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Master Thesis in Architecture and Urban Design

Modularism in Tehran

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Abstract

Housing and the need for shelter can be considered as a constant and historical concern of societies since long ago and certainly in the future. The fundamental concerns are that many processes of human life, such as the formation of a family, are dependent on, and life is not complete without it. You can go as far as to consider it as the important point for the formation of human societies.

The present thesis deals with the design of a low-rise and modular residential complex with the prefabricated system in Tehran. Due to the importance of many qualitative and quantitative factors that are involved in the issue of housing and considering the increasing construction of medium and high-rise residential complexes, the author decided to address the issue of low-rise and modular housing design.

Regarding the maximum use of the residential environment, the author has examined three separate sections of housing, introduction of housing, and types of dwellings. Then, in a separate chapter, modular systems and prefabricated systems and mechanisms and their use in housing.

Finally, according to the basis of the original design rules, the project planning is proposed according to the occupation level and the design of the residential types, and finally, the proposed project with 210 residential units, which is designed on land with an area of approximately 4 hectares, is introduced.

1. Definition of Home

1.1 Introduction

I want to start my introduction of thesis project based on what Charles Moore said "The house is the center of the world for its inhabitants, beyond its neighborhood, the most significant building in the consolidation of place".¹ Housing is one of the most basic needs of human life and is considered as the smallest element of settlements and the creator of one of the geographical phenomena. Home is a related space that a person has been influenced by and effects on a daily basis since long ago, and home is the first space where a person experiences the sense of spatial belonging. Rappaport stated this in his book "The house is primarily an institution and not a structure, and this institution was created for complex purposes. Even at that time when the house was considered as a shelter for early humans, its shelter aspect was considered as an implicit, necessary, and passive task, and the positive aspect of the concept of the house was to create an environment for the peaceful life of the family as a social unit".²

One of the issues that mankind has faced decisively and inevitably since birth is the issue of housing. Providing suitable housing is one of the important issues of human life and livelihood. On the other hand, among architectural topics, the issue of housing is precisely the one that has the strongest connections with the most delicate forms, cultural heritage, and environmental characteristics and is of special importance.

In general, it can be said that houses have different meanings for different people, but what is common to everyone is the concept of a house being a shelter. A house acquires a special meaning for the person who lives in it because of the special feeling of each person for the house. A person tries to build his house in a way that adds to his personality.

The house creates a situation in the space of behaviors, reflections, and life patterns are formed and act as an effective vector on social life. On the other hand, the residential context is the dominant and physical characteristic of cities due to its vastness, and for this reason, the house, its form, and its reproduction and repetition gain double importance and scale. This is why it is said that providing life privacy is very urgent and important, and people should have it wherever they live, be it a house, apartment, or any other type of housing. the place where the generations are born, grow, and take shape. The house as an architec-

1. Charles Moore
2. Rapaport

Picture number 1: The primitive hut (resource: Essai sur l'Architecture, Marc-Antoine Laugier, 1755)



1.1.1 The concept of residence and housing

The cognitive developments at the end of the second millennium and how humans are present on earth led to rethinking the problem and the general concept of habitation in modern thought and architecture. This brought about a wide change of qualitative aspects in the presence and choice of human housing and the creation of an appropriate environment. Philosophical and scientific approaches to the human world in modern thought provided a basis for rethinking the capabilities of the environment in providing human responses to human habitation and high human needs.

1.1.2 Housing and people

Family life, which in the past has continued extensively for hundreds of years in traditional societies, was changed under the influence of the requirements of urban industrial life. During this period, a family consisting of a father, mother, and a number of children emerged, which is called a nuclear family, and enjoyed a different life from the family, and its housing pattern was affected by the new conditions.³ In this way, in moving from pre-industrial society to post-industrial society, man inevitably experienced a new form of family, where housing, as a symbol and mirror of the whole view of changes, must have the resilience and organization of the changes.

During this period, architects proposed different definitions of human and housing. And they knew the need for humans in the living environment due to having the same body and similar movements, they also believed that the social behaviors of humans evolved with their growth and determined their social classes. In this perspective, functions and needs create a specific pattern that suggests a house for all nations and all climates.⁴

Explaining personal identity at every stage of human life, Marlowe⁵ introduces the basic hierarchical needs in five groups; he considered housing as a shelter that provides human needs such as rest, sleep, etc., and protects him from unfavorable weather factors and environmental hazards. But housing should be closely connected with the quality of his life, such as security, interaction with other people, or sometimes preventing certain people or groups from intruding into their private lives, because housing, compared to other environments, it is his permanent living environment. Man spends the most time of his life in it and finds the most dependence on it, on the other hand, the concept of housing, in addition to the physical scope of the residential unit, includes the entire residential environment, which includes all necessary services and

3. Purdeihami, 2003

4. John Lang, 1992

5. marlowe pyramid

facilities. Needs for the family such as employment, education, shopping, health, and recreation are also included. In fact, the general definition and concept of housing is not a residential unit but includes the entire residential environment. In other words, the concept of housing is not only a physical shelter but includes all the environments needed by the family, that is, services and public facilities necessary for life. This point of view emphasizes that the city, like any living thing, is made up of components, the main one of which is housing, which can be considered the most important factor in its formation. Therefore, the role of housing is to meet the quality needs of human life and to provide favorable conditions for the family and the realization of family activities. This brings stability and solidarity to the family. Another role of housing is in family participation in the larger community. Because social contact is one of the basic human needs, the type and extent of which depends on the culture of the society. In fact, this is appropriate because the social participation of the family affects the housing, on the one hand, this effect makes the hierarchy and regularity of the internal spaces of the residential unit different from the shelter, and on the other hand, on the way the units are combined and interact with each other in The macro system will affect the residential fabric.

1.2 Neighborhood unit

The neighborhood unit is one of the concepts that has attracted the attention of many urban planners and researchers in the field of planning and design. This attention is due to the importance of sustainable development and the role of the neighborhood unit in starting local communities as one of the main pillars of sustainable urban development. But despite this attention, there is still no collective agreement about the concept of neighborhood unit and providing a clear definition of it. It seems that the different approaches that exist in the environmental, demographic, social, institutional, economic, and cultural fields are effective in this matter. This term has been common in European urban planning since about a hundred years ago, and in recent years, it has entered the urban planning of our country with various urban plans.⁶

1.2.1 The concept of neighborhood unit from the perspective of Clarence Perry

The title of neighborhood unit is a word that deals with the design of possible arrangements in residential complexes. Research shows that residential complexes, by providing the needs of family life, have similar roles and similar functions. In the neighborhood unit system, these elements are placed next to each other as a whole natural unit. This plan

6. Biddulph Michael, 2013, an introduction to the design of residential areas

is considered as the framework of a sample complex, and not as an elaborate plan with details. Its real perception as a special project in a real scope requires the presence of supplies, facilities, and arrangements that can only be given to it by the planner, architect, and builder. The principle governing this plan is that the urban neighborhood unit should be considered simultaneously as an element of the larger whole and as a distinct entity.⁷

1.2.2 Clarence Perry's theory of self-help units

1. The main network and the network of busy roads should not pass through residential areas. It is better to create such streets around residential units.

2. The network of internal roads is better to be designed and built in the form of small alleys than light tasks that do not disturb the peace of the neighborhood in general. These kinds of roads should provide health, peace, and a low volume of traffic proportionately inside the neighborhood;

3. The population of residential neighborhoods is better formed according to the needs and scope of the performance of an elementary school, the population based on this theory is around 5,000 people (usually the size of a neighborhood is equal to 3,000 to 4,000 people based on the performance of an elementary school)

4. It is better for these self-help units to be created in the center of an elementary school that is located in the middle of a green space and the limits of its services are the limits and boundaries of the self-help unit;

5. The physical occupation limit of a self-help unit is approximately 160 acres (about 65 hectares) and the population density limit is 10 households per acre. The shape of the neighborhood unit should be such that a child does not walk more than half a mile (800 meters) from his residential unit to the school.

6. This unit is served by shopping facilities, religious centers, a library, and a social center (neighborhood) which is better located at the closest distance to the elementary school.⁸

1.2.3 Neighborhood unit in the traditional pattern of urban planning in Iran

The pattern of semi-urban/semi-rural residence in Iranian culture has always led to the formation of ethnic and racial solidarity, which can be clearly seen today in the pattern of tribal societies. In the model of clan societies, the general basis of all social actions is to treat each person as a member of the clan. In other words, ethnic belonging has led to the formation of a kind of conceptual cohesion, which on the one hand implies the security and physical and mental health of the individual,

7. Clarence Perry, 1929

8. Clarence Perry, 1929

and on the other hand, makes the individual responsible to the entire clan. In this way, this causes the self-sufficiency of the tribal society and the formation of a special type of coherent and purposeful society that contains the foundations of social stability in various aspects. With the arrival of Islam in Iran, this model has been mixed with one of the special and almost unique teachings of this religion, which is the concept of "Islamic Nation", and has created a new type of social solidarity regardless of clan and race system. This correlation can be well traced in the old neighborhoods and the system of social organizations.

Old neighborhoods have a definite and undeniable place in most cities with significant historical history, such as Shiraz, Isfahan, Yazd, Kerman, etc. Spatial and spatial solidarity and the existence of specific and defined areas, in addition to evoking a sense of belonging to a place and, as a result, a sense of social identity, also creates certain civic duties for each of the residents of the neighborhood in front of or in competition. Determines with other localities. Among these, one of the most prominent examples is the division of social duties, on a scale far beyond professional jobs and duties. Defined and placed next to each other, and in this way, it settles all social and even family disputes within the specific limits of the neighborhood. In other words, the old neighborhoods have been self-sufficient communities, because the residents of a coherent neighborhood with an identity far away from themselves know that they should leave the social or family issues of the neighborhood to an institution outside the place.

In this way, a coherent and self-sustainable neighborhood, like a tribal system, on the one hand guarantees the social and psychological security of its members, and on the other hand, by determining the duties and obligations of each member of the neighborhood, there is always a constant monitoring of the process of performing duties.

Another interesting point to note in this context is that even the physical occurrence of this issue in ancient societies is very close and consistent with the proposed solution in today's world. Spatial hierarchy, legibility found in the interweaving of its organs, maximum continuity while preserving the sanctity and spatial territory of the neighborhoods, etc., are all examples of the physical manifestation of sustainable development in ancient cities, which are still considered leaders of urban development in the world today.⁹

One of the interesting examples of this issue is the model of independent and at the same time coherent residential complexes, which are known as gated communities, and today they are considered an accepted model in the planning system of residential spaces. This pattern has been implemented in the old neighborhoods using various arrangements such as Sabat etc..and in the old context of Shiraz city,

9. Hassanzadeh, Morteza, master's thesis

it has been implemented using the front entrances with roofed gates, which are known as *anon taq*. Even today, very interesting examples of this model can be seen, which still maintain their position.

1.2.4 The concept of neighborhood in the traditional context of Iran and the process of its formation

As the main cell of the traditional city, the neighborhood is the residence of a particular tribe, race, religion, or sect. The urban society, influenced by the tribal system, created groups that became known as neighborhoods. Socio-cultural solidarity caused the creation of the psychological factor belonging to the neighborhood and people's adherence to the customs of the unit. Residents of the neighborhood had special duties and rights toward each other and toward the neighborhood. This sense of solidarity and prejudice caused neighborhood differences.

Social relations were effective in shaping and structuring the neighborhood. Each neighborhood had its own special economic facilities, but the market as the main pillar of the city's trade, the city's trade, provided the needs of the entire city. The physical structure of the neighborhood was cohesive and unique. One of the identifying factors of receiving localities was the existence of the hierarchy of access to spaces. Since there were no significant changes in the country until the middle of the Qajar period, the neighborhood and urban spaces continued to exist under the influence of local culture. In the contemporary era, the more complicated division of social work and the separation of work time from leisure time and the transformation of multi-structured human relationships into single-structured ones have changed the way people communicate with each other. This type of relationship has been established with more diversity, shorter term and more formality.⁹

1.2.5 The concept of neighborhood unit in contemporary Iranian urban planning

The concept of neighborhood unit from the preparation of the comprehensive plan of Tehran officially entered the urban development of Iran. In that plan, it is stated that each neighborhood unit is a biological complex consisting of 1000 households or 4 to 5 thousand people, which are settled in a space with a radius of 500 meters and an area of about 75 hectares. This definition was later used as a criterion in all urban plans and became the basis for planning and designing the residential areas of the city. After the Islamic revolution, this term was used in the description of land preparation services in the form of a new defi-

9. Hassanzadeh, Morteza, master's thesis

dition by the Ministry of Housing and Urban Development, according to which, in each land preparation plan, there should be a neighborhood unit model based on the characteristics of being prepared below:

"Residential units or residential complexes, up to 200 units for lands of up to 50 hectares, 300 units for lands of more than 50 hectares to 150 hectares, and 400 units for lands of more than 150 hectares should be studied and designed."¹⁰

Picture number 2: Sabat in the old town of Tunis, Tunisia (resource: <https://fa.wikipedia.org/>)



1.3 Conclusion

From what has been said, it can be concluded that the neighborhood unit is considered one of the levels of urban divisions in the heart of the service hierarchy and service areas, with requirements in the field of road and access, by addressing the visual aspects and Improving the environmental desirability can achieve immediate sustainability. These reasons are enough to use the neighborhood unit as a valuable tool in urban planning in order to integrate the whole city. Therefore, it is necessary to welcome ideas and theories that provide an opportunity to integrate and strengthen social activities. The social aspects of planning neighborhood units require special attention. It has often been stated that a neighborhood unit, in terms of the social structure of the residents, should be a representation of all the social strata and categories living in the city, or at least since such a thing cannot be guaranteed with mere planning arrangements. Planning and design should be done in such a way that it is possible for all these groups - different social, economic, occupational, and cultural groups - to live within the neighborhood unit.

2. Site Analysis

2.1 Introduction

In this section, firstly the large scale, Tehran, is analyzed and in District 2 of the Municipality (Shahrak-e Gharb). It is then evaluated on a microscale and finally the project site analysis is performed.

2.1.1 Geographic location of Tehran

As we look around from the center of Tehran, the Alborz Mountains in the north and the Alborz Heights in the east. The current range of Tehran has extended from about 900 to 1800 meters above sea level. The north of the city is about 1300 meters in Tajrish Square and is 1100 meters in the south of the Rah-Ahan Square. That is, there is 3.5 meters per kilometer.

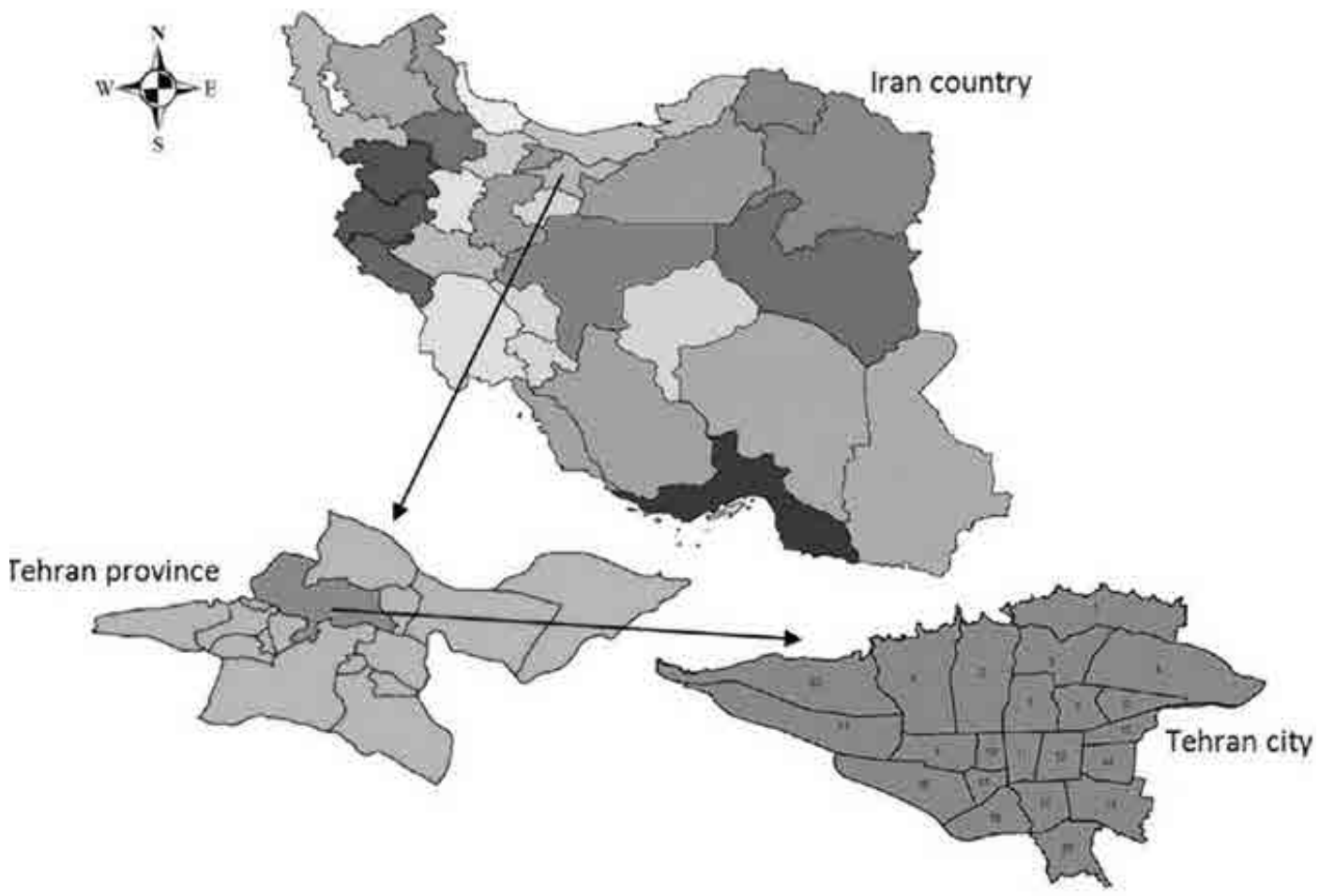
2.1.2 Climatic features of Tehran

One of the factors influencing the Tehran climate is its heights. To the north of the city, Tochal summit is 3933 meters. Also, mountains such as Damavand, Shemiranat and Imamzadeh Davood affect the climate. Water resources are also important factors in the formation of Tehran climate. These sources include the Jajrood and Karaj River and dams such as Amir Kabir, Latian and Lar. Another factor and factor that can be mentioned is the plain. The exception of the northern regions of the province, which is slightly temperate and humid due to its location on the Alborz foothills. The rest have hot, dry summers and temperate and sometimes cold winters that show the sign and characteristic of the plain areas. ¹¹

2.1.3 The impact of climatic design on energy saving

Climate is one of the most important factors in the design and formation of buildings, and since the housing sector is the most consumed energy sector among various activities, the need to take into account arrangements that can be maximized by maximizing the conditions. The natural climate of each region and preventing the maximum energy loss for residents seems more necessary. ¹¹

Picture number 3: Map of Tehran (Source: Tehran Municipality in District 2)



2.2.4 Natural Geography of Tehran

Tehran has expanded in the area between the two valleys of the mountain and the desert on the southern slopes of Alborz. From the south to the mountains of Ray and Bibi Sharbano and the plains of Shahriar and Varamin and the north are enclosed by the mountains. Tehran can be divided into three natural areas:

1. Northern Tehran Mountains; The tallest peak of this mountain -Tochal- 3933 meters overlooking the entire city of the city.
2. The second area is the Alborz domains; It leads to the hills of Mahmuru and the valleys of Evin, Darake, Niavaran, Hesarak and Sohank, and always calls a large crowd.
3. The third area is Dashti on which the large part of Tehran is expanded and has a gentle slope with the north-south direction.

2.2.5 Population of Tehran

According to the first official census in 1957, it was the most populous city of Iran with 1560934 population. Also, according to the latest official census in year 2022, the population of Tehran was more than 9039000 tonnes.

2.2 Site analysis in small scale

Features of District 2 of Tehran Municipality District 2 of Tehran is one of the urban areas that continues northeast of Azadi Square, from west to northwest of Tehran. The area is confined to the south to Azadi Street, from the west to Ashrafi Isfahani and Mohammad Ali Jinnah highway and from the east to Shahid Chamran Highway. 2

District 2 includes the neighborhoods of Ariashahr, Sadeghiyeh, Shahrara, Gisha, Gendarmerie Town, West Town, Saadat Abad, Farahzad, Tarasht and more.

2.2.1 Background of range changes and physical expansion

Identify four periods in the course of historical evolution:

First period: The formation of the primary nucleus of residence in the rural areas of the region.

Second period: Starting dense tissue development in the southern parts of Azadi axis.

Third period: Continuing the development of dense tissue in the southern parts of Azadi axis.

Fourth period: development in the foothills and the reduction of the

rural area and their transformation into problem-worn rural-urban contexts.

2.2.2 Skeletonization of the hierarchy of the road network in the region

Freeway-highway network: Yadgar Imam, Chamran, Sheikh Fazlullah, Niayesh, Shahid Hammet, Resalat, Mohammad Ali Jinnah

First grade arterial: Azadi, Ashrafi Esfahani, Jalal Al Ahmad, Marzdaran, Saadat Abad, Farhzadi Blvd., Sattar Khan, Paknejad Blvd., Khordin Blvd., Shahrdari.

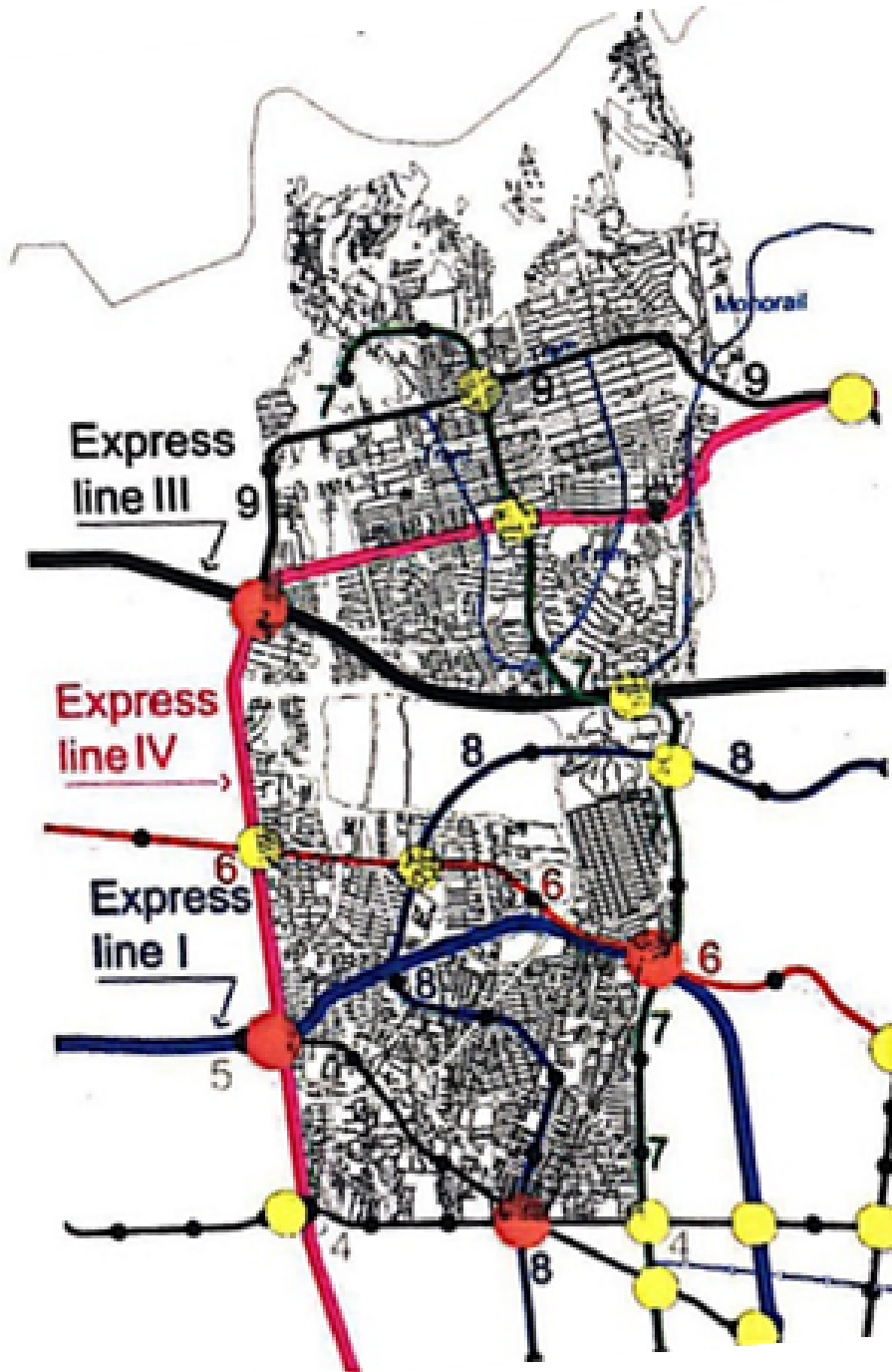
Second grade arterial: Ivanak Boulevard, Darya Boulevard, Farhang Boulevard, Nasr (Geisha), Salehi Boulevard, Habibullah, Fatemi, Suhrvardi Boulevard, Water Organization, Khosh Shamali, Ponk Bakhtari, Bavar Saru, Baqerkhan, Itsar (Farahzad).

Collectors and broadcasters: Shadmehr, Behbodhi, Rodaki, Parkhom, Derian Nou, Azizi Boulevard, Shahid Salehian, Zanjan Shamali, Allameh Tabatabai Boulevard, Niayesh, Patrice Lumumba, Shahrara, Nasim, Takestan, Jahani Nesab, Janbazan Boulevard, Danesh Boulevard, Isar (Gendarmerie Town), Shahid Khorram Rudi, Laleh, Forozanfar, Fadel, Farhangian, Alborz Boulevard, Simai Alborz, Simai Iran, Golestan, Iran Zameen, Mehstan, Hormzan, Zarafshan, Flamak, Arghvan.

