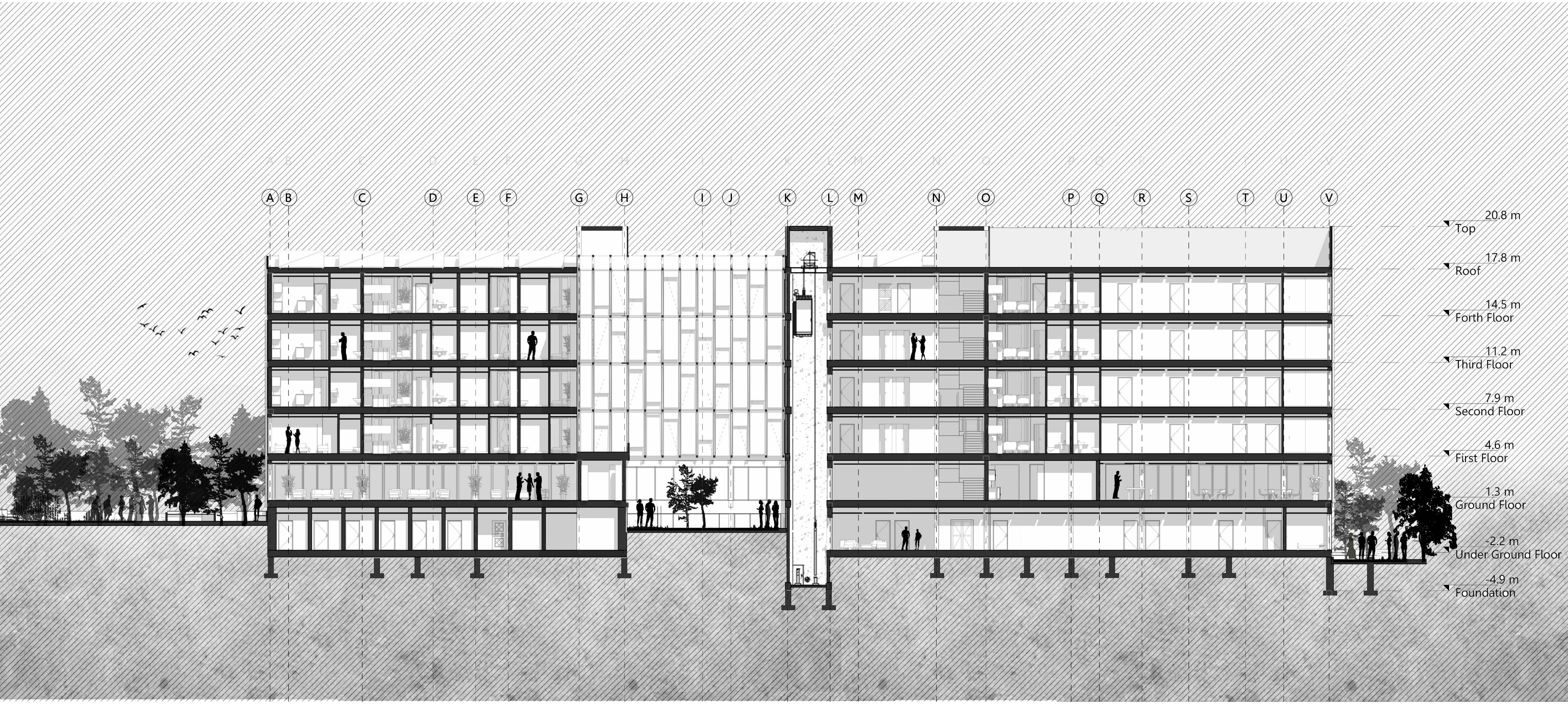
- FLOORS PLAN

SC 1:200

5.7. ARCHITECTURAL DETAILS

- **SECTION A_A**

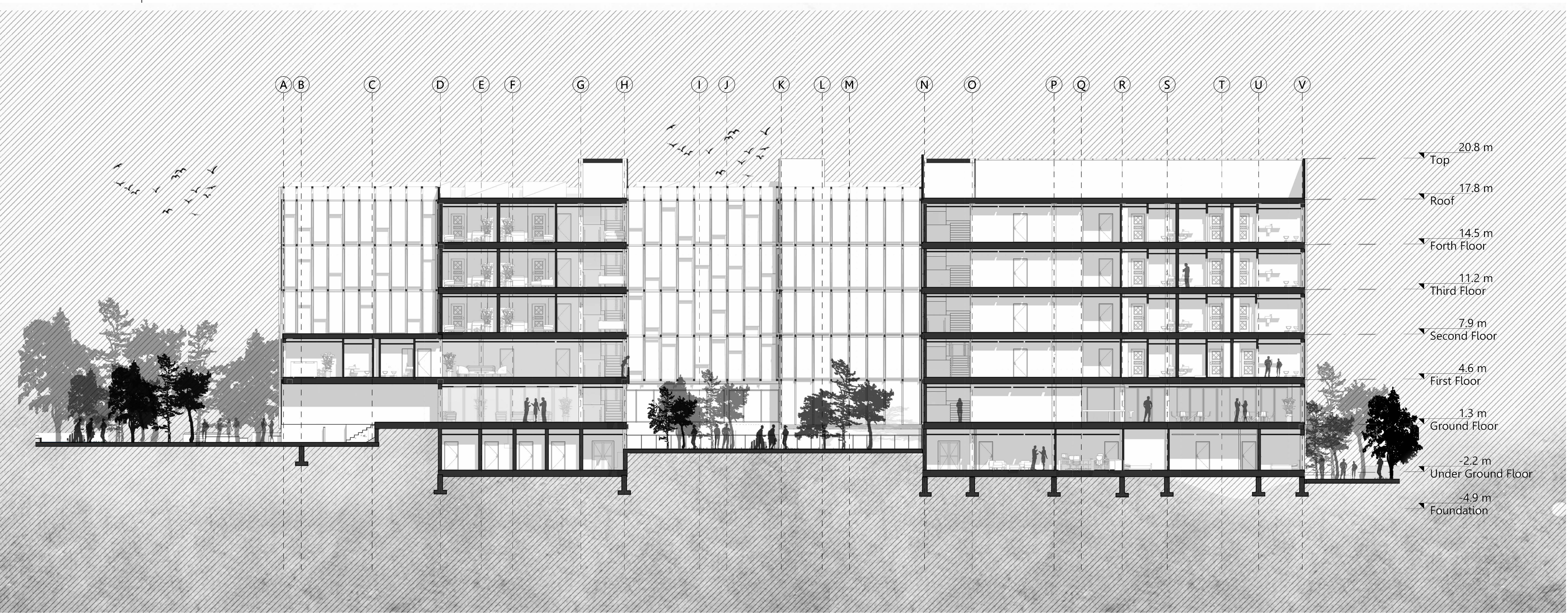
SC 1:300



5.7 ARCHITECTURAL DETAILS

- **SECTION B_B**

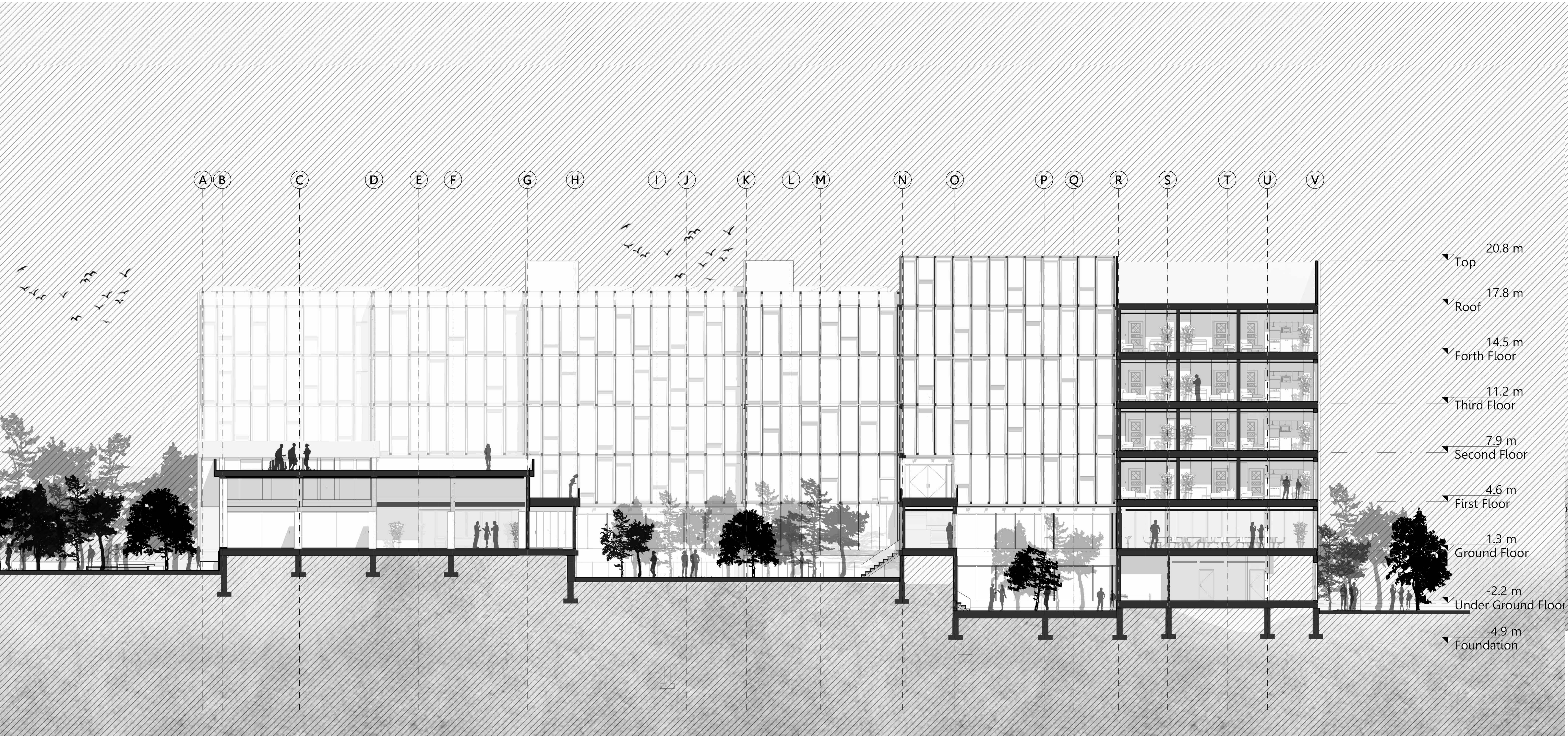
SC 1:300



5.7 ARCHITECTURAL DETAILS

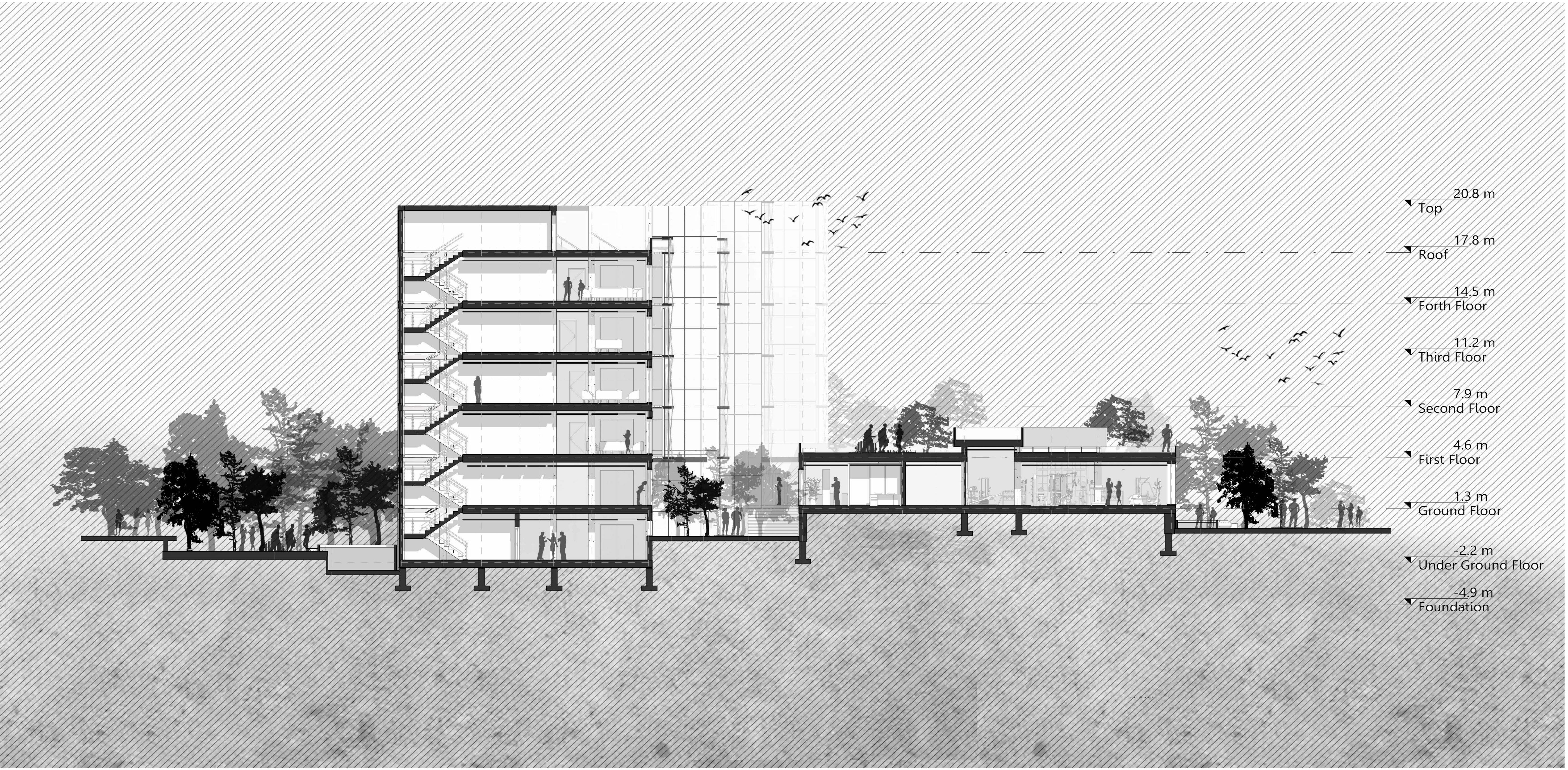
- **SECTION C_C**

SC 1:300



- SECTION D_D

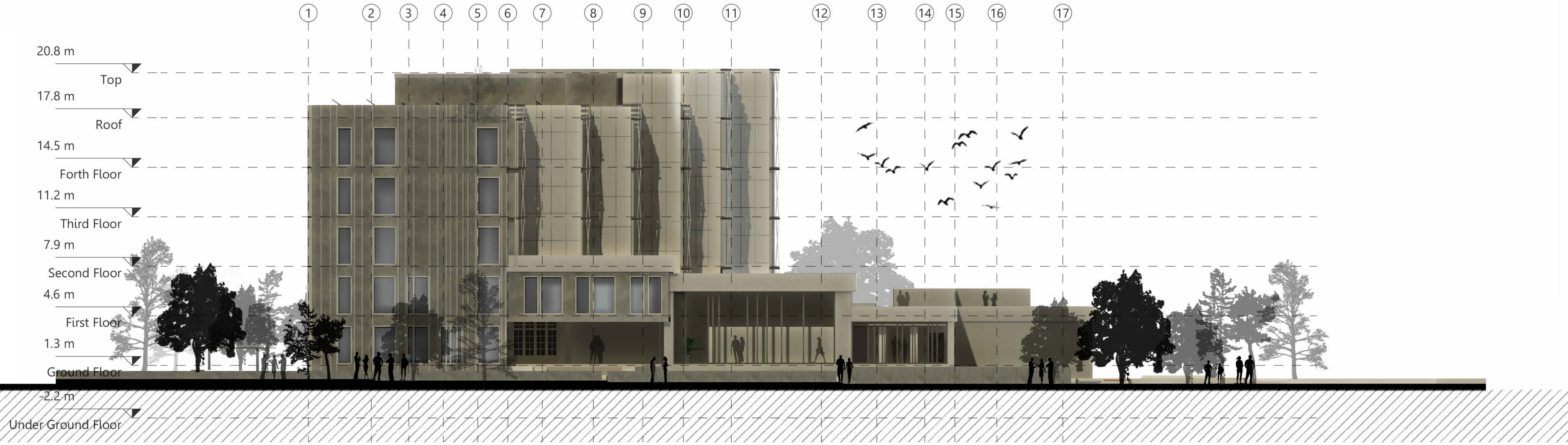
SC 1:300



5.7. ARCHITECTURAL DETAILS

- SOUTH_WEST ELEVATION

SC 1:300



5.7. ARCHITECTURAL DETAILS

- SOUTH_ EAST ELEVATION

SC 1:300

5.7. ARCHITECTURAL DETAILS

- NORTH_ EAST ELEVATION

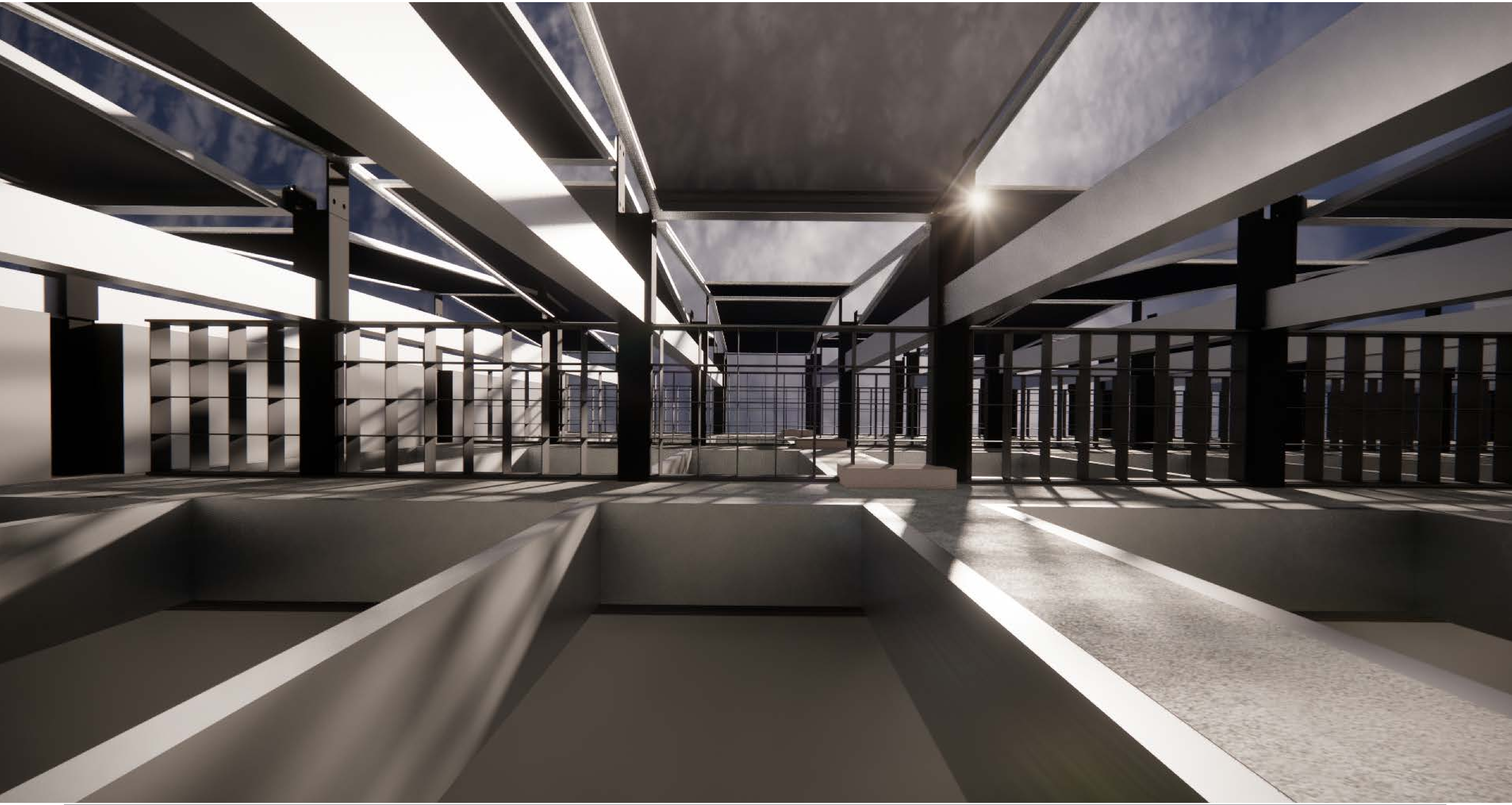
SC 1:300

5.7 ARCHITECTURAL DETAILS

- NORTH_ WEST ELEVATION

SC 1:300

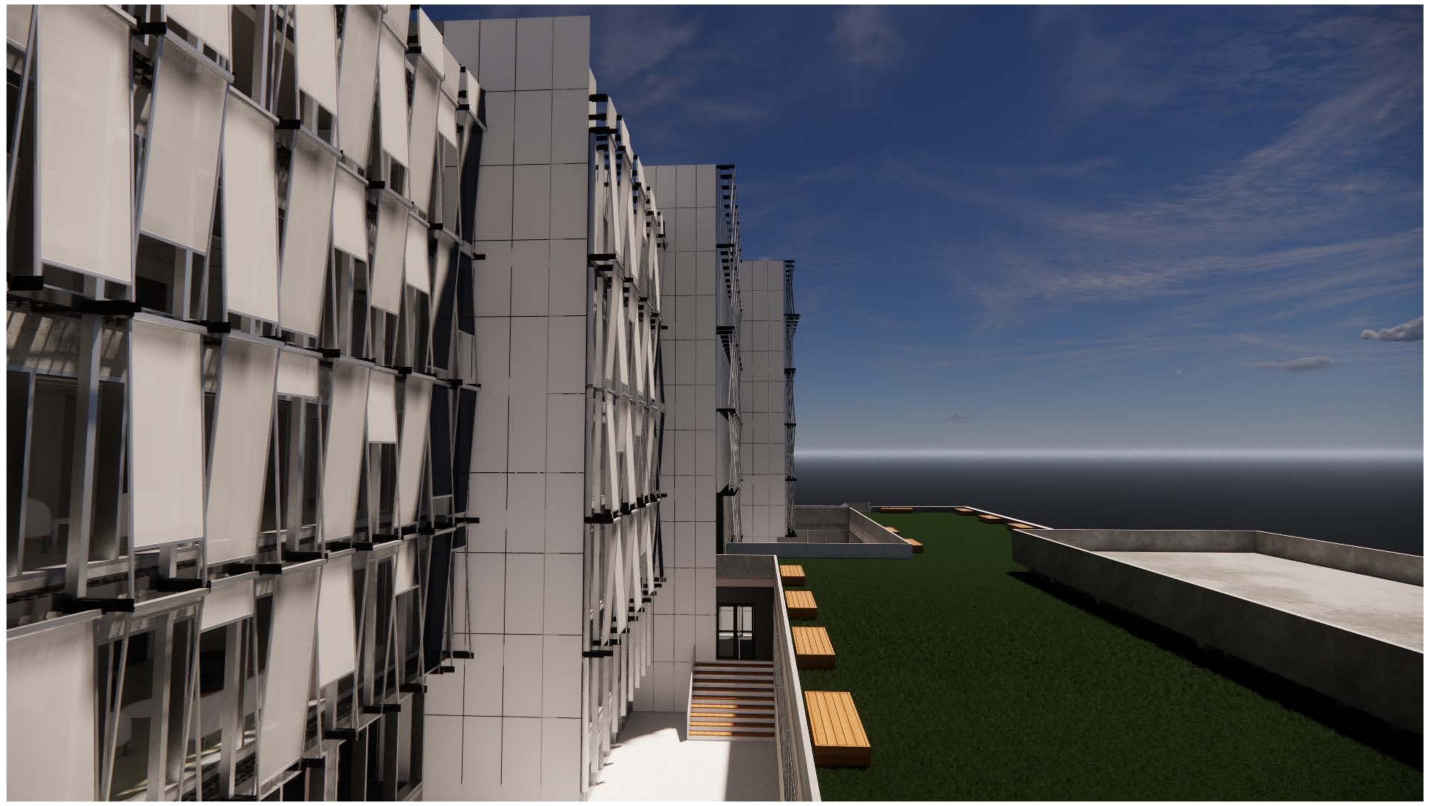
5.7 ARCHITECTURAL DETAILS
- RENDERS

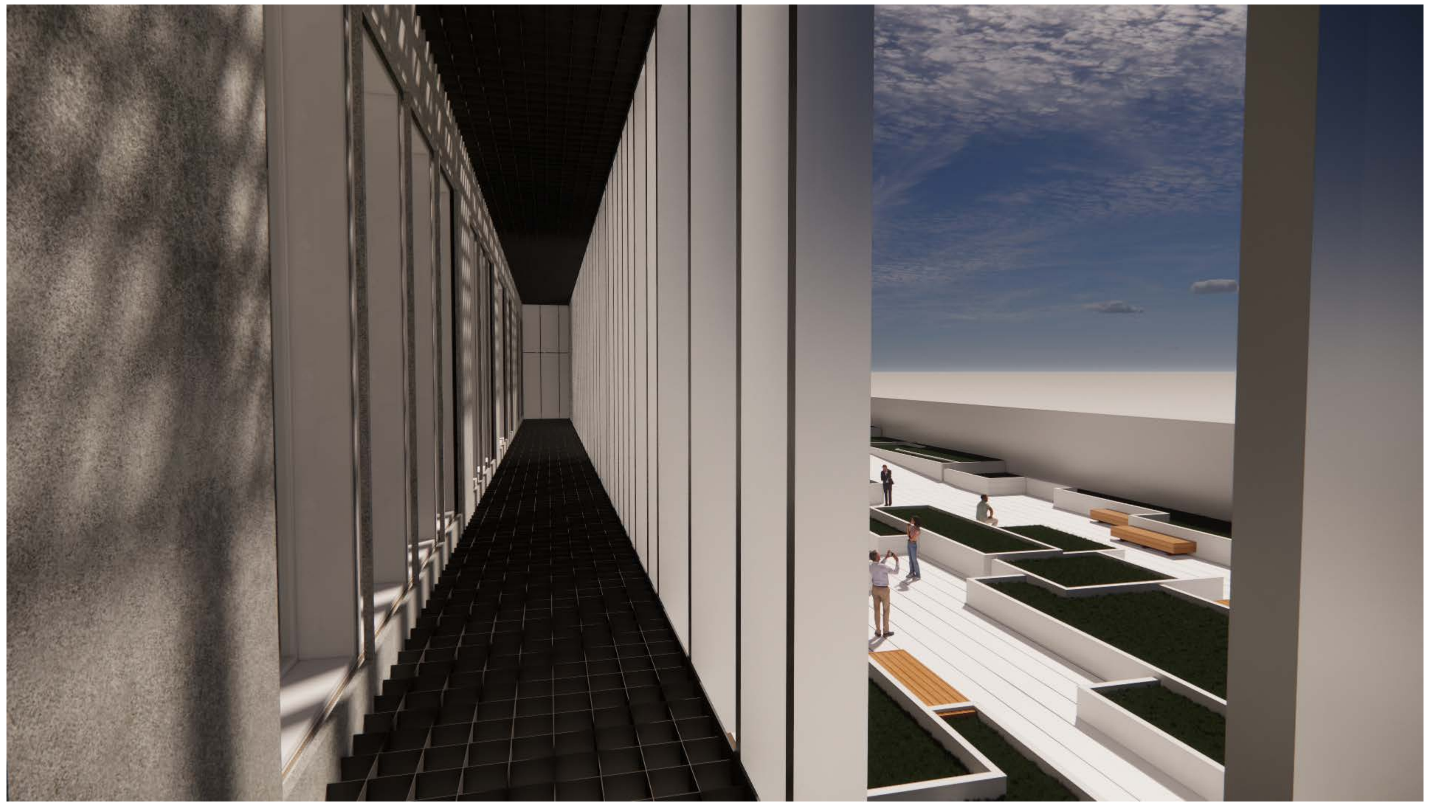


5.7 ARCHITECTURAL DETAILS

- RENDERS

5.7 ARCHITECTURAL DETAILS
- RENDERS





5.7 ARCHITECTURAL DETAILS
- RENDERS

5.7 ARCHITECTURAL DETAILS
- RENDERS

sitting area

unit 2 , living room

5.7 ARCHITECTURAL DETAILS
- RENDERS

GYM ,office

GYM

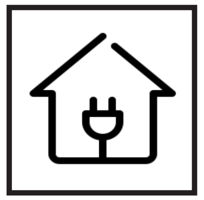
6

BUILDING TECHNOLOGIES

6.1 SCHEMATIC DESIGN

Ventilation

Atrium induces the air flux inside the building, moving the hot air from lower floors upwards. Moreover, the area of the balcony is naturally ventilated, whichmakes it more comfortable for occupants during summer period.



Energy efficiency:

-Solar panels

In order to decrease energy consumption of the building and make it more sustainable, the PV panels were placed on the south part of the roof. The area of PV panels was calculated considering the most effectivelayout in terms f energy consumption.

-solar heating pannels

During the winter period it allows to use less energy to heat the air inside the HVAC unit. Meanwhile, in the summer period the temperature of the air can be maintained in comfortable range without big energy demands.

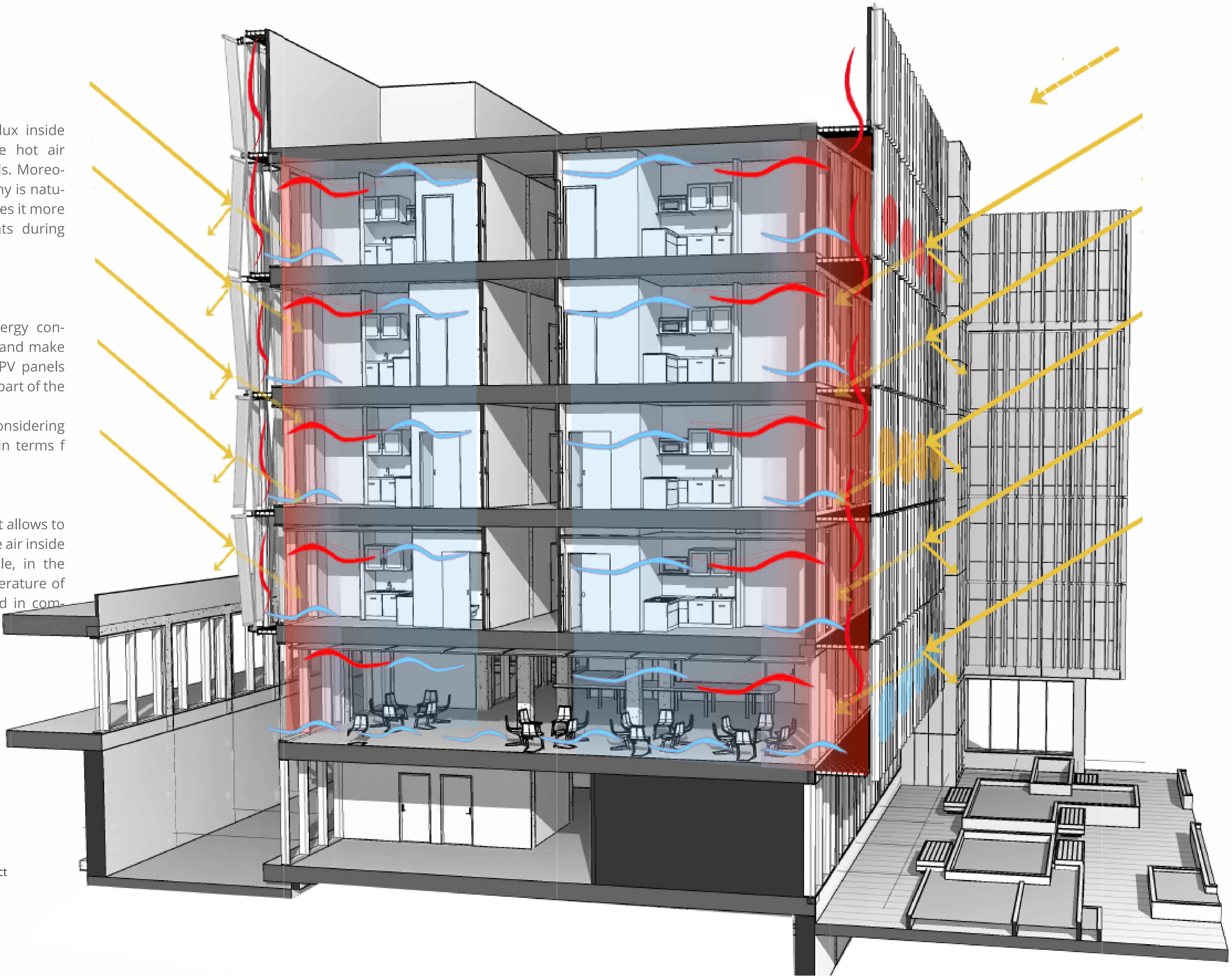


Fig 6.1
schematic design of the project

6.2 SCHEMATIC DESIGN

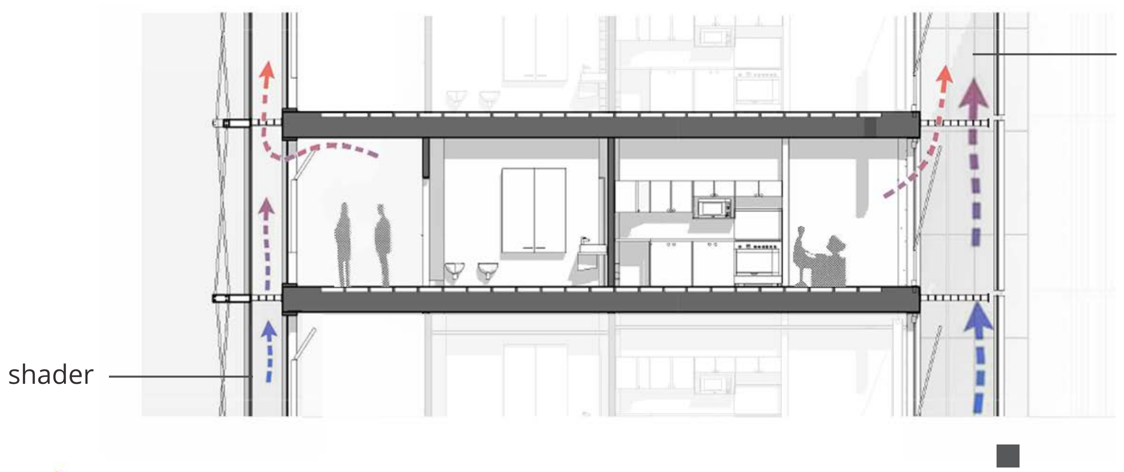


Fig 6.2
cross ventilation _ open plan

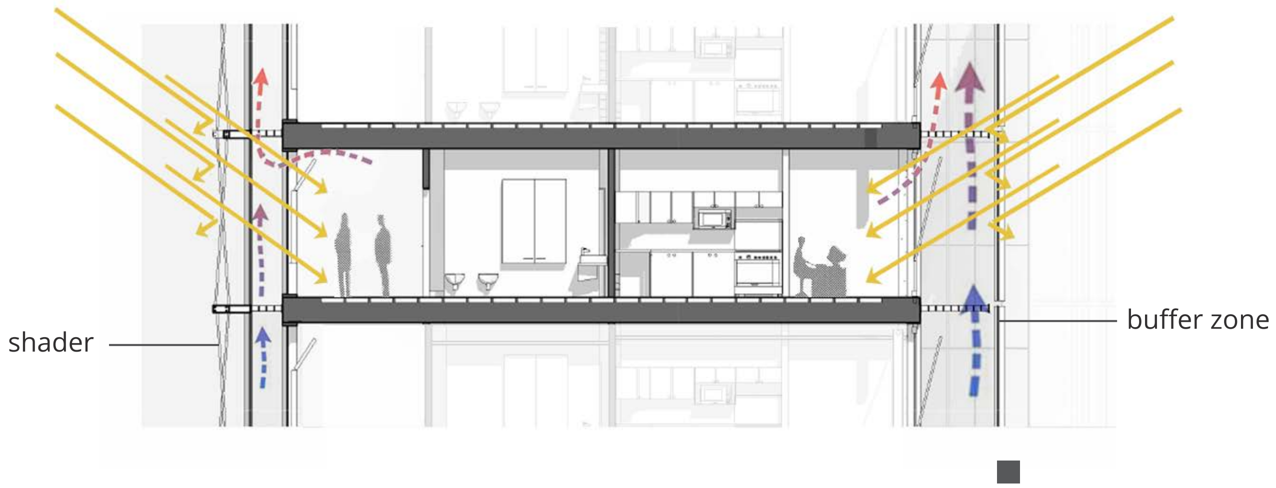


Fig 6.3
sun protection _ harsh climet

Fig 6.3
thermal mass _summer

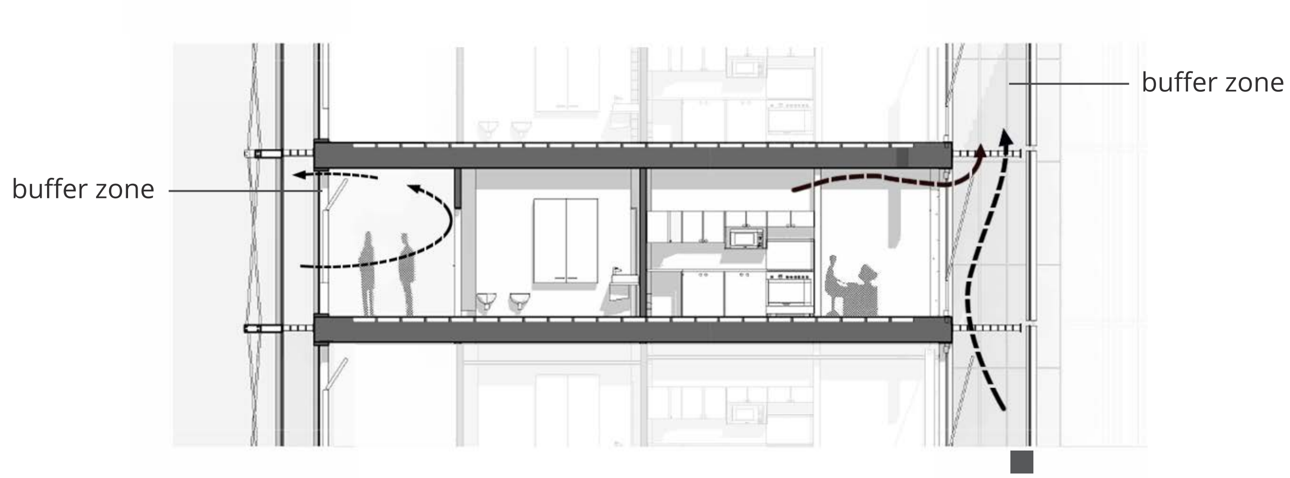


Fig 6.4
natural ventilation
supply fresh air

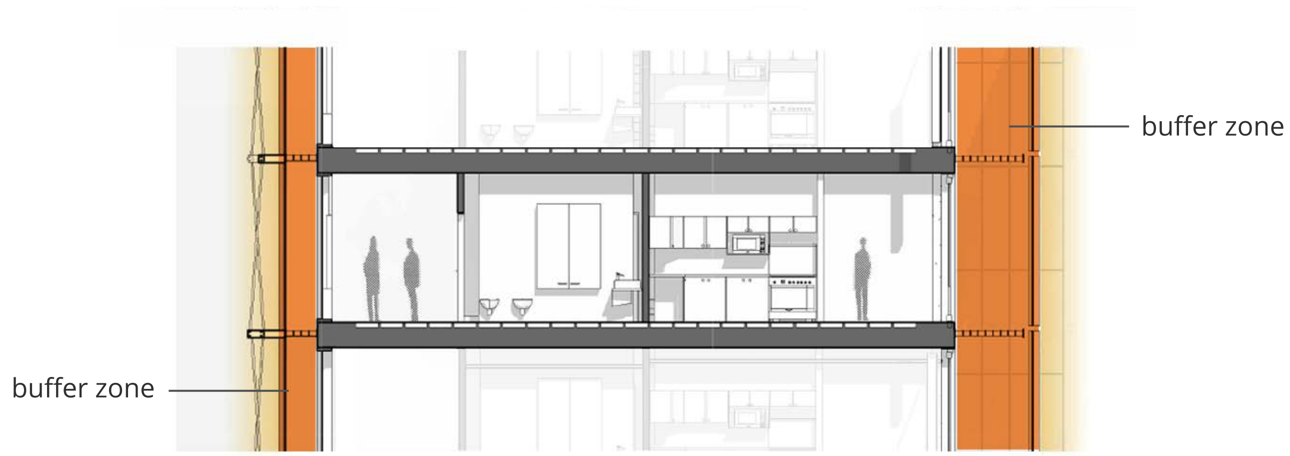


Fig 6.5
heat protection _winter

6.3 INTRODUCTION OF THE MATERIAL

6.3.1 ROCKWOOL

Summery :
Rock wool or mineral wool, comes in easy-to-install batts, similar to fiberglass. But instead of being composed of fluffy glass fibers, is made of rocks.
Rock wool insulation provides thermal and sound insulation and can be used as a firestop between floors.

The features:

- Made from natural, sustainable material

Typically contains up to 75 percent recycled content

- Retains heat well and traps air, which slows the transfer of heat
- Non-combustible and fire resistant to about 1,400 degrees
- Highly water repellent
- Excellent sound-deadening properties
- Higher insulating value than fiberglass
- Long-term performance—rock wool doesn't degrade over time
- Allows moisture to escape
- Dense, firm batts are friction-fit into place; no stapling necessary

Best usage situation :
actually it's particularly well-suited for rooms along the cold north side of the house and for interior rooms in need of sound deadening.
Because rock wool is highly fire resistant, it's ideal for use as a firestop between floors of a house.
The rock-wool fibers are compacted so tightly together that there's no chance of the insulation shifting out of position or slumping down, which would dramatically decrease its insulating value.

rock-wool insulation only comes un-faced, meaning there's no kraft-paper or foil barrier.
Depending on the situation, you may need to install an independent permeable membrane to serve as a vapor barrier.

About the price :

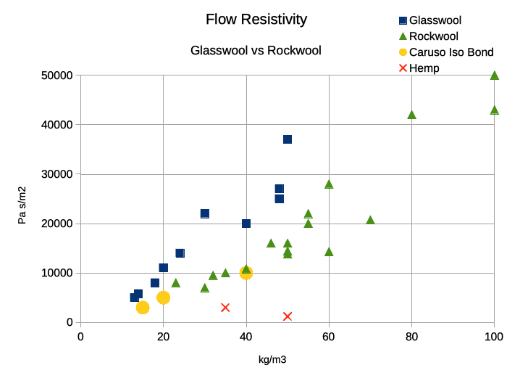
Fiberglass insulation for a 2×6 wall costs between 57 cents and 72 cents per square foot. Rock-wool insulation for the same wall cost about $1.06 per square foot. That's a significant difference, especially if you're insulating an entire house or large addition.

However, in most cases, you'll recoup the additional cost through lower energy bills, because, while fiberglass insulation has an R-value of 19, rock wool has an R-value of 23. The increased insulation capability allows you to keep your home at a comfortable temperature for longer without needing to adjust your thermostat, meaning you'll make up the initial cost within a couple years.

Plus, with rock wool insulation's long-term durability, your home will be well-insulated with little maintenance needed for years to come.

Fig 6.6
roclwool

- The relationship between weight and flow resistivity is most clearly shown in a graphic.



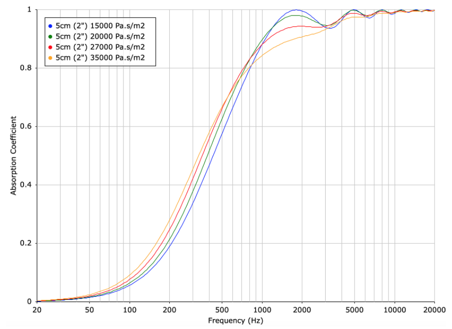


Fig 6.7
5cm without gap

EXAMPLES OF DIFFERENT ABSORBER DEPTHS

- the following examples, give a small guideline to find a reasonable flow resistance

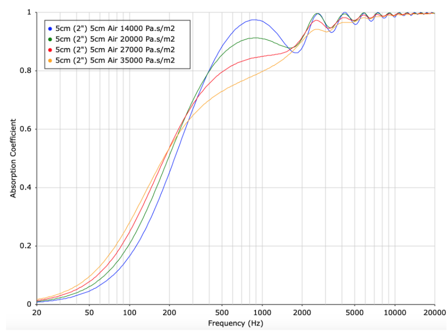


Fig 6.8
5cm (2") with 5cm (2") wall distance

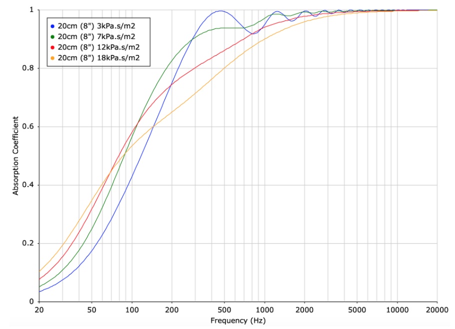


Fig 6.11
20cm (8") without gap

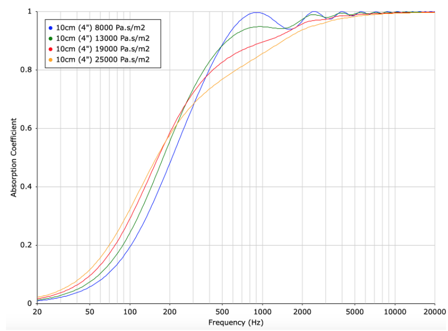


Fig 6.9
10cm (4") without gap

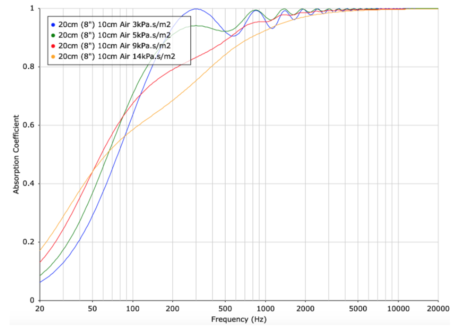


Fig 6.12
20cm (8") with 10cm (4") gap

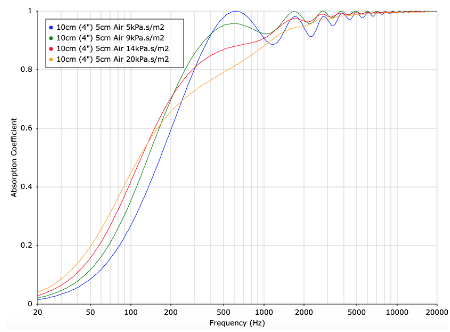


Fig6.10
10cm (4") with 5cm (2") gap

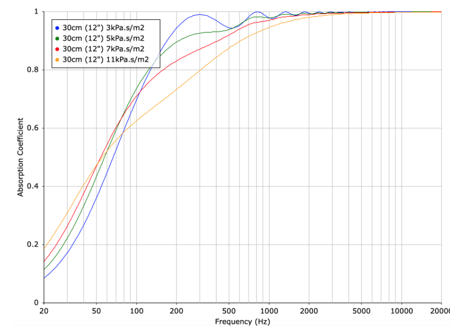


Fig 6.13
30cm without wall distance

6.3.2 KANAF AQUAPANEL/CEMENT BOARD OUTDOOR

Description

AQUAPANEL Cement Board Outdoor is a panel made of aggregatedPortland cement with coated glass fibre mesh embedded in back and front surfaces.

