Design and Modification of a Residential Context in Tehran's District 22 with a Multi-scale Approach

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Abstract

In today's world as the rate of urbanization is soaring to a dramatic measure, the economic and environmental effects of energy consumption in cities are being clearly sensed. Due to their huge sizes and complexity of their context, the situation is much severe in mega-cities and the necessity of taking more energy efficient and sustainable approaches towards new constructions and urban development is becoming very urgent in them. With this context, Tehran as a metropolis with an extraordinary rapid rate of urbanization, and notorious for its rankings in energy consumption and its polluted environment is absolutely one of the most needful cities of the world. The main aim of this thesis is to suggest an alternative approach to the development manner currently practices in Tehran. Applying *Integrated Modification Methodology* (IMM®), this task has been accomplished with a holistic approach and the intervention is practiced in a multi-scale manner. The relationship between morphology and energy efficiency has been studied in urban scale, neighborhood scale, and architectural scale, then modification and design have been carried out accordingly. Certain technological solution has been proposed in architectural scale, and the whole envelope of the building has been technologically designed. Moreover, the main structural features of the designed are proposed by the authors.

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Introduction

Being the capital, most populous and the largest city of a country that has the most dramatic international rankings in energy consumption, Tehran is experiencing a critical situation in terms of energy affairs. The rapid and rather unintentional development of this metropolis puts it in a condition in which a more sustainable approach toward its further urbanization will be unavoidable.

The main theme of this thesis is the application of *Integrated Modification Methodology* (IMM) on Shahrak-e Golestan in Tehran's District 22 which is a young and under development urban area. Forming this neighborhood for accommodating a part of city's growing population is a well representative of the common developing manners in Tehran, therefore the transformation approach of this study could be considered as a prototype for the similar local (or non-local) contexts.

In IMM, the city is regarded as a Complex Adaptive System (CAS), and in order to involve all the factors those affect the city's behavior in terms of producing and consuming energy –both in analyzing the current situation and in the design part- it is necessary to simulate the behavior rather than simplifying it. Therefore, the whole system is dismantled into four main subsystems, namely: *Volume, Void, Transportation*, and *Function.* Their individual behavior and mutual interaction are studied and modified in the project. The methodology consists of four main phases; the first two which embody the analysis part of the project are *Observation* and *Formulation* respectively. Based on individual behavior of the urban subsystems (*Horizontal* behavior), their mutual interaction (Vertical behavior), and energy indices, three sets of indicators are introduced and a *Catalyst* of transformation is selected from the mentioned subsystems (In this project the Transportation layer has been selected as the Catalyst). The horizontal modification in this layer triggers the transformation. This is happening at the first step of the third phase: *Intervention and design*. This phase is followed by similar individual modification in other subsystems and also vertical modifications in which the effect of changing each layer in the others is qualified. Then the process enters to the last phase that is *Retrofitting/Optimization* in which the contextual modification is carried out and the transformation is evaluated by means of same indicators those the actual situation was analyzed with. In this way, the neighborhood is compared with itself (before and after the transformation), and therefore the level of improvement can be felt much clearly.

After the intervention, whilst its whole built up density is expected to increase by nearly 20%, Shahrak-e Golestan which in actual situation is a highly car-depended neighborhood with poor public transportation would experience near two times growth in public transportation usage. Most of the energy indices especially those related to transportation section are also likely to considerably improve.

Having a multi-scale approach, neighborhood and architectural scales are also subjected to modification and design.

In the neighborhood scale, it has been tried to create a walkable environment with a network of public voids. With suggesting a mixed-use context the neighborhood was designed in a way to support a certain level of self-efficacy as well as to be lively and social friendly. Moreover, the formal regulations of the building those form the neighborhood's spatial characteristics were studied, and with the aim of reaching to a proper range of sun gain, through an optimization method the volume of buildings were redesigned.

In architectural scale the main aim of the authors was to design the building with maximum compatibility with its surrounding. For doing so, it has been avoided to follow the common forms of the building blocks that regardless of the environmental features are widely practiced in Tehran, and the building has been designed with consideration of its possible effects on the surrounding features. With inspiration from Iranian traditional architecture, authors made effort to provide cultural friendly architectural design. The amount of sun gain has been taken into consideration in optimizing the building's volume too.

With the target of having a sustainable design which offers high level of comfort for its residents, the technological aspects of the building has been well-studied, and an energy efficient envelope design has been proposed in details. Based on interior spaces' daylight gain, shading strategies were also suggested for certain parts of the envelope.

Finally, the structure of the building has been studied explicitly. Based on Iranian building code (part 6) the building went through loading analysis, and according to Iranian seismic code (Standard no.2800), the seismic loads have been calculated for it. Steel skeleton was selected as the main structural element, and thanks to the Software SAP2000 the whole structure of the building has been analyzed. Based on Iranian code, one of the critical frames has been modified, and a critical column also has been completely designed.

1 Theoretical Framework

1.1 Problem Statement

Nowadays the energy consumption efficiency and sustainable development is definitely an urban issue. Cities are huge energy consumers as they devour more than 80 percent of the produced energy. The majority of people are leaving in cities and each corner of the world is developing into more urbanized area day by day. The unrestrained trend of population growth which is reaching a dramatic measure raises serious questions regarding overall ecosystem's sustainability. Directly or indirectly, many other phenomena are under the impact of population growth and unstoppable urbanization: new migration flows and the need of new land occupation for housing, urban sprawling, the planet's deforestation, and so on. Moreover, the balance of evidence, from changes in global mean surface air temperature and from changes in geographical, seasonal and vertical patterns of atmospheric temperature, suggests a discernible human influence on global climate.

Although every parts of economic community are feeling the urgency of reducing energy demands, the urban and building sector is particularly under more pressure. In this situation, urban design could play the crucial role of identifying the long-term strategies of sustainable development.

Cities are composed of various elements and systems which consume energy in their own pattern. Most of the energy models and techniques which have been developed to study each of them as self-defined entities, are neglecting the importance of phenomena that occur at the urban scale. In particular, interaction of all the subsystems of the city and its effect on energy consumption still remains unclear.

In this context, the level of unclearness is higher in megacities as the matter of efficiency is much severe in them. The maximum intensity of urbanization is being occurred in megacities, they have a huge share of world's population, the urban features are forming a much more complexity in them, and it is needless to say that most of the world energy is consumed by them.

In terms of morphology and energy consumption, one of the most interesting megacities in the world is Tehran. Tehran is largest city in Western Asia, and with a population around 14 million in its metropolitan area, has the 24th place amongst the most populous megacities in the world.

Being a developing country, Iran has some of the most dramatic international rankings in energy consumption. Iran has the highest *Energy Intensity* among the world's countries, and is second in Energy Development Index. With having the world's fastest growth rate in natural gas consumption currently Iran is the 3rd natural gas consumer in the world. Fuel consumption is very intense too, as the country is world's 2nd in Gasoline Energy Balance Requirement, and is the world's 3rd in residual fuel consumption by households.

As the Iran's largest city, Tehran is responsible for having the biggest share of country's energy consumption which puts Iran in the above mentioned critical situation. Tehran contributes to over than 22% of the whole country's fuel consumption, near 14% of natural gas consumption, and more than 10% electricity consumption

The urbanization pattern in Tehran is also very particular, and the urban morphologies within it are strongly tied up to its development history. With regard to global scale, Tehran has passed the different levels of evolution from a castle-city to a modern and huge metropolis very quickly (in less than 2 centuries). The history of Tehran consists of several periods of intense and hasty urban development trends in which the city devoured its suburban elements many times, and again reclaimed more of them outside its newly established borders. The urbanization growth especially in the recent 50 years left a tortuous morphological legacy for Tehran. The main elements of its urban infrastructure have been formed only in 20 years (between 1956 and 1976), when the population of Tehran has increased nearly 3 times (from 1.5 million to 4.5 million). As a result of this unnatural rate of development, accidental and inharmonious morphologies began to grow in every corner of the city. Moreover, as Iran's capital city, Tehran has experienced two particular phenomenons in its recent 35 years which also contributed to its strange growth, and led to new morphological forms: 1979's revolution, and 8 years of war against Iraq (1980 – 1988). The first changed the social and political infrastructure of the city and by imposing new systems of validation extremely tried to fight with the former development patterns, while the latter dramatically increased the rate of immigration to Tehran and has forced the city to react to the newly demands urgently and quickly. The high volume of construction resulted from economic development in the recent years also is rapidly putting a vivid trace on the city's form and is changing its view in an extraordinary manner.

With the complex morphological inherence from its history, Tehran is still subjected to urbanization, and patterns of its energy consumption are changing and twisting even more quickly than before. In this context, applying a new approach towards this inevitable urbanization, with exclusive attention to sustainable methods of development is seemed to be the only logical solution.

Accordingly, the youngest region of Tehran in which the most recent and intense development is currently being occurred been selected as the subject of study for this thesis, and the development manner there is analyzed from a critical point of view. Then, with a holistic and multi-scale approach, alternative design principles those are compatible with sustainable development are proposed.

1.2 Theoretical Background

Sustainable urban forms had become a serious matter of debate in recent decades (Breheny, 1992; Frey, 1999; Jabareen, 2006; Williams, Burton, & Jenks, 2000). Majority of research has been carried out around the concept of *Compactness* of the city. There are scholars who believe that compact urban forms characterized by high density, mixed land use, pedestrian-oriented habitation and energy efficiency are more desirable for retaining the sustainability of development (Jenks & Burgess, 2000; Chen, Jia, & Lau, 2008; Thomas & Cousins, 1996). However, there are also evidences that challenge the superiority of compact urban forms. Holden and Norland (2005) indicated that lower energy consumption may be achieved by decentralized concentration.

Today it seems that the discussion over compactness aspect of the city is losing its validity in the realm of sustainability. The influence of urban forms on energy consumption is profound, albeit not dominant (Anderson, 1996).The effect of other urban systems (for example transportation) on energy consumption pattern is neglected in compactness debate, moreover this old argument suggests almost nothing for the necessity of dealing with existing urban context (regardless of its compact or sprawl form).

Several simulation methods had been introduced in which the energy consumption is studied through analyzing the form of the buildings in urban texture. One good example would be DEM (Ratti, Baker, Steemers; 2004); however the limited ability of these methods, to provide a realistic energy consumption figure at the urban level, is highlighting the fact that is crucial to close the eye that sees the city as a mere aggregation of buildings, and try to look the problem from a another point of view.

Owens (1986) states that Several aspects of urban forms can significantly affect urban energy consumption, such as the relationship between new developments and existing towns, the size, shape and function of new urban development, the mixing of land uses, and travel patterns. Accordingly, some researchers have tried to track the footprint of energy consumption through other aspects of city and to find the relationship between them and urban morphology: Banister, Watson, and Wood (1997) tried to reflect the links between energy use in transport and urban forms, based on six case studies in United Kingdom and Netherland. Factors significantly affecting urban energy consumption were identified, such as density, employment and car ownership. The fundamental effect of different types of urban functions and the pattern of their dispersal within the city is a huge missing part in this study. Moreover the data involved were coarse and the inconsistency of variables prevented the comparative analysis of different cities. Yimin Chen, Xia Li, Yong Zheng, Yanyan Guan, Xiaoping Liu (2011) also has tried to correlate the energy consumption to different features of city such as urban size and fragmentation of urban land use; But their study did not consider the relationship between the basic subsystems of the city which their indicators are resulted from.

Cities are incredibly complex systems, made of components that can be identified using different point of views. Assessments based on single or simple metrics such as energy flows are insufficient to address the wider socio-ecological aspects of cities (Bourdic, Salat , Nowacki; 2012). Putting much effort to simplify what is complex may be misleading. Massimo Tadi (2011) has considered the city as a single energy consuming entity and tried to study and simulate its behavior as a *Complex Adaptive System*. In this thesis, the mentioned approach is applied to an actual case study, and all morphological layers are accurately studied. It has been tried to look at the problem through a holistic approach, in order to fill the gap of existing studies.

1.3 District 22: an introduction

District 22 is the newest region of Tehran, and as it is indicated in the website of Tehran's Municipality, "it is being the last hope to launch a proper development manner and create an appropriate urbanization for the city of Tehran". With the aim of rectifying the welfare facilities for the adjacent areas, and providing alternative accommodation for citizens who live in Tehran's old textures, its municipality was established in 2000.

This region is surrounded by Alborz Mountains from north, Tehran's District 5 from east, Northern Vardavard zone form west, and Tehran-Karaj highway from south. With the area of 6200 hectares, it is the largest district in Tehran. Almost 1300 hectare of its area is currently devoted to green spaces. Fig 1-1

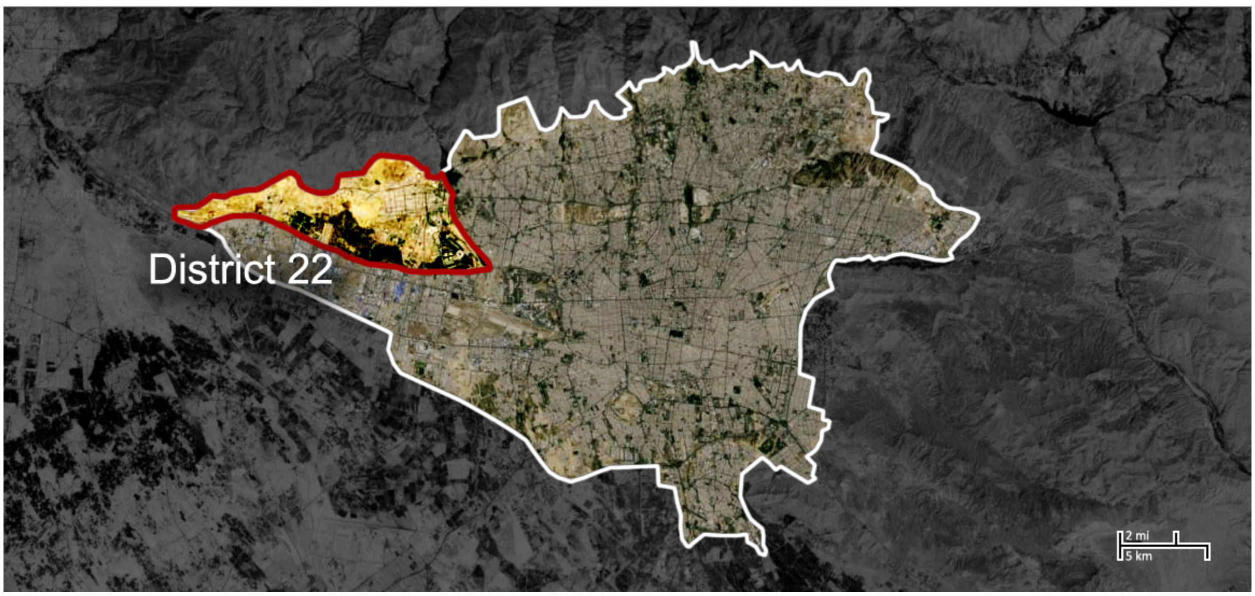


Figure 1-1 Location of Tehran's District 22

District 22 has preferable urban and suburban accessibilities. Its main accessibilities through highways are Hakim, Hemmat, Azadegan, Tehran-Karaj, and the under construction highway of Tehran-Shomal.

In the Tehran's Comprehensive Plan District 22 has been considered as an area for tourism attraction and concentration of welfare facilities. Accordingly, many projects like Tehran's Waterfall, Chitgar Artificial Lake, Charbagh Axis, Tehran's Amusement Park (Tehran Land), Tehran Mall, and Chitgar Water Park are being currently under construction in that zone.

Existence of forest parks of Chitgar, Khargoosh Darreh (Rabbit Valley), and Latman Kan in this region, alongside with the usual west-east wind direction in Tehran, make a rather cleaner and more preferable weather in District 22 comparing to other parts of Tehran.

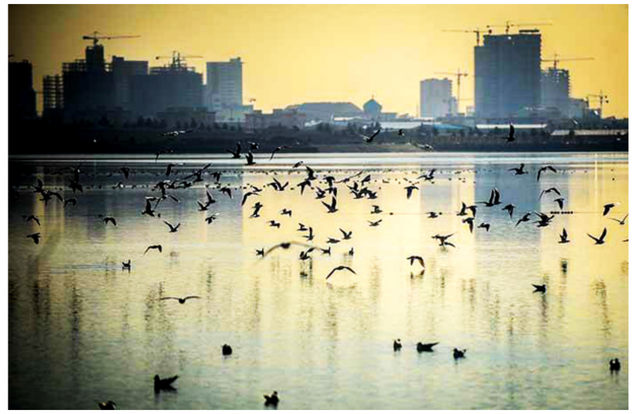



Figure 1-2 newly constructed welfare facilities in District 22. Tehran's Waterfall (Left), and Chitgar Lake (Right)



Figure 1-3 Forest Parks of District 22: Chitgar (left), Khargoosh Darreh (middle), and Latman Kan (Right)

1.3.1History

During the last 30 years, Tehran's District 22 has been objected to special development plans in terms of design and construction. Farmanfamayan and Firoozgar families were the primary owners of most of its lands.

In 1970's after approval of Tehran's Comprehensive Plan, with the proposal of Farmanfarmayan Engineering Company, this region has been defined as the New Town of Kan.

Between 1971 and 1980, 20% of region's land has been segregated and sold to minor owners, and rest of the area has been divided to larger lands with minimum area of $1000m^2$. After Islamic Revolution in 1979, lands owned by Farmanfarmayan and Firoozgar families announced national, and some of them were entrusted to Tehran's municipality.

Because of high level of accessibility of this region, during the war with Iraq (1980-1988), 25% of its lands have been used for constructing garrisons by the army. Spontaneously, some parts of it have been devoted to residential construction.

In 1991, with attention to the potential of Tehran's development in this region –that has been foreseen in Tehran's Comprehensive Plan- and with the aim of establishing preferable manners of urbanization, northeastern lands of the region have been added to Tehran's service area. In that period, municipality set the goal of recovering the lost identity of Tehran for developing lands of these areas. In 1994, the studies made by Bavand Engineering Group were accepted, and after approval of its Comprehensive plan in 2000, the municipality of District 22 was established. The land segmentation proposed in District 22's Comprehensive plan is indicated in the table 1-1

Land use	**Area (hectares)**
Parks and Green Spaces	1265
Educational	230
Services	238
Sport	327
Lake	355
Residential	1162

Table 1-1 District 22's Land use according to its Comprehensive Plan

Whilst majority of its lands are being under massive construction, currently district 22 is hosting scattered residential towns with different urban morphologies.

Figure 1-4 Residential Construction in District 22

2 Methodology

2.1 Introduction

The main aim of *Integrated Modification Methodology* is to morphologically transform the urban context into a much energy efficient form. For doing this, sophisticated understanding of the city -in its general concept, and also in its contextual condition- is needed. In *IMM,* city is regarded as a Complex Adaptive System (CAS), and the chief attempt is to simulate the behavior of this system (rather than simplifying it). The simulative model thus, should be able to reflect the complexity of the city as a whole, and to give broad comprehension of its consisting parts. Therefore, the whole process of making, analyzing, and evaluating this model should be based on a **holistic** and **multi-layer** approach. Moreover, for the functioning of the city can be skimmed only with respect to the spatial relationship between its different scales, the taken approach should overlook the system from a **multi-scale** point of view as well.

The whole process of transformation is consists of four sequencing phases. It starts with "Observation and Measurement" in which the system is dismantled into its composing parts and the properties of function for all the subsystems are studied individually and mutually. For the urban context, these subsystems are introduced as the layers of **Volume**, **Void**, **Function**, and **Transportation**. According to the nature of CAS, a mere action in one constituent will produce chain reaction in others. This means that from the interconnection between the mentioned layers another profound vision of system's operation emerges. Therefore, the one-by-one interactions of the layers are studied in order to reach tangible indices for skimming out the inward behavior of the system. These indices are known as **Key Categories** in IMM. They are six and are namely: **Porosity**, **Proximity**, **Diversity**, **Interface**, **Accessibility**, and **Efficiency**. In order to have a wider preview of the current situation, in the last step of the observation phase, the performance of the system is assessed with a set of indicators. With regard to the basic subsystems, the role of these indicators is to evaluate the morphological features of the context which are directly related to energy consumption pattern.

The second phase is named "Formulation". The framework of transformation is outlined here and as the first step one of the preliminary layers is chosen to be the Transformation's **Catalyst**. The election of the catalyst layer is based on the investigations and assessment of system's actual situation, which is carried out in the first phase, and naturally the layer in which the malfunctioning is much severe is chosen. Transformation starts in the *Catalyst Layer* and through a chain reaction changes the rest of the layers as well. Certain design principles are applied to the system in order to transform it into a better functioning form; here is where "Intervention and Design" phase begins. This process leads to a new CAS with new operation patterns in each of its components, and new connection links between the agents. This new system needs to be studied and be evaluated as well, and for doing so the same analyzing methods and assessment tools which has been used for the untransformed system, are to be practiced. The results of the latter process are a set of orientations through which the system is retrofitted, and its conclusive shape is emerged.

In the final phase, “Retrofitting and Optimization”, the project is subjected to local optimization and the design is finalized with regard to its contextual features (e.g. wind tunnels, solar gain, etc.). And finally, the result is evaluated through an analogy with the rest of the city.

In the following pages, with regard to the article “Integrated Modification Methodology (IMM): A Phasing Process for Sustainable Urban Design”, the main aspects of IMM is explained.

2.2 Approach

As above mentioned, the goal of Integrated Modification Methodology (IMM) is to transform the CAS (here urban context) into a better functioning morphology. The main characteristics of IMM are based on three fundamental approaches: Holistic, Multi-Layer, and Multi-scale.

Holistic

Due to the fact that the final performance of the every complex adaptive system emerges from the wide heterogeneous nonlinear connected elements’ actions, the final behavior of the system is hard to be anticipated. Accordingly, if one wants to deal with CAS, both performance prediction and performance optimization, should deal with its complexity in a holistic way. Dealing with complexity prompts him to face with convoluted difficulties; however, any approach based on simplification will cause unrealistic results. Dealing with complex system based on simplification is resembled to the eight blind monks who were examining an elephant.

As result, ―Complex Adaptive Systems (CAS) refers to a field of study and resultant conceptual framework for natural and artificial systems that defy reductionist (top-down) investigation. Such systems are generally interactions result is in non-linear complex dynamics, whose results are emergent system phenomena.

Multi-layer

The multi-layer, in IMM, could be achieved via involvement of different experts in different disciplines. To reiterate, in terms of sustainability for instance, the environmental layer integration has to be implemented with social layer, as well as economical layer. As mentioned, in urban field, the complex system must be studied with inclusion of its adaptive complexity if results that are more accurate are to be obtained; hence, simulation of a complex adaptive system is far preferable to the simplification of the complex adaptive system in further researches.

The reason behind multi-disciplinary intervention is that any urban development plan in every field will eventually manifest itself in physical results, a product, which needs to be shaped, designed. Accordingly, the neighborhood design task is not simply the urban designer duty; however, urban designers have to articulate different disciplines to achieve a uniform sustainable product.

Multi-scale

The modification of elements of the CAS, which causes the final transformation of the system, occurs in different scales. Equally, the urban interventions are operated in different scales. As the modifications of CAS are classified in the minor (local), medium (intermediate) and major (global) scale, any intervention effect has to be considered in the three mentioned scales. The intermediate interventions bridge the gap between minor and major scales. In a nutshell, ―thinking global and acting local‖ is the main strategy.

The designers should concentrate their concern on the fixed operational area, as the medium scale, if they want to deal with minor (local) scale modification and the major (global) transformation. As Aldo Rossi mentioned regarding to the urban transformation interventions, one should operate on a limited part of the city, although this does not preclude an abstract plan of the city's development and the possibility of an altogether different point of view .

For instance, if the city, including precinct and district levels is considered as the major scale, then the medium scale would be the neighborhood scale, and the local scale is the building block one.

2.3 Objectives

As it mentioned before, the main goal of the IMM is to transform the city context into a more energy efficient morphology. Applying the methodology to Tehran, this ultimate goal will be achieved in consequence and in consistency of a set of objectives. These objectives are:

Develop an urban assessment method

Prior to proposing any design principle or any modification, it is necessary to assess the urban context sophisticatedly. Based on the IMM®'s approach, a concepts and methodologies are to be found to help shape a better comprehension of the system in terms of its performance. Cities are obviously different with each other; therefore it is evident that the assessment method should address the particular properties of the understudied context which in this study is a young neighborhood in western side of Tehran.

Moreover, the proposed assessment method should be flexible to provide a realm of evaluating a urban context in comparison with other areas and different morphologies. With aim of transforming the context, this helps to compare the understudied area with itself before and after the modification, hence will result to eventually evaluating the transformation.

Needless to say that the assessment should be based on the elements with which the relationship of urban morphology and energy efficiency can be defined. Therefore knowing these particular elements, their properties on trustful comprehension of their performance within the system are stand in the highest level of importance.

Define compatible design principles

The transformation is carried out by modification of the current urban context, and proper modification is achieved through decisions taken by designers. Thus, design principles need to be defined in order to serve the ultimate goal which is to arrive at a sustainable morphology. Furthermore, in order to be integrative the modification should be compatible with the existing morphological code that any urban context may have, and also addresses the urban elements which are parts of complexity of the system. Therefore the design principles ought to be defined again with a holistic outlook.

Transformation into a more energy efficient form

This is the main aim of IMM® and it was explained before. Since this thesis is a case study on Tehran, the transformation should fulfill the needs of this megacity and be consistent with the policies those been considered for development of Tehran. Tehran is subjected to a high rate of urbanization and new districts are added to it in order to meet the urgent need of housing. Certain policies introduced to manage this urbanization in a proper way and avoid accidental growing. Certain level of compactness and definite range of densities has been decided to its regions. Hence, the final transformation should comply with the considered plans.

2.4 Instruments and Tools

As mentioned before, the constituents of CAS adapt themselves to react to the new imposed constrains, in order to improve the entire system‘s performance. The complex adaptive system is composed of heterogeneous elements, linked together either directly or indirectly, and the final system performance emerges from all of the elements as a whole. This adaptation occurs within or on members of a subsystem, hereafter known as Horizontal Adaptation, and between the different subsystems, hereafter termed Vertical Adaptation.

In other words, the adaptation of existing members in a subsystem, horizontal adaptation, as a response to the newly imposed conditions and constraints, changes the subsystem‘s performance, which will be the cause of the entire system transformation, over time.

The vertical adaptation is a specific kind of adaptation, likewise where the members modify themselves to optimize the performance of the entire complex system. However, unlike the horizontal one, which occurs inside each subsystem individually, the vertical adaptation takes place between different subsystems. In other words, the subsystems interact symbiotically in order to improve their own performances, and thereby the entire system‘s performance level. The horizontal adaptation occurs within or on members of a subsystem (horizontal adaptation), hereafter known as —Modification||, and between the different subsystems (Vertical adaptation), hereafter termed —Integration.

One can sharpen the performances of the entire complex system, utilizing the adaptive behaviors of the complex adaptive system, both horizontal and vertical. The entire complex system will be transformed by the mentioned symbiotic adaptive behaviors between the elements and subsystems, modification and integration, over time. By boosting, the performance of one subsystem, through the assistance of the transformation of another subsystem, creates a collaborative relation, which ultimately leads to transformation of the complex system in an optimal way. To reiterate, modification happens when the members of one layer are optimized, in order to improve their own layer‘s performances. On the other hand, integration is a symbiotic relation between different layers, in order to better their performance, which ultimately improves the entire system‘s performance. These adaptive features are the key elements of the CAS simulation method.

The IMM method could be applied in different disciplines, by different experts, in order to improve the performance of a complex system. The expert solely needs to choose the apt involved layers within numerous numbers of layers in the system. It is clear that involving more layers brings more complexity and accurate result to the final modification process; however, it makes also the simulation process more complicated.

As the main interest of this research are the urban form and the energy consumption of the city, the authors tried to indicate a number of layers which are correlated with Environmental layer and urban form concerns. After studying the city and its main constituent subsystems, the investigated subsystems in this research, which affect the urban morphology as well as the balance of total energy of the city, have been selected as follow:

- Urban Volume
- Urban Voids
- Functional Layer
- Transportation Layer

The superimposition, or symbiotic integration, of layers creates some morphological, typological and technological features-determinatives of the city, which are called Key categories‘ (KC), in the sustainable urban design intervention; therefore, they could be used by designers, in the observation phase of the design process, to analyze the urban context on the actual situation and its performance before intervening (Table 2-1). Thanks to the results of the research, carried out by the authors, and based on theory plus practice, the KCs have been literally defined. In addition, some measurable Indicators, correlated with every KC, are needed to give the numerical dimension to these Key categories. The Key categories are fixed, independently from the context, whereas the Indicators vary.. The Indicators‘ definition should be chosen differently in every specific urban context, by designers and planners; the selection criteria lay precisely on the contextual constraints, conditions, intervention‘s intentions and available data banks . The contextual selection criterions, the measurable Indicators, associated to the fixed Key categories, vary in each context. According to Hildebrand, designers have to pay attention to the fact that cities are all different in form and structure, owing to a host of place-specific factors such as topography, climate, and socio-economic conditions. It cannot be expected that they should all fit the same formula when it comes to the question of a sustainable city form. Additionally, the contextual Indicators are meant to evaluate the intervention process of IMM. In this case, the performances of an existing context before and after the modification process are needed. ―After all, we are generally confronted not with the task of planning and designing new towns and cities but, rather, that of re-planning and redesigning existing cities, towns and settlements to make them more readily sustainable. However, eventually designers could use global and standard Indicators to observe how the city performs respect to other cities.

Layers' superimposition	F.L.S (Key Categories)	S.L.S	Determinants	
Volume / Void	Porosity	Compactness	Morphology	Energy efficient form
Volume / Function	Proximity			
Function / Void	Diversity	Complexity	Typology	
Transportation / Void	Interface			
Transportation/ Function	Accessibility	Connectivity	Technology	
Transportation / Volume	Efficiency			

Table 2-1 Superimposition of the layers

Porosity

Vertical optimization of Volume and Void layer defines the Porosity. ―The Volume layer clearly defines the presence of this principle layer; the urban conveys the physical meaning of the city. Indeed, one can imagine the city as a solid porous Volume, sponge like, with various sizes of holes linked by linear Void layer; whereby the integration of these two layers, urban Volume and Void, porosities.

The Density could be categorized as an indicator associated to this Porosity. The built-up space volume ratio to total the area of the site, the ration between areas of the buildings to the intervention site area and the inhabitant‘s ratio to the Volume and area could be considered as density Indicators in the IMM. The right choice is contextual dependent, as previously underlined. The porosity, alike the other KCs, has an optimal span; henceforth, there are optimal limits for the maximum and the minimum of porosity. The optimal span is clearly based on the contextual drivers, the other KCs, and changes according to the different contexts. The optimal span of every KC highly depends on vertical relation with other KCs. The density‘s best condition is highly related to the other KC, i.e. Efficiency, which is connected to the infrastructural potentiality of the system.

Proximity

One of the possible ways of evaluating the Proximity is the number of different type of key functions in a predetermined distance; in fact, the predetermined area is walkable scale. In other words, proximity is highly related to the pedestrian fruition of a space; the number of key functions type that one can reach in walking distance. Key function types are educational spaces, administrative services, entertainment, commercial, business, etc. In the evaluation process, Proximity is dependent on the number of key function types; whilst it is independent from the quantity of each of the key function types by itself.

Despite the proximity is independent from the number of people and residence in the neighborhood, another possible way to evaluate the proximity of the neighborhood could be explicated by the relationship between the number of job availability and the number of dwellings in the integration of the Void layer with the function layer creates the diversity of the city, which has

Diversity

The integration of the Void layer with the function layer creates the diversity of the city, which has a direct relationship with the number of the nodes and Links. As result the more these nodes are complex. One can explain it as a number of interactions between nodes within a network; it could be seen as a number of Links between the network's nodes. The diversity, the distribution of the different functions in public open spaces as well as indoor, such as urban piazzas and shops, coincides with the probability of different urban activities and occurrence of the public to encounter and mingle for social and economic events. Diversity is dependent on the number and type of the functions and independent from the distance; however, in order to simplify it, the diversity could be measured as the number of different type of key functions in a predetermined distance. Despite the Proximity evaluation, not only the number key function type is important, but also the quantity of each key function is counted.

Diversity Face-to-face human interactions on the stage of public life are extremely relevant for supporting livability, safety and control, economic development, participation, and identity. The ingrowth of the number of members within a CAS system is coincided with the diversity level escalation, due to the increment of the nodes and Links numbers. However, there is a limit for the diversity, alike the other KCs. In the CAS system the number of elements is directly proportional to the complexity level, which leads to the increase the system's efficiency; nevertheless, the overcrowding of the system would hinder the movements of goods and data, by decreasing the connectivity between the elements. This congestion leads to system's efficiency to decline dramatically. Thus, there should be a balance between the complexity and connectivity within the CAS system. Again, this balance between complexity and connectivity requires a symbiotic relation and a Vertical modification between layers.

Interface

The integration of the Void layer with the transportation, layer creates the Interface, which has a direct relationship to movability inside the urban morphological cavities. The interface feature is the movability inside the building blocks. The permeability of the urban fabric is highly related to another KC, the porosity. One might categorize Interface as a feature of the porosity key category. However, the Interface is about movability inside the urban voids, both pedestrian and motorized, and it defines how complex they are; on the other hand, the porosity main concern is urban voids, even if they are closed courtyards. Due to this fact, the Interface increases the complexity of the system, by increasing the number of possible Links to connect two nodes; whilst, the porosity, concerns about how compact an urban fabric is. In order to increase the interface two different actions are requested: first of all increasing the fractal complexity of the urban porosity by linking voids and making a complex hierarchy of networks, then creating pedestrian walking scale porosities.

To increase the interface, most blocks must be short; that is, steers and opportunities of turning the corner must be frequent. To be clear, one of the main generators of diversity is the complexity of urban morphology and buildings typology. The complex configuration of Void and Links, interface and porosity, increases the diversity of the neighborhoods.

Accessibility

The Integration of Function and Transportation, creates the Accessibility, which refers to the ease of reaching destinations. People, in highly accessible places, can reach many other activities or destinations quickly; people living in inaccessible places can reach fewer places in the same amount of time. Unlike the Proximity, which depends on the distance parameter, Accessibility is a distance independent parameter that simply relies on a time factor.

As mentioned, the accessibility is the integration of the transportation layer and the function layer; hence, the symbiotic relation between these two layers comes to its own, if one wants to improve the accessibility of a place.

Accessibility is also highly related to the available technology in the context. It is necessary to point out another variable, such as the means of transport, high speed trains, in this specific case. The time dependency and distance independency is the main characteristic of this key category.

Efficiency

The integration between Transportation and Volume, Efficiency, is a complicated feature, mostly related to the economy. A possible and simple definition could be explained through the ratio between the number of trips operated by public transport and the total transportation demands of the study area. It means that efficiency could be evaluated by a classical ratio between supply and demands in the public transportation sector. As well as other KCs, the Horizontal modification of the Transportation layer, as well as its vertical optimization, or integration with other layers, have to be implemented in both local and global scale. In other words, the efficiency of the neighborhoods could not be improved without considering the entire urban transportation's system.

The results of the symbiotic integration of the preceding part, entailing the three layers, depict compactness, complexity and connectivity of the city, which are morphological, typological and technological feature of itself.

The sustainable form could be achieved through a right balance between the compactness, the complexity, and the connectivity. Any of them would not be sufficient on its own to achieve the sustainable form. The balance between the second level Key categories, KCs, the complexity, the compactness and the connectivity, is the foundation of a sustainable urban form.

2.5 Intervention and phasing

The IMM is a multi-stage, iterative process, applied to urban complex systems, for improving the complex adaptive system's performance, which comprises different but full integrated phases. The IMM methodology is based on a multi-stage process composed by different but full integrated four phases, respectively:

- Phase 1: Investigation/Analysis
- Phase 2: Interpretation/Assumption
- Phase 3: Modification
- Phase 4: Optimization

The following table indicates IMM phasing and sub-phasing and the way of application of each of them.

1	1a	Horizontal Investigation	Dismantling the system to investigate	Investigation/ Analysis	Observation & Measurement
	1b	Vertical investigation	The actual value of Key Categories		
	1c	Actual performance of the system based on 10 indicators		Data Collection	
2	2a	Detection of the transformation's *Catalyst*		Assumption and Interpretation/ Hypothesis	Formulation
	2b	Assumption of the 10 IMM Ordering principles		Assumption	
3	3a	Horizontal Modification	The *catalyst* drives the local transformation; changing the structure of the layers/Ligands	Modification	Intervention & Design
	3b	Vertical Modification	Local transformation acts globally, changing the entire system's configuration		
	4a	Performance of the new CAS based on 10 indicators		Contextual Evaluation	Retrofitting
4	4b	Local modification/optimization of new CAS physical components or subsystems, such as: Voids, Built spaces, Functions, and Transportations.		Local Design	Optimization
	4c	Universal indicators		Comparison	

Table 2-2 IMM's intervention phasing

Parallel to project description, the IMM's intervention phasing is being explicitly discussed in the *Int*

3 Intervention

3.1 Global Scale

3.1.1Introduction

As it has been explained before, one of the fundamental aims of this thesis is to study and understand the new development patterns which are being currently practiced in Tehran and for that purpose the district 22 as the youngest Tehran's region which is currently subjected to the most intensive development has been selected as the study area.

According to IMM, the analysis and intervention are to be carried out in a multi-scale manner, and in order to do that a major scale, an intermediate scale, and a local scale are needed to be introduced. In this section the selection of the major scale is discussed and its urban features are introduced.

Although the Tehran's district 22nd is the largest region in Iran's capitalcity, because of its developing situation most of its areas are currently empty and while extreme volumes of construction are happening there, it can be easily said that the region has not recognized its stabilized form yet. There are only a few established neighborhoods dispersed all over the area and the rest of region is evolving around them. The largest and the most stabilized zone in District 22 is Shahrak-e Golestan in the east of the region (Figure 3-1). With the area of near 200 hectares, Shahrak-e Golestan consists of three neighborhoods: Eastern Golestan, A part of Western Golestan, and Amir Kabir neighborhood (Figure 3-2). Besides being the largest established area in the region there are also several other justification of selecting Shahrak-e Golestan as the most suitable global study site:

- It has a very large size which provides a chance to apply the methodology in a big scale,
- It has a strategic location which helps to study the way it is integrating with the urban features in its surrounding,
- Its morphology represents the currently practiced developing trends in Tehran.

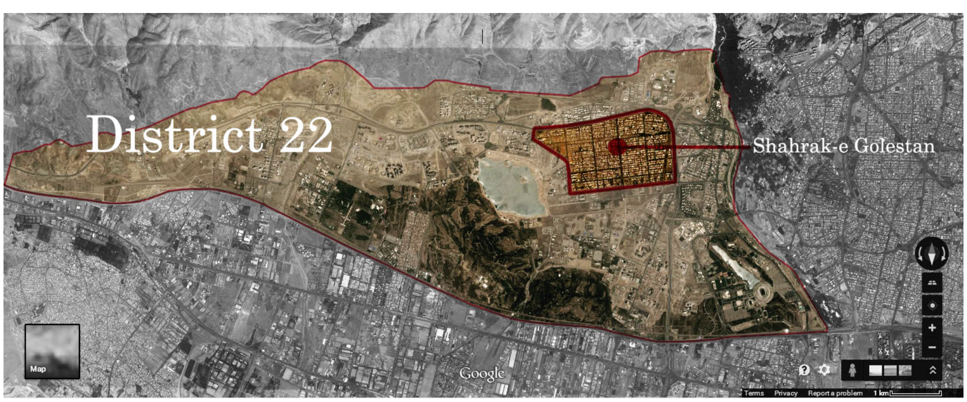


Figure 3-1 The position of Shahrak-e Golestan in District 22

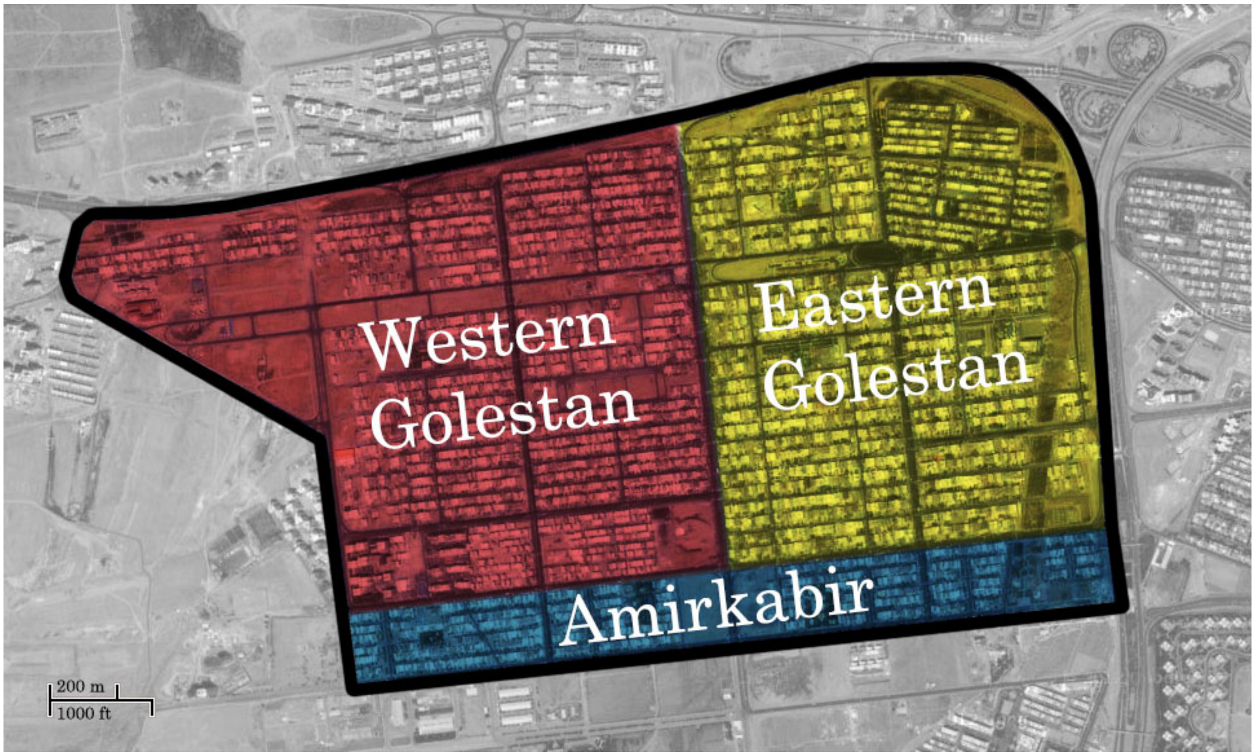


Figure 3-2 Neighborhoods of Shahrak-e Golestan

3.1.2 Shahrak-e Golestan

Shahrak in Persian means town, and with the area of 2 km^2 Shahrak-e Golestan quietly is a town-sized neighborhood. It is located in the Alborz's hillside in western Tehran and as it explained before it could be mentioned as one of the first development stages for Tehran's district 22. It is a part of Municipality's plan to meet the urgent need of housing in Tehran, and it has been designed for the middle-class citizens.

In terms of accessibility it has a very strategic location. The Hemmat Highway, which is the most important west-east axis of Tehran, is located just in its north side, which through motorized traffic connects the area to the main body of Tehran from the east, and to Karaj (the largest neighbor city of Tehran) from the west. Adjacent to Shahrak-e Golestan's east side Azadegan Highway acts as a strong suburban connector which from the north connects the area to Iran's northern cities (which are the main outing destination for Tehran's citizens), and from the south, while providing connections toward Tehran's center, relates the whole city to the suburban areas in west and southwest.

Some of the special urban elements of Tehran are located near the site: while it is surrounded by the mountains from north, the site has the Chitgar Lake in its southwest foot which with the area of nearly 120 hectares is the largest artificial lake in the Western Asia. Next to this lake is located Chitgar Park which with its natural topography and standard bike roads is being a famous sportive attraction. In south of Chitgar Park the Tehran's Industrial City is located which with its huge size embeds some of the most important industrial units of Iran like *Irankhodro,* the biggest Middle-eastern automobile manufacturing factory. The Azadi Sport Complex as the Iran's biggest sport complex and naturally Tehran's main stadium is located in the southeast of Shahrak-e Golestan. Below the stadium, Mehrabad Airport is placed which hosts nearly all the domestic flights those Tehran is either their origin or their destination. And just adjacent to the airport located the monumental Azadi Square which is the nearest urban functional node to the Shahrak-e golestan (Figure 3-5).

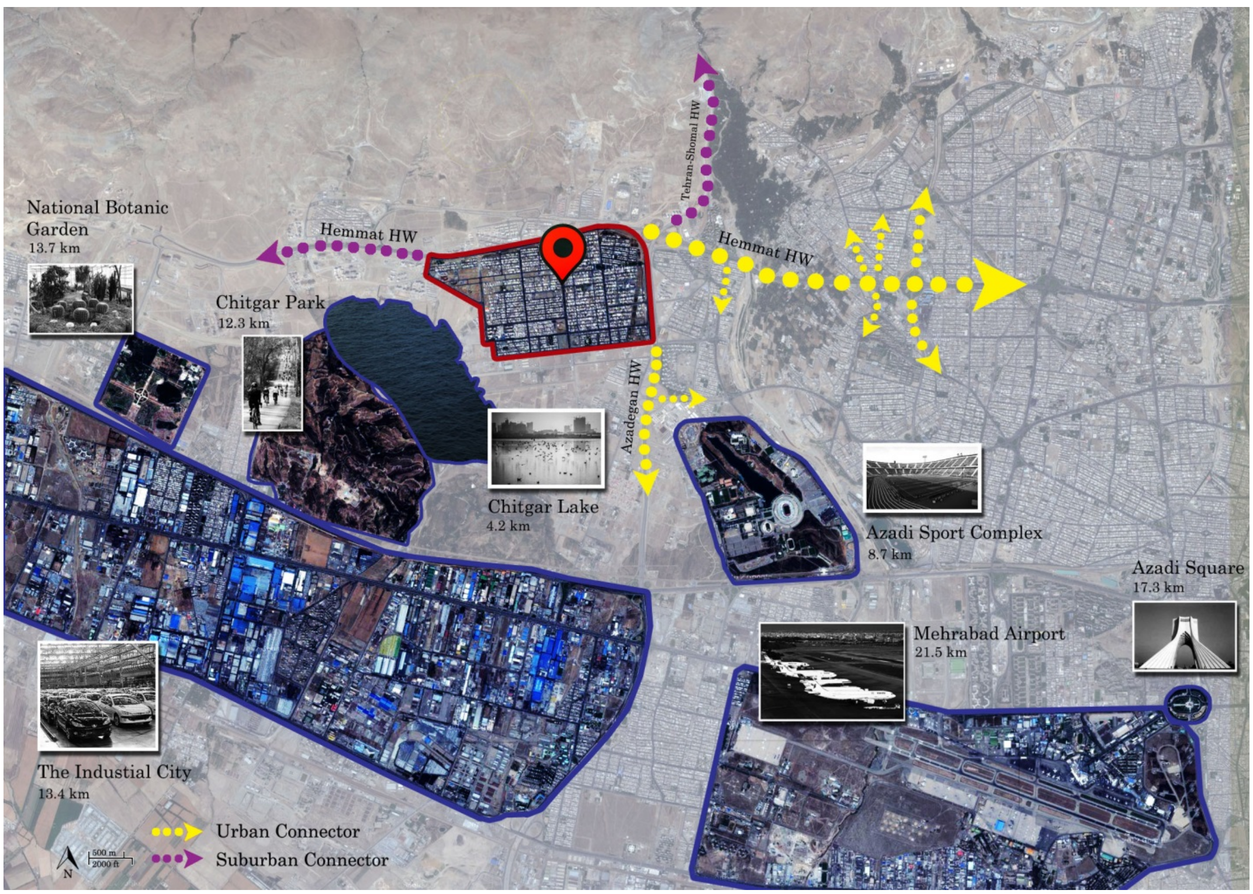


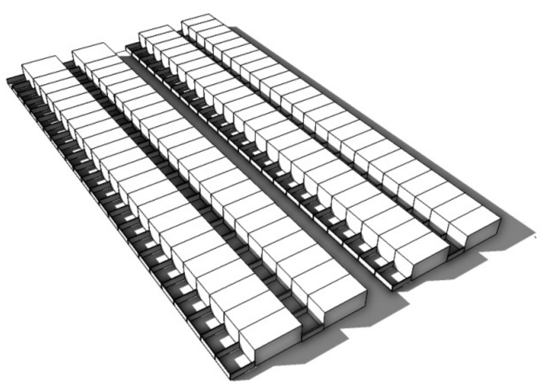
Figure 3-3 Site location and the surrounding urban features (Distances are calculated from the center of the site and through the nearest possible rout)

In its closer vicinity in the north, the site has the Police Academy, Latman Can Park which is a special Park for motor crossing, and Pomegranate Garden [Figure 3-4].

Figure 3-4 urban features in Shahrak-e Golestan close vicinity (Distances are calculated from the center of the site and through the nearest possible rout)

The dominant morphological theme of Shahrak-e Golestan is the greed layout in which straightforward oblong blocks of residential buildings are situated [Figure 3-5]. The residential buildings which form this context are normally buildings with 3 or 4 stories with 2 or 3 similar residential units in each level. According to municipality's criteria they have an area of void equal to 2/3 of their built up area which is located in their southern side. This area is enveloped from the outside and although it is a common space between all the residents of the building, is named the private yard in the construction law books [Figure 3-6]. This way of regulating the building for small housings is being widely practiced in Tehran especially in the last 30 years [Figure 3-7].

Figure 3-5 Typical morphologies inside Shahrak-e Golestan



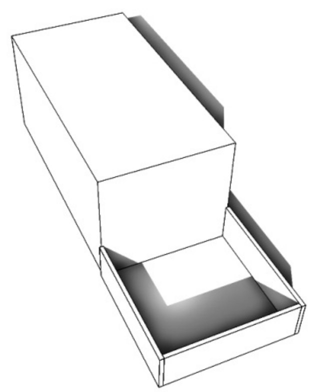


Figure 3-6 (left) Typical morphology of the residential blocks, (Right) Typical morphology of a building as a component

Figure 3-7 the typical morphology of residential blocks in Tehran

(Top from left to right) Jordan in north, Pasdaran in northeast, and Farjam in east

(Bottom from left to right) Gisha in West, Shahrak-e Valiasr in southwest, and Yaftabad in south

The land-use criterion which is suggested by the municipality for Shahrak-e Golestan is shown in Figure 3-8. According to municipality's documents most of the area in this site is devoted to low density residential blocks. This regulation changes only in a small area in the southern part of the site which higher densities of housing are located, and the area between the longitudinal 8th and 9th streets in which the commercial activities and offices are concentrated mainly. These streets and the area between technically form a strong axis that connects the western part to the eastern part. In the current actual situation this area plus some of the areas foreseen as parks and green spaces are the major parts that are still undeveloped [Figure 3-9].

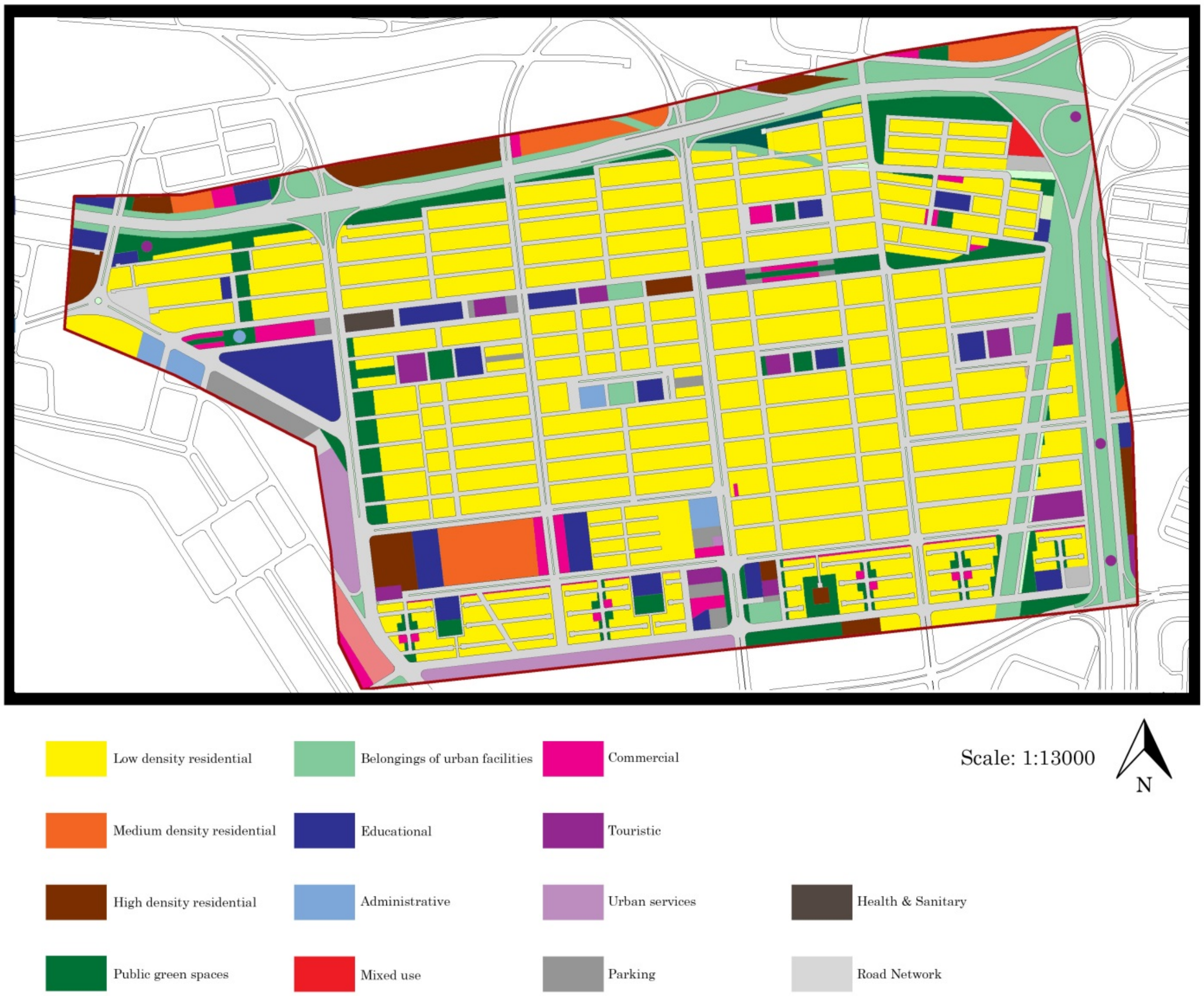


Figure 3-8 Land use suggested by municipality

Figure 3-9 the undeveloped axis of Shahrak-e Golestan

The street network of the area follows a very straightforward movement from internal traffic flow to external access. The hierarchy of traffic links of the site is illustrated in Figure 3-10.The majority of streets are those that form the greed shape between residential blocks. Their widths are mostly between 12 to 18 meters and they act as neighborhoods' traffic collectors with the role of connecting the houses to links with higher level of importance. Those links are specifically the streets which collect the traffic from neighborhoods and led it to inter-districts axes. They are named Major Collectors here and act as the intermediate links, and are namely Arghavan Street, Hashemzadeh Boulevard, Kaj Boulevard, Aghaghiya Boulevard which links those three horizontally, Golha, and the long horizontal Amirkabir. Arghavan Street and Hashemzadeh Boulevard are located in the west and together with Kaj Boulevard form the site's south-notrh connections. Aghaghiya Boulevard relates vertically the latter three, and Golha Boulevard which is located in the eastern part, is again a vertical connection. Amirkabir Boulvard in the south is the major west-east connection of the site with the outside. The role of Major Collectors is to connect the area to rest of the city (and also the suburban areas) through the Hemmat Highway in north and Azadegan highway in the west which is urban arterials.

Figure 3-10 Shahrak-e Golestan' street hierarchy

Figure 3-11 Urban Arterials. (Left) Hemmat Highway, (right) Azadegan Highway

Figure 3-12 Kaj Boulevard: one of the Major Collectors

3.2 Intervention: IMM Phasing

3.2.1 Phase 1a - Horizontal Investigation

As the first step of the *Investigation* phase, the role of the *Horizontal Investigation* is to provide individual visions of the urban subsystems by disassembling the CAS into its components. In other words, in this phase the CAS is being analyzed through a set of separate studies for each one of its layers (Volume, Void, Function, and Transportation). The main goal of Horizontal Investigation is to obtain a clear point of view for observing the individual characteristics of the urban layers, and understanding the urban configuration (morphology) as well as the socio-cultural space (Typology) and therefore the artificiality of the space (Technology).

The aim of Tehran's Municipality to develop District 22 of was to meet partially the urgent need of providing residential spaces for the citizens. This background has direct effects on the morphological, typological, and technological aspects of the whole region and also, on Shahrak-e Golestan as a young neighborhood. Due to its greed-based design with standardized blocks shapes and rather uniform height of the buildings (three story buildings), the volume layer is almost similar all over the site. The urban voids in this neighborhood are limited to uniform closed yards of the residential buildings and a low number of green areas which are mostly undefined in function. For the under development context of the region, the site is empty from some of the vital urban activities and the existing functions are distributed in a dispersed way. The main activity center of Tehran is remote from Shahrak-e Golestan, and there is no well-organized public transportation connection to it. This gives a rather suburban characteristic to the neighborhood and makes a car-depended transportation layer there. Furthermore, lack of well circulated inner public transportation provides nothing but a poor internal connectivity.

In the Horizontal Investigation phase, a try of translating the situation explained above into the numbers has been carried out, and in order to do that some simple formulas has been used. The table below shows the suggested procedure of system dismantling, and the actual values resulted from the related formula for investigating every single layer.

Figure 3-13 Volume and Void

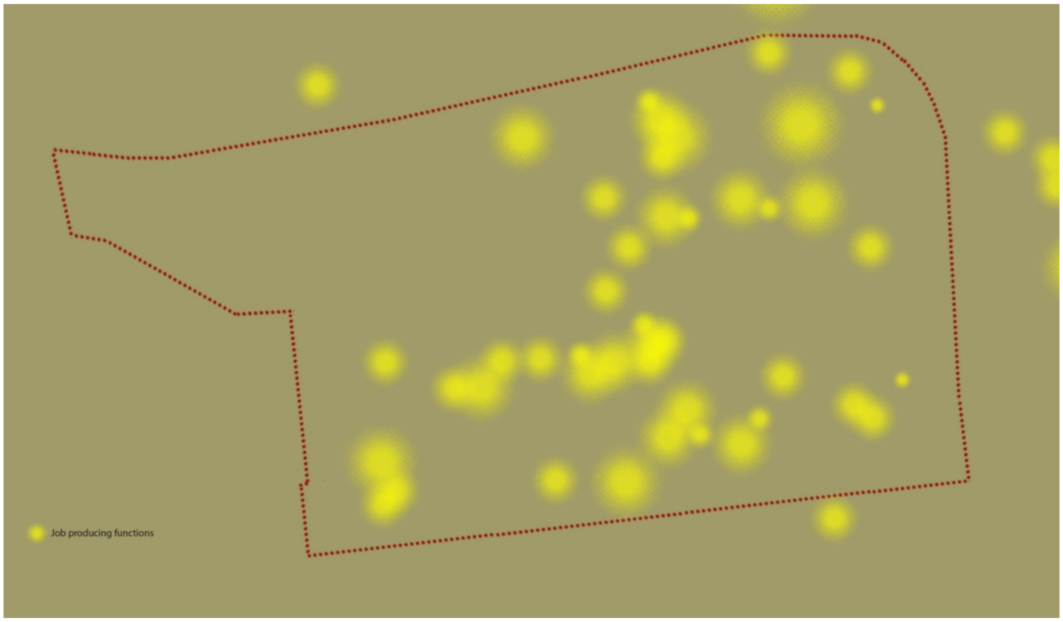


Figure 3-14 Function

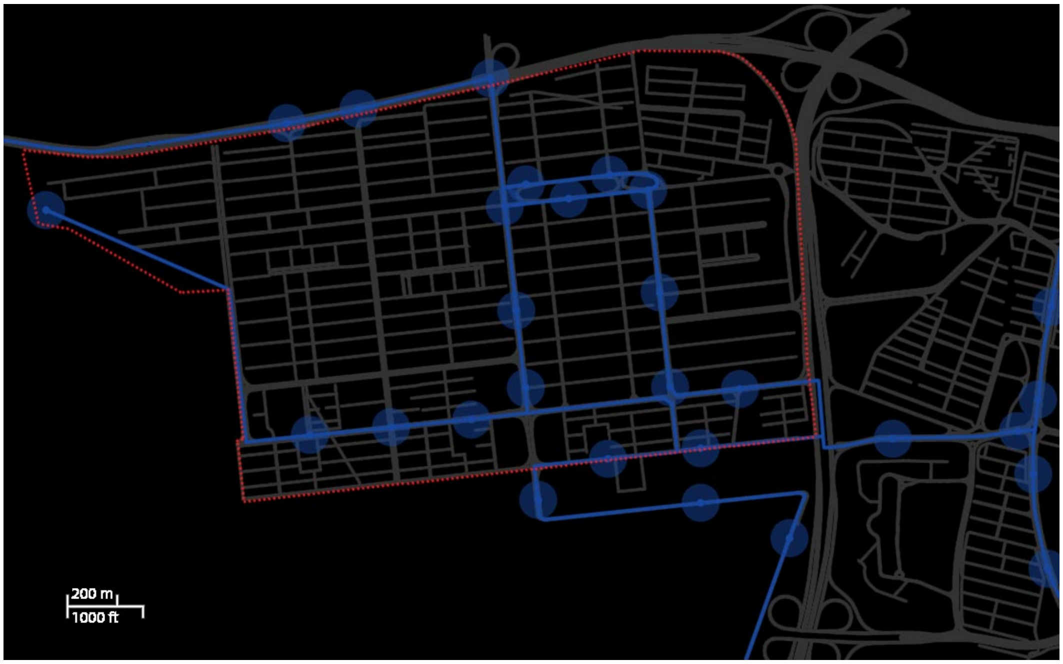


Figure 3-15 Public Transportation

Layer	Description	Formula	Value
Volume	Built volume density, Dwelling density, Human density	$V_l = V_{built}$ / Area	3.60
Void	Open space/area	$V_d = V_{open}$ / Area	1.86
Function	Job density, Number of legal entities in the intervention area	$F_n = J_{number}$ / Area	2E-4
Transportation	Number of carried out urban trips (daily)	N_{tr}	57,178

Table 3-1 Horizontal investigation

There are some commemorations needed to be considered about the calculations in this phase:

1. A new dimension has been added to the void, by multiplying the area of the open spaces into a certain height (3 meters, which is almost the height of a one story building). This way of calculation allows the void layer to be discussed completely alike the volume layer, in terms of number and dimension.
2. Based on the limited access to information sources, the number of existing jobs has been estimated rather roughly. There are some numbers of existing function types in the site (which also are not claimed to be exact), and a general contextual average of job

production for each of these types. For example there are four banks in Shahrak-e Golestan, and in Tehran, a bank produces twelve job opportunities in average; therefore the banking section provides forty eight jobs in the neighborhood. By taking the same way of calculation for other functions, the total number of jobs in Shahrak-e Golestan has been estimated to be 620.

3. The ratio between the numbers of daily trips in Shahrak-e Golestan and in District 22 has been considered to be the same ratio of the population between these two zones (40%).

3.2.2 Phase 1b - Vertical Investigation

The second step of the Investigation phase is a survey of the comprehensive configuration of the CAS. In this part the correlation between the different subsystems (global configuration) is described and a specific characteristic is assigned to each one of the key categories. The main goal of this phase is to understand the architecture of the links and the interrelation of the system components (Volume, Void, Function, and Transportation).

Porosity

Porosity can be determined with various indicators. Among them, the built up density seems to be the appropriate one for this study. It is easily understandable, and is directly related to the porosity's component layers (volume and void).

The majority of built up spaces in Shahrak-e Golestan belongs to residential section. Typical residential buildings here are three story buildings in which 40% of their occupied area is private yards (considered as urban void).

Built up density in shahrak-e Golestan is calculated as below:

$$Density = \frac{Total\ floor\ area\ of\ buildings}{Land\ area} = \frac{3{,}724{,}121}{3{,}098{,}738} = 1.20$$

Proximity

As it defined before, Proximity is related to the number of functions which are accessible in a walkable distance. It could be evaluated by considering one particular function as the center, counting the other functions and repeating this process for the other rest of the function. The mean number of functions in walkable distances is presented as Proximity's indicator. In Shahrak-e Golestan, because of the uneven dispersal pattern of functions, it has been decided that the standard deviation also be indicated alongside the mean number. No need to explain that the value of standard deviation solely does not distinguish high levels of quality from low levels; it only gives a feeling of situation when it comes with the mean number. For instance, a low mean number of function with a rather little standard deviation for a neighborhood such as Shahrak-e

Golestan tells that the overall proximity is low there, and also there is no specific functional center(s) in that context.

For its under development situation, some vast areas of Shahrak-e Golestan, like its western part, are almost empty from functions, and because of the monotonous context of the site which is based on medium residential blocks, other urban activities are limited to small units distributed in an unorganized way all over the area. It is difficult to find an axis or a center of functional concentration, however surrounding area of boulevard Kaj in the center seems to be more proximate than the rest of areas.

The image below illustrates the proximity of Shahrak-e Golestan:

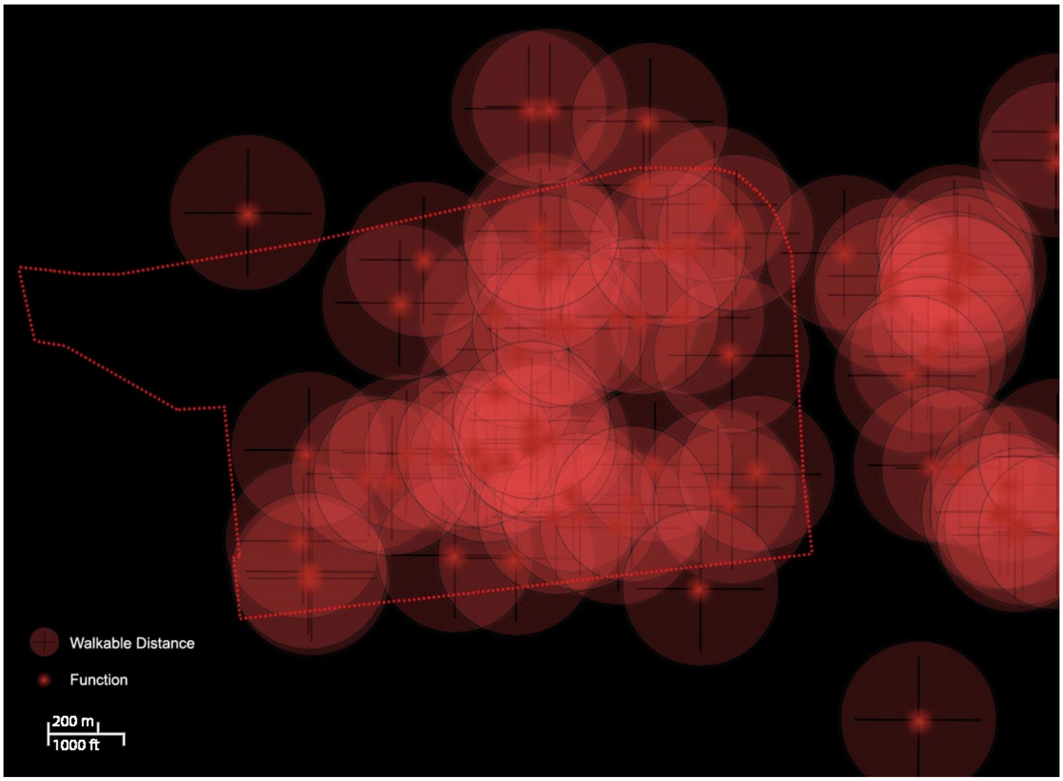


Figure 3-16 Proximity of Shahrak-e Golestan

The walkable distance has been considered as a radius of 250m here.

The numbers of functions in walkable areas fluctuate between 2 (in various areas) and 10 (in center). The Proximity indicator (mean number of functions in walkable distance) is indicated in table below with the values of variance and standard deviation.

F_n mean	S^2	S
5.41	5.20	2.28

Compared with the developed neighborhoods, the F_n mean is very low in Shahrak-e Golestan, and small value of the standard deviation suggests that the dispersal of functions is almost the same everywhere in the site. In other words, each area in the site experiences almost the same lowness of proximity as the other areas. The complete calculation table of the proximity is depicted in the enclosure section.

Diversity

The indicator of Diversity is expected to show the level of probability of different functions in predetermined area. Diversity is directly related to the quantity and the typology of functions, and naturally, different interpretations of typology assign different meanings to diversity. Whilst the formula remains fixed same functions could be categorized in unlimited ways, and for each categorizing method, the formula tells how diverse the context is in that particular compass.

For calculating the diversity a modified Simpson index is hired here. As an indicator, Simpson index describes how close is the dispersal of different categories of function, to an equal distribution, and again, depended on the types of categories this could mean differently. For example, if the existing functions are categorized only regard to the type of services they provide, the result of calculation will indicate, for example, whether there are as many cultural centers as commercial activities in the area under study or not, which of course, does not explain the diversity all alone. For achieving a better answer, calculation of the modified Simpson index could be repeated for more types of categories. One alternative way to categorizing the functions could be regarded to the quality that they add to city. In this way, necessary activities like educational and job providing functions can be classified in one group, and optional activities like cafes, restaurants and leisure activities come together in another group. The pattern of assembling necessary and optional activities around each other shows the level of activity and traces how live the area is, and the result of Simpson index here, describes the Diversity from that point of view. Other systematic, cultural and contextual types of categories can be added, and with analyzing and comparing the result of calculation for all of them the vision of Diversity will be clear and clearer.

Formula for calculating the Diversity (Key category) is based:

$$D_1 = \frac{C}{C-1}\left[1 - \sum_{i=0}^{C}\left(\frac{n_i}{N}\right)^2\right]$$

D_1: Modified Simpson Index

C: Number of Categories

n: Number of Functions in Each Particular Category

N: Total Number of Functions

In this thesis, functions are grouped in two typologies from two different points of view which were mentioned above: urban key functions, and quality. In urban key function typology, functions are simply categorized according to their types of service. Commercial activities, services, health care administrations, educational units, leisure activities, sport, and religious/cultural centers are the categories here. On the other hand, the quality typology is a little complicated. It consists of necessary and optional activities, and necessary activities themselves, are divided into necessary functions which are regularly must be done (e.g. school and sports activities), and occasional activities which are also necessary (e.g. banking and activities related to health care). The existence of a suitable number of optional activities alongside the necessary ones would mingle the social life and raise the quality of public spaces.

The table below shows the existing function and their categories in each typology:

Function	Service Category	Quality Category	Number
Shopping Center	Commercial	Necessary Occasional	4
Bank	Services	Necessary Occasional	4
Post Office	Services	Necessary Occasional	0
Police Office	Services	Necessary Occasional	1
Hospital	Health Care	Necessary Occasional	0
Clinic	Health Care	Necessary Occasional	9
Pharmacy	Health Care	Necessary Occasional	7
School	Educational	Necessary Regular	4
Library	Cultural	Optional	2
Restaurant	Leisure	Optional	2
Gym	Sport	Necessary Regular	2
Mosque	Cultural	Optional	11

Table 3-2 Existing function and their categories in each typology

Overall, there are 46 functions in Shahrak-e Golestan which there is information existed about them. Considering the largeness of the area, this number is extremely low, and in this situation of course the concept of *Diversity* is affected highly by the matter of quantity. Through this overall weakness there are some realms which even suffer more: whilst there is no data on existence of show theaters, music halls, live public spaces and places for any other interactive cultural activities, the cultural and leisure activities are limited only to a low number of restaurant, libraries and mosques. This brings a very poor quality of the optional activities in the site and consequently makes a monotonous atmosphere. In the service section also, the low quantity of related functions causes a high level of dependency to the other parts of Tehran. The educational and sport activities are experiencing the same weakness, and the low number of job producing function gives the feeling of just a large dormitory to the employed residents.

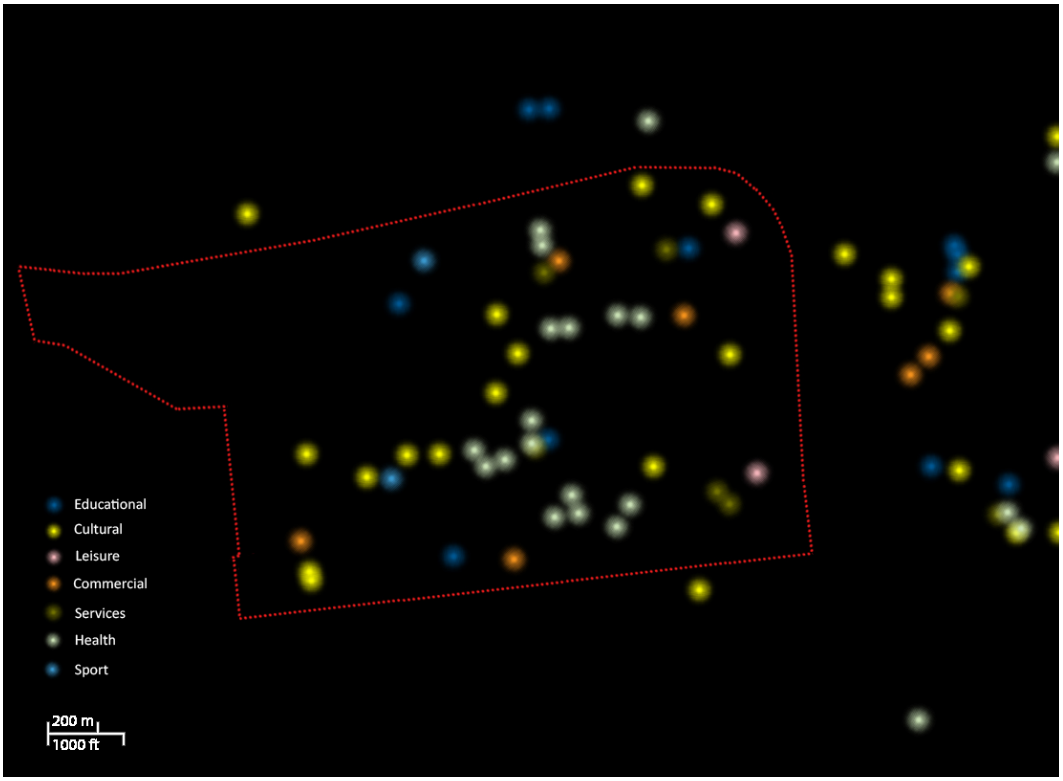


Figure 3-17 Diversity: According to the service types

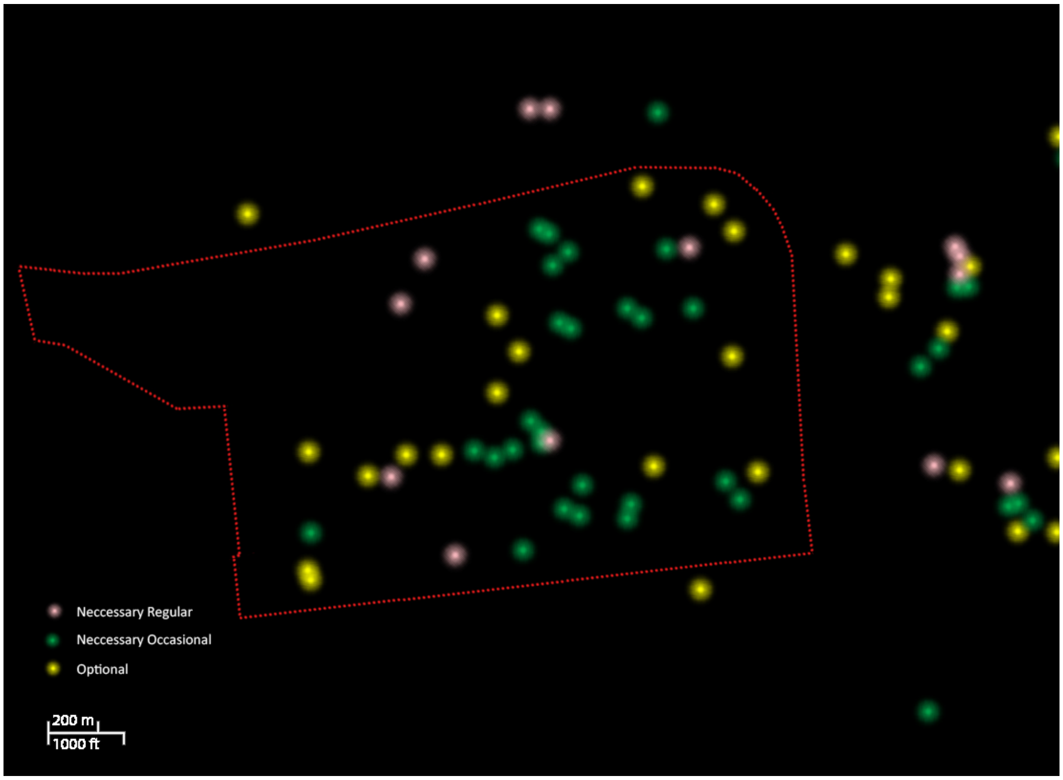


Figure 3-18 Diversity: According to the quality of services

The modified Simpson index for the both typologies is indicated below:

D_1 (S) = 0.78

D_1 (Q) = 0.59

Regardless of overall low quantity of functions, the calculation suggests that the area is less diverse in urban quality. The main reason for this result is the lack of appropriate number of optional activities in comparison to the other functions existing in other categories.

Interface

The concept of *Interface* roots the interaction of void and transportation layers. It is directly involved in movability between building blocks, and therefore, its index is expected to address the level of movability. No need to explain that here, the effective voids are streets, and they could be interpreted as the veins which are hosting the transportation flow (both motorized and car-free transportation), so the indicator of *Interface* must evaluate the quality of this flow.

An acceptable method for evaluating the interface could be calculating the Mean Depth for the street network. The depth of a unit space is the number of unit(s) that a trip-maker on average needs to cross to reach all other units in a system. The value of specific depth denotes the number of units the trip-maker needs to cross to reach all units of that depth. Using this process of quantification of unit connections determines how one unit space (urban void) is connected to all the others.

$$MD = \frac{\sum d.n}{k-1}$$

D: Mean Depth

d: Depth

n: number of unit spaces at a specific depth

k: total unit spaces that comprise the system

In this study, the calculation of the Mean Depth has been carried out with the “UCL Depthmap”. UCL Depthmap is an Open Source application to perform visibility analysis of architectural and urban systems. It is developed by University College London where the theory of Space Syntax was introduced for the first time.

The image below illustrates the result of Mean Depth analysis in Shahrak-e Golestan. The warmer the color indicates the higher of mean depth for the link:

Figure 3-19 Mean Depth analysis in Shahrak-e Golestan

The mean depth is calculated for all the links visible in the above image. The values for five of them are shown in the image below:

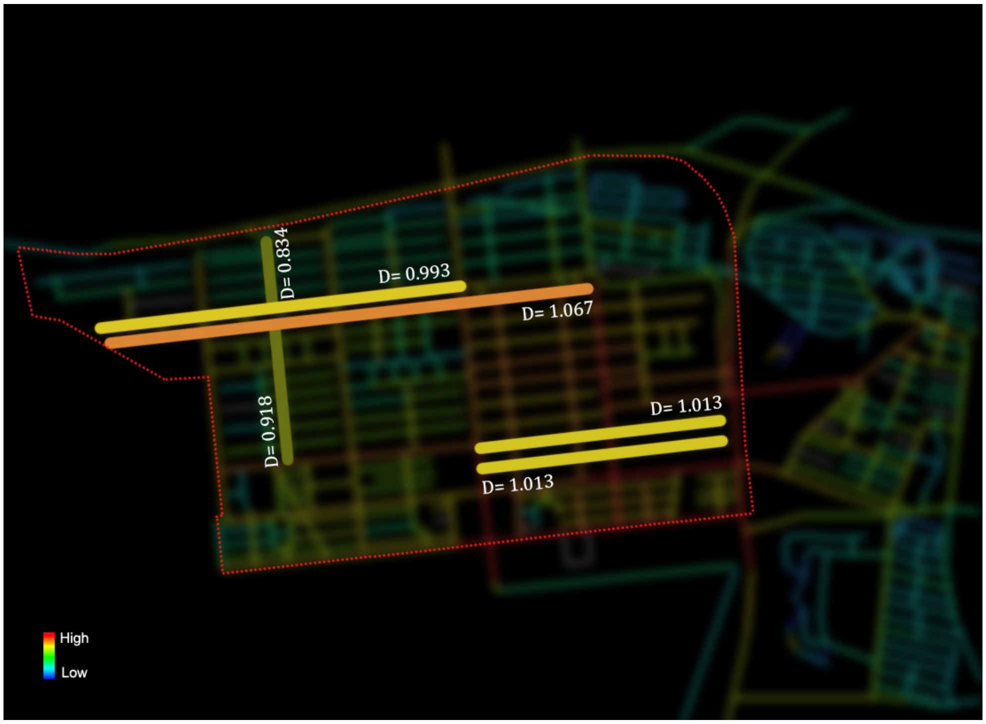


Figure 3-20 Value of mean depth in five links

Accessibility

Accessibility is related to the ease of reaching to destinations and it is directly depended on time factor. The value of accessibility is affected by features like transportation technology and streets network's quality as well as the quantity of desirable destinations. The indicator of *Accessibility* should build a symbiotic relationship between all these features. Therefore the time factor (which is related to available technology's types) and number of destination should be highlighted in the formula.

In Integrated Modification Methodology, accessibility is defined as the number of jobs reachable in 20 minutes using public transportation. In order to quantify this concept in an actual situation, the largest area in the context in which every point is accessible to all the others, within 20 minutes should be identified. For doing this, all the nodes including a limited walkable area around them which are accessible in a time less than 20 minutes from each single node should be highlighted. The largest area in common could be selected then, and it will be called the Accessibility Core hereafter. The size of accessibility core is highly depended to the properties of public transportation system (e.g. average velocities, time intervals, etc.).

Here the formula for calculating the accessibility is introduced as:

$$Acc = N_j \frac{A_c}{A_t}$$

N_j: number of available jobs in accessible core

A_c: area of accessible core

A_t: total area under study

In this case study the only available technology is urban bus. The accessibility core is calculated based on the average velocity of buses (17 km/h) and their arrival time intervals (10 minutes for each station). Around each node a radius of 150m of walkability is considered, and the geometric constrains gives the final shape to the accessibility area. The area of accessible core calculated as 1,539,527 m, whilst the total area of the site is 4,853,549 m. The total job numbers in Shahrak-e Golestan is estimated to be 620, and it is expected that 358 of them are located in the accessible core. So the accessibility in this area calculated as:

Acc = 358*(1,539,527/4,853,549) = **113.56**

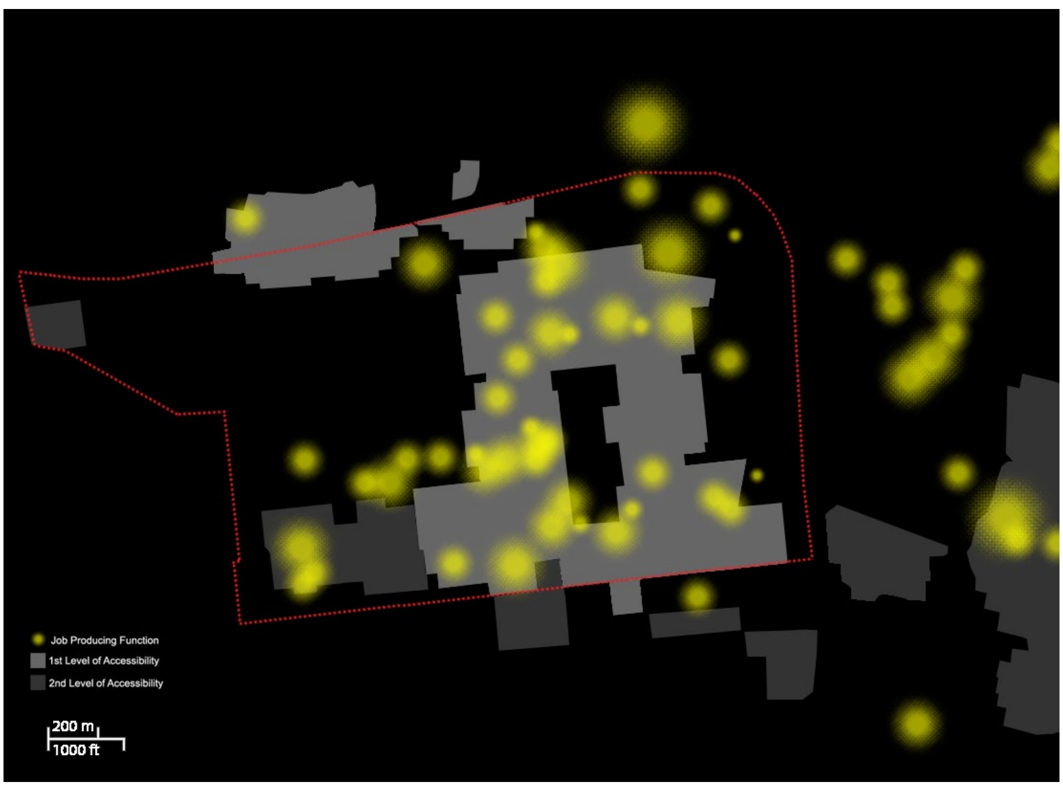


Figure 3-21 accessibility in Shahrak-e Golestan

Efficiency

Efficiency is directly depended on entire urban transportation's system and it could be evaluated by a classical ratio between supply and demands in the public transportation sector.

$$E_f = \frac{N_p}{N_t}$$

Np: Number of trips in public transportation

N_t: Total number of trips

Indeed, the public transportation is extremely poor in Shahrak-e Golestan. It is limited merely to a little number of buses and a weak network. Moreover, its location made this area highly depended on motorized transportation and private cars. In this situation there is no expectation of a high level of efficiency in this context. The estimated values of public and private transportation and the calculation of efficiency are brought below:

N_p = 1,715 (Daily)

N_t = 55,468 (Daily)

E_f = 0.03

Figure 3-22 Efficiency Map of Shahrak-e Golestan

KC	*Indicator*	*Value*
Porosity	Built Density	1.2
Proximity	Mean Number	5.41
	Standard Deviation	2.28
Diversity	Simpson Index (Services)	0.78
	Simpson Index (Quality)	0.59
Interface	Mean Depth	0.973
Accessibility	Number of jobs accessible in 20min	114
Efficiency	Public transportation tips/Total Trips	0.03

Table 3-3 Vertical Investigation table

3.2.3Phase 1c - Actual Energy performance of the system: Data Collection

In this step 10 Indicators will be used for achieving a first evaluation of the actual environmental characteristic and performance of the System. Same indicators will be used in the CAS Retrofitting process (Step 4a. Second measurement) which is necessary for the final evaluation of the system performance, after the transformation design process. It is important to emphasize that the 10 Indicators are also connected with a series of design principles, named DOP (Design Ordering Principles), tools used to arrange later the structure of the CAS. They are respectively. In the table below the indicators alongside their formula and their actual value in the project site is indicated:

Ground Use	Urban Built Density	∑Floor/Ground level Surface	1.20
	Compactness Factor	C = Surface/ (Volume) ^ (2/3)	64.12
Energy	Gas Consumption/Capita	m^3	3,230
	Electricity Consumption/Capita	KWh/Year per Capita	655
Walkability	KF in walkable distance	Average Number	5.41
	Car-free Streets	Km	-
Use of Space	Residents/Activities	C = residents/Activities	1,191.30
Open Spaces	Ratio of Green/Open Spaces	T = T(green)/T(total)	0.10
	Parks/Hectare	N/Ha	0.01
	Paved Public Spaces	N & Ha	-
Transportation	Private Tr. Energy use/Person	Petrol Consumption/Capita (Lit)	338
	Pub. Tr. Boarding	Number per Year/Person	0.003
	Length of Biking Roads	Km per Capita	-
Mobility Interchange	Kinds of Public Tr.	Number of Systems	1 (Bus)
	Number of Parking	N	-
	Number of Interchange Hubs	N	-
Food	Urban Farm Production	Kg/Capita	-
	Plots for Cultivation	Ha	-

Table 3-4 Energy indices

Because of lack of specific data for the Energy indices (Gas Consumption/Capita and Electricity Consumption/Capita) their values in whole Tehran are brought here.

3.2.4 Phase 2a - Detecting of the Transformation's Catalyst

The main purpose of the Hypothesis phase is to detect the transformation catalyst, thanks to the KCs and their associated Indicators. As discussed, the malfunctioning of the KC boosts the modification process. In this phase, the Key categories, with the consideration of the interventions' goal, are evaluated and compared with the rest of the urban fabric; thus, the intervention process could be initiated with the modification of the malfunctioning system.

Considering the result of the investigation phase (horizontal and vertical), it easily appears that the major malfunctioning relates to the features those are dealing with *Function* and *Transportation* layers. there is no doubt that in any urban area, weakness of one of these two layers leads to the failing of the other, as the powerfulness of one of them develops the another one. Here, in Shahrak-e Golestan, lack of defined functional centers actually emptied the area from the urban nodes, and consequently no powerful transportation node has been created. This tremendously affects the transportation circulation inside the site in a way that even the vital need of inner connectivity is almost not being felt. Shortage of job producing functions and key urban activities made Shahrak-e Golestan to be extremely depended to the other parts of Tehran in a situation that the poor public transportation is hardly able to meet even a small part of the needs. The remote location of the Shahrak-e Golestan from the Tehran's functional centers adds to seriousness of the problem. The only public transportation service available inside the area is a limited number of buses while the nearest subway station is located 7km outside the site.

Although Function layer could be a proper catalyst too, Transportation layer has been chosen as the main catalyst. This selection is supported by a holistic consideration with the goal of initiating a transportation flow to create inner circulation, and enrich the transportation links in order to develop the global connection. By selecting the function layer as the catalyst on the other hand, the role of surrounding areas in the feature development would be minimized. However, in the transformation process, it is obvious that the function layer comes immediately after the transportation layer and their integration gives the meaning to the design: transportation nodes will be located at the most needed or the abandoned places and the functional nodes grow in their surroundings. The connection needed between the functions define the links, and this transformation initiates.

3.2.5 Site Selection

As it explained, in the transformation process the catalyst layer takes the initiative, and all the decisions on the intervention will be taken by considering its actual performance and its potency of improvement. The individual and the mutual relationships of layers has been analyzed in the investigation phase and the catalyst layer (Transportation) has been chosen accordingly. Now it is time to decide about the level of intervention in different location of the site. In order to do so, the Key Categories in which the Transportation layer is involved, are considered simultaneously and the weaknesses and opportunities of them are analyzed. This Key Categories in this project are: Interface, Accessibility, and Efficiency.

The image below is resulted from overlapping the vertical analysis related to the Mentioned key Categories.

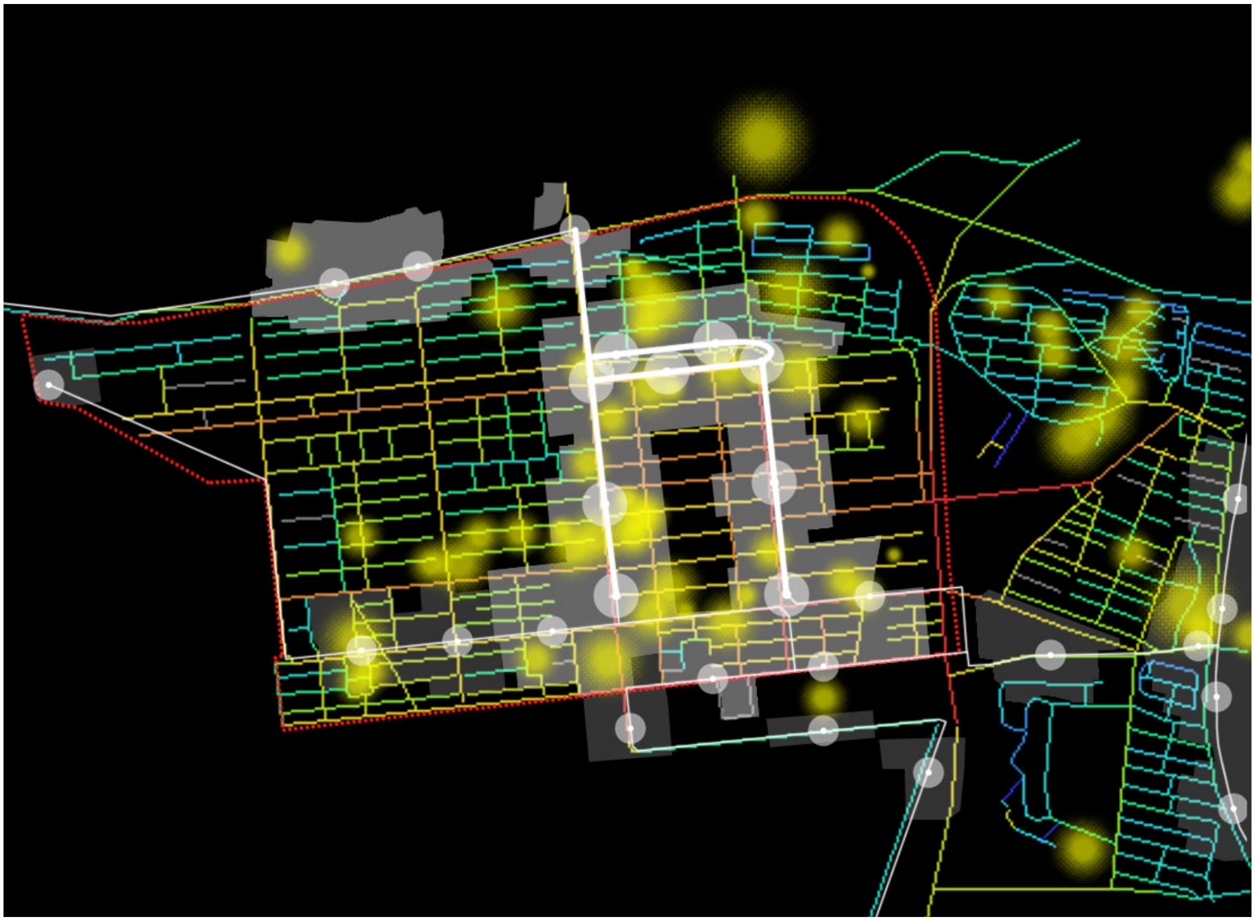


Figure 3-23 Overlapping of the Key Categories related to Catalyst Layer

The highlight of this image is the obvious weakness of the western part of the site in terms of Accessibility and Efficiency. This part is vast area which can be considered almost empty from function and public transportation. As function and transportation produce the urban metabolism by feeding each other, the lack of one of them weakens the other one, and the latter is exactly the case of the western part of Shahrak-e Golestan.

On the other hand, the axial analysis shows that while almost all the east-west oriented streets have poor values of mean depth, two of them which are the 8th and 9th streets have distinguishable power. This opportunity can be seized by making a powerful axis out of these two for which the transportation nodes and functional centers will be assembled around. If we resemble the context as a leaf, this axis could be interpreted as the midrib and the north-south oriented streets could be considered as the veins. Therefore, this strategy will scheme the level of intervention in different parts and the dispersal pattern of the urban features.

3.2.6 Phase 2b - Design Ordering Principles (DOP)

DOPs are certain design principles coming in the second step of the formulation phase. They are tools used for arranging the structure of the CAS with the role of driving the transformation toward a more sustainable form. Each one of them is defined in a way to improve the efficiency of the behavior of the subsystems, and the overlapping of all of them sketches the backbone of the master plan. The DOPs' role into the design process is significant for addressing the consequence of the Investigation/Analysis Phase.

It is really important to note that the DOPs are associated with the 10 Indicators previously used for the estimation of the actual Energy performance of the CAS (Data Collection-Step 1c) as well as for the CAS Retrofitting process (Step 4a-Second measurement).

The *Design Ordering Principles* are:

3.2.6.1 Balance the ground use

This DOP is based on the efficiency that the compactness brings to urban areas. Urban compactness is characterized by higher density and relative shorter distances. Accordingly, this principle highlights the fact that development should not just be denser but more compact. Many advantages arise particularly from the compact form of the city, such as reduction in need of motorized transportation, less transportation cost, and lower thermal loss in buildings.

In this project, the goal of increasing compactness will be achieving through designing buildings with higher densities and certain geometry of blocks which promotes well-connectivity and provides a better integration with open spaces. The average urban density of Shahrak-e golestan is 1.2, and the average density of the new buildings is expected to be more than 60% higher. In order to minimize the undeveloped land, there will be a special attention to the western part of the site.