2.2.3 Road network status

Zone 2 of Tehran due to being enclosed between Shahid Chamran, Mohammad Ali Jinnah and Ashrafi Esfahani highways, as well as the passage of highways such as Shahid Hemat, Shahid Hakim and Yadgar Imam and Niayesh, as well as including the number of 29 main arteries in about 13000 km length, one of the Important areas in terms of road network of Tehran city are considered. The passage of 4 BRT lines in this area, 5 metro stations, 54 bus lines and 600 bus stops in this area has greatly facilitated traffic and reduced intra-city traffic.¹²

Picture number 4: Skele-tonization of the hierar-chy of the road network in the region (source: Shi-razi,Sosan)



- | | |
|--------------------------|------------------------|
| Elevated Express line | Elevated Urban line |
| At grade Express line | At grade Urban line |
| Underground Express line | Underground Urban line |
| Existing Express line | Existing Urban line |

2.2.4 Physical and cultural characteristics

Among the most obvious physical characteristics of region 2 is the presence of natural complications resulting from the presence of the Alborz Mountain range in the northern end of the region. Other natural features such as Derkeh and Farahzad canals and Pardisan Park are also effective in distinguishing region 2 from other regions. The passage of the main fault north of Tehran and the secondary faults of Niavaran Dawoodieh and Bagh Faiz through this area increases its vulnerability to earthquakes. In addition to these issues, landslides are also other factors that make the area dangerous. The extent and geometric shape of this area is one of the other physical characteristics of the area. The extensive metro network in the region, which will be exploited in the future, is one of the potential capabilities of the region. Recreational and tourism use of the region, which consists of two major elements, Derkeh and Farahzad, is one of the functional characteristics of the region. The citizens of this region have a very high level of literacy to the extent that the percentage of literate people in this region is more than 90 percent of the population of the region. From a sociological point of view, many citizens of this region are among the middle class of the society, such as the educated, they include academics, managers, employees, and industrialists. The diversity of the social strata living in region 2 (village stratum, urban-marginal stratum, employee-trader... is one of the other characteristics of the region.¹¹

2.2.5 History

Shahrak-e Gharb, which in the new divisions of the municipality has become two neighborhoods of Quds town and Ivank town, is one of the prosperous areas of Tehran, located in the northwest of this metropolis. This neighborhood is bounded by Ponk-Bakhtari Boulevard from the north, Hemet Highway from the south, Shahid Farahzadi Boulevard from the west, and Chamran Highway from the east. In 1962, the residential complex of Shahrek Gharb was built with the design and architecture of American engineers and based on the typical model of the residential towers of the United States of America, and that is why this area was named Shahrek Gharb.¹²

The modern and different urban development of Gharb city creates the impression that this neighborhood of Tehran has no historical and old symbols, while Khordin Boulevard (one of the main boulevards of Shahrak-e Gharb) that connects Sanat Square to Iran Zameen, Hormzan and Boulevard Dadman (Bakhtari Punk) is connected, in the old days it was a village with a pleasant climate of the same name; A village whose

11. The website of the Municipality of Tehran Region

12. Shirazi, Susan

traces can still be seen in the stout trees on the side of the boulevard and the clear air that remains from the village aqueduct, a village that has been forgotten for years and nothing remains of it except its name, Khordin. This village was located 6 kilometers southeast of Imamzadeh Saleh Farahzad and 2 kilometers from Deh Vanak, and according to the Tehran Geography book, it had a population of 85 people, all of whom were Christians.¹³

The lands of this village were separated from the 1960s and large foreign and domestic construction companies started to build various buildings in it. Khordin Arbabi Garden and Khordin Aqueduct are the historical heritage of Gharb town, which today are fenced, and public entry is prohibited.

During the reign of Mohammad Reza Shah Pahlavi, specialists and craftsmen who came to Iran to expand their scientific and industrial activities, settled in "Shaharek Gharb Residential Complex" and some villas of that time, and urban development plans in a new and completely different style. It started with old Tehran by foreign construction companies in the divided lands around the historical village of Khordin.

The Americans, who constituted the majority of the community living in this neighborhood at that time, using their influence, created and expanded schools, sports facilities, and vast recreational facilities with the help of the Pahlavi government in the western settlement. For example, only the American school in this area was so large that after the Islamic revolution, even though it was divided into two separate schools for girls and boys at all levels of education, a gymnasium, a circus and show venue, a cinema hall, etc.¹²

The implementation of programs titled modernization of the capital during the Pahlavi government played an effective role in the formation of this neighborhood (a number of towers on the northeast side of Sanat Square are the result of this period). Different urban planning, modern towers and villa houses that were built quickly in these years, turned the western town into one of the new urban symbols of Iran.

With the intensification of the unrest in 1978 and 1979 and the change of the government, the revolutionaries who had taken over the government by insisting on the establishment of social justice and eliminating any discrimination, turned to confiscation and nationalization of many properties in this neighborhood. The property confiscated by the courts of the revolution was transferred to the Farman headquarters of the Imam (RA) and then to the foundation of the underprivileged and Astan Quds Razavi, in order to use them in accordance with the primary goals of the revolution to raise the standard of living of the people.

Since then, Mustafafan Foundation has become the determining body for construction projects in this region and for many years it played a

13. <http://region2.tehran.ir>

12. Shirazi, Sosan

stronger role than Tehran Municipality¹²

2.2.6 Geographical climate

Due to the constant winds blowing from west to east in Tehran and air purification by the abundance of trees in the nearby parks and mountains, Gharb town is considered one of Tehran's pleasant climate areas and has much better air than other northern areas of the city. In terms of geographical location, the town of Gharb is located at 51 degrees and 21 minutes of longitude and 35 degrees and 46 minutes of north latitude.¹²

2.3 Traffic condition and roads

Appropriate access to urban services and facilities from three perspectives, the spatial-temporal distance of access and the quality of access and paying attention to the per capita formation of local and public servants, is a physical element in the planning of residential complexes.¹⁴ Beautiful and wide streets and bridges and the possibility of quick access to several main highways of Tehran, including Chamran, Niayesh, Yadgar Imam, Hammat, Sheikh Fazlullah Noori and Hakim highways, make the traffic system very favorable in this part of the city.

The presence of numerous villas that accommodate a very small population has made the silence and beauty of the side streets of Shahrek Gharb popular among Tehranis. In the latest result of the contest "Good Alley of Tehran City", Gozer Ardibehesht of Iran Zameen Avenue was selected as the best alley of Tehran's 2nd district from among 3500 options.

2.4 Economic characteristics

One of the important factors in defining and determining the economic position of a region is the type of common activities in the region. The economic criteria of activities and uses are the volume of activity, the number of clients and the number of employees. The construction sector is one of the most important production activities in region 2, which has enjoyed good prosperity in recent years due to the residential nature of the region, and on the other hand, due to the administrative role of the region, the types of existing activities fuel the economic prosperity. The conditions and facilities of the region, such as the physical and social context, vast barren lands, important urban communication networks, as well as the establishment of government offices and organizations in this region, have provided a high potential for investment.

12. Shirazi, Sosan

14. Azizi and Malek Mohammadnejad, 2016, P37

perity. The conditions and facilities of the region, such as the physical and social context, vast barren lands, important urban communication networks, as well as the establishment of government offices and organizations in this region, have provided a high potential for investment. And employment has been created in the region in such a way that the employees of the administrative sector have a significant share compared to the total employees of the region.

Another important economic factor of the region is commercial activity, and the presence of large commercial centers after the activity, and the presence of large commercial centers after the construction of Yadman commercial center, which is the origin of an urban and suburban commercial center, these areas will attract employment and wide activities in the field of economic development.¹²

2.4.1 Economic potential

1. Passing the vital arteries of Tehran including highways and other streets from zone 2 will bring economic savings in terms of reducing the cost of transportation of goods and services for the region, as well as easy access to all parts of the city through the east-west and north-South highways is one of the other abilities of the region to attract other activities.

2. The existence of vast barren lands next to urban and regional transportation lines is one of the other potentials of the region, which play a very effective role in the establishment of commercial, administrative and service activities.

3. The vast green space inside the area can be a very important factor in creating leisure time. Farati Derkeh and Farahzad centers, whose functional level and contacts are in the city category, are among the region's potentials.

4. The presence of important commercial centers in the region and the locational concentration of many activities have shown the tendency of users to this region, which has stronger infrastructure facilities.

5. The concentration of administrative-educational-research activities has created employment and attracted users in the region.¹¹

2.4.2 Large commercial complexes

The large commercial complexes in Shahrak Gharb are among the most famous shopping centers in Tehran and have attracted many buyers from other areas of Tehran. The famous and active commercial complexes of this neighborhood are:

12. susan shirazi

11.The website of the Municipality of Tehran Region

- Milad Noor Commercial Complex, Shahrak Gharb, Farahzadi Blvd
 - Golestan Commercial Complex, Shahrak Gharb, Phase 1, Iran Zamin St
 - Iran Zameen Commercial Complex, Phase 1, Iran Zameen St
 - Shahrek Gharb Computer Complex, Farahzadi Boulevard, Shahrek Gharb
 - Sepehr Commercial Complex
 - Gol Afshan Commercial Complex
 - Shahriar complex under construction, Flamak St. corner of Derakhshan St
- Apart from the above, there are many hospitals, cinemas and cultural centers operating in the western settlement

2.5 Project site analysis

2.5.1 Introducing the project site

The site of this project is located in Shahrak-e Gharb, Tehran Iran. In terms of the urban area in Tehran, this site is located in urban area 2. Considering that our goal is low-rise, this site is located in zone R (residential) with a density of 160% (up to four floors). Our project site is located in Tehran city, District 2 on Hormzan Street. This land is located in the vicinity of the Twin Towers of Tehran and the corner of Hormzan and North Pirozan Streets.

2.5.2 Design system of residential complexes

The design of residential complexes is a multi-layered, multi-specialized and process related to different aspects of human life, because the purpose of such design is not only to provide shelter, but also to create a residential environment where its residents feel a sense of satisfaction and belonging to the environment and the local community. In order to achieve such a goal, especially in interventions between individuals, one should first gain sufficient knowledge of the site conditions and the style of the local community, and by analyzing the context and audience of the project, design a collection that matches the lifestyle of the residents and social structures. and the economic basis of the plan are compatible.¹⁵

The summation of the opinions of different groups and people regarding the different dimensions of housing can be found in Biddulph's valuable ideas in the book "Residential Site Design". In this book, he refers to eight layers in the analysis and design of residential sites.

2.5.3 Land subdivision

The legal division of a plot of land or a registration plate into several smaller plots (according to the approved rules and regulations) in order to solve ownership issues or assign to permitted uses.¹⁶

The methods of land separation in different places inside and outside the city, in the built context and in the lands considered for the development of the city, are different from each other. Several factors are effective in the separation of urban land, such as the topography of the land, the geometric shape of the land, the type of use, the crossing of roads has a decisive role in how the land is separated, from this point of view, the separation maps are actually considered urban planning maps, because the form of placement of buildings and system They determine and specify the communication network.¹⁷

Usually, in urban plans, the main characteristics of a piece of land, shape, area, length and width and front (building direction), according to the main factors affecting the characteristics such as lighting (use of light), wind (how to use or deal with it), the climate (thermal comfort in four types of temperature and humidity, light and wind), is selected in terms of natural factors, with the aim of determining the characteristics of the piece in such a way that the maximum (maximum) comfortable use of nature is made and the effects Its harmfulness should be minimized (at least).¹⁸

The simplest type of land separation, which has become famous in Iran's urban planning, is the division of land in regular rows and blocks

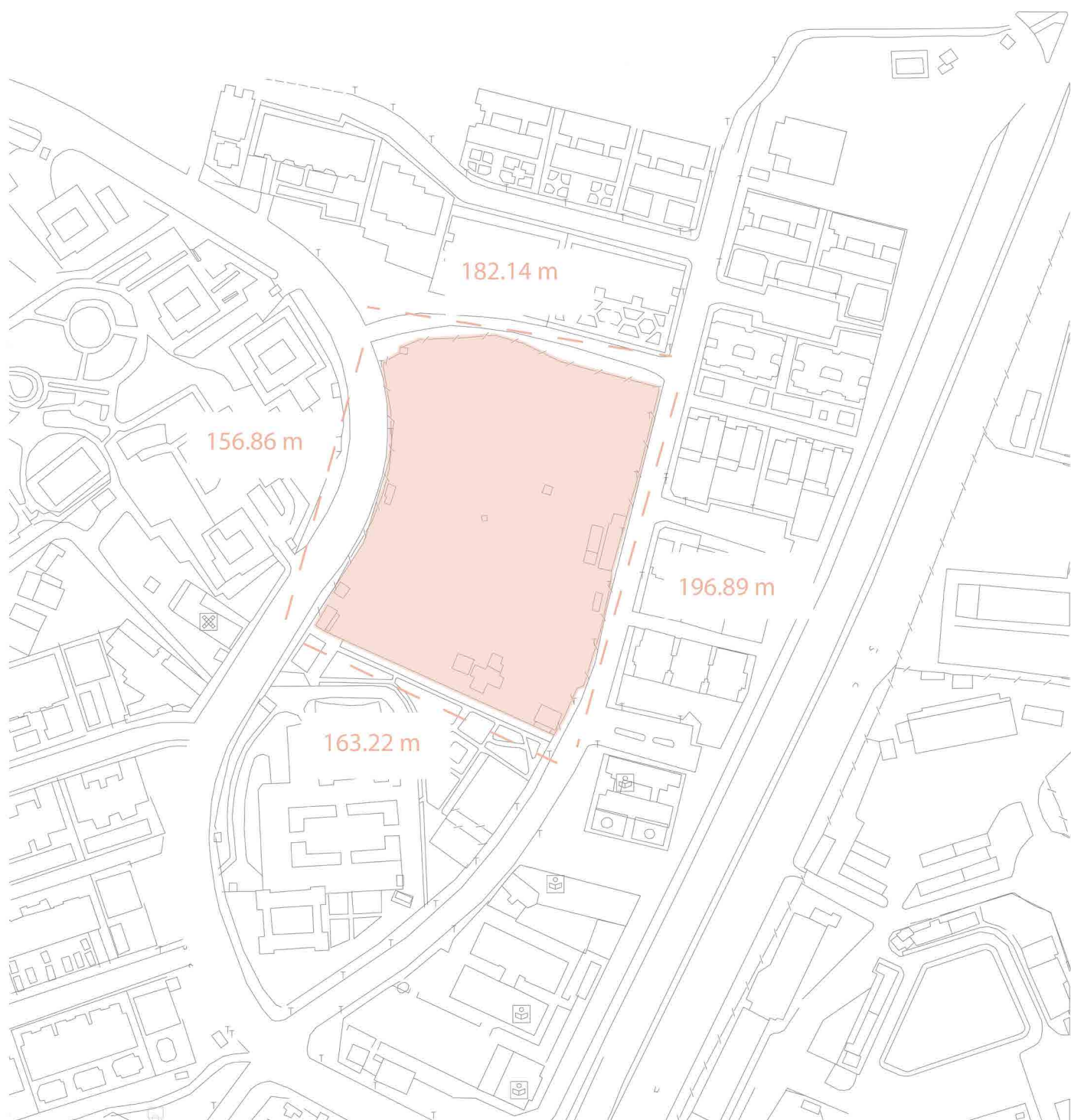
15. Nemati Mehr, Marjan and Ghafari, Ali, 2013, Booklet for Basics of Housing Design. Faculty of Architecture and Urban Planning, Shahid Beheshti University

16. Armanshahr Consulting Engineers. 1383. Special structural and detailed plan of Bam city, rules and regulations of architecture and urban development and urban design recommendations. Tehran: Ministry of Housing and Urban Development, Supreme Council of Urban Planning and Architecture of Iran: 5

17. Saeednia, Ahmed. 2013. The Green Book of Municipalities Guide, second volume, urban land use. Tehran: Organization of municipalities and villages of the country; P51

18. Arjamandania, 1369; P4

Picture number 5: the dimension of site plan (source: Municipality of Iran)



of land into equal parts. In this type of separation, rectangular blocks with an average length of 200 to 300 meters and a width of 50 meters are considered, each of which is divided into two rows of northern and southern parts. Each piece is also called north or south according to its adjacent street. In other words, a passage is built between each piece of land and the lands on both sides of the passage are divided into more or less equal pieces. The northern parts of the passage are called north, and the southern parts of the passage are called south.¹⁹

2.5.4 body system

Physical form system: In housing design, it is aimed at the simultaneous organization of mass and space and avoiding reduced space in such a way that social life is formed in the yard and the spaces formed between the designed masses.

The indicators examined in this system are Blocking system, grading system, clustering system (including employment level, density and how to organize mass and space), height and floor system and how to articulate spaces and maintain privacy.

As can be seen, the elongation and orientation of the blocks are completely consistent with the topographic and longitudinal lines. Also, the width of the blocks varies according to factors such as land with different slope percentages. The type of blocking in this site is introverted and does not provide different options for pedestrian movement and practically creates impenetrable walls.²⁰

19. Saeednia, Ahmed. 2013. The Green Book of Municipalities Guide, Volume 20, Urban Constructions. Tehran: Organization of municipalities and villages of the country: P52

Picture number 6: body system (Source: Country Mapping Organization)



2.5.5 Dimensions and grading of part

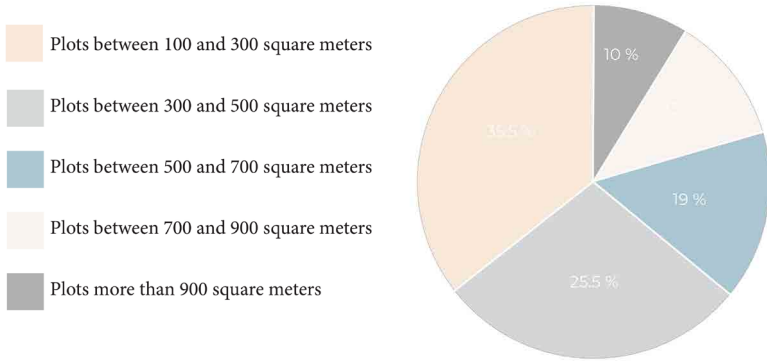
About 87 percent of residential lots have an area of more than 300 square meters. In this way, we are facing a coarse texture in this site.

Dimensions of parts	Number	Percent	Average residential plots
Plots between 100 and 300 square meters	4 parts	13%	On average, plots of 252 square meters
Plots between 300 and 500 square meters	7 parts	22.5%	On average, plots of 350 square meters
Plots between 500 and 700 square meters	6 parts	19%	On average, plots are 656 square meters
Plots between 700 and 900 square meters	11 parts	35.5%	On average, plots are 887 square meters
Plots more than 900 square meters	3 parts	10%	On average, the plots are 1396 square meters
Total	31 Parts	100%	

Table number 1: Frequency table of percentage and average dimensions of parts on the site (source: author)

Diagram number 1: dimensions and grading of parts (source: author)

Picture number 7: Dimensions and grading of parts (source: author)



2.5.6 The system of heights and floors

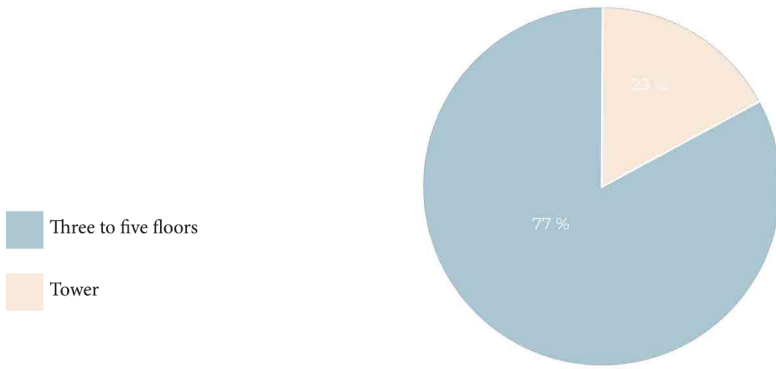
According to the observations made, there are short-rise buildings on the north and east sides, and high-rise buildings and towers on the south and west sides. This can be justified according to the topography of the land.

Number of floors	One to 3 floors	3 to 5 floors	Towers
-	-	20 blocks	6 blocks

Table number 2: Height and floor system table (source: author)

Diagram number 2: System of heights and floors (source: author)

Picture number 8: Examination of the system of heights and floors (source: the author)



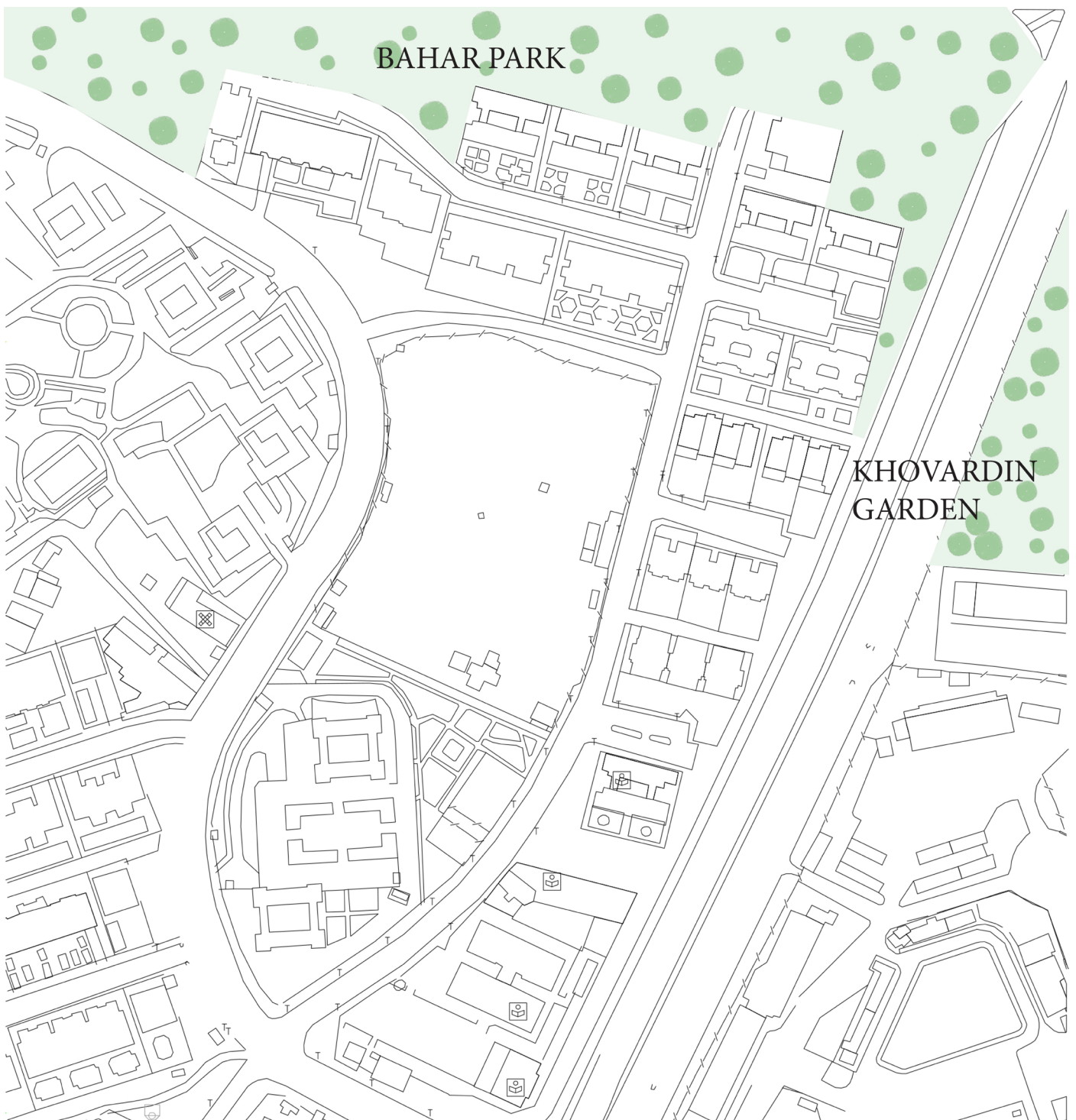
2.5.7 Types of architecture

The types of architecture in this site have been formed with the influence of various social and climatic factors. The modern and different urban development of Shahrak-e Gharb creates the impression that this neighborhood of Tehran has no historical and old symbols, while Khordin Boulevard (one of the main boulevards of Shahrak-e Gharb) that connects Sanat Square to Iran Zameen, Hormzan and Dadman Boulevard (Western Punk)) connected, in the old days a village with a pleasant climate was of the same name; A village whose traces can still be seen in the stout trees on the side of the boulevard and the clear air that remains from the village's aqueduct, a village that has been forgotten for years and nothing remains of it except its name, Khordin. This village was located 6 kilometers southeast of Imamzadeh Saleh Farahzad and 2 kilometers away from Deh Vanak, and according to the Tehran Geography book, it had a population of 85 people, all of whom were Christians.

The lands of this village were separated from the 1960s and large foreign and domestic construction companies started to build various buildings in it. Khordin Arbabi Garden and Khordin Aqueduct are the historical heritage of Gharb town, which today are fenced, and public entry is prohibited.

During the reign of Mohammad Reza Shah Pahlavi, specialists and industrialists who came to Iran to expand scientific and industrial activities, settled in "Shaharek Gharb residential complex" and some villas of that time, and urban development plans in a new style and completely different from the old Tehran by Foreign construction companies started in the divided lands around the historical village of Khordin.

