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SUSTAINABLE, ENERGY SAVEING AND DEVELOPED URBAN AND HOUSING PROJECT IN DISTRICT 6th OF SHIRAZ CITY

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Abstract

Cities are known as dynamic elements and they are constantly evolving and changing. In this regard, city projects must have dynamic features, and changes are inevitable. Also, cities are regularly reviewed and updated to match the new policies and are associated with the new urban conditions.

Rapid changes and transformations have shown that the preparation and implementation of any urban development project, which led to adoption of process approach to sustainable urban planning, first of all need to identify requirements, opportunities and objectives, and afterwards, strategies, policies and the approach. Additionally, over time social relationships are become more complex in this area, thus, knowledge and urbanization has led to the design of new topics. Among the topics for getting people's opinions, urban management participation, understanding the main challenges and bottlenecks can be mentioned. Another important problem of cities in terms of sustainable urban development is energy consumption. Fortunately, recently reduction of energy demand is feasible through modern technologies and criterions in building construction. Therefore, these knowledge and information make it possible to achieve to the one integrated and sustainable urban design.

This project is mostly dealing with the needs and requirements for sustainable housing units and sprawl green network of the city in district 6^{th} of Shiraz and offers a solutions for the energy saving by means of Architectural design/Architectural energy efficiency and employing of solar power systems which at the same time provides net zero energy buildings, and also adequate urban services and a more active social life for residents and offering them comfortable colorful life. And moreover, introducing opportunities and possibilities for energy saving and sustainable urban and housing project in cities of Iran.

Acknowledgement

This project would not have been possible without the support of many people. The authors wish to express their gratitude to their supervisor, Prof. Massimo Tadi who was abundantly helpful and offered invaluable assistance, support and guidance. Deepest gratitude is also due to the members of the supervisory assistant, especially to Prof. Gabriele Masera without his knowledge and assistance this study would not have been successful.

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The authors wish to express their love and gratitude to their beloved families; for their understanding and endless love, through the duration of their studies.

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Chapter 1
Introduction

Introduction

1-1-City of Shiraz

City of Shiraz is situated in Fars province of Iran, and is located in Southern direction in accordance to the capital, Tehran. Geographically, it is located at longitude 32-52'E, latitude 29-37'N and 1,540 meters above the sea level and about 900 kilometers away from capital. Shiraz is the land of royal civilization of the world and of Persian history [1].

Shiraz is one of the most important cities that make the connection between two north-south poles of Iran. This city connecting Bushehr and Bandar-Abass port from south to Rasht, Babol and Chalus ports in the north through the Tehran and Isfahan. For many migrants Shiraz is the place of jobs, recreational facilities and beautiful new and old buildings that attract people. This city has a moderate climate, green nature, several rivers and lakes, also with its old culture this city has been a regional trade center for more than a thousand years. Shiraz was the capital of Iran during the Zand period (1750 to 1781), likewise, briefly during the Saffarid period. With its very old culture and history this city has reputation because of Persian poets, literature, wine and gardens [2]. The word of "shir" has tow meanings in Persian language, "lion" and "milk". Due to the national parks, city gardens and greeneries in the city, among Iranians also it is known as the city of gardens. Among other cities in Iran Shiraz was the city which consist majority of different religious communities in its territory, meanwhile, triangular mosaic, silver ware, pile carpet and Kilim are the crafts of tribes of this city. On the other hand, cement, metalwork, sugar, fertilizers, textile and wood products, and rugs are the main production in industries of Shiraz [3, 4]. Also, it is worthwhile to mention that oil refinery and more than a half of electronic investment for industries is centered here in Shiraz [5]. This city has experienced the technology of first solar power plant and also wind turbine in Iran [6]. These wind turbines are installed in the city near to the Babakooho Mountain.

City of Shiraz has different urban structures, old and modern. The old structure consists of different gates and districts at different times. The modern structure specially has been set up all around the old regions and areas in suburbs. The main purpose of all changes in the Shiraz was to build new appropriate streets that accountable for a vehicular network [1].

This city is captivated by many problems that result damage in environment and reduction in the quality of life of its citizens such as environmental, waste, and pollution that evacuate natural resources. Moreover, in past fifty years before and after revolution there was migration of rural people and small cities around, this is making the situation more difficult.

Process of Shiraz urbanism data; demonstrates that expansion of Shiraz is 46 times, but the population growth is only 15 times since 1921, which shows that Shiraz has lost its compactness in these days. And also data shows of about 200 hectare/year as the yearly average expansion of built up areas. This growth has occupied on former agricultural land and rural areas especially in recent 80 years, and more importantly and sadly agricultural lands were arbitrary for its expansion. It resulted of ruining agricultural activity and displaced it to less productive areas. Many villages and regions have joined in this activity around Shiraz and they lost its cultivated area [1]. Anyhow, Shiraz is among the sixth most popular cities in Iran had 1,455,073 inhabitants in 2009.

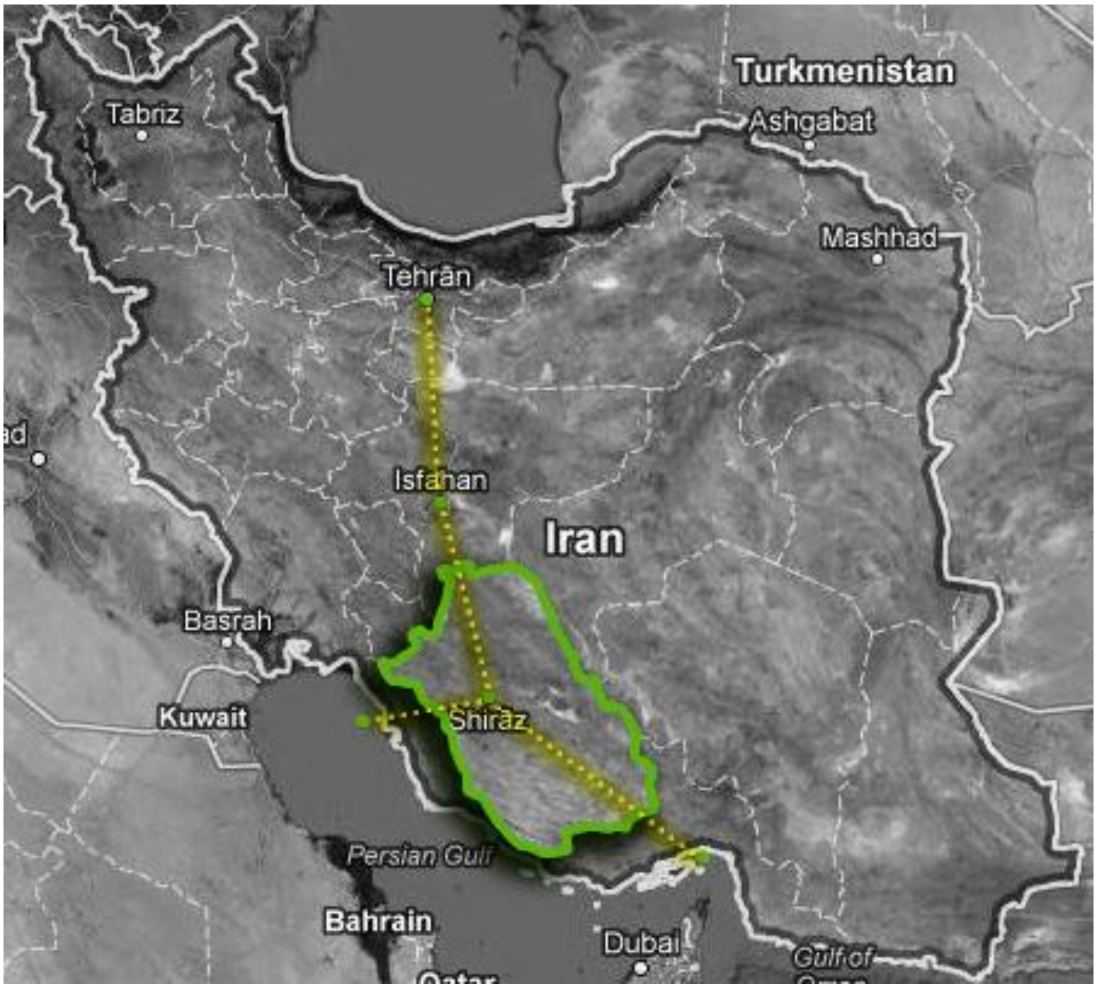


Fig.1. 1.Location of the Shiraz city and connections with other cities and ports

1-1-1-Etymology

In June 1970, while workers were digging for a brick factory the earliest reference to the city is found on Elamite clay tablets dated to 2000 BC, in the south western corner of the city. The tablets were written in ancient Elamite script and a name of the city on it which was Tirazis [7]. The word was arrived from ancient Persian language and going through usual pronunciation change became to current Persian pronunciation and called Shiraz. Also, at Sassanid periods in the eastern portion of the city the word “Shiraz” found on clay sealing. According to the native writers in Iran and from Ferdowsi's Shahnameh one of the well-known between Iranian as oldest historical written; “Tahmures” the third Shah (King) of the world had a son named “Shiraz” [8].

1-1-2-Relation with surroundings & touristic attractions

As mentioned before, city of Shiraz is located in Fars province with its unique climate, historical and touristic attractions; Shiraz surrounded by lakes, seasonal rivers and national parks, including places as “Beheshte Gomshode” means “The lost Paradise”, and Persepolis Palace. The major interest of people in this area (Fars province) is to take the benefits of these sites in weekends and holidays, predominantly in the Persian New Years. In this regard the city also has remarkable wide green lands as Persian gardens inside itself, which gives additional features to the city, in comparison to other cities.

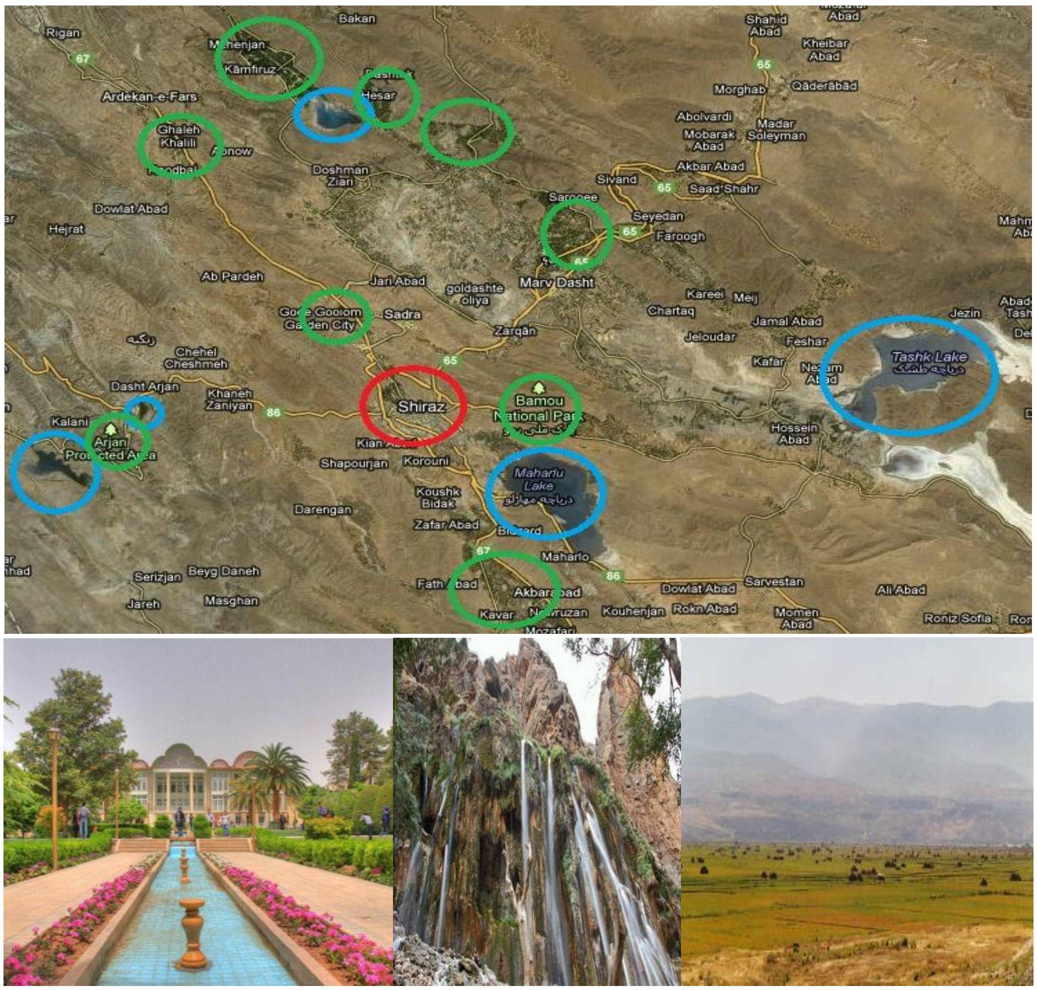


Fig.1. 2.Shiraz with surroundings and touristic attractions

1-1-3-History

Shiraz is most likely more than 4,000 years old [9]. In Achaemenian era, for going from city of Susa to Perspolis palace and Pasargadae place the road was connected by city of Shiraz and this city was on the way. The Persian Emperor Artabanus V expanded his rule over Shiraz, again according to Shahnameh, and Based on many Iranian mythological traditions, shiraz was originally arose by Tahmures, and afterward fell to ruin [10]. It should be mentioned that the oldest sample of wine on clay jars which related to about 7,000 years ago was found and recovered around city of Shiraz [11].

After the Arab invasion, Shiraz became a capital of Fars province for a while and then from 945 to 1055 the Buwahid Empire ruled it as their capital, and they build new buildings, library and an extended city wall in this period [17]. Between the important Iranian prominent figures that born in Shiraz were the Saadi and Hafez [12, 13], and in the part of mystic there were Roozbehan, and as a philosopher were MulahSadra [14]. Therefore, Shiraz was called “The Athens of Iran" [15].

Fig.1. 3.Left: Quran gate in Shiraz entrance, Right: Persepolis

From the early 11th century to 14th century Shiraz had several hundred thousand people and sixty thousand inhabitants respectively [16]. In the 16th century its population growth arrived to 200,000 inhabitants, but interestingly during the 18th century it is declined to only 50,000 people. Shiraz suffered a period of downfall, deteriorated by the Afghans attack after the fall of the Safavids Empire, and the uprising of its ruler against Nader Shah; whom sent troops to suppress the revolt then the city was surrounded for several months and in the long run despoiled. In 1747 when Nader Shah was murdered, major historical monuments of the city were damaged or devastated, and its population fell to 50,000 [17]. The erector of the Safavid dynasty the Ismail I conquered Shiraz (1504). Shiraz stayed as capital of Fars from 1501 to 1722 during the Safavid Empire. The governor of Fars Emam Koli Khan, build up many monuments and clad buildings in the same style as those built in Isfahan during the same period [17]. In 1762, Shiraz returned to success under the rule of Karim Khan Zand in very short time, and again the city became a capital of Iran, and constructed a royal area with a castle, administrative monuments, one of the finest covered bazaars and a well-known mosque in Iran [17]. The ruler also built a ditch around the city and reconstructed the city walls, and he built cleaver system for irrigation and drainage [17]. When the erector of the Qajar dynasty, Agha Mohamad Khan, finally came to power, he removed the national capital to Tehran and took his revenge on Shiraz by deteriorate the city's infrastructures [17]. Although, city was lowered to the level of a provincial capital, Shiraz stayed at the order of success, which caused by the continuity importance of the commerce path to the Persian Gulf [17]. Several famous national parks and gardens, monuments and buildings constructed during this period contribute to the city's present skyline.

1-2-Urban studies

Since the cities are as dynamic elements, they are constantly evolving and changing; city projects must have dynamics features and changes are inevitable. Also, cities are regularly reviewed and updated to match the new policies and are associated with the new conditions. Rapid changes and transformations that led to adoption of process approach to urban planning, has shown that the preparation and implementation of any urban development project, first of all requires identifying needs and opportunities, and objectives, Strategies and policies, and the approach.

Over time social relationships had become more complex, knowledge and urbanization has led to the design of new topics. Among the topics for getting people's opinions, urban management participation, understanding the main challenges and bottlenecks can be mentioned. Projects of this kind of attitude can meet public needs and the level of urban management that had to make decisions on urban development issues in general which can supply help [18]. The main social structure difference between less developed and developed countries lays in the social living behavior. Thus, imitation in urban planning of other communities cannot categories the other community's needs. Meanwhile, developed countries knowledge and experiences in basis of the new urbanism and planning are inevitable. However, this does not mean to take the transcription which is done by other communities. In this regard, first there is a need to identify urban indigenous accurately, then use the knowledge and provide Strategies consistent with the needs of this specific community, based on scientific principles [18].

This residential project is located in 6th area of Shiraz city which is related to the 6th municipality and one of the finest districts in this city. Thus in this regard, accurate urban indigenous study and analysis are shown in the following topics lead to provide design strategies from appropriate knowledge and based on the mentioned district's community needs.

1-2-1-City development of Shiraz

During the long era, different metamorphosis can be identified for city of Shiraz. Individually, the city has expanded extraordinary and its very old formation was complemented by massive new urban improvements. But, now, it has two different structures, old and modern. The old structure consists of different gates and districts at different times. The modern structure has been specially built up around the old regions in margins. Subsequently, one of its metamorphoses had begun about 250 years ago, when the city was assigned the capital of Iran. During this time, the city became a renowned city, with the magnificence of functioning urban spaces and foundation. The other transformation of the city occurred in the more contemporary stages, when the city changed into a modern city. Like any other Iranian important cities, Shiraz has been the subject matter of a most program of road network and physical reforming. The comprehensive plans for the city significantly transformed city of Shiraz resulted by these extremist shifts [19].

Today Shiraz is a large, modern and has inherited a massive inheritance, but is faced with the problems made by the encounters between its past and present. Whilst, development happened in the 18th century mainly were in connection with the traditional formation of the city, but the 20th century transformations were in complete contrast with the past [19].

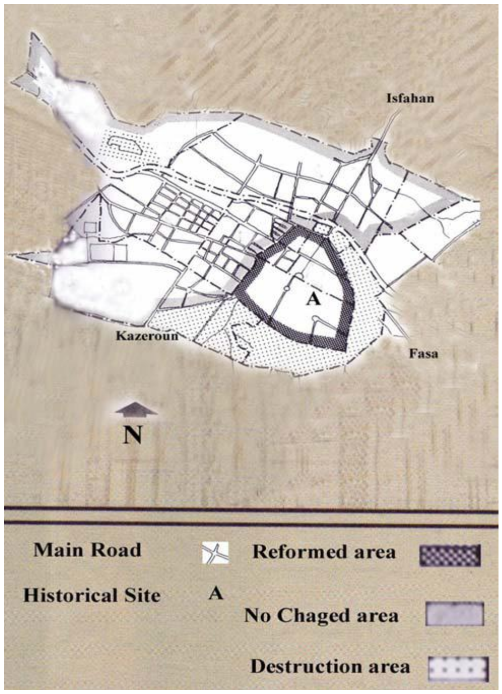


Fig.1. 4.Shiraz proposed Master Plan in 1966 [19]

In 1966 Tehran University department of architecture submitted the Shiraz's primary master plan, right after the first plan of roadway building in Shiraz. The produced program and plan by these designers were provocatively radical (Figure1.4). A rectangular grid of roadways planed for vehicular has been superimposed on the older grid without smallest observance to the historic transformation and older templates of enhancement. The operational land area for various urban agents expanded from 22 km^2 in 1962 to around 80 km^2 in 1992 [19].

In last 20 years several gardens of Shiraz started to disappear. The reasons are that these areas have become very marvelous for new apartments and commercial developments. On the other hand, these sites carry great potentials for a new urban formation. Unfavorable the traditional reformations which were gradual and adaptive, the modern developments have been rapid, large-scale and ruinous [19].

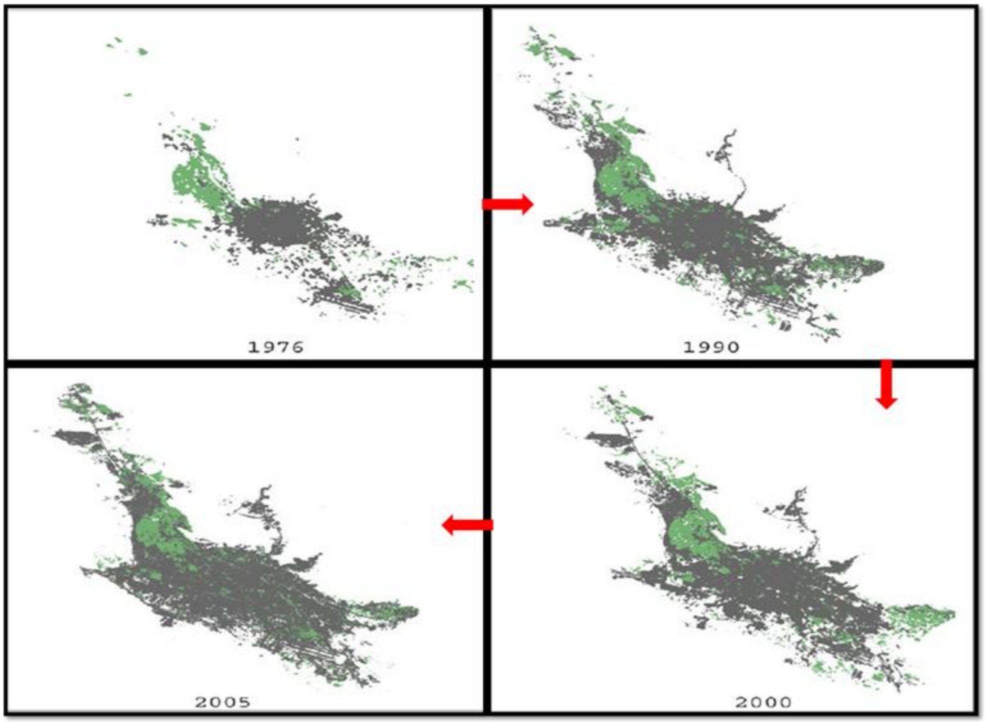


Fig.1. 5.Shiraz city development plan [21]

City of Shiraz linearly expanded in last 40 years and is clearly shown in Figure 1.5 and 1.6. The city is growing towards north-west and south-east due to the siege of mountains all around.

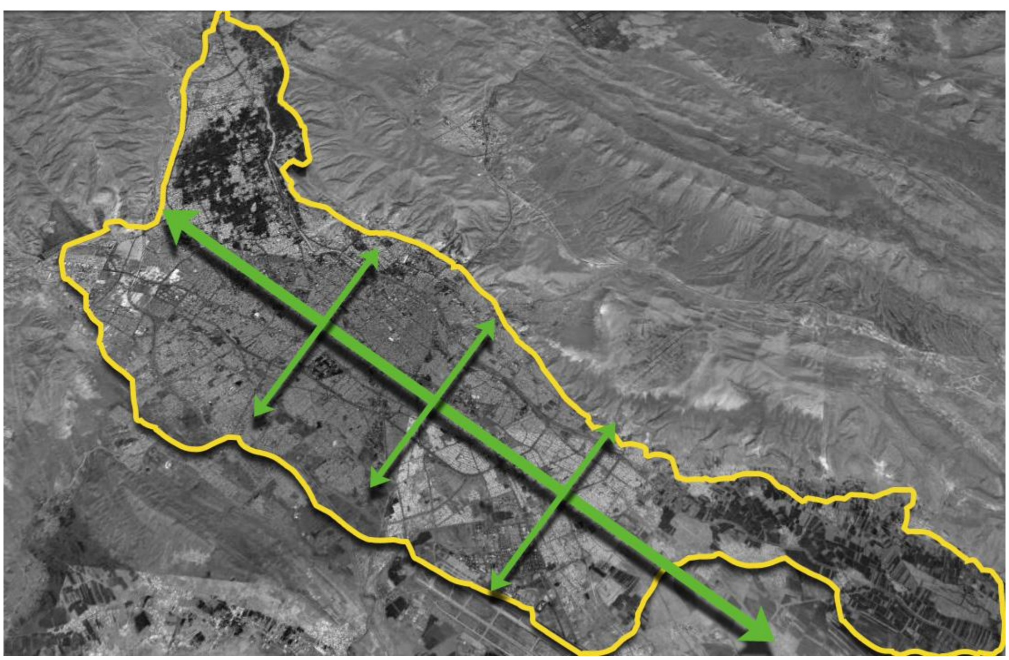


Fig.1. 6.Shiraz city development directions

But this deterrent also was not being able to prevent the city from its growing. And the city has been growing and becoming more widespread. Thus, the city has continued to expand, but in a different way by establishing new small towns and villages on this linear path and by connecting of these small towns to one another Shiraz is growing wider.

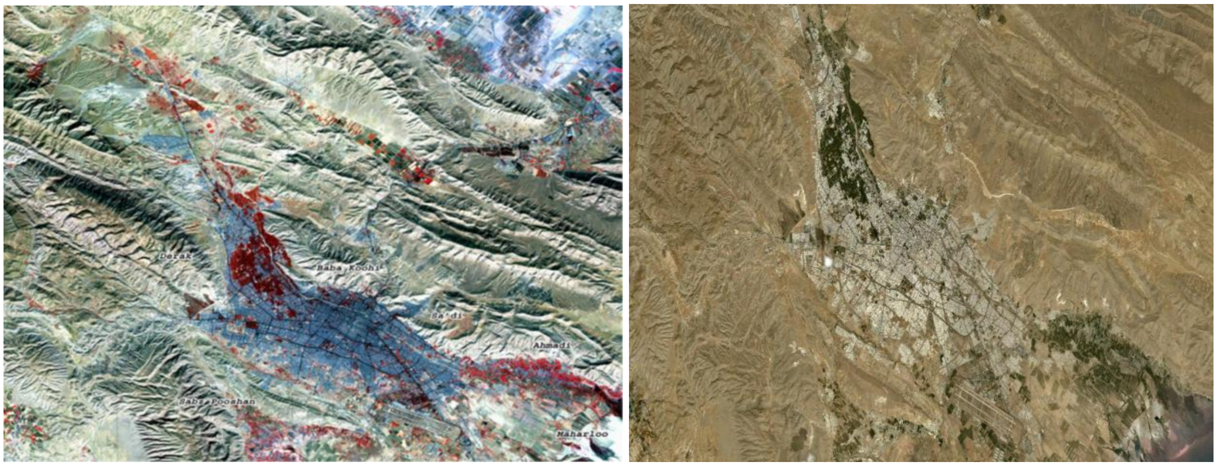


Fig.1. 7.Shiraz Topography [21]

As mentioned before, Shiraz urbanism data; demonstrates that expansion of Shiraz is 46 times, but the population growth is only 15 times since 1921, which shows that Shiraz has lost its compactness in these days. And also data shows of about 200 hectare/year as the yearly average expansion of built up areas. This growth has occupied on former agricultural land and rural areas especially in recent years, and sadly agricultural lands were arbitrary for its expansion. It resulted of ruining agricultural activity and displaced it to less productive lands [1].

Shiraz residents discovered themselves deserting several difficulties of sprawling the city since 21st century has begun. After a while period in the past, the population of Shiraz rapidly increased about more than eight times from 170,656 to 1.44 million, between 1956 and 2006. The rural regions, green areas and agricultural land and also open areas inside and around city of Shiraz cannot be necessarily stopped, unless anti-sprawl efforts happen [20].

1-2-2-The factors in sprawling Shiraz city

It is clear that new policies and tools are obligatory to govern urban sprawl so that urban districts can increase in a more sustainable scheme. There are various ways to evaluate city expansion. First way is to understanding expansion in terms of the factual value of village land that is lost to urbanization. Second way is to consider more on the method of the alteration of rural land to urban usage than on the value of the alteration. Whenever the land use for the intermediate resident enhances, it is called Per Capita Sprawl and it causes the urbanization of surrounding rural land [20].

1-2-3-Population growth

Shiraz has moderate climate. There are glorious gardens all over the city that makes its atmosphere temperate. As mentioned before, the population of Shiraz is increased from 170,656 people to 1,442,842 inhabitants referring to the 2006 census. Table 1.1 Shows trends of Shiraz population from 1921 to 2006.

Table: 1. 1.Trends of Shiraz population from 1921 to 2006 Year Population Number [21]

1921	about	85000
1956		170659
1966		269865
1976		425813
1986		848289
1996		1053025
2006		1442842

Source: Shiraz Central Statistical Office

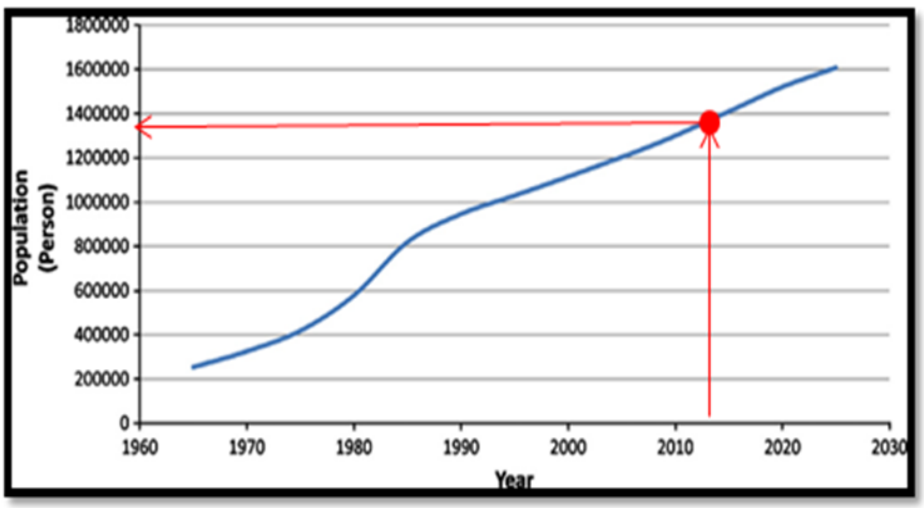


Fig.1. 8.Shiraz Population growth [21]

Shiraz population grows are based on different reasons:

- Productivity rates can be the leading reason of population enhancement in Shiraz
- Departure from smaller areas and rural regions to Shiraz
- Government helps such as financial public assistances for the fundamentals that support businesses, new housing and residents

1-2-4-Factors merge to make growth in per capita land use

Population growth is a strong determinative of expansion. In this term Shiraz data trend shows that inhabitance enhancement rate was about 4 present in 50 years from 1956 to 2006. It demonstrates that there might be some bend between both population growth and per capita land use increase [21]. Table 1.2 Shows per capita land use in Shiraz from 1921 to 2006.

Table: 1. 2.Shiraz per capita land consumption from 1921 to 2004 Year P.C.L consumption (m^2/p) [21]

1921	about	47
1971		127
1991		153.8
2004		151.7

Source: Calculation by author

And these factors are as follows:

- Economic factors
- Housing preferences
- Inner city problems
- Transportation networks
- The quality of urban planning and zoning
- Behavioral factors

Expansion increases the duration of city journey between home and work place and also the price of transportation will increase refer to enhancement of the length and distance. Also the cost of the fundamentals and facilities has increased refer to sprawl of Shiraz city.

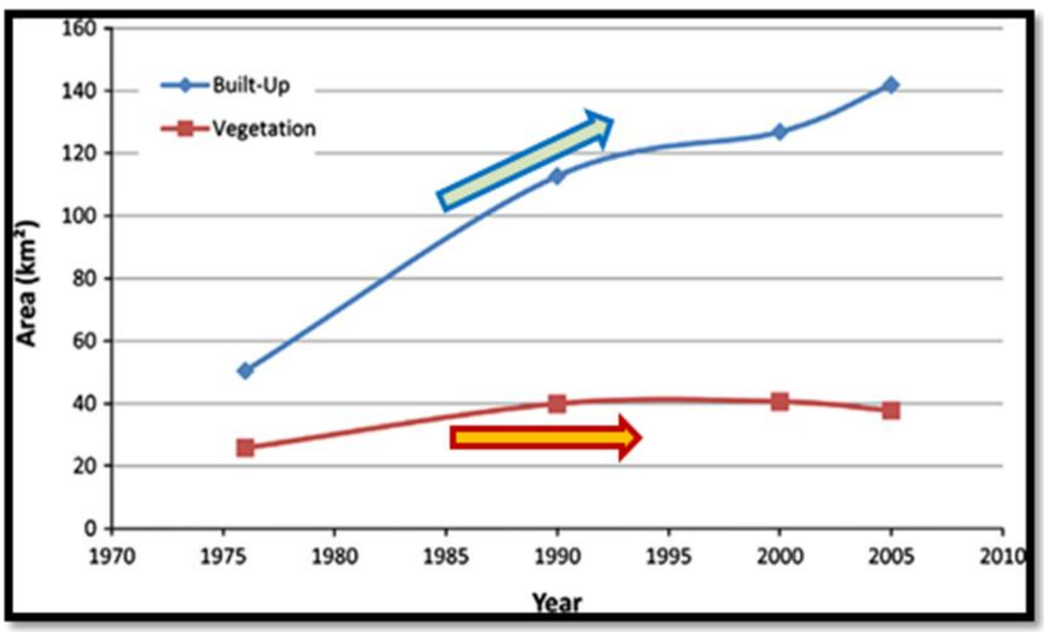


Fig.1. 9. Shiraz constructed and vegetation coverage [21]

As shown in figure 1.9 in 20 years from the year 1975 to the year 1995, built up development leave behind vegetation enhancement, whereas, the amount of building construction slowdown its speed at 2000. This happened resulting of two factors; the first was due to the economical problems in that time and downturn in urban construction work. The second factor was a universal change resulted by increasing land costs, mainly from horizontal to vertical building construction. Starting from 2000, the amount of built up increased significantly, caused by socio-economic shifts and draw public attention in the construction market. However, sadly this rapid development caused much destruction in some of vegetation texture and the demolition of natural greenery in the city.

This data show that people of Shiraz started to have more and more interest on urban lands. Also it is obvious that the increscent of land use is almost twice as rapid as population increasing. The major reasons of Shiraz sprawl is economical operation outreach in which contributed with reduction in attractiveness of city center and living in the historical area, and moreover, the big difference in cost old urbanized land against rural lands around the city with the advantage of fast development in transportation network.

For this aim, 25 circles were fixed to show this phenomenon very clearly, each of them with the radius of two seriate circles divers by 1 km distance. And of course the center these circles is the city center of Shiraz city. An area was determinate as the decussating of the city form with the rink defined by means of two seriate concentric circles. The proceeds were carried out in ArcGIS for all the attainable images of the city (Figure 1.10) [21].

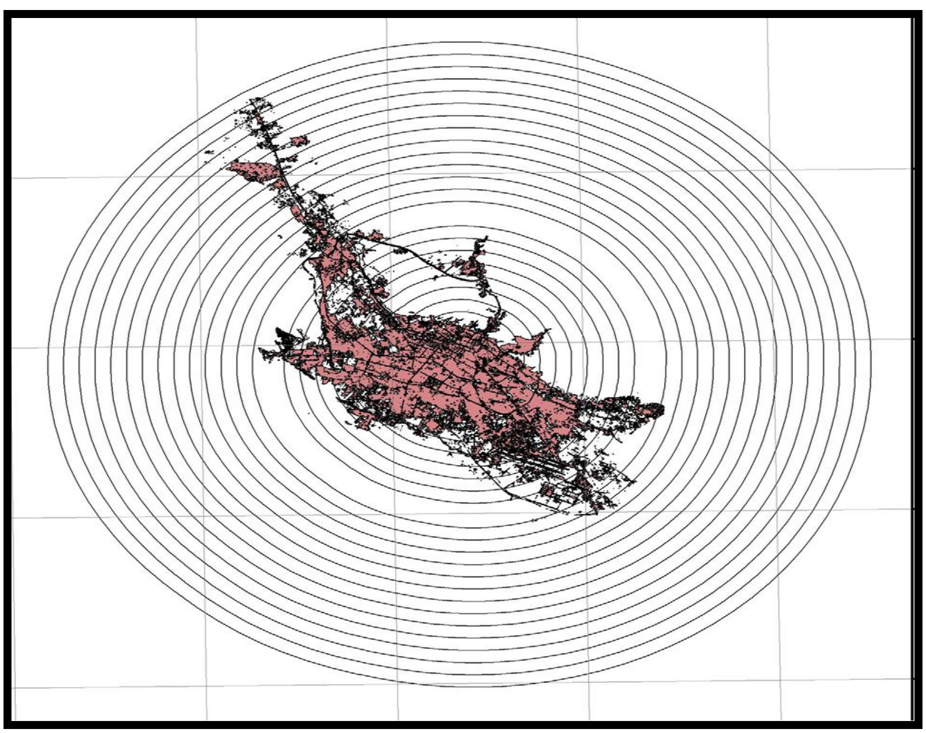


Fig.1. 10. Twenty-five different areas around city center of Shiraz [21]

In 1976, the entirety constructed land area referring to the land use maps was about 50.48 km^2. This amount in 1990 and 2000 also developed more and more to 112.68 and 126.82 km^2, respectively and eventually arrived to 141.86 km^2 in 2005. These trends demonstrate of about 181% development in construction part more than a thirty year. Whereas, on the other hand, in 1976 the vegetation texture rate was 25.78 km^2 and this rate developed to 39.91 km^2 after 14 years and arrived to rate of 40.58 km^2 in 2000 as its peak rate. Eventually in 2005, it reduced to level of 37.73 km^2. This means that, despite, Shiraz had almost 50% growth of vegetation texture, but, simultaneously, the population growth was constant from 418,000 to 946,000 in 1976 and 1990, respectively and finally arrived from 1115,000 to 1203,000 in 2000 and 2005, respectively. Therefore, generally 186% is the proportion of population growth in Shiraz where it is just a bit higher than the development of the construction portion [21].

This data show that the amount of built-up development was high until the early 1990s years and this continued by slower speed afterward. Produced maps and land witnessing disclosed that new urban development was mainly focused in the northwestern part of the city, means in and around the 6^{th} district of Shiraz. This caused by the district geographical location and geological characteristics. Therefore, the only unused and pristine places for new build up works were the 6^{th} district that located in north-west part of the Shiraz with flat and attendant of leading roads and transportation networks [21].

Chapter 2
Urban Design

Site Analysis

2-1-Site location

The site is located in the west part of district 6th of the Shiraz. And urban planning of this project is consisted of two parts. The first section is large scale urban planning by the area of around 160 hectares. The second part is in the middle of the main site with the area around 10 hectares. Figure 2.1 shows the boarder of the site.