It offers all the benefits of a dry panel system with the strength of brick and block.

Transportation and storage

Always carry boards upright using a board trolley or on a pallet using a forklift truck. The supporting surface must be able to carry the weight of the boards.

AQUAPANEL Cement Board Outdoor must be protected from the effects of moisture and weather before installa-tion. Boards that have become damp must be dried on both sides before use.

Allow time for the boards to acclimatise to the ambient temperature and moisture conditions before installation. The material, ambient air and background temperature must not be below +5°C.

Fileds of Application For exterior applications:

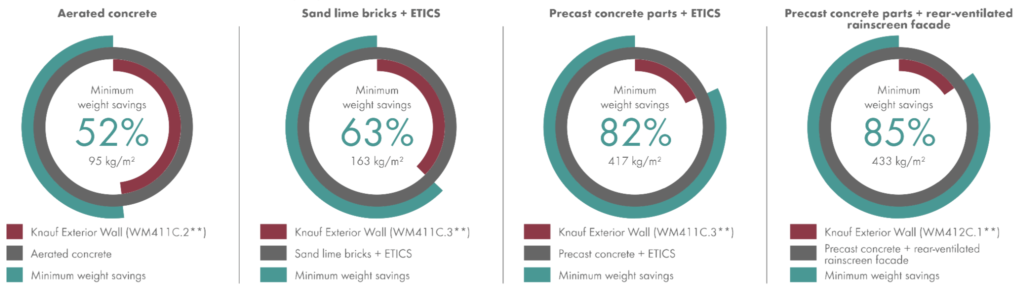
- Exterior walls
- Wall claddings
- Suspended ceilings under canopy

Properties

- Weather-resistant
- 100% water resistant
- Strong, robust, impact-resistant
- Chip and cellulose free
- A1 class non-combustible material
- Mould and fungus resistant
- Can be cut using “score and snap” technique
- Can be bent when dry - up to 1 metre bending radius
- Simple and easy to install

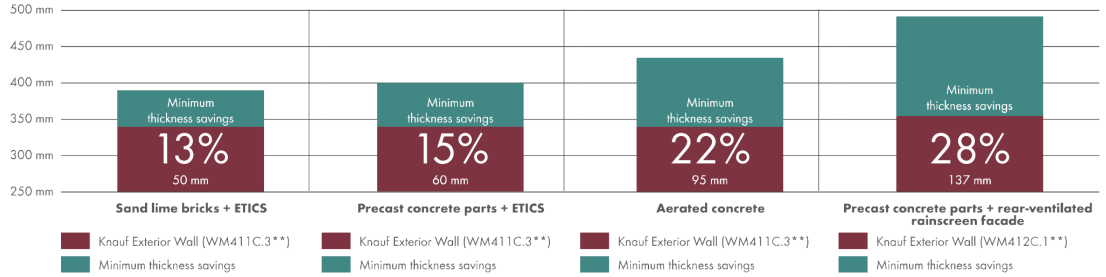
Minimum weight savings due to the usage of Knauf Exterior Wall compared with traditional solutions*

hese figures show the minimum difference in weight per square metre of an undisturbed wall based on the six drywall olutions, shown in this brochure (see pages 26-49).

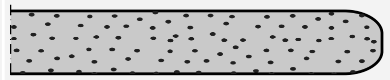
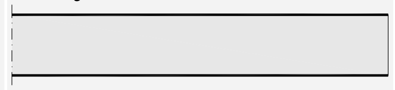


Minimum difference in wall thickness of Knauf Exterior Wall compared with traditional solutions*

These figures show the minimum difference in wall thickness based on the six drywall solutions, shown in this brochure (pages 26-49).



Technical Data

Description	Unit	12,5 mm	Standard
Reaction to fire	class	A1	EN 13501
Weight	kg/m²	appx. 16	-
Long edges	-	Round edges (EasyEdge™) 	-
Front edges	-	Cut edges 	-
pH value	pH	12	-
Min. bending radius (full board)	mm	r ≥ 3000	-
Min. bending radius (300 mm wide strip)	mm	r ≥ 1000	-
Thermal conductivity λ	W/(m·K)	0,35	EN ISO 10456
Water vapour diffusion coefficient	μ	66	EN ISO 12572
Thickness variation (65% - 85% humidity)	%	0,2	EN 318
Length variation (65% - 85% humidity)	mm/m	0,23	EN 318
Bending strength	MPa	≥ 7	EN 12467
Shearing strength	N	607	EN 520
Tensile strength perpendicular to the plane of the board	N/mm²	0,65	EN 319
Thermal expansion	$(10^{-6}K^{-1})$	7	-

Product Range

Description	Width (mm)	Length (mm)	Weight (kg/m²)	Packaging (pcs./pallet)	Material Number
AQUAPANEL® Cement Board Outdoor 12,5 mm	1200	2400	approx. 16	30	129866
	1200	2500	approx. 16	30	103617
	1200	2800	approx. 16	30	103618

6.4 OPAQUE

6.4.1 ACOUSTICALLY INSULATED PARTITION PREFABBRICATED

Acoustic insulation is installed between two leaves of plasterboard. Variables within the system can include the type of plasterboard used, the types of studwork used and the orientation of studwork, all of which can be varied to provide differing levels of performance.

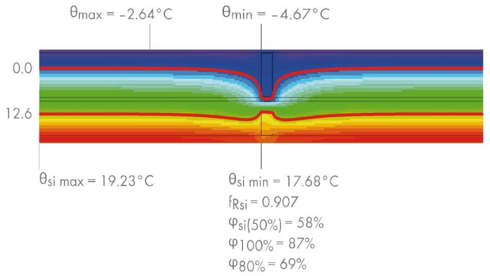
In addition to high levels of mass which is provided by the plasterboard layers, absorbent insulation is used to improve the sound reduction properties of internal walls. In certain buildings there may also be specific fire resistance requirements for walls between specific room types.

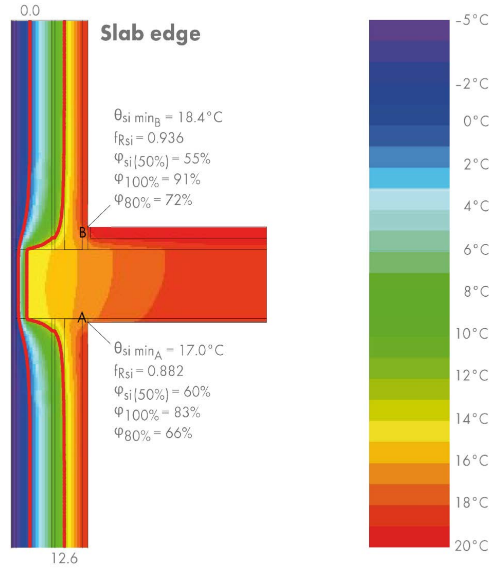
Our non-combustible solutions for internal walls provide the high levels of absorption required to contribute to excellent levels of sound reduction, and can also help towards high levels of fire resistance where required.

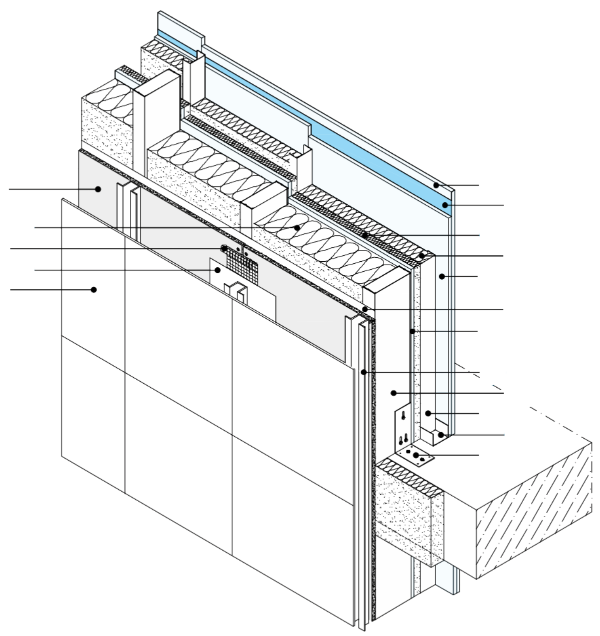
Fig 6.14
prefabricated insulated partition

6.4.3 DOUBLE STUD, THIRD-PARTY RAINSCREEN FACADE

In this WM412C.1 system Knauf Exterior Wall facade profiles 150 are boxed in one another, providing the necessary support to allow for the attachment of cladding materials. The cladding is mounted to the AQUAPANEL® Cement Board Outdoor simply using a hat profile and because the required insulation is already installed inside the drywall, the advantages of drywall and rear-ventilated rainscreen facades are combined in a very thin construction of only 355 mm. With this solution the versatility of AQUAPANEL® Cement Board Outdoor becomes apparent: rather than simply being just a render carrier.







1 Knauf Exterior Wall Steel Angle 70x135/100 (min. corrosion protection C3)
2 Knauf Exterior Wall Facade Profile 150 (min. corrosion protection C3) – boxed
3 AQUAPANEL® Water Barrier
4 AQUAPANEL® Cement Board Outdoor
5 AQUAPANEL® Joint Tape (10 cm)
6 AQUAPANEL® Joint Filler – grey
7 Hat profile (to be provided on site)
8 Rear-ventilated rainscreen facade system (to be offered by third-party supplier)
9 Insulation board (thickness: 150 mm) according to local needs
10 Gypsum board: Knauf Diamant 12.5 mm (GKFI/DFH2IR)[1] or similar
11 UW-stud 75/40/06 (min. corrosion protection C3)
12 CW-stud 75/50/06 (min. corrosion protection C3)
13 Insulation roll (thickness: 40 mm) according to local needs
14 Insulation board (thickness: 75 mm) according to local needs
15 Gypsum board: Knauf Diamant 12.5 mm (GKFI/DFH2IR)[1] or similar
16 Vapour barrier: Knauf Insulation LDS 10 silk or similar
17 Gypsum board: Knauf Diamant 12.5 mm (GKFI/DFH2IR)[1] or similar

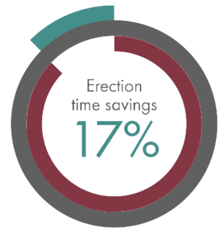
[1] acc. to DIN 18180 and EN 520

› Wall thickness: 355 mm › Weight: 79.16 kg/m² › Construction time: 130 min/m²
All figures are valid for a stud spacing of 600 mm, exterior profile web height of 150 mm and depend on the choice of the ventilated facade system (here: 40 mm wall thickness, 10 kg/m² weight and 45 min construction time)

Based on a specific intended use and location of a building, the dead weight is the most important factor of the total loads, which can be influenced by planning. Basically, lower loads enable a leaner structure and thus significant cost savings.

The calculation of explicit cost saving amounts for load-bearing walls and ceilings as well as foundations achieved by the weight reduction when using Knauf Exterior Wall is generically not possible, since this is always to be calculated project specifically on the basis of floor plan geometries, spans and the load-bearing capacity of the building ground.

29 tons WM412C.1 | 188 tons Precast concrete parts + rear-ventilated rainscreen facade | 159 tons Weight savings



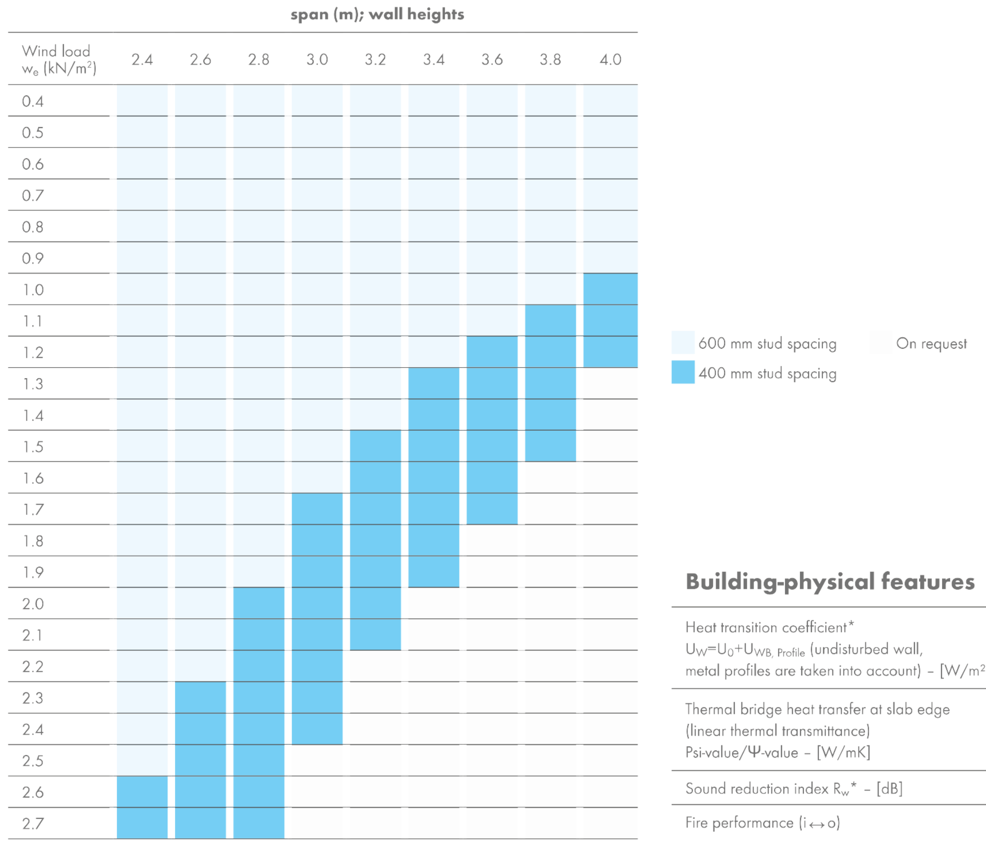
With a longer production time, considerable costs for personnel employment are involved. Additionally, a longer building process means a longer supply of building site facilities, where costs should be minimised. The efficient construction of Knauf Exterior Wall as well as the shorter drying times and the significantly lower weather dependency compared to massive constructions offer a considerable cost reduction potential and entails much less risk in the planning of the construction process.

39 days WM412C.1 | 47 days Precast concrete parts + rear-ventilated rainscreen facade | 8 days Erection time savings

16.30 m² Space gain when using WM412C.1 compared to precast concrete parts + rear-ventilated rainscreen facade

€1,956.00 Additional income through rental (in €/year)**

By using Knauf Exterior Wall more space can be realised inside the building with a comparable thermal insulation value. Consequently, rentable space and resulting rental income are larger. For landlords and investors, the best possible use of the land area plays an important role. By using Knauf Exterior Wall, this area efficiency and land utilisation are significantly improved.



Building-physical features

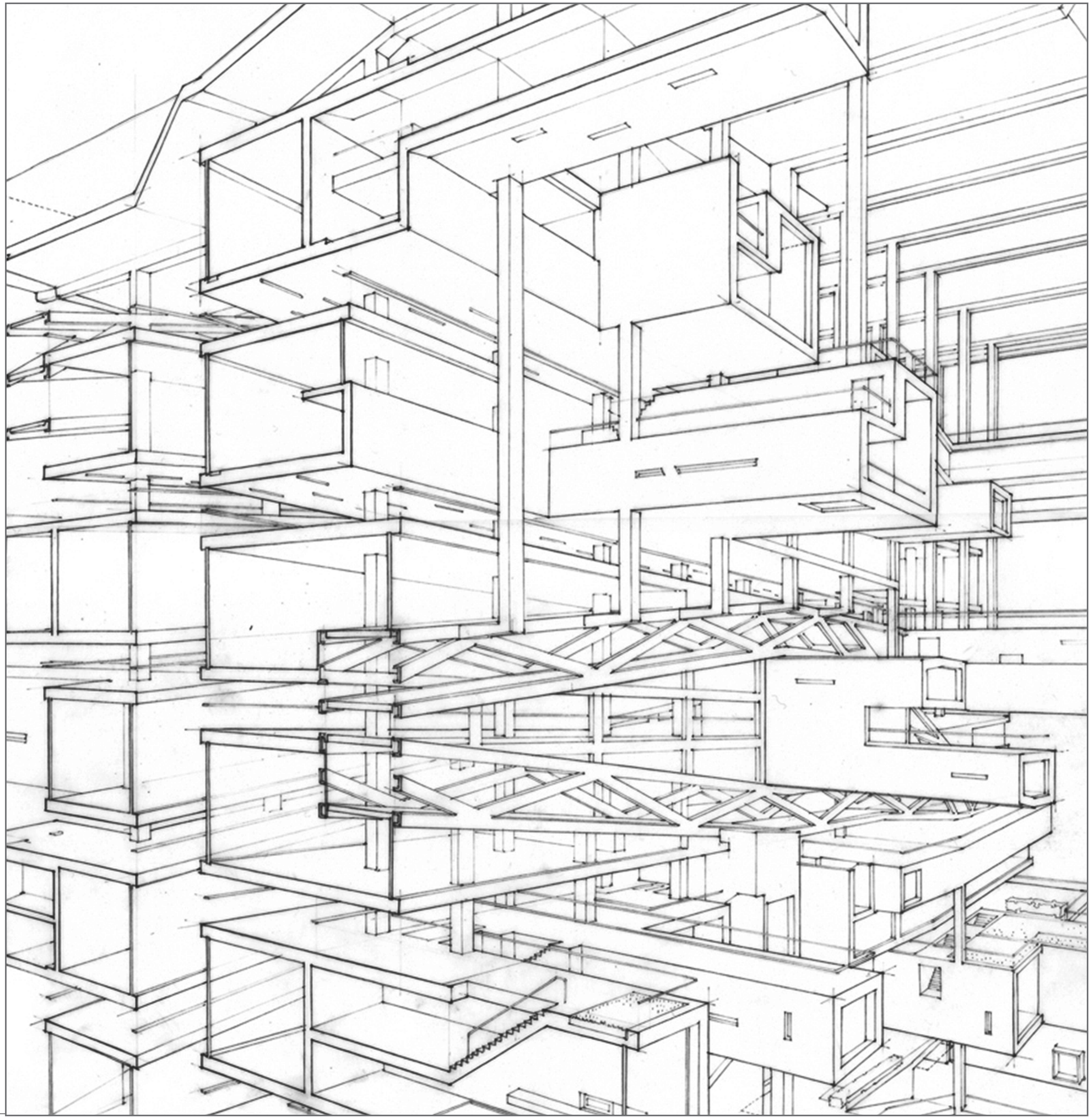
Heat transition coefficient* $U_W=U_0+U_{WB,\ Profile}$ (undisturbed wall, metal profiles are taken into account) – [W/m²K]	0.189
Thermal bridge heat transfer at slab edge (linear thermal transmittance) Psi-value/Ψ-value – [W/mK]	0.172
Sound reduction index R_w* – [dB]	73.8**
Fire performance (i↔o)	EI30

6.5 TRANSPARENT
6.5.1 WINDOWS TYPOLOGY

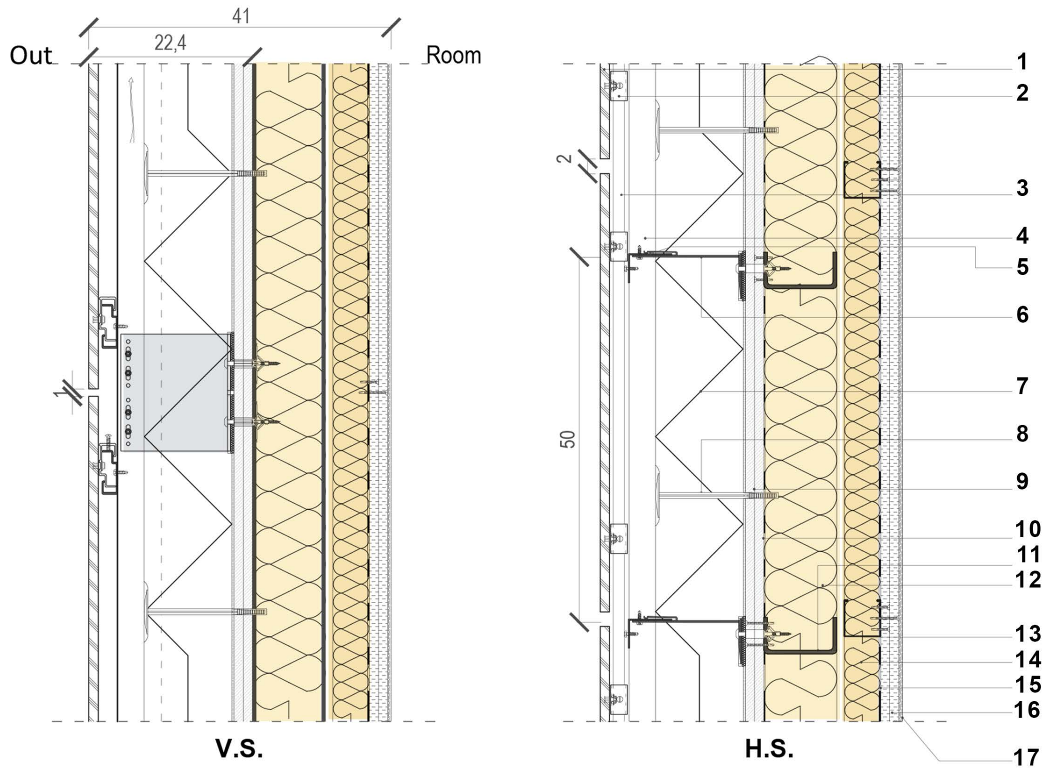
Window Schedule

Level	Family	Count	Height	Width	Head Height	Sill Height
Ground Floor	M_window single-hung	14	2.55 m	0.96 m	2.71 m	0.16 m
Ground Floor	M_window single-hung	40	2.55 m	0.96 m	2.72 m	0.17 m
Ground Floor	M_window dauble-hung	9	2.55 m	1.5 m	2.72 m	0.17 m
Ground Floor	M_window dauble-hung	2	2.55 m	2 m	2.72 m	0.17 m
Ground Floor	heroal VS Z - Front Mount - Single-Part	2	3.3 m	0.78 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	4	3.3 m	0.82 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	7	3.3 m	0.86 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	2	3.3 m	0.87 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	3	3.3 m	0.9 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	3	3.3 m	0.95 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	24	3.3 m	0.98 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	13	3.3 m	1.03 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	139	3.3 m	1.06 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	18	3.3 m	1.1 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	3	3.3 m	1.12 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	9	3.3 m	1.13 m		
Ground Floor	heroal VS Z - Front Mount - Single-Part	19	3.3 m	1.14 m		
First Floor	M_window single-hung	27	2.55 m	0.96 m	2.71 m	0.16 m
First Floor	M_window single-hung	1	2.55 m	0.7 m	2.72 m	0.17 m
First Floor	M_window single-hung	1	2.55 m	0.8 m	2.72 m	0.17 m
First Floor	M_window single-hung	4	2.55 m	0.96 m	2.72 m	0.17 m
First Floor	M_window dauble-hung	15	2.55 m	1.5 m	2.72 m	0.17 m
First Floor	M_window single-hung	4	0.8 m	0.96 m	2.9 m	2.1 m
First Floor	M_window dauble-hung	2	0.8 m	1.5 m	2.9 m	2.1 m
Second Floor	M_window single-hung	26	2.55 m	0.96 m	2.71 m	0.16 m
Second Floor	M_window single-hung	1	2.55 m	0.7 m	2.72 m	0.17 m
Second Floor	M_window single-hung	1	2.55 m	0.8 m	2.72 m	0.17 m
Second Floor	M_window single-hung	1	2.55 m	0.96 m	2.72 m	0.17 m
Second Floor	M_window dauble-hung	12	2.55 m	1.5 m	2.72 m	0.17 m
Third Floor	M_window single-hung	26	2.55 m	0.96 m	2.71 m	0.16 m

6.6. TECHNOLOGICAL DETAILS

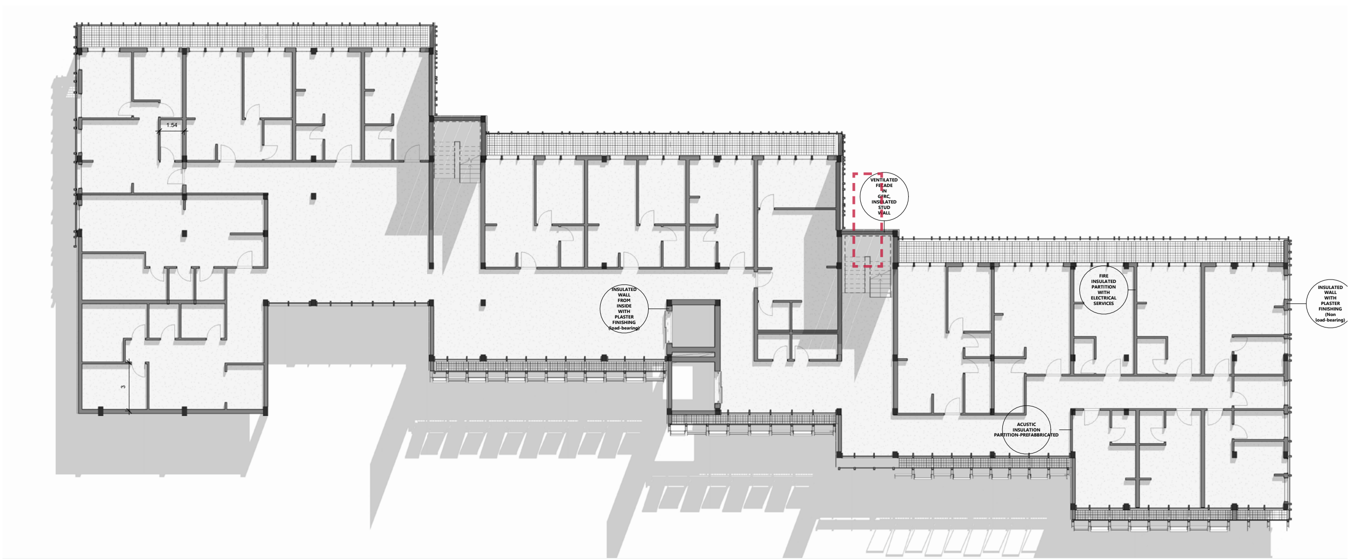


01. MAIN VANTILATED FACADE , INSULATED STUD WALL 1:5



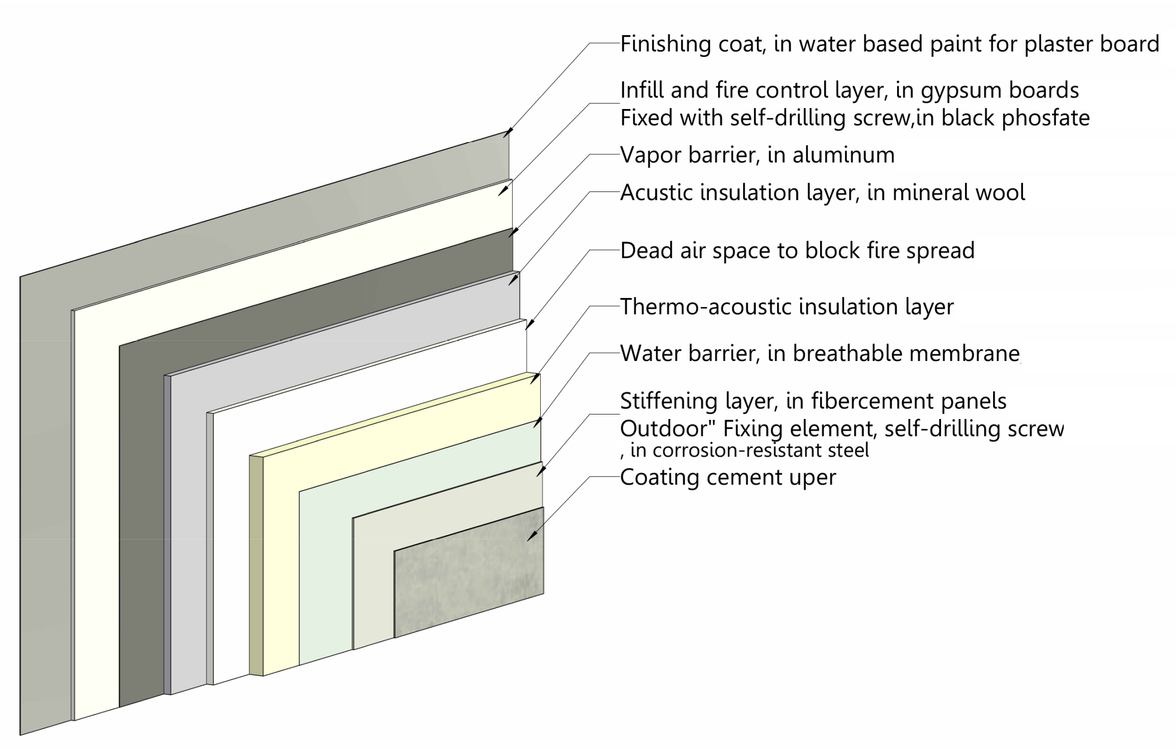
U = 0.11 W/m^{2}K

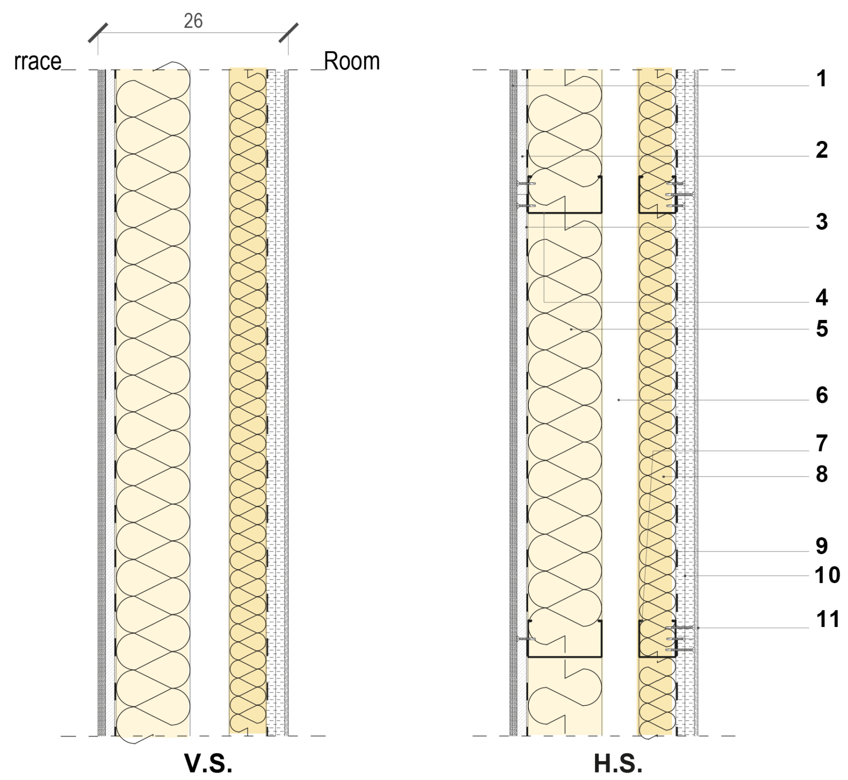
Main ventilatated facade in GFRC, insulated stud wall



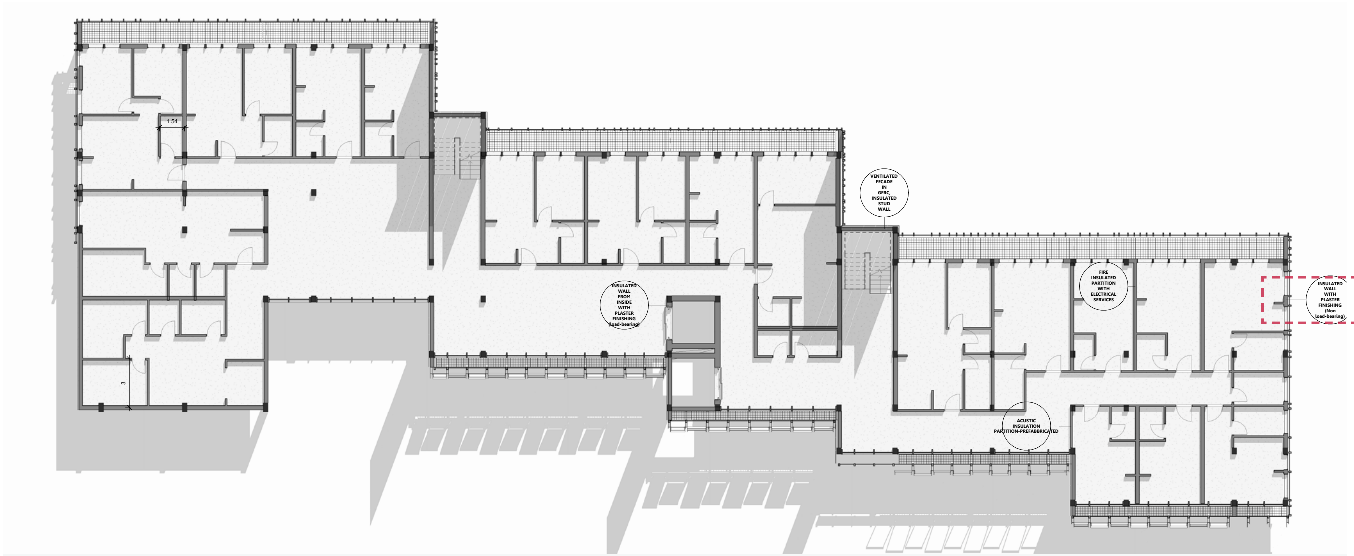
06	N°	function	description	material	Thickness (cm)	Density (kg/m3)	Thermal conductivity (w/mK)	Dim (cm)	Specific heat (j/kgK)
out	1	Fiber Facade Panels	Cladding grassfire	concrete (GFRC)	1.3	2300	1	variable	840
	2	Fixing elements	Undercut anchor and locking ratchet	stainless steel	–	–	–	ø=0.7	–
			Anchoring element "HILTI, MFT-H 200K"	aluminum	–	2.7	235	h=6 w=4	890
			Adjusting screw "HILTI, MFT-JS"	aluminum	–	2.7	235	L=2 ø=0.35	890
	3	Horizontal hanger profile	"HILTI, MFT-HP 200"	aluminum	0.2	2.7	235	w=2.15 h=6	890
			Fixer: self-drilling screw, "HILTI"	–	–	–	–	–	–
	4	Air space	Ventilated cavity	–	0.4	1.225	0.02	variable	1000
	5	Vertical L profile	"HILTI, MFT-L"	aluminum alloy	0.18cm	–	–	4x6	–
			Fixer : self-drilling screw "HILTI"	aluminum	–	–	–		
	6	L bracket	with clamping spring with thermal separator in polypropylene "HILTI, MFT-MFI L".	aluminum alloy	0.25	2.7	235	15x16	890
			Fixer : umbrella expansion plug "HILTI, HLD 4"	polyamide	–	–	–	–	–
	7	Insulation layer	Thermal insulation layer "ROCKWOOL Rainscreen Duo slab"	mineral wool	12		0,035	60x120	
			Fixer : "FASSABORTOLO, A96"	cement-based adhesive	0.3	–	–	–	–
	8	Insulation fastener	"HILTI, IDP120, fungo per pannelli isolanti"	HDPE	–	–	–	variable	–
	9	Double stiffening layer	"KNAUF - ACQUAPANEL cement board Outdoor".	fiber cement panels	1.25+1.25			200x120	
			Fixer: self drilling screws "KNAUF Maxi Screws TEKS"		–	–	–	–	–
	10	Water barrier breathable layer	"KNAUF -TYVEK Stucco Wrap".	fabric	0.02		0.0430		
			Fixer adhesive tape	–	–	–	–	–	–
	11	Stud frame	"Marcegaglia"	stainless steel	0.2	–	–	5x10x5 Span: 60	–
	12	Thermal and acoustic insulation layer	class A1, "ROCKWOOL, Acoustic 225 Plus"	stone wool boards	10		0,033	120x60	
	13	Secondary substructure	"KNAUF C stud	DX51 steel	0.08	–	–	5x5x5	–
	14	Thermoacoustic insulation layer	class A1, "ROCKWOOL, Acoustic 225 Plus"	stone wool boards	5			variable	
	15	Insulation layer	Vapor barrier	aluminum	0,03	2.7	235	variable	890
	16	Infill and fire control layer	"KNAUF, F-Zero"	double gypsum board	1.25+1.25	600	0.083	120x300	880
			Fixer: screws, “KNAUF Jackpoint Self-Drilling Screw"	black phosphate				L=2.5 or 4.2	
In	17	Finishing layer	"FASSA BORTOLO Gypsopaint"	water based paint	0.5	–	–	variable	–

02. INSULATED WALL, WITH PLASTER FINISHING (NON LOAD-BEARING) 1:5



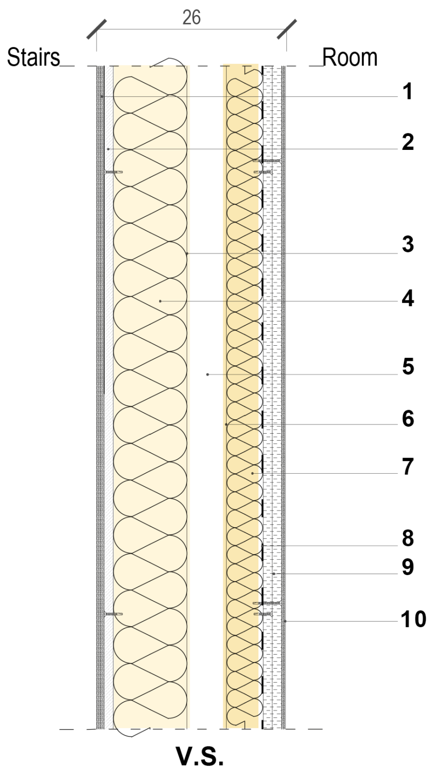


U = 0.21 W/m^{2}K



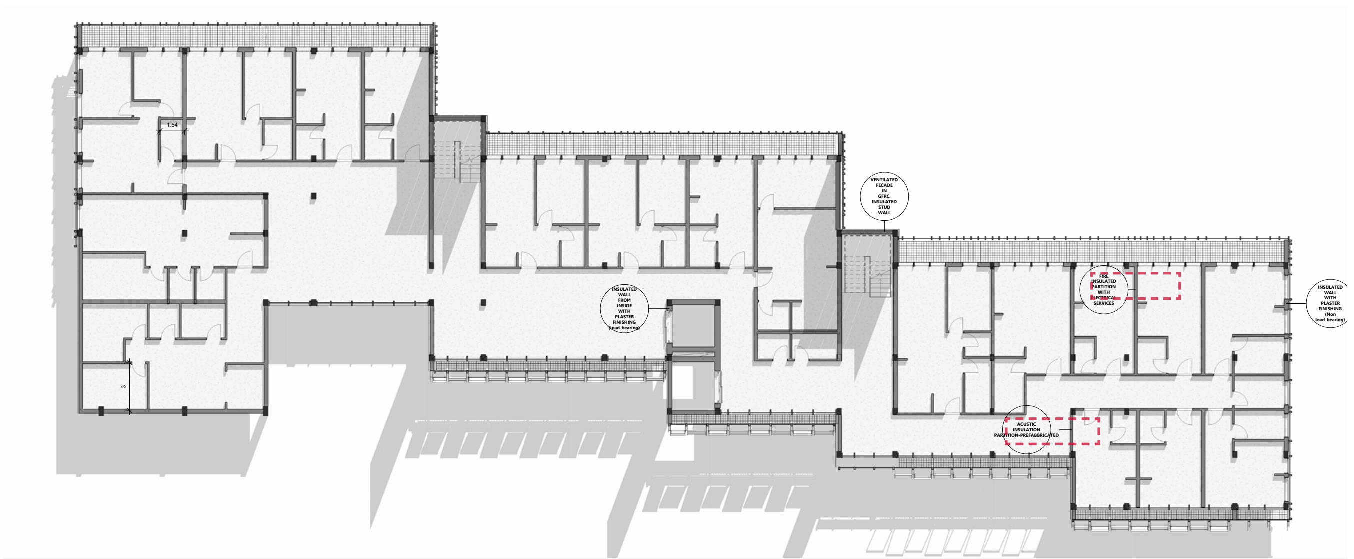
07	N°	function	description	material	Thickness (cm)	Density (kg/m3)	Thermal conductivity (w/mK)	Dim (cm)	Specific heat (j/kgK)
out	1	Finishing layer	"KNAUF Aquapanel Outdoor solution"	reinforcing mesh	1	_	_	variable	_
	2	Stiffening layer	"KNAUF AQUAPANEL Outdoor".	fibercement panels	1.25	1800	0.9	120x120	880
			Fixer: self-drilling screws, "KNAUF, Aquapanel Maxi Screws, TEKS"	corrosion-resistant steel	_	_	_	_	_
	3	Water barrier breathable layer	"KNAUF -TYVEK StuccoWrap",	fabric	0.02		0,033	variable	
			Fixer : double sided adhesive tape to substructure	adhesive tape	_	_	_	_	_
	4	Substructure	"KNAUF C stud"	DX51 steel	0.1	_	_	5x10x5	_
	5	Thermal insulation layer	K, class A1, "ROCKWOOL Steel Frame Slab"	mineral wool	10		0.0430	120x60	
	6	Air space	Dead air space to block fire spread	_	5	1.225	0.02	variable	1000
	7	substructure	"KNAUF C stud"	DX51 steel	0.08	_	_	5x5x5	_
	8	Acustic insulation layer	class A1, "ROOKWOOL Acoustic 225 Plus"	mineral wool	5		0.0430	60x120	
	9	Insulation layer	Vapor barrier	alluminium	0,03	2.7	235	variable	890
	10	Infill and fire control layer	"KNAUF, F-Zero"	double gypsum board	1.25+1.25	600	0.083	120x300	880
			Fixer: KNAUF Jackpoint Self-Drilling Screw"	black phosphate	_	_	_	L=2.5 or 4.2	_
In	11	Finishing layer	"FASSA BORTOLO Gypsopaint"	water based paint	0.5	_	_	variable	_

03. FIREPROOF INSULATED PARTITION 1:5

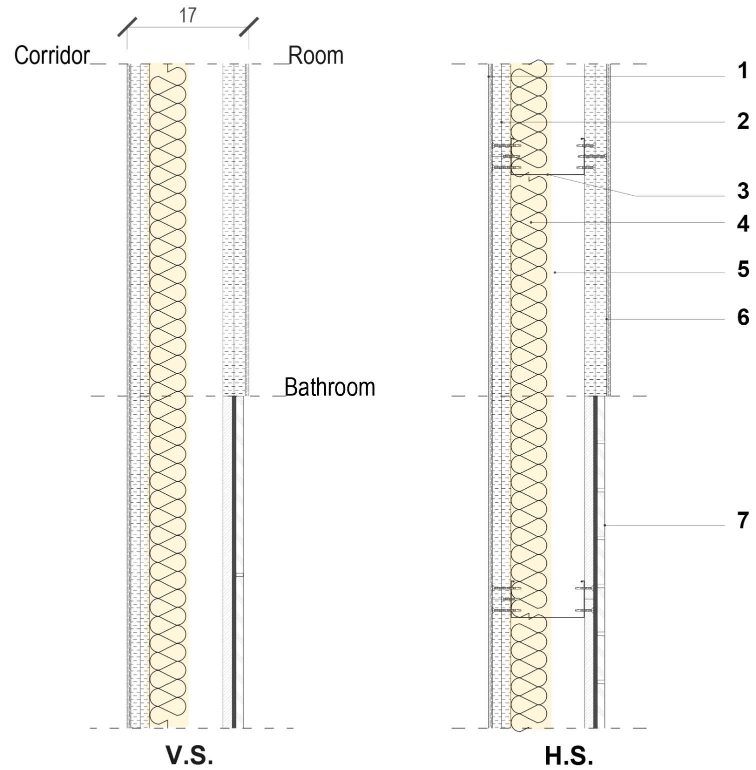


08	N°	function	description	material	Thickness (cm)	Density (kg/m3)	Thermal conductivity (w/mK)	Dim (cm)	Specific heat (j/kgK)
in	1	Finishing layer	"KNAUF Uniflott Q2"	basecoat plus finishing coat with reinforcing mesh	1	_	_	variable	_
	2	Infill and water repellent layer,	class A1, "KNAUF, Aquapanel Indoor". "	reinforced cement boards	1.25	1800	0.9	120x90	880
			Fixer : self-drilling screw, "KNAUF, Aquapanel Maxi Screws, TEKS	corrosion-resistant steel	_	_	_	_	_
	3	Substructure	"KNAUF C stud"	DX51 steel	0.1	_	_	5x10x5	_
	4	Thermal insulation layer	K, class A1, "ROCKWOOL Steel Frame Slab"	mineral wool	10		0.0430	120x60	
	6	Air space	Dead air space to block fire spread	_	5	1.225	0.02	variable	1000
	7	substructure	"KNAUF C stud"	steel	0.08	_	_	5x5x5	
	8	Acustic insulation layer	class A1, "ROOKWOOL Acoustic 225 Plus"	mineral wool	5		0,035	60x120	
	9	Insulation layer	Vapor barrier	alluminium	0,03	2.7	235	variable	890
	10	Infill and fire control layer	"KNAUF, F-Zero"	double gypsum board	1.25+1.25	600	0.083	120x300	880
			Fixer : "KNAUF Jackpoint Self-Drilling Screw"	black phosphate	_	_	_	L=2.5 or 4.2	_
In	11	Finishing layer	"FASSA BORTOLO Gypsopaint"	water based paint	0.5	_	_	variable	_