3.2.6.2 Fostering the local energy efficiency

This DOP is rooted in the holistic approach toward the energy efficiency, and its purpose is to introduce buildings as components of community energy system. Its basic orders are listed here and the effect of applying this principle on the design decisions will be completely discussed in the architecture part.

- Optimize the relationship between building form and heat loss as well as natural ventilation.
- Optimize the relationship between the building shape and energy production (solar gain, natural ventilation)
- Evaluation of the solar potential of the project area.

3.2.6.3 Promote walkability

Regardless of numerous social benefits, promoting walkability extremely improves the city behavior in terms of energy efficiency. It decreases the demanded energy in transportation section by reducing the unnecessary traffic and generally, the need of drive. Functions in walkable cities are usually better oriented and the high level of integration between them provides better connectivity, hence supports *Compactness.* The level of integration between open spaces and walkable transportation links is also much higher.

For this project, the idea is to promote walkability while the original interface is maintained. In other words, no major link will be added to the context, but certain streets will become car-free, and will make a walkable network. This transformation, of course, takes place in a process that may last for years.

Figure 3-24 Car Free Streets

To select the car-free streets some principles were taken into consideration:

- **Size:** Car-free links should not be selected from the wide streets. Unfortunately, majority of streets in Shahrak-e Golestan are relatively wide. Therefore some of the selected streets are rather larger than normal walkable avenues. This problem could be solved in some level by providing small spaces in large ones (e.g. dividing the streets into sections by means of rows of trees, urban furniture, or small urban activities)
- **Connectivity:** Car-free links should not interfere in connectivity. For this reason the adjacent links to a walkable street remain open to motorized transportation.
- **Integration with open spaces:** car-free links are tried to be selected in a way that provide maximum integration with existing open spaces and the areas which have the

potential to be defined as strong open spaces in future. This will raise the chance of creation of powerful public spaces in the site.

Figure 3-25 A typical car-free street in Shahrak-e Golestan

3.2.6.4 Fostering mixed used spaces

Mixed-use development surely is a matter of sustainability. It reduces the need of travel by increasing the level of self-efficacy in smaller scales. In mixed-use neighborhoods, jobs and other vital urban functions are more accessible and transportation modes are usually following a targeted pattern. Walking flows are created between the mixed-use blocks, social life is promoted and live public spaces emerge.

By involving volume, void and function layers directly, mixed-use development plays a key role in transformation of Shahrak-e Golestan. It is decided that almost all the new construction in the site to be mixed use buildings. The main parts of the physical feature of the project will be shaped by this approach, and thanks to the investigation phase, appropriate sizes and functions will be assigned to the new blocks.

The picture below shows a possible arrangement of mixed-use building in Shahrak-e Golestan

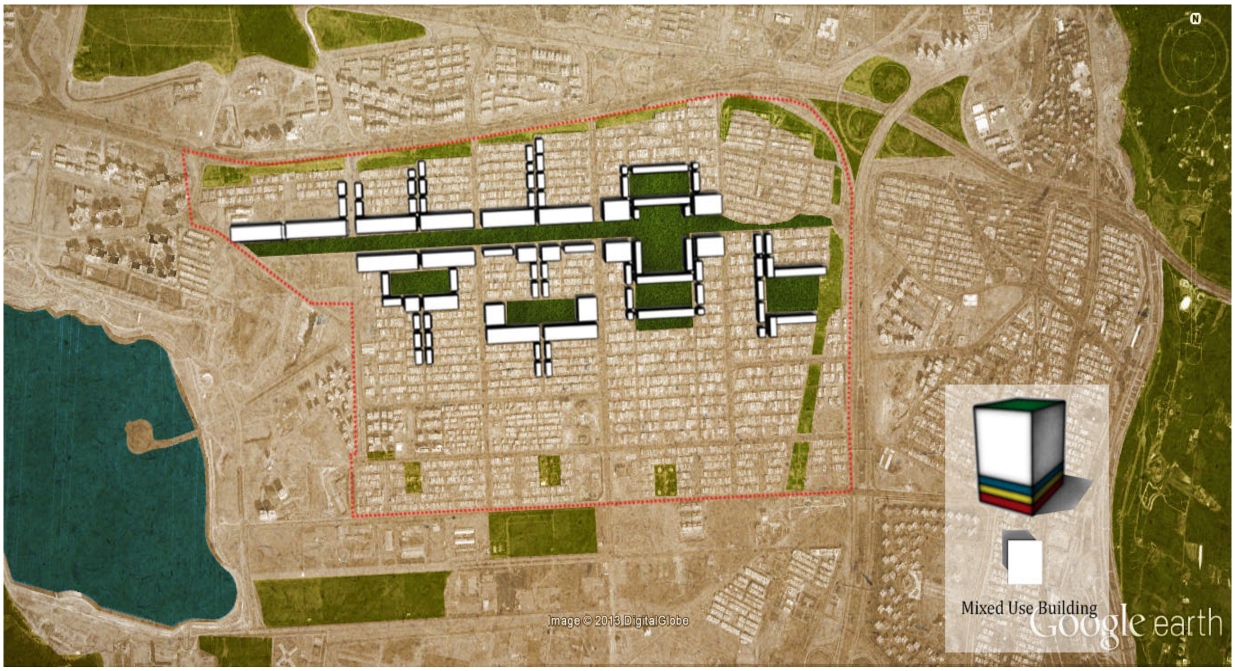


Figure 3-26 possible arrangement of mixed-use building in Shahrak-e Golestan

3.2.6.5 Create connected green open spaces and protect urban biodiversity

The main purpose of this design principle is to define strong connections between city and countryside through the green corridors. The aim is to promote the implementation of an integrated open and public green system for fostering the urban metabolism. A well designed green network could also help reducing the temperature by affecting *Urban Heat Island* and this could be a very positive contribution to the sustainable strategy, especially during the warm season.

A serious need of green spaces is being felt in the current situation of Shahrak-e Golestan. Not only the extent of the existing green is very low, but also there is no hierarchy and connection between them. In such situation, the green spaces are acting like abandoned voids with an unknown identity.

Accordingly, in order to meet the current needs, a vast continues green axis had been considered in the design. This axis has the role of a green fountain branched out with a number of green connections and occasionally meet some green islands. The resulting system is supposed to produce a green network. Considering the surrounding areas in different parts, various functionalities could be defined to the green spaces. Public spaces, sport fields and in small scale urban farms could be defined in different areas. Certain streets would play the role of the green connectors. These streets mostly would be selected from the walkable streets between the greens, and will be designed with strong rows of trees in order to represent green links visually as well as functionally.

Figure 3-27 the green network

Figure 3-28 The Green Network (region scale)

Figure 3-29 A typical green link in Shahrak-e Golstan

3.2.6.6 *Cycling and reinforcing public transportation*

The main aim of this DOP is to reduce the dominance of the private cars and to increase the use of more sustainable forms of transportation. A high quality bicycle network alongside walking and a supportive public transportation elevate the general connectivity, and extremely raise the efficiency of the transportation system. Existence of cycling station beside other transportation nodes not only increase the level of inter-modality, but also add quality to the area and provide new public infrastructure nodes as magnets for the urban development. Moreover, entry of cycling into transportation modes can positively affect the lifestyle of the citizens. It encourages the social bonding, and most obviously, promotes a very healthy behavior.

The motorized free streets are of course good containers for bicycle traffic, but cycling circulation should also be extended through the other links. Introduction of bicycle lanes cause a reduction in quantity of car lanes in the most congested areas, and this increase the accessibility for cycling mode while equilibrates the traffic flow in the whole area. For this reason, alongside the motorized free links bicycle paths are added to a number of streets of Shahrak-e Golestan in order to create a cycling network. Selection of street for the cycling purpose must be carried out in a manner that supplies a continuous multi-directional network and provides maximum accessibility for bicycle users.

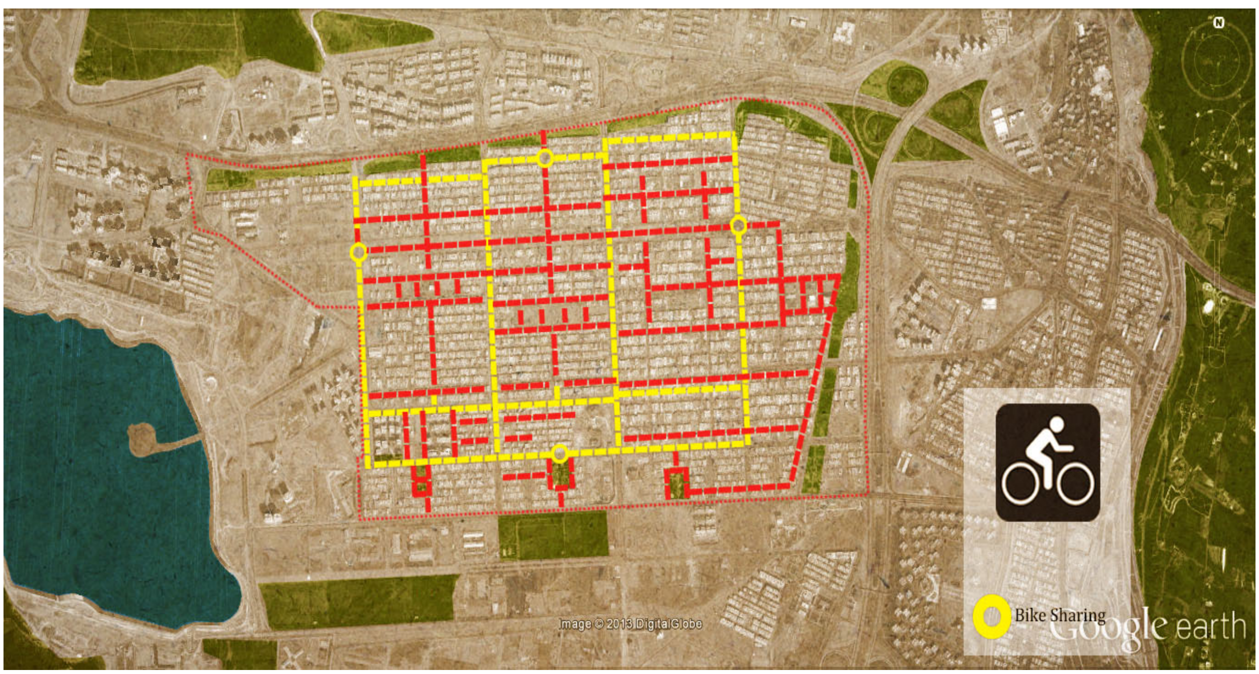


Figure 3-30 Cycling Network of Shahrak-e Golestan

Certain bicycle paths could be defined in the streets beside the car lanes, or the paved pedestrian path could be extended to provide a proper width for cycling alongside the walkways.

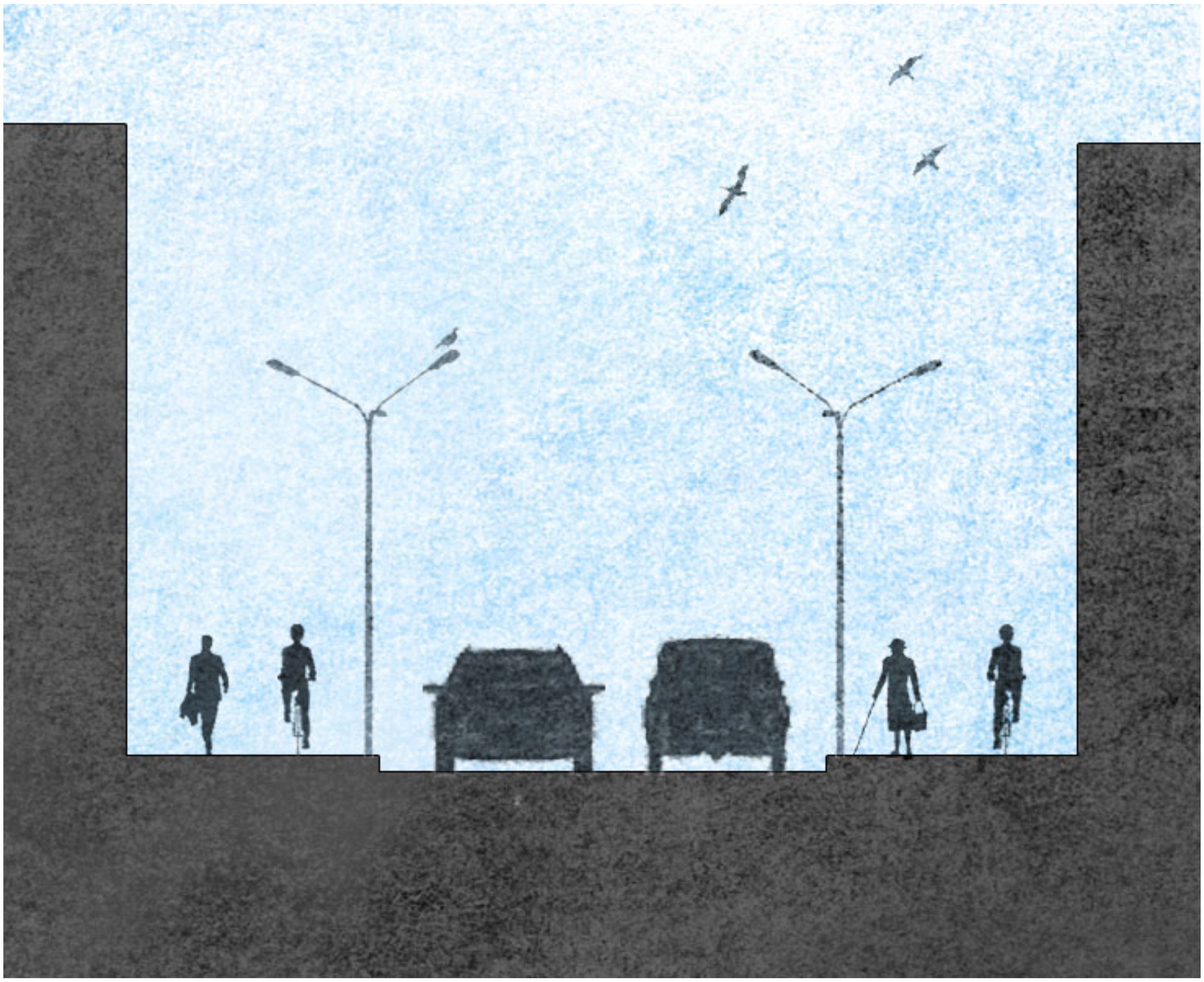


Figure 3-31 A typical street with bike path

Bike sharing nodes are also introduced to Shahrak-e Golestan. It has been tried for their locations to be selected in a way that helps to give a good covering area and make inter-modal and good integrated public transportation nodes.

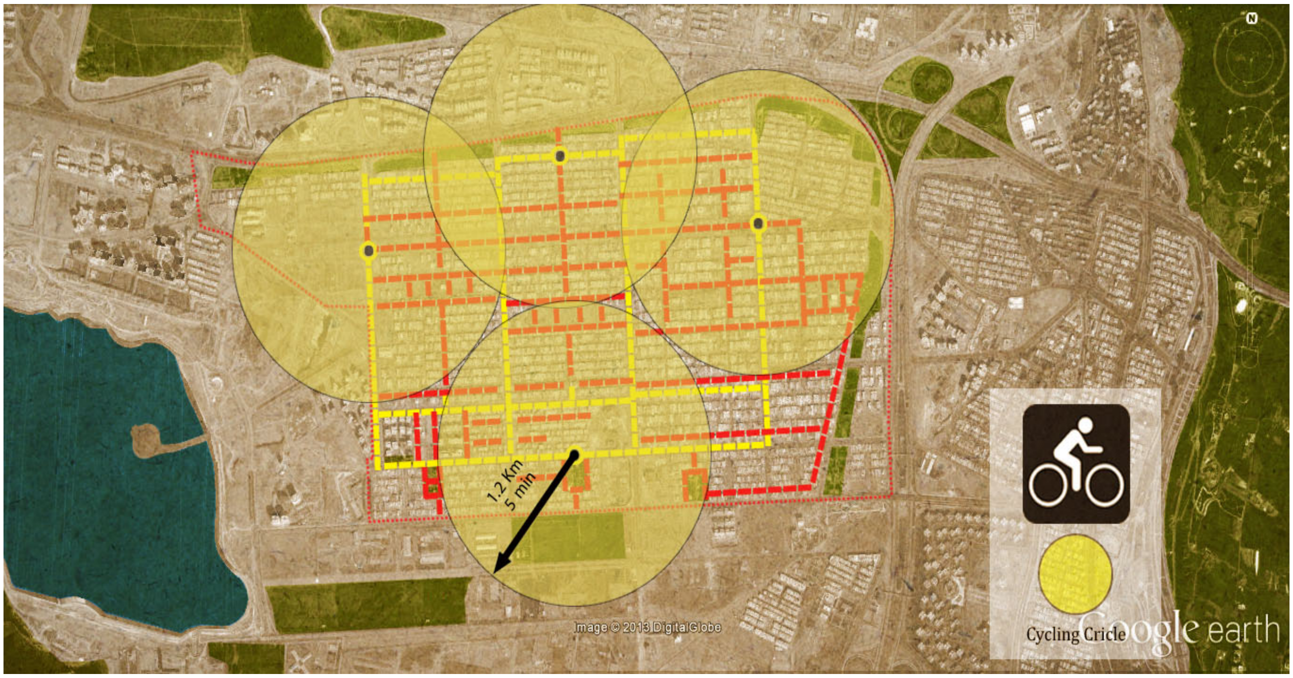


Figure 3-32 cycling accessibility from bike sharing stations

3.2.6.7 Change from multimodality to inter-modality concept

Changing to Inter-modal forms of transportation is a significant contribution to the urban sustainability. The most important effect of this strategy is the moderation of private car usage resulted by introduction of wider range of choices between different transportation modes. Replacing the private cars with more energy efficient forms of transportation brings environmental and social benefits. The car pollution will be reduced, traffic jams will occur less, and social interaction will be increased through the using of public transportation.

Inter-modality raises the level of urban complexity. For the citizens, this concept is being felt in the transportation nodes more than any other places: Different nodes which suggest various forms of travel to the desired destinations, which themselves are inter-modal origins for other destinations.

Accordingly, the turning point of this project is to empower the existing transportation nodes and define new inter-modal nodes. For this reason the introduced walking and cycling network is reinforced by the bus system. New bus stations are added in certain locations for serving two main purposes: 1. to cover the less accessible areas, 2. to create inter-modal transportation nodes. The following step is to define the links between these nodes. The bus system that exists now in Shahrak-e Golestan provides mere connection to the western part of the city which can be considered very poor. The new bus lines therefore should make a good inside circulation in order to provide a better internal accessibility while producing a better connectivity to the rest of the city.

The picture blow shows the suggested bus system for Shahrak-e Golestan.

Figure 3-33 Transportation Modes

Regardless of privated cars, now there are three types of transportation: walking, cycling, and buses. By the over lapping of the station and nodes of each type, different transportation hubs with different level of inter-modality are created. The image below illustrates the hierarchy of transportation nodes in terms of inter modality:

Figure 3-34 Hierarchy of transportation nodes

3.2.6.8 Convert the City in a food producer

This DOP has the aim of providing more land for green space towards urban and peri-urban agriculture implementation. In addition to produce some extent of citizen's daily needed food, urban farms could positively affect the urban sustainability by reducing energy consumption and pollution associated to transportation, lowering the UHI effect, reducing storm water run-off, and improving air quality.

Although it will be in a very little extent, certain strategies can be decided for food production in Shahrak-e Golestan. As it has been shown before, some part of the designed green lands could be devoted for limited food production. On top of the new buildings, green roofs could be designed and they can contribute to the urban farm too. Green roofs provide many benefits such as reducing heat island effect as well as energy demand for heating and cooling. There is also an agricultural area close to the eastern part of Shahrak-e Golestan. Its production could be transported directly to the site and be sold in a local market.

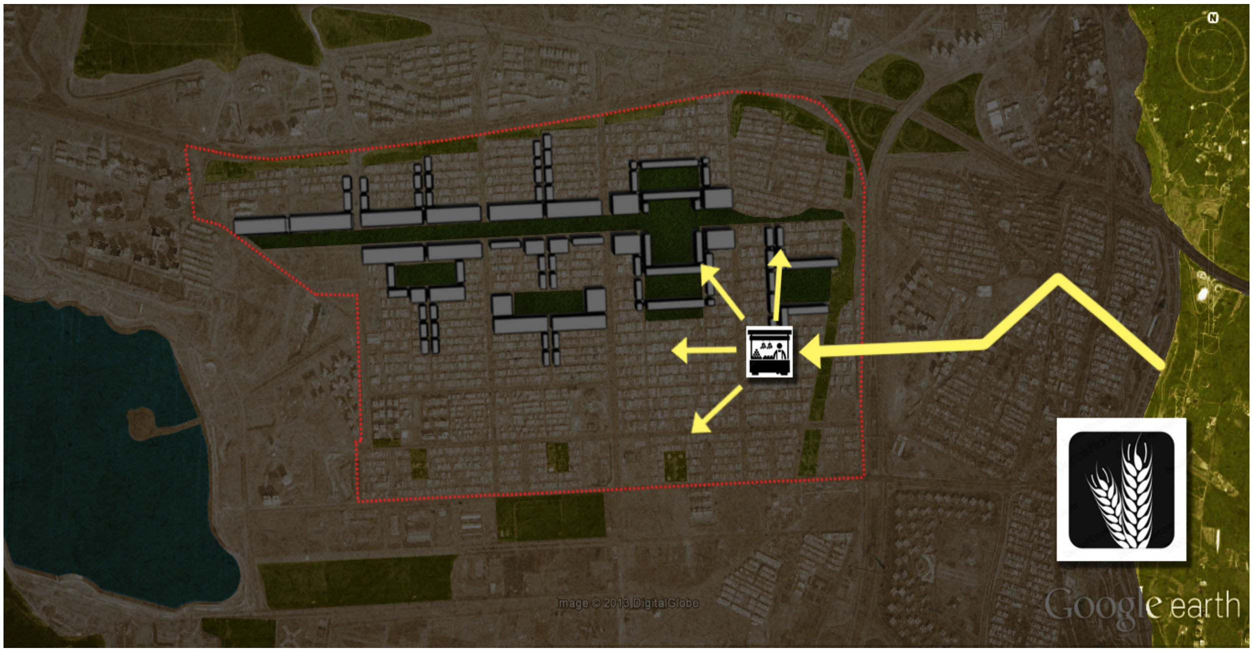


Figure 3-35 Strategies could be decided to transport food from eastern agricultural land to the site

3.2.6.9 Prevent the negative impact of waste

The main aim of this principle is to integrate in a more sustainable way the micro- urban utilities as well as the making the treating and recycling water and waste process possible on site, avoiding transportation and distribution costs and implementing the efficiency of the system.

A simple though useful strategy for small scale waste management is the waste separation. Different types of waste should be separated in residential units, buildings and neighborhoods. The easiest separation could be distinguishing between organic waste, recyclable waste, and hazardous waste. After separation, each of these types go through their own treatment mechanism. Organic waste is converted to soil, recyclable waste is collected in recyclable centers, and hazardous waste is annihilated in specific centers. It is important that this policy is taken in a synergetic manner, which means that residents should separate the waste in their home, and a compatible separation system should exist in building blocks and neighborhoods.

Figure 3-36 Waste management Strategies

3.2.6.10 Implement water management

Beside the waste management, policies could be taken to minimize waste water and implement water management. In the building scales, the use of eco-friendly installations (washing machines and dishwashers, low flush toilets and air mixer taps) could reduce the consumption level up to 25%. Green roofs also could play the role of local storm water management. Certain technologies could be used in the green roofs to collect the rain water, delay it and evaporate it. In the neighborhood scale too, specific canals could be designed for collecting the storm water and conduct it to the Chitgar Lake. The domestic waste water goes to the Tehran's water treatment center and the treated water will be used in agricultural section.

Figure 3-37 Water Management Strategies

3.2.7 Phase 3 - Modification

The third step of the IMM is called F.L.S. and corresponds to the First level of Superimposition. This is a specific design phase, which applies to a multi-layer and multi-disciplinary approach. Thanks to a driver (Catalyst) a local modification (Horizontal modification) marks the starting point of a chain reaction (Vertical modification) towards the global transformation of the CAS. Actually due to the fact that CAS is composed of four subsystems, we consider its state as a superposition of products of the subsystems' states. Once the subsystems interact, their states are no longer independent. In urban term this phase is oriented to the local modification (neighborhoods/local nodes) with the aim of global transformation achievement. According to IMM, in this phase, the project works horizontally (modifying the local subsystems individually) and vertically (modifying the other subsystems and the architecture of their connections). Folding and superimposing the selected layers collaboratively, in a way in which the transformation of each layer changes the other one's structure/performance and characteristic, is the key factor of the main system transformation. At the end of the transformation, a new structure of the system will emerge once all of the superimposed layers meet each other and they integrate together simultaneously and collaboratively; as a consequence, a new morphology will have emerged and new will occurred as well as different performance. The main outcomes of this phase are:

- The design/project of the chosen catalyst layer, in order to achieve a local modification that will be transmitted to process to the reactants layers.
- To drive the local transformation towards a structural transformation of the CAS.
- Preliminary evaluation of the transformation.

As it was explained, the transformation is initiated with *Horizontal Modification* which is the local modification of the Catalyst layer, and is being proceed with *Vertical Modification* in which the other the urban layers will be formed in compatibility with the mentioned horizontal movement. The local modification as designed perturbation of a system causes a series of effects that lead to macroscopic consequences starting up a chain reaction, which can transform structurally the CAS. Actually, IMM considers CAS not depending only from the individual components but there are some interactions between them, which create emergent patterns as well as specific characteristic and different performances of the CAS.

The Vertical modification is a chain reaction of the system propelled by the project. The aim of this step is to make possible the propagation of local changes towards the distant parts of the system as a consequence of connectivity, and making this propagation cause of a global change. The Vertical modification is driven by the response of the reactants layers catalyzed by a selected layer (catalyst), which modifies the architecture of the ligands activating the reaction, which transform the structure of the System. Actually the system's components are strongly connected, almost to all of the other components, so that simple local changes in their structures can influence the other subsystems in such a way that the same CAS results affected. Like in a chemical conversion the Catalyst layer catalyzed the other reactants adjusting the architecture of their joints and transforming structurally the System (CAS).

The general design concepts of this project have been discussed in the assumption phase. In this section, the role of Catalyst (Transportation layer), and the applying sequence of Design Ordering Principles in the transformation process will be argued.

Since the *Transportation Layer* has been elected as the catalyst, strengthening the structure of transportation and its related aspects are coming to the first level of priority. As the trigger of transformation, the transportation system should be modified in a way to become able to meet the needs of current situation, and also to sketch the further development. The designed system thus should promote the use of public transportation, introduce more energy efficient forms of transportation, and provide higher level of overall accessibility. In order to do so, while the existing nodes and links are empowered with new modes of transportation, new links and nodes are generated in a way to cover the undeveloped and less accessible areas. In this project the transportation system is based on three main modes: walkable links, cycling network, and bus system. The overlapping of these modes defines the quality of transportation nodes and these nodes are the places which urban development starts from. Considering the whole context and depended on the level of accessibility of each node suitable functions are suggested around them, and this is where *Function Layer* is involved in the transformation process, and the project enters to Vertical Modification phase.

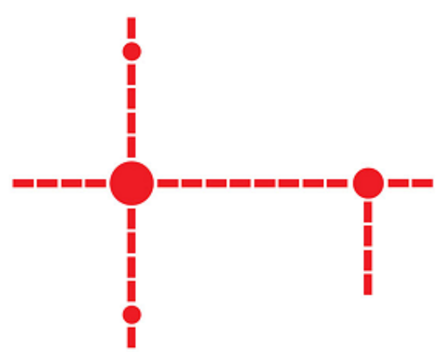


Figure 3-38 Step 1: setting a hierarchy between nodes

The rank and the situation of the transportation nodes help to decide about the type, quantity and the location of urban functions. In order to modify the function layer, different kinds of urban activities should be suggested in surrounding areas of transportation nodes in a way that increase the job opportunities as well as raise the level of efficacy of the neighborhood. Placing a particular type of function on its proper vicinity to a certain node is the main objective of the modification phase in function layer. Deciding about the different features of the buildings, in which selected functions are to be placed, embodies the physical modification within the *volume and void layers*.

Figure 3-39 Step 2: Assigning proper functions around transportation nodes

Modification in the volume and void layers take place in a parallel manner. Volume of the buildings should be designed with the aim of satisfying the desired density and providing good serviceability related to their assigned functions. Voids on the other hand, should create proper connection between buildings and provide an interactive network of public spaces. Optimum solar access for the buildings and other urban areas should be resulted from the integration of these two layers.

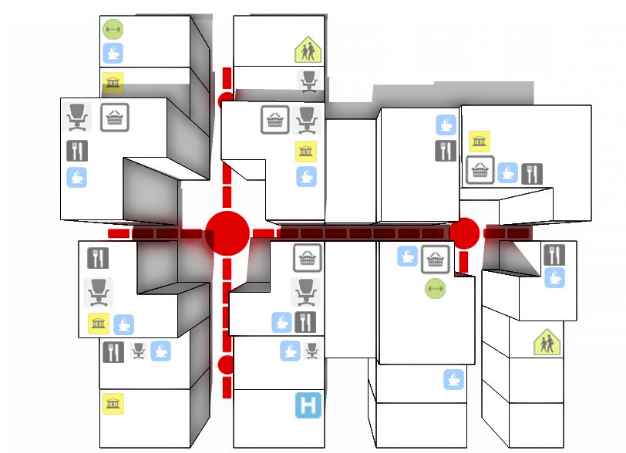


Figure 3-40 Step 3: Designing proper volumes for the functions

The table below indicates the scheme of the modification phase in Shahrak-e Golestan project. To modify each layer, a number of missions have been set. These missions are regulated contextually, and are based on the result of the investigation and analysis phase as well as design objectives which root in energy efficiency of the system. These missions will be accomplished to the accompaniment of certain actions which in their setting, design principles play their role and shape the project step by step.

Modification			
Type	**Layer(s)**	**Missions**	**Actions**
Horizontal Modification	*Transportation (Catalyst)* ↓	• Promote public transportation • Cover the less accessible areas • Involve more sustainable types of transportation • Create nodes for urban development	• Create a new transportation network (nodes and links) • Import new modes of transportation • Set a hierarchy between nodes and links
Vertical Modification	Function ↓	• Introduce job productive functions • upgrade neighborhood's self-efficacy • Locate activities properly(based on transportation nodes and links)	• Select and place the function in an integrative matter in a mixed use context
	Volume/Void	• Fulfill the desired density • Provide compatible functional serviceability • Develop urban integration • Promote interactive network of open public spaces • Reach an optimum solar gain	• *Shape the physical form of the project (Master Plan)*

Table 3-5 Modification Process

The transformation process of Shahrak-e Golestan according to the Modification phase is brought below:

Transportation Layer

Accordingly, in Shahrak-e Golestan the transformation begins with the introduction of a new transportation system. A central axis of transportation has been considered for this new system and it is supposed to act like a midrib which branches into secondary links to feed the rest of areas. This axis is defined between the Otrish square (east) and Arghavan Boulevard (west) in 9th streets and 8th Streets. The structure of the new system is based on more than 17km of car-free streets and 10km additional bike path. With the aim of supporting this structure, 14 new bus stations have been suggested in different places and some of the existing stations have been strengthened with new links. The resulted network consists of links and nodes with various level of importance (regarding to their distance from the central axis). Next step is to define the needed functions around the transportation nodes.

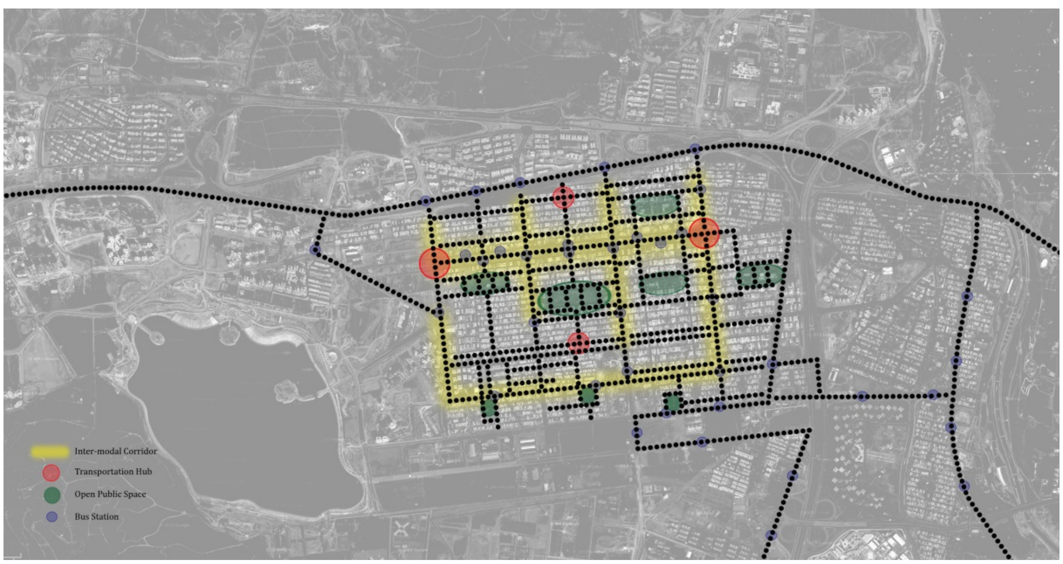


Figure 3-41 Node Evaluation

Function Layer

The main theme of the function layer is residential use mixed with urban key activities. The functions are to be assembled in three sections around the central axis and be reinforced by walkable vertical axes. The western section is the Qaem neighborhood which is the area between Arghavan and Hashemzadeh boulevards. Beside residential use, offices would be concentrated here around the main axis. The Sarvestan neighborhood is the central section which is located between Hashemzadeh Boulevard and Zeinali Boulevard. Because of its central location, destination based functions would be arranged here to support its centrality. Therefore, main function around the central axis here would be a mixture of commercial and residential. The eastern section in the area is surrounded with Zeinali and Golha boulevards. Here more emphasis would be on residential use around the main axis while vertical axes provide other functionalities. Vertical axes in this section and in the other sections are dedicated to the mixture of residential use and small businesses and commercial activities. The car-free atmosphere of these streets stimulates a smooth movement for shopping and flowing between public spaces. Based on the current needs and radius of service, educational, cultural, health care and leisure activities would be located around the context.

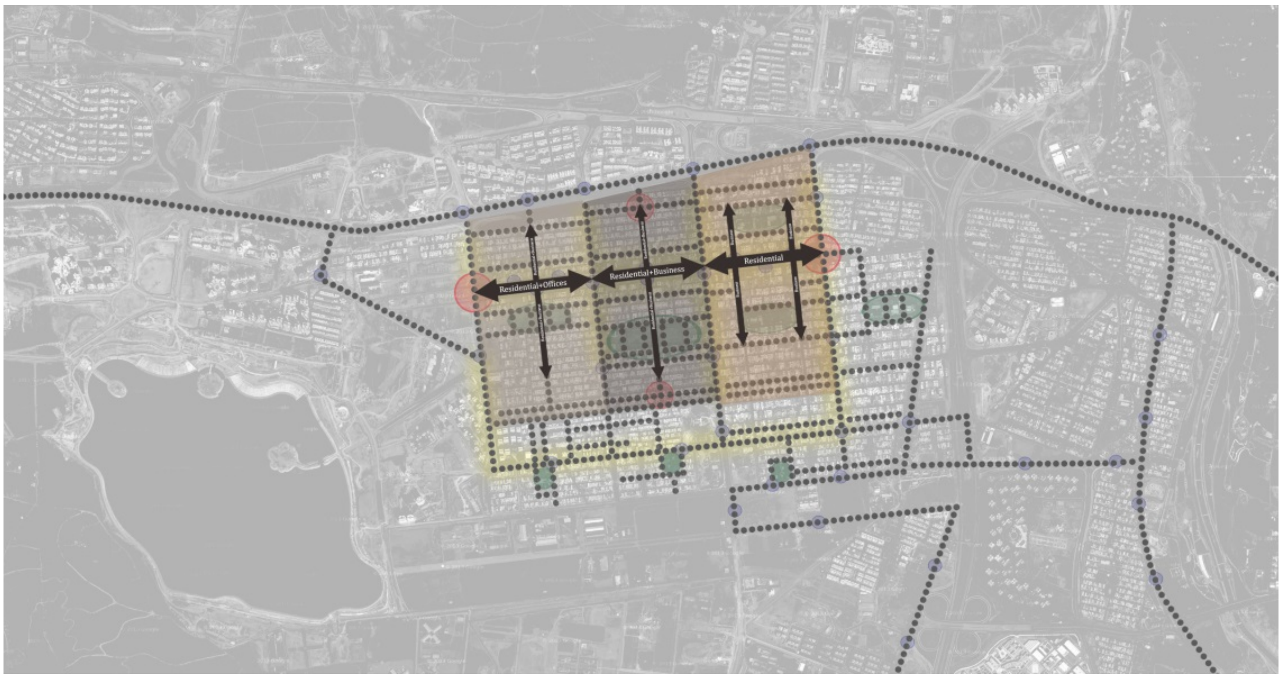


Figure 3-42 Assigning functions to the neighborhoods

Volume and Void Layers

A linear open green space is suggested in on the main axis. This green space would be extended through the residential blocks in the eastern section in order to create a powerful network of public spaces with the Kowkab and Baghrah parks. The buildings blocks would be located in surrounding the created and existing voids and their volume would be decided in a way to provide the desired density. Overall, the buildings around the main axis would have higher volume rather than the others.

In this step the general scheme of the global master plan appears:

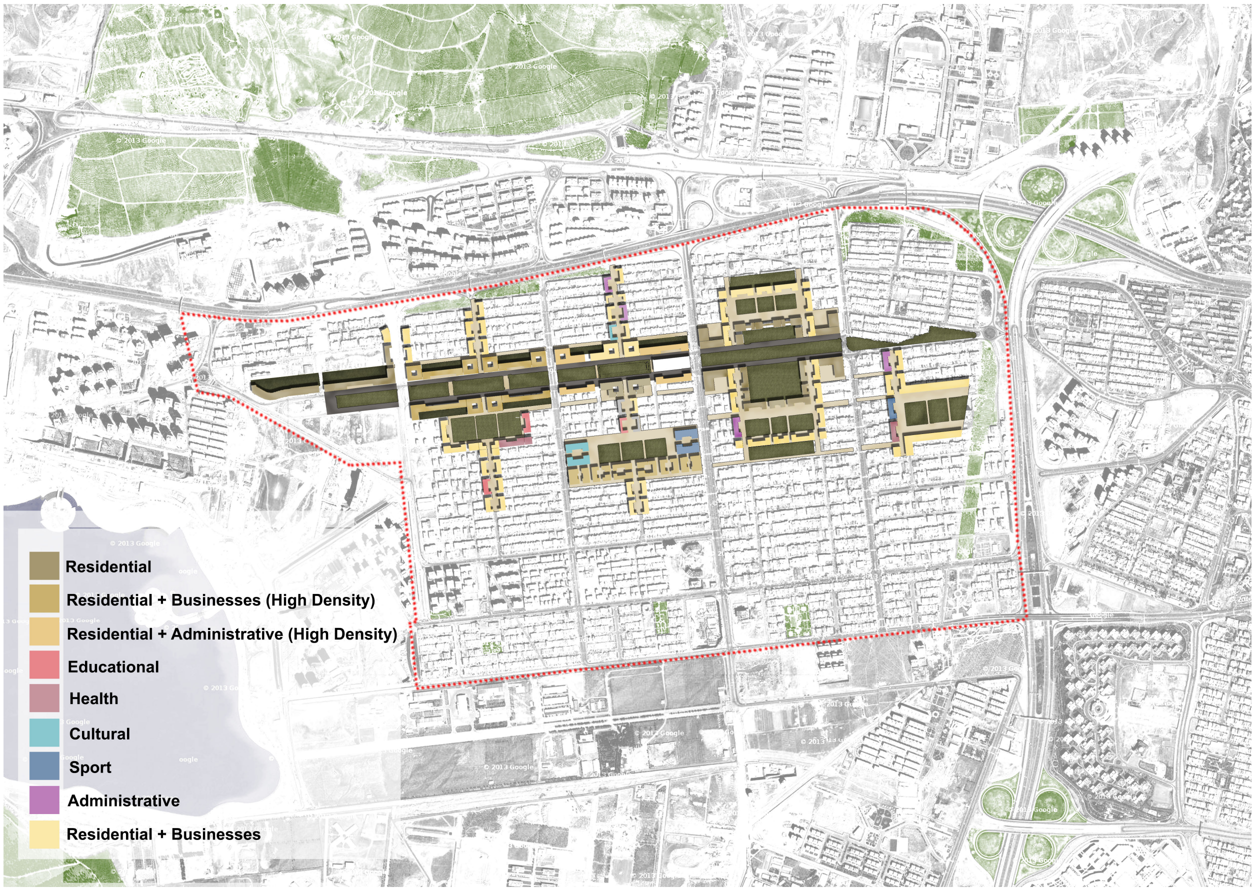


Figure 3-43 Global master plan

After the intervention, it is expected that the total number of daily trips increases about 25%, and 920 new job opportunities would be produced. The volume of the new construction would be about 2,200,000m^3 whilst 6,737m new green spaces would be introduced to the area.

Accordingly, the horizontal indicators after intervention will be close to the values indicated in table below:

Layer	Description	Formula	Value	growth
Volume	Built volume density, Dwelling density, Human density	$V_l = V_{built}$ / Area	7.75	115%
Void	Open space/area	$V_d = V_{open}$ / Area	2.75	48%
Function	Job density, Number of legal entities in the intervention area	$F_n = J_{number}$ / Area	8.9E-04	345%
Transportation	Number of carried out urban trips (daily)	N_{tr}	71,473	25%

Table 3-6 Horizontal modification

3.2.8 Phase 4a - Retrofitting and Optimization

After the transformation, the project enters into the retrofitting phase. This phase starts with evaluating the performance of the new design by means of comparison between the neighborhood's behavior before and after the intervention. In order to carry out dimensional measurements and make possible such comparison, indicative tools are required. So the 10 Indicators already used are still help for making the comparison possible and then to drive the process toward an optimization phase in order to lead the complex system transformation in a correct way.

The table below contains the value of indicators before and after the transformation.

			Before	After
Ground Use	Urban Built Density	∑Floor/Groun level Surface	1.2	1.44
	Compactness Factor	C = Surface/ (Volume) ^ (2/3)	64	30.65
	Building/Hectare	N/Ha	Not Specified	Not Specified
Energy	Gas Consumption/Capita	m^3	3,230	3,230
	Electricity Consumption/Capita	KWh/Year per Capita	655	655
Walkabilty	KF in walkable distance	Average Number	5.41	11.57
	Car-free Streets	Km	-	17.70
Use of Space	Residents/Activities	C = residents/Activities	1,191.30	576.84
Open Spaces	Ratio of Green/Open Spaces	T = T(green)/T(total)	0.10	0.18
	Parks/Hectare	N/Ha	0.01	0.01
	Paved Public Spaces	N & Ha	-	Not Specified
Transportation	Private Tr. Energy use/Person	Petrol Consumption/Capita (Lit)	338	334
	Pub. Tr. Boarding	Number per Year/Person	0. 03	0.08
	Length of Biking Roads	Km per Capita	-	27.62
Mobility Interchange	Kinds of Public Tr.	Number of Systems	1	2.00
	Num of Parkings	N	-	-
	Num of Interchange Hubs	N	-	4
Food	Urban Farm Production	Kg/Capita	-	Not Specified
	Plots for Cultivation	Ha	-	Not Specified

Table 3-7 Comparison values before and after transformation

Because the energy consumption in building section is highly related to the construction methods and energy class of the buildings, for the indicators related to this subject the average ranking of Tehran is repeated again. In food production part too, although the new design raise the expectation of improvement, because of the complexity of prediction no number has indicated.

Although the raised density and 80% growth in the area of green spaces point out a huge physical transformation, the most remarkable features of this table are those which are related to Transportation and Function layers. Besides of being a prototype in Tehran, the introduction of car-free streets, bike path and inter-modal public transportation system would completely change the quality and related quantities of transportation layer in this site. This change would definitely brisk the activities and businesses and transform the functional behavior of the neighborhood too. According to the suggested planning, the average number of key functions in walkable distances could raise by more than two times, and the ratio between the numbers of residents and activities would gain less than half of its value in existing situation. This would elevate the self-efficacy in Shahrak-e Golestan, and in some extent would reduce the number of trips to the outside of the neighborhood. Beside the population growth associated with the increase in neighborhood's density and the attraction made by new functions inside the context the new values of almost all the indicators suggest that there would be less usage of private cars and more energy efficient forms of transportation.

3.2.9 Phase 4b - Optimization

After the retrofitting process the last phase named S.L.S. is driven by the Key categories for achieving the conclusive optimization of the CAS.

KCs are morphological, typological and technological features -determinatives- expressed by the superimposition, or symbiotic integration, of CAS subsystems (Inner layers). KCs are applied in the investigation phase for analyzing the urban context and its performance before the design intervention, as well as in the final as evaluation phase after the intervention.

Here, the key categories are, respectively: Porosity, Proximity, Diversity, Interface, Accessibility and Efficiency, like the follows, express the new superimposition, or symbiotic integration:

Porosity

The volume added to context resulted by the intervention is estimated to be 2,784,921m^3. This volume provides 738,893m^2 of additional building area for various uses. Hence, the urban density is calculated as:

$$Density = \frac{Total\ floor\ area\ of\ buildings}{Land\ area} = \frac{4{,}469{,}795}{3{,}098{,}738} = 1.44$$

This is 20% above than what it is in actual situation.

Proximity

The 48% increase in job opportunities which is mentioned before, which is a minimal assumption based on raising the number of activities by nearly 148%. Depended on their location, this extent of growth in number of function could bring major changes in *Proximity* index. The following image is the visual analysis of proximity based on the proposed master plan.

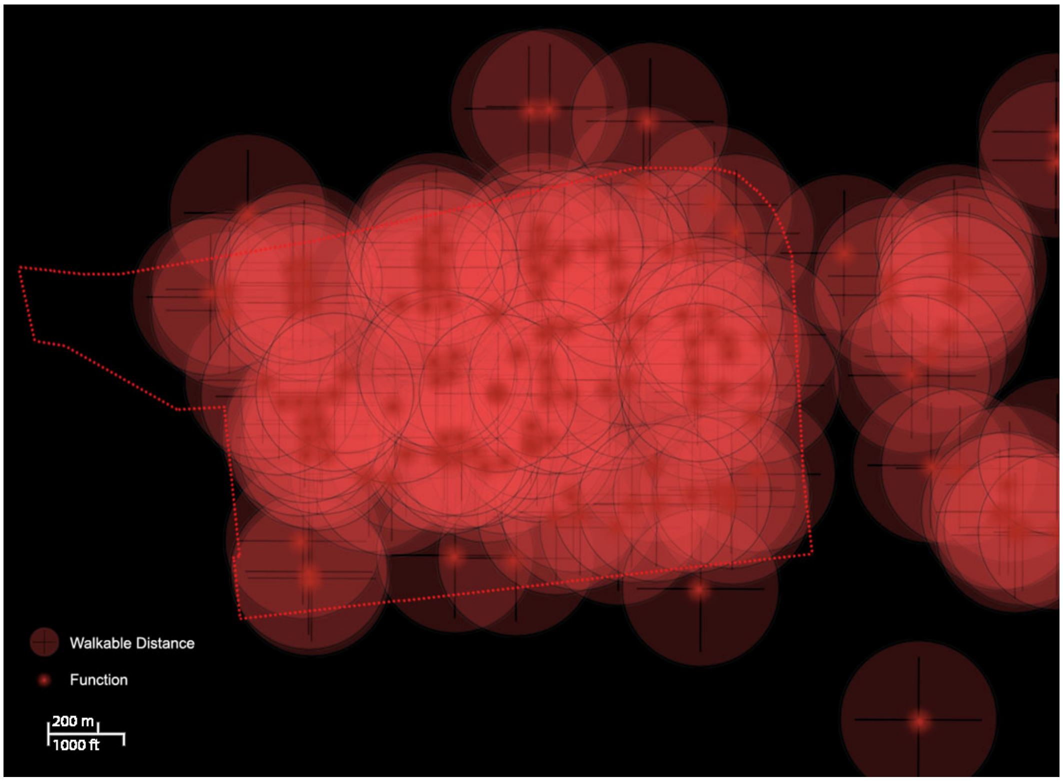


Figure 3-44 Estimation of the Proximity after Intervention

In the master plan 68 new functions are predicted. Although most of them are assembled around the main axis, it has been tried to reach an equal dispersal of functions in the rest of the area. In the image, it is vividly shown that the western part of the site which in actual situation is almost empty from functions now enjoys almost the same level of proximity as the other areas in context. The proximity indices for the master plan are also calculated and the result is contained in the table below:

F_n mean	S^2	S
11.57	16.26	4.03

Comparing with the actual situation the average number of activities in walkable circles all around the site is raised by 113% which can be considered as a tremendous change in the overall Proximity. The growth in standard deviation which is almost two times, on the other hand, is the result of the centralized approach in planning and shows that the functions are assembled in some places (around the main axis), and dispersed in the other areas.

Diversity

In the master plan, for the suggested activities certain types of function have been considered. This will change the Diversity of the functions in the area. The most highlight change would be in the number of commercial centers which will be increased from 4 to 53. Obviously most of the commercial units will be located in the vicinity of the central axis. Activities related to urban services also will experience a raise in number from 5 to 13. In the images below the expected situation of the site in terms of diversity of functions are shown. According to the explanation of the diversity's concept in our project functions have been categorized from two different points of view: from urban functions point of view, and from urban quality point of view.

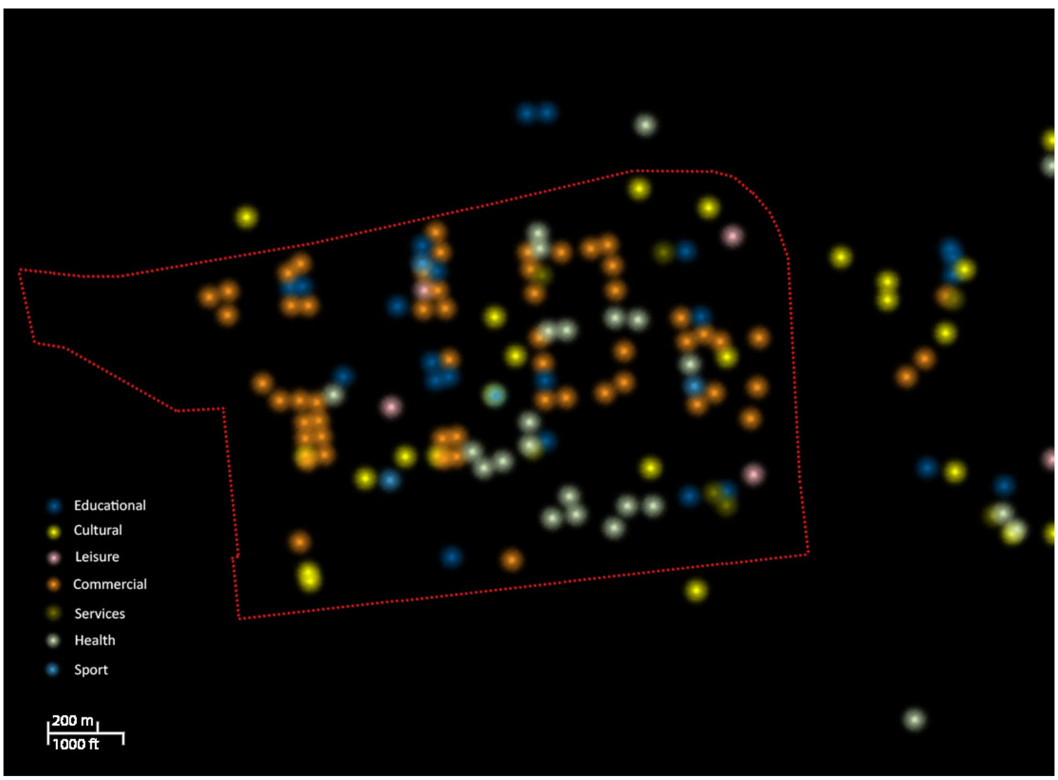


Figure 3-45 Estimation of the Diversity from functional point of view after Intervention

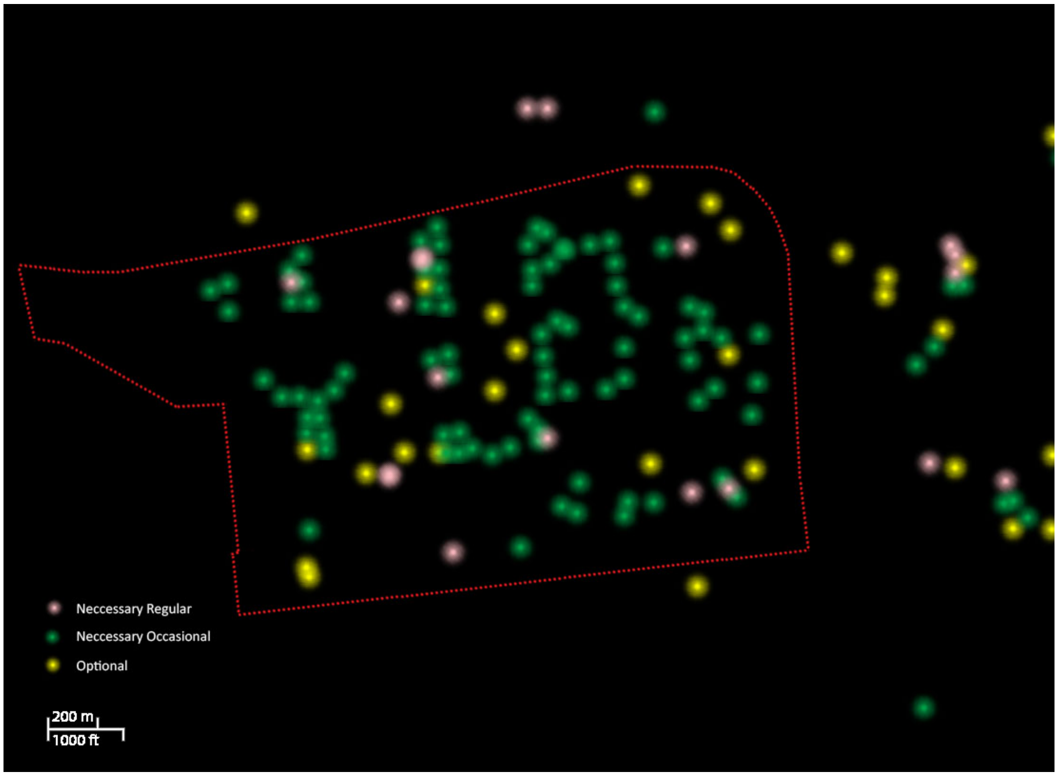


Figure 3-46 Estimation of the Diversity from quality point of view after Intervention

Comparing with the actual situation, the modified Simpson Index as the indicator of Diversity shows that placement of different functions in the master plan would be rather closer to an equal distribution in both cases. From the urban services point of view D_1 would be equal to 0.84, and from urban quality point of view it would be equal to 0.62. These values in the existing situation are 0.78 and 0.59 respectively.

Interface

In the master plan there are no major changes in the physical interface of the streets. The only change would be the continuity of vertical walkable links all over their sections. In the actual situation these streets are interrupted with the central axis and parks, but regard to their new definition in the master plan (being free from motorized traffic) they can be assumed continues. This continuity is maintained with crosswalks in the 8^{th} and 9^{th} streets in the central axis. The vertical walkable links are Banafsheh St. and Golfam St. in the eastern section, Sarvestan St. and Qaem St. in central section and western section respectively.

Mean Depth analysis for the master plan is illustrated in the image below. The analysis is carried out via the software "UCL Depthmap".

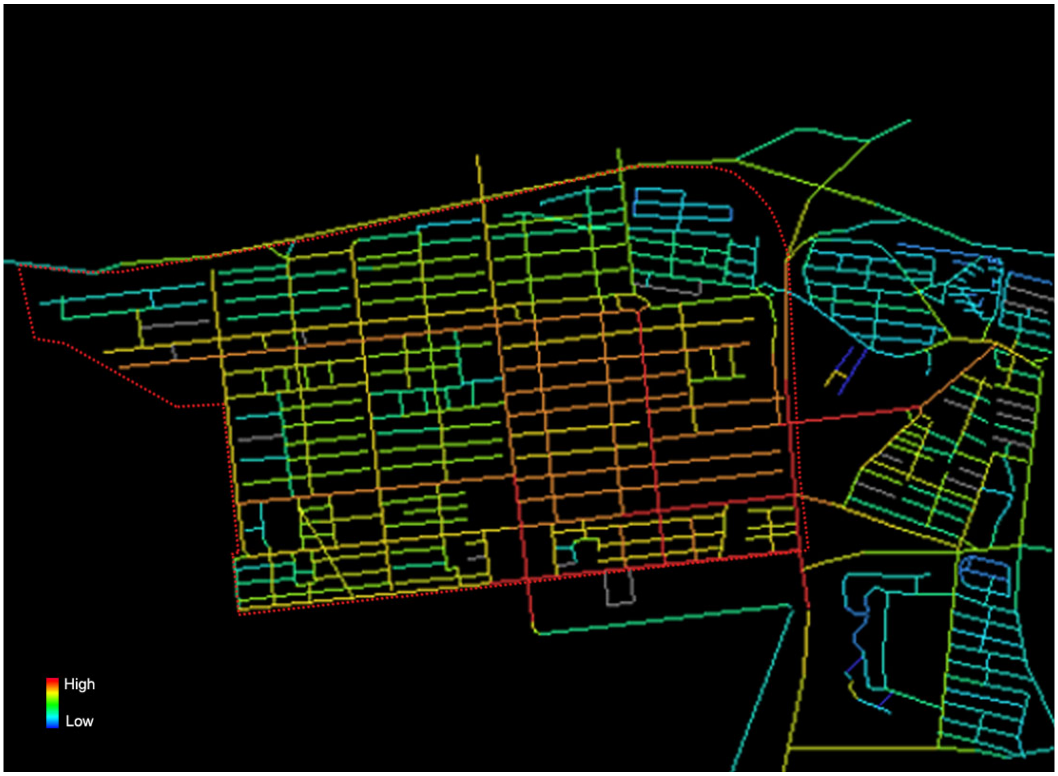


Figure 3-47 Estimation of the Mean Depht after Intervention

Although the mentioned changes can be considered as a minor switch in definition of links, it changes the value of Mean Depth in so many streets. For comparison sake, new Mean Depth values of the links which have been elected in the analysis part are shown in the following image:

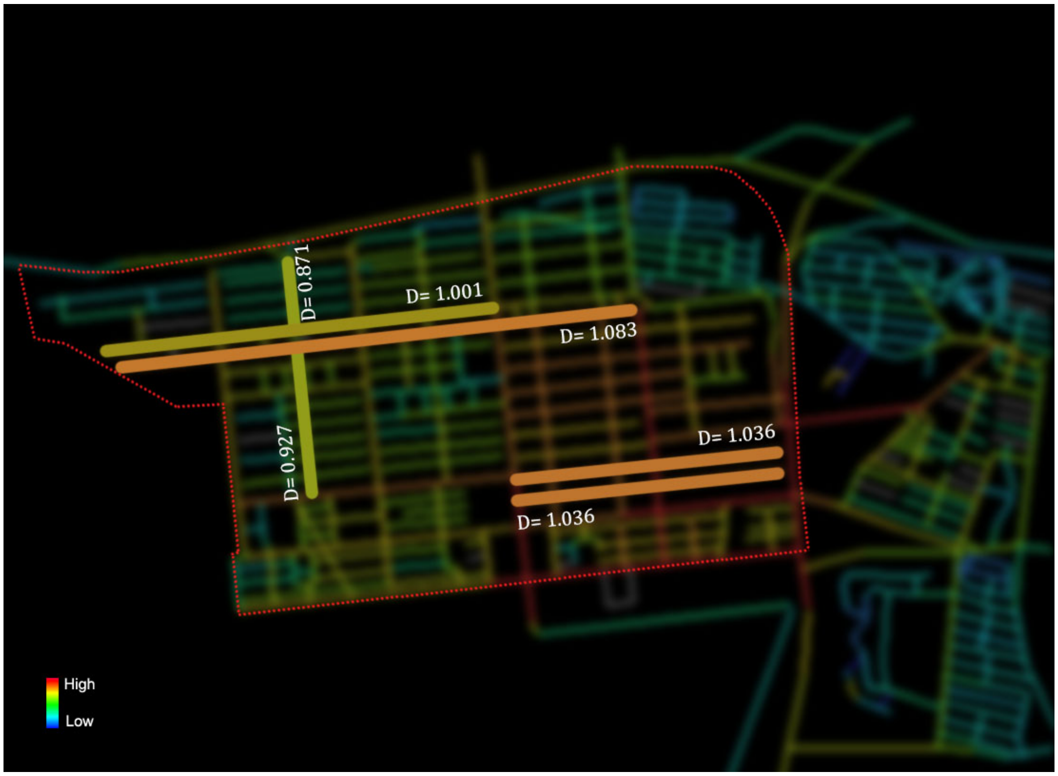


Figure 3-48 Estimation of Mean Depth values of five links

There is a slight increase in the value of Mean Depth in all the selected links which shows that the overall pedestrian accessibility has been elevated.

Accessibility

There are two main ways to promote accessibility: 1. to increase the number of jobs in the context, 2. to enlarge the accessible core area. Both strategies are taken in the planning. While nearly 300 new job opportunities would be produced by placing the new functions, thanks to enhancing the public transportation the area of the Accessibility Core would become to almost 3591626m^2. This area is more than two times larger than what it is in the actual situation. Hence, the indicator of Accessibility for the proposed master plan is calculated as:

Acc = 934*(3,591,626/4,853,549) = **691.16**

Comparing to the existing situation, the Accessibility has more than five times growth in this particular index. This major improvement is indeed one of the highlights of this project.

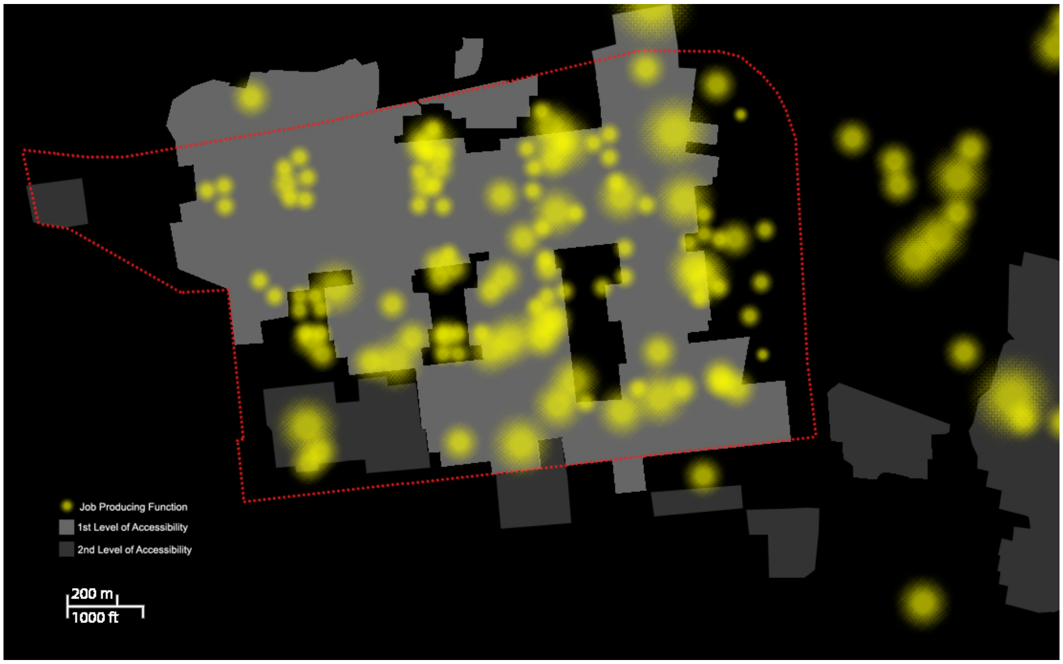


Figure 3-49 Estimation of the Accessibility after Intervention

Efficiency

It is assumed that by increasing the density, the population of Shahrak-e Golestan would raise by 20%. The total number of urban trips associated with this population growth is estimated to be 25% higher than its number in the existing situation. This means that around 71,473 trips would be originated from and designated in Shahrak-e Golestan daily. According to rough estimations (based on average contribution of public transportation nodes in Tehran's traffic) the new transportation system would carry out 5,718 trips out of the total trips which is an 8.7% contribution. Correspondingly the indicator of efficiency is calculated as below:

$$E_f = \frac{N_p}{N_t} = \frac{5718}{65755} = \mathbf{0.08}$$

This value is 166% higher than the efficiency in the actual situation, and remarks a significant improvement in this index.

The hierarchy of public transportation nodes and links is illustrated below:

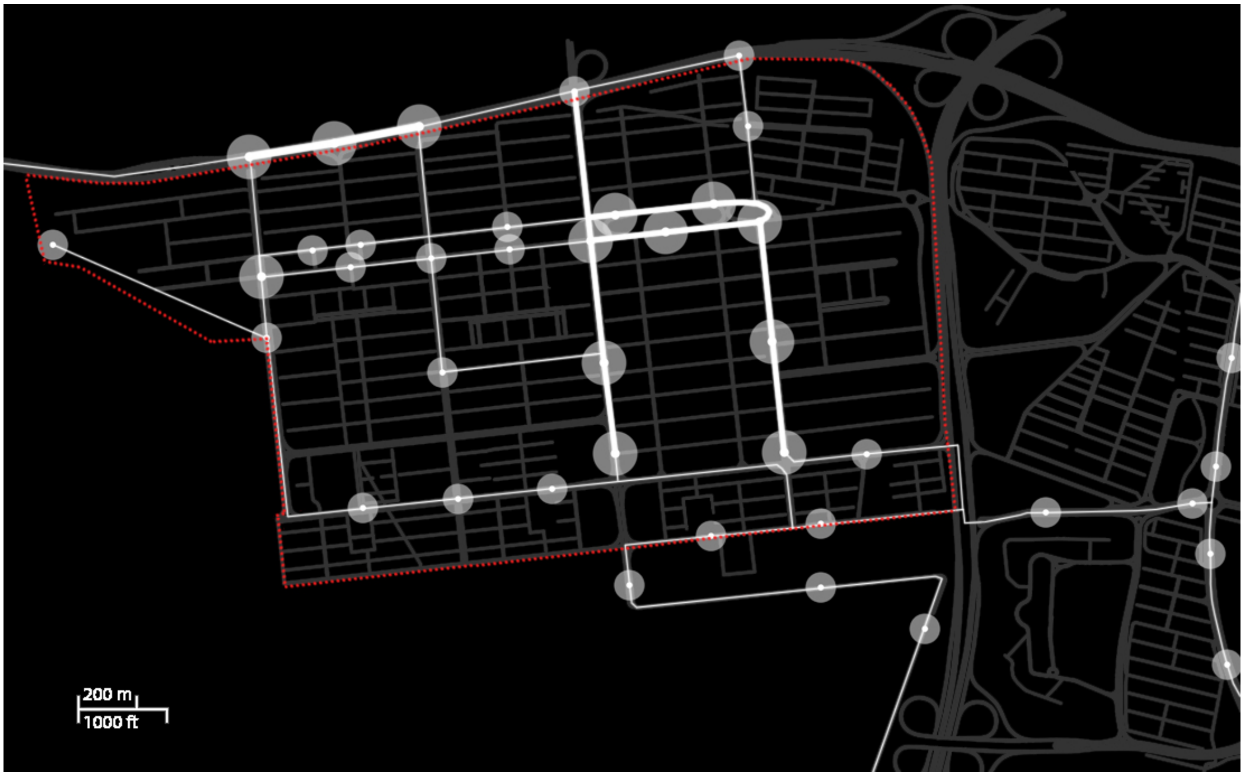


Figure 3-50 Hierarchy of public transportation nodes and links after the Intervention

KC	***Indicator***	***Value***	***Improvement***
Porosity	Built Density	1.44	20%
Proximity	Mean Number	11.57	114%
	Standard Deviation	4.03	77%
Diversity	Simpson Index (Services)	0.84	8%
	Simpson Index (Quality)	0.62	5%
Interface	Mean Depth	0.992	2%
Accessibility	Number of jobs accessible in 20min	691.16	506%
Efficiency	Public transportation tips/Total Trips	0.08	167%

Table 3-8 Optimization values

3.3 Intermediate Scale

3.3.1 Introduction

As a fixed area of intervention, an intermediate scale is needed to be defined by the designers. It is in this scale that the spatial features, regulation of the buildings, connectivity, and distribution of functions become clearer, and the whole context could be analyzed in a much detailed manner thanks to analyzing a neighborhood as a part of it. In order to serve one of the main principles of IMM® which is the necessity of the integration between the scales, neighborhoods should be studied based on the previous analysis which is carried out on the broader scale, and intervention should be accomplished in accordance with the decisions those have been taken for the district.

Two major elements had been considered for selecting the intermediate scale: 1. the neighborhood should be chosen from a location where the characteristic features of global master plan could be referred, and 2. it must have been selected where the most intense modification is anticipated for.

Hence, Qaem neighborhood which consists of residential blocks in the western side of Shahrak-e Golestan has been chosen as the Intermediate Scale. This neighborhood reflects the main characteristics of the master plan because it is one of the neighborhoods which located where the main green Spine (the area between 8^{th} St. and 9^{th} St.) intersects with one of the green corridors (here Qaem St.) and create one of the strategic locations in the project. Moreover, the most repeated typologies of the buildings could be found here: the large buildings in the side of the spine and the average residential buildings located in the green corridors. The existence of Sonbol Park together with the spine and the new buildings' voids provide a context in which the hierarchy of voids and the neighborhood's interface can be studied more deeply.

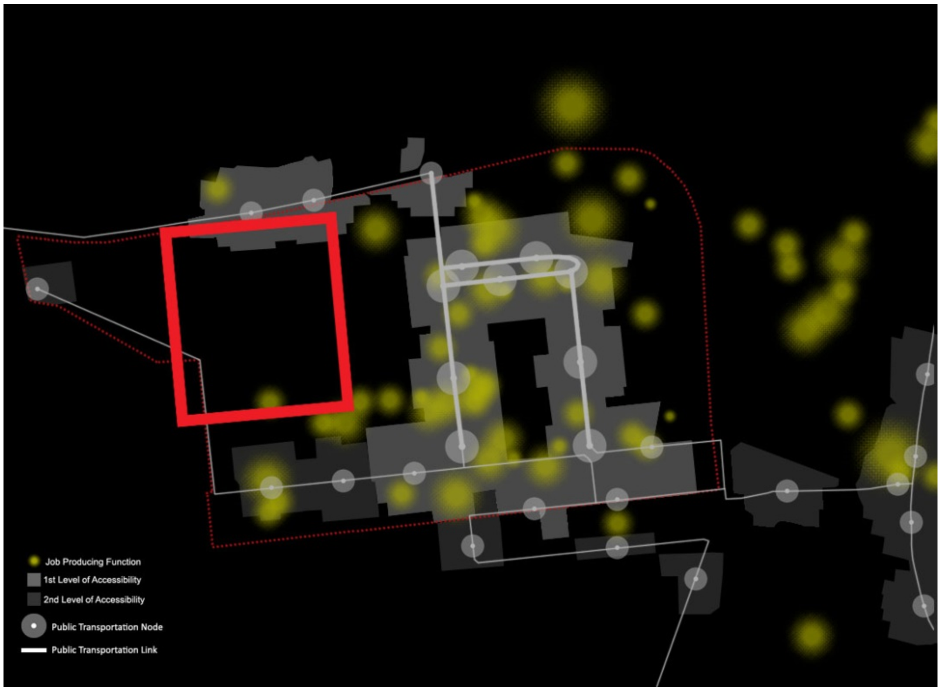


Figure 3-51 Overlapping Accessibility and Efficiency: Current situation of Qaem neighborhood

This neighborhood is also one of the places where the intervention would be very intense. As it has been shown in Figure 3-54 which is the overlapping of Accessibility and Efficiency from the Key Categories,at the existing situation the Qaem neighborhood experiences a special situation. The lowest number of key functions and lack of any public transportation nodes, made this area too monotonous and empty from desirable urban quality. Therefore in the proposed master plan, this area is subjected to an extreme modification. The selection of this neighborhood as the intermediate scale hence provides chance of evaluating the design for one of the most critical parts of Shahrak-e Golestan.

In Figure 3-55 the proposed master plan is showed in a more detailed way for this neighborhood

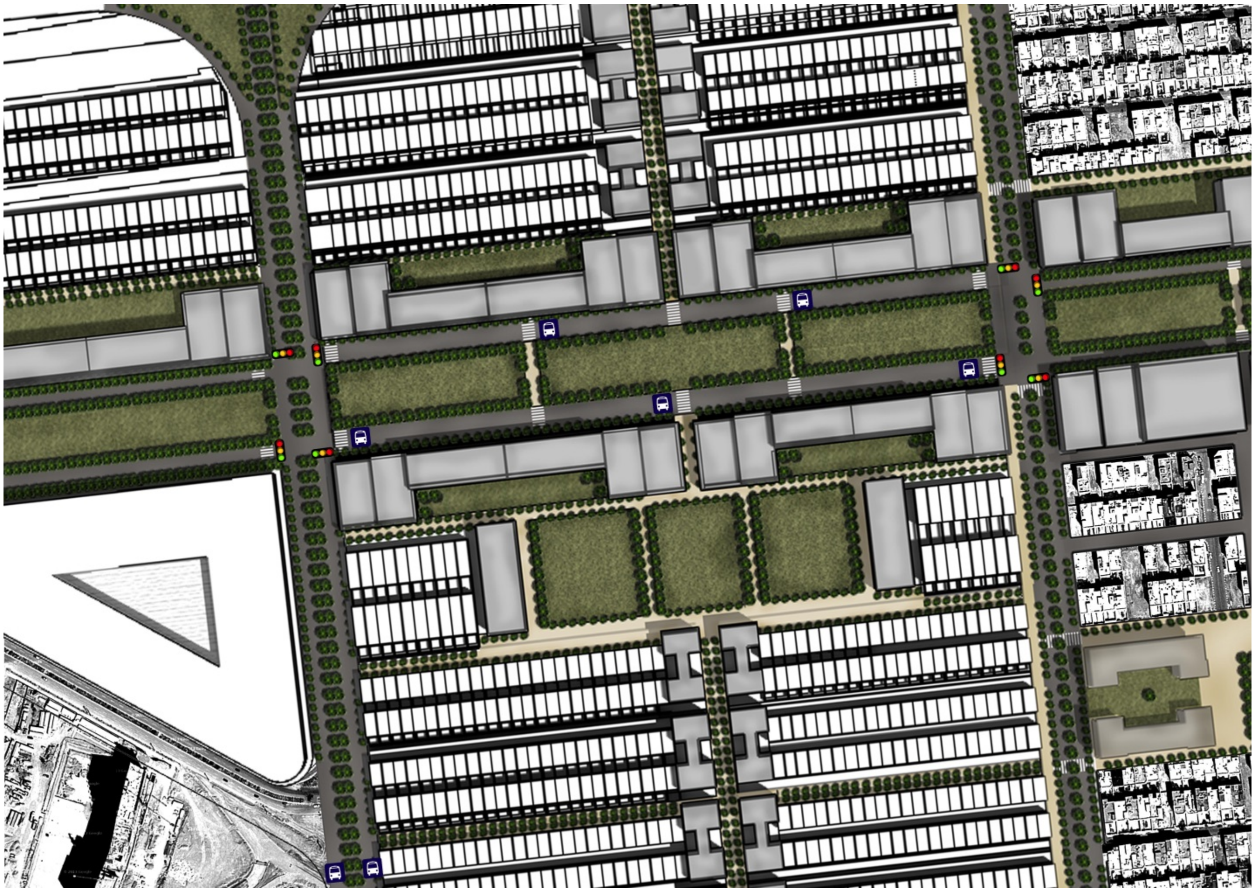


Figure 3-52 proposed master plan for Qaem neighborhood

The Qaem neighborhood is located at the western part of Shahrak-e Golestan, and it is surrounded with Arghavan Boulevard from the west and Hashemzadeh Boulevard from the east. These two boulevards are of the main connectors of the whole area to the Hemmat Highway which as explained before is the main east-west axis of Tehran for motorized traffic, and is located just in the north of the area. So, as it can be seen in Figure 3-56, the important connectors of the neighborhood are the Qaem st. which in proposed master plan is devoted to motorized free transportation and could act as the main neighborhood internal connector, Spine and its side streets (8^{th} and 9^{th}) which are strong relators of the intermediate scale to global scale by means of walking and also motorized traffic, the Boulevards Arghavan, and Hashemzadeh which through motorized traffic connect the neighborhood to Hemmat Highway, and Hemmat itself as the strong connector of the area to the rest of the city.

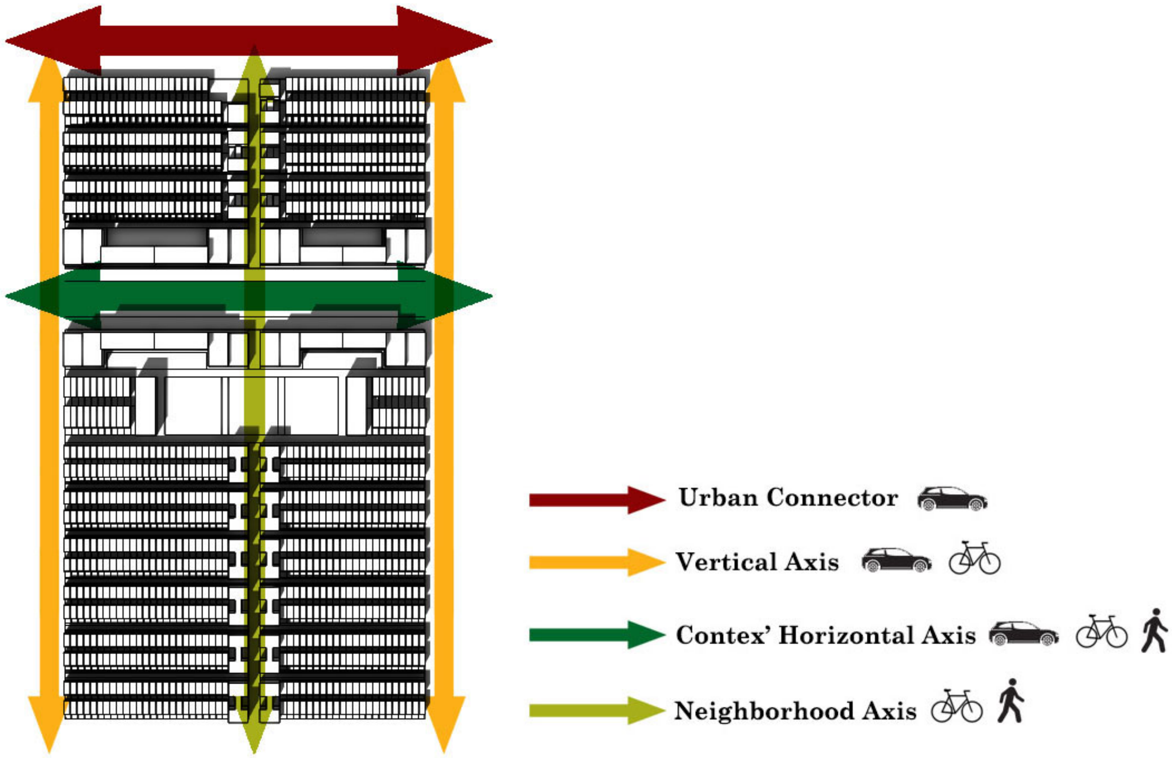


Figure 3-53 Neighborhood's Main Connectors: Hemmat Highway as the urban connettor, Arghavan Boulevard (Left), and Hashemzadeh Boulevard (Right) as the vertical axes, 8th and 9th streets as the horizontal axis and Qaem street as the neighborhood axis

In the master plan, certain functions had been assigned to the new construction in the Qaem neighborhood. The four large buildings in the north side and south side of the Spine are mixed usage of residential, retail and administrative activities, an educational building is designed in the eastern part of Sonbol Park, and the function which has been assigned to the majority of average buildings in sides of the Qaem street is residential with retail and administrative activities in their first two levels. (Figure 3-60).

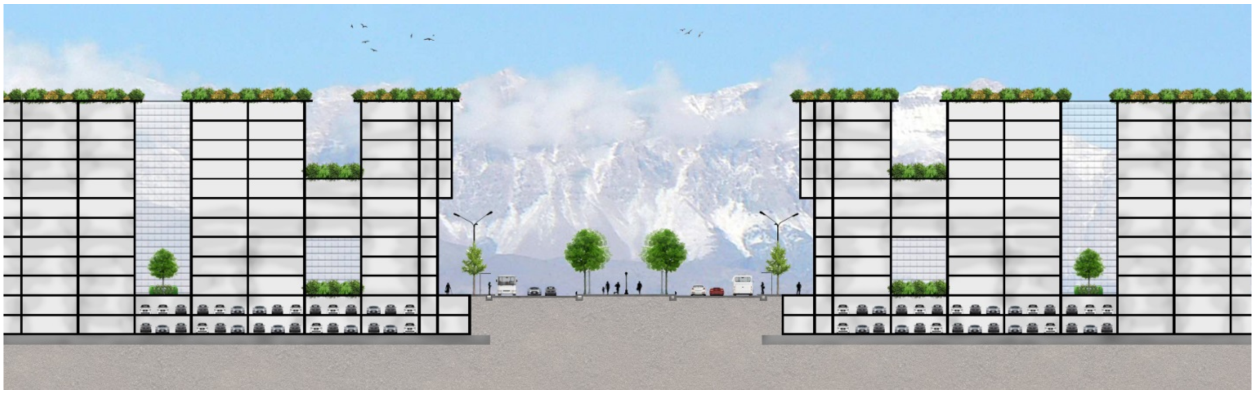


Figure 3-54 Section of Context' Horizontal Axis

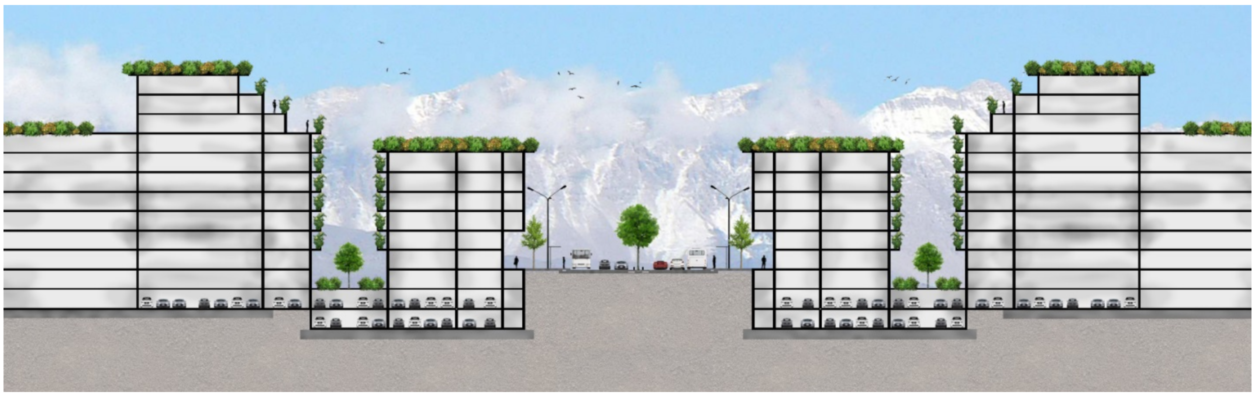


Figure 3-55 Typical Section of Vertical Axes

Figure 3-56 Section of Neighborhood Axis (Qaem Street)

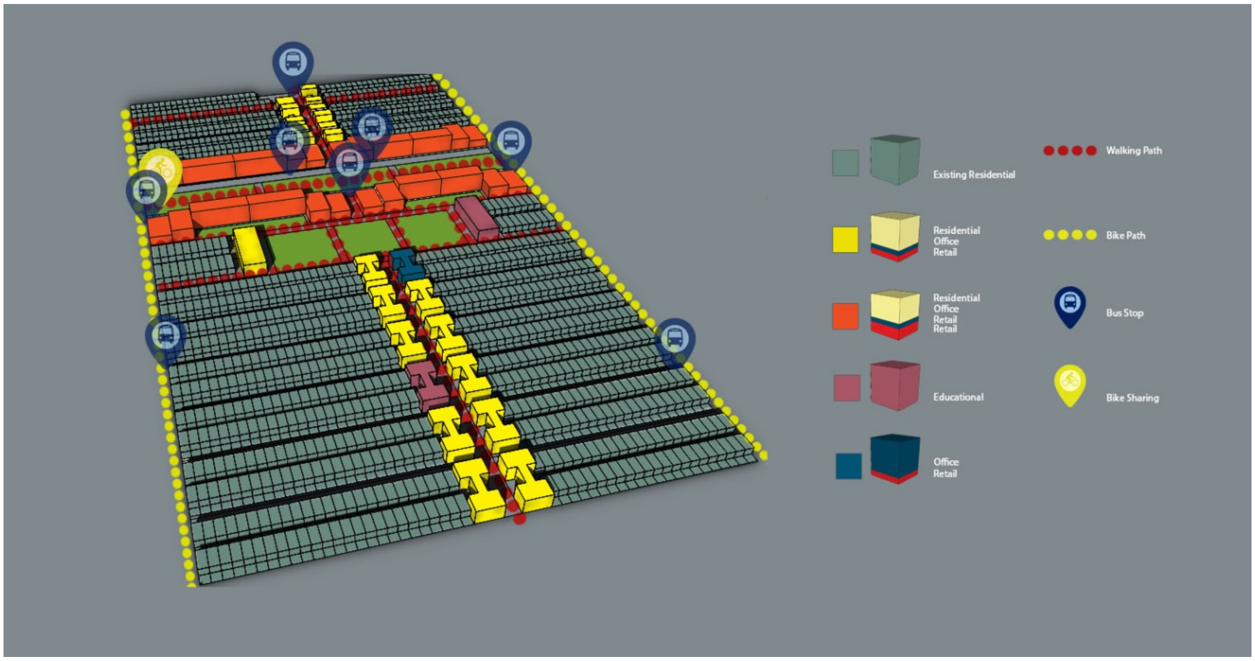


Figure 3-57 Typologies of Buildings in Qaem Neighborhood

The spatial regulation of the buildings have been decided based on the solar energy that different levels of buildings gain and the amount of shadow that buildings fall on their adjacent features during the critical seasons. In the following section, the methodology that the spatial features of dense buildings (orange ones in fig 3-60) which are located in either sides of the Context's horizontal axis is explained.

3.3.2 Shape Development of Peripheral Buildings

In the process of reaching to the basic plans and volume of high buildings in southern part of the project site, the main physical features of the project have been shaped by facing three main limitations:

- Municipality's construction and Building laws for Region 22 of Tehran
- New Design Dimension calculations (Based on Municipality codes and new density calculation)
- The result of Shadow Analysis for the Intermediate scale

3.3.2.1 Design Process

Peripheral dens buildings have been chosen as sample case studies for explaining this process.

Technical characteristics those define the geometrical limitations of the alternative scenarios, and the method of comparison which is used for selecting the final shape, have been brought in details in each step.

For the starting point, plain rectangular form (as the simplest possible form) has been examined for the blocks. With regard to the above mentioned limitations this simple shape has been subjected to further development in order to reach the most proper form.

In the second part, the compatibility of the resulted form with the legal principles considered by the municipality has been tested, and in parallel, shadow analysis and solar gain optimization have been used for modifying the volume and consequently for reaching to the final shape of the buildings in block RC3 and RC5 in all scenarios.

Finally, the most appropriate shape has been selected through a set of comparison between all the scenarios and the project enters to the optimization phase. All the further decisions and design approaches in intermediate and local scales will be based on this newly reached volume.

Note that the volume proposed here is a mere basic form, and not necessarily the most detailed and the best possible form in terms of function. Because designing all the shape features in the intermediate scale is not the main interest of this project, providing a basic appearance has been considered sufficient in this level, and further design in local scale will be carried out with regard to this groundwork.

The legal restrictions considered by the municipality's construction codes –as the most important limitations that the project is faced to have been listed below. These limitations have been used as a testing instrument for different cases in order to reach the final volume shape.

Maximum allowable occupied area: According to municipality's construction code For considered cases this limitation is %50. This means that only 50% of the area must be occupied by the buildings and rest of the areas must be consider as various open spaces (public or privet) by the designer. According to the new design dimensions for the case, with attention to the Area of the block (Around 16800 m²) the occupied area must be around 8400 m² and the same amount must be devoted to different kinds of open spaces.

Maximum allowable story level: According to the municipality's building codes the maximum story levels have range from 3 to 12 in different parts of Shahrak-e Golestan. For the considered cases maximum allowable level is limited to 12 stories.

Other tools used in the process were:

New dimension considered in the design: This Calculation has been made according to the municipality's building codes. Based on the proposed global master plan, the most important parts which has been used for the comparison between different cases is the sum of the Residential and commercial areas in all floor levels. This number will be summarized as the maximum building areas. Its value is around 100000 m² for RC5 and is 89000 m² for RC3.

Shadow analysis: As it mentioned before, alongside the other limitations, shadow analysis has been used in parallel for shaping the volume of the building in different parts of the process. This analysis has been carried out via the software *Ecotect* .

The designing process for the block RC5 is demonstrated below as the first case, and same strategy will be taken for designing the block RC3 in the following.

The basic principles for with which the volume is checked in each of the following cases are:

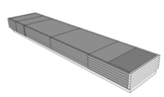
1. The story level of the building ≤ Maximum allowable story level (According to Municipality's construction building codes)
2. total area ≤ Maximum allowable amount of buildings area
3. the amount of open spaces ≥ Minimum allowable amount of open spaces (Including different types of open area)

3.3.2.1.1 Case A

As it was explained before, simple rectangular shape for the building block is tested in the beginning of the process. Randomly, nine story buildings have been assigned to these blocks as the first choice, and their open spaces are merely limited to the pedestrian path extended in sidelong of the blocks. Analyzing this bulk volume gives valuable clues useful for developing the final form.

The analysis' result in this part is summarized in two main numbers:

1. The total area include Residential and Commercial areas in all levels of building
2. The total Area of the open spaces

CASE A					
			Base Area (m^2)	Number of Stories	Total Area (m^2)
		A	1458	9	13122
		B	1620	9	14580
		C	4320	9	38880
		D	4320	9	38880
		E	1458	9	13122
		F	1620	9	14580
Total Building Area (m^2)					133164
Open Area	First Degree		0	0	**2004**
	Second Degree	Y	0		
	Pedestrian	P	2004		

Total Base Area of the Block (m^2)	16800
Standard Open Area (m^2)	8400
Maximum allowable amount of buildings area (m^2)	100800

Table 3-9 Volume feature of case A

According to the calculations, the values for the first case are indicated in the table below:

Index	Value	Permitted amount	Approval status
The story level of the building	9 stories	12 stories (max)	Approved
The total area	135168m^2	100800m^2 (max)	Not Approved
Open spaces	2004m^2	8400m^2 (min)	Not Approved

Table 3-10 Comparison of features of case A with the permitted values

The shadow analysis has been taken into consideration in parallel. In this analysis, the effect of the proposed volume's shadow on the residential buildings and walking corridors in the northern side of the building has been studied for each scenario.

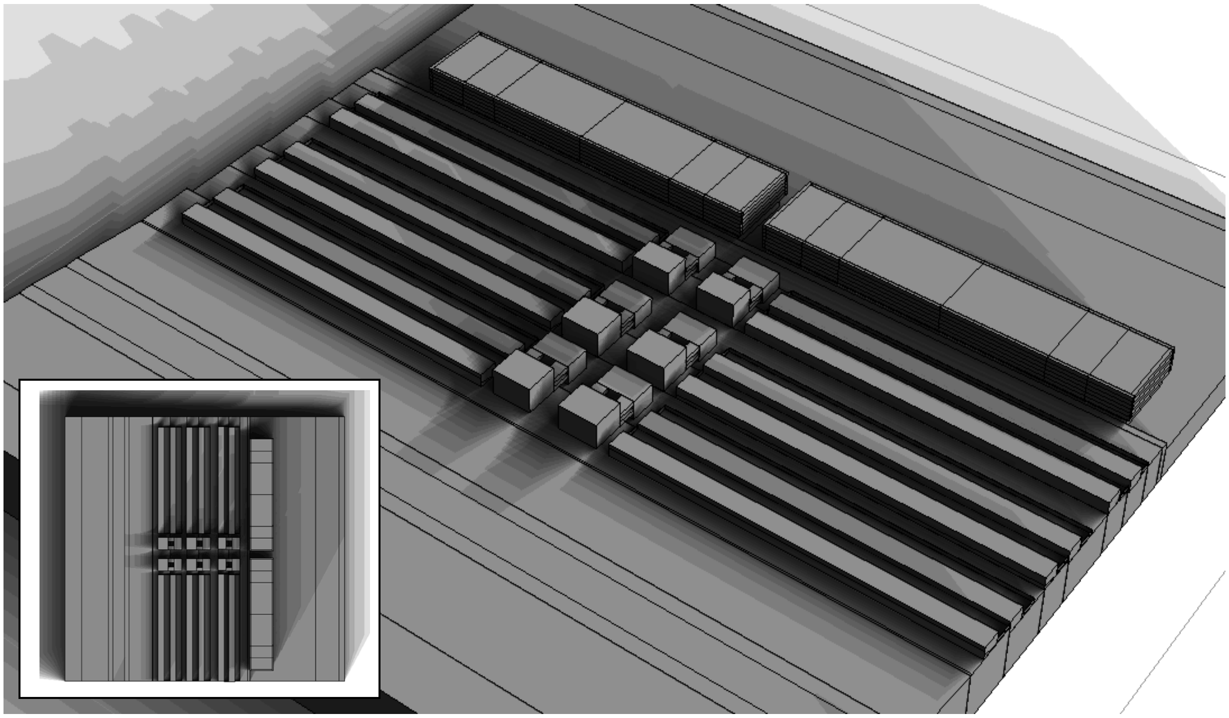


Figure 3-58 Shadow Analysis/solar range for case A (20th December 8:00am, 5:00pm)

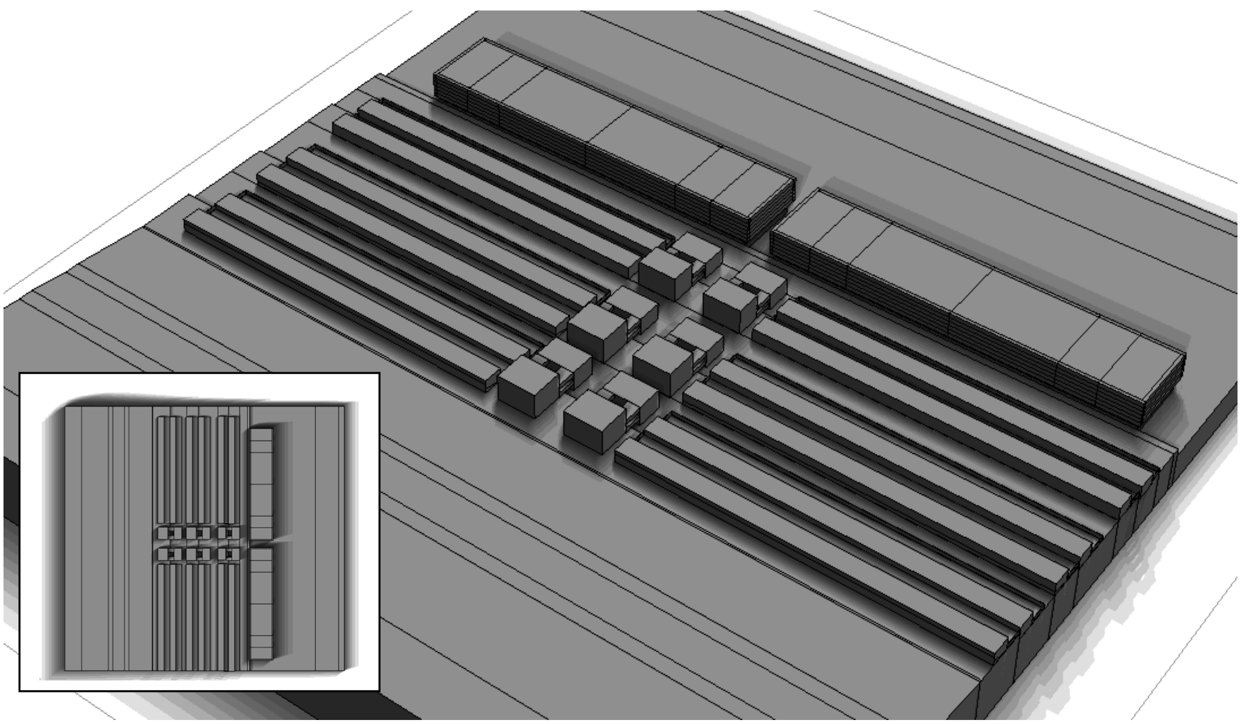
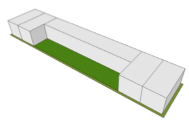


Figure 3-59 Shadow Analysis/solar range for case A (20th June 8:00am, 5:00pm)

3.3.2.1.2 Case B

In case B, while the maximum story level has been kept in 9, it has been tried to increase the area of open spaces. Moreover, in order to minimize the negative shadow effect which was associated to the height of the building (27m), in this case, an open semi-public area has been considered in the northern part of the building.