Fig.2. 1. Site borders

2-2-Comparison of the site

To get more familiar to the scale of the site, it has been compared with the district from piazza Piola to piazzale Vincenzo Cuoco in the city of Milan. (Figures 2.2 and 2.3)

This comparison shows that district 6th covers a very huge area in the city. Thus, adequate information, data and knowledge is required for a sustainable designing and planning for this region.

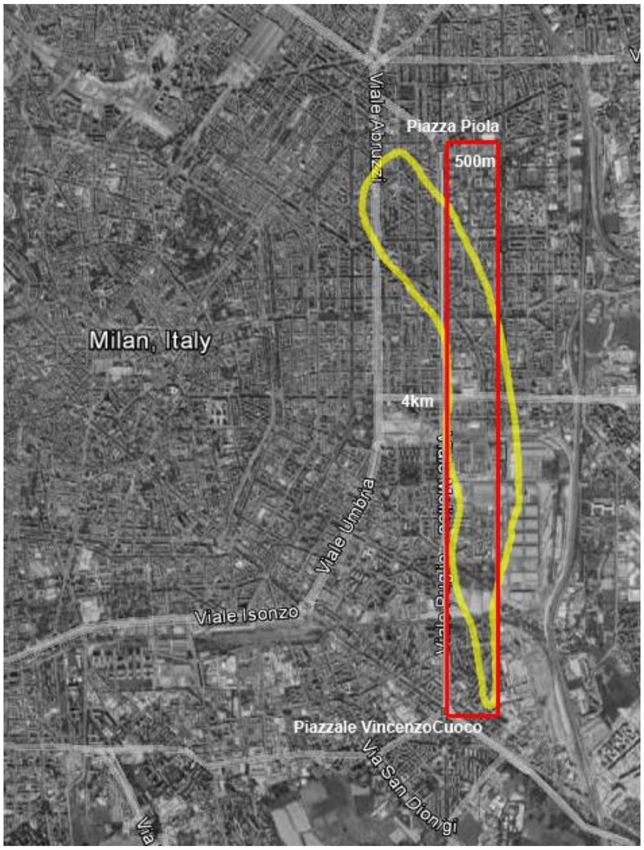


Fig.2. 3.Large scale site comparison

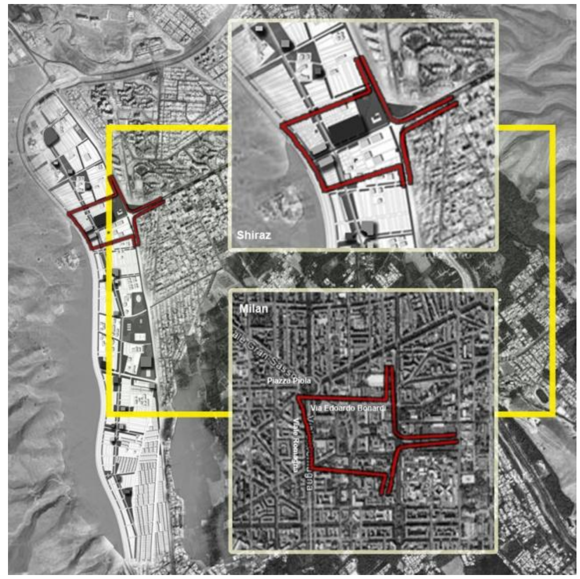


Fig.2. 2.site comparison

2-3-Introducing the 6th district

6th district municipality of Shiraz is located in the northwest terminal of Shiraz City, with the comparison to the total area of the municipality in shiraz it is the smallest area of the region and its population in 2002 was equivalent to 44,063 people. 6th district is generally limited by Farhang Boulevard from West, on the north by electronics industry lands and Dry River (Rudkhaneye Khoshk), north-east and south by the Qasrodasht Gardens and the East by the Shams Mali Abad Avenue.

Although the 6th district municipality area has the lowest area in the city, but the influencing area of Shiraz 6th municipality management plan in the North West of Shiraz has a large effect on the scope of approved services for the whole city.

This district is located in one of the most desirable areas in the north-west of the Shiraz and is generally the product of new urban fabric development for the north-west of Shiraz in recent decades. Before the revolution in 1978 in Iran, electronics plants construction and residential complexes of Mali Abad and convenient access to the attractions in the region provided residential development potentials and required plans. After the revolution, land division has begun in this area. It was often without observing the minimum standards of urban design, with activity of construct and sell, and land speculation [22].

Mali Abad complex construction as the first movement of this kind with high density took place in Shiraz City (years 1967-1977), creating an integrated fabric in the area. Single dwelling units (one to two stories) were built after the revolution, and have already undergone several changes. Nevertheless residential complex construction has greatly increased. This phenomenon is apparent mostly in south of Mali Abad Street, which is shown in figure 2.4. This district is under very fast development and becomes a one of richest part among other districts of Shiraz. The land area is of about 2779 hectares and population of 79083 people [22].
The proportion is shown below:

Table.2. 1.Population of Shiraz and 6th district [22]

	Area (hectares)	%	Population	%
District 6	2779	15	79083	6
Whole city	18622	100	1314437	100

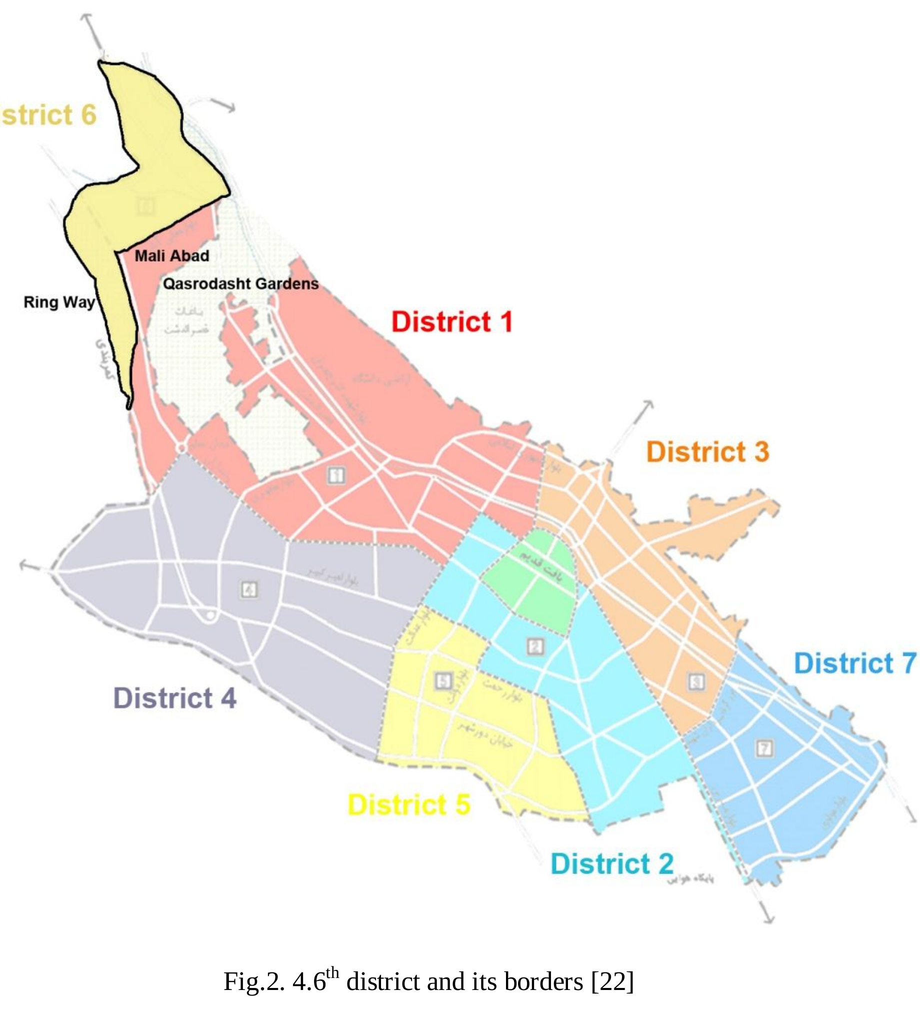


Fig.2. 4.6th district and its borders [22]

2-3-1-Social and Economic status in district 6th

According to the website 6th municipality of Shiraz social status of this area in terms of economic, educational and employment has obtained as follows:

- This region has the highest population growth rates in the city area
- The lowest level in terms of family size, right after district 1
- Highest literacy rate compare to other urban areas
- After district 1, this district has the highest percentage of employees in higher education courses
- The highest relative percentage of employed men & women, and a lowest percentage of unemployment
- Highest employed in the administrative sector
- lowest employed in the industry sector
- Representing of 30% unstated jobs, caused by tax evasion and illegal occupations
- District 6th of Shiraz has first rank in terms of social-economical performance and development compare to other regions [22]

2-3-2-History (General characteristics and geographic of region 6th)

Also after study and review on the topics relevant with 6th district municipality, general characteristics and geographical matters were obtained:

- Municipality of this region has been constituted 20 years ago
- This area is located on one of the best North lands in the city of Shiraz
- Newest constructed buildings under municipality's authority in recent decades
- Under very fast development with owning of untouched (non constructed) lands

And historically, after Islamic revolution this part of the city also was gone under different changes:

Before revolution:

- Creation of a good and appropriate accessibilities
- Construction of Electronics Factory in the area
- Construction of Mali-Abad Apartment complexes

After revolution:

- Land Division plans was given
- Construction business often without observance minimum standards of urban planning
- Arising of "Construct and Sell" activity and speculation [22]

Fig.2. 5.Views around the site

2-3-3-Environmental features

In this part of the city favorable climate, adequate water resources, vision and perspective that lead to the desired leisure spaces for the region and whole city itself exists. On the other hand should be considered that the city air flow (winds from West to East) passes through this area and also city's flood start point is from this region. Moreover, city's calcareous drinking water source is stored in southern domains of this area. Thus, by understanding these features and according to 6th municipality review, it would not be wrong if said that by controlling natural hazards, air pollution, water pollution, destruction of vegetation in this area will directly help the impact of these effects on entire city [22].

2-3-4-Transportation and Traffic

- Distress fixes in several sidewalks and ways
- Improved network access and mobilize them to traffic signs
- Construction of pedestrian overhead bridges in the connectivity with the avenue
- Equipped Mali Abad belt road to traffic signs and safety issues for cars and pedestrian
- Make a decision about the st. 20 meters radiating from a belt road in Hossein Abad
- Taxi and bus transit station off the streets [22]

2-3-5-Urban infrastructure shortages

- Lack of street lighting in area and various neighborhoods
- Lack of asphalt cover at some pass ways
- Lack improved sewage system
- Lack of optimal collection system, especially in Hossein Abad rural

And generally:

Structure (city skeletal) - Space

- Lack of educational services at all levels
- Lack of sports facilities at all levels
- Lack of green space
- Lack of recreational facilities and amenities [22]

2-3-6-Physical – Space characteristic

Due to the residential characteristic of the 6th district and its neighbor districts, and to indicate the lack of job opportunities in these districts, this part of the city has largest transportation demand to the downtown among other regions, particularly from northwest to the city center.

According to 6th municipality official website urban train (Metro) transports 9,444 out of 12,186 people from west towards east in the peak hours, and this indicates almost 77.5% of transportation is done from west side towards city center.

Fig.2. 6.City Subway

Moreover, municipality website also claims that 5 functions business, offices, education centers, temporary residents (hotels) and military offices are as known employment opportunities, since this area is not a military desired land, 4 other functions are not in appropriate or desirable use level [22].

Table.2. 2.Different functions and services in the district 6th [22]

Function	Permanent residential	Temporary residential	Business	Public education	Higher education	Offices	Military	Network connectivity
Space (Dist.6)	231	2.1	8	2.4	8.4	1.5	2	7.124
% (Dist.6)	8.4	9.4	33	74.2	04.2	48.2	0.06	82.3
Whole City	4815	25	242	153	235	205	293	3262

2-3-7-Existing Public functions

In this zone, different functions such as school, university, commercial, hospital and residential buildings are available. Since this area is getting one of the main nodes of the city, obviously it is possible to find important centers like educational, commercials, Therapeutic and etc, (Figure 2.7).

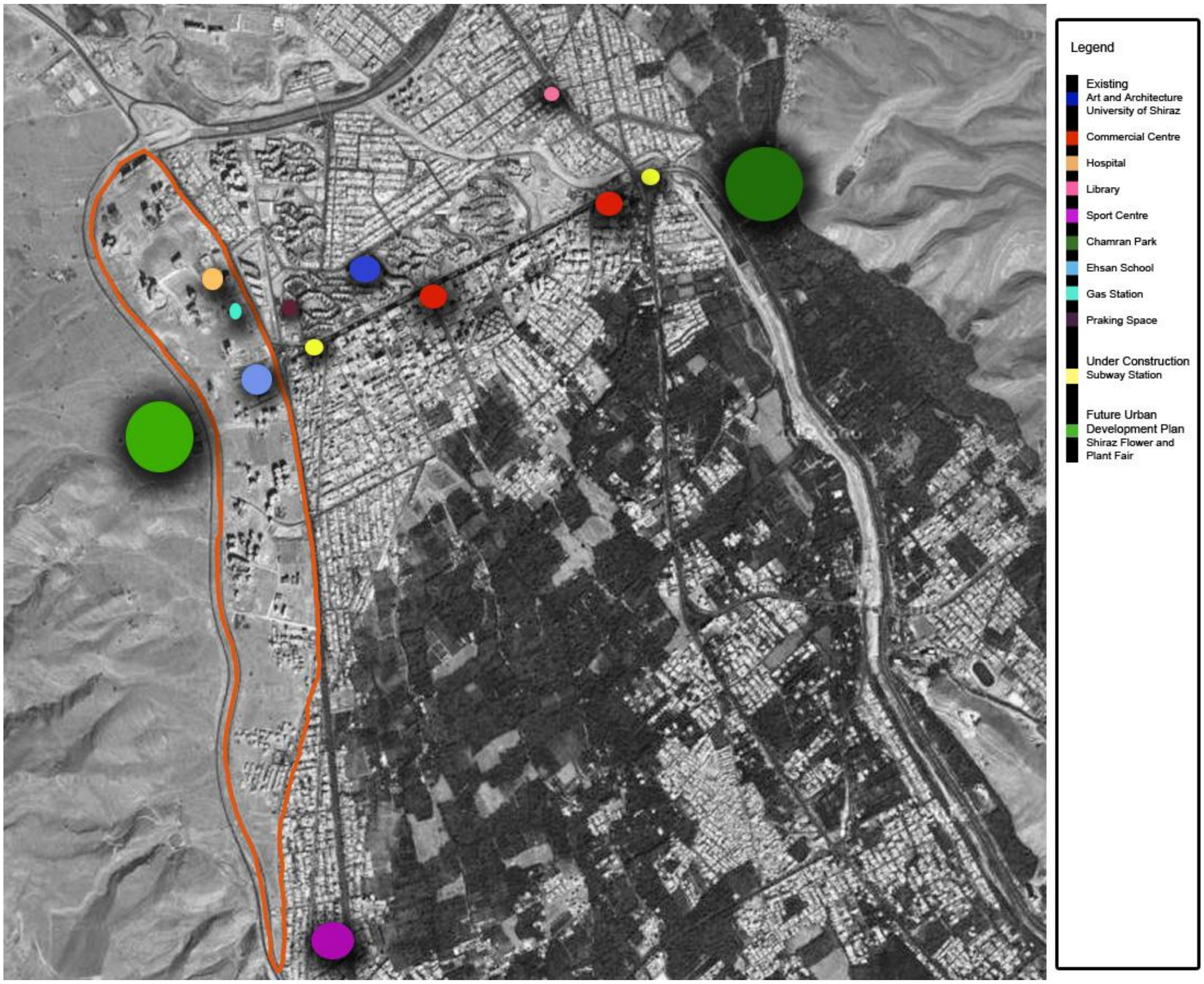


Fig.2. 7.Existing public functions

But according to the analysis of the municipality, there are lack of schools, offices, public spaces, sportive, clinics, residential, mosques, hotels and hostels that mentioned significantly.

And more radically, referring to municipality office poll in March of 2012, the results were not in good state in asking of “How you see the new green spaces of this area (district 6th)? “, which totally shows the high rank in lack of green space in the area.
The results are as follows:

- Very good 0 %
- Good 29.4 %
- Medium 11.8 %
- Weak 58.8 %

Almost 60% agreed with lack of green spaces in the district [22].

Fig.2. 8.Lack of green spaces in the area

2-3-8-Current status and role of District 6th

Status and role announced by the municipality are obtained as below:

- Supply employee in technical and administrative jobs
- Having a communication with the city center
- Development in North-West of the city
- A gate to nearby towns (Yasuj and Sepidan)
- As urban development management & administrative support
- Responsible for North-West roads access to gathering places (recreations), mostly areas related with west region
- Providing residential places for employees
- Gate way axis based on main road (Dr.Hesabi road) in the district
- Role in bear the traffic due to high transportation in the city and areas around [22]

2-3-9-Targets & Goals

- Efficient use of space in order to balance the city
- Improving environment conditions
- Promoting of city functions & superior activities
- Preservation, dissemination and promotion to the historical, cultural and social activities

- Strengthening urban management system relying on the most popular institution in partnership
- Improving of economic conditions and employment security along with economic prosperity [22]

More importantly, as passengers in the area are not getting any interest from the district, it should be considered an appropriate guiding, controlling and principled approach to the potentials and development in the area, and simultaneously by marginal role the region can become effective joint.

Generally, by making district 6th an efficient joint that connecting the north-west development arm to the main body of city, with set an end to its marginal role and adding of tourism and leisure role to this district, this area will become one of the most spectacular area in the city of Shiraz, which is as same goal as the municipality prospect for district 6th.

Table.2. 3.District 6th urban proposals [22]

Proposals Relating to the 6th District
- Reopening the Mali Abad pathway (relocation of military station, telecommunication and release possession) - Implementation Plan of underpass and overpass in Golestan town, Sadra and Sepidan road - Implementation of highway between Industrial Station and Golestan town - Urban furniture - Creating green spaces, sports and recreational places near Mali Abad apartments - Hossein Abad Bridge Maintenance Plan - Make partition to the river side - Green belt project around the 76 m belt road - Establishment of regional centers of Mali Abad across the Namazi School - Establishment of community center in the Bezin village - Establishment of 5 community centers in the Golestan town - Construction of a community center located in 12m street behind the electronics industry

Analyzed the current situation of Shiraz green areas, provides recommendations for achieving the desired location. Year 2020 is considered as the perspective projection. Reduce the potential of pollution of natural and environmental degradation can be considered to the main strategy plans. Shiraz has good facilities and resources for water, soil and climate in which the land is located adjacent to mountains. Mountain and valley and a mountainous area near the town are a safe place for climbers and relationship between citizens and nature. In valley and mountain, all elements of the natural marina namely water, soil, rocks, mountain species, gardens, trees and various birds can be seen. But unfortunately in mountainous areas and valleys by capital pressure, uncontrolled expansion of city, inappropriate civil design implementations and prevalent marginalization is on the verge of extinction [22].

District 6 is the new constructed regional that parts of it covered by the Razy orchards and Moleh gardens and the most desirable Shiraz lands are located in this area. There are many specific gardens and rivers across the region which gives an identity to the area. In terms of public green space region 6th is in shortcomings. The region had 179,643 square meters of public green space in 2003, whereas 47,136 square meters and 132,507 square meters is for parks and pedestrian green spaces respectively. The following table compares the public green spaces per capita in 6th district and the city itself [22].

Table.2. 4.The state of existing public green area per person in 6th district (m^2) [22]

Zone	Parks	Public green space	80 years Population	Green space and pathways
District 6th	0.81	3.90	58155	2.28
City	1.66	8.33	1173697	6.67

Urban design has considered all (natural or artificial vegetation areas) of Angle diverse and essential functions in the context of the region, but the green space per capita is used for leisure spaces and other public functions. Meanwhile, the most active part of the public is known as urban green landscape, therefore, First is to specify public green spaces per capita, and then based on that, these spaces are planned separately. The comparison result of green space per capita proposed by detailed plan of the city is shown in the table below.

Table.2. 5.The amount of public green space per capita proposed in Shiraz comprehensive plan [22]

Description	Proposed capita (sqm)	
	* The mean areas	The minimum suggested
Total public green space	8.5	6.5
Active green spaces (recreation and leisure)	2.5	1.5
Passive green spaces (pedestrian zone)	6	5

* Average of public green space per capita regarding to the total area of the city is about 8.5 square meters, and particularly each region can be realized at least 6.5 square meters.

This plan considered scientific, cultural, sports, entertainment, business and other needs of today's urban parks in a form of educational, commercial, industrial and in which makes the possibility of public participation activities as gardening, sports, tourism and any other activity (which has no contradicts with green space). Reportedly, despite of the huge cost in projects development and maintenance of green spaces, there is believe that supportive and protective legislation and cooperation of people can overcome the serious obstacle and acceptable costs achieve the goal of a green city. In the table below goals, strategies, plans, policies and proposals are considered.

Table.2. 6.goals, strategies, suggestions and policies for green city [22]

Strategies	Goals
- Use of natural potential - Greater participation of the private sector in the conservation, preservation and development of urban green spaces - Preserve valuable environmental resources - Care and protection of agricultural areas, and gardens in rural contexts - The mechanism of urban entertainment centers and administrative regulations	- Preservation, maintenance and development of urban green spaces, both public and private acceptable standards in order to: • Reduction in environmental pollution • Prevent urban flooding • Deal with the development of dry climate • Restore, vitality and freshness of the citizens • Create wooden areas and urban centers to provide leisure • Creation of opportunity for the increase of domestic and foreign tourists

Suggestions

- Granting ownership and benefits of green space creation
- The versatile design of the appropriate use of green space
- Acquisition and preservation of military and industrial applications as storage of urban green space to move them out of town after the Perspective Plan
- Invite stakeholders for research, education and implementation of green space
- Detailed studies in the field of soil and water resources on recreational lands a proposed comprehensive plan
- Detailed studies on project proposals
- River (Roodkhaneye Khoshk) organize plan
- Developed a semi-private green spaces in the mass projects
- Yard landscaping requirement in accordance with regulations
- Removing walls of small buildings and replacing them with green walls
- Building permits shall be subject to confirmation by the end of the green space
- The Chenary valley and Derak Mount plane as resort
- Gratuitous transfer of land to garden owners of Qasrodasht
- The green belt
- Technical education, aesthetics, choice of appropriate species and how to keep them free
- 7 Regional parks and a Park for district 1

Policies

- Tax relief and side relief and rehabilitation operations to the private sector in exchange of green space
- Walkway construction and resorts within the city and outside the city with natural potentials
- Community participation, cooperatives, government agencies and legal entities regarding supervision, protection, preservation and development of public green spaces
- Preservation, maintenance and improvement of green spaces
- Studies are necessary to determine the characteristics, capabilities and limitations of soil and water resources in the planning area
- Development of public green spaces, regarding to the allocation design
- In considering the legal issues, property and the costs for allocation of green space
- Development of available land for the establishment of private green space and providing accrued expenses

2-3-11-Morphology

With data gathering and analysis on plans and topography pictures related to municipality of 6th region in Shiraz, it was possible to survey and emphasis on the old lines regard to the formation of area helping in re-creation and determination of new lines for multiple division in the area as a morphology of this huge area.

In the morphology that is shown in figure 2.9, the new streets are connected with the old path ways through the site.

Fig.2. 9.Morphology of District 6th

2-3-12-SWOT Analysis

Table.2. 7.SWOT analysis of the district 6th

STRENGTH	OPPORTUNITY	WEAKNESS	THREAT
Very close to the Metro station(Accessibility)	Zone is under fast construction and development	Lack of Cultural Center in the area (Cinemas, Exhibitions, Libraries...)	Low and high class region next to one another
Natural Landscape nearby	Touristic attraction because of the location	Poor public facilities in the neighborhood	Existence of ring road adjacent to the region
Existing Residential buildings around	Piazza(square) next to the site	No energy efficiency buildings considered in district	Transition of traffic to the area
Gas station, Hospital & school are located next to the site. Also a big Parking area near to the site	Good relation and connection with whole city (because of the location)	Poor greenery in district 6th	
Area is confined with the mountain and ring road	Interaction between two different social/economical classes	Lack of main taxi and bus station in the area	
Far from the city center (lowest traffic area)	Ring road as highway to reduce traffic		

2-4-Design Concepts

Since Shiraz is famous by its gardens and green spaces so to keep this identity, the concepts are inspired by Persian Garden, and green connections between green spaces through the city. As the area suffered by lack of green spaces, developing this zone by means of the concept of historical gardens would make it more attractive.

2-4-1-Persian Garden

- **History and Philosophy**

In order to understand the Persian garden, it is better to investigate more on Iran climate and Iranian culture. The biggest proportion of Iran's territory is located in deserts and dry lands where gain little amount of rain yearly. Thus, water becomes the most precious element in this area and the image of green spaces is the most desirable dream. In Iranian culture human is not separated from nature, even he is known along with other elements of nature and it considers an

integral part of the nature. Ancient Iranian believed in a Goddess known as “Oraza” who got angry at those who make damage to nature and plants.
Iranian art and architecture strongly grasp nature. In the Garden, Man and Nature are in perfect attunement with each other. Garden is a place for quiet thought or philosophical discussions. Existing of a cozy and quiet atmosphere and being in a corner of nature in the Persian Garden is a rule, And Garden space is mystical and poetic reflection. Iranian lives are linked to nature. Celebrating the New Year (Norooz) in the beginning of spring, which is the evangel of the nature’s revival, is an important indication of this claim.

- **Symbols in Persian Garden**

In Iranian culture green is a symbol of happiness, freshness, life and heaven, before and after the Islam cypress has been a holy tree, and it is a symbol of elegance and freshness, pine is a symbol of power. After Islam the Sycamore and palm have been very sacred trees, the Sycamore leaf represent number 5 which is the holy number among Iranians. Another holy element in Persian garden is water, which makes garden more spiritual space with its sound, reflection and movement. Presence of the garden can be seen in the other arts. Painting on old dishes show, how much Iranians were interested in gardens and nature. Iranian designs garden on the rug in order to bring nature into their home, or in miniature the garden make the space more romantic.
In pre-Islamic architecture, the garden is the element index, for example Persepolis is the pre-Islamic Intellectual peak of garden making. It’s the stony garden with the carving sacred trees. Also after Islam the plants shape were used in mosques tiling.

- **Main elements in Persian gardens**

- Land
- Water
- Plant
- Space

- **Sub-elements of Persian gardens**

- Decorative elements
- Edges
- Wall
- Pools

- **Land**

Land is one of the main elements of Persian Garden. Different characteristics of the land, including shape, general position, soil features, slope and level differences and fertility and irrigation capabilities are effective in designing the Persian Garden. The Persian garden may be built on a land with a gentle or high slope. Usually when the slope of land is high, the garden is built on several levels. In this case, it is possible to have a waterfall. Similarly, one of the main reasons for building gardens in the steep lands is to allow the natural movement of water in the garden, which has shown in figure 2.11.

Fig.2. 10.Persian garden land use plan

Fig.2. 11.Persian garden with different level

- **Water**

Water is present in the Persian Garden from three points: Conceptual, functional and aesthetic. Searching about water in Persian Garden, several items should be considered including: How water is present in the garden, quality of water flow and its movement, water sources and irrigation of garden. In most cases, springs and aqueducts were the main sources of water supply. Subterranean (aqueduct) water is located in ordered narrow streams and it passes through the main creek to secondary creeks and streams. Usually, the amount of water and how it is managed and shared, determine the area of the garden. In many Persian gardens, water flows in different stairs which creates the sound of water.

Fig.2. 12.Water use in Persian gardens

Aqueduct *(Kareez)* is a water management system used to provide a reliable supply of water to human settlements and for irrigation in hot, arid and semi-arid climates. Bringing water down from the mountains where it was stored as snow or collected as rain, the aqueducts enabled otherwise desolate land to be transformed into an oasis in the desert. But the aqueducts enabled life in these otherwise desolate areas to rise above mere survival.

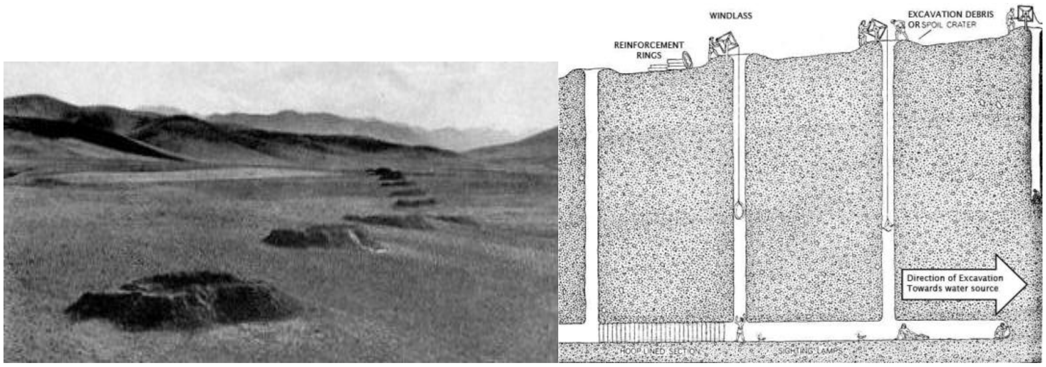


Fig.2. 13.Aqueduct system

- **Plant**

Plants in the Persian Garden are considered in several points of view including:
Species, Location, Planting Design, Beauty and Usefulness

Plants are used for different purposes: Shading (for the warm and dry climate), producing fruits, decorating the garden and protecting the garden against natural disasters. As productivity is one of the main characteristics of Persian gardens, most plants are fruit trees, then, shady trees and ornamental plants which full fewer areas. Location of any trees and plants has specific logic. Along the two sides of the main streets, alongside the streams, Cypress trees, cedar trees and bushes are planted.

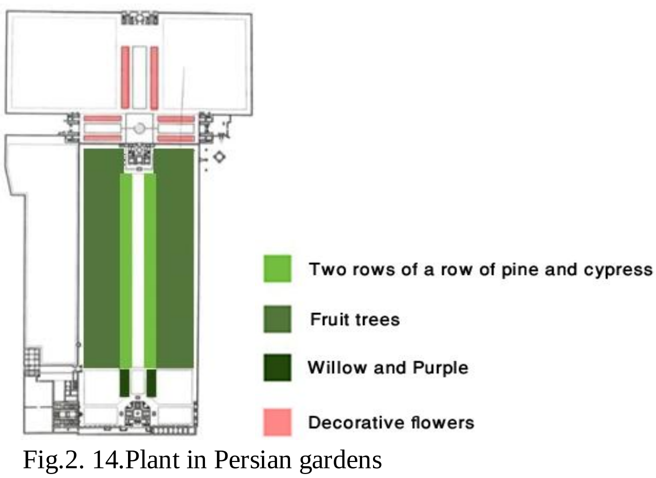


Fig.2. 14.Plant in Persian gardens

Around the pool maple, willow and Judas trees are located (plant). In garden plots along the streets, fruit seedlings, in the corner plots vine trees and near the garden wall Jujube trees are planted. Instead of planting tall plants and trees in the middle of garden plots, which covers the building landscape, alfalfa and grass is plant. Flowers play a key role in Persian garden. Smelly colorful flowers are plant in front of the building, around the trees and sometimes instead of the pool in front of the building.

- **Spaces and Walls**

Buildings, landscaping, interior space of gardens, and decorative elements associated with ground, water, plant and the building create a specific architectural space.

In Persian garden, buildings (indoors) and outdoor gardens are combined together and are not apart from each other. Even in some examples the flow of water continues in the middle of the buildings.

- **Garden Pavilion (small palace)**

Garden pavilion has different locations in Persian garden. In the middle of the garden in a way that is seen from four sides or one that side of the garden along the main axis of the garden.

Main principles in design of Persian gardens:

- Hierarchy
- Symmetry
- Centrality
- Rhythm
- Independence of the spaces
- Diversity in unity, unity in diversity

And, general characteristics of Persian Gardens:

- Use of sloped land
- Use of straight lines
- Use of enclosing walls surrounding the garden
- The garden is divided into four sections
- A building is situated in the centre or the highest point of the garden
- Use of flowing water such that a calming sound is created
- Use of large pools as mirrors
- Use of a variety of ornamental and medicinal plants
- Use of trees with shadows

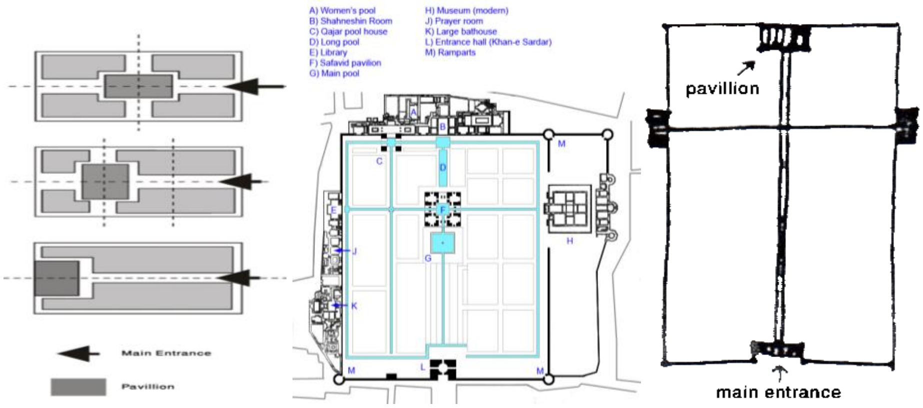


Fig.2. 15.Garden pavilion location

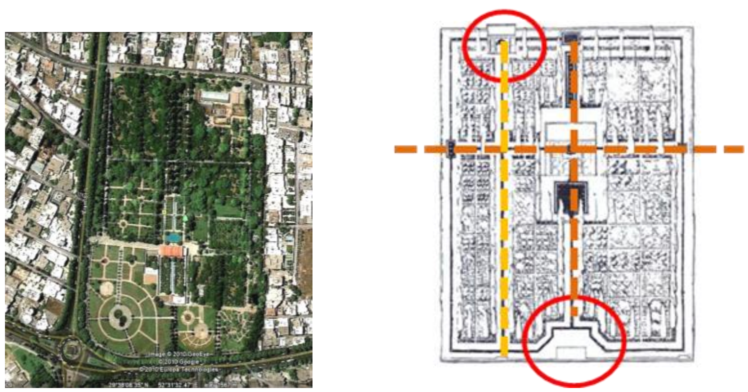


Fig.2. 16.Persian garden with its characteristics

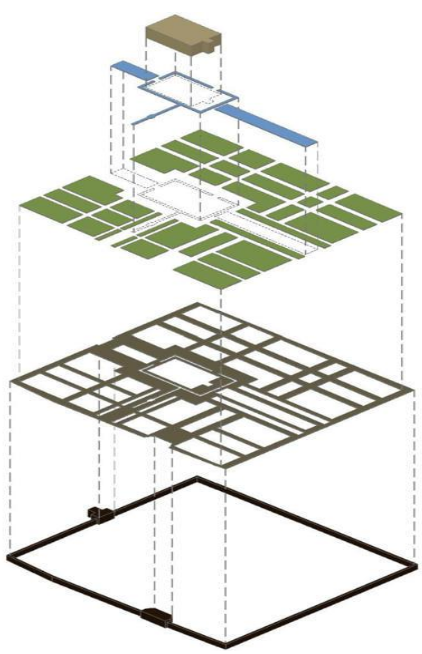


Fig.2. 17.Different parts and functions of a Persian garden

2-4-2-Connecting green areas

Another concept of design is connecting east green area to the site, to have two linked strong green arms in east and west of the city.

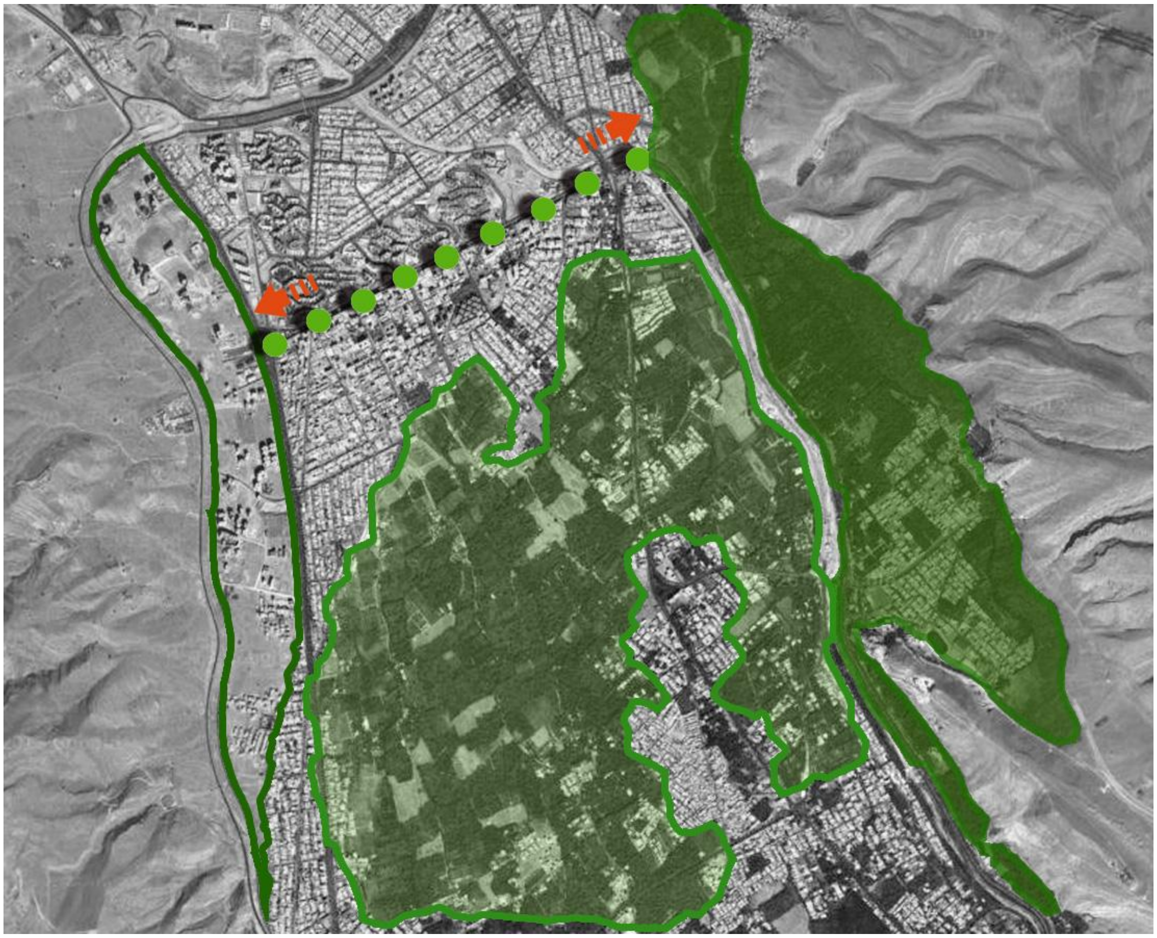


Fig.2. 18.Conceptual plan

2-5-Design elements

The suggested urban design of this huge area is done according to the urban analysis and information of the 6th district, and respect to the data gathering from related municipality such as strategies, suggestions, policy and goals and using of Persian Garden concept which truly includes the history and culture of Shiraz city. In this regard, the suggested urban design demonstrates well connected public, semipublic and private green areas with different needed functions and facilities by means of pedestrian and bike pathways and limited car accessibility. In this case this site becomes more close to zero emission and sustainable area in the city.