V.P. 08 U = 0.20 W/m^2K



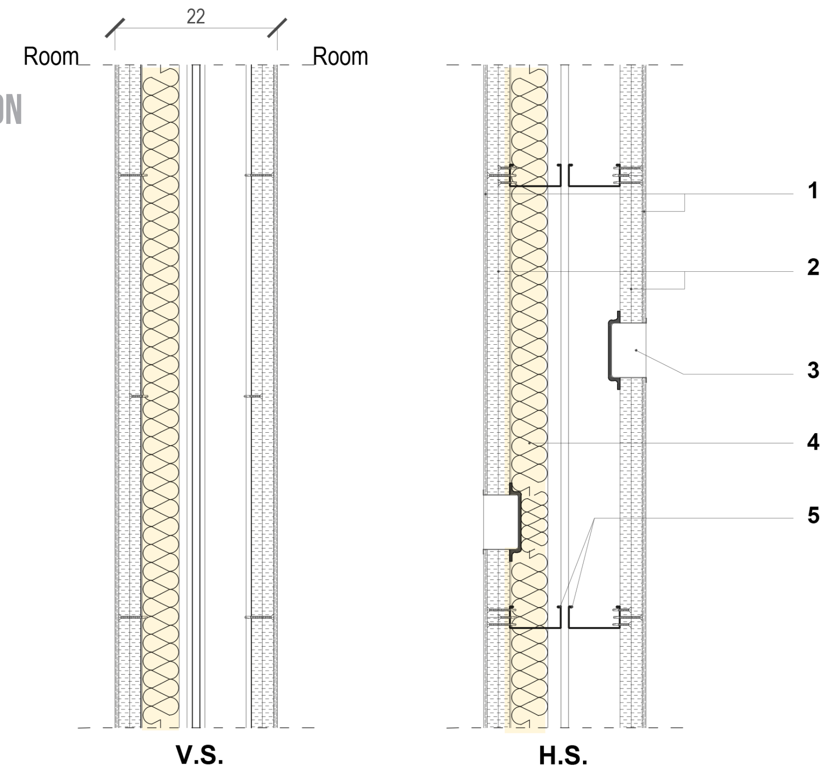
04. ACOUSTICALLY INSULATED PARTITION, PREFABBRICATED 1:5



U = 0.50 W/m^2K

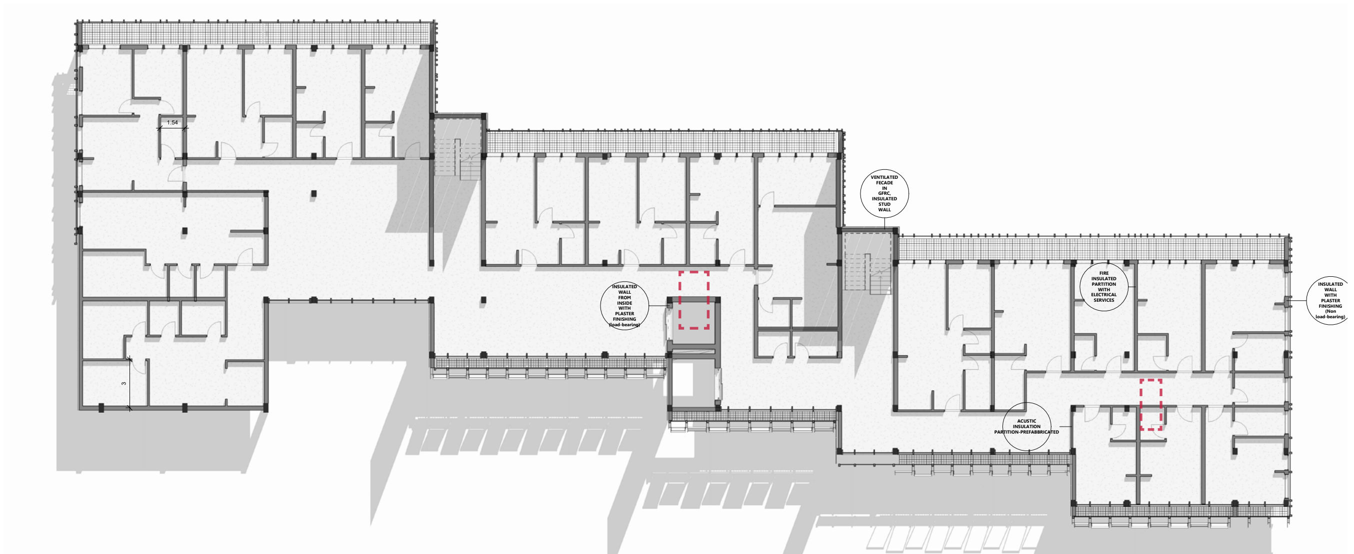
10	N°	function	description	material	Thickness (cm)	Density (kg/m3)	Thermal conductivity (w/mK)	Dim (cm)	Specific heat (j/kgK)
in	1	Finishing layer	"FASSA BORTOLO Gypsopaint"	water based paint	0.5	_	_	variable	_
	2	Infill and water repellent layer,	class A1, "KNAUF, Aquapanel Indoor". "	reinforced cement boards	1.25	1800	0.9	120x90	880
			Fixer: self-drilling screw, , "KNAUF Jackpoint Self-Drilling Screw"	black phosfate	_	_	_	L=2.5 or 4.2	_
	3	Single substructure	"KNAUF C stud"	DX51 steel	0.08	_	_	5x10x5 span 60	_
	4	Acustic insulation layer	class A1, "ROOKWOOL Acoustic 225 Plus"	mineral wool	5		0,035	60x120	
	5	Air space	Dead air space to block fire spread	_	5	1.225	0.02	variable	1000
	6	CORRIDOR finishing layers	Finishing coat, "FASSA BORTOLO Gypsopaint"	water based paint	0.5			variable	
			Fixer: self-drilling screw, "KNAUF Jackpoint Self-Drilling Screw"	black phosfate	_	_	_	L=2.5 or 4.2	_
			Euroclass A1, "KNAUF Soundshield Plus"	gypsum board,	1.5+1.5	600	0.083	120x300	880
	7	BATHROOM finishing layers	Infill and water repellent layer: class A1, "KNAUF, Aquapanel Indoor"	reinforced cement boards	1.25	1800	0.9	120x90	880
			Gluing layer: "MAPEI - Karaflex" Tiling layer, in porcelain stoneware tiles	cement-based adhesive	1	_	_	variable	_
In			Tiling layer	porcelain stoneware tiles	1	2300	1	6x24	840

05. ACOUSTICALLY INSULATED PARTITION PREFABBRICATED, WITH ELECTRICAL SERVICES 1: 5

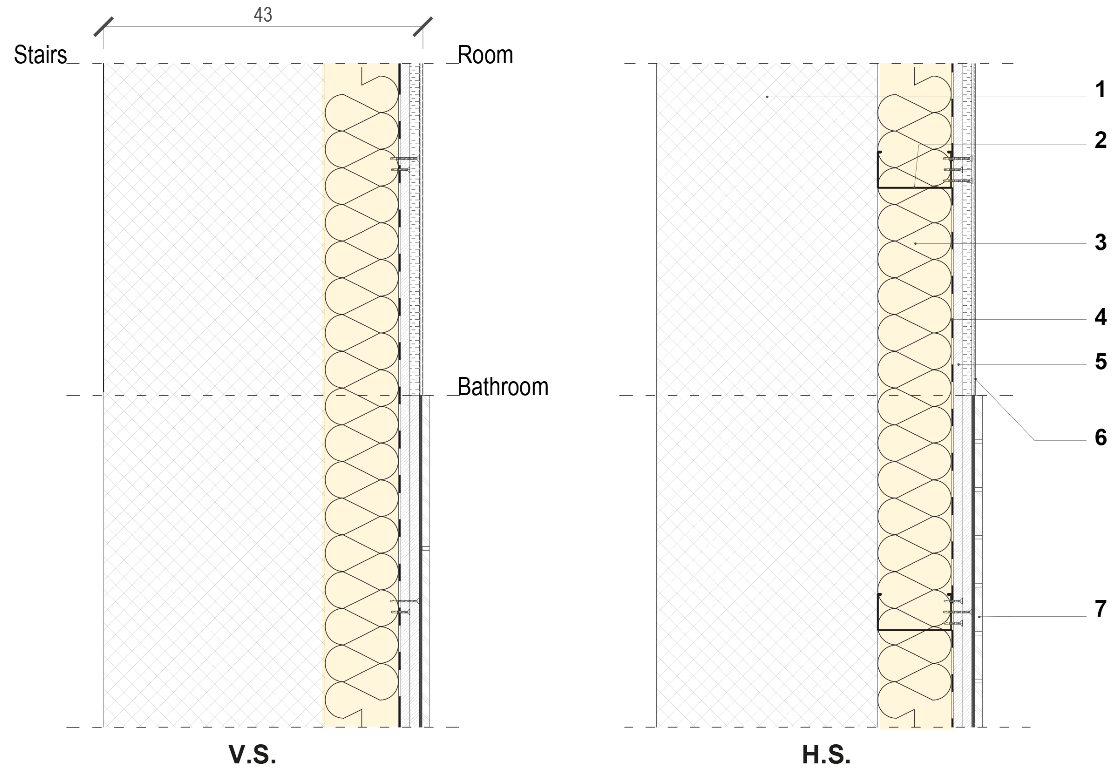


U = 0.49 W/m²K

11	N°	function	description	material	Thickness (cm)	Density (kg/m3)	Thermal conductivity (w/mK)	Dim (cm)	Specific heat (j/kgK)
in	1	Finishing layer	"FASSA BORTOLO Gypsopaint"	water based paint	0.5	_	_	variable	_
	2	Infill and water repellent layer,	class A1, "KNAUF, Aquapanel Indoor". "	reinforced cement boards	1.25	1800	0.9	120x90	880
			Fixer: self-drilling screw, , "KNAUF Jackpoint Self-Drilling Screw"	black phosfate	_	_	_	L=2.5 or 4.2	_
	3	Electrical services	"Knauf Putty Pad"	_	_	_	_	variable	_
	4	Acustic insulation layer	class A1, "ROOKWOOL Acoustic 225 Plus"	Glass mineral wool	5		0,035	60x120	_
			Fixer: glue	glue	0.2	_	_	variable	_
	5	Double substructure	"KNAUF C stud"	DX51 steel	0.055	_	_	3.5x7x3.5 span 60	_
	6	Air space	Dead air space to block fire spread	_	5	1.225	0.02	variable	1000



06. FIREPROOF PARTITION, LOAD-BEARING, INSULATED FROM INSIDE 1:5



U = 0.19 W/m²K

09	N°	function	description	material	Thickness (cm)	Density (kg/m3)	Thermal conductivity (w/mK)	Dim (cm)	Specific heat (j/kgK)
in	1	Structural layer	_	reinforced concrete	30	1800	0.9	variable	880
	2	Single substructure	"KNAUF C stud"	DX51 steel	0.08	_	_	120x90	_
			Fixer: self-drilling screw, , "KNAUF Jackpoint Self-Drilling Screw"	black phosfate	_	_	_	L=2.5 or 4.2	_
	3	Thermal-acoustic insulation layer	class A1, "ROCKWOOL Steel Frame"	mineral wool	10	_	0.0430	120x60	_
	4	Insulation layer	Vapor barrier	alluminium	0,03	2.7	235	variable	890
	5	Fire control layer	class A1, "Isostyle"	calcium silicate board	1.25			120x280	
	6	ROOM finishing layers	"KNAUF, F-Zero".	gypsum board,	1.25	600	0.083	120x300	880
			Fixer: self-drilling screw, "KNAUF Jackpoint Self-Drilling Screw"	black phosfate	_	_	_	L=2.5 or 4.2	_
			Finishing coat, "FASSA BORTOLO Gypsopaint"	water based paint	0.5	_	_	variable	_
	7	BATHROOM finishing layers	Infill and water repellent layer: class A1, "KNAUF, Aquapanel Indoor"	reinforced cement boards	1.25	1800	0.9	120x90	880
			Gluing layer: "MAPEI - Karaflex	cement-based adhesive	1	_	_	variable	_
In			Tiling layer	porcelain stoneware tiles	1	2300	1	6x24	840

07. CIELING DETAILS , SC 1: 5

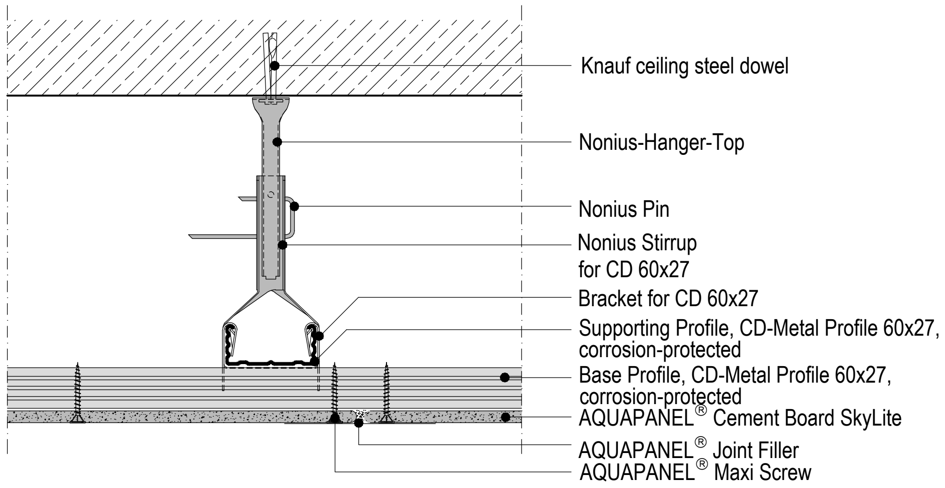


Fig
Vertical section
with longitudinal
joint

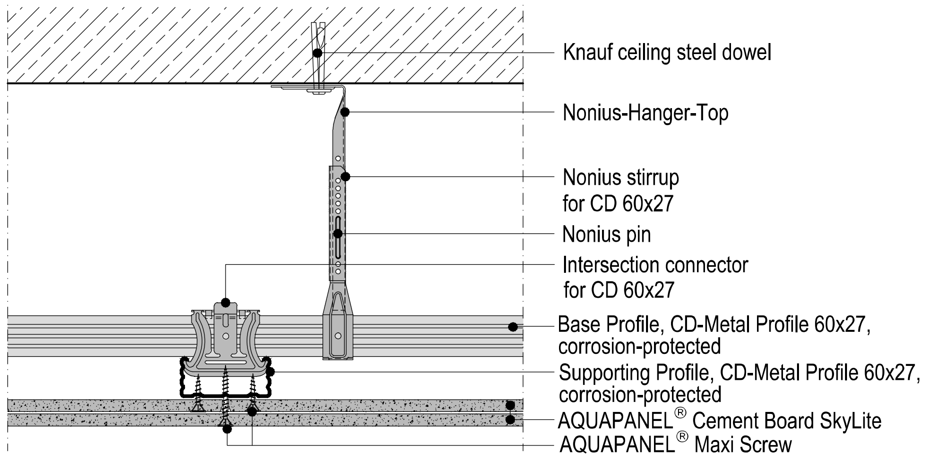


Fig
Vertical section
with longitudinal
joint

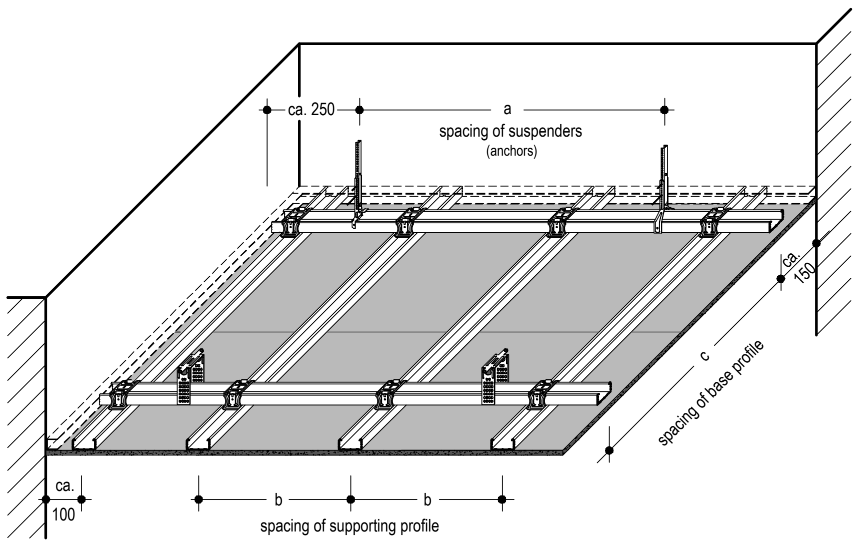
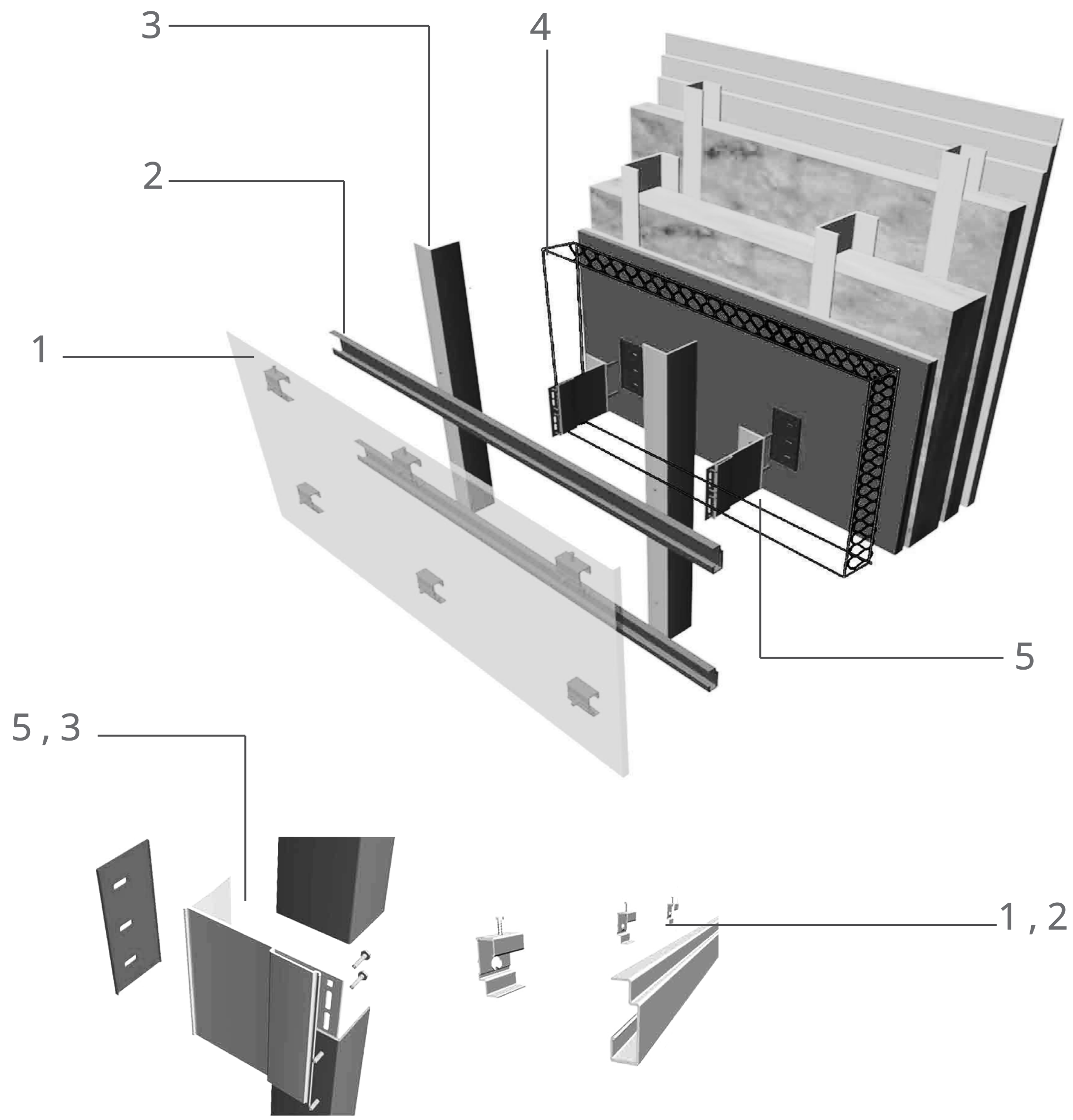


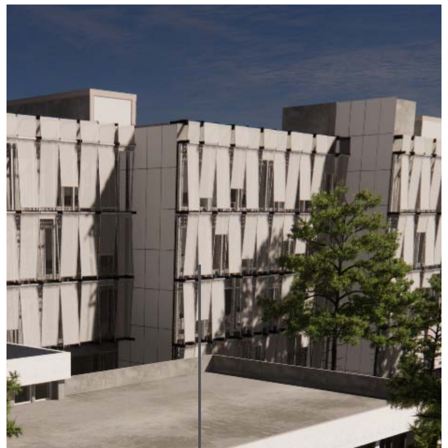
Fig
Base Profile and
Supporting Profile
/ suspended

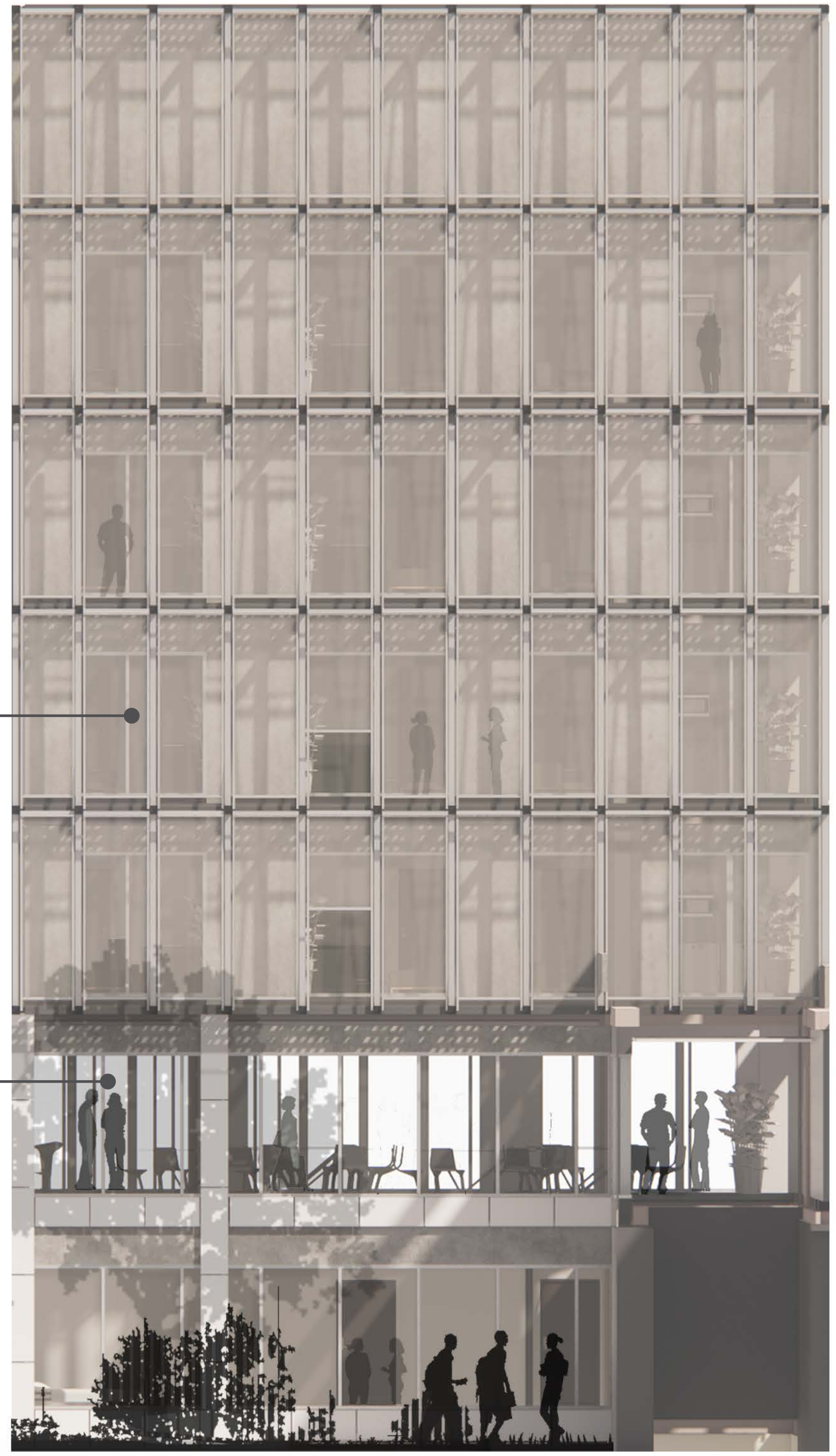
08. GLASSFIBER REINFORCED CONCRETE: GFRC FIXING DETAILS

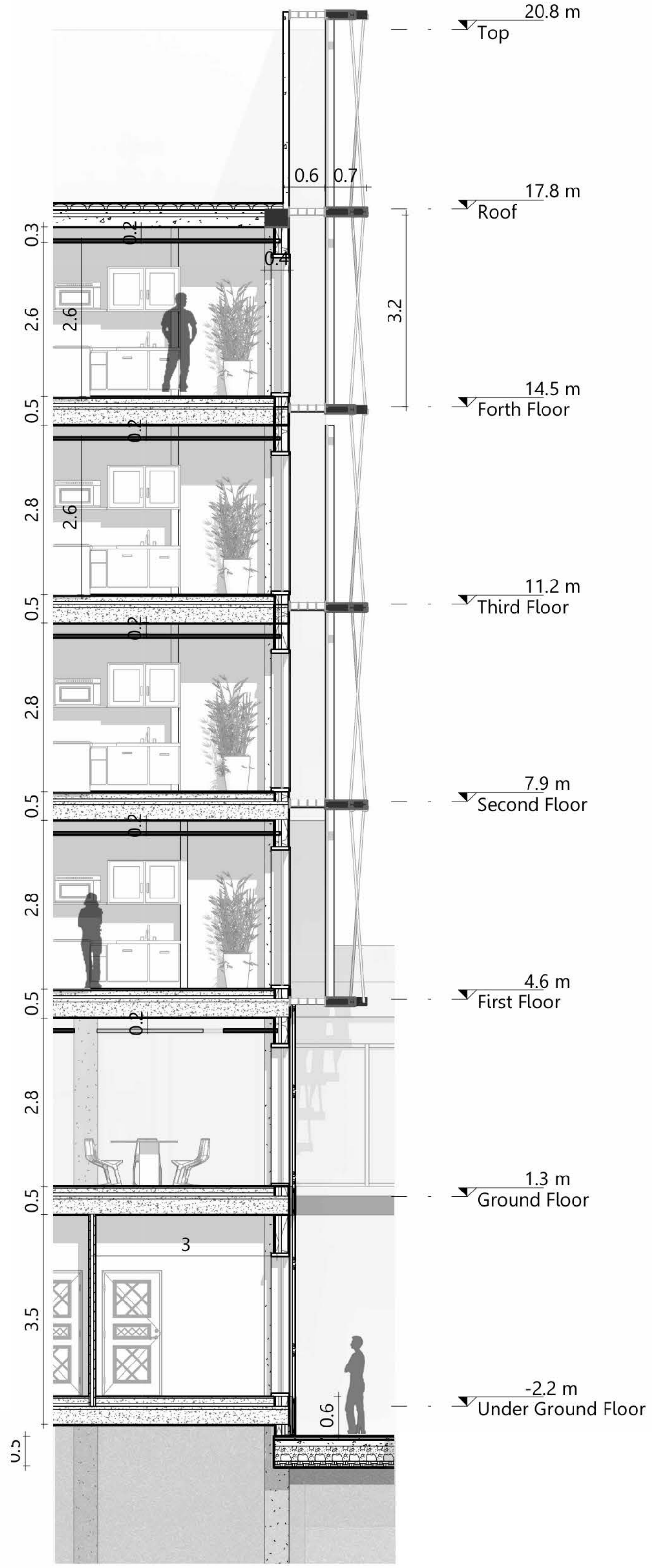
1. Cladding, in glassfibre reinforced concrete (GFRC), tk. 1.3cm, dim. 74x270 & 74x76cm, “RIEDER, Fiber C Façade Panels”
   Fixed with: - Undercut anchor and locking ratchet, in stainless steel, ø=7mm, “KEIL, KH AA”
   - Anchoring element, in aluminum alloy, h=6cm, w=4cm, “HILTI, MFT-H 200K”
   - Adjusting screw, in aluminum, L=2cm, ø=3.5mm “HILTI, MFT-JS”
2. Horizontal hanger profile, in aluminum alloy, tk. 2mm, w=2.15cm, h=6cm, “HILTI, MFT-HP 200”
   - Fixed with self-drilling screw, “HILTI”
3. Vertical L profile, in aluminum alloy, tk. 0.2cm, dim. 4x6cm, “HILTI, MFT-L”
   - Fixed with self-drilling screw, “HILTI”
4. Thermal insulation layer, in mineral wool, tk. 12cm, dim. 60x120 cm, λ=0,035 W/mK, class A1, “ROCKWOOL Rainscreen Duo”
   - Fixed with insulation fastener, in HDPE, “HILTI, IDP120, fungo per pannelli isolanti”
5. L bracket with clamping spring, in aluminum alloy, tk. 0.25cm, dim. 15x16cm; with thermal separator in polypropylene, tk. 0.5cm, “HILTI, MFT-MFI L”
   - Fixed with umbrella expansion plug, in polyamide, “HILTI, HLD 4”

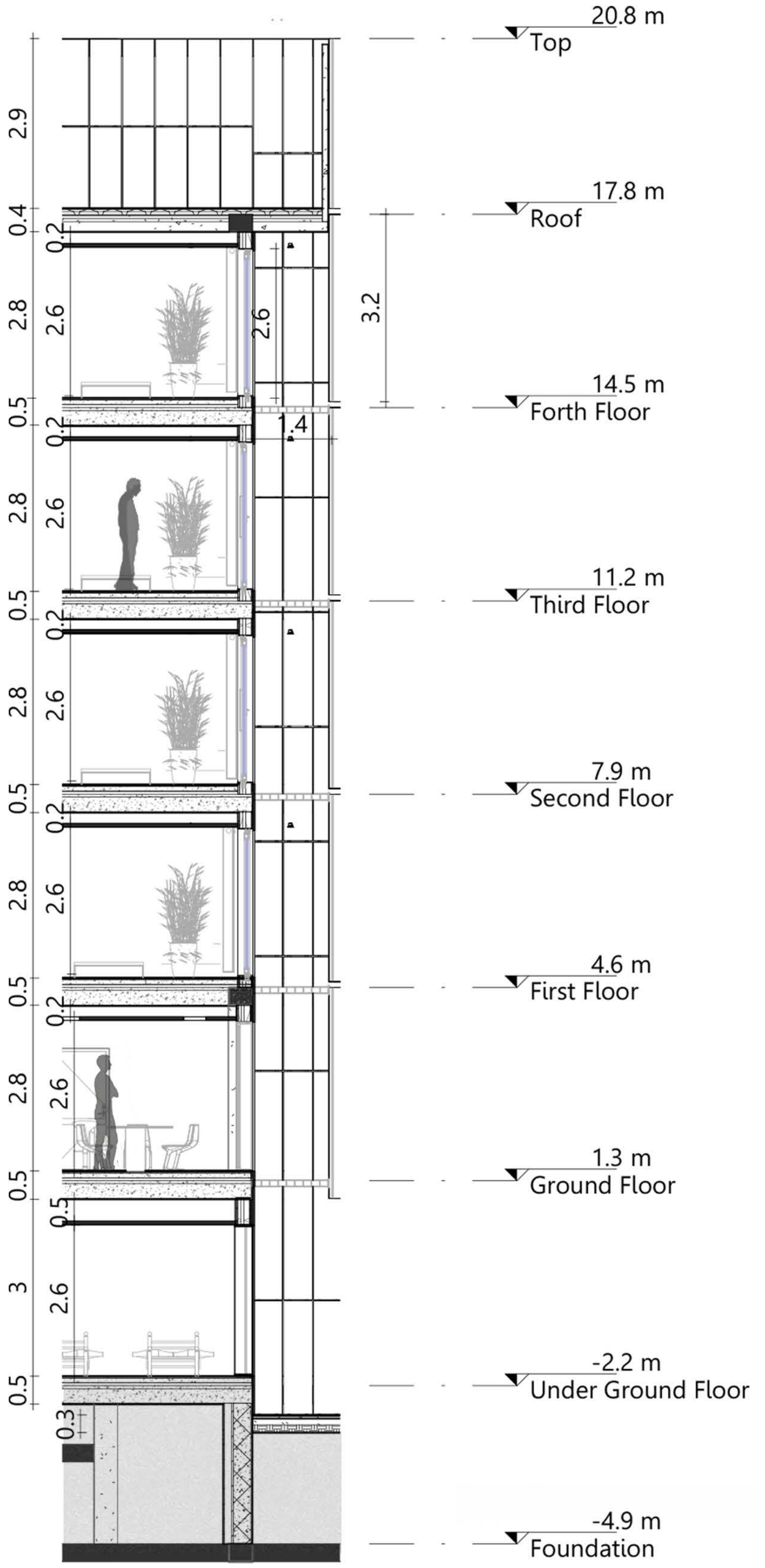


09. WALL SECTION E_E

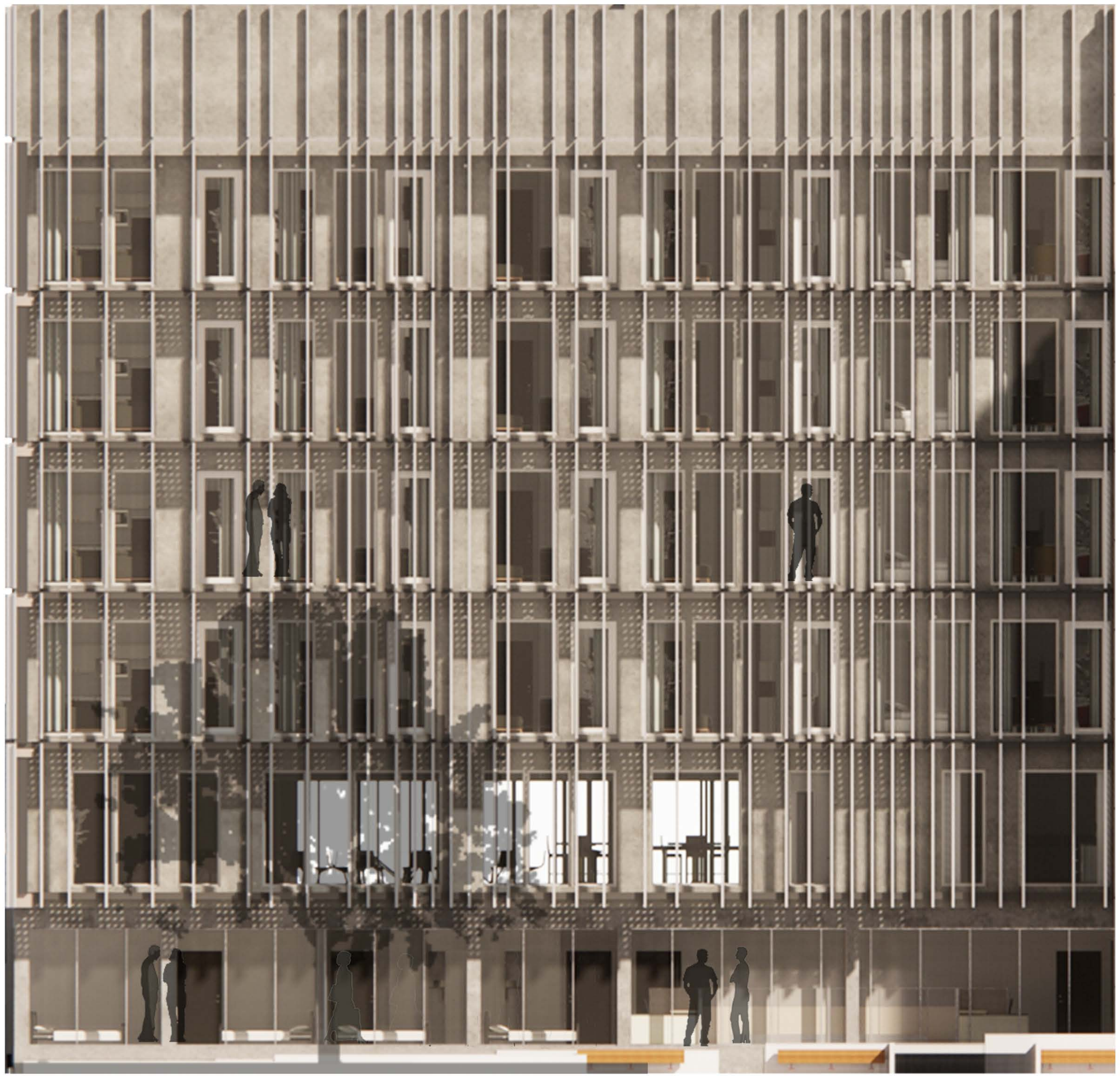


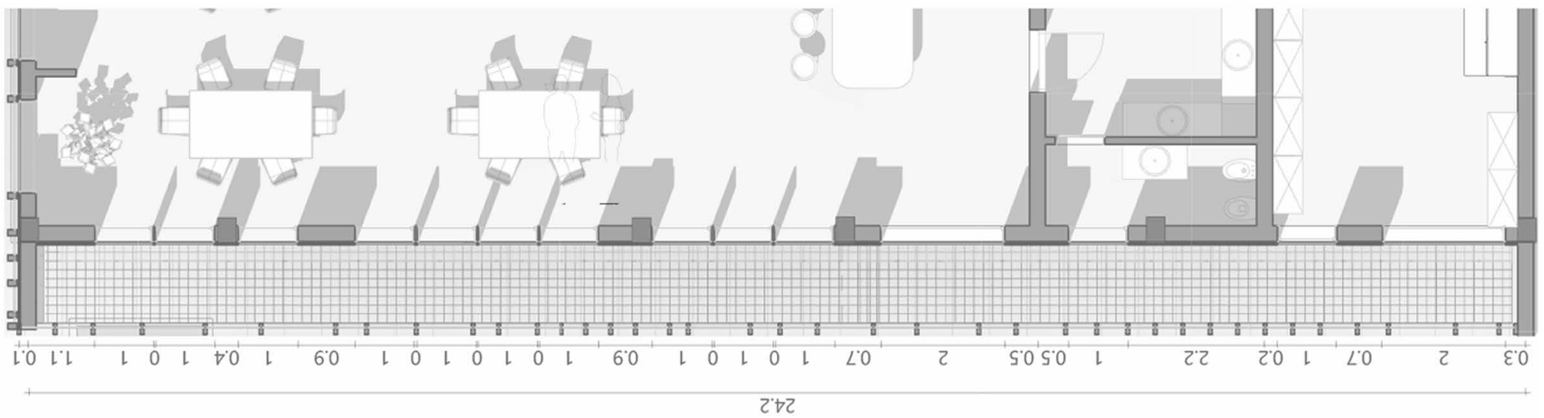






10. WALL SECTION F-F





7

ENERGY AND DAYLIGHT

7.1. DAYLIGHT ANALYSIS
7.1.1 INTRODUCTION

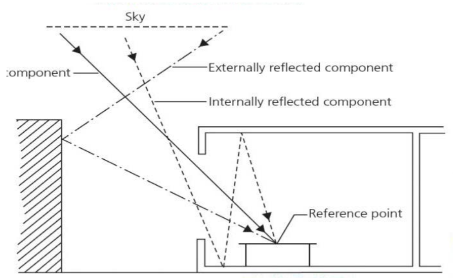
In general, daylight is the primary source of light in buildings. With a holistic and custom-made approach, we aspire to improve the quality of daylight and consequently energy consumption in the building.
Buildings with optimal daylight design attain high energy performance not only by receiving as much daylight as possible but also by controlling the brightness of surfaces within users' fields of vision. Such designs generally encourage daylight to penetrate a building but in some cases the goal is to reduce its degree or intensity.
We consider sustainable design as an integral aspect of contemporary architecture. Sustainable solutions such as daylight systems are not treated as add-ons, but related to each and every building element.

These development are expressed in three main features: design strategies, architectural elements and tools and devices. Depending on location and building typology, the parameters of direct and diffuse radiation and sun impact studies lead to conclusions that have influence on orientation, massing, programme and envelope.
After a process of daylight analysis and simulations, the building geometry and the amount of facade openings help to find a tailor-made solution for the project.

Finally, all these considerations are integrated into a holistic solution which aims to decrease the total number of components and, consequently, the energy consumption of the building.

7.1.2 METRICS

• DAYLIGHT FACTOR (DF)



The daylight factor (DF) is a very common and easy to use measure for the subjective daylight quality in a room. It describes the ratio of outside illuminance over inside illuminance, expressed in per cent. The higher the DF, the more natural light is available in the room. It is expressed as such:

$$DF = 100 * E_{in} / E_{ext}$$

The Ein illuminance can be considered as the sum of three different illuminances:

- the direct iluminance if the sky is visible from the considered point (ED)
- the illuminance due to the reflexions on the out side environment (EER)
- the illuminance due to the reflexions on the inside surfaces (EIR)

Hence, the daylight factor can be expressed as the sum of three component:

$$DF = DC + ERC + IRC$$

A daylight factor can be measured for a specific point or expressed as an average. The latter is the arithmetic mean of the sum of point measurements taken at a height of 0.85 m in a grid covering the whole floor area of the room. Different countries have different regulations and may require the use of point or average measurements.

A daylight factor can also be expressed as an average using experimental formulas. Several formulas for estimating the averageDF in a room are in use today. Depending on the country and its legislation, one or the other might be more common:

IES formula

$$DF_{m,\ IES} = (A_{window}\ \varepsilon\ U * 100) / (A_{floor})$$

BRE formula

$$DF_{m,\ BRE} = (A_{window}\ \alpha\ M\ t) / (A_{total} (1 - \rho_m^2))$$

Sumpner formula

$$DF_{m,\ Sumpner} = (A_{window}\ \alpha\ M\ t) / (2 A_{total} (1 - \rho_m))$$

Italian legislation

$$DF_{m,\ Italy} = (A_{window}\ \varepsilon\ \psi\ t) / (A_{total} (1 - \rho_m))$$

Rooms with an average DF of 2% are considered daylit. However, a room is only perceived as well daylit when the DF is above 5%. Daylight factors are always measured under an overcast sky or in an artificial sky which simulates a standard CIE overcast sky.

Average DF	Appearance	Energy implications
< 2%	room looks gloomy	Electric lighting needed most of the day
2% to 5%	Predominantly daylit appearance, but supplementary artificial lighting is needed.	Good balance between lighting and thermal aspects
> 5%	Room appears stongly daylit	Daytime electric lightin rarely needed, but potential for therm problems due to overheating in summer and heat losses in winter

DF and appearance, thermal performance

• ILLUMINANCE (LUX)

Illuminance is the measure of the amount of light received on the surface. It is typically expressed in lux (lm/m2). Illuminance levels can be measured with a luxmeter or predicted through the use of computer simulations with recognised and validated software (e.g. VELUX Daylight Visualizer).

lluminance is the measure of light currently used by most performance indicators to determine daylight availability in the interior.

Illuminance can be expressed as

$$E = \Phi / A$$

where

E = light intensity, illuminance (lm/m2, lux)

Φ = luminous flux - the quantity of light emitted by a light source (lumen, lm)

A = area (m2)

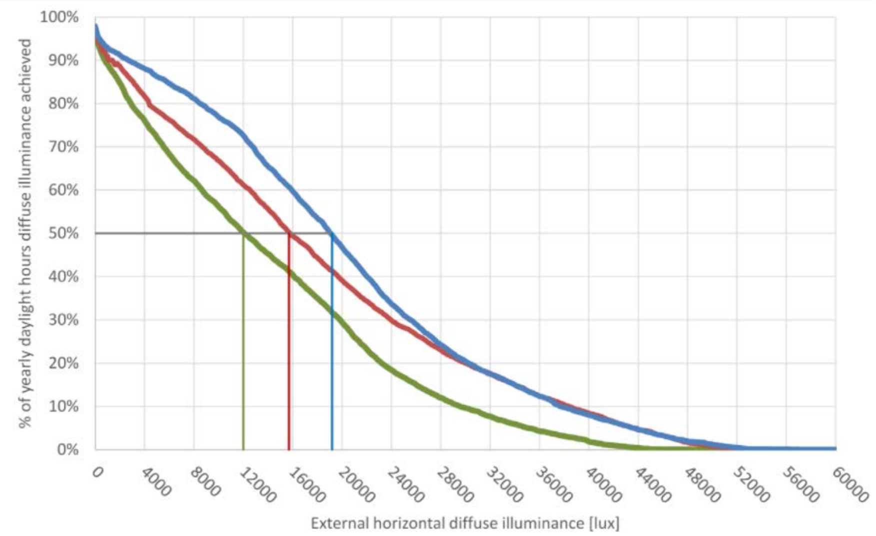


Fig 2.
Cumulative curves of available external diffuse horizontal illuminance for Oslo (Norway), Paris (France) and Rome (Italy).