Picture number 9: Greenery nearby site (source: the author)



2.5.8 Movement and access system

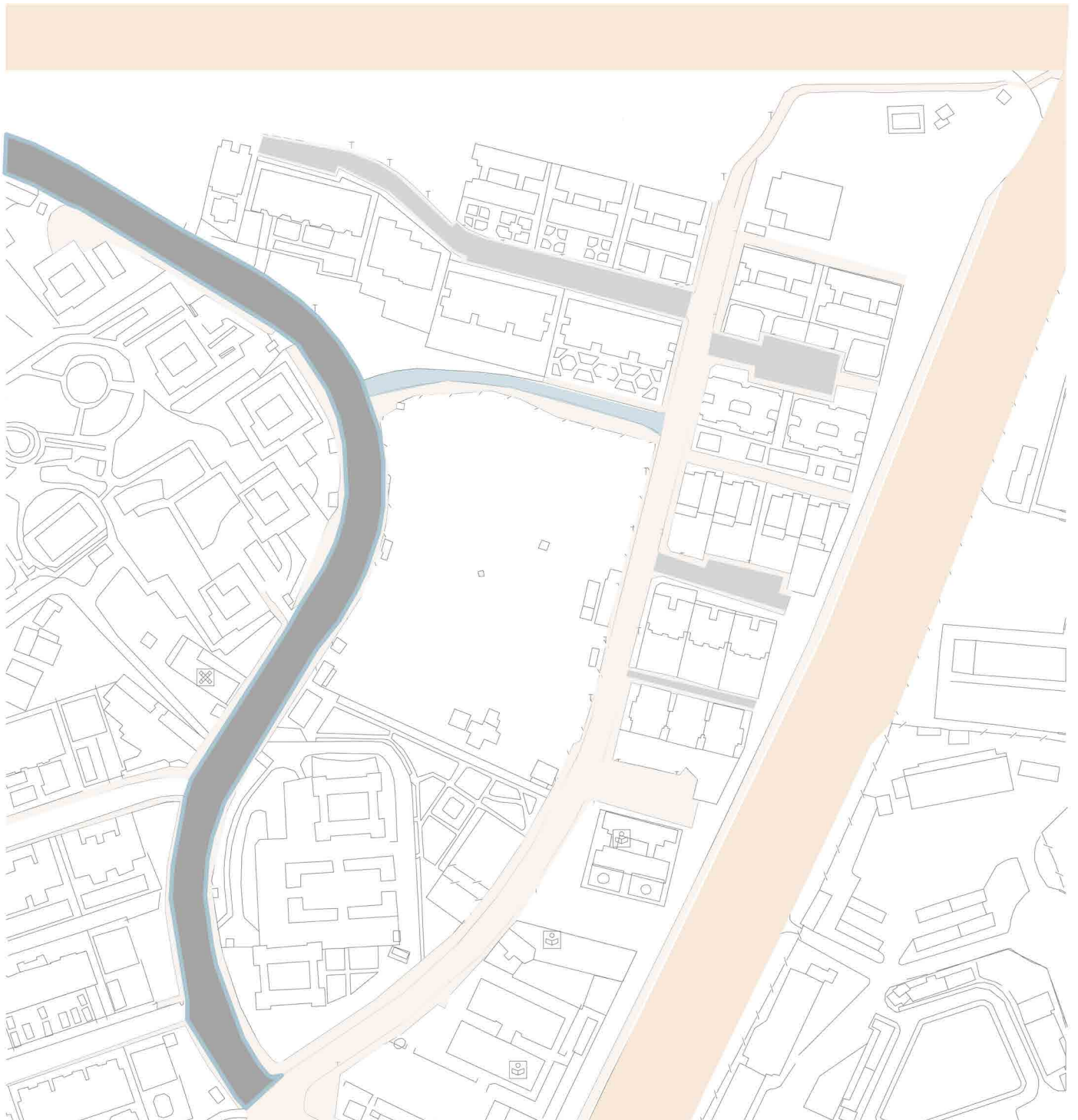
In this site, due to the distance between the public transportation stations and the site in question, it has caused residents to travel outside the area with private cars. Also, part of the parking requirement is provided by newly built residential units, and part of it is in the form of marginal parking along the roads, which causes the interference of pedestrian and pedestrian movement and threatens the safety of pedestrians in some places, and the lack of separation between the pedestrian and The rider also fuels this issue.

2.5.9 Spatial articulation

Due to the fact that there is a lot of slopes around this site, all the streets and alleys have a gentle slope and no stairs are used in any of them. It should be noted that there is no variety of movement in this space.

Picture number 10: Movement and access routes (source: author)

- Highway
- Local distribitory artery
- Main access road
- Secondary access road
- Deadlock access
- Walking path



2.5.10 Visual system

The visual appeal of residential complexes as well as their perceptibility is one of the main issues of this topic. For example, in the city of Tehran and especially in District 22, we are faced with flats that are completely flat and without any variation in volume. Designers of residential buildings should also pay attention to the quality of urban landscapes that result from the designs.²⁰

To create beauty in the perspective of the collection, the quality of order and unity, proportions, scale, symmetry, balance, rhythm and contrast can be considered as its most important forming components. These components express the quality of the skyline not only on a small scale, but on a large urban scale.

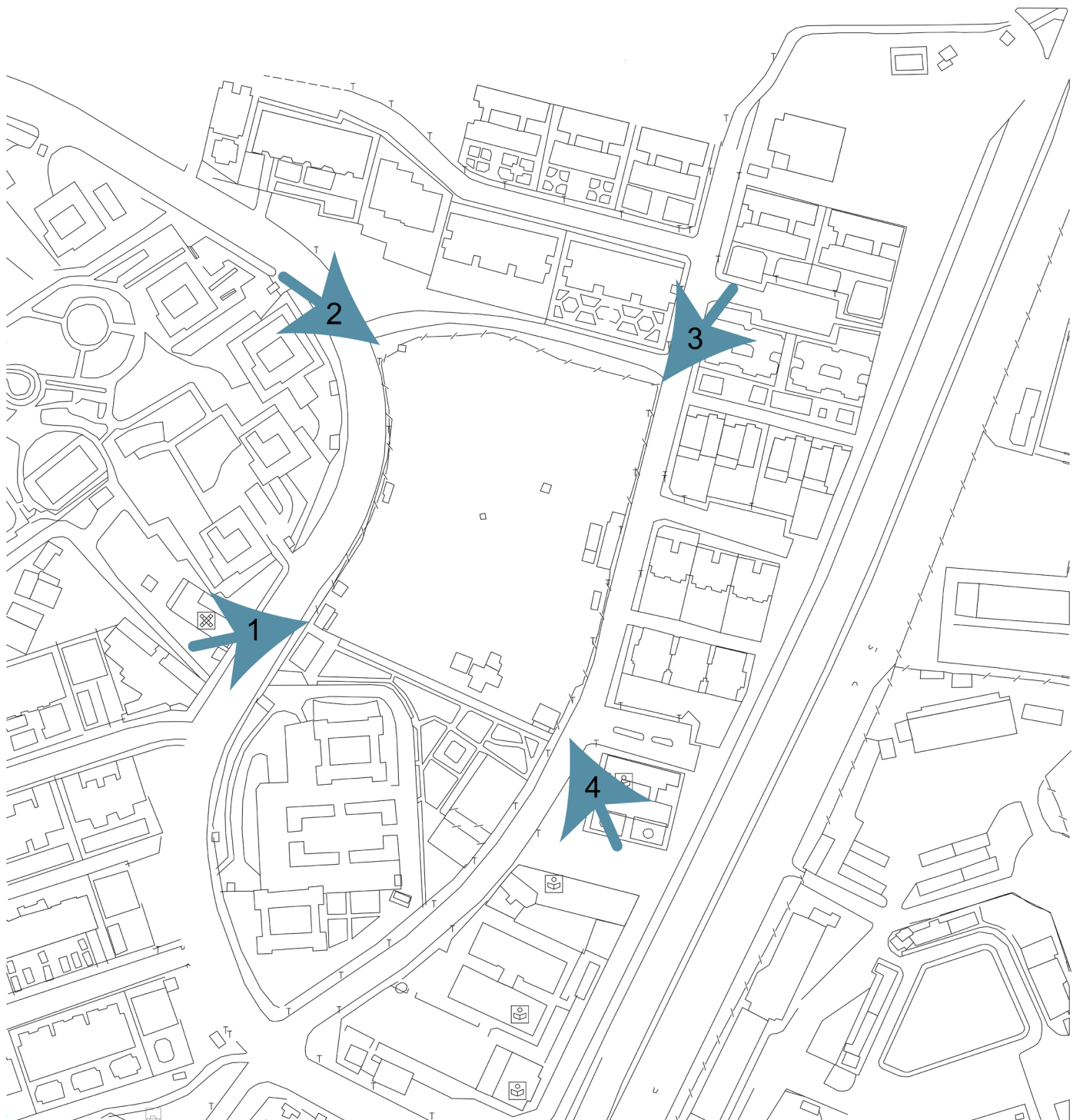
In the micro scale of the residential complex, the method of dividing the complex into blocks and sub-complexes has a direct effect on the way it is perceived by the individual.

On the other hand, the lack of volume diversity in the building means that even the residents are not able to recognize their unit when they look at the facade of the building as an observer.²¹

The feature that can be presented in this site is the difference in height and slope on the north and south sides and the view downstream. As mentioned, short-rise buildings have been built at the highest height and high-rise buildings have been built at the lowest height, and this has preserved the skyline.

20 Mahouti, Banafsheh, 2013, Thesis on the design of a high-rise residential complex in District 22

21 Mehrnaz, Hashemi, P11





Picture number 12: visual system (source: author)

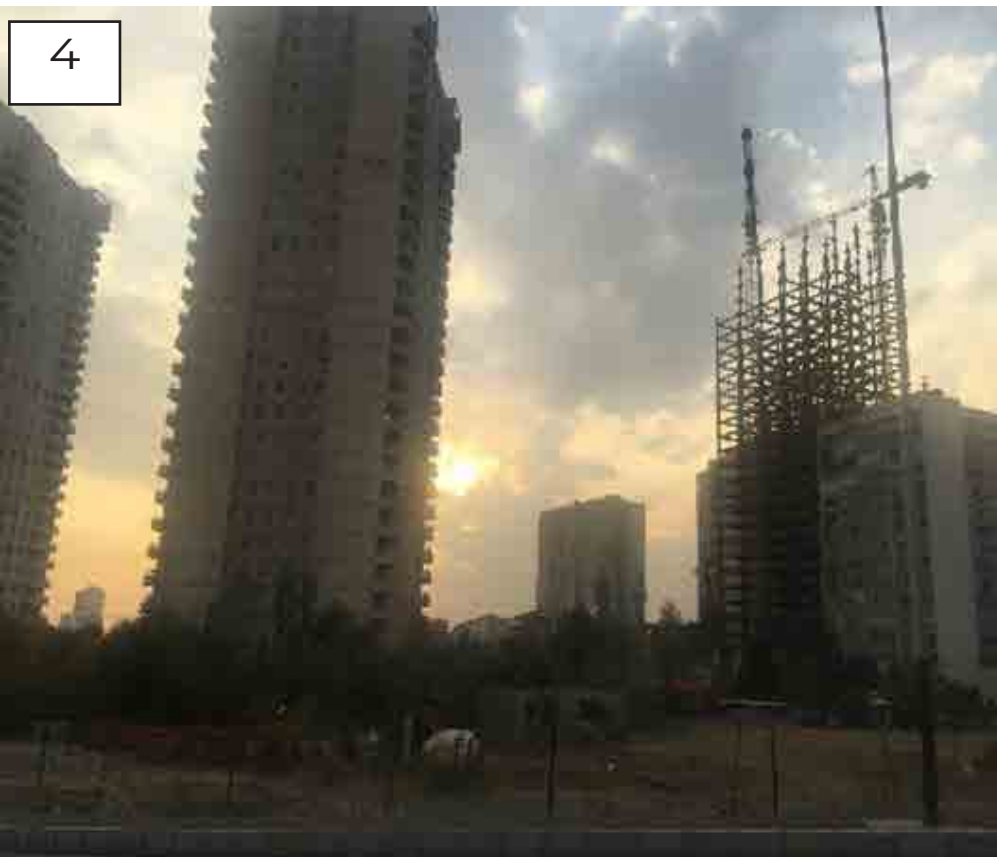
Picture number 13 visual system (source: author)

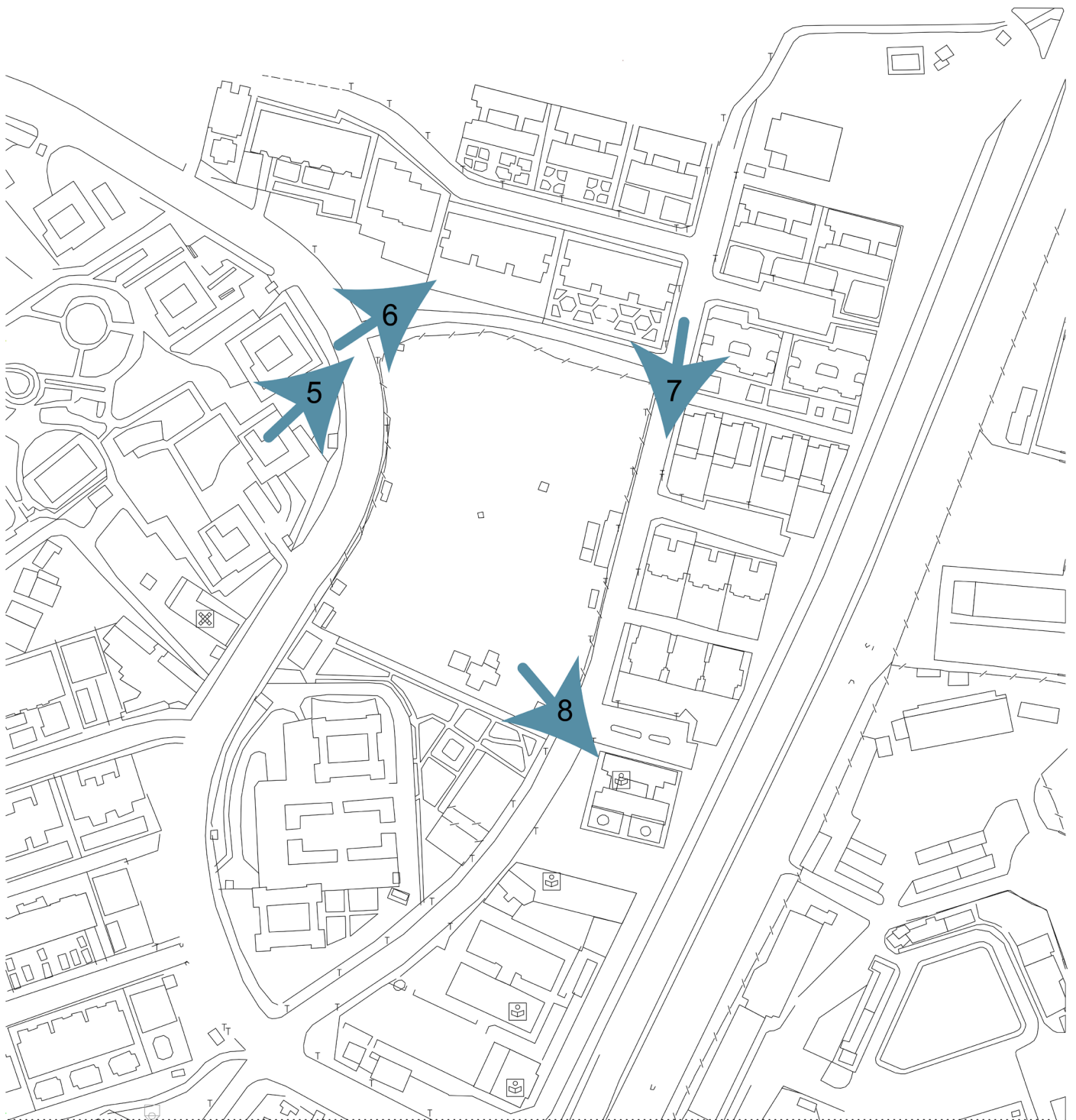




Picture number 14: visual system (source: author)

Picture number 15: visual system (source: author)







Picture number 17: visual system (source: author)

Picture number 18: visual system (source: author)





Picture number 19: visual system (source: author)

Picture number 20: visual system (source: author)



2.5.11 Land use system

Hormzan neighborhood has a gentle slope and is suitable for settlement. Hormzan Street has the highest density for the location of the uses required by the neighborhood with a suitable and comprehensive slope for pedestrians and vehicles, and considering the radius of influence, it provided a suitable pedestrian access for all the residents. Also, Pirozan Street can be considered a quiet and suitable space for riding and walking.

However, there is a lack of educational facilities such as schools and kindergartens in this neighborhood. Also, this neighborhood has no uses such as retail stores. ²²

22 Mahouti, Banafsheh, 2013, Thesis on the design of a high-rise residential complex in District 22

- Residential use
- Educational use
- Religious use
- Gardens
- Services
- Office use

Picture number 21: land use system (source: author)



2.6 Conclusion

According to the surveys carried out in this chapter and by surveying the project land, we come to the conclusion that in some parts of the land, we are facing trenches that were most likely created by earthworks, as a result of changes in the site and topographical lines of the land and by creating plates at different heights, we adjusted the height difference from south to north of the land, which included 9 meters. Also, topographic lines have been used for rider access so that we can create access with a gentle slope. As a result of this work, we are facing a main road that connects the north and south of the land, which we have considered as the main street of the residential complex. By creating courtyards at different heights, we have covered the environmental system and the visual system, and we have arranged the units on the site according to the slope of the land and proper visibility.

3. Modular system

3.1 Introduction

Today, in Iran, buildings are built in two ways traditional and industrial. According to the definition, in the industrial method, parts and components of the building are produced under the industrial system in the factory tested from various aspects in terms of quality, and then transported to the workshop. With this method, the volume of building operations in the workshop is reduced and the production rate is increased. In the traditional method, the building is built on site.

The history of modern society has become increasingly more complex and global, these developments have also affected construction methods. Quality and time have been balanced with the cost and limitations of a building. These variables must remain in balance regardless of whether they are most important to a project. However, the construction industry has not changed much compared to the automotive, shipbuilding, and aerospace industries. The complexity of customization and scale is more than architecture. Design in architecture has failed to re-equip itself with the ever-increasing demand for innovation. Architects are mainly on an uncoordinated and connected product supply chain. This in many cases does not guarantee uniformity of quality in all projects.²²

Static was a means to create lasting works in the world. Iranian architecture were lead from the Greeks and Romans and their architecture (though valuable) in many fields, and the scientists of Iranian architects in this field (proportion and modulus) developed a proportionality called Piemon with the help of geometry and they created other tools to design the buildings as best as possible. But at present, maybe few people know the name of Iranian proportions, and on the contrary, most of the technical people have heard the name of module and classical Greek golden proportions.

The main goal of this thesis is to update the concept of houses and fill the big gap between nature and the new way of life we live today. Therefore, the housing should also be deeply suited to the needs of customers and expected users and have the ability to adapt and be flexible.

3.1.1 Defining the coordination of dimensions in the building

Coordinating the dimensions means adjusting the dimensions in the building in order to reduce the numerical and dimensional diversity of the building parts and the possibility of placing them next to each other without the need to measure them in the workshop. This coordina-

22. Scalable Modular Apartment Building, MA Architecture Thesis Politecnico di Milano A.Y. 2014.2015, Supervisor_Joseph di Pasquale / Students_Ekow Aseda Inkoom_Abhay Kausshik, Aamir Ahmed Patel_Aleksandra Makuch_Pablo Munoz Montaner_Angelo Michele Pagano, Matteo Piras_Diana Ranghetti, Michele Tomasini_Yifan Zhang

tion is achieved when the dimensions of all parts and the building itself are multiples of the same standard Basic Module size. Determining the basic modulus based on general conditions (size for construction in accordance with the design, simple and complete, ability to adapt to the system of international scales) and local conditions in different parts of Iran (adaptation to the social and cultural traditions of Iran, climatic conditions and the dimensions of local construction materials of the region) should be formed.

In the past architecture of Iran, we see the use of Pimon in various sizes and scales; Specific sizes to be repeated in the plan. The peymon is wide and known in two main types: the small peymon with a length of 14 knots and the large peymon with a length of 18 knots. The primary scales for measuring length were often the measurements of the human body. Gaz was among the units that became common in Iran during the Islamic era. This length is also equal to the length of a human hand from the tip of the fingers to the elbow. It is stated in a certain culture that a yard is equal to a yard and is equal to 16 knots.²³

3.1.2 Pimon in Iranian architecture

Iranians always pay the most attention to the positive aspects of architecture; Such as logic, principles, stability, technical and scientific issues of building, human scale, use of local materials, saving, and so on. The basis for obtaining the type and shape of the coverings and load-bearing organs and their location and dimensions was difficult, and the architect had complete control over its quantity and quality. Calculations and geometry were so important that only the first-class architects called scientists and named engineers. The highest task of the architect is to recognize, understand and spatially visualize the static and current forces in the load-bearing body of the building, which he has precisely defined the proportions and dimensions of the filled and empty parts with complete nobility. "Pimon" in Iran was used in the past by rules similar to the usual module and the classical architecture of Greece and Rome, which they called. In Iranian architecture, since it created proportions and harmony in the system by using the geometry of traditional Iranian architecture, geometry has determined the optimal design process. The arrangement of architectural components in an Iranian plan is done by experience and the combination of certain sizes and criteria, in which the architect creates the required spaces in proportion, and by reducing, adding, and moving those components, he prepares the subject plan. slow Pimon has an effect not only on the plan and size of the bases and columns and the width and length of the rooms and corridors. Rather, it also determines the state of the facade,

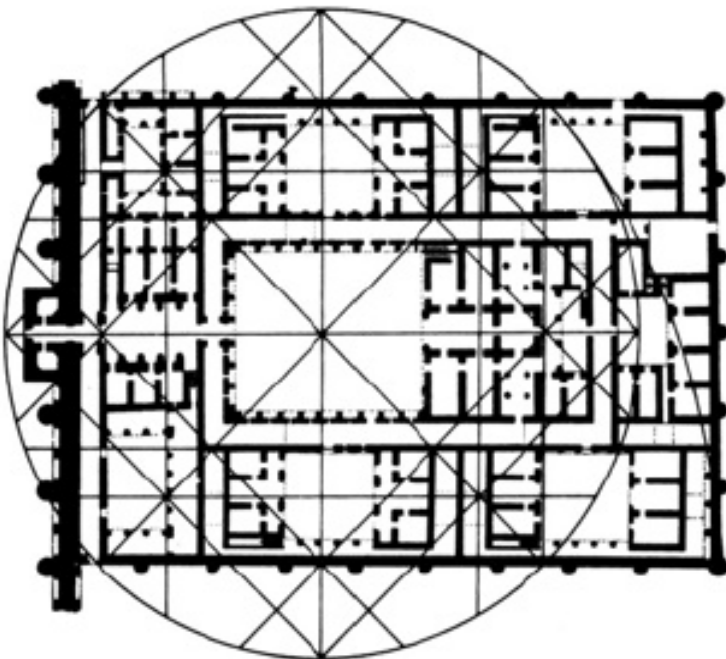
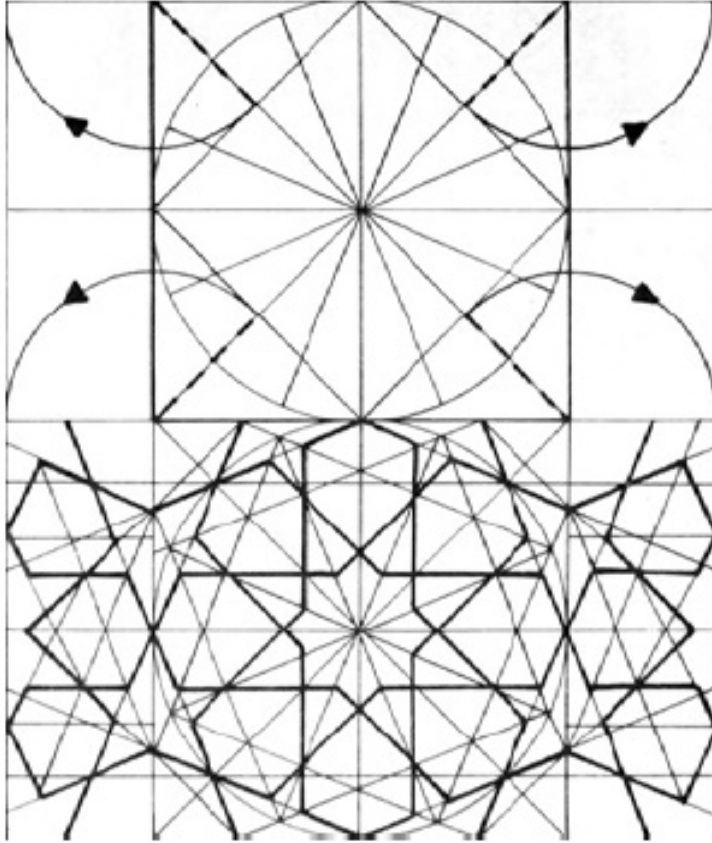
23. pirnia, 2004

door, and window and the ratio between them. In this architecture, with Jangdaz's attention to intended spaces, it is a means of adjusting dimensions and sizes, and geometry is a guide for architecture in providing proportions and basic harmony.²⁴

Pimon is a tool that adjusts dimensions and sizes in Iranian architecture and it is divided into two types: small pimon and big pimon. In fact, the pimon is wide and is divided into two types, small and large: the small pimon, with a length of fourteen knots and equal to ninety-three centimeters; the Big pimon, eighteen knots long and equivalent to one hundred and twenty centimeters. On the one hand, the mentioned collection is responsive to the conventional area, and on the other hand, it adapts to the selected dimensions of the yurts in terms of yards and other determining parameters. This collection seeks help from geometry, which always plays a fundamental role, in order to reach the goal, achieving the necessary proportions, and providing multilateral coordination. The doors overlooking the middle of the house are all either small or large, and sometimes both are needed. In this way, in addition to being able to adjust the dimensions and proportions, Pimon also enables the pre-fabrication of doors and openings and provides remarkable facilities in terms of implementation and construction.²⁴

24. A comparative comparison of the modular system in Western architecture and the Pimon system in Iranian architecture, Meis-ham Mehdizadeh, the first annual conference on architecture, urban planning and urban management research, p. 2

Picture number 22: Pi-
mon und Iranian module
(source: Analysis and Study of
Geometry of Persian
Carpets with Geometry
and Architecture
Approach, Shahri, Kavos,
Henareh Ashgehsou, Shab-
nam)



3.2 Definition of module

After the World War, when the need for standard design arose, it led to extensive studies for the pre-construction of the building. In the traditional buildings of Iran, the observance of this discussion has had many manifestations with the title of Pimon. Today, due to the double need to design and implement the correct and appropriate residential spaces in Iran, it seems necessary to reach a modular design based on what we have in our culture and history in order to accelerate, dry, and strengthen. This process of reaching prefabrication does not mean a lack of flexibility or uniform design, but the goal is to adapt the design to a harmonious geometry.