2-5-1-Network

The road network is one of the major parts of the skeleton of the project and is divided into two cross and service paths. Detailed plans for organizing the street network as proposed in a neighborhood centers and regional proposed services are hierarchy distribution. Set of canonical axes (centers and community areas) makes up the skeletal.

Fig.2. 19.Suggested street network

2-5-2-Urban main and secondary nodes

The urban district is a complex skeleton but single organism which makes up life, the life that is not only consisting of lands, buildings and services; its improvement depends on the social parts and conditions. Since for the future development of the Shiraz city the linear development has proposed, which will inevitably bring balance to the city in terms of land use, thus, paying special attention to the distribution of the urban cores (dense residential areas, business offices and government agencies) are inevitable. To make same shared language in a urban district, there should be a appropriate design of main nodes respected to every components and conditions of its district's social life, that could be a urban services such as public parks, commercials, institutions and offices where brings up life in a region in which coming from a shared main nodes that covers about 200m of radial.

Fig.2. 20.Urban nodes and its radial service effect

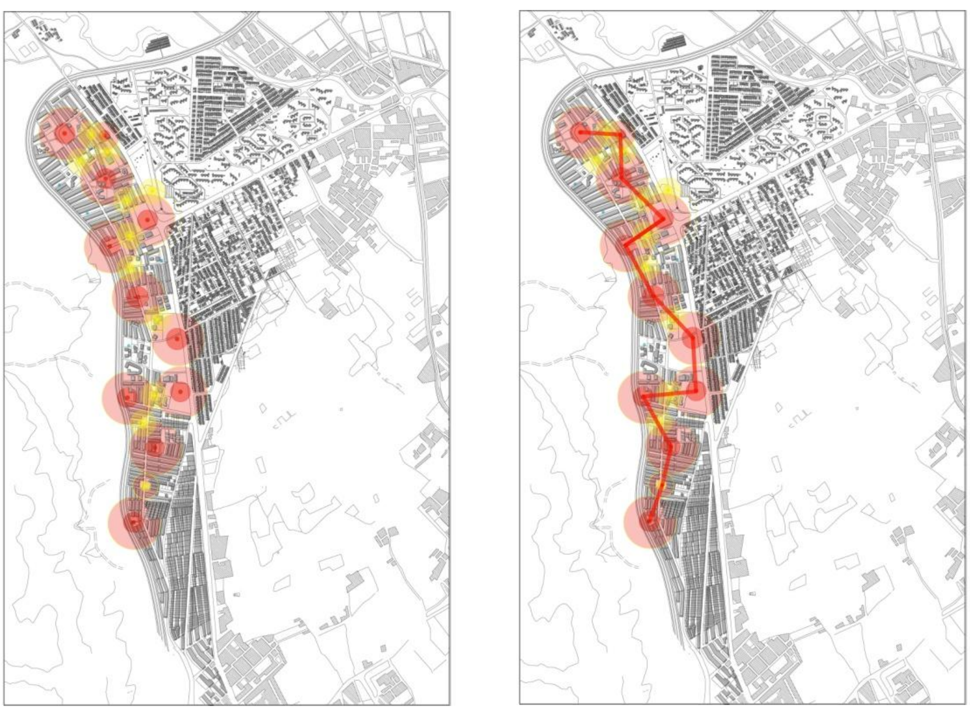


Fig.2. 21.Main and secondary urban nodes and its connections

And by these urban nodes and radial service effects in all over the district, there will be smaller urban nodes in every interaction between main node's radials as a district secondary node. In a wide district as 6^{th} district, by connecting these urban main and secondary nodes it is possible to make a smooth life flow in the selected district and in larger scale bring this sprit to the whole city.

Secondary urban nodes in the district make proximity of different nodes possible and radial service effect efficient and effective. Therefore, this system of design makes district covered by appropriate public services more than 60 %. Moreover, by allocating bus stops as a public transportation in whole main road of the district as shown in the next figure and also design district's street network convenient these would easily help the social life more active in the area.

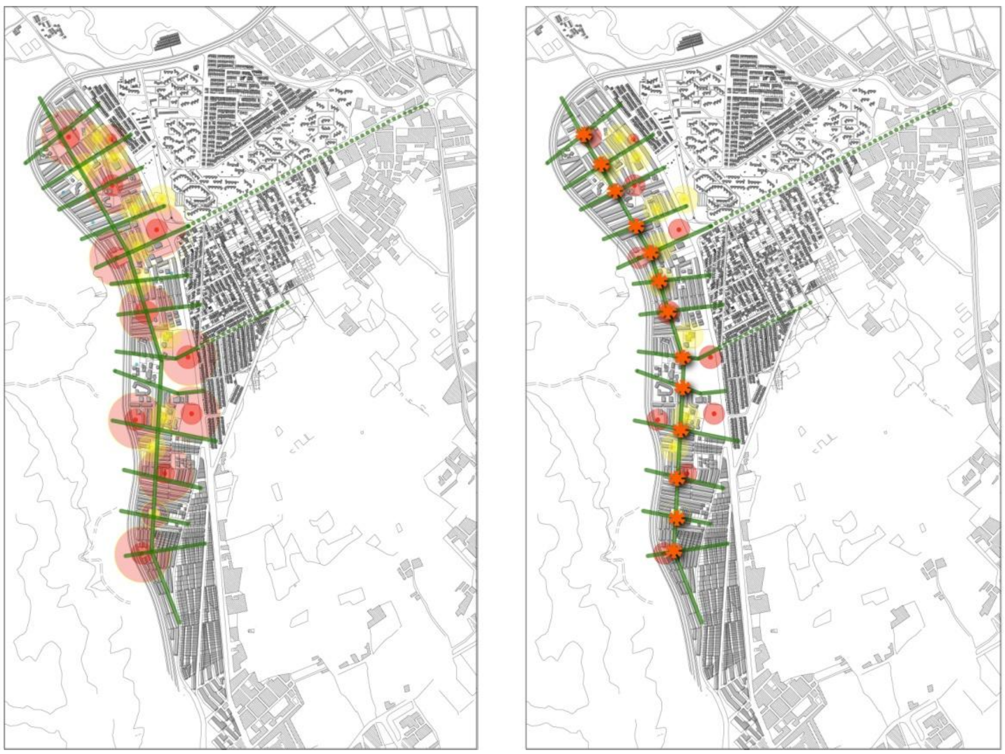


Fig.2. 22. Nodes and street connections (left), bus stops (right)

Communication networks is designed and suggested based on the detailed plan. But in some cases, the proposed networks in the master plan have been removed. Often proposed grid pattern, widening and layout of new streets on the existing streets remained, because most of these widening are gradual and only would be possible if the reconstruction had been done. As previously mentioned, most of the major networks in the region are exist in St. Shams Mali Abad.

2-5-3-Green nodes

As mentioned before in order of Persian garden concept utilization and pulling up the city's green texture to the project area after public service node design, it is time to use same design and concept for making green points and put them in suitable location of the district, and then, inside the area connecting these green points together by means of green pathways, not only it will bring a green nature to the district, but it will help the region to become brighter, succulent and attractive district that have strong connection with other older green regions in shiraz city.

Fig.2. 23. Green nodes and the connections

In this stage neighbors playing significant role, it means every neighbor could play a role of a green point or green node in very local scale in a district. Therefore, it should be considered that to arrive to this aim of green district it needs to start from smaller scales to a larger scale. In this regard, green nodes are divided to public, semipublic and private portions. National and local parks, sport complexes and pedestrian pathways are related to the public sector. On the other hand, courtyards and gardens are related to the private part. Using these components in very appropriate scheme, harmonic and elegantly it will make sure that the final design become sustainable, alive and efficient from a very basic place. And finally it is very important to make same well-shaped design for other neighbors to place this local green network all over the district to maintain this sprit in bigger scale.

Fig.2. 24.Green nodes and connections in neighbor scale

Fig.2. 25.Greenery connections

2-5-4-Suggested functions

After defining roads and nodes, according to site analysis and municipality strategies and goals main functions have been defined. Distributing needed functions through the site to have a balance between land use and accessibility was in design priority as well as suitable connection between different facilities.

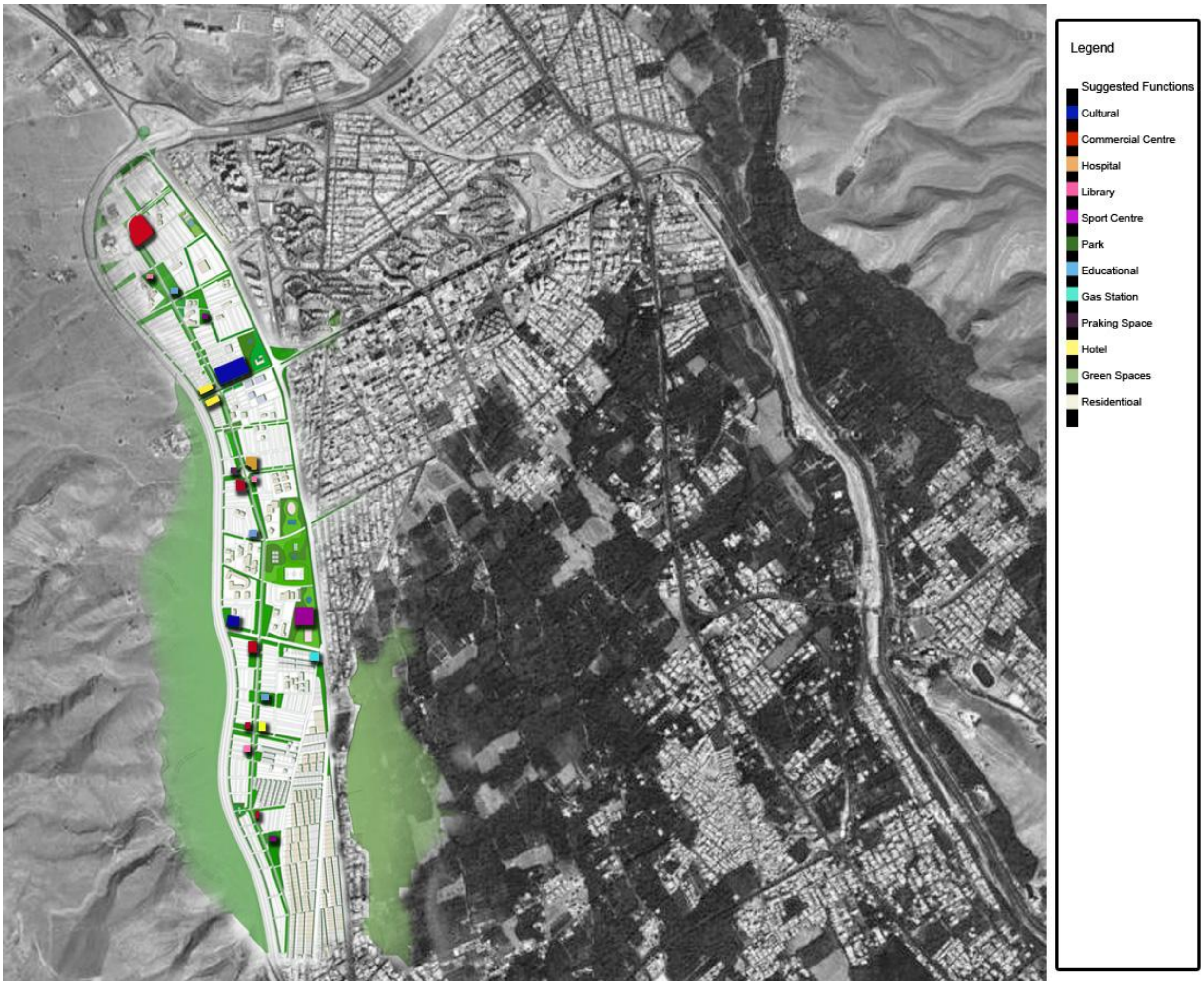


Fig.2. 26.Suggested functions

2-5-5-Large scale Master plan

The master plan for the 6th district with the respect to every urban and municipality needs are considered. By data gathering from district municipality, city council and residents for analyzing and study on suggestions, policies, goals and strategies to fulfill the shortages and overcome the difficulties such as urban public area, vegetation texture, urban facilities, residential and commercial buildings, transportation networks and its facilities and every other urbanism tools that a district needs to equipped for a new, modern and sustainable urban, were considered. So the master plan is a combination of existing buildings, new streets, defined land uses and functions and green spaces. Figure 2.27, shows the various structure portion of this master plan in different levels namely, vegetation cover in the area, transportation networks, buildings and lands.

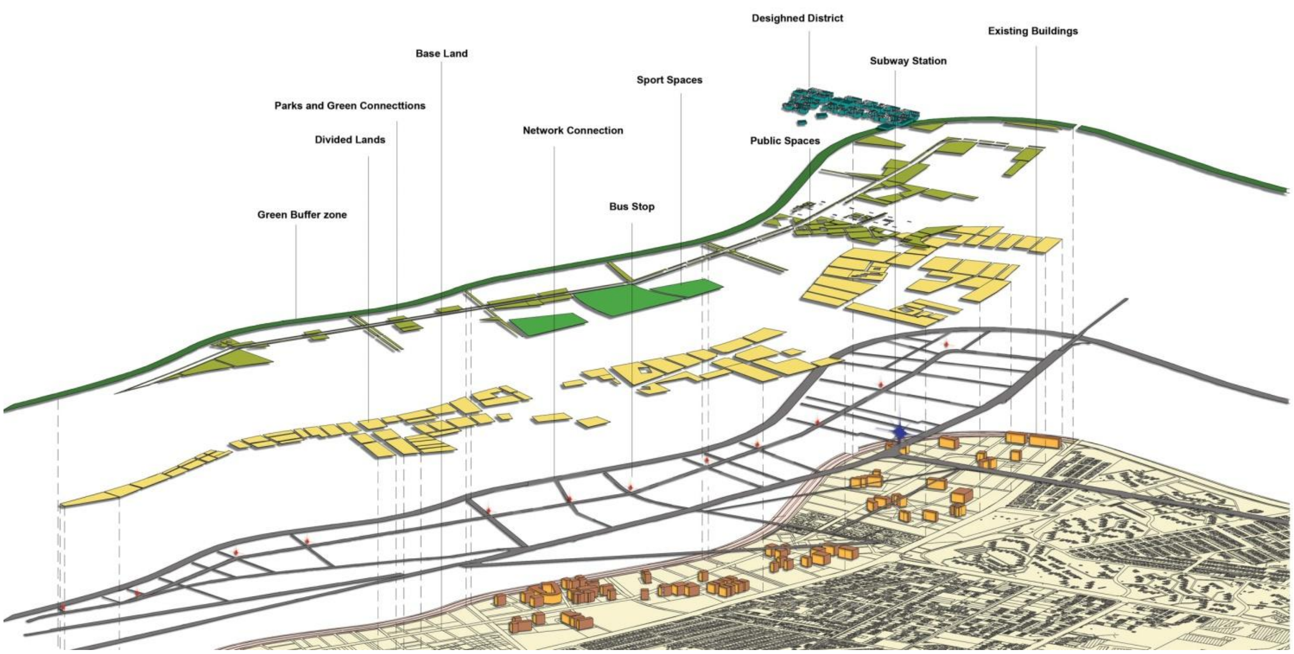


Fig.2. 27.Different elements of master plan structure

Therefore, in the master plan all effort has been taken to cover every lacks and problems that was mentioned by its residents and municipality of the district, the major problem was about the greenery cover in the north west of the city, which by in this plan this difficulty was clearly is solved.

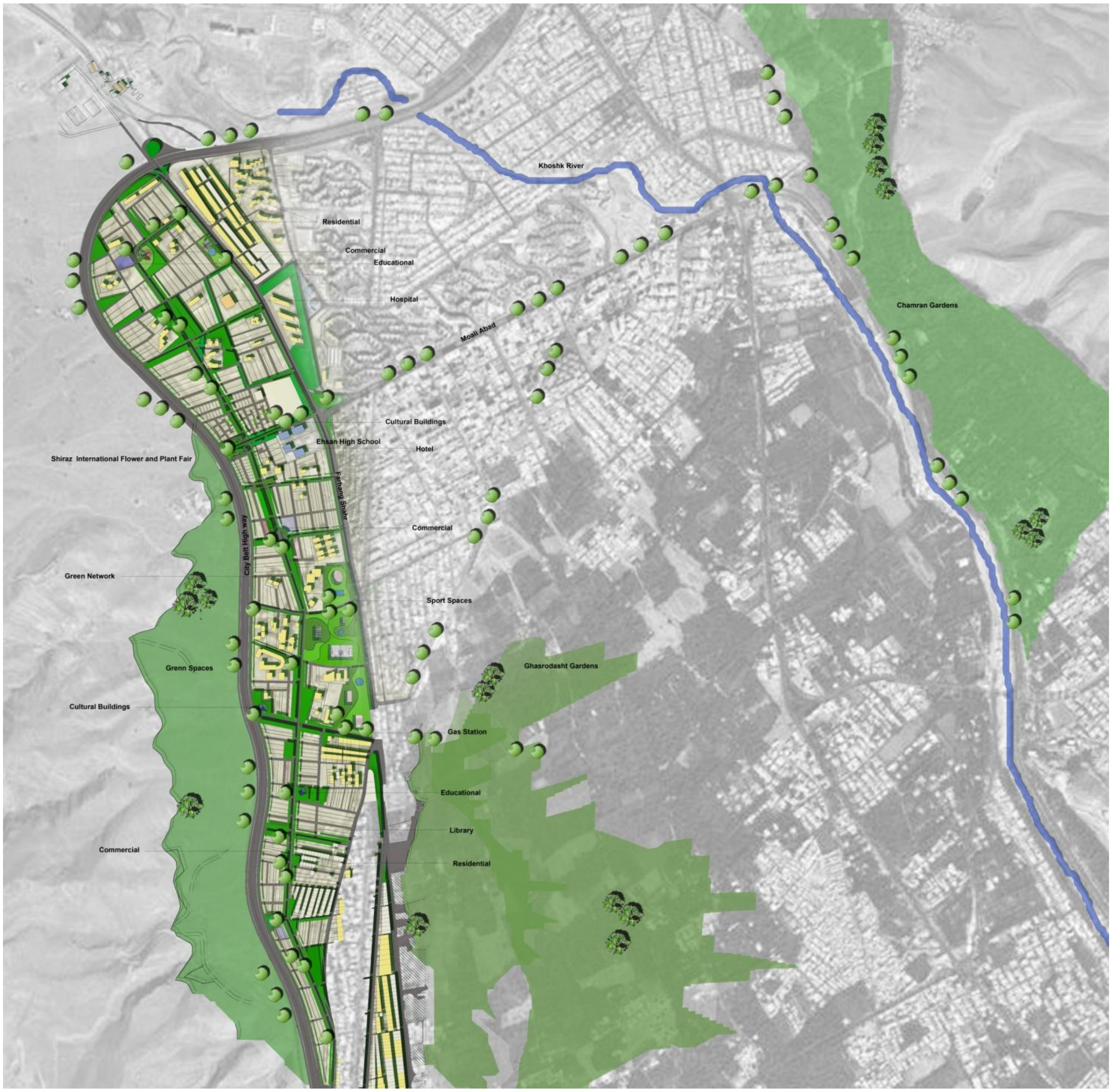


Fig.2. 28.Master plan of 6th district

2-5-6-Small scale urban design and master plan

Regarding the main structure of large scale master plan, focusing on one of the main nodes was necessary. Since one of the important zones was the connection of Mali Abad Street with Farhang Shahr Boulevard and the site, so this part is coming with more details to show its urban fabric and structure.

The idea of this node is following the concept of Persian garden but with different circulation in different levels.

Fig.2. 29.Small scale Master plan

The master plan is consists of two parts, one is a huge pedestrian and bike promenade from Ehsan Metro station through the ring way, since different functions are spread among the site which are more with cultural functions like cinema, theater, museum and gallery. The second part is the neighborhood with residential and commercial buildings. In both of these two parts car access is limited, since this district is considered as a green and clean zone, so it is reasonable to encourage habitants to avoid using car.

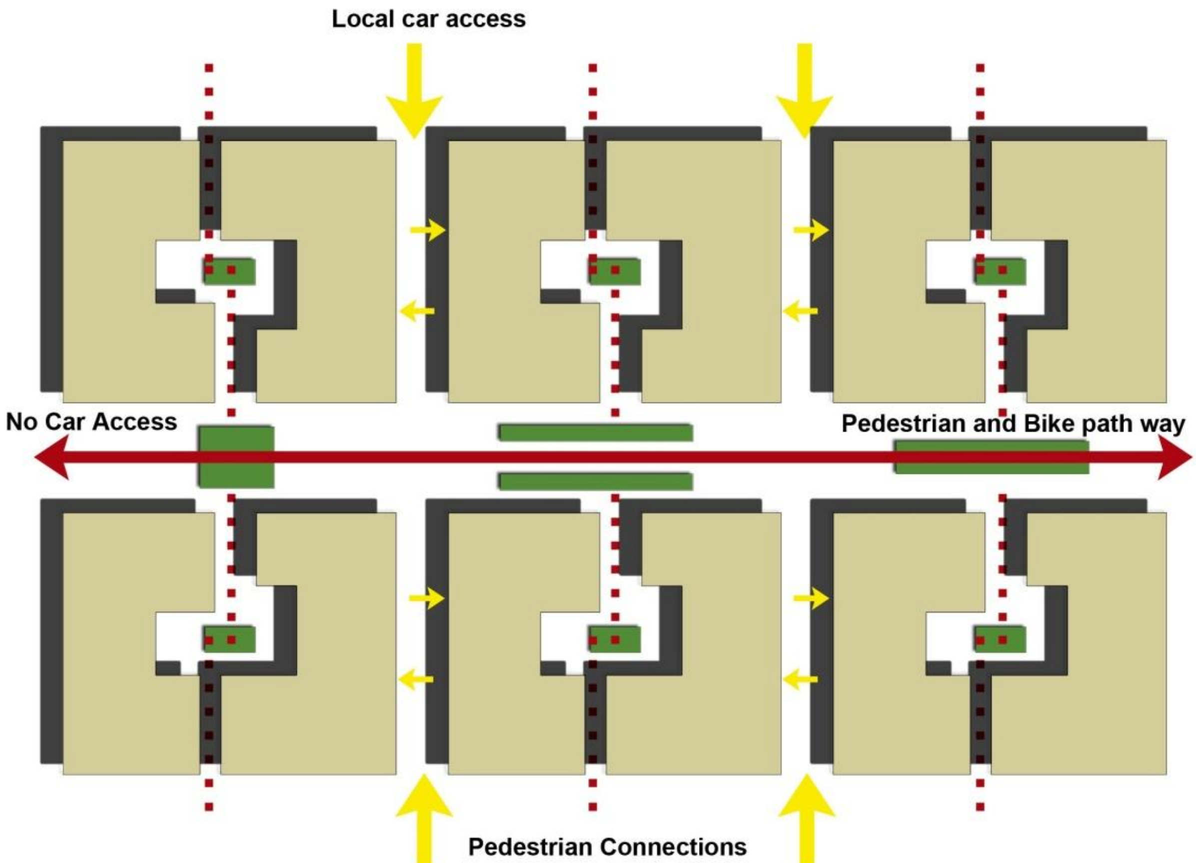
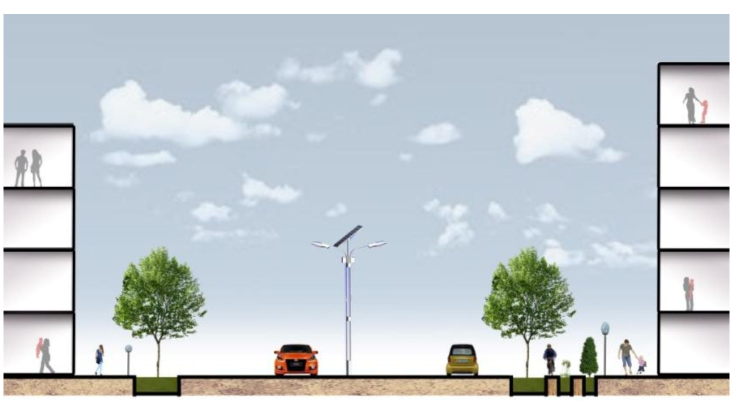


Fig.2. 30.pedestrian and car accessibility

2-5-7-Street sections

As it shows in figures below two types of proposed streets are considered for this district. One is with car access, since in both of them pedestrian and bike pathways with green sidewalks are under attention.



Section A-A

Section B-B

Fig.2. 31.Street sections

Figure below shows overall 3D view of site, then in the architectural chapter we will focus on neighborhood and residential buildings.

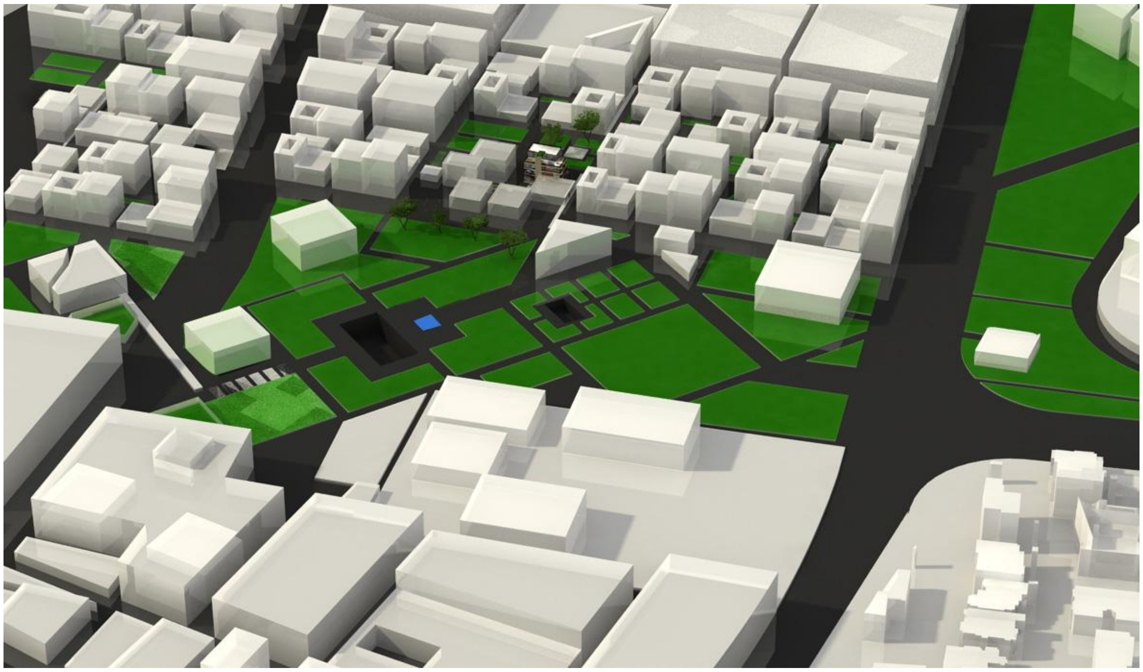


Fig.2. 32.Site 3D view

After analyzing the potentials, strength, shortage and weaknesses of site, also by considering the municipality proposals and statistics, the final master plans have been designed to compensate limitations and develop the district to the desired and attractive zone in the city. Regarding this approach different functions and facilities provided and designed through the site.

2-5-8-Conseptual section of the site

As it is illustrated in the section in figure 2.33, different functions are connected through the site in different levels to get various views and experiences in the site. Meaning that unlike the Persian Gardens in which building always is located on the ground level, in this project buildings are implemented in various levels in the project area.

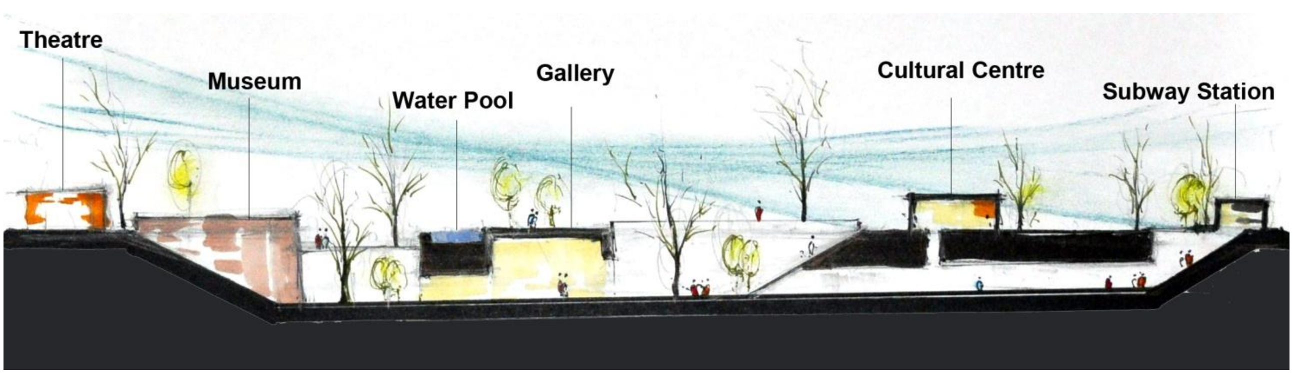


Fig.2. 33. Conceptual section of the site

2-5-9- Result and Conclusion

As the table 2.8 shows in this project, urban standards and Shiraz 6^{th} district city hall demands regarding of providing main functions starting from the local scale to the district scale and eventually to service the whole city are considered. By estimating approximately 8000 inhabitants for the large scale site, it can be seen that the project achieved its goal to reach the standards of each function per capita for this aim, as an example in this project green space per capita is around 22.5m^2, in comparison with the urban green space standard per capita which is between 20m^2 to 25m^2.

Table: 2.8. Different urban functions by area and capacity

	Residential	**Educational & cultural**	**Commercial**	**Green Space**	**Sport (open and close space)**
Area(Hectares)	80	4	7	18	15
Per capita(m^2)	100	5	8.75	22.5	18.75

Chapter 3
Architectural Design

Introduction

For each person home is the first place for relaxation and spending free time. For Iranian home is not a place just for dormitory, also it is a place for family gatherings and parties, and it is a main core to bring all the family members together, and so it is considered as a "sacred" space, which should be well-protected and well- separated from the outside.. In this regards privacy and comfort are the main part of each Persian home. In Iranian architecture the border of indoor and outdoor of the building is distinguishable, whereas the hierarchy between public and semi-public and private spaces are under attention. The entrance of the building plays the main role to give a maximum sense of privacy to the house from outside. By the way the life style of Iranian has been changed during these years, consequently the way of architecture and urban neighborhood are changed. In this chapter firstly some case studies of the best Iranian traditional homes are coming, then the relation of home with the neighborhood and its' context in traditional and contemporary would be discussed. And finally the proposed neighborhood and residential building plans and details will be shown.

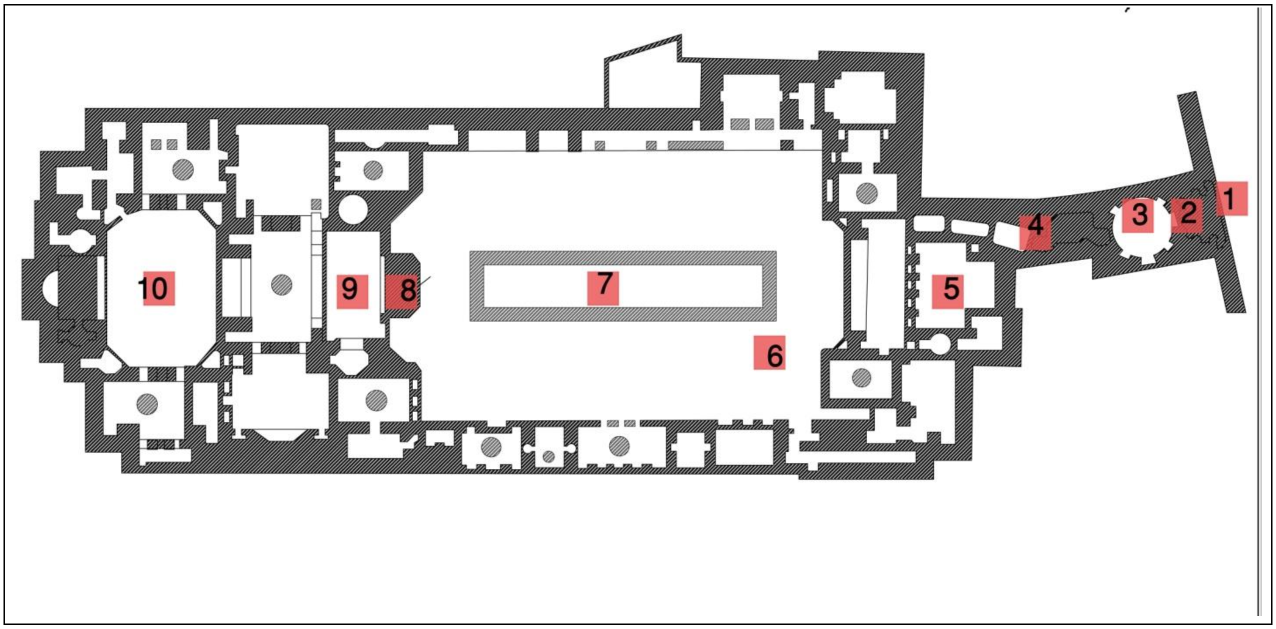
3-1-Case Studies

3-1-1-Boroojerdi- ha House:
The city of Kashan has characteristics as 34-N latitude, 955 m above the sea level, with cold winters, and hot arid climate in the summers, dusty sometimes strong winds.
As mentioned in the inscription in the reception hall of the building, the construction of the house dates back to 1875 AD. It is estimated that it took 18 years to be fully built, with the cooperation of more than 150 masons, stucco carvers, mirror cutters and designers, and other artists.

To better understand the design of the house, it is important to pay attention to the design strategies regarding the climatic considerations of this residential building in the city of Kashan.
To achieve a lower temperature in the building, the architect designed lower level spaces, underground, that has frigid temperature in the middle of the day. The thickness of the air trap walls helped to reach a more pleasant temperature inside. Besides, the linear form of house that is organized in to two volumes, with a courtyard in the middle, in addition to the deep Eivans (terraces) that provide sufficient shadows and hence cool temperature, contribute to the human comfort. The use of the vernacular material, and the wind catchers, are the other innovative and successful solutions of the designer [1]. The southern part of the house, the most important part of the house so to say, has a huge astonishing hall in design of a vestibule, with a space designed in front of the hall with a beautiful view to the garden.

The rate of the greeneries in the courtyard, in these areas depends on the accessibility to the water. Planting is used in the design of the courtyards, for several reasons, such as, Decreasing the strong radiations of the sun to the habitant, and the dust present in the air, and the unpleasant wind, to produce a desirable shading on the body of the building, to direct the wind blow to the wanted direction (to the wind catchers, to some specific rooms, etc), to increase the air humidity and moderate the temperature in the house.

Fig.3. 1.Northern Eivan of Boroojerdi- ha House [1]



1. Pass to the Entrance	6. Courtyard
2. Entrance	7. Pool
3. Vestibule (Hashti)	8. Stair to the basement
4. Corridor	9. Basement
5. Porch (Eivan)	10. Living room (Talar)

Fig.3. 2.Boroojerdi- ha House plan [1]

Fig.3. 3.Boroojerdi- ha House [1]

Boroujerdiha house, built by architect Ali Maryam, as a traditional house that was used in all the four-seasons, is one of the most famous houses in the area because of its unique and human-nature oriented design, in the middle of a hot arid climate. Nowadays it is considered as one of the important cultural heritage constructions in Iran. The plot is 1700 square meters.

The house has only one entrance, that opens to the Hashti (a well-designed geometrical lobby), which leads to the main courtyard. The house has two functionally different parts, the summer part placed in the south, and the winter part in the north, in order to seize as much sun light as possible in the winters, and vice versa in the summers. It has a ground floor and a basement. The basement which has a very pleasant moderate temperature is most used in the summer. The building is constructed mainly using bricks and adobe, That is considered as a very sustainable solution, since it is local, it contribute well regarding the comfort temperature , and can be recycled reused easily later. The materials used inside the house are mostly bricks covered with plaster.

In terms of ventilation, the wind catcher is used, that works with three different functions, sucking, and blowing and chimney effect. If there is wind, it will be directed to the wind catcher, if there is no wind, as a result of the chimney effect, the vertical airflow will be provided.