<table>
<tr><th colspan="6">CASE B</th></tr>
<tr><td colspan="3"></td><td>Base Area (m^2)</td><td>Story Number</td><td>Total Area (m^2)</td></tr>
<tr><td colspan="2" rowspan="6"></td><td>A</td><td>1458</td><td>9</td><td>13122</td></tr>
<tr><td>B</td><td>1620</td><td>9</td><td>14580</td></tr>
<tr><td>C</td><td></td><td></td><td>0</td></tr>
<tr><td>D</td><td>4320</td><td>9</td><td>38880</td></tr>
<tr><td>E</td><td>1620</td><td>9</td><td>14580</td></tr>
<tr><td>F</td><td>1458</td><td>9</td><td>13122</td></tr>
<tr><td colspan="5">Total Building Area (m^2)</td><td>94284</td></tr>
<tr><td rowspan="3">Open Area</td><td>First Degree</td><td>C</td><td>4320</td><td rowspan="3">0</td><td rowspan="3">6324</td></tr>
<tr><td>Second Degree</td><td>Y</td><td></td></tr>
<tr><td>Pedestrian</td><td>P</td><td>2004</td></tr>
</table>

Total Base Area of the Block (m^2)	16800
Standard Open Area (m^2)	8400
Maximum allowable amount of buildings area (m^2)	100800

Table 3-11 Volume feature of case B

Related values for the case B:

Index	Value	Permitted amount	Approval status
The story level of the building	9 stories	12 stories (max)	Approved
The total area	100608m^2	100800m^2 (max)	Approved
Open spaces	6324m^2	8400m^2 (min)	Not Approved

Table 3-12 Comparison of features of case B with the permitted values

In this case too, the minimum area required to be dedicated to open spaces has not been provided, therefore more modification is needed.

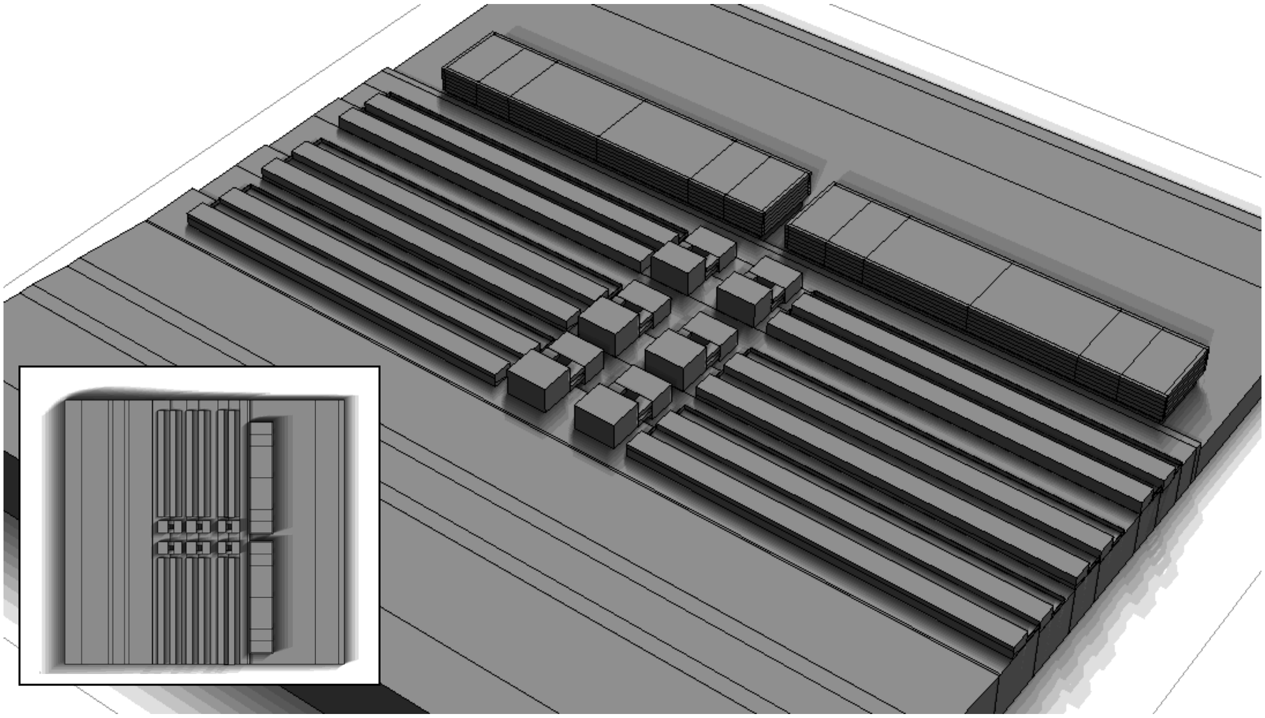


Figure 3-60 Shadow Analysis/solar range for case B (20th December 8:00am, 5:00pm)

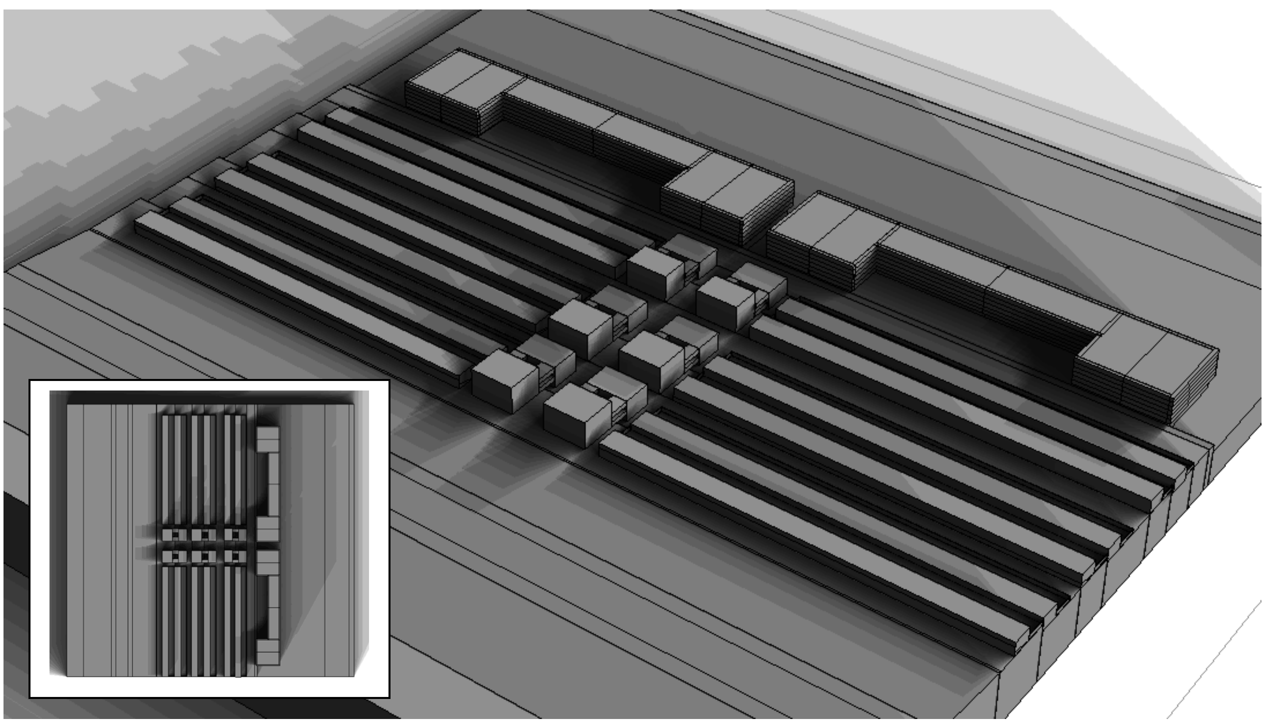


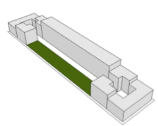
Figure 3-61 Shadow Analysis/solar range for case B (20th June 8:00am, 5:00pm)

3.3.2.1.3 Case C

In order to provide the needed open spaces which have been felt in previous cases, it has been decided to design central open spaces in two sides of the blocks. These open spaces could also act as the natural light source for the ending sections.

Shadow analysis in this part highlights some particular problems in the Eastern walking corridor which are directly related to the height of the proposed building (27m). In terms of connection, this corridor with its considerable width (18m) has a critical role and therefore, its shadow rate ought to be optimized. Moreover, this street could be subjected to problems due to the wind tunnel effect.

For solving these problems, one possible way is to decrease the story level in the blocks of the building in eastern and western nodes to 6 stories. In order to optimize the shadow effect of the building level of the middle block could be reduced by one story too. To amend the needed floor area which has been cut here, 3 stories could be added to the middle part of the building which is located in front of this block.

CASE C					
			Base Area (m²)	Story Number	Total Area (m²)
		A	1170	6	7020
		B1	576	8	4608
		B2	576	8	4608
		C			0
		D	3520	12	42240
		E1	576	6	3456
		E2	576	8	4608
		F	1170	8	9360
Total Building Area (m²)					75900
Open Area	First Degree	C	3520		**8636**
	Second Degree	Y	3112		
	Pedestrian	P	2004		

Total Base Area of the Block (m²)	16800
Standard Open Area (m²)	8400
Maximum allowable amount of buildings area (m²)	100800

Table 3-13 Volume feature of case C

The critical values for this case:

Index	**Value**	**Permitted amount**	**Approval status**
The story level of the building	12 stories	12 stories (max)	Approved
The total area	75900m²	100800m² (max)	Approved
Open spaces	8636m²	8400m² (min)	Approved

Table 3-14 Comparison of features of case C with the permitted values

With regard to these values which are totally compatible with the basic principles, this case can be considered as the basic form for the blocks RC3 and RC5. Needless to say that this form merely draws the design guidelines for these building and further modification could be taken into consideration by designers in the architectural phase.

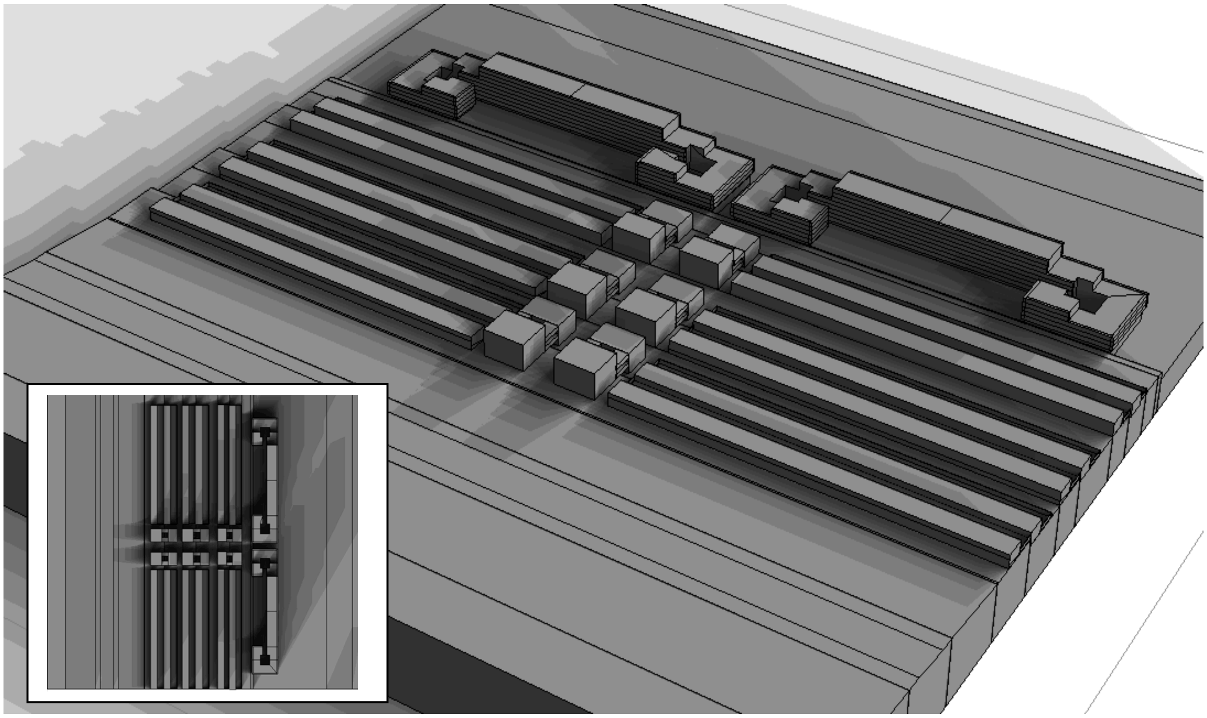


Figure 3-62 Shadow Analysis/solar range for case C (20th December 8:00am, 5:00pm)

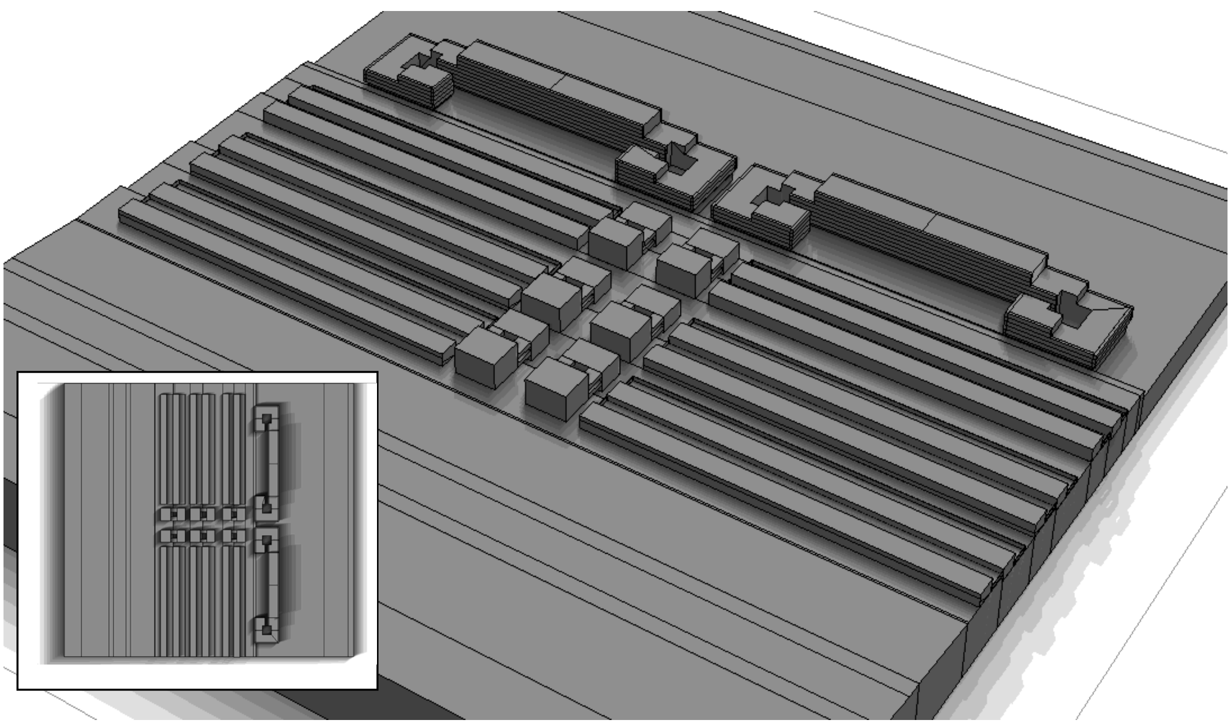


Figure 3-63 Shadow Analysis/solar range for case C (20th June 8:00am, 5:00pm)

3.4 Local Scale

3.4.1 Architectural design

3.4.1.1 Site Description

In the architectural design phase, selection of the building had been carried out regarding two main aspects: Typology, and surrounding features.

Since a residential theme has been considered for Shahrak-e Golestan by the municipality, the building has been selected from the residential typology. This typology is also dominant amongst the new construction suggested by this thesis' master plan. Therefore the location of the building has been decided with consideration of the possible urban features in the building's vicinity. In order to provide the chance of studying and involving various elements in the design process of one single building, existence of a diversity of urban typologies was in preference.

As it appears in the following images one of the residential building in the Northern Qaem St. has been selected. In its first level of vicinity are located the buildings related to the existing context as well as buildings from the same typology of itself. Qaem St. as one of the main green corridors is in direct relationship with it in this level. Not very far from it in its south, large volume buildings are located and finally it is related to the main green spine suggested by the master plan in its third level of vicinity.

Figure 3-64 Building's Location, Large Scale

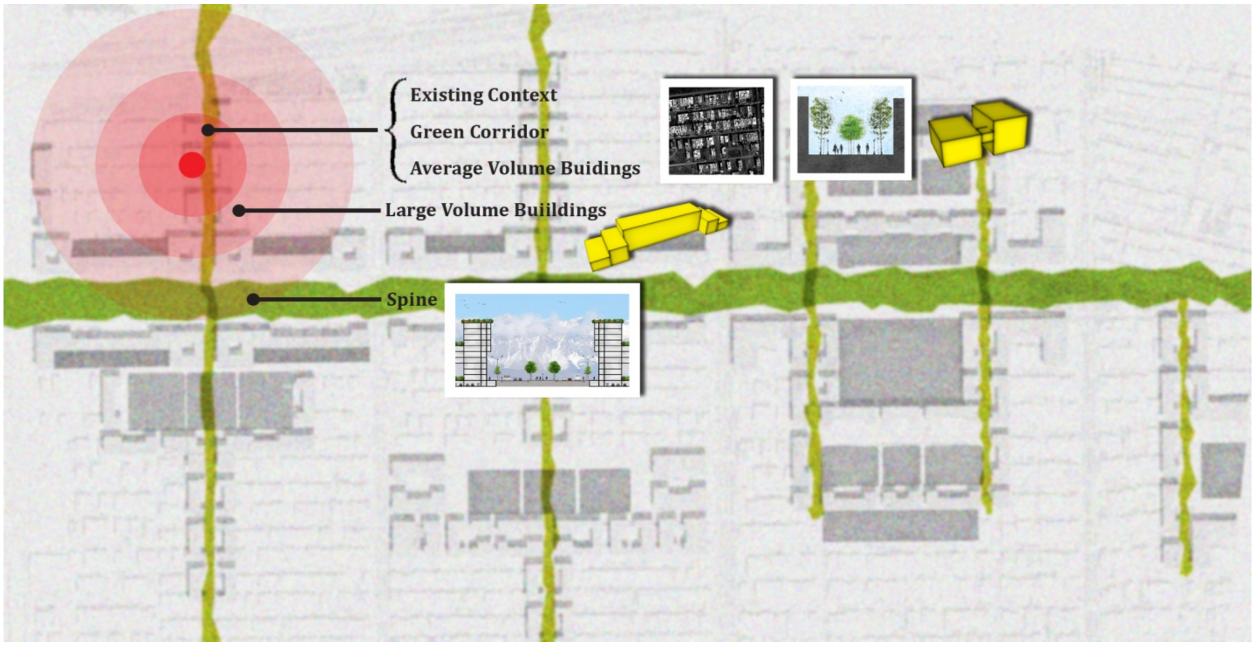


Figure 3-65 Building's Vicinities

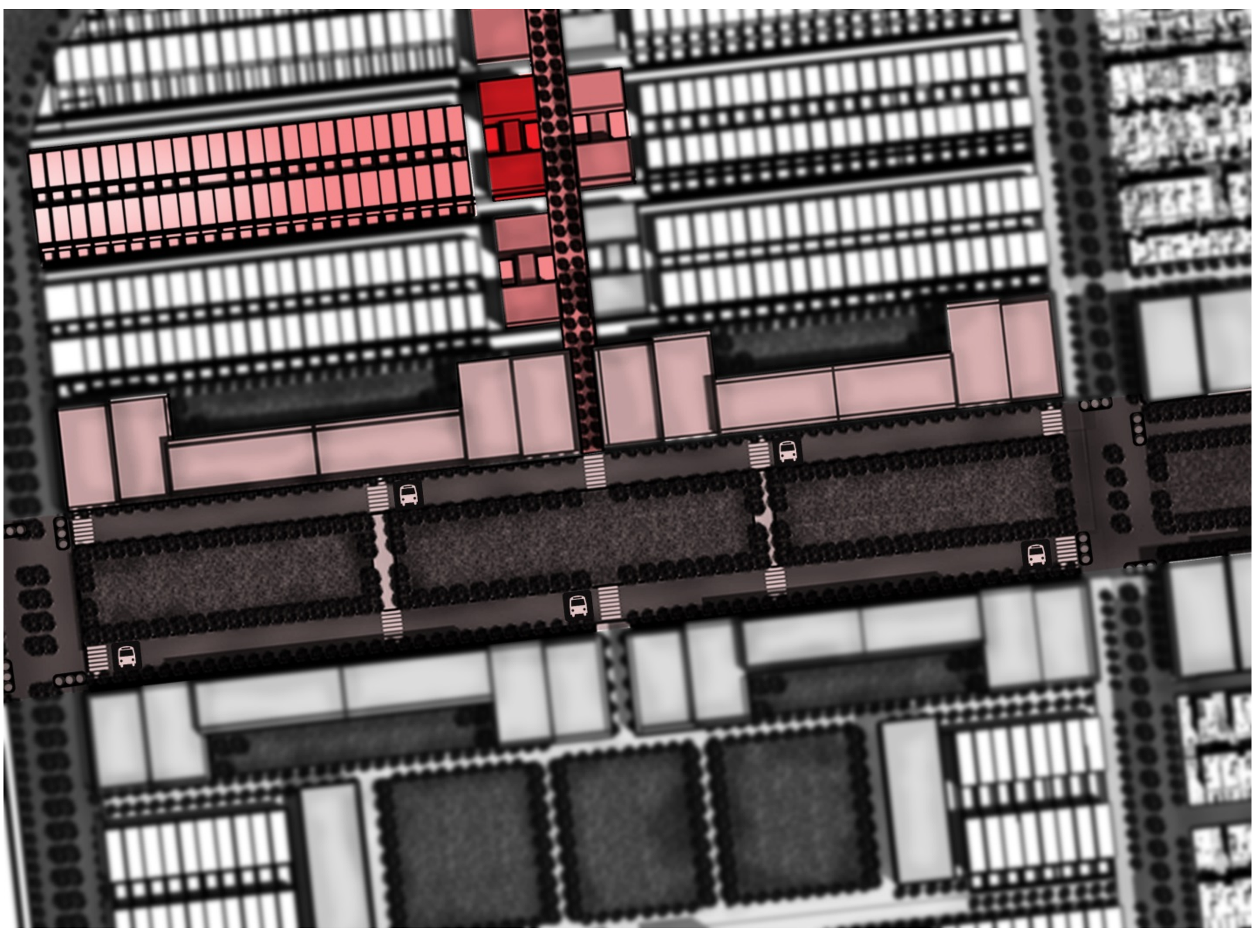


Figure 3-66 Building's Location, Neighborhood Scale

3.4.1.2 Objectives

Following objectives had been considered for designing the building, and it is needless to say that here the role of architectural design is to provide a form to support the overall target outlined by these objectives.

Promote multi-scale integration

One of the main characteristics of the *Integrated Modification Methodology (IMM®)* is the multi-scale outlook. In this context, the building as the very local scale should be designed in the integration with its neighborhood (intermediate scale), and moreover with the urban district (global scale). With this particular definition the building is not merely a building, but it is a little though significant part of a larger system. Accordingly the identity of the building, the neighborhood, and the city is defined in a nonlinear process and on an interconnected and mutual basis. From this point of view, it could be said that designing a building means designing the city.

Here, in the local scale, integration can be interpreted as supporting a lively metabolism in terms of environmental, social, and functional aspects. Strong senses of place and Well-functioning layout are the immediate consequents of this outlook.

This particular principle could be considered as the key of design and its traces could be noticed in the rest of the objectives too.

Promote mixed-use development

This objective represents locally one of the *Design Ordering Principles (DOPs)* introduced in IMM®.

Lively and sustainable neighborhoods are those that proper combinations of activities like residential, commercial, and cultural uses are physically and functionally integrated. Buildings as the most basic spatial components of the city and as the containers of activities and functions should support this essential integration. Some of the benefits of mixed-use design are:

- Reduced distances between housing, possible workplaces, retail businesses, and other amenities and destinations,
- More compact development, land-use synergy,
- Stronger neighborhood character, sense of place,
- Increased accessibility and proximity,
- And possibilities of healthier transportation through walkable and bike-able accessibilities.

Although here the main theme of the building is residential, other typologies of functions will be assigned to its lower levels in order to support the overall mixed-use development.

Provide required density

Shahrak-e Golestan as a part of Tehran's District 22 is being developed by the purpose of accommodating a certain amount of citizens. Therefore, a particular built up density has been decided by the municipality of this region. Through modifying the pattern of compactness, this limitation has been considered in the proposed master plan, and the architectural design should comply with the decided density as well. This could be achieved mainly by the volume of the building, and the housing sizes which it provides.

Provide housing diversity

Cities are consisted of citizens with variant typology and sizes of families coming from different life stages and different income levels. One objective in the architectural stage of this project is to provide a proper housing diversity for accommodating various typologies of citizens, by designing housing units in different sizes and different layouts.

Below, some of the possible benefits which may be resulted from housing diversity are listed:

- Provide a more compact form by combining various sizes and typologies of housing in one volume,
- Accommodate people from different walks of life hence provide housing for wider range of citizens who may work near neighborhood,
- Ease changes in type and size of houses to the citizens according to their future developments in family size and income level,
- Empower social bonds by creating a diverse neighborhood and helping to avoid cultural segregation,
- Provide stronger communities comprised of residents in different life stages.

Support community

The architecture could support the public by providing spaces devoted to communal activities. This, eases the inhabitant's access to social facilities, involves the residents in social activities at higher levels, and consequently stronger communities will be produced.

Culture friendliness

The proposed design ought to be compatible with Iranian's housing culture. Proper strategies should be adopted to address the historical and cultural elements of Iranian architecture, and simultaneously, fulfill the contemporary requirements. Moreover, the proposed design should reflect the identity of the city too. This is rapidly becoming a severe problem for Tehran particularly, that the city is losing its identity under the vast volume of new construction. Here, the architectural design seeks its root in the forgotten characteristics of Tehran.

Energy efficiency

The design should be energy efficient, and provide simultaneously maximum comfort for the occupants and minimum effect on the environment. This target could be achieved through:

- Positioning the building in a proper orientation,
- Optimizing the volume of building with regard to the quantity of solar gain,
- Adopting suitable strategies to achieve an efficient envelop design,
- Using proper materials,

3.4.1.3 Design process

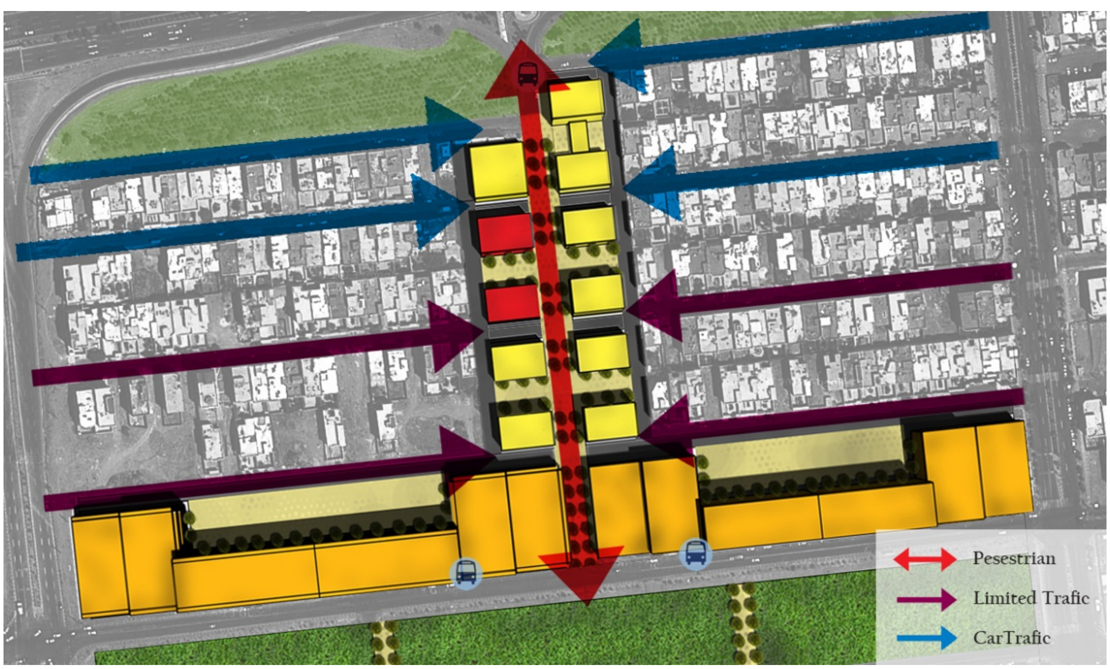


Figure 3-67 Site position

Considering the mentioned objectives, site location, and the physical features in vicinity the architectural design has been proceeded. No need to indicate that designing is not a linear process, and the its various features had been formed through a back-and-forth movement. This back-and-forth movement took place between the different scales too. Local decisions had been taken with regard to their possible effects on the neighborhood scale, and accordingly architectural features went through a set of modification with the aim of being well integrated with the urban context which is located at.

In this chapter the formation of general aspects of the architectural form is discussed, and then the actual design will be presented.

3.4.1.3.1 Land Segmentation

According to Tehran's construction law, the area of the land which is dedicated to the building should be no more than 60% of the total land area, and the remaining 40% must be devoted to voids which normally considered as the private yards. In compliance with this law, the construction approach which is taken normally in Tehran is to simply divide the land into two segments of building and yard. The building section will be located in northern part and the southern yard section allows the sunlight to the building. The existing buildings of Shahrak-e Golestan follow the same pattern, with their private yards enveloped with peripheral walls.

With this approach, Shahrak-e Golestan like most of the residential areas in Tehran gained a monotonous greedy context in which buildings are located as the closed seeds and the intersection has no morphological definition in the urban scale.in such the voids are either private or public and no hierarchy rules over them. Moreover, the so called private yards of the buildings carry a rather lost identity. Traditionally, private yards were defined in Iranian architecture for low level buildings those used to accommodate one family or a limited number of relative families in same level. It provided space for small gardens and gathering places. With the urgent need of housing in recent history of Tehran, the building got higher and higher in order to provide more density. Dedication of the total area of void to absolute private yards seems pointless in this context. Theses voids with no means could be defined private for many families will live in different levels of those buildings. The only function they provide is closed, not well-defined passage ways which most of the time are empty.

The proposed design in this thesis complies with the land segmentation rule but does not follow the common construction layout. Instead it divides the building area into two segments and puts the void in the middle. Not enveloping the yard by peripheral walls it will be defied as semi-public void. Consider that according to the proposed master plan the ground level of the building will be dedicated to retail activities which their access point will be defined from the public street and the mentioned semi-public void. This will bring a strong quality of space between buildings, and with the hypothesis that all the new buildings in Qaem St. follow the same approach in their design a network of hierarchic voids will be formed in this neighborhood. Moreover, this approach increases the interface index of the street network and makes the neighborhood more accessible and pleasant for the pedestrian traffic.

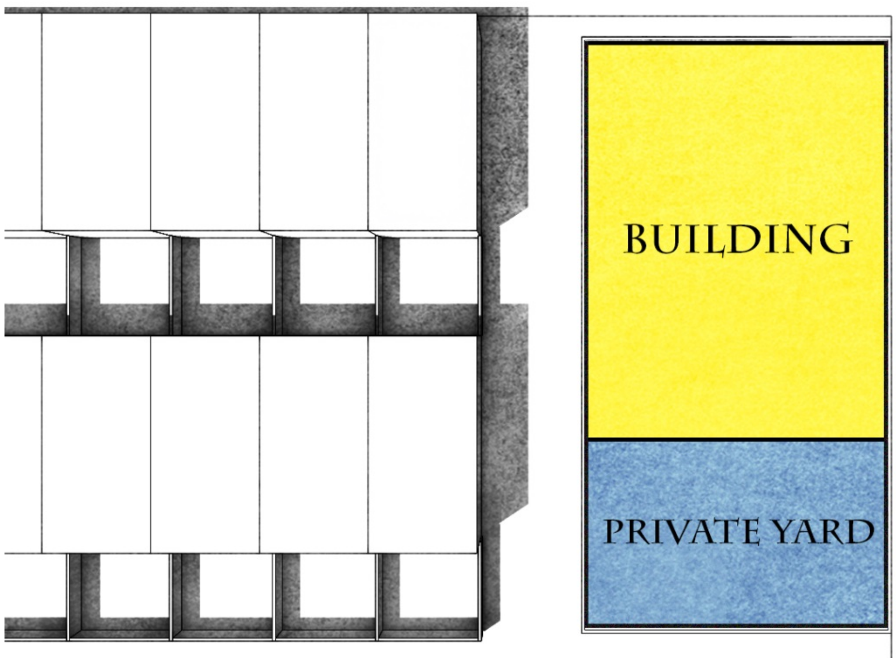


Figure 3-68 Common Land Segmentation in Tehran

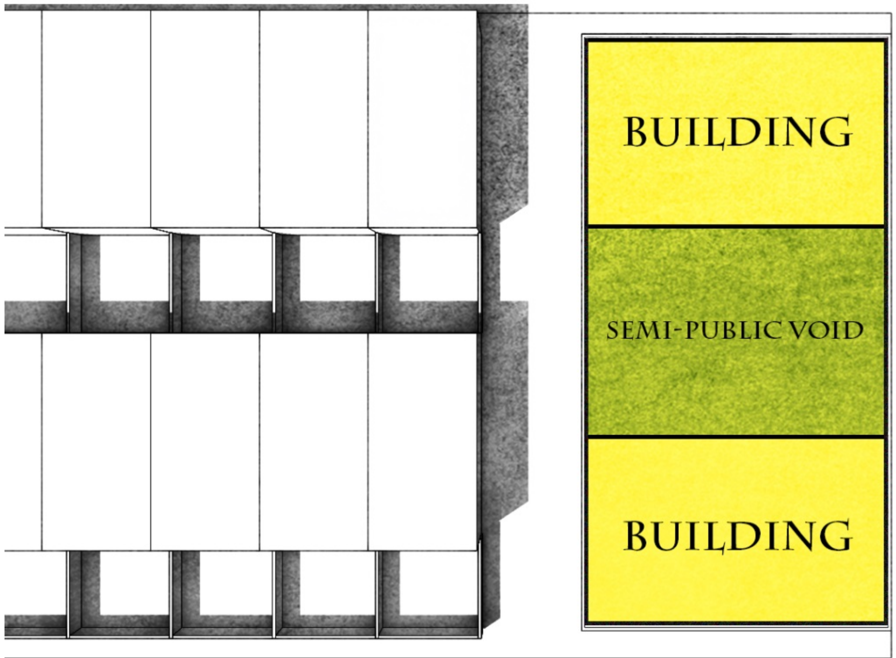


Figure 3-69 Proposed Land Segmentation

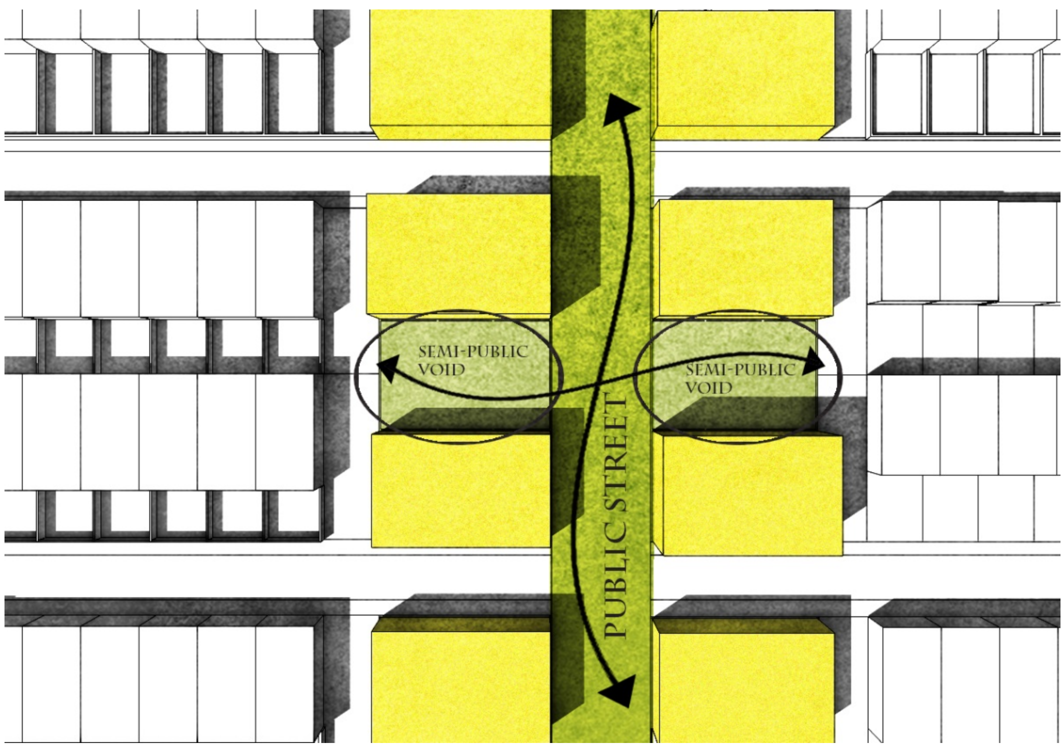


Figure 3-70 Morphological Node Resulted From Proposed Land Segmentation

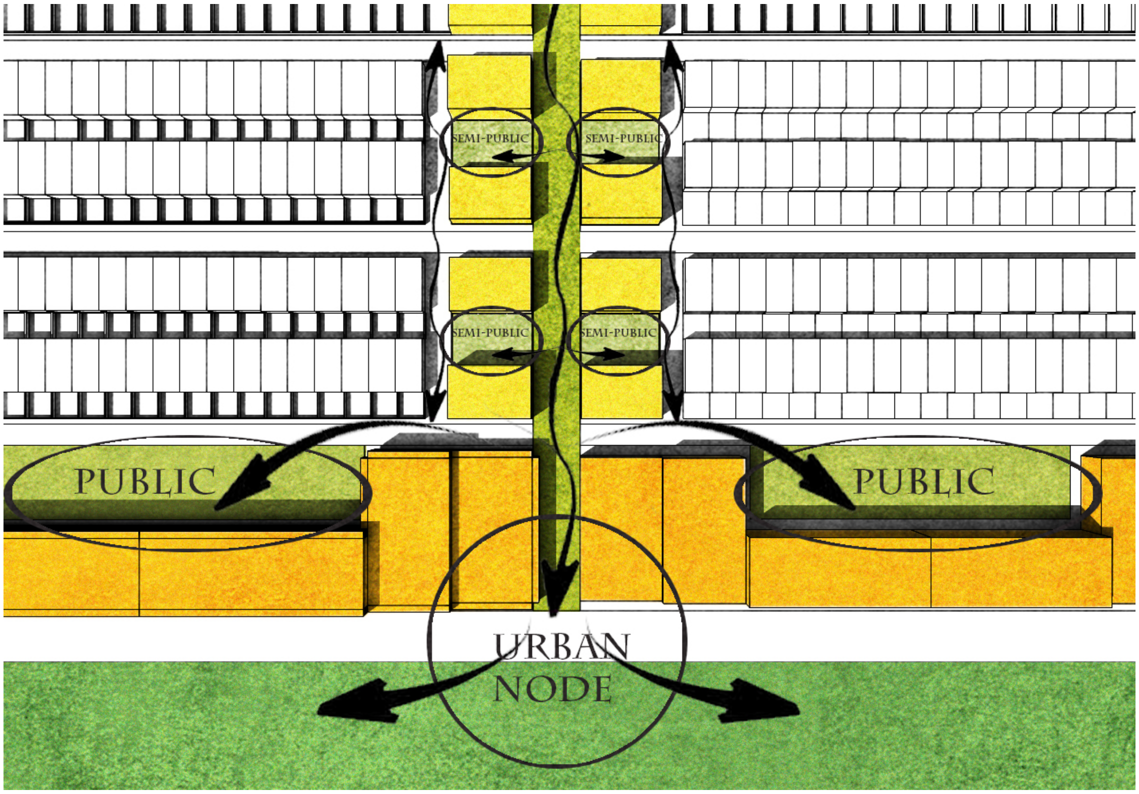


Figure 3-71 Void Hierarchy in Neighborhood Scale

3.4.1.3.2 Accesses

The access points of the building are decided mainly with consideration of the typologies of the surrounding streets, topography of the site, and the nature of different functions defied in it.

The building block is surrounded by four intersections of different street types. Car traffic is existed in its southern and northern part where 11th and 12th street are located respectively. Therefore, it is reasonable for the entrance of the parking to be defined in these sides. Due to the steeply topography of the site, the parking will be located in underground level from north, and it will be emerged on the ground level from south part only. Hence, the entrance of the parking is defined in the southern side of the building. The interface of the streets made the car access easier from the western part specially.

The pedestrian accesses for the residents and employees are defined in the internal sides where the semi-public yard is existed. These entrances are accessible from both western and eastern streets and defining them in the middle also serves the hierarchy of the spaces.

The retail units which all located ate the street levels have their individual entrances to their adjacent street. Applying this pattern to all of the similar buildings in Qaem St. considered by the master plan will create a powerful and lively axis in the walking corridor.

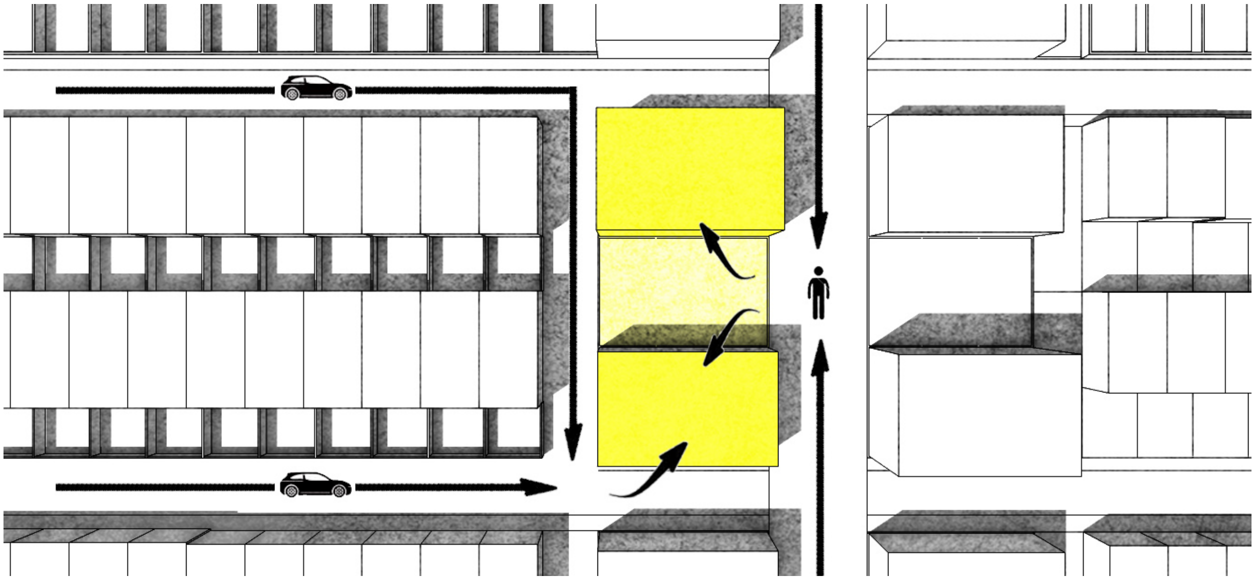


Figure 3-72 Building Accessibilities (Top View)

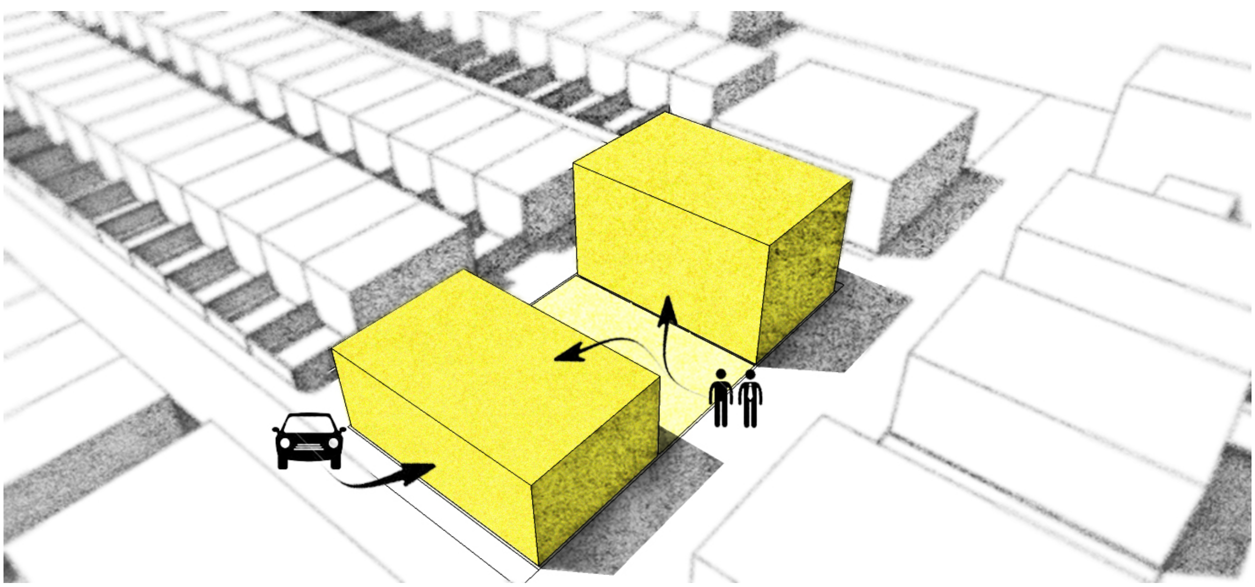


Figure 3-73 Building Accessibilities

3.4.1.3.3 Volume

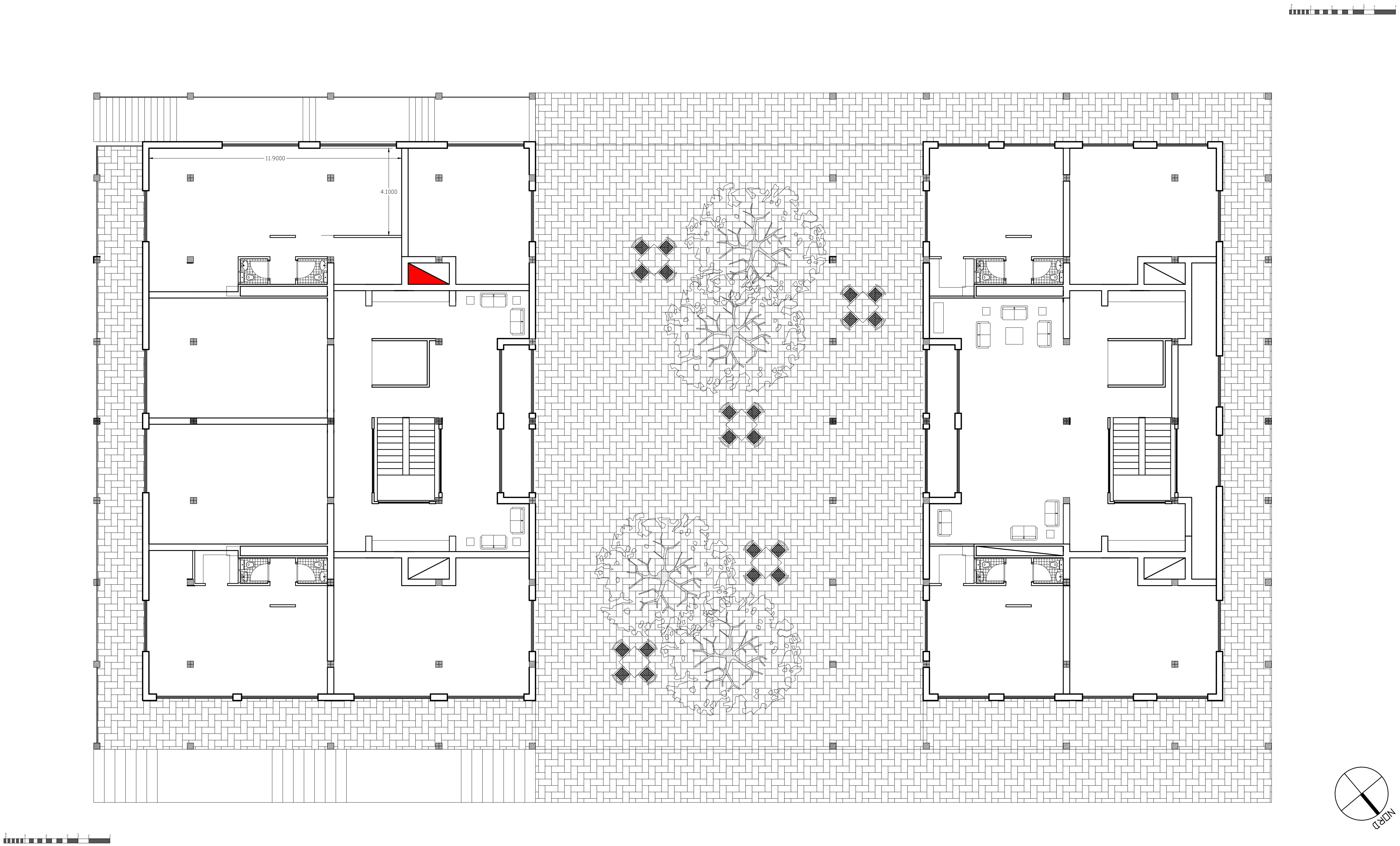
The ultimate shape and the volume has been formed regard to three different sets of the elements: the housing and the function densities that has been foreseen by the master plan, the geographical and topographical features of the site location, and the layout of the units.

Being in the northern hemisphere, the building naturally gains solar energy from its south. If the southern and northern part has been designed in same height, considering the 18.5m width of the semi-public yard which is the actual distance between two parts of the building, the southern part would almost entirely block the northern part. In this regard, it is more sensible that the southern part be designed shorter than the northern part. Moreover, the downward topographical steep in the site location allows to northern building to naturally stand in a higher elevation. Therefore, based on their solar gain, the general outline of the volume optimized in a way that the northern building be designed taller than the southern one with 2 stories exceeding. With taking into account the ground level which is dedicated to the retail activities and first floor which will be design for the offices, the northern part will be a 7 stories building, while the southern part will be consist of 5 stories.

Finally, the ultimate shape emerged from putting the layouts of stories on each other. These layouts differ mainly by the characteristics of the functions which have been considered for different levels, and the difference of the needed spaces for each activity.

In following pages the plan architectural plan sheets are presented

3.4.1.3.3.1 Architectural plan sheets

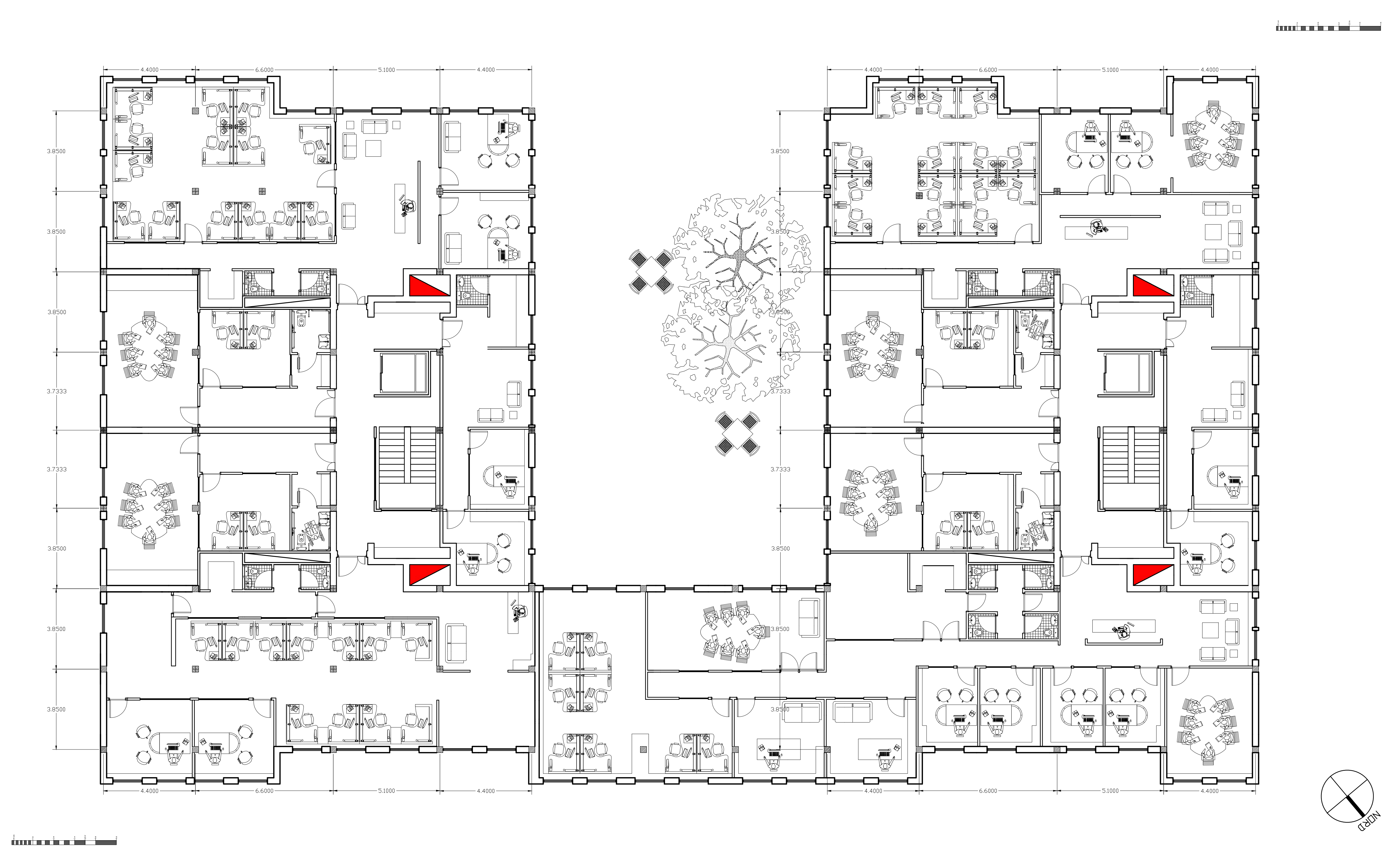


Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (LC)

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Architecrural Design Sheet		Sheet Number : 1
		Scale :
Floor Plan		
First Floor Plan (Commercial Area)		
Amirali Naraghi	755237	
Mohammad Hadi Mohammad Zadeh	754940	



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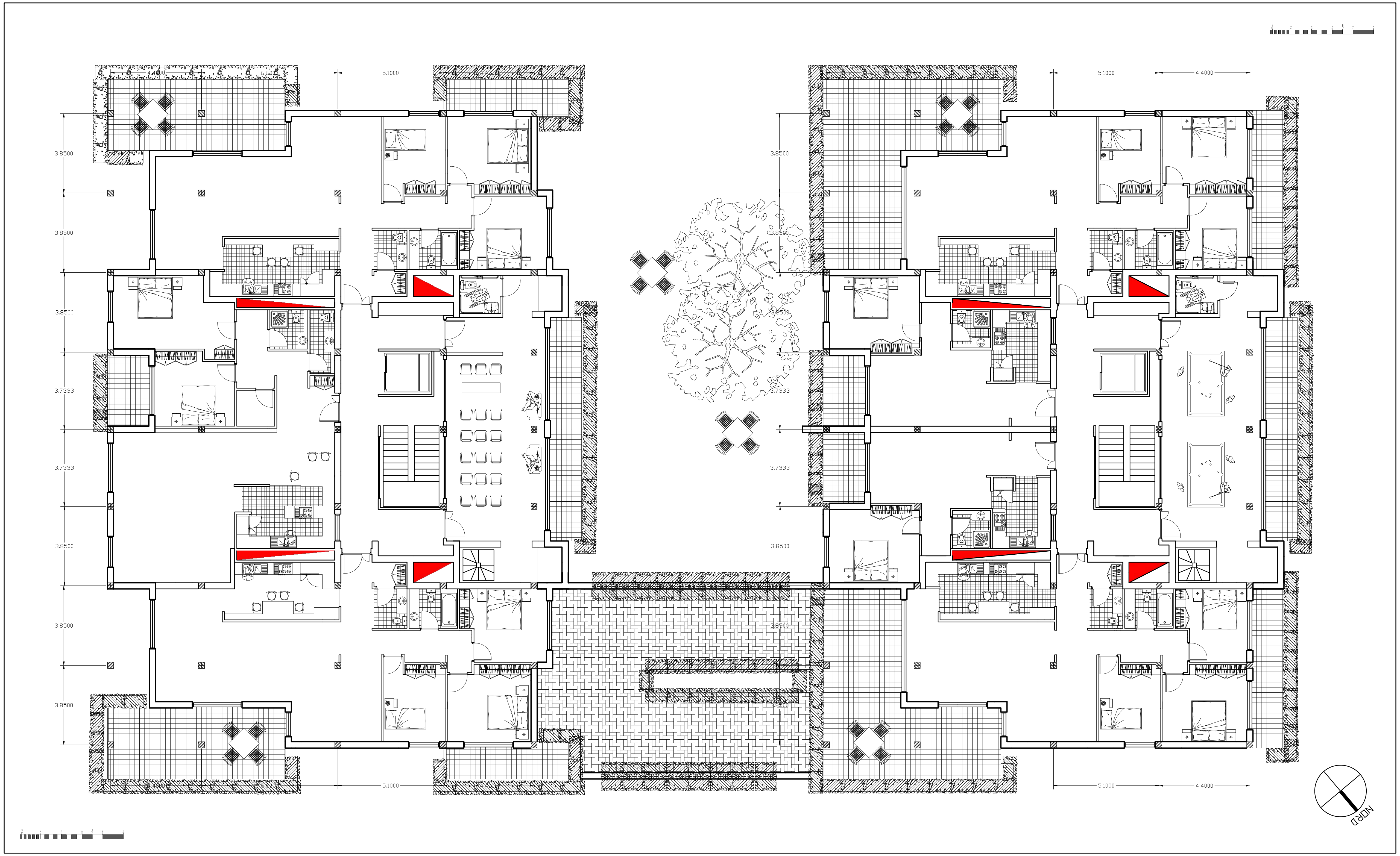
Architecrural Design Sheet	Sheet Number : 2 Scale :
Floor Plans	
Second Floor Plan (Offices)	
Amirali Naraghi	755237
Mohammad Hadi Mohammad Zadeh	754940



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Architecrural Design Sheet

Sheet Number : 3

Scale :

Floor Plans

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Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Second Floor Plan (Residential Units)

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

CREATO CON LA VERSIONE DIDATTICA DI UN PRODOTTO AUTODESK
CREATO CON LA VERSIONE DIDATTICA DI UN PRODOTTO AUTODESK
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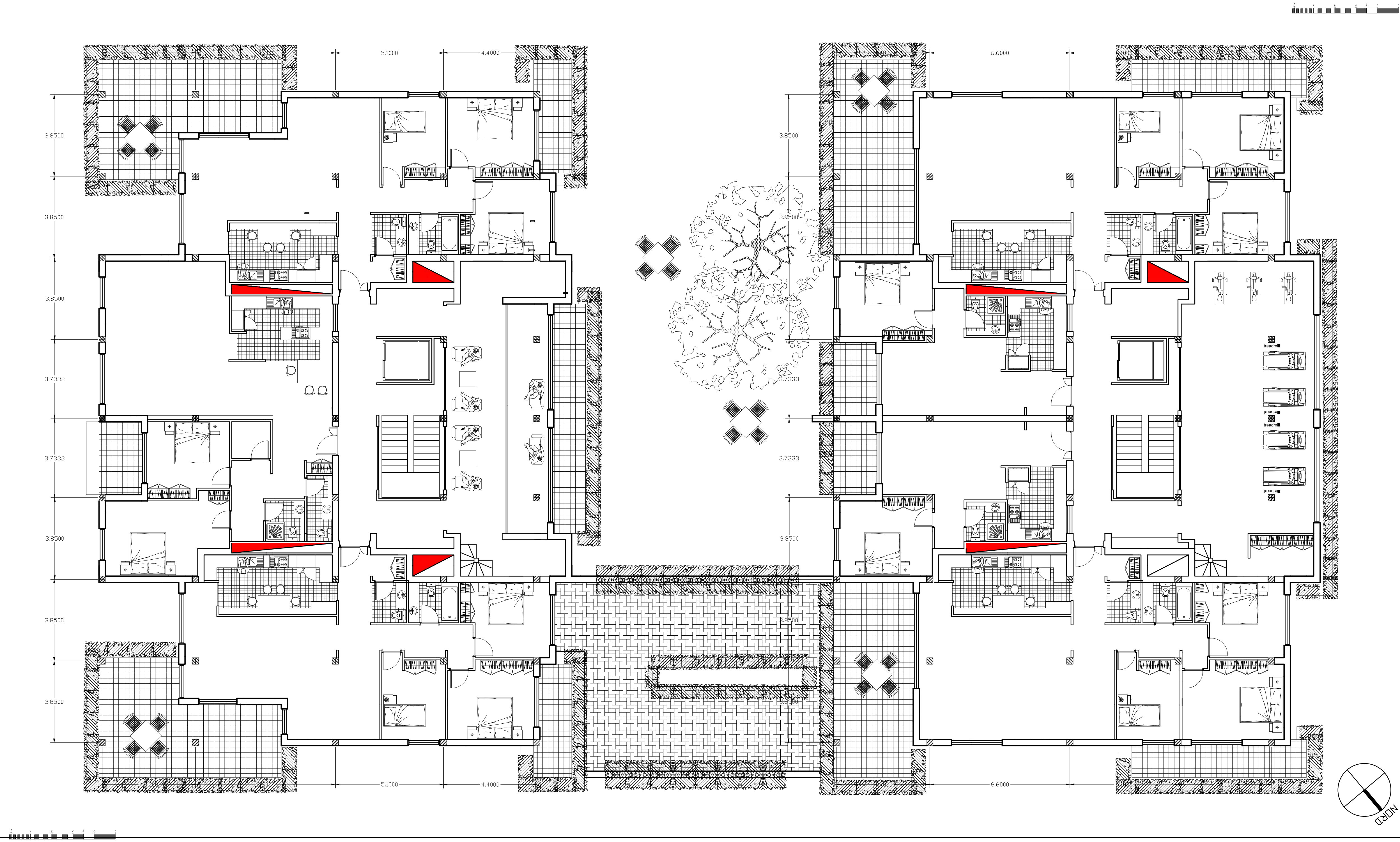

Politecnico Di Milano VI-Scuola Di Ingegneria MI Ingegneria Dei Systemi Edilizi (LC)	Architecrural Design Sheet	Sheet Number : 5 Scale :
Ms.c Final Graduating Project Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach Supervisor : Prof. Massimo Tadi Co- Supervisor : Prof.Gabriele Masera	Floor Plans Third Floor Plan (Residential Units) Amirali Naraghi 755237 Mohammad Hadi Mohammad Zadeh 754940	

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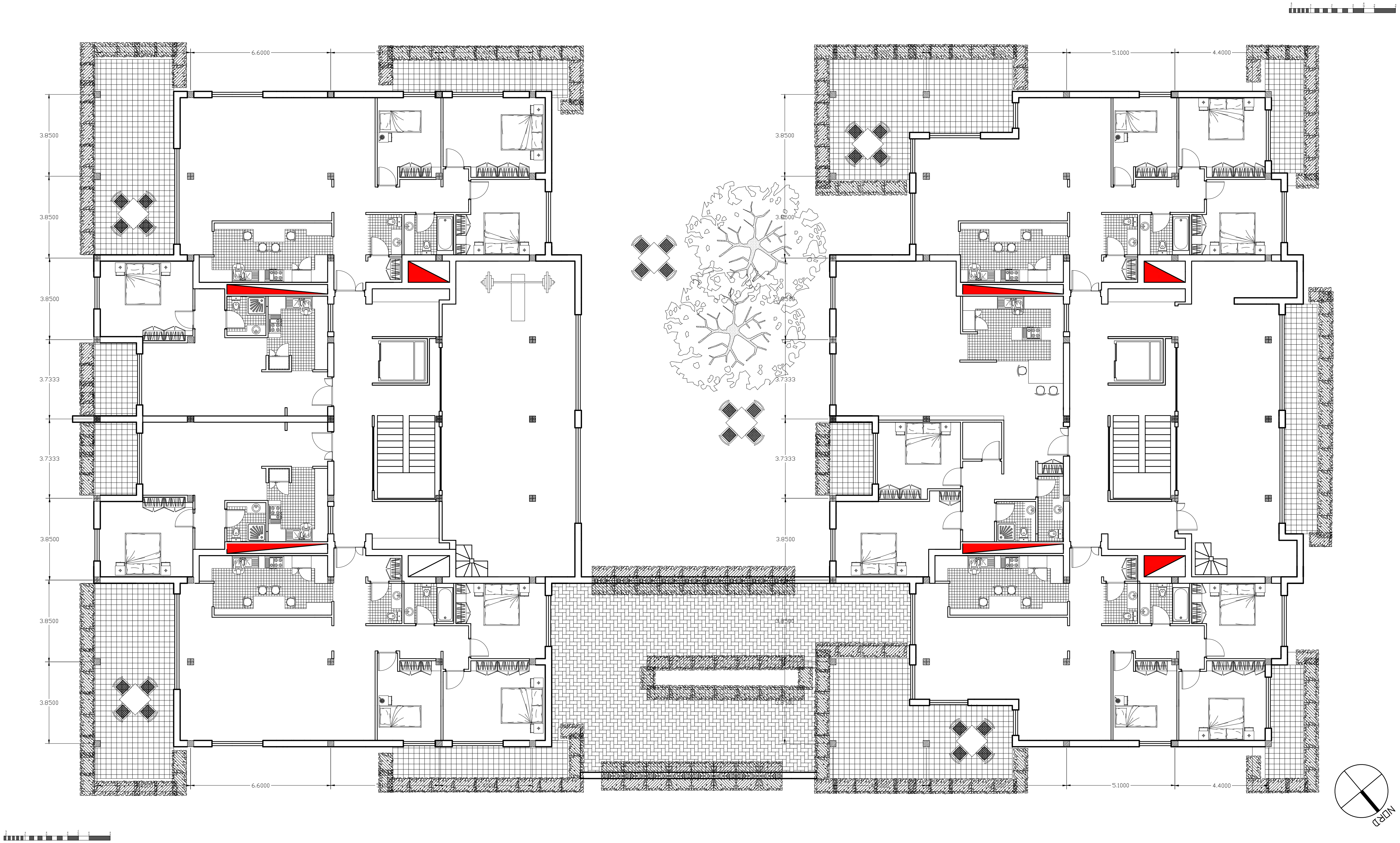
CREATO CON LA VERSIONE DIDATTICA DI UN PRODOTTO AUTODESK



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Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Architecrural Design Sheet

Sheet Number : 6

Scale :

Floor Plans

Forth Floor Plan (Residential Units)

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

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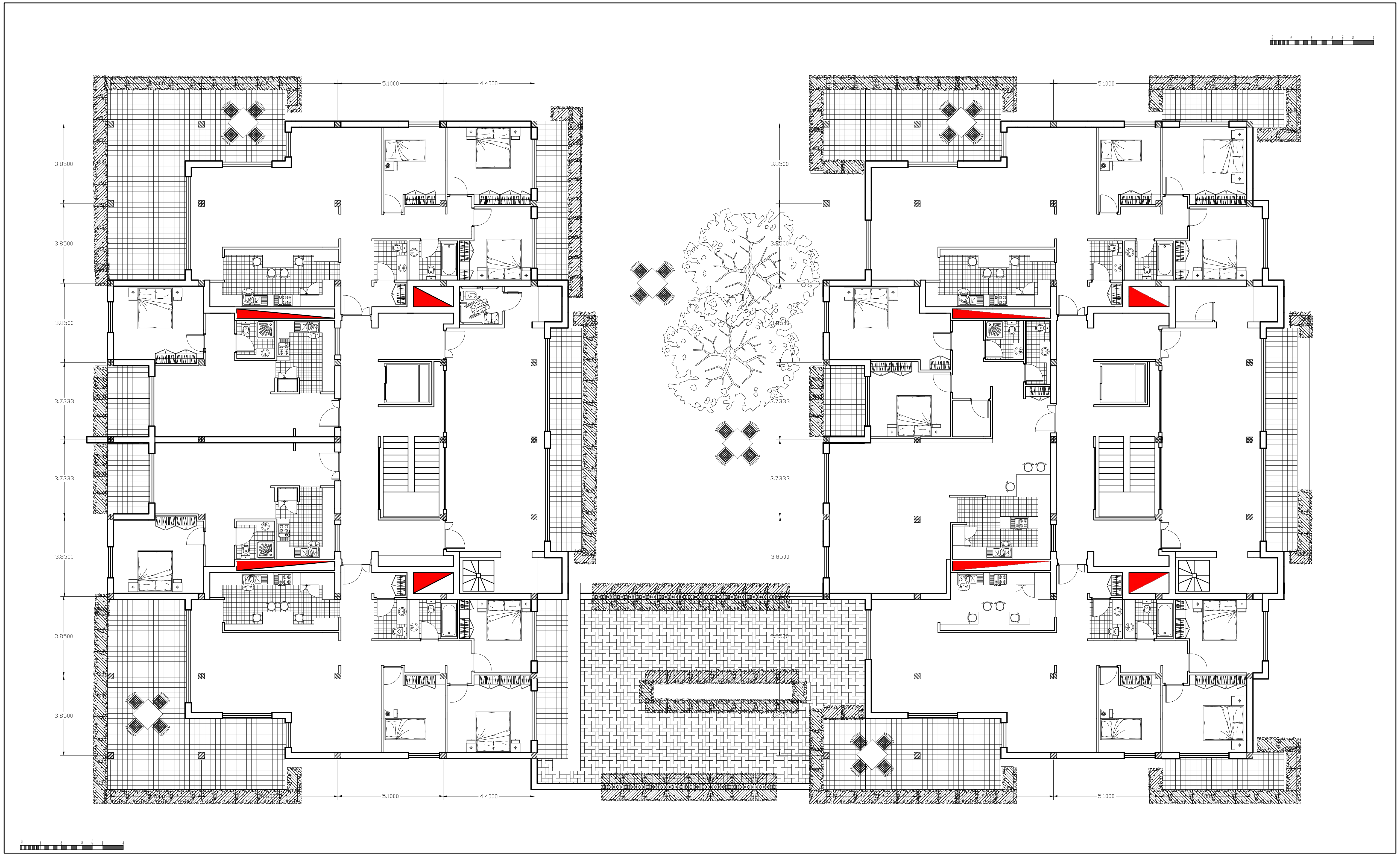

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Architecrural Design Sheet

Sheet Number : 7
Scale :

Floor Plans

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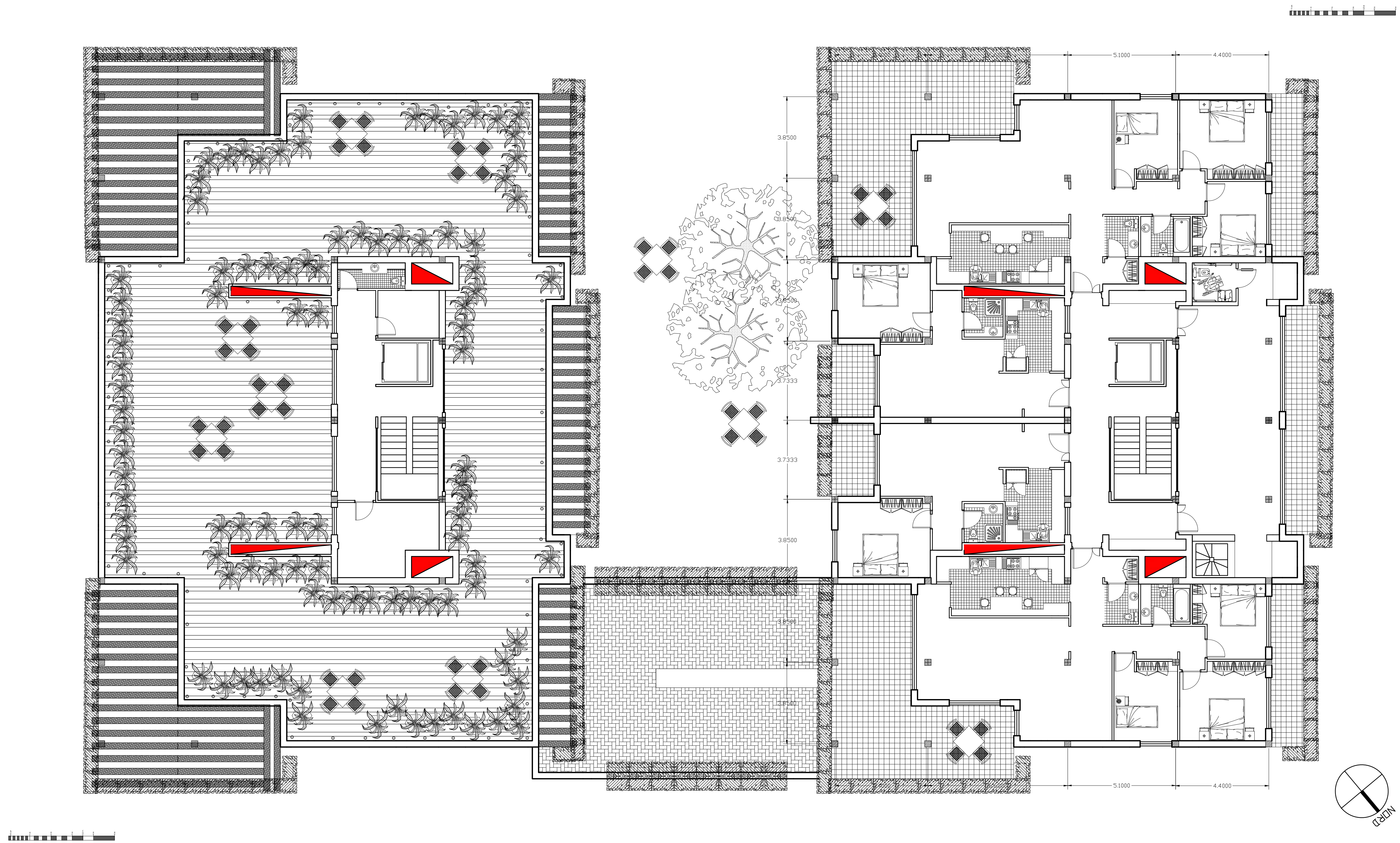
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Fifth Floor Plan (Residential Units)

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940



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Architecrural Design Sheet

Sheet Number : 8
Scale :

Floor Plans

Sixth Floor Plan
(Residential Units and Green Roof)

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Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

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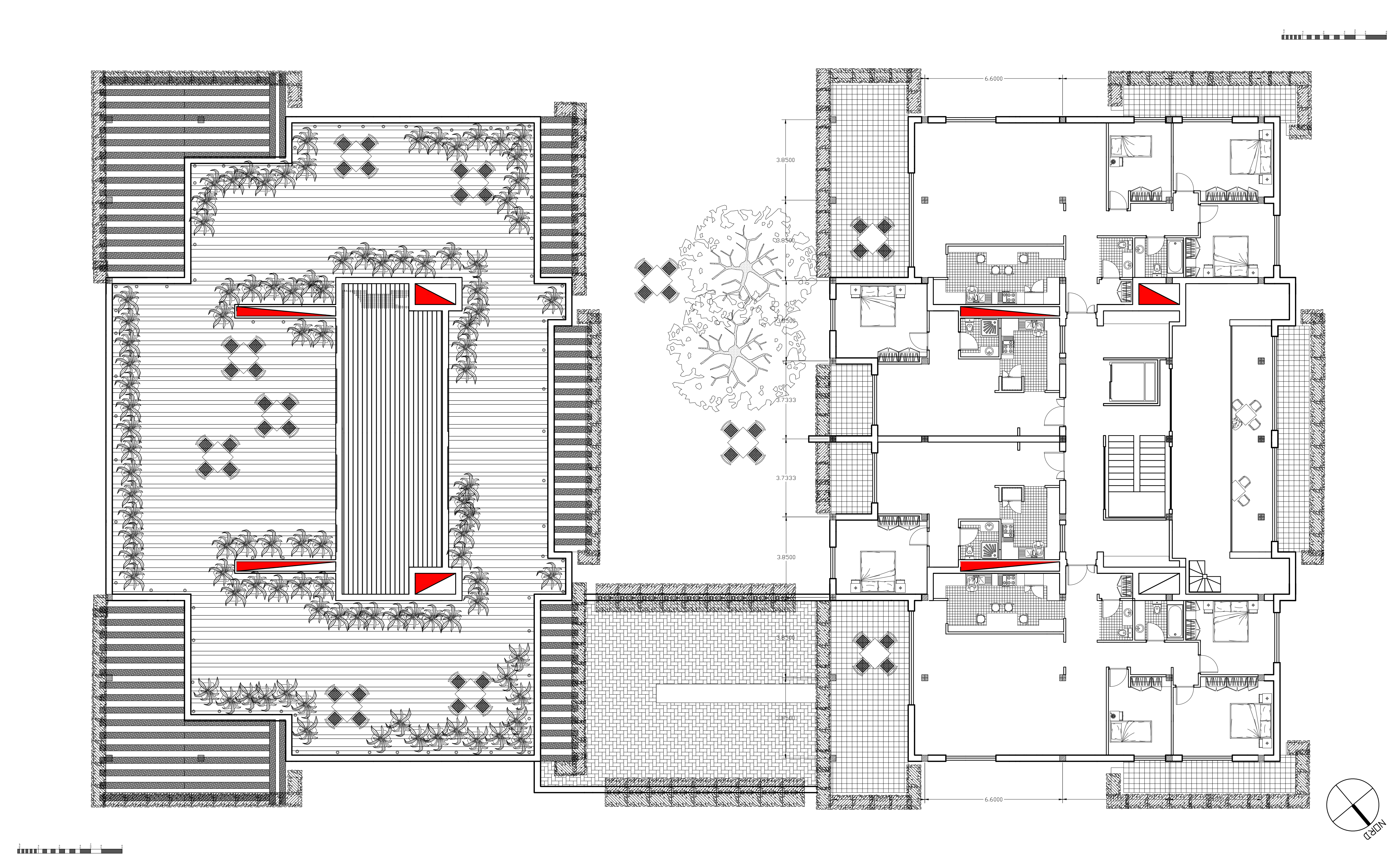
CREATO CON LA VERSIONE DIDATTICA DI UN PRODOTTO AUTODESK



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Architecrural Design Sheet

Sheet Number : 9

Scale :

Floor Plans

Seventh Floor Plan (Residential Units)

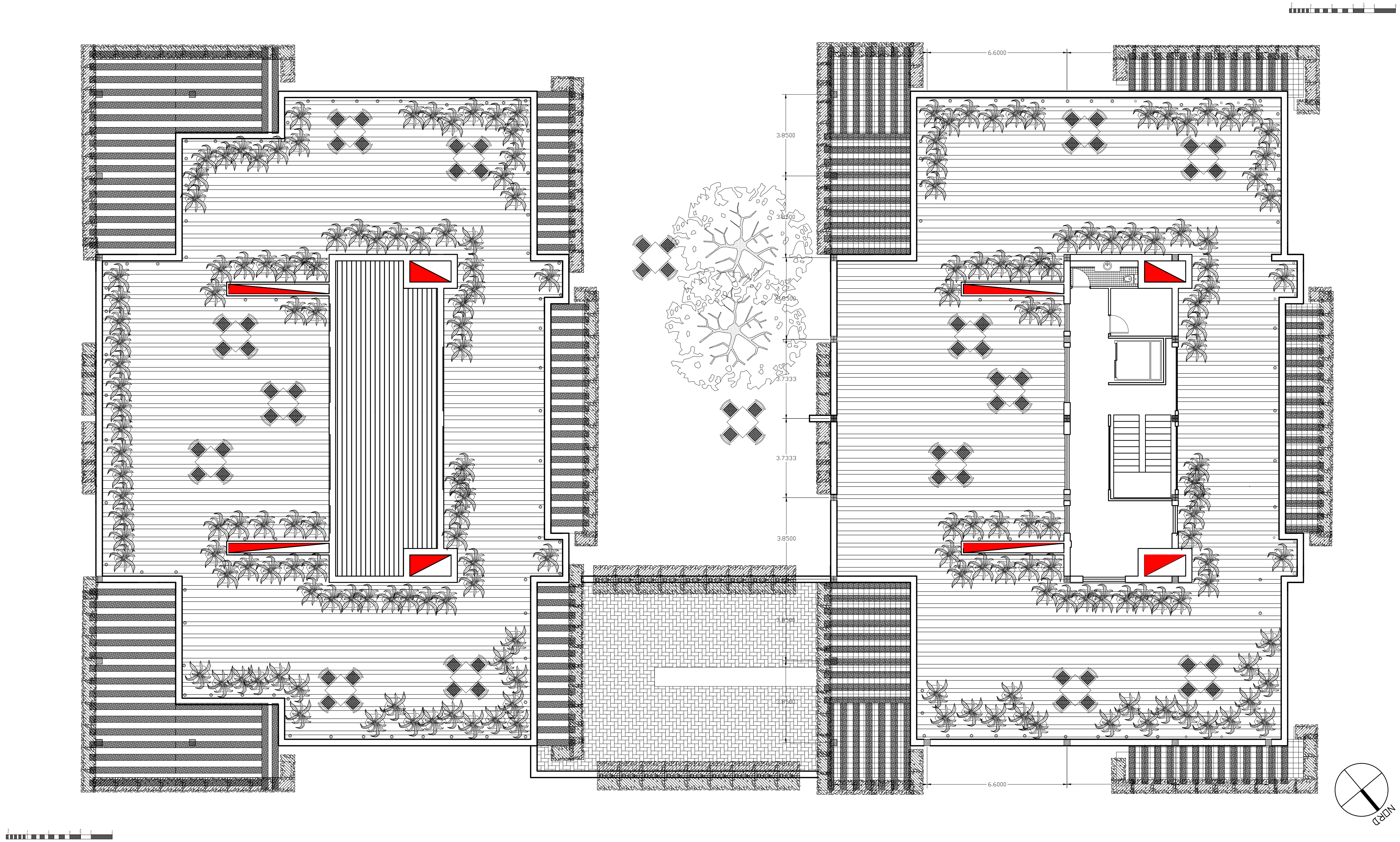
Ms.c Final Graduating Project

Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

CREATO CON LA VERSIONE DIDATTICA DI UN PRODOTTO AUTODESK



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Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Architecrural Design Sheet

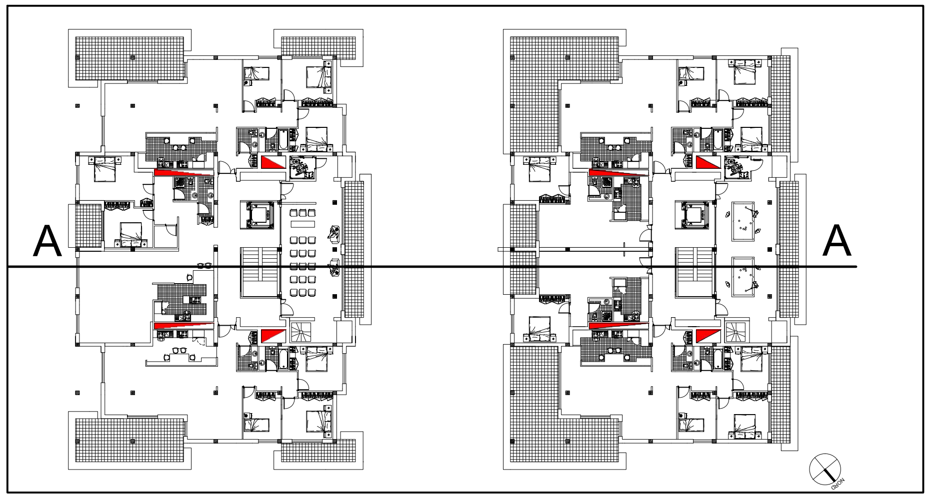
Sheet Number :

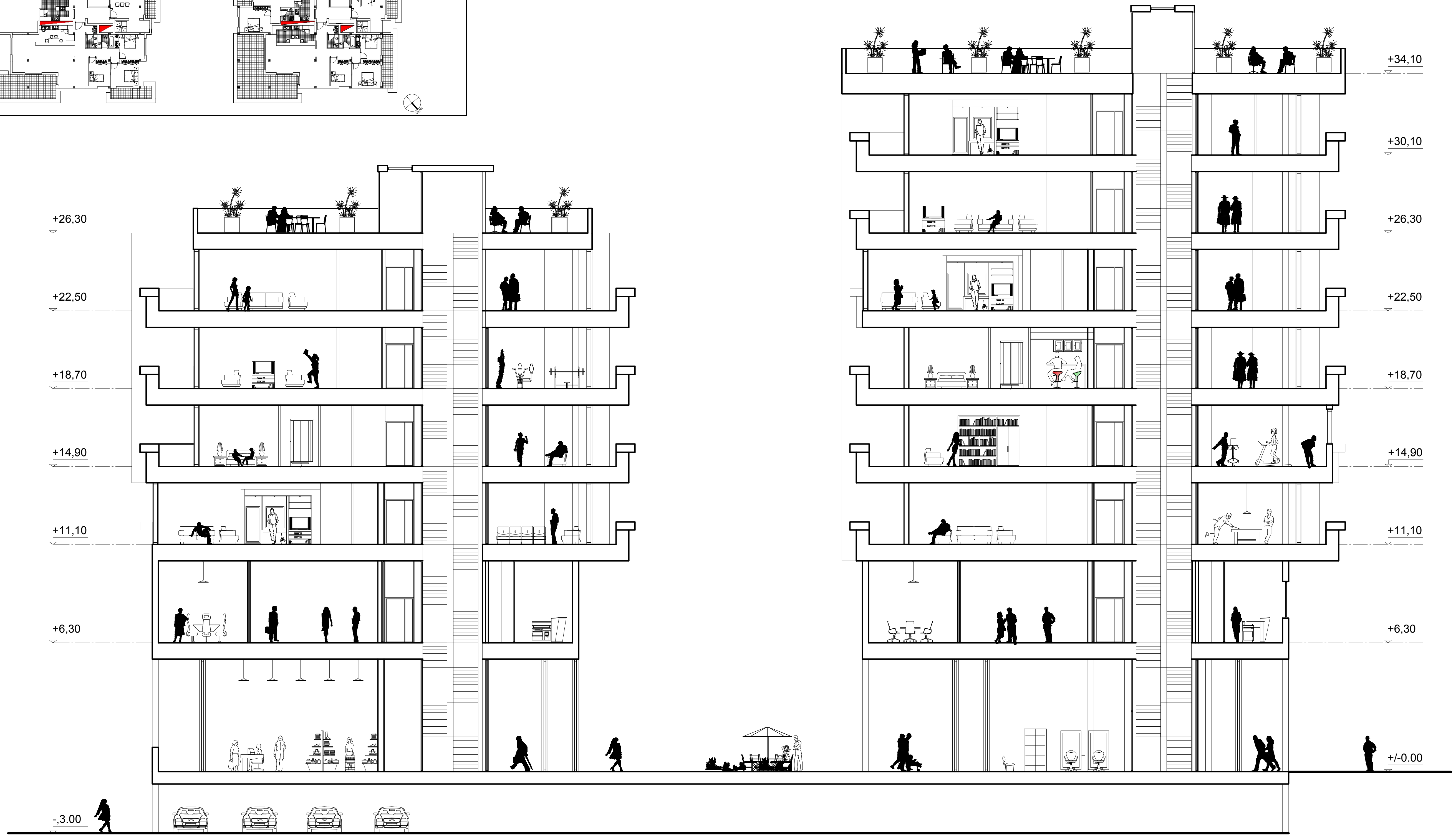
Scale :

Floor Plans

Eight Floor Plan (Residential Units)

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940





Politecnico Di Milano VI-Scuola Di Ingegneria MI Ingegneria Dei Systemi Edilizi (LC)	Architecrural Design Sheet	Sheet Number : Scale :
	Architectural Section	
Ms.c Final Graduating Project Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach Supervisor : Prof. Massimo Tadi Co- Supervisor : Prof.Gabriele Masera	Section A - A)	
	Amirali Naraghi 755237 Mohammad Hadi Mohammad Zadeh 754940	

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Architecrural Design Sheet

Sheet Number :
Scale :

Architectural Elevations

Elevation North - East

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

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3.4.1.3.3.2 Functional description

As it has been indicated before, in the master plan a certain level of functional mixed-use characteristic has been assigned to the building. Accordingly, while the dominant use of the building remains residential by designing 5 stories of apartment, it should also provide one level of ground level retail activities, and one story should provide offices for the administrative use. The underground level will be the parking for the residents, and the employees. It is obvious that depended to the nature of all these functions different layouts with certain shape characteristics ought to be designed, and this directly affects the form of the building. In the following, design features of the different levels depended to their functions are explained:

3.4.1.3.3.2.1 Retail (Ground Level)

The purposes of mixing retail activities in the building are to locally meet the daily needs of the citizens, increase the proximity and the accessibility to workplace, and strengthening the neighborhood character. It is needless to say that different typologies of retail activities require different characteristics of spaces. Moreover the sustainable design ought to supply maximum flexibility for different uses. Therefore, one of the main principles for designing the retail's layout was to offer various spaces with different properties and sizes in order to promote the diversity of the functions. For this purpose, 10 shops are designed in the ground floor in 7 different types.

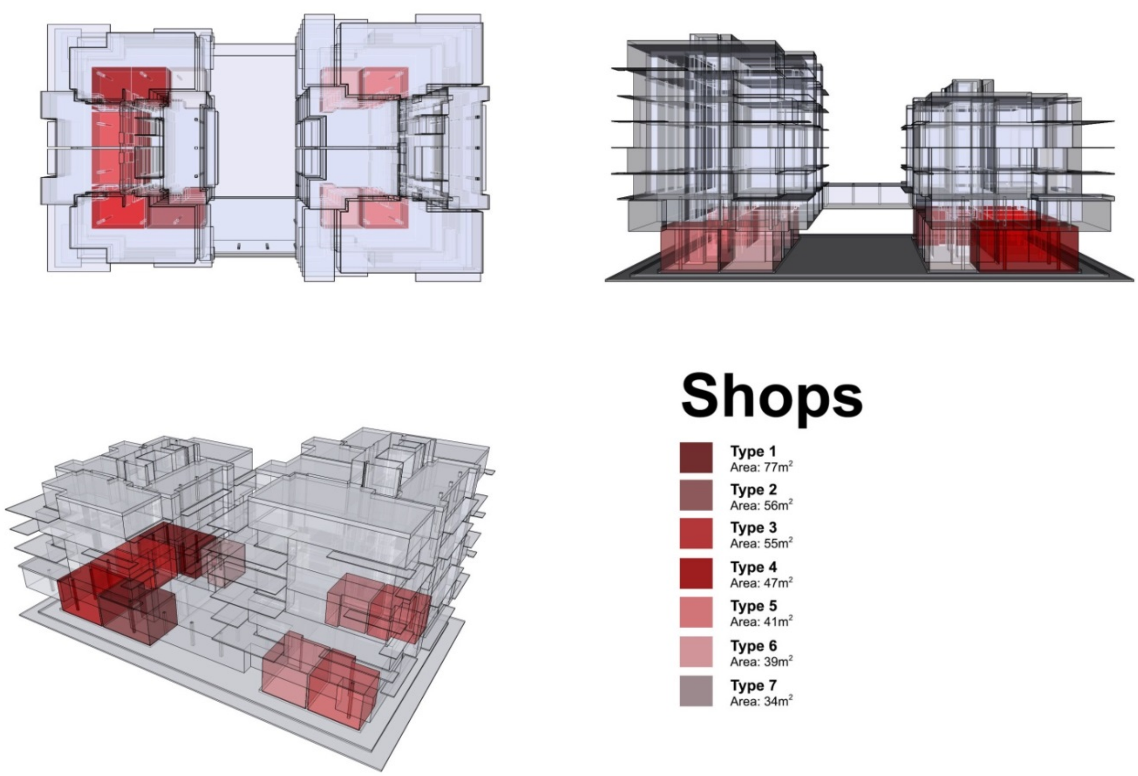


Figure 3-74 Designed spaces for retail activities

The access points of the shops obviously defined from the adjacent streets. Although the shops on the eastern side benefit a more strategic location, the semi-public court yard with four retail units inside acts as a powerful connector and produces a flow which reach to the western side too.

A significant design element here is the extended pedestrian area all around the retail level. This area acts as an intermediate space between the public streets and the shop windows and morphologically connects the building to its surrounding streets. Consequently the building is being smoothly related to its environment rather than divided with strong cuts. Moreover, the difference in the area of the ground level and the upper levels resulted from this extended area produces arcade shape space. With the hypothesis that all the new construction in the Qaem street follow the same pattern in their ground level, a powerful arcade system will be produced alongside the walking corridor which adds to the quality of space, and makes walking more pleasant, safer, and sheltered in rainy and snowy weathers.

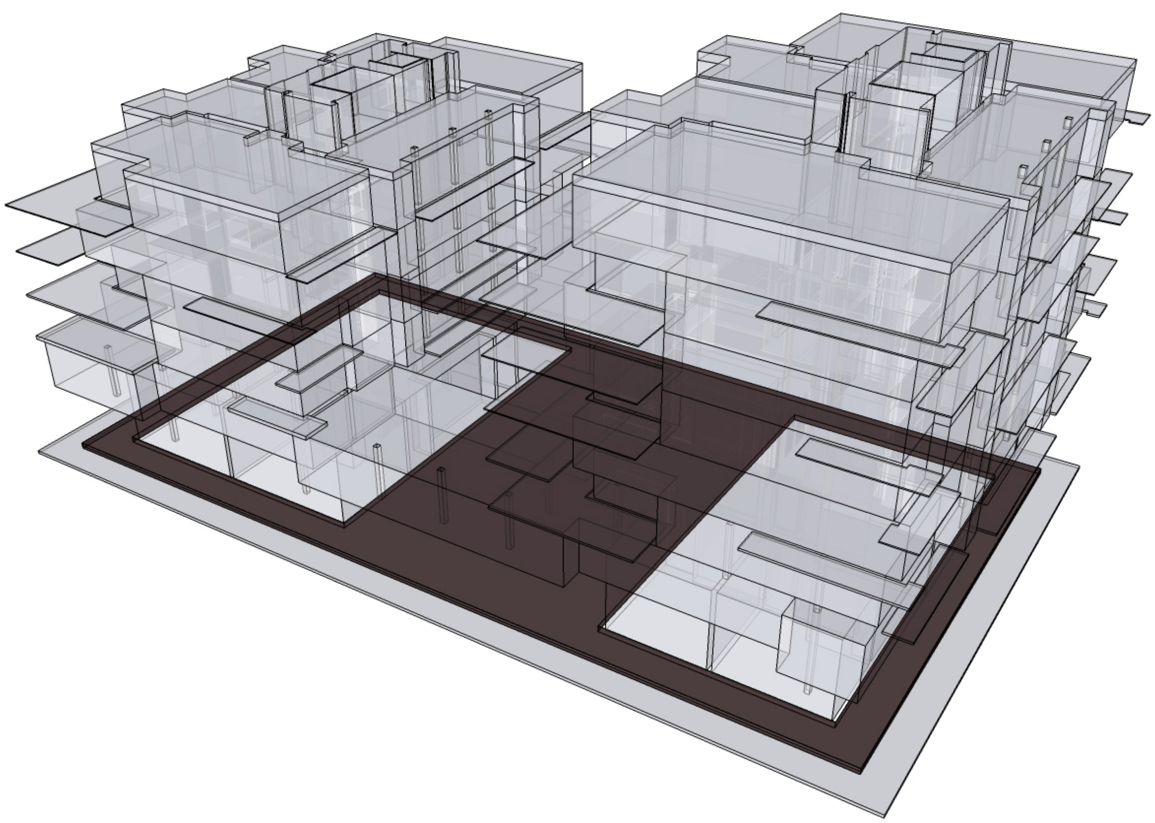


Figure 3-75 2.5m extended pedestrian pathway which together with the semi-public yard make a passage way with the area of 855m2

3.4.1.3.3.2.2 Offices (second Floor)

The second floor of the building is devoted to offices. This decision too, serves the goal of mixed-use development, and adds to the complexity of the area. Different types of activities mingled with each other reduce the unnecessary travels and increase the level of neighborhood's self-efficacy, and the mix of the administrative functions with retail activities could act very successfully in terms of creating a diverse context.