The use of dimensional patterns has been known for a long time by the ancient civilizations of Rome and Greece. In 1936, Albert Bemis published a book entitled *Reasonable Design*, and in it he presented the 4-inch cube as a design module. Ernst Neufert, based on the human dimensions and defeat, the Swedish scientists achieved slightly different results.

3.2.1 Definition of modular architecture

Modular architecture refers to the construction of individual units that eventually combine with each other to form a part of a larger complex than a complete building. In many cases, it also refers to volumetric components, which can sometimes be a complete building or a part of a larger system that forms a complete building.²⁵

With the transition to the age of information technology, society has changed, and this change affects family lifestyles and their organization and leads to different types of families. One of the newly emerging types is the single-occupancy house, which consists of one resident. Accordingly, the demand for affordable housing that guarantees access to suitable housing for single-person households has increased. In particular, there can be a high demand for affordable, temporary housing for college students who live temporarily in cities while away from home. The public sector has attempted to provide affordable dormitories for college students, temporary housing for residents of reconstruction areas, and reasonable housing standards for low-income migrant workers. Various types of pre-built housing have been suggested, urban housing with smaller sizes and modular housing, which seems to be suitable for saving construction time and cost.²⁶

25. Scalable Modular Apartment Building, MA Architecture Thesis Politecnico di Milano A.Y. 2014.2015, Supervisor_Joseph di Pasquale / Students_Ekow Aseda Inkoom_Abhay Kaushik, Aamir Ahmed Patel_Aleksandra Makuch_Pablo Munoz Montaner_Angelo Michele Pagano, Matteo Piras_Diana Ranghetti, Michele Tomasini_Yifan Zhang

26. Shi et al 2005

In addition to the cost of housing, the demand for flexible space has also increased to a great extent. The flexibility of the space may be associated with the adaptation to the changes in the space needs, including the mobility and transformation of the space in terms of color, lighting, texture, etc. The concept of affordable and flexible housing is recently often used in providing dormitories for college students. The strength of modular housing is that it is a precast structure that can be easily assembled and moved to other locations if necessary. However, the efforts that have been applied to modular housing are mainly focused on the development of hardware aspects of architecture, rather than the quality of life and living experience of residents. In general, it is believed that the physical condition of modular architecture is weak, and because of this, the comfort and life of citizens are reduced.²⁶

We have considered this house as a scalable hybrid system consisting of two elements: the mother structure which is the permanent infrastructure of the house and a modular system which is industrial and prefabricated and inserted into the mother structure which can be adjusted through the user. The modular house can be arranged and configured by the user through the Internet. It can be installed and configured within a day. Scalability allows users to expand their homes according to changes that happen in their lives, including marriage, a new baby, or a new activity. Even when the children grow up and leave the house, a part of the space can be rearranged and separated to become a source of income.²⁷

In the future, if a family needs an extra room for their apartment, it is enough to pick up their iPad, select and confirm the new room, order it, and wait a few weeks for the experts to build the room in a day without any overhead. And the sound or problems of building the site make it. This is where technology will lead. If a new product appears in this file, the user will pay additional fees for the additional functions that this "advanced home" provides.²⁸

3.2.2 Prefabricated system

When you are talking about modular systems, one of the best options for structure which comes up is Prefabricated system, prefabricated housing has been routinely promoted as a means to improve the efficiency, quality and environmental performance of house construction, use and demolition.. There is a quote by Gropius that brings an interesting approach to the subject: "Just as nowadays 90% of the population no longer thinks about ordering made-to-measure shoes, limiting themselves to use mass products as a result of improved manufacturing methods, in the future the individual will be able to order his or

26. Affordable Modular Housing for College Students Emphasizing Habitability, Mi Kyoung Kim, Mi Jeong Kim

27. Scalable Modular Apartment Building, Politecnico di Milano A.Y. 2014.2015 / Supervisor_Joseph di Pasquale / Students_Ekow Aseda Inkoom_Abhay Kaushik, Aamir Ahmed Patel_Aleksandra Makuch_Pablo Munoz Montaner_Angelo Michele Pagano, Matteo Piras_Diana Ranghetti, Michele Tomasini_Yifan Zhang

28. The Future of Architecture in Modular Construction, Mlčochová Martina, Řihák Pavel, Applied Mechanics and Materials, ISSN: 1662-7482, Vol. 835, pp 489-493

her most suitable dwelling from the warehouse. Modern technology is perhaps up to this task, but not the economic organization of the construction industry, which still depends entirely on manual work methods and does not reserve a less restricted role for the machine.”

Prefabrication has been promoted in recent academic and industry literature as a means to improve the efficiency, quality and environmental performance of house construction, use and demolition.²⁹ For example, research from Hong Kong shows a 52% reduction in waste generation across all building types with the application of prefabrication.³⁰ The factory-precision of prefabricated housing panels has also been associated with superior insulation performance³¹, reducing household energy demands and improving occupant comfort. Prefabrication aligns with several strategies for the creation of a sustainable urban environment including improved waste management, minimisation of onsite work and community disturbances, and simplified reuse and recycling of products at the end of a building's lifecycle.³² Despite strong calls for change in construction methods, backed by growing evidence of sustainability improvements, prefabrication uptake has lagged in many jurisdictions.

Prefabricated housing involves the manufacturing and assembly of components offsite, before their final installation at a chosen location.³³ While traditional onsite construction routinely employs some manufactured products such as plasterboard sheets or finished doors, the term ‘prefabrication’ is generally reserved for more comprehensive products, comprising manufacture of structural volumetric spaces (e.g., enclosed modules or whole houses); non-structural volumetric spaces (e.g., bathroom pods); and significant assemblies that do not alone define space (e.g., wall panels). Various overlapping terms have been used to describe prefabrication. For example, ‘modular housing’ has typically been synonymous with volumetric construction, while more inclusive terms such as ‘industrialised building systems’ and ‘modern methods of construction’ have included volumetric and non-volumetric prefabrication, along with advanced onsite construction methodologies like tunnel-form construction.³⁴

The housing industry is a complex product system (CoPS) that employs site-based construction methods. Prefabricated housing is a promising way of producing housing in factories. This represents a disruptive innovation because it has the potential to transform housing from a complex product into more of a commodity product, with less need for site-based production. Disruptive innovation is difficult,³⁵ particularly in CoPS industries³⁶ due to dense and complex network relations.³⁷ Consequently, adoption of prefabricated housing is slower than might be expected, given its benefits over traditional housing.³⁸

29. Eastman and Sacks, 2008, Elnaas et al., 2009, Goodier and Pan, 2010, McIntosh and Guthrie, 2008, Monahan and Powell, 2011, Pan and Goodier, 2011

30. Jaillon, Poon, & Chiang, 2009

31. Pan, 2010

32. Sev, 2009

33. Goodier & Gibb, 2007

34. (Walker, Harley, & Mills, 2015

35. Slaughter Citation1998

36. Liu and Su Citation2014

37. Dedehayir et al. Citation2014

38. Hall et al. Citation2018

, particularly in CoPS industries³⁶ due to dense and complex network relations.³⁷ Consequently, adoption of prefabricated housing is slower than might be expected, given its benefits over traditional housing.³⁸

Today, it is largely accepted that there are uncontested and substantial advantages including (1) faster all-weather production and therefore quicker return on investment for developers; (2) lower running costs for residents due to factory-driven precision providing air-tight joining of components and superior insulation placement; (3) safer working conditions with no need for working “at height”; and (4) better environmental outcomes for society stemming from reduced running costs, combined with waste minimization due to repeatable production at a fixed location.³⁹ Prefabricated production is also becoming cheaper than on-site production as the prefabricated housing industry matures and gains economies of scale. In part, this increases the supply of affordable housing (e.g. BoKlok Citation2018). So, how can the adoption of prefabricated housing be accelerated?

3.2.3 Precast and Prefabricated Concrete Structures

The precast and prefabricated elements made of concrete (such as slabs, pillars, beams and walls) are part of the constructive process known as modular construction. A construction methodology carried out in stages, based on the standardization of the parts that make up the building, with its modules produced on an assembly line, transported and assembled to shape the architecture.⁴⁰

Precast and prefabricated concrete structures are increasingly present in the field of construction, applied in different programs and scales over the last decades. Among its innumerable advantages, it is worth mentioning: the reduction in waste generation, reducing disturbances in the site with a leaner construction; speed in execution, since the production of the parts occurs concurrently with other works on the site; efficiency, in the sense that it is possible to evaluate the parts' performance and identify measures that increase structural and economic capacity; and, finally, the improvement in safety issues, with a work environment that reduces the risk of accidents.⁴¹

36. Liu and Su Citation2014

37. Dedehayir et al. Citation2014

38. Hall et al. Citation2018

39. Kibert Citation2012, Li et al. Citation2014

40. https://www.archdaily.com/996804/what-is-the-difference-between-precast-and-prefabricated-concrete-structures?ad_campaign=normal-tag

41. https://www.archdaily.com/996804/what-is-the-difference-between-precast-and-prefabricated-concrete-structures?ad_campaign=normal-tag

However, despite their growing popularity, precast and prefabricated structures are still treated as synonyms, which ignores some basic differences between the two construction processes. Precast concrete is produced by molding this material in an often-reusable mold. Manufacturing is done on-site in a dedicated space for this purpose. Therefore, the main difference between prefabricated and precast structures is that one is industrially made while the other can be produced in specific locations and does not require control, such as laboratory tests. This difference reflects in how structures are applied since precast elements are often present in small and medium-scale buildings, such as single-family homes, and prefabricated elements are applied in large-scale structures, such as factories, industries and sheds. However, due to the high production control, the prefabricated tends to offer more guarantees concerning safety, quality and durability compared to the precast. Its application will depend on the type of project and other needs that must be met in terms of costs, construction time and use.⁴¹

This idea is by no means new. Architects such as Frank Lloyd Wright, Le Corbusier, Jean Prouvé and Walter Gropius have developed several projects to effectively integrate housing construction with this industry. Specifically, the latter deserves to be highlighted for his efforts on the subject: the publication “The Dream of the Factory Made House”, by Walter Gropius and Konrad Wachsmann, edited by MIT Press, provides an overview of the experiences of the two German architects, their achievements and their many setbacks. The Packaged House System, developed by the two, is a prototype whose ingenuity attracts attention, developed after World War II, which can expand or reduce as needed, but unfortunately, did not survive commercially.⁴¹

Combination of concrete structure and modular prefabricated units: As we know already concrete structure is really successful in Iran. We can have a concrete structure as a mesh in the site and add buildings as units in the site. With this system, we can have the possibility to extend add, or even remove units and have a variety of neighborhoods to achieve the cultural feature known as living in the colony.

41. https://www.archdaily.com/996804/what-is-the-difference-between-precast-and-prefabricated-concrete-structures?ad_campaign=normal-tag



Site work and public space structure



Modular unit installation



Adding accessories - stair and corridors



Amenity and finish work

3.2.4 Advantage and disadvantage of Prefabricated

Prefabrication technology has several advantages, such as energy efficiency, minimal waste and inspection, efficient construction, work speed, protection, sustainability and quality.

As self-supporting ready-made components are used, the need for formwork, shuttering and scaffolding is substantially lowered.

- Building time is thereby decreased, resulting in lower labor costs.

- Reduced the quantity of waste materials relative to building on site.

- Reduction in construction time to allow an earlier return of the invested principal.

- Construction guarantees precise compliance with building codes and excellent quality assurance.

- Along with quality control and factory sealing, high-energy performance.

- It is possible to place prefabrication sites where skilled labor is more readily accessible and the costs of labor, electricity, materials, space and overhead are reduced.

- Prefabrication permits building throughout the year, regardless of the weather (related to excessive cold, heat, rain, snow, etc.).

- Material waste from the building is less.

- Regardless of climatic conditions.

- Security and worker comfort levels are higher in the off-site building.

There are also several disadvantages such as:

- Leakage occurs in joints in prefabricated parts.

- For huge, prefabricated parts, transportation costs can be high.

- To ensure affordability through prefabrication, increased production volume is required.

- Initial costs for construction are higher.

- The initial production of designs is time-consuming.

- Large prefabricated parts require heavy-duty cranes and measurement of precision from handling to position on site.

- Local employment can be lost, as skilled labor is needed.

- Modular building design and construction require high levels of cooperation between project parties, particularly architects, structural engineers and manufacturers.

- These buildings usually depreciate more rapidly than standard site-built housing due to their shorter economic existence.

3.2.5 Prefabricated system and costs

Prefabrication technology has several advantages, such as energy efficiency, minimal waste and inspection, efficient construction, work speed, protection, sustainability and quality.

As self-supporting ready-made components are used, the need for formwork, shuttering and scaffolding is substantially lowered.

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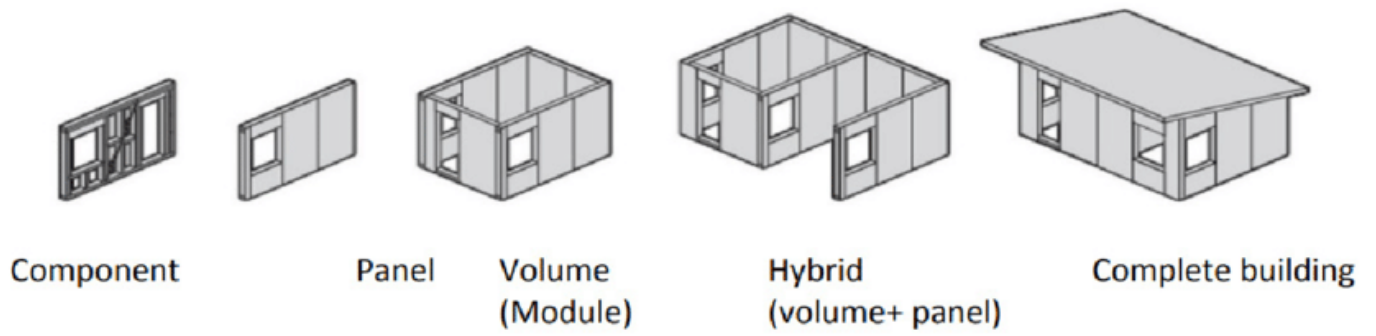
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Picture number 24: structure system (Potential for Prefabrication to Enhance the New Zealand Construction Industry, Milad Moradibistouni)



3.3 Conclusion

Modular in the modern world, Ken in Japanese architecture, and Pimon in traditional Iranian architecture are all witnesses to this claim that the concept of modular design has always existed in architecture with strengths and weaknesses. In Iranian architecture, there have been many reasons based on the existence and use of Pimon, the function, type of thinking and even worldview are among these reasons. The main goal of all theories of proportions is to create a sense of order and harmony between the visual elements of a building. These systems have been used not only to coordinate the sizes but also to create artistic beauty and harmony (proportion) between the organs. They were in the building to observe the proportions. One of the differences that can be mentioned for them is that when we use modular, the proportions are out of the human condition and they are not used for the parts of the building where human proportions are needed. and modular can be used more for facade or interior proportions that do not require human proportions; however, Pimon refers to both external proportions and parts that require human proportions, such as doors and other proportions. The interior moves the building towards the ideal by expressing a series of rules and laws. Also, its module and relationships can be used in other sciences, and it can be clearly stated that It is a much more general law than the concept of Pimon in Iran, by stating this point, it can be understood that pimon can only be used in architecture and is practically useless in other sciences and is not a universal law, for example, it is stated The size of the large door is 120 cm and it is not concerned with the dimensions of the wall on which it is placed, but in the module, all these proportions are measured together and often very large scales are obtained which It expresses the solidity and awe of Greek architecture, the architecture that is a manifestation of strength and stability and shows greatness and greatness, and everything is calculated in it, even the errors of vision are corrected in it to make everything simple and humble to the viewer. supply But with small differences between these introduced proportional systems, they all somehow create order and harmony and provide the possibility of prefabrication, and this is one of the advantages of using these rules. Ken measurement unit was introduced in Japan in the second half of the Middle Ages, although Ken was originally used only to determine the distance between two columns and had different sizes, but it soon became a standard in residential architecture. Unlike the module (Pimon) of classical methods, which was the diameter of a column and changed according to the size of each building, the ken was proposed as an absolute and unconditional measure. The ken was not only

a measure for building a building but A beautiful modular form was developed that regulated the structure, materials, and atmosphere of Japanese architecture. In Iran, pimon has a separate application from tatami. Although both are a means to speed up and ease work. Tatami was formed based on the human being in a sleeping state. And it affects the entire space and even the placement of the columns. The pimon is the width of the door, the width of the door is in human scale, and the rest of the elements are multiples of the pimon. In Iranian architecture, the Pimon and the chosen size for Creating a harmonious and proportional plan have been used; in this architecture, the use of human-like proportions (having a human scale) has always been mentioned, which is carefully implemented in the whole building, in the partial elements and even in the decorative elements. A problem that is important in the use of pimon is that Iranian architects, along with using pimon and repeating it in sizes and shapes, used the building in many different ways. A pimon was used in them, but no two buildings were alike and each one had its characteristics.

4.1 Introduction and goals of project

One of the most important reasons for choosing the topic is the importance of housing. Residential environments play the role of a platform for human societies. It means that it lives, grows and works in a residential environment. Therefore, it is in constant interaction and influence with this man-made environment. In order to achieve physical concepts about housing and residential complexes, several examples have been evaluated. Another reason is the creation of a modular residential settlement for a certain stratum in the city of Tehran, Iran in the area of Shahrak-e Gharb. Due to the growth of the population and the need for housing, based on a housing development plan, I decided to achieve a fast and flexible supply between the fast and growing demand by using the module in housing design. There are variety of choices to achieve this goals and one of them is prefabricated system.

As I mentioned before the site of this project is located in Shahrak-e Gharb, Tehran Iran. In terms of the urban area in Tehran, this site is located in urban area 2. Considering that this site is located in zone R (residential) with a density of 160% (up to four floors). Our project site is located in Tehran city, District 2 on Hormzan Street. This land is located in the vicinity of the Twin Towers of Tehran and the corner of Hormzan and North Pirozan Streets.



4.2 WHAT is the novelty in Tehran

4.2.1 What should improve in Tehran

As I mentioned earlier, Tehran faces with population increase these days, because of migrating people from the nearest cities and villages for some reasons, like, more job opportunities, better facilities, and good infrastructure. So, the first and the most important thing that should be focused there is finding a solution to build houses fastly. Having more greenery is another important point because that area was a green village in the past it changed from a green spot to a concrete and metal spot full of buildings. As a result, it is necessary to bring back greenery in this part of the city. And also, due to new trends in the world, a lot of countries forget their culture and their roots not only in routine lifestyle but also in design. Tehran as a capital city in Iran has a strong culture which is important to illustrate in new buildings.

4.2.2 What is very successful in Tehran

The traditional Persian house is a representative of the culture, way of life, and beliefs of the Persian people during the golden era of Persian civilization in 17th to early 20th centuries. If you see and follow old architectural houses in Iran, the courtyard is one of the strong elements in most of the housing. In Old houses was the center and heart of the building. Central courtyard with porch on each side was the features that were seen in past Iranian architecture. Also the courtyard was a space for various ceremonies such as religious rituals, weddings and family gatherings.

Courtyard is usually rectangular. Its dimensions normally were determined by the number and type of surrounding spaces. Usually, there were a pool and a garden in every courtyard that their geometry was different depending on local conditions such as climate and cultural factors.

Also, one of the most beautiful habits in the past was families lived in a neighborhood for a long time like a colony, even if one of the children got married they just moved to another house in that neighborhood or they split the big house into small houses for children. It could be nice to use this feature in the design process.

4.2.3 What is very unsuccessful in Tehran

In Tehran, it is usual to use concrete, and brick for low-raised buildings and metal structures for high-raised buildings, due to weather features

and climate, easy access and availability, low cost, and the knowledge of building them. As a result, new structures like prefabricated structures (cell type) were not successful as much as concrete and brick in Iran because people were not eager to live them and they rejected new trends because they looked cheap and unreliable, so we need a new type of prefabricated system to be matched with our design.

4.3 Symmetry in Persian architecture

Architectural past periods of Iran were always inspired by the use of geometry and rich and detailed drawing practices. So far, knowledge of the mathematics rules and drawing and the use of specific types was the duty of every architecture and beyond it, the engineering knowledge and knowledge of geometric means and the distinction between architects and their competition with each other has been based on the same axis. That is why you can see, a variety of geometric relations, details and decorations have been respected. One of these relations is symmetry, according to Antonio Palladio, the need for symmetry to coordinate has no place for the question and is considered as one of the aesthetic principles, although it is essential to say that symmetry argument cannot be proposed apart from the balance. The purpose of this design is to show how can we have symmetry in new design, and how we can avoid of repetitive shapes. So in first step we can have one block with around 33 units, not to mention 60 m² 90 m², 120 m² and 150 m², and keep it as one block and mirror it to have symmetry. Then we can put these 2 blocks next to each other in siteplan.

with this concept we have step by step modularities. First module is a square with 1.8 m * 1.8 m that it calls small module. Next module, known as medium module, is made by our units, 60 m² unit is based that it is made by 9 module of 1.8 m * 1.8 m. 90 m² unit is made by 3 modules and ect. Then we put them next to each other to make a block, so this block can be our large module.

Picture number 26: Tabatabaei Historical House, Kashan, Iran (source: /www.dreamstime.com)

Picture number 27: Abbasian Historical House, in Kashan, Iran (source: www.freepik.com)

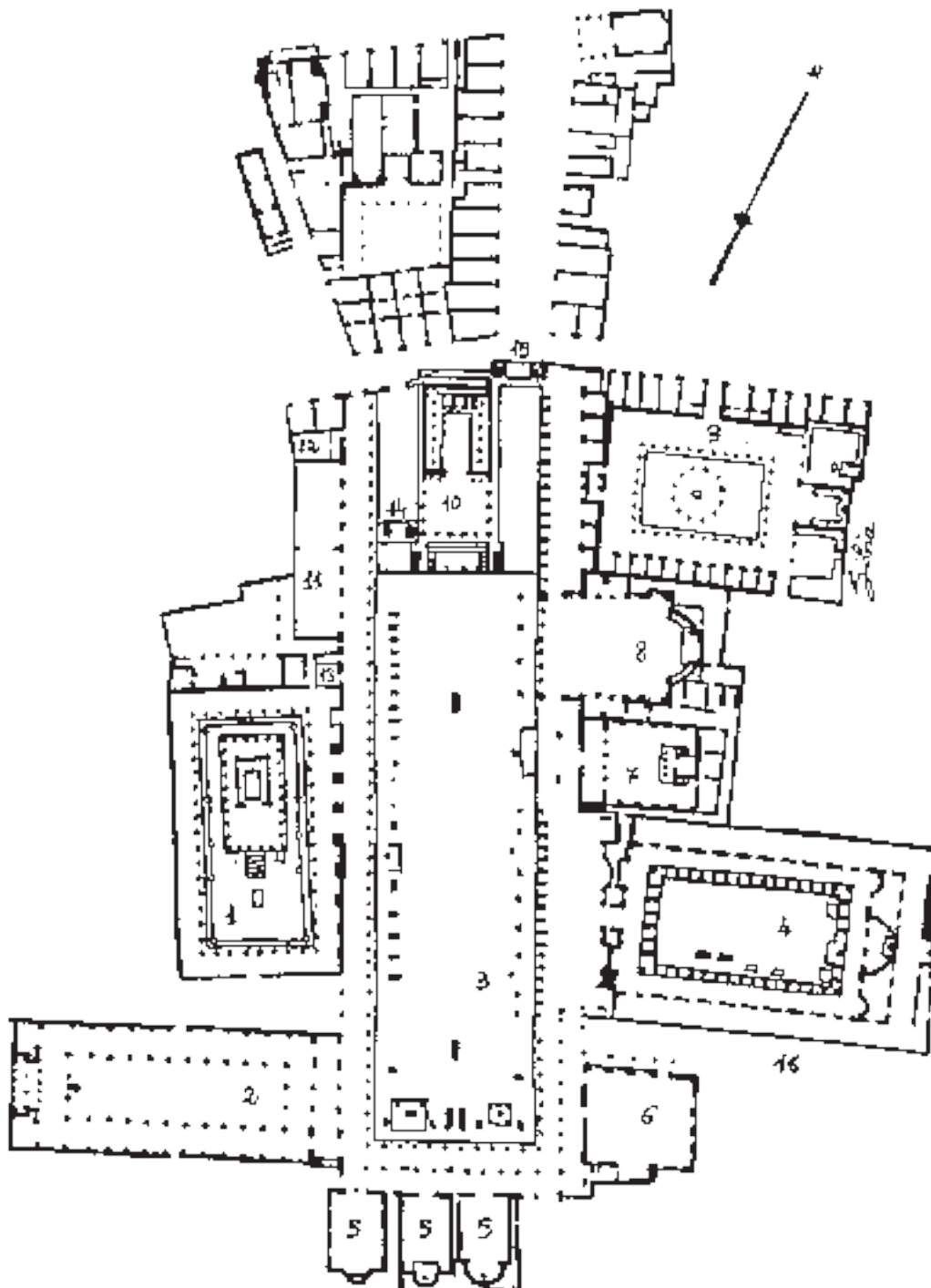
Picture number 28: Vakil Mosque, Shiraz, Iran (source: <https://www.flickr.com/photos/camelkw/49905678261>)



Picture number 29: Six traditional Iranian courtyard houses: (a) Lotfali Khan House, Kerman; (b) Azimi House, Kerman; (c) Movahedi House, Kerman; (d) Dehdashti House, Isfahan; (e) Alam House, Isfahan; and (f) Charmi House, Isfahan (source: Traditional Iranian courtyards as microclimate modifiers by considering orientation, dimensions, and proportions, Soflaei, Farzaneh; Shokouhian, Mehdi; Mofidi-Shemirani, Seyed-Majid)