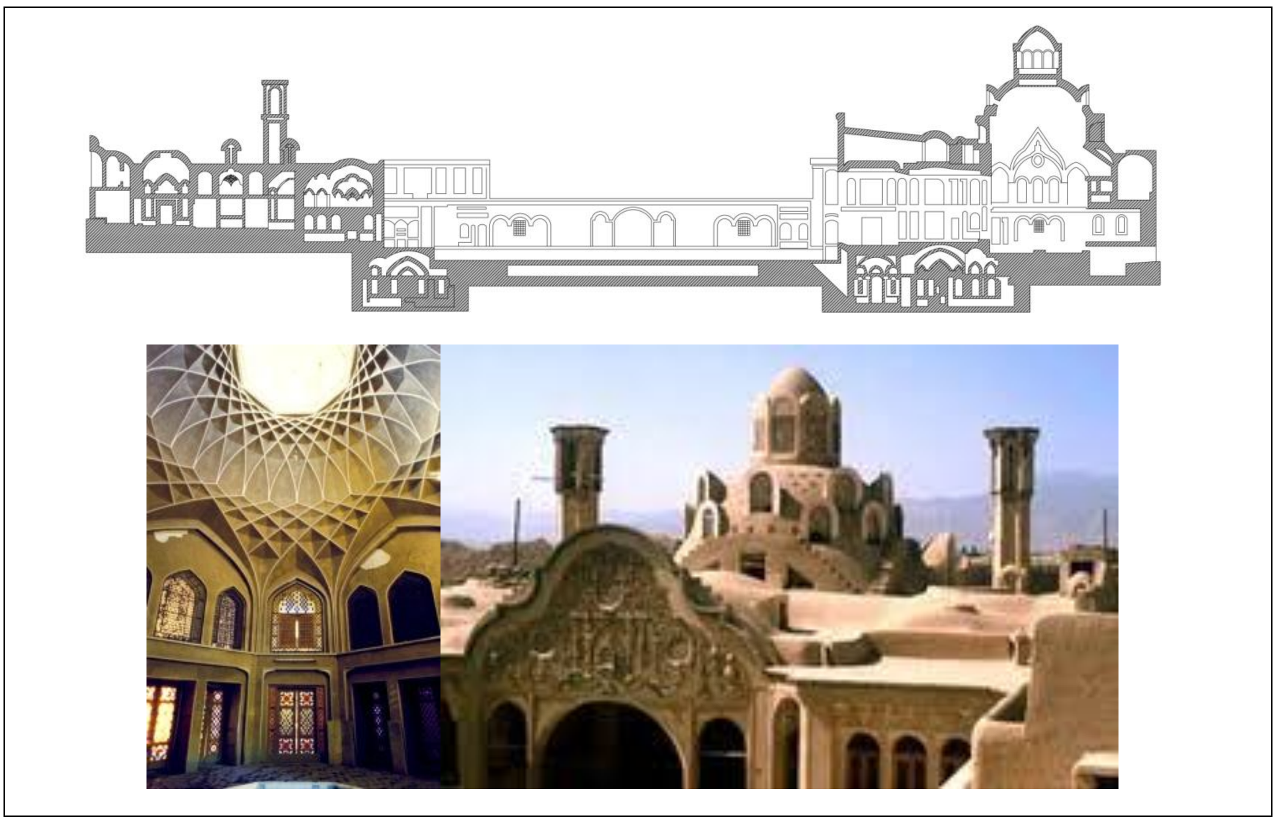


Fig.3. 4.Natural ventilation in Boroojerdi ha House [1]

As mentioned before, there are two different sections in the house, winter, and summer sections. The residents live in the winter section when the cold season comes; this section is in the northern part of the building to receive as much direct sun light and heat as possible. When the warm season comes, the residents move to the summer section, placed in the south part of the house that provides them with indirect sunlight and deep shadows. To add more to the comfort, the building is design in a way to protect the courtyard and the heart of the house from the undesired warm dusty wind and storms.

Another important element of the nature used in the house is water, which is placed in the middle of the garden with a pool and fountains. This makes the courtyard even more pleasant when the temperature goes really high. The courtyard so becomes a semi private part of the building, in which the inhabitants can sit, socialize, eats, and chill on the platforms placed inside it.

Fig.3. 5.Section of the building [1]

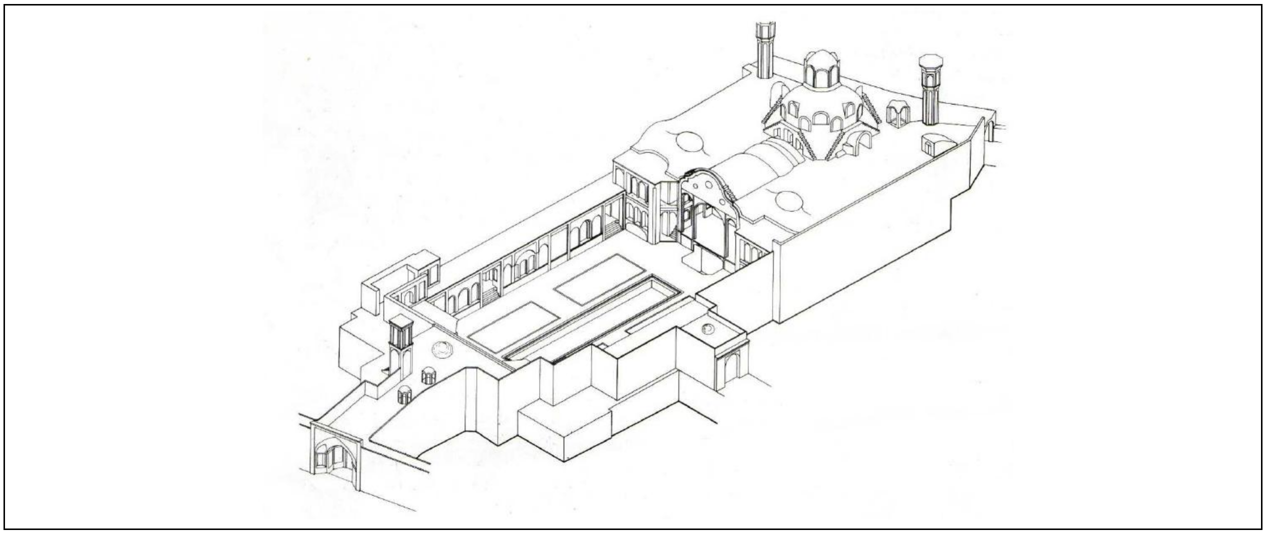


Fig.3. 6.3D Model of the building [1]

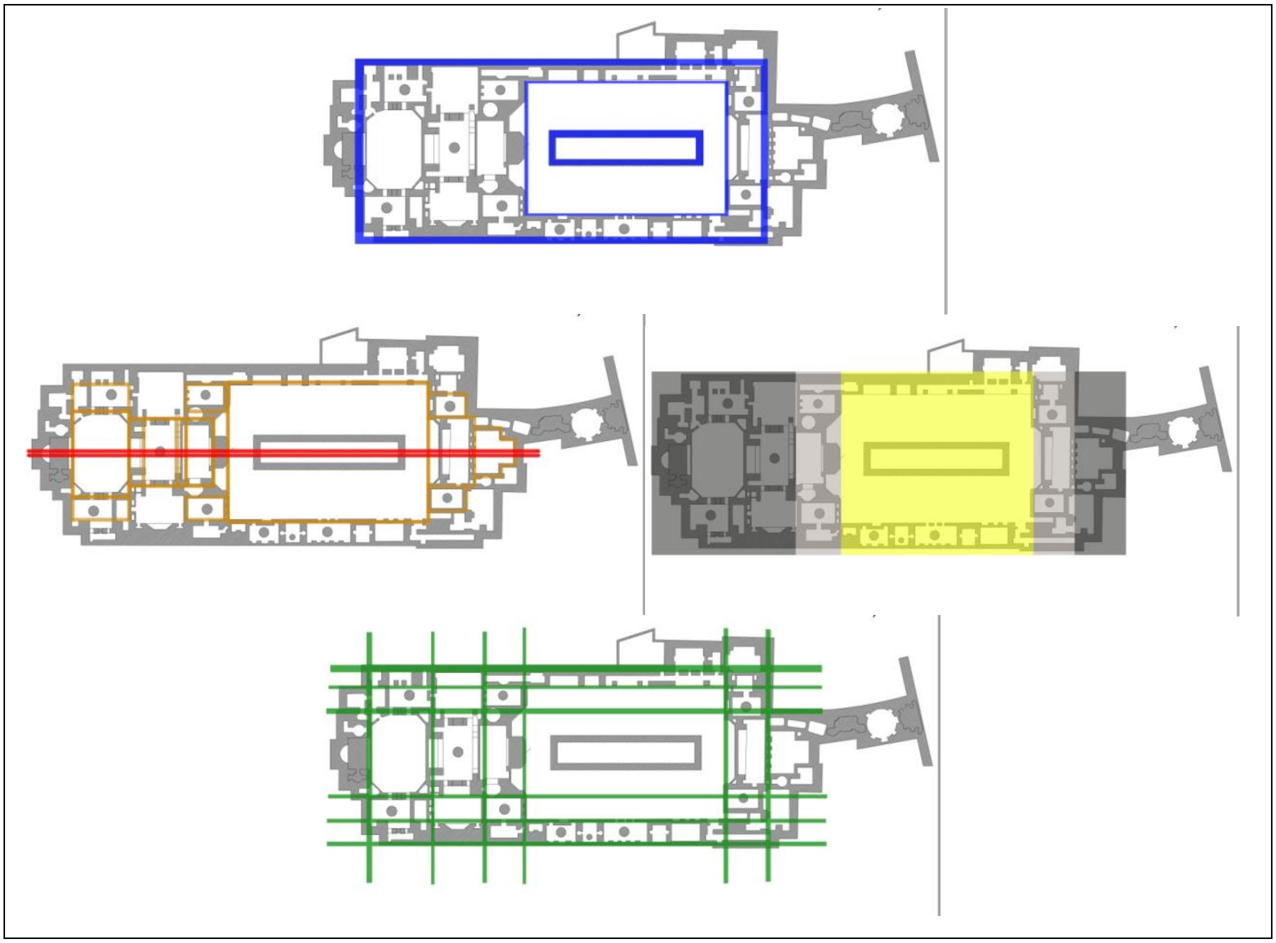


Fig.3. 7. Analysis of the house in terms of Central organization, Grid organization, Symmetry, and Sequence of open-closed space

3-1-2-Tabatabaee-ha House

This house is also one the novel designs of its own era and is placed in Kashan city as well. It consists of two different and independent sections that were later connected to each other in a clever way.

The larger section of the house has a rectangular shape courtyard. This courtyard has four cantons in each corner. The most area of the house is constructed in the southern part. The facade of this part of the house, as can be seen in the photos and the 3D model, has a higher semicircular vestibule, beautifully decorated and ornamented in pillars and stuccos, walls and ceiling.

The main entrance of the house is in the southeastern part of it, which leads to a series of hieratical spaces that reach to the main courtyard, and the other attached section of the house. Behind the main porch (Eivan) there is a main reception hall, decorated with Yazdi-bandi, which connects the first building to the second one with small yard. These two small courtyards, are located in the two part of the main hall, and are in the center of two story buildings, with a small pool in the middle.

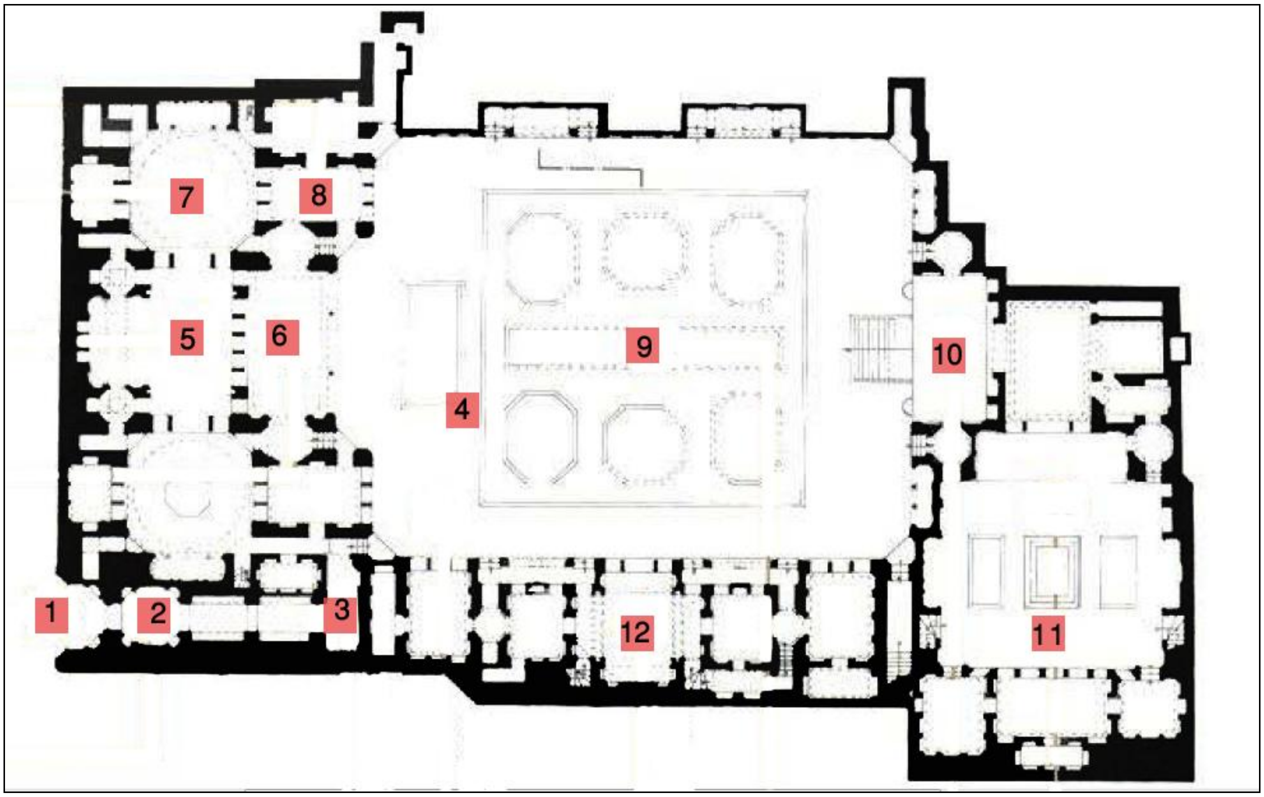
The reception hall and four, 3-dari (the rooms with three openings) are in the eastern part of the house, and are connected to each other. The facade of this part of the house has a unique composition of the semicircular arcs, with stucco carving.

The second section of the house (the smaller house that was connected afterwards to the big one), is more a private space, with a small courtyard, and small porches (Eivan). 5- dari (rooms with 5 openings), and a reception hall. There is a large basement area in the house, for summer uses. One of the main characteristics of the house is the obvious symmetry used in every part of the house.

Fig.3. 8.Tababaee-ha House [1]

The construction of this house, according the inscription in the main hall of the building, dates back to 1880 AD.

Fig.3. 9.Tabatabaee-ha House [1]



1. Entrance 2. Vestibule (Hashti) 3. Corridor to the courtyard 4. Courtyard 5. Living room	6. Porch (Eivan) 7. Pool house (Howz Khane) 8. Three doors room 9. Pool 10. Porch (Eivan)	11. Minor Courtyard

Fig.3. 10.Tabatabaee-ha House plan [1]

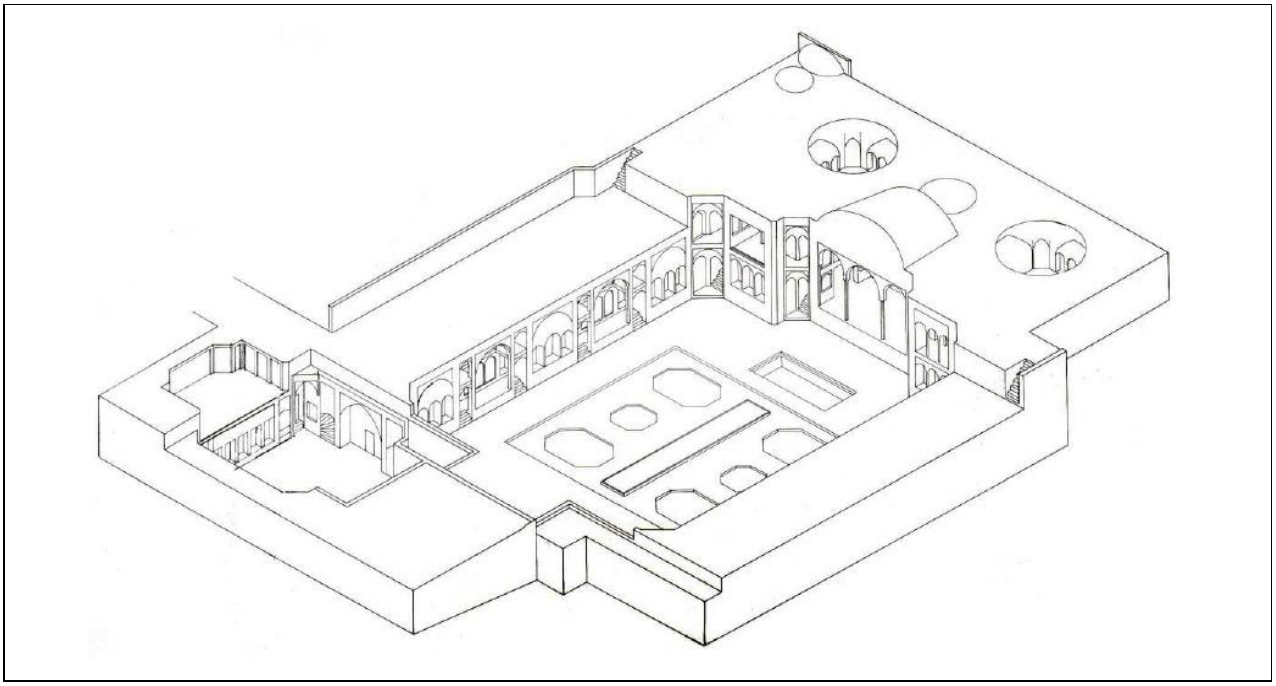


Fig.3. 11.3D Model of the building [1]

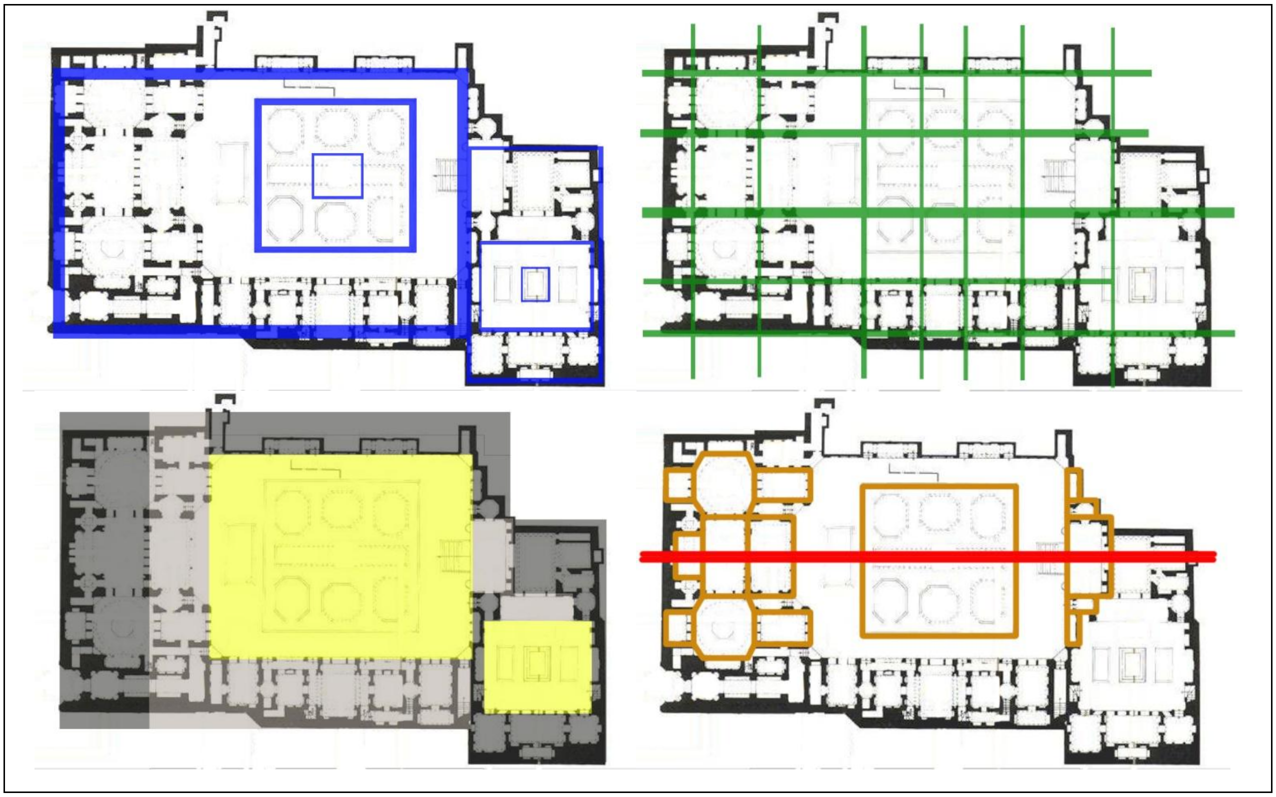


Fig.3. 12.Analysis of the house in terms of Central organization, Grid organization, Symmetry, and Sequence of open-closed space

3-1-3-Abbasian House

This house is one the most famous and interesting house among the houses in Kashan. It has a very diverse set of spaces and rooms that is unique of its kind. In addition to that, the spiritual quality of the spaces in this house is dissimilar to the other houses. It has a small yard, widened in the upper floors, in order to create a well-proportioned open space in the southwest and northeast parts. This also contributes to a better view for the main vestibule, which is a little higher than the other parts of the construction and has amazing Yazdi-work ornaments [2].

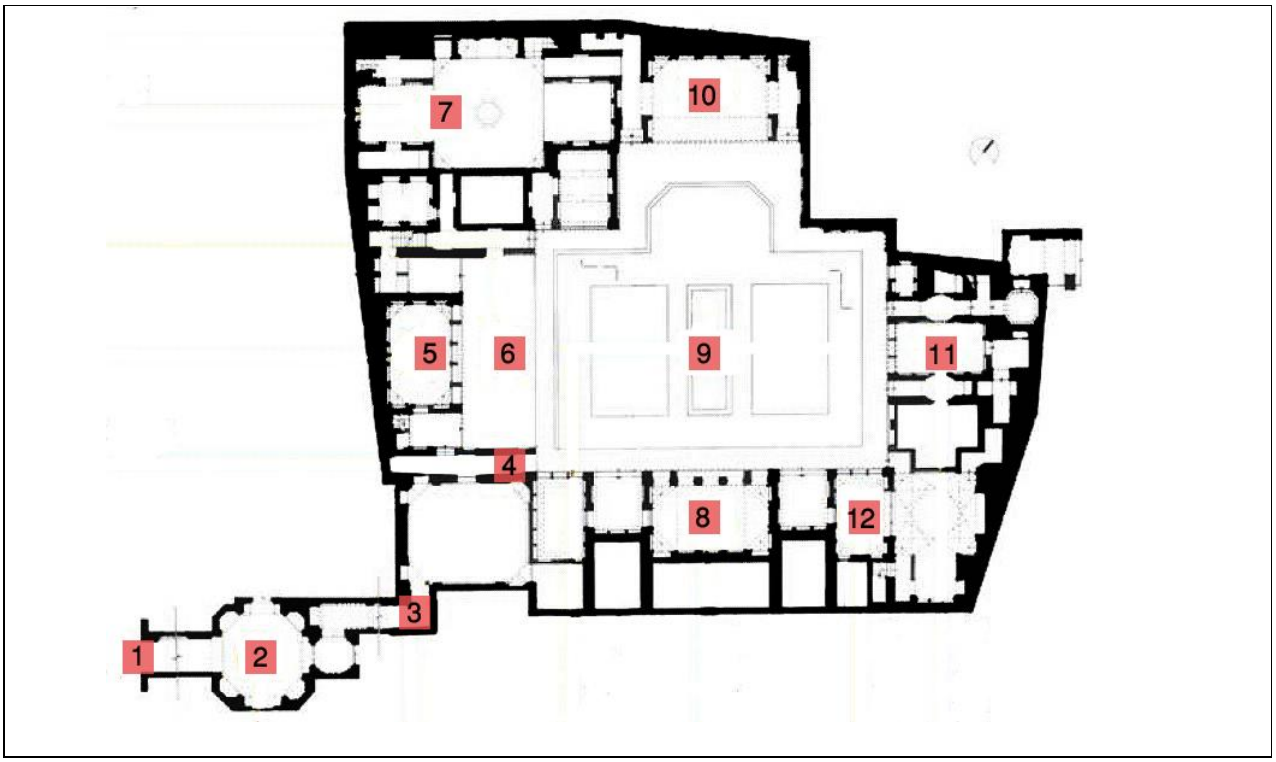
Differently from the other houses mentioned, this house has two entrances, one of which is placed in the southern part and leads to two corridors and two lobbies (Hashti). One of them of course makes the access to the yard. The other entrance is located in the northern part of the house, same as the other one, leads to a small lobby (Hashti), and a corridor, and reaches to the courtyard. The courtyard is relatively small, but widened in the upper level.

There are two reception halls in the southwestern and northeastern part of the house. There is a big living room behind the porch, which is the most important part of the house. The porch (Eivan) which is slightly higher than the other rooms has Yazdi-bandi ornaments. In the southeastern part of the courtyard there is a huge living room, with two 3-dari rooms besides, that can be added to main hall by opening the sliding up Orosi doors, and make a huge space out of it, which is a good example of flexibility in traditional architecture of Iran. Above these big hall, one the first floor there are the private rooms, in different sizes.

In the western part of the building, there are two big reception halls connected to each other, and on the upper level, there is a 5-dari room (room with 5 openings) , with two big terraces, and a higher arc in the facade, which makes it more specific and unique from the other parts of the house.

The northeastern part of the house, which is a little bit lower than the other parts has similar facade to the one face. At the upper level there is one 3-dari room, and a reception hall. At the western part of the house, as you can see in the plans too, there is a pool house (Howzkhaneh), which has a dome, and barrel vaults that make it unique from the other sections. There is an exceptional characteristic in this house, which is the shared area and space with the neighbor houses in the southeast part of the house. The house is decorated in rasm-bandi, orosi doors, colorful glasses, yazdi bandi, stucco carving, and mirror works [2].

Fig.3. 13.Abbassian House yard [2]



1. Entrance
2. Vestibule (Hashti)
3. Corridor
4. Corridor to the courtyard
5. Living room (Talar)
6. Porch (Eivan)
7. Pool house (Howz Khane)
8. Five doors room
9. Courtyard
10. Main Living room
11. Three doors room
12. Three doors room

Fig.3. 14.Abbasian House plan [2]

Fig.3. 15.View from Inside of Abaseean Home yard [3]

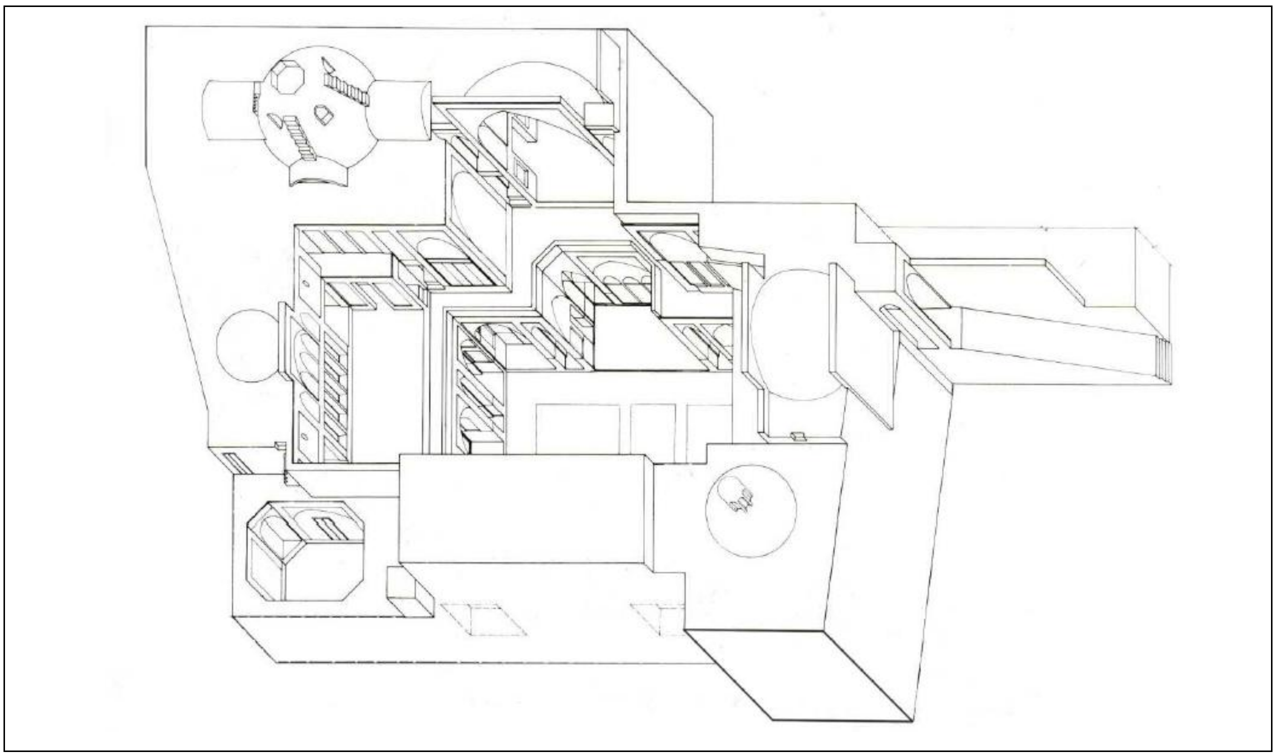


Fig.3. 16.3D Model of the building [3]

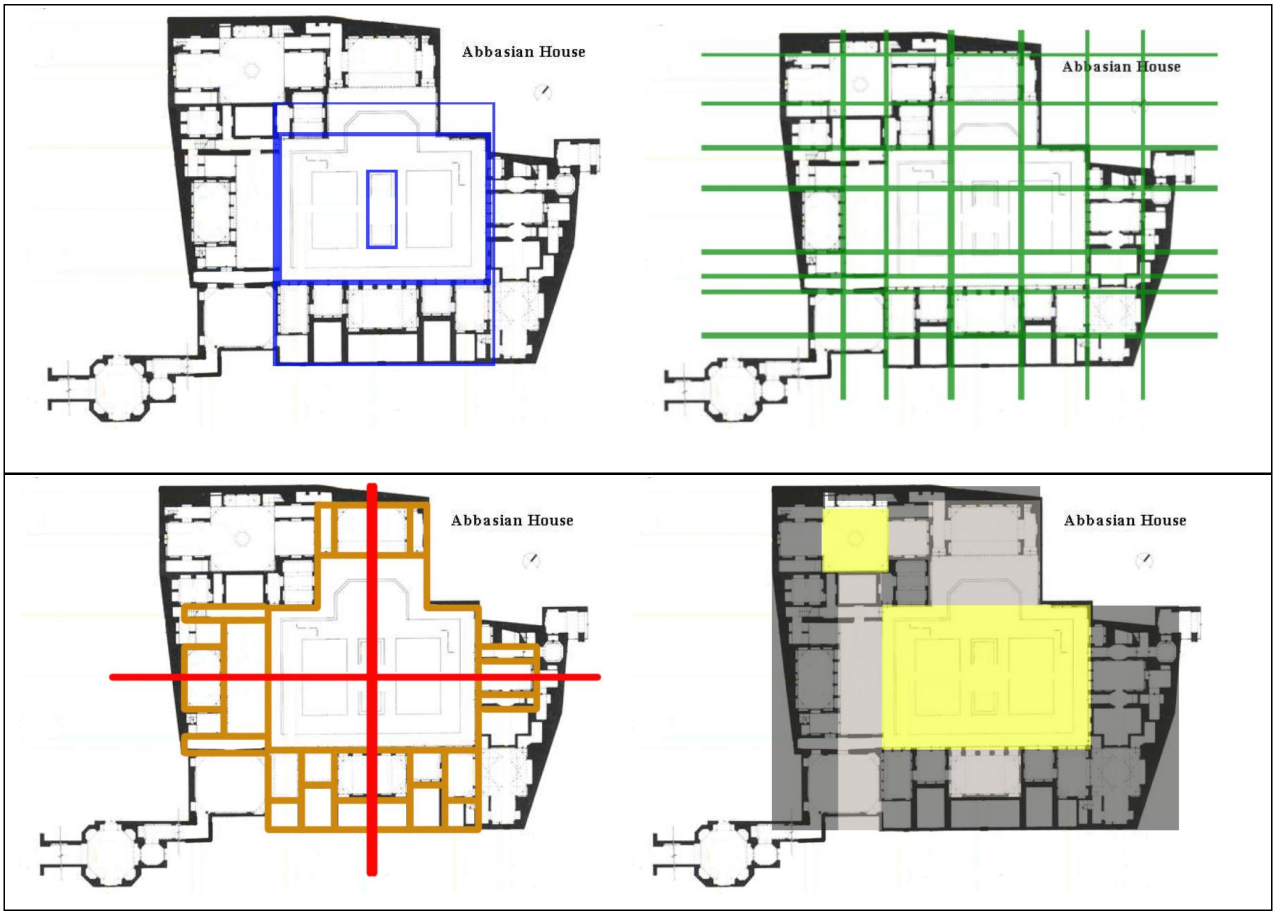
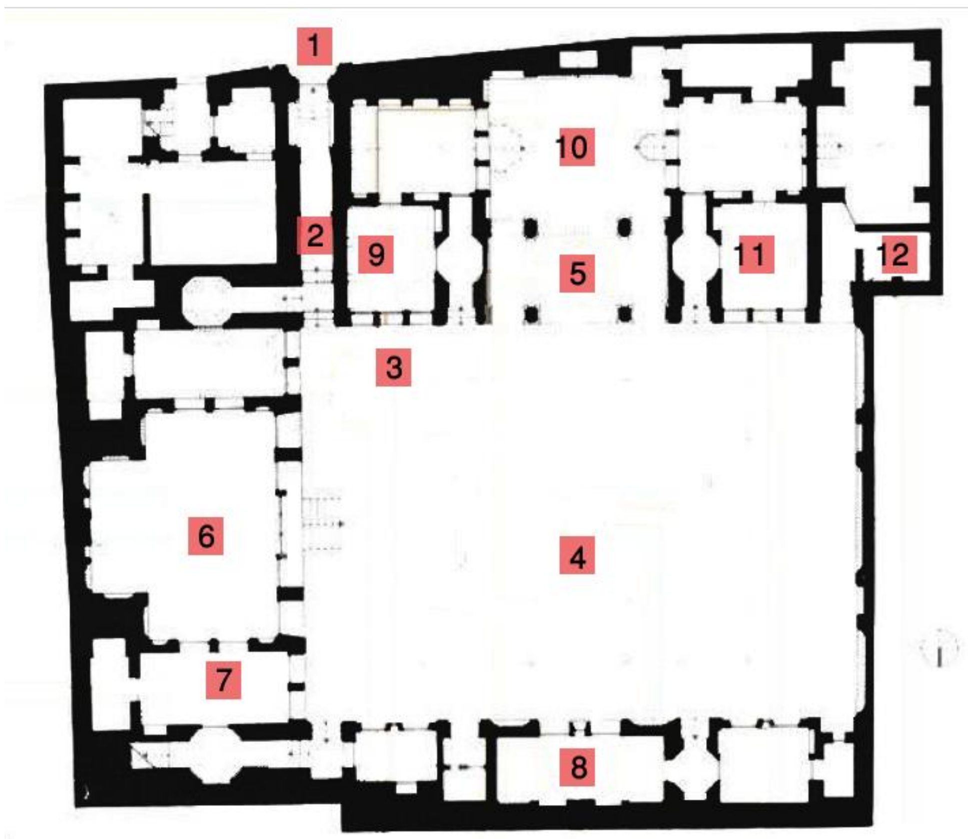


Fig.3. 17.Analysis of the house in terms of Central organization, Grid organization, Symmetry, and Sequence of open-closed space

3-1-4-Attarha house



1. Entrance	6. Main living room	11. Three doors room
2. Corridor to the courtyard	7. Two doors room	12. Staircase
3. Courtyard	8. Five doors room	
4. Pool	9. Three doors room	
5. Porch (Eivan)	10. Pool house (Howz Khane)	

Fig.3. 18.Attarha House Plan [4]

Fig.3. 19.Attarha House [4]

Attar ha house is constructed in three sides of the plot with the centralization of the courtyard. It is a two story building in the western section, and one story in the northern and southern section, which gives a sense of openness to the garden. In the southern edge of the house, we have the main entrance with a direct connection to the courtyard, and differently from some other Persian houses, this house has also a secondary entrance.

The main part of the house, located in the eastern section, contains a large living room with dome shape roof, and yazdi-bandi decoration, and two, 2-dari and a huge basement with direct accessibility to the garden. Connected to this basement, there are two wind catchers, to moderate the temperature, which are located in the northern and southern parts of the building.
The main facade, in the front, has a unique simple Orosi door (wooden door designed by colorful glasses) in the center.

The Pool house (Howzkhaneh) with dome shape ceiling and a wind catcher behind, and the porch (Eivan) defined as two semi- open spaces are placed in the southern part, in addition to two, 3-dari rooms on the sides. Three, 3- dari rooms and corridors are situated in the northern part of the house, with good accessibility to the biggest room. The facade of this section is similarly proportional to the opposite one.