Similar to retail level, in designing the offices' layouts it has been tried to maintain the maximum flexibility. Various spaces designed in this level with respect to the nature of administrative functions. There are 10 office units designed with two different approaches toward their plans: Open layouts (Types 1 and 2), in which circulation is easier and the plan is more flexible for different uses, and closed layouts (Types 3 and 4), which provide spaces for activities those need calmer environments and private spaces (e.g. clinics, Law offices, etc.).

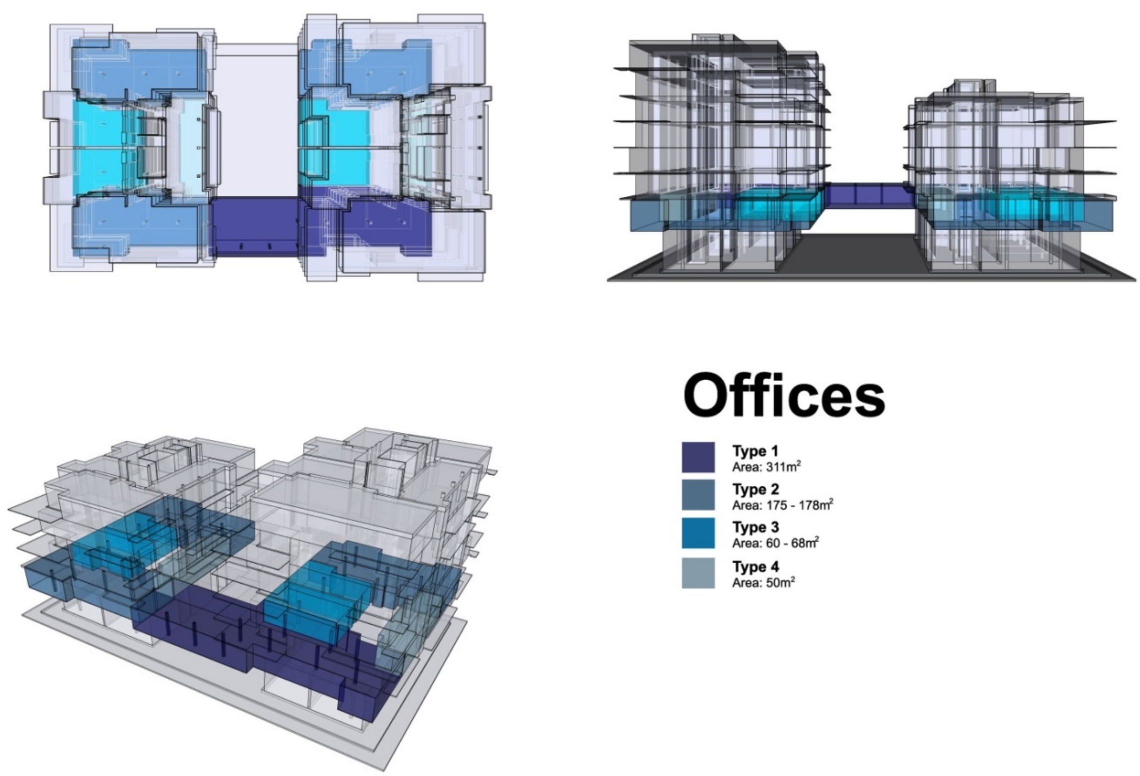


Figure 3-76 Designed spaces for offices

Because the administrative spaces are ought to be used mainly during the daytime, this level is enveloped with external walls with a rather high percentage of transparent cover. As it will be explained in the technological chapter the designing of the envelope is optimized based on the daylight factor analysis for each single unit.

Another specific feature of this level which tremendously affects the ultimate shape of the building is that in this story the northern building and the southern one are physically connected by an office space from the west.

3.4.1.3.3.2.3 Residential (2nd floor-7th floor)

As it mentioned earlier, due to the amount of solar energy that each building can gain, and the residential density that the whole complex should support, the northern building consists of 5 residential floors, whilst the southern building has 3 residential stories. Overall, 36 residential units with total area of 4028m^2 have been designed in this building.

The average number of household members in Tehran is 3.4, in Tehran province 3.6. The factors which explain the small size of the household in Tehran include: lower level of fertility, growth of the nucleus household; and increasing the number of households living in flats. However, the size of the household is not the same in all parts of the city. In the district 22 where the site is located this number reaches to 5 in some areas.

Supporting community and creating a good level of housing diversity are the main objectives in designing the residential floors. Accordingly, different residential units with different sizes and layouts have been designed. The design pursues the goal of providing various space of living suitable for wide range of citizens depended on their life stage, level of income, and the family sizes. The aim was to provide house for families with household members between 2 and 6. The potential of growing to bigger sizes also has been considered for small families, and the design supports the possible decision of a little family to develop its housing to the unit just next to their current apartment. Three types of housing units has been considered for this complex: large units with 3 bedrooms and yard-size balcony, medium units with 2 bedrooms and balcony, and small units with 1 bedroom and balcony.

3.4.1.3.3.2.4 Large Units

Large units could be suitable for families with 4 to 6 members. Their overall areas are between 172m^2 to 188m^2 and they contain three large bedrooms, a spiteful hall, 2 bathrooms (one with bathtub), and 2 balconies. All the bedrooms' areas can provide space for king-size beds, and in their envelop walls are placed windows with proper areas which allows a suitable range of daylight in. usually, one of the bedrooms has direct access to a small balcony with various view to the adjacent streets depended of the unit's location.

The living room is also supplied with proper sunlight due to its glazed envelope, and has an access to a private large balcony with the areas between 39m^2 to 63m^2. As it mentioned before in the Iranian housing culture, private yards as spaces for small gardening and family gatherings have a very strong root. The balconies designed for the large apartment in this complex could support such activities and act similar to traditional private yards. The parapet of all the balconies in this building (regardless of the area of the balcony) are designed with proper width to support small size gardening. In addition to being a cultural element for the residents, these gardening spaces create pleasant places with good quality of air and space. Moreover, they become a very strong feature of the external view of the building. There are 20 apartments of this typology in the complex.

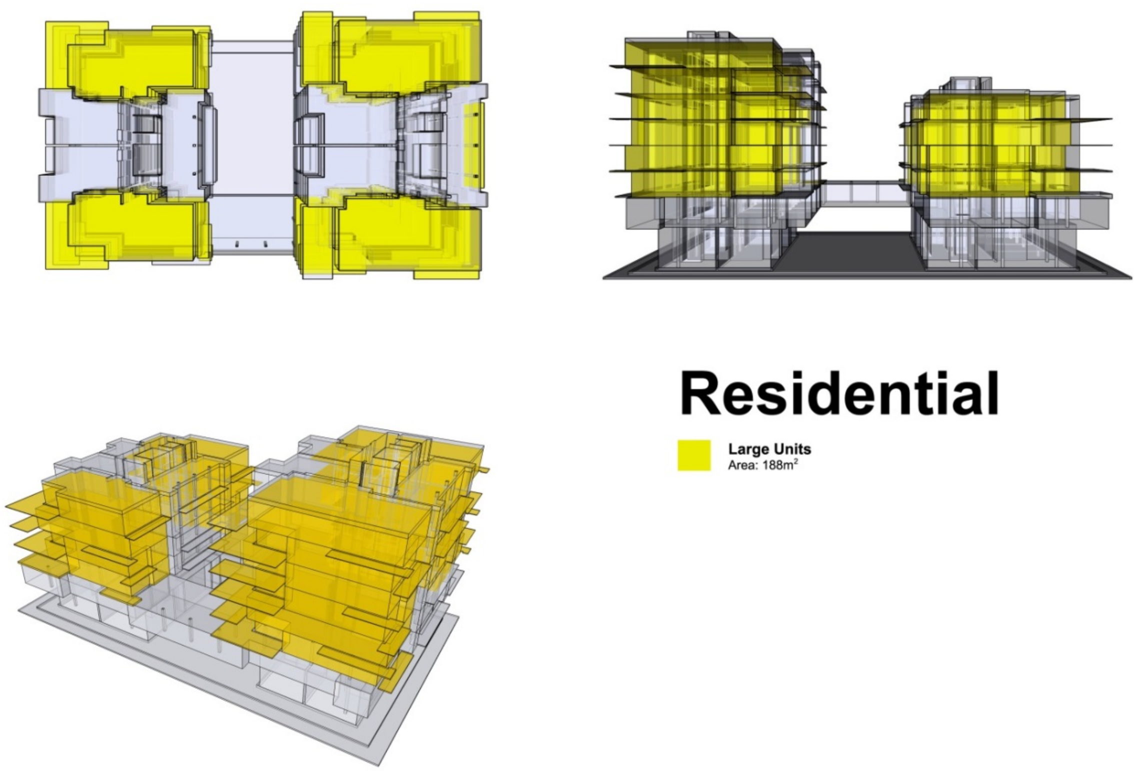


Figure 3-77 Large Residential Units

Figure 3-78 Typical Layout of Large Units

3.4.1.3.3.2.5 Medium Units

The medium units with 2 bedrooms, two bathrooms, and one slam balconies are suitable for families with 3 to 4 members. Their large living rooms have plenty of spaces and benefit from proper sunlight due to the amount of their glazed envelop. Two large bedrooms provide spaces for one king-size bed or three single beds in each. One of the bedrooms has a direct access to a small balcony, which has enough space to put a little table and three or four seats. There are storages in proper sizes designed in these units in vicinity of the bedrooms. There are overall 4 units of these apartments in the building.

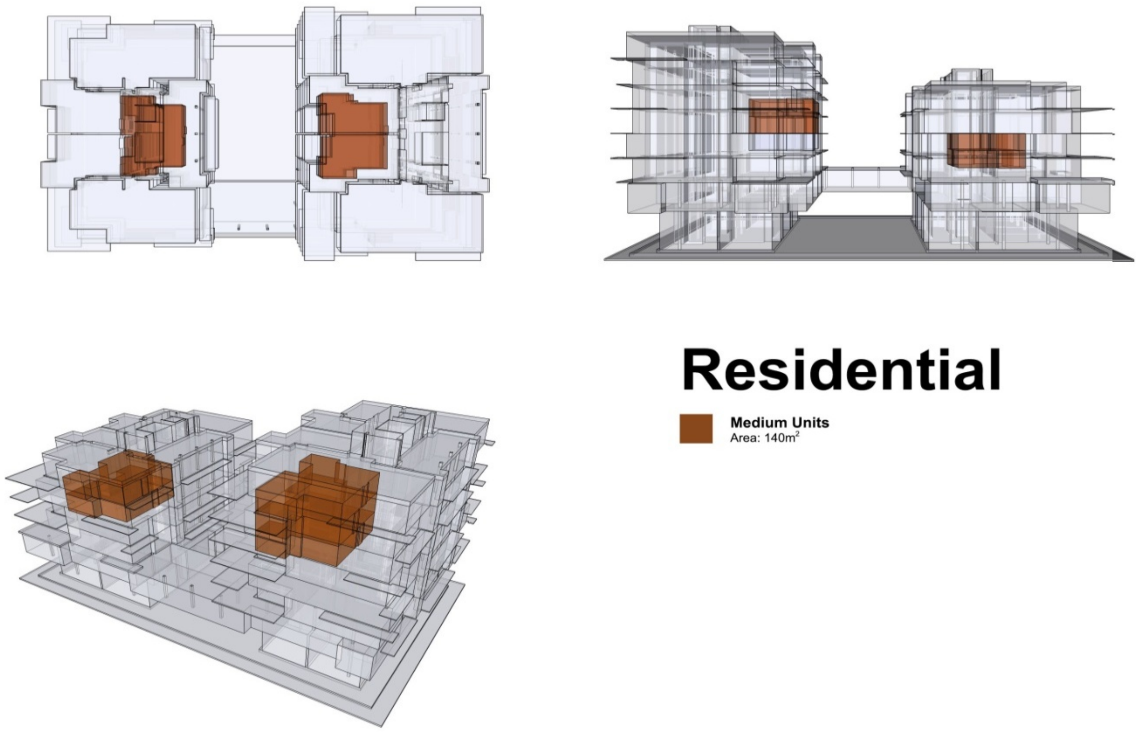


Figure 3-79 Medium Residential Units

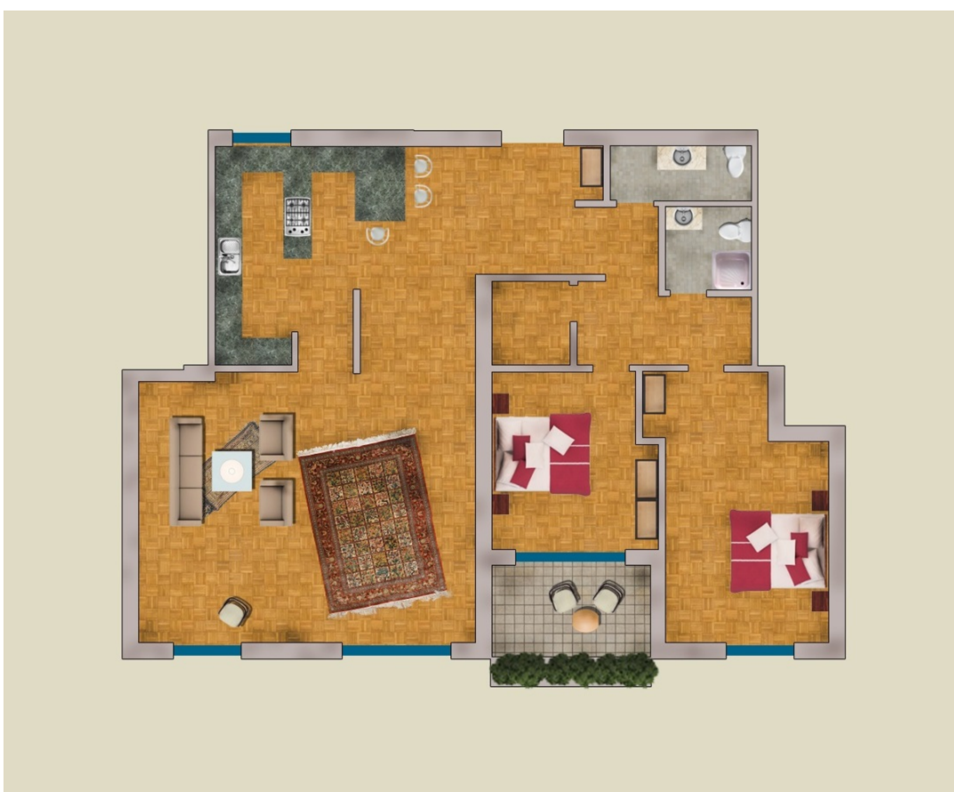


Figure 3-80 Typical Layout of Medium Units

3.4.1.3.3.2.6 Small Units

The small units with area of 68 m^2 are suitable for single persons or couples. They contain an average size living room with good light quality and a large bedroom with plenty of space. The living room has a direct access to a small balcony in the same size of them in the average units. Twelve apartments of such units are designed in the complex.

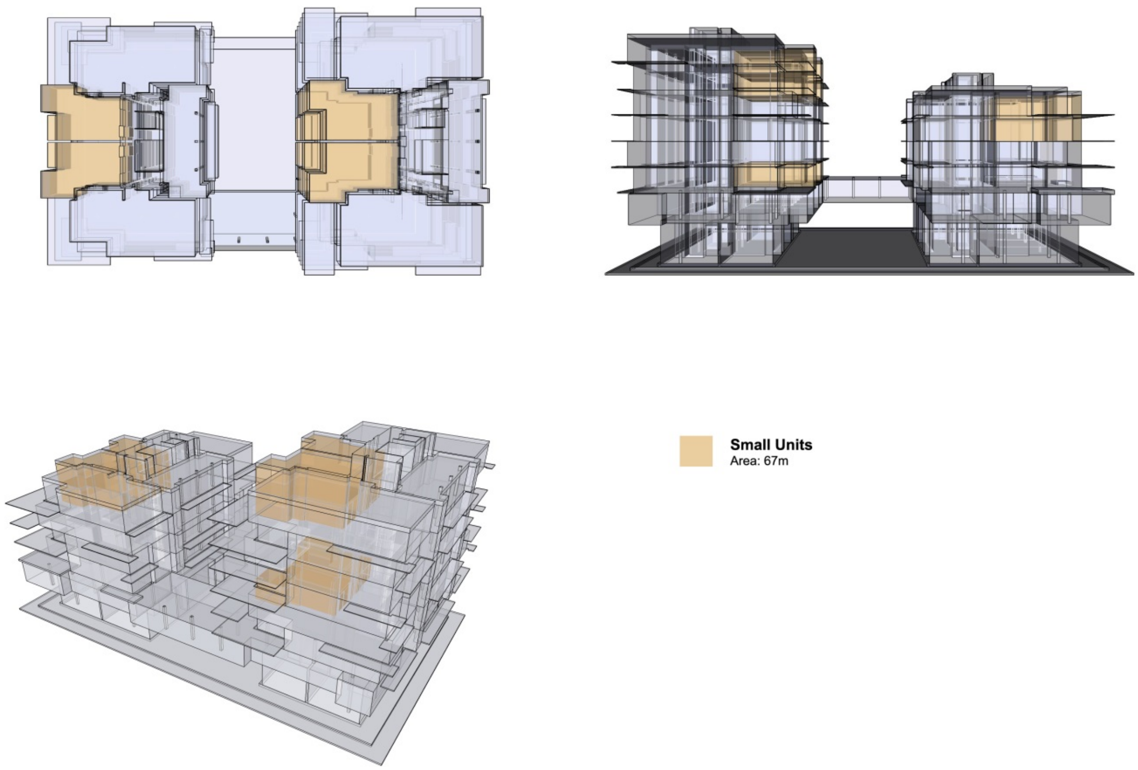


Figure 3-81 Small Residential Units

Figure 3-82 Typical Layout of Small Units

3.4.1.3.3.2.7 Community Spaces

With the aim of supporting the community, strengthening the social bonds, and supply the residents with needed activities, in each of the residential levels of both northern and southern buildings a community room has been designed. Variety of functions could be assigned to these spaces due to their flexible layouts. Depended to decision of the residents they could act as small kindergarten, gym, lobby, gathering room and etc. mix of such activities in different levels could create the building as a vertical lively neighborhood with a strong community and plenty of social functions. This strategy reduces the distances between house and some of the urban activities too, and helps prevention unnecessary trips.

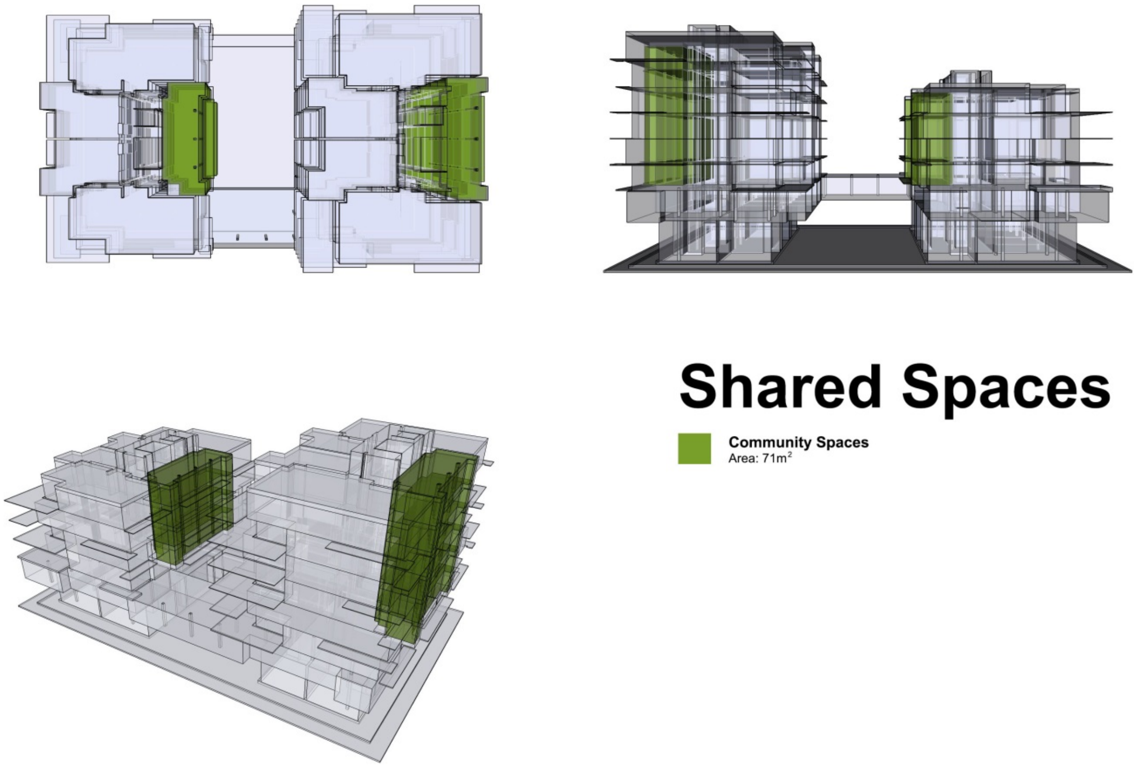


Figure 3-83 Community Spaces

Figure 3-84 possible functionalities of community spaces: Up: gathering room (Left), recreational room (Rigth)

Bottom: Gym (two levels could related to each other through the stairs and provide enough space for certain activities)

3.4.1.3.3.2.8 Other Shared Facilities

In figures 3-88 to 3-90 other shared facilities and building's elements including lobbies, vertical accesses, and green roof are illustrated:

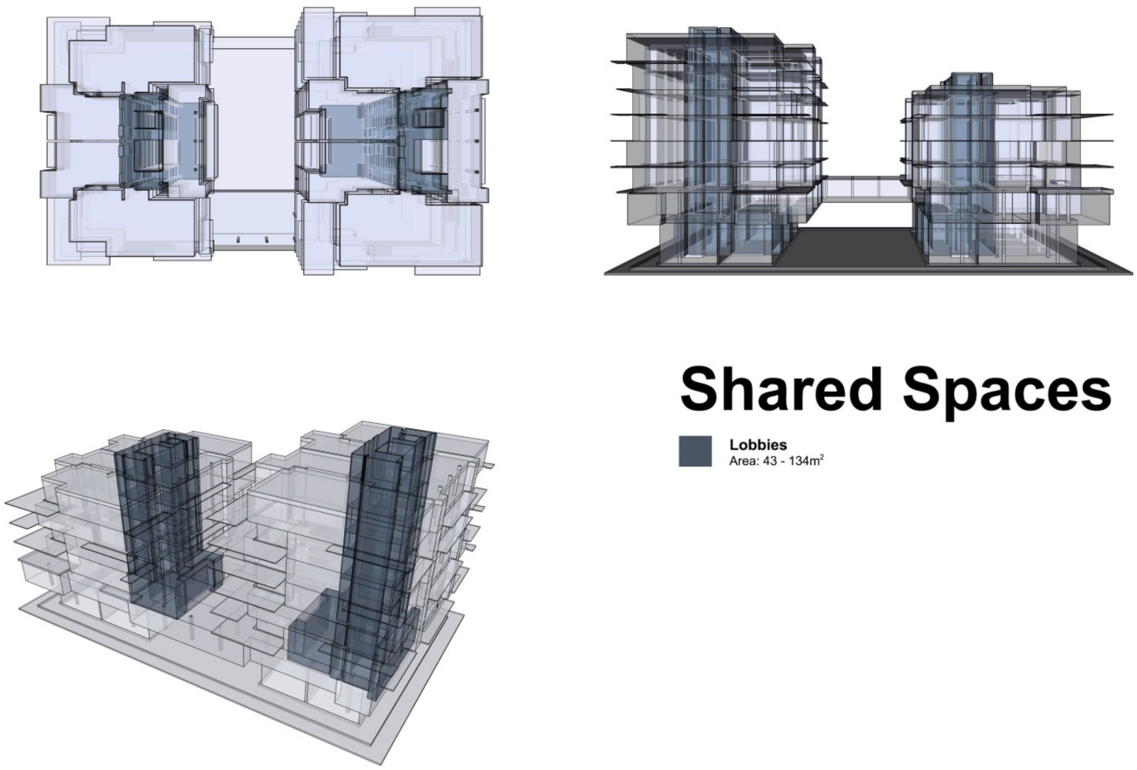


Figure 3-85 Lobbies

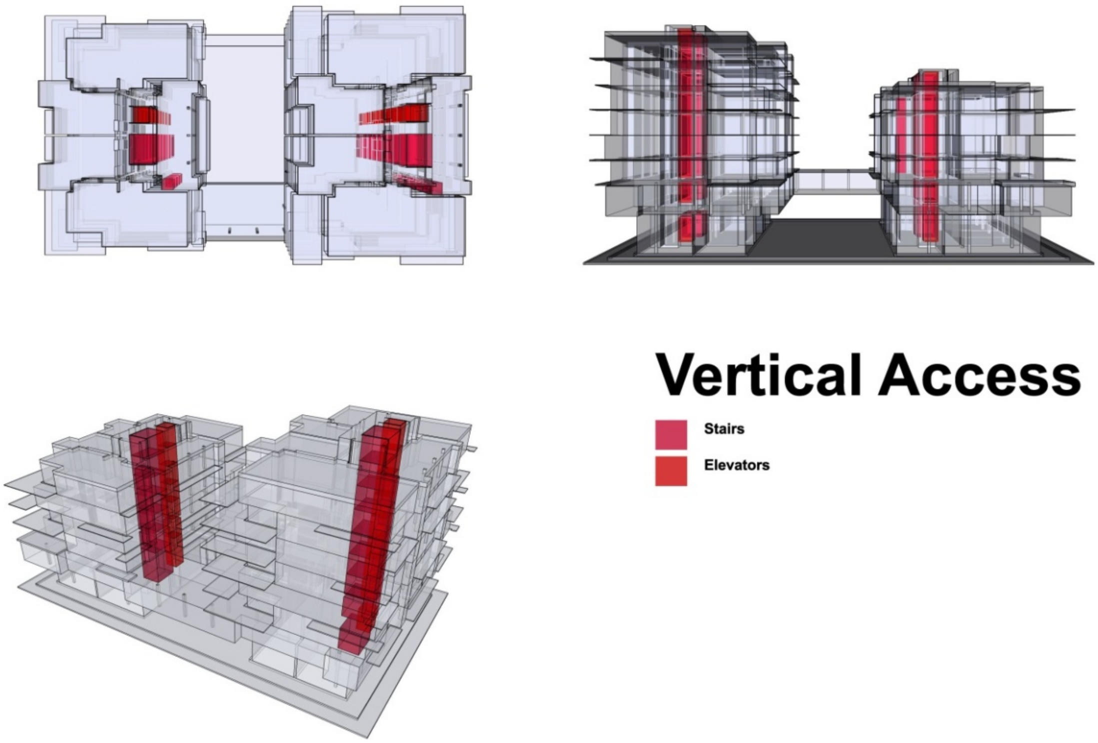


Figure 3-86 Vertical Accesses

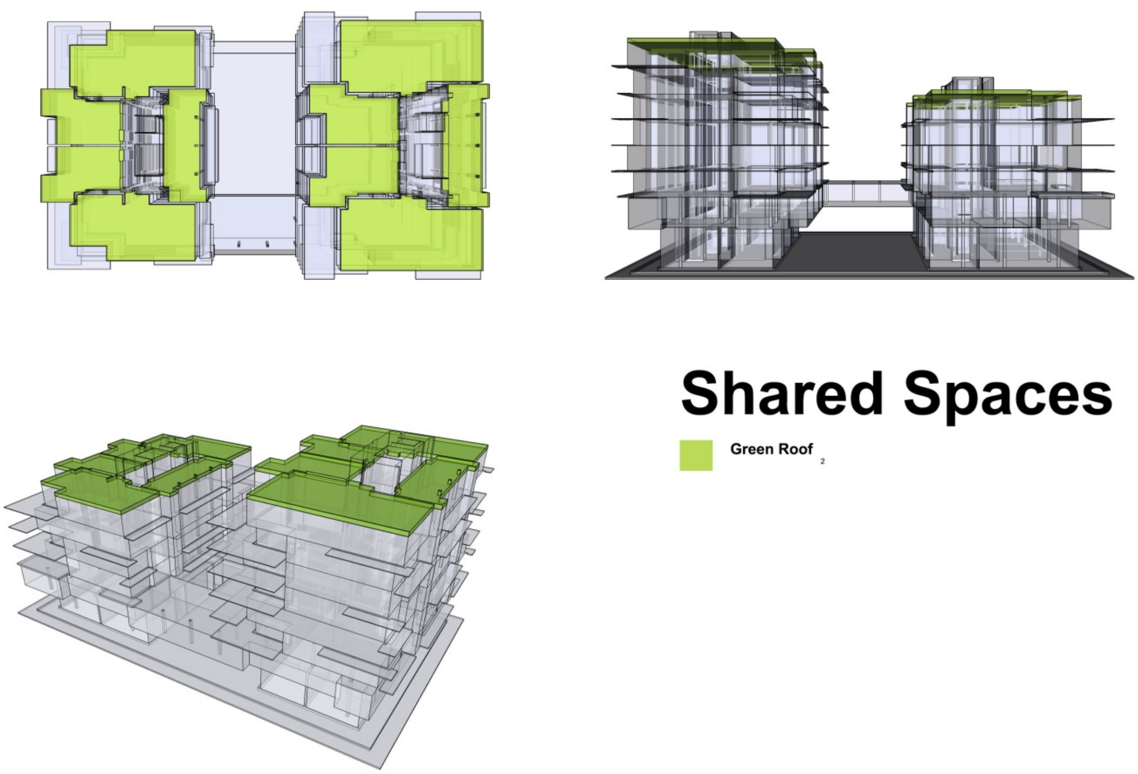


Figure 3-87 Green Roof

3.4.1.3.3.2.9 Levels

In this section, the features of different levels are illustrated in Figures 3-91 to 3-98 and their related information are brought in Tables 3-15 to 3-17.

Retail

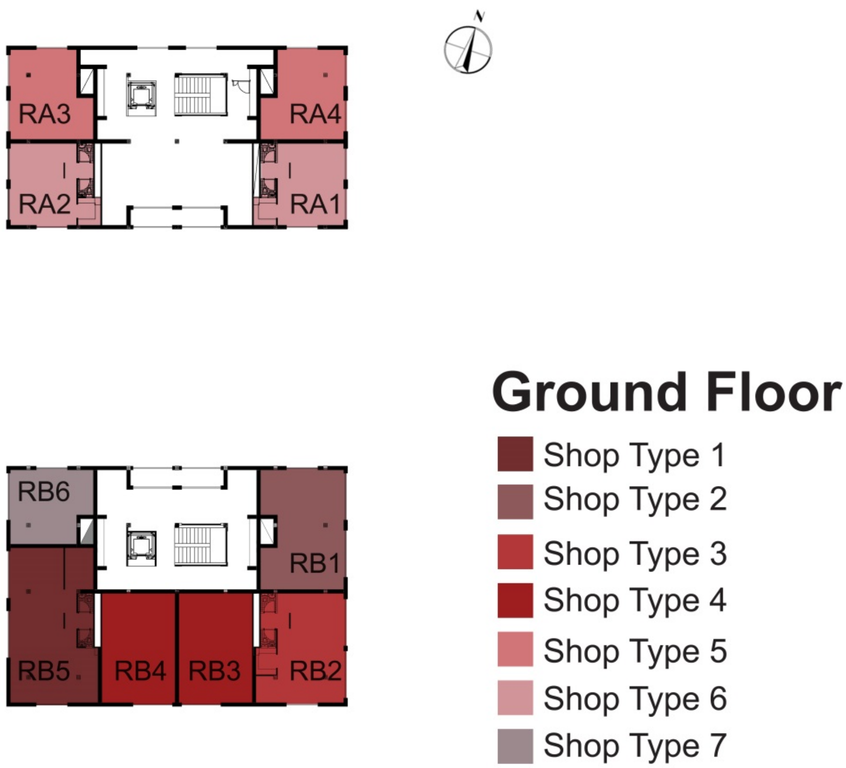


Figure 3-88 Ground floor dedicated to retail activities

Shops	Area
RA1	41
RA2	41
RA3	39
RA4	39
RB1	56
RB2	55
RB3	47
RB4	47
RB5	77
RB6	34
Total	**476**

Table 3-15 Shops' areas (areas are on m2)

Administraive

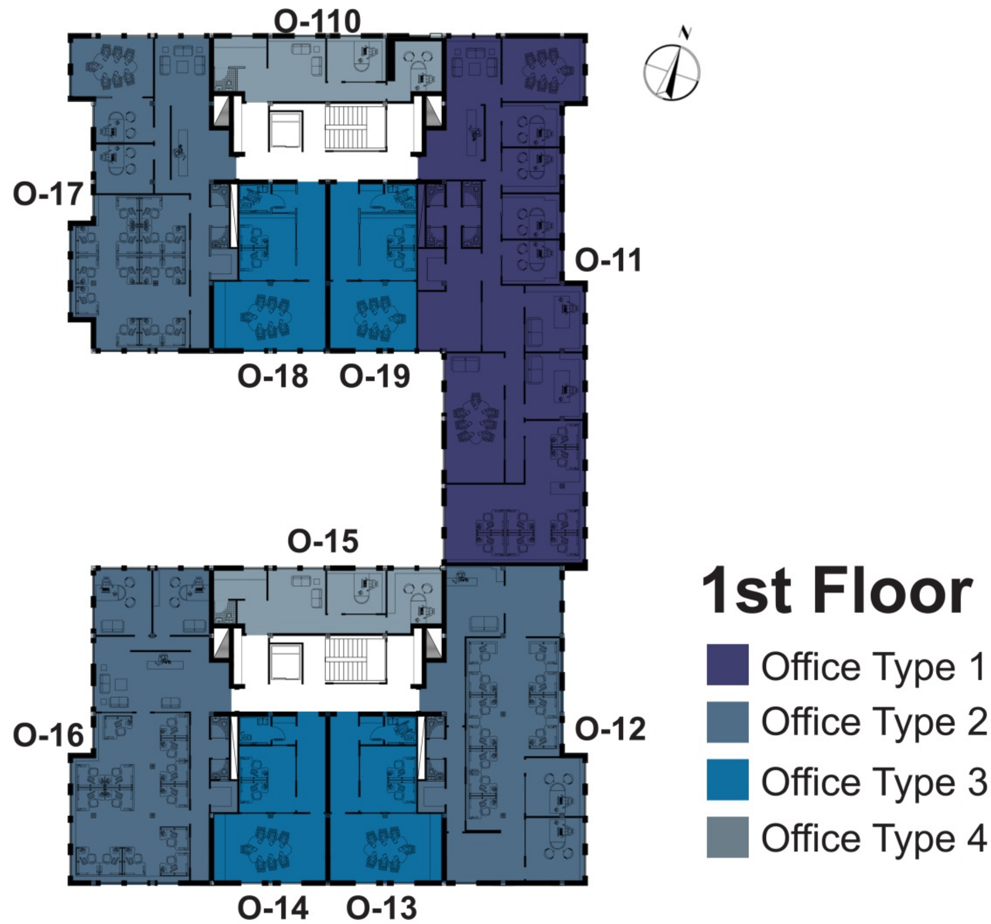


Figure 3-89 First floor which is designed for administrative activities

Offices	Area
O-11	311
O-12	178
O-13	67
O-14	67
O-15	58
O-16	175
O-17	178
O-18	68
O-19	60
O-110	58
Total	**1220**

Table 3-16 Offices' Areas (areas are on m2)

Residential

Figure 3-90 Second floor (Residential)

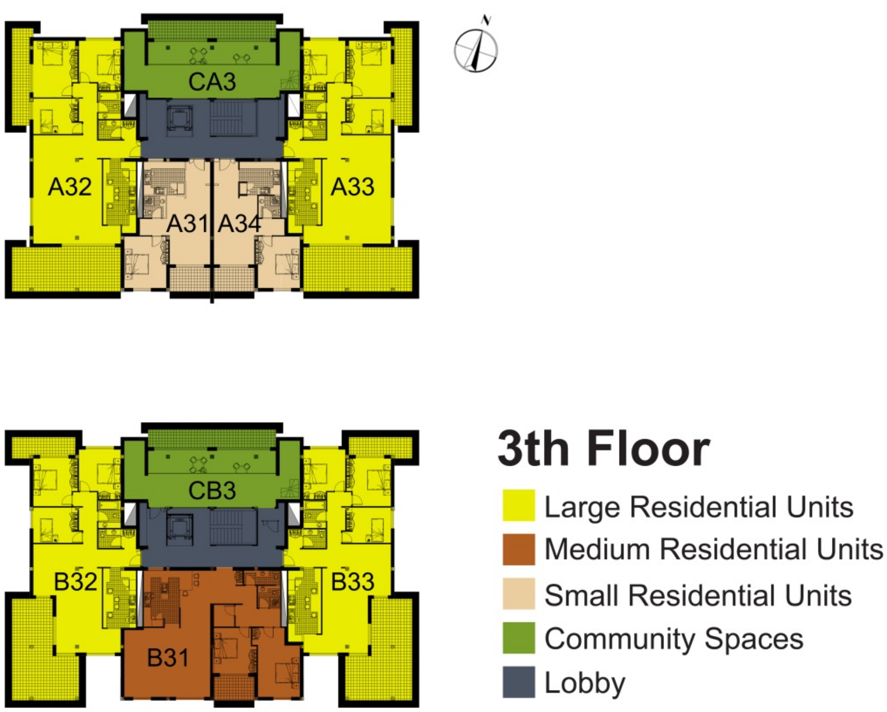


Figure 3-91 Third floor (Residential)

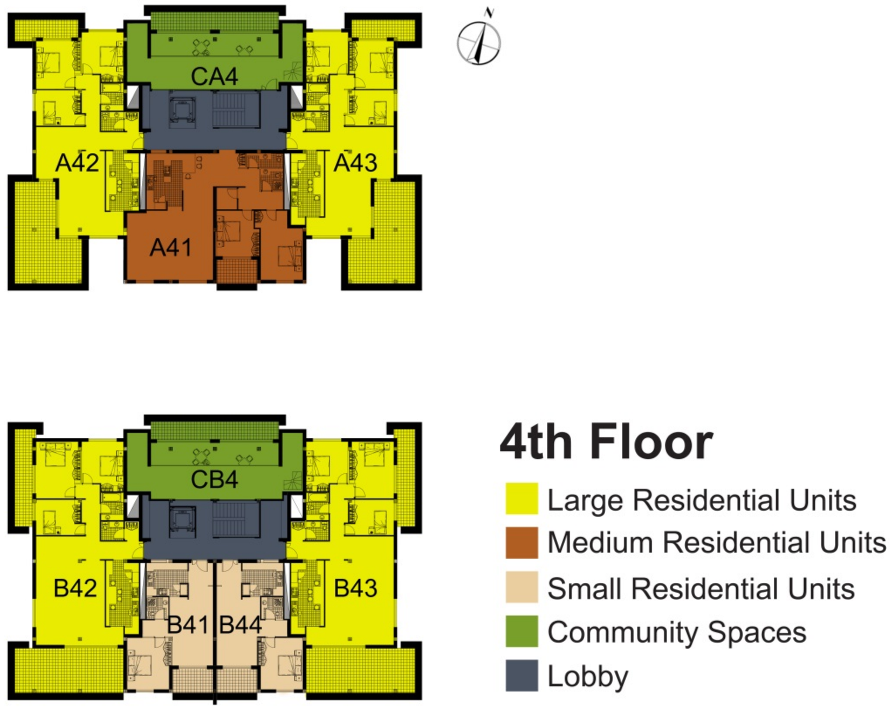


Figure 3-92 Fourth floor (Residential)

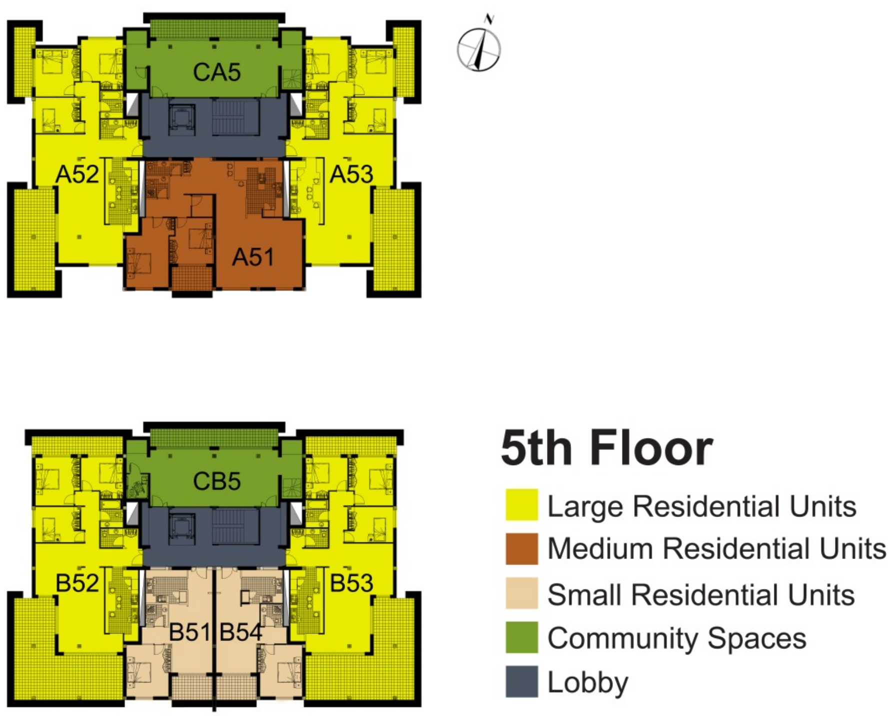


Figure 3-93 Fifth floor (Residential)

Figure 3-94 sixth floor (Residential)

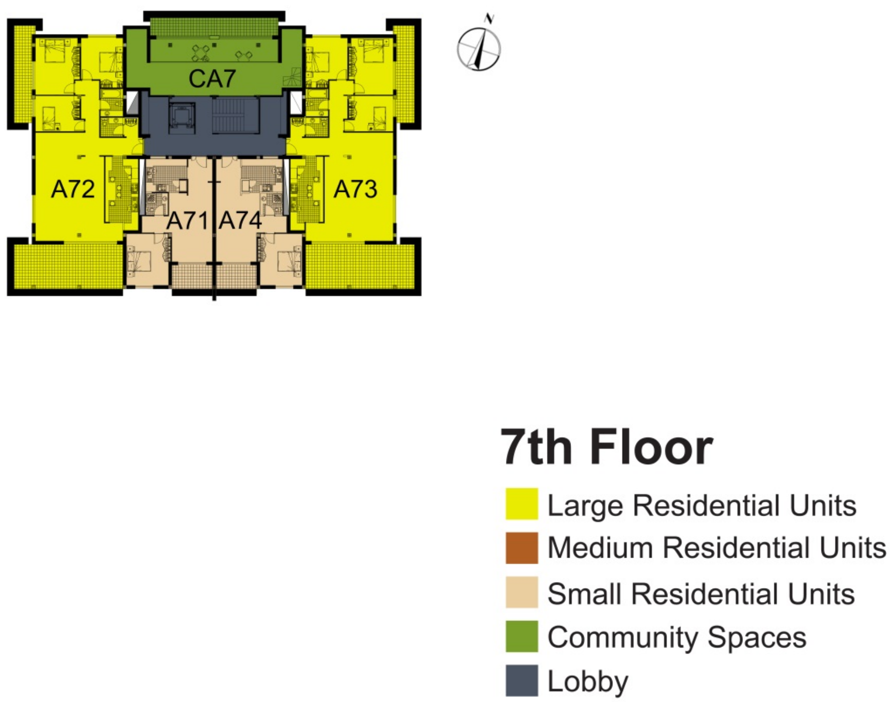


Figure 3-95 Seventh floor (Residential)

	Apartments	Sheltered Area	Balcony Area	Total Area
3rd Level	A31	61	7	68
	A32	125	63	188
	A33	125	63	188
	A34	61	7	68
	B31	133	7	140
	B32	137	39	176
	B33	136	39	175
4th Level	A41	133	7	140
	A42	126	46	172
	A43	128	46	174
	B41	61	7	68
	B42	140	48	188
	B43	140	48	188
	B44	61	7	68
5th Level	A51	133	7	140
	A52	137	39	176
	A53	136	39	175
	B51	61	7	68
	B52	125	63	188
	B53	125	63	188
	B54	61	7	68
6th Level	A61	61	7	68
	A62	125	63	188
	A63	125	63	188
	A64	61	7	68
7th Level	A71	61	7	68
	A72	140	48	188
	A73	140	48	188
	A74	61	7	68
Total		**3119**	**909**	**4028**

Table 3-17 Areas of different spaces in residential levels

In the following pages some architectural rendering of the building are shown.

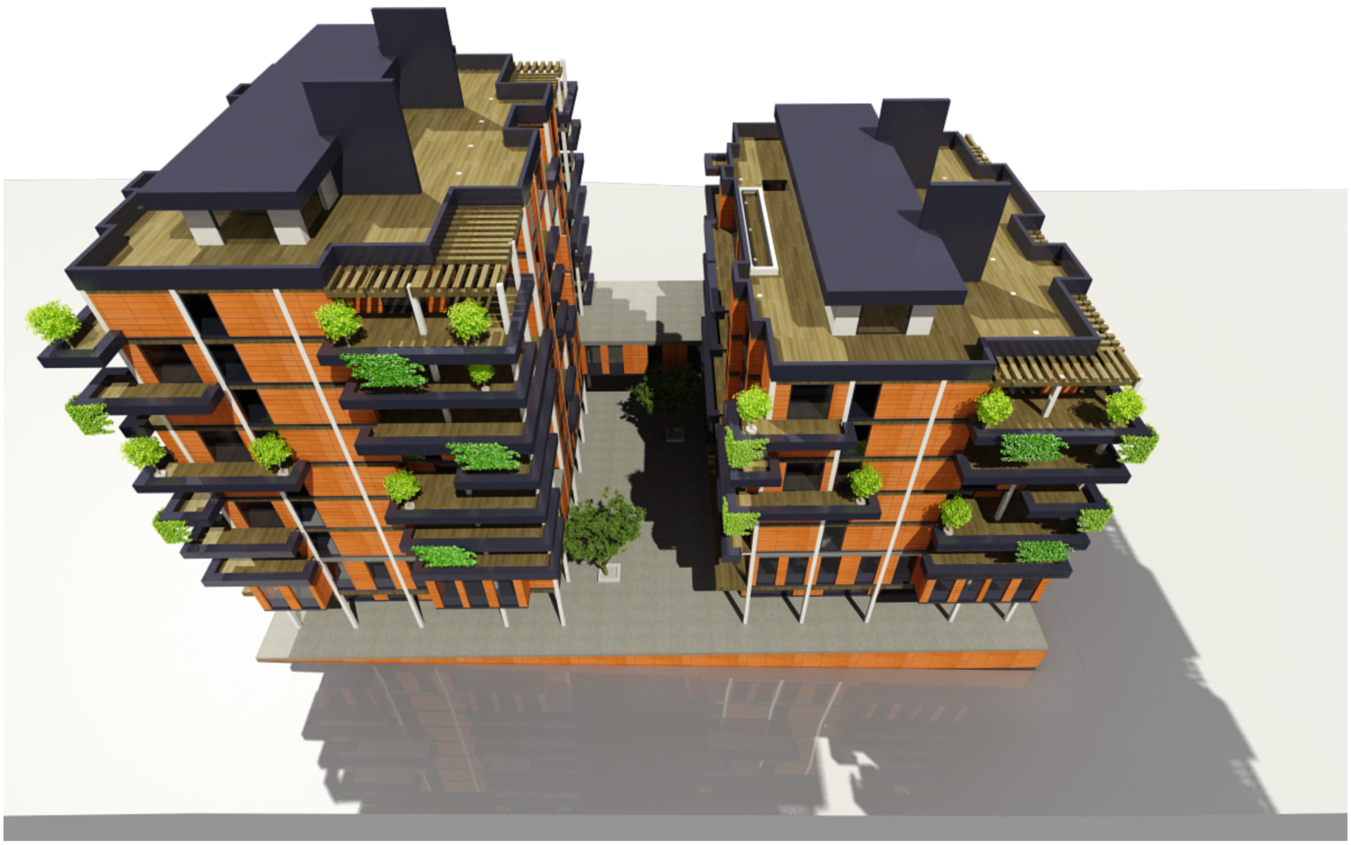


Figure 3-96 Building 3D model

Figure 3-97 Building Elevation (N-E)

Figure 3-98 Building view from walking corridor

Figure 3-99 Building view from semi-public yard

Figure 3-100 Building view (N-E)

3.4.1.4 Conclusion

Comparing with the existing situation, the most dominant feature of the proposed architectural design is its compactness. According to the common morphological approach in Tehran, and with consideration the land area, the maximum built up area would be 6950 m^2 in that land which all would be dedicated to residential use.

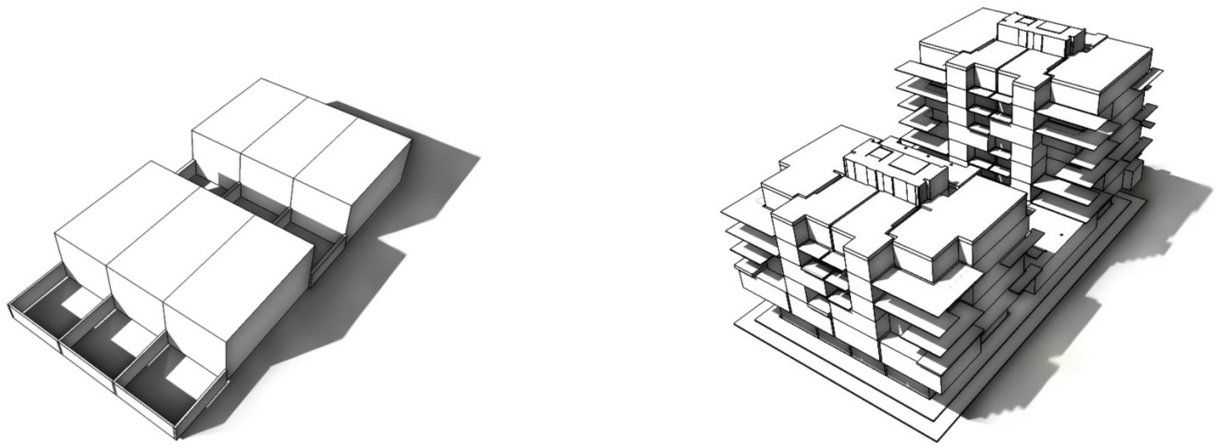


Figure 3-101 formal comparison between actually existing morphology (Left), and the proposed design (Right)

In the design proposed in this thesis, the total residential area would be 4028m^2. This amount is more that 30% more than that in the existing situation (near 3080m^2), whilst the total built density of this building is being 4.1 which is near 3.4 times of the average built density in Shahrak-e Golestan.

In the Comprehensive Plan of the District 22 is depicted that with respect to the land's size, increasing density is allowed by a proper justification plan. Of course increasing the residential density should be supported by providing the needed facilities for the exceeding population. This has been considered by designers and accordingly 2246m^2 of the total area has been designed for different activities which as been explained before are retail, administrative activities, and community spaces. Amongst them, retail and administrative activities would nourish the whole neighborhood and provide job opportunities, and also add values to neighborhood's characteristics. On the other hand, designed community spaces would provide some of the needed facilities for the building's residents, and strengthens their social bond through involving them in shared activities. In the existing typical buildings, the only shared shared between the residents is the private yard which with its lost identity solely acts as a deadly passageway.

On the contrary of the boxlike and straightforward volume of the typical buildings existing in the actual situation, the volume proposed here is location sensitive and create functional, and morphological integration with the surrounding.

In the Table 3-18 some of the features of the proposed architectural design are compared with those of the common architecture which is practiced in the actual situation:

	Actual	Design
Residential Area	$3080m^2$	$4028m^2$
Administrative Area	none	$1220m^2$
Retail Area	none	$476m^2$
Shared Facilities	none	$568m^2$
Residential Density	1.8	2.4
Built Up Density	2.4	4.1

Table 3-18 Comparison between actually existing morphology and the proposed design

3.4.2 Technological Design

3.4.2.1 Introduction

Although there is no exact statistics of the amount of energy being consumed in Tehran's residential section, it is not difficult to conclude that the city has a dramatic situation in that field. Tehran is the largest city of a country which has the world's 3rd place in residential energy consumption; and assuming that the Tehran's share would be at least 30% of the whole, the seriousness of current situation, and the necessity of taking new consumption approaches becomes much more tangible.

Accordingly, energy efficiency stands in a high level of importance with an immediate priority in designing the building which is proposed in this study. In this chapter the different aspects of technological design which has been practiced in this thesis is explained.

With envelop designing, studying the orientation of the building, choosing energy efficient materials, optimizing solar gain through designing proper area of glazing envelope and shading strategies, and etc. it has been tried to reduce the building's energy consumption in a considerable value.

Designing in Tehran, it is necessary to study it climate to learn about the environmental features and possible cooling and heating loads. Below general features of Tehran's climate is explained briefly:

3.4.2.2 Climate

Tehran is coordinated in 35°41′46″N 51°25′23″E in hillside of Alborz Mountains. Its elevation can rise up to 1900m from the sea level in its northern parts.

Tehran features a semi-arid, continental climate. Tehran's climate is largely defined by its geographic location, with the towering Alborz Mountains to its north and the central desert to the south. It can be generally described as mild in the spring and autumn, hot and dry in the summer, and cold in the winter. Because the city is large with significant differences in elevation among various districts, the weather is often cooler in the hilly north than in the flat southern part of Tehran.

Summer is usually hot and dry with very little rain, but relative humidity is generally low and the nights are cool. Most of the light annual precipitation occurs from late autumn to mid-spring, but no one month is particularly wet. The hottest month is July, mean minimum temperature 26 °C; mean maximum temperature 36 °C, and the coldest is January, mean minimum temperature −1 °C; mean maximum temperature 8 °C.

Tehran has seen an increase in relative humidity and annual precipitation since the beginning of the 21st century. This is most likely because of the afforestation projects, which also include expanding parks and lakes. The northern parts of Tehran are still lusher than the southern parts.

Tehran's climate can be described to have some monsoon influences; the summers are very dry, and the spring and fall are rather lush, with the main precipitation occurring at this time.

Figure 3-102 Topographical map of Tehran

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	19.6 (67.3)	23.0 (73.4)	28.0 (82.4)	32.4 (90.3)	37.0 (98.6)	41.0 (105.8)	43.0 (109.4)	42.0 (107.6)	38.0 (100.4)	33.4 (92.1)	26.0 (78.8)	21.0 (69.8)	43 (109.4)
Average high °C (°F)	7.9 (46.2)	10.4 (50.7)	15.4 (59.7)	22.1 (71.8)	27.9 (82.2)	33.9 (93)	36.6 (97.9)	35.6 (96.1)	31.6 (88.9)	24.4 (75.9)	16.2 (61.2)	10.0 (50)	22.67 (72.8)
Average low °C (°F)	−0.4 (31.3)	1.2 (34.2)	5.4 (41.7)	11.2 (52.2)	16.1 (61)	20.9 (69.6)	23.9 (75)	23.3 (73.9)	19.3 (66.7)	13.3 (55.9)	6.7 (44.1)	1.7 (35.1)	11.88 (53.39)
Record low °C (°F)	−15.0 (5)	−13.0 (8.6)	−8.0 (17.6)	−4.0 (24.8)	2.4 (36.3)	5.0 (41)	14.0 (57.2)	13.0 (55.4)	9.0 (48.2)	2.8 (37)	−7.0 (19.4)	−13.0 (8.6)	−15 (5)
Precipitation mm (inches)	34.6 (1.362)	32.2 (1.268)	40.8 (1.606)	30.7 (1.209)	15.4 (0.606)	3.0 (0.118)	2.3 (0.091)	1.8 (0.071)	1.1 (0.043)	10.9 (0.429)	26.0 (1.024)	34.0 (1.339)	232.8 (9.166)
Avg. rainy days	9.1	8.4	10.9	10.7	8.8	3.0	2.1	1.3	1.0	5.2	7.1	8.8	76.4
Avg. snowy days	5.1	2.9	1.1	0.1	0	0	0	0	0	0	0.4	2.7	12.3
% humidity	64	56	48	41	33	25	26	26	27	36	49	62	41.1
Mean monthly sunshine hours	173.6	182.8	205.5	222.8	289.5	345.1	349.5	340.3	304.0	256.1	194.9	166.1	3,030.2

Figure 3-103 Climate data for Tehran: Mehrabad Airport (Altitude: 1190.8m), which is very close to the intervention site

3.4.2.3 General Technological Strategies

Figure 3-104 Winter Strategies

Figure 3-105 Summer Strategies

3.4.2.4 Shading Proposal

One of the main strategies in architectural design was to develop the peripheral features of building's volume in a way to allow the optimum solar gain inside the internal spaces. Therefore, typical layouts for all the story levels have been avoided, and each level has been designed with respect to its effect on the rest of the building. Accordingly, balconies with different geometrical features were designed in different levels and the position of windows has been decided with respect to architectural elements of their upper levels.

Afterwards, the amount of solar gain for the ultimate design has been checked by means of measuring the Daylight Factor for each of internal spaces. In this section, a strategy for shading the internal spaces in which the range of solar gain during the year may become critical is discussed, and different technologies for that purpose are proposed.

In this thesis, Daylight Factor analysis has been carried out using the software "Velux Daylight Visualizer 2". The result of this analysis for critical spaces is indicated in the appendix. Each of internal spaces has been considered separately, and here the shading devices are proposed only for the spaces those their average Daylight Factor exceeds 5%. The classification of different shading strategies are depended to the usage of spaces, architectural elements nearby the transparent envelopes, and the range of Daylight Factor. Overall three different shading strategies for the transparent envelopes of the designed building are proposed: terracotta sunscreens, green curtains, and window blinds.

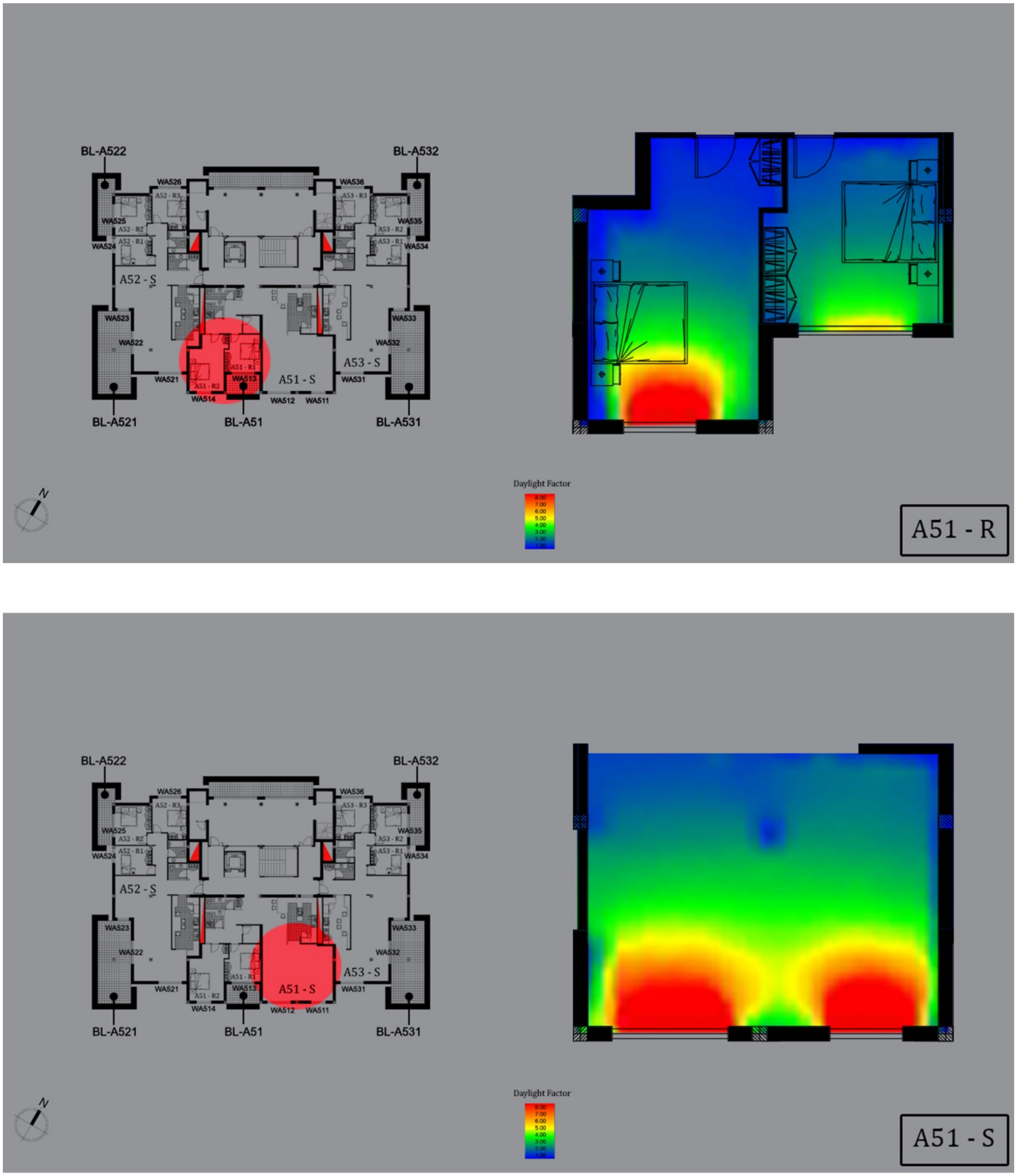


Figure 3-106 Example of daylight factor analysis in a medium residential unit (A51)

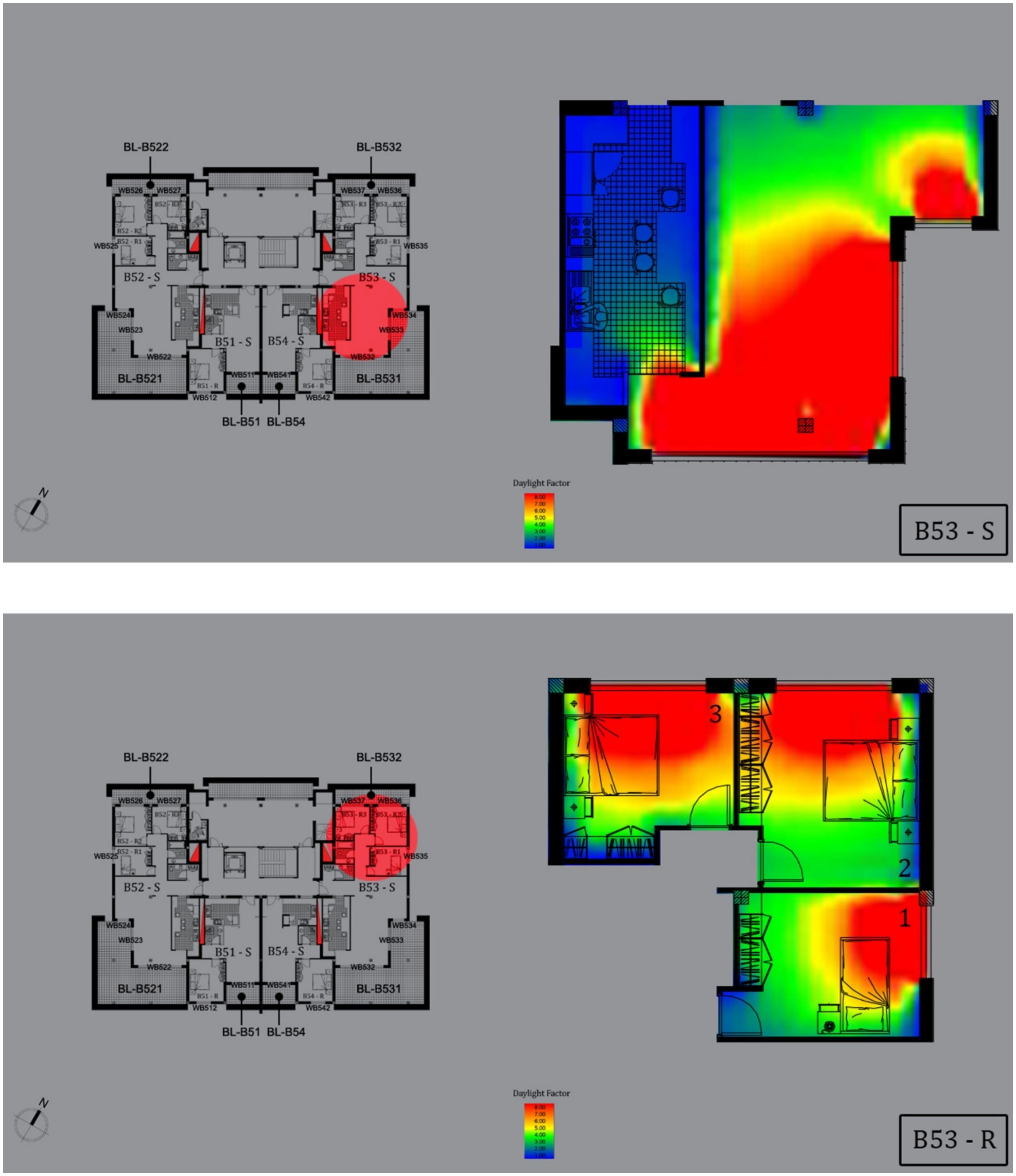
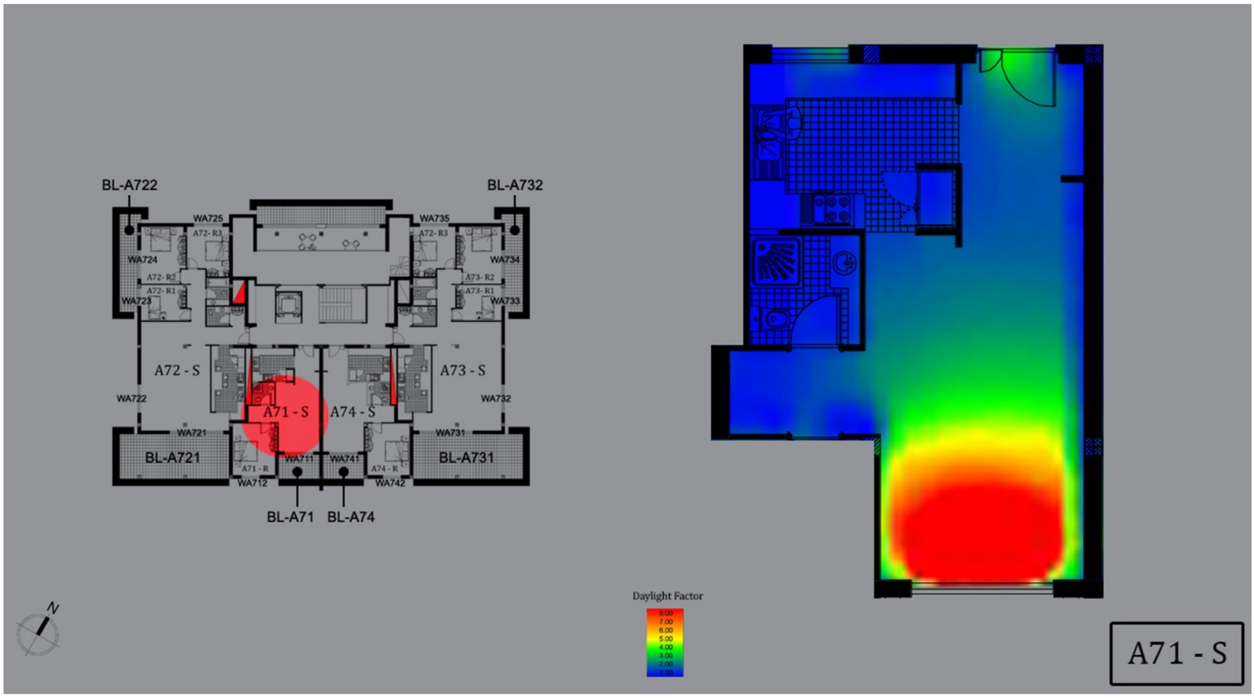


Figure 3-107 Example of daylight factor analysis in a large residential unit (B53)



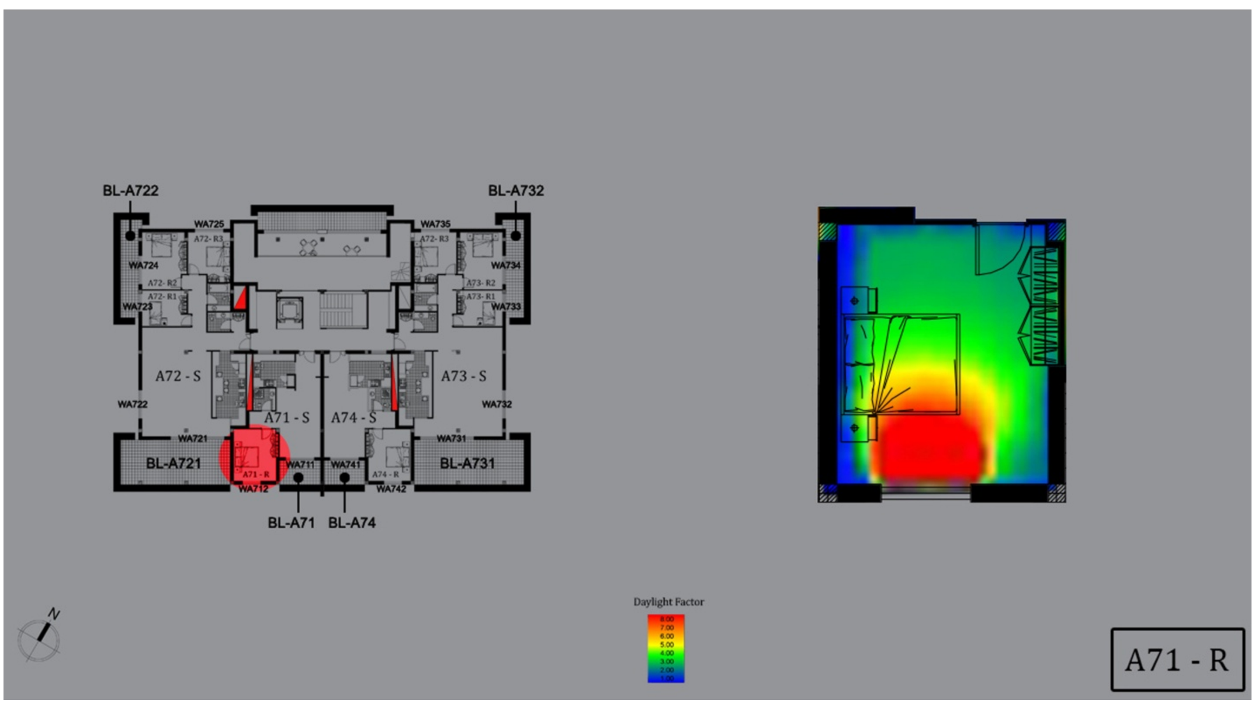


Figure 3-108 Example of daylight factor analysis in a small residential unit (A71)

3.4.2.4.1 Terracotta Sunscreens

This technology is suggested for the office level (Second Floor). Due to the large glazed area in this level, sunscreens seemed to be an appropriate choice, and for being visually compatible with the façade, terracotta is suggested as their material.

Sunscreens are so beneficial in terms of energy efficiency. In summer the sun is high in the sky and solar radiation is largely blocked by the sunscreen, which either reflects or absorbs it. As a material with a high thermal inertia, terracotta delays and reduces the re-emission of energy absorbed within it. Non-transmitted energy does not even reach the windows, which therefore does not heat up from a local greenhouse effect. By dramatically reducing the cooling load, applying this strategy decreases the need of using mechanical cooling in the offices.

Moreover, being strong absorbers of incident solar energy, terracotta sunscreens play an equal role as horizontal reflectors. Incident light bounces off the horizontal surfaces of the sunscreens and supplements direct lighting through solar radiation, with indirect light which penetrates more deeply into the room.

In winter, incident solar radiation, produced by a sun which is low on the horizon, does not suffer from the presence of a sunscreen. The shade it provides is weak on this occasion due to the space between the blades, if it has been installed in its traditional orientation with the blade horizontal. Then there is full benefit from the reduced need for electric heat and light; without disturbing the effectiveness of the openings normally provided in a building. A sunscreen also allows for the inclusion of larger, more productive bays in the design, carefully sized in relation to the orientation of the façade without the downside of overheating in summer.

In Fig 3-109 one possible type of terracotta sunscreen is illustrated.

Figure 3-109 Terracotta sunscreen suggested for glazed areas in offices (first level)

With adjusting the spacing of the blades between 150mm and 200mm, the range of shaded area becomes 27% to 21% when sun is at 0° height of shade and 77% to 58% when sun is at 45° height of shade. With consideration Tehran's climate and solar path, these ranges could be appropriate.

According to Daylight Factor analysis, critical places in offices are mainly the whole eastern and western envelopes and the southwest corners in both northern and southern buildings(Figure 3-110).

In figure 3-111 Daylight Factor analysis for the office O-16 is illustrated as heat map. The average DF for this space is 6.9% which is rather high in terms of overheating risks as well as sharpness of sunlight. With installing Hermattan® Sunscreens (with spacing of 150mm between two blades) on the glazed envelope of the room, DF has been analyzed for the same room and the result is illustrated in the figure 3-112. in this case the average of DF becomes 3.3 which is a preferable amount.

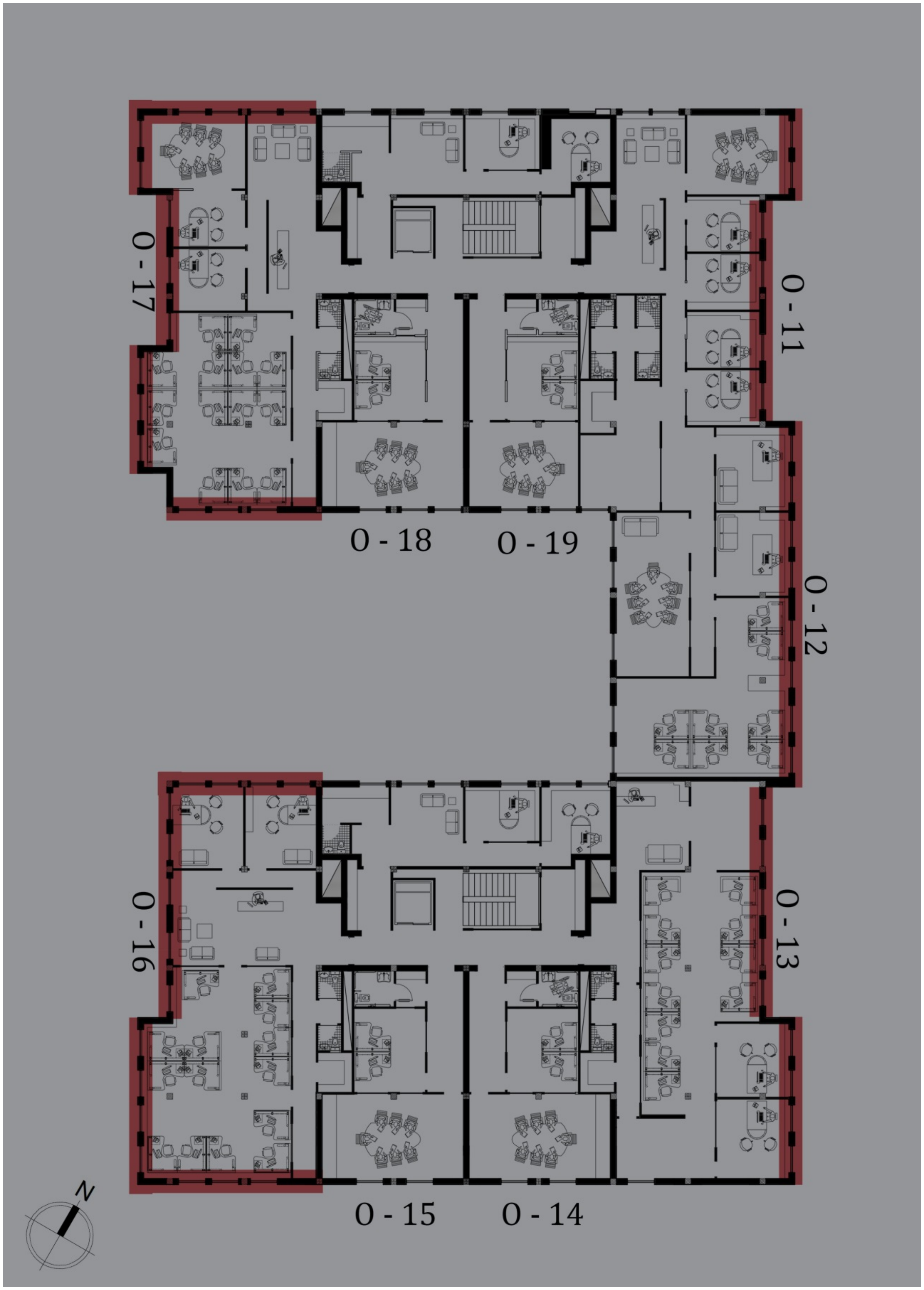


Figure 3-110 Critical envelopes of second floor (offices) with respect to Daylight Factor analysis (shown with red color)

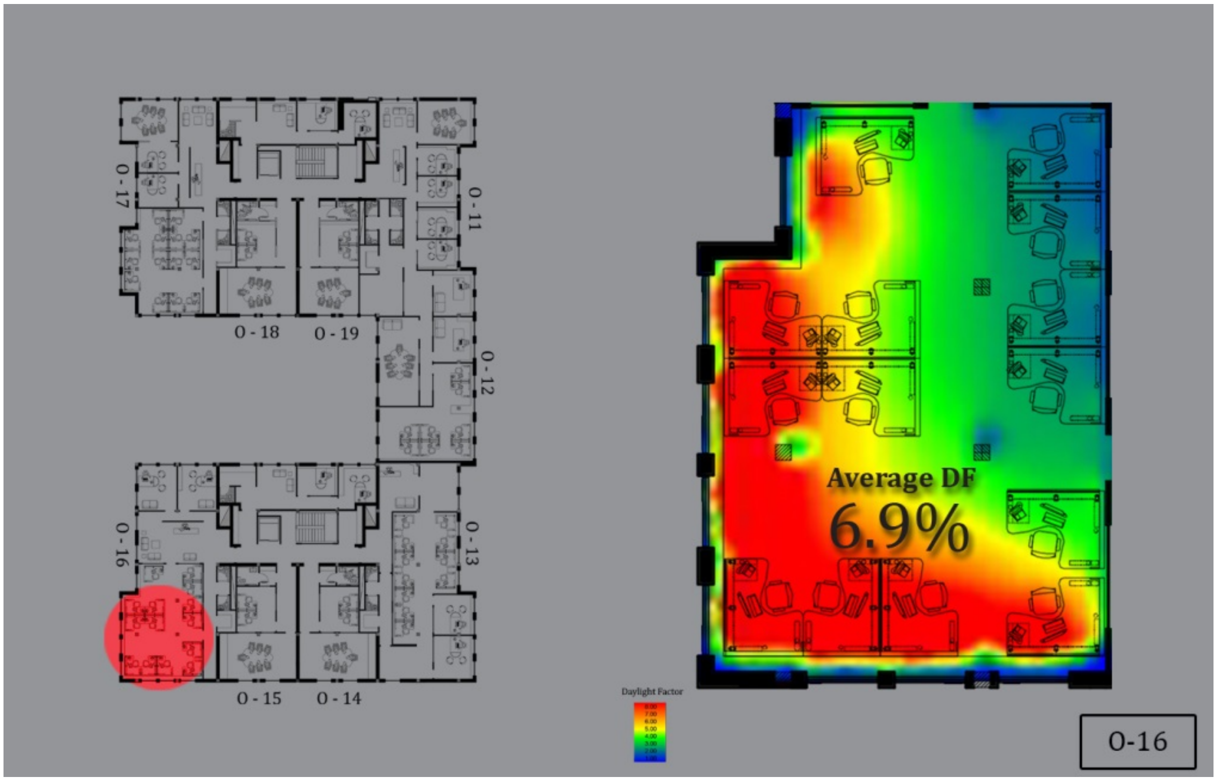


Figure 3-111 DF analysis for the office O-16 when the glazed envelopes are not shaded

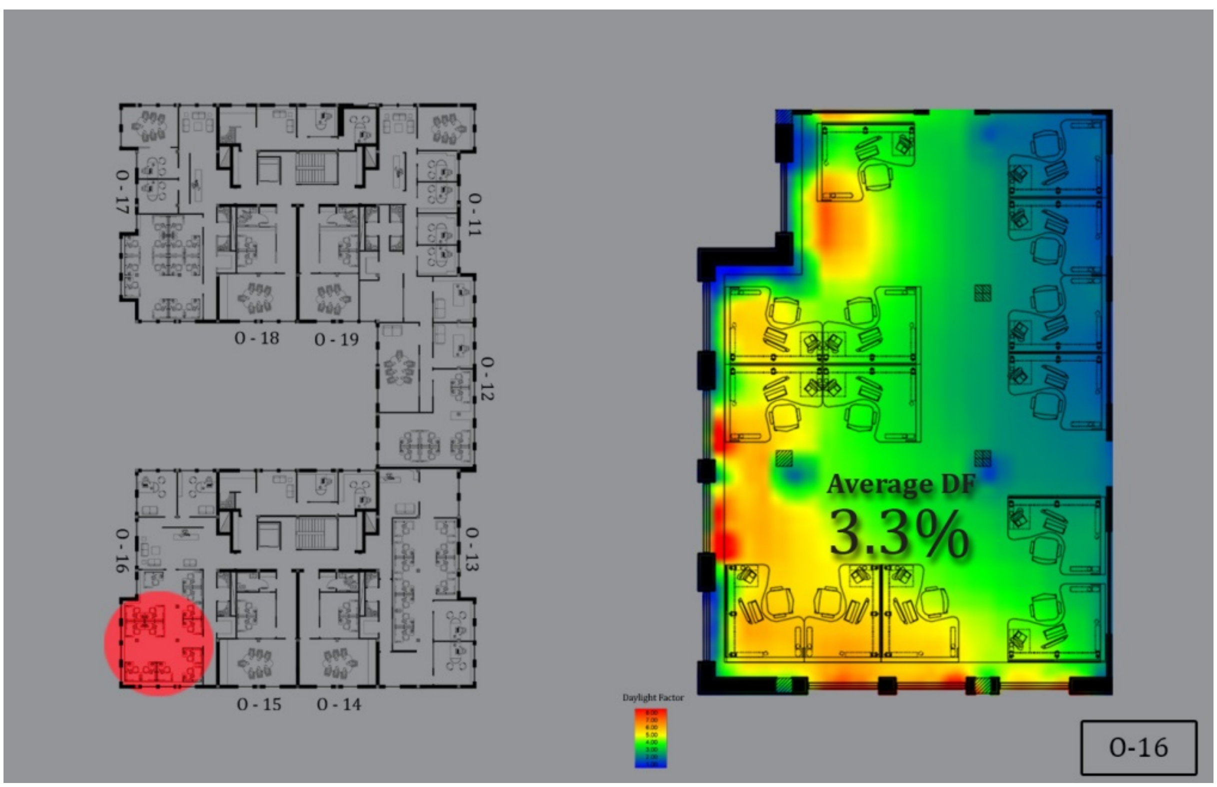


Figure 3-112 DF analysis for the office O-16 when the glazed envelopes are shaded by Hermattan® Sunscreens with 200mm spacing

Figure 3-113 internal views of Office O-16 when it is not shaded (top), an when it is shaded by Hermattan® Sunscreen (bottom)

3.4.2.4.2 Green Curtains

This strategy is applicable for internal spaces which are separated from balconies by transparent envelopes. Many of such spaces are designed in residential levels, and for critical ones, green curtains could be an appropriate barrier in terms of being powerful shading as well as being strong architectural features.

Green Curtains are consist of up growing plants on a thin mesh which allow the natural light inside the mentioned spaces while block the direct rays of strong summer sun. With using this type of shading, overheating inside the spaces adjacent to balconies is prevented and a pleasant environment inside the balconies is created thanks to cooling down effect of plants. Moreover, CO_2 emission would be reduced in balconies, and this make the quality of air more preferable.

Certain plants those are proliferous in hot seasons, and are lifeless in cold seasons are preferable in this strategy. In those cases, while the ambient is shaded during the summer, residents could benefit from adequate sunlight during the winter.

Figure 3-114 an example of Green Curtain used in balconies

In this project, Green Curtains could be also interpreted as strong architectural features both in functional and aesthetical aspects. While they transform the view of building's façade, they add to gardenlike characteristics that have been considered in designing the balconies.

Based on Daylight Factor analysis, the balconies those this typology of shading is suggested for are listed in table 3-19.

Story Level	Balconies which Green Curtain is Suggested for							
3rd Floor	BL-A322	BL-A331						
4th Floor	BL-A422	BL-A432	BL-B422	BL-B432				
5th Floor	BL-A522	BL-A532	BL-B51	BL-B54	BL-521	BL-522	BL-531	BL-532
6th Floor	BL-A622	BL-A632						
7th Floor	BL-A71	BL-A721	BL-A722	BL-A731	BL-A732	BL-A74		

Table 3-19 Balconies that Green Curtain is suggested for

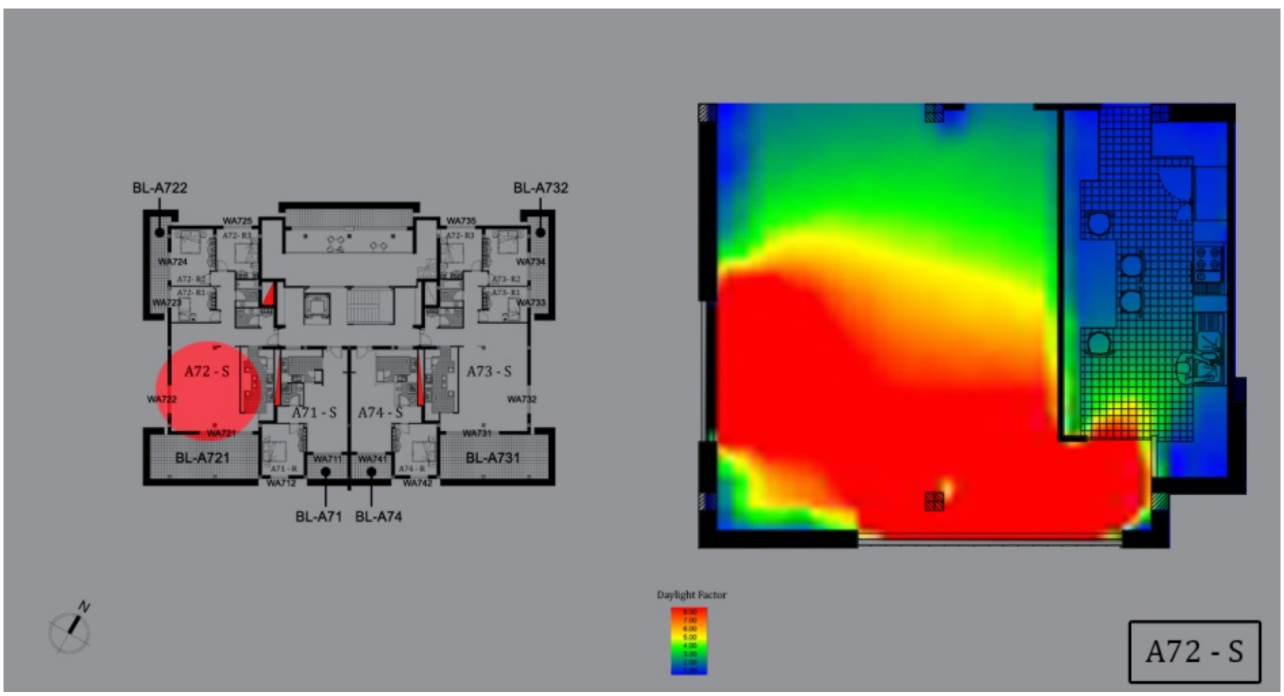


Figure 3-115 Example of an internal space which could be shaded by placing Green Curtain on its adjacent balcony: A72-S (Living room of the apartment A72 in 7th floor)

3.4.2.4.3 Window Blinds

This typology is appropriate for the glazed areas of internal spaces which are not adjacent to shaded balconies (figure 3-116), or those in which the rate of Daylight Factor is that intense that the Green Curtains in the balconies before them may not provide enough capacity of shading by themselves (Fig 3-117).

Although internal shading by means of using fabric curtains is well-defined in Iranian culture, external blinds would be more desirable in terms of energy efficiency for they prevent overheating during the summertime. In order to provide maximum flexibility, it is important that window blinds for the residential buildings be adjustable and easy to regulate.

Based on Daylight Factor analysis, windows those window blind is suggested for are listed in table 3-20.

Story Level	Windows which external adjustable blind is Suggested for								
3rd Floor	WA325	WA335	WB313	WB314	WB327	WB337			
4th Floor	WA412	WA413	WA424	WA426	WA434	WA436	WB412		
5th Floor	WA526	WA536	WB512	WB522	WB523	WB525	WB532	WB533	WB535
6th Floor	WA624	WA634							
7th Floor	WA712	WA721	WA722	WA725	WA731	WA732	WA735	WA742	

Table 3-20 Windows which are suggested to be shaded by window blinds

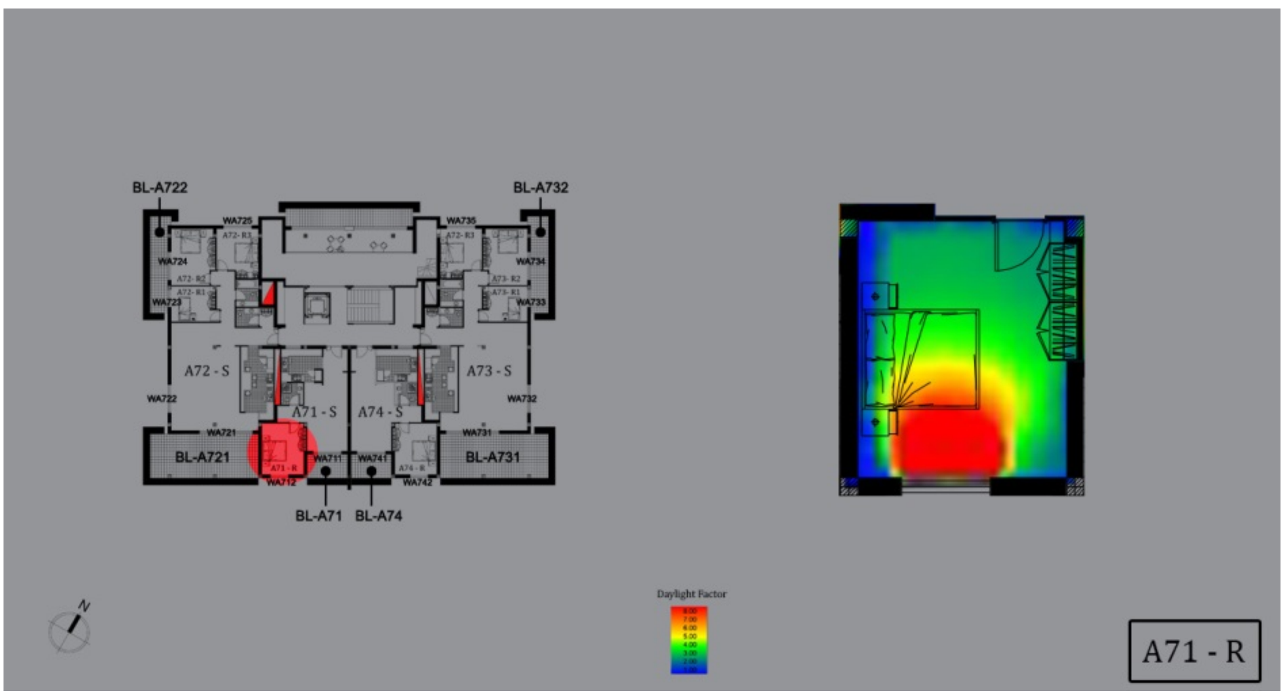


Figure 3-116 Example of an internal space which could be shaded by window blinds: A71-R (Bedroom of the apartment A71 in 7th floor)

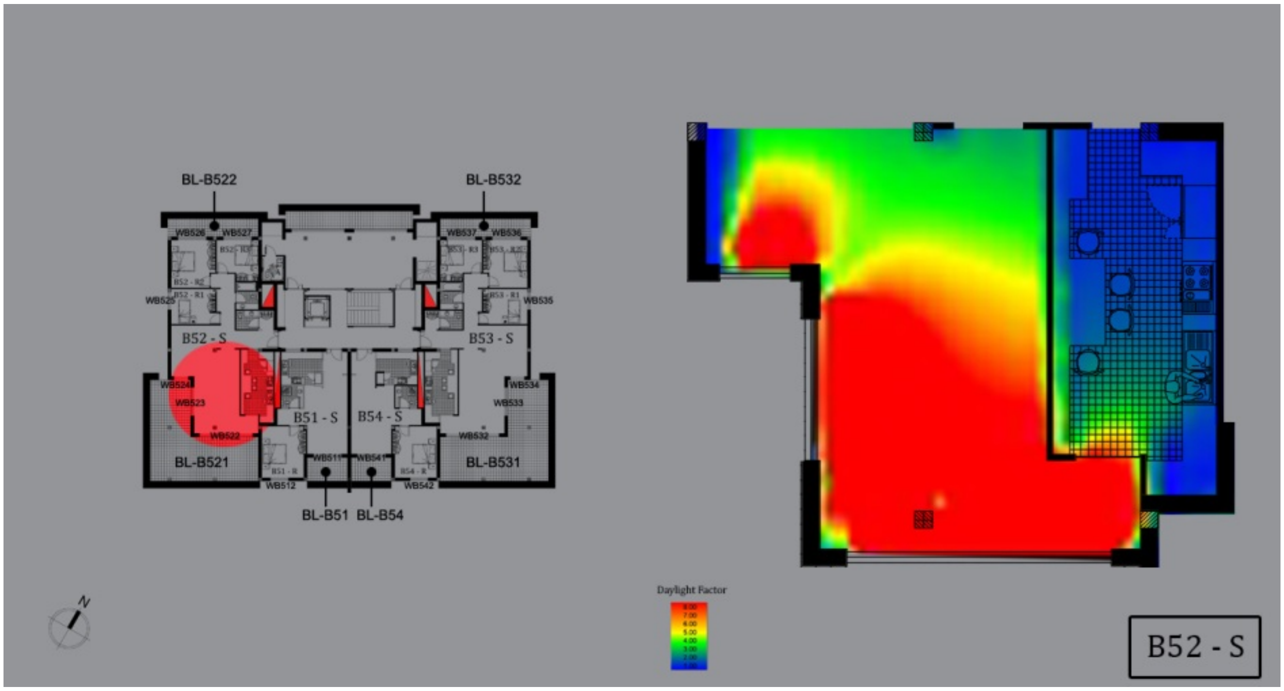
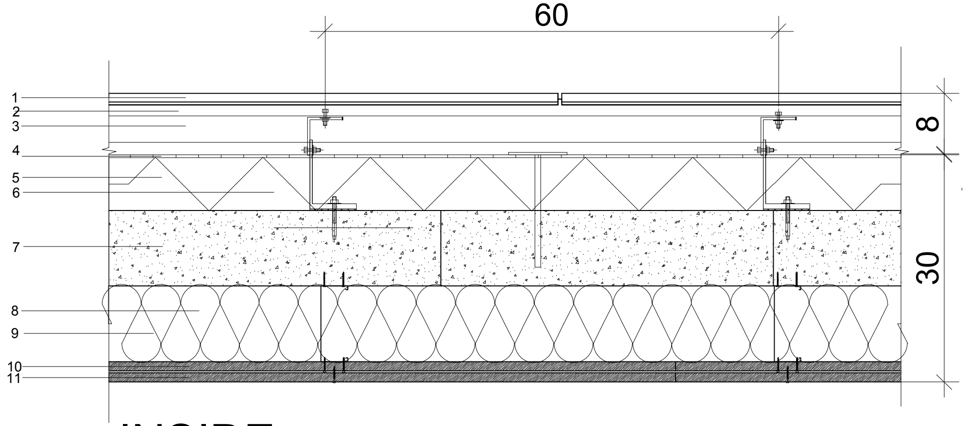


Figure 3-117 Example of an internal space which is suggested to be shaded by placing Green Curtain on its adjacent balcony as well as using window blinds (Living room of apartment B52 in 5th level): Green Curtain on balcony BL-521 and window blinds on windows WB522 and WB523

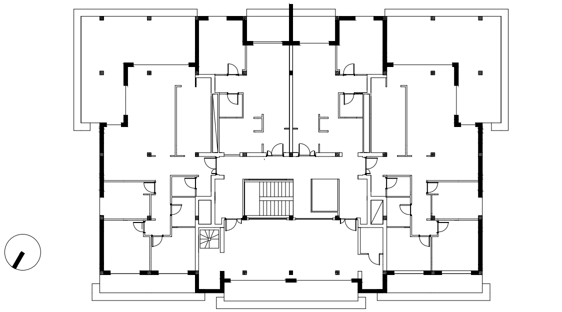
In conclusion, it can be said that the critical spaces are located mostly in 5th and 7th floors, and consequently the number of shading devices would be more these levels. However, the effect of the southern building in optimizing the sun gain of the northern building is clearly visible in DF analysis. The shading effect of the balconies on their lower levels also is considerable in some parts This can be vividly felt in the 6th level that although there is no volume on front of it to block the sun, but the amount of Daylight Factor remains preferable in almost all the internal spaces of this level.