0.0.2 PERPENDICULAR ILLUMINANCE (LUX)

while LIGHT LEVEL or ILLUMUNANCE is The vertical light hitting a horizontal surface. The difference to the "Perpendicular illuminance" is that here the number of measuring points is automatically determined on the basis of the minimum and maximum values. This makes the calculation more accurate.

Typical illuminance values:	
Direct sunlight	100,000 lux
Diffuse skylight	3,000-18,000 lux
Minimum levels for tasks and activities:	
Residential rooms	200-500 lux
Classrooms (general)	300-500 lux
Workspace lighting	200-500 lux

0.0.2 CLIMATE-BASED DAYLIGHT FACTOR

The amount of daylight in a building's interior depends on the availability of natural light outside at that location, as well as the properties of the building spaces and its surroundings.

The evaluation of daylight performance should, therefore, take account of the availability of daylight on site in addition to the properties of the space (1). Using recorded climatic data (outdoor diffuse illuminance), we can determine what DF levels will be needed to reach the target illuminance level over a given period of the year.

The example below shows how the target DF is determined from climate data to achieve daylight levels of 300 lux for 50% of the year.

1: CIE, 1970

7.1.3 SKY TYPES

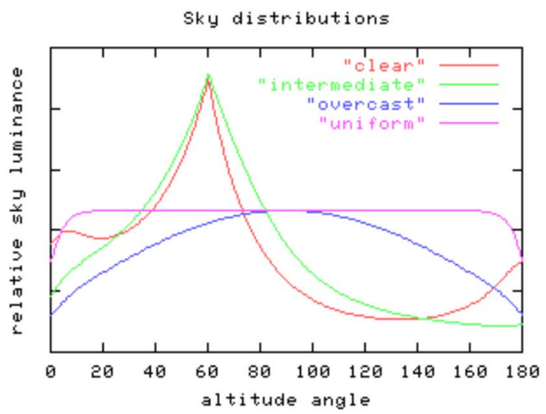
Whenever we take a look at the sky, its appearance has changed. Wheather it's clouds drifting across, the sun making its way from the East to the West, or the blue colour changing into a glowing red-- the sky has many faces. they make it difficult to create an accurate description or even a mathematical model of the sky. Architects and engineers, however, need to be able to model the sky so they can plan the daylight performance of buildings accurately.

- **Clear sky** : The luminance of the standard CIE clear sky varies over both, altitude and azimuth. It is brightest around the sun and dimmest opposite it. The brightness of the horizon lies inbetween those two extrems.

- **Intermediate sky** : The standard CIE intermediate sky is a somewhat hazy variant of the clear sky. The sun is not as bright as with the clear sky and the brightness changes are not as drastic.

- **Overcast sky** : The luminance of the standard CIE overcast sky changes with altitude. It is three times as bright in the zenith as it is near the horizon. The overcast sky is used when measuring daylight factors. It can be modelled under an artificial sky.

- **Uniform sky** : The standard uniform sky is characterised by a uniform luminance that does not change with altitude or azimuth.



Sky distributions

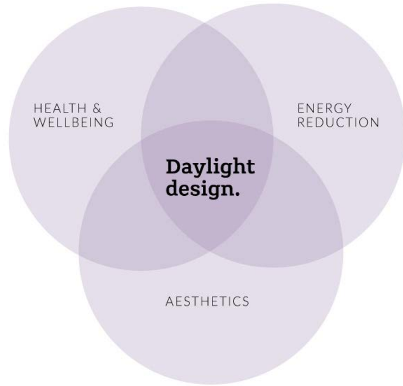
The sky distributions in the graph were generated with the RADIANCE synthetic imaging system. The sun was assumed to be at an altitude of 60° due South. The sky luminance was then mapped between the Southern (0°) and the Northern (180°) horizon passing through the zenith (90°).

7.1.4 METODOLOGY

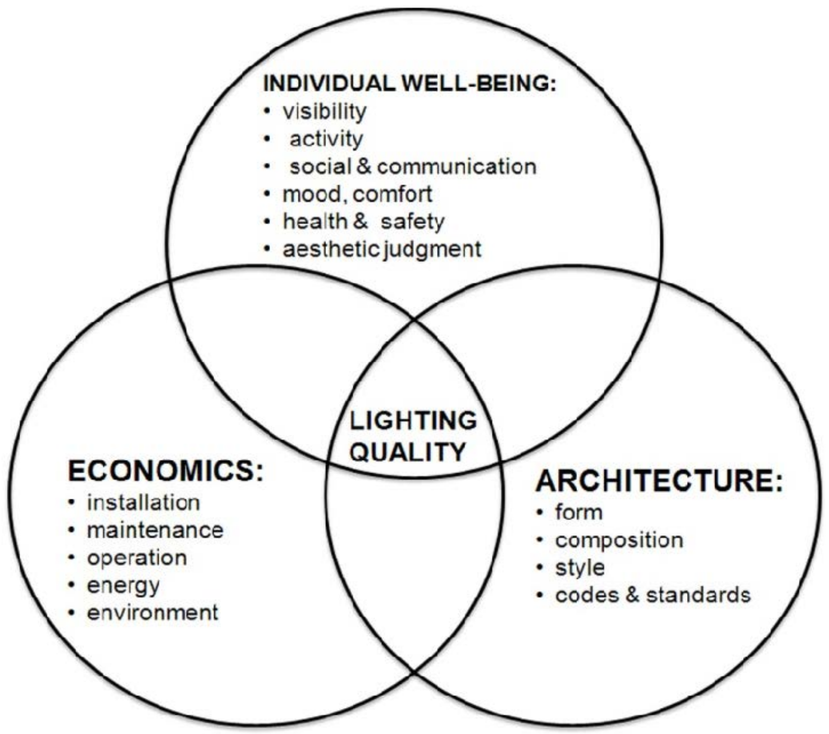
After reviewing the energy analysis results for the optimal window-to-wall ratio and performing a preliminary analysis, a window-to-wall ratio of 0.65 was obtained. daylight analysis is performed as the basis for the determination, with more optimized examples added as needed. By replacing curtain walls with windows in some spaces, we were able to achieve the ideal window-to-wall ratio. Different shading options were tested, taking into account heating loads and solar conditions, to determine the best solution for each orientation.

After analyzing buildings using horizontal and vertical shading systems and studying about existing projects in its context, we concluded that it would be more efficient to use vertical shading systems on all sides and movable shaders in critical parts. To sum it up The results show good interior conditions in terms of light and glare.

Also The Optimization of The windows shape and size had been taken into consideration . as the result we applied the following process to all the building.



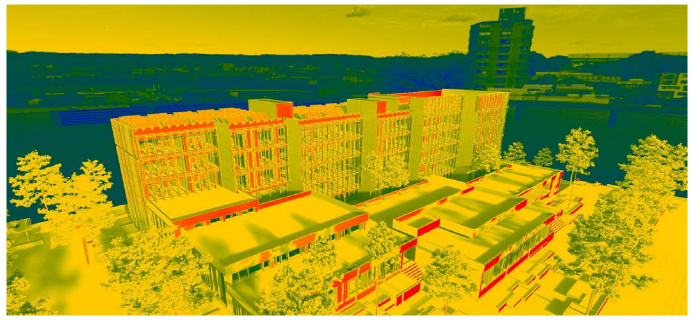
The upcoming results are demonstrating the average values for specific space in each floor. The important zones that are considered without the dark nods have the standard range for daylight quality factors.



7.1.5 DAYLIGHT ANALYSIS ON DIFFRENT HOURS OF THE DAY

- Time : 7 AM

- Time : 8 AM

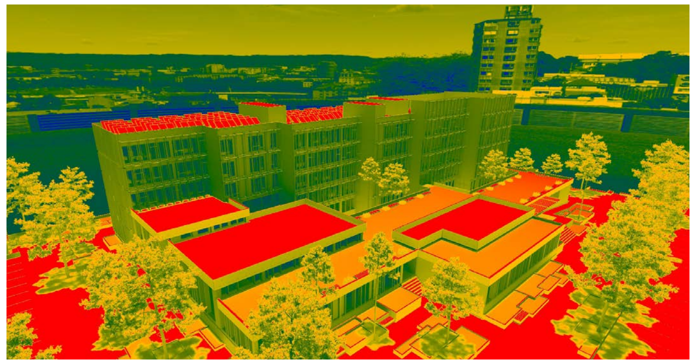


- Time : 9 AM

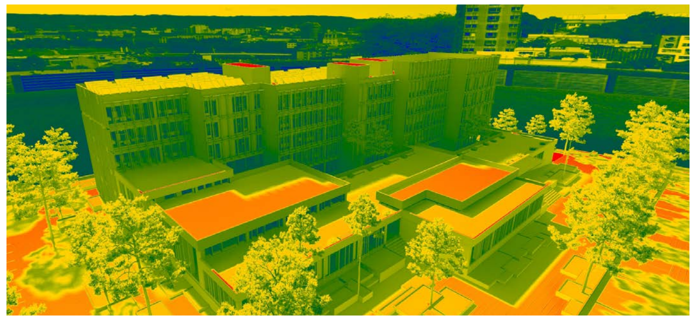
- Time : 10 AM

- Time : 12 AM

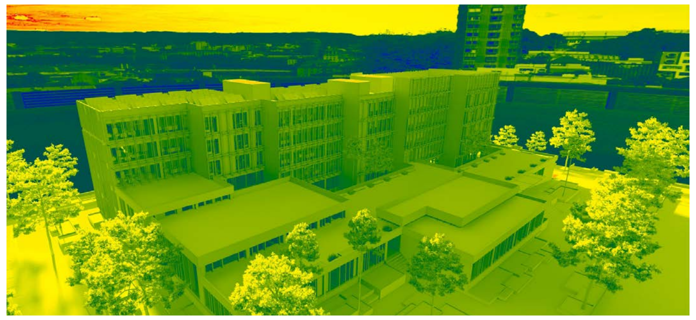
- Time : 15 AM



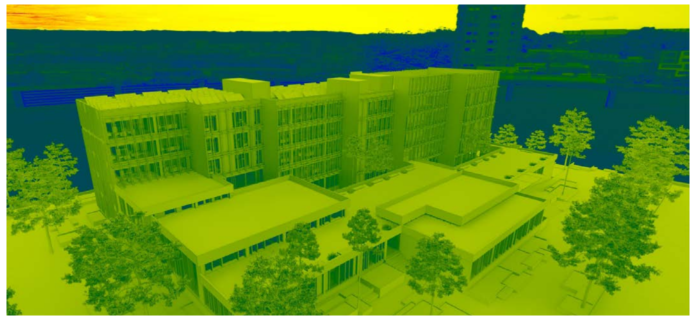
- Time : 17 AM



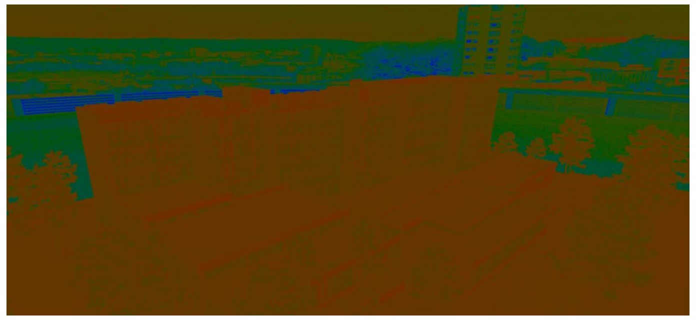
- Time : 18 AM



- Time : 19 AM



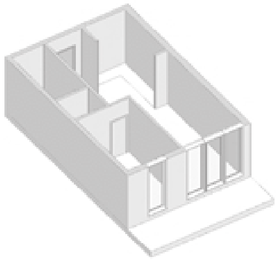
- Time : 7 AM



7.1.6 ANALYSIED SPACES

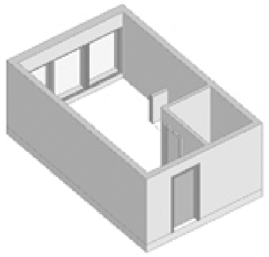
- **CASE1 : UNIT 2**

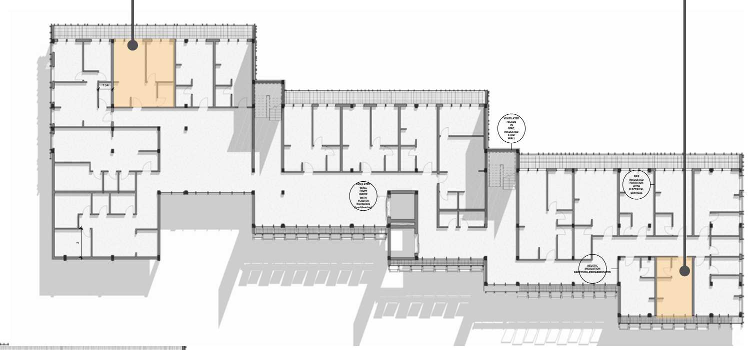
Function: residential -UNIT 2
location in the building : first floor
Windows: Full Height, Without shading
Window to Wall Ratio : 0.65
Window orientation : facing to North-west

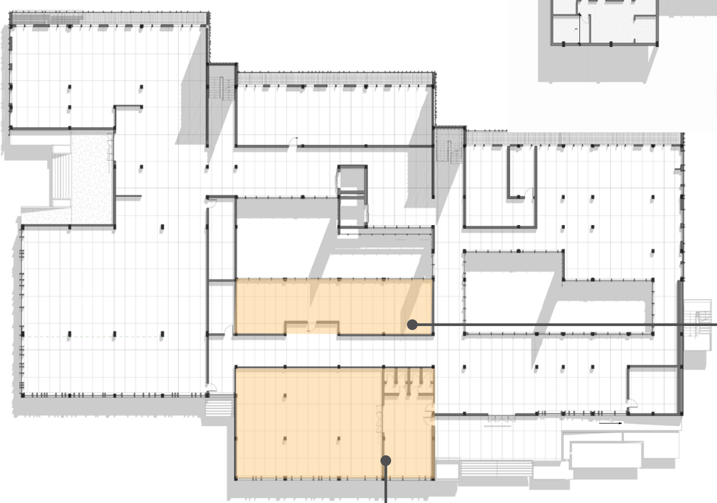


- **CASE2 : UNIT 1**

Function: residential -UNIT 1
location in the building : first floor
Windows: Full Height, Without shading
Window to Wall Ratio : 0.65
Window orientation : facing to south-east

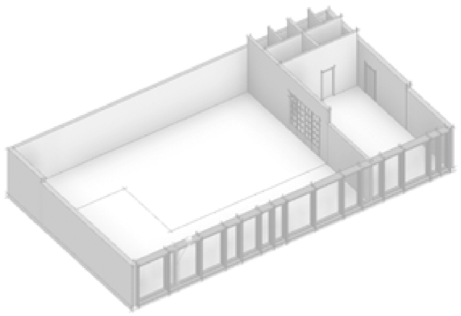






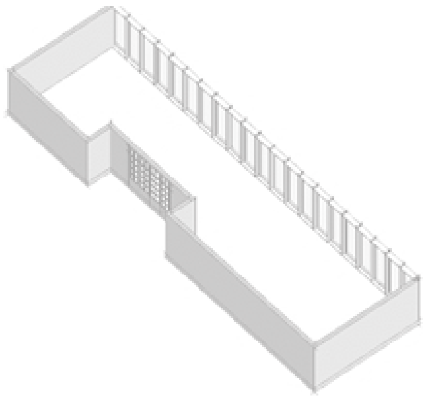
- **CASE3 : GYM**

Function: Gym
location in the building : ground floor
Windows: Full Height, Without shading
Window to Wall Ratio : 0.55
Window orientation : facing to south-east



- **CASE4 : LIBRARY**

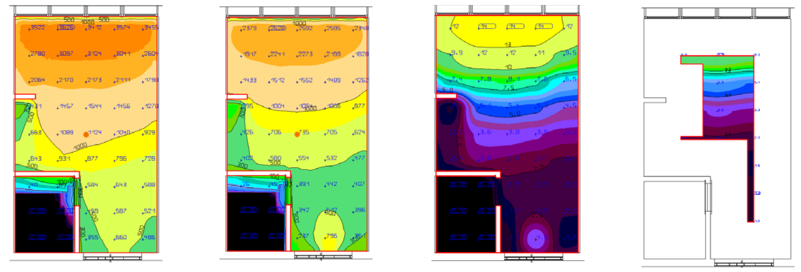
Function: library
location in the building : ground floor
Windows: Full Height, Without shading
Window to Wall Ratio : 0.7
Window orientation : facing to North-west



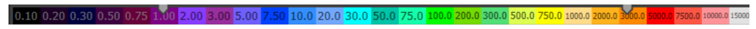
7.1.7 STAGE 1 : PRE OPTIMIZATION DAYLIGHT ANALYSIS

7.1.7.1 CASE1 : UNIT1

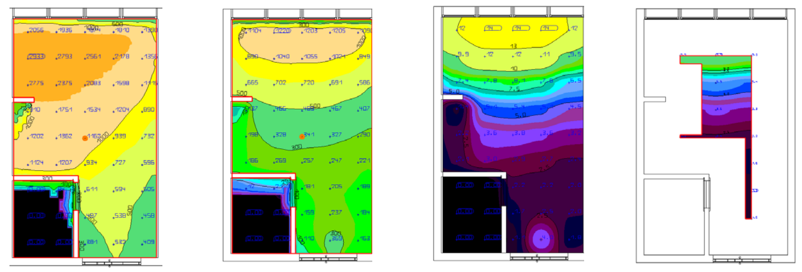
Analysis time :
15 June



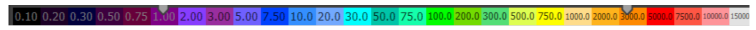
LUX Average perpendicular Clear sky	LUX Average perpendicular Over cast	DF daylight factor	DF Effective area



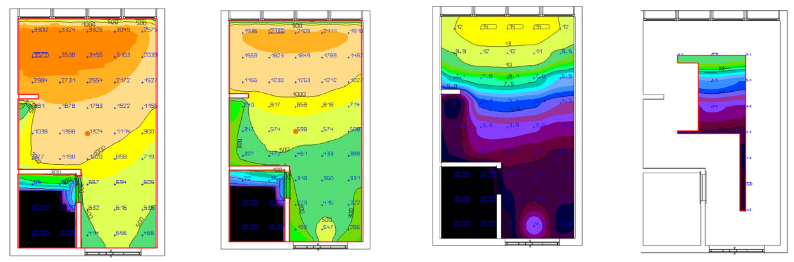
Analysis time :
December 21



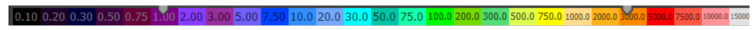
LUX Average perpendicular Clear sky	LUX Average perpendicular Over cast	DF daylight factor	DF Effective area



Analysis time :
March 21
September 23

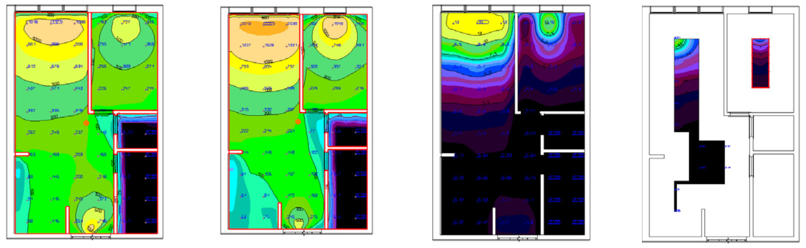


LUX Average perpendicular Clear sky	LUX Average perpendicular Over cast	DF daylight factor	DF Effective area

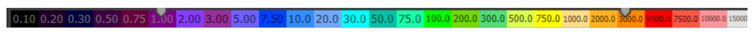


7.1.7.2 CASE 2 : UNIT 2

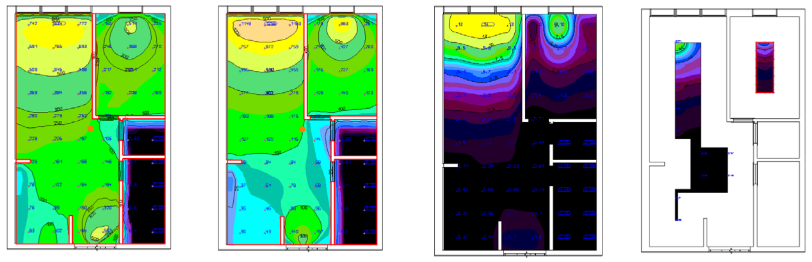
Analysis time :
15 June



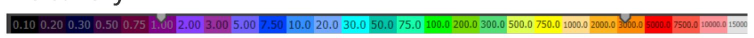
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



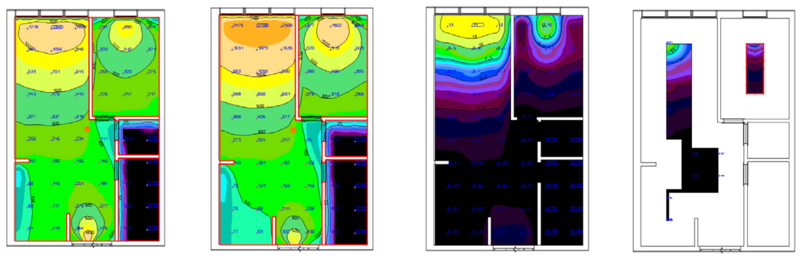
Analysis time :
December 21



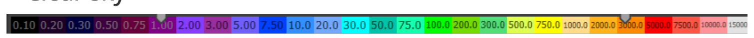
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



Analysis time :
March 21
September 23

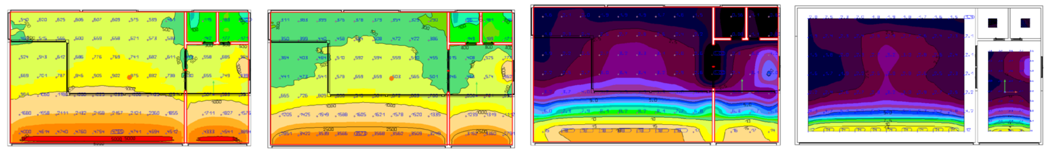


LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area

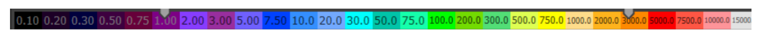


7.1.7.3 CASE 3 : GYM

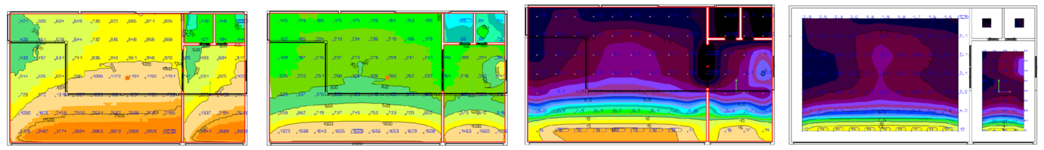
Analysis time :
15 June



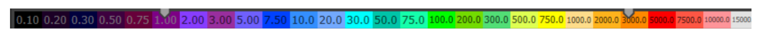
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



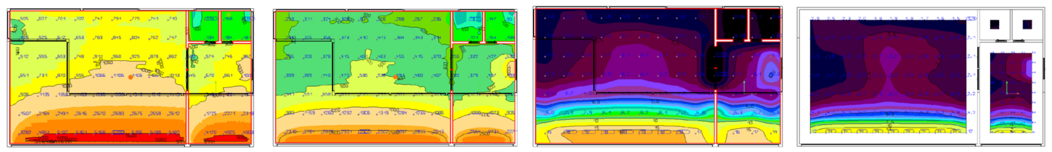
Analysis time :
December 21



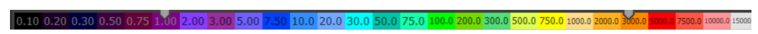
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



Analysis time :
March 21
September 23

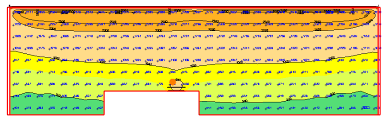


LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area

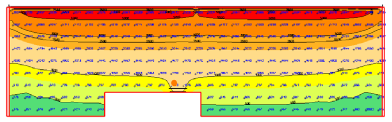


7.1.7.4 CASE 4 : LIBRARY

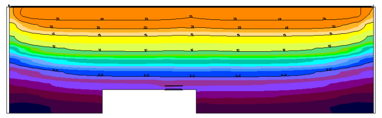
Analysis time :
15 June



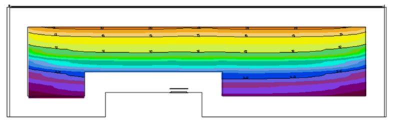
LUX
Average
perpendicular
Clear sky



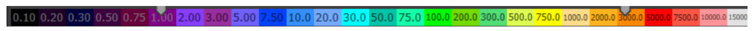
LUX
Average
perpendicular
Over cast



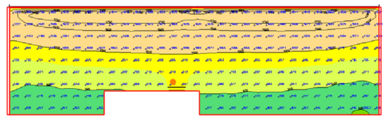
DF
daylight factor



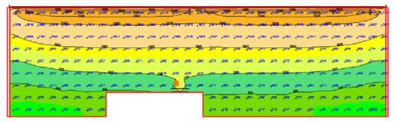
DF
Effective area



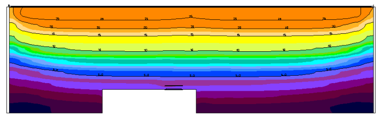
Analysis time :
December 21



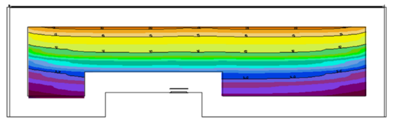
LUX
Average
perpendicular
Clear sky



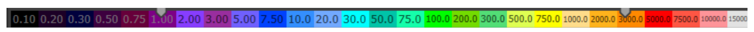
LUX
Average
perpendicular
Over cast



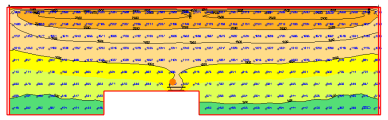
DF
daylight factor



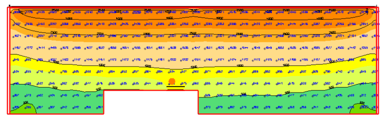
DF
Effective area



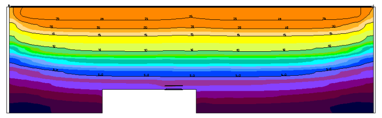
Analysis time :
March 21
September 23



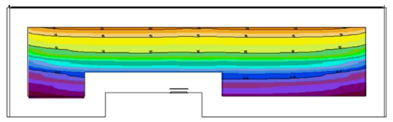
LUX
Average
perpendicular
Clear sky



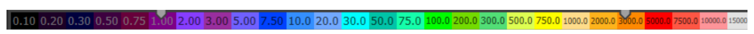
LUX
Average
perpendicular
Over cast



DF
daylight factor



DF
Effective area

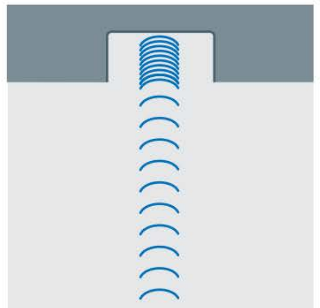


7.1.8 STAGE 2 : OPTIMIZATION (DAYLIGHT CONTROL SYSTEMS)

Because of the ability to minimize lighting energy consumption and mitigate glare, daylight management systems are attracting increased attention to building façade design. These control systems may manage the strength of solar rays entering internal areas through glazed building components based on the varying solar ray angles in different seasons and hours of the day. We narrowed it down to four key systems after doing study. The outcomes of the inquiry among the listed systems will be shown in the following data. We'll go through how we used these methods on the project in the following step.

7.1.8.1 EXTERNAL MOVABLE SHADING SYSTEMS

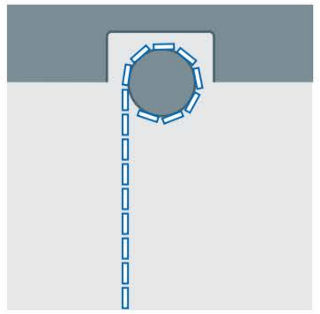
External blinds



Applications
- Daylight harvesting
- Daylight glare control
- Optimum view out
- Best thermal protection

Features
- The narrower the slats, the more attractive their appearance
- Non-fading
- Suitable for high wind speeds
- Difficult to retrofit
- Not light-tight

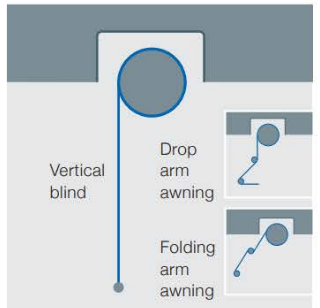
Roller shutter



Applications
- Protection from sun light
- Blackout
- Intruder security

Features
- Daylight tracking is not possible
- Suitable as protection against heat
- Difficult to retrofit

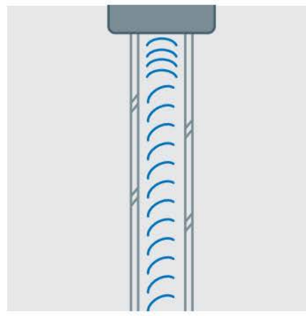
Awnings



Applications
- Protection from sun-light

Features
- Very sensitive to wind
- Sensitive to rain
- Depending on position of sun, glare control ,shading may not be possiblee

Interstitial blinds



Applications
- Daylight harvesting
- Daylight glare control
- Optimum view out
- thermal protection
- Privacy

Features
- Not susceptible to wind or dust
- Sometimes possible to retrofit
- Functions are inopera-tive if window is opened

Advantages of externalshading systems
- Façade design element
- Innovative daylight-based solutions
- Good thermal insulation

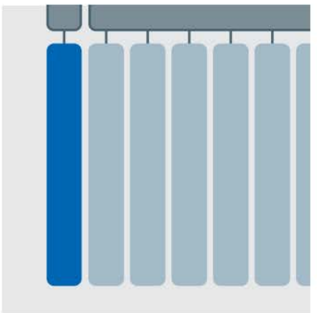
Disadvantages of external shading systems
- Cannot be used in all weathers
- Investment cost is higher than that of internal pro-tection from sunlight
- More maintenance required

Advantages of built-in shading systems
- Space saving
- Maintenance free
- Unaffected by weather

Disadvantages of built-in shading systems
- Expensive to repair
- High investment cost

7.1.8.2 INTERNAL MOVABLE SHADING SYSTEMS

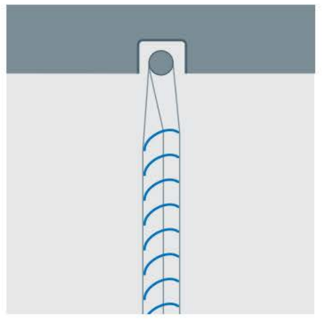
Vertical slat blind



Applications
- Partial daylight glare control
- Privacy
- Visual link possible to external environment

Features
- Unpredictable view out
- Can be retrofitted
- If left partially open, glare problems may transfer to other things of the space
- Heating up of rooms in summer cannot be pre vented
- Currently less popular than in previous periods

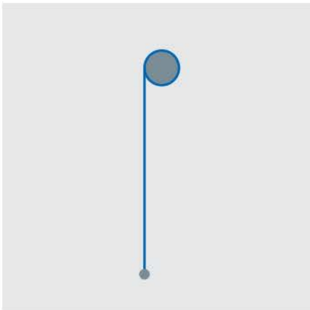
Venetian blind



Applications
- Daylight harvesting
- Daylight glare control
- Optimum view out
- Moderate thermal pro tection
- Room partitioning function

Features
- Decorative element of interior
- Most popular UK solu- tion
- Easiest access for maintenance of mech anism
- Potentially distracting motor noise
- "Solar flare", leading to disturbing glare, can be a problem with decora tive blinds

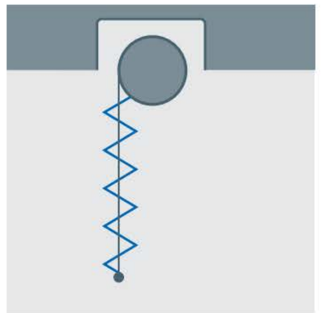
Roller blind



Applications
- Privacy
- Blackout
- Protection from sun light
- Possible future day light harvesting

Features
- Requires little space
- Sheer fabric produces pleasant lighting condi- tions
- Decorative element
- Heating up of rooms in summer cannot be pre- vented
- Quality of light con- trol depends upon the choice of fabric
- Twin roll screens can give

Pleated blind



Applications
- Privacy
- Protection from sun- light

Features
- Decorative element
- Suitable for locations where space is cramped
- Suitable for various win- dow shapes

Advantages of internal shading systems
- Can be used regardless of weather conditions
- Provide decorative room effect
- Lower investment cost
- Inexpensive to install, uninstall and maintain Dis- advantages of internal shading systems
- Sometimes no protection from glare if window is opened
- Once inside the room, not all solar radiation can be reflected out again

7.1.8.3 FUNCTIONS - BLINDS AND THEIR CONTROL OPTIONS

General information

Maximum energy efficiency, more convenient operation, improved quality of life and protection against break-in are becoming increasingly important aspects of building design. intelligent lighting and blinds management is making its contribution. Its sophisticated automatic control system can handle control of individual windows, specified areas, storeys, façades or entire buildings.

Functions

Short keypress up
Fully opens the blind. Benefit: individual adaptation of daylight conditions to suit one's own needs.

Brief keypress down
Fully closes the blind. Benefit: individual adaptation of daylight conditions to suit one's own needs.

Long keypress up
Opens the blind as long as the key is pressed. Benefit: individual adaptation of daylight conditions to suit one's own needs.

Long keypress down
Closes the blind as long as the key is pressed. Benefit: individual adaptation of daylight conditions to suit one's own needs.

Restore automation
After manual operation, restoration of automatic control can be set in the room automation computer as a time func- tion.

Automatic protection from sunlight
The window treatment is lowered if a defined, measured outside bright- ness is exceeded. Benefit: protection from glare and heat, and potential high energy savings.

Daylight-based control
Regulation of daylight by means of slat positioning accurate to within one degree. Benefit: as much natural light as possible is let in without glare being caused by high sky luminance or direct sun- light. Rapid fluctuations in daylight can also be compensated by measurement.

Shadow edge control
Blinds are controlled in their extended position depending on the posi- tion of the sun so that a specific area is always shaded. Benefit: the edge of the shadow cast by the blinds always remains in the same place regardless of the position of the sun.

Solar function
General opening and closing times are adapt- ed to suit sunrise and sunset. Benefit: opening and closing at sunrise and sunset.

Auto weekend control
Regardless of outdoor brightness, blinds are shut. Benefits:
- Closed, e.g. for protec- tion against break-in
- Temporarily opened to allow indoor plants to get sunlight
- Special programs make it possible to obtain promotionally effective façades. If buildings are sufficiently large, together with lighting, your own logo or other symbol can be simulat- ed.

Automatic day/night timer
The automatic timer makes sure that window treatments are closed or opened throughout the building or one façade at a time. Benefit: blinds can be lowered in the evening in commercially used buildings to prevent people in the vicinity being bothered by stray light in case of shift working. Conversely, blinds can be opened again automatically at dawn.

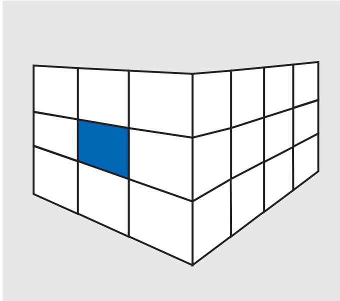
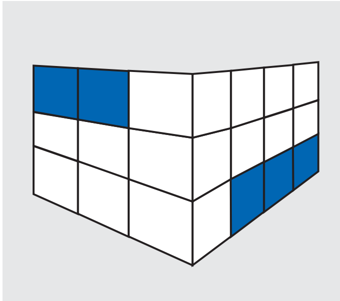
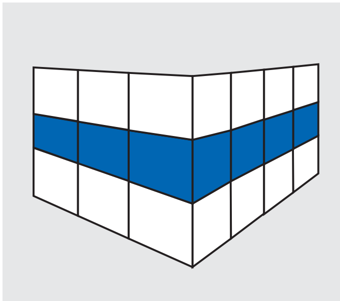
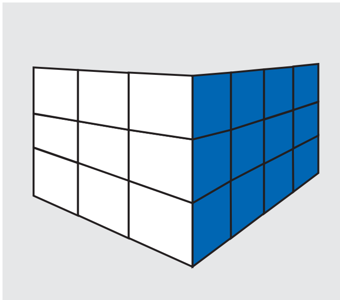
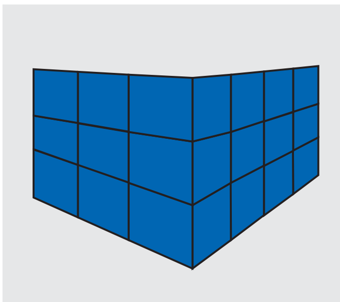
Manual or automatic lighting scene
A combination of various systems such as day- light, artificial light, emergency lighting, window and projection screen can be combined to give defined lighting scenes by pressing a scene pushbutton or by retrieving a scene on the basis of various parameters.

Automatic wind control
The wind speed is measured by a weather station. If sensor values are exceeded, the shading device is raised and manual intervention is disabled. Benefit: protects external blinds against damage by high winds.

Automatic precipitation control
A weather station measures the amount of precipitation. When a specific precipitation level is reached, awnings, for example, are retracted. Benefit: protection against excessive precipitation.

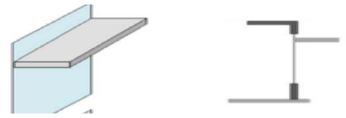
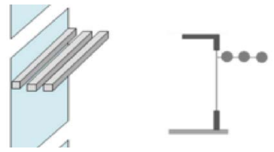
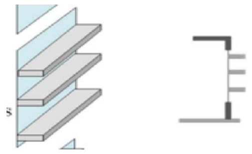
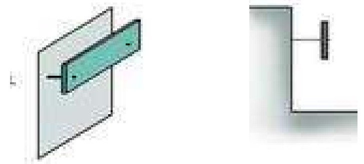
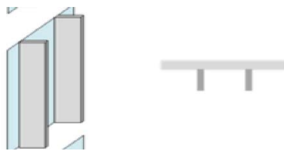
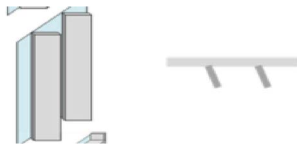
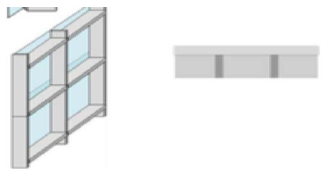
Automatic frost control
If there is risk of frost or icing (measured by special sensors), auto- matic and manual use of the window treatment system is disabled. Benefit: protection against damage by icing.

Climate-dependent blinds control
In summer, slat blinds are controlled so that shading systems are closed when an interior temperature limit value is exceeded on sunlit façades. In winter, auto- matic control opens all shading system on sunlit façades. Benefit: energy savings thanks to reduc- tion of cooling load in summer and heat output in winter.

Individual blind control	Individual blinds are primarily operated manually but also controlled in conjunction with redirection of daylight and daylight glare control, in single-person offices such as executive offices.	Operation: locally by manual override or automatic control system Applications: single-person offices, executive offices, workrooms Benefits: individual, user-oriented operation	
Sector or group control	Sector or group control is used in addition to manual operation, especially in team offices and open-plan offices. Operation: locally by manual intervention or automatic control system	Applications: team offices and open-plan offices, presentation areas, shop windows, exhibition areas Benefits: affordable, application-linked control	
Floor control	Control is horizontally geared towards floors or storeys. Individual systems can be merged floor by floor and controlled consecutively without causing peak energy loads.	Operation: by automatic control Applications: utility buildings, "investment properties" Benefits: peak energy loads are prevented when the building is being cleaned, building is used floor by floor	
Facade controls	Façade-by-façade control is used when daylight-based control is also used for uniform façade design by window treatments. It is also used when protection against wind is controlled one façade at a time.	Operation: by automatic system Applications: utility buildings, medium to large sized administrative buildings Benefits: complete shading of a façade during the day, or protection of neighbours against light trespass at night	
Building control systems	These include all the window treatments of a building. Operation: by automatic system Application areas: utility buildings, medium to large sized administrative buildings	Benefits: complete blackout, protection from heat at the weekend, protection against break-in at night and at weekends; maintenance and cleaning, window treatments are protected against wind and weather damage	

7.1.8.4 EXTERNAL FIXED SHADING SYSTEMS

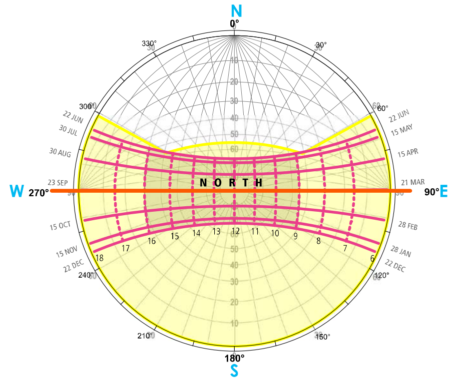
Fixed shading devices can be horizontal, vertical, or a combination of both, commonly called an "eggcrate." Horizontal shading devices are effective on the equatorial facing façades when the sun altitude is high and are suitable for the summer months. Vertical shading devices are preferred in the east and the west directions where the solar altitude is low and the entire window faces the sun. They function best when placed on the polar side, perpendicular to the window. The exception to this is in tropical latitudes where the sun is much higher even in the winter. It is recommended that the ratio between the depth of the shading device and the spacing of the element remain constant. (DeKay & Brown, 2013) The designing of shading devices should consider the position of windows, their location, and essentially latitude. The various categories of shading devices according to Lechner are:

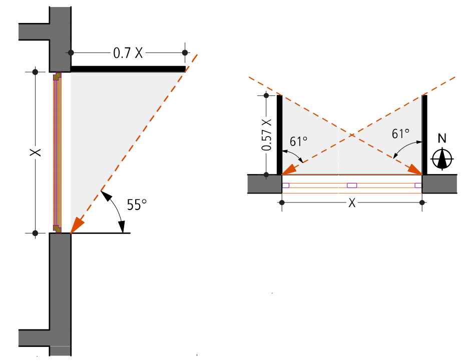
NAME	3D VIEW	BEST ORIENTATION	PROS AND CONS
Overhang		south, west, east	• Traps hot air • Can be loaded by snow and wind
Overhang Horizontal Louvers		south, west, east	• Free air movement • snow or wind load is small
Overhang Multiple Blades		south, west, east	• Traps hot air • Can be loaded by snow and wind • View restricted
Overhang Vertical panel		south, west, east	• Free air movement • No snow load • View restricted
Vertical Fin		west, east, north	• Restricted view • for north facades in hot climates only
Slanted Vertical Fin		west and east	• Slant toward north • restricts view significantly
Eggcrate		west and east	• For very hot clmates, • view restricted and traps

7.1.8.4.1 ADEQUATE SHADING , SIZING OVERHANGS AND FINS

Case study location : Garissa, Kenya 0° 27′ S, 39° 39′ E

North windows (N)

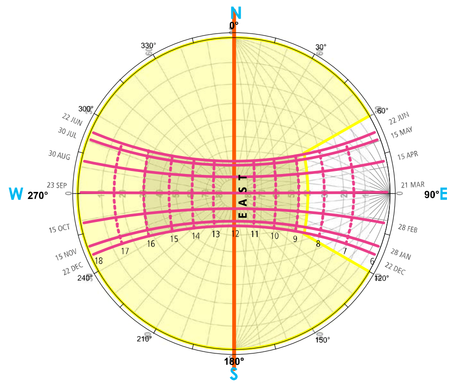


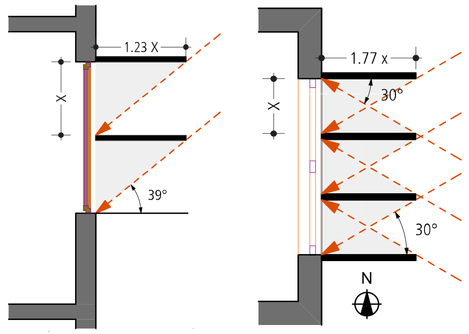


Recommendations

An overhang at a cut-off angle of 55 degrees (or depth equivalent to 0.7 times the window height). A vertical fin in addition to the overhang will provide complete shading. The vertical fin should have a cut-off angle of 61 degrees (depth should equivalent to 0.57 times the window width).

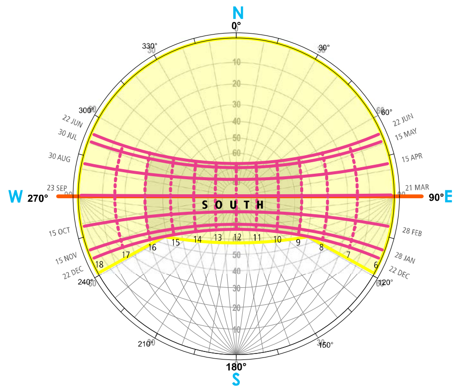
East windows (E)

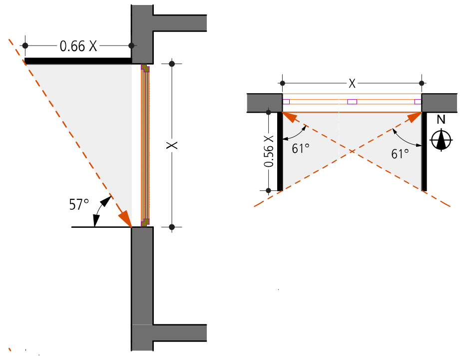




A combination of overhangs with a cut-off angle of 39 degrees (or depth equivalent to 1.23 times the height of the window being shaded) and side fins that are 1.77 times the width of the window, or cut-off angle of 30 degrees.