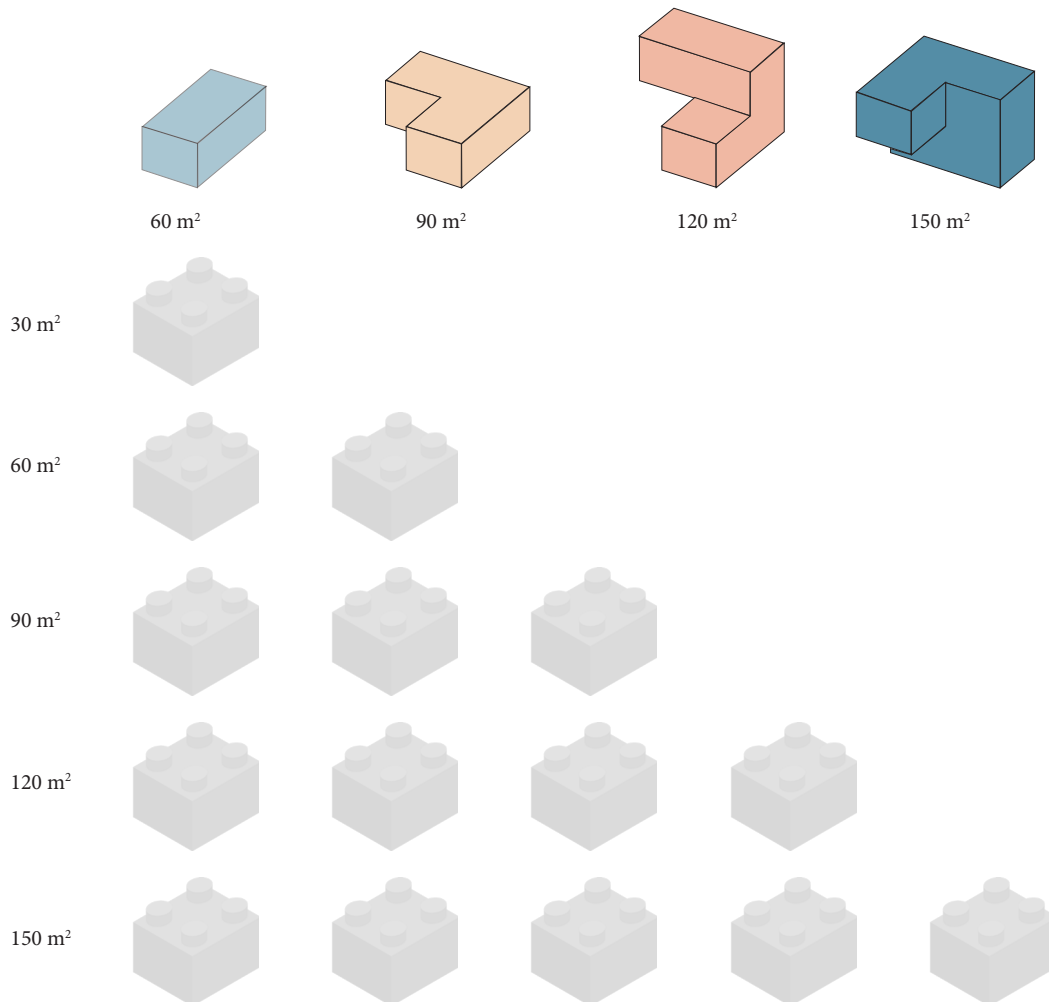
Picture number 30: pianta del Foro civile di Pompei (source: www.pompeionline.net)

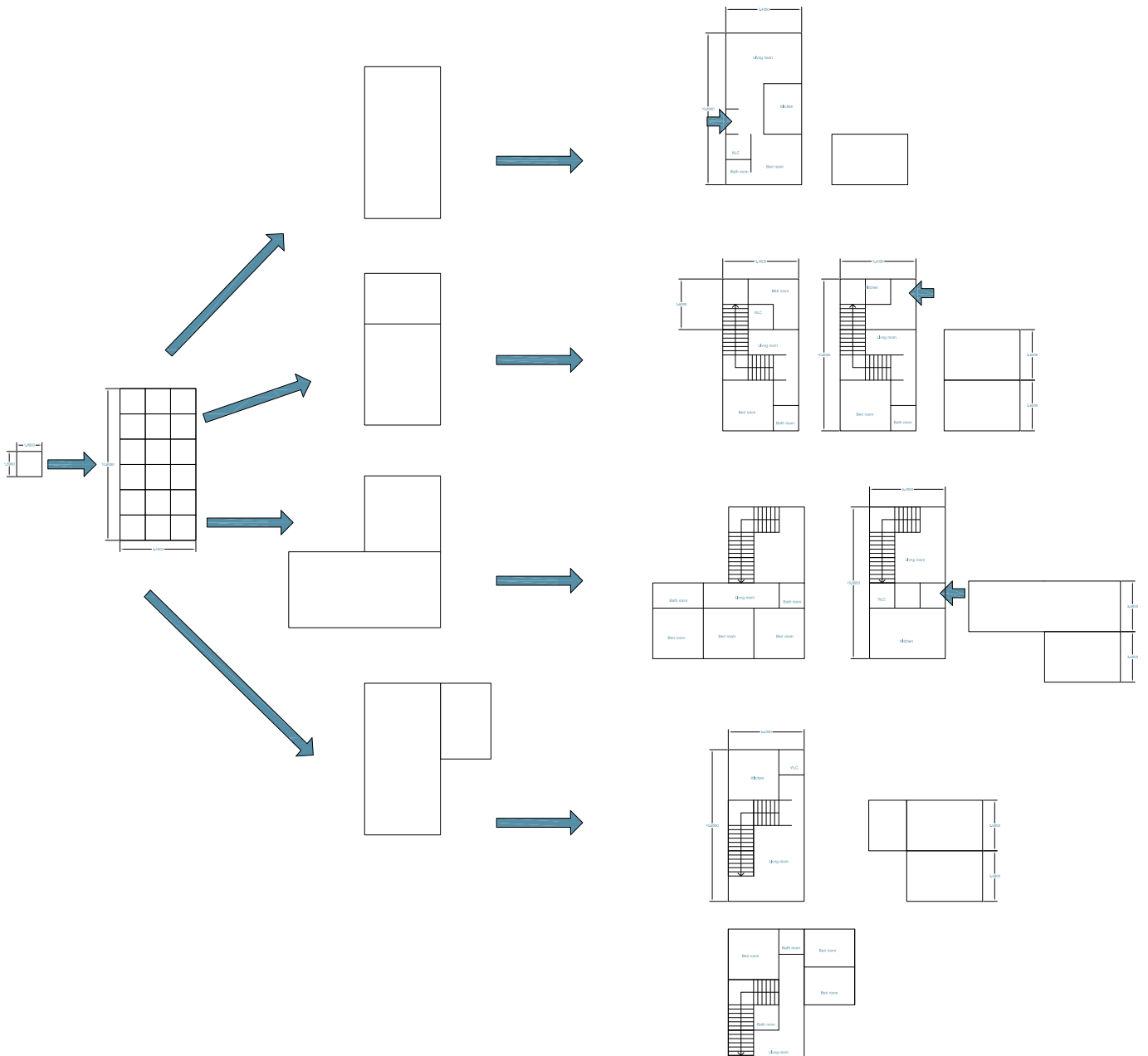


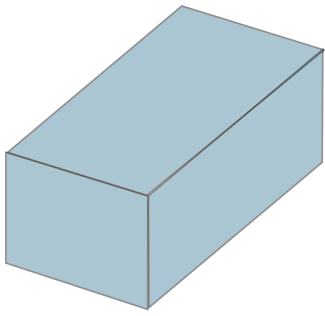
4.3 Modular units

Picture number 31: Design process (source: author)

According to the previous research and all case studies that are modular design, we have 3 different modules from the small scale to the large scale. In the first step as the smallest scale, one module is a square with 1.8 m x 1.8 m it is the base of all plans. The second module is our units, there are 4 different units, 60m², which consists of 18 small modules, 90m², which consists of 24 small modules, 120m², consisting of 30 small modules, and 150 m², consisting of 36 small modules. In the next step, these units make a block with different variations of housing, this block is the largest module which has 35 units.

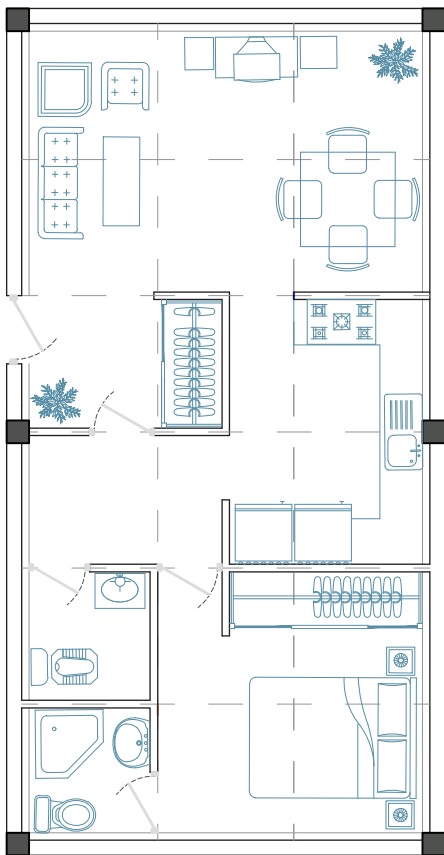




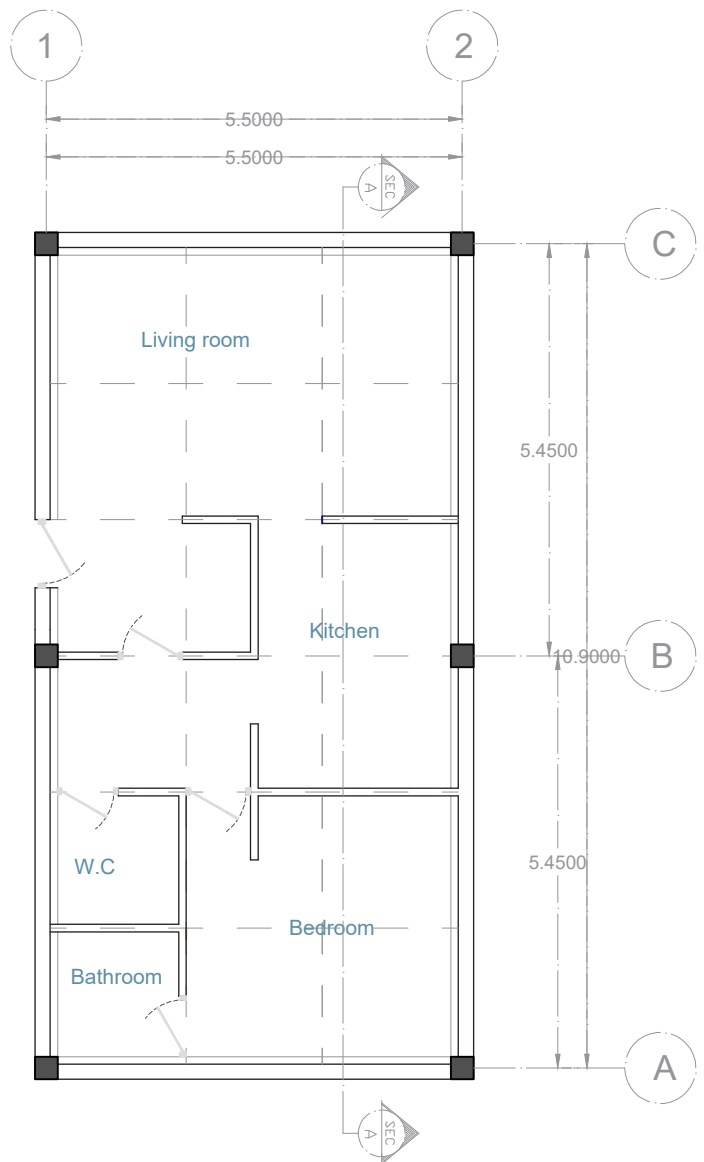


Picture number 33: plan unit 60m² SC 1.100 (source: author)

60 m²

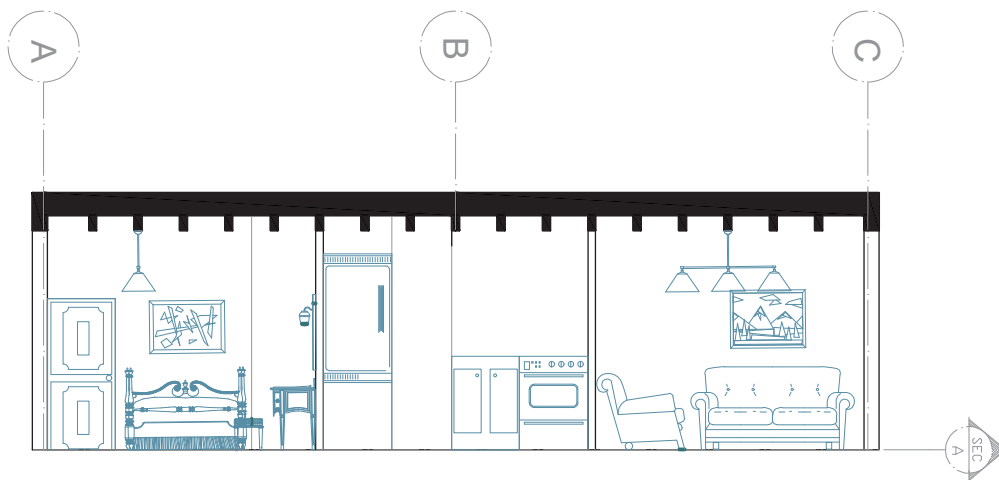


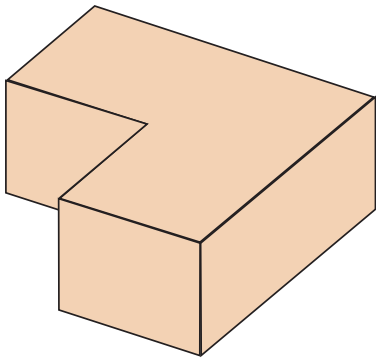
60 m²



60 m²

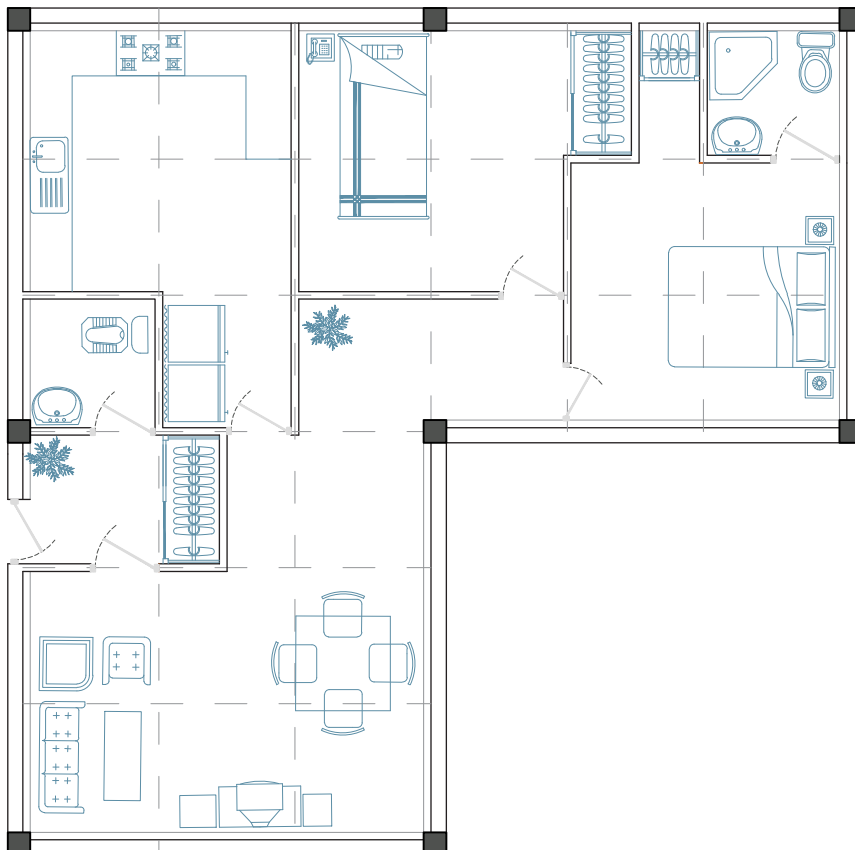
Picture number 34: Section unit 60 m², SC 1.100 (source: author)





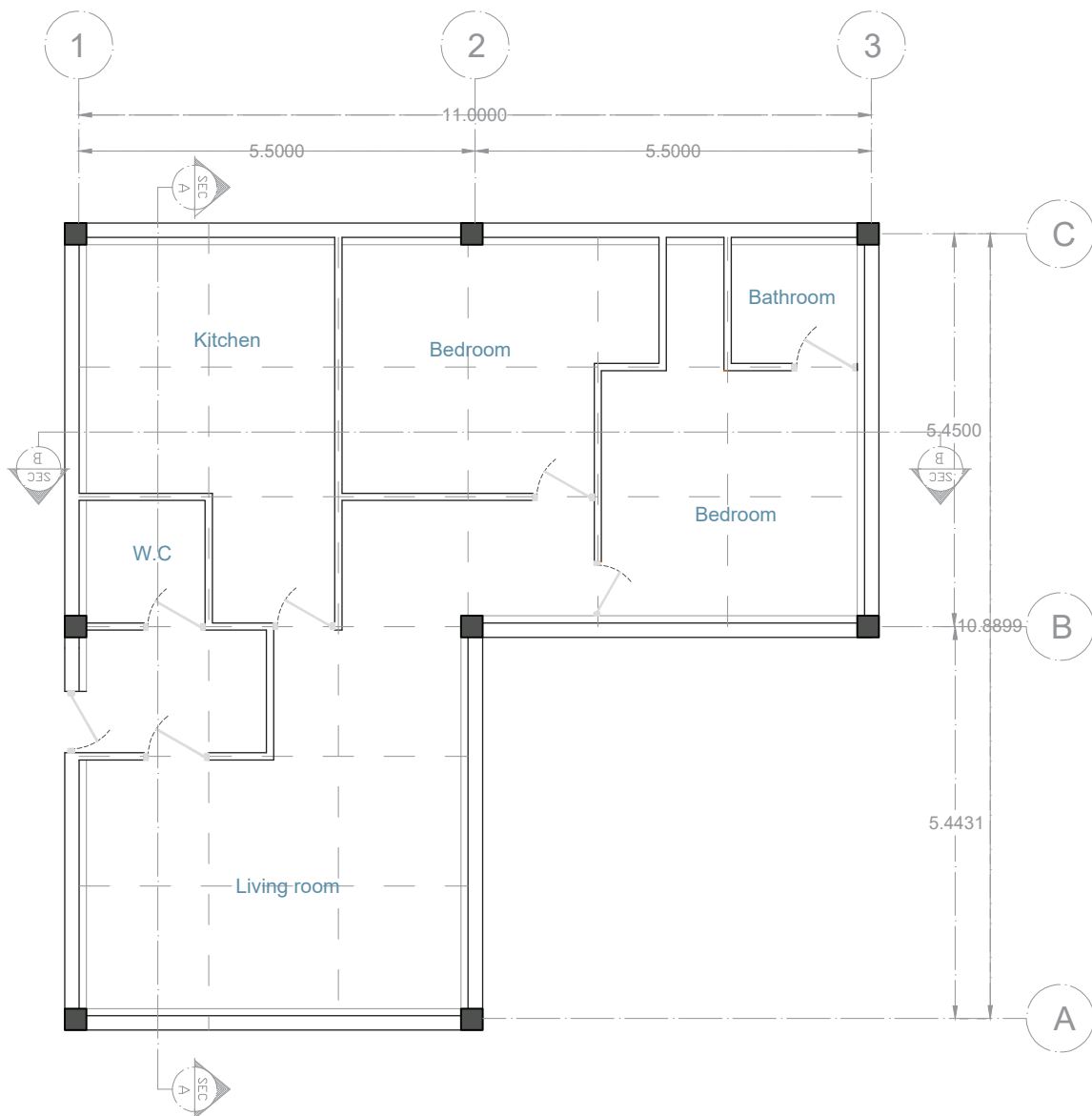
90 m²

Picture number 35: plan unit 90 m²-SC 1.100 (source: author)

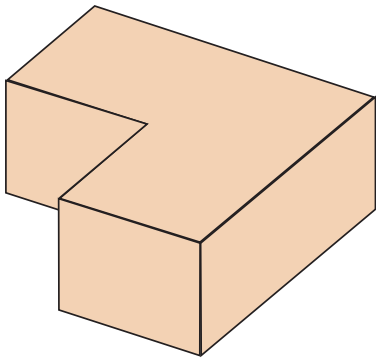


90 m²

Picture number 36: plan unit 90 m² SC 1.100 (source: author)

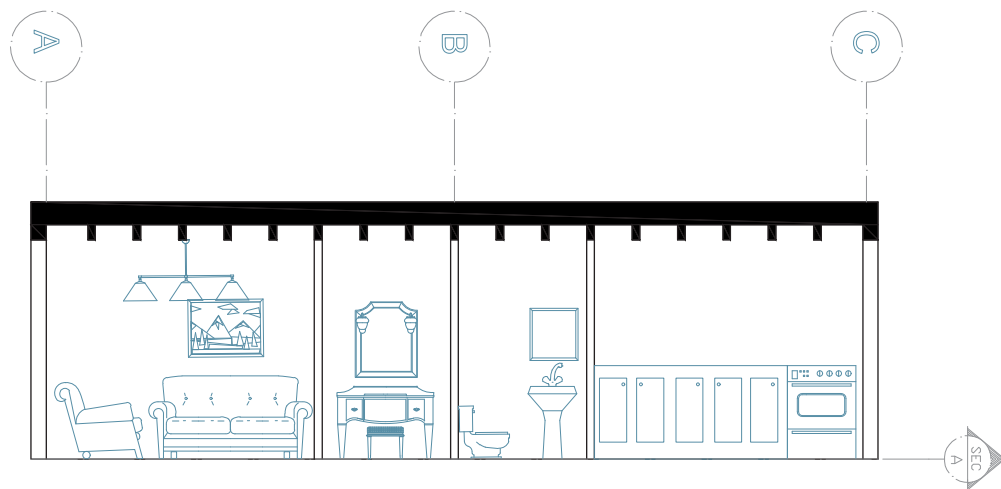
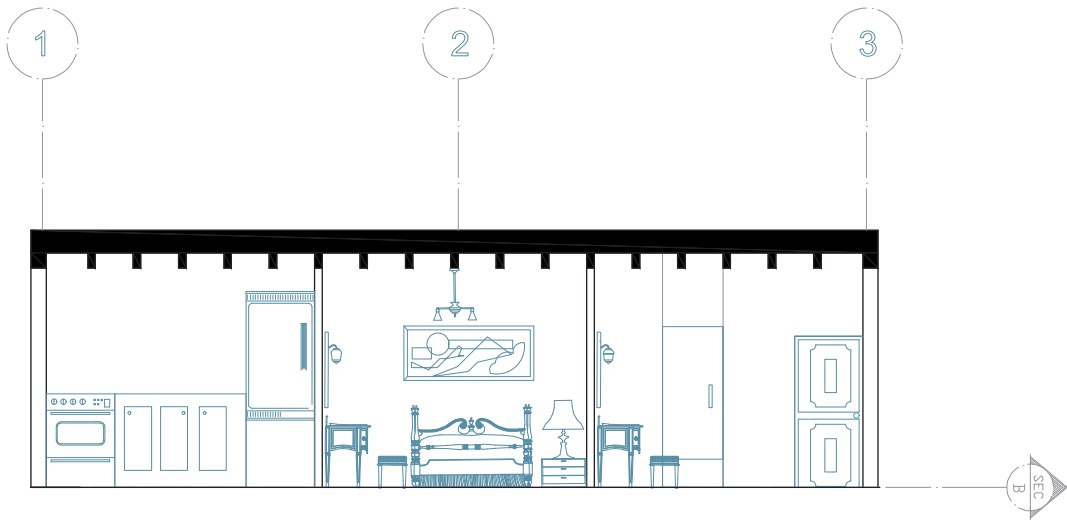


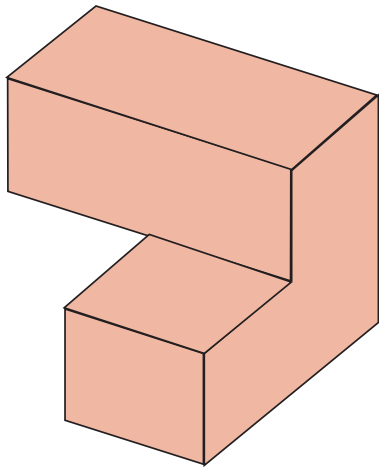
90 m²



90 m²

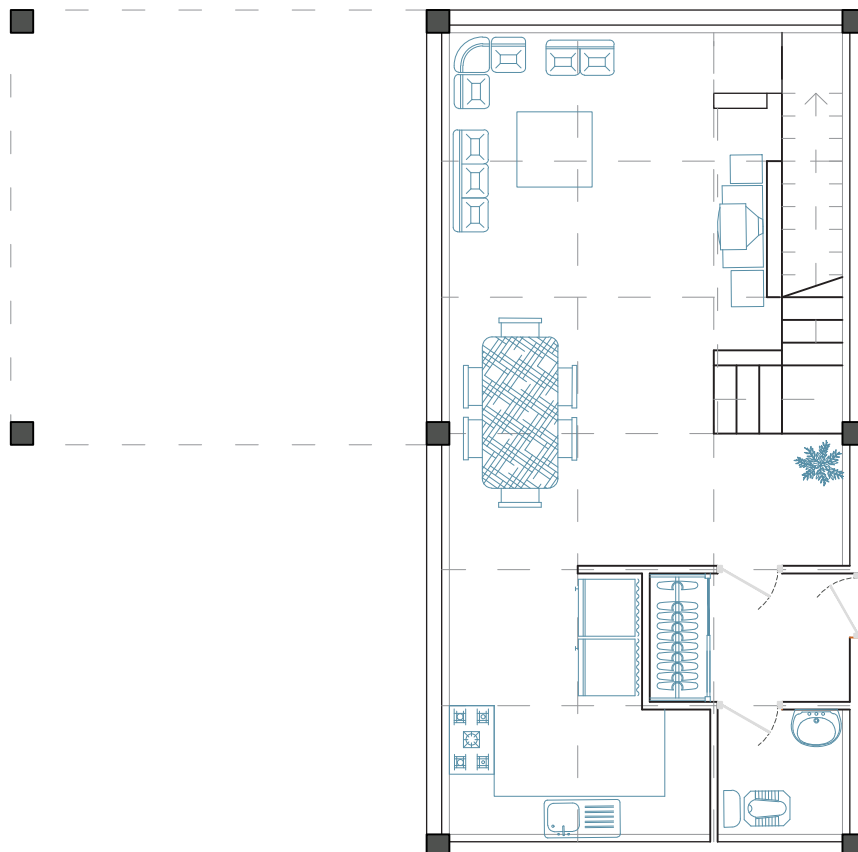
Picture number 37: Section unit 90 m², SC 1.100 (source: author)