3.4.2.5 Envelope Design sheets

EW-1



INSIDE



Layer	Thickness (Cm)
Re	
1-Zeohire Terracota Tile	1.5 cm
-Air Cavity	7 cm
2-Zephlr Standard Rall	
3-Standard Substructure Profill	
4- Humidity resistance Layer	0.5 cm
5-Knauf Eartheool Rainscreen Slab	7 cm
6- Fastener	
7-Dence Concrete Block	10 cm
8- Galvanized Knauf Standard Stud	
9-Knauf Earthwool	10 cm
10-Knauf Plaster Board	1.25 cm
11-Knauf Plaster Board	1.25 cm
Final Thickness	38 cm
U Value	0.18 (W/m²k)

EW-1			
Layer	Thickness (m)	λ	R
re			0.040
Zephire Terracota Tile	0.0150	1.3	0.012
Air Cavity	0.0700	0.278	0.252
Humidity Resistance layer	0.0020	1.6	0.001
Knauf Earthwool® Rainscreen Slab	0.0700	0.035	2.000
Dense Concrete Block	0.1000	0.92	0.109
Kanauf Earth wool	0.1000	0.04	2.857
Knauf Plasterboard	0.0125	0.16	0.078
Knauf Plasterboard	0.0125	0.16	0.078
ri			0.130
Sum	0.38		5.557

U-Value: 0.18

POLITECNICO DI MILANO
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Sheet Number :

Scale :

Walls Detail

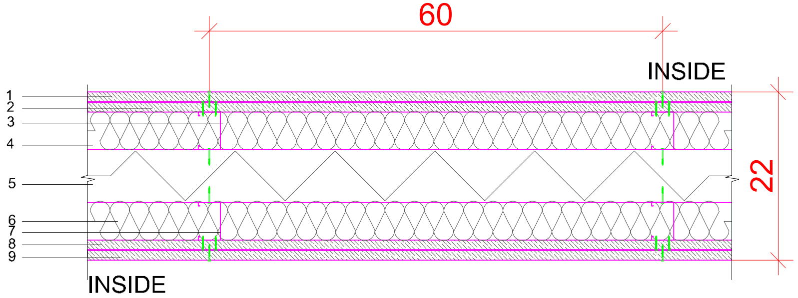
Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

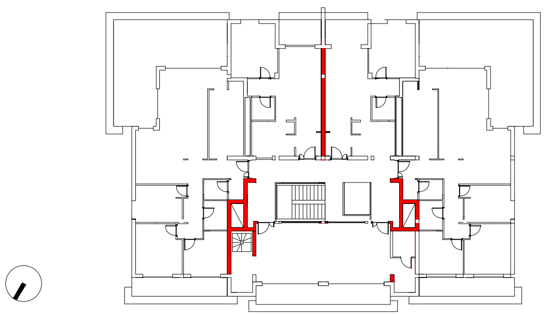
EW-1

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

IW-1





Layer	Thickness (Cm)
Re	
1-Knauf Plaster Board	1.25 cm
2-Knauf Plaster Board	1.25 cm
3- Galvanized Kanauf Standard Stud	
4-Knauf Earthwool	5 cm
5-Knauf Earthwool rainscreen slab	7 cm
6-Knauf Earthwool	5 cm
7- Galvanized Kanauf Standard Stud	
8-Knauf Plaster Board	1.25 cm
9-Knauf Plaster Board	1.25 cm
Final Thickness	22
U Value	0.20 (W/m^2k)

IW-1			
Layer	Thickness (m)	λ	R
ri			0.130
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Earthwool	0.0500	0.04	1.250
Knauf Earthwool® Rainscreen Slab	0.0700	0.035	2.000
Kanauf Earthwool	0.0500	0.04	1.250
Knauf Plasterboard	0.0125	0.16	0.078
Knauf Plasterboard	0.0125	0.16	0.078
ri			0.130
Sum	0.22		5.073
	U-Value:		0.20

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IW-1

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Supervisor : Prof. Massimo Tadi
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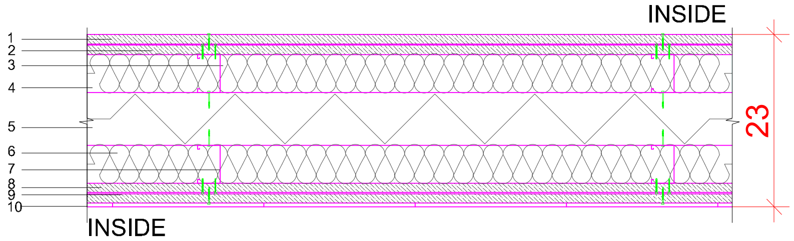
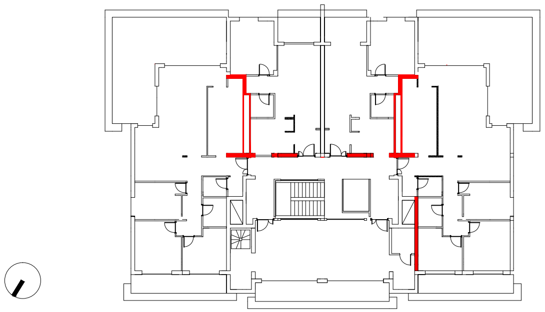
IW-2	Layer	Thickness (Cm)
	Re	
	1-Knauf Plaster Board	1.25 cm
	2-Knauf Plaster Board	1.25 cm
	3- Galvanized Kanauf Standard Stud	
	4-Knauf Earthwool	5 cm
	5-Knauf Earthwool rainscreen slab	7 cm
	6-Knauf Earthwool	5 cm
	7- Galvanized Kanauf Standard Stud	
	8-Knauf Plaster Board	1.25 cm
	9-Knauf Aqua Panel	1.25 cm
	10-Tile (With or Without Humidity Insulation)	0.5-1 cm
	Final Thickness	23
	U Value	0.20 (W/m²k)

IW-2			
Layer	Thickness (m)	λ	R
ri			0.130
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Earthwool	0.0500	0.04	1.250
Knauf Earthwool® Rainscreen Slab	0.0700	0.035	2.000
Kanauf Earthwool	0.0500	0.04	1.250
Knauf Plasterboard	0.0125	0.16	0.078
Knauf Plasterboard	0.0125	0.16	0.078
Tile	0.0050	1.6	0.003
ri			0.130
Sum	0.23		5.076
	U-Value:		0.20

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Sheet Number : 1

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IW-2

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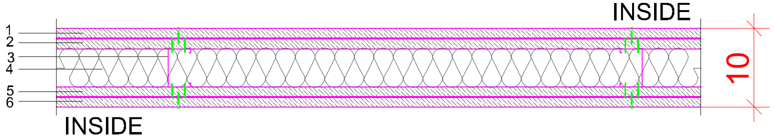
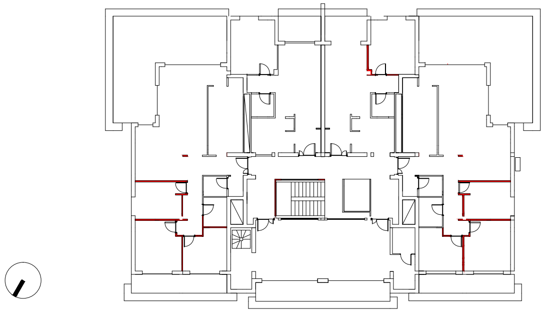
IW-3





Layer	Thickness (Cm)
Re	
1-Knauf Plaster Board	1.25 cm
2-Knauf Plaster Board	1.25 cm
3- Galvanized Knauf Standard Stud	
4-Knauf Earthwool	5 cm
5-Knauf Plaster Board	1.25 cm
6-Knauf Plaster Board	1.25 cm
Final Thickness	10 cm
U Value	0.55 (W/m²k)

IW-3			
Layer	Thickness (m)	λ	R
ri			0.130
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Earthwool	0.0500	0.04	1.250
Knauf Plasterboard	0.0125	0.16	0.078
Knauf Plasterboard	0.0125	0.16	0.078
ri			0.130
Sum	0.10		1.823

U-Value:	0.55

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Supervisor : Prof. Massimo Tadi
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IW-3

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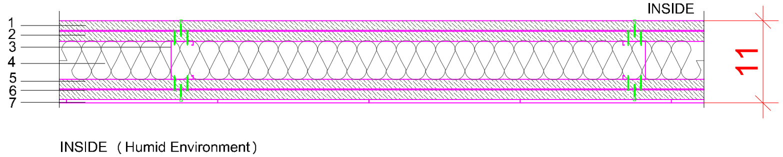
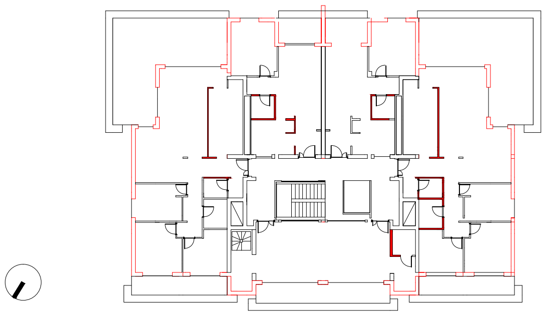
IW-4





Layer	Thickness (Cm)
Re	
1-Knauf Plaster Board	1.25 cm
2-Knauf Plaster Board	1.25 cm
3- Galvanized Knauf Standard Stud	
4-Knauf Earthwool	7 cm
5-Knauf Plaster Board	1.25 cm
6-Knauf Aqua Panel	1.25 cm
7-Tile (With or Without Humidity Insulation)	0.5-1 cm
Final Thickness	11 cm
U Value	0.55 (W/m²k)

IW-4			
Layer	Thickness (m)	λ	R
ri			0.130
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Earthwool	0.0500	0.04	1.250
Knauf Plasterboard	0.0125	0.16	0.078
Knauf Plasterboard	0.0125	0.16	0.078
Tile	0.0050	1.6	0.003
ri			0.130
Sum	0.105		1.826

U-Value:	0.55

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Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

IW-4

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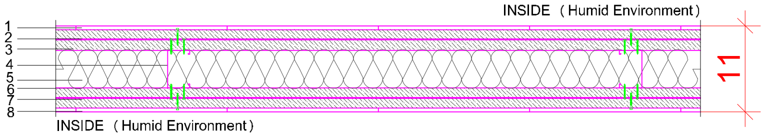
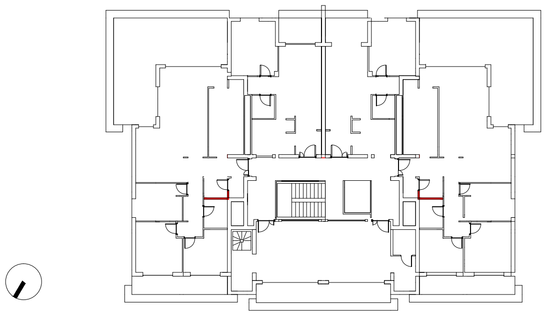
IW-5





Layer	Thickness (Cm)
Re	
1-Tile (With or Without Humidity Insulation)	0.5-1 cm
2-Knauf Aqua Panel	1.25 cm
3-Knauf Plaster Board	1.25 cm
4- Galvanized Kanauf Standard Stud	
5-Knauf Earthwool	7 cm
6-Knauf Plaster Board	1.25 cm
7-Knauf Aqua Panel	1.25 cm
1-Tile (With or Without Humidity Insulation)	0.5-1 cm
Final Thickness	11 cm
U Value	0.55 (W/m²k)

IW-5			
Layer	Thickness (m)	λ	R
ri			0.130
Tile	0.0050	1.6	0.003
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Plaster Board	0.0125	0.16	0.078
Kanauf Earthwool	0.0500	0.04	1.250
Knauf Plasterboard	0.0125	0.16	0.078
Knauf Plasterboard	0.0125	0.16	0.078
Tile	0.0050	1.6	0.003
ri			0.130
Sum	0.11		1.829
	U-Value:		0.55

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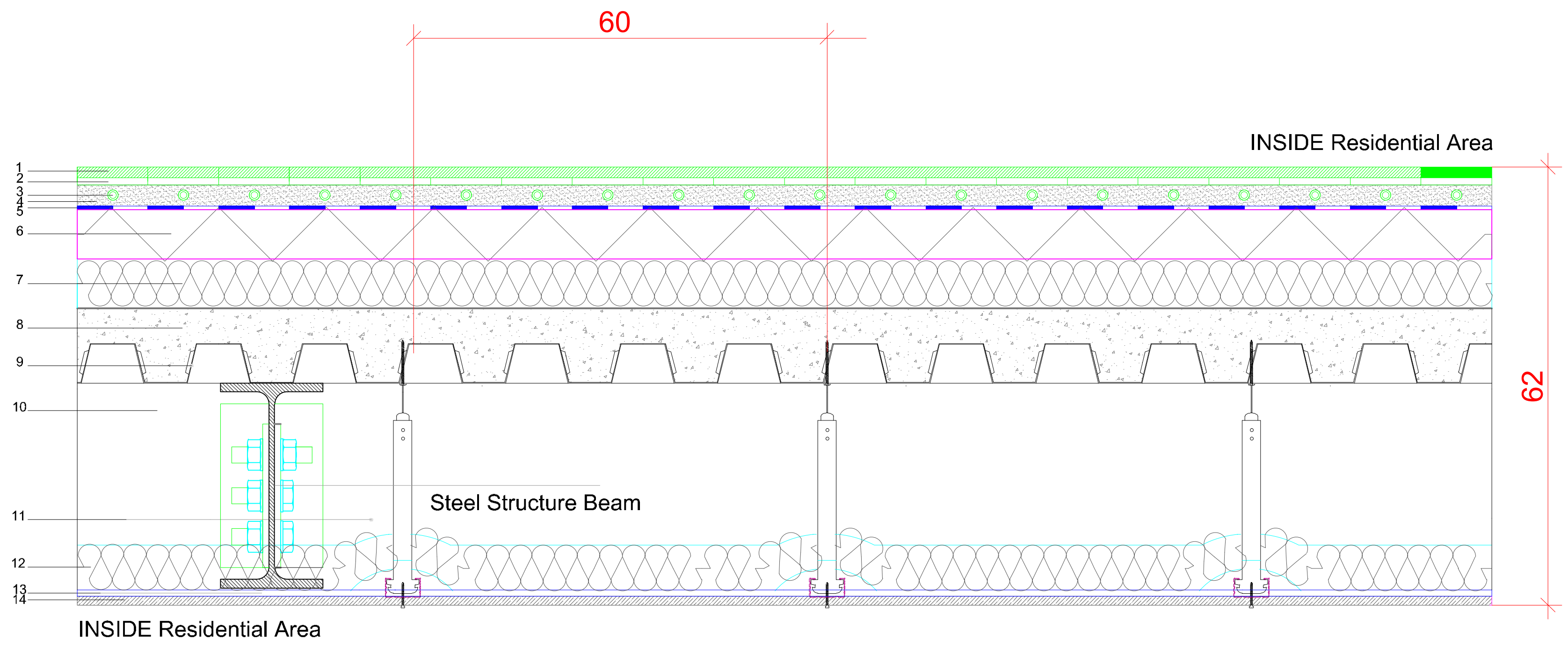
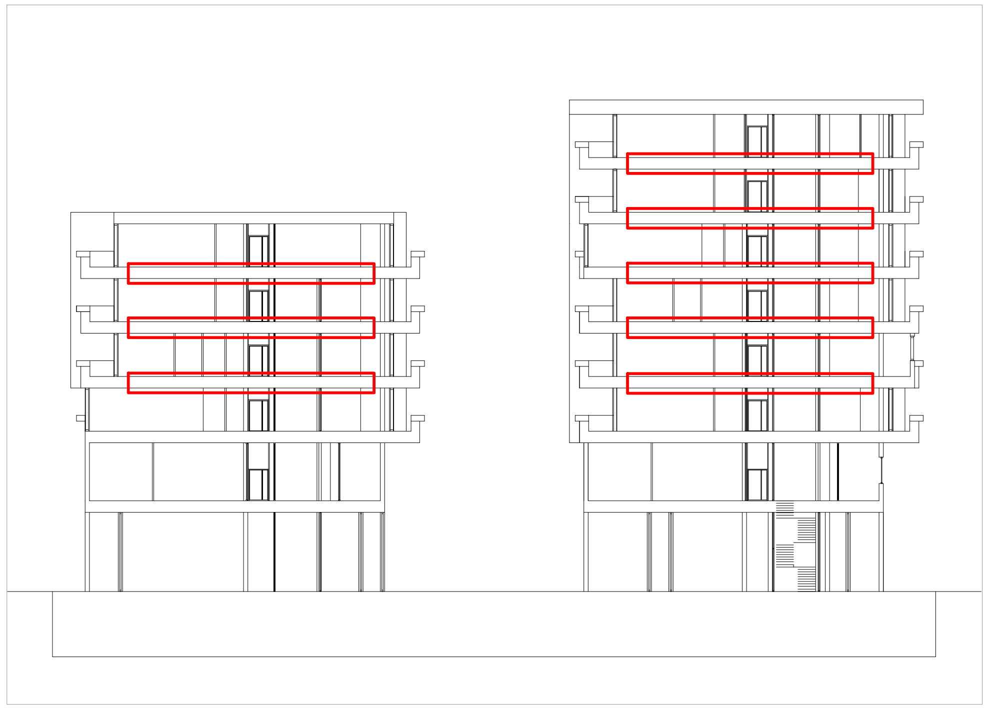
SL-1



Layer	Thickness (Cm)
Re	
1-Laminate Finishing Board	Max 1 cm
2-Laminate Flooring System	1 cm
3- Pipe (Floor Heating System)	
4- Light Concrete	3 cm
5-Humidity Insulation	0.5 cm
6-Knauf Earthwoll	7 Cm
7-Knauf Earthwoll	
Steel Deck Floor System	
8- Concrete	10 -15 cm
9-Steel deck	
10- Air Cavity (for Services Used)	23 - 28 cm
11- Roof Support	
12-Knauf Acoustic Insulation	7 cm
13- Roof Supporting Gird	
14- Knauf Plaster Board	1.25
Final Thickness	62 cm
U Value	



POLITECNICO DI MILANO
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Ingegneria Dei Systemi Edilizi (Lc)

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Sheet Number :

Scale :

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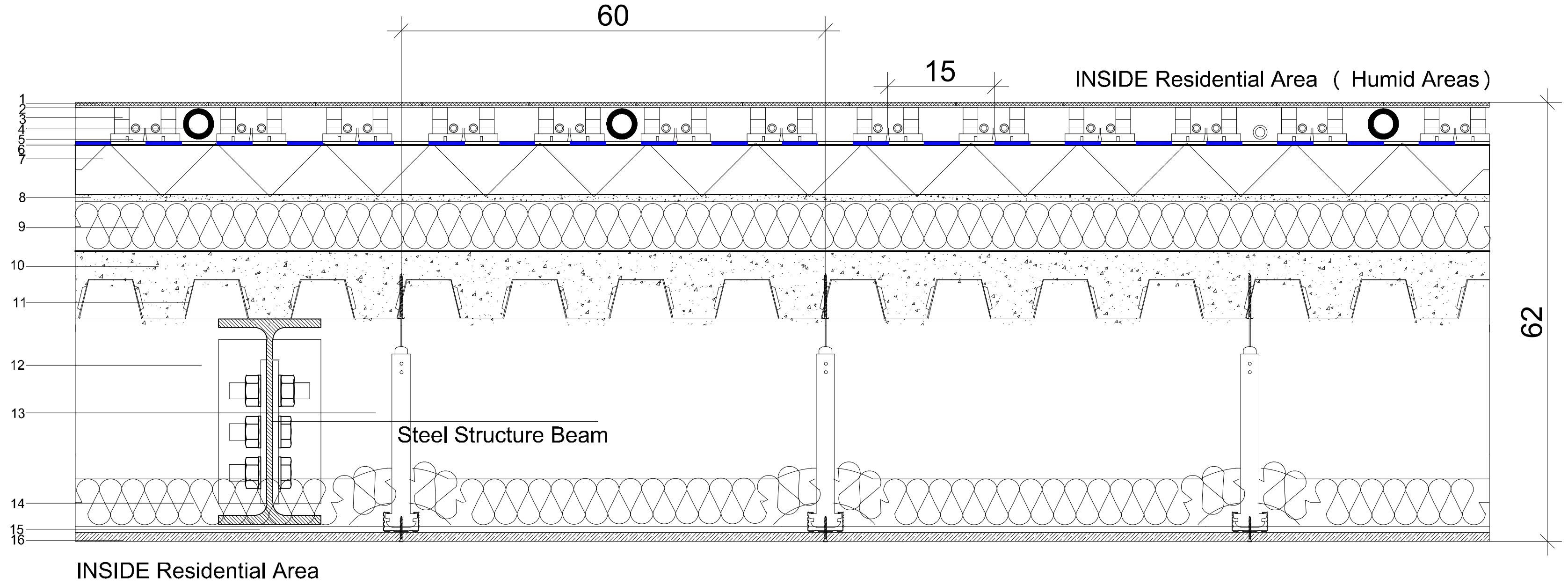
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

IW-2

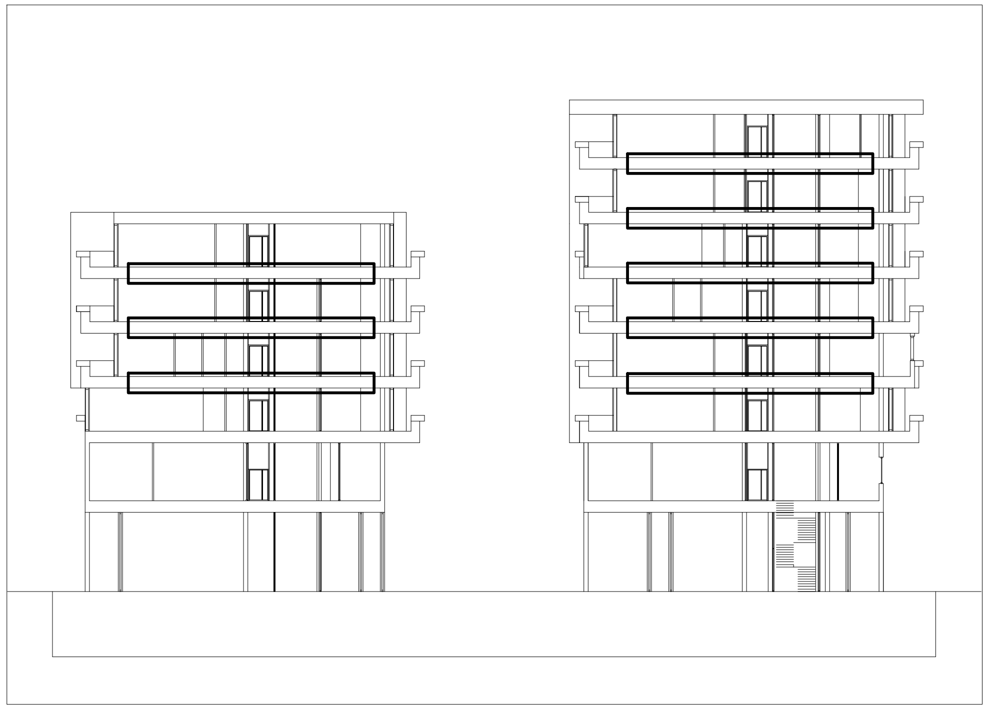
Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

SL-2



Layer	Thickness (Cm)
Re	
1-Ceramic Tile (include Structural gird)	Max 1 cm
2-Ceramic Flooring Profil System	
3- Spacer (Air Cavity)	5 cm
4- Drainage Pipe	
5-Heating Pipe	
6-Humidity Insulation	0.5 cm
7- Knauf Earthwool Rainscreen Slab	7 cm
8- Light Weight Leveling Concrete)	1 cm
9-Knauf Acoustic Insulation	7 cm
10- Concrete	10 - 15 cm
11-Steel deck	
12- Air Cavity	23 - 28 cm
13- Roof Support	
14-Knauf Acoustic Insulation	7 cm
15- Roof Supporting Gird	
16- Knauf Aqua Panel	1.25 cm
Final Thickness	62 cm
U Value	



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Sheet Number :

Scale :

Slab Detail

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

SL-2

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

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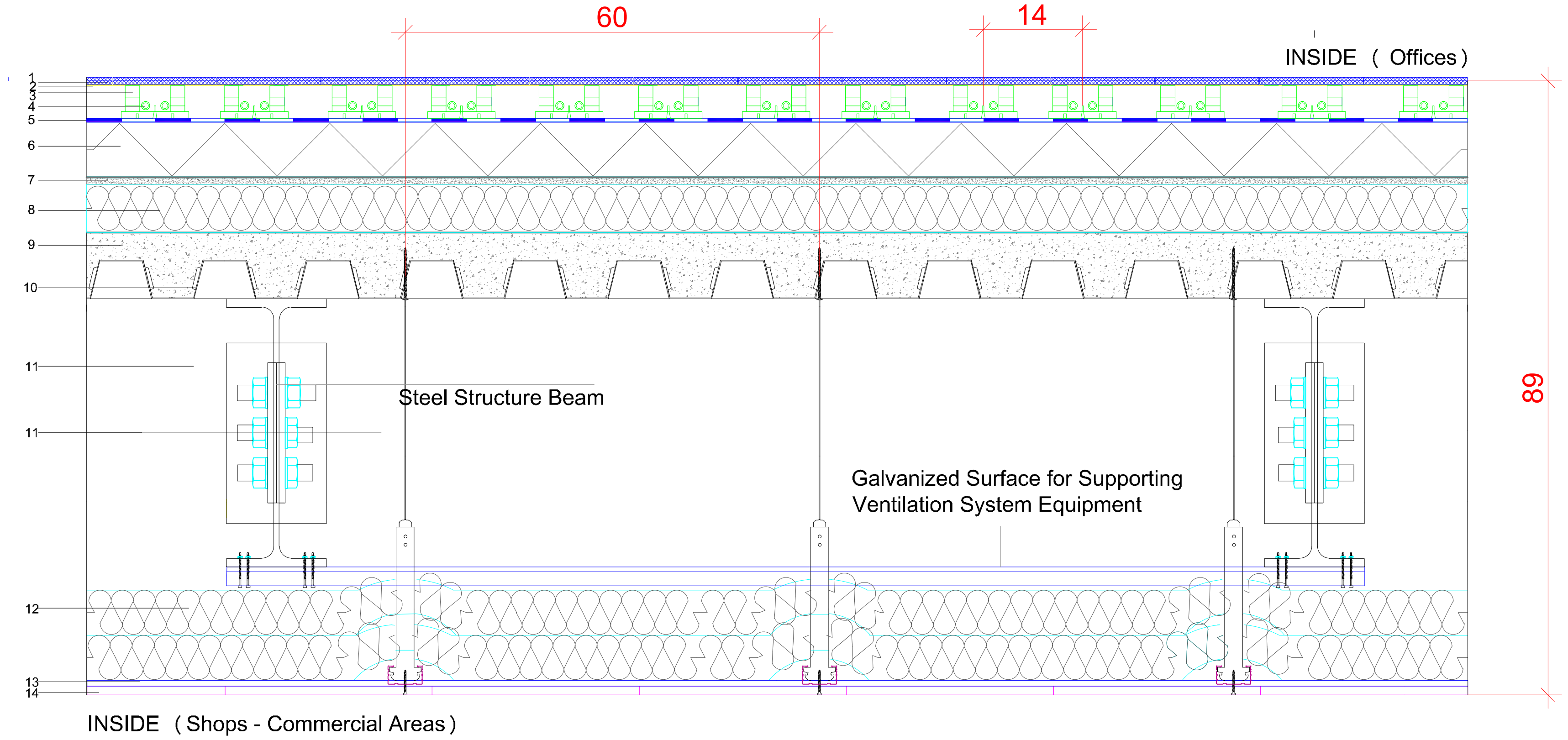
Mohammad Hadi Mohammad Zadeh 754940

SL-3



Layer	Thickness (Cm)
Re	
1-Ceramic Tile (include Structural gird)	Max 1 cm
2-Ceramic Flooring Profil System	
3- Spacer (Air Cavity)	5 cm
4-Heating Pipe	
5-Waterprofing Insulation	0.5 cm
6- Kanauf Earthwool Rainscreen Slab	7 cm
7- Light Weight Concret	1 cm
8-Kanauf Acoustic Insulation	7 cm
9- Concrete	10 - 15 cm
10-Steel deck	
11- Air Cavity	23 - 28 cm
12- Roof Support	
13-Knauf Acoustic Insulation	7 cm
14- Roof Supporting Gird	
15- Knauf Aqua Panel	1.25 cm
Final Thickness	89 cm
U Value	

POLITECNICO DI MILANO
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (Lc)

Thechnological Design Details sheet

Sheet Number :

Scale :

Slab Detail

SL-3

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

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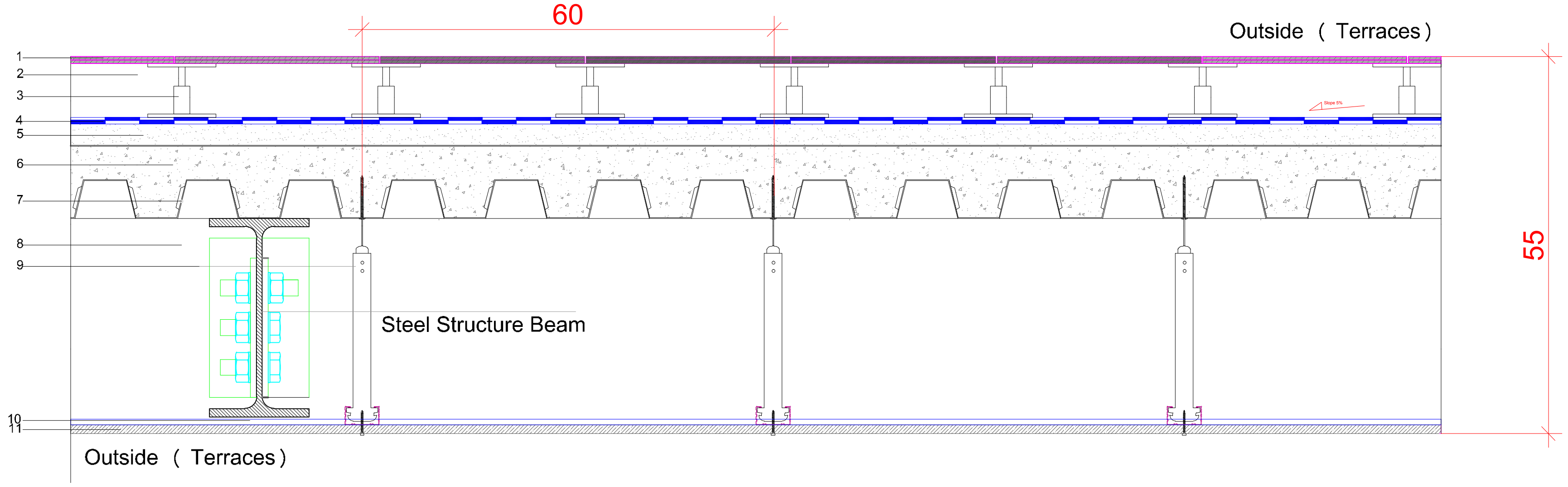
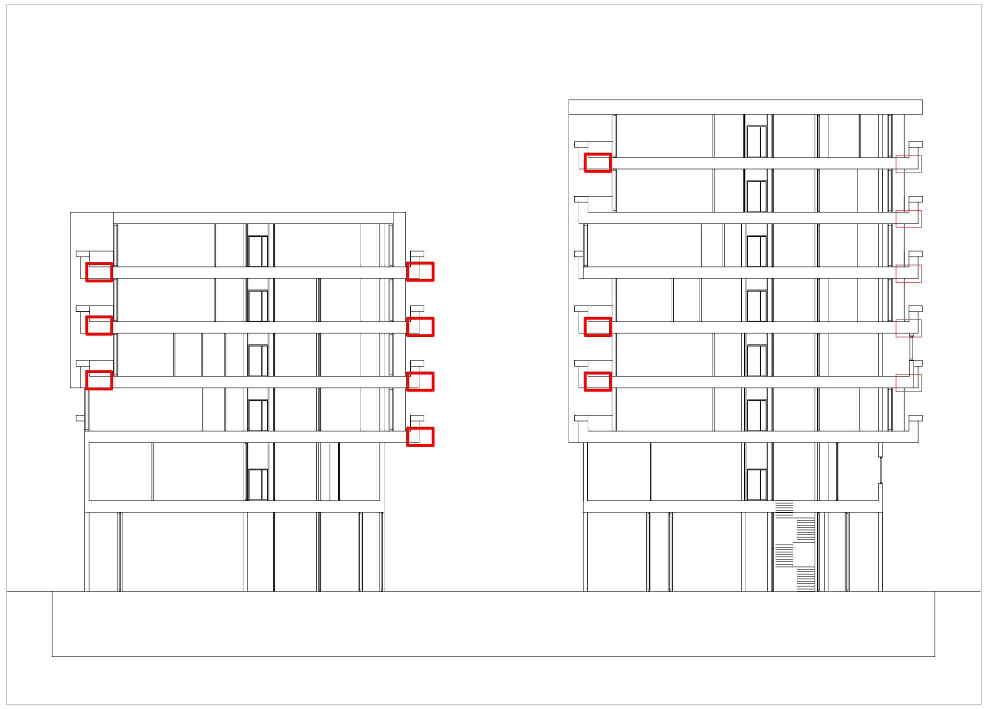
RO- 1



Layer	Thickness (Cm)
Re	
1- Ceramic Tile	1 cm
2- Air Cavity	2 cm
3- Spacer	
4- Waterprofing Insulation (2 Layer)	1 cm
5- Light Concrete	3 cm
Steel Deck Floor System	
6-Concrete	10-15 cm
7-Steel deck	
8- Air Cavity (for Services Used)	17 - 23 cm
9- Roof Support	
10- Roof Supporting Gird	
11- Kanauf Aqua Panel	1.25
Final Thickness	49 cm
U Value	



POLITECNICO DI MILANO
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (Lc)

Thechnological Design Details sheet

Sheet Number :

Scale :

Roof Detail

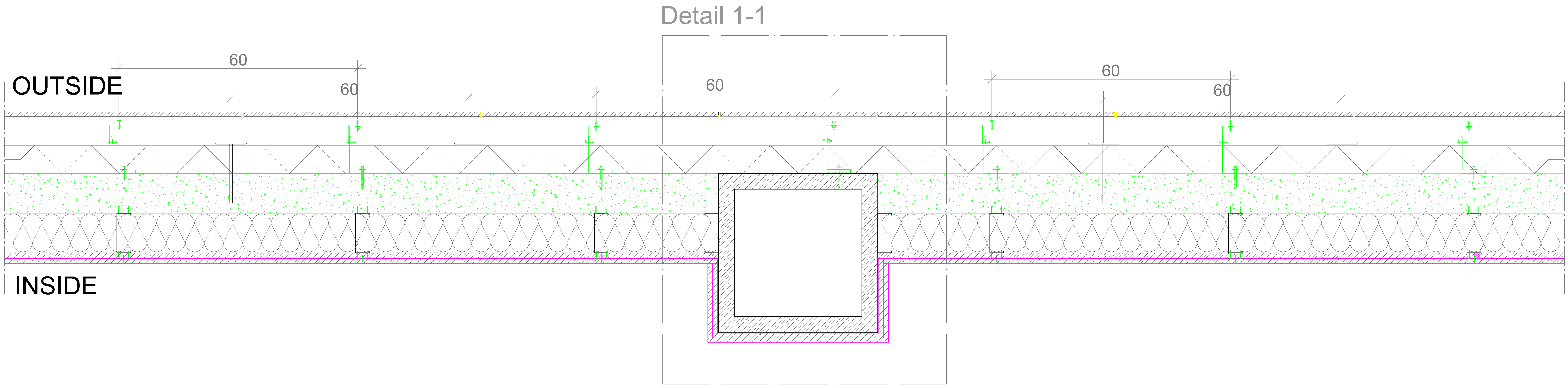
Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's District 22 with a multi-scale Approach

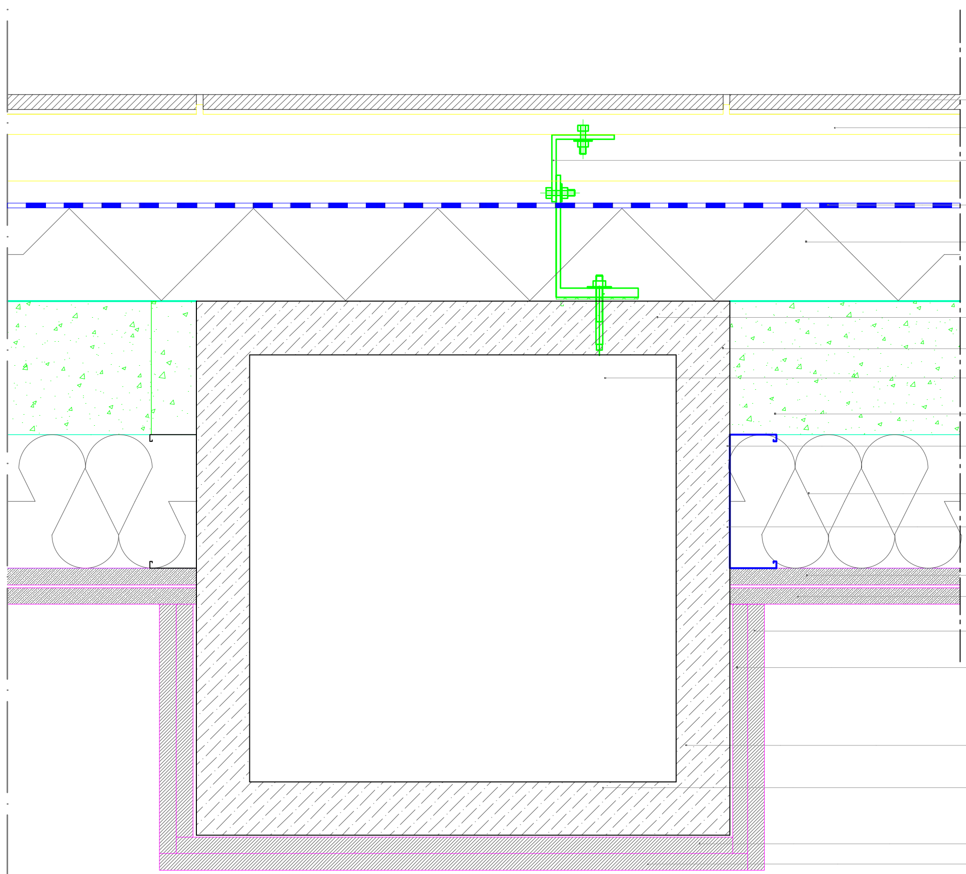
RO-1

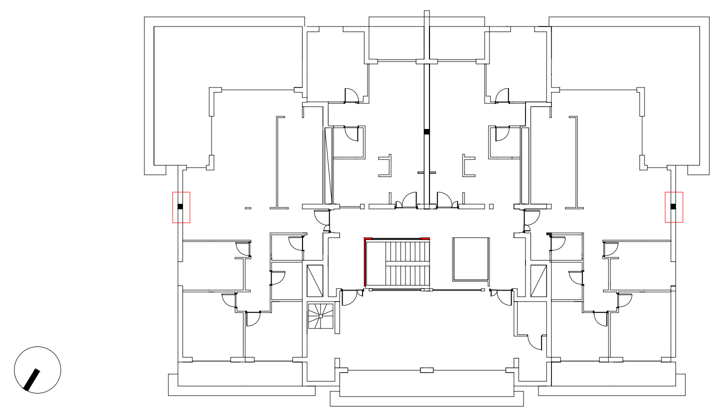
Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

Detail 1

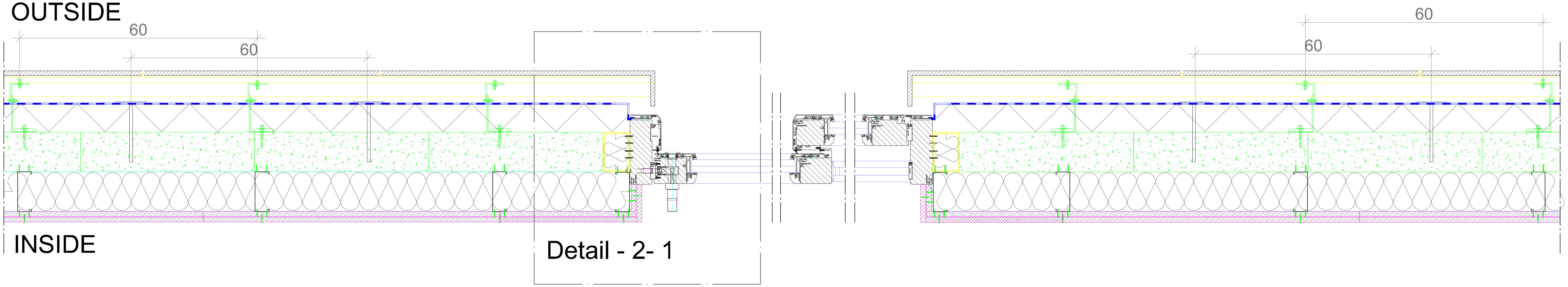


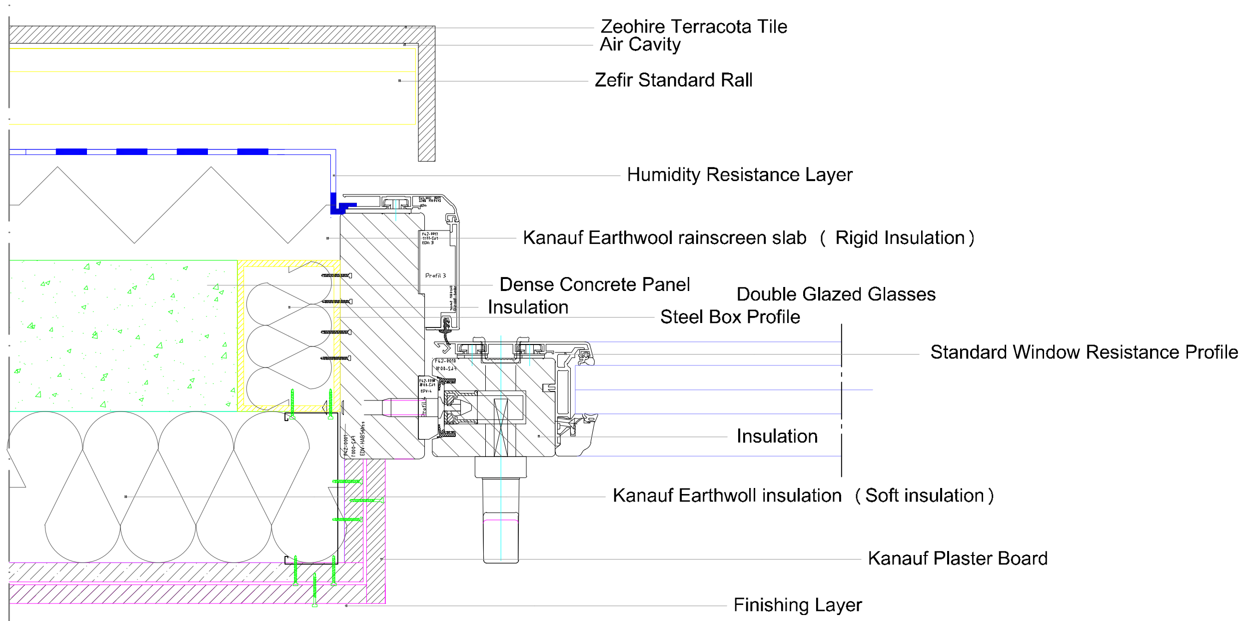




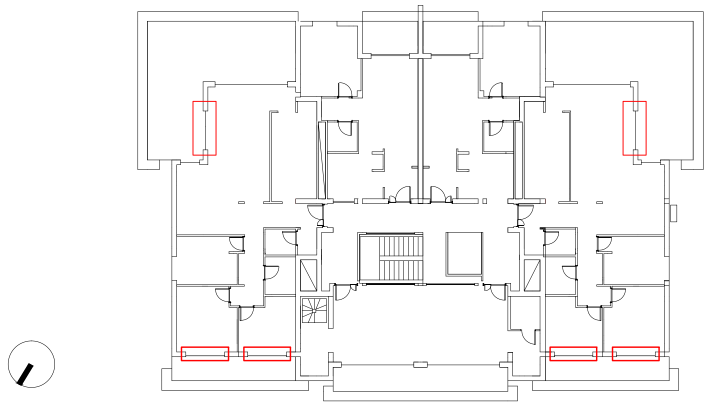
POLITECNICO DI MILANO VI-Scuola Di Ingegneria MI Ingegneria Dei Systemi Edilizi (Lc)	Thechnological Design Details sheet	Sheet Number : Scale :
	Horizontal Detail	
Ms.c Final Graduating Project Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach Supervisor : Prof. Massimo Tadi Co- Supervisor : Prof.Gabriele Masera	Detail -1	
	Amirali Naraghi	755237
	Mohammad Hadi Mohammad Zadeh	754940

Detail 2





Detail - 2- 1



POLITECNICO DI MILANO
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (Lc)

Thechnological Design Details sheet

Sheet Number :

Scale :

Horizontal Detail

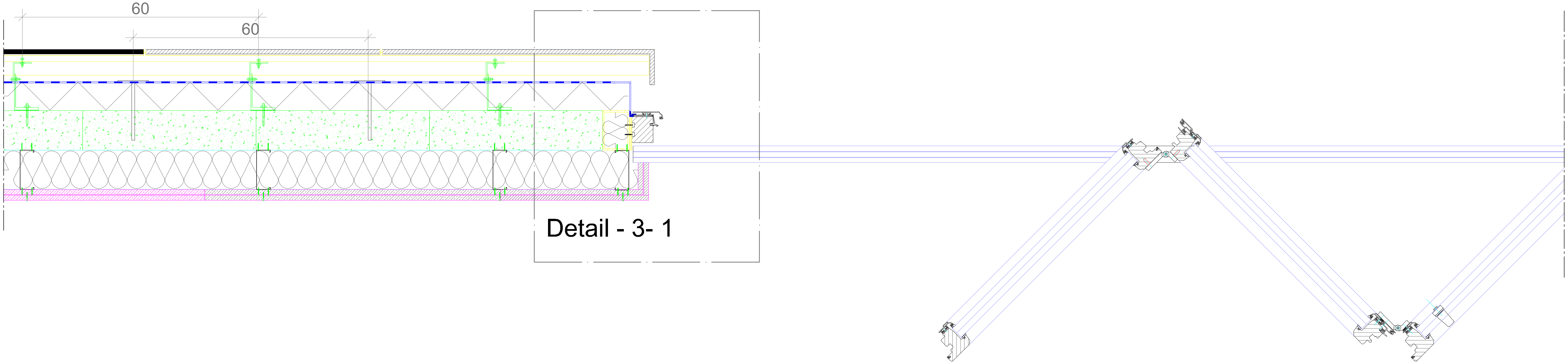
Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

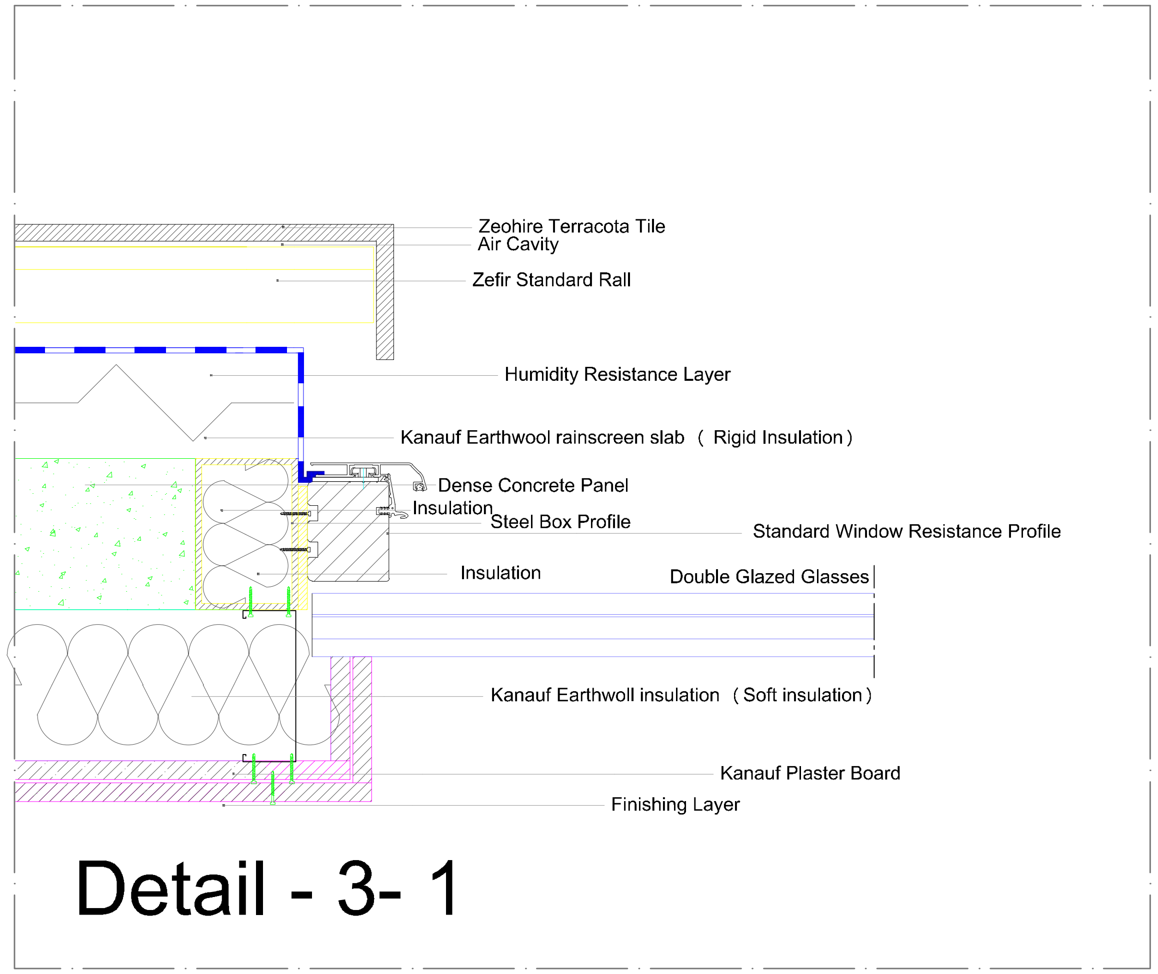
Detail -2

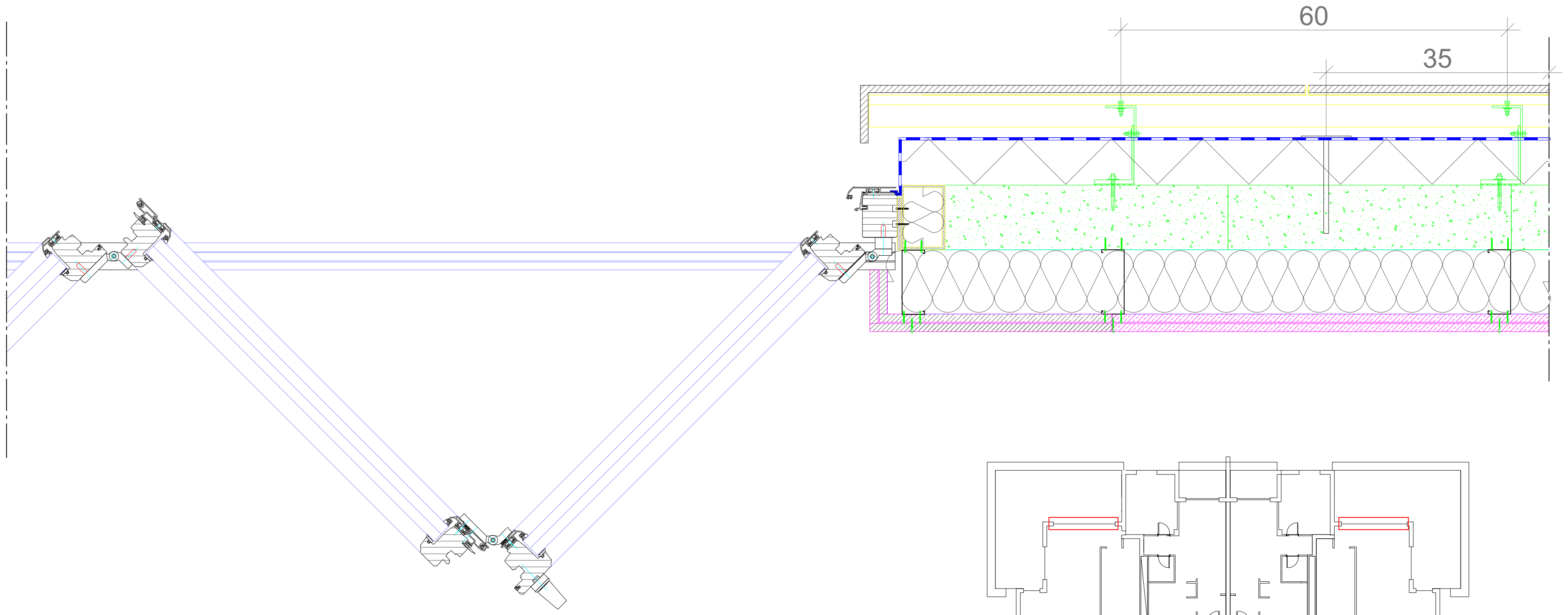
Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

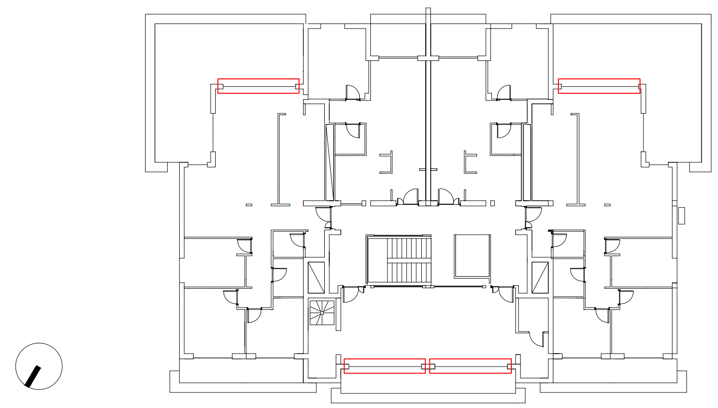
Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

Detail 3









POLITECNICO DI MILANO
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (Lc)

Thechnological Design Details sheet

Sheet Number :
Scale :

Horizontal Detail

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Detail -3

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

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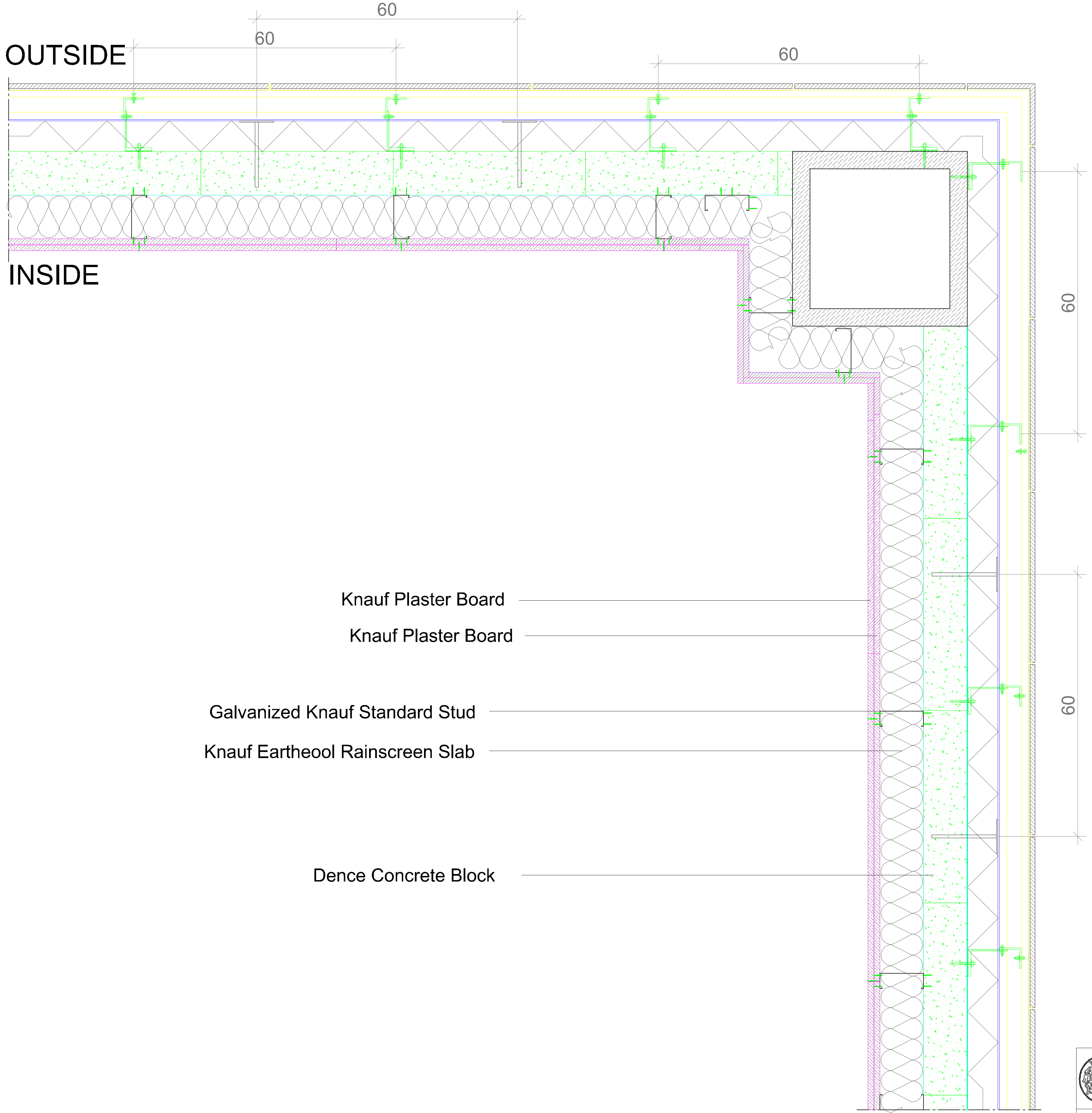

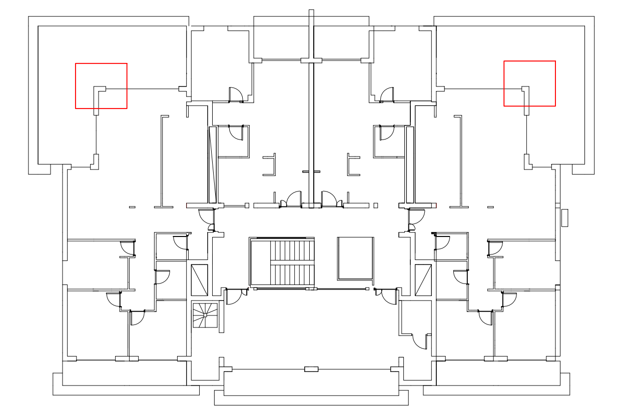

POLITECNICO DI MILANO
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (Lc)

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Thechnological Design Details sheet

Sheet Number :

Scale :

Horizontal Detail

Corner Joint

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

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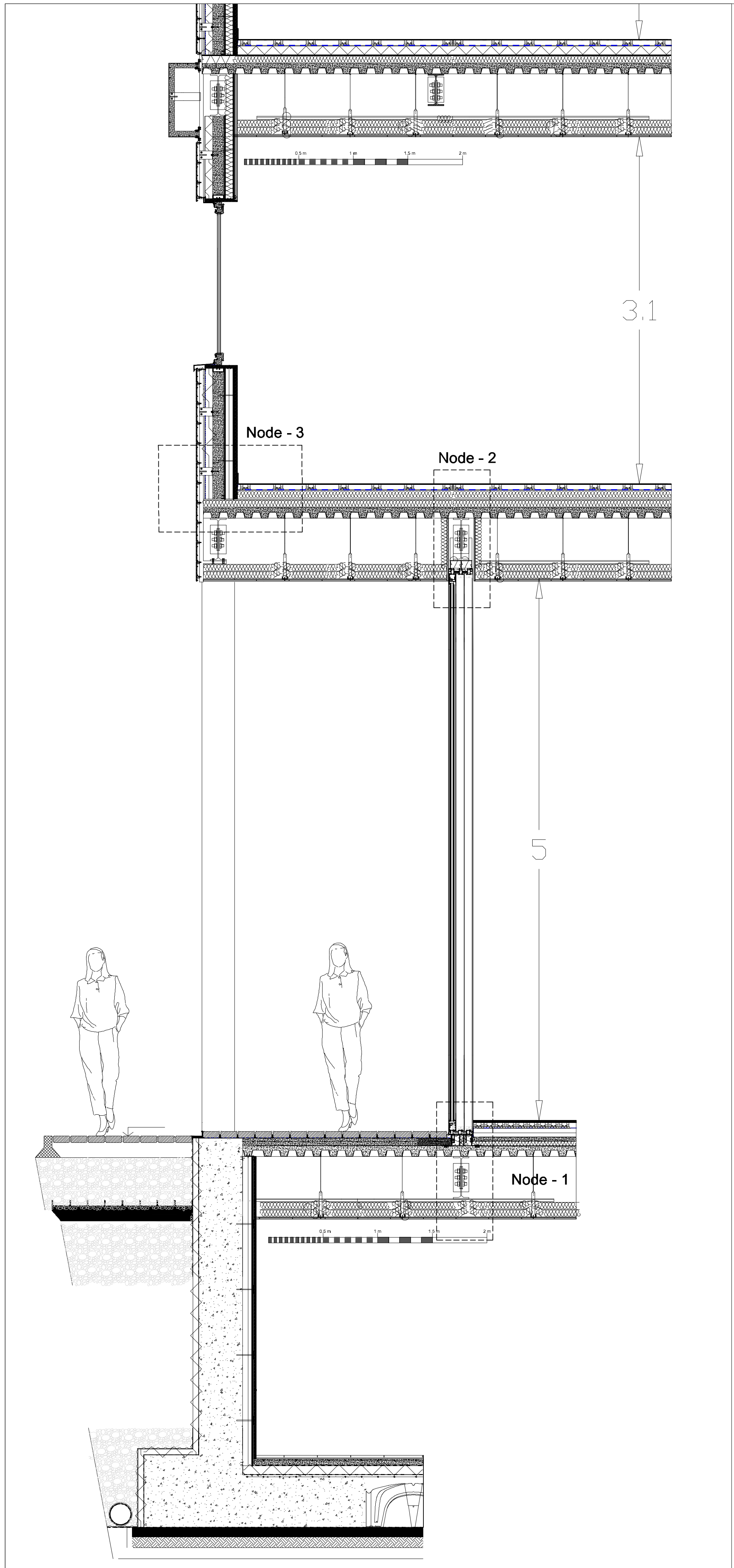
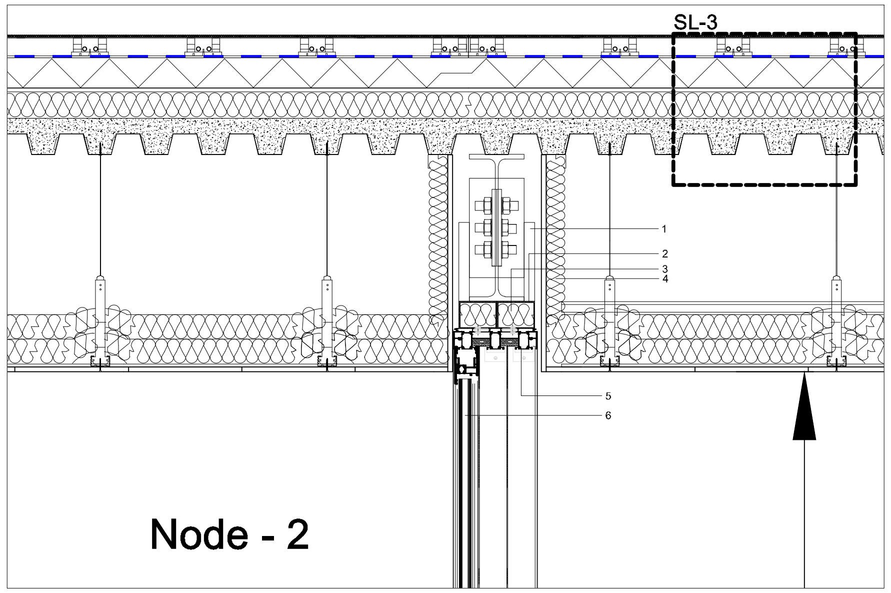
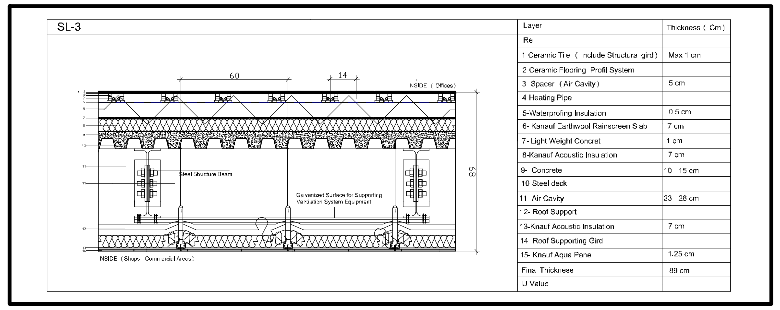
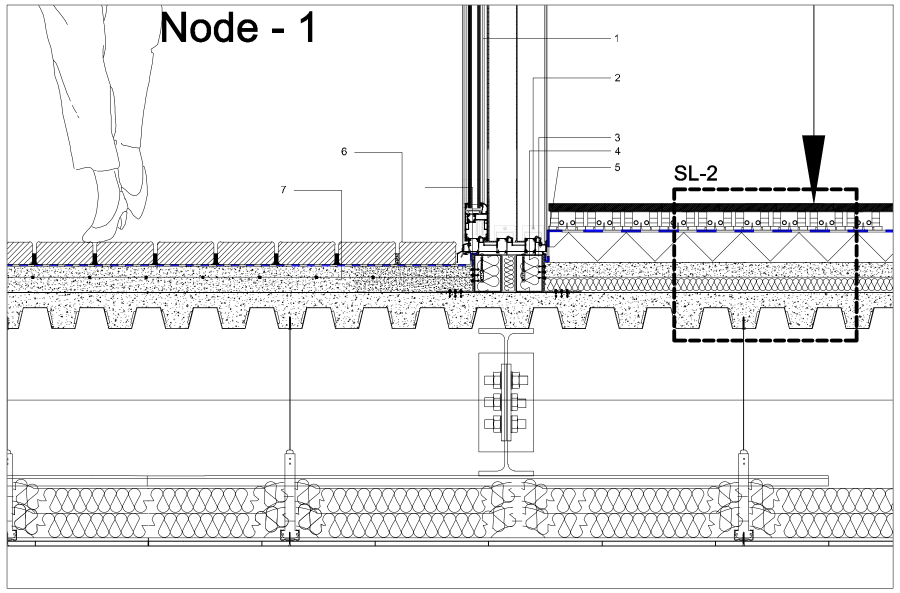
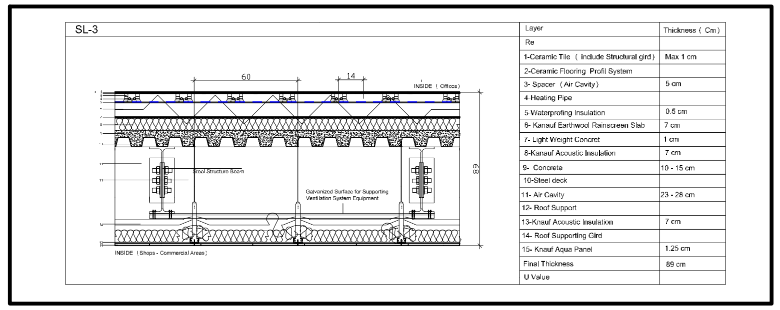




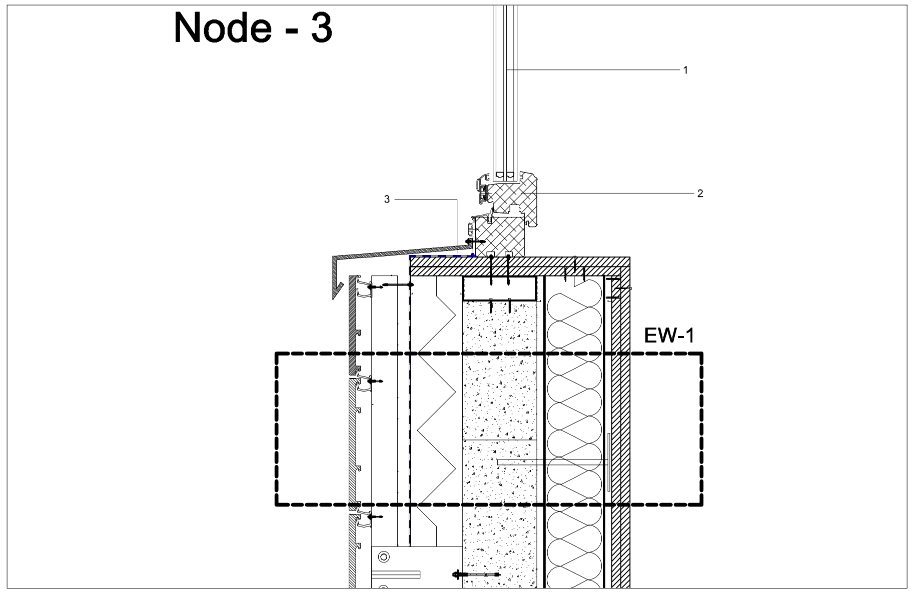


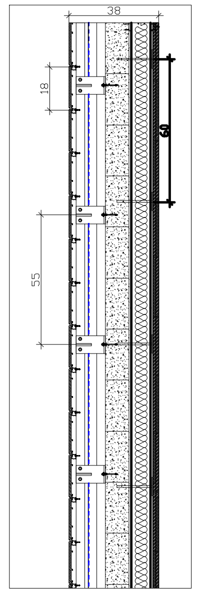
1- Steel band for Supporting Window Frame
2- Steel Box for Supporting Window Frame
3- Thermal Insulation
4- Thermal Insulation
5- Standard Window Prifil
6- Double Glazed Window

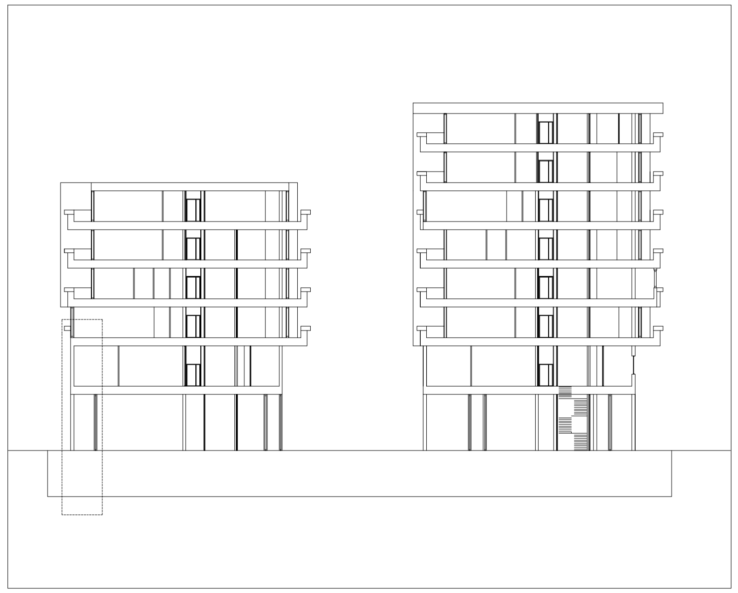




1- Double Glazed Window
2- Standard Window Prifil
3- Steel Box for Supporting Window Frame
4- Thermal Insulation
5- Humidity Insulation
6- Pavament
7- Reinforced Concrete







1- Double Glazed Window
2- Standard Window Prifil
3- Humidity Insulation

Politecnico Di Milano VI-Scuola Di Ingegneria MI Ingegneria Dei Systemi Edilizi (LC)	Technological Design Sheet	Sheet Number : Scale :
	Technological Sections	
Ms.c Final Graduating Project Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach Supervisor : Prof. Massimo Tadi Co- Supervisor : Prof.Gabriele Masera	Vertical Section - Part 1	
	Amirali Naraghi Mohammad Hadi Mohammad Zadeh	755237 754940

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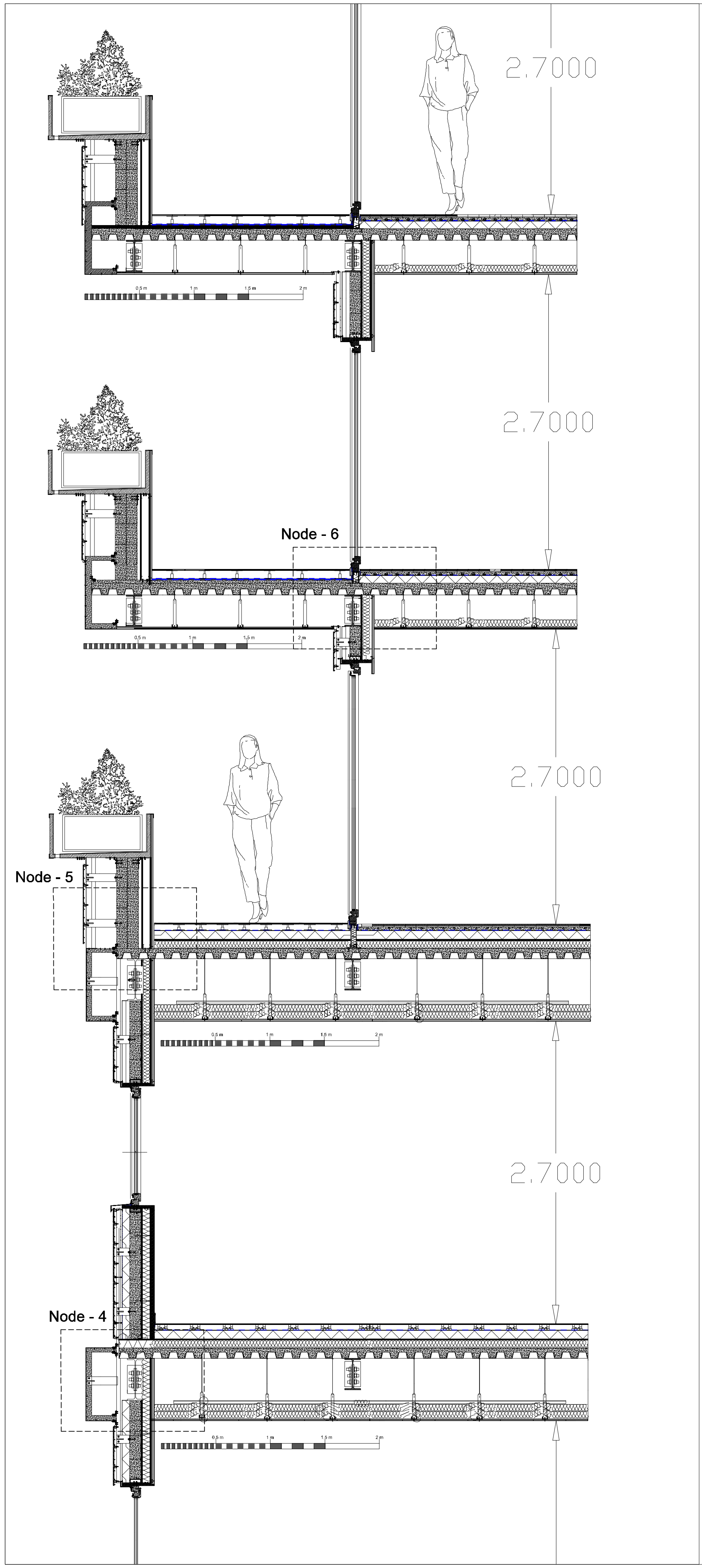
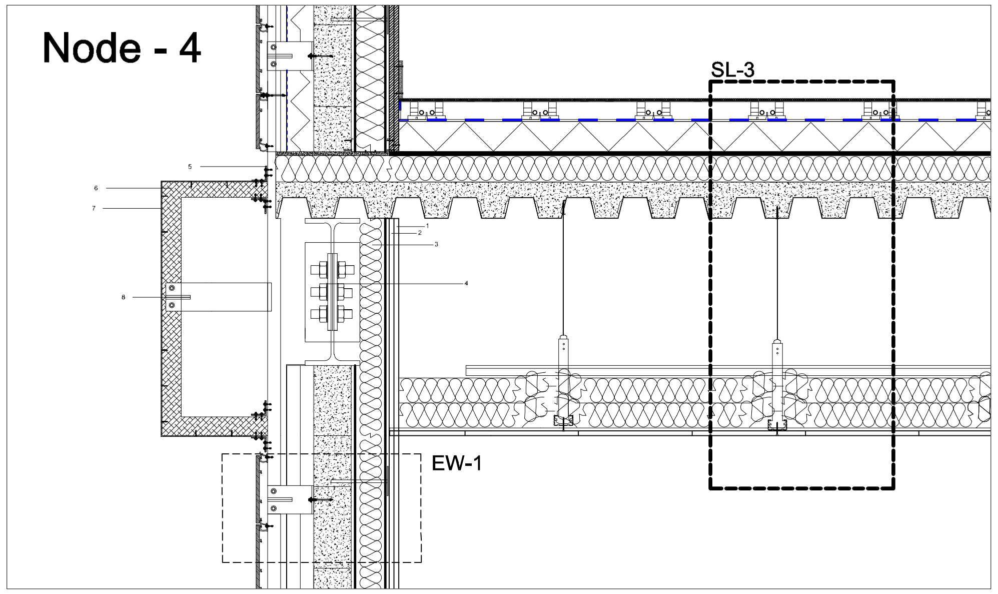
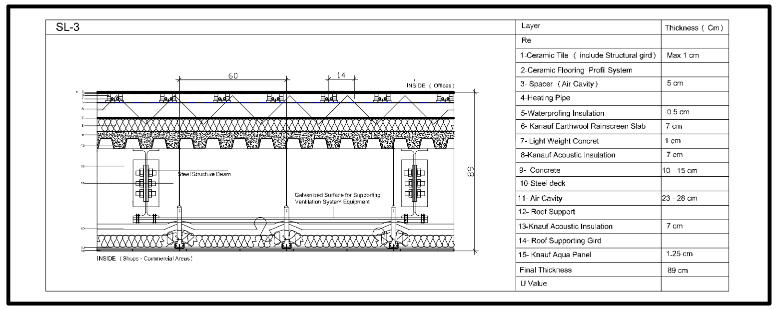
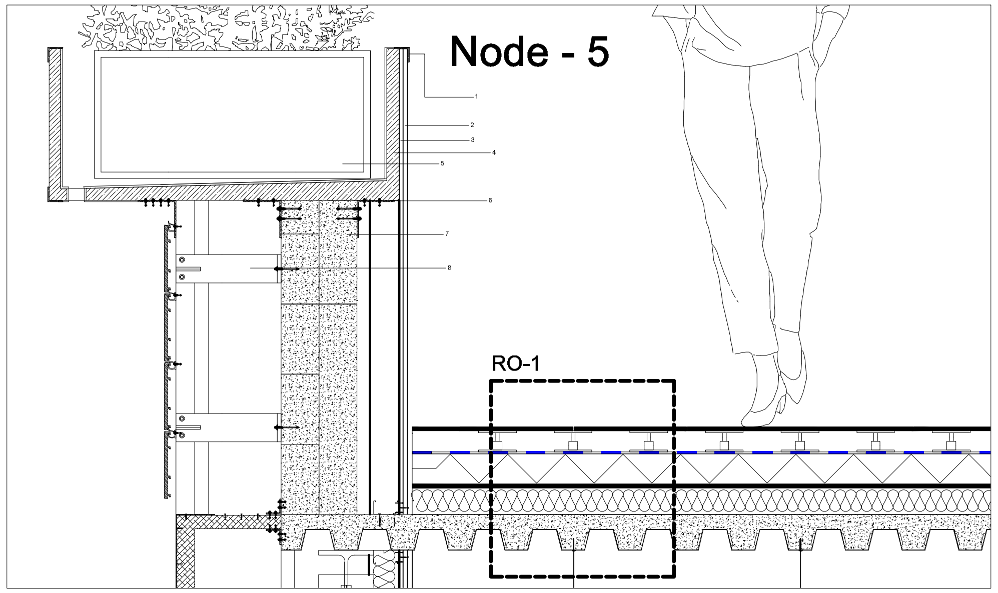
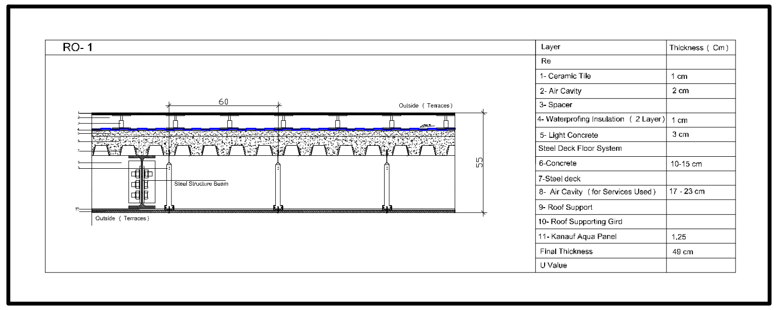




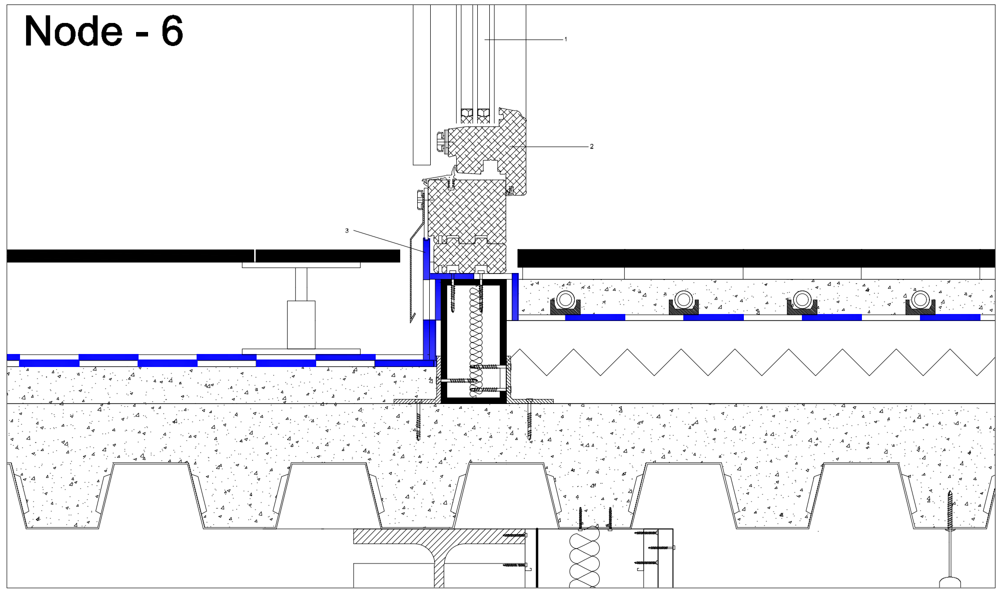


1- knauf Plaster Board
2- Knauf Plaster Board
3- Thermal Insulation
4- Main Structural Beam
5- L Section （Steel）
6- Light Weight Profil for supporting Cover
7- Steel Low Thickness Cover
8- Support

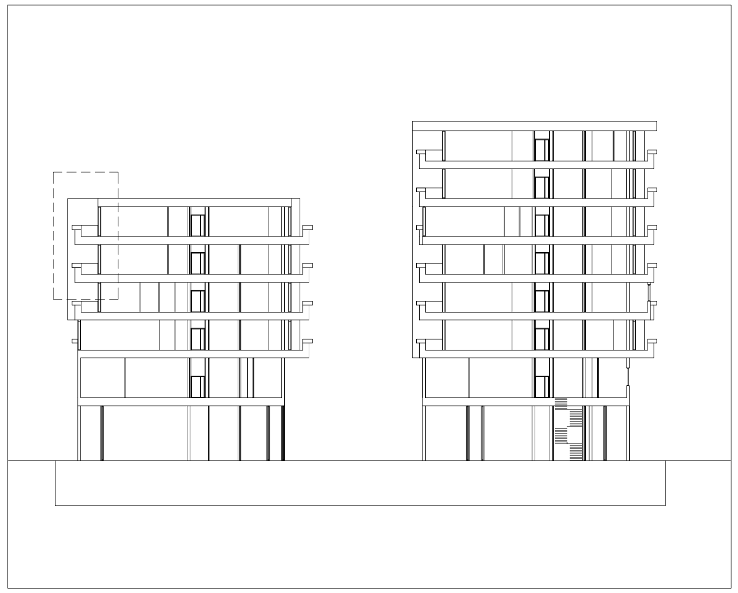




1- L Section （Steel）
2- Knauf Plaster Board
3- Knauf Plaster Board
4- Aluminume Box
5- Flower Box
6- L Section Steel
7- Concrete Dense block
8- Support



1- Double Glazed Window
2- Standard Window Prifil
3- Humidity Insulation



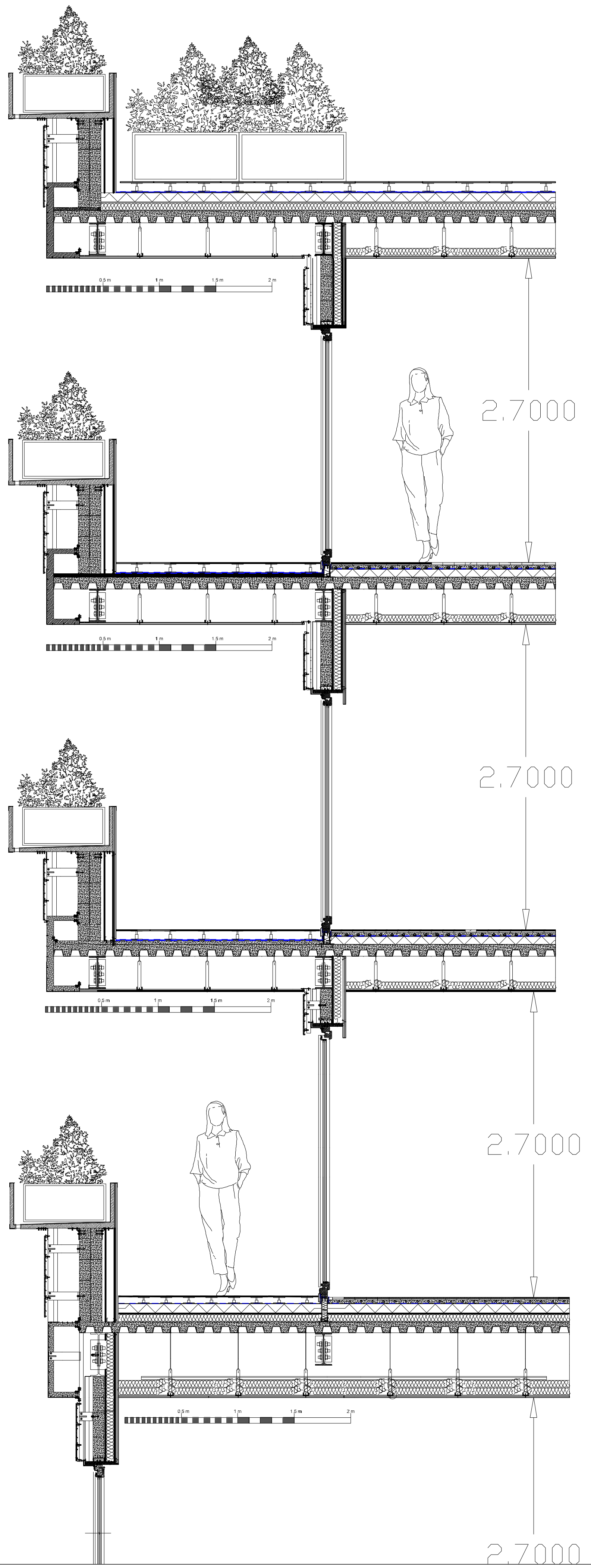
Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi（LC）

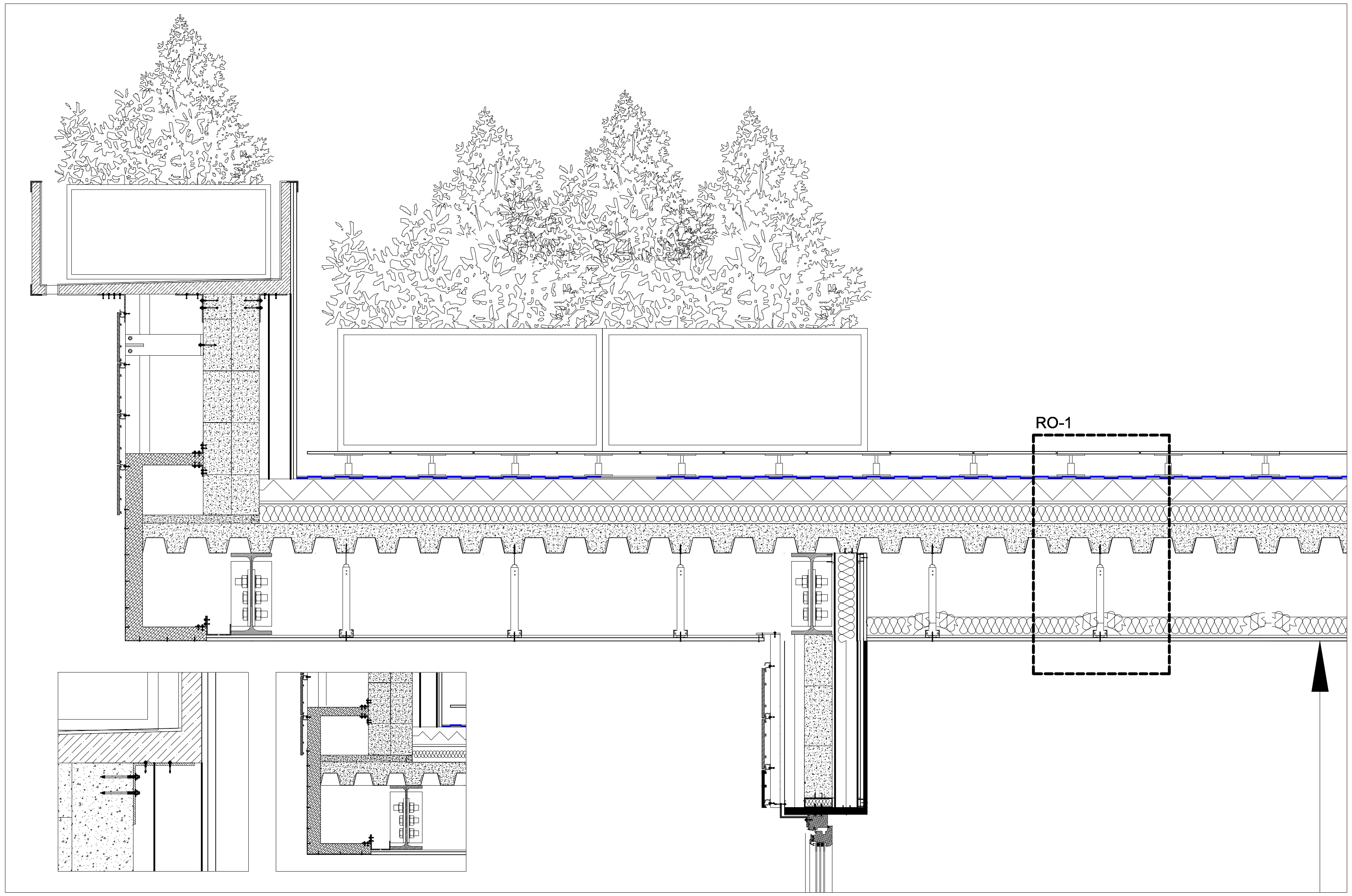
Technological Design Sheet
Sheet Number :
Scale :
Technological Section
Vertical Section - Part 2

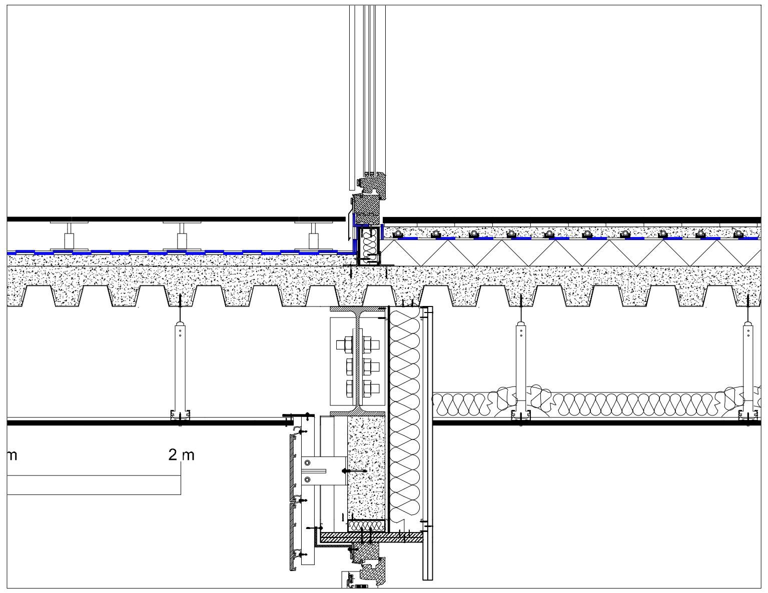
Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

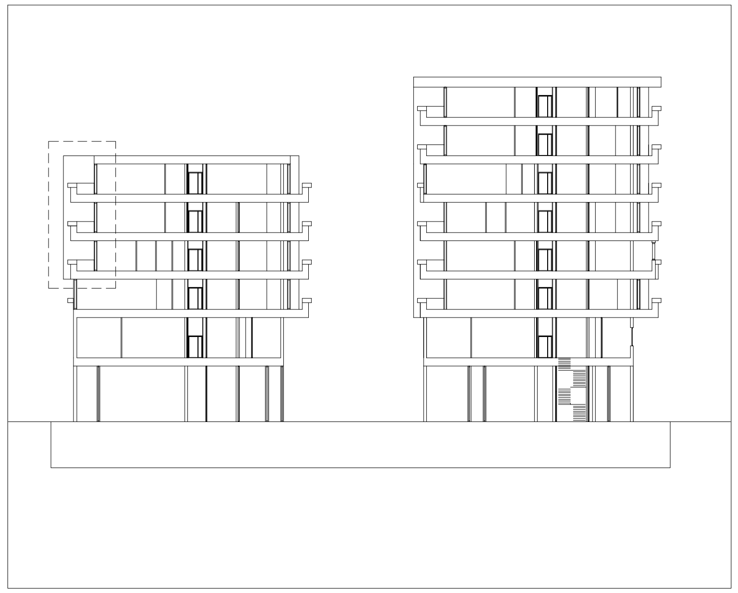
Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 75237
Mohammad Hadi Mohammad Zadeh 754940









Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi（LC）

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Thechnological Design Sheet

Sheet Number :

Scale :

Technological Section

Vertical Section（Part-3）

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

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3.4.3 Structural Design

The building is divided to the three completely separate structures, the structural analysis and designs has been done for Part A of the Building in following. The structural system is chosen as steel intermediate moment frame (IMF) with high strength structural bolts for the connecting parts. The design of the structure is performed based on Allowable Stress Design (ASD) method mentioned in Iranian national building code for steel structures (Part 10).