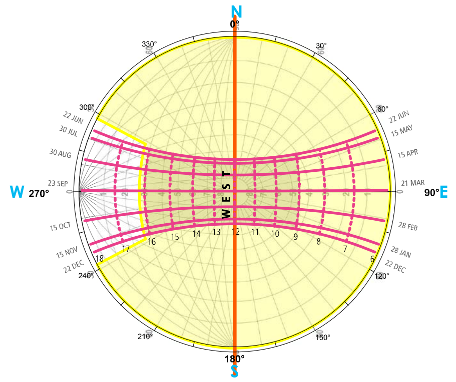
South windows (S)

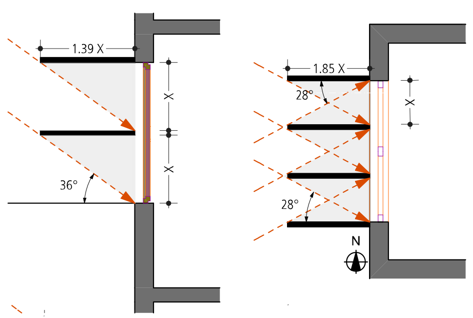




An overhang at a cut-off angle of 57 degrees (or depth equivalent to 0.66 times the window height). A vertical fin in addition to the overhang will provide complete shading. The vertical fin should have a cut-off angle of 61 degrees (depth should equivalent to 0.56 times the window width).

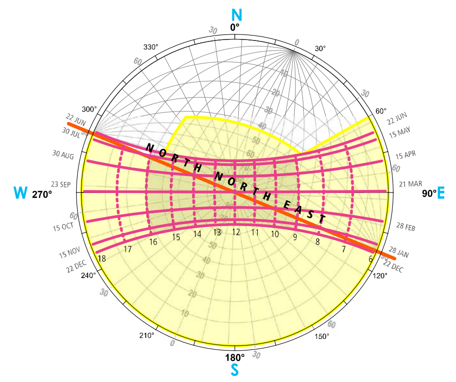
West windows (W)

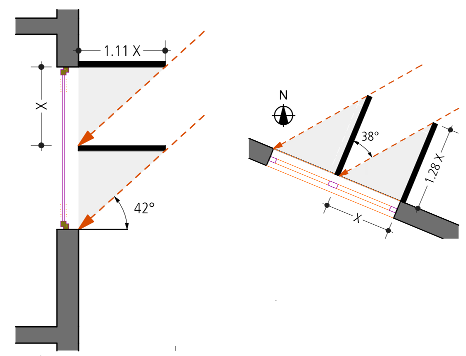




A combination of overhangs with a cut-off angle of 36 degrees (or depth equivalent to 1.39 times the height of the window being shaded) and side fins that are 1.85 times the width of the window, or cut-off angle of 28 degrees.

North north east windows (NNE)

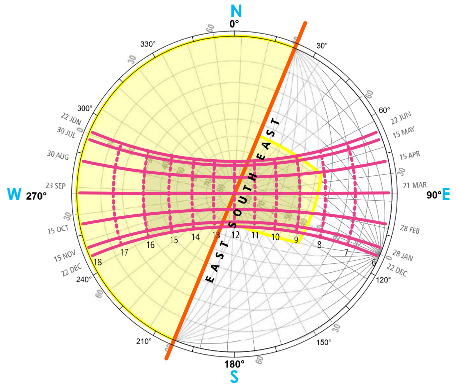


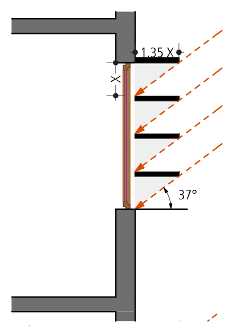


Recommendations

A combination of overhangs with a cut-off angle of 42 degrees (or depth equivalent to 1.11 times the height of the window being shaded) and side fins that are 1.28 times the width of the window, or cut-off angle of 38 degrees.

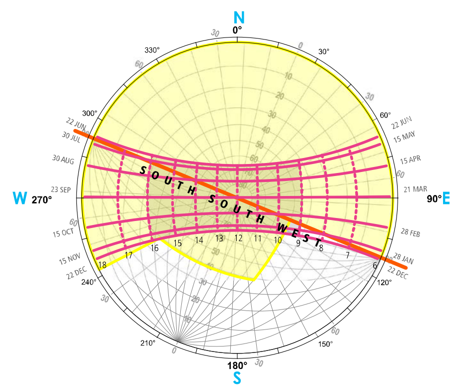
East south east windows (ESE)

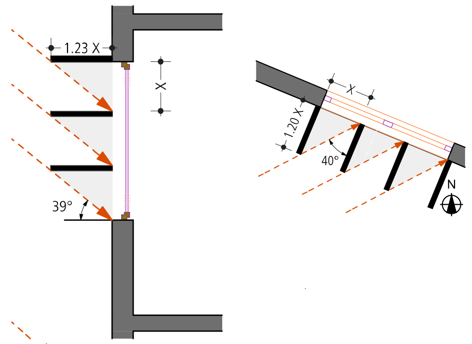




Overhangs with a cut-off angle of 37 degrees (or depth equivalent to 1.35 times the height of the window being shaded).

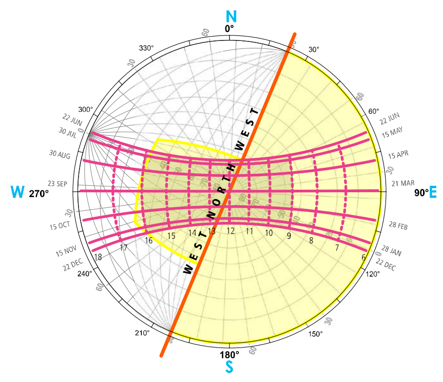
South south west windows (SSW)

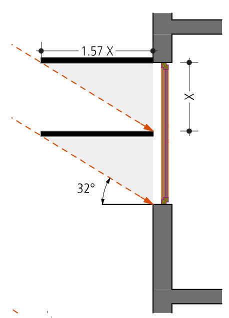




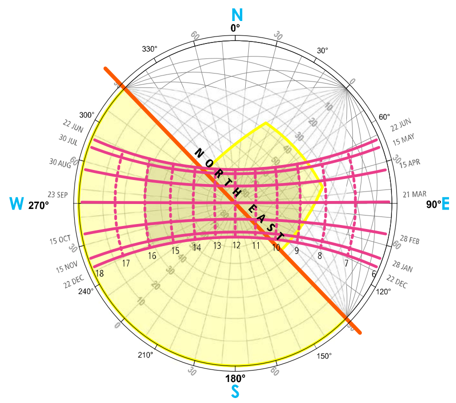
A combination of overhangs with a cut-off angle of 39 degrees (or depth equivalent to 1.23 times the height of the window being shaded) and side fins that are 1.20 times the width of the window, or cut-off angle of 40 degrees.

West north west windows (WNW)

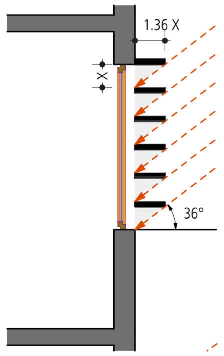




Overhangs with a cut-off angle of 32 degrees (or depth equivalent to 1.57 times the height of the window being shaded).

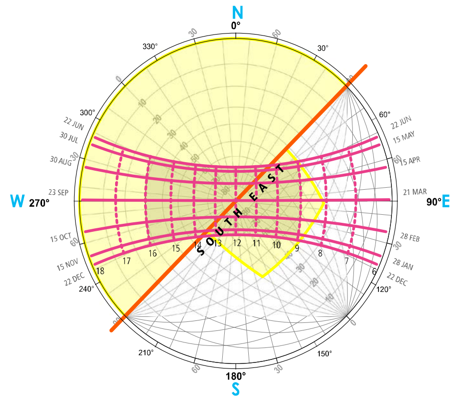


North east windows (NE)

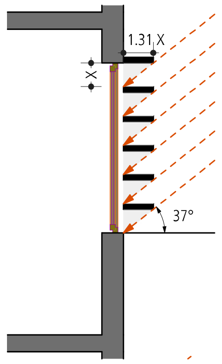


Recommendations

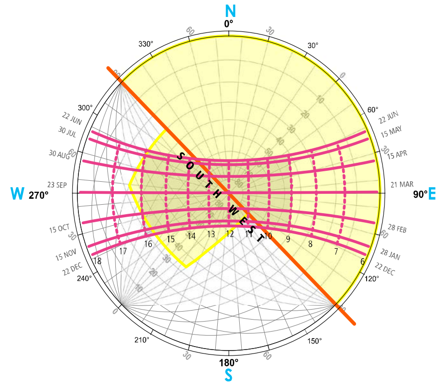
Overhangs with a cut-off angle of 36 degrees (or depth equivalent to 1.36 times the height of the window being shaded).



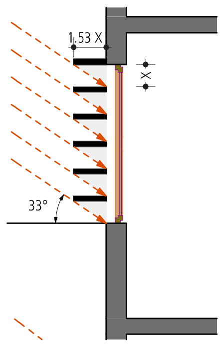
South east windows (SE)



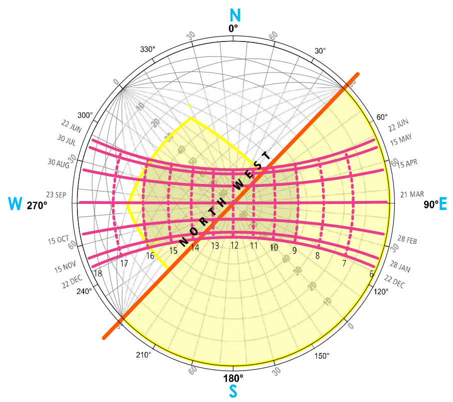
Overhangs with a cut-off angle of 37 degrees (or depth equivalent to 1.31 times the height of the window being shaded).



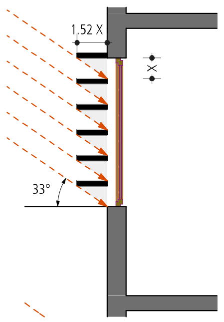
South west windows (SW)



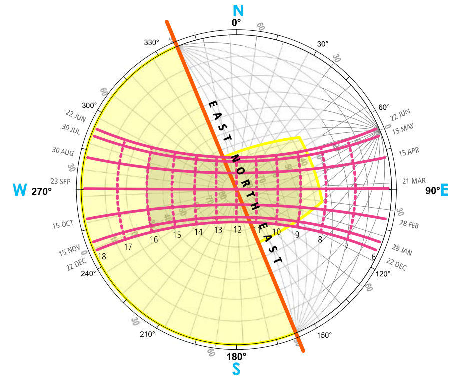
Overhangs with a cut-off angle of 33 degrees (or depth equivalent to 1.53 times the height of the window being shaded).



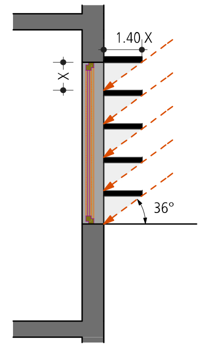
North west windows (NW)



Overhangs with a cut-off angle of 33 degrees (or depth equivalent to 1.52 times the height of the window being shaded).

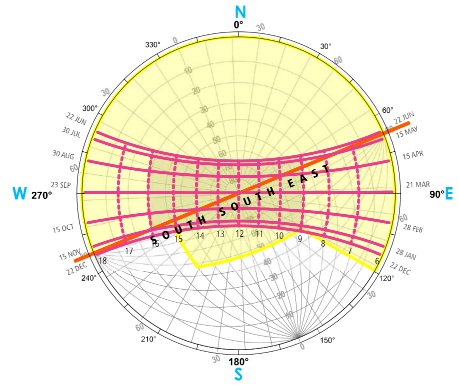


East north east (ENE)

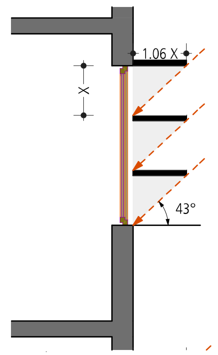


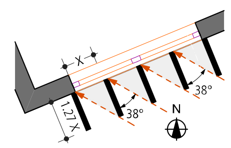
Recommendations

Overhangs with a cut-off angle of 36 degrees (or depth equivalent to 1.40 times the height of the window being shaded).

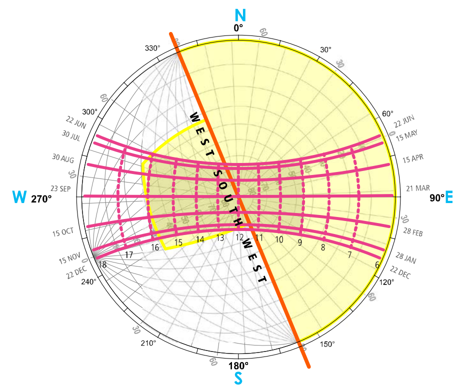


South south east (SSE)

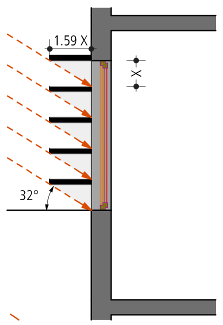




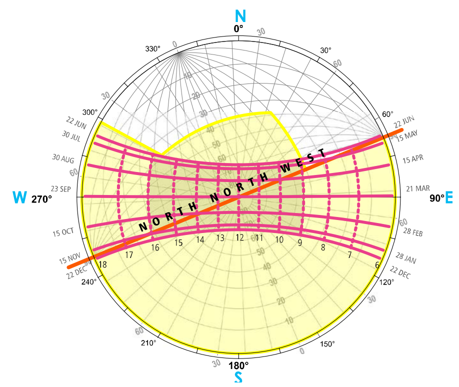
A combination of overhangs with a cut-off angle of 43 degrees (or depth equivalent to 1.06 times the height of the window being shaded) and side fins that are 1.27 times the width of the window, or cut-off angle of 38 degrees.



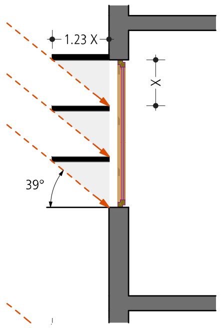
West south west (WSW)

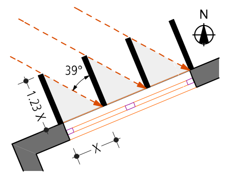


Overhangs with a cut-off angle of 32 degrees (or depth equivalent to 1.59 times the height of the window being shaded).



North north west (NNW)





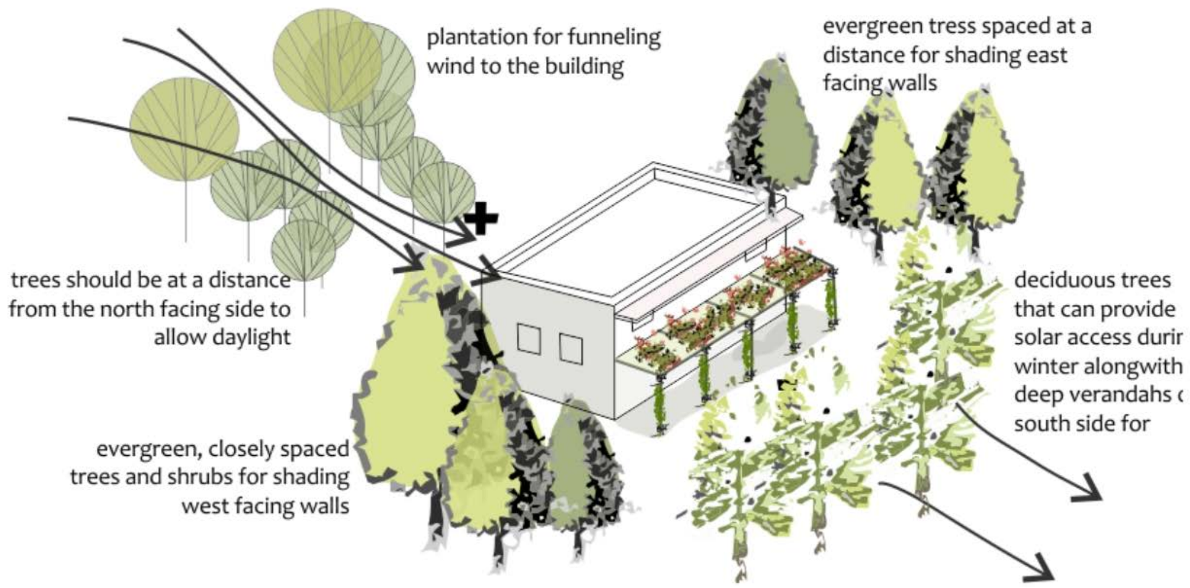
A combination of overhangs with a cut-off angle of 39 degrees (or depth equivalent to 1.23 times the height of the window being shaded) and side fins that are 1.23 times the width of the window, or cut-off angle of 39 degrees.

7.1.8.5 VEGETATION

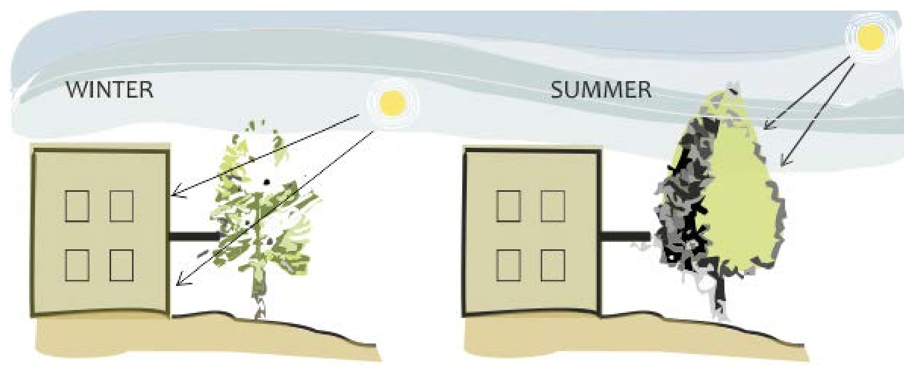
Landscaping building and open space shading Roof garden (or rooftop greening) It reduces the impact and heating of the building surface due to direct sunlight and lowers the outside air temperature. When used with due consideration of seasonal variations in building location, it can be a cost-effective and flexible shading element. Planting also covers the surface of the building and the open ground, lowering the surface temperature. This shade is almost permanent, so the low temperatures do not change much, even with occasional strong radiation during the hot season.

Rooftop greens and roof gardens can also be used as they help reduce the heat load on the building. The green cover lowers the ambient temperature by evapotranspiration. Soil depth is at least 300 mm for intensive rooftop greening, about 25-125 mm for large roofs, and about 100 mm for modular blocks. Architects can effectively use proper landscaping and vegetation early in the design phase to reduce ambient temperature and reduce the need for air conditioning loads in the building.

- Use of local species for vegetation is highly recommended as they are accustomed to the variations in temperature, rainfall patterns and soil conditions for that region. They are relatively low maintenance in terms of water usage, and are resistant against local pests. In addition, that also support birds and insects that thrive naturally in the region and help maintain the balance of natural flora and fauna.
- the exotic species should cover no more than 25% of the landscaped area of a building.
- Reduce lawn area in the garden to a minimum to reduce the amount of water that is needed for irrigation.
- Reduce the area of hard paved surfaces through the use of polypropylene grass pavers. Absence of hard surfaces also ensures lower ambient temperature. It is also more pleasant for pedestrians to walk on a green, soft surface that does not radiate heat.



- Evaluate the possibility of creating “structural shading” using recycled and otherwise discarded components. Installing structural shading with a minimum Solar Reflectance Index of 29 (usually materials with light, reflective surfaces) absorbs less heat, and mitigates the probability of heat islands.
- Deciduous vegetation can be considered as flexible shading devices. During winter, the vegetation will shed leaves to allow penetration of sunlight to the same occupied space which it would shade in summer.

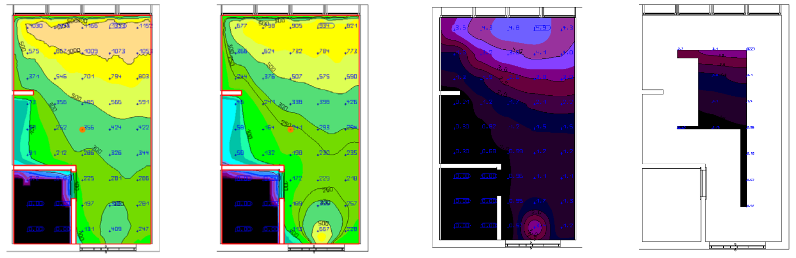


7.1.9 STAGE 2 : POST OPTIMIZATION DAYLIGHT ANALYSIS

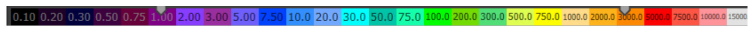
Demonstrating the analysis in figures proves that the use of the shadings and vertical elements as the main core of the design has made an resistible situation for the building.
in adition retrofiting the existed atriums in the middle of the plans in the ground floor, has positive effects on the natural daylight of the building and consequently positive effect on the energy consumption.
in the last step by applying the selected daylight controling systems,we made the daylight simulation in the critical cases again.

7.1.9.1 CASE1 : UNIT1

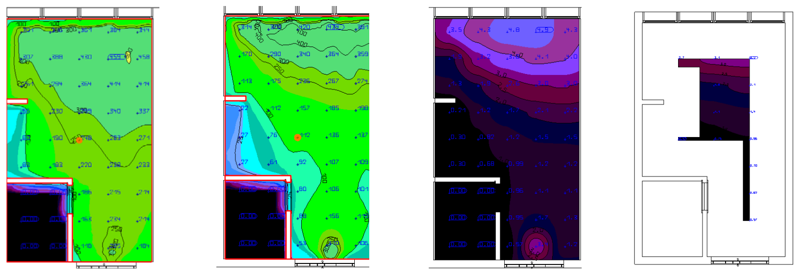
Analysis time :
15 June



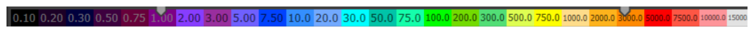
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



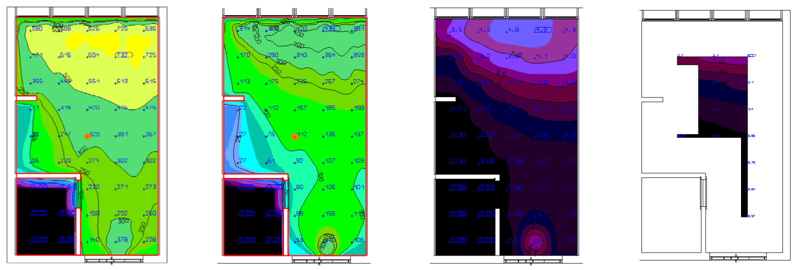
Analysis time :
December 21



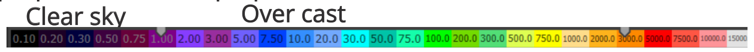
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



Analysis time :
March 21
September 23

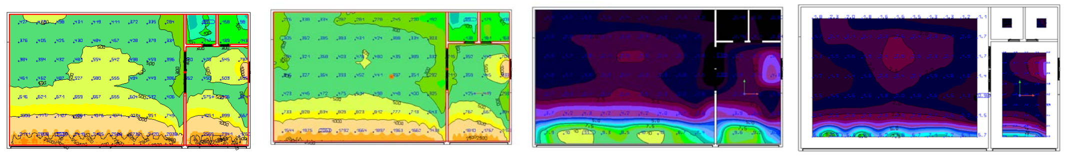


LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area

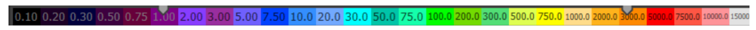


7.1.9.2 CASE 3 : GYM

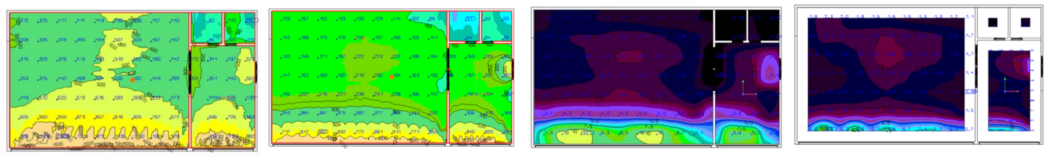
Analysis time :
15 June



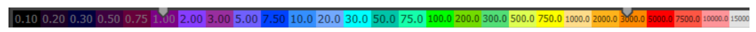
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



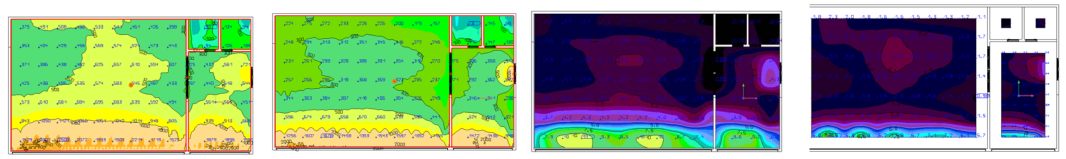
Analysis time :
December 21



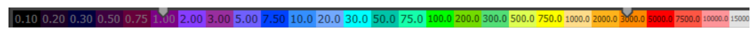
LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area



Analysis time :
March 21
September 23



LUX Average perpendicular Clear sky | LUX Average perpendicular Over cast | DF daylight factor | DF Effective area

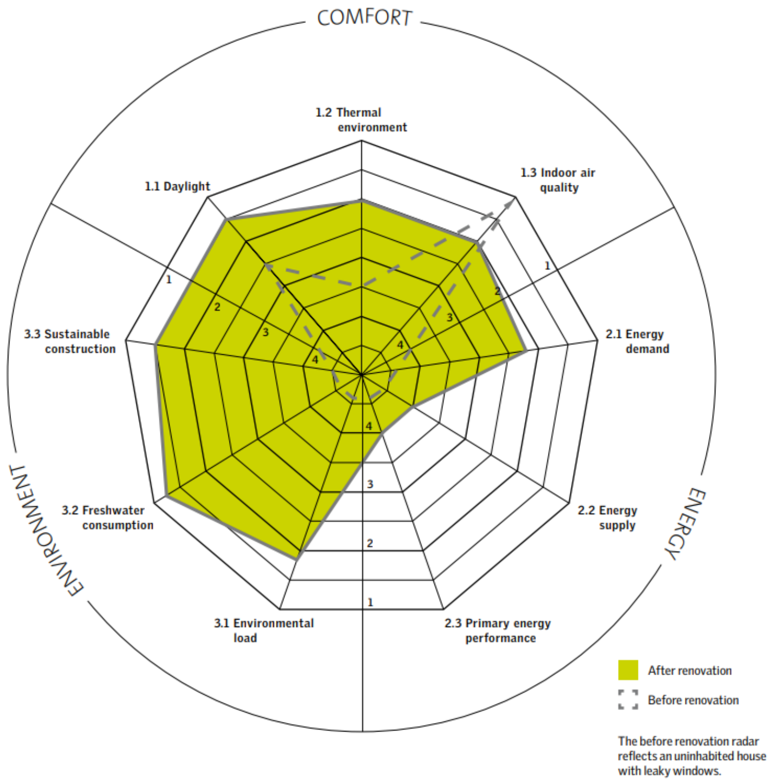


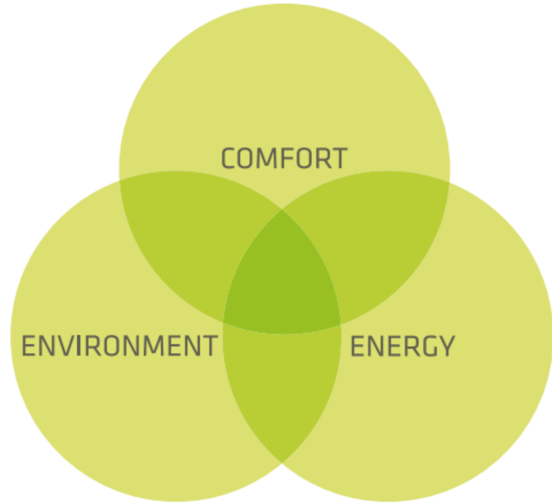
7.2 ENERGY ANALYSIS

Given the fact that the design process of the project took into account the sustainable part in parallel with the development of the architectural and structural design, in this section of the work is shown how the energy performance of the building had been changing due to the decisions taken for the realization of the final product.
The analysis was done to the main target of the project which is in fact the New Aarch, and then was developed in a more detailed procedure which can be found in the following section of this chapter. Starting from the analysis of the shape factor, passing through the daylight analysis and finishing with the energy consumption analysis of the building complex.

7.2.1 ACTIVE HOUSE

The purpose of the Active House vision is to set long-term goals for the future building stock and to unite interested parties around a balanced and holistic approach to building design and performance. Translated into everyday ventures, the aim is to evaluate the active house according to the building's energy consumption,
indoor climate conditions and impact on the environment.





Comfort
An Active House creates healthier and more comfortable indoor conditions with a generous supply of daylight and fresh air.

Energy
An Active House is energy-efficient and prioritises renewable energy sources which are integrated into the building or collected from nearby energy systems.

Environment
An Active House interacts positively with the local and global environment, focusing on the use of resources and the overall environmental impact throughout its life cycle.

• HEALTH

The Active House vision was created to ensure that homeowners and t nants can achieve healthier and more comfortable living conditions with a minimal impact on the environment.
The purpose of the Active House vision is to set long-term goals for the future building stock and to unite interested parties around a balanced and holistic approach to building design and performance.

Translated into everyday ventures, the aim is to evaluate the Active House according to the building's energy consumption, indoor climate conditions and impact on the environment.

• AFFORDABILITY

Financial accessibility is the hallmark of the RenovActive concept. the main priority was to propose a financially affordable climate renovation project. Choices made for the renovation concept were based on the budgetary framework of social housing organisations in rome and requirements established under the Energy Performance of Buildings (EPB). Based on the known costs of similar renovations, reproducing a RenovActive solution is within the social housing budget framework for reproduction.

While the project is fully financed by the, building materials have been provided carefully. The standard rate for these materials was taken into account to determine the final cost of the renovation.

• REPRODUCIBILITY

RenovActive intends to be a renovation concept that can be applied directly to existing buildings throughout Europe on a large scale. The renovation concept is developed for a five-façade house, but can be easily transferred to the other buildings. The reproducible elements can be applied to both renovation and newbuild projects.
Construction techniques and materials were carefully chosen to make the concept reproducible in as many homes as possible.
Furthermore, the concept is scalable, which means that individual elements from the concept can be picked and applied independently, the level and quality of daylight, e.g. the dynamic sunscreening, the hybrid ventilation system and the pv pannels.

7.2.2 WHAT IS EUI?

Energy use intensity (EUI) is an indicator of the energy efficiency of a building's design and/or operations. EUI can be thought of as the miles per gallon rating of the building industry. It is used in a number of different ways including to set a target for energy performance before beginning design, to benchmark a building's designed or operational performance against others of the same building type, or to evaluate compliance against energy code requirements. It is important to remember that EUI varies with building type[i]. A hospital or laboratory will have a higher EUI than a residence or small office building.

EUI is expressed as energy per square foot or meter per year. It is calculated by dividing the total energy consumed by the building in one year by the total gross floor area of the building. EUI is expressed as thousands of British thermal units used per square foot per year (kBtu/sq. ft./year) or gigajoules per square meter per year (GJ/m2/year). To calculate EUI, energy used for one year must be converted from kilowatt hours of electricity or therms of natural gas to kBtu or GJ.

7.2.3 HOW ENERGY AFFECT EUI ?

The amount of energy used by a building can be considered in two different ways, at the building site or at the source, meaning where it was generated. It's important to know which definition of energy you're using. There is also a third definition, Time Dependent Valuation (TDV) energy, used only in California in the Performance Approach to documenting compliance with the California Energy Commission's Title 24 Part 6 Building Energy Standards.

Site energy is the amount of energy consumed at the building site indicated in utility statements or via metering for an existing building or as predicted by energy modeling software for a building in design. Utility delivered energy plus Renewable Energy generated and used onsite are included because they are required to operate the building. Renewable energy exported to the electric grid is not included because it is not used for building operations. Site EUI is the amount of site energy used in one year divided by the total square feet of building area.

Source energy traces heat and electricity used at the site back to the original raw inputs. Electricity, for example, can be generated at a power plant by burning raw fuels such as coal or natural gas, from clean sources such as large hydropower plants, or from renewable 'fuels' such as sun, wind, small hydropower, and geothermal. Source energy includes the total amount of raw fuel used at power plants to operate a building.

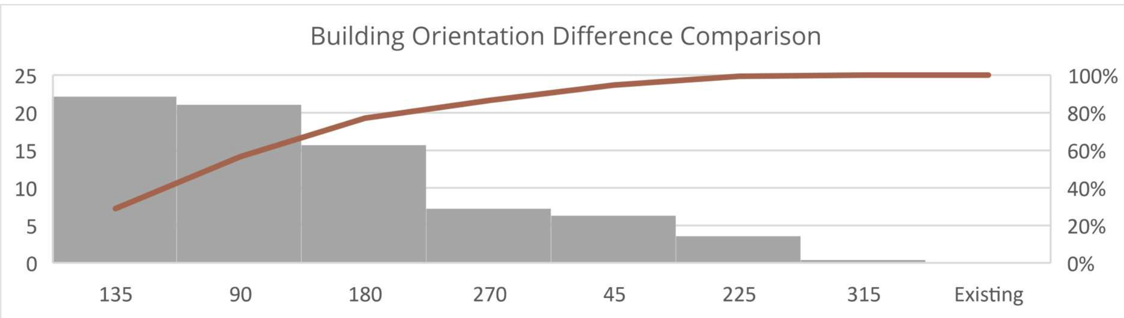
In calculating source energy, a 'multiplier' or 'factor' is applied to metered site energy to reflect the raw fuel used to generate and deliver the metered site energy. The Source Energy Factor used by the US EPA as of 2019 for utility delivered electricity was 2.8.[iv] As grid-supplied electricity replaces fossil fuels with renewable sources such as sun and wind, this multiplier grows smaller.[v] In calculating source energy, the amount of utility-supplied electricity used on site would be multiplied by the Source Energy Factor. Onsite solar or wind energy used in building operations has a Source Energy Factor of 1.0, meaning there is no multiplier. For natural gas used at the building, the Source Energy Factor is 1.05. Adding together utility delivered energy with the multiplier applied, plus the actual amount of on-site renewable energy used in operations gives the total amount of source energy required to operate the building. Renewable energy exported to the electric grid is not included because it is not used for building operations. Source EUI is the total amount of source energy used in one year divided by the square feet of building area.

Net EUI adds consideration of the amount of renewable energy exported to the grid in a year. The amount exported is subtracted from Annual Energy Use and the remainder is divided by square feet of building area. A Net Zero Energy building has a Net EUI of zero.

7.2.4 DETAILED ENERGY ANALYSIS

7.2.4.1 BUILDING ORIENTATION

Building Orientation	EUI (kWh/m^2/yr))
315	0.42
270	7.26
225	3.59
180	15.72
135	22.17
90	21.09
45	6.31
Existing	0

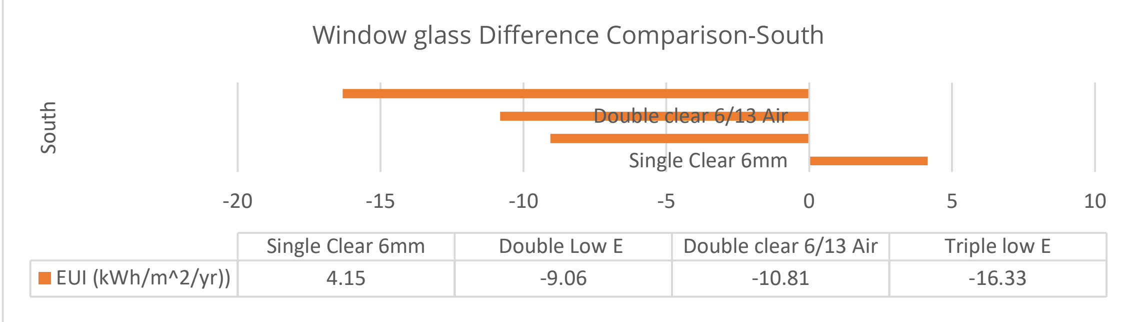


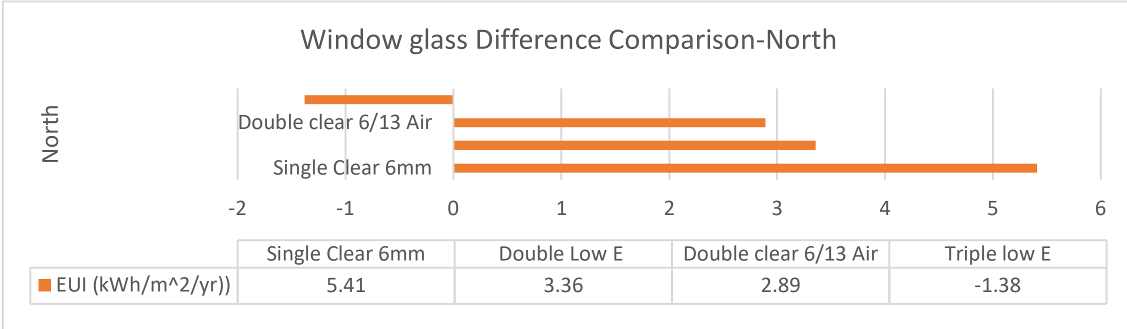
Comparison between "Building Orientation Differences in EUI"

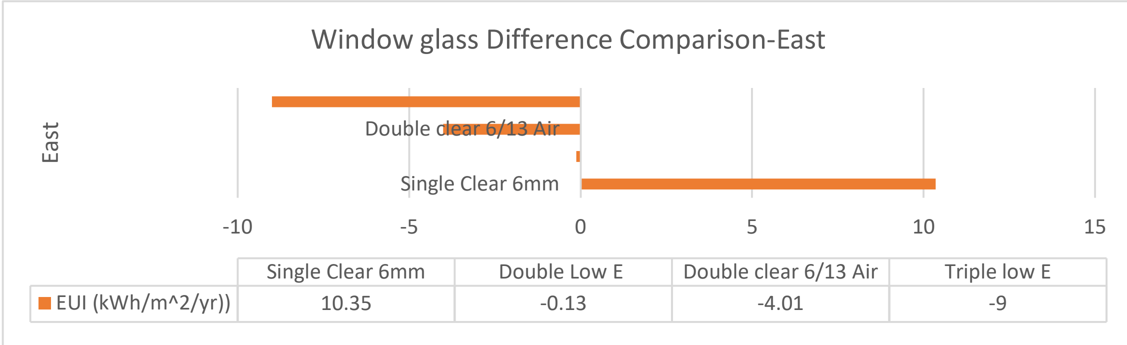
The line shows that the existing orientation is the most significant one.

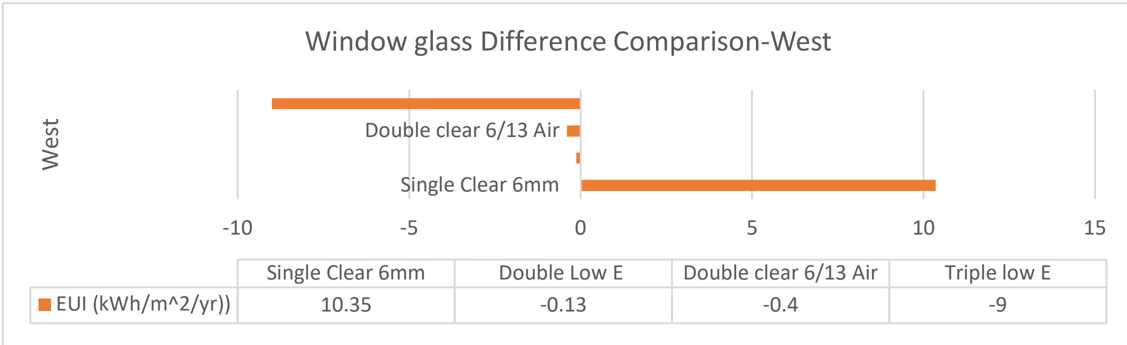
EUI: 184 kWh/m^2/yr

7.2.4.2 WINDOWS GLASS DIFFRENCE COMPARISON









Comparison between "Window glass Difference Comparison in EUI"

The Triple low E is the most significant one.

EUI: 161 kWh/m^2/yr

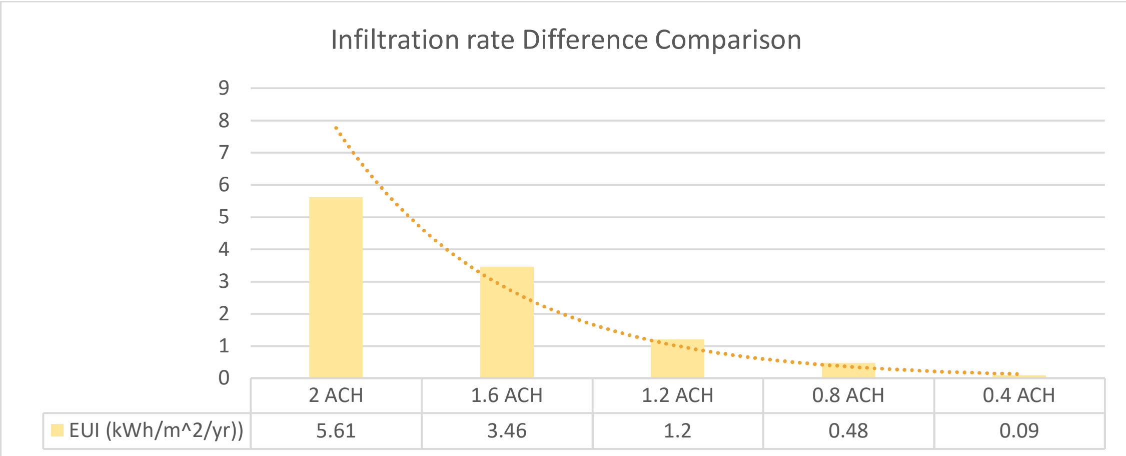
7.2.4.3 INFILTRATION

With exception of a few analyses of the impacts of ANSI/ASHRAE Standard 62-1989 and energy use, the energy used in the buildings due to infiltration and ventilation flows has received little attention. However, as improvements have been made in insulation, windows, etc., the relative importance of these airflows has increased. The energy impacts of infiltration and ventilation flows was estimated based on some analysis. actually the energy calculation was performed by a bin method with infiltration flows determined by multizone airflow model simulations.

The results show that infiltration is responsible for about 13% of the heating load and 3% of the cooling load of the buildings. In newer buildings, infiltration is responsible for 25% of the heating load and 4% of the cooling load due to the higher levels of insulation. The total annual energy impact of infiltration is 60 PJ of heating energy (15%) of the total heating energy) and and 6 PJ of cooling energy (4% of the total cooling energy). It is also estimated that heating and cooling energy use due to ventilation is 17 PJ at a rate of 2.5 L/s (5 cfm) per person and 138 PJ at 10 L/ss (20 cfm) per person. The results also show the potential energy savings due to tightening building envelopes and better control of ventilation system airflows.

This calculation of the energy impacts of infiltration and ventilation in the building is a rough estimate, with its accuracy limited by the calculation method and imput data. in the following table we represent intermediate step of this analysis..

It is also estimated that energy use due to ventilation is 17 PJ at a rate of 2.5 L/s (5cfm) per person and 138 PJ at 10 L/s (20 cfm) per person. The results also show the potential energy savings due to tightening building envelopes and better con-



Comparison between "Infiltration Difference Comparison in EUI"

EUI: 143.6 kWh/m^2/yr

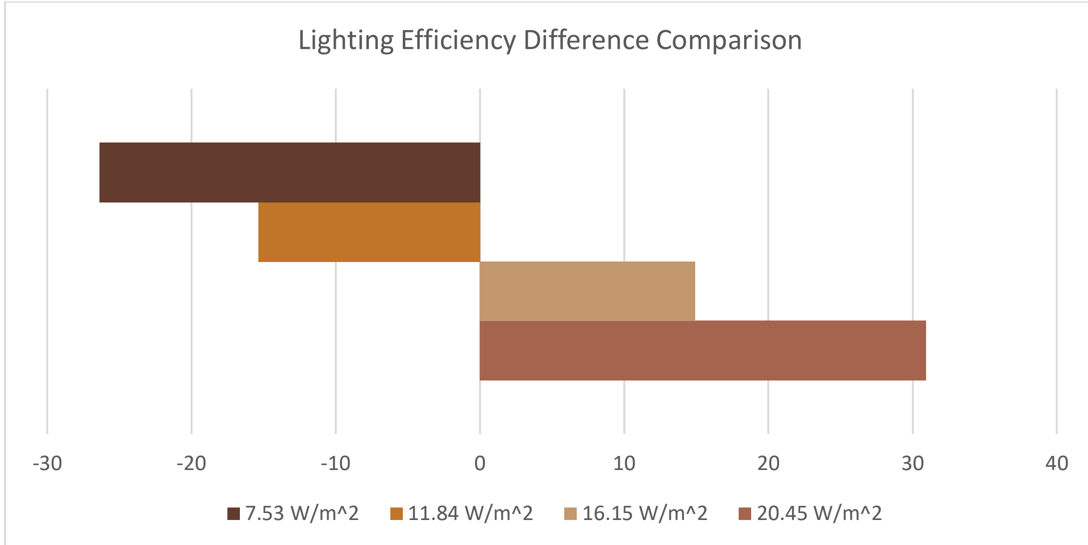
7.2.4.4 LIGHTING EFFICIENCY

Energy used for lighting is one of the major components of total energy consumption in buildings. Nowadays, buildings have a great potential to reduce their energy consumption, but to achieve this purpose additional efforts are indispensable. In this analysis, the need for energy savings evaluation before the implementation of lighting control algorithms for the project is highlighted.

Therefore, some analysis have been carried out according to the effeciency of the lighting in comparison with the energy consumtion of the building.

actually a A control strategy has been investigated, dependent on effeciency of the lighting system for the rough estimation of electrical energy savings. Since, according to the EN 15232 standard, Building Automation and Control Systems (BACS) play an important role in buildings' energy efficiency improvements, although it depend on specific building parameters as well.