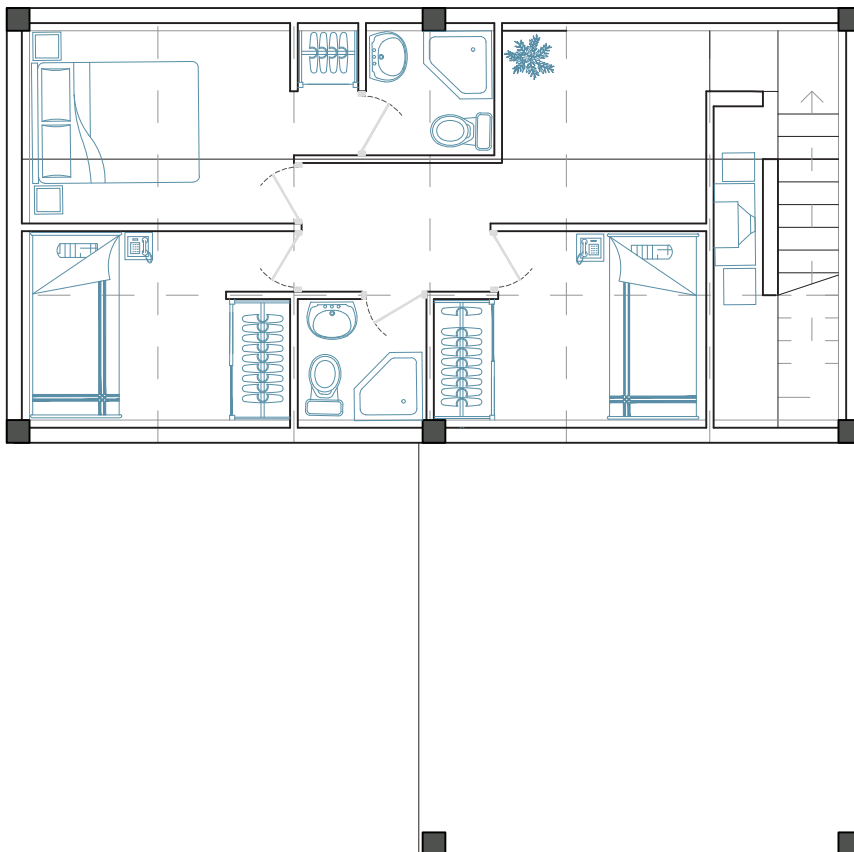


Picture number 38: plan unit 120 m² SC 1.100 (source: author)

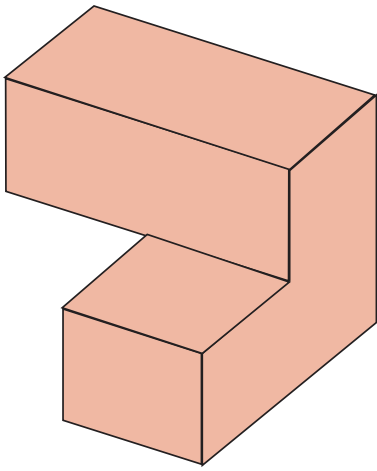
120 m²



120 m²

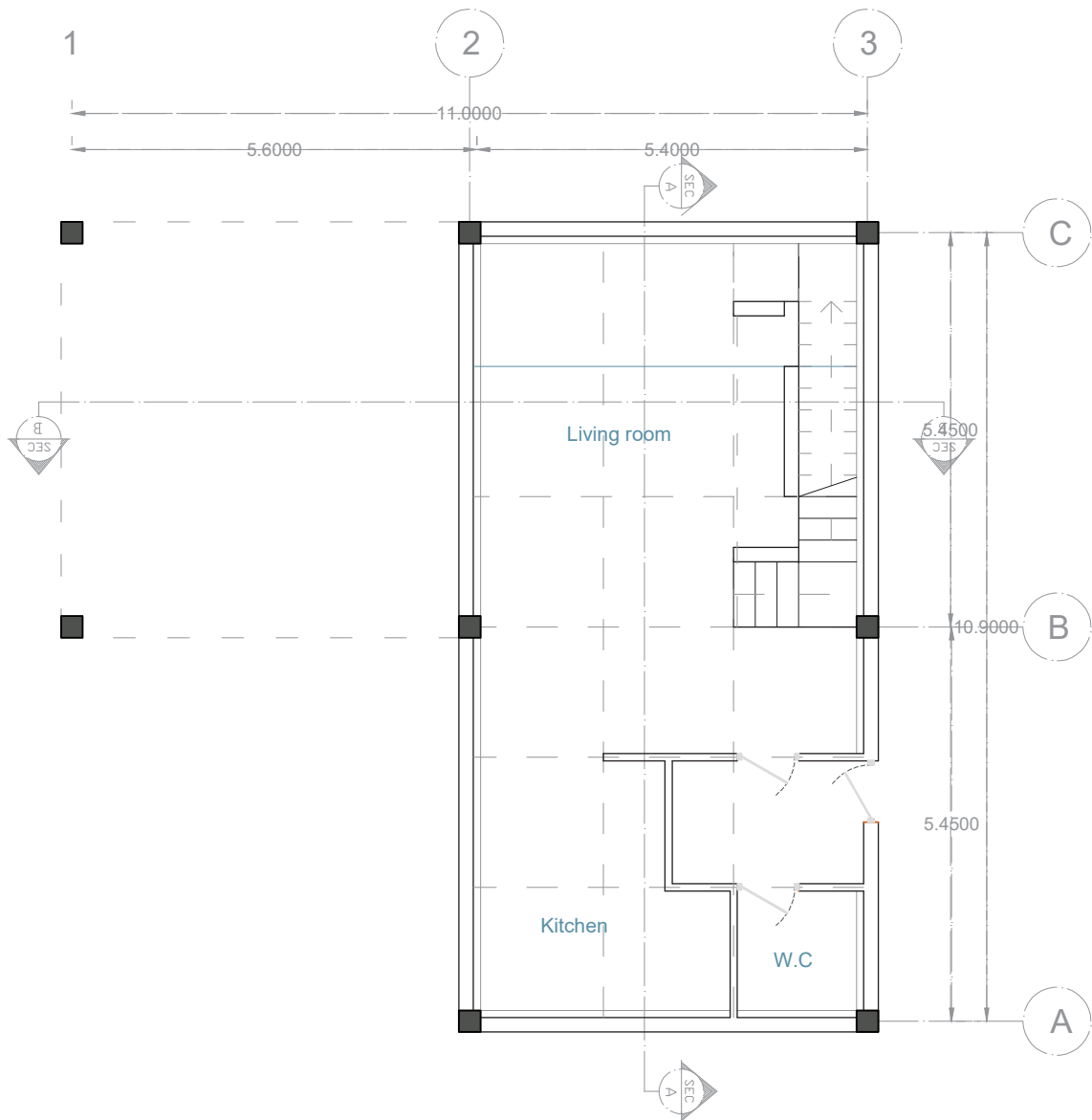


120 m²



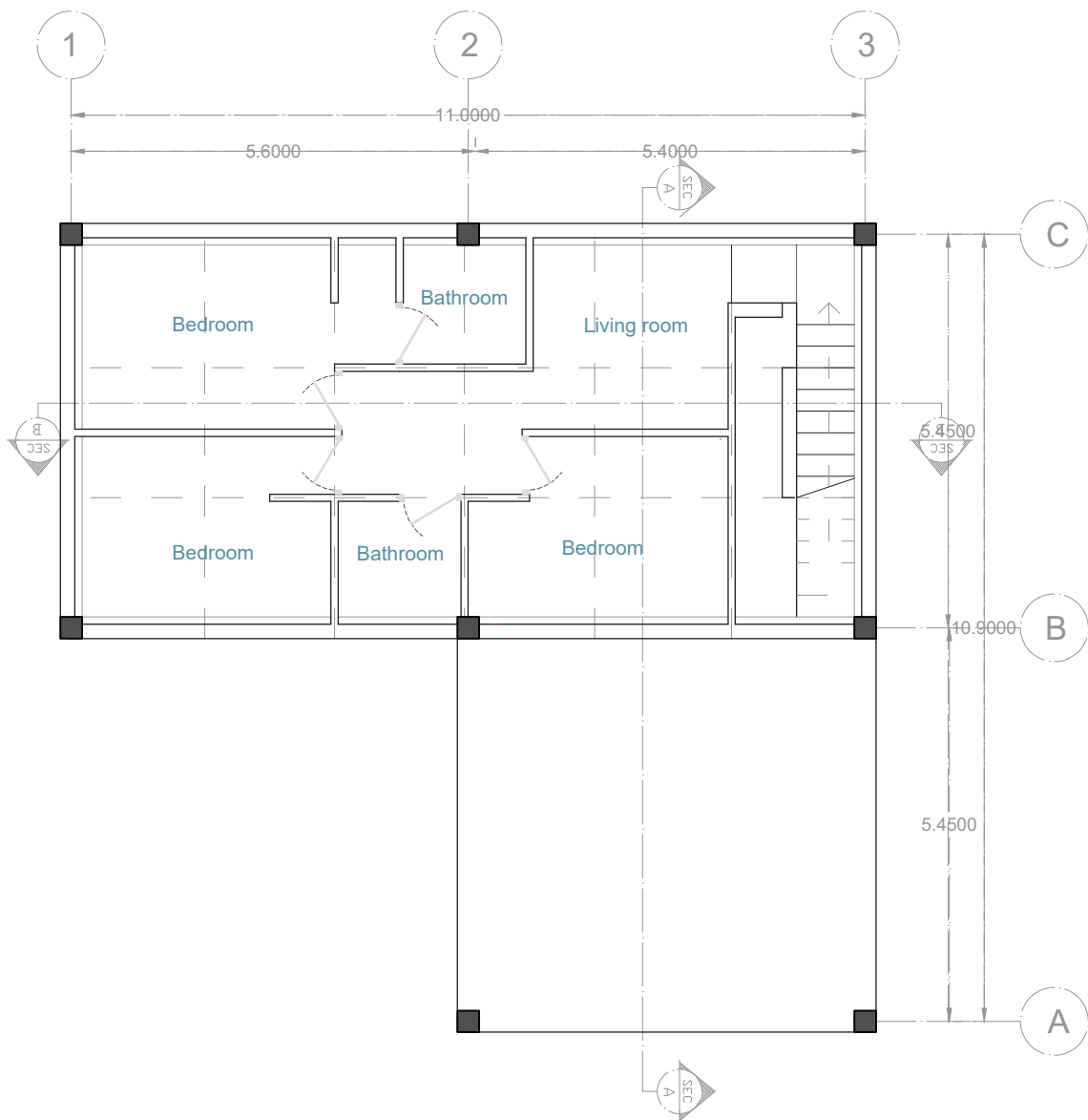
Picture number 40: plan unit 120 m² SC 1.100 (source: author)

120 m²

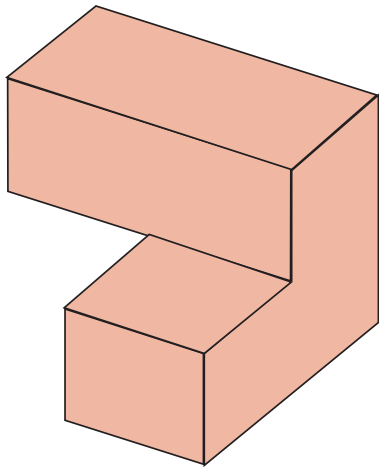


120 m²

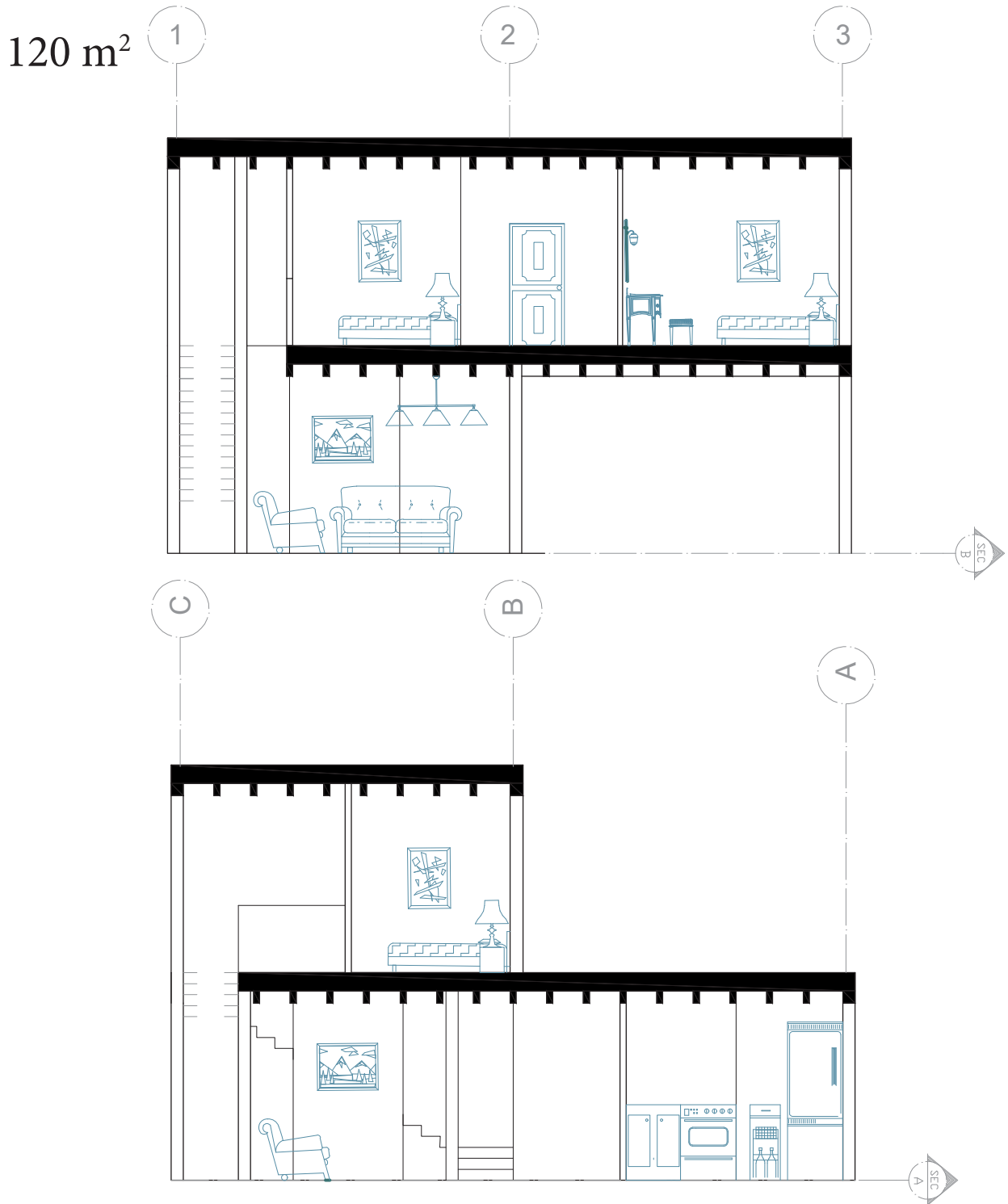
Picture number 41: plan unit 120 m² SC 1.100 (source: author)



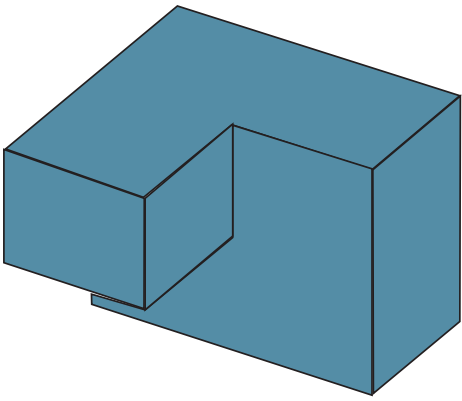
120 m²



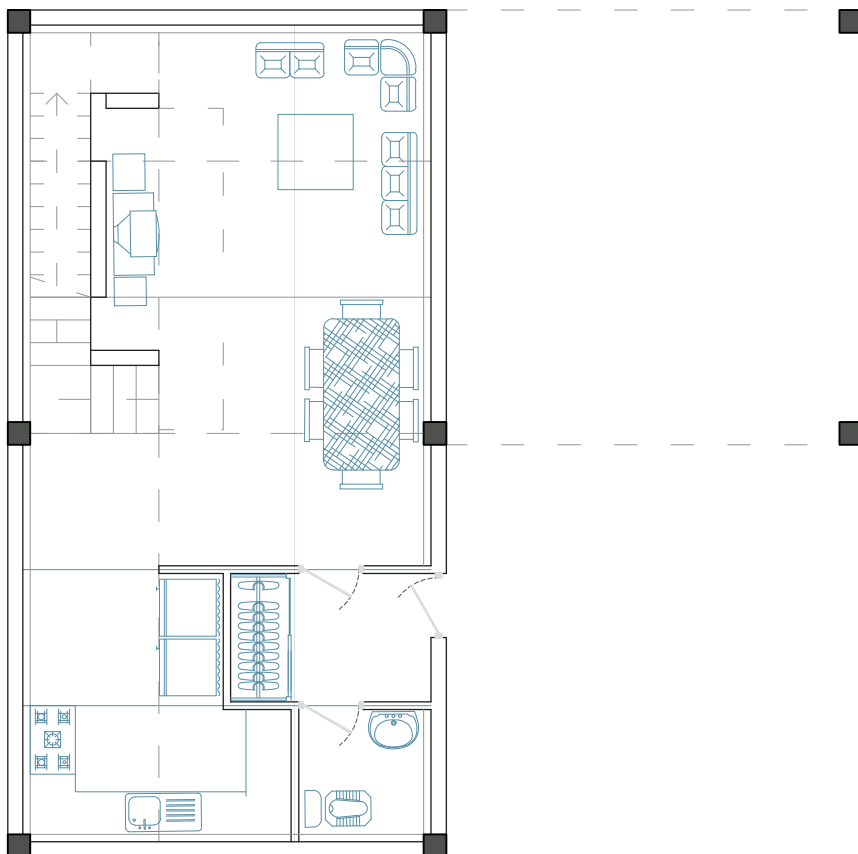
Picture number 42: Section unit 120 m², SC 1.100 (source: author)



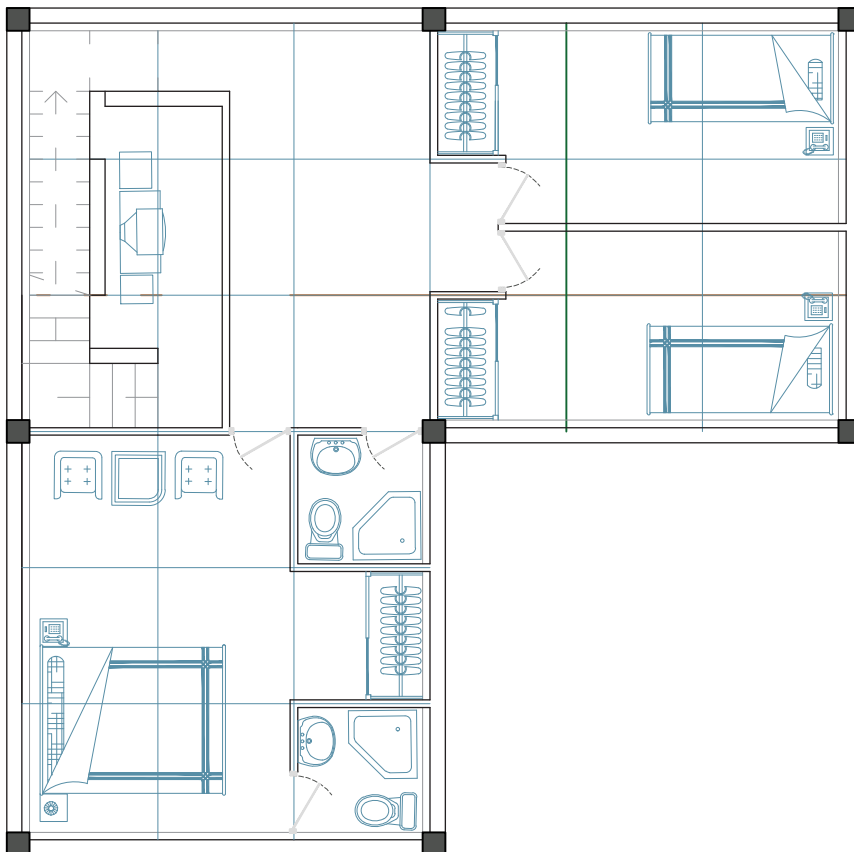
Picture number 43: plan
unit 150 m² SC 1.100 (source:
author)