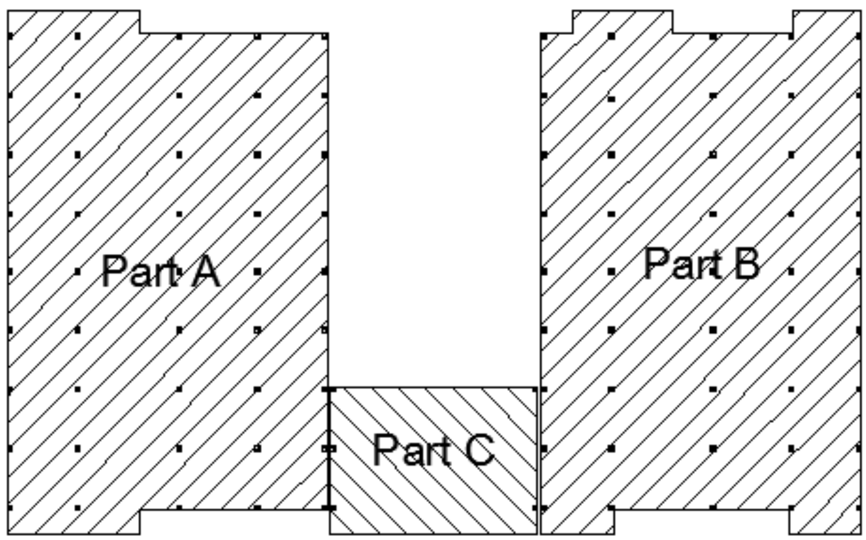


Figure 3-118 Scheme of separated building structure

Applied codes:

Iranian National Building Code Part 6 – Loading on the structures

Iranian National Building Code Part 10 – Steel Structure Design

IRANIAN CODE OF PRACTICE FOR SEISMIC RESISTANT DESIGN OF BUILDINGS (Standard No. 2800) 3rd Edition

Structural analysis has been carried out in *SAP -2000* software.

3.4.3.1 Structural Loading Calculation Sheets

Shops

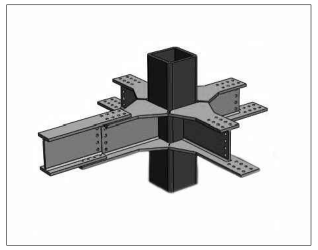
BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m^2)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m^2)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM 1 - A - B	4.40	0.82	370.00	0.00	41.00	303.40	410.00	344.40
BEAM 1 - B - D	6.60	0.82	370.00	0.00	41.00	303.40	410.00	344.40
BEAM 1 - D -G	5.10	0.82	370.00	0.00	41.00	303.40	410.00	344.40
BEAM 1 - G - H	4.40	0.82	370.00	0.00	41.00	303.40	410.00	344.40
BEAM 2 - A - B	4.40	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 2 - B - D	6.60	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 2 - D -G	5.10	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 2 - G - H	4.40	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 4 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 4 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 4 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 4 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 5 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 5 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 5 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 5 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 7 - A - B	4.40	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 7 - B - C	6.60	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 7 - D -G	5.10	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 7 - G - H	4.40	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 8 - A - B	4.40	3.73	370.00	0.00	186.50	1380.10	1865.00	1566.60
BEAM 8 - B - D	6.60	3.73	370.00	0.00	186.50	1380.10	1865.00	1566.60
BEAM 8 - D - E	1.60	3.73	370.00	0.00	186.50	1380.10	1865.00	1566.60
BEAM 8 - E -G	5.10	3.73	370.00	0.00	186.50	1380.10	1865.00	1566.60
BEAM 8 - G - H	4.40	3.73	370.00	0.00	186.50	1380.10	1865.00	1566.60
BEAM 9 - A - B	4.40	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 9 - B - C	6.60	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 9 - D -G	5.10	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 9 - G - H	4.40	3.79	370.00	0.00	189.50	1402.30	1895.00	1591.80
BEAM 11 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 11 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 11 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 11 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 12 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 12 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 12 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 12 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	1925.00	1617.00
BEAM 14 - A - B	4.40	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 14 - B - C	6.60	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 14 - D -G	5.10	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 14 - G - H	4.40	2.25	370.00	0.00	112.50	832.50	1125.00	945.00
BEAM 15 - A - B	4.40	0.82	370.00	0.00	41.00	303.40	410.00	344.40
BEAM 15 - B - C	6.60	0.82	370.00	0.00	41.00	303.40	410.00	344.40
BEAM 15 - D -G	5.10	0.82	370.00	0.00	41.00	303.40	410.00	344.40
BEAM 15 - G - H	4.40	0.82	370.00	0.00	41.00	303.40	410.00	344.40

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m^2)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m^2)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM A-1-2	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-2-4	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-4-5	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-5-7	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-7-8	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-8-9	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-9-11	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-11-12	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-12-14	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM A-14-15	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-1-2	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-2-4	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-4-5	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-5-7	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-7-8	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-8-9	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-9-11	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-11-12	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-12-14	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM B-14-15	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-1-2	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-2-4	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-4-5	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-5-7	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-7-8	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-8-9	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-9-11	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-11-12	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-12-14	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM D-14-15	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM E-8-9	3.70	0.00				0.00	0.00	0.00
BEAM G-1-2	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-2-4	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-4-5	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-5-7	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-7-8	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-8-9	3.70	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-9-11	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-11-12	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-12-14	3.90	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM G-14-15	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00
BEAM H-1-2	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0
BEAM H-2-4	3.90	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-4-5	3.90	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-5-7	3.90	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-7-8	3.70	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-8-9	3.70	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-9-11	3.90	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-11-12	3.90	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-12-14	3.90	0.00	370.00	935.00	0.00	0.00	0.00	935.00
BEAM H-14-15	1.50	0.00	370.00	0.00	0.00	0.00	0.00	0.00

Structural System	Moment Resisting Frame
Connections	Fixed Joints

General Suggestion Ranges For Structural Elements

Columns	BOX : 450mm * 450 mm * 25 mm
	BOX : 400mm * 400 mm * 15 mm
	BOX : 350mm * 350 mm * 15 mm
	BOX : 300mm * 300 mm * 10 mm
Beams	IPE -360
	IPE -320
	IPE -280
	IPE -240
Connections	BOLTS

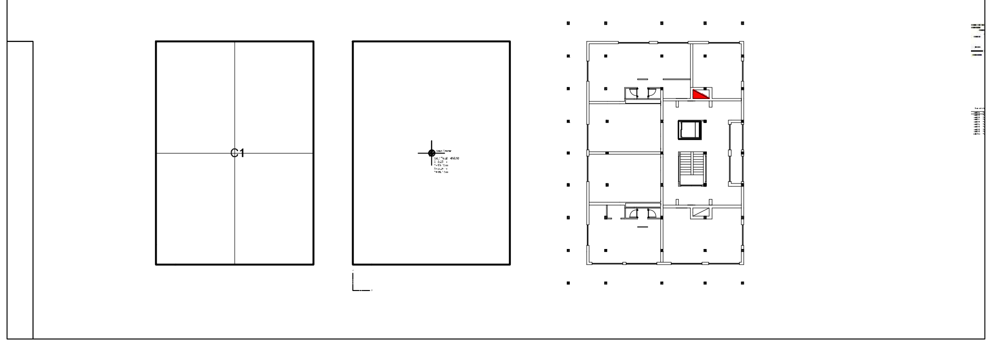


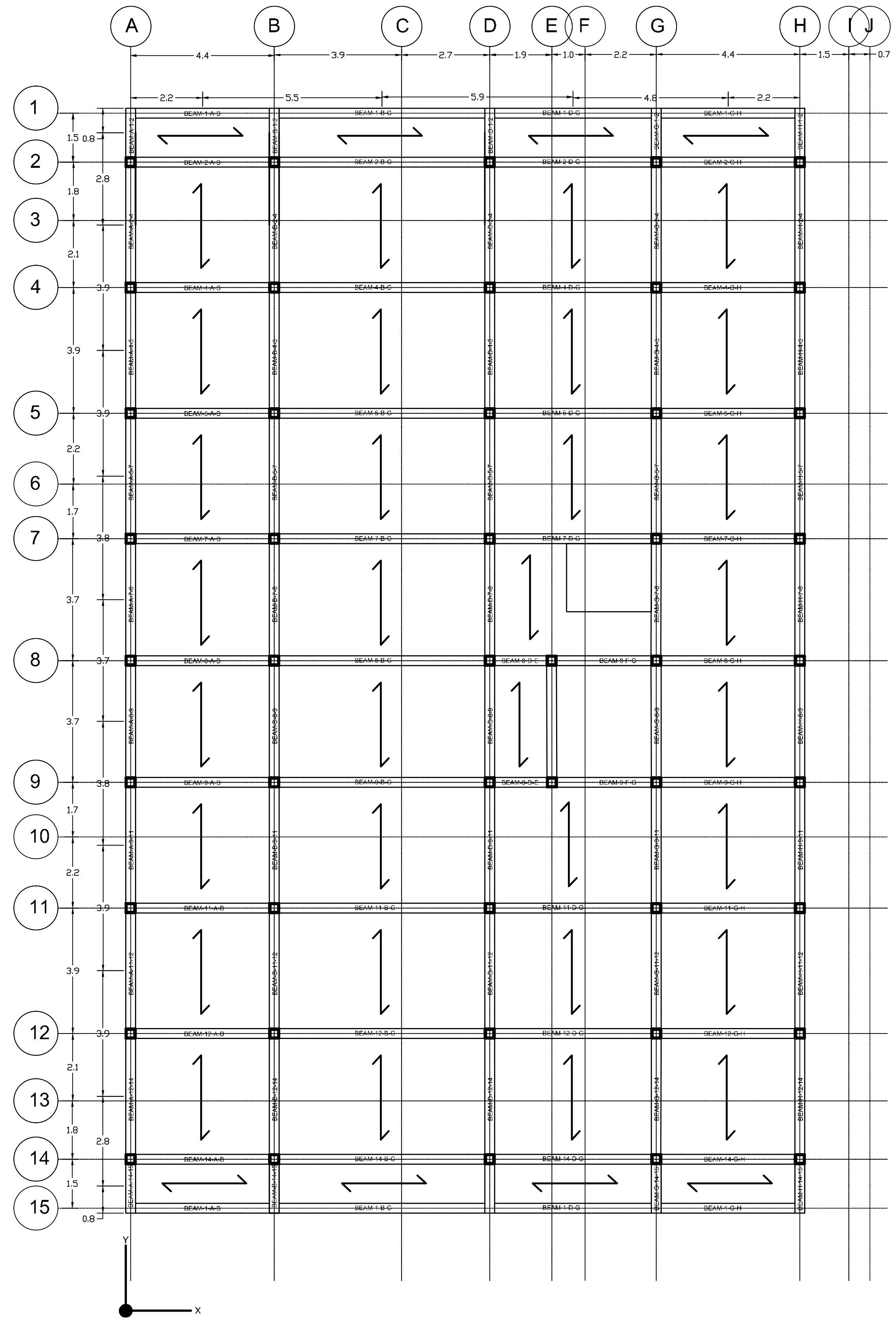
Load Combinations (According to Iran Building Codes)

COMB-1	Total Dead
COMB-2	Total Dead + Live
COMB-3	Total Dead + Ex
COMB-4	Total Dead - Ex
COMB-5	Total Dead + Ey
COMB-6	Total Dead - Ey
COMB-7	Total Dead+ Live + Live (Green Roof)+ Ex
COMB-8	Total Dead+ Live + Live (Green Roof)- Ex
COMB-9	Total Dead+ Live + Live (Green Roof)+Ey
COMB-10	Total Dead+ Live + Live (Green Roof)- Ey

Ground Floor (Shops)

Dead Loads	Slabs Dead Load	370 kg/m2			According to Technological Detail SL-3
	Average Dead Load Inside	50 kg/m2			According to Iran Building Codes (Part 6)
	Side Walls Dead Loads	935 kg/m2			According to Technological Detail EW-1 for Shops with 30% Reduction of Opening
Live Loads	Live Load	500 Kg/m2			According to Iran Building Code (For Commercial Areas)
Total Floor Weight of the Floor	Total Dead Load Slabs	179.82	Ton	346.25	According to Iran Building Code (Part 6) and Iran Structural Siesmic Design Code(2800) - The Details of Calculations are available in Siesmic Design Part
	Total Dead Side Walls	84.15	Ton		
	Structural Elements Weight	33.68	Ton		
	20% of Live Load	48.6	Ton		
Siesmic Load	Ex	5.76 Ton-F			According to Iran Structural Siesmic Design Code (2800)
	Ey	5.76 Ton-F			Details of Calculation is Available in Siesmic Design Part
	MZx	7.5 Ton F-m			According to Iran Structural Siesmic Design Code (2800)
	MZy	5.3 Ton.F-m			Details of Calculation is Available in Siesmic Design Part





Ground Floor (Shops)	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
	9.25	13.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Section Area (m^2)	485.93		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
{X*Area }	4494.85		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
{Y*Area}	6381.86		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Total Area (m^2)	485.93				Xtotal =		9.25				Ytotal=		13.13																	

Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Sistemi Edilizi (LC)

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Structural Design Sheet

Sheet Number : 1

Scale :

Structural Plan - Load Calculation

Ground Floor (Shops)

Amirali Naraghi — Matricola Number : 755237
Mohammad Hadi Mohammad Zadeh — Matricola Number : 754940

Offices

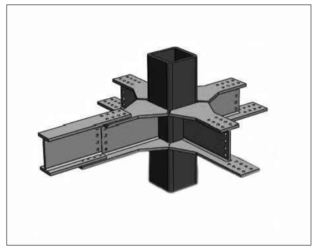
BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM 1 - A - B	4.40	0.85	370.00	560.00	42.50	314.50	212.50	917.00
BEAM 1 - B - C	3.90	0.85	370.00	560.00	42.50	314.50	212.50	917.00
BEAM 2 - A - B	4.40	2.75	370.00	0.00	137.50	1017.50	687.50	1155.00
BEAM 2 - B - D	6.60	2.75	370.00	0.00	137.50	1017.50	687.50	1155.00
BEAM 2 - D -G	5.10	2.75	370.00	560.00	137.50	1017.50	687.50	1715.00
BEAM 2 - G - H	4.40	2.75	370.00	560.00	137.50	1017.50	687.50	1715.00
BEAM 4 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 4 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 4 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 4 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 5 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 5 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 5 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 5 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 7 - A - B	4.40	3.79	335.00	0.00	189.50	1269.65	947.50	1459.15
BEAM 7 - B - C	6.60	3.79	335.00	0.00	189.50	1269.65	947.50	1459.15
BEAM 7 - D -G	5.10	3.79	335.00	0.00	189.50	1269.65	947.50	1459.15
BEAM 7 - G - H	4.40	3.79	335.00	0.00	189.50	1269.65	947.50	1459.15
BEAM 8 - A - B	4.40	3.73	370.00	0.00	186.50	1380.10	932.50	1566.60
BEAM 8 - B - C	6.60	3.73	370.00	0.00	186.50	1380.10	932.50	1566.60
BEAM 8 - D - E	1.60	3.73	370.00	0.00	186.50	1380.10	932.50	1566.60
BEAM 8 - D -G	5.10	3.73	370.00	0.00	186.50	1380.10	932.50	1566.60
BEAM 8 - G - H	4.40	3.73	370.00	0.00	186.50	1380.10	932.50	1566.60
BEAM 9 - A - B	4.40	3.79	370.00	0.00	189.50	1402.30	947.50	1591.80
BEAM 9 - B - C	6.60	3.79	370.00	0.00	189.50	1402.30	947.50	1591.80
BEAM 9 - D -G	5.10	3.79	370.00	0.00	189.50	1402.30	947.50	1591.80
BEAM 9 - G - H	4.40	3.79	370.00	0.00	189.50	1402.30	947.50	1591.80
BEAM 11 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 11 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 11 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 11 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 12 - A - B	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 12 - B - C	6.60	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 12 - D -G	5.10	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 12 - G - H	4.40	3.85	370.00	0.00	192.50	1424.50	962.50	1617.00
BEAM 14 - A - B	4.40	2.83	370.00	560.00	141.50	1047.10	707.50	1748.60
BEAM 14 - B - D	6.60	2.83	370.00	560.00	141.50	1047.10	707.50	1748.60
BEAM 14 - G - H	4.40	2.83	370.00	560.00	141.50	1047.10	707.50	1748.60
BEAM 15 - A - B	4.40	0.82	370.00	560.00	41.00	303.40	205.00	904.40
BEAM 15 - B- C	4.05	0.82	370.00	560.00	41.00	303.40	205.00	904.40

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM A-1-2	1.50	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-2-4	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-4-5	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-5-7	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-7-8	3.70	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-8-9	3.70	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-9-11	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-11-12	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-12-14	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM A-14-15	1.50	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM B-1-2	1.50	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-2-4	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-4-5	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-5-7	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-7-8	3.70	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-8-9	3.70	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-9-11	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-11-12	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-12-14	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM B-14-15	1.50	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM C-1-2	1.50	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM C-14-15	1.50	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM D-1-2	1.50	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-2-4	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-4-5	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-5-7	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-7-8	3.70	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-8-9	3.70	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-9-11	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-11-12	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-12-14	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM D-14-15	1.50	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM E-8-9	3.70	0.00			0.00	0.00	0.00	0.00
BEAM G-2-4	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM G-4-5	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM G-5-7	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM G-7-8	3.70	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM G-8-9	3.70	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM G-9-11	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM G-11-12	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM G-12-14	3.90	0.00	335.00	0.00	0.00	0.00	0.00	0.00
BEAM H-1-2	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-2-4	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-4-5	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-5-7	3.70	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-7-8	3.70	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-8-9	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-9-11	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-11-12	3.90	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-12-14	3.85	0.00	335.00	560.00	0.00	0.00	0.00	560.00
BEAM H-14-15	1.50	0.00	335.00	560.00	0.00	0.00	0.00	560.00

Structural System	Moment Resisting Frame
Connections	Fixed Joints

General Suggestion Ranges For Structural Elements

Columns	BOX : 450mm * 450 mm * 25 mm
	BOX : 400mm * 400 mm * 15 mm
	BOX : 350mm * 350 mm * 15 mm
	BOX : 300mm * 300 mm * 10 mm
Beams	IPE -360
	IPE -320
	IPE -280
	IPE -240
Connections	BOLTS

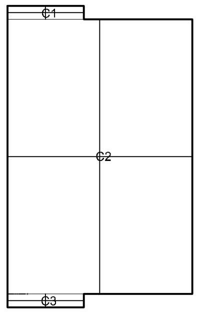


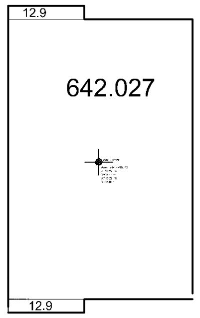
Load Combinations (According to Iran Building Codes)

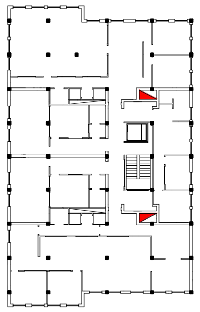
COMB-1	Total Dead
COMB-2	Total Dead + Live
COMB-3	Total Dead + Ex
COMB-4	Total Dead - Ex
COMB-5	Total Dead + Ey
COMB-6	Total Dead - Ey
COMB-7	Total Dead+ Live + Live (Green Roof)+ Ex
COMB-8	Total Dead+ Live + Live (Green Roof)- Ex
COMB-9	Total Dead+ Live + Live (Green Roof)+Ey
COMB-10	Total Dead+ Live + Live (Green Roof)- Ey

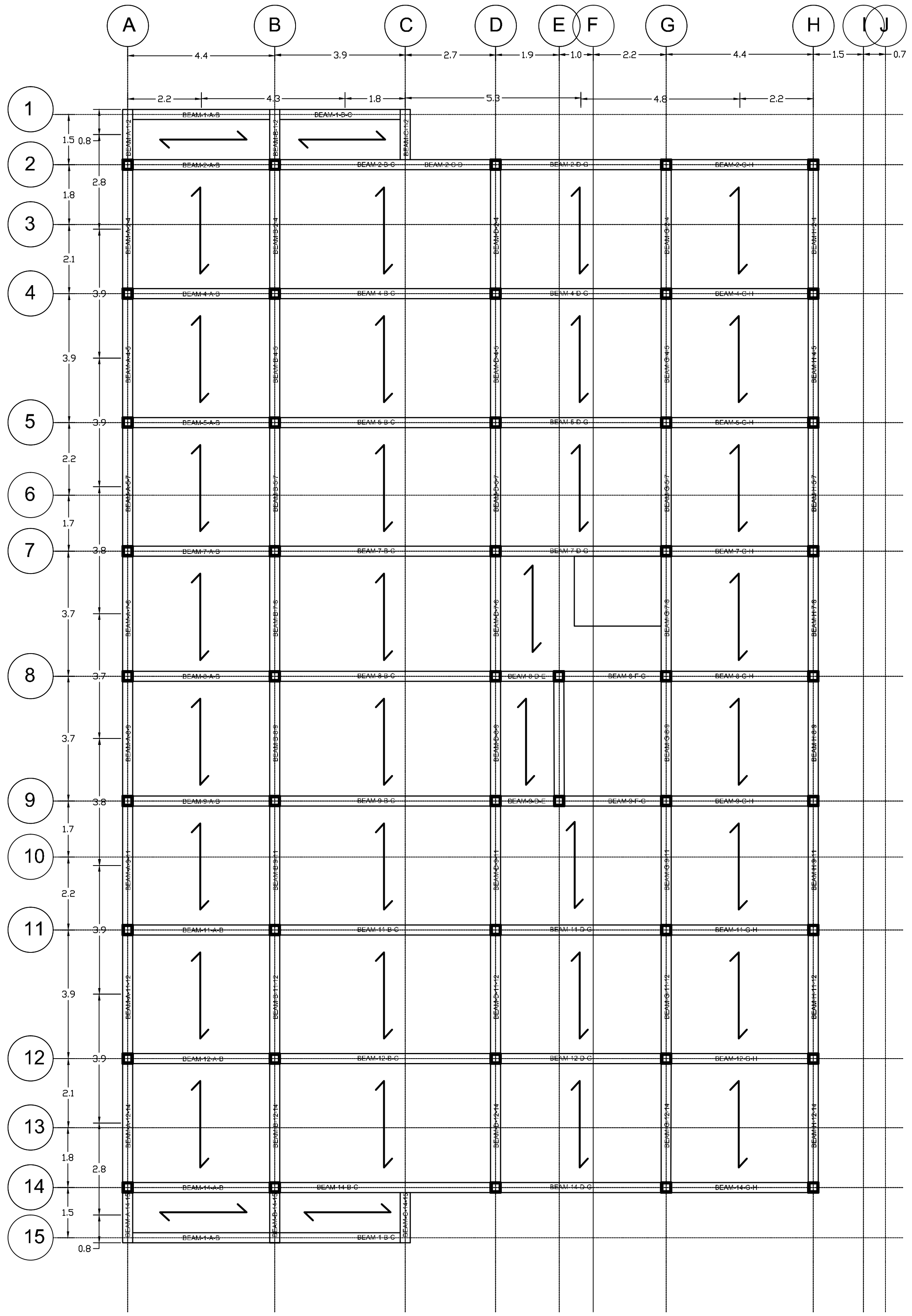
First Floor (Offices)

Dead Loads	Slabs Dead Load	370 kg/m2		According to Technological Detail SL-3
	Average Dead Load Inside	50 kg/m2		According to Iran Building Codes (Part 6)
	Side Walls Dead Loads	560 kg/m2		According to Technological Detail EW-1 for offices with 30% Reduction of Opening
Live Loads	Live Load	250 Kg/m2		According to Iran Building Code (For Offices Areas)
Total Floor Weight of the Floor	Total Dead Load Slabs	247.16	Ton	371.22 — According to Iran Building Code (Part 6) and Iran Structural Siesmic Design Code(2800) - The Details of Calculations are available in Siesmic Design Part
	Total Dead Side Walls	61.04	Ton	
	Structural Elements Weight	29.62	Ton	
	20% of Live Load	33.4	Ton	
Siesmic Load	Ex	20.41 Ton-F		According to Iran Structural Siesmic Design Code (2800)
	Ey	20.41 Ton-F		Details of Calculation is Available in Siesmic Design Part
	MZx	34.56 Ton F-m		According to Iran Structural Siesmic Design Code (2800)
	MZy	21.22 Ton.F-m		Details of Calculation is Available in Siesmic Design Part









First Floor (Offices)	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
	4.30	31.62	10.46	15.43	4.30	-0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Section Area (m²)	12.90		642.03		12.90		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
{X*Area }	55.47		6717.24		55.47		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
{Y*Area}	407.86		9908.64		-9.68		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Total Area (m²)	667.83				Xtotal =		10.22				Ytotal=		15.43																	

Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Sistemi Edilizi (LC)

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's District 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Structural Design Sheet

Sheet Number : 2

Scale :

Structural Plan - Load Calculation

First Floor (Offices)

Amirali Naraghi — Matricola Number : 755237
Mohammad Hadi Mohammad Zadeh — Matricola Number : 754940

Second Floor (Residential)

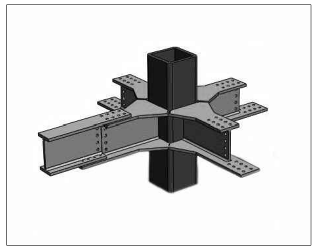
BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM 1 - A - B	4.40	0.82	350.00	320.00	41.00	287.00	164.00	648.00
BEAM 1- B - C	3.90	0.82	350.00	320.00	41.00	287.00	164.00	648.00
BEAM 1- G - H	4.40	0.82	350.00	320.00	41.00	287.00	164.00	648.00
BEAM 1- H - I	1.50	0.82	350.00	320.00	41.00	287.00	164.00	648.00
BEAM 2 - A - B	4.40	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 2 - B - D	6.60	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 2 - D -G	5.10	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 2 - G - H	4.40	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 2 -H -I	1.50	2.83	350.00	0.00	141.50	990.50	566.00	1132.00
BEAM 4 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 7 - A - B	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - B - C	6.60	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - D -G	5.10	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - G - H	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 -H -J	1.50	3.79	350.00	320.00	189.50	1326.50	758.00	1836.00
BEAM 8 - A - B	4.40	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - B - D	6.60	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - D -E	1.60	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM8 -E -G	2.90	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - G - H	4.40	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 -H -J	1.50	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 9 - A - B	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - B - C	6.60	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - D -G	5.10	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - G - H	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 -H -J	1.50	3.79	350.00	320.00	189.50	1326.50	758.00	1836.00
BEAM 11 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 14 - A - B	4.40	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 14 - B - D	6.60	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 14 - D -G	5.10	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 14 - G - H	4.40	2.83	350.00	504.00	141.50	990.50	566.00	1636.00
BEAM 14 -H -I	1.50	2.83	350.00	0.00	141.50	990.50	566.00	1132.00
BEAM 15 - A - B	4.40	0.82	350.00	0.00	41.00	287.00	164.00	328.00
BEAM 15 - B - C	3.90	0.82	350.00	0.00	41.00	287.00	164.00	328.00

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM A-1-2	1.50	0	350	320	0	0	0	320
BEAM A-2-4	3.90	0	350	0	0	0	0	0
BEAM A-4-5	3.90	0	350	0	0	0	0	0
BEAM A-5-7	3.90	0	350	504	0	0	0	504
BEAM A-7-8	3.70	0	350	320	0	0	0	320
BEAM A-8-9	3.70	0	350	504	0	0	0	504
BEAM A-9-11	3.90	0	350	504	0	0	0	504
BEAM A-11-12	3.90	0	350	0	0	0	0	0
BEAM A-12-14	3.90	0	350	0	0	0	0	0
BEAM A-14-15	1.50	0	350	0	0	0	0	0
BEAM B-1-2	1.50	0	350	0	0	0	0	0
BEAM B-2-4	3.90	0	350	0	0	0	0	0
BEAM B-4-5	3.90	0	350	0	0	0	0	0
BEAM B-5-7	3.90	0	350	0	0	0	0	0
BEAM B-7-8	3.70	0	350	0	0	0	0	0
BEAM B-8-9	3.70	0	350	0	0	0	0	0
BEAM B-9-11	3.90	0	350	0	0	0	0	0
BEAM B-11-12	3.90	0	350	0	0	0	0	0
BEAM B-12-14	3.90	0	350	0	0	0	0	0
BEAM B-14-15	1.50	0	350	0	0	0	0	0
BEAM C-1-2	1.50	0	350	320	0	0	0	320
BEAM C-14-15	1.50	0	350	0	0	0	0	0
BEAM D-1-2	1.50	0	350	0	0	0	0	0
BEAM D-2-4	3.90	0	350	0	0	0	0	0
BEAM D-4-5	3.90	0	350	0	0	0	0	0
BEAM D-5-7	3.90	0	350	0	0	0	0	0
BEAM D-7-8	3.70	0	350	0	0	0	0	0
BEAM D-8-9	3.70	0	350	0	0	0	0	0
BEAM D-9-11	3.90	0	350	0	0	0	0	0
BEAM D-11-12	3.90	0	350	0	0	0	0	0
BEAM D-12-14	3.90	0	350	0	0	0	0	0
BEAM D-14-15	1.50	0	350	0	0	0	0	0
BEAM E-8-9	3.70	0			0	0	0	0
BEAM G-1-2	1.50	0	350	320	0	0	0	320
BEAM G-2-4	3.90	0	350	0	0	0	0	0
BEAM G-4-5	3.90	0	350	0	0	0	0	0
BEAM G-5-7	3.90	0	350	0	0	0	0	0
BEAM G-7-8	3.70	0	350	0	0	0	0	0
BEAM G-8-9	3.70	0	350	0	0	0	0	0
BEAM G-9-11	3.90	0	350	0	0	0	0	0
BEAM G-11-12	3.90	0	350	0	0	0	0	0
BEAM G-12-14	3.90	0	350	0	0	0	0	0
BEAM G-14-15	1.50	0	350	0	0	0	0	0
BEAM H-1-2	1.50	0	350	0	0	0	0	0
BEAM H-2-4	3.90	0	350	504	0	0	0	504
BEAM H-4-5	3.90	0	350	504	0	0	0	504
BEAM H-5-7	3.90	0	350	504	0	0	0	504
BEAM H-7-8	3.70	0	350	504	0	0	0	504
BEAM H-8-9	3.70	0	350	504	0	0	0	504
BEAM H-9-11	3.90	0	350	504	0	0	0	504
BEAM H-11-12	3.90	0	350	504	0	0	0	504
BEAM H-12-14	3.90	0	350	504	0	0	0	504
BEAM H-14-15	1.50	0	350	0	0	0	0	0
BEAM I - 1-2	1.50	0	350	320	0	0	0	320
BEAM I-4-5	1.50	0	350	504	0	0	0	504
BEAM I-11-12	1.50	0	350	504	0	0	0	504
BEAM I -14-15	1.50	0	350	320	0	0	0	320
Beam J-7-9	7.40	0	350	0	0	0	0	0

Structural System	Moment Resisting Frame
Connections	Fixed Joints

General Suggestion Ranges For Structural Elements

Columns	BOX : 450mm * 450 mm * 25 mm
	BOX : 400mm * 400 mm * 15 mm
	BOX : 350mm * 350 mm * 15 mm
	BOX : 300mm * 300 mm * 10 mm
Beams	IPE -360
	IPE -320
	IPE -280
	IPE -240
Connections	BOLTS

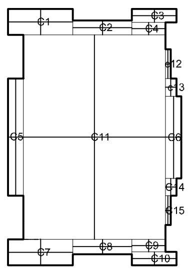


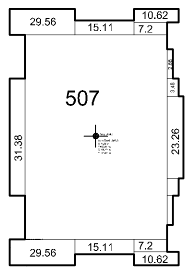
Load Combinations (According to Iran Building Codes)

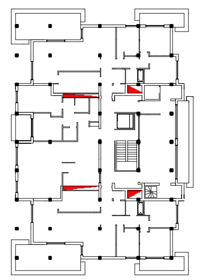
COMB-1	Total Dead
COMB-2	Total Dead + Live
COMB-3	Total Dead + Ex
COMB-4	Total Dead - Ex
COMB-5	Total Dead + Ey
COMB-6	Total Dead - Ey
COMB-7	Total Dead+ Live + Live (Green Roof)+ Ex
COMB-8	Total Dead+ Live + Live (Green Roof)- Ex
COMB-9	Total Dead+ Live + Live (Green Roof)+Ey
COMB-10	Total Dead+ Live + Live (Green Roof)- Ey

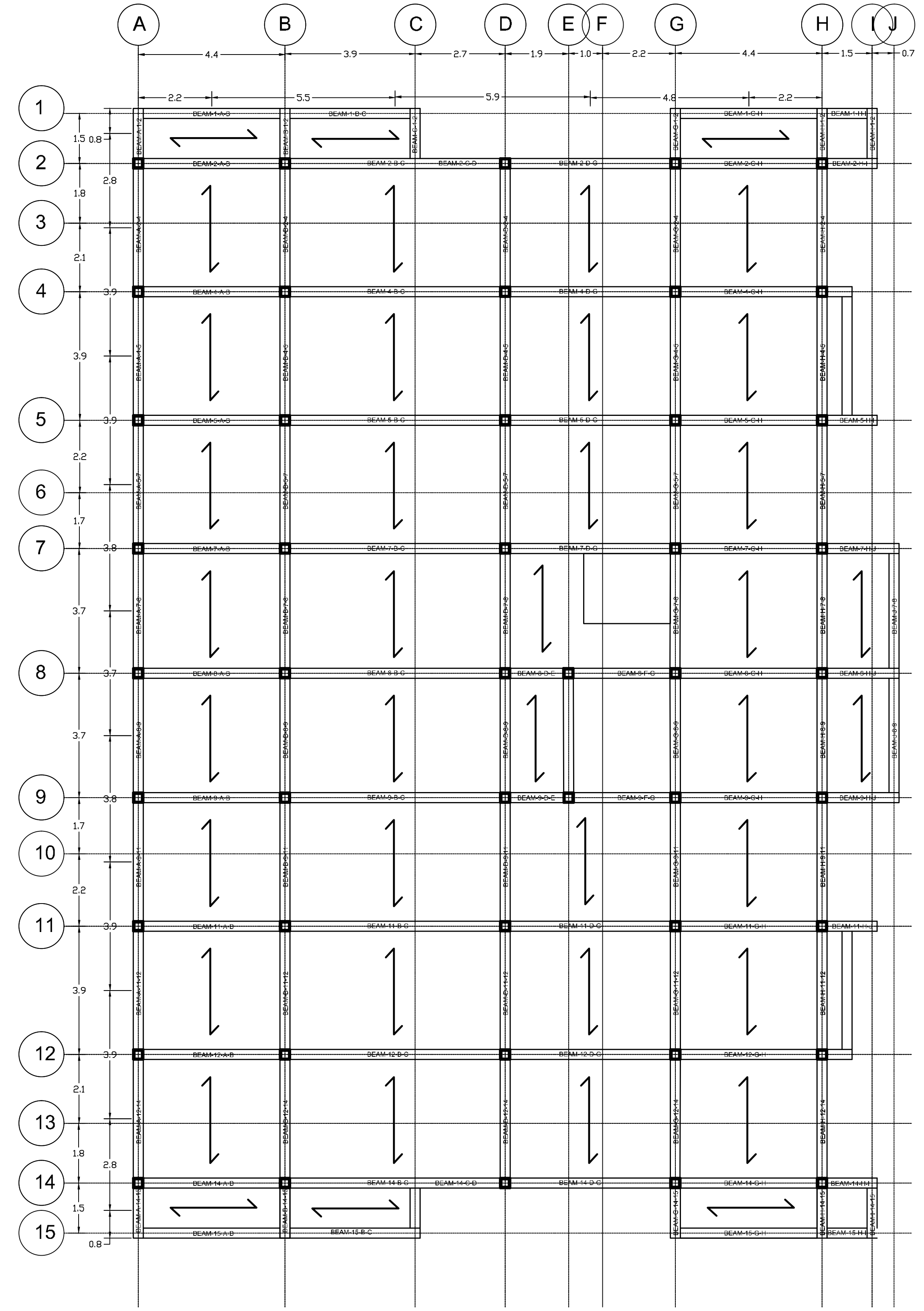
Second Floor (Residential Units)

Dead Loads	Slabs Dead Load	344 kg/m2			According to Technological Detail SL-3
	Average Dead Load Inside	50 kg/m2			According to Iran Building Codes (Part 6)
	Side Walls Dead Loads	504 kg/m2			According to Technological Detail EW-1 for Residential Units with 30% Reduction of Opening
Live Loads	Live Load	200 Kg/m2			According to Iran Building Code (For Residential Units)
Total Floor Weight of the Floor	Total Dead Load Slabs	240.8	Ton	360.248	According to Iran Building Code (Part 6) and Iran Structural Siesmic Design Code(2800) - The Details of Calculations are available in Siesmic Design Part
	Total Dead Side Walls	56.448	Ton		
	Structural Elements Weight	29.6	Ton		
	20% of Live Load	33.4	Ton		
Siesmic Load	Ex	29.15 Ton-F			According to Iran Structural Siesmic Design Code (2800)
	Ey	29.15 Ton-F			Details of Calculation is Available in Siesmic Design Part
	MZx	49.37 Ton F-m			According to Iran Structural Siesmic Design Code (2800)
	MZy	32.50 Ton.F-m			Details of Calculation is Available in Siesmic Design Part









Second Floor Floor (Residential)	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
	2.27	30.43	10.47	27.96	17.32	29.53	16.57	27.81	-1.01	13.50	19.85	13.50	2.27	-1.72	10.47	-0.97	16.57	-0.88	17.32	2.54	9.45	13.50	19.15	23.15	19.52	20.07	19.52	6.92	19.15	3.84
Section Area (m²)	29.56		15.11		10.62		7.20		31.38		23.26		29.56		15.11		7.20		10.62		507.00		2.88		3.48		3.48		2.88	
{X*Area }	67.10		158.21		183.95		119.31		-31.84		461.61		67.12		158.21		119.31		183.95		4790.09		55.14		67.93		67.93		55.14	
{Y*Area}	899.49		422.48		313.60		200.23		423.50		313.91		-50.81		-14.64		-6.35		26.95		6842.37		66.68		69.84		24.10		11.05	
Total Area (m²)	699.34				Xtotal =		9.33				Ytotal=		13.64																	

Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (LC)

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Structural Design Sheet

Sheet Number : 3
Scale :

Structural Plan - Load Calculation

Second Floor (Residential Units)

Amirali Naraghi — Matricola Number : 755237
Mohammad Hadi Mohammad Zadeh — Matricola Number : 754940

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

Forth Floor New (Residential)

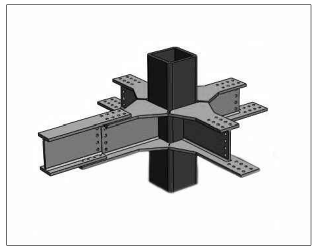
BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM 1 - A - B	4.40	0.82	350.00	0.00	41.00	287.00	164.00	328.00
BEAM 1- B - C	3.90	0.82	350.00	0.00	41.00	287.00	164.00	328.00
BEAM 2 - A - B	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 - B - D	6.60	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 - D -G	5.10	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 - G - H	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 -H -I	1.50	2.83	350.00	0.00	141.50	990.50	566.00	1132.00
BEAM 4 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 7 - A - B	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - B - C	6.60	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - D -G	5.10	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - G - H	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 -H -I	1.50	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 8 - A - B	4.40	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - B - D	6.60	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - D -E	1.60	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM8 -E -G	2.90	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - G - H	4.40	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 -H -I	1.50	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 9 - A - B	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - B - C	6.60	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - D -G	5.10	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - G - H	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 -H -I	1.50	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 11 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 14 - A - B	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 - B - D	6.60	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 - D -G	5.10	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 - G - H	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 -H -I	1.50	2.83	350.00	0.00	141.50	990.50	566.00	1132.00
BEAM 15 - A - B	4.40	0.82	350.00	0.00	41.00	287.00	164.00	328.00
BEAM 15 - B - C	4.05	0.82	350.00	0.00	41.00	287.00	164.00	328.00

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM A-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-5-7	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM A-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-8-9	3.70	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM A-9-11	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM A-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM E-8-9	3.70	0.00				0.00	0.00	0.00
BEAM F-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM F-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM H-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM H-2-4	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-4-5	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-5-7	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-7-8	3.70	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-8-9	3.70	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-9-11	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-11-12	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-12-14	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM I-4-5	1.50	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM I-11-12	1.50	0.00	350.00	720.00	0.00	0.00	0.00	720.00
Beam J-7-9	7.40	0.00	350.00	0.00	0.00	0.00	0.00	0.00

Structural System	Moment Resisting Frame
Connections	Fixed Joints

General Suggestion Ranges For Structural Elements

Columns	BOX : 450mm * 450 mm * 25 mm
	BOX : 400mm * 400 mm * 15 mm
	BOX : 350mm * 350 mm * 15 mm
	BOX : 300mm * 300 mm * 10 mm
Beams	IPE -360
	IPE -320
	IPE -280
	IPE -240
Connections	BOLTS

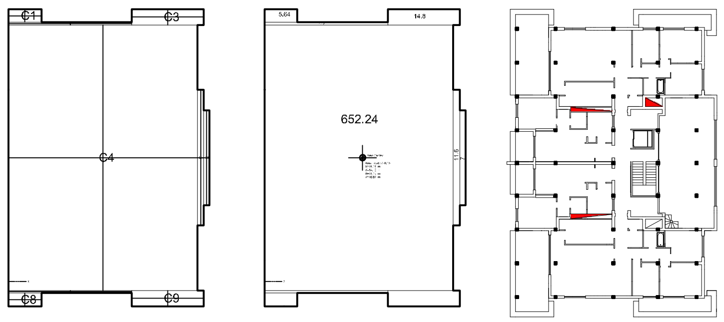


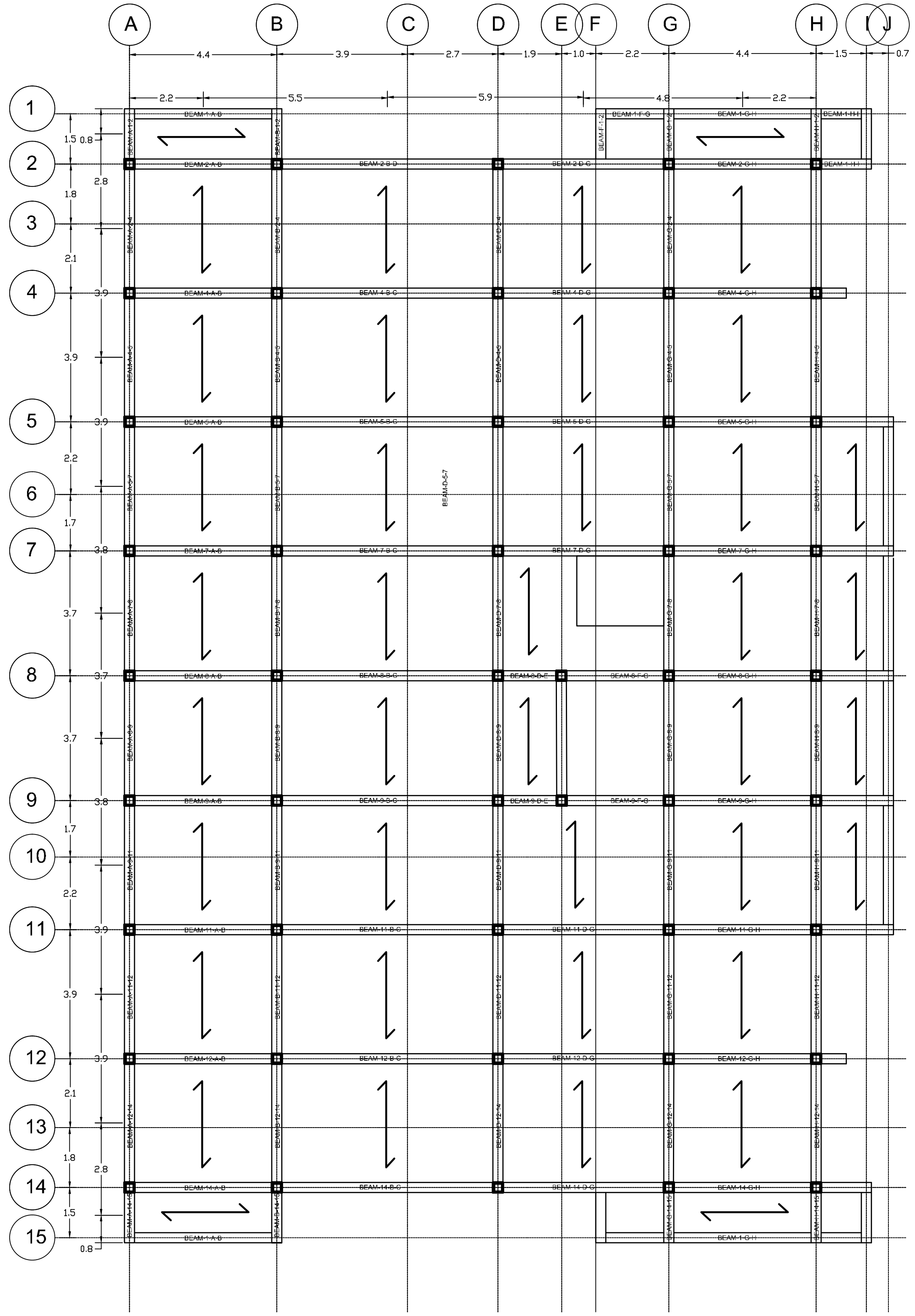
Load Combinations (According to Iran Building Codes)

COMB-1	Total Dead
COMB-2	Total Dead + Live
COMB-3	Total Dead + Ex
COMB-4	Total Dead - Ex
COMB-5	Total Dead + Ey
COMB-6	Total Dead - Ey
COMB-7	Total Dead+ Live + Live (Green Roof)+ Ex
COMB-8	Total Dead+ Live + Live (Green Roof)- Ex
COMB-9	Total Dead+ Live + Live (Green Roof)+Ey
COMB-10	Total Dead+ Live + Live (Green Roof)- Ey

Third Floor (Residential Units)

Dead Loads	Slabs Dead Load	344 kg/m2			According to Technological Detail SL-3
	Average Dead Load Inside	50 kg/m2			According to Iran Building Codes (Part 6)
	Side Walls Dead Loads	504 kg/m2			According to Technological Detail EW-1 for Residential Units with 30% Reduction of Opening
Live Loads	Live Load	200 Kg/m2			According to Iran Building Code (For Residential Units)
Total Floor Weight of the Floor	Total Dead Load Slabs	239.08	Ton	358.548	According to Iran Building Code (Part 6) and Iran Structural Siesmic Design Code(2800) - The Details of Calculations are available in Siesmic Design Part
	Total Dead Side Walls	56.448	Ton		
	Structural Elements Weight	29.62	Ton		
	20% of Live Load	33.4	Ton		
Siesmic Load	Ex	36.26 Ton-F			According to Iran Structural Siesmic Design Code (2800)
	Ey	36.26 Ton-F			Details of Calculation is Available in Siesmic Design Part
	MZx	61.40 Ton F-m			According to Iran Structural Siesmic Design Code (2800)
	MZy	40.43 Ton.F-m			Details of Calculation is Available in Siesmic Design Part





Third Floor Floor (Residential)	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
	4.30	28.21	14.55	27.62	21.40	28.37	15.08	25.52	12.65	23.59	11.15	20.68	11.48	14.10	11.15	7.54	12.65	4.60	15.13	2.68	4.55	0.00	14.55	0.60	21.40	-0.15	0.00	0.00	0.00	0.00
Section Area (m²)	49.00		45.81		9.63		4.50		62.27		51.80		248.35		51.80		62.27		4.50		49.00		45.81		9.63		0.00		0.00	
{X*Area }	210.70		666.54		206.08		67.84		787.98		577.57		2849.82		577.57		787.98		68.09		222.95		666.54		206.08		0.00		0.00	
{Y*Area}	1382.29		1265.12		273.17		114.83		1468.95		1071.22		3501.74		390.39		286.44		12.04		0.00		27.49		-1.44		0.00		0.00	
Total Area (m²)	694.37				Xtotal =		11.37				Ytotal=		14.10																	

Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (LC)

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Structural Design Sheet

Sheet Number : 4
Scale :

Structural Plan - Load Calculation
Third Floor (Residential Units)

Amirali Naraghi — Matricola Number : 755237
Mohammad Hadi Mohammad Zadeh — Matricola Number : 754940

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

Third Floor New (Residential)

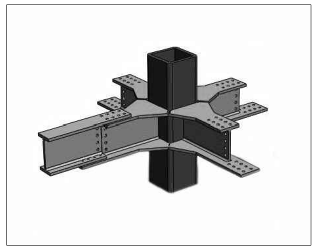
BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM 1 - A - B	4.40	0.82	350	320	41	287	164	648
BEAM 1- B - C	3.90	0.82	350	320	41	287	164	648
BEAM H-1-2	1.50	0.82	350	320	41	287	164	648
BEAM 2 - A - B	4.40	2.83	350	504	142	991	566	1,636
BEAM 2 - B - D	6.60	2.83	350	504	142	991	566	1,636
BEAM 2 - D -G	5.10	2.83	350	504	142	991	566	1,636
BEAM 2 - G - H	4.40	2.83	350	504	142	991	566	1,636
BEAM 2 -H -I	1.50	2.83	350	0	142	991	566	1,132
BEAM 4 - A - B	4.40	3.85	350	0	193	1,348	770	1,540
BEAM 4 - B - C	6.60	3.85	350	0	193	1,348	770	1,540
BEAM 4 - D -G	5.10	3.85	350	0	193	1,348	770	1,540
BEAM 4 - G - H	4.40	3.85	350	0	193	1,348	770	1,540
BEAM 4 -H -I	1.50	3.85	350	0	193	1,348	770	1,540
BEAM 5 - A - B	4.40	3.85	350	504	193	1,348	770	2,044
BEAM 5 - B - C	6.60	3.85	350	0	193	1,348	770	1,540
BEAM 5 - D -G	5.10	3.85	350	0	193	1,348	770	1,540
BEAM 5 - G - H	4.40	3.85	350	0	193	1,348	770	1,540
BEAM 5 -H -I	1.50	3.85	350	0	193	1,348	770	1,540
BEAM 7 - A - B	4.40	3.79	350	0	190	1,327	758	1,516
BEAM 7 - B - C	6.60	3.79	350	0	190	1,327	758	1,516
BEAM 7 - D -G	5.10	3.79	350	0	190	1,327	758	1,516
BEAM 7 - G - H	4.40	3.79	350	0	190	1,327	758	1,516
BEAM 7 -H -I	1.50	3.79	350	0	190	1,327	758	1,516
BEAM 8 - A - B	4.40	3.73	350	0	187	1,306	746	1,492
BEAM 8 - B - D	6.60	3.73	350	0	187	1,306	746	1,492
BEAM 8 - D -E	1.60	3.73	350	0	187	1,306	746	1,492
BEAM8 -E -G	2.90	3.73	350	0	187	1,306	746	1,492
BEAM 8 - G - H	4.40	3.73	350	0	187	1,306	746	1,492
BEAM 8 -H -I	1.50	3.73	350	0	187	1,306	746	1,492
BEAM 9 - A - B	4.40	3.79	350	0	190	1,327	758	1,516
BEAM 9 - B - C	6.60	3.79	350	0	190	1,327	758	1,516
BEAM 9 - D -G	5.10	3.79	350	0	190	1,327	758	1,516
BEAM 9 - G - H	4.40	3.79	350	0	190	1,327	758	1,516
BEAM 9 -H -I	1.50	3.79	350	0	190	1,327	758	1,516
BEAM 11 - A - B	4.40	3.85	350	0	193	1,348	770	1,540
BEAM 11 - B - C	6.60	3.85	350	0	193	1,348	770	1,540
BEAM 11 - D -G	5.10	3.85	350	0	193	1,348	770	1,540
BEAM 11 - G - H	4.40	3.85	350	0	193	1,348	770	1,540
BEAM 11 -H -I	1.50	3.85	350	0	193	1,348	770	1,540
BEAM 12 - A - B	4.40	3.85	350	0	193	1,348	770	1,540
BEAM 12 - B - C	6.60	3.85	350	0	193	1,348	770	1,540
BEAM 12 - D -G	5.10	3.85	350	0	193	1,348	770	1,540
BEAM 12 - G - H	4.40	3.85	350	0	193	1,348	770	1,540
BEAM 12 -H -I	1.50	3.85	350	0	193	1,348	770	1,540
BEAM 14 - A - B	4.40	2.83	350	504	142	991	566	1,636
BEAM 14 - B - D	6.60	2.83	350	504	142	991	566	1,636
BEAM 14 - D -G	5.10	2.83	350	504	142	991	566	1,636
BEAM 14 - G - H	4.40	2.83	350	504	142	991	566	1,636
BEAM 14 -H -I	1.50	2.83	350	0	142	991	566	1,132
BEAM 15 - A - B	4.40	0.82	350	0	41	287	164	328
BEAM 15 - B - C	4.05	0.82	350	0	41	287	164	328

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM A-1-2	1.50	0.00	350.00	320.00	0.00	0.00	0.00	320.00
BEAM A-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-5-7	3.90	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM A-7-8	3.70	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM A-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-9-11	3.90	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM A-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-4-5	3.90	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM B-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM C-1-2	1.50	0.00	350.00	320.00	0.00	0.00	0.00	320.00
BEAM C-14-15	1.50	0.00	350.00	320.00	0.00	0.00	0.00	320.00
BEAM D-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM E-8-9	3.70	0.00			0.00	0.00	0.00	0.00
BEAM G-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-8-9	4.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM H-1-2	1.50	0.00	350.00	320.00	0.00	0.00	0.00	320.00
BEAM H-2-4	3.90	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM H-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM H-5-7	3.90	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM H-7-8	3.70	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM H-8-9	3.70	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM H-9-11	3.90	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM H-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM H-12-14	3.90	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM H-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM I-4-5	1.50	0.00	350.00	504.00	0.00	0.00	0.00	504.00
BEAM I-11-12	1.50	0.00	350.00	504.00	0.00	0.00	0.00	504.00
Beam J-7-9	7.40	0.00	350.00	0.00	0.00	0.00	0.00	0.00

Structural System	Moment Resisting Frame
Connections	Fixed Joints

General Suggestion Ranges For Structural Elements

Columns	BOX : 450mm * 450 mm * 25 mm
	BOX : 400mm * 400 mm * 15 mm
	BOX : 350mm * 350 mm * 15 mm
	BOX : 300mm * 300 mm * 10 mm
Beams	IPE -360
	IPE -320
	IPE -280
	IPE -240
Connections	BOLTS

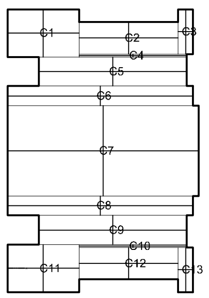


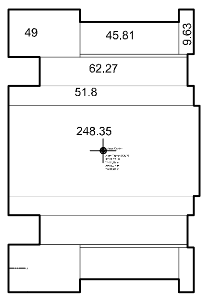
Load Combinations (According to Iran Building Codes)

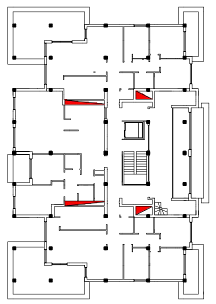
COMB-1	Total Dead
COMB-2	Total Dead + Live
COMB-3	Total Dead + Ex
COMB-4	Total Dead - Ex
COMB-5	Total Dead + Ey
COMB-6	Total Dead - Ey
COMB-7	Total Dead+ Live + Live (Green Roof)+ Ex
COMB-8	Total Dead+ Live + Live (Green Roof)- Ex
COMB-9	Total Dead+ Live + Live (Green Roof)+Ey
COMB-10	Total Dead+ Live + Live (Green Roof)- Ey

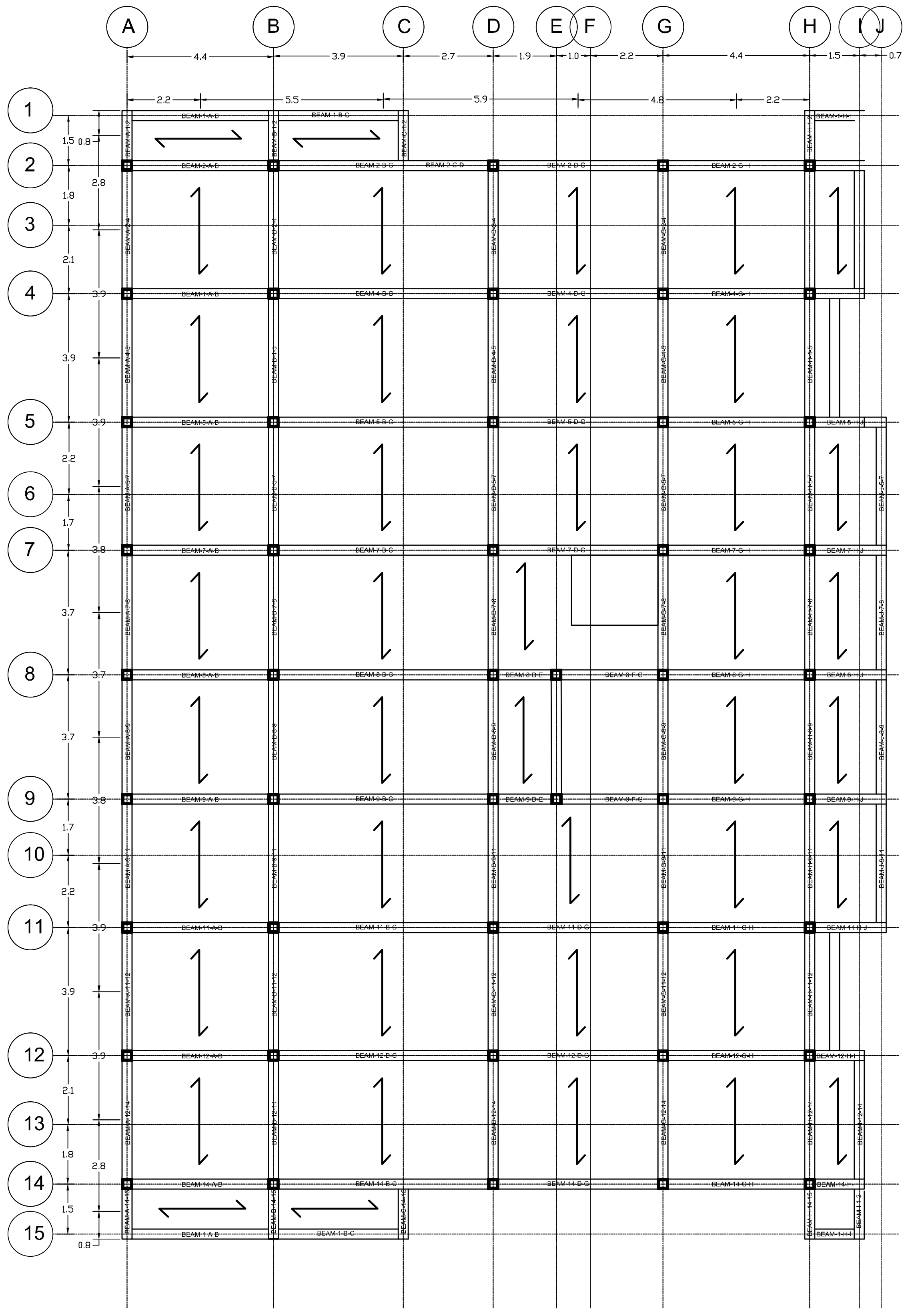
Forth Floor (Residential Units)

Dead Loads	Slabs Dead Load	344 kg/m2		According to Technological Detail SL-3
	Average Dead Load Inside	50 kg/m2		According to Iran Building Codes (Part 6)
	Side Walls Dead Loads	504 kg/m2		According to Technological Detail EW-1 for Residential Units with 30% Reduction of Opening
Live Loads	Live Load	200 Kg/m2		According to Iran Building Code (For Residential Units)
Total Floor Weight of the Floor	Total Dead Load Slabs	247.68	Ton	According to Iran Building Code (Part 6) and Iran Structural Siesmic Design Code(2800) - The Details of Calculations are available in Siesmic Design Part
	Total Dead Side Walls	56.448	Ton	
	Structural Elements Weight	29.62	Ton	367.148
	20% of Live Load	33.4	Ton	
Siesmic Load	Ex	44.6 Ton-F		According to Iran Structural Siesmic Design Code (2800)
	Ey	44.6 Ton-F		Details of Calculation is Available in Siesmic Design Part
	MZx	75.5 Ton F-m		According to Iran Structural Siesmic Design Code (2800)
	MZy	49.7 Ton.F-m		Details of Calculation is Available in Siesmic Design Part









Forth Floor Floor (Residential)	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
	1.88	30.29	7.03	29.39	18.18	30.14	10.77	14.10	21.92	14.10	22.62	14.10	7.03	-1.17	1.87	-2.07	18.18	-1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Section Area (m²)	5.64		4.22		14.80		652.24		11.60		7.00		4.22		5.64		14.80		0.00		0.00		0.00		0.00		0.00		0.00	
{X*Area }	10.60		29.67		269.06		7024.62		254.27		158.34		29.67		10.55		269.06		0.00		0.00		0.00		0.00		0.00		0.00	
{Y*Area}	170.84		124.03		446.07		9196.58		163.56		98.70		-4.94		-11.67		-28.42		0.00		0.00		0.00		0.00		0.00		0.00	
Total Area (m²)	720.16				Xtotal =		11.19				Ytotal=		14.10																	

Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Sistemi Edilizi (LC)

Structural Design Sheet

Sheet Number : 5

Scale :

Structural Plan - Load Calculation

Forth Floor (Residential Unit)

Ms.c Final Graduating Project

Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi — Matricola Number : 755237
Mohammad Hadi Mohammad Zadeh — Matricola Number : 754940

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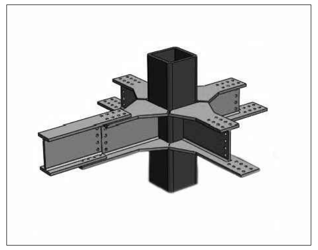
Forth Floor New (Residential)

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM 1 - A - B	4.40	0.82	350.00	0.00	41.00	287.00	164.00	328.00
BEAM 1- B - C	3.90	0.82	350.00	0.00	41.00	287.00	164.00	328.00
BEAM 2 - A - B	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 - B - D	6.60	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 - D -G	5.10	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 - G - H	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 2 -H -I	1.50	2.83	350.00	0.00	141.50	990.50	566.00	1132.00
BEAM 4 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 4 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 5 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 7 - A - B	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - B - C	6.60	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - D -G	5.10	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 - G - H	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 7 -H -I	1.50	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 8 - A - B	4.40	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - B - D	6.60	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - D -E	1.60	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM8 -E -G	2.90	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 - G - H	4.40	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 8 -H -I	1.50	3.73	350.00	0.00	186.50	1305.50	746.00	1492.00
BEAM 9 - A - B	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - B - C	6.60	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - D -G	5.10	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 - G - H	4.40	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 9 -H -I	1.50	3.79	350.00	0.00	189.50	1326.50	758.00	1516.00
BEAM 11 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 11 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - A - B	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - B - C	6.60	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - D -G	5.10	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 - G - H	4.40	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 12 -H -I	1.50	3.85	350.00	0.00	192.50	1347.50	770.00	1540.00
BEAM 14 - A - B	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 - B - D	6.60	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 - D -G	5.10	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 - G - H	4.40	2.83	350.00	720.00	141.50	990.50	566.00	1852.00
BEAM 14 -H -I	1.50	2.83	350.00	0.00	141.50	990.50	566.00	1132.00
BEAM 15 - A - B	4.40	0.82	350.00	0.00	41.00	287.00	164.00	328.00
BEAM 15 - B - C	4.05	0.82	350.00	0.00	41.00	287.00	164.00	328.00

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM A-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-5-7	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM A-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-8-9	3.70	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM A-9-11	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM A-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM A-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM B-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM D-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM E-8-9	3.70	0.00				0.00	0.00	0.00
BEAM F-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM F-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-2-4	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-4-5	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-5-7	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-7-8	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-8-9	3.70	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-9-11	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-11-12	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-12-14	3.90	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM G-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM H-1-2	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM H-2-4	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-4-5	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-5-7	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-7-8	3.70	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-8-9	3.70	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-9-11	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-11-12	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-12-14	3.90	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM H-14-15	1.50	0.00	350.00	0.00	0.00	0.00	0.00	0.00
BEAM I-4-5	1.50	0.00	350.00	720.00	0.00	0.00	0.00	720.00
BEAM I-11-12	1.50	0.00	350.00	720.00	0.00	0.00	0.00	720.00
Beam J-7-9	7.40	0.00	350.00	0.00	0.00	0.00	0.00	0.00

Structural System	Moment Resisting Frame	
Connections	Fixed Joints	
General Suggestion Ranges For Structural Elements		
Columns	BOX : 450mm * 450 mm * 25 mm	
	BOX : 400mm * 400 mm * 15 mm	
	BOX : 350mm * 350 mm * 15 mm	
	BOX : 300mm * 300 mm * 10 mm	
Beams	IPE -360	
	IPE -320	
	IPE -280	
	IPE -240	
Connections	BOLTS	

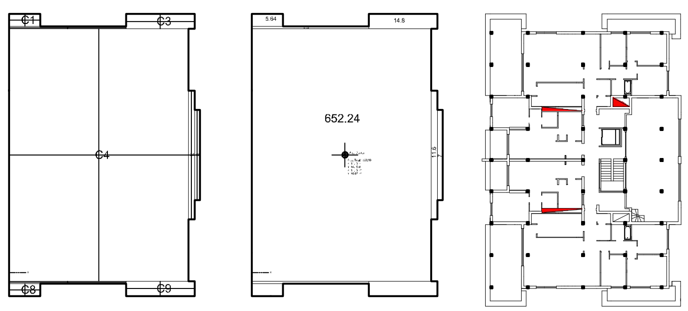


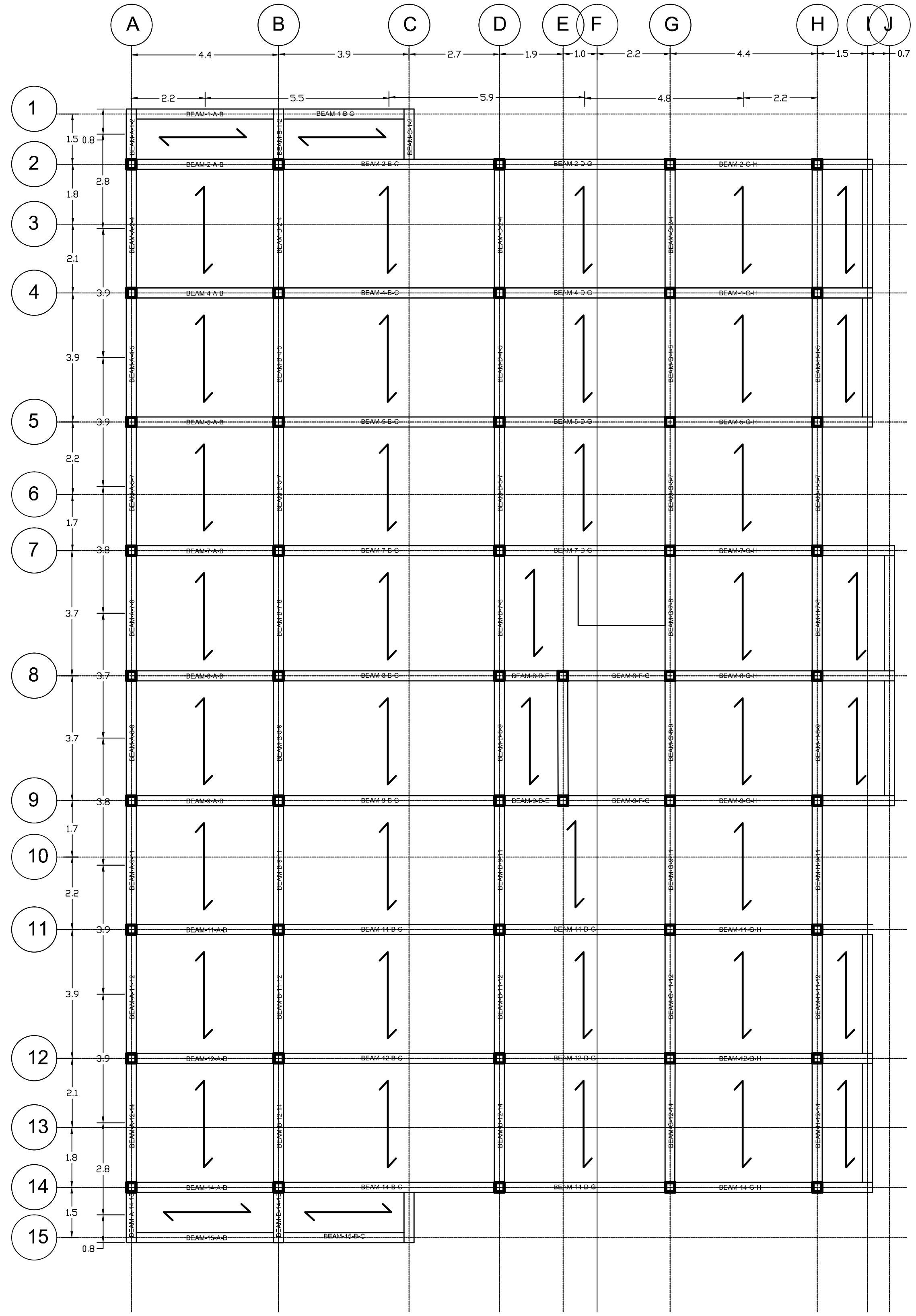
Load Combinations (According to Iran Building Codes)

COMB-1	Total Dead
COMB-2	Total Dead + Live
COMB-3	Total Dead + Ex
COMB-4	Total Dead - Ex
COMB-5	Total Dead + Ey
COMB-6	Total Dead - Ey
COMB-7	Total Dead+ Live + Live (Green Roof)+ Ex
COMB-8	Total Dead+ Live + Live (Green Roof)- Ex
COMB-9	Total Dead+ Live + Live (Green Roof)+Ey
COMB-10	Total Dead+ Live + Live (Green Roof)- Ey

Fifth Floor (Residential Units)

Dead Loads	Slabs Dead Load	344 kg/m2	According to Technological Detail SL-3		
	Average Dead Load Inside	50 kg/m2	According to Iran Building Codes (Part 6)		
	Side Walls Dead Loads	504 kg/m2	According to Technological Detail EW-1 for Residential Units with 30% Reduction of Opening		
Live Loads	Live Load	200 Kg/m2	According to Iran Building Code (For Residential Units)		
Total Floor Weight of the Floor	Total Dead Load Slabs	247.68	Ton	367.148	According to Iran Building Code (Part 6) and Iran Structural Siesmic Design Code(2800) - The Details of Calculations are available in Siesmic Design Part
	Total Dead Side Walls	56.448	Ton		
	Structural Elements Weight	29.62	Ton		
	20% of Live Load	33.4	Ton		
Siesmic Load	Ex	52 Ton-F	According to Iran Structural Siesmic Design Code (2800)		
	Ey	52 Ton-F	Details of Calculation is Available in Siesmic Design Part		
	MZx	88.1 Ton F-m	According to Iran Structural Siesmic Design Code (2800)		
	MZy	58 Ton.F-m	Details of Calculation is Available in Siesmic Design Part		





Forth Floor Floor (Residential)	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
	1.88	30.29	7.03	29.39	18.18	30.14	10.77	14.10	21.92	14.10	22.62	14.10	7.03	-1.17	1.87	-2.07	18.18	-1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Section Area (m²)	5.64		4.22		14.80		652.24		11.60		7.00		4.22		5.64		14.80		0.00		0.00		0.00		0.00		0.00		0.00	
{X*Area }	10.60		29.67		269.06		7024.62		254.27		158.34		29.67		10.55		269.06		0.00		0.00		0.00		0.00		0.00		0.00	
{Y*Area}	170.84		124.03		446.07		9196.58		163.56		98.70		-4.94		-11.67		-28.42		0.00		0.00		0.00		0.00		0.00		0.00	
Total Area (m²)	720.16				Xtotal =		11.19				Ytotal=		14.10																	

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Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Structural Design Sheet

Sheet Number 6:
Scale :

Structural Plan - Load Calculation
Fifth Floor (Residential Units)

Amirali Naraghi — Matricola Number : 755237
Mohammad Hadi Mohammad Zadeh — Matricola Number : 754940

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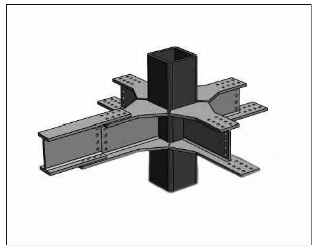
BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM 2 - A - B	4.40	0.82	500.00	0.00	0.00	410.00	164.00	410.00
BEAM 2 - B - D	6.60	0.82	500.00	0.00	0.00	410.00	164.00	410.00
BEAM 2 - D -G	5.10	0.82	500.00	0.00	0.00	410.00	164.00	410.00
BEAM 2 - G - H	4.40	0.82	500.00	0.00	0.00	410.00	164.00	410.00
BEAM 2 -H -I	1.65	0.82	500.00	0.00	0.00	410.00	164.00	410.00
BEAM 4 - A - B	4.40	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 4 - B - C	6.60	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 4 - D -G	5.10	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 4 - G - H	4.40	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 4 -H -I	1.65	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 5 - A - B	4.40	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 5 - B - C	6.60	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 5 - D -G	5.10	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 5 - G - H	4.40	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 5 -H -I	1.65	3.85	0.00	0.00	0.00	0.00	770.00	0.00
BEAM 7 - A - B	4.40	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 7 - B - C	6.60	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 7 - D -G	5.10	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 7 - G - H	4.40	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 7 -H -I	1.65	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 8 - A - B	4.40	3.73	500.00	0.00	0.00	1865.00	746.00	1865.00
BEAM 8 - B - D	6.60	3.73	500.00	0.00	0.00	1865.00	746.00	1865.00
BEAM 8 - D - E	1.60	3.73	500.00	0.00	0.00	1865.00	746.00	1865.00
BEAM 8 - E -G	5.10	3.73	500.00	0.00	0.00	1865.00	746.00	1865.00
BEAM 8 - G - H	4.40	3.73	500.00	0.00	0.00	1865.00	746.00	1865.00
BEAM 8 -H -I	1.65	3.73	500.00	0.00	0.00	1865.00	746.00	1865.00
BEAM 9 - A - B	4.40	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 9 - B - C	6.60	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 9 - D -G	5.10	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 9 - G - H	4.40	3.79	500.00	0.00	0.00	1895.00	758.00	1895.00
BEAM 9 -H -I	1.65	3.79	0.00	0.00	0.00	0.00	758.00	0.00
BEAM 11 - A - B	4.40	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 11 - B - C	6.60	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 11 - D -G	5.10	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 11 - G - H	4.40	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 11 -H -I	1.65	3.85	0.00	0.00	0.00	0.00	770.00	0.00
BEAM 12 - A - B	4.40	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 12 - B - C	6.60	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 12 - D -G	5.10	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 12 - G - H	4.40	3.85	500.00	0.00	0.00	1925.00	770.00	1925.00
BEAM 12 -H -I	1.65	3.85	0.00	0.00	0.00	0.00	770.00	0.00
BEAM 14 - A - B	4.40	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 14 - B - C	6.60	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 14 - D -G	5.10	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 14 - G - H	4.40	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00
BEAM 14 -H -I	1.65	2.83	500.00	0.00	0.00	1415.00	566.00	1415.00

BEAM CODE	Lentgh	Loading width	Dead Load (Kg/m²)	Dead Load Side Walls (Kg/m)	Dead Load Inside Walls (Kg/m²)	Final Floor Dead Load Roof (Kg/m)	Live Load (Kg/m)	Total Dead Load (Kg/m)
BEAM A-1-2	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-2-4	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-4-5	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-5-7	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-7-8	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-8-9	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-9-11	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-11-12	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-12-14	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM A-14-15	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-1-2	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-2-4	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-4-5	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-5-7	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-7-8	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-8-9	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-9-11	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-11-12	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-12-14	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM B-14-15	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-1-2	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-2-4	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-4-5	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-5-7	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-7-8	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-8-9	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-9-11	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-11-12	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-12-14	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM D-14-15	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM E-8-9	3.73	0.00	500.00			0.00	0.00	0.00
BEAM G-1-2	1.65	0.00	500.00			0.00	0.00	0.00
BEAM G-2-4	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-4-5	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-5-7	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-7-8	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-8-9	3.73	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-9-11	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-11-12	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-12-14	3.85	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM G-14-15		0.00	500.00	0.00	0.00	0.00	0.00	
BEAM H-1-2	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00
BEAM H-2-4	3.85	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-4-5	3.85	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-5-7	3.85	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-7-8	3.73	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-8-9	3.73	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-9-11	3.85	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-11-12	3.85	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-12-14	3.85	0.00	500.00	713.00	0.00	0.00	0.00	713.00
BEAM H-14-15	1.65	0.00	500.00	0.00	0.00	0.00	0.00	0.00

Structural System	Moment Resisting Frame
Connections	Fixed Joints

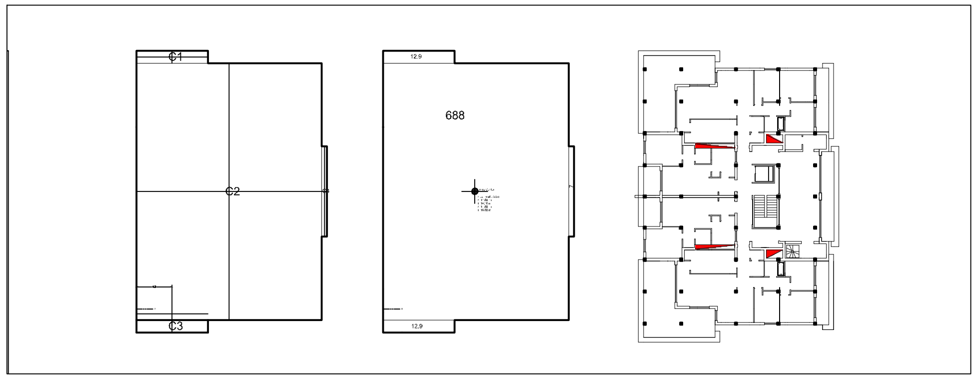
General Suggestion Ranges For Structural Elements	
Columns	BOX : 450mm * 450 mm * 25 mm
	BOX : 400mm * 400 mm * 15 mm
	BOX : 350mm * 350 mm * 15 mm
	BOX : 300mm * 300 mm * 10 mm
Beams	IPE -360
	IPE -320
	IPE -280
	IPE -240
Connections	BOLTS

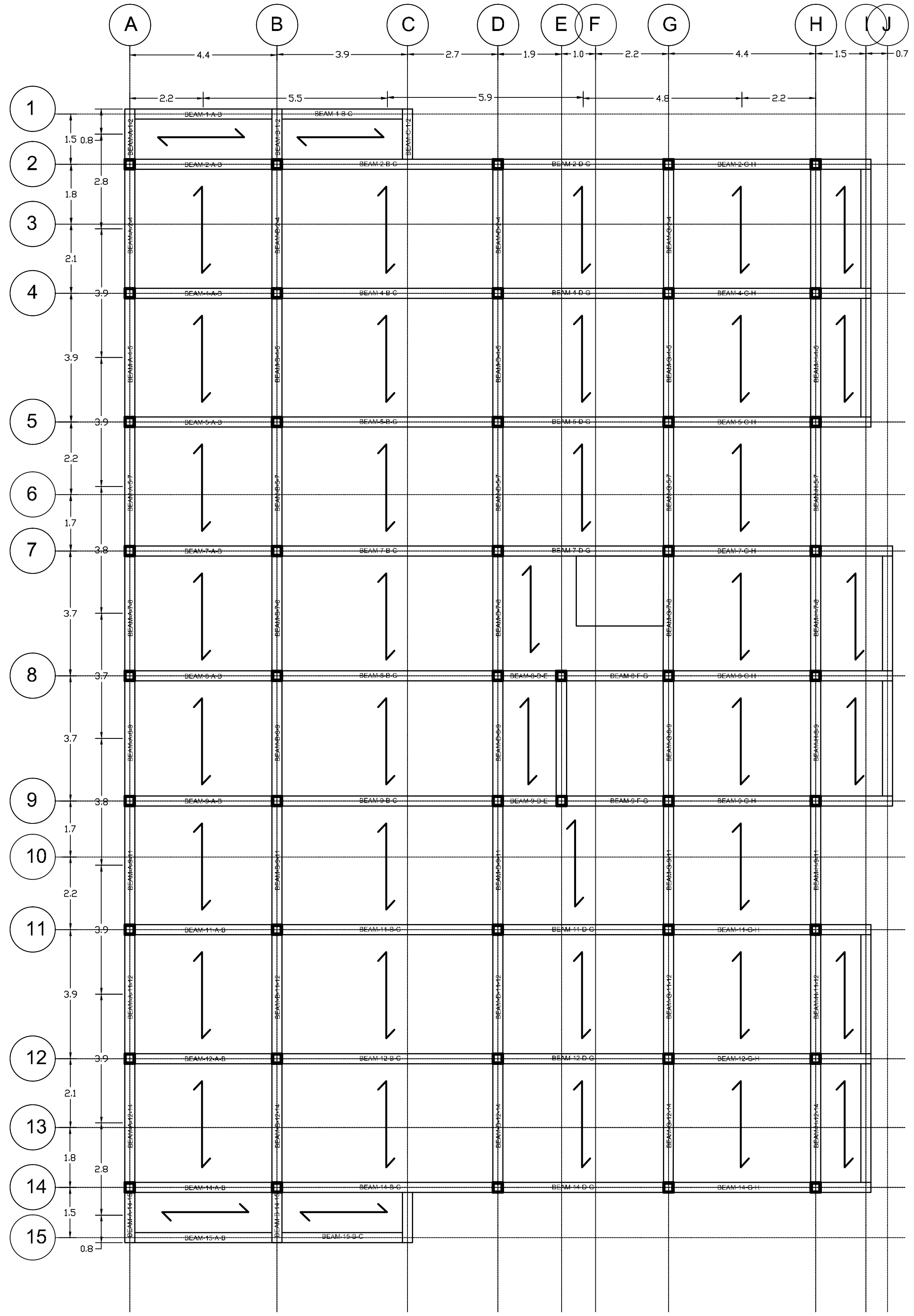


Load Combinations (According to Iran Building Codes)	
COMB-1	Total Dead
COMB-2	Total Dead + Live
COMB-3	Total Dead + Ex
COMB-4	Total Dead - Ex
COMB-5	Total Dead + Ey
COMB-6	Total Dead - Ey
COMB-7	Total Dead+ Live + Live (Green Roof)+ Ex
COMB-8	Total Dead+ Live + Live (Green Roof)- Ex
COMB-9	Total Dead+ Live + Live (Green Roof)+Ey
COMB-10	Total Dead+ Live + Live (Green Roof)- Ey

Green Roof

Dead Loads	Slabs Dead Load	400 kg/m2			According to Technological Detail SL-3
	Average Dead Load Inside	0 kg/m2			According to Iran Building Codes (Part 6)
	Side Walls Dead Loads	320 kg/m2			According to Technological Detail EW-1 for Green roofs
Live Loads	Live Load	300 Kg/m2			According to Iran Building Code (For Semi Green Roof)
Total Floor Weight of the Floor	Total Dead Load Slabs	247.68	Ton	346.54	According to Iran Building Code (Part 6) and Iran Structural Siesmic Design Code(2800) - The Details of Calculations are available in Siesmic Design Part
	Total Dead Side Walls	35.84	Ton		
	Structural Elements Weight	29.62	Ton		
	20% of Live Load	33.4	Ton		
Siesmic Load	Ex	66.33 Ton-F			According to Iran Structural Siesmic Design Code (2800)
	Ey	66.3 Ton-F			Details of Calculation is Available in Siesmic Design Part
	MZx	112.33 Ton F-m			According to Iran Structural Siesmic Design Code (2800)
	MZy	75.9 Ton.F-m			Details of Calculation is Available in Siesmic Design Part





Fifth Floor Floor (Residential)	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
	4.30	30.29	11.15	14.10	4.30	-2.07	22.62	14.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Section Area (m²)	12.90		688.00		12.90		7.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
{X*Area}	55.47		7671.20		55.47		158.34		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
{Y*Area}	390.74		9700.80		-26.70		98.70		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Total Area (m²)	720.80				Xtotal =		11.02				Ytotal=		14.10																	

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Structural Design Sheet

Sheet Number : 7

Scale :

Structural Plan - Load Calculation

Sixth Floor (Green Roof)

Ms.c Final Graduating Project
Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi Matricola Number : 755237
Mohammad Hadi Mohammad Zadeh Matricola Number : 754940

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3.4.3.2 Calculation of Seismic Loads

Calculation of seismic loads in this chapter has been done regarding to **IRANIAN CODE OF PRACTICE FOR SEISMIC RESISTANT DESIGN OF BUILDINGS (Standard No. 2800) 3rd Edition**

3.4.3.2.1 General Description about the code

The purpose of this code is to provide minimum provisions and regulations for the design and construction of buildings to resist the earthquakes effects. By these provisions, it is expected that:

- a) In major seismic ground motions the loss of life is minimized while the stability of the building is maintained, and in moderate and low seismic ground motions the building is left without major structural damage,

- b) In moderate and low seismic ground motions, buildings designated as “high importance” in section 1-7 maintain their serviceability, and for buildings designated as “intermediate importance” in section 1-7 the structural and nonstructural damage shall be minimized,

- c) In major seismic ground motion, buildings designated as “Very High Importance” in section 1-7 shall maintain their operational level without major structural damage.

NOTE- Major seismic ground motion or “Design Level Earthquake” is the ground motion with a 10 percent probability of not being exceeded in 50 years, the lifetime of the building. Low and moderate seismic ground motions or “Service Level Earthquake” is the ground motion that has a 99.5 percent probability of not being exceeded in50 years, the lifetime of the building.

- This code is applicable for the design and construction of buildings with reinforced concrete, steel, wood and masonry structures.

3.4.3.2.2 Architectural Considerations (Related to the Project)

- In order to avoid or decrease the damage due to pounding, buildings shall be separated from each other by “isolation joints” or shall be constructed with a minimum distance from the adjacent building’s property land. The width of the isolation joint shall conform to the provisions of Clause 1-6-3.

- Buildings plan shall be as simple and symmetrical as possible, in two orthogonal directions, without excessive projection or setback. Vertical asymmetry shall also be avoided to the extent possible.

- Large adjacent openings in floor diaphragms shall be avoided.

- Using lightweight and high strength structural material with appropriate ductility, and lightweight non-structural materials, to minimize the weight of the building, is recommended.

- Split floor levels shall be avoided to the extent possible.

- Any change in floor area over the elevation of the building that leads to considerable variation in floor masses shall be avoided.

- Considerable variation in floor masses shall be avoided.

3.4.3.2.3 Structural Configuration Considerations (Related to the Project)

- Vertical load carrying elements shall be aligned vertically, to the extent possible, in order to avoid the transfer of loads by means of horizontal elements.

- Elements that carry the horizontal earthquake loads shall be configured in such a way that loads are transferred to the foundation as directly as possible, and the relevant lateral load resisting elements be located in one vertical plane.

- Lateral load resisting elements shall be configured in a manner that the torsion resulting from earthquake loading is minimized. For this purpose, it is recommended that the eccentricity between the center of mass and center of stiffness, at each floor level, be less than 5% of the building dimension in that level in the direction under consideration.

- The building and its elements shall be designed in such a way that adequate ductility and strength in each of them is ensured.

- Buildings with moment resisting frames system shall be designed in such a way that any damage in the beams occurs prior to columns, to the extent possible.

- Non-structural components such as partition walls and façades in buildings shall be detailed in such a way that they do not impose any restraint for the displacement of structural systems during earthquake. Otherwise, their interaction with structural system shall be considered.

3.4.3.2.4 General Requirements (Related to the Project)

- All the lateral load resisting elements shall be adequately connected to each other to ensure the integrity of the structure as a whole during earthquake. In this regard, floors shall be connected appropriately to the vertical load bearing elements, frames or walls; so that they can transfer the earthquake loads to the lateral load resisting elements as a diaphragm.

- The structure shall be able to resist horizontal earthquake loads in both orthogonal directions. Moreover, these loads shall be transferred appropriately to the foundation in both directions.

- The minimum width of the isolation joint at each story level shall be equal to 1/100 of the height of that level from the base level. For this purpose, the minimum clear distance between any floor level to the property line shall be equal to 5/1000 of the height of that story from the base level. The isolation joint may be filled with low strength material that are easily crushed during an earthquake and may be easily refilled and repaired

3.4.3.2.5 Building Classification according to Importance

- **Group3-** Buildings with "Moderate Importance" All buildings that are within the scope of this Code, except those included in other categories, fall in this group. These include: residential, office and commercial buildings, hotels, multistory parking, warehouses, workshops, industrial buildings, etc.

3.4.3.2.6 Building Classification according to Configuration

- Regular Buildings: Buildings are "Regular" if they conform to all of the following criteria:
  Plan Regularity- Vertical Irregularity-

3.4.3.2.7 Building Classification according to Structural System

- **Moment- Resisting Frame System**: A structural system with an essentially complete space frame providing support for gravity and lateral loads. Structures with complete moment-resisting frames, and structures with moment-resisting frames at the perimeter or part of the plan and simple frames in other locations, shall be considered in this category. The concrete and steel frames used in this system may be ordinary, intermediate or special, according to their ductile behavior.

3.4.3.2.8 Design of Building for Earthquake Loading

3.4.3.2.8.1 Equivalent Static Procedure

The equivalent static lateral force shall be determined in accordance with the criteria of this section and shall be applied in opposite directions to the structure.

Base Shear (V)
The minimum base shear or the sum of the horizontal seismic loads, in each direction of the structure, shall be determined from:

$$V=CW$$

Where:
V= The shear force at base level.
W= The total seismic weight of building, that is equal to the total dead load plus a percentage of live and snow loads
C= The seismic coefficient, that is determined from the following formula:

$$C=\frac{ABI}{R}$$

Where:
A= Design base acceleration ratio (ratio of seismic acceleration to gravity acceleration, g)
B= Building response factor determined from the design response spectrum,
I=Importance factor, as given in
R= Building behavior factor,
Note: The design base shear shall not be considered less than: $V=0.1\,AIW$

3.4.3.2.9 Calculation Related to the Project

Design base acceleration ratio
Location of the Project: Tehran with Very High Level of relative Seismic hazard
A=35%

Building response factor (B)

$\boldsymbol{T=0.08\,H^{\frac{3}{4}}}$ **T= 0.08(27)$^{\frac{3}{4}}$** **T=0.94**

$$\boldsymbol{B=(S+1)\left(\frac{T_s}{T}\right)^{\frac{2}{3}}} \qquad \boldsymbol{T\geq T_S}$$

Soil profile type	T_0	T_s	"Moderate" and "Low" seismicity	"High" and "Very high" seismicity
			S	S
I	0.1	0.4	1.5	1.5
II	0.1	0.5	1.5	1.5
III	0.15	0.7	1.75	1.75
IV	0.15	1.0	2.25	1.75

Table 3-21 Values for S, T0 , Ts

Soil Profile Type: 1

$$\boldsymbol{B=(S+1)\left(\frac{T_s}{T}\right)^{\frac{2}{3}}} \qquad B=1.41$$

Building Importance factor (I)

Building Classification	Importance Factor
Group 1	1.4
Group 2	1.2
Group 3	1.0
Group 4	0.8

Table 3-22 Building Importance Factor

Building Classification: Group 3 I=1

Building behavior factor (R)

Structural System	Lateral-Force, Resisting System	R	H_m (m)
A- Bearing Wall System	1- Special reinforced concrete shear walls	7	50
	2- Intermediate reinforced concrete shear walls	6	50
	3- Ordinary reinforced concrete shear walls	5	30
	4- Reinforced masonry shear walls	4	15
B- Building frame System	1- Special reinforced concrete shear walls	8	50
	2- Intermediate reinforced concrete shear walls	7	50
	3- Ordinary reinforced concrete shear walls	5	30
	4- Reinforced masonry shear walls	4	15
	5- Steel eccentric braced frame	7	50
	6- Steel concentric braced frame[1]	6	50
C-Moment-resisting frame system	1-Special reinforced concrete moment-resisting frame[2]	10	150
	2- Intermediate reinforced concrete moment-resisting frame[2]	7	50
	3- Ordinary reinforced concrete moment-resisting frame[2],[3]	4	---
	4-Special steel moment-resisting frame[1]	10	150
	5- Intermediate steel moment-resisting frame	7	50
	6- Ordinary steel moment-resisting frame[3],[4]	5	---
D-Dual systems	1-Special moment-resisting frame(steel or concrete)+special reinforced concrete shear walls	11	200
	2- Intermediate concrete moment-resisting frame+ intermediate reinforced concrete shear walls	8	70
	3- Intermediate steel moment-resisting frame+ intermediate reinforced concrete shear walls	8	70
	4- Special steel moment-resisting frame+ Steel eccentric braced frame	10	150
	5- Special steel moment-resisting frame+ Steel concentric braced frame	9	150
	6- Intermediate steel moment-resisting frame+ Steel eccentric braced frame	7	70
	7- Intermediate steel moment-resisting frame+ Steel concentric braced frame	7	70

Table 3-23 Building behavior factor

Structural System

Intermediate steel moment resisting Steel moment

R=5

$$C = \frac{ABI}{R} \qquad V = CW \qquad C = 0.09 \qquad V = 0.09\,W$$

3.4.3.2.10 Vertical Distribution of Seismic Forces

The Design Base Shear, V, determined from the provisions part, shall be distributed over the height of the structure in accordance with Formula

$$F_i = (V - F_t)\frac{W_i h_i}{\sum_{j=1}^{n} W_j h_j}$$

Where:

F_i : The lateral force at level i

W_i: The seismic weight of level i, that is equal to the dead plus a percentage of live load at this level as defined in Table-1, and half of walls

H_i : Height of the story of level i, from the base level

n: Total number of stories above the base level

F_t : A concentrated force at the top level that is determined from the following formula:

$F_t = 0.07\,TV \leq 0.25\,V \quad If \quad T < 0.7$ S T= 0 in Formula

Note: If the weight of the loft is greater than 25 percent of the roof, the concentrated force *t F* , shall be applied at loft level. Otherwise, it shall be applied at roof level.

3.4.3.2.11 Horizontal Distribution of Seismic Forces

The design story shear, determined from the vertical distribution of seismic forces as above, shall be distributed among the various vertical lateral-force-resisting systems in proportion to their rigidities. The shear due to horizontal torsion resulting from eccentricities of the applied design Lateral forces at levels above any story, shall also be included. Where diaphragms are not rigid, the effect of their deformations shall also be considered in horizontal distribution of shears.