Fig.3. 20.Attarha House courtyard [4]

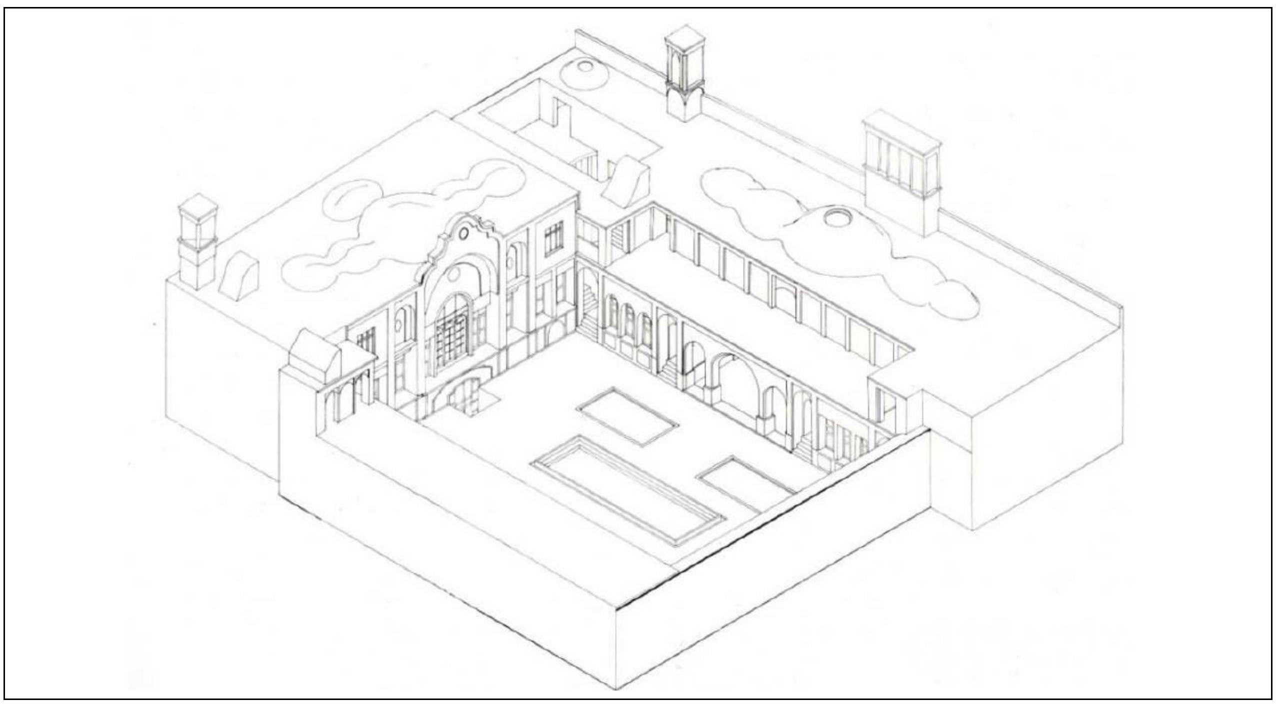


Fig.3. 21.3D Model of the building [4]

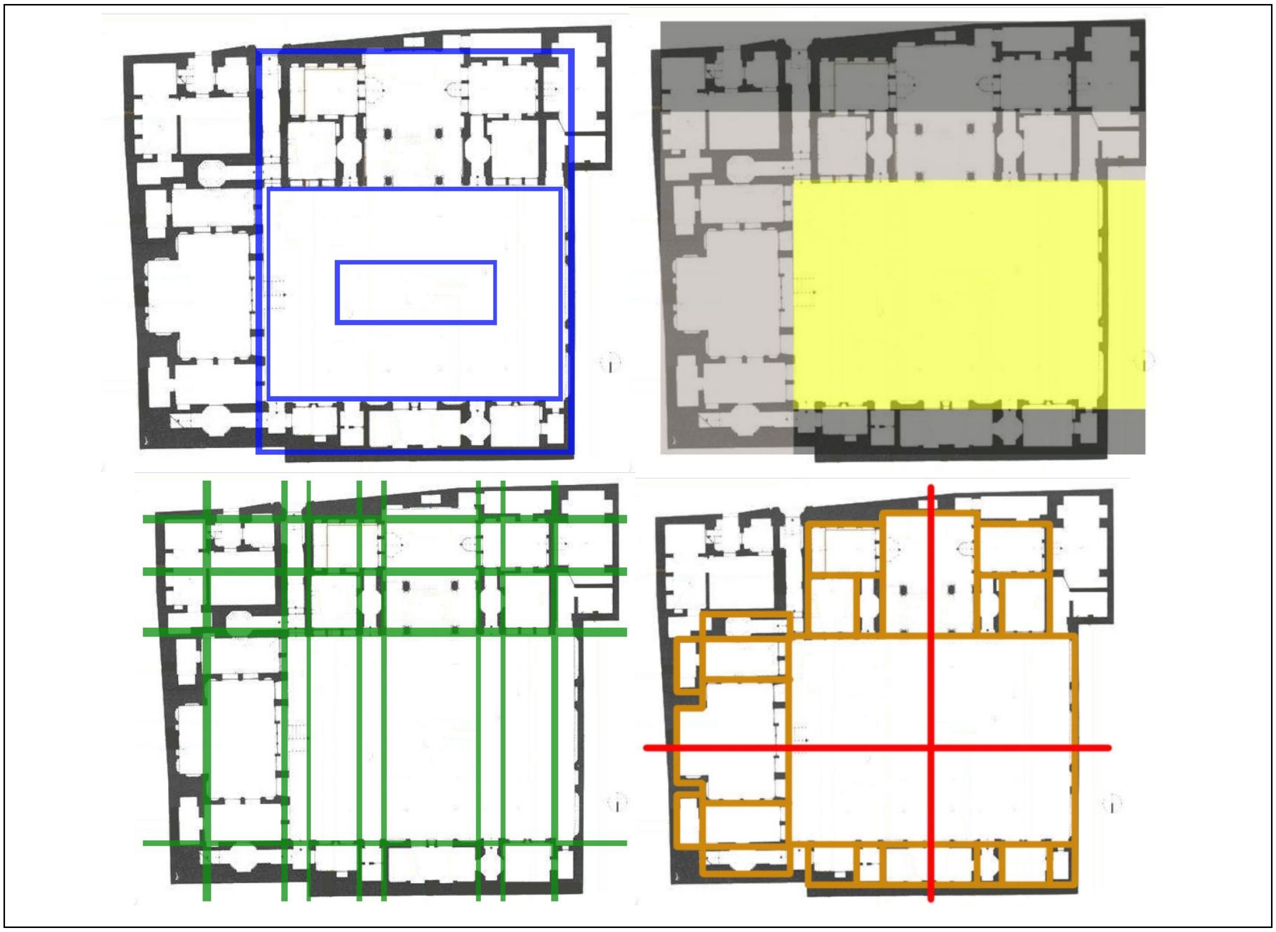


Fig.3. 22.Analysis of the house in terms of Central organization, Grid organization, Symmetry, and Sequence of open-closed space

3-2-Iranian house

3-2-1-General characteristics and definitions

Having the history of 6000 years behind, Iranian houses amazingly has kept the following characteristics:

1. It contains humanistic aspects
2. It is functional in means of design, planning and construction
3. It is using the vernacular building material
4. It is proportional, modular and scaled
5. It has an introverted design

The outer appearance of Iranian houses is simple, which gives a good feeling of peaceful and protected habitation. In order to give a maximum sense of privacy to the house, the entrance of the house is hardly noticeable from outside. The house is the main core to bring all the family members together, and so it is considered as a "sacred" space, which should be well-protected and well- separated from the outside. In such society, house is more than just a dormitory, but it has its own meaning and function in all aspects of its inhabitants' lives. The traditional Iranian house is consisted of two main spaces, divided due to the privacy issues, with a series of key characteristics as follows:

- **The External Sections (Birooni)**

It includes the vestibule (Hashti), the atriums and corridors, the courtyard, the summer part of the building, the basement that is connected to the wind catcher, the stories, and the kitchen.

- **The Inner Section (Andarooni)**

It includes the rooms with different uses, the closet, the living room and another big basement, the courtyard and the guest room.

- **Light**

There are different ways of provision of light for each spaces mentioned above, for instance skylight for the vestibule (Hashti), netted windows for the basements to allow ventilation at the same time, and skylight and big colorful windows for the living rooms that are facing the courtyard.

The main facade of the building that, as explained before, is inside the house, is emphasized by its height, stairs, the different organization of the greeneries that leads to it, and with its geometrical form. The symmetry and use of special ornaments gives a spiritual beauty to it, and this beauty is emphasized by existence of a pool in front that reflects its magnificent design in it. The colorful glasses and the continuity and symmetry add to its value.
Although different in size and character, most of the traditional Iranian houses have strong order, modularity, and same space organization.

As it can be seen in the case studies too, most of the traditional houses are centrally organized and are inward looking. The other functional elements of the house are all around the courtyard and most of them open to it. The partially grid organization can also be seen in most of the houses. Some of the houses have clustered organization, in both summer section and winter section of the building, and each of them contains of different sizes of rooms (rooms with 5 openings, or 3 openings, etc) Symmetry organization can also be recognized in some of the plans, but never in the whole plan of the building. The connection between different spaces of the house is formed in two different systems. It is either with corridors, or some smaller transition spaces between the two main interior rooms. The sequence of the open to closed spaces in the houses is either linear or central. As it can be seen in the analysis of the plans, the sequence of open to close spaces in houses are somewhat different, some of them have linear organization, and some have central organization, but there is always a hierarchy as a basic principle in all of them [4].

- **Privacy**

As Iran became an Islamic country shortly after Islam arrived to Saudi Arabia around 600 AD, it was truly effective on the revolution of architecture in Iran too. Although it was of importance before Islam too, the clear influence of Islam can be seen in the obvious separation of the spaces inside the dwelling, to private, semi-private, and public. This division was more emphasized in houses as Islam became more accepted in the families. It is much related to the concept of Hijab in such religious societies.

- **Hashti**

This hierarchy in the houses is most complemented by use of corridors, and "Hashti". A Hashti is a small space usually placed right after the entrance, often in shape of octagon, half-octagon or square in plan. It often benefits from the daylight by using skylight. As it is the very first transition space while entering the house, the importance of the design and its dimension is very significant, this represents the financial situation of the owner. In order to make it an even more pleasant space in such hot-arid climate, they use to keep the walls wet to reduce the temperature.

- **Courtyard**

Although the outline of the houses is mostly non-geometrical, the courtyard is always rectangular, and on south to north axis, in order to maximize utilization of the natural light. The buildings are mostly one or two stories, and it is very common to utilize the underground space for everyday activities, since often it is the most pleasant area in terms of the temperature. It used to have different functions, such as storage, bathroom, kitchen or simply the room to gather and chill.
In most of the houses in Iranian architecture, the Hashti either leads to the guest area, or the courtyard. The largest proportion of Iran's territory has hot and arid climate, where gain little amount of rain yearly, which makes water as one of the most precious elements, both for agriculture and habitation. Thus, the image of living beside a green area is always perceived as the most desirable dream. In Iranian history, literature and culture, not only human being is never separated from the nature, but even he is considered as one of its elements.

- **Nature**

Studies show that there is huge lack of natural elements in the contemporary residences of Iran, comparing to the traditional ones. What has been ignored in these new constructions is the psychological inherent need of human being to feel connected to the nature [5, 6]. The traditional architects has bared this strong need in mind, and considered nature and human both as a purpose for their design.

As mentioned before, garden has a very strong and important role in Iranian architecture. It is the most important space in organization and design, a secure and calm space for the residents to rest and have fun .As you walk through the courtyard, you pass a pool with greeneries on both side. Some small rooms containing secondary functions of the house are on the side of the courtyard. The view towards the winter section of the building is south facing façade, in order to get a strong light and be warmer. But yet you can obviously see that the openings are less than other facades in order to lose less energy.

Nature as a purpose for the design is one of the reasons why most of the vernacular houses in Iran are based and centered on the courtyard, with all the four elements of nature (water, soil, wind, and light) inside it.

- **Water**

As a symbol of purity, life and productivity, is one of the most important elements of nature in traditional architecture. It has a sacred meaning in Iranians' beliefs, both in Islam and Zoroastrian (worshiping of sun). It should also be considered that it has an important role in terms of agriculture too, and there is a strong principle among Iranians not to waste it.

- **Soil**

As the second element, has also a very particular meaning in Iranian culture. It is said that the human body has originally made from soil, and shall return to soil, same as architecture.

- **Wind**

Wind is the clearest symbol of the ether, a carrier for light, and indicator of heat and moisture properties. The air flow gives lightness, softness and ability to rise. Wind is the clearest symbol of air in the nature. This element is symbol of human being's invocations of God, speeches and blessings. Plentiful shapes of roof spaces, wind towers and wind catchers are the constructive shapes that are related to the wind that is the air layer movement [7].

- **Daylight**

As the last element, resembles to fire that is a strong element in nature. Its main characteristics are softening and warming and lighting. In most of the religious beliefs light are a symbol of wisdom and the spring of wholesomeness [7]. On the other hand, the use of nature in Iranian architecture can be assessed and categorized in a more physical and mechanical point of view:

- Nature is also used to provide a more pleasant weather and make a more regular geometry inside the building.
- Nature as a form is also used in most of the decorations and ornaments in traditional buildings.
- Conceptual naturalism and the deep integration of the building with nature are of importance.

- The climatic responsive design and the innovative use of wind, sun and natural energies with help of wind catchers, skylight windows, etc to achieve inhabitants' comfort, is one of the most popular innovative solutions for such areas.
- Use of natural and vernacular materials in order to achieve a more environmentally and economically sustainable design is another aspect of nature that has been taken into account by the traditional architect.

3-2-2-Privacy, security and peace

Privacy, security and peace, are the three main factors of that effects in the inhabitants' everyday life. From the very beginning, Iranian architecture has always respected the relation between building and user. In order to have a suitable and pleasant dwelling, it is of important to consider the culture and religious believes which relates to the society .This is where the concept of privacy becomes vital. The combination of the open, semi-open and closed spaces is the formal definition of the privacy in architecture. But in recent decades, as the means of communications and the culture transfer changes, the Iranian architecture has been influenced by the western and "modern" rules. The problem arises when one pays attention to the very same needs and expectation of the Iranian user of the building, concerning the cultural privacy and religious beliefs. Also, considering the fact that the houses have become very smaller than the ones in the past, there is the need to redefinition of the privacy, and the use of flexibility of design as a tool to enhance the quality of the living environment.

Yusuf Al Qaradawi, the Islamic researcher, defines the house as, the area that each person protects himself from climatic discomforts and feels free and relaxed toward outside of the house. This definition or function of the house is based on many Qur'anic verses, such as, 'It is Allah who made your habitations homes of re stand quiet' (Qur'an, Su. 16:80) Privacy is one of the human's primary requirements in dwelling. According to Michel Georgiou "it's clearly obvious that the concept of privacy has a general definition, privacy is a property". People with different characteristics and personalities, need different levels of privacy, which they form in their everyday lives by defining private, semi-private and also semi-public spaces, in order to get a certain level of relieve that they desire to have in their dwellings.

The penetration of architecture in Iranian life style was more spectacular and has different ideas for organizing the spaces. These ideas tried to solve the cultural and religious needs of inhabitants. In 19th and 20th centuries, after the political changes during the reign of Qajar dynasty, there were big differences in the architectural forms of Iran. This evolution caused the shrinkage of houses and omission of courtyard because they changed to be apartments [8]. As a result, people face a number of conflicts in their living environment. One of which is losing the multi-functionality which was deeply rooted in the Iranian culture, and the other is the change of definition of privacy in small apartments, which was not desirable.

Flexibility as a tool in architecture can be used in order to redefine the open and free plans, and open spaces. Considering the Islamic rules too, while designing the circulation inside the apartments, as well as in the semi-public and public spaces, is of importance. It is also worthy to mention that one should take into account both physical, acoustical and visual considerations when designing in such cultures. Having considered these boundaries, the architect will be more successful in designing a dwelling which will be a pleasant and comfortable for its inhabitants.

3-2-3-Privacy in Iranian Dwellings, the Influence of Religion and Cultural Views

The traditional Iranian house is a combination of a series of different open, semi-open, and closed spaces, which are well-separated due to the different functions. This combination is pleasingly mixed with the nature that has a key role in Iranian design. The ability of movement and circulation is ultimately brought into play in order to create a useful and enjoyable space for the dwellers.

In traditional Iranian architecture, buildings were built on more than one floor. As mentioned before, due to the need of having visual and acoustical boundaries, In order to block the view from the outside, the architects usually leave no opening on the outdoor facades. This leads to an inward looking and introverted design of houses, and reached to a more visual and acoustical privacy. The same concept, with different design has been used inside the buildings in order to achieve this goal. To attain more visual privacy for the inner spaces, the rooms were raised from the ground floor level, to block the view from the courtyard.

The acoustical privacy is also as important as the visual and physical one. Thick walls, roofs, and floors were used to achieve the comfortable level. Besides, the hierarchy and the arrangement of the internal spaces were in such way that would contribute to the convenience.

3-2-4-The obligatory changes in social, economical lifestyles and the results

Due to the huge social, economical, and cultural changes the central courtyard could not be achieved anymore, because the plots have become much narrower. So the building should have been placed, either in the southern or northern part of the plot. This caused also a certain changes in the inhabitant's lifestyles. The buildings, often designed as two story residential structures, were divided functionally in a completely different pattern. In contrary of the traditional houses, the contemporary ones have smaller living areas, and shared courtyard, which belongs to all the families living in the apartment. The new regulations were introduced, stating the necessity of allocating 40% of the plot to an open space, which means that 60% of the plot is allowed to be constructed. This had a huge influence on the spatial organization of the houses and consequently, the organization of the open spaces and greeneries, both in the houses and the neighborhood. In despite of all the cultural, social and environmental troubles, now most of the buildings are designed with this new typology and it is largely accepted by the citizens, as a normal type for their apartments [9].

As one could imagine, the influence of the "modern" design in Iran, has covered all the social, cultural, and physical aspects of architecture. However, these influences did not reach the deepest cultural norms and expectation of the inhabitant of the living milieu. The cities are growing surprisingly fast, and in the today's chaos lifestyles in the big cities, everyone needs his/her own private spaces in vicinity to their work place, to achieve the desired tranquility. As a result, the large families who used to live together are not able to continue the same habits and lifestyles.

According to Darab Diba, since the Revolution of 1979, Iran's population has doubled. Iranian cities have grown, especially Tehran (from 1.5 million in 1956 to 2.7 million in 1966 to 6 million in 1986 and 12 million in 2002) [8]. The maximum two story houses have changed to the medium-rise apartments. The buildings no longer follow the introverted pattern; they are much more outward looking, which do not meet the housing need and expectations due to the lack of connectivity to Iranian culture.

Of course it is of importance to consider the economical situation as well, as a factor to manipulate to such designs. The price of the land has increased tremendously, and the families could no longer afford the beautiful traditional houses. This has led to change the definition of privacy, and the struggle to create it by different means. Today's new apartments in most of the big cities are much alike the ones found in western cities. The houses consist of either combined or separated interior spaces in order to function. In case of the combined spaces, it is very difficult to clearly distinguish and define one from another, as an example the vague district of the living room, dining room and entrance can be mentioned. Due to the absence of enough space, Iranian houses have lost their quality. Flexibility and getting back to the traditional definitions of the space can help the architect to offer the desirable living space to the inhabitants of the today's "modern" cities.

This process of transformation has been illustrated as a schematic drawing by Madanipour (1998) as shown in 3.23 which indicates 3 steps of transformation of house in Iran. As it is obvious in the drawing, the traditional form of dwelling had an inward-looking pattern with a courtyard as the focal point. The second pattern shows the transition period and the third one exemplifies modern residential towers now common in most of residential complexes in Iran. At the time being, almost all residential constructions in major cities of Iran follow the third pattern with minor differences due to site limitations, economic considerations or in some cases personal preferences of developer [10].

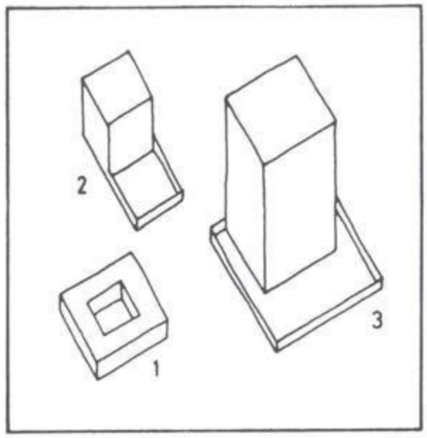


Fig.3. 23.Madanipour, 1998 [10]

3-2-5-To Achieve Privacy and Social Interaction in Neighborhoods of Contemporary Cities

Privacy as a property was not only of importance in the Iranian architecture, but also in the urban design. Although the traditional architect and urban designer in the ancient Iranian towns pay an immense attention to the inside, this has not leaded to isolation in those cities. The lack of this consideration in contemporary planning and designs has decreased the quality of not only the houses, but also the neighborhoods, which are in fact the most important spaces relating to the social interaction of the inhabitants.

In this project, we have tried to give an alternative solution for the neighborhoods that would respect and consider more, both the urban growth and peoples' cultural background. In order to attain a more sustainable urban space, that not only considers the inclusiveness of the public space, but also adequately respects the comfort zones.

All above can be achieved by create transition spaces, and by giving a sense of hierarchy in the modern neighborhoods, same as the traditional ones. We tried to contemporize the traditional forms and definition of the private, semi-private, semi-public and public spaces.

Following the introverted personality of Iranians, the traditional houses and cities have pursued a specific sequence inside them. To gain the same level of quality in the urban spaces, we tried to learn from the traditional architects and extract the key values and contemporize them, considering all the economical and social and historical boundaries that we are facing in the last decades. To enrich the chosen area, we follow some of the main characteristics in the structure of the Iranian traditional cities, which were successful to provide a convenient space for the dwellers, and encourage the everyday interactions, by considering both environmental and social sustainability.

3-3-Structure of Iranian traditional cities

Analyzing the environment and arrangement of Iranian traditional cities shows a general status. In all of them, there is a main axis, which often has economical functionality. This main axis often leads towards one of the key junctions of the city. From this main axis, other secondary passageways are branched, and they connect this axis to the secondary nodes in the neighborhoods. Often there could be found some of the typical public buildings in the city, such as Mosques, water reservoirs, and plazas designed for the public gatherings.

These nodes were the semi-public spaces. They offer a space for everyday social interactions among the residents in the surrounding area. In most of them, a kind of "gateways" was placed to control passing the strangers to this well-defined space.

These nodes would then lead to a semi-private space. This latter one would belong to a certain number of families only. This was the space in which deeper and more continuous social interactions would occur, especially between the elderly, children, and housewives. These semi-private spaces, would lead to the so called "private" spaces, which are the houses. This is by definition the urban hierarchy considered by the traditional architects in Iranian cities, who have well-realized the need to protect the private spaces and the intervarsity of the Iranian people, as well as the strong will of interaction among them. Below you can find a perfect example of this hierarchy and sequence in the traditional city plan of Naien.

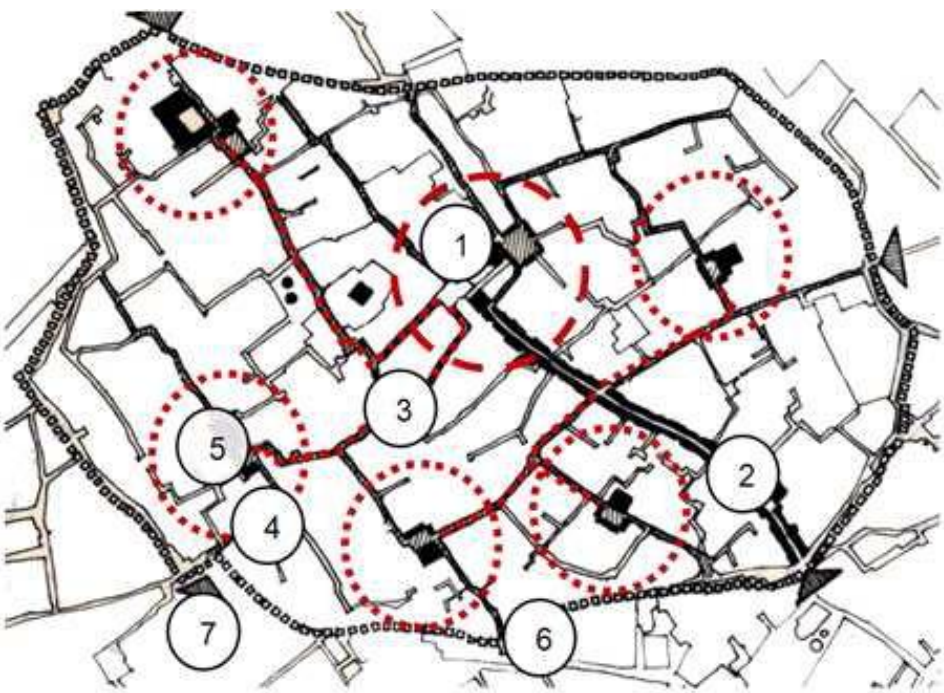


Fig.3. 24.The structure of old context of Naien, one of the historical cities of Iran: (1) City centre; (2) Bazaar; (3) Main route; (4) Neighborhood area;(5) Neighborhood centre; (6) city wall; (7)Main gates [11]

3-4-Modernism and formation of contemporary cities in Iran

Iranian traditional urban form follows a spatial sequence starting from Bazaar (public space), followed by neighborhood centre (semi-public), the semi-private space owned by a few number of households and ending to the house as a privately owned space (Tavassoli, 1990) [11].

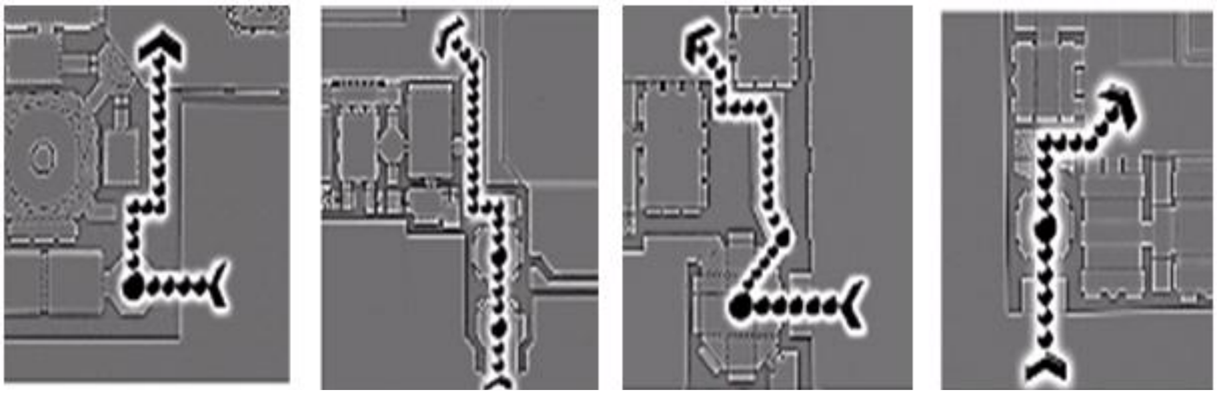


Fig.3. 25.The indirect path in the entrance space blocks a direct view towards the private parts of the house [11]

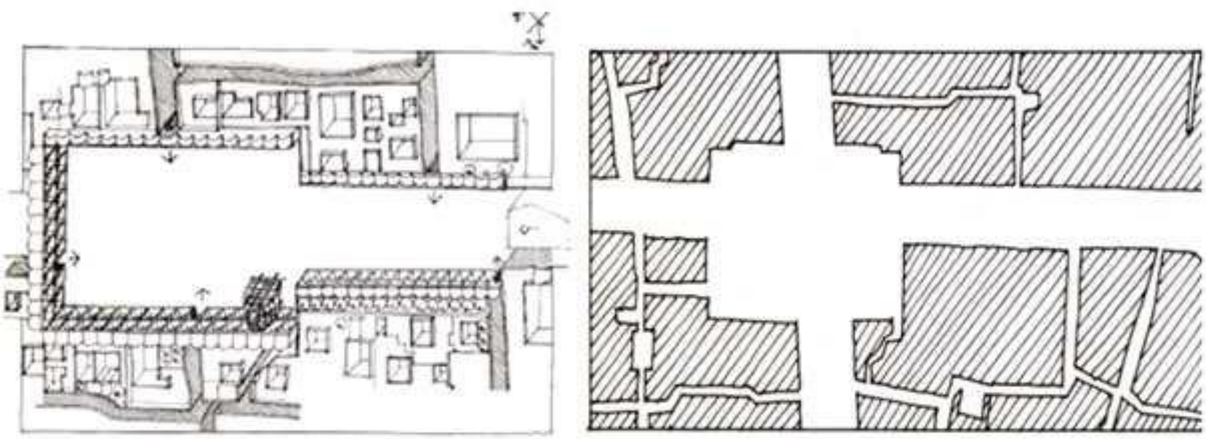


Fig.3. 26.Shah Tahmasb Square (left) in Yazd: the functionalist concept of modernism has changed the urban squares to car oriented junctions (right) (Tavassoli, 1990) [11]

In the recent decades, utilizing the scheme suggested by Hosman (1991) who encouraged wide and perpendicular gridded street pattern, street was introduced not as a complementary element and part of a continuous urban fabric but as an element dominating the whole system of urban spaces.

Consequently, there was no consideration of the sequence in contemporary neighborhoods in urban form that existed in traditional cities. Neighborhoods were segregated by wide urban roads and appeared as disconnected islands.

Fig.3. 27.A narrow alley in Yazd, Iran, promoted by the principle of social solidarity, and relationship of people [12]

Despite of the success of such designs in contributing in the creation of the modern and rapidly growing cities, they are by no means successful to satisfy the social and cultural needs of Iranians. As mentioned before, these qualities have been developed in during thousands of years, and are deeply rooted in the Iranian culture. In other words, because of the fast social and economical transitions happening in Iran, there was a need to pursue these rapid changes. Due to all this, the so-called modern urban planning, has more considered the quantitative needs above the qualitative values in the neighborhoods.

Fig.3. 28.Traditional and modern neighborhood [12]

As the modern urban planning were introduced, the inhabitants of the new Iranian cities found themselves living in the neighborhoods with open wide streets that were open to the strangers. These neighborhoods did not satisfy the sense of privacy and security needed.

As researchers believe, there is a direct connection between the lack of security and decrease of constructive social interaction. This is caused due to the strong sense of disruption by the others, which occurs when the spaces do not have any hierarchical values.

As a result the residents would not feel any sense of belonging to their living milieu. The neighborhoods are more vehicle-oriented, and so one leaving the house would step in a wide crowded street that is not designed for pedestrians. This is very common in the contemporary big cities in Iran. It is needed to mention that this hierarchy and sequence of spaces has also been suggested by western literature. For instance this transitional space had also been discussed before by Newman (1972) [11].

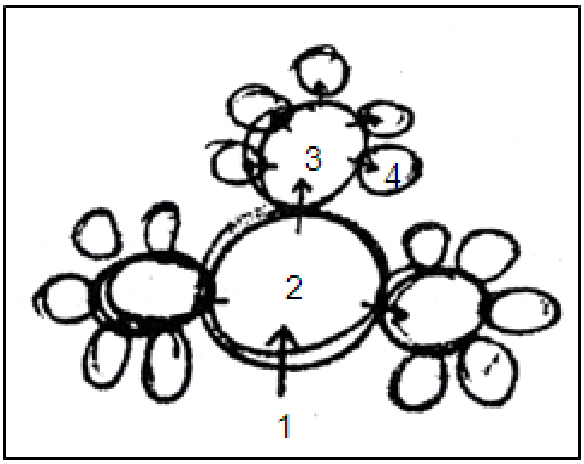


Fig.3. 29.The hierarchy of spaces suggested by Newman (1972), for enabling residents to control their territory: (1) public space; (2) semi public space; (3) semi private space; (4) private space [11]

3-5-Neighborhood solution

Following the traces of the traditional urban design in the cities of Iran, in this project we have designed a hierarchical neighborhood, which is branched from the main economical axis of the area to the semi-public and semi-private spaces. In order to give a stronger sense of belonging, the semi-private spaces, are functionally "owned" by a few households. These semi-private spaces work as a transitional spaces, in which residents can experience a pleasant social interaction with their neighbors, as well as it gives the sense of security to their private dwellings.

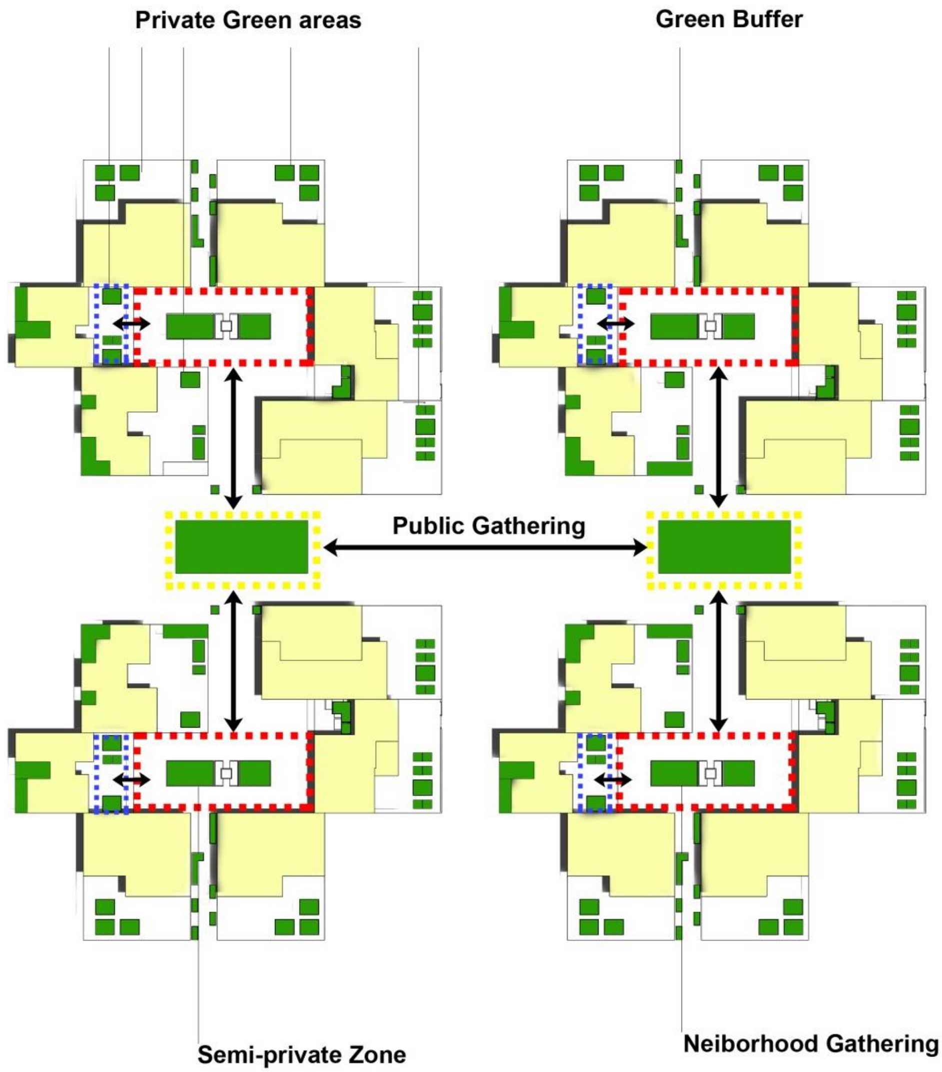


Fig.3. 30.The hierarchy of spaces of the proposed neighborhood

In other words, with this structured hierarchy in the living environment, each and every households and dwellers are assured of their privacy to be protected, as well as they are free to control the flow of social contact among them. At the same time they will not face a wide street when leaving their own house, to the so-called "no man's land".

The public buildings, such as shops, offices, mosques, and schools, complement the functional viability of the neighborhood. Although there is a clear division between private and public spaces, but they are both deeply related and dependant to each other and that is the main reason and result of a livable neighborhood.

To summarize, these public, semi-public, semi-private and private spaces, as well as in the traditional cities of Iran, will offer a sense of privacy, security, and belonging to the inhabitants, besides, it offers them to choose how much, how often, and in what way they prefer to communicate and interrelate with their neighbors, as well as the other residents in the bigger scale.

As stated by researchers, there is no point to ignore the recent changes in the urban contexts in Iran. The best reaction would be to consider both traditional history of architecture in these areas, and the modern lifestyle accompanied by the new city structures. The most desirable urban designs would occur by satisfying the different criteria of each issue. The transitional spaces as an alternative solution, based on the researches and studies on this area, would successfully meet the desirable social sustainability, and will be a balance between the two divided worlds of ancient cities, and the modern ones. This revitalization of the new neighborhood will lead to more healthy societies, in which the boundaries of social context are better defined.