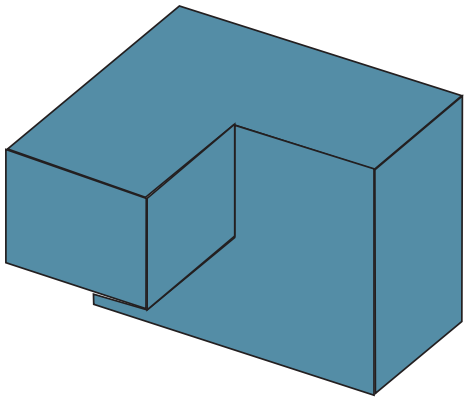
150 m²



150 m²

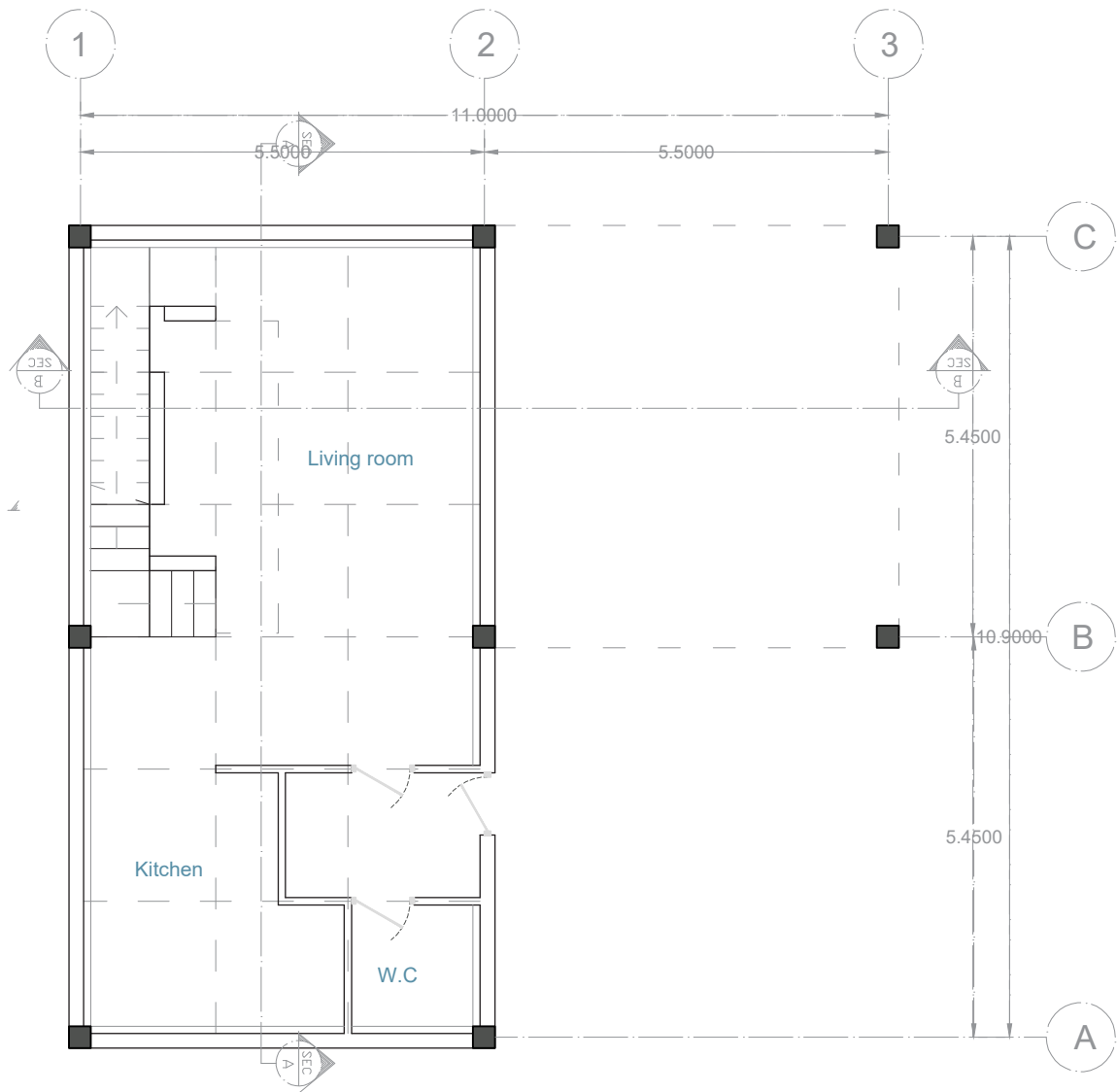


150 m²

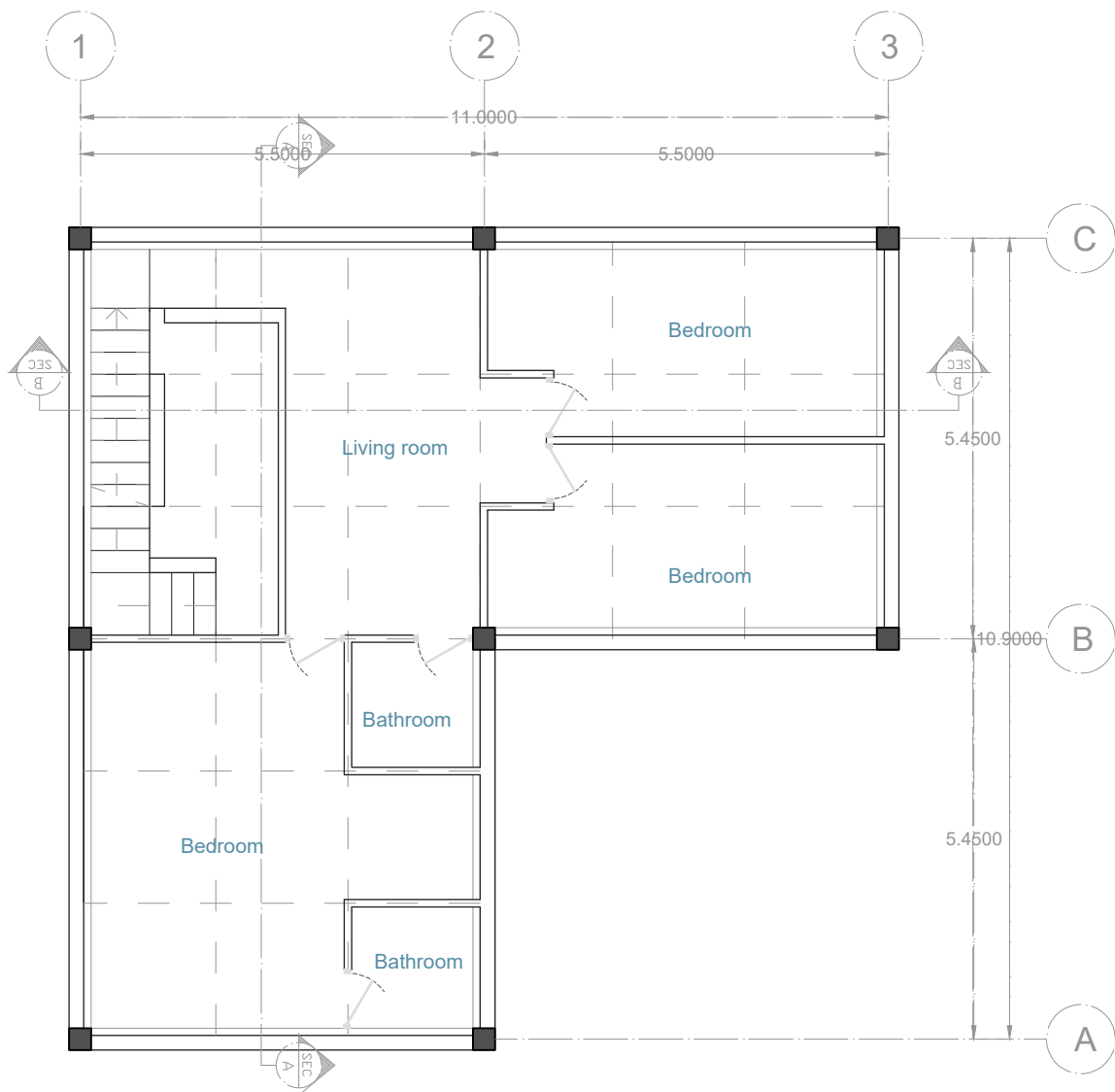


Picture number 45: plan unit 150 m² SC 1.100 (source: author)

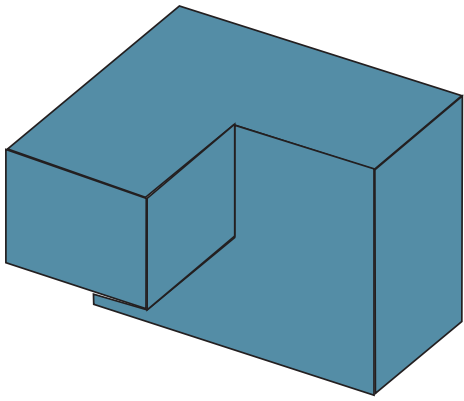
150 m²



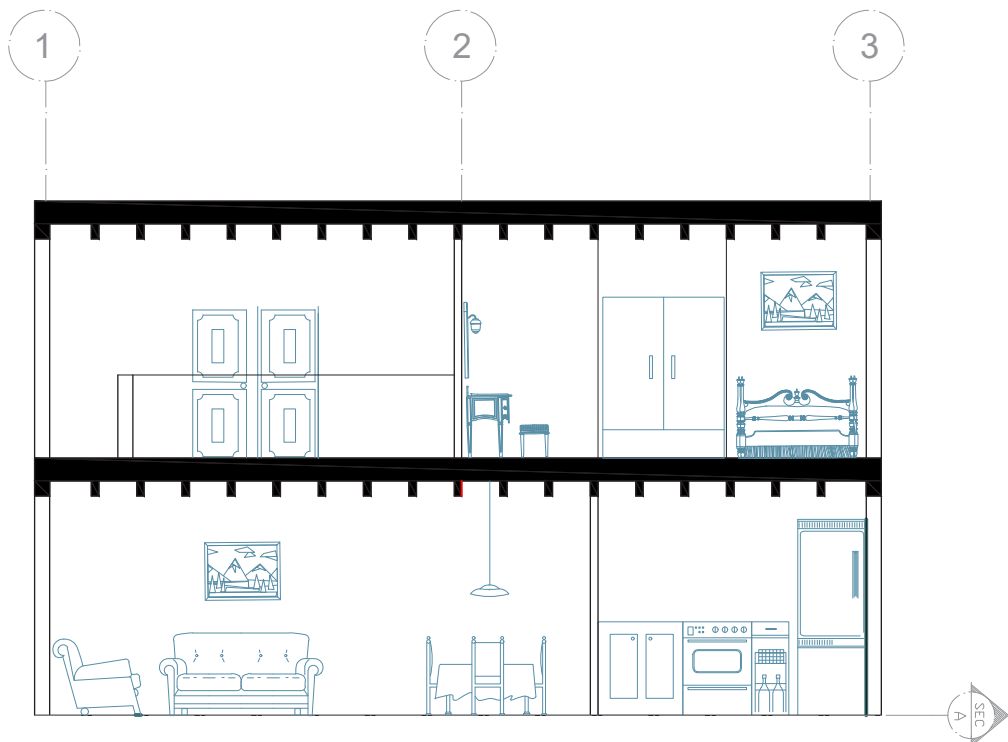
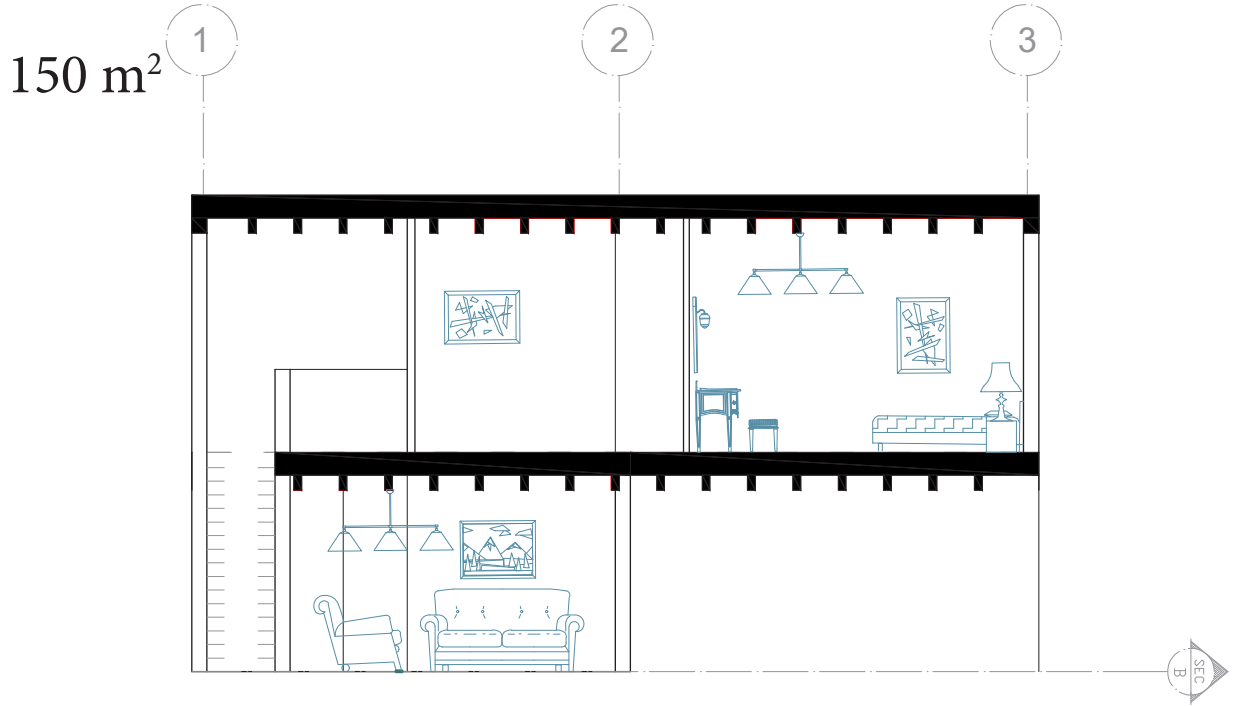
150 m²



150 m²



Picture number 47: Section unit 150 m², SC 1.100 (source: author)



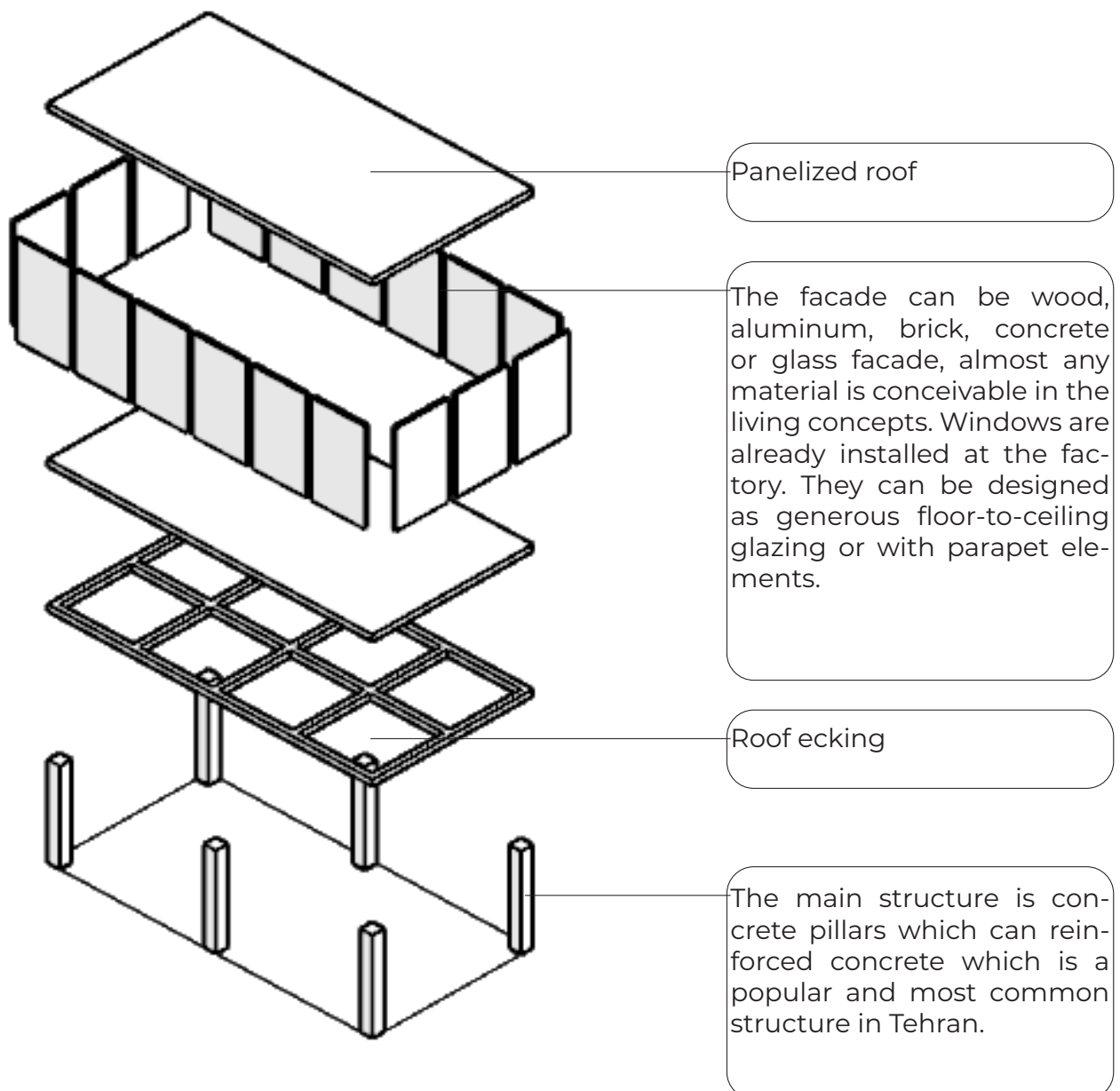
4.4 Which system and structure

Diagram number 3: structure system (source: author)

Combination of concrete structure and modular prefabricated units: As we know already concrete structure is really successful in Iran. We can have a concrete structure as a mesh in the site and add buildings as units in the site. With this system, we can have the possibility to extend add, or even remove units and have a variety of neighborhoods to achieve the cultural feature known as living in the colony.

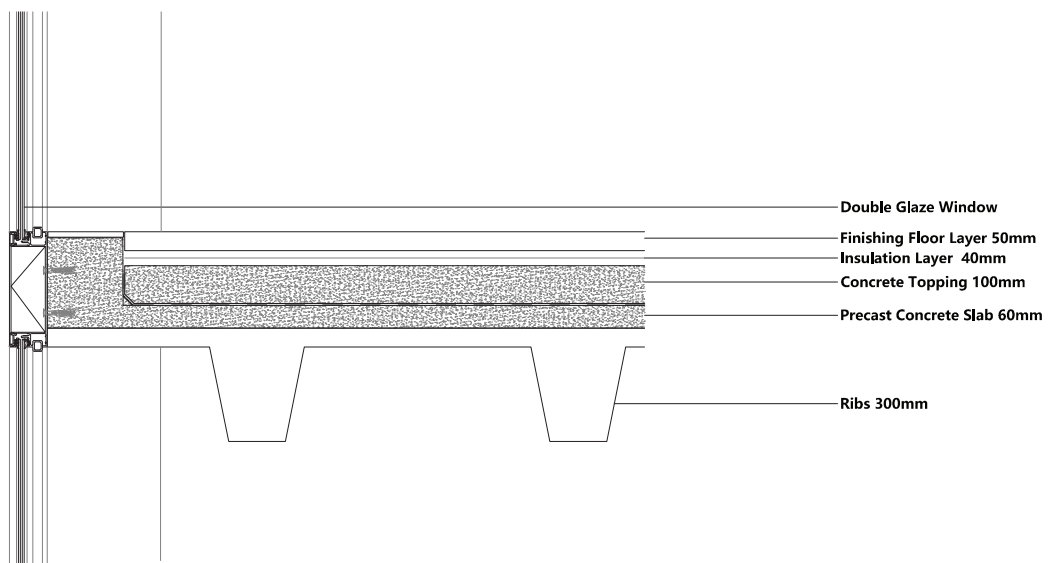
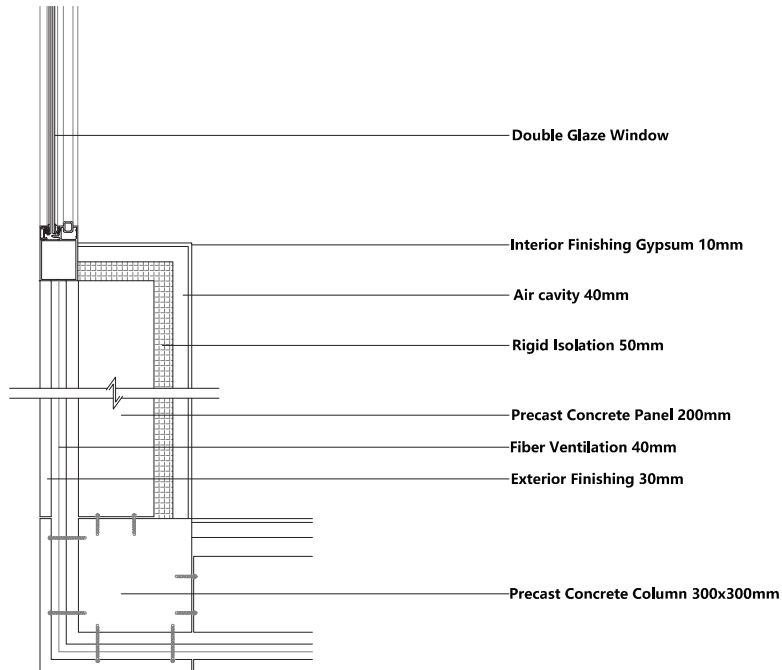
4.4.1 Prefabricated units

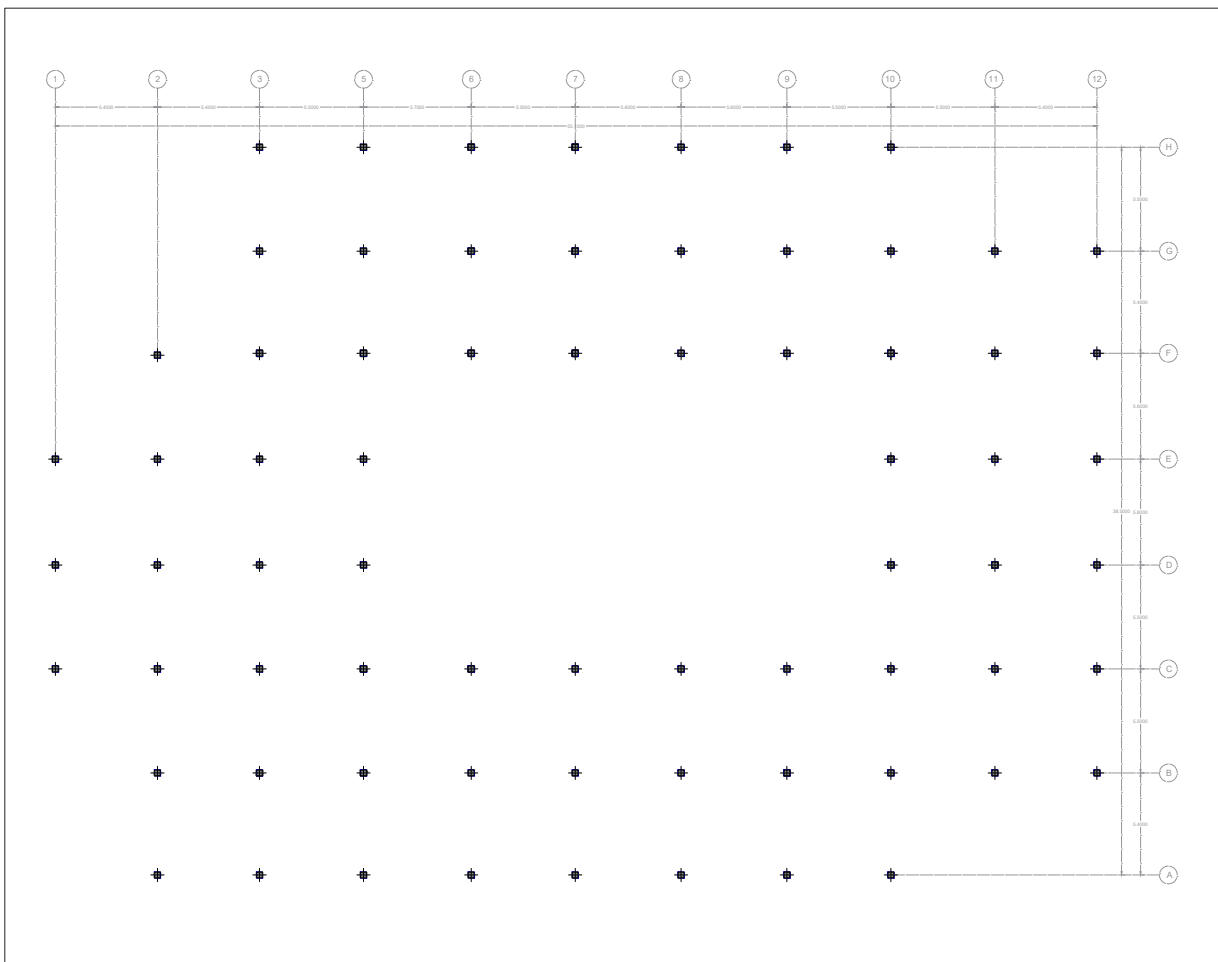
The high level of prefabrication reduces the duration of the construction site by up to 50 percent. There is also the effect of simultaneity. While the underground car park is being concreted on the construction site, the modules can already be manufactured in the factory. Shell construction and expansion take place at the same time.



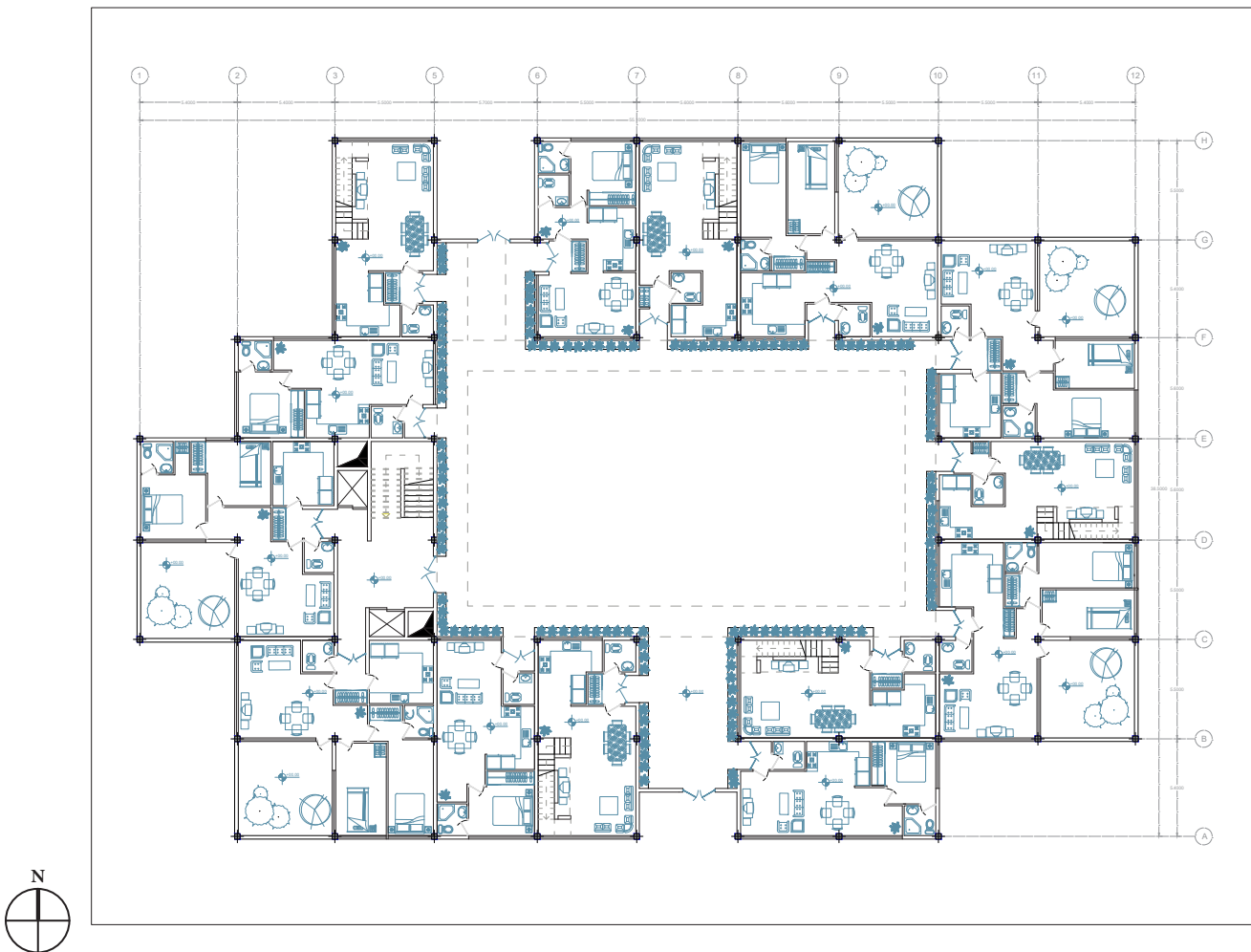
Picture number 48: technical section, SC1.20 (source: author)