The torsional design moment at a given story, i, shall be determined from the following formula:

$$M_i = \sum_{j=1}^{n} (e_{ij} + e_{aj}) F_j$$

e_{ij} : Eccentricity between the lateral force at level j and the center of stiffness at level i (the horizontal distance between the center of mass at level j and center of rigidity at level i)

e_{aj}: Accidental eccentricity at level j

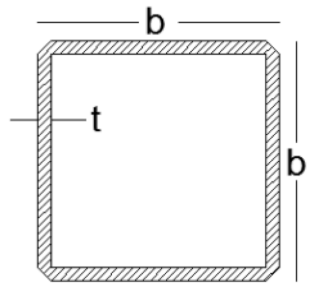
Floor	Area (m^2)	Diameter Side Walls (m)	High From Base (m)	Total weight of floor (Ton)	$V = CW$	$F_i = (V - F_t)\frac{W_i h_i}{\sum_{j=1}^{n} W_j h_j}$	$M_i = \sum_{j=1}^{n}(e_{ij} + e_{aj})F_j$	
				Include Total Dead Load floor + Total Weight Side Walls + Total Dead Laod Structure +20% of Total Floor Live Load	Ton	Ton-F	Mx	My
							Ton-F/m	
Ground Floor (Shops)	486	90	3	346	250.68	6,516	8,559	6,028
First Floor (Offices)	668	109	8.5	371		21,189	35,884	22,037
Second Floor (Residential Units)	700	112	12	352		28,333	47,981	31,591
Third Floor (Residential Units)	695	112	15	350		35,222	59,649	39,273
Forth Floor (Residential Units)	720	112	18	359		43,427	73,544	48,421
Fifth Floor (Residential Units)	720	112	21	359		50,665	85,801	56,492
Sixth Floor (Green Roof)	720	112	24	402		64,865	109,849	72,325

Total Weight Of Building	2,540

3.4.3.3 *Structural Analysis*

3.4.3.3.1 Structural Elements primary Check (According To Iranian Steel Structure Design Code)

3.4.3.3.1.1 Compact Section Verification



$F_y = 2400\ Kg/cm^2$

$E = 2.1e^6 kg/cm^2$

$\frac{b}{t} \leq 1.12\sqrt{\frac{E}{f_y}}$ $\quad \frac{b}{t} \leq 33.12$

$\frac{h}{t} \leq 2.42\sqrt{\frac{E}{f_y}}$ $\quad \frac{h}{t} \leq 71.58$

Column 450mm-450mm-25mm $\frac{b}{t} = \ 18 < 33.12 \ \ OK$

Column 400mm-400mm-15mm $\frac{b}{t} = 26.66 < 33.12 \ \ OK$

$Column\ 350mm - 350mm - 10mm \ \ \frac{b}{t} = 35 > 33.12\ (\ Not\ Compact\ )$

$Column\ 350mm - 350mm - 15mm \ \ \frac{b}{t} = 23.3 < 33.12\ \ (ok)$

$Column\ 300mm - 300mm - 10mm \ \ \frac{b}{t} = 30 < 33.12\ (ok)$

$\boldsymbol{Ratio\ Checks\ for\ \ \frac{h}{t}\ \ is\ ok\ for\ all\ sections}$

Chosen Frame for Design Check Frame 7

Structural Analysis Result from SAP2000

3.4.3.3.1.2 Moment Diagram (Frame 7) in Combo 7 (Critical Combo)

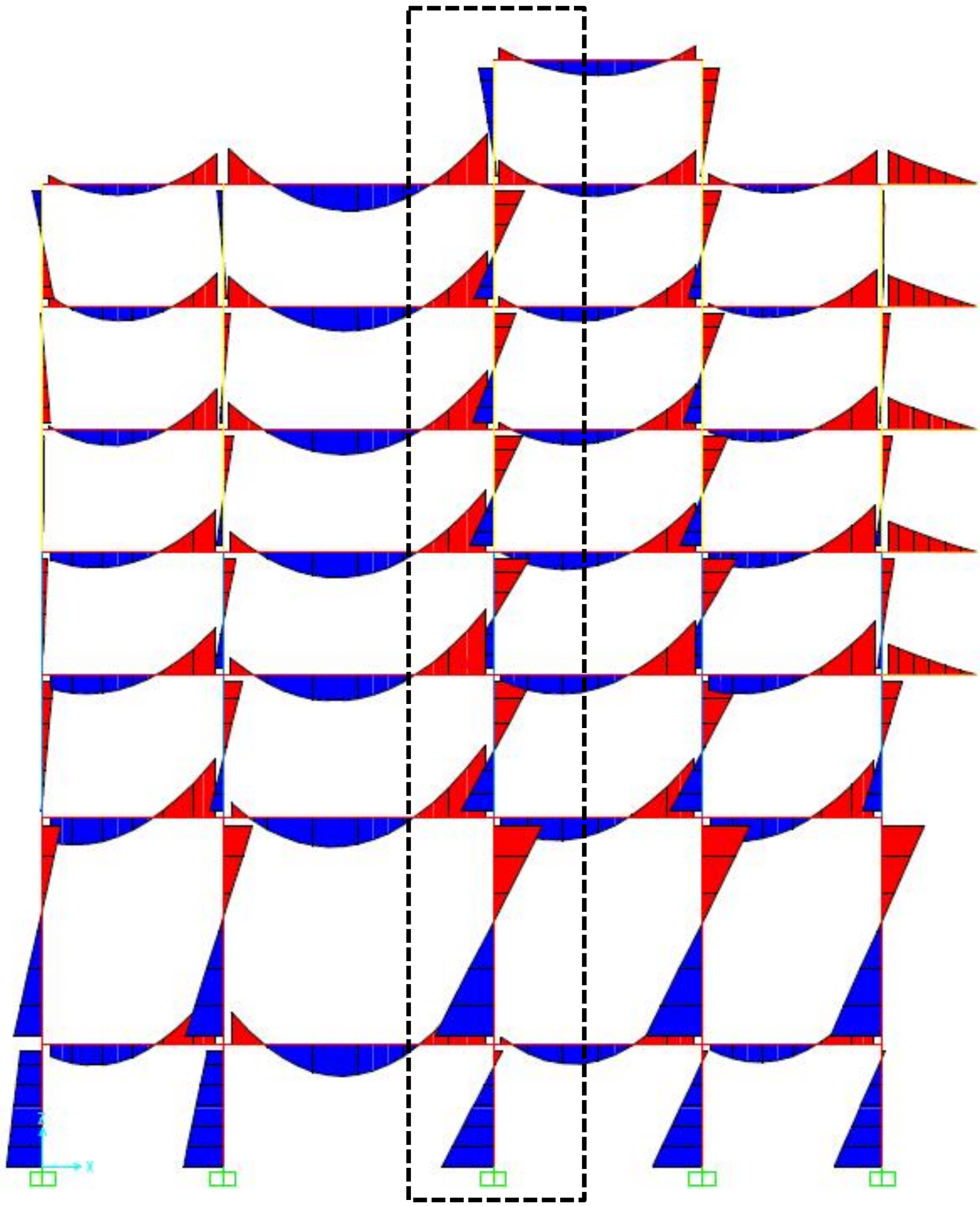


Figure 3-119 Moment diagram fill (frame 7)

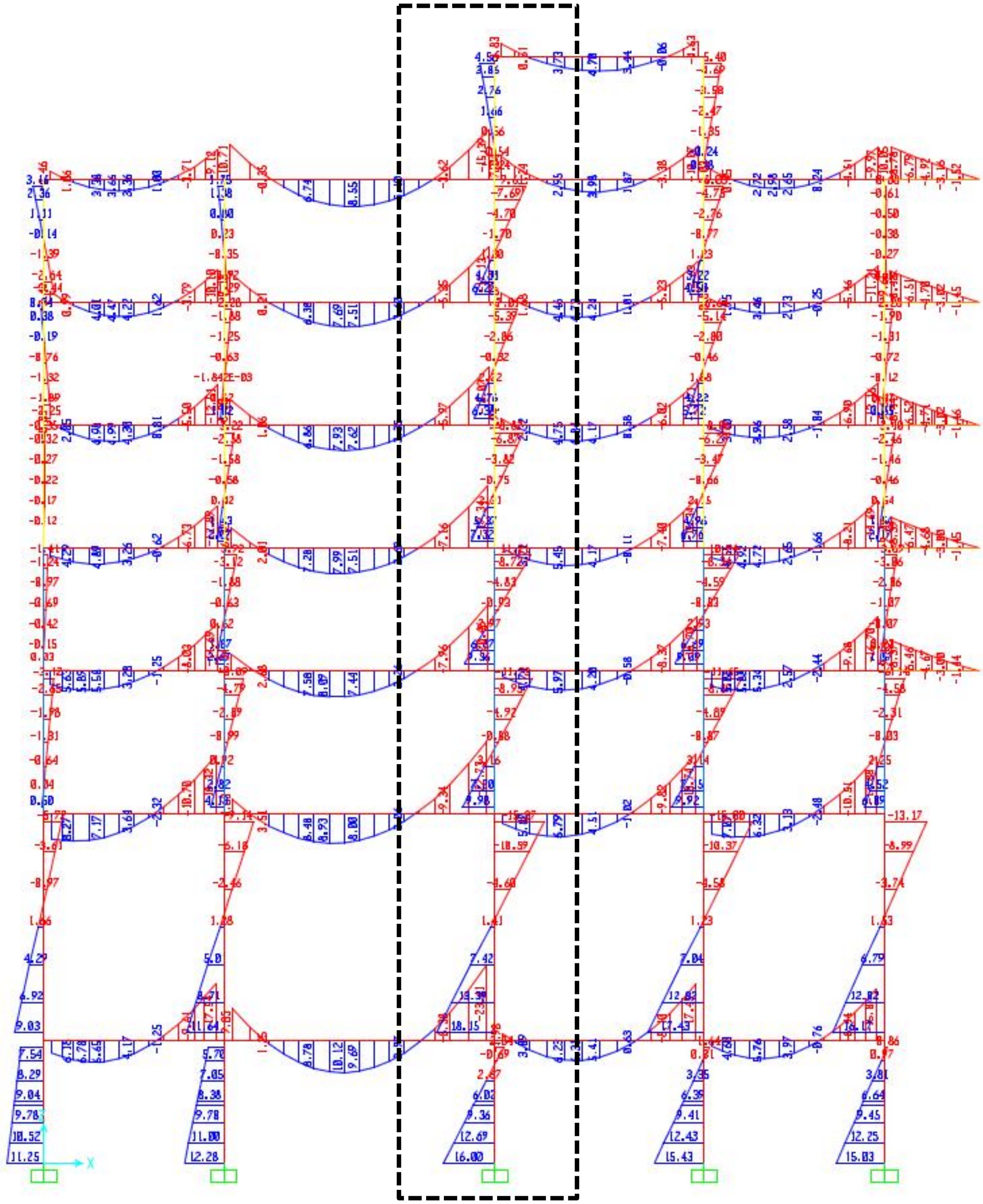


Figure 3-120 Moment diagram value (frame 7)

3.4.3.3.1.3 Shear diagrams (Frame 7) in Combo 7

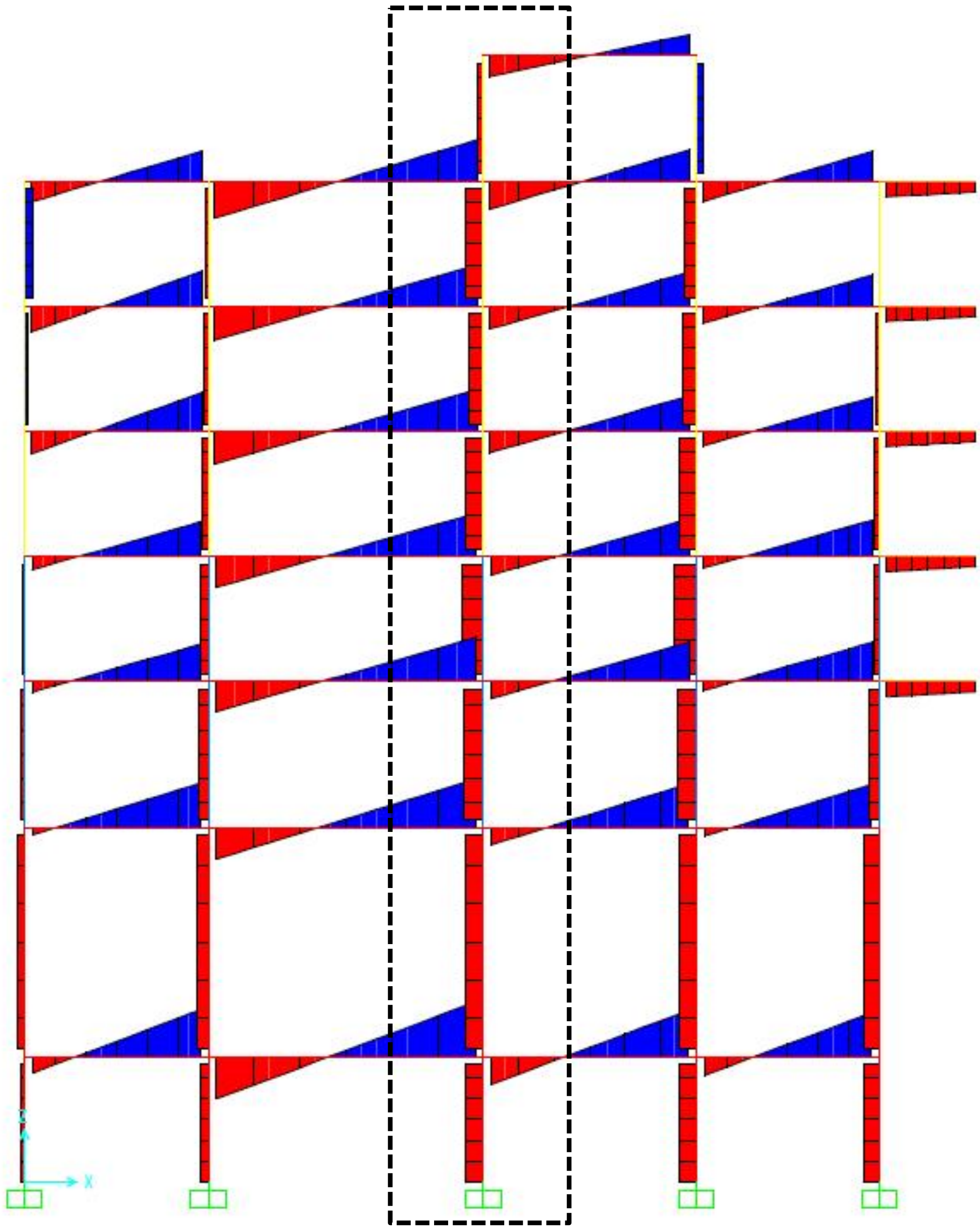


Figure 3-121 Shear diagram fill (frame 7)

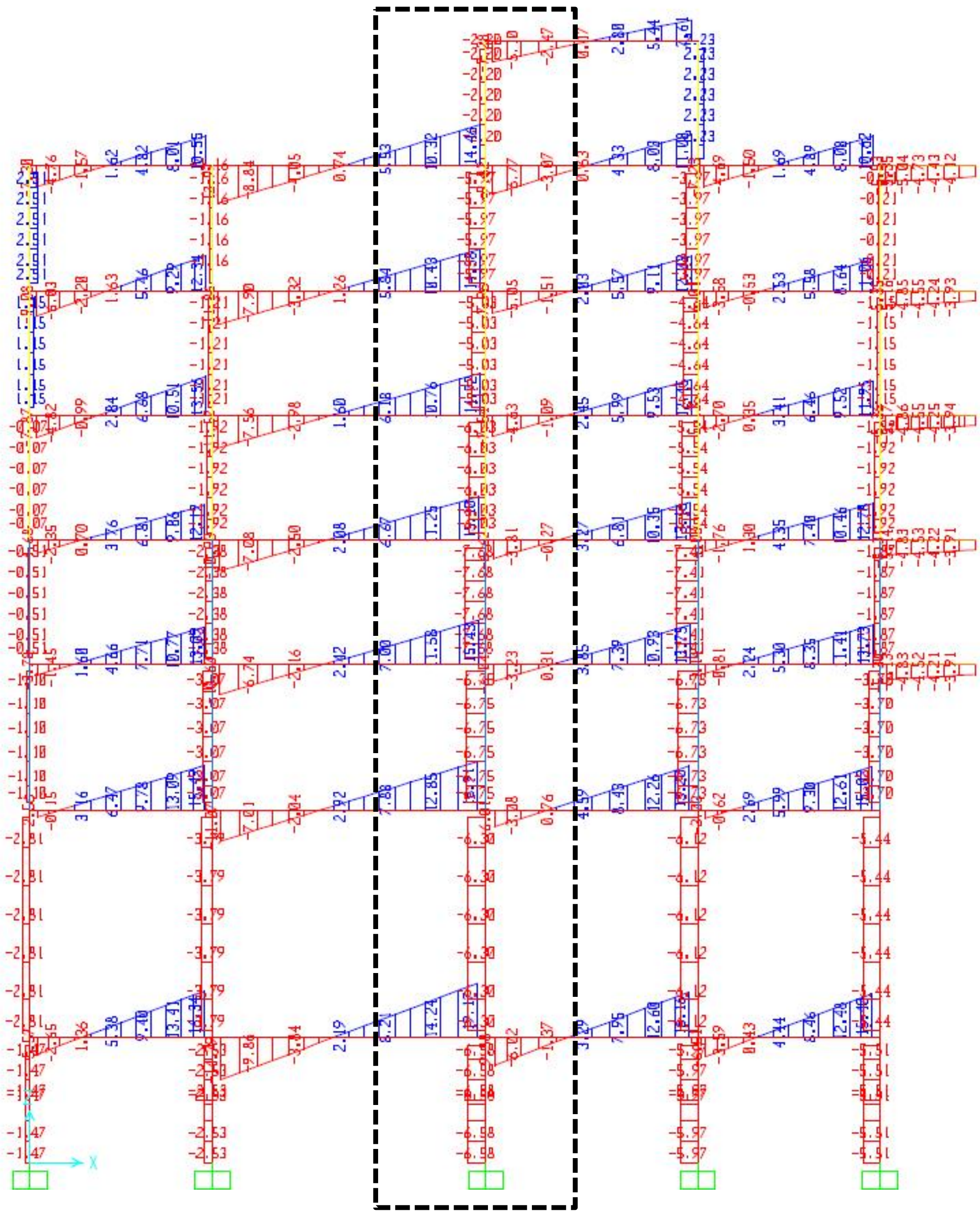


Figure 3-122 Shear diagram value (frame 7)

3.4.3.3.1.4 Axial Load diagram (Frame 7) in Combo 7

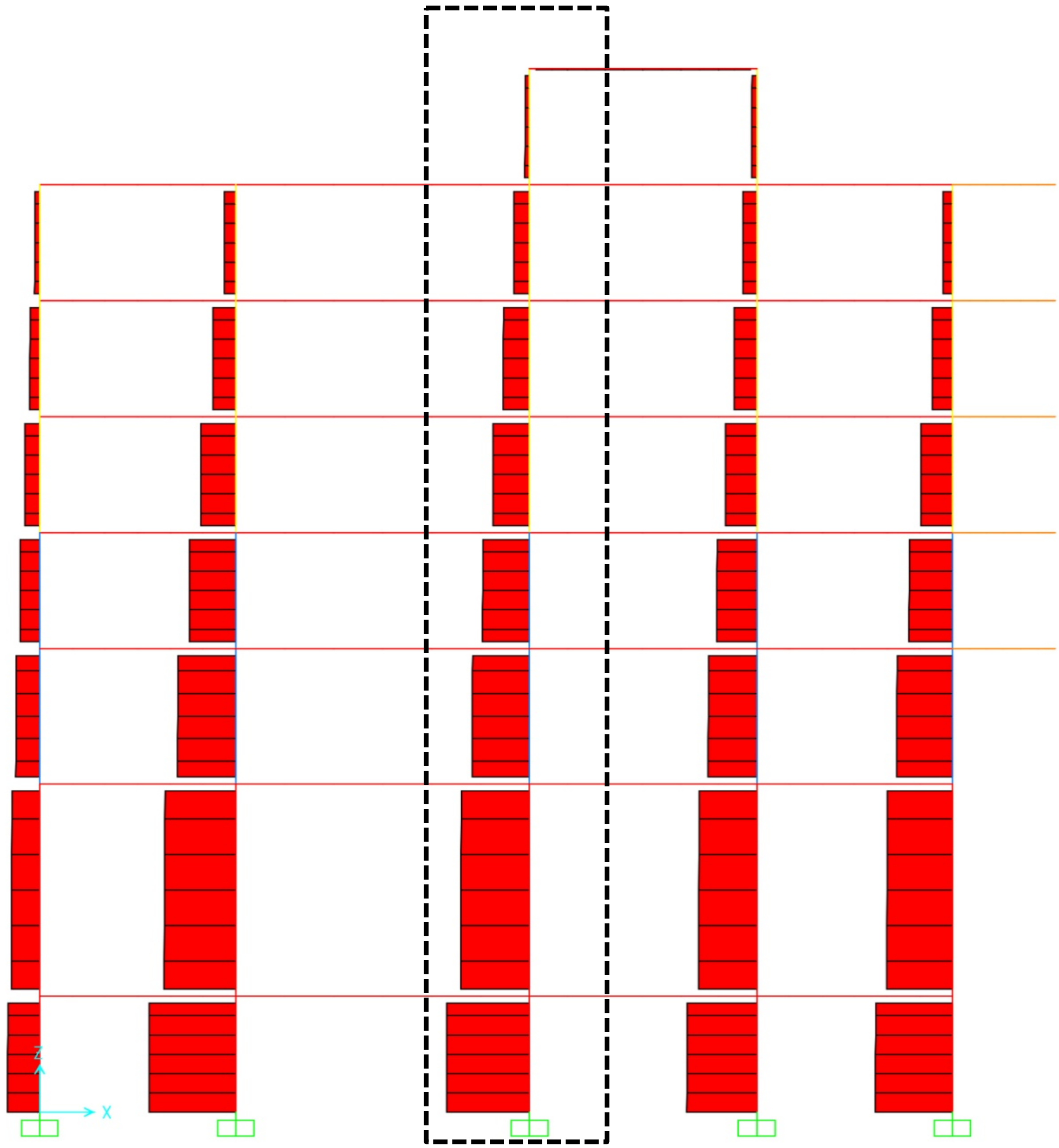


Figure 3-123 Axial load diagram (frame 7)

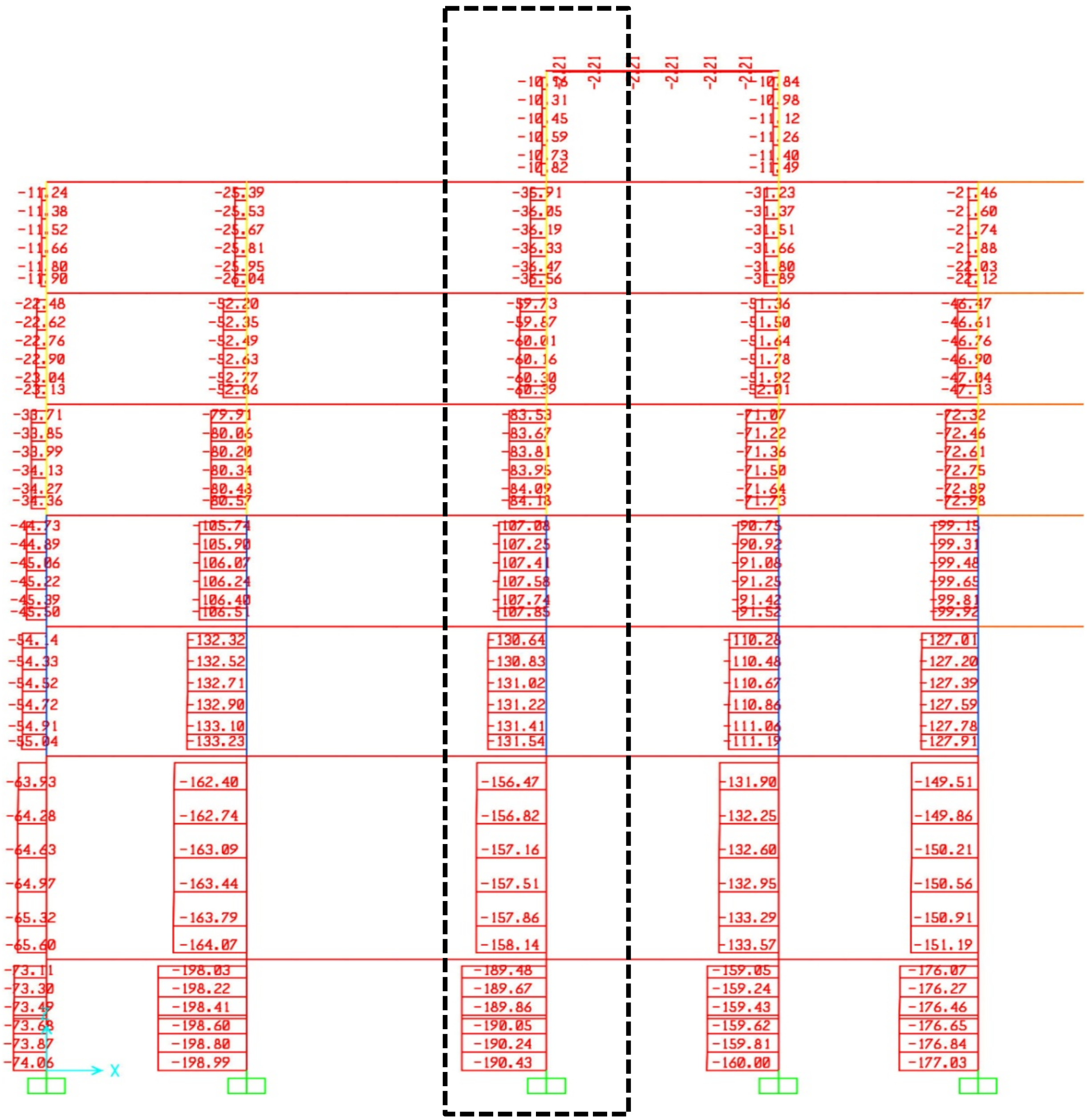


Figure 3-124 Axial load diagram (frame 7)

3.4.3.3.2 Design of Beam Sections

Check if the Section is Compact:

$\frac{b}{t} \leq \frac{545}{\sqrt{f_y}} = 11.12$ $\quad For\ IPE360 \quad$ $\frac{b}{t} = \frac{14.3}{1.3} = 11 < 11.12$ $\quad (Section\ is\ Compact\ )$

Checking for lateral Bracing

$$Equation\ A\ :\quad L_c = \frac{635\ b_f}{\sqrt{f_y}}\ cm \qquad Equation\ B\ :\quad L_c = \frac{14\times10^5}{\left(\frac{d}{A_f}\right)f_y}\ cm$$

$L_b \leq Min\ \ Equation\ A\ and\ Equation\ B$

$$L_c = \frac{635\ b_f}{\sqrt{f_y}} \quad For\ IPE360 \qquad L_C = \frac{635\ \times14.3}{\sqrt{2400}} = 182\ cm$$

$$L_c = \frac{14\times10^5}{\left(\frac{d}{A_f}\right)f_y} \quad For\ IPE360 \qquad L_C = \frac{14\ \times10^5}{(\frac{36}{14.3\times1.3})\times2400} = 301\ cm$$

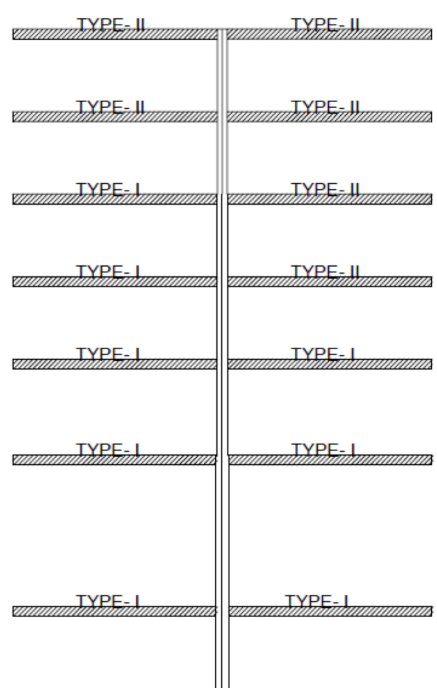
$L_b = 1.5\ m < 1.8\ m \qquad (ok)$

$L_b = distance\ between\ steel\ deck\ roof\ beams$

$therefore \qquad F_b = 0.66f_y$

Beams in this frame (Frame 7) has been categorized in to two different type,

Based on Ultimate moment actions applied on them



Checking Type I of the beam in bending

$M_u = 27.35 \ \ ton - m \quad (\ Maximum \ cretical \ \ Design \ Moment (Combo - 7) for \ Type \ \boldsymbol{I} of \ the \ Beam$

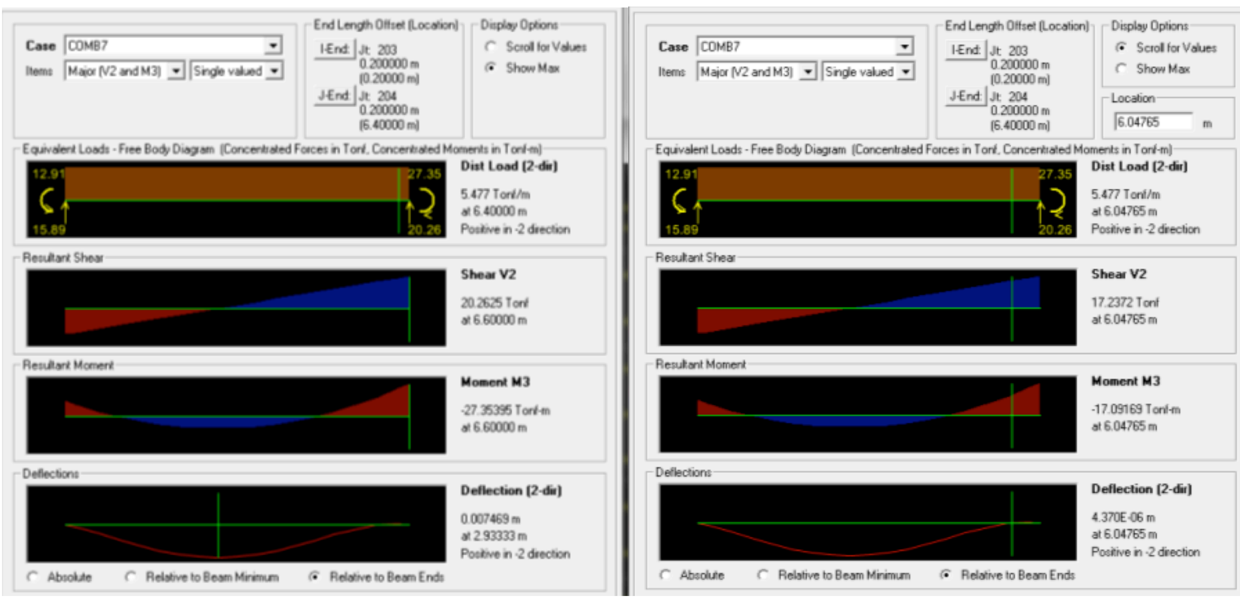
$V_u = 20.26 \ \ ton \qquad (\ Maximum \ cretical \ Design \ Shear \ (Combo \ 7) for \ Type \ I \ of \ the \ Beam)$

Checking for IPE 360

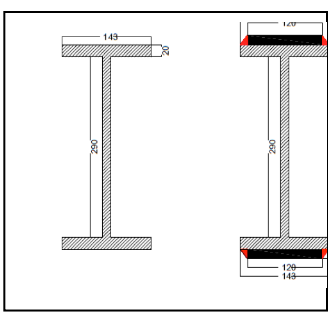
$\boldsymbol{\sigma_{allowable}} = \dfrac{\boldsymbol{M_R C}}{\boldsymbol{I}} \qquad (\sigma_{allowable} = 0.6 f_y) \qquad \dfrac{\boldsymbol{I}}{\boldsymbol{C}} = \dfrac{\boldsymbol{M_U}}{\boldsymbol{0.66 \times 2400}} \qquad W_{req} = 1726 \ cm^3$

$\boldsymbol{IPE \ 360 : \ \ W = 1090 \ < 1726 \ cm^3}$

(Checking moment on the selected beams for possibility of using additional reinforced steel plates in critical parts of the beam in order to reaching to the acceptable W (> 1726) for the element in these parts and accept the Section



$IPE360 \qquad w_X = 1090 \ Cm^3 \qquad M_R = 1090 \times 0.66 \times 2400 = 17.3 \ ton - m$



$Add \ 2 \ Plates \ (120mm \times 20mm \ ) \qquad C_{y,rein} = 20 \ cm$

$IPE \ 360 \qquad I = 19610 \ cm^4$

$IPE \ 360 + 2Plate \ (120mm \times 20mm) \qquad I_{reinf} = 36954 \ cm^4$

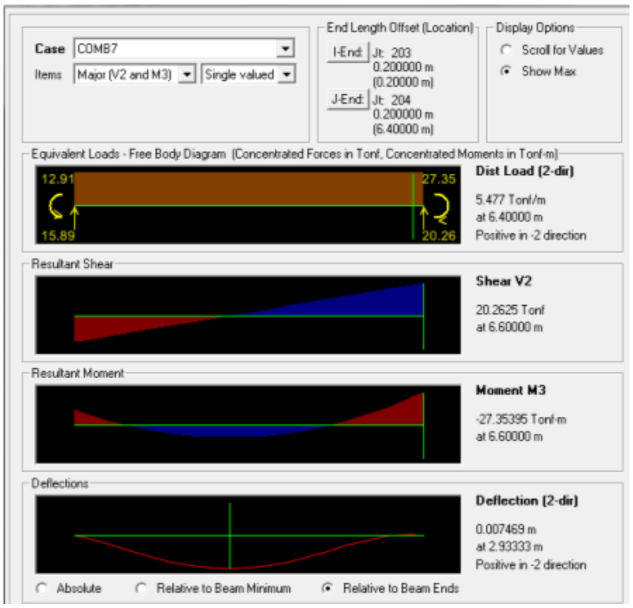
$W_{xnew} = \dfrac{I_{new}}{C_{new}} = \dfrac{36954}{20} = 1847 \ Cm^3 \quad > 1726 \ Cm^3 \qquad (OK)$

Checking Type I of the beam in shear

Checking for Slenderness of the Web:

$$For\ IPE\ 360 \qquad \frac{h}{t_w} = \frac{360}{13} = 27.69 < \frac{3185}{\sqrt{f_y}} = 65.01 \qquad F_b = 0.4\, f_y$$

$$IPE360 \qquad h = 290\ mm \qquad T_W = 13mm \quad \frac{h}{t_w} = 22.30 < 65.01 \quad (OK\ )$$



$$F_b = 0.4\, F_y = 0.4 \times 2400 = 960\ \ Kg/cm\text{^}2$$

$$V_u = 20.26\ \ ton$$

$$F_v = \frac{20.26 \times 10^3}{36 \times 1.3} = 432 \frac{kg}{cm^2} < 960 \quad (OK)$$

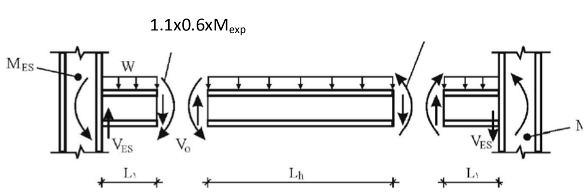
Check for web stiffener requirement:

$$\frac{h}{t_w} = 22.30 < 260$$

$Section\ Dont\ Need\ web\ Stiffener$

Special consideration for IMF in shear

According to the Iran Steel, structure design Code, beams in IMF (Intermediate Moment Frame) structures should be capable of resisting the shear action produced by formation of the plastic hinge in section



$$V_{es} = \frac{2 \times 0.6 \times 1.1 \times M_{exp}}{L_h} + V + W = V_0 + W$$

$$M_{exp} = Z_b F_y \times 1.15$$

$$M_{exp} = 1284 \times 1.15 \times 2400 = 35.44\ \ Ton.m$$

$$V_{es} = 15.72\ Ton - F \qquad L_h \approx 40\ cm \quad According\ to\ the\ code$$

Check for web stiffener requirement:

$$\frac{h}{t_w} = 27.69 < 260 \qquad Section\ Dont\ Need\ web\ Stiffener$$

Checking Type II of the beam in bending

$M_u = 17.6\ ton - f \qquad (\,Maximum\ cretical\ \ Design\ Moment(Combo - 7) for\ Type\ II\ of\ the\ Beam$

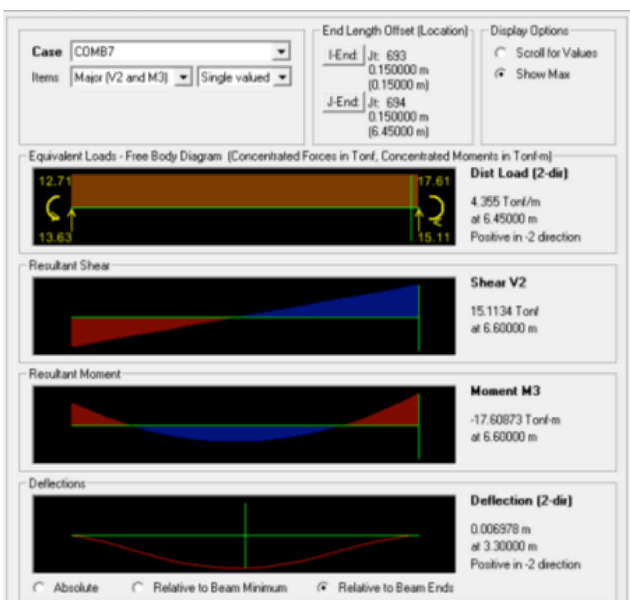
$V_u = 20.26\ ton \qquad (\,Maximum\ cretical\ Design\ Shear\ (Combo\ 7) for\ TypeII\ of\ the\ Beam)$

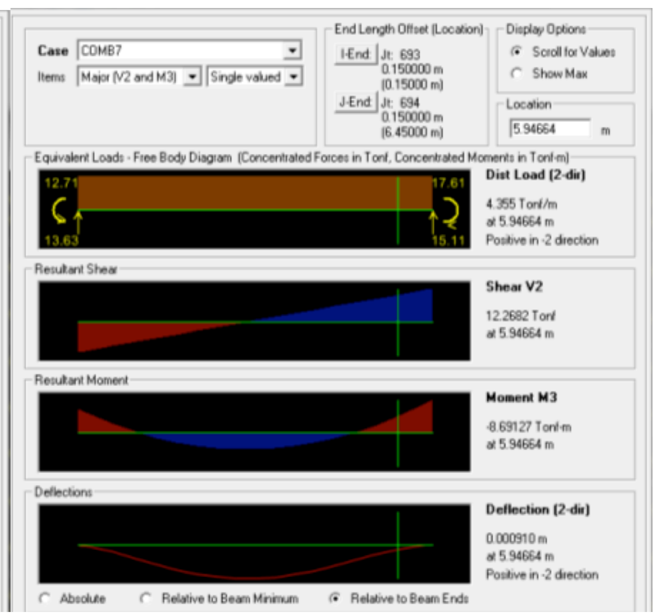
Checking for IPE 320

$\boldsymbol{\sigma_{allowable}} = \dfrac{\boldsymbol{M_R C}}{\boldsymbol{I}} \qquad (\sigma_{allowable} = 0.66 f_y) \qquad \dfrac{\boldsymbol{I}}{\boldsymbol{C}} = \dfrac{\boldsymbol{M_u}}{\boldsymbol{0.66 \times 2400}} \qquad W_{req} = 1111 cm^3$

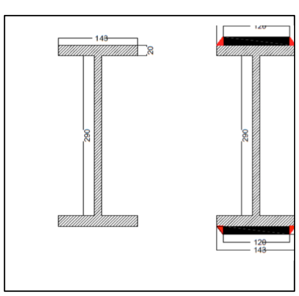
$\boldsymbol{IPE\ 360:\ \ W = 782\ < 1111}$

(Checking moment on the selected beams for possibility of using additional reinforced steel plates in critical parts of the beam in order to reaching to the acceptable W (> 1111) for the element in these parts and accept the Section.





$IPE\ 320 \qquad w_X = 782\ Cm^3 \qquad M_R = 782 \times 0.66 \times 2400 = 12.38\ \dfrac{ton}{m}$



$Add\ 2\ plate\ (100mm \times 20mm) \qquad C_{ynew} = 18cm$

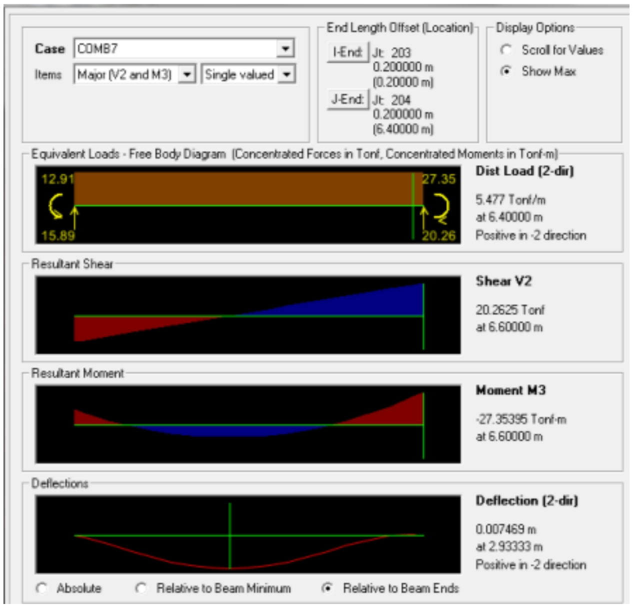
$IPE\ 320 \qquad I = 12510\ cm^4$

$IPE\ 320 + 2\ Plate\ (120mm \times 10mm) \quad I_{rein} = 24083\ Cm^4$

$W_{xnew} = \dfrac{I_{new}}{C_{new}} = \dfrac{24083}{18} = 1338\ Cm^3 \qquad M_{Rrei} = 21.19\ ton - m$

$$For\ IPE\ 320 \qquad \frac{h}{t_w} = \frac{320}{11.5} = 27.82 < \frac{3185}{\sqrt{f_y}} = 65.01 \qquad F_b = 0.4\, f_y$$

$$IPE320 \qquad h = 258\ mm \qquad T_W = 11.5mm \qquad \frac{h}{t_w} = 22.43 < 65.01 \qquad (OK\ )$$



$$F_b = 0.4\ F_y = 0.4 \times 2400 = 960 \quad Ton - F$$

$$V_u = 20.26\ \ ton - F$$

$$F_v = \frac{20.26}{32 \times 1.1} = 575\ Ton < 960 \qquad (OK)$$

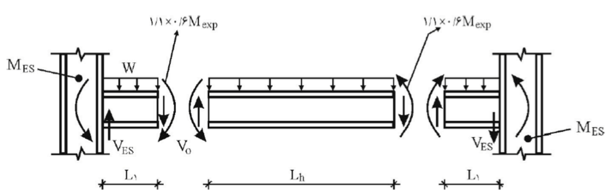
Check for web stiffener requirement:

$$\frac{h}{t_w} = 22.43 < 260$$

$Section\ Dont\ Need\ web\ Stiffener$

Special consideration for IMF in shear:

According to the Iran Steel, structure design Code, beams in IMF (Intermediate Moment Frame) structures should be capable of resisting the shear action produced by formation of the plastic hinge in section



$$V_{es} = \frac{2 \times 0.6 \times 1.1 \times M_{exp}}{L_h} + V + W = V_0 + W$$

$$M_{exp} = Z_b F_y \times 1.15$$

$$M_{exp} = 1284 \times 1.15 \times 2400 = 35.44\ \ Ton.m$$

$V_{es} = 15.72\ Ton - F \qquad L_h \approx 40\ cm \quad According\ to\ the\ code$

3.4.3.3.3 Design of Column Section

Column Design : (Floor-1 & Floor 2)

Effective Length

Checking for Critical column (Floor 1 & Floor 2)

$$K = \sqrt{\frac{1.6\ G_A G_B + 4(G_A + G_B) + 7.5}{G_A + G_B + 7.5}} \geq 1$$

$$G_A = \frac{\sum \frac{EI_C}{L_c}}{\sum \frac{EI_b}{L_b}} \quad In\ Node\ A \qquad G_B = \frac{\sum \frac{EI_C}{L_c}}{\sum \frac{EI_b}{L_b}} \quad In\ Node\ B$$

Column (Floor 1 & Floor 2)	Box 450mm-450mm-25mm	$I_C = 128385\ Cm^4$
Column (Floor 3)	Box 350mm-350mm-15mm	$I_C = 37670\ Cm^4$
Beams (In Weaker Side of the Frame)	IPE-28	$I_b = 7590\ Cm^4$

$$G_A = \frac{(2.1 \times 10^6)(\frac{128385}{550} + \frac{37670}{350})}{2\left((2.1 \times 10^6) \times \left(\frac{7590}{385}\right)\right)} = 8.74$$

$$G_B = \frac{(2.1 \times 10^6)(\frac{128385}{550} + \frac{128385}{350})}{2\left((2.1 \times 10^6) \times \left(\frac{7590}{385}\right)\right)} = 15.39$$

$$K = \sqrt{\frac{1.6\ (8.74)(15.39) + 4(8.74 + 15.39) + 7.5}{8.74 + 15.39 + 7.5}} = 3.17 > 1$$

$$R_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{128385}{425}} = 17.38 \qquad C_c = \frac{6440}{\sqrt{2400}} = 131.45$$

$$\lambda = \frac{KL}{R} = \frac{3.17 \times 550}{17.38} = 100.31 < 200 \quad AND \quad < C_c = 131.45 \qquad (OK)$$

Allowable Compressive Stress:

$$F_a = \frac{1}{F_s}\left[1 - 0.5\left(\frac{\lambda}{C_c}\right)^2\right]\times F_y \qquad F_s = 1.67 + 0.375\left(\frac{\lambda}{C_c}\right) - 0.125\left(\frac{\lambda}{C_c}\right)^3$$

$$F_s = 1.67 + 0.375(\frac{100.31}{131.45})\text{-}0.125\left(\frac{100.31}{131.45}\right)^3 = 1.90$$

$$F_a = \frac{1}{1.90}(1 - 0.5(0.76)^2)\times 2400 = 898.56$$

Allowable Flexural Stress:

Since the section is tubular, the un braced length $L_b < L_{c,}$ Where

$$L_c = 10^3\left(137 + 84\frac{M_1}{M_2}\right)\frac{b}{F_y} \geq 84\times 10^3\frac{b}{F_y} \qquad L_c = 10^3\left(137 + 84\left(\frac{16.53}{19.3}\right)\right)\frac{45}{2400} = 3917 > 1575$$

$F_{bx} = F_{by} = 0.6\ F_y$

$$\frac{f_a}{F_a} = \frac{372}{898.56} = 0.41 > 0.15 \quad (Ok) \qquad f_a = \frac{158.14}{425}\times 1000 = 372$$

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{F_a}{F_{ex}}\right)F_{bx}} + \frac{C_{my} f_{by}}{\left(1 - \frac{F_a}{F_{ey}}\right)F_{by}} \leq 1 \qquad f_{bx} = \frac{MC}{I} = \frac{19.3\times 10^5\times 22.5}{128385} = 338 \quad F_{by} = F_{bx} = 1440$$

$$f_{by} = \frac{MC}{I} = \frac{16.53\times 10^5\times 22.5}{128385} = 289$$

$$P - Delta\ Analysis\ has\ been\ performed \quad \frac{C_{mx}}{\left(1 - \frac{F_a}{F_{ex}}\right)} = 1 \qquad \frac{f_a}{F_p} + \frac{f\_bx}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1$$

$$\frac{f_a}{F_a} + \frac{f\_bx}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1 \quad 0.41 + 0.23 + 0.2 = 0.84 < 1 \quad (\boldsymbol{Ok})$$

Shear Check:

$$\boldsymbol{\frac{h}{t_w} \leq \frac{3185}{f_y} \qquad \frac{45}{2.5} = 18 < 65 \qquad F_b = 0.4\ F_y}$$

$$V_u = 7.67\ Ton - F \qquad F_v = 34\frac{Kg}{Cm^2} < 0.4\ F_y \qquad (\boldsymbol{Ok})$$

Column Design: (Floor-3 & Floor 4 & Floor 5)

Effective Length:

Checking for Critical column (Floor 1 & Floor 2)

$$K = \sqrt{\frac{1.6\ G_A G_B + 4(G_A + G_B) + 7.5}{G_A + G_B + 7.5}} \geq 1$$

$$G_A = \frac{\sum \frac{EI_c}{L_c}}{\sum \frac{EI_b}{L_b}} \quad In\ Node\ A \qquad G_B = \frac{\sum \frac{EI_c}{L_c}}{\sum \frac{EI_b}{L_b}} \quad In\ Node\ B$$

Column (Floor 3 & Floor 4 & Floor 5)	Box 400mm-400mm-15mm	$I_C = 57152\ Cm^4$
Column (Floor 2)	Box 450mm-450mm-25mm	$I_C = 128385\ \ Cm^4$
Beams (In Weaker Side of the Frame)	IPE-28	$I_b = 7590\ \ Cm^4$

$$G_A = \frac{(2.1 \times 10^6)(\frac{57152}{350} + \frac{57152}{300})}{2\left((2.1 \times 10^6) \times \left(\frac{7590}{385}\right)\right)} = 8.97$$

$$G_B = \frac{(2.1 \times 10^6)(\frac{128385}{550} + \frac{57152}{350})}{2\left((2.1 \times 10^6) \times \left(\frac{7590}{385}\right)\right)} = 10.05$$

$$K = \sqrt{\frac{1.6\ (8.97)(10.05) + 4(8.97 + 10.05) + 7.5}{10.05 + 8.97 + 7.5}} = 2.93\ > 1$$

$$R_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{57152}{231}} = 15.72 \qquad C_c = \frac{6440}{\sqrt{2400}} = 131.45$$

$$\lambda = \frac{KL}{R} = \frac{2.93 \times 300}{15.72} = 55.91\ < 200 \quad AND \quad < C_c = 131.45 \qquad (OK)$$

Allowable Compressive Stress:

$$F_a = \frac{1}{F_s}\left[1 - 0.5\left(\frac{\lambda}{C_c}\right)^2\right]\times F_y \qquad F_s = 1.67 + 0.375\left(\frac{\lambda}{C_c}\right) - 0.125\left(\frac{\lambda}{C_c}\right)^3$$

$$F_s = 1.67 + 0.375(\frac{55.91}{131.45})\text{-}0.125\left(\frac{55.91}{131.45}\right)^3 = 1.81$$

$$F_a = \frac{1}{1.81}(1 - 0.5(0.42)^2)\times 2400 = 1209$$

$$\frac{f_a}{F_a} = \frac{569}{1209} = 0.47 > 0.15 \qquad (Ok) \qquad f_a = \frac{131.54}{231}\times 1000 = 569$$

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{F_a}{F_{ex}}\right)F_{bx}} + \frac{C_{my} f_{by}}{\left(1 - \frac{F_a}{F_{ey}}\right)F_{by}} \leq 1 \qquad f_{bx} = \frac{MC}{I} = \frac{11.21\times 10^5\times 20}{57152} = 392 \quad F_{by} = F_{bx} = 1440$$

$$f_{by} = \frac{MC}{I} = \frac{12.96\times 10^5\times 20}{57152} = 453$$

$$P - Delta\ Analysis\ has\ been\ performed \quad \frac{C_{mx}}{\left(1 - \frac{F_a}{F_{ex}}\right)} = 1 \qquad \frac{f_a}{F_a} + \frac{f\_bx}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1$$

$\frac{f_a}{F_a} + \frac{f\_bx}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1 \qquad 0.47 + 0.27 + 0.31 = 1.05 > 1 \quad Change\ section$

$New\ Suggested\ Section\ \ Box\ 400mm - 400mm - 18mm$ In Critical Area

Shear Check:

$$\frac{\boldsymbol{h}}{\boldsymbol{t_w}} \leq \frac{\mathbf{3185}}{\boldsymbol{f_y}} \qquad \frac{\mathbf{40}}{\mathbf{1.5}} = \mathbf{26.66} < \mathbf{65} \qquad \boldsymbol{F_b = 0.4\, F_y}$$

$$V_u = 7.67\ Ton - F \qquad F_v = 34\frac{Kg}{Cm^2} < 0.4\, F_y \qquad (\boldsymbol{Ok})$$

Column Design: (Floor-6 & Floor 7)

Effective Length:

Checking for Critical column (Floor 1 & Floor 2)

$$K = \sqrt{\frac{1.6\ G_A G_B + 4(G_A + G_B) + 7.5}{G_A + G_B + 7.5}} \geq 1$$

$$G_A = \frac{\sum \frac{EI_C}{L_c}}{\sum \frac{EI_b}{L_b}} \quad In\ Node\ A \qquad G_B = \frac{\sum \frac{EI_C}{L_c}}{\sum \frac{EI_b}{L_b}} \quad In\ Node\ B$$

Column (Floor 6 & Floor 7)	Box 350mm-350mm-15mm	$I_C = 37669\ Cm^4$
Column (Floor 5)	Box 400mm-400mm-15mm	$I_C = 57152\ \ Cm^4$
Beams (In Weaker Side of the Frame)	IPE-28	$I_b = 7590\ \ Cm^4$

$$G_A = \frac{(2.1 \times 10^6)(\frac{57152}{300} + \frac{37669}{300})}{2\left((2.1\times 10^6)\times\left(\frac{7590}{385}\right)\right)} = 8.01$$

$$G_B = \frac{(2.1 \times 10^6)(\frac{57152}{300} + \frac{37669}{300})}{2\left((2.1\times 10^6)\times\left(\frac{7590}{385}\right)\right)} = 8.01$$

$$K = \sqrt{\frac{1.6\ (8.01)(8.01) + 4(8.01 + 8.01) + 7.5}{8.01 + 8.01 + 7.5}} = 2.72 > 1$$

$$R_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{37669}{201}} = 13.67 \qquad C_c = \frac{6440}{\sqrt{2400}} = 131.45$$

$$\lambda = \frac{KL}{R} = \frac{2.72\times 300}{13.67} = 59.69 < 200 \quad AND \quad < C_c = 131.45 \qquad (OK)$$

Allowable Compressive Stress:

$$F_a = \frac{1}{F_s}\left[1 - 0.5\left(\frac{\lambda}{C_c}\right)^2\right]\times F_y \qquad F_s = 1.67 + 0.375\left(\frac{\lambda}{C_c}\right) - 0.125\left(\frac{\lambda}{C_c}\right)^3$$

$$F_s = 1.67 + 0.375\left(\frac{59.69}{131.45}\right) - 0.125\left(\frac{59.69}{131.45}\right)^3 = 1.82$$

$$F_a = \frac{1}{1.90}(1 - 0.5(0.45)^2)\times 2400 = 1135$$

$$\frac{f_a}{F_a} = \frac{181}{1135} = 0.159 > 0.15 \qquad f_a = \frac{36.56}{201}\times 1000 = 181$$

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1-\frac{F_a}{F_{ex}}\right)F_{bx}} + \frac{C_{my} f_{by}}{\left(1-\frac{F_a}{F_{ey}}\right)F_{by}} \leq 1 \qquad f_{bx} = \frac{MC}{I} = \frac{11.21\times 10^5\times 20}{57152} = 392 \quad F_{by} = F_{bx} = 1440$$

$$f_{by} = \frac{MC}{I} = \frac{12.96\times 10^5\times 20}{57152} = 453$$

$$P - Delta\ Analysis\ has\ been\ performed \quad \frac{C_{mx}}{\left(1-\frac{F_a}{F_{ex}}\right)} = 1 \qquad \frac{f_a}{f_a} + \frac{f\_bx}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1$$

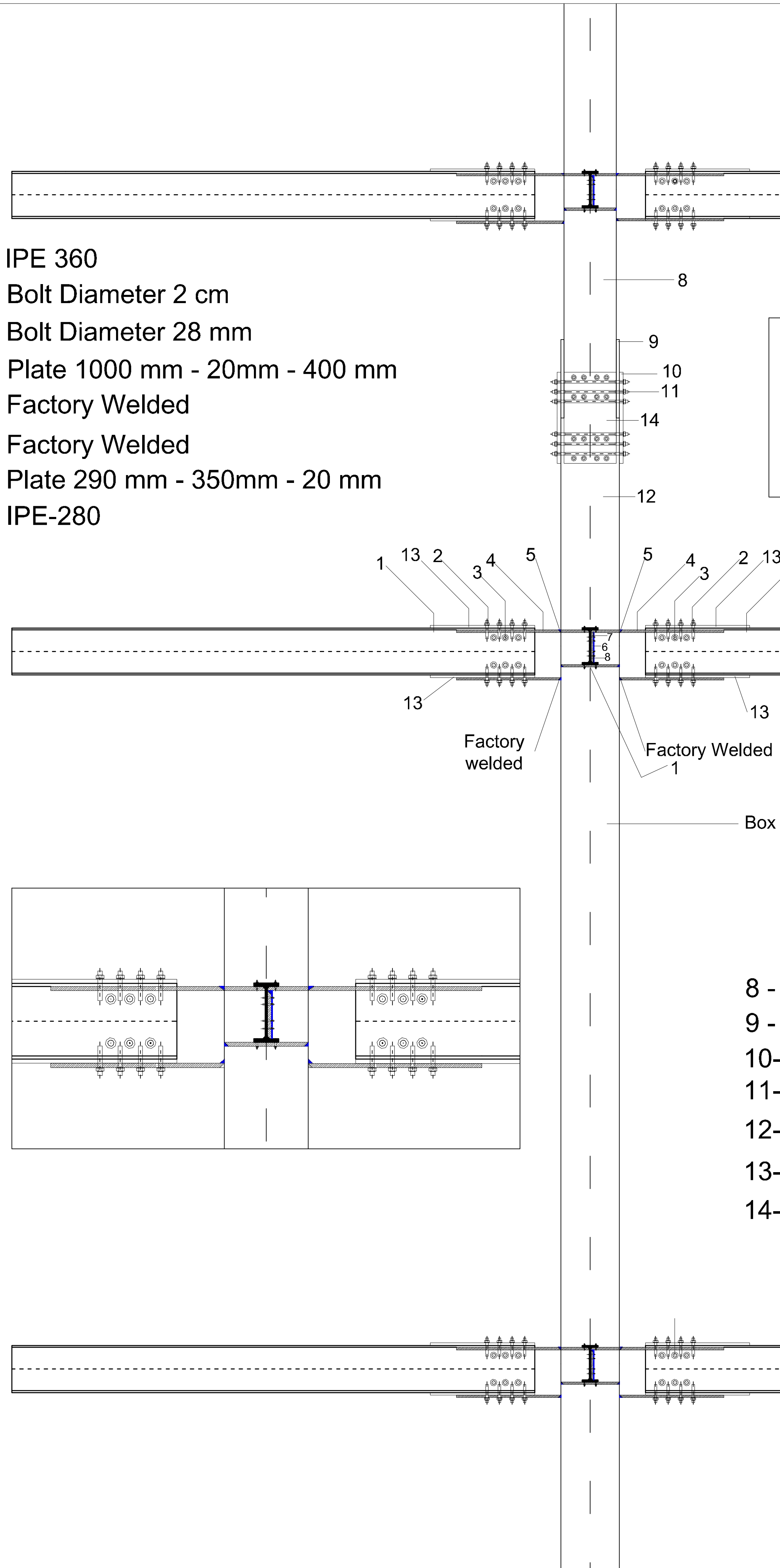
$$\frac{f_a}{F_a} + \frac{f\_bx}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1 \qquad 0.15 + 0.27 + 0.31 = 0.73 < 1 \quad (\boldsymbol{Ok})$$

Shear Check:

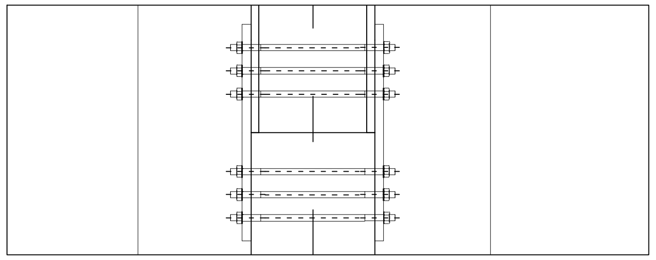
$$\boldsymbol{\frac{h}{t_w} \leq \frac{3185}{f_y} \qquad \frac{35}{1.5} = 23.33 < 65 \qquad F_b = 0.4\,F_y}$$

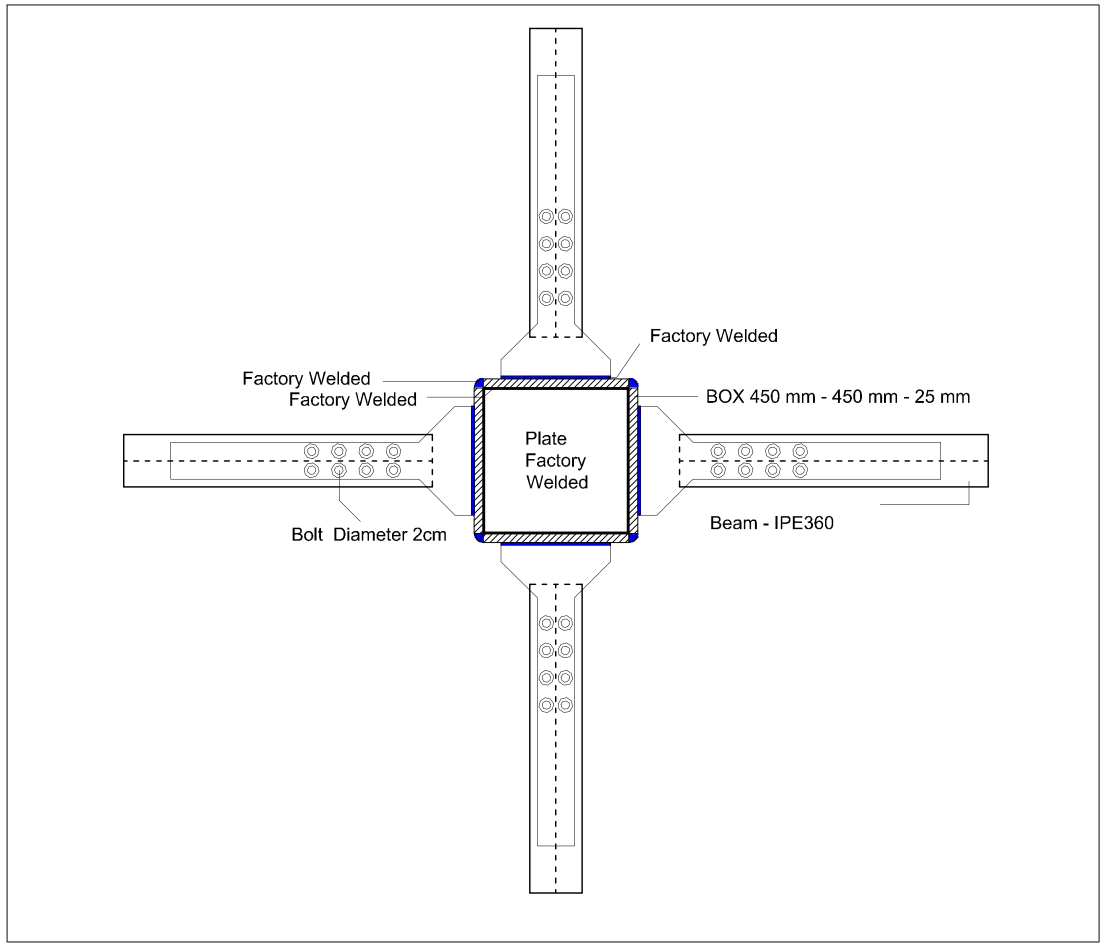
$$V_u = 7.67\ Ton - F \qquad F_v = 34\frac{Kg}{Cm^2} < 0.4\,F_y \qquad (\boldsymbol{Ok})$$

3.4.3.3.4 Structural Plan Sheets (Sample Connections)

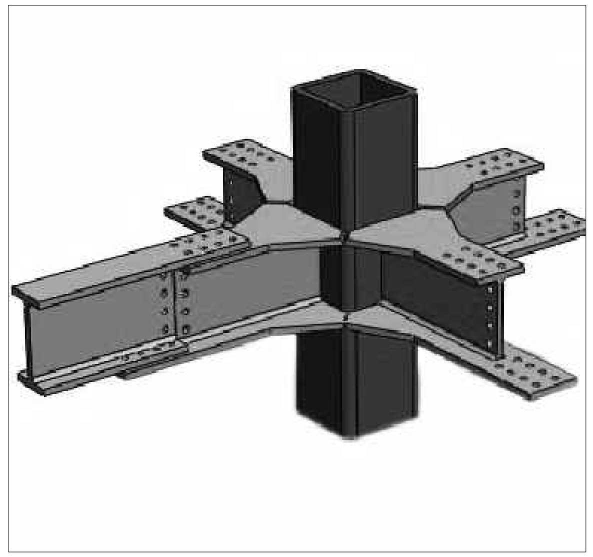


1 - IPE 360
2 - Bolt Diameter 2 cm
3 - Bolt Diameter 28 mm
4 - Plate 1000 mm - 20mm - 400 mm
5 - Factory Welded
6 - Factory Welded
7 - Plate 290 mm - 350mm - 20 mm
7 - IPE-280





8 - BOX - 400 mm - 400 mm - 25 mm
9 - Filler Plate 600 mm - 400 mm - 25 mm
10- Plate 700 mm - 400 mm - 28 mm
11- Bolt Diameter 20 mm
12- BOX 450mm-450mm-25mm
13-strenghening Plate 800 mm - 100 mm - 20 mm
14-Plate 700 mm - 400 mm - 20 mm



Politecnico Di Milano VI-Scuola Di Ingegneria MI Ingegneria Dei Sistemi Edilizi (LC)	Structural Design	Sheet Number : 1 Scale :
	Structural Design	
Ms.c Final Graduating Project Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach	Connections (Sample Design))	
Supervisor : Prof. Massimo Tadi Co- Supervisor : Prof.Gabriele Masera	Amirali Naraghi	755237
	Mohammad Hadi Mohammad Zadeh	754940

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References

- Brownlee, J., Complex Adaptive Systems. CIS Technical Report 070302A, 2007: p. 1-6.
- Clarke, C. and P. Anzalone, Architectural Applications of Complex Adaptive Systems, XO (eXtended Office). p. 19.
- Vahabzadeh Manesh, S. and M. Tadi, Sustainable urban morphology emergence via Complex Adaptive System analysis. Procedia Engineering, 2011. 21: p. 89-97.
- Salat S, CSTB: Cities and Forms on Sustainable Urbanism: Hermann Editeurs des Sciences et des Arts; 2011.
- Porta S, et al. "Street centrality and the location of economic activities in Barcelona." Urban Studies 49.7 (2012).
- Simpson, E. H. (1949) Measurement of diversity. Nature, 163, 688.
- Al_Sayed, K., Turner, A., Hillier, B., 2013, "Space Syntax Methodology", Bartlett School of Graduate Studies, UCL, London. Copyright @ 2013
- Geurs, Karst T., and Bert VAn Wee. "Accessibility evaluation of land-use and transport strategies: review and research directions." Journal of Transport geography 12.2 (2004): 127-140.
- Salat S, Bourdic L: Urban complexity, scale hierarchy, energy efficiency and economic value creation. WIT Transactions on Ecology and The Environment, 2012,Vol 155:11.
- Schwarz, N. InUrban form revisited; Selecting indicators for characterising European cities. Landscape and Urban Planning, 2010. 96, 19 DOI: 10.1016/j. landurbplan.2010.01.007.
- Porta, S. and J. Luciano Renne, Linking Urban Design to Sustainability, Formal indicators of social urban sustainability field research in Perth, Western Australia. URBAN DESIGN International, 2005: p. 14.
- Vahabzadeh Manesh, S. and M. Tadi, Integrated Modification Methodology (IMM): A Phasing Process for Sustainable Urban Design.
- Jenks, M., E. Burton, and K. Williams, The compact city, a sustainable form? 1996: a FN Spon, an imprint of Chapman & Hall. 288.
- Zhai XQ, Wang RZ, Dai YJ, Wu JY, Xu YX, Ma Q, Solar integrated energy system for a green building, Energy and Buildings, Vol.39, 2007, pp. 985-993.
- Brian E. Saelens, James F. Sallis, Lawrence D. Frank, Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures Annals of Behavioral Medicine, 2003, Volume 25, Number 2, Page 80

- Filion P, 2001, "Suburban mixed-use centres and urban dispersion: what difference do they make?" Environment and Planning A 33(1) 141 – 160

- Kong, Fanhua, et al. "Urban green space network development for biodiversity conservation: Identification based on graph theory and gravity modeling." Landscape and urban planning 95.1 (2010): 16-27.

- Ahern, J. "Green Infrastructure for Cities: The spatial Dimension". In Cities of the Future Towards Integrated Sustainable Water and Landscape Management, edited by Vladimir Novotny and Paul Brown, 267-283. London: WA publishing. (2006).

- Black JA, Paez A, Suthanaya PA: Sustainable Urban Transportation: Performance Indicators and Some Analytical Approaches. Urban Planning and Development 2002:26.

- Darmaillacq, S. Chardonnet. "Smart & sustainable mobility in a complex urban context." (2011): 40-40.

- Steel, C. Hungry City: How Food Shapes Our Lives, Random House UK, 2009

- Costi, P., et al. "An environmentally sustainable decision model for urban solid waste management." Waste Management 24.3 (2004): 277-295.

- Niemczynowicz, Janusz. "Urban hydrology and water management present and future challenges." Urban water 1.1 (1999): 1-14.

- Mehdizadeh Javad, *The city and History: a look towards historical process of contextual and spatial development in Tehran*, Art and Architecture 2003

- International Energy Agency (IEA) Statistics Division

- BP Statistical Review of World Energy, 2010

- CIA World Factbook

- National Iranian Oil Products Distribution Company

- K.N. Toosi University's Research Center

Appendix

- Urban Analysis

-Daylight Factor Analysis

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Politecnico Di Milano VI-Scuola Di Ingegneria MI Ingegneria Dei Systemi Edilizi (LC)	Urban Design Sheet Urban Design Analysis	Sheet Number : 1 Scale :
Ms.c Final Graduating Project Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach Supervisor : Prof. Massimo Tadi Co- Supervisor : Prof.Gabriele Masera	Areas and Locations Current Situation	
	Amirali Naraghi	755237
	Mohammad Hadi Mohammad Zadeh	754940

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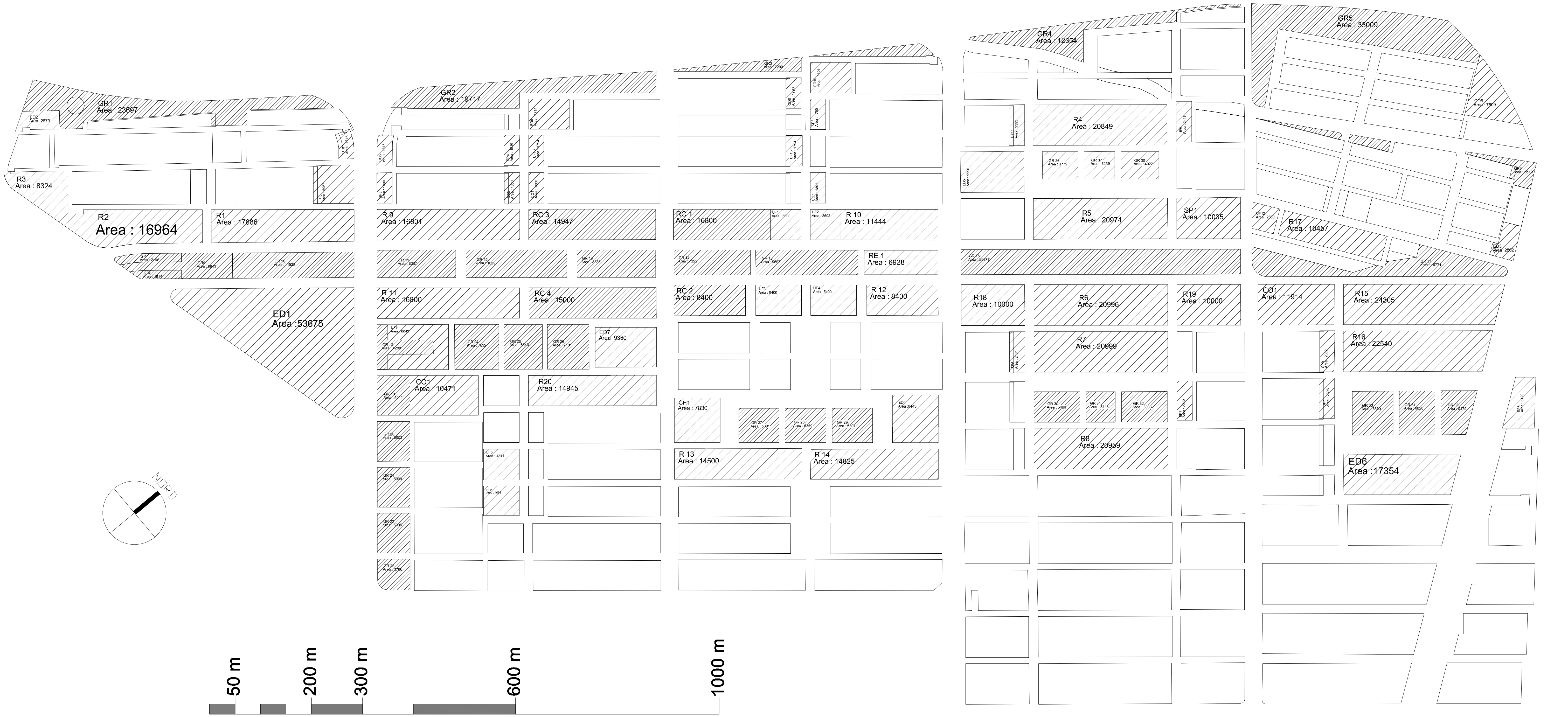


Politecnico Di Milano
VI-Scuola Di Ingegneria MI
Ingegneria Dei Systemi Edilizi (LC)

Urban Design Sheet

Sheet Number : 2

Scale :

Urban Design Analysis

Ms.c Final Graduating Project

Design and Modification of a residential context in Tehran's Distrit 22 with a multi-scale Approach

Modification Area

Supervisor : Prof. Massimo Tadi
Co- Supervisor : Prof.Gabriele Masera

Amirali Naraghi 755237
Mohammad Hadi Mohammad Zadeh 754940

New Design Dimentions (According to the Sheet Plan number 2-1 & 2-2

Texture	General Code	Code	Area	Unit	Maximum occupied Area			Open Area	Max Story	Density		Useful Residential Area	Total	Volume m³	Code Reference
Residential	R	R1	17,886	m²	%	50.0	8,943	8,943	12	%	600	107,316	1,187,982	321,948	R263
		R2	16,964	m²	%	50.0	8,482	8,482	12	%	600	101,784		305,352	R263
		R3	8,324	m²	%	50.0	4,162	4,162	12	%	600	49,944		149,832	R263
		R4	20,849	m²	%	50.0	10,425	10,425	12	%	600	125,094		375,282	R263
		R5	20,974	m²	%	50.0	10,487	10,487	12	%	600	125,844		377,532	R263
		R6	20,996	m²	%	50.0	10,498	10,498	12	%	600	125,976		377,928	R263
		R7	20,999	m²	%	40.0	8,400	12,599	7	%	280	58,797		176,392	R261
		R8	20,959	m²	%	40.0	8,384	12,575	7	%	280	58,685		176,056	R261
		R10	11,444	m²	%	40.0	4,578	6,866	7	%	280	32,043		96,130	R261
		R12	8,400	m²	%	50.0	4,200	4,200	12	%	600	50,400		151,200	R263
		R13	14,500	m²	%	75.0	10,875	3,625	7	%	280	40,600		228,375	R261
		R14	14,825	m²	%	75.0	11,119	3,706	7	%	280	41,510		233,494	R261
		R15	24,305	m²	%	40.0	9,722	14,583	7	%	280	68,054		204,162	R261
		R16	22,540	m²	%	40.0	9,016	13,524	7	%	280	63,112		189,336	R261
		R17	10,457	m²	%	60.0	6,274	4,183	3	%	180	18,823		56,468	R112
		R18	10,000	m²	%	75.0	7,500	2,500	12	%	600	60,000		270,000	R263
		R19	10,000	m²	%	50.0	5,000	5,000	12	%	600	60,000		180,000	R263
														0	
			274,422				138,063	136,359							

Texture	General Code	Code	Area	Unit	Maximum occupied Area			Open Space	Max Story	Density Residential		Density (Commercial)		Max Useful Residential Area	Max Useful Commercial Area	Max Story	Total Residential Area	Total Commercial Area	Code Reference
Residential Commercial	RC	RC1	11,400	m²	%	50	5,700	5,700	12	%	400	%	200	45,600	22,800		438,373	196,766	R263
		RC2	8,400	m²	%	50	4,200	4,200	12	%	400	%	200	33,600	16,800				R263
		RC3	14,947	m²	%	50	7,474	7,474	12	%	500	%	100	74,735	14,947				R263
		RC4	15,000	m²	%	50	7,500	7,500	12	%	400	%	200	60,000	30,000				R263
		RC5	16,801	m²	%	50	8,401	8,401	12	%	400	%	200	67,204	33,602				
		RC6	16,800	m²	%	50	8,400	8,400	12	%	400	%	200	67,200	33,600				R263
		RC7	14,945	m²	%	50	7,473	7,473	12	%	400	%	200	59,780	29,890				
		RC8	1,800	m²	%	60	1,080	720	6	%	240	%	120	4,320	2,160				R131
		RC9	1,800	m²	%	60	1,080	720	6	%	240	%	120	4,320	2,160				R131
		RC10	1,816	m²	%	60	1,090	726	6	%	240	%	120	4,358	2,179				R131
		RC11	1,794	m²	%	60	1,076	718	6	%	240	%	120	4,306	2,153				R131
			1,800	m²	%	60	1,080	720	6	%	240	%	120	4,320	2,160				R131
		RC13	1,800	m²	%	60	1,080	720	6	%	240	%	120	4,320	2,160				R131
		RC14	1,796	m²	%	60	1,078	718	6	%	240	%	120	4,310	2,155				R131
			110,899				56,710	54,189						438,373					

Texture	General Code	Code	Area	Unit	Maximum occupied Area			Open Spaces	Max Story	Density		Max Useful Commercial Area	Total	Volume m³	Code Reference
Cmmercial	CO	CO1	10,471	m²	%	50	5,236	5,236	8	%	440	46,072	134,426	125,652	S122
		CO2	11,914	m²	%	50	5,957	5,957	8	%	440	52,422		142,968	S122
		CO5	1,815	m²	%	60	1,089	726	1.5	%	80	1,452		4,901	
		CO7	1,801	m²	%	60	1,081	720	1.5	%	80	1,441		4,863	
		CO8	7,509	m²	%	50	3,755	3,755	8	%	440	33,040		90,108	
														0	
			33,510				17,117	16,393							

New Design Dimentions (According to the Sheet Plan number 2-1 & 2-2

Texture	General Code	Code	Area	Unit	Maximum occupied Area			Open spaces	Max Story	Density		Max Useful Building Area	Total	Volume m³
		GR1	23,697	m²	%	2	474	23,223	1	%	2	474		1,422
						2	0	0						0
		GR3	7,290	m²	%	2	146	7,144	1	%	2	146		9
														0
		GR5	33,009	m²	%	2	660	32,349	1	%	2	660		40
		GR6	5,619	m²	%	2	112	5,507	1	%	2	112		7
		GR7	2,146	m²	%	2	43	2,103	1	%	2	43		3
		GR8	1,514	m²	%	2	30	1,484	1	%	2	30		2
		GR9	6,843	m²	%	2	137	6,706	1	%	2	137		8
		GR10	11,923	m²	%	2	238	11,685	1	%	2	238		14
		GR11	8,337	m²	%	2	167	8,170	1	%	2	167		10
		GR12	10,692	m²	%	2	214	10,478	1	%	2	214		13
		GR13	8,336	m²	%	2	167	8,169	1	%	2	167		10
		GR14	7,322	m²	%	2	146	7,176	1	%	2	146		9
		GR15	9,697	m²	%	2	194	9,503	1	%	2	194		12
		GR16	26,877	m²	%	2	538	26,339	1	%	2	538		32
		GR17	16,771	m²	%	2	335	16,436	1	%	2	335		20
		GR18	4,288	m²	%	2	86	4,202	1	%	2	86		5
		GR19	5,011	m²	%	2	100	4,911	1	%	2	100		6
		GR20	5,002	m²	%	2	100	4,902	1	%	2	100		6
Green Spaces	**GR**	GR21	5,009	m²	%	2	100	4,909	1	%	2	100	5,779	6
		GR22	5,005	m²	%	2	100	4,905	1	%	2	100		6
		GR23	3,760	m²	%	2	75	3,685	1	%	2	75		5
		GR24	7,632	m²	%	2	153	7,479	1	%	2	153		9
		GR25	6,640	m²	%	2	133	6,507	1	%	2	133		8
		GR26	7,191	m²	%	2	144	7,047	1	%	2	144		9
		GR27	5,301	m²	%	2	106	5,195	1	%	2	106		6
		GR28	5,360	m²	%	2	107	5,253	1	%	2	107		6
		GR29	5,307	m²	%	2	106	5,201	1	%	2	106		6
		GR30	5,400	m²	%	2	108	5,292	1	%	2	108		6
		GR31	3,446	m²	%	2	69	3,377	1	%	2	69		4
		GR32	5,393	m²	%	2	108	5,285	1	%	2	108		6
		GR33	6,880	m²	%	2	138	6,742	1	%	2	138		8
		GR34	6,020	m²	%	2	120	5,900	1	%	2	120		7
		GR35	5,175	m²	%	2	104	5,072	1	%	2	104		6
		GR36	3,779	m²	%	2	76	3,703	1	%	2	76		5
		GR37	3,239	m²	%	2	65	3,174	1	%	2	65		4
		GR38	4,022	m²	%	2	80	3,942	1	%	2	80		5
		GR39		m²	%	2	0	0	1	%	2	0		0
		GR40		m²	%	2	0	0	1	%	2	0		0
		GR41		m²	%	2	0	0	1	%	2	0		0
		GR42		m²	%	2	0	0	1	%	2	0		0
			288,933				5,779	283,154				5,779		

Texture	General Code	Code	Area	unit	Maximum occupied Area			Open spaces	Max Story	Density		Max Useful Building Area	Total	Volume m³
		UF1	3,600	m²	%	70	2,520	1,080	6	%	400	14,400		45,360
		UF2	3,602	m²	%	70	2,521	1,081	6	%	400	14,408		31,770
		UF3	5,400	m²	%	70	3,780	1,620	6	%	400	21,600		47,628
		UF4	5,400	m²	%	70	3,780	1,620	6	%	400	21,600		47,628
		UF5	8,043	m²	%	70	5,630	2,413	6	%	400	32,172		70,939
Urban Facilities	**UF**	UF6	4,241	m²	%	70	2,969	1,272	6	%	400	16,964	163,236	37,406
		UF7	2,396	m²	%	70	1,677	719	6	%	400	9,584		21,133
		UF8	1,616	m²	%	70	1,131	485	3	%	200	3,232		7,127
		UF9	2,418	m²	%	70	1,693	725	6	%	400	9,672		21,327
		UF11	2,393	m²	%	70	1,675	718	6	%	400	9,572		21,106
		UF12	2,508	m²	%	70	1,756	752	6	%	400	10,032		22,121
			41,617				29,132	12,485				163,236		

New Design Dimentions (According to the Sheet Plan number 2-1 & 2-2

Texture	General Code	Code	Area	unit	Maximum occupied Area			Open spaces	Max Story	Density		Max Useful Building Area	Total	Volume m³
Educational	ED	ED1	53,675	m²	%	40	21,470	32,205	6	%	280	150,290	395,335	386,460
		ED2	2,879	m²	%	40	1,152	1,727	6	%	280	8,061		20,729
		ED3	2,802	m²	%	40	1,121	1,681	6	%	280	7,846		20,174
		ED4	8,443	m²	%	40	3,377	5,066	6	%	280	23,640		60,790
		ED5	9,996	m²	%	40	3,998	5,998	6	%	280	27,989		71,971
		ED6	17,354	m²	%	40	6,942	10,412	6	%	280	48,591		124,949
		ED7	9,360	m²	%	40	3,744	5,616	6	%	280	26,208		67,392
		ED8	5,967	m²	%	40	2,387	3,580	6	%	280	16,708		42,962
		ED9	1,794	m²	%	40	718	1,076	6	%	280	5,023		12,917
		ED10	4,805	m²	%	40	1,922	2,883	6	%	280	13,454		34,596
		ED11	2,700	m²	%	40	1,080	1,620	6	%	280	7,560		7,776
		ED12	2,396	m²	%	40	958	1,438	6	%	280	6,709		
		ED13	11,200	m²	%	40	4,480	6,720	6	%	280	31,360		
		ED14	2,420	m²	%	40	968	1,452	6	%	280	6,776		
		ED15	1,800	m²	%	40	720	1,080	6	%	280	5,040		
		ED16	1,800	m²	%	40	720	1,080	6	%	280	5,040		
		ED17	1,800	m²	%	40	720	1,080	6	%	280	5,040		
			141,191				56,476	84,715				395,335		

Texture	General Code	Code	Area	unit	Maximum occupied Area			Open spaces	Max Story	Density		Max Useful Building Area	Total	Volume m³
Sport	SP	SP1	10,035	m²	%	85	8,530	1,505	6	%	480	48,168	92,528	153,536
		SP2	4,059	m²	%	70	2,841	1,218	3	%	250	10,148		25,572
		SP3	1,800	m²	%	90	1,620	180	1	%	90	1,620		4,860
														0
		SP5	1,790	m²	%	90	1,611	179	1	%	90	1,611		4,833
		SP6	2,404	m²	%	90	2,164	240	1	%	90	2,164		6,491
		SP7	2,313	m²	%	90	2,082	231	1	%	90	2,082		6,245
		SP8	5,129	m²	%	85	4,360	769	6	%	480	24,619		78,474
		SP9	2,352	m²	%	90	2,117	235	1	%	90	2,117		6,350
			29,882				25,324	4,558				92,528		

Texture	General Code	Code	Area	unit	Maximum occupied Area			Open spaces	Max Story	Density		Max Useful Building Area	Total	Volume m³
Clinics and health Centers	CH	CH1	7,830	m²	%	80	6,264	1,566	6	%	280	21,924	33,684	112,752
		CH3	4,200	m²	%	50	2,100	2,100	6	%	280	11,760		#REF!
			12,030				8,364	3,666				33,684		

Texture	General Code	Code	Area	unit	Maximum occupied Area			Open spaces	Max Story	Density		Max Useful Building Area	Total	Volume m³
Cultural Activities	CA	CA1	10,035	m²	%	50	5,018	5,018	6	%	300	30,105	42,705	
		CA2	4,200	m²	%	50	2,100	2,100	6	%	300	12,600		
								0						
								0				0		
			14,235				7,118	7,118						

Texture	General Code	Code	Area	unit	Maximum occupied Area			Open spaces	Max Story	Density		Max Useful Building Area	Total	Volume m³
Relegion	RE	RE1	6,928	m²	%	50	3,464	3,464	5	%	280	19,398	19,398	51,960
								0						
								0						
								0						
			6,928				3,464	3,464				19,398		

General Code	Code	Area	unit	unit	Maximum occupied Area			Open spaces		Density		Max Useful Parking Area	Total	
Parking	Pa	Pa1	12,354	m²	%	95	11,736	618	0	%	95	11,736	35,027	0
		Pa2	19,717	m²	%	95	18,731	986	0	%	95	18,731		
		Pa3	2,400	m²	%	95	2,280	120	0	%	95	2,280		
		Pa4	2,400	m²	%	95	2,280	120	0	%	95	2,280		
			36,871				35,027	1,844				35,027		

Comparison Results

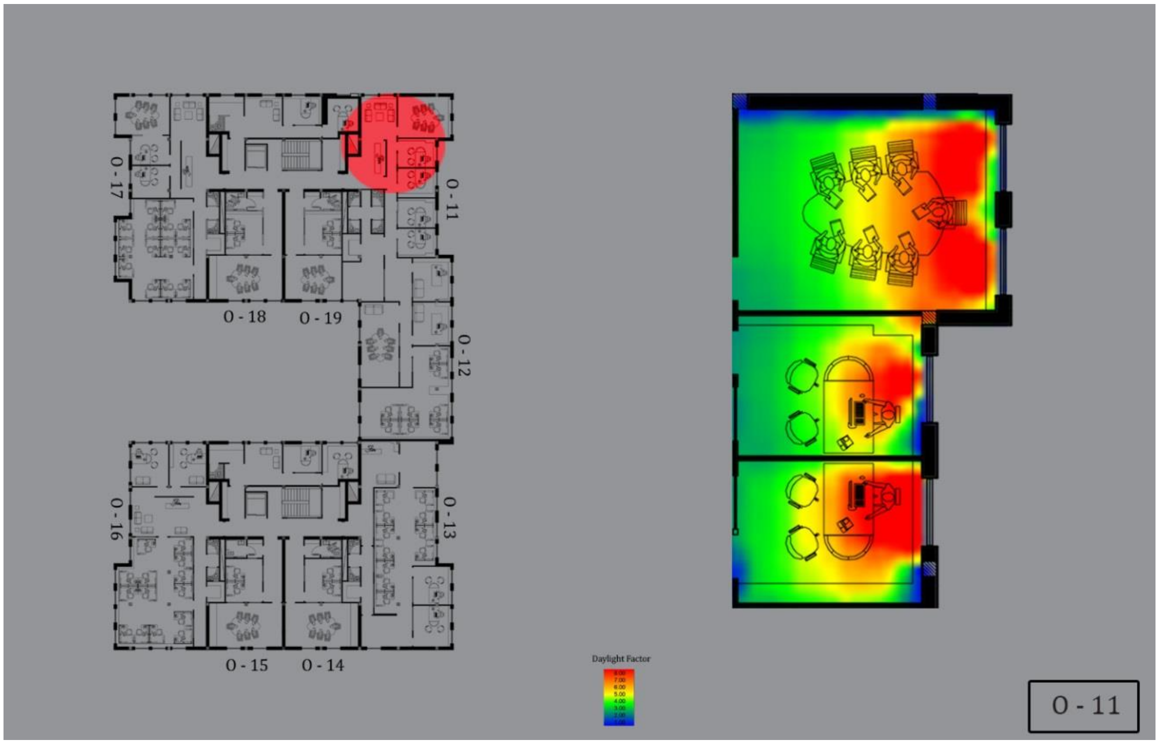
Curent Situation	Residential	Useful Residential Area	3,017,889		302	Hectar		**605,676**	**20.07**	%
		Privet Yards	670,642		67	Hectar				
New Design Modification	Residential	Useful Residential Area	3,623,565		362	Hectar				
		Privet Yards	443,824		44	Hectar				
Curent Situation	Green Open Spaces	Green Area	190,493		19	Hectar		**92,661**	**49**	%
		Facilities	5,715			Hectar				
New Design Modification	Green Open Spaces	Green Area	283,154		28	Hectar				
		Facilities	8,495		1	Hectar				
Curent Situation	commercial	Useful Area	90,787		9	Hectar		**43,639**	**48**	%
		Open Spaces	16,212			Hectar				
New Design Modification	commercial	Useful Area	134,426		13	Hectar				
		Open Spaces			0	Hectar				
Curent Situation	Educational	Useful Area	354,504		35	Hectar		**40,831**	**12**	%
		Open Spaces	22,775		2	Hectar				
New Design Modification	Educational	Useful Area	395,335		40	Hectar				
		Open Spaces	11,871		1	Hectar				
Curent Situation	Sporting Area	Useful Area	51,923		5	Hectar		**40,605**	**78**	%
		Facilities + Open Spces	3,709			Hectar				
New Design Modification	Sporting Area	Useful Area	92,528		9	Hectar				
		Facilities + Open Spces	528		0	Hectar				
Curent Situation	Urban Facilities	Useful Area	0		0	Hectar		**163,236**		%
		Other Area	11,415			Hectar				
New Design Modification	Urban Facilities	Useful Area	163,236		16	Hectar				
		Other Area			0	Hectar				
Curent Situation	Clinics and Health Centers	Useful Area	23,344		2	Hectar		**10,340**	44	%
		Opan spaces	1,667			Hectar				
New Design Modification	Clinics and Health Centers	Useful Area	33,684		3	Hectar				
		Opan spaces			0	Hectar				
Curent Situation	Cultural / Relegion	Useful Area	13,856		1	Hectar		**48,247**	348	%
		Open spaces	1,386			Hectar				
New Design Modification	Cultural / Relegion	Useful Area	62,103		6	Hectar				
		Open spaces	1,386		0	Hectar				
Curent Situation	Parking Area		17,420		2	Hectar		**17,607**	101	%
						Hectar				
New Design Modification	Parking Area		35,027		4	Hectar				
					0	Hectar				

Estimate Population (Current Situation)

Useful Residential Area	Average Family Size	Average Appartment Size	Standard Living Area /Person		Estimated Population (Person)
3,017,889	4.0	110	27.50	m²	109,741

Estimate Population (Design)