Fig.3. 31. Residential neighborhood border

3-5-1-Proposed Neighborhood Plans

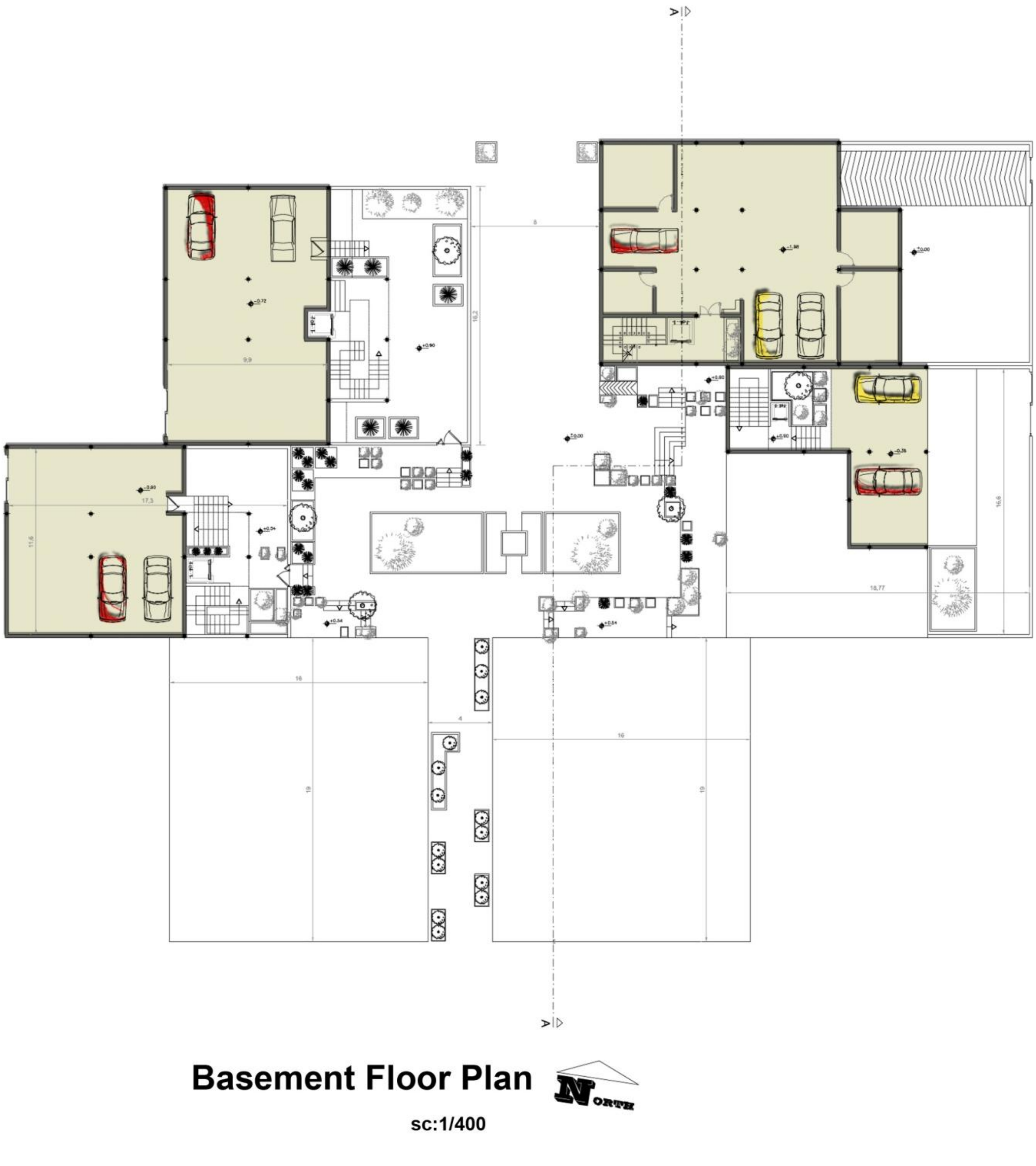


Fig.3. 32.Neighborhood Basement Floor Plan

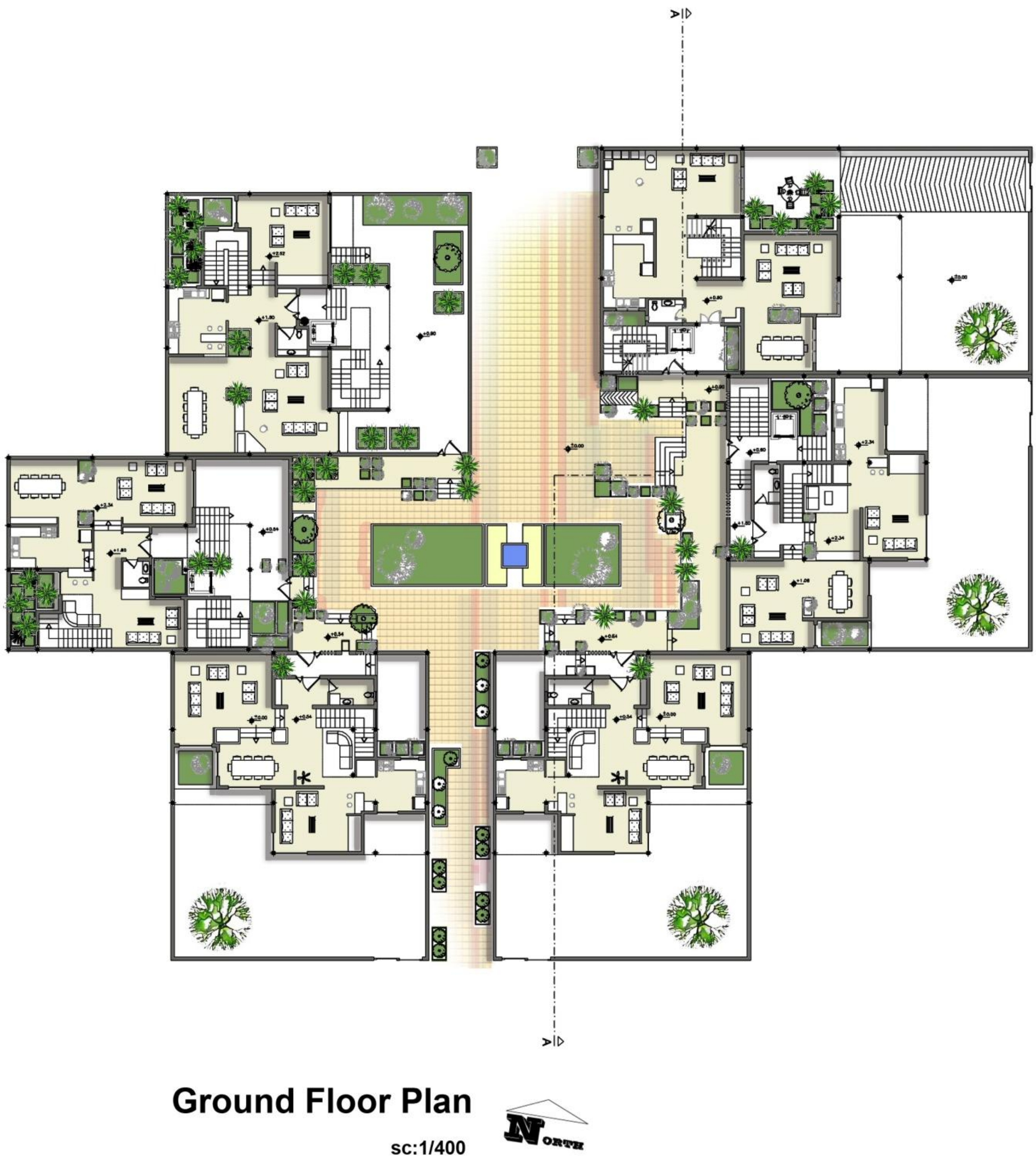


Fig.3. 33.Neighborhood Ground Floor Plan

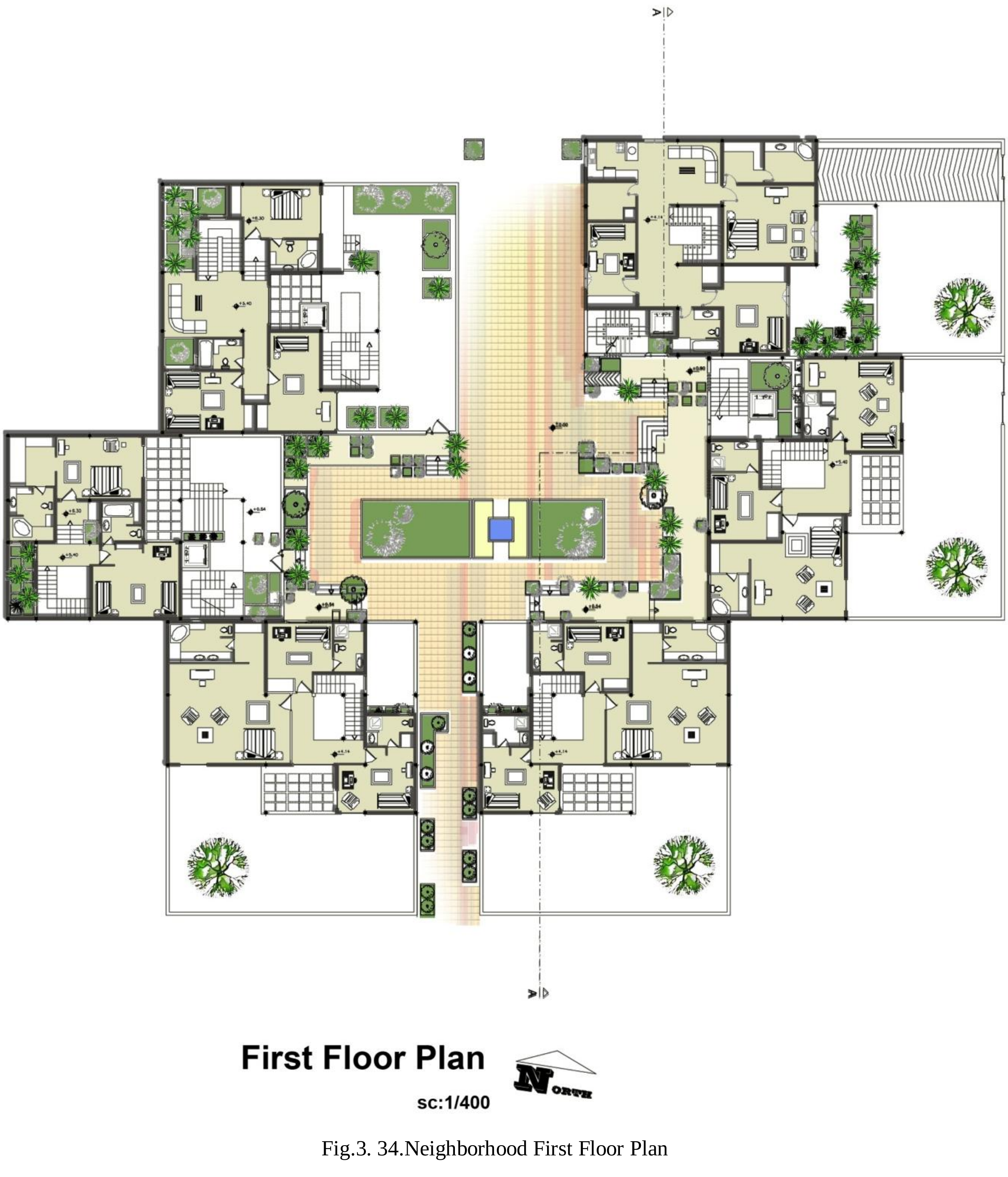
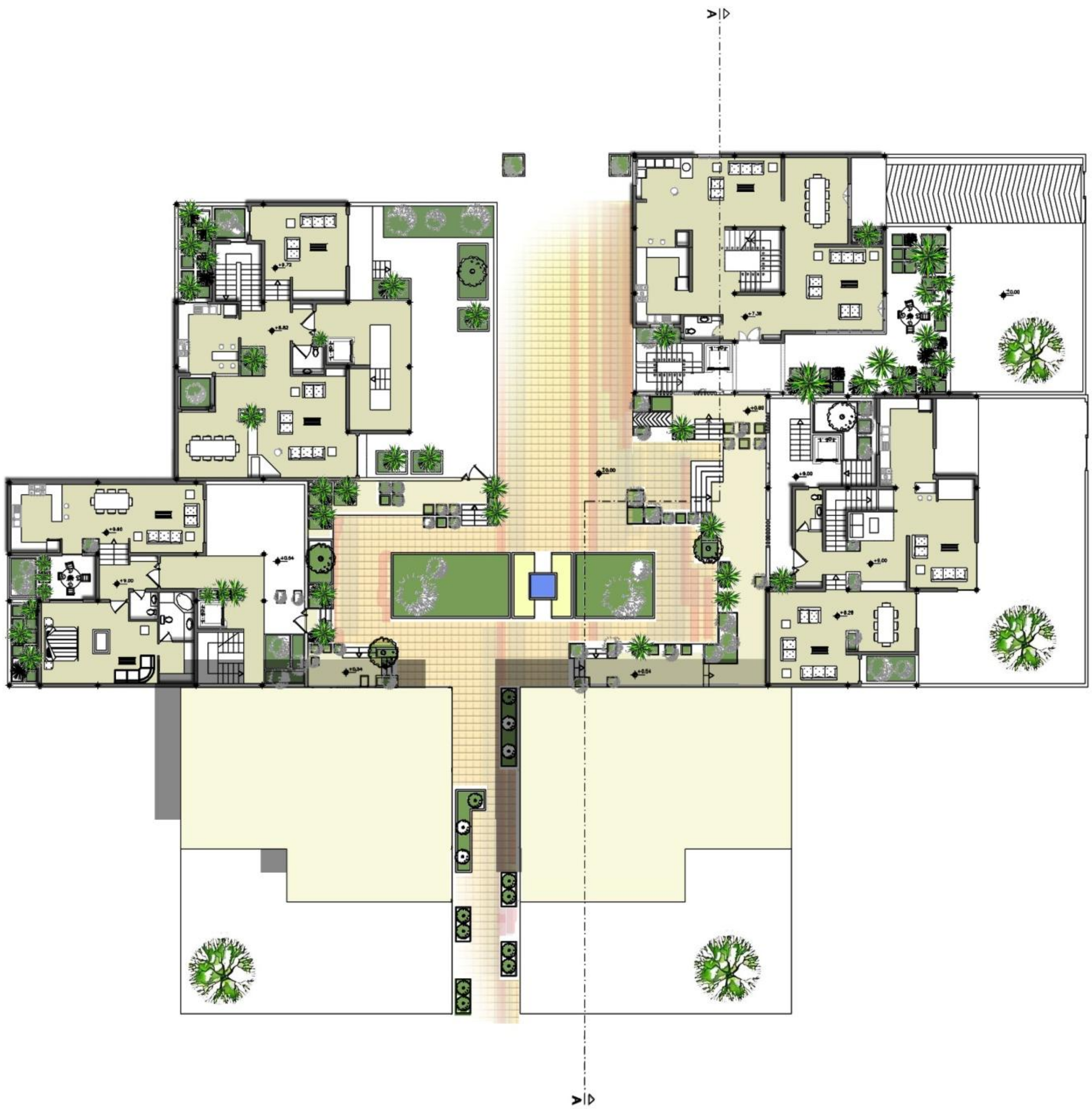


Fig.3. 34.Neighborhood First Floor Plan



Second Floor Plan

sc:1/400

Fig.3. 35.Neighborhood Second Floor Plan

Fig.3. 36.Neighborhood Third Floor Plan

Fig.3. 37.Neighborhood Section A-A

And below are the 3D views of the designed site.

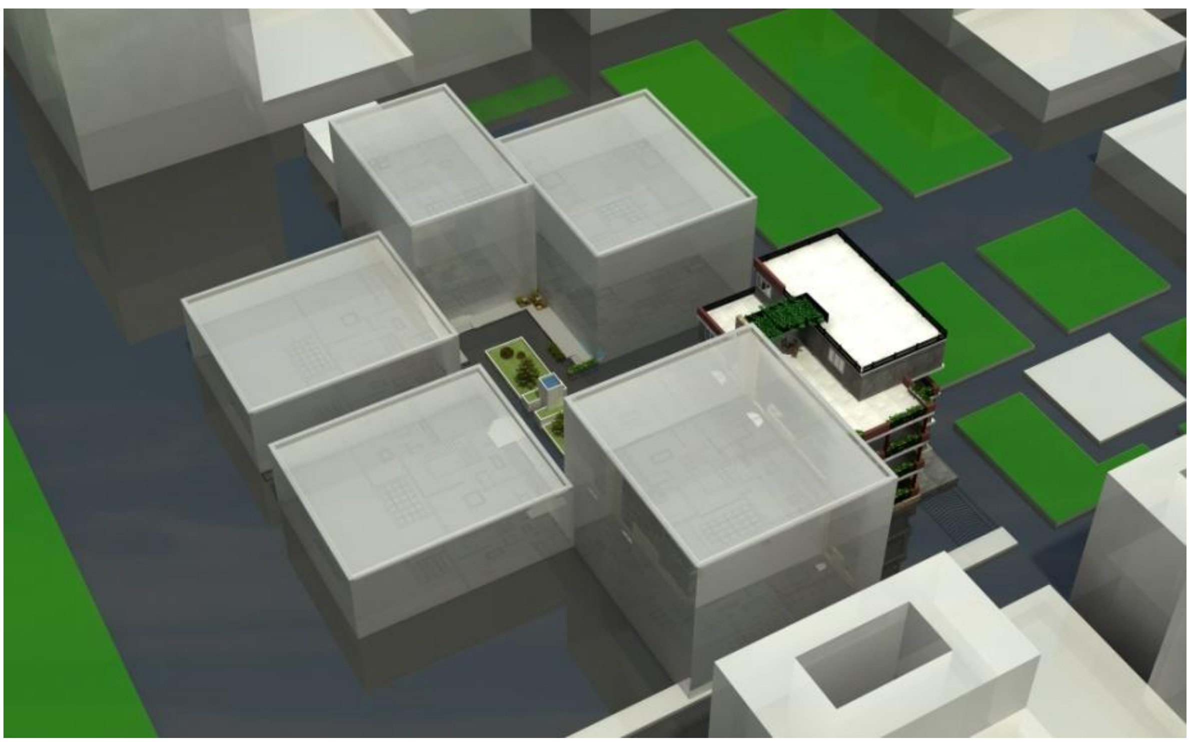


Fig.3. 38. Neighborhood bird’s eye view

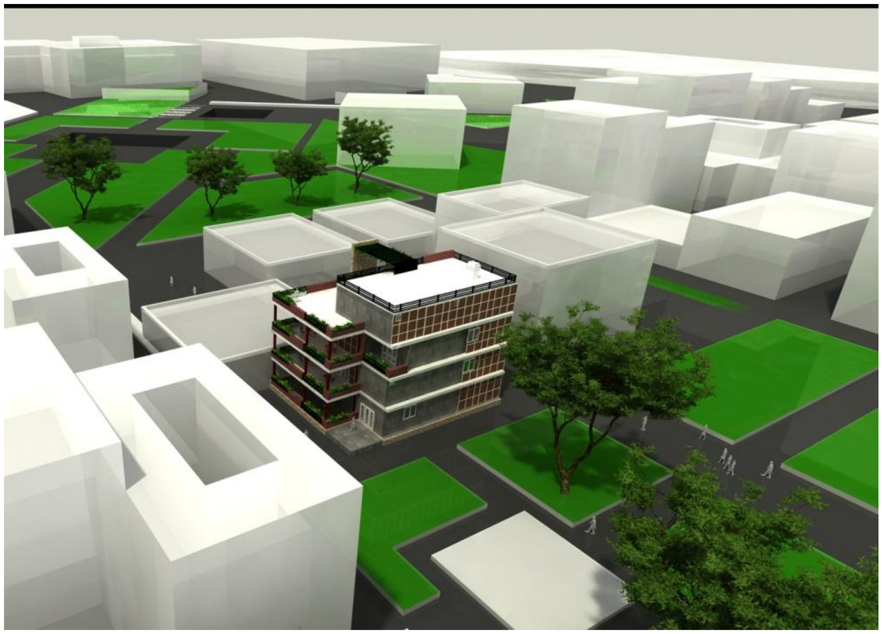


Fig.3. 39. Site view

Fig.3. 40. Neighborhood view


Fig.3. 41. Residential building in site


Fig.3. 42. The view of Residential building

Fig.3. 43. Residential building

3-5-2-Proposed residential plan

Fig.3. 44.Proposed Residential Basement Floor Plan

Ground Floor Plan

Fig.3. 45.Proposed Residential Ground Floor Plan

Fig.3. 46.Proposed Residential First Floor Plan

Fig.3. 47.Proposed Residential Second Floor Plan

Third Floor Plan

Fig.3. 48.Proposed Residential Third Floor Plan

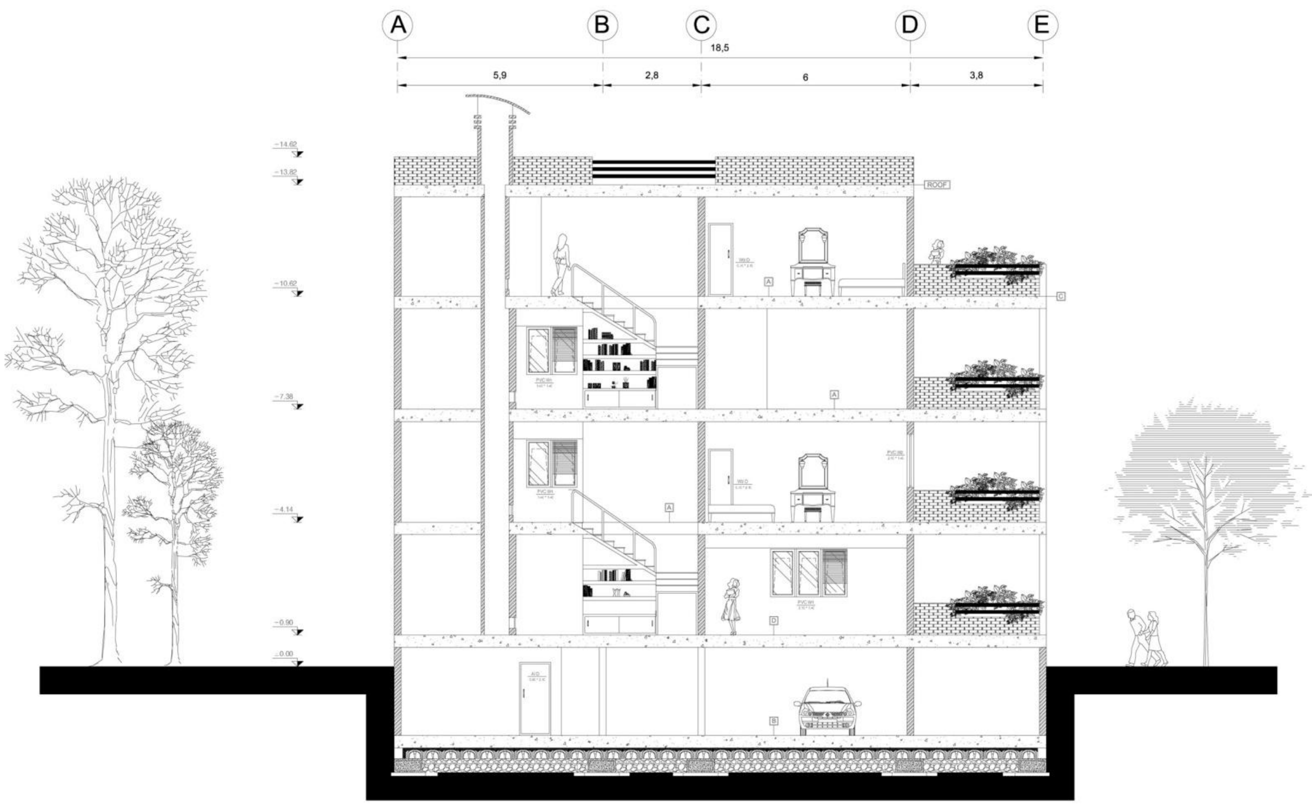


Fig.3. 49.Proposed Residential Section A-A

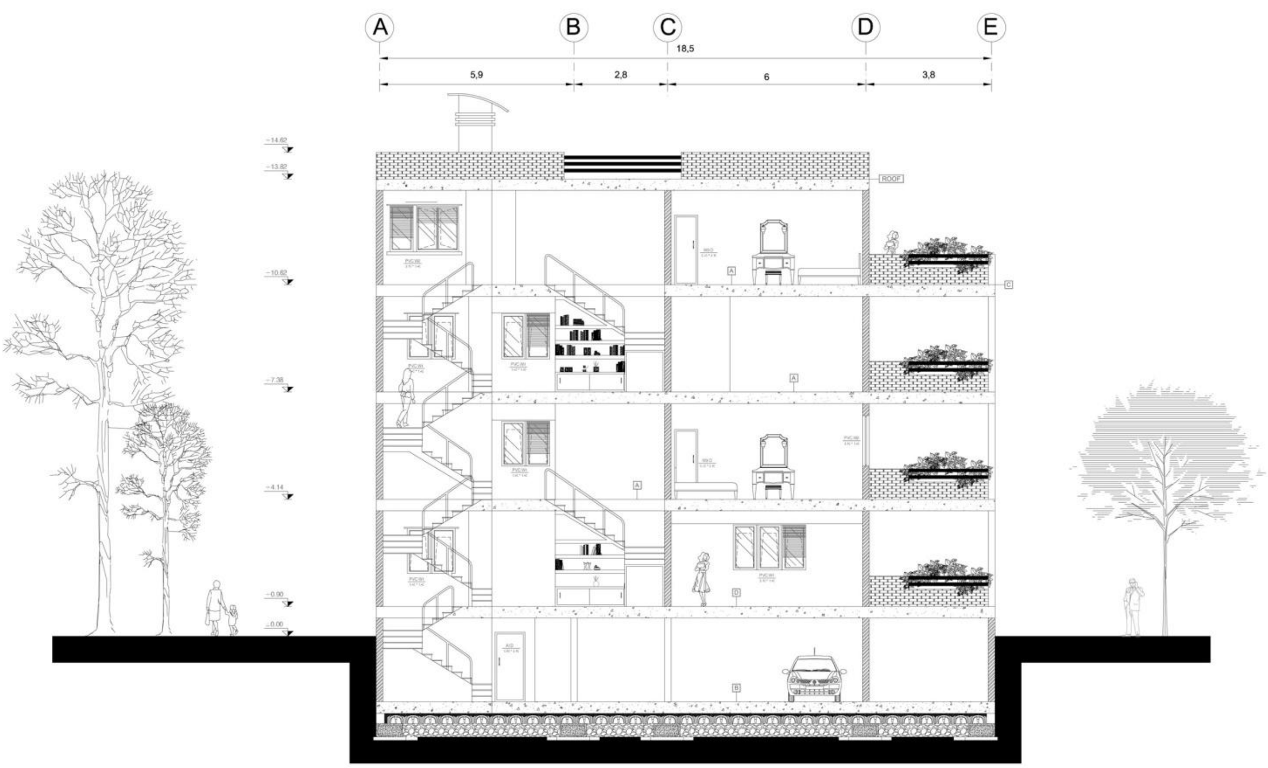
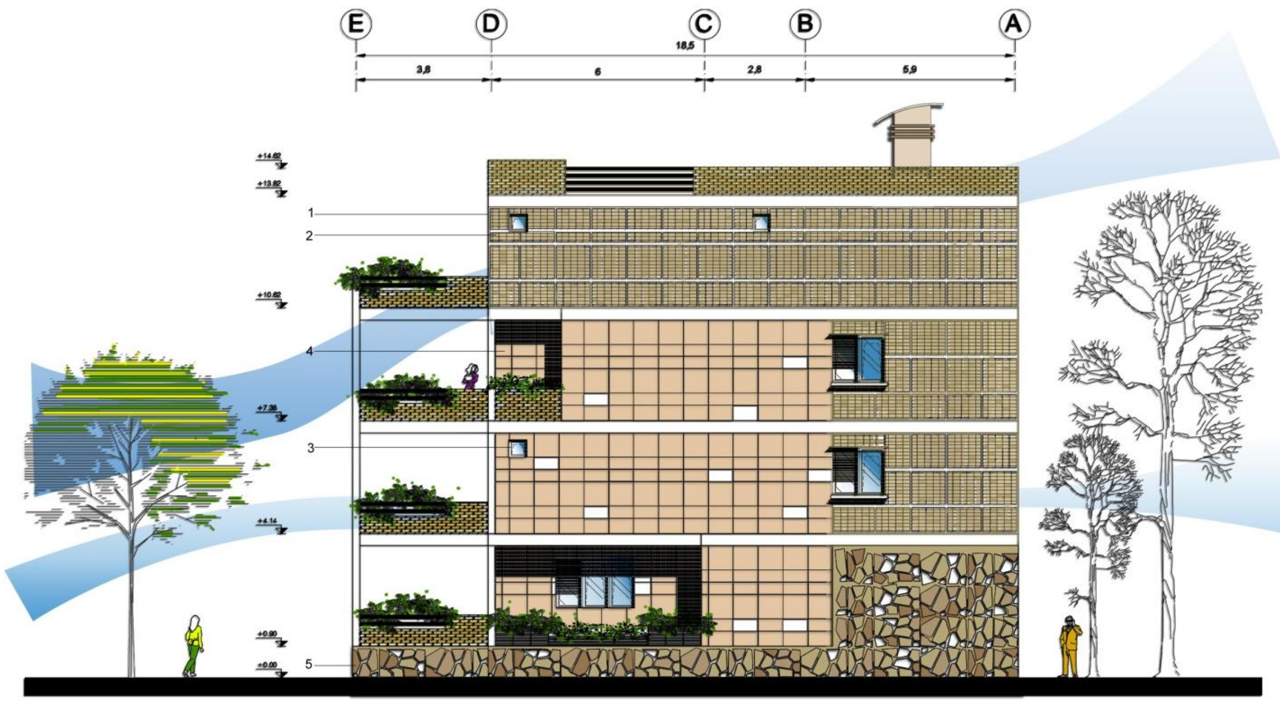


Fig.3. 50.Proposed Residential Section A-A'

Fig.3. 51.Proposed Residential Section B-B



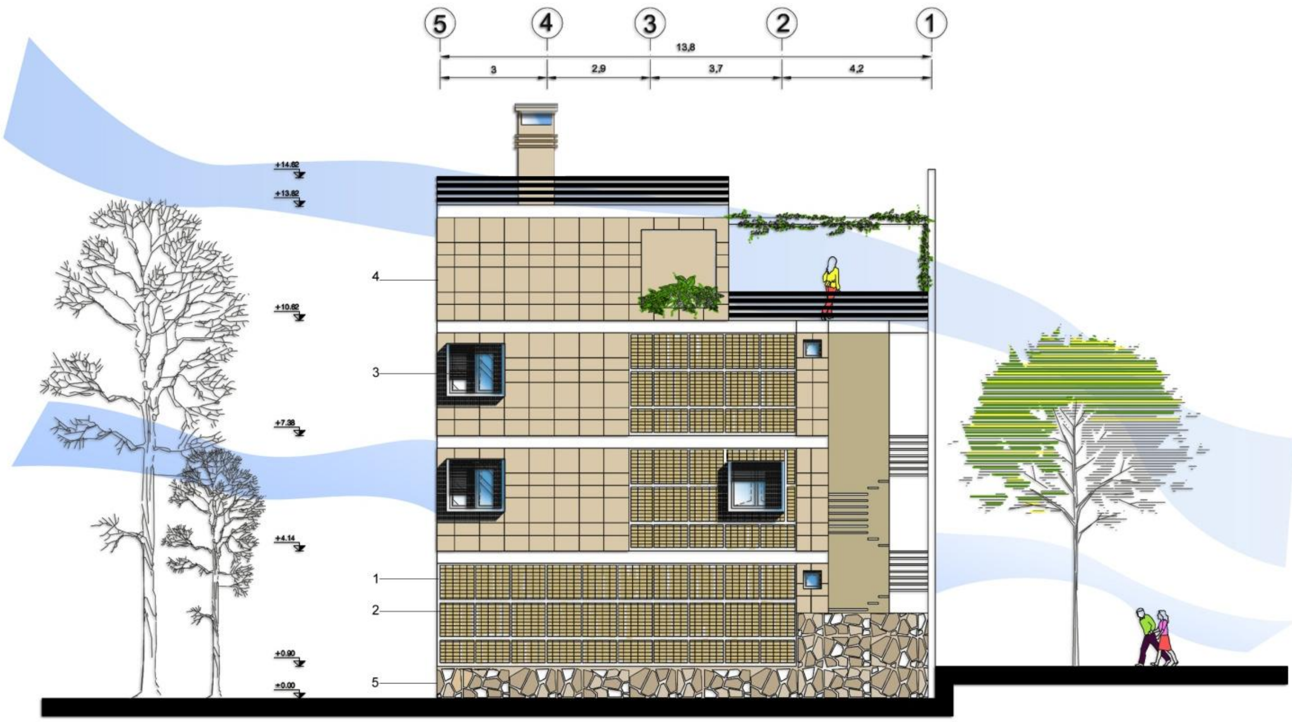
NORTH ELEVATION

North Elevation	
Number	Material
1	Metal suspended frame
2	Brick
3	PVC frame Double glazed window
4	Fiber Cement Cladding
5	Stone

Fig.3. 52.Proposed Residential North Elevation

South Elevation	
Number	Material
1	Metal suspended frame
2	Brick
3	PVC frame Double glazed window
4	Fiber Cement Cladding
5	Stone

Fig.3. 53.Proposed Residential South Elevation



WEST ELEVATION

West Elevation	
Number	Material
1	Metal suspended frame
2	Brick
3	PVC frame Double glazed window
4	Fiber Cement Cladding
5	Stone

Fig.3. 54.Proposed Residential West Elevation

East Elevation	
Number	Material
1	Metal suspended frame
2	Brick
3	PVC frame Double glazed window
4	Fiber Cement Cladding
5	Stone

Fig.3. 55.Proposed Residential East Elevation

Chapter 4
Technological Design

Introduction

The most energy consumption occurs in the building sector worldwide. Today, building energy saving mainly is done by expense and energy-intensive actions in utilization of qualified materials, insulations, high-tech materials, renewable energy systems. Whereas for manufacture of these efficient and new materials and systems, a wide amount of wellspring are needed and used, and a huge value of pollution is driven out. In this regard sometimes the outlay expenses of these buildings are so high, that for the economic reasons, they are not valuable. Thus, for these reasons, the method for energy saving matters should not be considered mainly and only on energy efficiency in constructional and technological manners. However, it must be considered that for advancement of energy proficiency in buildings new and accessible building technologies and building materials must also be used.

Alongside of the universal energy saving difficulties such as cost and energy-intensive ways, in Iran there are extra difficulties related to expense intensive measures of building and commercial energy saving sector. Due to the low energy cost in Iran comparing to the other developed and under developed countries, usually the methods of energy efficiency by utilization of high-tech materials and insulation materials are not economically permanent. This is why there is not adequate public concern on energy saving methods, where effectively make the building expenses high such as usage of building insulation materials and renewable energy technologies.
Thus, the purpose is to arrive to a procedure of energy saving for buildings with the respect of economically and ecologically friendly method. One of the most well-known methods is architectural energy efficiency method. Following the concept of an incorporated and cost efficient energy issues, architectural design is an extremely profitable method. To increase the energy proficiency and to reduce the energy consumption in building sectors this method for building design deals with the optimization issues in architectural design. Architectural design/Architectural energy efficiency is an effective method for a building to reduce energy consumption by minimizing expenses and emissions in construction, and from economical and ecological point of view it is remarkably sustainable. In order to overcome the problems of energy usage in buildings like heating, cooling and lighting, the key factors of this method are the main solution to these problems which are orientation, building shape, opening ratio in various directions, radiation rate, sun shading, zoning of functions, natural ventilation [1].

In a series of studies and researches, for a climate relative design, while, these parameters are serious key factors the effect of various architectural design on energy usage of residential, office and commercial buildings is parametrically studied. The outcomes of these studies are guided to an instruction that fulfill the answers for designing energy efficient buildings in the climatic condition of Shiraz region.

4-1-Study and Description

4-1-1-Net Zero Energy Buildings

Buildings are the primary energy consumer among flourishing matters in terms of increasing energy expenses, energy independence, and the influence of climate variation. In a country this fact emphasizes the significance of marking building energy consumption as a factor to reducing the people's energy consumption. In order to prosper the performance of existing buildings the building division is able to remarkably decrease energy utilization via compounding energy efficient tactics towards the design, build-up and construction of new buildings. In addition, it is also able to decrease affiliation on fossil fuel produced energy thru increasing use of new technologies such as “on-site” and “off-site” renewable energy resource.

Recently, producing of energy as much as possible over the period of a year usage is developing from research stage to a reality stage which has been one of the concepts of a Net Zero Energy Building (NZEB). Nowadays, it is hard to find energy saving buildings that match the Net Zero standards. However, the construction of Net Zero Energy buildings is becoming much more practical significantly in progress of building and renewable energy technologies and research studies [2, 3].

Engineers and architects agree that the quantification of metrics for net zero energy might be incorporated with, Sample of building design to reduce energy consumption and/or Renewable energy technologies that cover these decreased energy requirements, yet the precise explanations are different.

4-1-1-1-Definitions

As mentioned earlier the concepts of "zero energy" and "net zero energy" are rather different and not yet defined precisely, but major agreed to zero energy metrics. Recently, most of the acts on net zero energy buildings have pioneered in the Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL). And remarkably for building designers, proprietors and operators NREL provided various explanations for net zero energy, and they persuade them to choose the best metric definition that fits their projects. The NREL suggests four types of definitions in which net zero energy might be defined as Net Zero in:

- Site Energy
- Source Energy
- Energy Costs
- Energy Emissions

Site Energy is about the energy that used and produced at a building site, irrespective of details like how/where the energy originated. In this type of net zero buildings, it must produce an amount of energy for more than a year, every unit of energy that building uses.

Source Energy relates to incipient energy required to distillate and hand over energy to a site, consisting of the energy that might be missed or spoiled in the method of production, dispatch and diffusion. For instance, if at a site natural gas were used, to transition a gas to the site 1 Joule may be required to distillate and diffuse the gas for every 20 Joules consumed. For attainment to these factors though precise metrics can be different appertain on site and productivity factors, metrics for net zero source energy buildings are considered.

Net Zero Energy Cost is probably the most ordinary metric: meaning the building has an energy productivity receipt of $0 for more than one year. Also, owners or operators in buildings in some cases might have a possibility of selling Renewable Energy Credits (RECs) from on-site renewable production. Many common energy resources cause the CO_2 emission, NO and NO_2, SO_2 and etc. A Net Energy Emissions building usually from on-site renewable energy systems in addition to use of energy which causes no emissions, they also deviates the emissions thru sending out emissions free energy [2, 3].

4-1-1-2-Grid Connection and Net Zero

Permitting the electricity generated from common and traditional energy resources, major Net Zero Energy Buildings are still attached to the electric grid to be utilized when renewable energy production is not able to provide the required building's energy. Unlike, on-site energy production invades the required building energy, the over plus energy could be sent out back to the productivity grid in which legally supported. The over plus energy generation deviates afterwards cycles of surplus request which out coming in a net energy utilization of zero. Usually, grid communication is obligatory referring to recent technology and cost constraints related with energy storage, to authorize the Net Zero Energy balance. For energy that is sent out from the building to the grid in which has diversities in how utilities and jurisdictions indicate disbursement should be carefully evaluated and possible to affect project economically [2, 3].

4-1-1-3-Renewable Energy

- **On-Site Renewable Energy**

Utilizing renewable energy technologies can be faced the residual energy requires, once performance measures have been combined. Typical on-site electricity production tactics contain photovoltaic panels, solar collectors and wind turbines. Sometimes, impressive utilization of biomass is possible to be provided by renewable on-site thermal energy. To supply space heating and service water heating on-site as renewable energy generation, wood and wood tablets, agricultural waste and equivalent products can be used. Also, biodiesel might be utilized as bio-fuels in continuity with typical fossil fuels to supply thermal loads.

Preference is better to be given for renewable methods that are already accessible, importantly frequent and very cost effective. It is important to give system surveillance on maintenance in a specified period of time. In this term to measure the economical eligibilities of different systems expenses, costs should be obtained over their operational lifetimes thru life cycle analysis [2, 4].

- **Off-Site Renewable Energy**

Buildings are might be authorized to spend energy produced off-site to balance energy consumed in a building, appertain on the net zero energy metric and instructions used. And in this regard a facility holder might erect allocated wind turbines and/or solar water heating systems at a separate location, if room is restricted. Whereas, majorly credit for this aim of off-site renewable production is achieved thru procurement renewable energy credits called RECs, which accessible from number of renewable energy technologies.

In fact, there are different type of plants that produce electricity without consuming fossil fuels or primitive energy such as wide scale and efficiency scale wind farms, solar and geothermal plants and hydropower devices. Interestingly thru selling the credit for producing renewable energy the charges of installing and operating of these production tools are paid. The formation and marketplace for Renewable Energy Credits is progressing and it is different in accordance to the regions.