Lighting Efficiency	EUI (kWh/m^2/yr))
20.45 W/m^2	30.92
16.15 W/m^2	14.9
11.84 W/m^2	-15.36
7.53 W/m^2	-26.4



Comparison between "Lighting Efficiency Difference Comparison in EUI"

Represents the average Internal heat gain and power consumption of electric lighting per unit floor area.

Choosing the 11.84 w/m^2

EUI: 137.2 kWh/m^2/yr\

7.2.4.5 DAYLIGHT AND OCCUPANCY

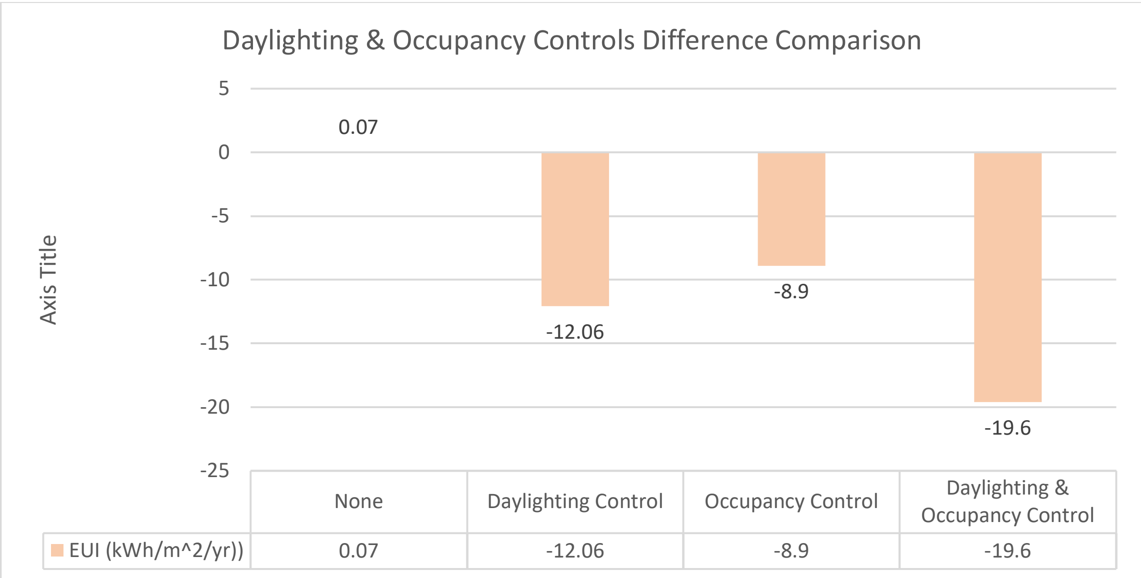
As mentioned in previous sections, daylight illuminance and its distribution in the rooms are crucial for possible electrical energy savings.
However, for the estimation of daylight in the rooms, there are two illuminance levels considered in research simulations and experiments:

- external—outside the building
- internal—inside the rooms.

Moreover, the well-known Daylight Factor (DF) is used for indication of daylight availability in each room. The DF is defined as:

$$DF = \frac{E_{int}}{E_{ext}},$$

where E_{int} is the internal illuminance and E_{ext} is the external illuminance, simultaneously available on the horizontal plane from the whole of an unobstructed CIE overcast sky given by the International Commission on Illumination.



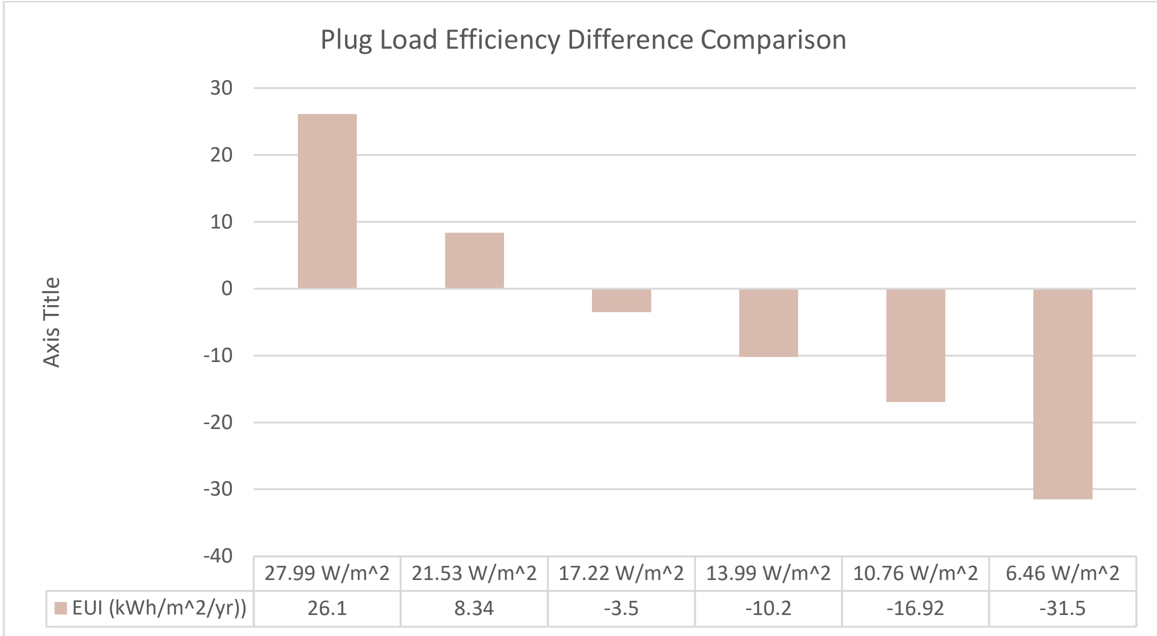
Comparison between "Daylighting & Occupancy Control Difference Comparison in EUI"

Represents typical daylighting & Occupancy Sensor systems.

EUI: 129.6 kWh/m^2/yr

7.2.4.6 PLUG LOAD EFFICIENCY

Plug and Process Loads (PPLs) account for an increasingly large percentage of building energy use in the E.U due to the rising number of energy intensive plug-in devices. Multiple studies show that plug loads consume approximately 22% of residential building energy use (DOE 2010) (NREL 2013) (Stanford 2014) (GSA 2012).
In simplest terms, PPLs are defined as anything that is plugged into an outlet, and they cover a wide variety of electronic, computer, refrigeration, and cooking devices, including equipment essential to information processing, medical treatment, and food service businesses. Each of these categories contains hundreds of types of devices (DOE 2016).
As buildings become more and more efficient, plug load efficiency has become ever more pertinent to achieving aggressive energy targets and net-zero energy status.



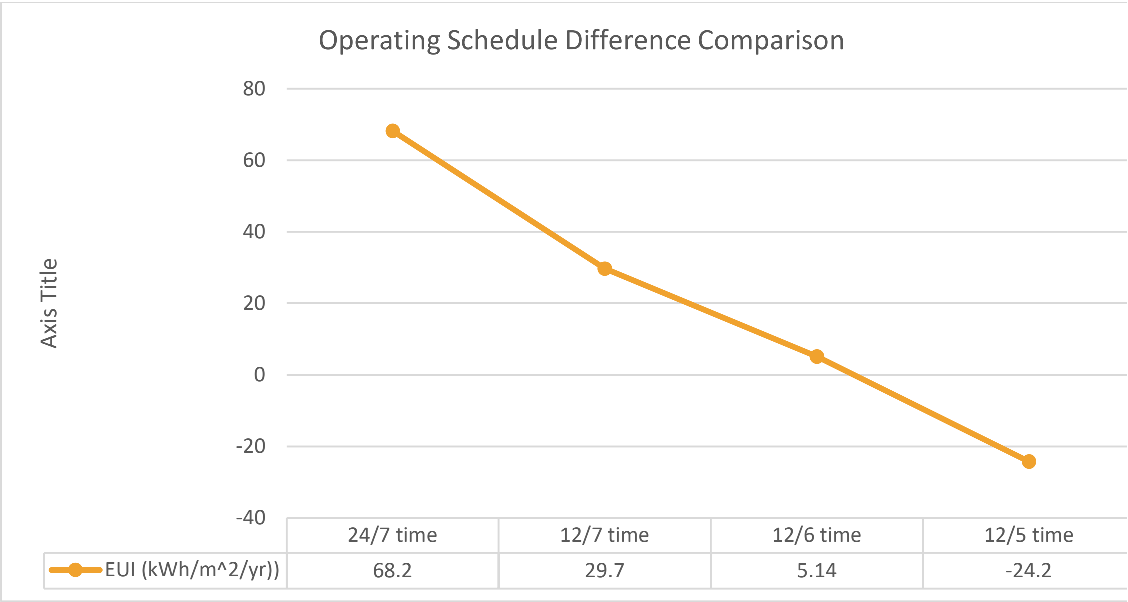
Comparison between "Plug Load Efficiency Difference Comparison in EUI"

The power used by equipment and small appliances. Excludes lighting or heating and cooling equipment.

EUI: 114.8 kWh/m^2/yr

APS Type	Description	Usage Examples
MasterControlled	Turn peripheral devices off when anprimary device is turned off by the user.	• library/Computer Lab: Desktop/laptop computers connected to a control/master outlet. Monitors/lamps/phone chargers connected to "switched" outlets. • Entertainment Centers: TVs connected to a master outlet. DVD players, speakers, etc., connected to switched outlets. Exceptions include cable boxes or other always-on devices. • residential : TVs connected to a master outlet. DVD players, game consoles, speakers, lamps, etc. connected to switched outlets. Exceptions include cable boxes or other always-on devices.
Timer	Automatically turn off outlets based on a pre-set schedule.	• Conference Rooms: Projectors, monitors, speakers, etc. Optional motion sensors can be used to turn equipment on or off if meetings end early or if unplanned meetings occur. • Break Rooms: Toasters, microwaves, coffee makers, or any other powered kitchen device. • Printer Rooms: Printers, copiers, fax machines, laminators, pencil sharpeners, hole punchers, etc. • Electronic Display Area: TV displays, computer/cellphone tryout stations, cosmetic lights/mirror stations, jewelry light stations, etc. • Cashier Aisles: Cash registers, conveyor belts, aisle lights, etc. • Gyms in Hotel or Multifamily Spaces: Workout equipment such as treadmills and elliptical machines, TVs, sound systems, etc. • Multifamily Game Room/Party Room: TVs, speakers, other plug-in equipment.
Activity Monitor	Turn equipment on or off in response to motion detected in a room.	• Office Desk – Commercial office, medical office, higher education research office, multifamily leasing office • Conference Rooms: Projectors, monitors, speakers, etc. • Break Rooms: Non-critical appliances • Hotel Business Centers: Computer monitors, printers, etc. • Game Room/ Party Room Multifamily: TVs, speakers, other plug-in-equipment.
Remote Switch	Enable users to easily turn off a power strip via a remote switch.	• Office Desk Areas: Computers, monitors, task lamps, printers, miscellaneous plug-in office equipment. • Computer Lab: Computers, monitors, task lamps, printers. • Hotel Room Entertainment Centers: TVs, speakers, other plug-in equipment. • Electronic Display Area: TV displays, computer/cellphone try-outstations, cosmetic lights/ mirror stations, jewelry light stations, etc. • Cashier Aisles: Cash registers, conveyor belts, aisle lights, etc. • Game Room/ Party Room Multifamily: TVs, speakers, other plug-in-equipment.
Masterless	Turn off power to outlets completely when the controlled devices are turned off, eliminating vampire loads.	• Office Desk Area: Computers, monitors, task lamps, printers,miscellaneous plug-in office equipment. • Electronic Display Area: TV displays, computer/ cellphone try-out stations, cosmetic lights/ mirror stations, jewelry light stations. • Cashier Aisles: Cash registers, conveyor belts, aisle lights. • Conference Rooms: Projectors, monitors, speakers, etc.

7.2.4.7 OPRATING SCHEDULE DIFFRENCE



Comparison between "Operating Schedule Difference Comparison in EUI"

The Typical hours of use by building occupants.

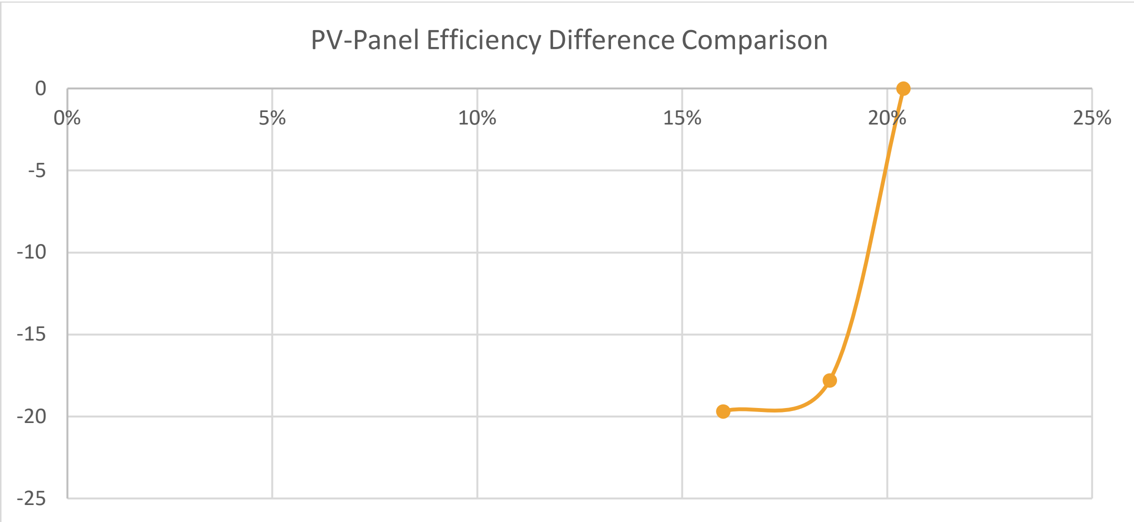
Choosing 12 hours of 7 days

EUI: 99.27 kWh/m^2/yr

7.2.4.8 RENEWABLE ENERGY
PHOTOVOLTAIC PANELS

PV panels consist of small photovoltaic cells that are connected together. PV Cells are made out of semiconducting material, silicone being the most commonly used. Combination of several PV cells increase its efficiency. Once the sun rays reached the PV cell, an electric field is created. The stronger the sun, the more electric energy is produced. Nevertheless, the cells do not need direct sunlight to work, and they can still produce electricity on a cloudy day. One of the most important parameters of the PV panel is its efficiency. The current parameter doesn't show if the PV module quality is premium or average. The efficiency is in direct ratio with amount of energy. Therefore, the main output from this characteristic is that the higher efficiency we have, the more energy we will get. The panel that we decided to use in the project is: X series : SPR-X22-370 by SunPower company with 18.6% of efficiency. The PV panels are place on the roof, facing the south side tilted for 15 degrees to have as much as possible perpendicular situation with the sun rays in order to get the highest efficiency through the time.

Pv Panel Efficiency	EUI (kWh/m^2/yr))
16%	-19.7
19%	-17.8
20.40%	0



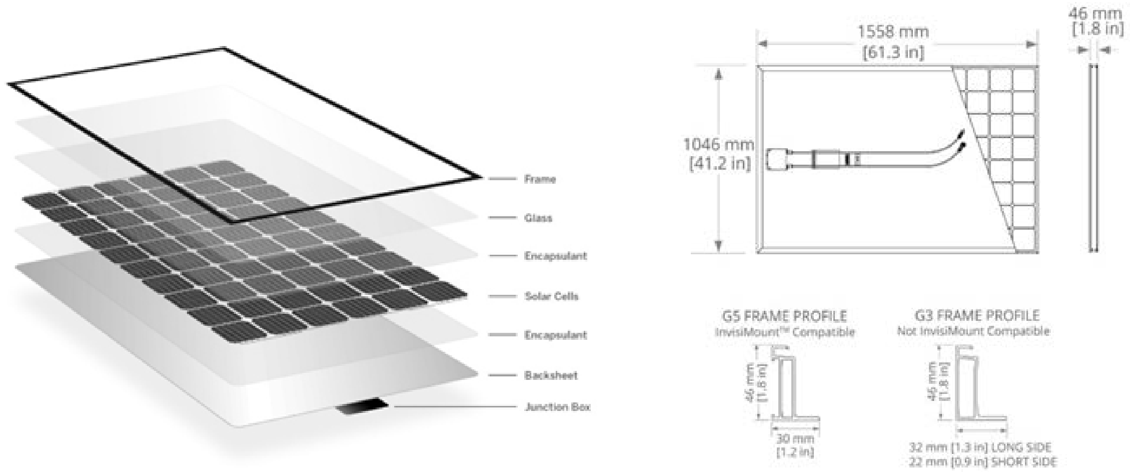
Comparison between "PV-Panel Efficiency Difference Comparison in EUI"

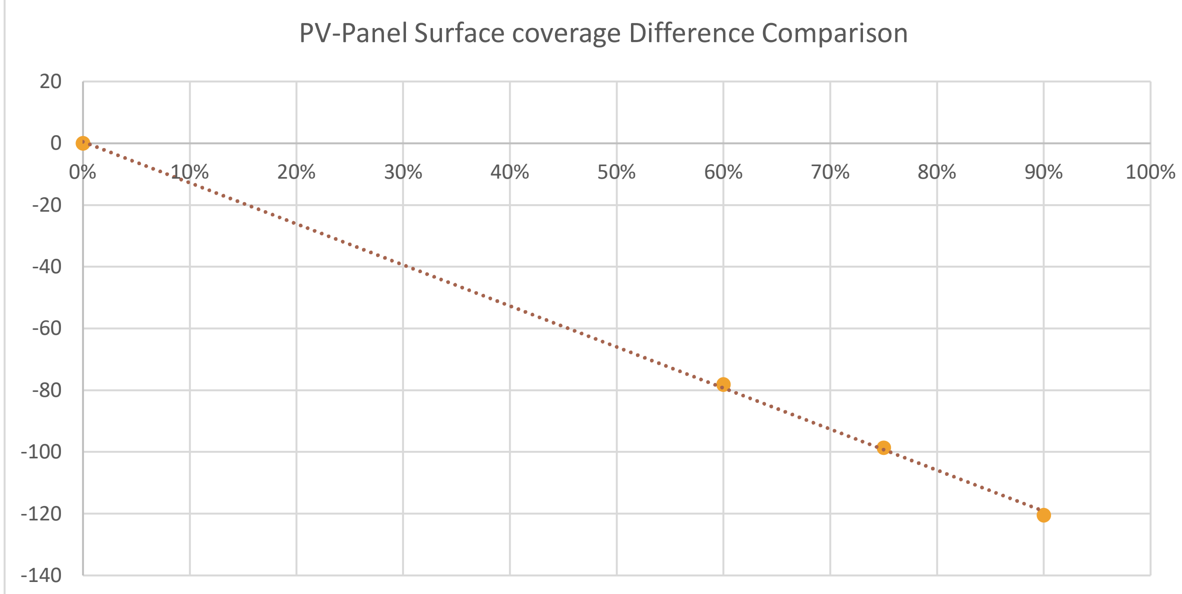
The percentage of sun's energy that will be converted to AC energy. Higher efficiency panels cost more, but produce more energy for the same surface area.

Choosing 18.6%

EUI: 90.2 kWh/m^2/yr

PV-Panel surface coverage	EUI (kWh/m^2/yr)
0%	0
60%	-78.14
75.00%	-98.6
90%	-120.47





Comparison between "Surface Coverage Difference Comparison in EUI"

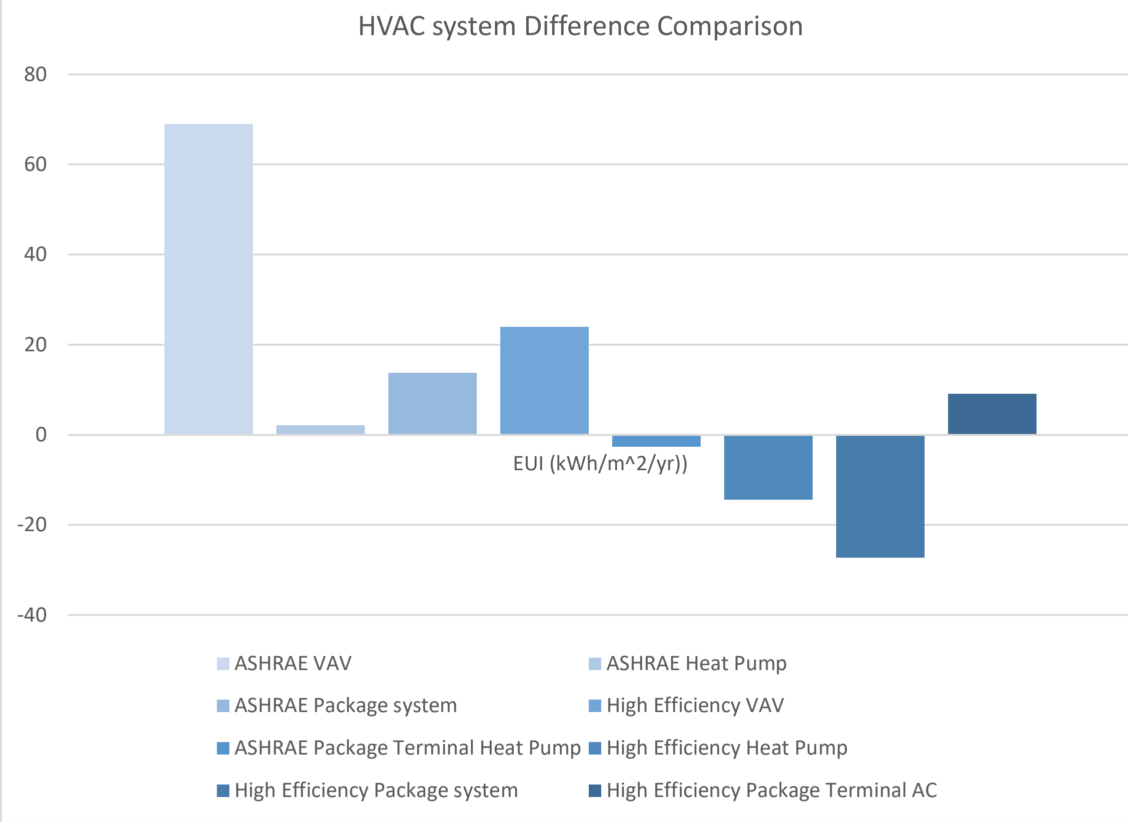
Defines how much Roof area can be used for PV panels, assuming area for maintenance access, rooftop equipment and system infrastructure

Choosing 40% coverage

EUI: 78.4 kWh/m^2/yr

7.2.4.9 HVAC SYSTEM

HVAC system	EUI (kWh/m^2/yr))
ASHRAE VAV	69
ASHRAE Heat Pump	2.07
ASHRAE Package system	13.8
High Efficiency VAV	24
ASHRAE Package Terminal Heat Pump	-2.6
High Efficiency Heat Pump	-14.4
High Efficiency Package system	-27.3
High Efficiency Package Terminal AC	9.1



Comparison between "HVAC Difference Comparison in EUI"

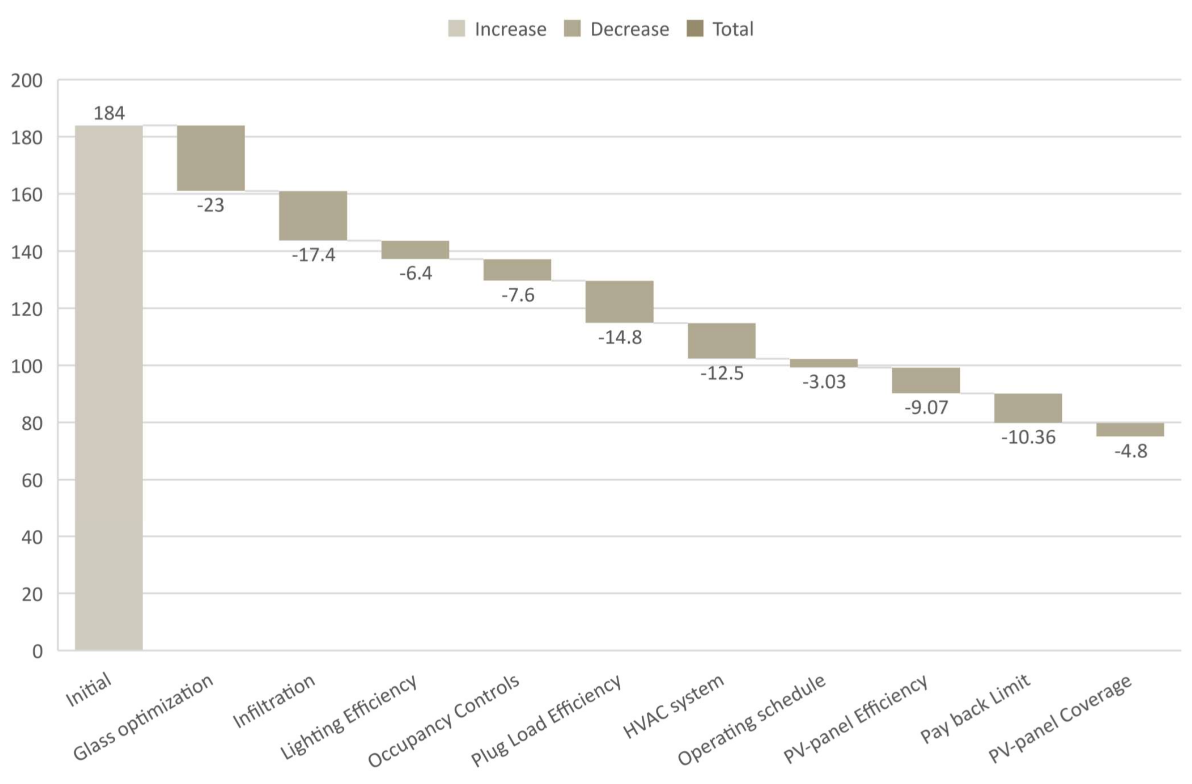
Represents a Range of HVAC system efficiency which will vary based on location and building size.

By choosing High efficiency VAV it would be:

EUI: 102.3 kWh/m^2/yr

7.2.4.10 CONCLUSION

Column1	INITIAL
Initial	184
Glass optimization	-23
Infiltration	-17.4
Lighting Efficiency	-6.4
Occupancy Controls	-7.6
Plug Load Efficiency	-14.8
HVAC system	-12.5
Operating schedule	-3.03
PV-panel Efficiency	-9.07
Pay back Limit	-10.36
PV-panel Coverage	-4.8
Total	75.04



8

STRUCTURAL DESIGN

8.1 INTRODUCTION

The importance of sustainable building that meet the majority criteria of LEED standards is essential since the project target is to attain structural sustainability. During the project, property of materials, technologies were based reliability and sustainability assessment. The structural frames such as concrete and steel frames, currently, considered as the most widely used materials due to their properties, structural benefits, cost and characteristics. Since the project aim to create co-working space in the building, the factors of wide open spaces was one of the reasons to consider the longspan frame structure which will be described and compared in the following paragraphs.

The selection of the construction materials is crucial stage in project development in terms of economy, structural stability that can withstand site loads over time. Since the program C40 Reinventing Cities aims to drive carbon neutral and resilient urban regeneration, the priority in the material choice will be sustainable building materials that will contribute to create carbon free environment as well as economic sustainability. The next list comprises possible structural frame options for multi-storey building:

- Cast-in-situ reinforced concrete framePrefabricated
- reinforced concrete frame
- Steel frame

In-situ concrete is concrete which is produced by casting concrete in formwork on site, cured to attain the strength of RCC elements. This type of concrete allows to be filled into ranges of shapes and volumes. Currently, it is widely used for foundation structures and ground floor elements. However, it is being replaced last decades by precast and prefabricated structural elements due to economical, quality reasons and construction time.

Precast concrete is produced off-site by casting in mold, cured and transported to the construction site for desirable application. The most common used element of precast concrete is prefabricated slab units including hollow core slab, flat slab and others that are characterized by their stiffness ratios, strength and large spans over high load. The other vertical and horizontal frame elements could be arranged in large span configuration by providing pre-stressed sections with steel rebars.

The major drawback of applying precast concrete frame is its cost to manufacture as well as the time needed to mount the elements.

Steel framework consists of steel section vertical and horizontal elements, that is most commonly used currently construction approach for both small and tall buildings. Unlike, concrete frame, steel frames need fire protection since the fire resistance capacity is weaker in comparison to concrete structures. However, there are more benefits of steel frame such as fast mounting, easy joining solutions, low cost options for industrial buildings, large span, flexibility. Since, both precast concrete structure and steel framework demonstrate their effectiveness for use, the key factor of selection will be based on mounting efficiency, cost and possible reuse with minimum impact to environment .

Thus, the structural frame of the New steps is executed in the concrete framework as the existing structure is concrete. The problem was that there is no exact information about the used concrete in the school, so we relied on some database information that comes from a study that contains the result of comparison testing on a large number of buildings made of concrete in different years. These data base information gives us some assumptions from which we were able to calculate and design slabs, columns and beams which are shown in the coming pages. Accordingly, several methods of flexural strengthening of members for the concrete buildings are examined as well. The structure is composed of hollow core slab elements of different thickness depending on span and load, which distribute in two dimensions to beams resting on columns, which transfer it to foundations directly. Structural element design is based on hand calculation. Elements including slab, beam and column were analyzed and designed according to Eurocode. Other design of column-to-beam connection, column base plate were considered.

8.2 STEP 1 _ANAYSIS

8.2.1 ANALYSIS OF THE DATABASE

The DB analyzed in the present study has been collected during the large campaign of seismic vulnerability assessments of public buildings located in Basilicata region that was carried out by the local government in execution of the national law OPCM 3274/2003 [14]. The campaign initially involved strategic buildings, such as hospitals, and buildings with considerable risk in case of collapse, such as schools. Data under study is made up of the compression test results on concrete cores extracted from the buildings under assessment. Therefore, note that the structural members (beam, column or wall) and the location from which core specimens were extracted were chosen from the professionals in charge for the assessment activities. The results of the compression tests in terms of concrete strength are reported in the test certificates also including basic information on the core specimens (location in each structure, height, diameter, specific weight, etc.).

The DB contains results of compression tests on 1557 concrete cores extracted from 333 buildings, 275 of which are schools and 58 are hospitals, thus providing a wide data source on the actual concrete properties of as-built RC public buildings. Unclear or unreliable data were discarded. The main data obtained from the compression test on core specimens is the ultimate strength. As well known [15], this strength value can be different from the in situ strength as a consequence of some factors influencing core strength such as the h/D (height/diameter) ratio, the possible presence of rebars, the damage occurred during the extraction, etc. Therefore, in the first step of the study, strength values representative of the in situ concrete quality have been determined. After, based on these values, the influence of the construction period on concrete properties has been investigated.

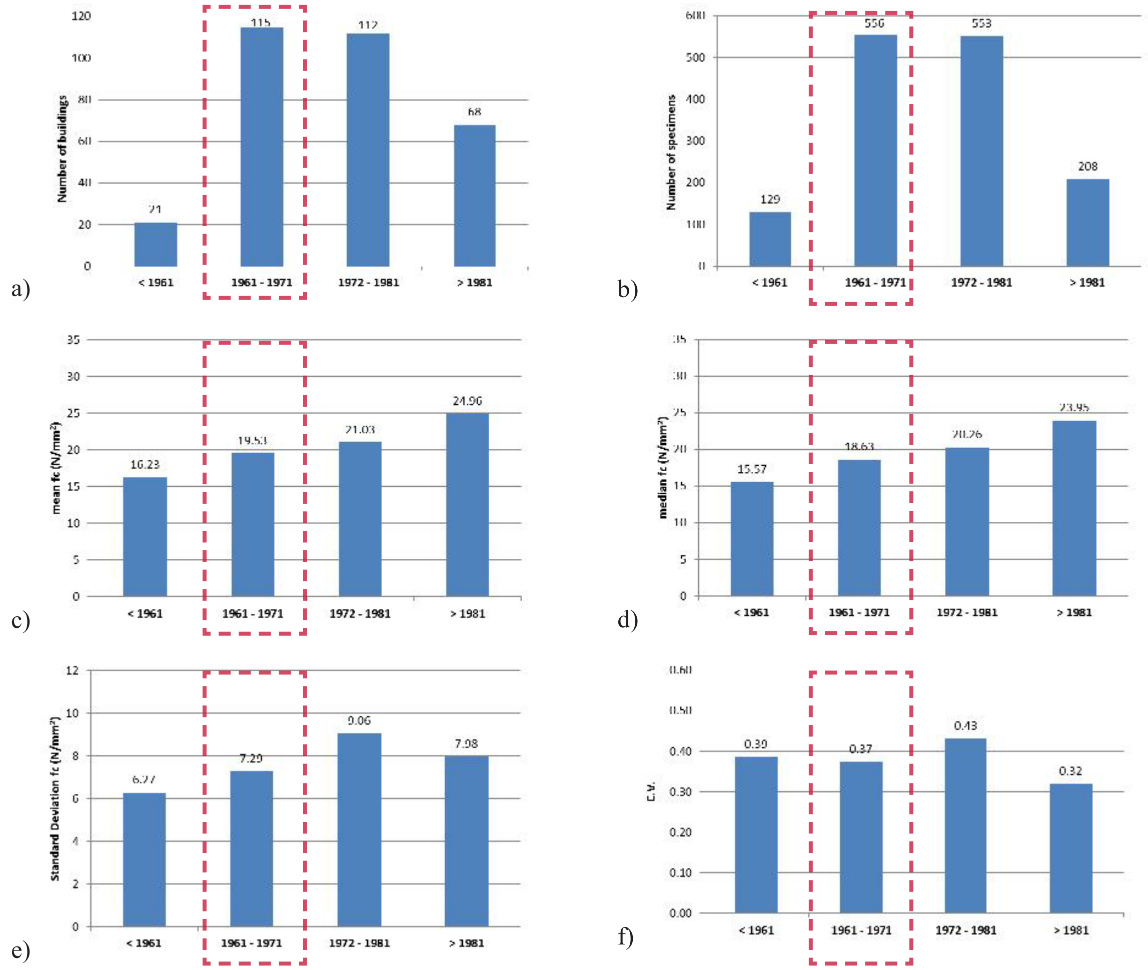


Fig. 1: Main statistical values for the concrete strength in the four identified periods: a) Number of buildings, b) Number of specimens, c) Mean values, d) Median values, e) Standard Deviations, f) Coefficients of Variation (C.V.).

Table 1: Main statistical values of concrete strength in different construction periods.

Statistical values	Construction period			
	<1961	1961 – 1971	1972 – 1981	>1981
Number of buildings	21	115	112	68
Number of specimens	129	556	553	208
Mean number of specimens per building	5.9	4.9	4.9	3.1
Mean value (N/mm²)	16.23	19.53	21.03	24.96
Median value (N/mm²)	15.57	18.63	20.26	23.95
Standard Deviation	6.27	7.29	9.06	7.98
C.V.	0.39	0.37	0.43	0.32

Taking into account the changes in the Italian building code, the suggestions provided in the most used design handbooks and the usual design practice, some tentative default values of concrete strength can be identified for each of the considere d periods [13]. Before 1972 the structural code in force was th e R.D. 2229 released in 1939 [17].

This code prescribed mean cube strength values Rcm starting from a minimum of 120 kg/cm2 (about 12 MPa). Higher strength concretes were also covered as, for example, having cube strength equal to 160 kg/cm2 . When the D.M. 30 May 1972 [18] came into force in 1972 the reference strength values were represented by characteristic cube values Rck measured after 28 days of curing. The most common concrete class was Rck25 (25 MPa).

In the years after 1981, due to the larger presence of zones seismically classified as a consequence of the 1980 Irpinia earthquake, greater attention was devoted to materials' quality and higher strength values were averagely required.

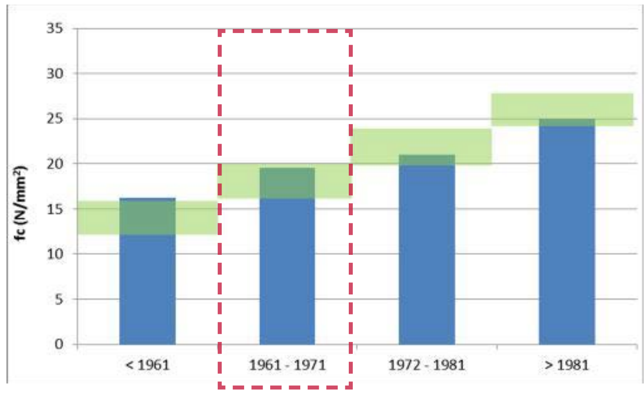


Fig. 2: Comparison between experimental mean values and expected default ranges of values (green)

Summarizing, expected maximum and minimum values of the cylinder concrete strength for each construction period can be defined. In Fig. 2 these default ranges have been compared with the mean values obtained from the DB under study.

As can be seen, the mean experimental values substantially agree with the proposed default ranges generally providing larger values, except for the period < 1961 where the expected values are slightly lower than those obtained from the DB.

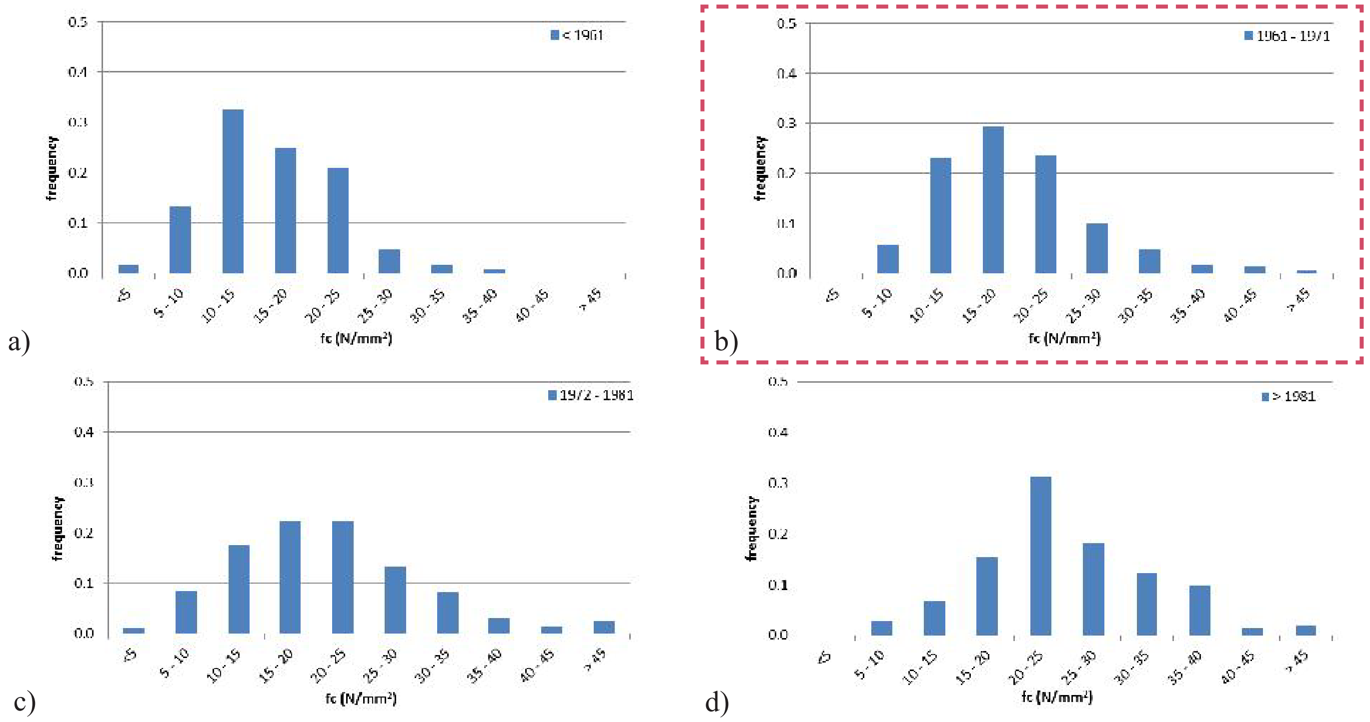


Fig. 3: Frequency distributions of concrete strength for each construction period:

- a) <1961,
- b) 1961-1971,
- c) 1972-1981,
- d) >1981.

To better analyse the variation of strength values within each construction period, the strength values displayed in Fig. 1 have been disaggregated splitting them into strength intervals for each construction period. Considering strength intervals with an amplitude of 5 MPa, Fig. 3 shows the frequency distributions (histograms) relevant to each construction period. As expected, histograms in Fig. 3 confirm the increment of concrete strength over time.

It is worth noting that the distributions appear rather regular and, thus, suitable to be approximated with theoretical continuous frequency distributions. To this end, some probability distributions widely used in engineering practice have been considered, namely the Normal and the Lognormal distribution.

Fig. 4 displays the comparison between experimental histograms and theoretical distributions (Normal and Lognormal) whose parameters are reported in Tab. 2

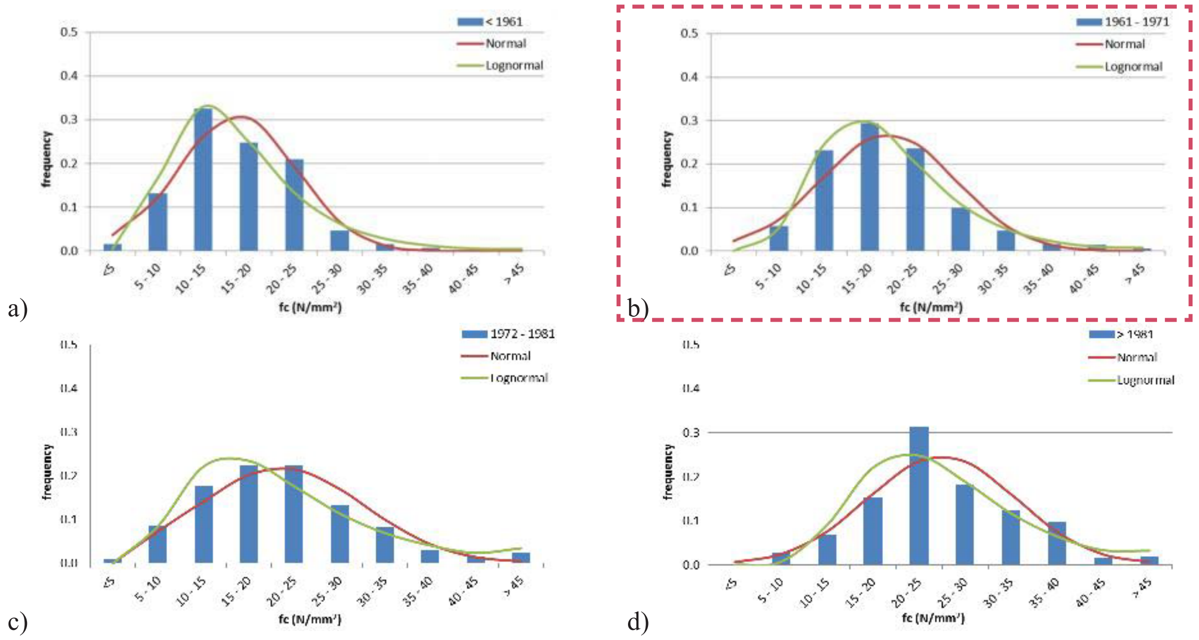


Fig. 4: Comparison between experimental histograms and theoretical distributions (Normal and Lognormal): a) <1961, b) 1961-1971, c) 1972-1981, d) >1981.

Table 2: Parameters of the Normal and Lognormal distribution

Distributions		Periods			
	Parameter	<1961	1961-1971	1972-1981	>1981
Normal	μ	16.23	19.53	21.03	24.96
	σ	6.27	7.29	9.06	7.98
Lognormal	μ	2.70	2.90	2.94	3.16
	σ	0.43	0.37	0.47	0.35

Establishing if and how well a theoretical distribution fits experimental data cannot be appropriately made through a visual inspection. For this reason, in order to evaluate the degree of agreement between the theoretical (continuous) and experimental (histogram) distribution, statistical tests on the goodness of fitting (goodness-of-fit tests) are needed. Literature (e.g. [19])

offers several types of tests although the more reliable one for this kind of problems is the Kolmogorov-Smirnov test (K-S test). It allows comparisons between datasets and relevant theoretical distributions in order to check if the population from which the experimental data derives can be considered the same described by the distribution.

The assumptions on which the K-S test is based are as follows:

H0: there are not significant differences between the theoretical and the experimental distribution;

H1: there are significant differences between the theoretical and the experimental distribution.

K-S test requires that the maximum absolute scatter δ, between theoretical and empirical cumulative functions, is evaluated and after compared to the critical associated value, δmax. For a two-tailed test and a significance level α = 0.05 (which defines the probability of rejecting H0 when it is true), the results of the K-S test, in case of Normal distribution, are reported in Table 3. In all periods δ ≤ δmax, therefore the H0 assumption cannot be rejected.

As a consequence, there are not significant differences between the theoretical and experimental distribution, thus the experimental dataset can be considered as a random sample extracted from the theoretical distribution. The K-S test has been applied also to the Lognormal distribution. The results reported in Table 4 show that also in this case the H0 assumption cannot be rejected and, then, there are not significant differences between the theoretical and the experimental distribution.

Table 3: Results of the K-S test for the Normal distribution assuming α = 0.05.

	Construction periods			
	< 1961	1961 - 1971	1972 - 1981	> 1981
δ	0.05	0.06	0.05	0.06
δ_{max}	0.12	0.06	0.06	0.09
	OK	**OK**	**OK**	**OK**

Table 4: Results of the K-S test for the Lognormal distribution assuming α = 0.05.

	Construction periods			
	< 1961	1961 - 1971	1972 - 1981	> 1981
δ	0.04	0.02	0.05	0.07
δ_{max}	0.12	0.06	0.06	0.09
	OK	**OK**	**OK**	**OK**

Seeing that K-S test provides positive results for both distributions, it seems interesting examining which of them better fits the experimental data, that is the distribution having the lower scatter (α value being equal). Comparing δ values in Tables 3 and 4 it comes to light that the better distribution for the first two periods is the Lognormal one. In the third period they are equally suitable, while in the last period the Normal one is better.