Useful Residential Area	Average Family Size	Average Appartment Size	Standard Living Area /Person		Estimated Population (Person)
3,623,565	4.0	110	27.50	m²	131,766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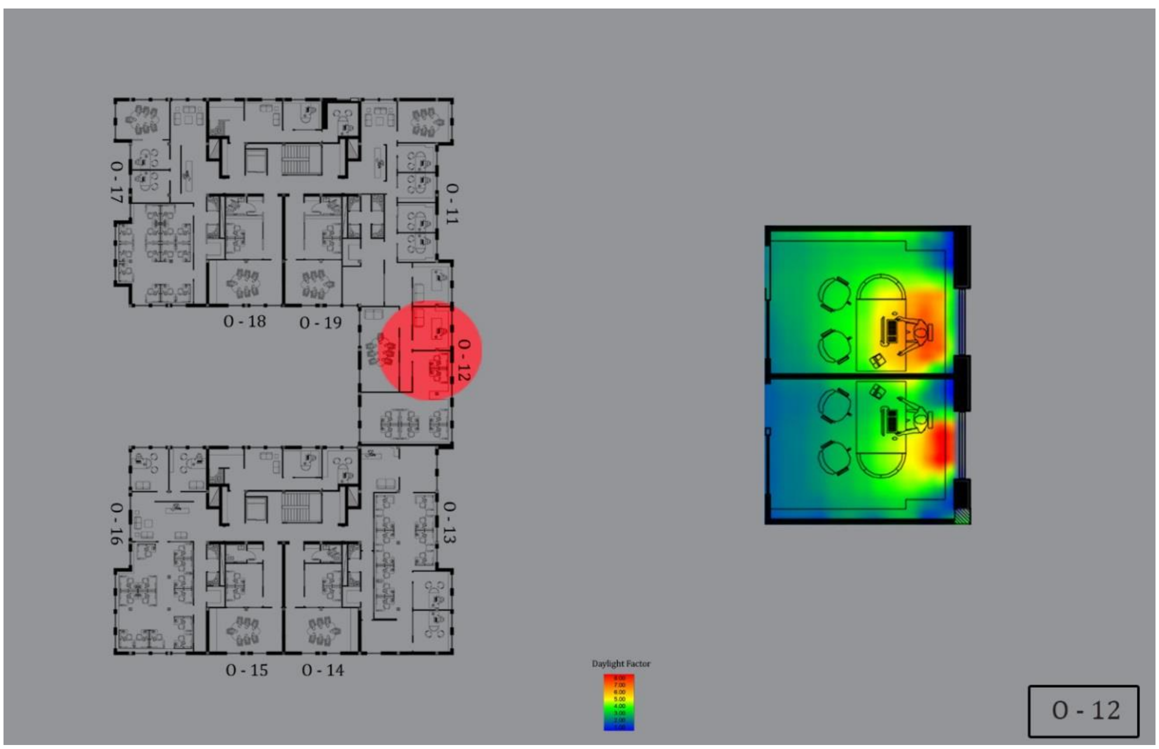
O - 16
O - 13
O - 15
O - 14
Daylight Factor
O - 11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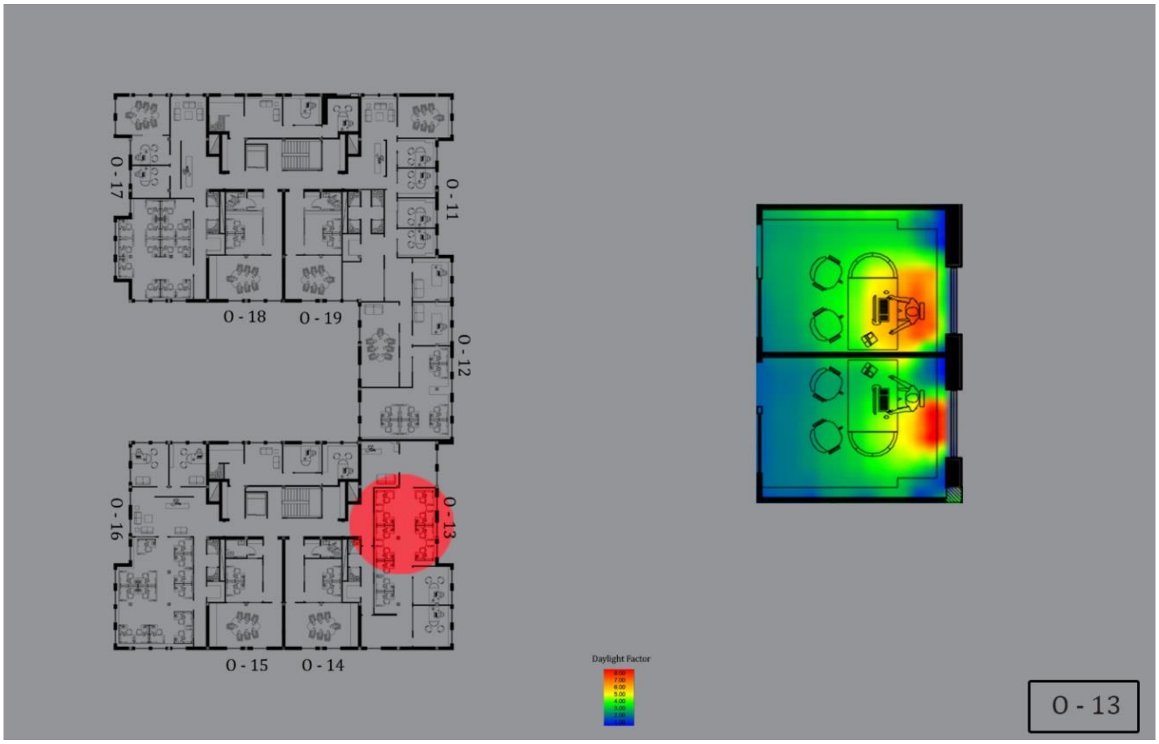
Daylight Factor
O - 12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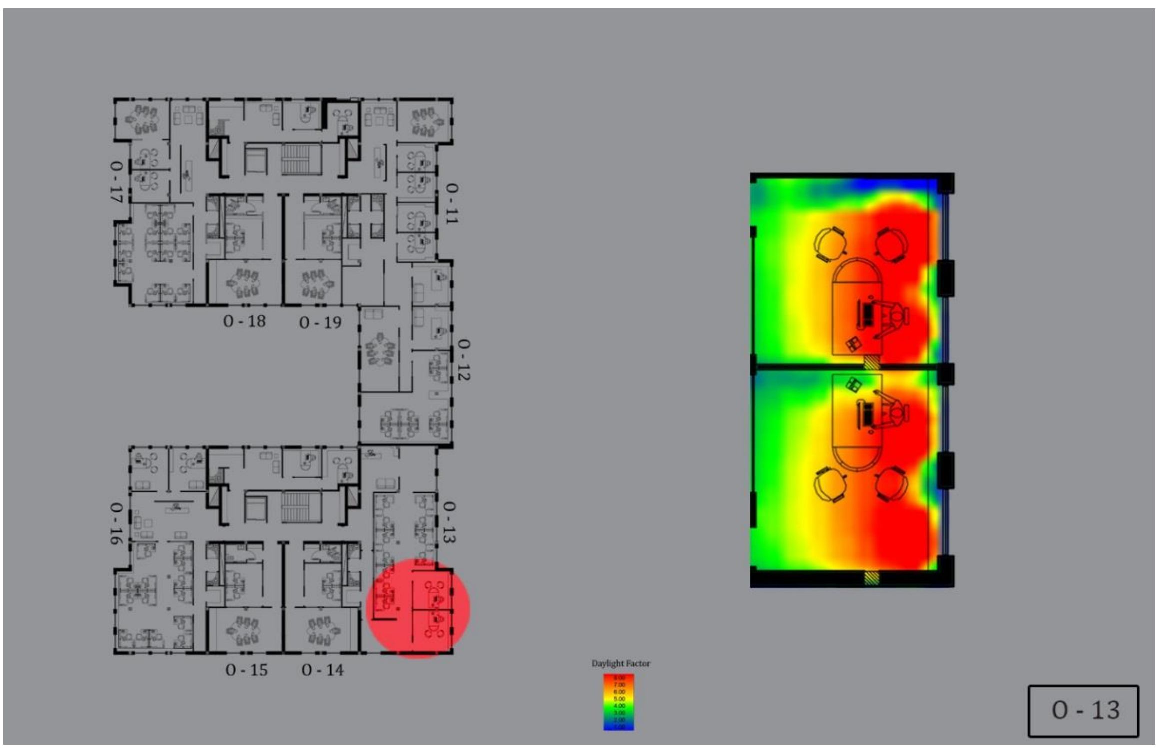
Daylight Factor
O - 13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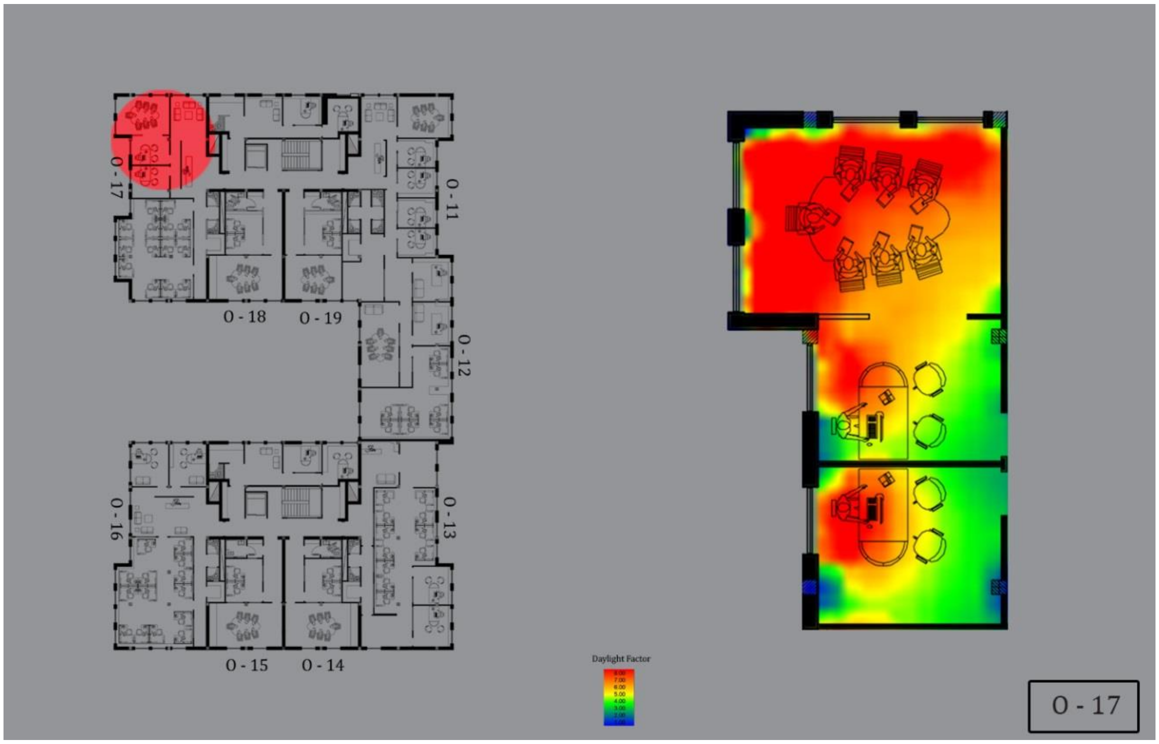
O - 14
Daylight Factor
O - 13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5.00
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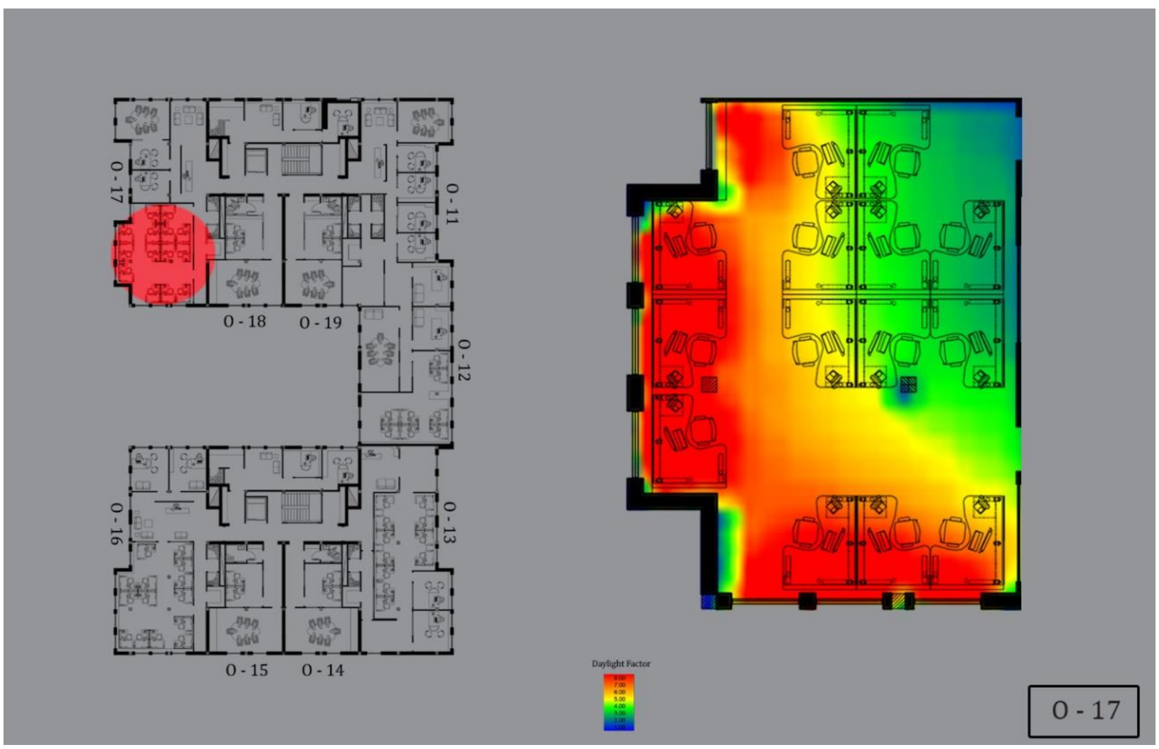
O - 17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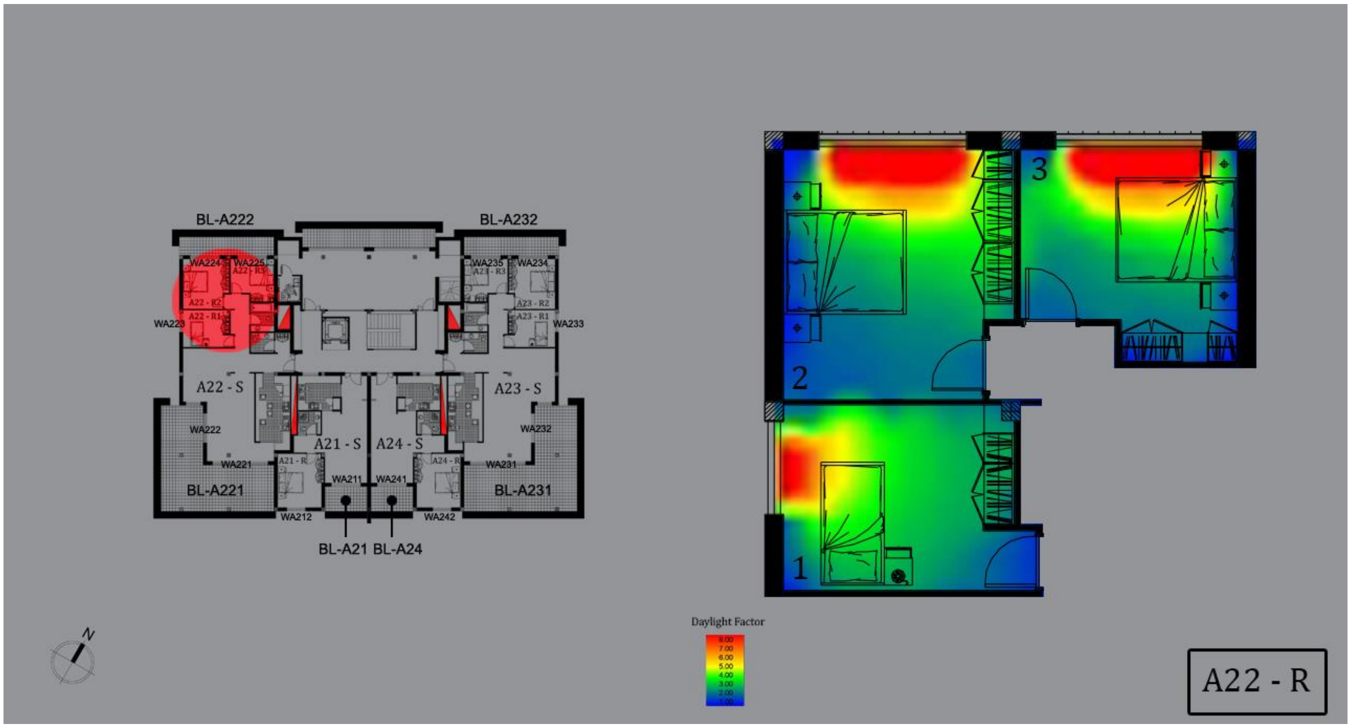
O - 13
O - 15
O - 14
Daylight Factor
O - 17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Daylight Factor
1
2
3
A22 - R


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Daylight Factor
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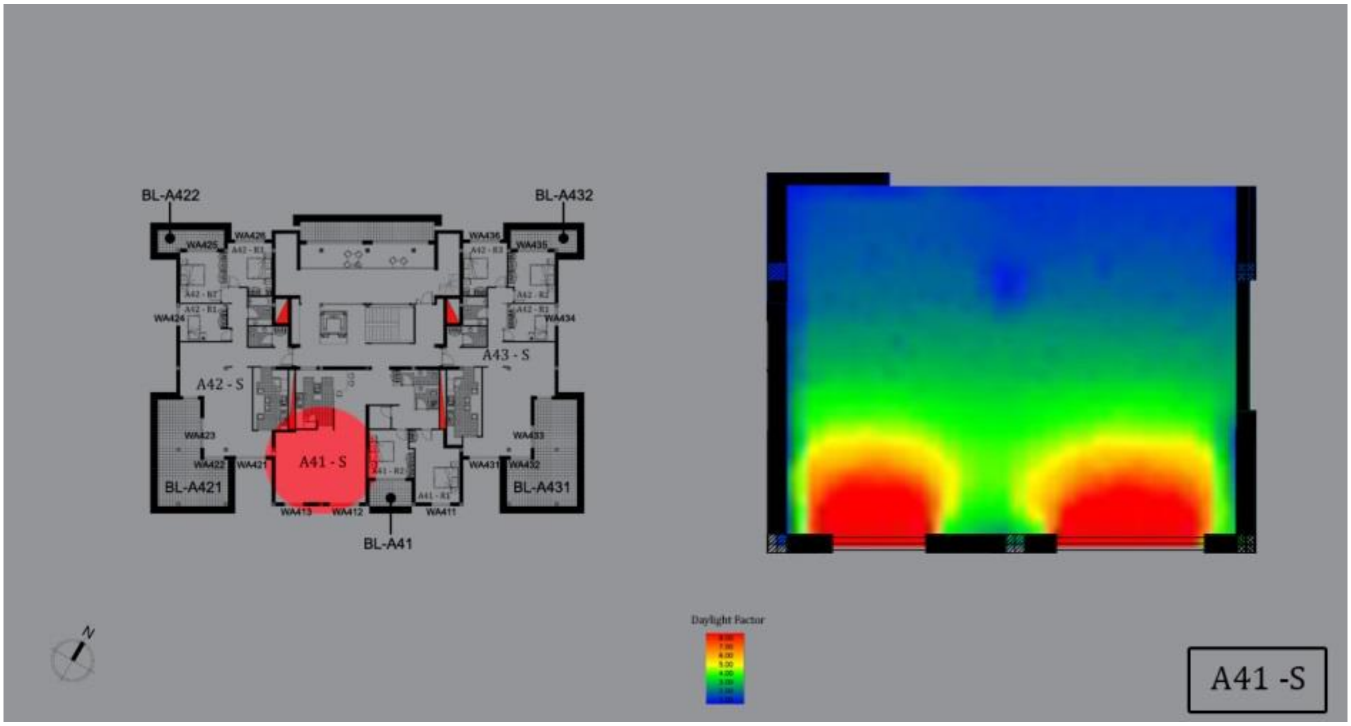
2
3
A33 - R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BL-A432
A42 - S
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A41 - S
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BL-A431
BL-A41
1
2
3
Daylight Factor
A42 - R


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Daylight Factor
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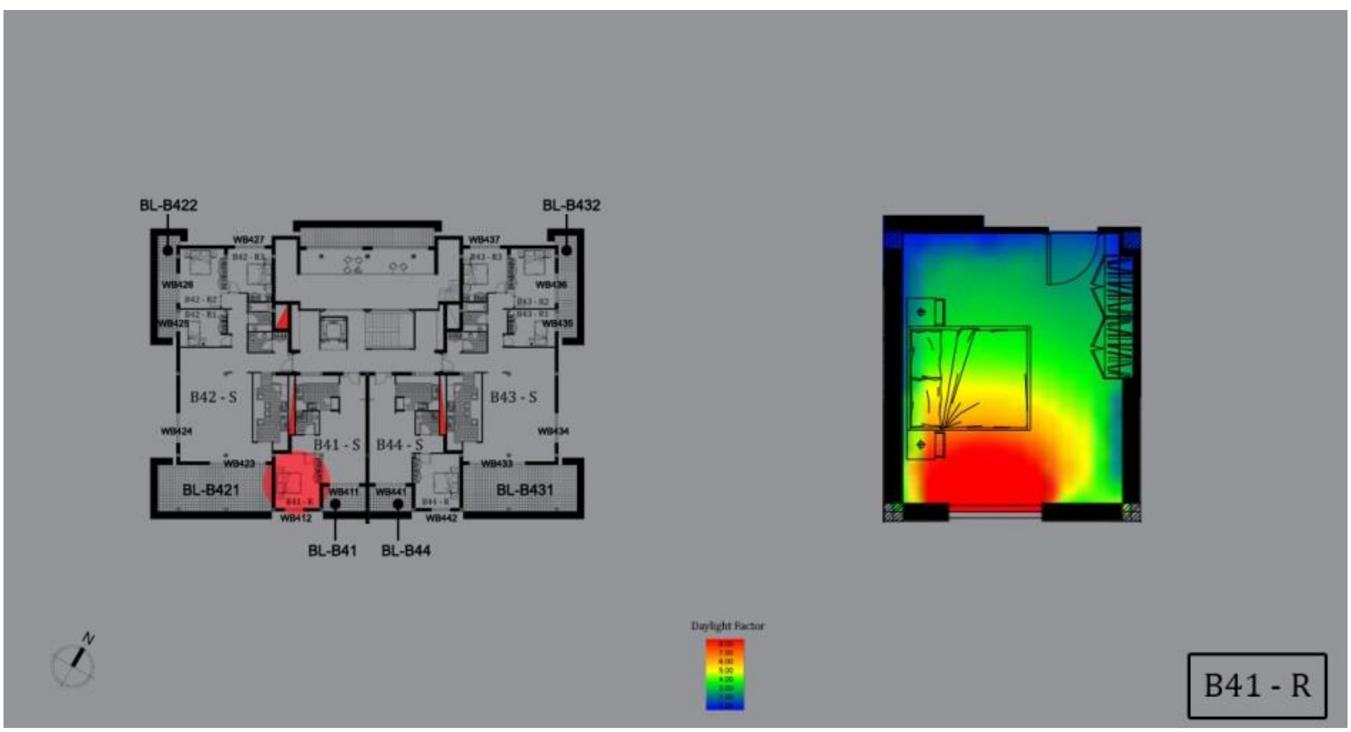
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WB424
WB434
B41 - S
B44 - S
WB423
WB433
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WB442
BL-B41
BL-B44
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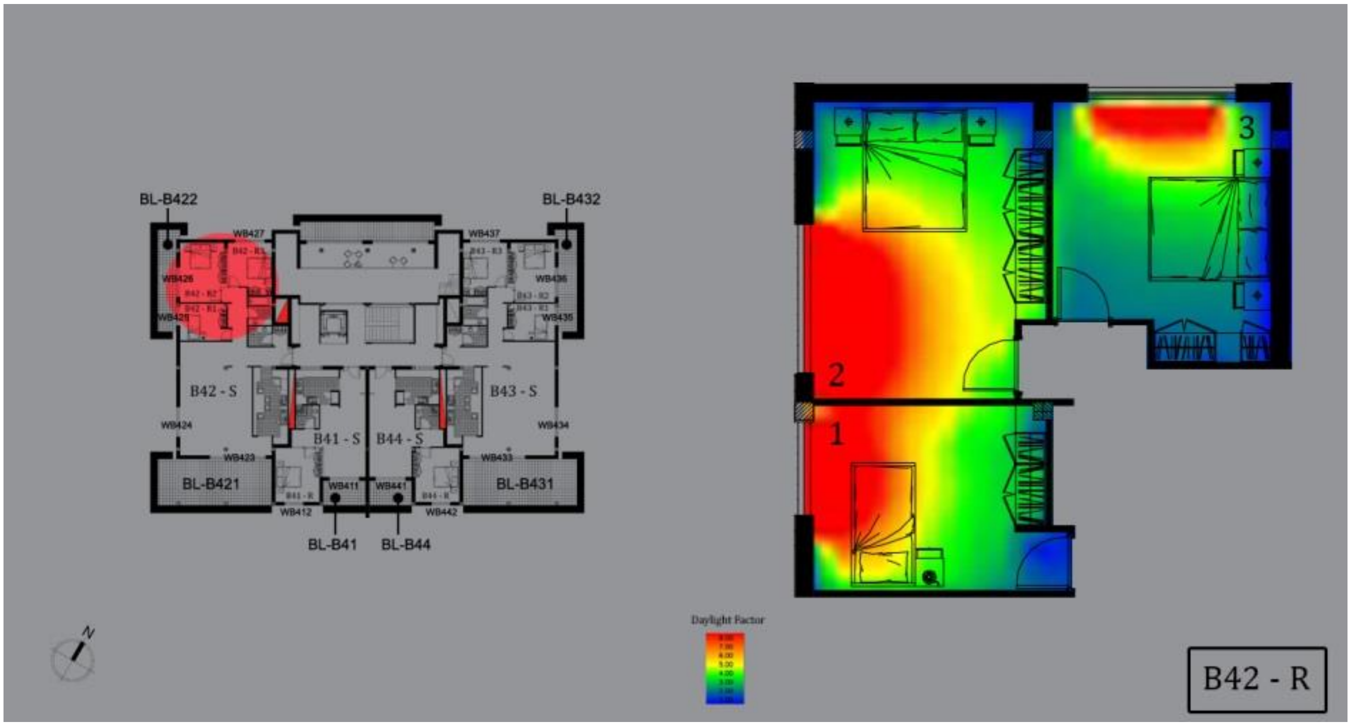
Daylight Factor
B41 - R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3
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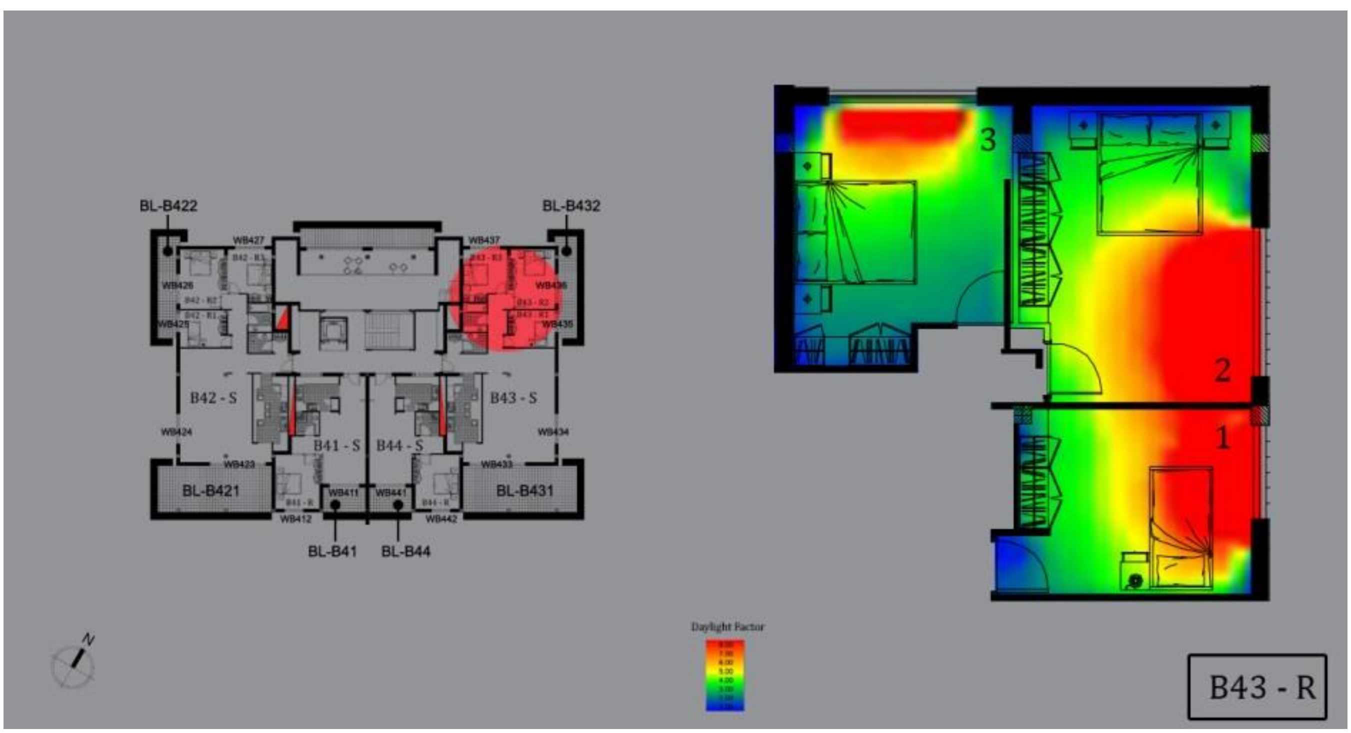
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Daylight Factor
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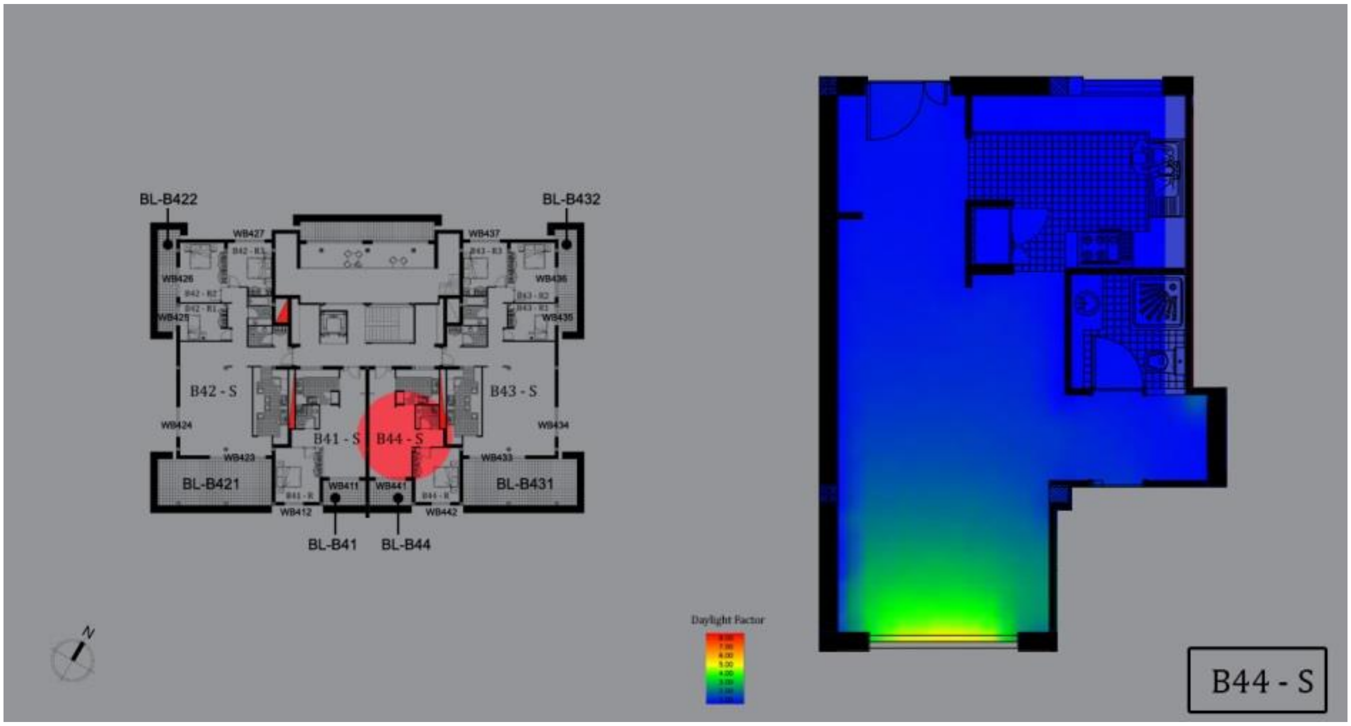
2
1
B43 - R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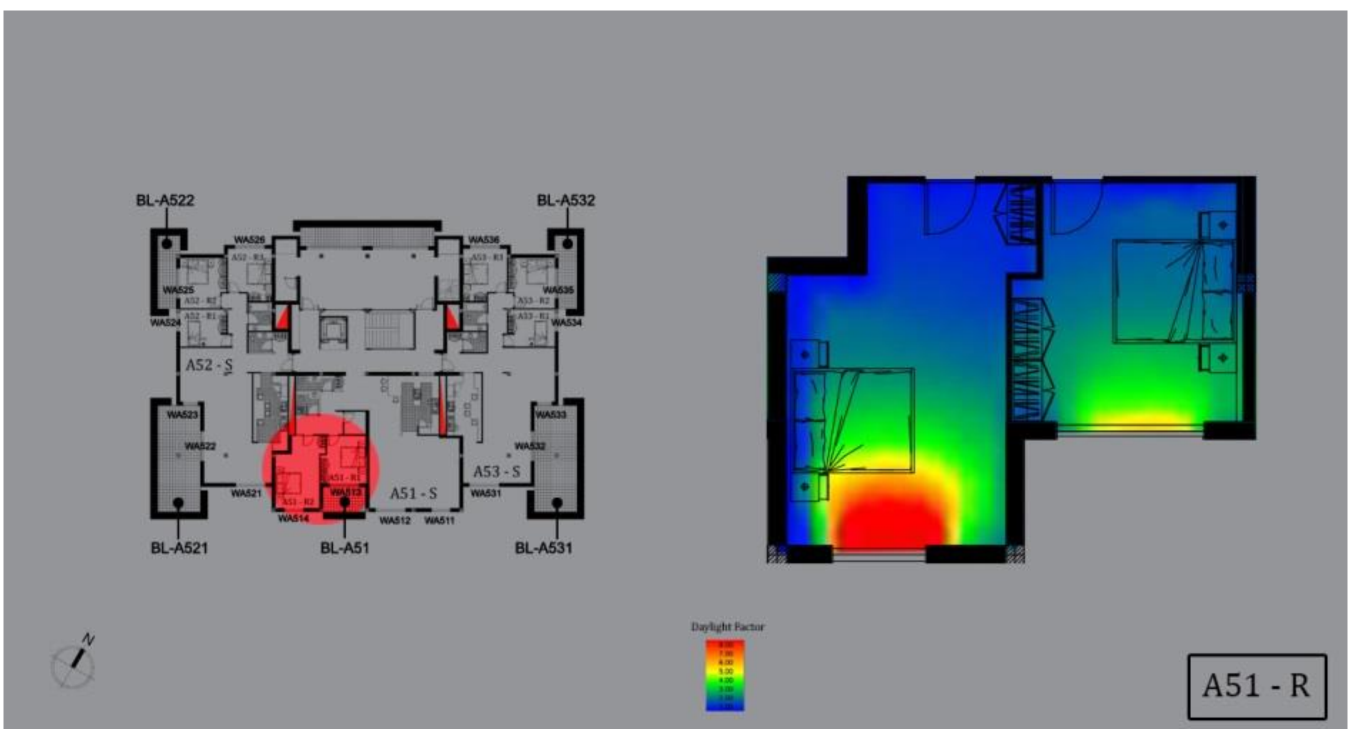
Daylight Factor
B44 - S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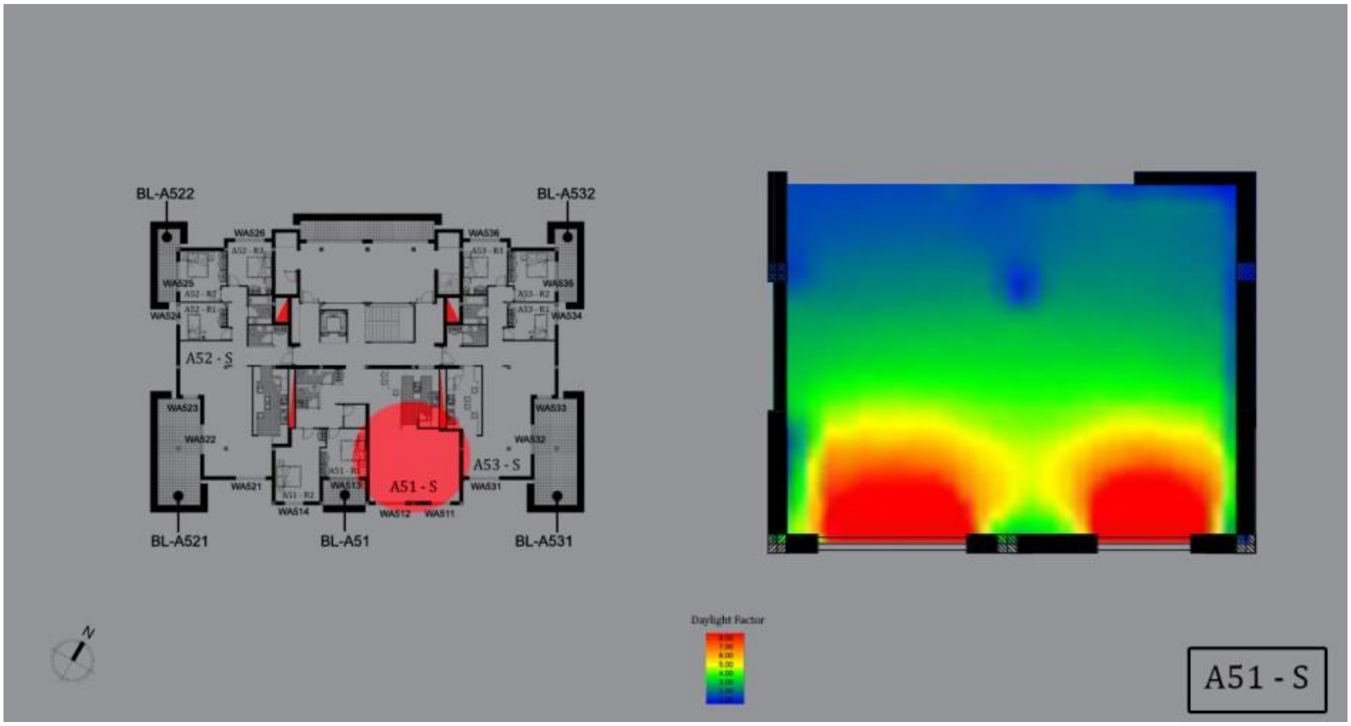
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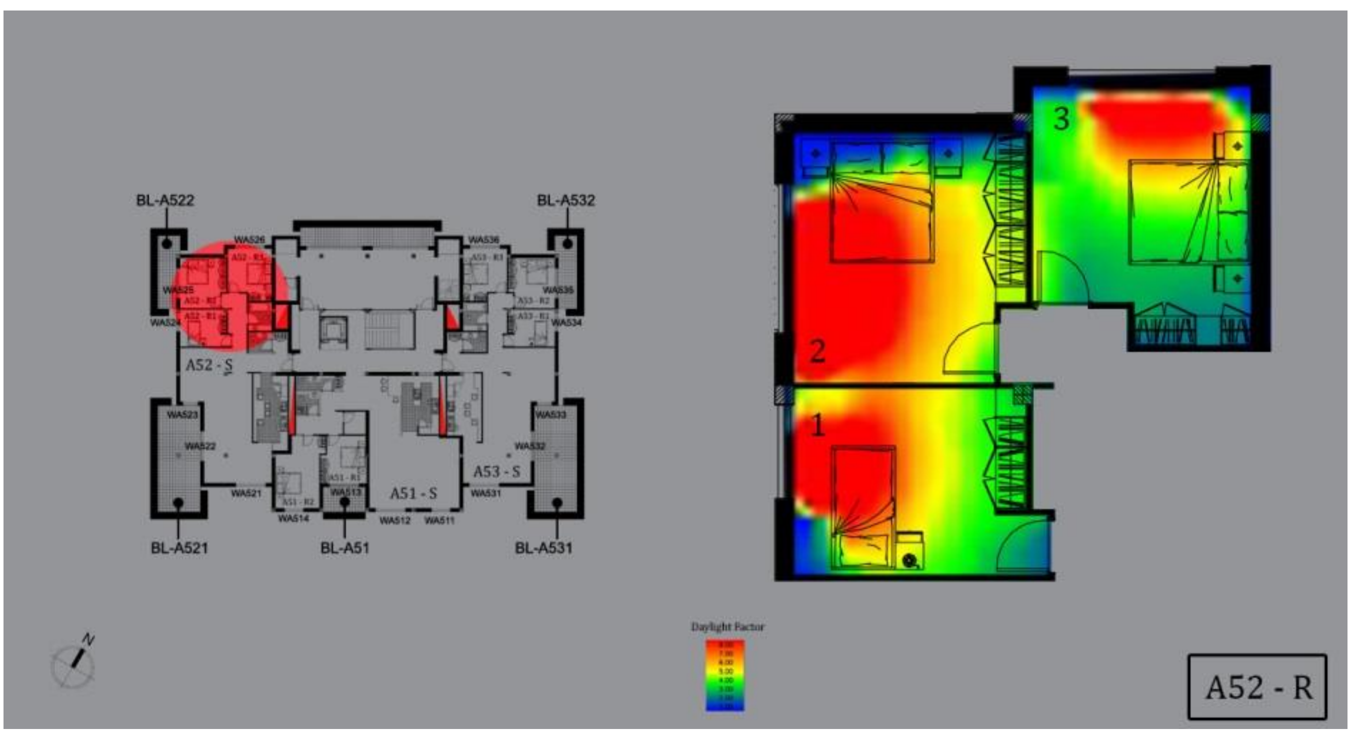
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Daylight Factor
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WA525
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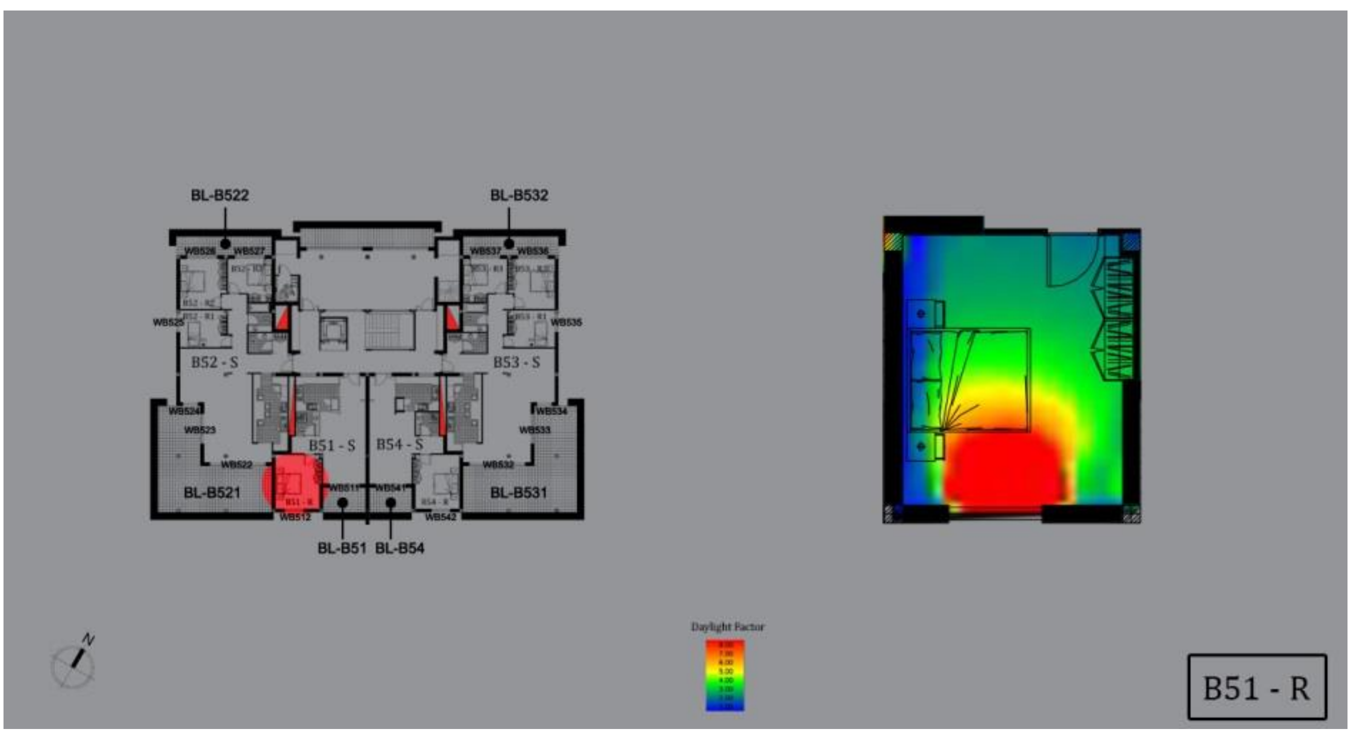
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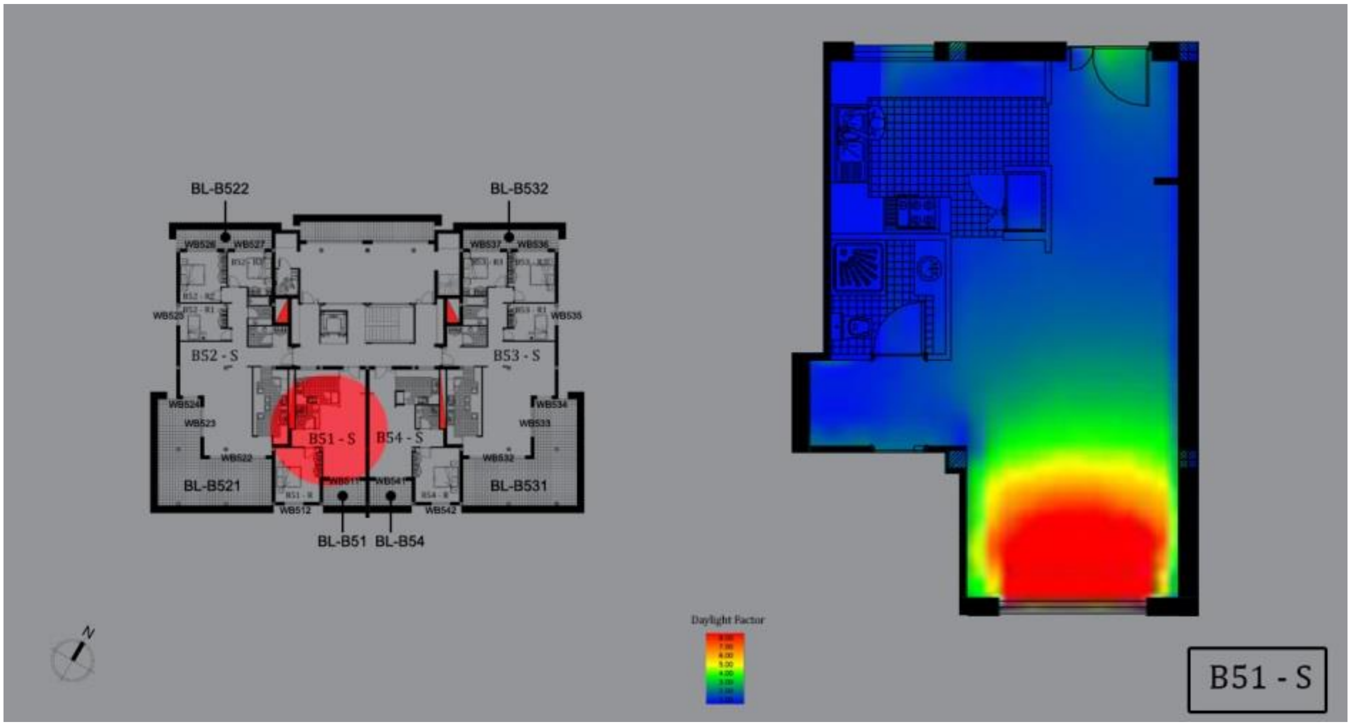
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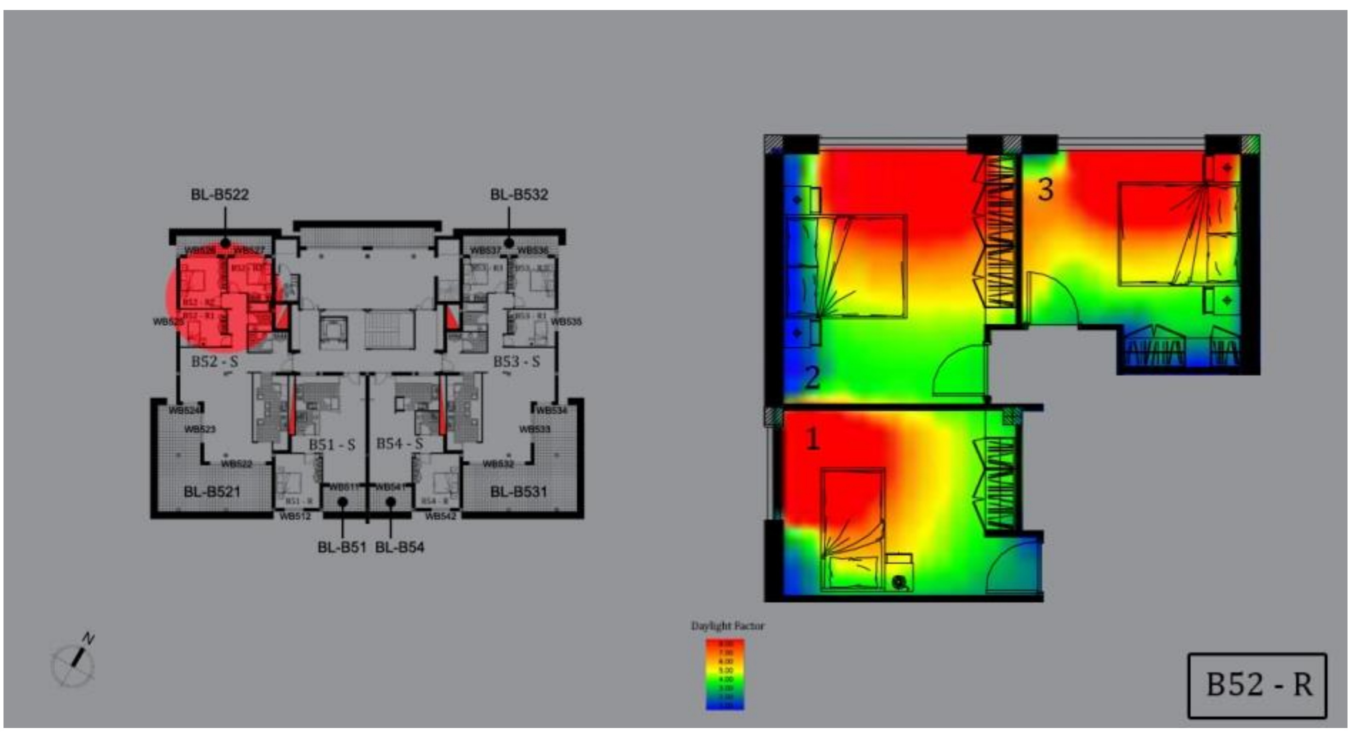
Daylight Factor
B51 - S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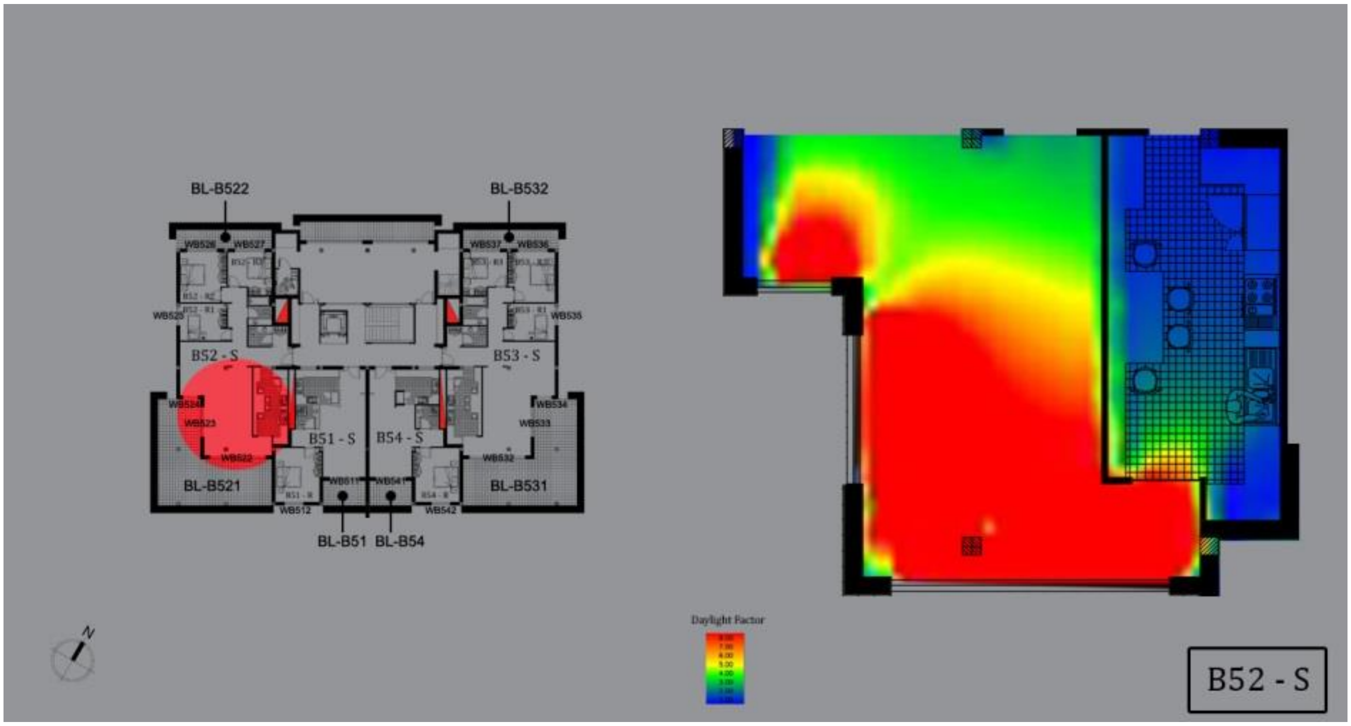
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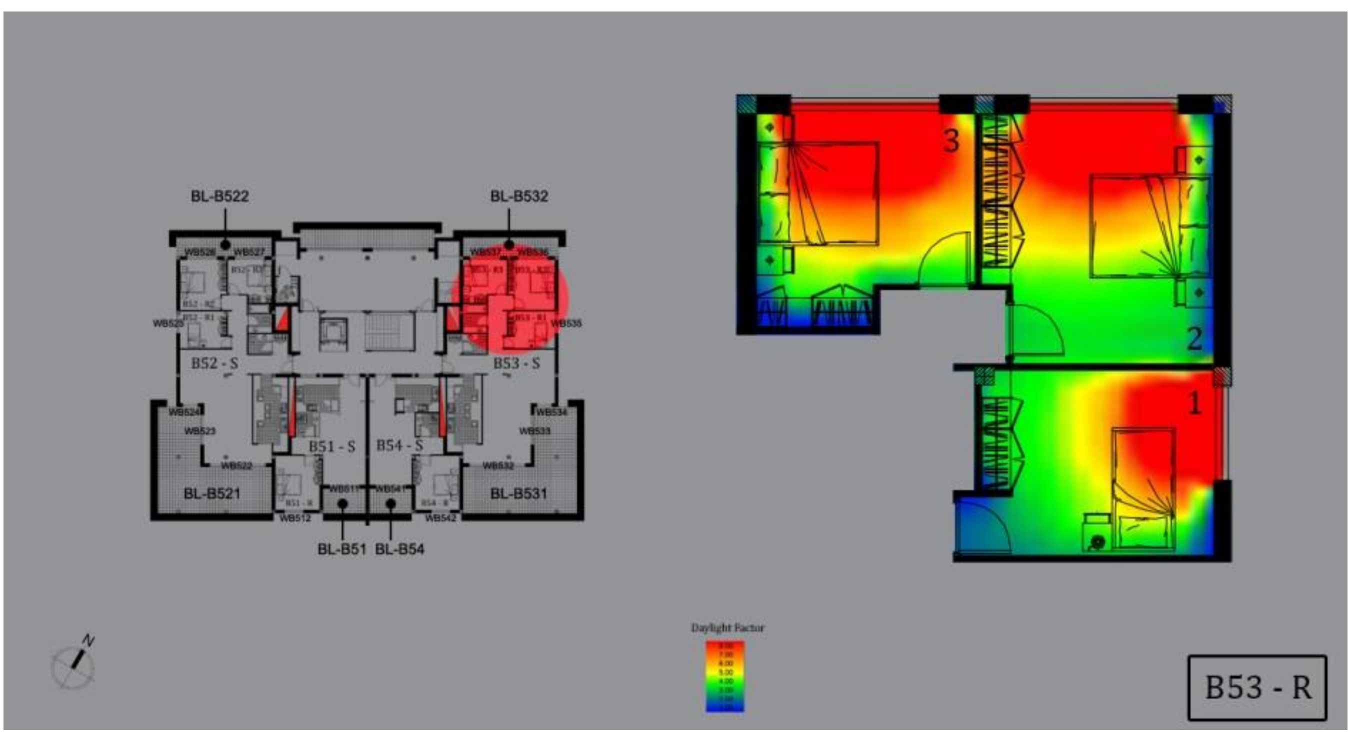
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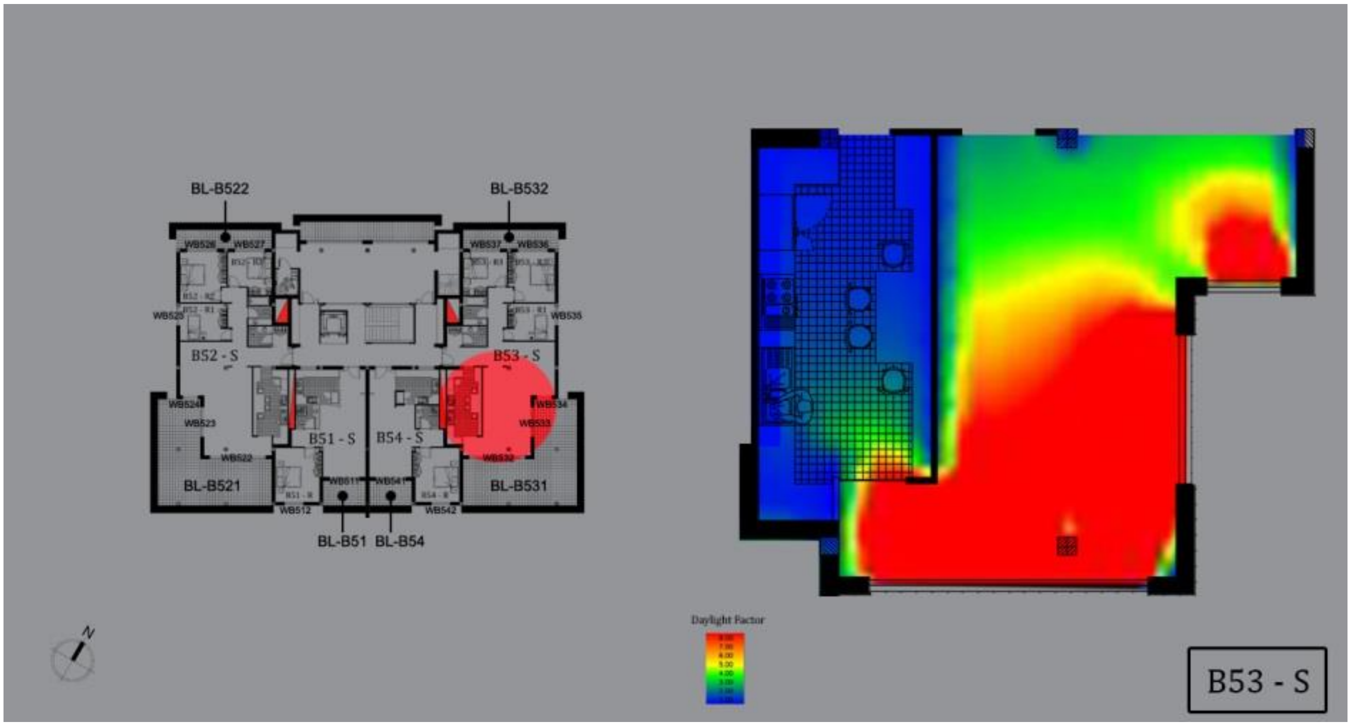

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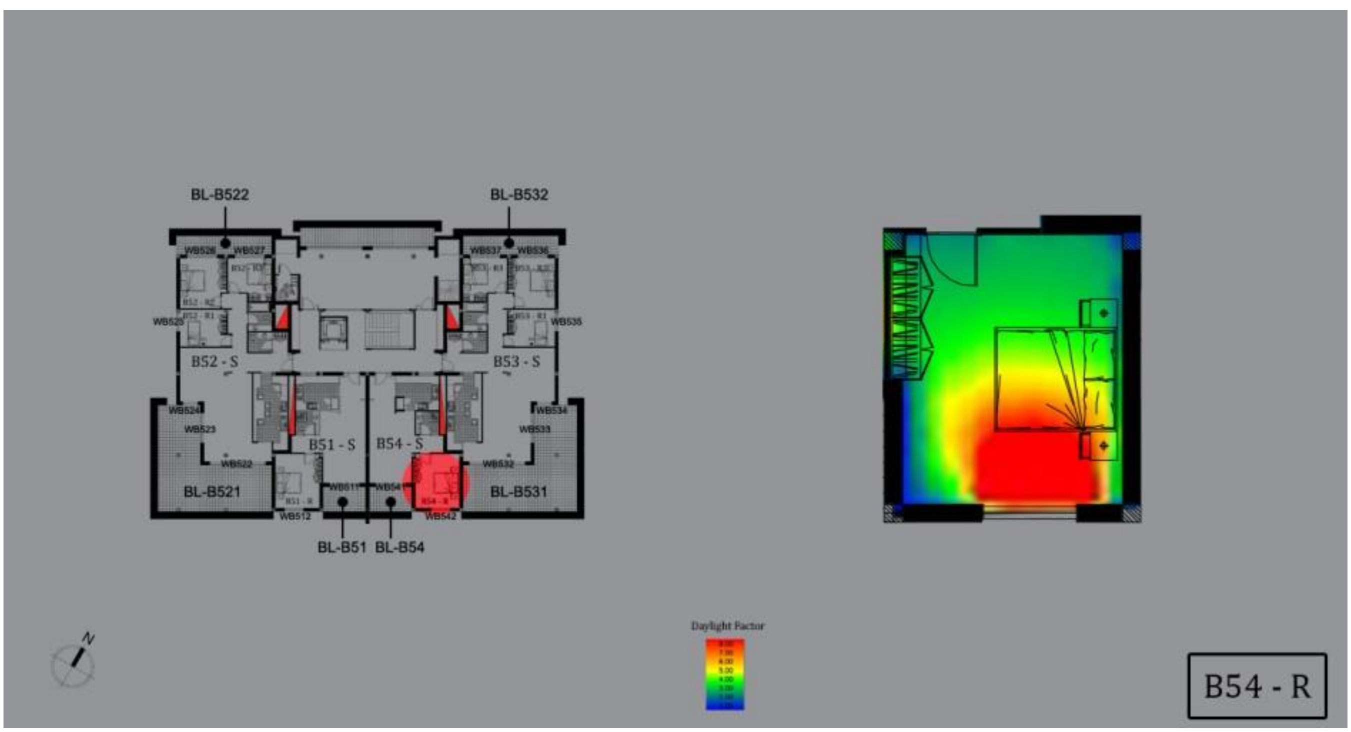
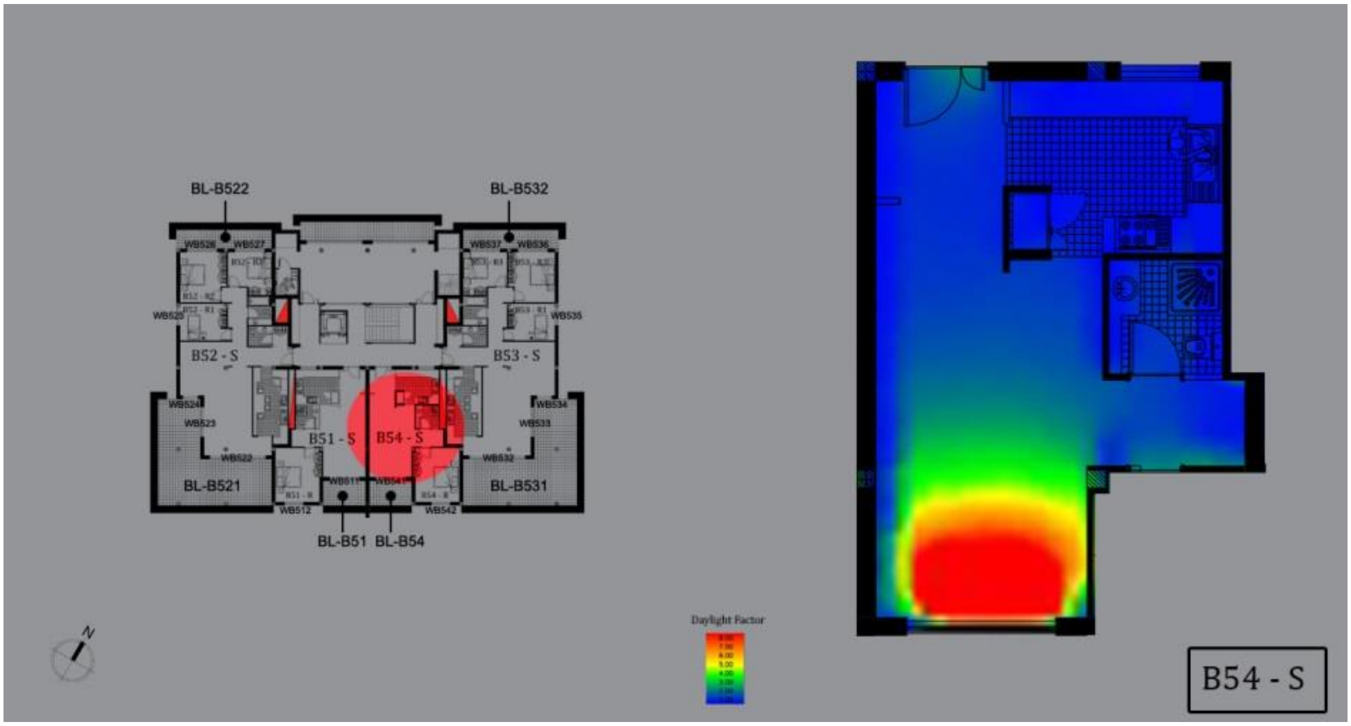
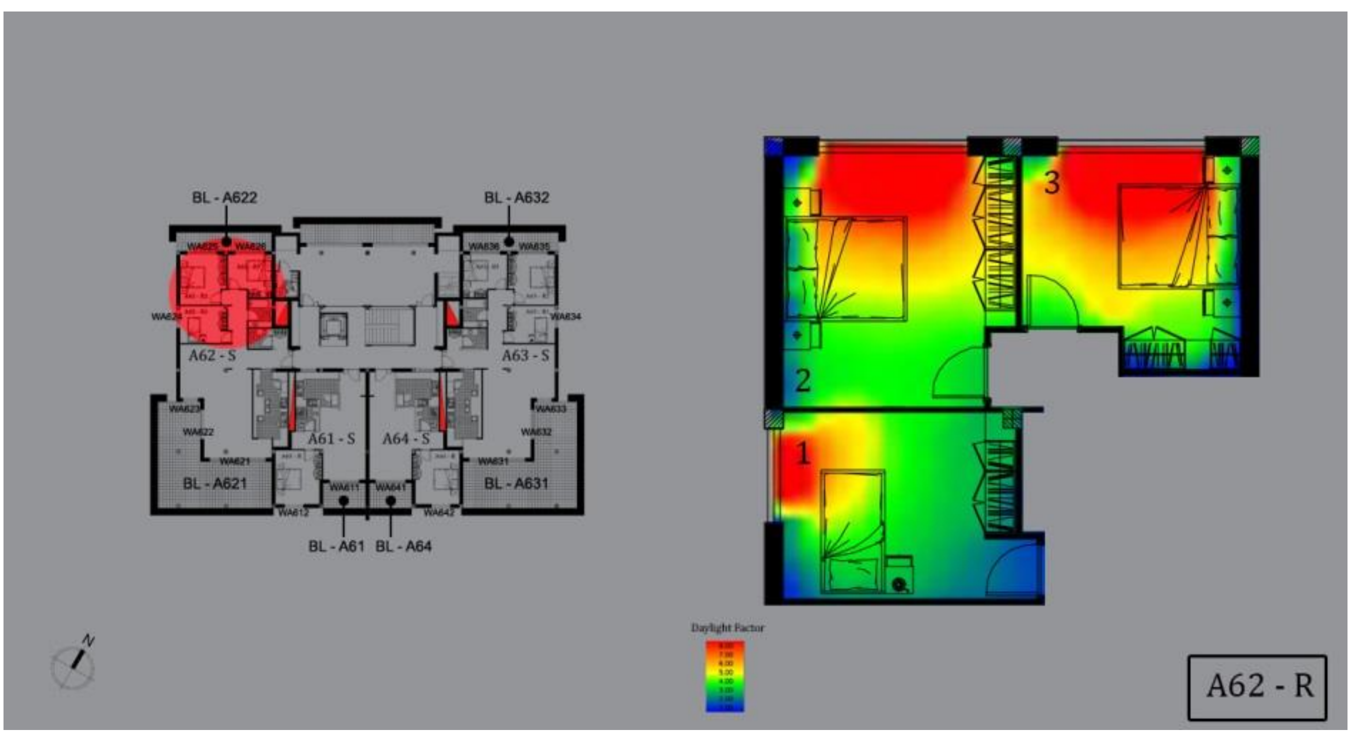
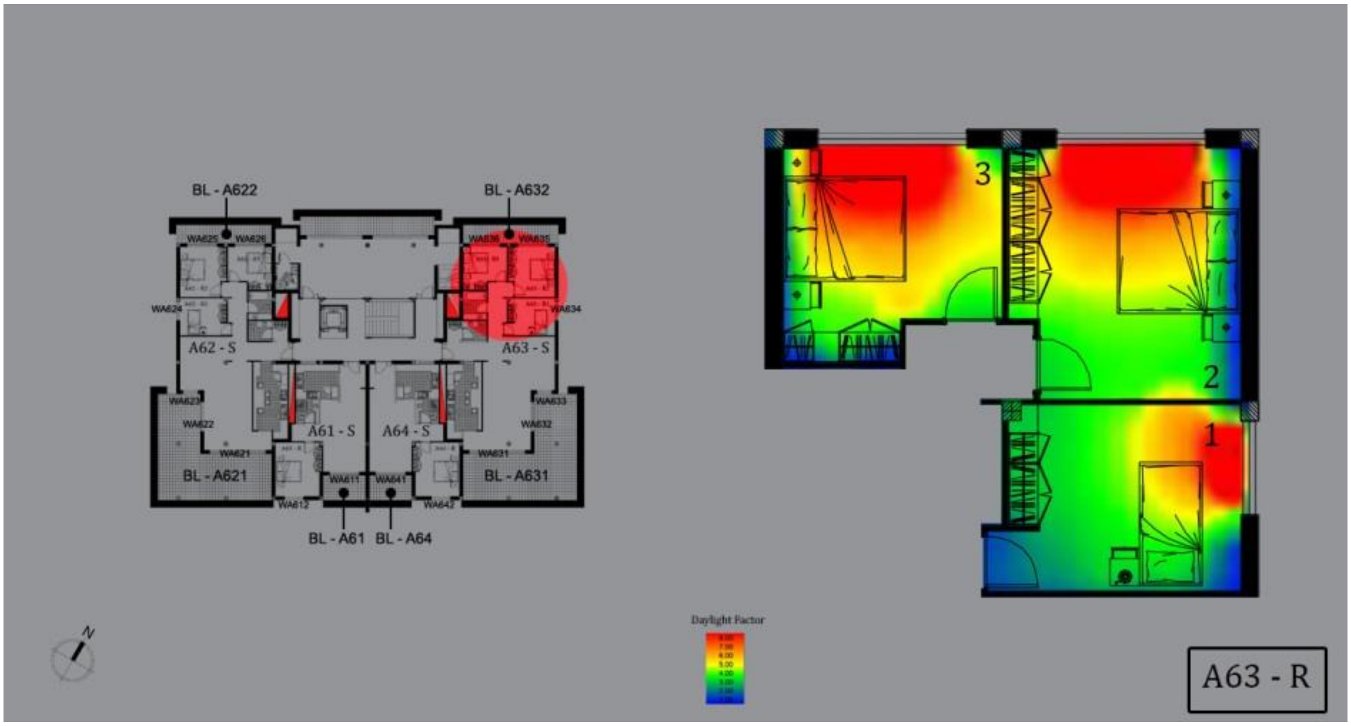
Daylight Factor
B53 - S



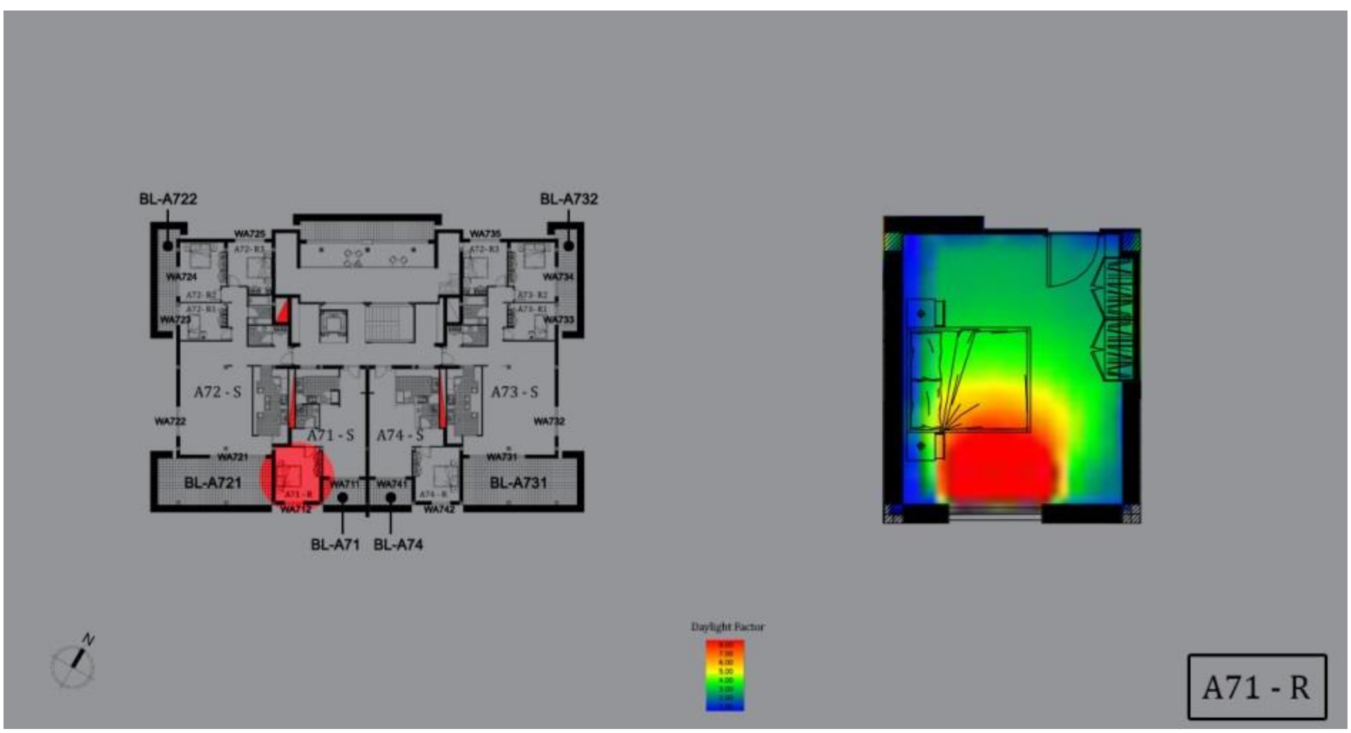
BL-B522
BL-B532
B52 - S
B53 - S
B51 - S
B54 - S
BL-B521
BL-B531
BL-B51
BL-B54
N
Daylight Factor
B54 - R


BL-B522
BL-B532
WB526
WB527
WB537
WB536
WB525
WB535
B52 - S
B53 - S
WB524
WB523
WB522
WB534
WB533
WB532
B51 - S
B54 - S
BL-B521
BL-B531
WB511
WB541
WB512
WB542
BL-B51
BL-B54
N
Daylight Factor
B54 - S

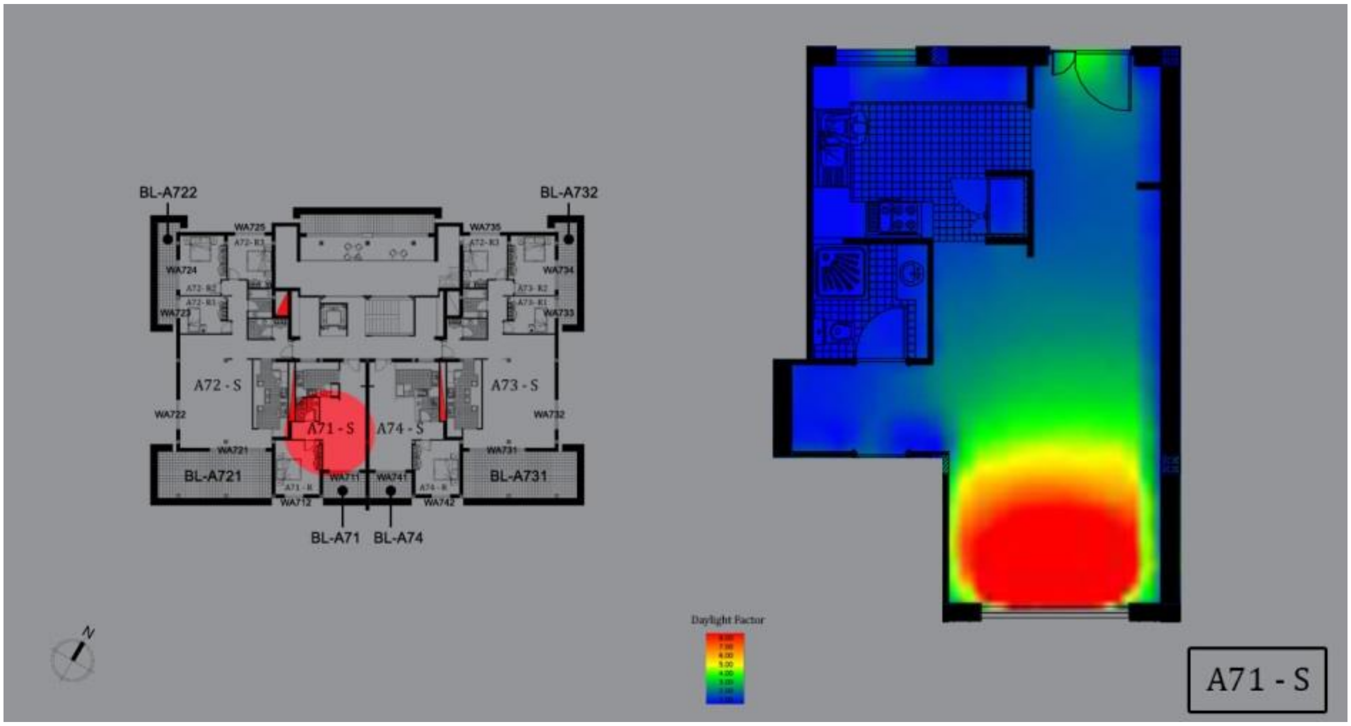

BL - A622
BL - A632
WA625
WA626
WA636
WA635
WA624
WA634
A62 - S
A63 - S
WA623
WA622
WA621
WA633
WA632
WA631
A61 - S
A64 - S
BL - A621
BL - A631
WA611
WA641
WA612
WA642
BL - A61
BL - A64
N
Daylight Factor
1
2
3
A62 - R

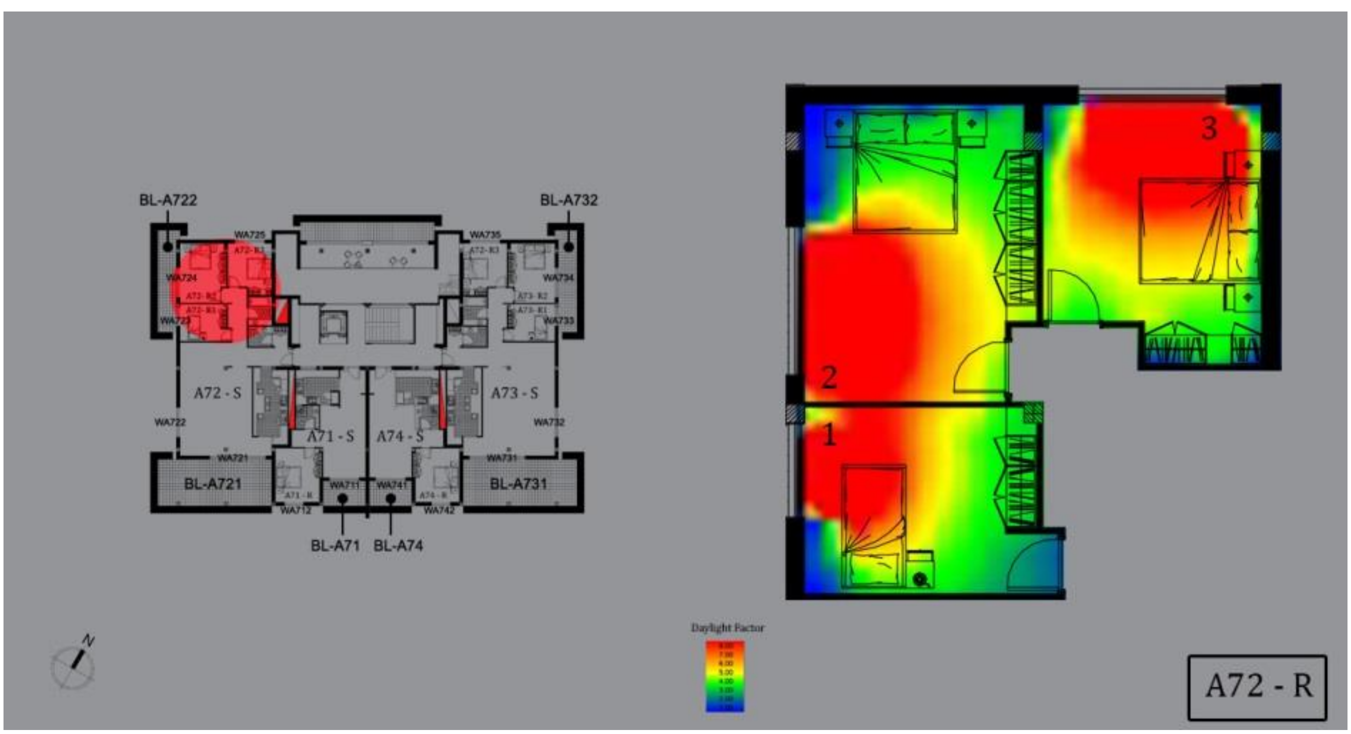


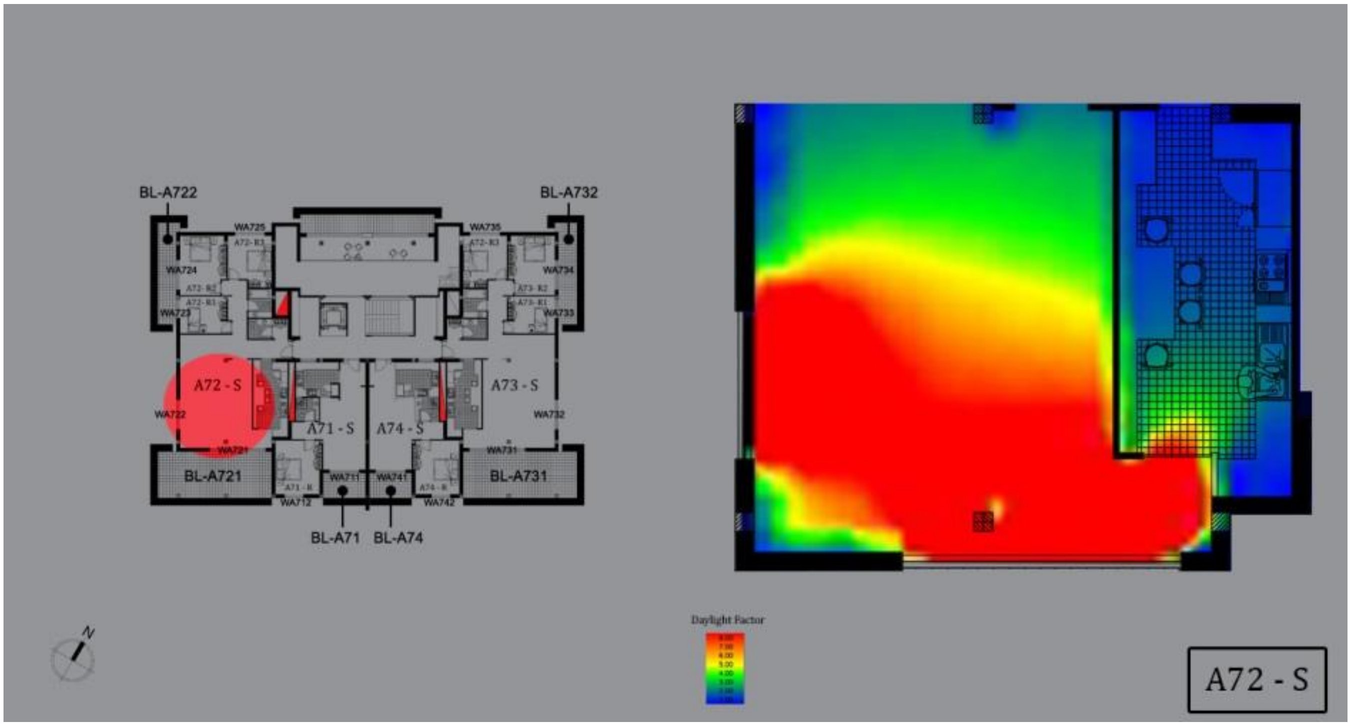
BL - A622
BL - A632
A62 - S
A63 - S
A61 - S
A64 - S
BL - A621
BL - A631
BL - A61
BL - A64
3
2
1
Daylight Factor
A63 - R

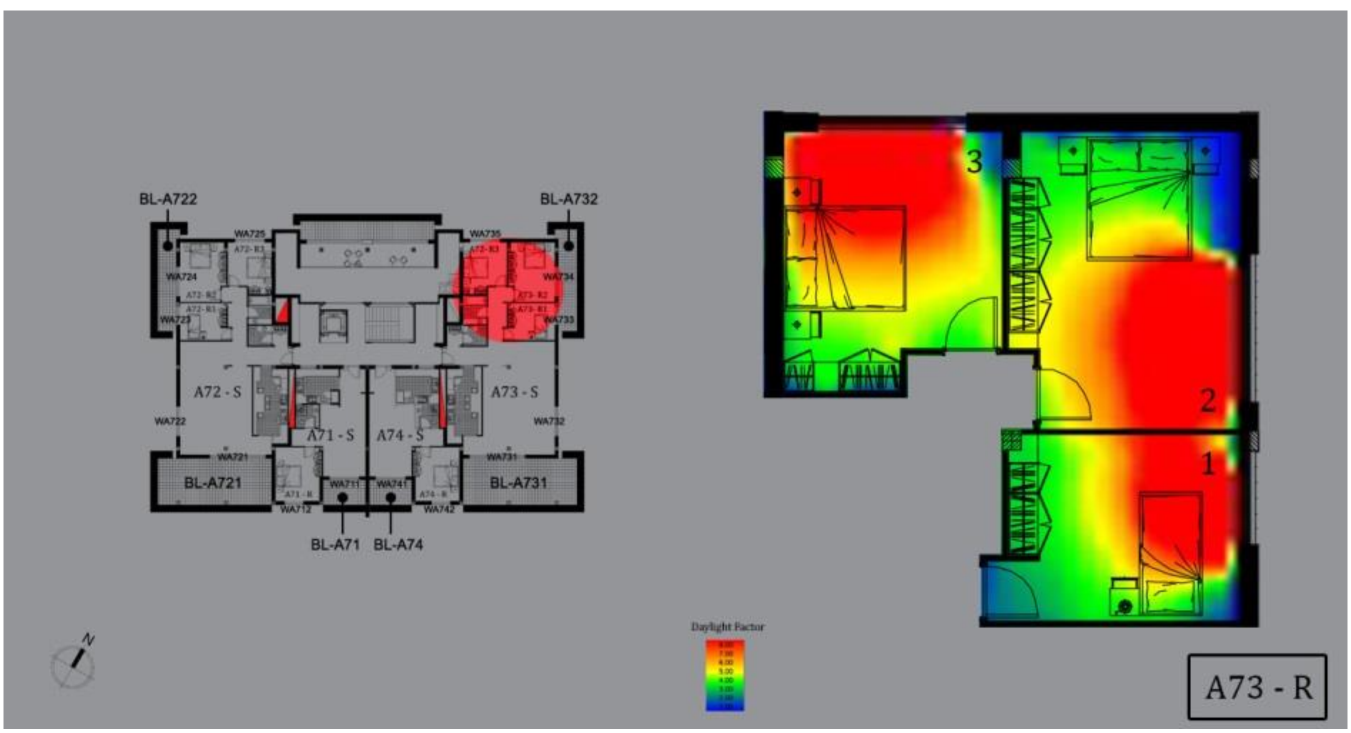


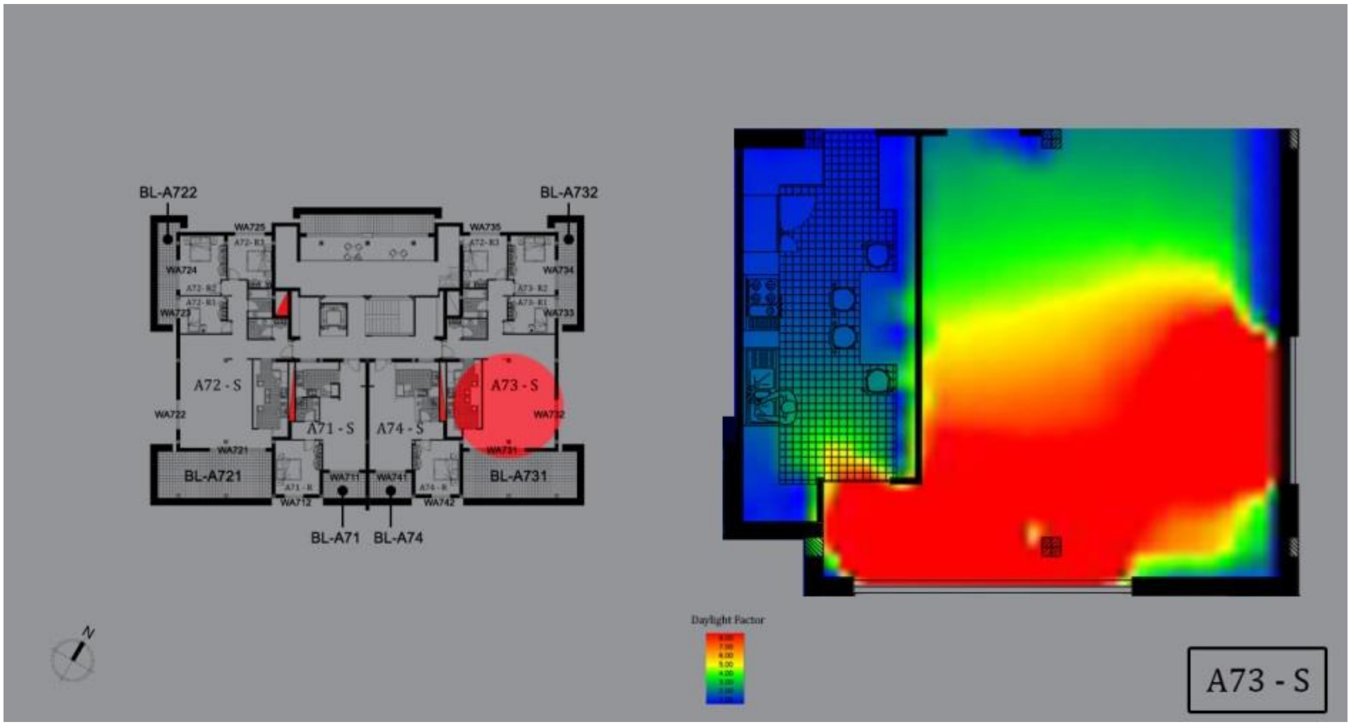
BL-A722
BL-A732
A72 - S
A73 - S
A71 - S
A74 - S
BL-A721
BL-A731
BL-A71
BL-A74
Daylight Factor
A71 - R

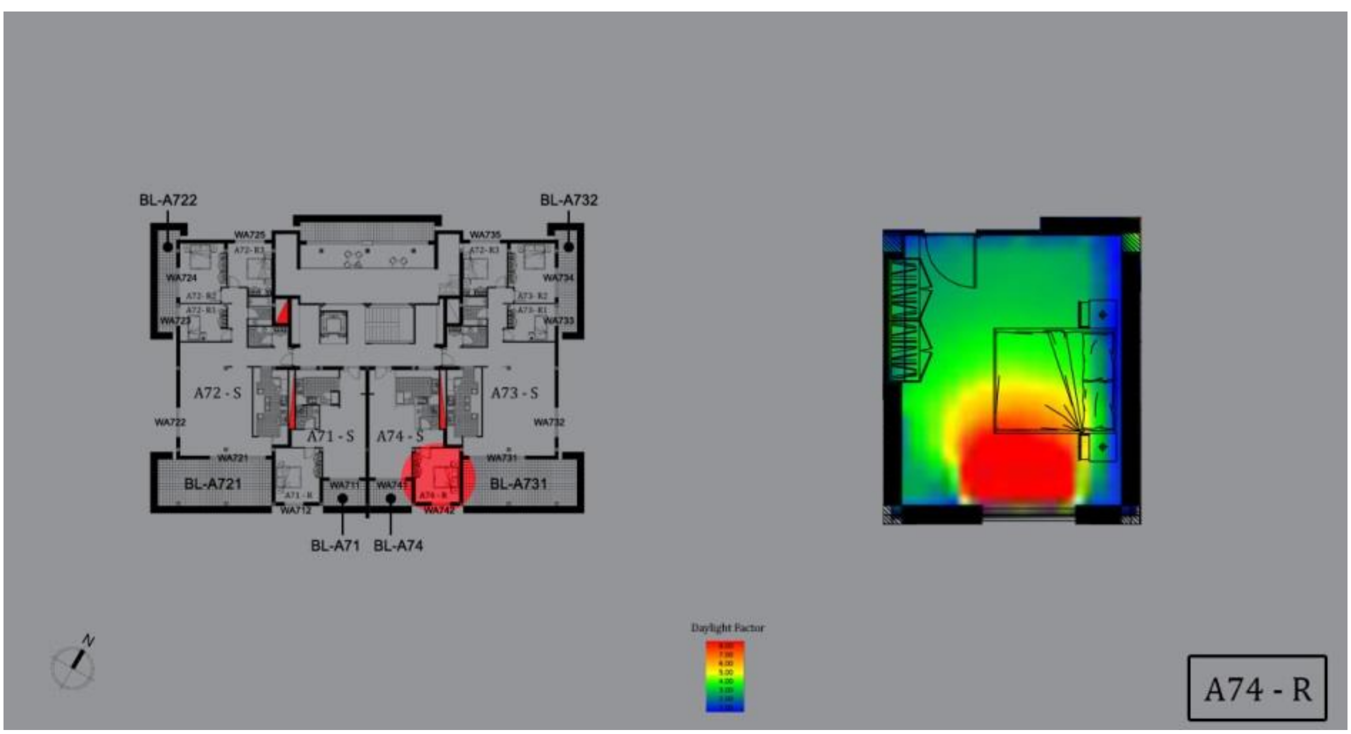

BL-A722
BL-A732
A72 - S
A71 - S
A74 - S
A73 - S
BL-A721
BL-A731
BL-A71
BL-A74
Daylight Factor
A71 - S

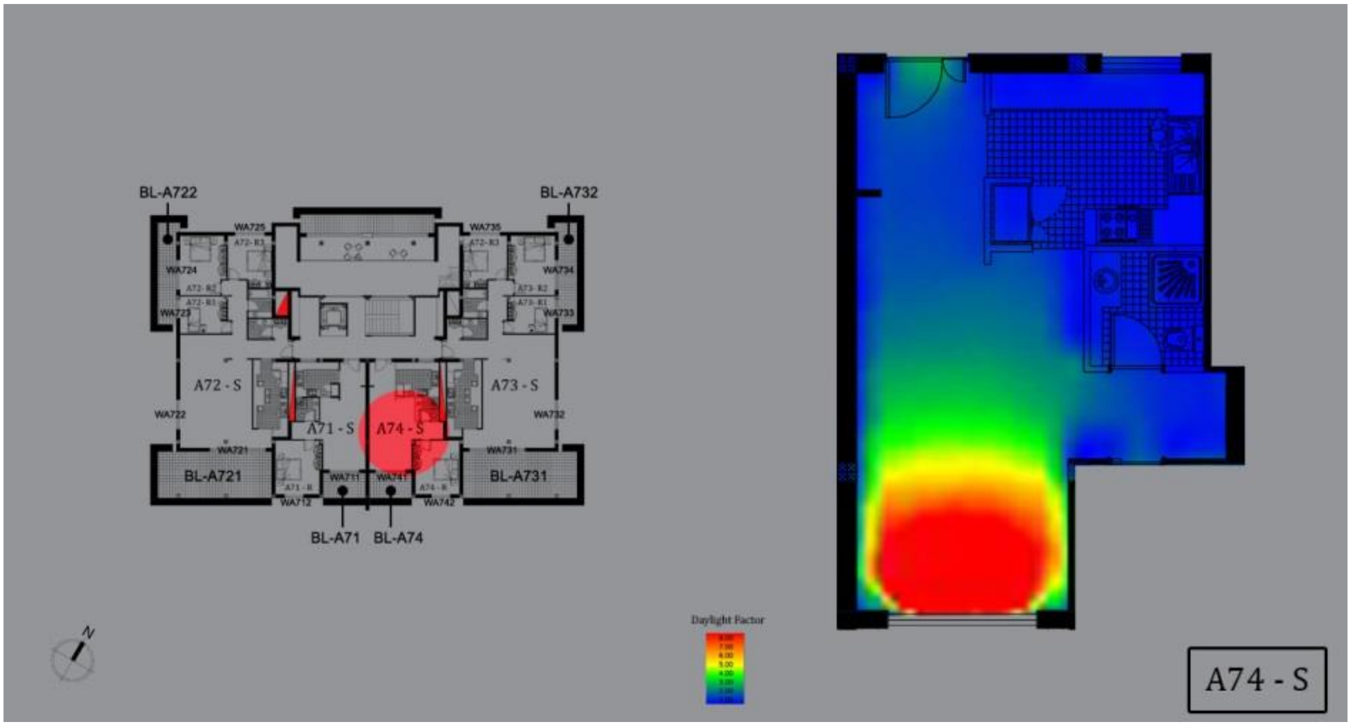

BL-A722
BL-A732
A72 - S
A71 - S
A74 - S
A73 - S
BL-A721
BL-A731
BL-A71
BL-A74
Daylight Factor
3
2
1
A72 - R


BL-A722
BL-A732
A72 - S
A73 - S
A71 - S
A74 - S
BL-A721
BL-A731
BL-A71
BL-A74
Daylight Factor
A72 - S


BL-A722
BL-A732
A72 - S
A73 - S
A71 - S
A74 - S
BL-A721
BL-A731
BL-A71
BL-A74
Daylight Factor
3
2
1
A73 - R


BL-A722
BL-A732
WA725
WA735
WA724
WA734
WA723
WA733
A72 - S
A73 - S
WA722
WA732
A71 - S
A74 - S
WA721
WA731
BL-A721
BL-A731
WA711
WA741
WA712
WA742
BL-A71
BL-A74
N
Daylight Factor
A73 - S


BL-A722
BL-A732
WA725
WA735
WA724
WA734
WA723
WA733
A72 - S
A73 - S
WA722
WA732
A71 - S
A74 - S
WA721
WA731
BL-A721
BL-A731
WA711
WA741
WA712
WA742
BL-A71
BL-A74
N
Daylight Factor
A74 - R


BL-A722
BL-A732
WA725
WA735
WA724
WA734
WA723
WA733
A72 - S
A73 - S
A71 - S
A74 - S
WA722
WA732
WA721
WA731
BL-A721
BL-A731
WA711
WA741
WA712
WA742
BL-A71
BL-A74
N
Daylight Factor
A74 - S