Executive Order 13514 summarizes authorize renewable energy tactics that consist:
"energy produced by solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project" [2, 4].

Fig.4. 1. Left: A photovoltaic panels and Right: Wind turbines [2]

4-1-1-4-Energy Efficiency

Irrespective to the explanation or metric utilized for a NZE Buildings, for effective building design to reducing the energy consumption, should be a substantial design standard and the top preference of projects of all net zero building energy. Generally, energy performance is the major cost effective method with the maximum turn back on outlay, and to increase performance chances before expanding renewable energy designs will reduce the expense of the renewable energy projects required. Utilizing progressive energy analysis utilities design groups are able to optimize effective designs and technologies.

Energy efficiency measures consist of design tactics and properties that reduce the load requests like high proficiency covers, air barrier devices , day radiation, sunlight control and shading systems, accurate selection of openings and glazing, passive solar heating, natural ventilation, and water keeper.

The Building loads are to be faced with effectual facility and devices by using of energy proficient lighting with electrical control, high-efficient HVAC and geothermal pumps, aiming loads to be minimized. However, it should be kept in mind that energy keeper systems such as composed heat and power devices, fuel cells and micro turbines do not produce renewable energy. Unlike, they turn fossils fuel into heat and electricity and are able to be evaluated energy proficiency tactics [4].

4-1-2-Building policies to promote energy efficiency

To promote energy proficiency in new construction buildings, building energy criteria are considered as important leaders. The codes which include:

- Necessitate prosperity of yearly energy use level through general efficiency supported codes or energy expense budget referring to a modulus way. While well learned occupational are needed to execute the code, this kind of code suggests pliability.
- Proposed codes for building envelop and members that place determined efficiency rates.
- A composition of a general efficiency demand and some ingredient performance needs (IPCC, 2007) [5].

The Iranian Council of Ministers confirmed energy saving code in buildings in 1992. Whereas, climatic factors were not considered, but the major rule was the amount of energy saving in the building. Buildings were classified in four different categories in terms of energy saving levels. A composition of necessitate and efficiency methods are the building code in these criteria (Kari & Fayaz, 2006) [5].

Building and Housing Research Center (BHRC) erected a well-known Iran national building code, chapter 19, in 1995. In 2000 this national code became mandatory with vary respite for every areas in respect to climates and building floor areas. In this code two methods are consist: firstly for small flats and single dwellings medium and low level of energy saving were anticipated based on necessitate method. And secondly, with accordance to the envelope efficiency which is related to the heat loss ratio of the building itself. The BHRC showed that 30% conservation of energy is possible through Iranian national building code chapter 19 (Kari & Fayaz, 2006). Moreover, with the goal of developing energy performance in envelopes thru Iranian Standards and Industrial Research Institute number of criterions recorded. Based on European standards these criterions are related to building materials and technological systems such as doors, walls and windows, glazing, insulation and etc [5].

4-1-3-Iranian buildings and Energy efficiency

As mentioned earlier national building code's chapter 19 is the principal method to cure Iranian building in terms of energy efficiency. The accepted method is mainly to improve architecture design from climatic and construction point of view. In fact, it is rarely to find ZEB, passive house or green house in Iran with concepts of particular energy saving buildings. However, in this stage there are number of existing building projects collected in purpose of energy efficiency development, yet, accurate efforts on new buildings are not carried out. According to the research of "Energy efficient buildings in warm climates of the Middle East: Experience in Iran and Israel" in 2008, only 18 energy efficient building projects are found in Iran. But, most of them are not ever arrived in to the implementation level [5].

4-1-3-1-Construction requirements on the Iran building market

However, several standard building materials and equipments are manufactured in Iran's market. Utilization of materials without standard codes is a biggest problem for Iranian building construction based on its lower prices. In addition, the quality of products and the energy efficiency of materials also require being specified [5].

4-1-4-Common approaches

Various methods are confirmed to improve energy efficiency in buildings worldwide, with the aim of control impacts on the environmental and building energy usages. Followings are the basic principles in general passive design for building energy saving strategies [5].

There are several ways to overcome building requirements such as cooling and heating instead of using fossil fuels. Indeed, these methods are directly related to traditional architecture elements for buildings. However, nowadays some of these solutions are not applicable due to the urban reform and changes in people lifestyles; therefore they need to be improved to modern solutions [5].

4-1-4-1-Typology and Shape

The formation of the building is one of the aspects that significantly affected the building energy demand during day and night. Therefore, as it is a main factor for heating and cooling, buildings can be divided in detached houses, semi-detached and terraced houses, also buildings formations can be categorized via "compactness" in which can be obtained by the ratio of the building volume to its exterior wall area. The higher compactness, the lower energy demands [5].

4-1-4-2-Orientation

The orientation of building is relevant to its solar radiation absorption amount. Generally, a building with south direction with maximum glazing façade area on the south side enhances absorbed solar radiation and also decreases heating energy demand in winter. In this regard the glazed windows are better to be protected by shading systems to reduce overheating during summer time. Subsequently, buildings with the orientation on east and west sides are not suitable solution for solar radiation absorption in winter [5].

4-1-4-3-Shading

By appropriate utilization of shading system in summer, make it possible to decrease the demand in building cooling energy. Also, it should be considered that by using of suitable shading systems such as overhangs it is important to let solar radiation to reach the building in winter. Therefore, as shown in Figure below, during summer and winter the change in solar beam angles requires a movable and permanent system to satisfy this aim [5].

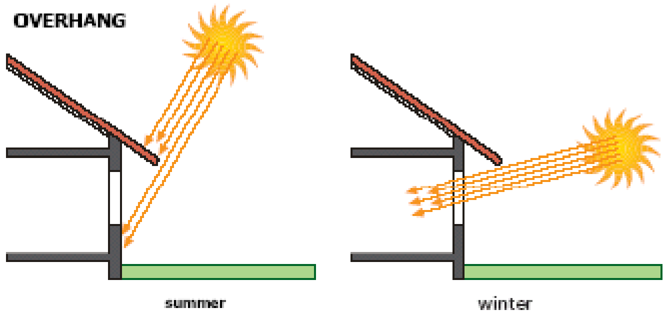


Fig.4. 2. Overhangs system in summer and winter [5]

4-1-4-4-Natural ventilation

The aim of ventilation system is to provide exceptional indoor air quality in buildings. Therefore, importantly a ventilation system might be utilized as cooling method thru venting the indoor warm air to the outside in summer. For this aim there are two ways to require fresh air into a building which are mechanical ventilation and removing foul air methods. Also, should be kept in mind that a mixed mode is obtainable throughout the combination of these two methods of ventilation. Generally, the naturally made pressure changes thru temperature difference and wind, or both provide natural ventilation in buildings. Natural ventilation is performed through the windows and doors or chimneys.

Natural ventilation is no energy supply passive ventilation method. The main problem for this system is the weather conditions dependence while this problem is possible to overcome thru utilization of mechanical ventilation such as fans. Using the mixed method allows the both energy saving and autonomous of weather conditions. The climate zone, air tightness and the amount of heat recovery are the relevant aspects for ventilation system selection [5].

Some significant common systems are:

- **Single sided ventilation**

Windows allow outdoor air goes in and leave out by the same opening or another opening on the same wall. This method is reasonable and appropriate for moderate climates zones and small building spaces. To increase the performance of this ventilation system is to utilize double opening which shown in next figure [5].

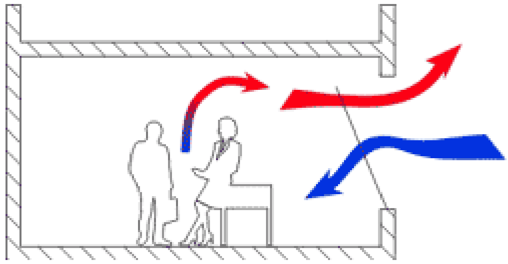


Fig.4. 3. Single sided ventilation through one opening
(Source: Dyer Environmental Controls, 2008) [5]

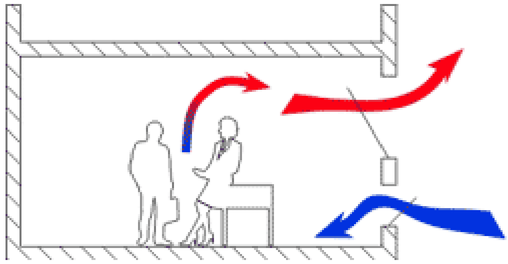


Fig.4. 4. Single sided ventilation through double opening
(Source: Dyer Environmental Controls, 2008) [5]

- **Cross flow ventilation system**

The cool fresh air (blue flow) enters into the room space thru windows on a wall while warm and foul air (red flow) leaves from windows and walls on the other side of the room. This method is more efficient for airflow rates and larger building spaces [5].

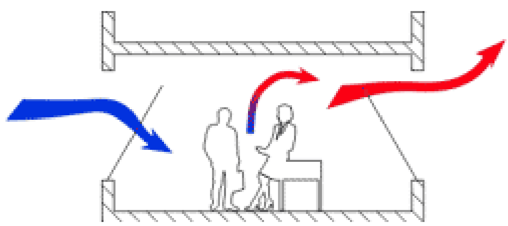


Fig.4. 5. Cross flow ventilation
(Source: Dyer Environmental Controls, 2008) [5]

- **Evaporative cooling**

In the Middle East and surrounded countries the cooling of evaporated water is used to cool down hot air. Indeed, hot air is cooled by flowing in contact with water and transferring its heat to water, which makes the water to be evaporated. The humidity of the air flow is the main element to decrease temperature. The evaporative coolers are more efficient in low humidity conditions, because of the temperature variety of relatively humid air in 12°C, and when the air is relatively dry. And more importantly, to avoid over humidification in building space the rate of evaporation and the airflow by ventilation must be controlled [5].

4-1-4-5-Wall and Roof Insulation

Reduction in the average heat flow is possible by the wall insulation, which also decreases both heating and cooling energy requests in buildings. This phenomena is defined by U-value which implies the heat flow through one square meter of wall area at a constant temperature difference of 1 K (= 1 °C) (Passive-On, 2007). Adequate insulation in walls reduces thermal losses in winter and also helps the energy saving and thermal comfort in buildings. Inversely, thermal insulation decreases the heat transfer from the outside to the inside, subsequently bring down of the cooling demand in summer. In addition, roofs are commonly more subjected to solar radiation than building walls in summer time. Thus, insufficient roof insulation helps heat to transfer from the roof into the building during summer [5].

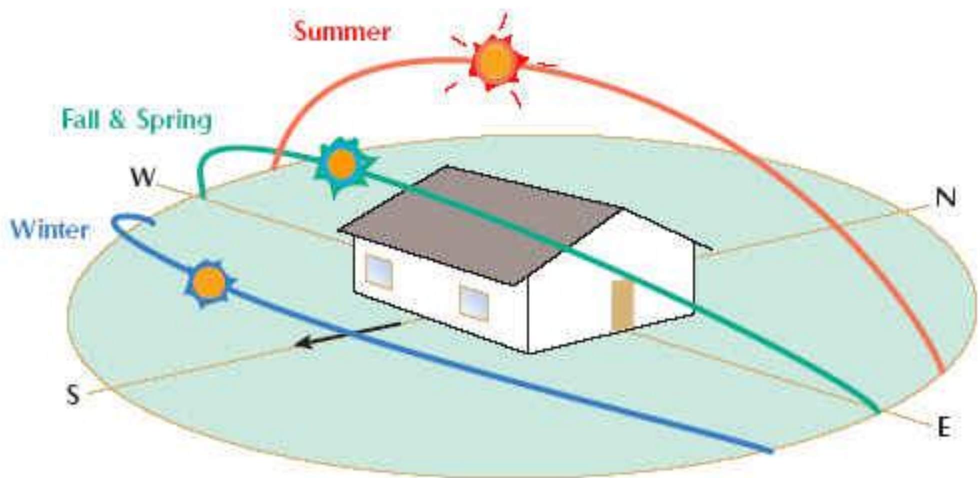


Fig.4. 6. Sun radiation in different seasons [5]

4-1-5-Traditional architecture in Iran

According to artistic climatic design, with the respect to decreasing energy utilization such as architectural components and technical members installed in new buildings are based on traditional architecture methods. The Middle East traditional architecture solution regarding the concept of energy saving and sustainability is concerned. The aim is to understand more about ancient architect technical solutions that easily help the reduction in energy consumption in new buildings.

The main nature elements water, soil, and wind as air and fire as light were very important for ancient Persian (Iranian) which affected their culture. Thus, in order to meet living requirements in buildings, the appropriate use of this mentioned elements are affected Persian architecture through their culture. The examples of this use to provide natural ventilation and cooling are water lavers in courtyards and wind catchers on roofs. Followings are defined some of these elements utilization in buildings [5].

4-1-5-1-Courtyards and ponds

One of the main and popular aspects in residential buildings in Iran is courtyards. Courtyards provide excellent performance regarding the passive cooling systems along with water ponds and green plants. Courtyards can be used as suitable places to relax in summer times, plus water lavers in courtyards provide evaporative cooling for the buildings, and in addition, courtyards protect the building internals from hot and dusty winds. In fact, this system is a microclimate that has a few degrees lower air temperature compared to the external environment temperature as well as the relative humidity in the courtyard area is a bit higher than that the outside ambient [5].

Fig.4. 7. A courtyard with water pool in a traditional house in Iran
(Source: www.Flickr.com, 2008) [5]

It is worthwhile to mention that the size of the courtyard is fundamental aspect for arriving to a suitable cooling and heating efficiency. Courtyard should be well designed in terms of the scale to provide shading in summer and solar radiation in winter [5].

4-2-Energy consumption

4-2-1-Energy use in Iranian residential and commercial sectors

Iranian residential and commercial sectors used 40.5% of total final energy in 2006 (Iran Ministry of Energy, 2006). The main energy utilized for this portion is natural gas, petroleum products and electricity (Iran Fuel Conservation Organization, 2008). Cooling and lighting are major electricity energy consumption in Iranian buildings. In this regard, the amount for electricity that generated from fossil fuels is about 91% and the rest is from hydropower. The energy consumption in Iranian residential sector is distributed and electricity consumption is about 33.2%, which was the largest portion amongst all sectors in 2006, and the transportation portion with about 26% of total energy consumption is in the second place. Also, electricity consumption per capita is 2690 kWh showing a 2.4% increase compared to last year(2005), (Tavanir, 2008). In addition, the industrial sector by about 23% of total energy consumption is in the third place. And surely, pollution rate due to fossil fuel consumption is increased [5, 6].

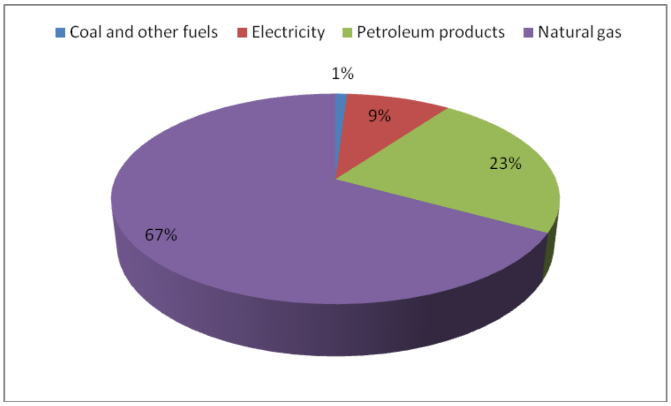


Fig.4. 8. Energy consumption in residential and commercial sectors in Iran (According to IFCO Statistics, 2008) [5]

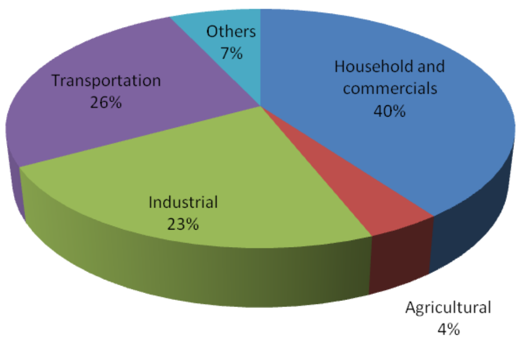


Fig.4. 9. End use sector share of total consumption, 2006 [5]

4-2-2-Environment and emissions

In 2004, Iran's per capita carbon dioxide emission was 6.4 metric tons (World Bank, 2008). 381,938,000 tons of energy consumption was caused total CO_2 emission of about 29% by residential and commercial sectors in 2006 (Iran Ministry of Energy, 2006); In 2006 the air was clean only less than 40 days according to Iran Department of Environment (Iran DOE). As shown in Figure 4.25, the air quality in Tehran was reported as healthy for about 244 days which can be harmful for are sick and/or sensitive civilians [5].

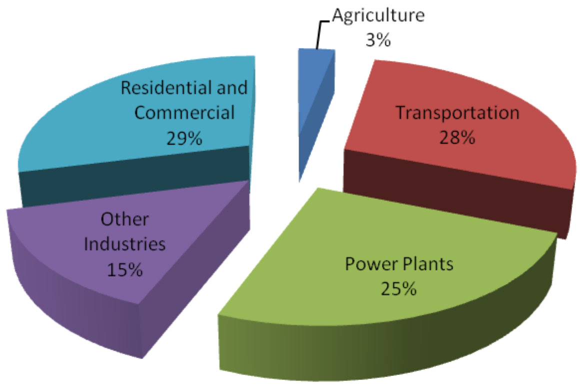


Fig.4. 10. CO_2 emissions in different Iranian sectors (2006)
(Source: Iran Ministry of Energy, 2006) [5]

Radically, people were subjected to unhealthy air in more than 80 days (23%) of year time, (Iran DOE, 2008). In this regard, energy consumption in buildings need urgent actions to decrease the pollution affects. For this aim, building codes as policy tools play a critical first step towards of improving energy efficiency in buildings [5, 6].

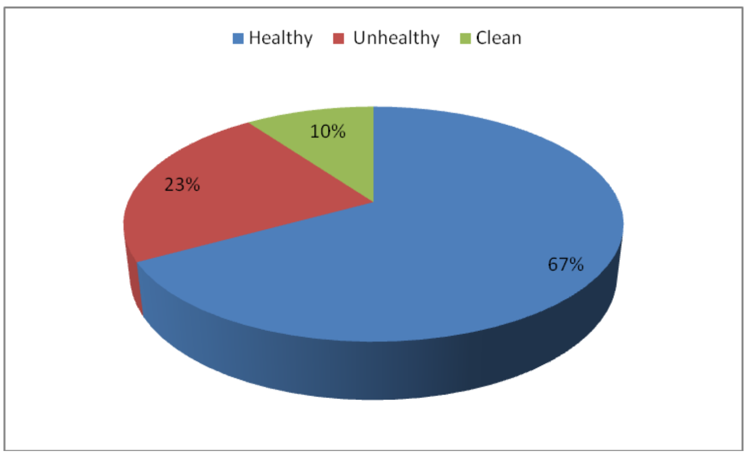


Fig.4. 11. Quality of air in Tehran, 2006
(Source: Iran DOE, 2008) [5]

4-2-3-Analysis of building energy consumption in Iran

In 2008, Iran total energy consumption in building sector was about 41.9%. The major resources of energy are divided as natural gas 66%, petroleum 20%, electricity 2.5% and other sources 1.5%. The construction techniques and the methods of highly energy using systems in manufacture caused significant quantity of energy loss in this. Thus, in construction projects the effective policies and strategies to reduce energy consumption should be considered such as insulations and double glazed windows, sealing doors and etc., are required. On the other hand, also, one of the main reasons for low energy efficiency in this sector is the old and rusty generation technologies in energy using apparatuses used in residential and commercial sectors as much as utilizing heating systems leads to consuming a great share of energy use in this sector.

In residential sector energy consumption average by comparison between Iran and in Europe with the same conditions, the average for Iran is over 2.5 times higher than EU, and is over 3.5 times higher than cold regions in Europe. This implies the importance of energy efficiency policies for this sector [6, 7].

Several energy saving projects has done for this aim by Iranian Fuel Conservation Organization (IFCO), but energy consumption per capita in Iran is significantly higher than world standard. Commercial and residential sectors mainly consume natural gas for heating and cooling, providing warm water and cooking. In Iran natural gas with high efficiency and low cost is the main fuel for this sector [6].

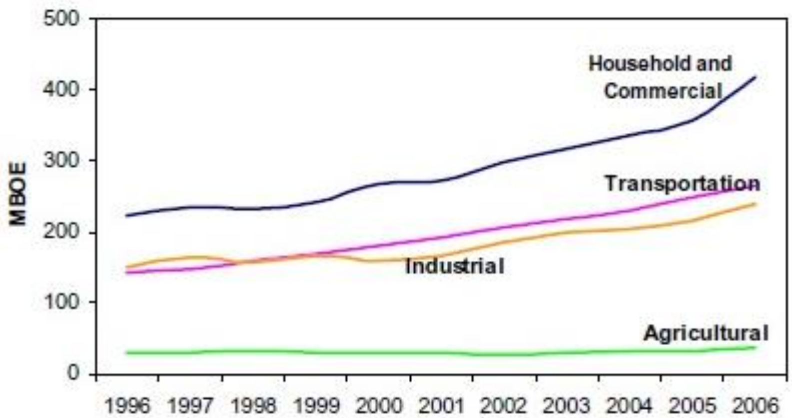


Fig.4. 12. Total consumption by end-use sector, 996 to 2006 [6]

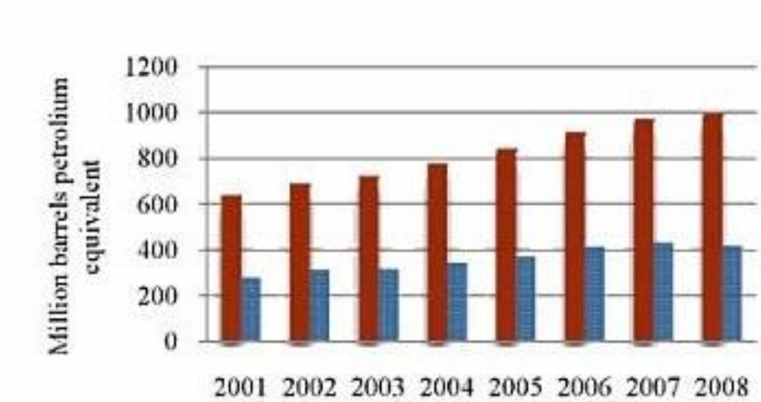


Fig.4. 13. Building energy consumption in Iran,
(red bar: total energy consumption, blue bar: building energy consumption) [6]

However, the increase of the building energy consumption in from 2001 to 2006, a slight reduction from 44.5% to 41.9%in 2007 was occurred , this implies the importance of some policies in this sector such as energy cost reform, codification of the national code for sustainable design (no.19) and challenging programs during recent years [6, 7].

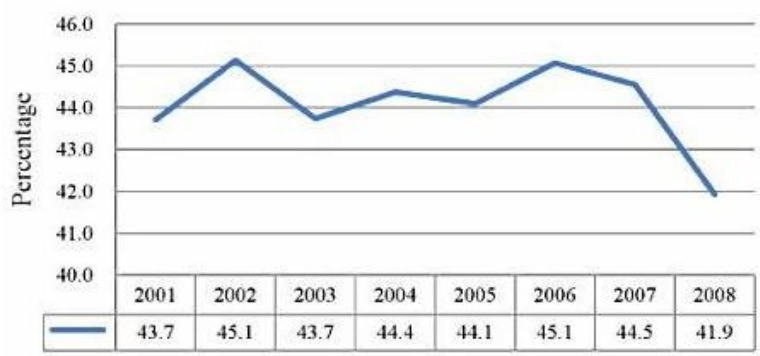


Fig.4. 14. The percentage of building energy consumption in Iran [6]

In Iran the energy consumers in buildings are divided as follows: Heating, cooling and hot water is about 83% of the total consumption, appliances is about 8%, lighting and other elements accounts for 9%. Also, the great building energy consumption leads a considerable CO_2 emission in Iran, mostly in the capital and big cities [7].

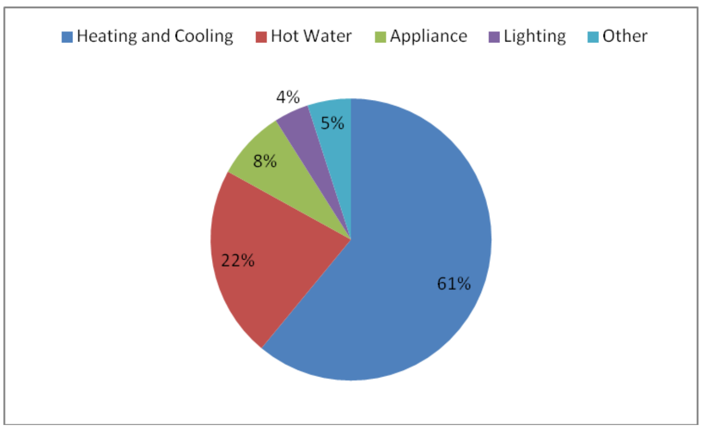


Fig.4. 15. Share of energy consumers in building sector in Iran [6]

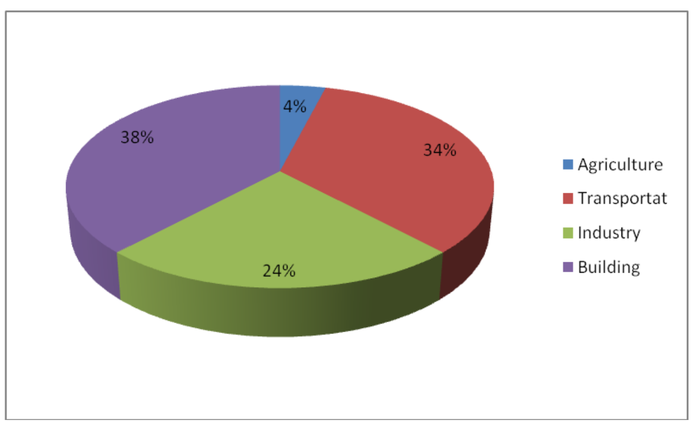


Fig.4. 16. Share of CO2 emission resources in Iran (2008) [6]

4-2-4-The energy saving policy for the Iranian buildings

Generally, energy saving matters in the Iranian second five-year plan (1995-1999) is considered. Some of the ideas are show below:

- Providing technical characteristics and standards for equipment.
- Imposing tariffs for importers and manufacturers who do not follow the consumption patterns related to energy efficiency standards.
- Incorporating energy efficiency schemes in education, and allocating an appropriate fund for research into energy efficiency.
- Preparing energy efficiency regulations in the design and construction of buildings in order to avoid energy waste. And encourage the use of standards in existing buildings.
- Promoting energy efficient equipment and technologies for factories, and developing the principles of sustainable development in various regions [7].

National energy efficiency regulation; Iran national building provisions thread No.19. This Iranian national building code on energy saving was approved by the ministry of Housing and Urbanism in 1991, and finalized in 2001and imposed on construction and building organizations. Finalized code No.19 in energy conservation is now mandatory for all public buildings. Also, this building regulation code considers buildings energy saving that includes:

- External wall insulation.
- Install double glazing windows with thermal brick frames (wooden or standard PVC).
- Insulation of air channels, pipe installations and hot water production system.
- Installation of local control systems such as thermostatic valves on the radiators.
- Installation of weather compensators [7].

Despite the applied code in building results enhancement in initial expense about 5%, but in the long term it will decrease the overall building expenses. The capacity of heating and cooling systems will be decreased by 40% that results a reduction in building expenses in the future. Unfortunately, development in the execution of code No. 19 is slow and by 2010 only applied to an approximately 20% of the buildings. Also, there are some barriers to the accomplishment of code No.19 in Iran:

- Low energy price in the country
- Lack of the particular code for residential buildings (code No.19 is a general code)
- Unrealistic legislation which is not considering executive potential of the country
- The high cost of code No.19 and energy efficiency standards implementation
- Lack of assessment system to evaluate energy wastage and CO_2 emission (Energy Performance Certificate)
- Lack of controlling bodies for code No.19 in order to control new buildings step by step

- Lack of co-operation and liaison with relevant organizations (Engineering, Municipalities, Ministry of Housing and Institute of Standards, IFCO and…) in the implementation of code No.19
- Insufficiently trained engineers, supervisors and architects for code No.19
- Lack of skilled workers in the fields of code No.19 (insulation, installing double glazing windows, thermostatic valves and…) [7].

4-2-5-Renewable energy development policy

Nowadays, the enhancement in energy consumption worldwide, also the danger of quick exhaustion of fossil fuel made the politicians to consider more on alternative resources. The fact of reduction in use of fossil fuels is not the main purpose for finding renewable energy. But the global warming is the most. And, utilizing of fossil fuel causes the carbon dioxide emission. Countries with huge oil and gas resources like Iran should introduce an energy policy to encourage alternative resources for consumption. In this regard, Iran is one of the countries that considered as richest in the world based on its different energy resources. However, it keeps great non renewable resources, but in terms of the renewable energies it has significant potentials such as wind and solar energy. In Iran, further to policies made by for Energy, has been looking into this area since 1995, in order to gain further knowledge and develop technology for the utilization of renewable energy resources. Measurement of potentials and execution of various researches and projects are done by the ministry of the Energy's Deputy Directorate and Iran Renewable Energy Organization (SUNA), which includes solar, wind, geothermal and biogas energy resources [7].

4-2-5-1-Solar energy

As mentioned before, Iran consists of 60% desert which leads to significant potential for application of solar energy systems. For this aim, the annual average sun radiation is 20-30 MJ/m^2 per day. During the four seasons the daylight hours are: during spring 700hr, summer1050hr, during autumn 830hr and 500 hours in the winter. In this regard, approximately 22% of the total energy that used for providing hot water in residential building can easily be conserved. In order to persuade residential sectors to use solar collectors and photovoltaic energy generation systems results reduction by 15% of the total energy demand in the building sector. Thus, the government has provided motivational policies like substantial subsidies. Solar power capacity increased dramatically from 21 MW in 1998 to 110MW in 2001, and due to the replacement of oldest equipment with newer technology it has reduced in 2002 [7].

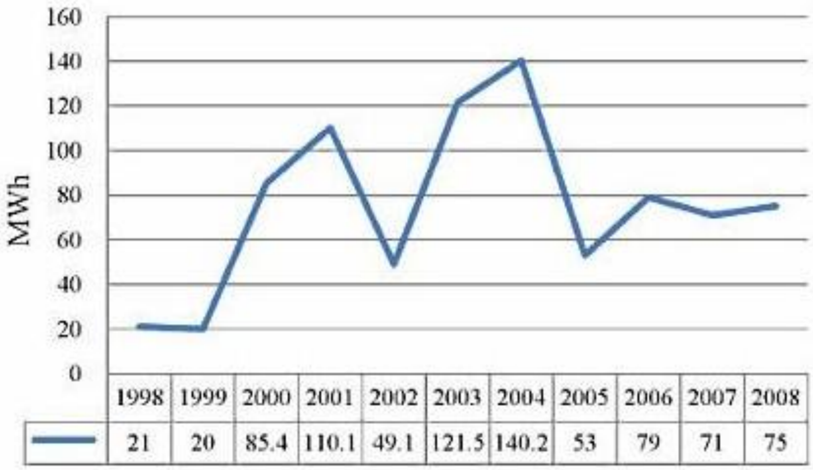


Fig.4. 17. The solar power generation in Iran [7]

4-2-5-2-Wind energy

The land of Iran is majorly covered by mountains, from the north the Caspian Sea and from the southern part is adjacent by Persian Gulf and Oman Sea. This geographical situation of the country and its climate shows the high potentials in wind energy, accordingly the country also experiences different tropical wind flows. For this aim, as an alternative source for fossil fuel the wind energy producers are an appropriate system. Recent studies and researches in Iran referring to wind potential illustrates that in 26 regions with more than 45 suitable locations, the normal capacity of the sites is about 6500MW with a general proficiency of 33%. The capacity of installed wind farms in 2001 was about 10.8 MW in Iran, which increased significantly to 89.9MW in 2008 [7].

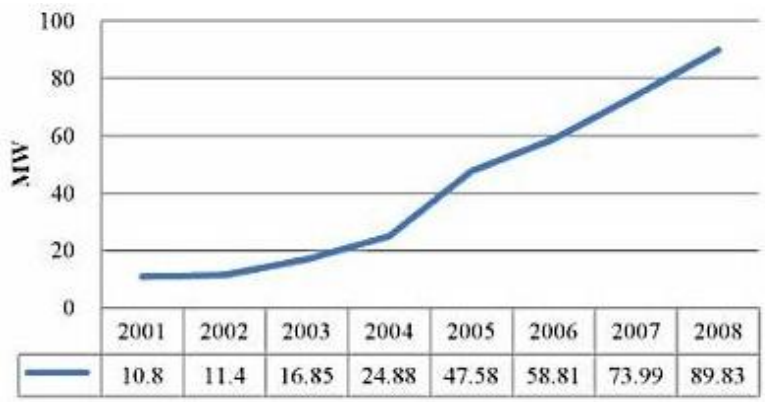


Fig.4. 18. The capacity of installed wind farms in Iran [7]

4-2-5-3-Geothermal energy
Back in 1974, after a United Nations geothermal expert James R.McNitt visited Iran, the interest in geothermal energy originated in 1983, and several researches declared the main regions as effective geothermal sites such as Sabalan, Damavand, Khoy-Maku and Sahand areas in Iran. SUNA also involved in series of countrywide researches in terms of suitable areas for future energy production investments. And as a result ten potential geothermal sites were discovered in addition to the four existent ones.

Recently, the main geothermal energy production project is located in the Sabalan region near Meshkinshahr, with a capacity and possibility of 50 MW and 370 MWh annual energy productions respectively [7].

4-2-5-4-Biomass and Biogas plants
Domestic and industrial sewage, animal waste, and excess of agricultural outcomes, also 80% of the country's domestic productions are the major resources for biogas energy. Some benefits in biogas:

- Converting waste into two useful products
- Providing smokeless fuel for cooking and generating electricity and keeping households and surroundings clean
- Transforming organic waste into high quality fertilizer and using human waste as a raw material for bio-latrines as bio-digesters
- Reducing fuel wood consumption and environmental pollution

As a main benefit, biogas production also does not emit additional emissions into the environment. In this regard two projects for this source of energy is attended in Mashhad with the capacity of 650 and Shiraz and with 1060 KW power from the solid waste of the mentioned cities. And the aim is to generate 10 MW power from the waste of other large cities. A biogas prototype project with a capacity of 600 KW power is in Saveh, which is near to the capital, Tehran [7].

4-3-Sustainable energy in Shiraz
As a matter of fact sustainable energy is energy that, in its generation or utilization, has minimal adverse effect on man health and the health of the global environment. Solar energy is known as sustainable energy that became more popular in the recent years. Several methods of energy conversion for the solar energy to electricity production exist. Iran with its wide lands and with high amount of solar irradiance it is one of the countries that can absorb considerable amount of good solar energy in its dry lands. In most part of Iran particularly in the city of Shiraz at least 300 sunny days are defined in a year, furthermore, average yearly clearness index in this city is higher than 0.67. With these great potential and conditions, Shiraz has been supported and

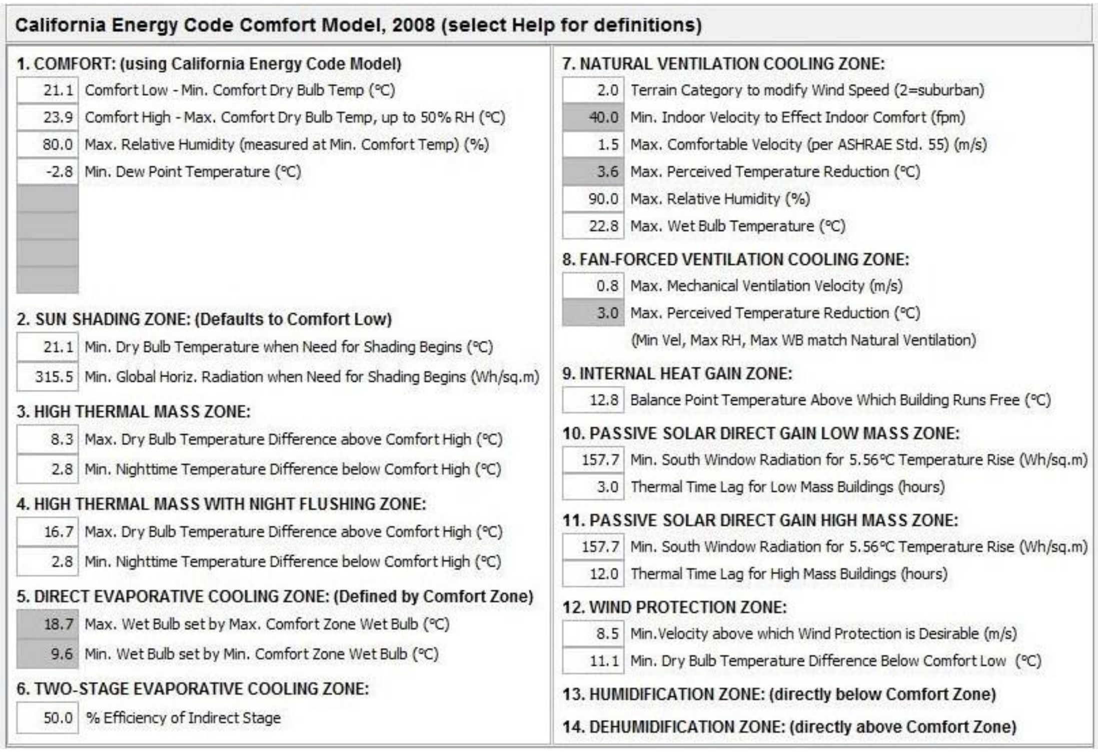
implemented the first 250KW pilot thermal power plant. The average of electricity utilization of each Iranian family is nearly equivalent to 250 KWh per month [8, 9].