8.2.2 CONCLUDING REMARKS

Seismic risk in Italy as well as in other earthquake-prone countries represents a serious threat to human safety as demonstrated by the heavy human and economic losses suffered in the last years. As a rule, this mainly derives from the vulnerability of the building stock due to absent or inadequate seismic design further exacerbated by deterioration from ageing and lack of maintenance. Therefore, in order to mitigate seismic risk the most important action should be the reduction of the vulnerability through more or less invasive structural interventions. The knowledge of the material properties is a preliminary and fundamental step in the vulnerability evaluation and design of consequent, if any, retrofit intervention: the more accurate is the knowledge phase, the more safety- and cost-effective can be the interventions. The Italian and European codes prescribe that design strength to be used in safety verifications is obtained through tests on in situ materials, without reference to the nominal values used in the design of new buildings.

In this study, based on a huge DB of concrete tests, the changes over time of concrete strength in public buildings located in Basilicata region have been outlined. Analysing the DB as a function of different periods of construction, some Normal and Lognormal distributions able to carefully describe the related experimental data have been provided. Results from the present study can provide useful suggestions in the vulnerability evaluation of individual buildings, as well as they can be assumed as valid estimations of the expected mean strength in the building stock when performing large scale risk analyses. To this end, theoretical distributions obtained for the concrete strength related to different construction periods can be really helpful when data directly obtained from the buildings at hand are not available and hard to obtain.

8.3 STRENGTHENING OF MEMBERS

8.3.1 FLEXURAL STRENGTHENING OF MEMBERS

a) **Concrete Overlays:** this can include the addition of extra reinforcement and concrete cover to the existing deficient member. It is mostly used for buildings and bridges.

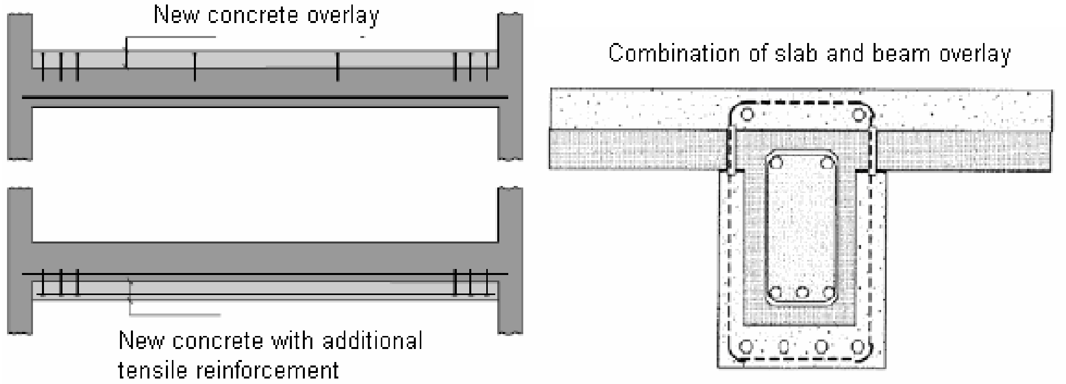


Figure 4.14 Slab and beam overlays [17]

b) **Externally bonded reinforcement:** by using steel plates and Fiber Reinforced Polymers (FRP). Steel plates are mostly used in the repair and strengthening of bridges, but FRP is currently used for both bridges and buildings and other structures.

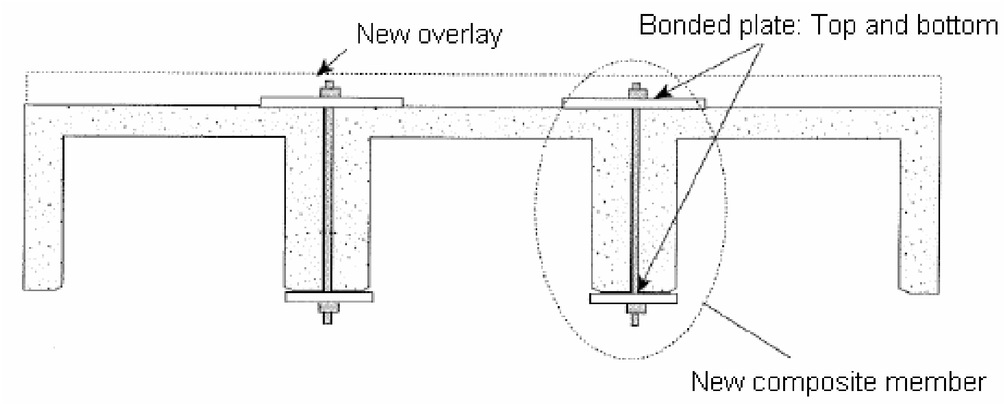


Figure 4.15 externally bonded plates using steel plates [17]

Figure 4.16 externally bonded plates using FRP [21]

c) **External post tensioning:** it is widely used in bridges.

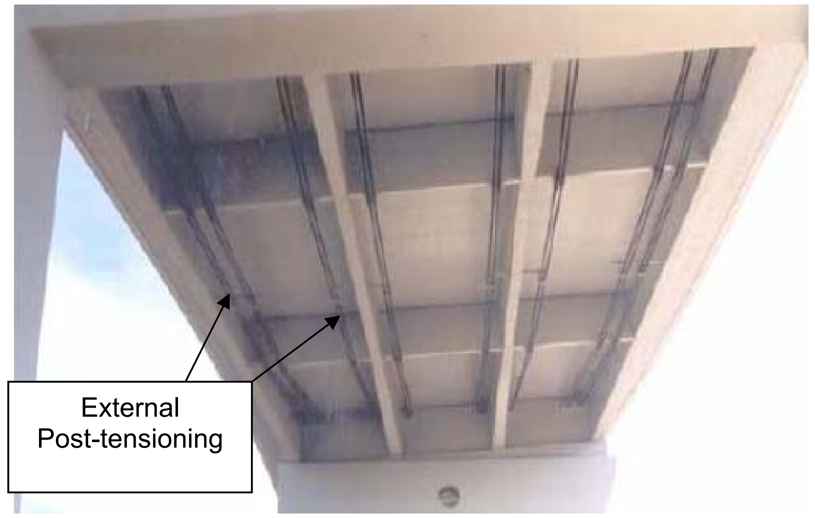


Figure 4.17 external post-tensioning of a bridge [17]

d) **Span length shortening:** this can create a negative moment at the new supports which can creates tension on the upper side of the member, which can cause damage if provision at the new support is not provided.

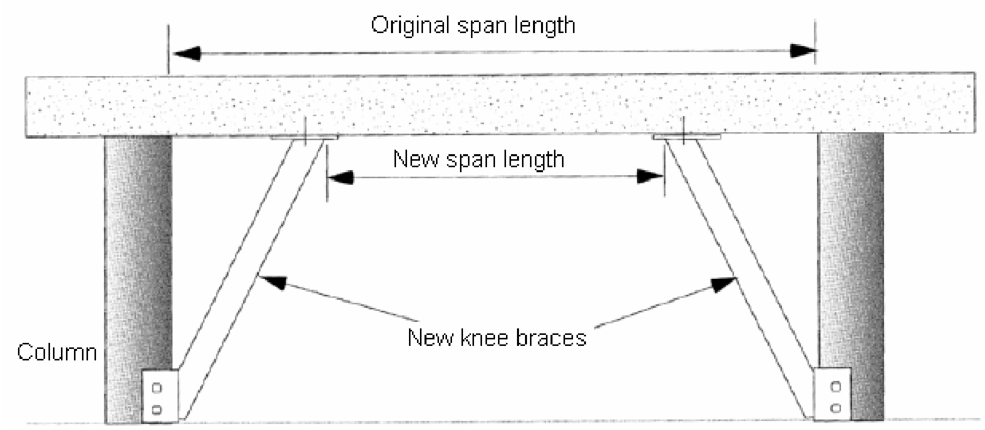


Figure 4.18 span length shortening [17]

8.3.2 SHEAR STRENGTHENING OF MEMBERS

a) **Concrete overlays:** this can include the addition of shear reinforcements or stirrups and a cover concrete. It can be used both for buildings and bridges.

Figure 4.19 addition of steel reinforcement and concrete overlay [17]

b) **Internally placed reinforcement:** It is common in bridges.

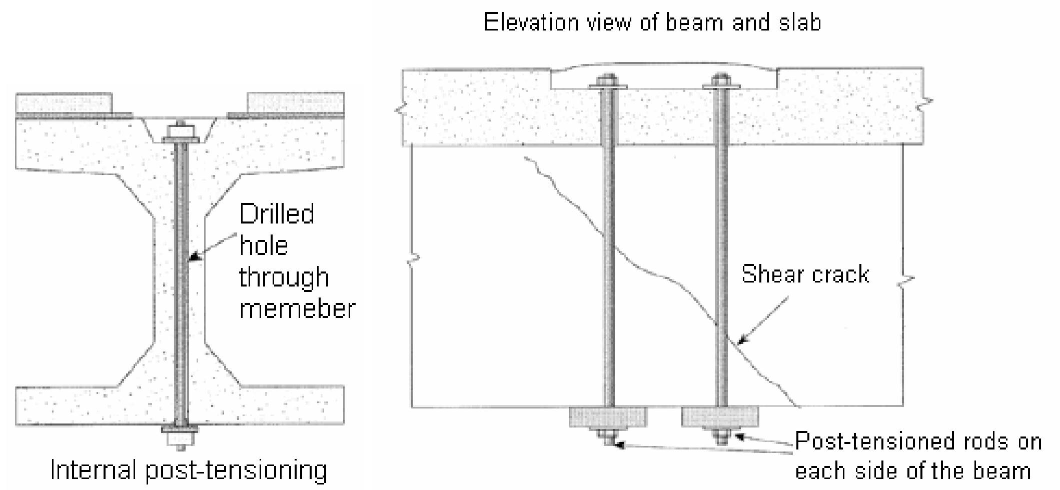


Figure 4.20 internally placed reinforcement of I-section beam and T-beam [17]

c) **External post-tensioning:** it is mostly used for bridges

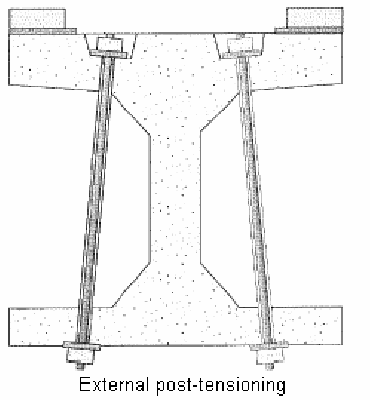


Figure 4.21 external post-tensioning [17]

8.3.3 PUNCHING STRENGTHENING OF MEMBERS

a) **Increase the depth of the member or overlay:** this can include the addition of extra concrete layer on the member to increase the punching depth or the influence area of punching. This method is widely used both for buildings and bridge structures.

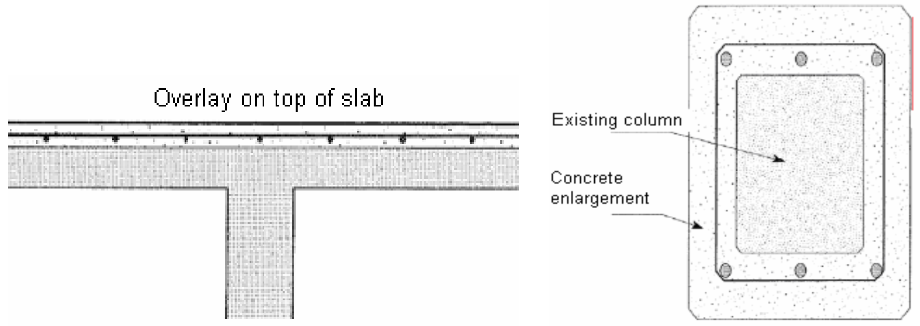


Figure 4.22 shear strengthening by overlay [17]

b) Transversal reinforcement

Figure 4.23 shear strengthening using internal post-tensioning and using bolts [17]

c) Fiber reinforced polymers (FRP)

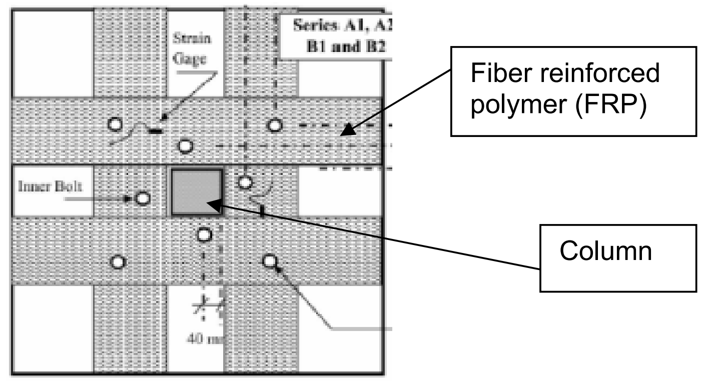


Figure 4.24 punching strengthening using FRP [17]

d) **Enlarger the column head with concrete:** this method is used to increase the punching perimeter and depth.

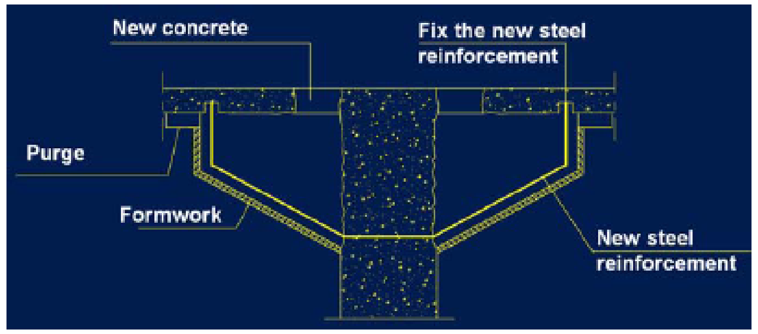


Figure 4.25 enlarging the column head of a column to increase punching resistance [17]

e) **Enlarger the column head with steel:** steel plates and ribs are applied on the influence area of punching to resist the punching force.

Figure 4.26 enlarging column head with steel plates and ribs [17]

8.4 STEP 3 _DESIGN
8.4.1 DESIGN CODES AND REGULATIONS

In the structural analysis and design development, all necessary calculations and assessments were conducted by hand as well as with the aid of software tool SAP2000. The following part of the paper consists of identifying the actions including dead, live, wind, snow load for complete building. Since the site is located in earthquake zone, the seismic action will be also considered in design process. Based on action results, the proper design will be carried out for the most critical structural elements, specifically: slab, beam, column, foundation and connections. Appropriate calculations and diagrams will be provided to verify the final section. All analysis and design will be based on Eurocode normative. The following list comprises those basic structural references:

EN 1990: Eurocode. Basis of structural design
EN 1991.1-1: Eurocode 1. Actions on structures. Part 1-1: General actions: densities, self-weight and imposed loads for buildings
EN 1991.1-3: Eurocode 1. Actions on structures. Part 1-3: General actions: snow loads
EN 1991.1-3: Eurocode 1. Actions on structures. Part 1-4: General actions: wind actions
EN 1992-1.1: Eurocode 2. Design of concrete structures. Part 1-1. General rules and rules for buildings.
EN 1993-1.1: Eurocode 3. Design of steel structures – Part 1-1. General rules and rules for building
EN 1994: Eurocode 4: Design of composite steel and concrete structures
EN 1997-1: Eurocode 7. Geotechnical design
EN 1998: Eurocode 8. Design of structures for earthquake resistance, when composite structures are built in seismic regions.
For Nationally Determined Parameters (NDP), the recommended values will be in general adopted. However, different assumptions according to National Annexes will be applied if needed.

8.1.1 MATERIAL PROPERTIES

Concrete strength class: C25/30 for foundation and shear wall design

$\Upsilon_c=1.5$	Partial safety coefficient for concrete
$f_{ck}=30\ {}^{N}/_{mm^2}$	Characteristic compressive cylinder strength of concrete at 28 days
$f_{cd}=\frac{\alpha_{cc}*f_{ck}}{\Upsilon_c}=17\ {}^{N}/_{mm^2}$	Design value of concrete compressive strength
$\sigma_{c,adm}=18\ {}^{N}/_{mm^2}$	Allowable compressive strength under characteristic combinations
$f_{ctk,\,0.05}=2.03\ {}^{N}/_{mm^2}$	Characteristic tensile strength
$f_{ctm}=2.9\ {}^{N}/_{mm^2}$	Medium tensile strength
$\alpha_{cc}=0.85$	Coefficient that takes into consideration the long time effect resulted from the way of loads application

Concrete strength class: C50 for Hollow Core Slab units

$\Upsilon_c=1.5$	Partial safety coefficient for concrete
$f_{ck}=45\ {}^{N}/_{mm^2}$	Characteristic compressive cylinder strength of concrete at 28 days
$f_{cd}=\frac{\alpha_{cc}*f_{ck}}{\Upsilon_c}=25.5\ {}^{N}/_{mm^2}$	Design value of concrete compressive strength
$f_{ctk,\,0.05}=2.7\ {}^{N}/_{mm^2}$	Characteristic tensile strength
$f_{ctm}=3.8\ {}^{N}/_{mm^2}$	Medium tensile strength
$\alpha_{cc}=0.85$	Coefficient that takes into consideration the long time effect resulted from the way of loads application

Steel reinforcement type: B450C for concrete reinforcement

$\Upsilon_s=1.15$	Partial safety coefficient for steel
$f_{yk}=450\ {}^{N}/_{mm^2}$	Characteristic Yield strength of reinforcement
$f_{yd}=\frac{f_{yk}}{\Upsilon_s}=391\ MPa$	Design Yield strength of reinforcement

8.4.2 INTRODUCTION OF WEIGHT ANALYSIS

This part of the chapter summarizes the action loads on the complete building including self-weights of different structural elements and envelopes of the building, live loads, snow load and wind load according to the site zone and earthquake consideration. Then will follow with more detailed design calculations for the most critical structural elements which span reaches 12 m length for slab and beams.

8.4.2.1 SELF WEIGHT

CONSTRUCTION ELEMENT	#	LAYER	THICKNESS (m)	SPECIFIC WEIGHT (KN/m3)	LOAD CHARACTERISTIC VALUE (KN/m2)
1	2	3	4	5	6
EXTERIOR WALL	1	BENCHMARK thin brick including support trail	0.05	16	0.8
	2	BENCHMARK by Knigspan insulated metal panel	0.1	1	0.1
	3	insulation panel	0.15	0.2	0.03
	4	Insulation	0.03	1	0.03
	5	double gypsum board wih pluster	0.03	20	0.6
		TOTAL			1.56
INTERIOR WALL	1	Plaster	0.02	20	0.4
	2	Masonry	0.08	11	0.88
	3	Plaster	0.02	20	0.4
		TOTAL			1.68
FLOOR FINISH	1	Concrete	0.24	2400	-
	2	Rest of layer	0.23	1800 kg/m3	-
	3	thermaatex panel (ceiling)	0.019	5	0.095
		TOTAL			0.419
GREEN ROOF	1	DAKU Substrate	0.09	9.81	0.883
	2	Drianage layer	0.062	0.245	0.015
	3	Waterproofing	0.004	0.29	0.001
	4	Foamglass	0.08	1.13	0.090
		TOTAL			0.990

For the floor height of 3 meter and with assuming 20% of openings the linear weight of the wall is $1.56\ x\ \ 3.3\ x\ \ 0.8 = 4.2\ \text{KN}/m$, which load is directly applied for the edge beams and it is not shared with slabs.

Similarly, for the internal wall the linear weight is $1.68\ x\ \ 3.3 = 5.54\ \text{KN}/m$

According to the EN 1991-1-1 [6.3.1.2(8)], the internal partition loads can be considered equivalently as an uniformly distributed load on whole slab, instead of free actions. The following data is applied:

-for movable partitions with a self-weight ≤ 1 kN/m wall length: q_k=0.5 kN/m^2

-for movable partitions with a self-weight ≤ 2 kN/m wall length: q_k=0.8 kN/m^2

-for movable partitions with a self-weight ≤ 3 kN/m wall length: q_k=1.2 kN/m^2

In case of exceedance of this value, it is recommended to use effective span between the partitions in accordance with assumptions of EN 1991-1-1, which is 5.04/4=1.26 kN/m^2

8.4.2.2 SELF WEIGHT

According to EN 1991-1-1, the following imposed values were retrieved and used further.

Table 2.1. List of existing imposed loads in building

Categories of loaded areas	q_k [kN/m^2]
Category Residential	
Floors	1.5 to 2
Stairs	2 to 4
Balconies	2.5 to 4
Office	2 to 3
Public open spaces	3 to 5
Inaccessible roof	0 to 1
Accessible green roof	2 to 3
Balcony trees up to 6 m	4.8
Atrium tree	1 to 2

8.4.2.3 SNOW WEIGHT

In correspondence with EN 1991-1-3 and referring to National Annex, the following snow load on roof was obtained:

Table 2.2. Snow load magnitude and related parameters

s	1.2 KN/m²	$\mu_i . C_e . C_t . S_k$
S		Characteristic value of snow on the roof
μ_i	0.8	Snow load shape coefficient equal to 0.8 for an angle of the pitch of the roof less than 30°
C_e	1	Exposure coefficient function of the topography of the site. Ce=1.0 for normal topography that is “areas where there is no significant removal of snow by wind on construction work, because of terrain, other construction works, or trees”.
C_t	1	Thermal coefficient that should be used to account for the reduction snow loads on the roof without high thermal transmittance Ct=1
S_k	1.5 KN/m²	Characteristic value of the snow load on the ground. For provincial di Milano, for a design working life of the structure of 50 years in accordance with the initial design assumptions Sk=1.5KN/m2

8.4.2.4 WIND LOAD

Referring to the normative EN 1991-1-4 the wind load on building was retrieved by following the next procedure.

1. The basic wind velocity, $v_{b,0}$ is identified, which corresponds to characteristic 10 minutes mean wind velocity that doesn’t take into consideration the direction and time. According to National Annex, the respective value is:
$v_{b,0} = v_{b,0}$ for $a_s \leq a_0$
$v_{b,0} = v_{b,0} + ka\ (a_s - a_0)$ for $a_0 \leq a_s \leq 1500$
All specifications could be found from National Annex. For Roma the altitude is 1000m which basic wind velocity is $v_{b,0}$ =25 m/s
The final basic wind velocity is calculated by taking into consideration direction and season influence factor, with recommended values c_{dir}=1 and c_{season}=1. Thus, v_b = 25 m/s

2. The mean wind velocity $v_m(z)$ at a height z above the terrain can be calculated with the factors of terrain roughness and orography and basic velocity:
$v_m(z)=c_r(z)\ c_0(z)\ v_b$

where c_0 (z) is the orography coefficient, taken equal to 1,0 (reccomended value) Where orography (e.g. hills, cliffs etc.) increases wind velocities by more than 5% the effects should be taken into account using the orography factor c_0 to be calculated following the procedure given in Annex A.3 or, correspontenly, in the National Annex.

c_r (z) is the roughness coefficient It accounts for the variability of the mean wind velocity at the site of the structure due to the height above ground level and the ground roughness of the terrain upwind of the structure in the wind direction considered. The raccomended procedure for the determination of the roughness factor at height z is based on a logarithmic velocity profile and is given by the following expression [Expression 4.4-EC1-1-4]:

$c_r = k_r \ln\ z/z_0$ for $z_{min} \leq z \leq z_{max}$ =200m

$c_r = c_r\ (z_{min})$ for $z \leq z_{min}$

where: $k_r = 0.19\ \ z_0 / z_{0,II}\ ^{0.07}$ with $z_{0,II}$ = 0.05 m [Expression 4.5-EC1-1-4]

Recommended values for z_0 e z_{min} are given in Tab. 3.1 [Table 4.1 – EC1-1-4] depending on the five representative terrain category.

Table 2.3. Recommended values for z0 e zmin corresponding to terrain category

Terrian category	z0	zmin
0 Sea or coastal area exposed to the open sea	0.003	1
I Lakes or flat and horizontal area with negligible vegetation and without obstacles	0.01	1
II Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0.05	2
III Area with regualr cover of vegetation or buildings or with isolated obstacels with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0.3	5
IV Area in which at least 15 % of the surface is covered with buildings and their average height eceeds 15 m	1	10

The site is located in Roma (IV category).

$k_r = 0.19\ (1/0.05)^{0.07}$=0.234

$c_r(z_{min})$ = 0.234 ln 10 = 0.539

$c_r(z)$ = 0.234 ln (z)

3. The turbulence intensity Iv(z) at height z can be assessed subsequently:

$I_v = k_I /[\ c_0\ (z) \ln (z/z_0\ )]$ for $z_{min}<z<z_{max}$

$I_v = I_v\ (z_{min})$ for $z > z_{min}$

where k_I is the turbulence factor, taken equal to the recommend value (1,0) and $c_0(z)$ is the orography factor previously described.

The peak velocity pressure $q_p(z)$ at height z, which includes mean and short-term velocity fluctuations, can then be determined [Expression 4.8-EC1-1-4]:

$$q_p(z) = [1 + 7\ I_v(z)]\frac{1}{2}\rho\ v_m(z)^2 = [1 + 7\ I_v(z)]\frac{1}{2}\rho\ c_r(z)^2\ c_0(z)^2 v_b^2 = c_e(z) q_b$$

where ρ = 1.25 kg/m^3 is the air density (recommended value)

is the basic velocity pressure [Expression 4.10-EC1-1-4] bb

$q_b = \frac{1}{2}\rho v_b^2$ is the basic velocity pressure

$c_e(z)=[1+7\ I_v(z)]\frac{1}{2}\rho\ c_r(z)^2\ c_0(z)^2$

The wind pressure acting on the external surfaces, w_e , can be obtained from the following expression $w_e = c_{pe}\ q_p\ (z_e)$ where z_e is the reference height and c_{pe} is the pressure coefficient.
Since the building is located between other buildings that could be treated as protection blocks from east-west direction wind loads, only in one direction the action of wind will be considered further.

The reference height z_e depends on the following parameters:
Since h<b

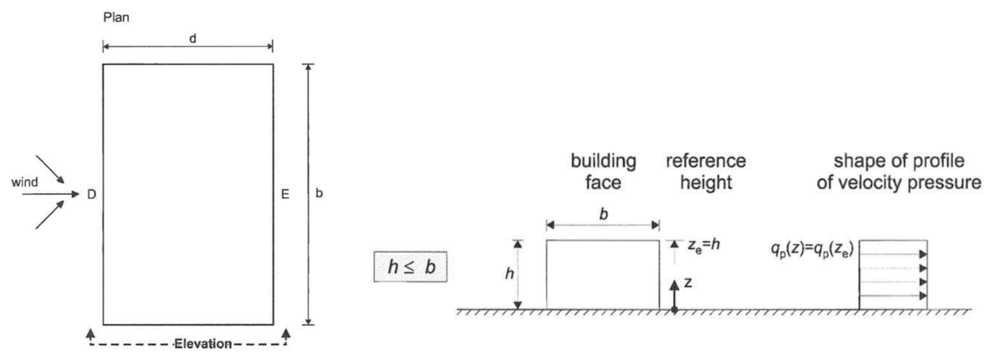


Figure 2.1. The reference height mode for h<b

Where,
h is the height of the building,
b is the building dimension in the horizontal direction perpendicular to wind, d is the structural depth
h/d = 19.8/15 = 1.65 ; z_e = 19.8 m. Accordingly, other values were evaluated:

Table 2.4. Calculated results

z (m)	$c_r(z)$	$I_v(z)$	$c_e(z)$	q_b (N/m²)	q_p (N/m²)	Windward, c_{pe}	Leeward, c_{pe}
19.8	0.794	0.295	1.93	390.6	753.86	0.8	0.575

Which final obtained figure is illustrated below:

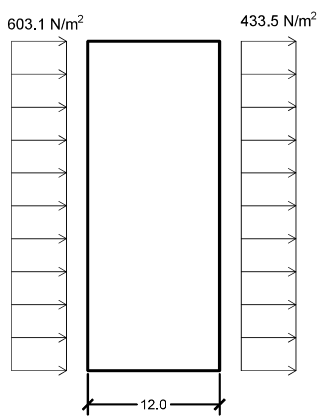


Figure 2.2. Final wind load pressure on structure

8.4.3 SLAB DESIGN

8.4.3.1 HOLLOW CORE SLAB SELECTION

In accordance with the aim of the project, the easy mounted slab system with large span application was selected. As the result, among several slab options, Hollow Core Slab units were chosen. The preliminary size of the units identified in respective to imposed load action that below graph demonstrates.

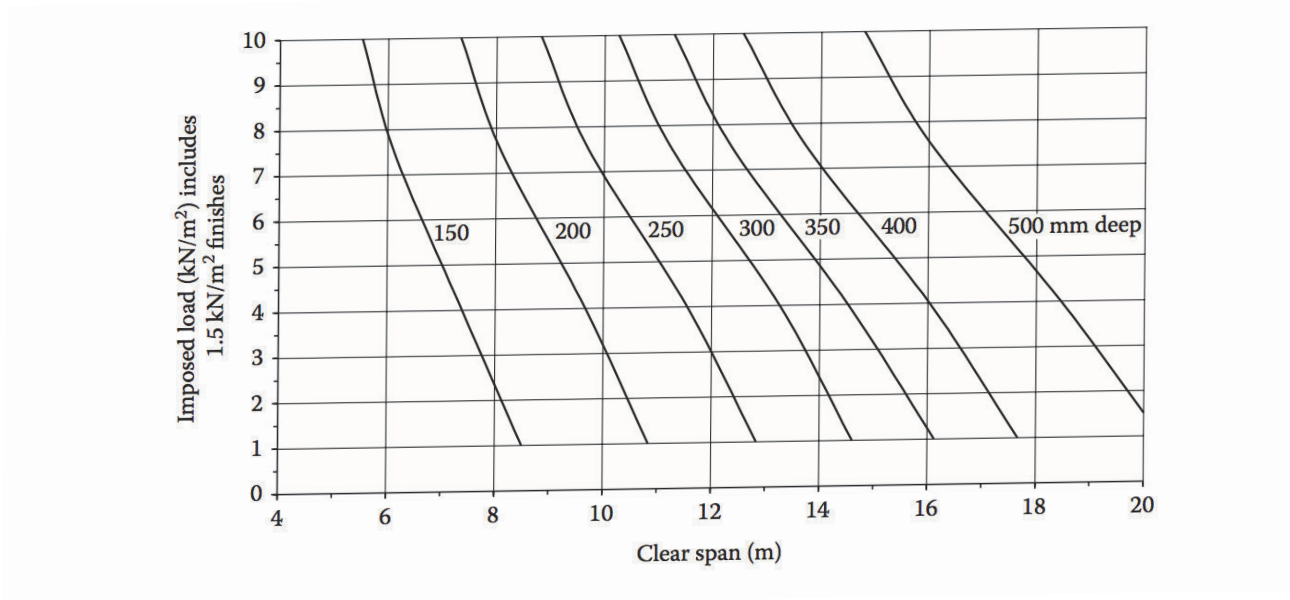


Figure 3.1. HCU clear span vs imposed load correlation

Depth (mm)	Number and breadth (mm) of cores	Self-weight (kN/m²)	Service moment of resistance M_{sR} (kNm)	Ultimate moment of resistance M_{Rd} (kNm)	Ultimate shear capacity $V_{Rd,c}$ (kN)
150	11 × 60	2.69	67.5	100.1	120.5
200	6 × 140	3.33	123.7	179.0	101.1
	11 × 60	3.33	120.8	175.7	158.5
250	6 × 140	3.71	183.9	258.1	131.1
	11 × 60	4.03	180.9	256.8	200.1
300	6 × 135	4.22	249.0	342.3	174.0
	11 × 60	4.75	246.8	341.7	238.2
350	6 × 135	4.62	326.9	448.0	212.0
400	6 × 135	5.03	407.9	551.2	247.0
450	6 × 135	5.43	507.6	677.8	283.0
500	6 × 135	5.84	598.7	792.7	317.1

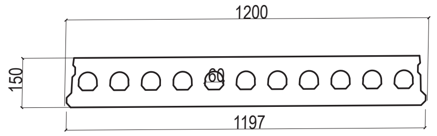
Figure 3.2. HCU design details and resistance capacity

According to Figure (above), the preliminary dimention of HC slab with 7.5m clear span including 4.26 kN/m2 imposed load, the 240 mm thickness is chosen. The thickness of slab various according to span. The table below summarizes the appropreiate thinknesses for different spans:

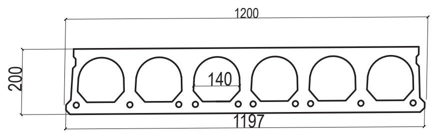
Table 3.1. Thickness for span design

Span	Thickness (mm)	Self weight	Number and breadth of cores
12 m	300	4.22	6x135
10m	250	3.71	6x140
9m	200	3.33	6x140
6-7 m	150	2.69	11x60

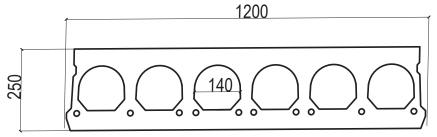
HCU slab, th. 150 mm, for 6-7 m span
Scale 1:20



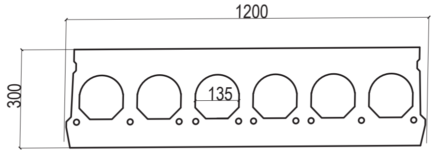
HCU slab, th. 200 mm, for 9 m span
Scale 1:20



HCU slab, th. 250 mm, for 10 m span
Scale 1:20



HCU slab, th. 300 mm, for 12 m span
Scale 1:20



For design consideration, the most critical slab will be analyzed further. Each unit of hollow core slab with (250 mm) thickness and 1.2 m width is based on class 2 pre-stressed concrete structure with minimum 2h fire rating. Hollow core slabs are casted with C50 concrete type. The cross section of hollow core slab is considered as a solid element and circular voids are not included. The reduction factor 1.25 is applied to shear reactions (Kim S. Elliot, p.137).
As an example the following slab section with the most unfavorable load will be analyzed further. Unit depth: 250 mm
Unit width: 1200 mm
Number of cores: 6
Core diameter: 135 mm
Self-weight: 4.22 kN/m2
Pre-tensioned strands: 6 no. x 12.5 mm + 4 no. x 9.3 mm at 35 mm cover

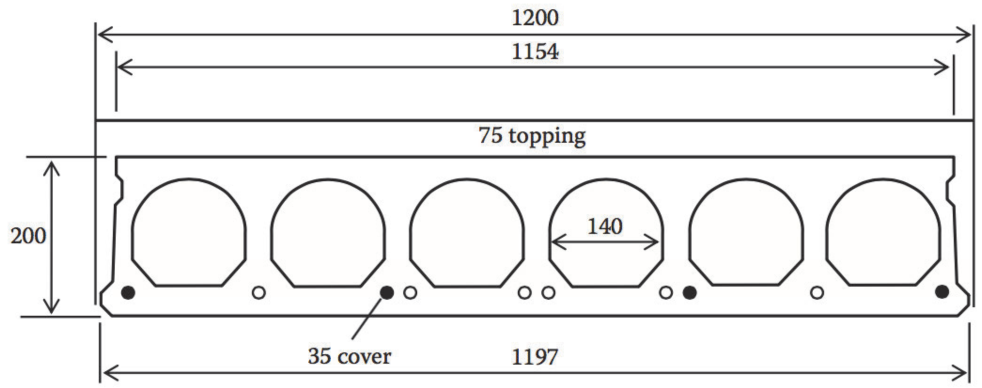


Figure 3.3. HCU illustration for 200 mm deep unit, solid dots-9.3 mm diameter and open dots-12.5 mm dia.

8.4.3.2 LOAD COMBINATION

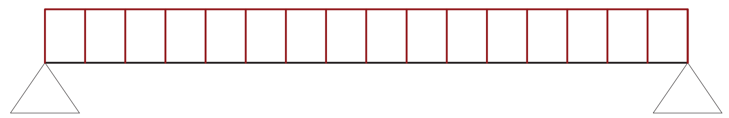
The structural analysis will be carried out using linear analysis based on the theory of elasticity. The combination of actions for Ultimate Limit States (ULS) is expressed as follows (EN1990):

$$\Sigma_{j\geq 1}\Upsilon_{Gj}G_{kj}+\Upsilon_{Q1}Q_{k1}+\Sigma_{i>1}\Upsilon_{Qi}\Psi_{0i}Q_{ki}$$

where $\Upsilon_G = 1.35$, $\Upsilon_Q = 1.5$, $\Psi_Q = 1$ and G_{kj} - dead load, Q_{k1} leading variable load, Q_{ki} - live load

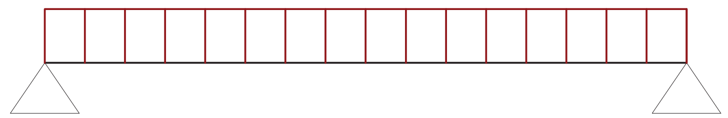
Note: Since slab is held between two primary beams, the most unfavorable load combination is analyzed, which is 7.5 m long span. Combination for ULS (1.35G+1.5Q)

1.35G+1.5Q



COMBINATION FOR SLS (G+Q)

G+Q

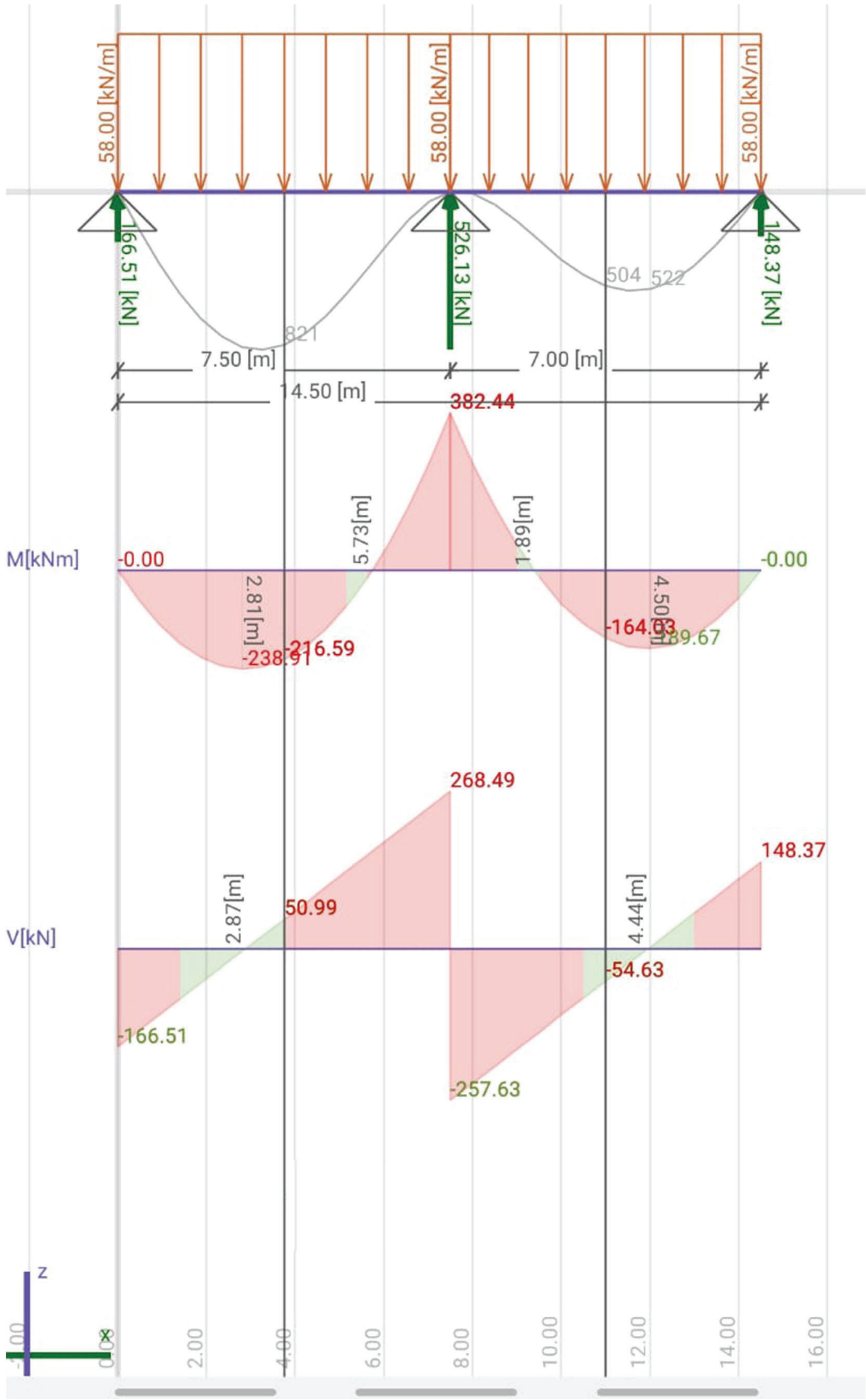


8.4.3.3 CALCULATION

The hollow core slab is analysed as a simply supported (pin-pin) element with 1.2 m width.

$g_k = 8.1\ kn/m^2$ $\quad q_k = 3.39\ kn/m^2$ $\quad ULS = 1.35g+1.5q = 15.2\ kn/m^2$

8.4.3.4 LOAD ANALYSIS WITH SOFTWARE



From the obtained results it can be clearly seen that moment and shear diagrams are matching.

8.4.4 BEAM DESIGN
8.4.4.1 CALCULATION

For frame design, the maximum moment and shear were selected. The details are shown in the picture below

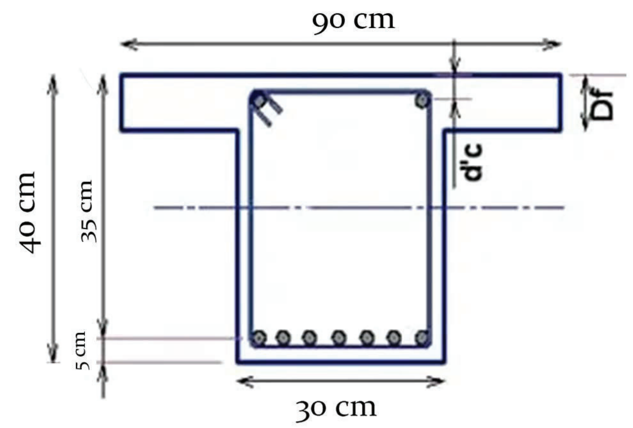


Figure 4.1. Junction between supporting edge beam and floor units for Class 2B buildings

One of the most critical beam elements with 12.5m long span was chosen for design (grid I6-M6) on 3th floor. The fit in scale structural plan is provided below, refer to appendix for enlarged scale.

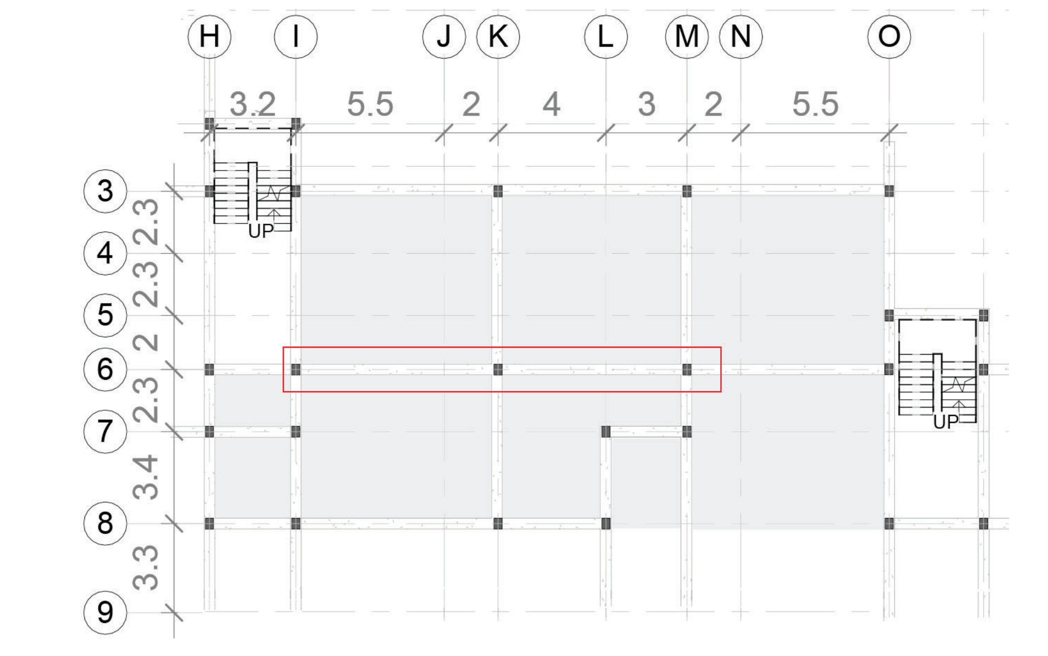


Figure 4.2. Structural plan of 3th floor, fit in scale.