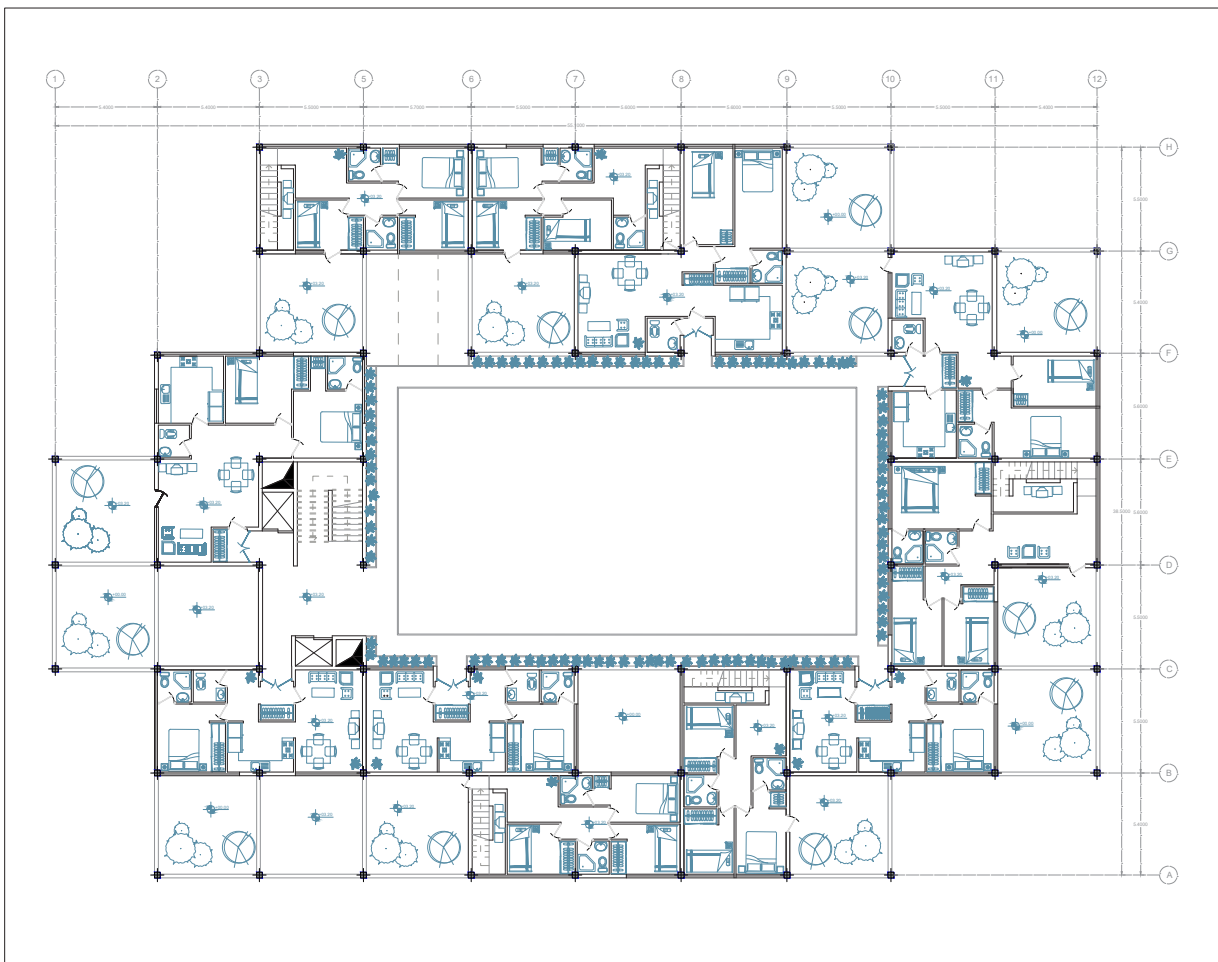
Picture number 49: technical plan, SC 1.20 (source: author)

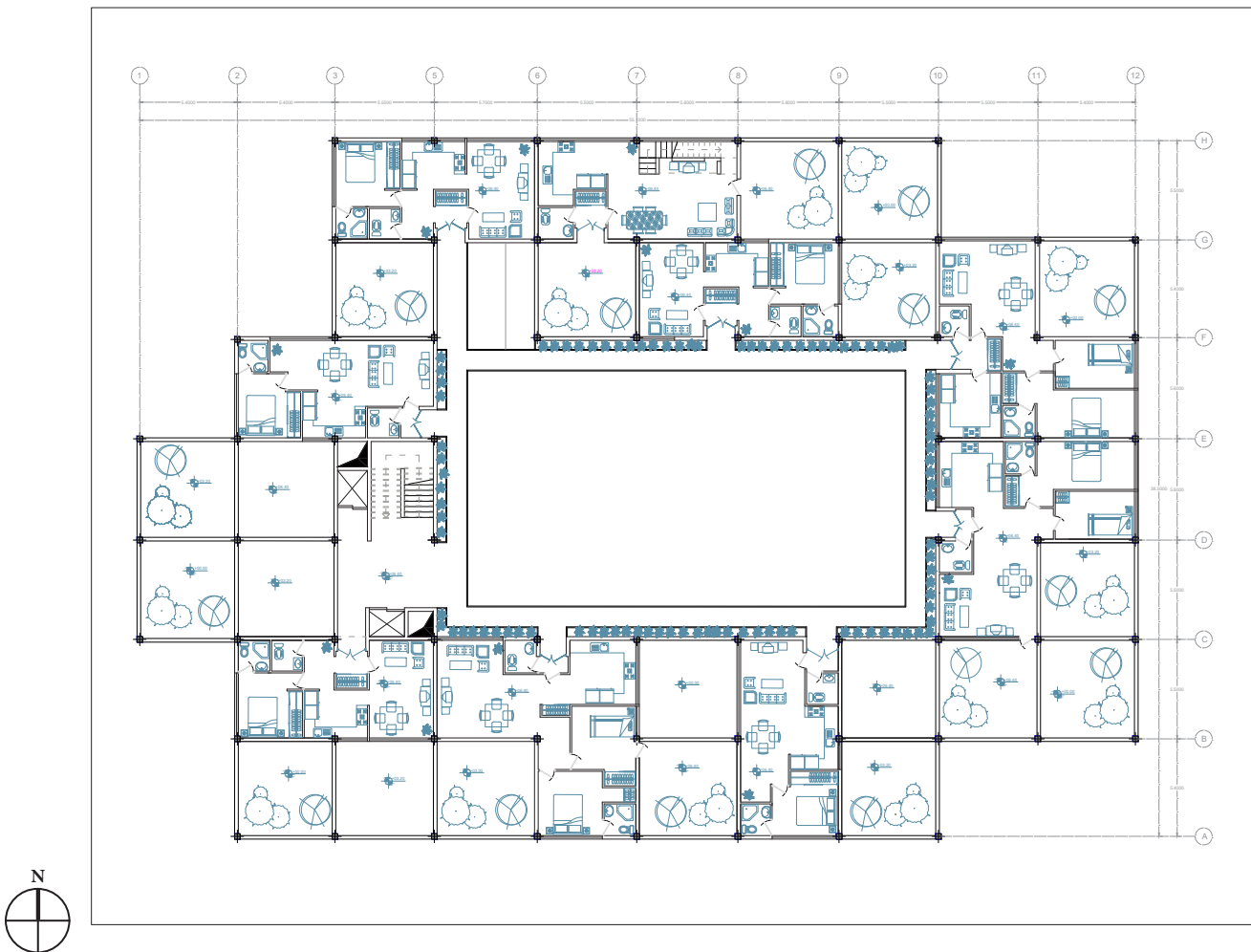




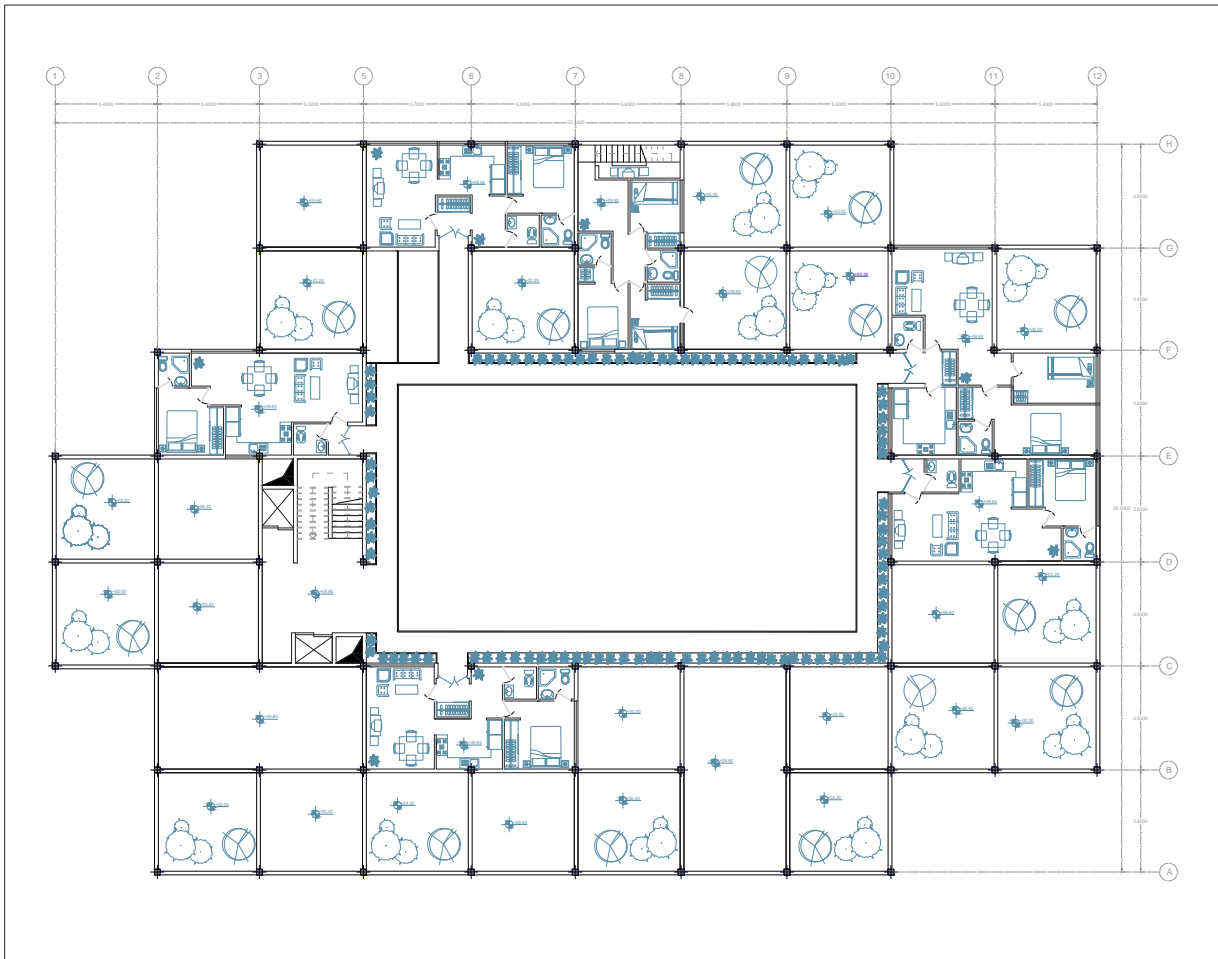
Picture number 51: Ground floor plan (source: author)



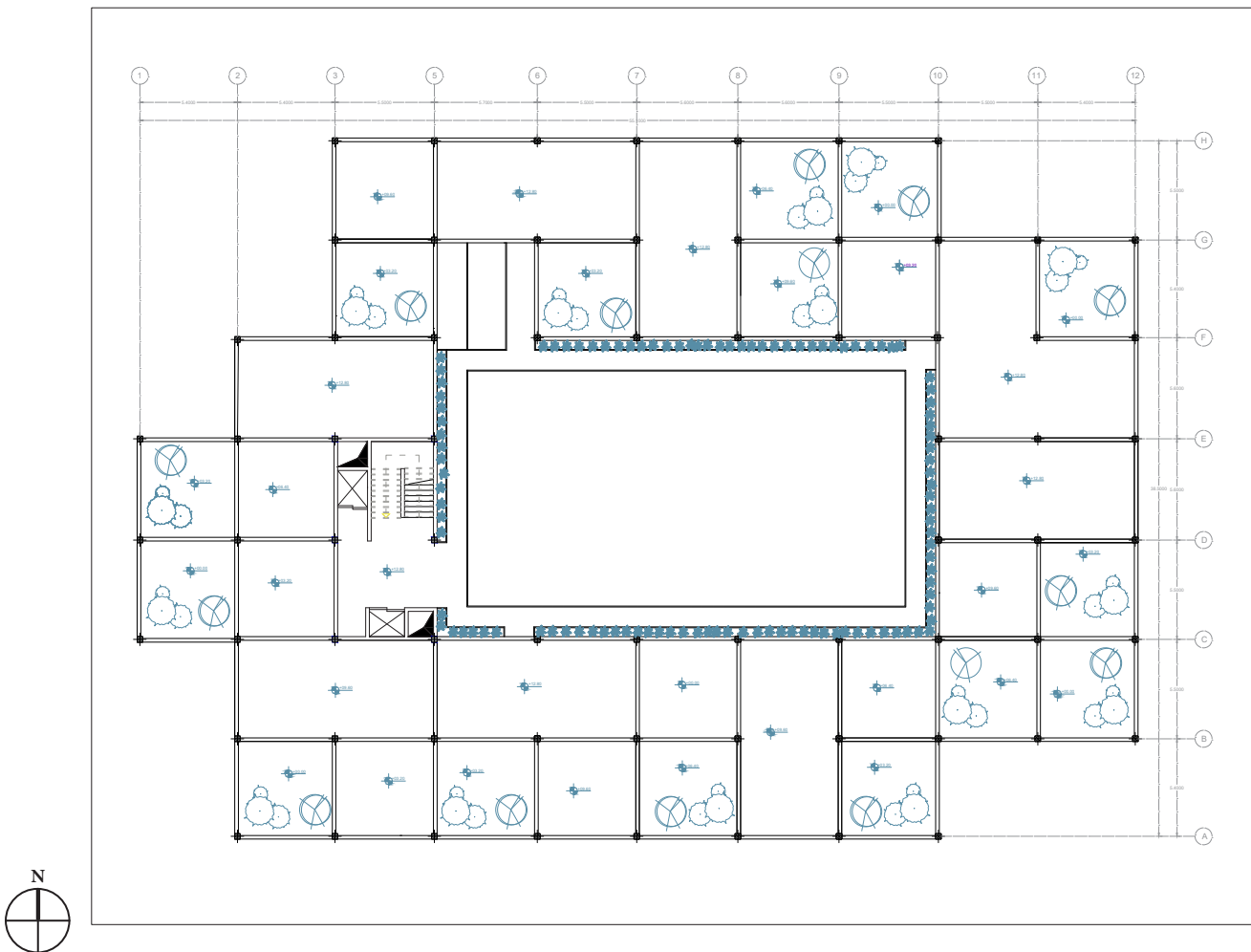




Picture number 54: Third floor (source: author)



Picture number 55: Fourth floor (source: author)



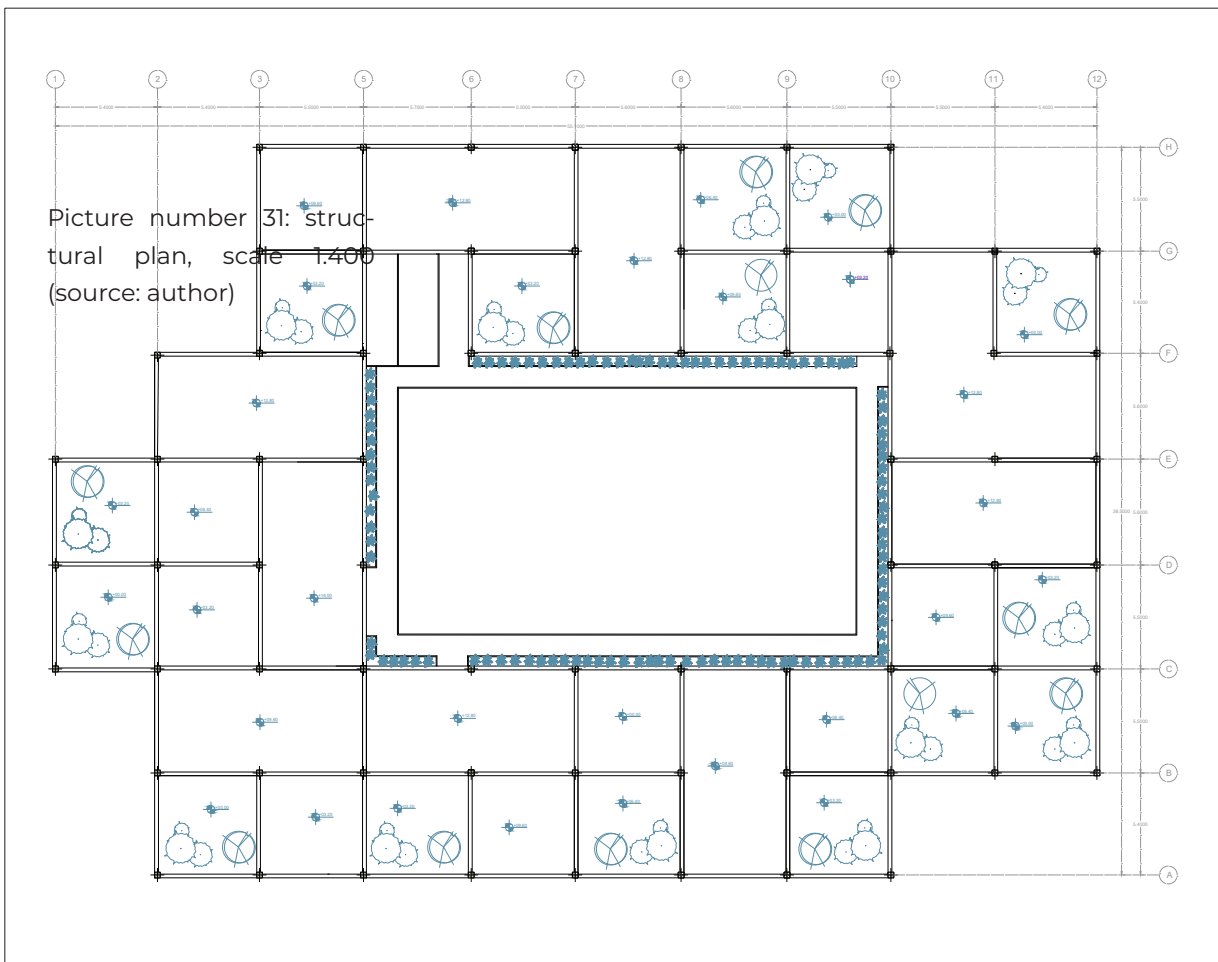


Diagram number 4: Axonometric view (source: author)

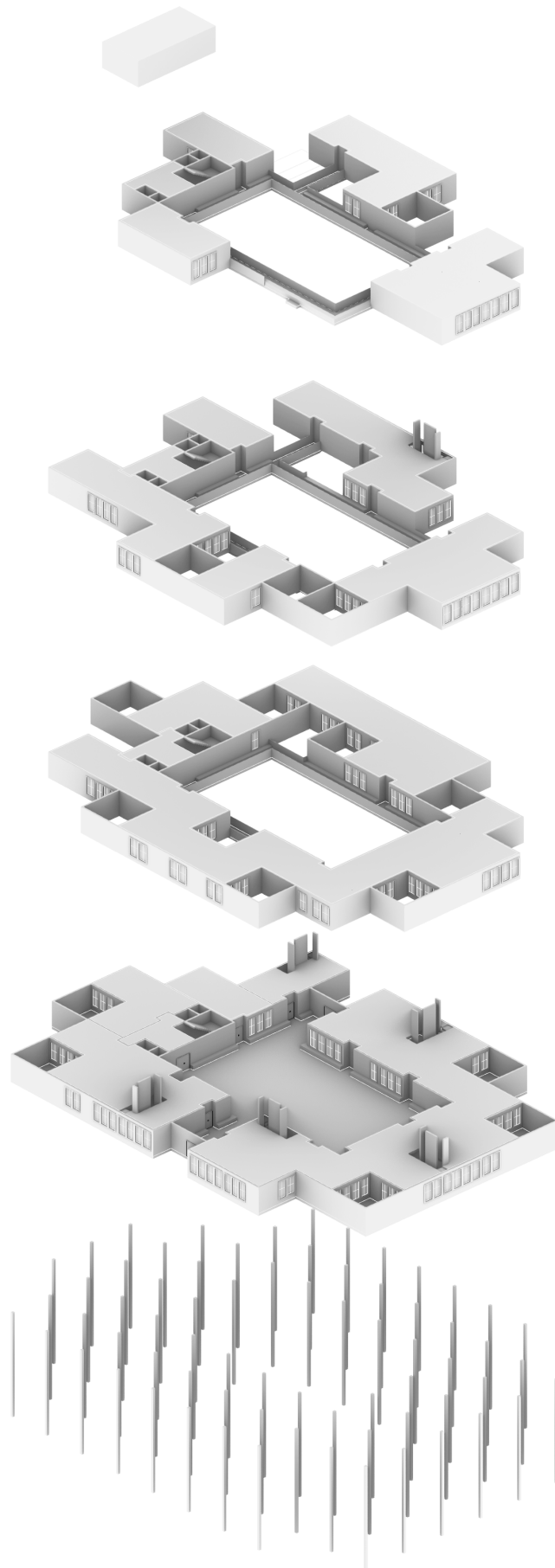
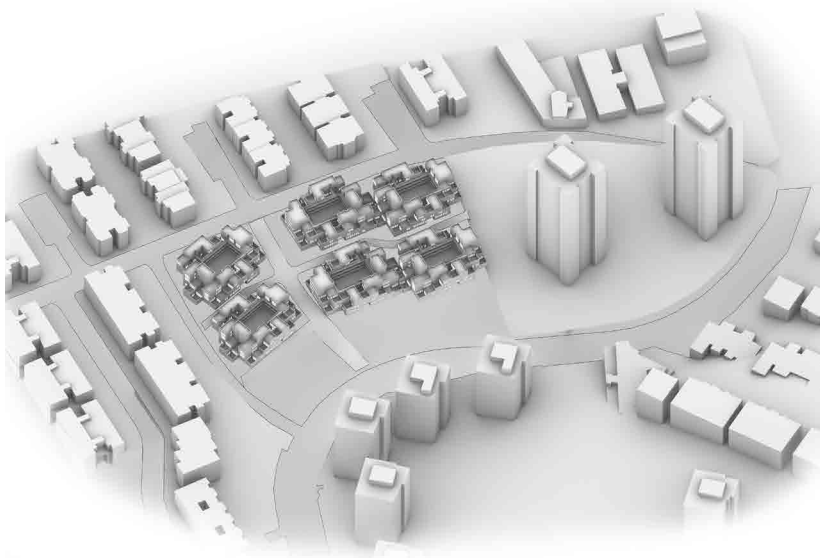
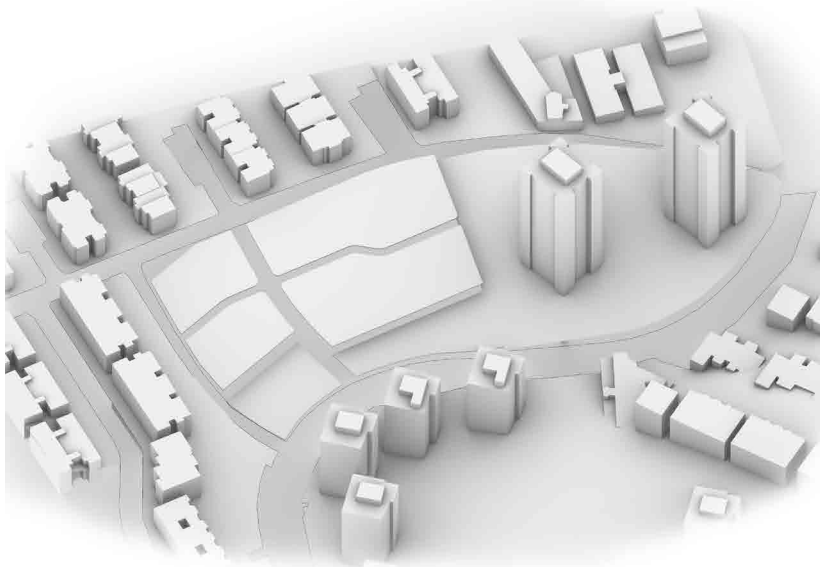
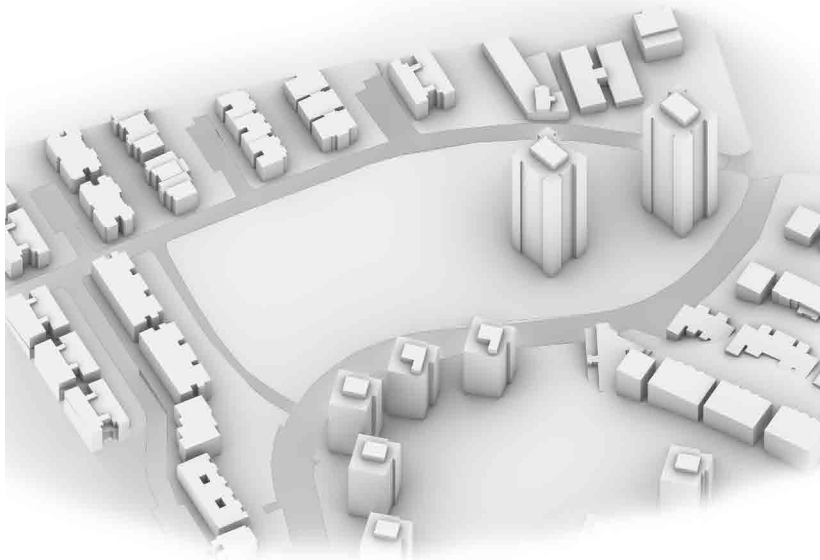


Diagram number 5: Site design (source: author)



4.5 Site analysis

As we mentioned in second chapter, there are 9 meters height different from north to south of the location. For making access from north to south, the site is divided into two pieces, then to solve the height difference, there are 6 different surfaces at different height some of them include residential blocks and some of them are open to the public and green space. Finally, there are 6 blocks, all in all 210 units, all around the siteplan. All of them are in the north part to avoid the shadow of towers.

The green areas are public and accessible by all people, meanwhile, residence in this area have their own private green space, known as a courtyard.