8.4.4.2 BEAM CALCULATION FORMULA'S

BEAM 1

l_{beam} = 7.50[m]

Finite element 1

l_{beam} = 3.75[m]

$$q_x(x) = 0.00[\text{kN/m}]$$

$$q_z(Z) = 116.00[\text{kN/m}]$$

$$N(x) = -N_{pi}$$

$$= -0.00[\text{kN}]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} - \frac{l_{beam} \cdot q_z}{2}$$

$$= \frac{-433.19[\text{kNm}] + 0.00[\text{kNm}]}{3.75[\text{m}]} - \frac{3.75[\text{m}] \cdot 116.00[\text{kN/m}]}{2}$$

$$= -333.02[\text{kN}]$$

$$V(x) = V_{pi} + q_z \cdot x$$

$$= -333.02[\text{kN}] + 116.00[\text{kN/m}] \cdot x$$

$$M(x) = M_{pi} + V_{pi} \cdot x + \frac{1}{2} \cdot q_z \cdot x^2$$

$$= -0.00[\text{kNm}] - 333.02[\text{kN}] \cdot x + \frac{1}{2} \cdot 116.00[\text{kN/m}] \cdot x^2$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3 + \frac{1}{24} \cdot q_z \cdot x^4\right)}{EI}$$

$$= 0.00[\text{mm}] + 0.85[\text{rad}] \cdot x -$$

$$\frac{\left(0.5 \cdot -0.00[\text{kNm}] \cdot x^2 + \frac{1}{6} \cdot -333.02[\text{kN}] \cdot x^3 + \frac{1}{24} \cdot 116.00[\text{kN/m}] \cdot x^4\right)}{1272.98[\text{mm}^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.00[\text{mm}] + \frac{0.00[\text{mm}] - 0.00[\text{mm}]}{3.75[\text{m}]} \cdot x$$

$$\varphi(x) = \; = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2 + \frac{1}{6} \cdot q_z \cdot x^3\right)}{EI}$$

$$= 0.85[\text{rad}] - \frac{\left(-0.00[\text{kNm}] \cdot x^2 + \frac{1}{2} \cdot -333.02[\text{kN}] \cdot x^2 + \frac{1}{6} \cdot 116.00[\text{kN/m}] \cdot x^3\right)}{1272.98[\text{mm}^4]}$$

FINITE ELEMENT 2

l_{beam} = 3.75[m]

$$q_x(x) = 0.00[\text{kN/m}]$$

$$q_z(Z) = 116.00[\text{kN/m}]$$

$$N(x) = -N_{pi}$$

$$= -0.00[\text{kN}]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} - \frac{l_{beam} \cdot q_z}{2}$$

$$= \frac{764.87[\text{kNm}] + 433.19[\text{kNm}]}{3.75[\text{m}]} - \frac{3.75[\text{m}] \cdot 116.00[\text{kN/m}]}{2}$$

$$= 101.98[\text{kN}]$$

$$V(x) = V_{pi} + q_z \cdot x$$

$$= 101.98[\text{kN}] + 116.00[\text{kN/m}] \cdot x$$

$$M(x) = M_{pi} + V_{pi} \cdot x + \frac{1}{2} \cdot q_z \cdot x^2$$

$$= -433.19[kNm] + 101.98[kN] \cdot x + \frac{1}{2} \cdot 116.00[kN/m] \cdot x^2$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3 + \frac{1}{24} \cdot q_z \cdot x^4\right)}{EI}$$

$$= -1.64[mm] - 0.19[rad] \cdot x -$$

$$\frac{\left(0.5 \cdot -433.19[kNm] \cdot x^2 + \frac{1}{6} \cdot 101.98[kN] \cdot x^3 + \frac{1}{24} \cdot 116.00[kN/m] \cdot x^4\right)}{1272.98[mm^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.00[mm] + \frac{0.00[mm] - 0.00[mm]}{3.75[m]} \cdot x$$

$$\varphi(x) = \ = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2 + \frac{1}{6} \cdot q_z \cdot x^3\right)}{EI}$$

$$= -0.19[rad] - \frac{\left(-433.19[kNm] \cdot x^2 + \frac{1}{2} \cdot 101.98[kN] \cdot x^2 + \frac{1}{6} \cdot 116.00[kN/m] \cdot x^3\right)}{1272.98[mm^4]}$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3 + \frac{1}{24} \cdot q_z \cdot x^4\right)}{EI}$$

$$= 0.00[mm] - 0.10[rad] \cdot x -$$

$$\frac{\left(0.5 \cdot 764.87[kNm] \cdot x^2 + \frac{1}{6} \cdot -515.27[kN] \cdot x^3 + \frac{1}{24} \cdot 116.00[kN/m] \cdot x^4\right)}{1272.98[mm^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.00[mm] + \frac{0.00[mm] - 0.00[mm]}{3.50[m]} \cdot x$$

$$\varphi(x) = \ = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2 + \frac{1}{6} \cdot q_z \cdot x^3\right)}{EI}$$

$$= -0.10[rad] - \frac{\left(764.87[kNm] \cdot x^2 + \frac{1}{2} \cdot -515.27[kN] \cdot x^2 + \frac{1}{6} \cdot 116.00[kN/m] \cdot x^3\right)}{1272.98[mm^4]}$$

FINITE ELEMENT #2

$l_{beam} = 3.50[m]$

$$q_x(x) = 0.00[kN/m]$$

$$q_z(Z) = 116.00[kN/m]$$

$$N(x) = -N_{pi}$$

$$= -0.00[kN]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} - \frac{l_{beam} \cdot q_z}{2}$$

$$= \frac{-0.00[kNm] + 328.06[kNm]}{3.50[m]} - \frac{3.50[m] \cdot 116.00[kN/m]}{2}$$

$$= -109.27[kN]$$

$$= -109.27[kN] + 116.00[kN/m] \cdot x$$

$$M(x) = M_{pi} + V_{pi} \cdot x + \frac{1}{2} \cdot q_z \cdot x^2$$

$$= -328.06[kNm] - 109.27[kN] \cdot x + \frac{1}{2} \cdot 116.00[kN/m] \cdot x^2$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3 + \frac{1}{24} \cdot q_z \cdot x^4\right)}{EI}$$

$$= -1.01[mm] + 0.18[rad] \cdot x -$$

$$\frac{\left(0.5 \cdot -328.06[kNm] \cdot x^2 + \frac{1}{6} \cdot -109.27[kN] \cdot x^3 + \frac{1}{24} \cdot 116.00[kN/m] \cdot x^4\right)}{1272.98[mm^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.00[mm] + \frac{0.00[mm] - 0.00[mm]}{3.50[m]} \cdot x$$

$$\varphi(x) = \ = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2 + \frac{1}{6} \cdot q_z \cdot x^3\right)}{EI}$$

$$= 0.18[rad] - \frac{\left(-328.06[kNm] \cdot x^2 + \frac{1}{2} \cdot -109.27[kN] \cdot x^2 + \frac{1}{6} \cdot 116.00[kN/m] \cdot x^3\right.}{1272.98[mm^4]}$$

8.4.4.3 BEAM CALCULATION FORMULA'S

FROM MOMENT DIAGRAM

MED=382 kn/m

Assumption:

1) As= 7Ø24=3164 mm^2
2) Beam dimensions: 30 cm × 40 cm

Translational equilibrium:

X= $(A_s f_{yd})/(0.8bf_{cd})$=(3164×450)/(0.8×300×50)=11.8 cm

Rotational equilibrium:

M_{crd}= $A_s f_y$(d - 0.4X) = 3104 ×450×(400-0.4×11.8) =501 kn/m2

M_{crd}>M_{Ed} So it is OK

8.4.4.4 BEAM CALCULATION FORMULA'S

FROM SHEAR DIAGRAM

V_{max} = 268

V_{crd}=fyd/γ As

268 kn< 450/(1.15 γ) As

As>50 mm^2

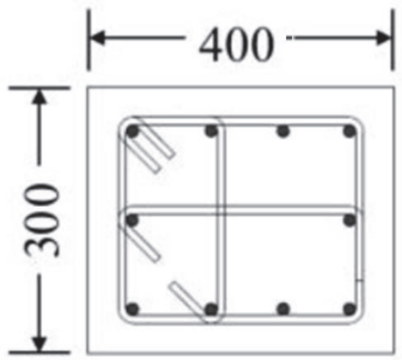
V_{crd}>V_{ed}

we are using table of rebar and area

8.4.5 COLUMN DESIGN

8.4.5.1 LOAD CALCULATION

Internal column J6 on the third floor with 3.3 m height which carries upper floor action will be considered.



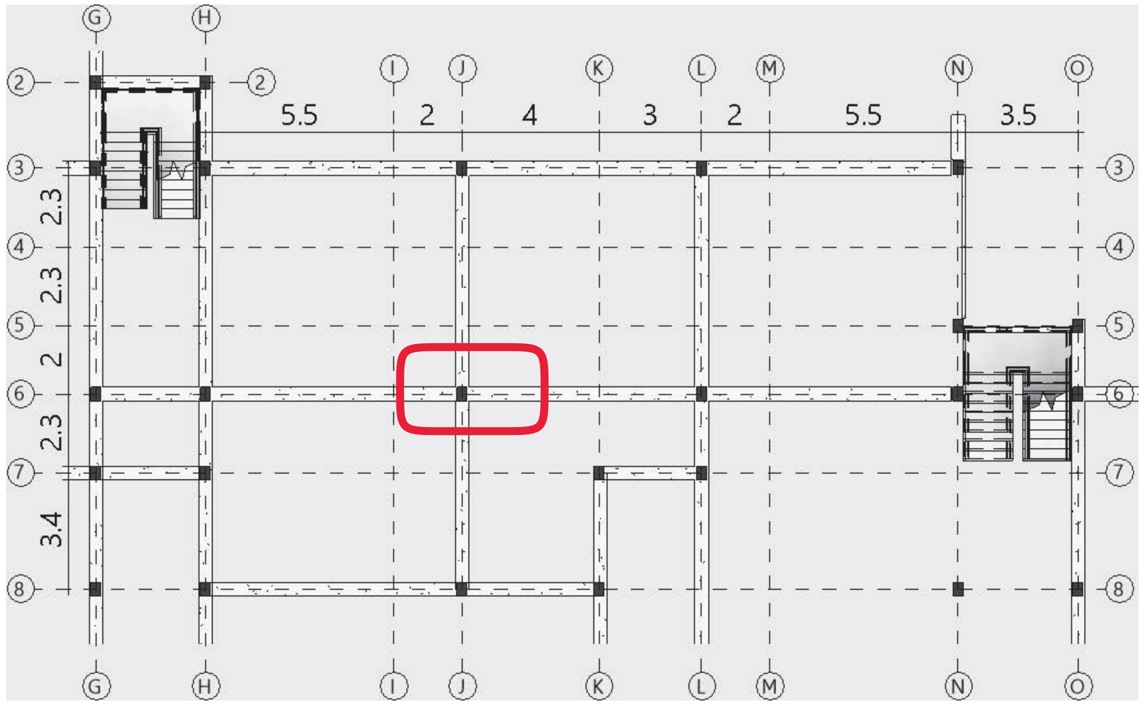


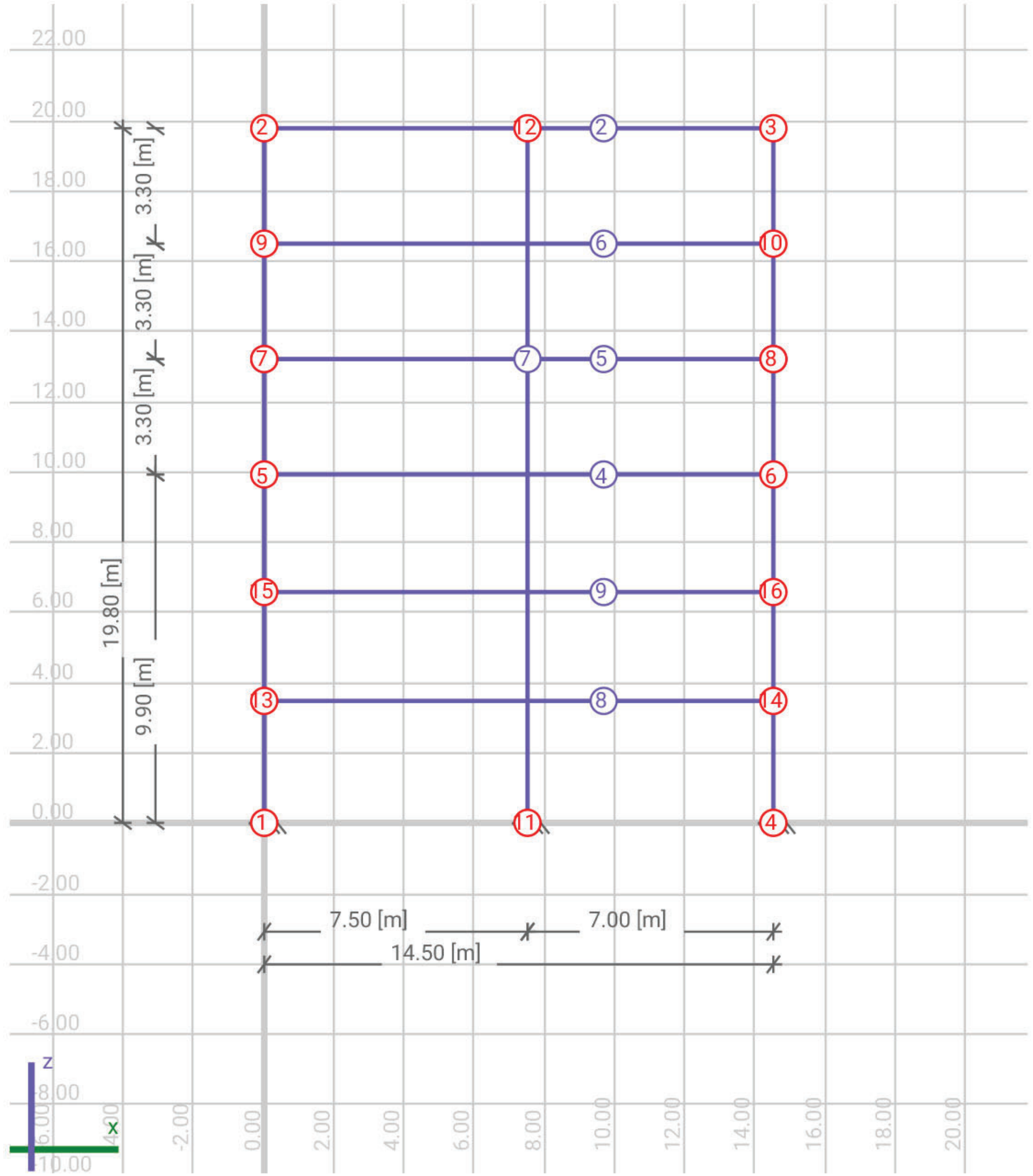
Figure 5.1. Structural plan of second level, fit in scale.

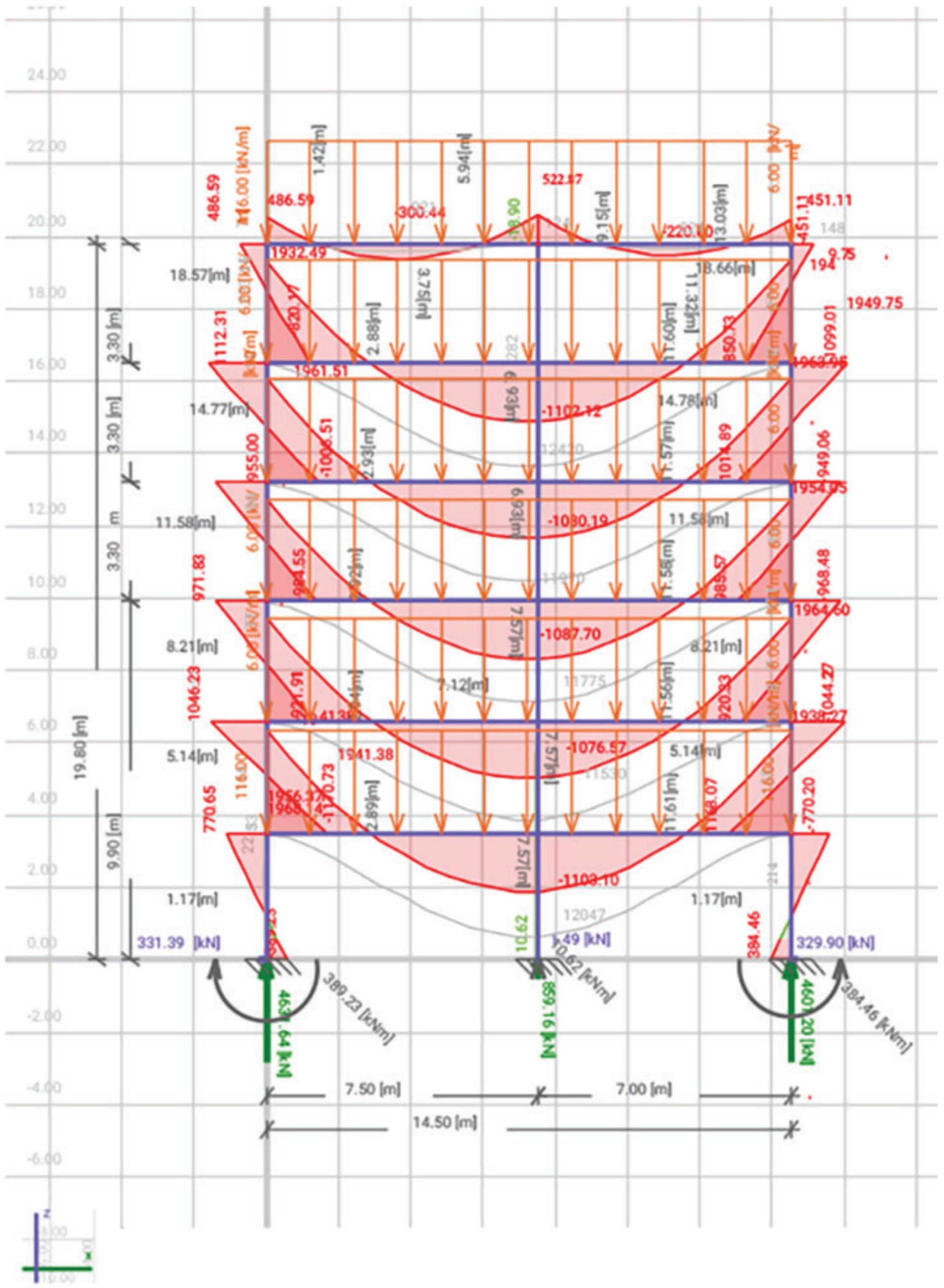
The following table comprises data of permanent and live load action at each floor level coming from 7.5 m and 7 m long beams. The effective slab area is taken to calculate the acting amount of load. Force represent load sum of dead and live load on each floor, whereas Ned already takes into account the previous floor load. The preliminary sectional area is calculated according to stress-force relationship.

Based on the graph above the effective area of J6 column is calculated:

$$(7.5+7)\times(4.6+5.7)/4= 37.34\ m^2$$

8.4.5.2 GRAPHS FROM THE APPLICATION





8.4.5.3 COLUMN CALCULATION FORMULA S

BEAM #1

$l_{beam} = 19.80[m]$

FINITE ELEMENT #1

$l_{beam} = 3.50[\text{m}]$

$$q_x(x) = 0.00[\text{kN/m}]$$

$$q_z(x) = 0.00[\text{kN/m}]$$

$$N(x) = -N_{pi} = -4631.64[\text{kN}]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} = \frac{770.65[\text{kNm}] + 389.23[\text{kNm}]}{3.50[\text{m}]} = 331.39[\text{kN}]$$

$$V(x) = V_{pi}$$

$$= 331.39[\text{kN}]$$

$$M(x) = M_{pi} + V_{pi} \cdot x$$

$$= -389.23[\text{kNm}] + 331.39[\text{kN}] \cdot x$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3\right)}{EI}$$

$$= 0.00[\text{mm}] + -0.00[\text{rad}] \cdot x - \frac{\left(0.5 \cdot -389.23[\text{kNm}] \cdot x^2 + \frac{1}{6} \cdot 331.39[\text{kN}] \cdot x^3\right)}{1272.98[\text{mm}^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.00[\text{mm}] + \frac{0.03[\text{mm}] - 0.00[\text{mm}]}{3.50[\text{m}]} \cdot x$$

$$\varphi(x) = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2\right)}{EI}$$

$$= -0.00[\text{rad}] - \frac{\left(-389.23[\text{kNm}] \cdot x + \frac{1}{2} \cdot 331.39[\text{kN}] \cdot x^2\right)}{1272.98[\text{mm}^4]}$$

FINITE ELEMENT #2

$l_{beam} = 3.10[m]$

$$q_x(x) = 0.00[kN/m]$$

$$q_z(x) = 0.00[kN/m]$$

$$N(x) = -N_{pi} = -3790.42[kN]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} = \frac{1046.23[kNm] + 1170.73[kNm]}{3.10[m]} = 715.15[kN]$$

$$V(x) = V_{pi} = 715.15[kN]$$

$$M(x) = M_{pi} + V_{pi} \cdot x$$

$$= -1170.73[kNm] + 715.15[kN] \cdot x$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3\right)}{EI}$$

$$= 0.01[mm] + 0.52[rad] \cdot x - \frac{\left(0.5 \cdot -1170.73[kNm] \cdot x^2 + \frac{1}{6} \cdot 715.15[kN] \cdot x^3\right)}{1272.98[mm^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.03[mm] + \frac{0.05[mm] - 0.03[mm]}{3.10[m]} \cdot x$$

$$\varphi(x) = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2\right)}{EI}$$

$$= 0.52[rad] - \frac{\left(-1170.73[kNm] \cdot x + \frac{1}{2} \cdot 715.15[kN] \cdot x^2\right)}{}$$

FINITE ELEMENT #3

$l_{beam} = 3.30[m]$

$$q_x(x) = 0.00[kN/m]$$

$$q_z(x) = 0.00[kN/m]$$

$$N(x) = -N_{pi} = -2949.18[kN]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} = \frac{971.83[kNm] + 921.91[kNm]}{3.30[m]} = 573.86[kN]$$

$$V(x) = V_{pi} = 573.86[kN]$$

$$M(x) = M_{pi} + V_{pi} \cdot x$$

$$= -921.91[kNm] + 573.86[kN] \cdot x$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3\right)}{EI}$$

$$= 0.02[mm] + 0.37[rad] \cdot x - \frac{\left(0.5 \cdot -921.91[kNm] \cdot x^2 + \frac{1}{6} \cdot 573.86[kN] \cdot x^3\right)}{1272.98[mm^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x = 0.05[mm] + \frac{0.07[mm] - 0.05[mm]}{3.30[m]} \cdot x$$

$$\varphi(x) = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2\right)}{EI} = 0.37[rad] - \frac{\left(-921.91[kNm] \cdot x + \frac{1}{2} \cdot 573.86[kN] \cdot x^2\right)}{1272.98[mm^4]}$$

$$q_x(x) = 0.00[kN/m]$$

$$q_z(x) = 0.00[kN/m]$$

$$N(x) = -N_{pi} = -2108.02[kN]$$

FINITE ELEMENT #4

$l_{beam} = 3.30[m]$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} = \frac{955.00[kNm] + 984.55[kNm]}{3.30[m]}$$

$$V(x) = V_{pi} = 587.74[\text{kN}]$$

$$M(x) = M_{pi} + V_{pi} \cdot x = -984.55[\text{kNm}] + 587.74[\text{kN}] \quad x$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3\right)}{EI}$$

$$= 0.03[\text{mm}] + 0.44[\text{rad}] \cdot x - \frac{\left(0.5 \cdot -984.55[\text{kNm}] \cdot x^2 + \frac{1}{6} \cdot 587.74[\text{kN}] \cdot x^3\right)}{1272.98[\text{mm}^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x = 0.07[\text{mm}] + \frac{0.08[\text{mm}] - 0.07[\text{mm}]}{3.30[\text{m}]} \cdot x$$

$$\varphi(x) = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2\right)}{EI}$$

$$= 0.44[\text{rad}] - \frac{\left(-984.55[\text{kNm}] \cdot x + \frac{1}{2} \cdot 587.74[\text{kN}] \cdot x^2\right)}{1272.98[\text{mm}^4]}$$

FINITE ELEMENT #5

$l_{beam} = 3.30[\text{m}]$

$$q_x(x) = 0.00[\text{kN/m}]$$

$$q_z(x) = 0.00[\text{kN/m}]$$

$$N(x) = -N_{pi} = -1267.18[\text{kN}]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}} = \frac{1112.31[\text{kNm}] + 1006.51[\text{kNm}]}{3.30[\text{m}]} = 642.07[\text{kN}]$$

$$V(x) = V_{pi}$$

$$= 642.07[\text{kN}]$$

$$M(x) = M_{pi} + V_{pi} \cdot x$$

$$= -1006.51[\text{kNm}] + 642.07[\text{kN}] \cdot x$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3\right)}{EI}$$

$$= 0.03[\text{mm}] + 0.40[\text{rad}] \cdot x - \frac{\left(0.5 \cdot -1006.51[\text{kNm}] \cdot x^2 + \frac{1}{6} \cdot 642.07[\text{kN}] \cdot x^3\right)}{1272.98[\text{mm}^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.08[\text{mm}] + \frac{0.09[\text{mm}] - 0.08[\text{mm}]}{3.30[\text{m}]} \cdot x$$

$$\varphi(x) = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2\right)}{EI}$$

$$= 0.40[\text{rad}] - \frac{\left(-1006.51[\text{kNm}] \cdot x + \frac{1}{2} \cdot 642.07[\text{kN}] \cdot x^2\right)}{1272.98[\text{mm}^4]}$$

FINITE ELEMENT #6

$l_{beam} = 3.30[\text{m}]$

$$q_x(x) = 0.00[\text{kN/m}]$$

$$q_z(x) = 0.00[\text{kN/m}]$$

$$N(x) = -N_{pi}$$

$$= -427.38[\text{kN}]$$

$$V_{pi} = \frac{M_{pj} - M_{pi}}{l_{beam}}$$

$$= \frac{486.59[kNm] + 820.17[kNm]}{3.30[m]} = 395.99[kN]$$

$V(x) = V_{pi}$ N]= 395.99[k

$$M(x) = M_{pi} + V_{pi} \cdot x$$

$$= -820.17[kNm] + 395.99[kN] \cdot x$$

$$u_z(x) = u_{z;\,pi} + \varphi_{pi} \cdot x - \frac{\left(0.5 \cdot M_{pi} \cdot x^2 + \frac{1}{6} \cdot V_{pi} \cdot x^3\right)}{EI}$$

$$= -0.00[mm] + 0.54[rad] \cdot x - \frac{\left(0.5 \cdot -820.17[kNm] \cdot x^2 + \frac{1}{6} \cdot 395.99[kN] \cdot x^3\right)}{1272.98[mm^4]}$$

$$u_x(x) = u_{x;\,pi} + \frac{u_{x;\,pj} - u_{x;\,pi}}{l_{beam}} \cdot x$$

$$= 0.09[mm] + \frac{0.09[mm] - 0.09[mm]}{3.30[m]} \cdot x$$

$$\varphi(x) = \varphi_{pi} - \frac{\left(M_{pi} \cdot x + \frac{1}{2} \cdot V_{pi} \cdot x^2\right)}{EI}$$

$$= 0.54[rad] - \frac{\left(-820.17[kNm] \cdot x + \frac{1}{2} \cdot 395.99[kN] \cdot x^2\right)}{1272.98[mm^4]}$$

8.4.5.4 RESULTS

Beam#			p_i	p_j	min	max	u.c.
1	M	[kNm]	-389.23	486.59	-1170.73	1112.31	
	V	[kN]	331.39	395.99	331.39	715.15	
	N	[kN]	4631.64	427.38	-4631.64	-427.38	
	σ_M	[MPa]	-3659.97	4575.47	-11008.59	10459.29	46.85
	σ_N	[MPa]	-1827.80	-168.66	-1827.80	-168.66	7.78
2	M	[kNm]	486.59	451.11	-300.44	543.77	
	V	[kN]	-427.38	-10.54	-427.38	442.62	
	N	[kN]	395.99	394.50	-395.99	-394.50	
	σ_M	[MPa]	4575.47	4241.83	-2825.13	5113.19	21.7
	σ_N	[MPa]	-156.27	-155.68	-156.27	-155.68	
3	M	[kNm]	384.46	-451.11	-1099.01	1168.07	
	V	[kN]	-329.90	-394.50	-713.66	-329.90	
	N	[kN]	4601.20	395.46	-4601.20	-395.46	
	σ_M	[MPa]	3615.14	-4241.83	-10334.21	10983.60	46.74
	σ_N	[MPa]	-1815.79	-156.06	-1815.79	-156.06	7.73
4	M	[kNm]	1956.37	1954.05	-1087.70	1956.37	
	V	[kN]	-841.16	-0.16	-841.16	840.84	
	N	[kN]	-13.88	-13.88	13.88	13.88	
	σ_M	[MPa]	18396.13	18374.28	-10227.85	18396.13	78.28
	σ_N	[MPa]	5.48	5.48	5.48	5.48	

Beam#			p_i	p_j	min	max	u.c.
5	M	[kNm]	1961.51	1963.95	-1080.19	1963.95	
	V	[kN]	-840.83	0.17	-840.83	841.17	
	N	[kN]	-54.33	-54.33	54.33	54.33	
	σ_M	[MPa]	18444.42	18467.37	-10157.18	18467.37	78.58
	σ_N	[MPa]	21.44	21.44	21.44	21.44	
6	M	[kNm]	1932.49	1949.75	-1102.12	1949.75	
	V	[kN]	-839.81	1.19	-839.81	842.19	
	N	[kN]	246.08	246.08	-246.08	-246.08	
	σ_M	[MPa]	18171.53	18333.82	-10363.43	18333.82	78.02
	σ_N	[MPa]	-97.11	-97.11	-97.11	-97.11	
7	M	[kNm]	10.62	-18.90	-18.90	10.62	
	V	[kN]	-1.49	-1.49	-1.49	-1.49	
	N	[kN]	859.16	859.16	-859.16	-859.16	
	σ_M	[MPa]	99.88	-177.76	-177.76	99.88	
	σ_N	[MPa]	-339.05	-339.05	-339.05	-339.05	
8	M	[kNm]	1941.38	1938.27	-1103.10	1941.38	
	V	[kN]	-841.21	-0.21	-841.21	840.79	
	N	[kN]	-383.76	-383.76	383.76	383.76	
	σ_M	[MPa]	18255.17	18225.92	-10372.67	18255.17	77.68
	σ_N	[MPa]	151.44	151.44	151.44	151.44	
9	M	[kNm]	1968.14	1964.60	-1076.57	1968.14	
	V	[kN]	-841.24	-0.24	-841.24	840.76	
	N	[kN]	141.29	141.29	-141.29	-141.29	
	σ_M	[MPa]	18506.79	18473.48	-10123.17	18506.79	78.75
	σ_N	[MPa]	-55.76	-55.76	-55.76	-55.76	

8.4.5.5 COLUMN DESIGN CHECK

.CHECK BENDING

$M_{max} < M_D$

Both for concrete and steel

$+1117 < \gamma cz = 0.8bf_{cd} B_0 z = 0.8\times0.6\times0.7\times0.4\times30\times0.8 = 3225$ kn/m

$-1117 < A_s$ f_yd/γ z$=A_s$ 450/1.15×0.7×0.6

$A_s > 6796$ mm2

10 Ø28 rebars

.AXIAL FORCE CHECK

$N_{max} < N_D$

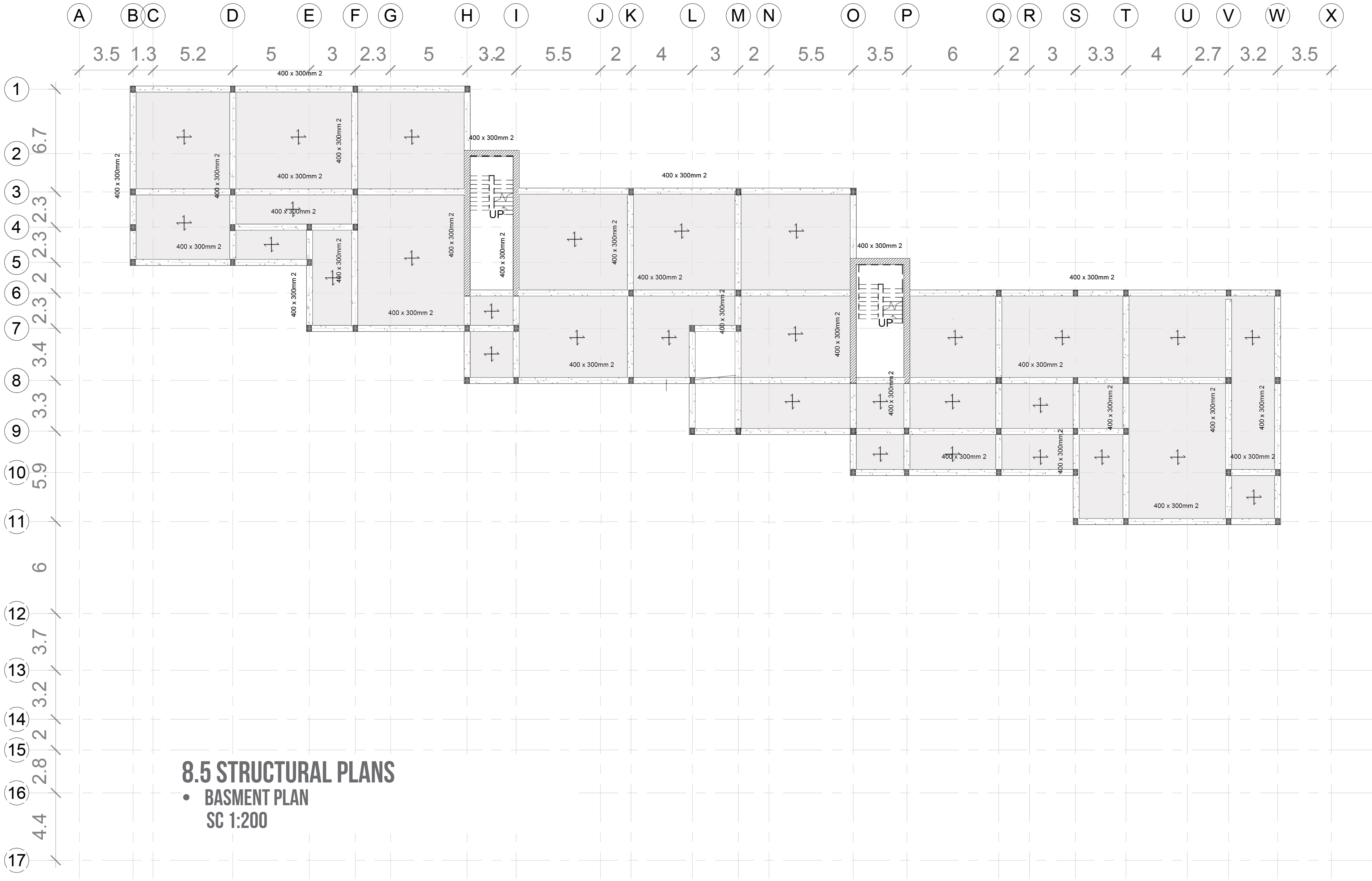
$859 < \gamma bdf_{cd} = 0.8\times0.6\times0.7\times30 = 10080$ kn

$859 < A_s\ f_{yd}/\gamma = 8040\times450/1.15 = 3146$

.COMBINATION CHECK

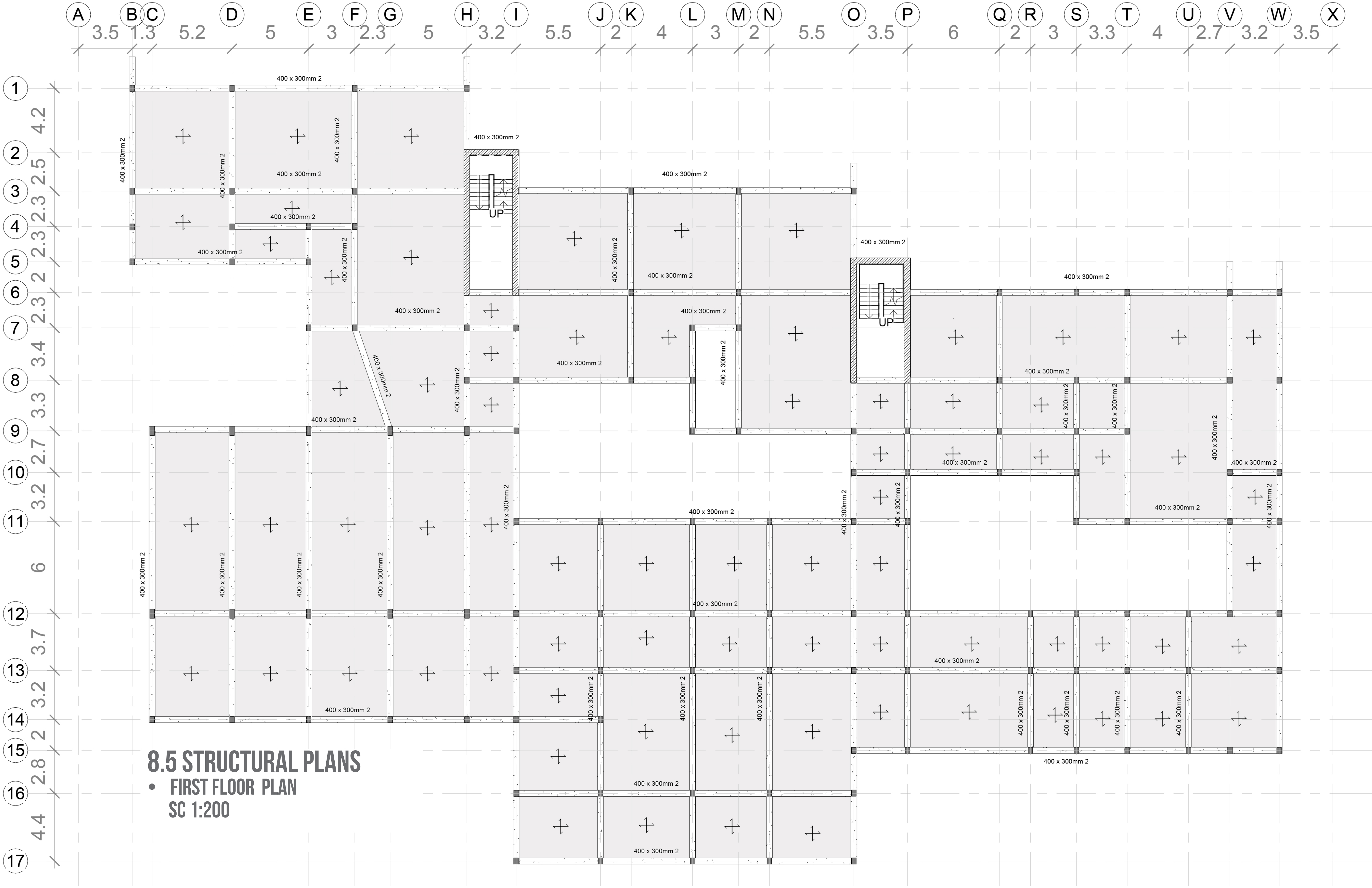
$M_{max}/M_D + N_{max}/N_D < 1$

$1117/3225 + 859/3146 < 1$



8.5 STRUCTURAL PLANS

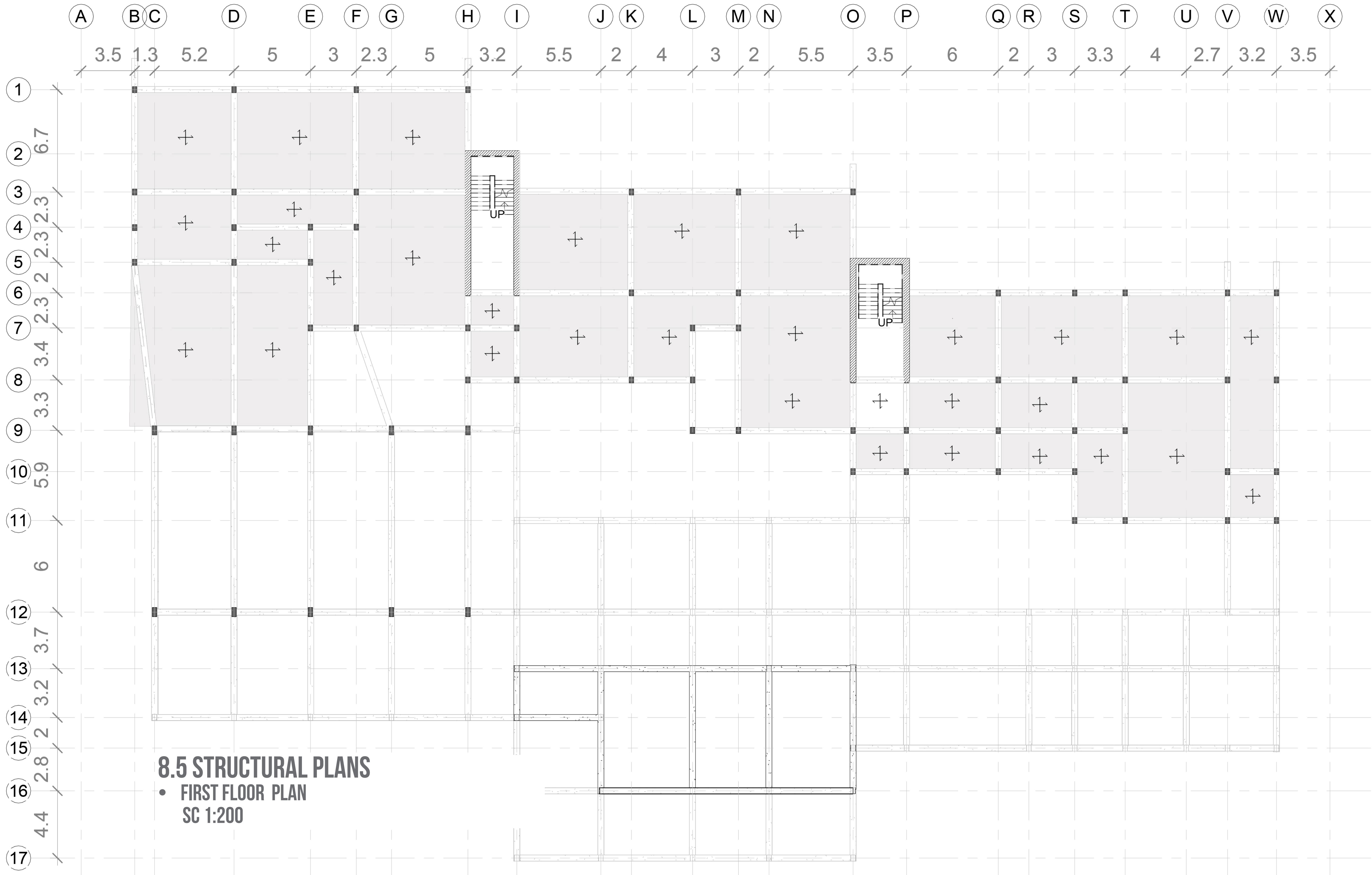
- BASMENT PLAN
  SC 1:200



8.5 STRUCTURAL PLANS

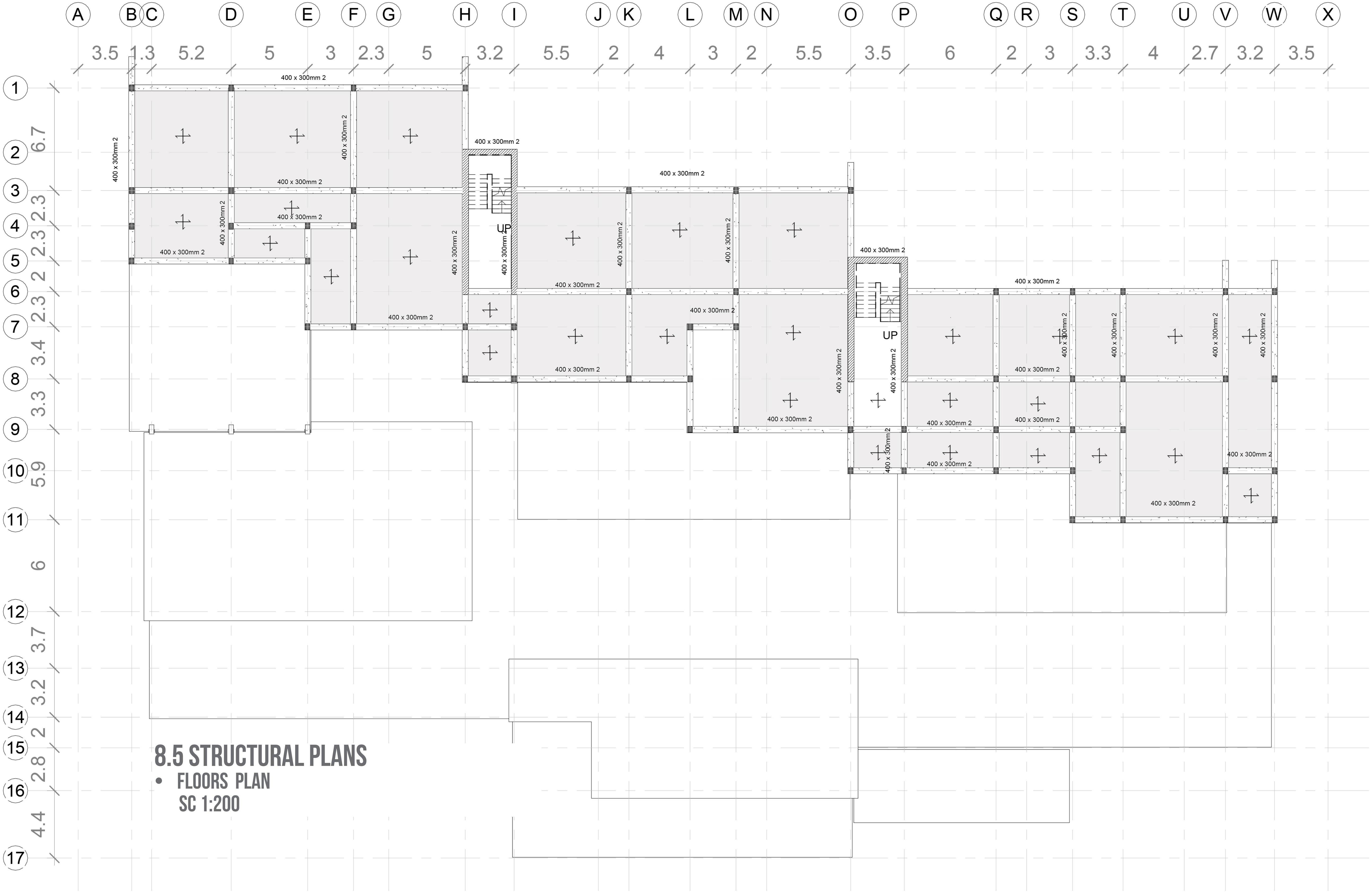
- FIRST FLOOR PLAN

  SC 1:200



8.5 STRUCTURAL PLANS

- FIRST FLOOR PLAN
  SC 1:200



8.5 STRUCTURAL PLANS

- FLOORS PLAN
  SC 1:200

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