4-4-Shiraz climate

As mentioned before, geographically Shiraz is one of the most leading cities that connect two poles of north and south in Iran. Bushehr and Bandar-Abass port is connected to Rasht, Babol and Chalus ports by Tehran, Isfahan and Shiraz. For many people Shiraz is the place for recreation and journey which has beautiful historical and old monuments that attract its visitors. This city has a moderate climate, green nature such as many gardens and fruit trees, several rivers and lakes that also made this part of the country also attractive for tourists. Blow shows some of useful data related to Shiraz city:

Altitude	1600 m
Latitude	29˚ 36' 54" N
Longitude	52˚ 32' 17" E
Prevailing Wind Direction	NW, W, SW
Average Wind Velocity	6.9

By utilization of this data and numbers to the California Energy Code Comfort Model software (CECCM), it is possible to achieve results, tables and charts related to Shiraz climate data in which possible to compare the numbers and outcomes with the already given information from relevant sites and articles. Meanwhile, the outputs of the software are shown below:



California Energy Code Comfort Model, 2008 (select Help for definitions)

1. COMFORT: (using California Energy Code Model)

21.1	Comfort Low - Min. Comfort Dry Bulb Temp (°C)
23.9	Comfort High - Max. Comfort Dry Bulb Temp, up to 50% RH (°C)
80.0	Max. Relative Humidity (measured at Min. Comfort Temp) (%)
-2.8	Min. Dew Point Temperature (°C)

2. SUN SHADING ZONE: (Defaults to Comfort Low)

21.1	Min. Dry Bulb Temperature when Need for Shading Begins (°C)
315.5	Min. Global Horiz. Radiation when Need for Shading Begins (Wh/sq.m)

3. HIGH THERMAL MASS ZONE:

8.3	Max. Dry Bulb Temperature Difference above Comfort High (°C)
2.8	Min. Nighttime Temperature Difference below Comfort High (°C)

4. HIGH THERMAL MASS WITH NIGHT FLUSHING ZONE:

16.7	Max. Dry Bulb Temperature Difference above Comfort High (°C)
2.8	Min. Nighttime Temperature Difference below Comfort High (°C)

5. DIRECT EVAPORATIVE COOLING ZONE: (Defined by Comfort Zone)

18.7	Max. Wet Bulb set by Max. Comfort Zone Wet Bulb (°C)
9.6	Min. Wet Bulb set by Min. Comfort Zone Wet Bulb (°C)

6. TWO-STAGE EVAPORATIVE COOLING ZONE:

50.0	% Efficiency of Indirect Stage

7. NATURAL VENTILATION COOLING ZONE:

2.0	Terrain Category to modify Wind Speed (2=suburban)
40.0	Min. Indoor Velocity to Effect Indoor Comfort (fpm)
1.5	Max. Comfortable Velocity (per ASHRAE Std. 55) (m/s)
3.6	Max. Perceived Temperature Reduction (°C)
90.0	Max. Relative Humidity (%)
22.8	Max. Wet Bulb Temperature (°C)

8. FAN-FORCED VENTILATION COOLING ZONE:

0.8	Max. Mechanical Ventilation Velocity (m/s)
3.0	Max. Perceived Temperature Reduction (°C)

(Min Vel, Max RH, Max WB match Natural Ventilation)

9. INTERNAL HEAT GAIN ZONE:

12.8	Balance Point Temperature Above Which Building Runs Free (°C)

10. PASSIVE SOLAR DIRECT GAIN LOW MASS ZONE:

157.7	Min. South Window Radiation for 5.56°C Temperature Rise (Wh/sq.m)
3.0	Thermal Time Lag for Low Mass Buildings (hours)

11. PASSIVE SOLAR DIRECT GAIN HIGH MASS ZONE:

157.7	Min. South Window Radiation for 5.56°C Temperature Rise (Wh/sq.m)
12.0	Thermal Time Lag for High Mass Buildings (hours)

12. WIND PROTECTION ZONE:

8.5	Min.Velocity above which Wind Protection is Desirable (m/s)
11.1	Min. Dry Bulb Temperature Difference Below Comfort Low (°C)

13. HUMIDIFICATION ZONE: (directly below Comfort Zone)

14. DEHUMIDIFICATION ZONE: (directly above Comfort Zone)

Fig.4. 19. California energy code comfort model for Shiraz

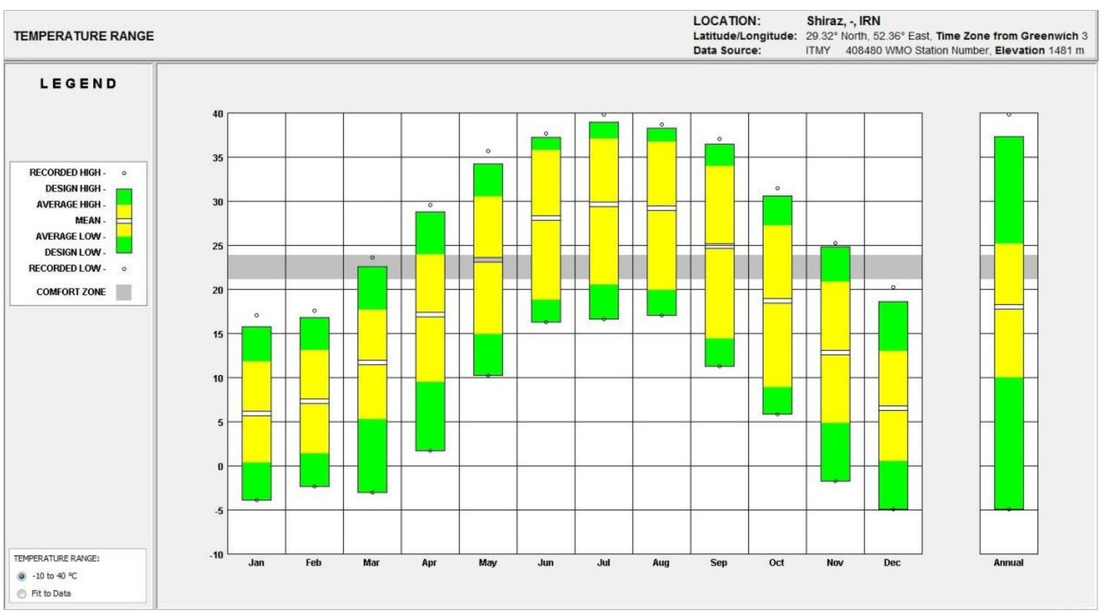


Fig.4. 20. Temperature range for Shiraz

Following the temperature range result, the annual mean temperature value is about 18°C at the meantime the temperature comfort zone is indicated between 21°C to 24°C. Whereas, the annual average high value and the design high value is in the range of 25 to 37°C, and same amount for average low and design low value is between 10 to -5°C, subsequently, highest and lowest recorded temperature for a year is 40°C and -5°C, respectively. And also data show that Jun, July and August have been the hottest and December, January and February have been the coldest season for Shiraz city (Figure 4.20).

Monthly diurnal average of Shiraz is shown in figure 4.21, where in summer time from Jun to August the solar radiation is in its peak of about 900Wh/m^2, and for the same period of time high deference between the dry and wet bulb temperature indicates that the humidity in ambient is in low situation, while this difference of range in winter is very low, which means in the winter in Shiraz there is a much of humidity in the air and in this period the solar radiation value is about 600Wh/m^2. Furthermore, the annual radiation average range that is shown in figure 4.22, for portion of global horizontal and total surface the values are between 70Wh/m^2/hr and 750Wh/m^2/hr. And this amount for direct normal part is between 110 to 380Wh/m^2/hr.

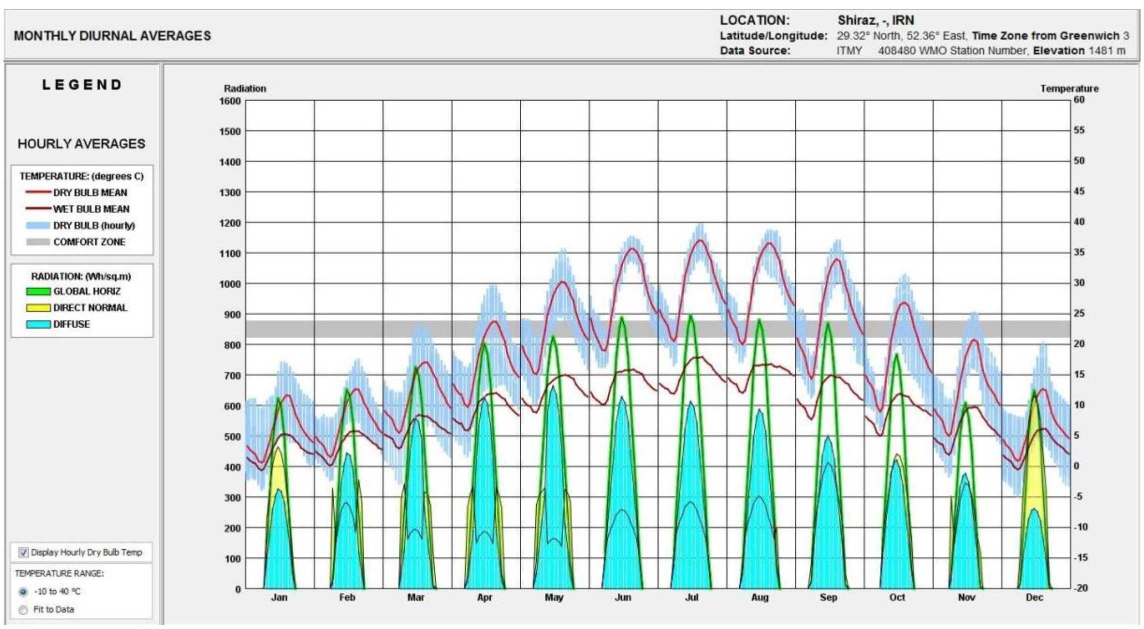


Fig.4. 21. Monthly diurnal average of Shiraz

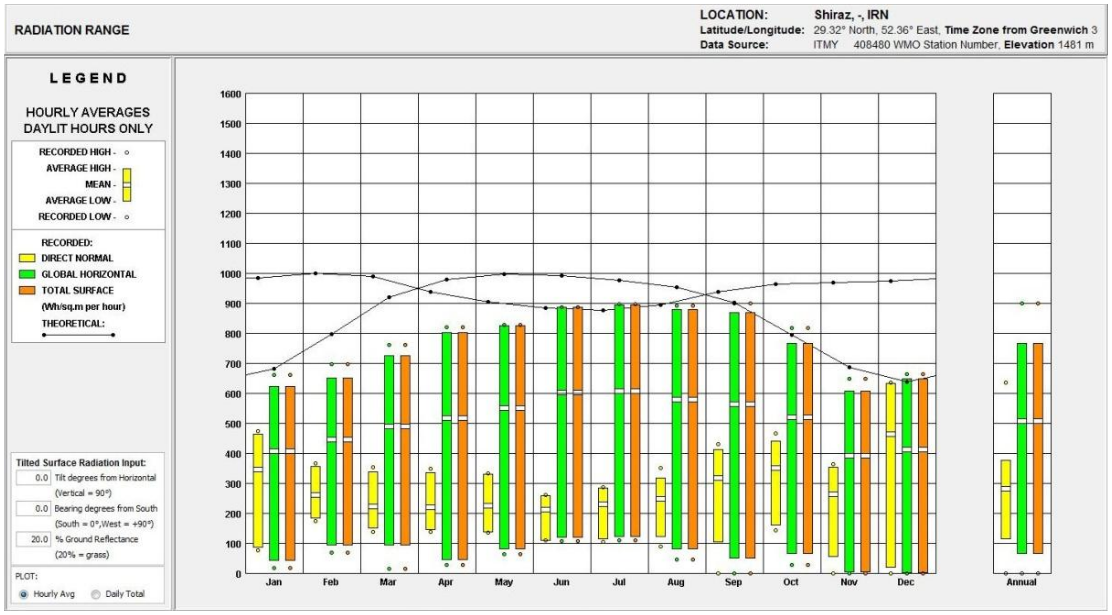


Fig.4. 22. Shiraz radiation range

CECCM software also shows the sky cover range and wind velocity in figure 4.23 and figure 4.24, respectively, in Shiraz. The related data illustrate that the highest wind speeds of Shiraz is allocated in early seasons of spring, fall and winter. The highest range is for December with wind speed of 17m/s and the lowest is for January and November with same wind speed of 4m/s.

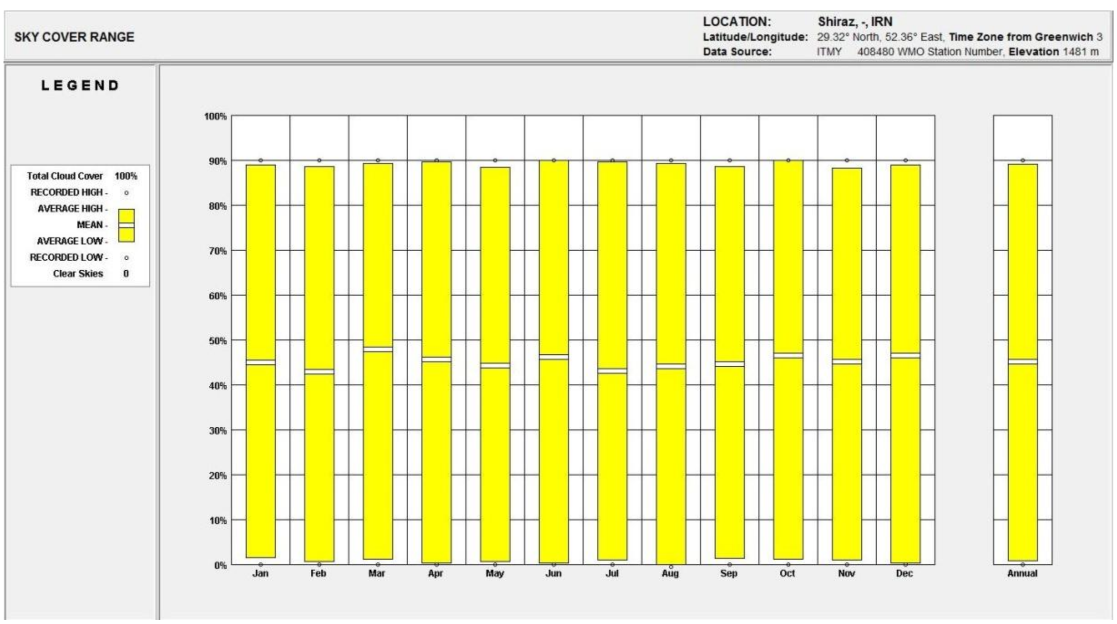


Fig.4. 23. Shiraz sky covers range

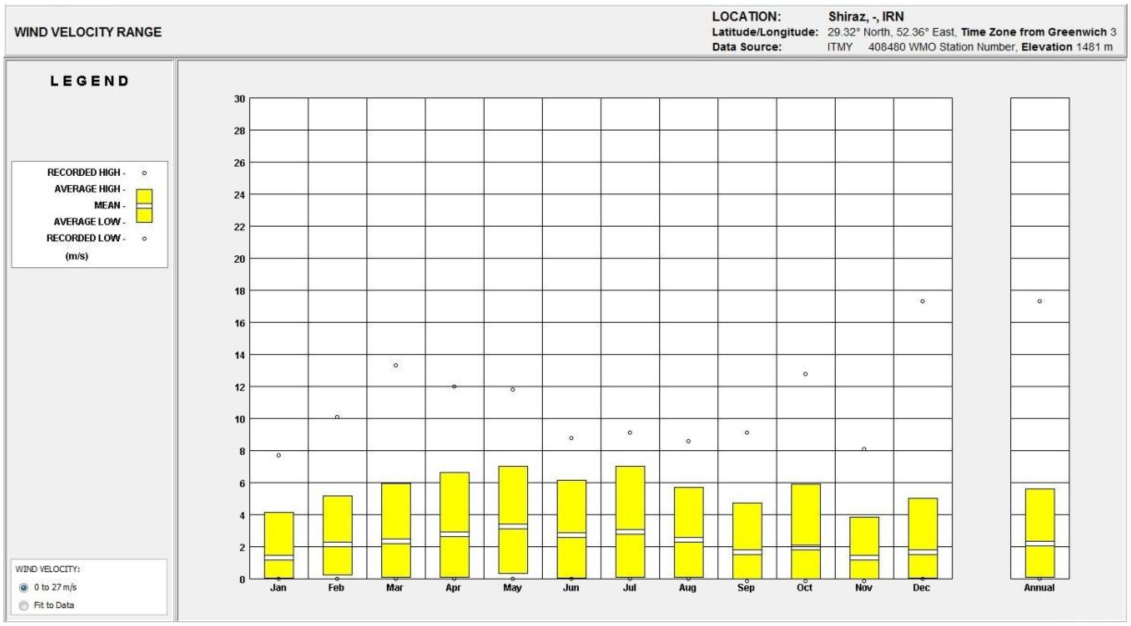


Fig.4. 24. Monthly wind velocity range in Shiraz

Now the major combined outputs and data of what has been discussed to this moment such as city temperature, relative humidity and wind velocity and its direction is clearly and comprehensibly shown in figure 4.25.

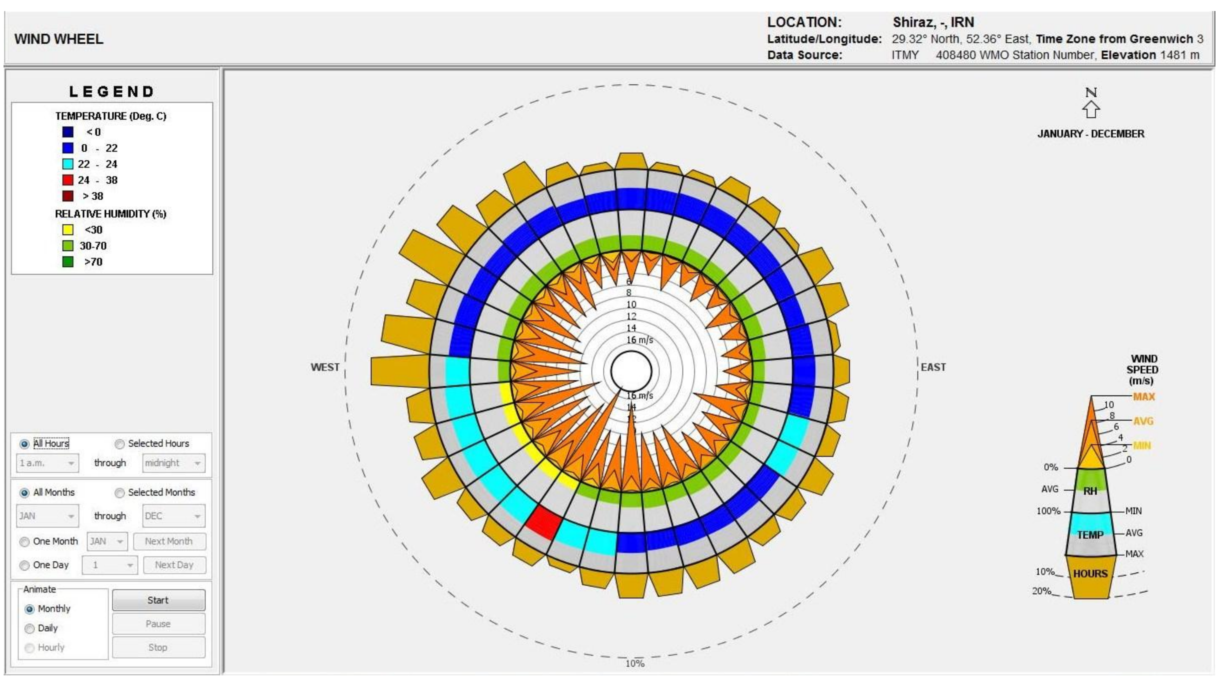


Fig.4. 25. Wind wheel in Shiraz city

Also other information and outcomes; ground temperature, dry bulb and relative humidity, dry bulb and dew point, sun chart, sun and shading chart and psychometric chart for Shiraz city that focus more on detail of results and would help more for analysis are given in subsequent figures. These data and charts are very helpful for technological design plan in which helps the engineers and architects to maintain the concept of low energy building that leads to a low energy urban by selecting of appropriate materials, new technologies and architectural guidelines with the respect to building energy consumptions in every region for arriving to a sustainable city.

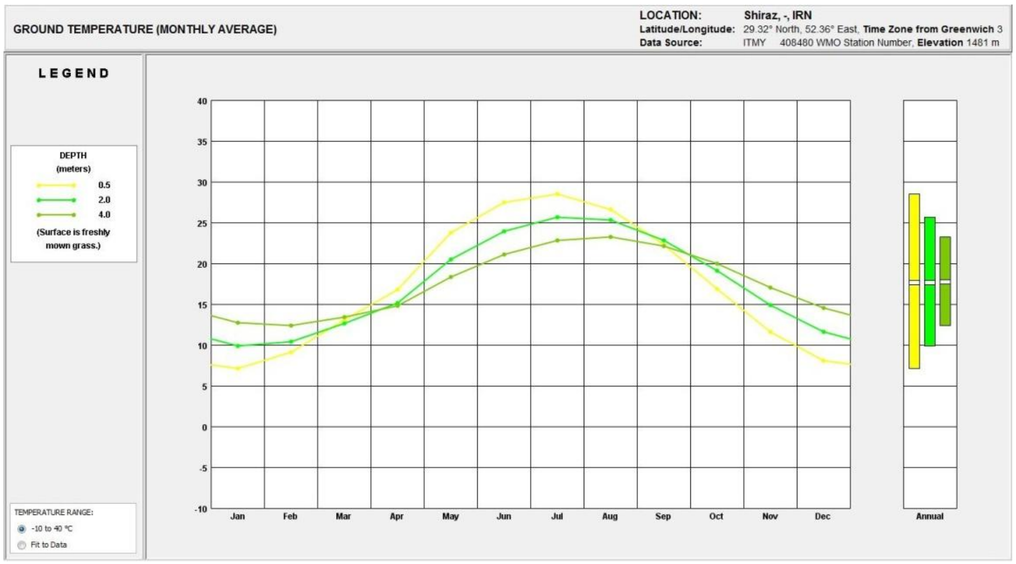


Fig.4. 26. Monthly average of Shiraz ground temperature

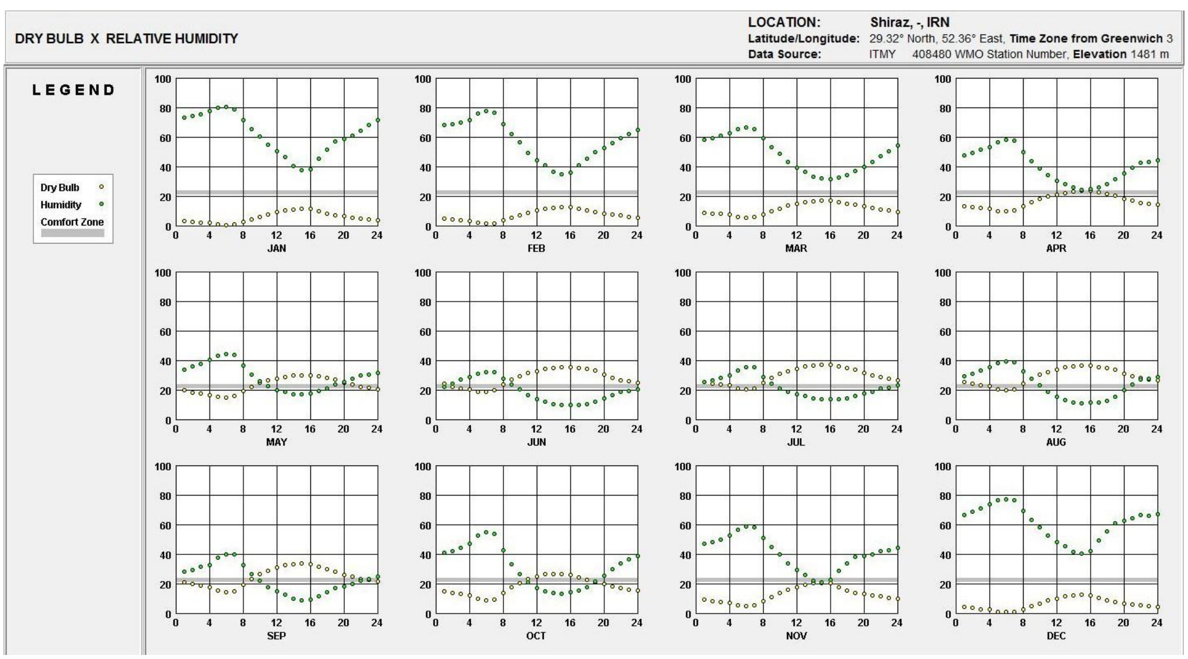


Fig.4. 27. Dry bulb and relative humidity in Shiraz

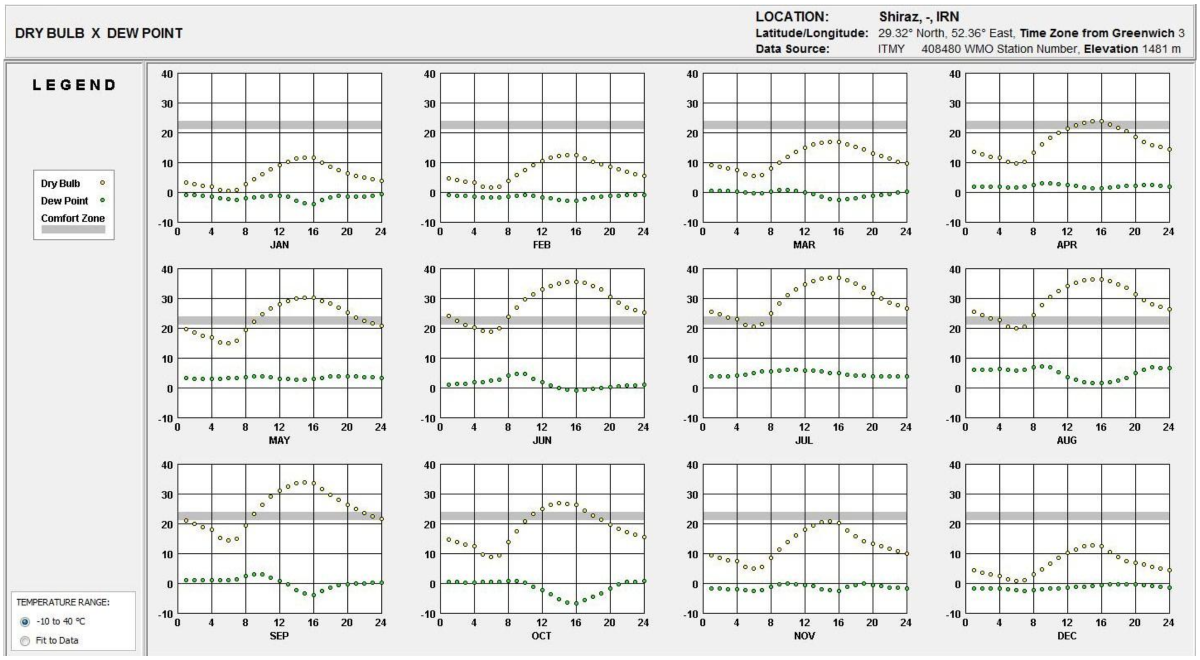


Fig.4. 28. Dry bulb and dew point in Shiraz

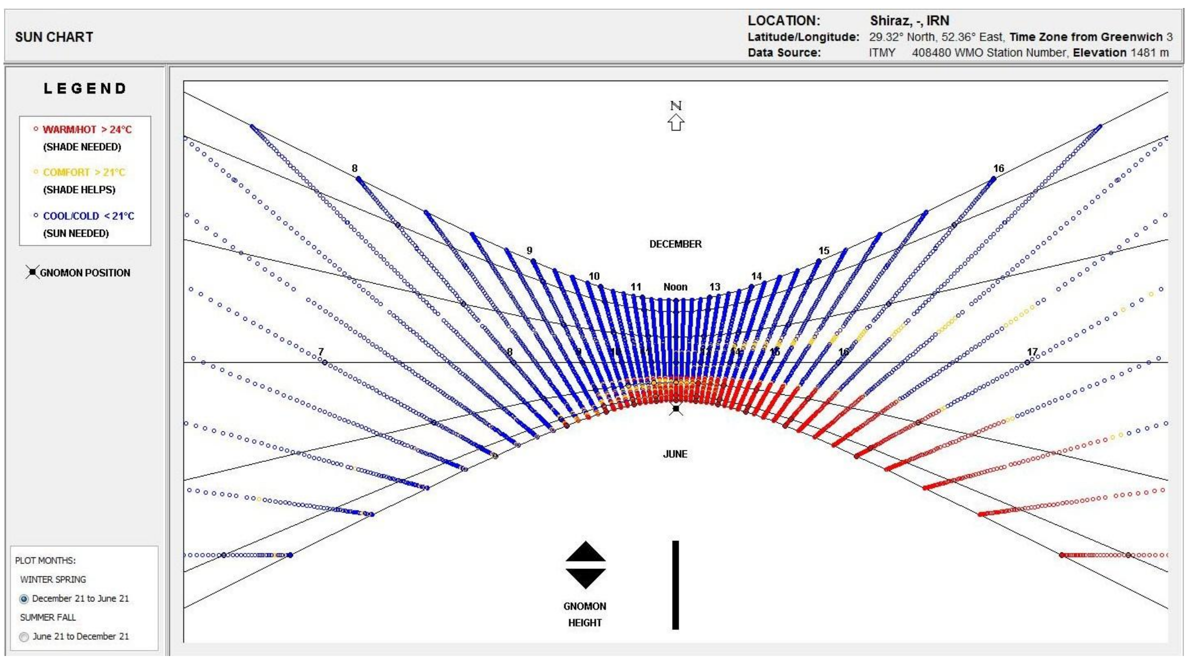


Fig.4. 29. Shiraz sun chart

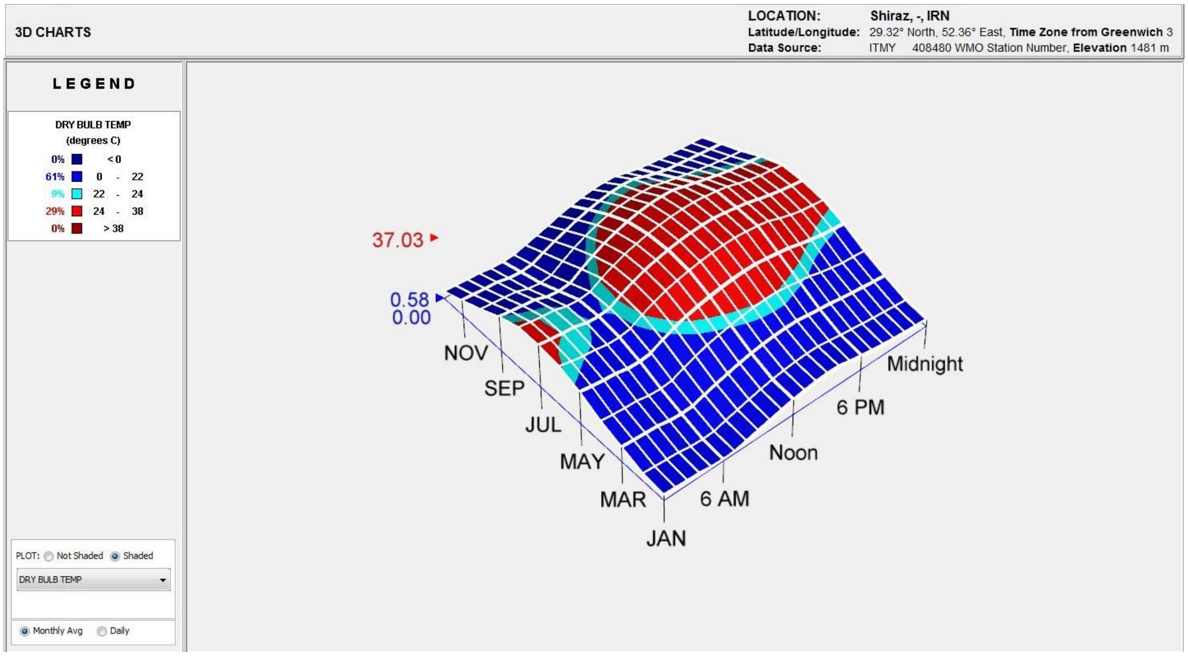


Fig.4. 30. Shiraz sun chart in 3D

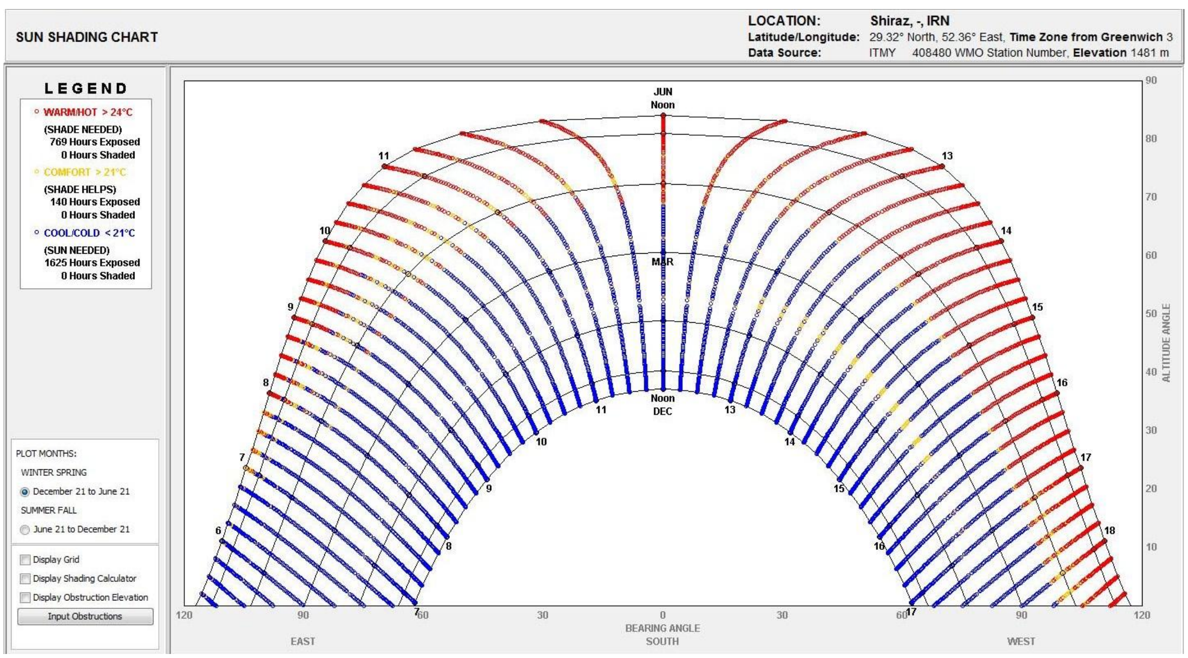


Fig.4. 31. Shiraz sun shading chart

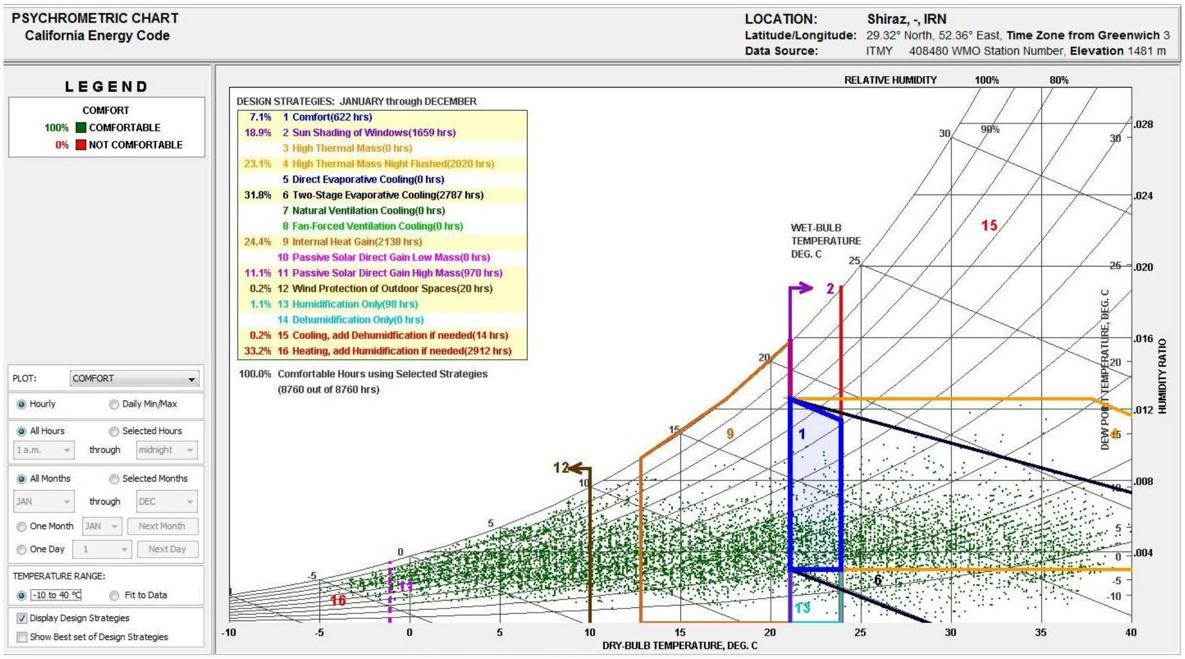


Fig.4. 32. Psychometric chart (California energy code) for Shiraz

Table 4.1 shows the monthly report for Shiraz climate, including of different variable such as clearness, insulation, temperature, wind speed, precipitation and wet days, these data that given by NASA Langley research center are more or less very close to the results which obtained by CECCM. Therefore it is to make sure that the analysis for the technological design may be followed by few errors in its procedure of design. In this regard, also rainfall in figure 4.33 and table 4.2 shows that the in Shiraz when the temperature is high in summer season the chance of precipitation in very low, but inversely in the winter when the temperature is in its lower position the chance of rain is impressively high along with the humidity value.

Table: 4.1. Shiraz climate data
(NASA Langley Research Center Atmospheric Science Data Center; New et al. 2002)

Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Insulation (kWh/m²/day)	2.92	4.00	4.85	5.75	6.86	7.40	7.14	6.78	6.07	4.81	3.48	2.84
Clearness (0 – 1)	0.50	0.56	0.55	0.57	0.62	0.65	0.64	0.65	0.66	0.63	0.56	0.52
Temperature (°C)	2.70	4.39	8.16	14.8	20.7	25.4	27.4	26.17	21.86	16.21	9.81	4.79
Wind speed (m/s)	5.70	6.03	6.10	5.64	6.33	6.74	7.14	6.78	6.05	5.32	5.24	5.71
Precipitation (mm)	77	44	47	34	8	0	2	0	0	4	28	60
Wet days (d)	8.5	7.7	7.9	6.5	2.4	0.4	0.9	0.5	0.1	1.3	3.7	7.0

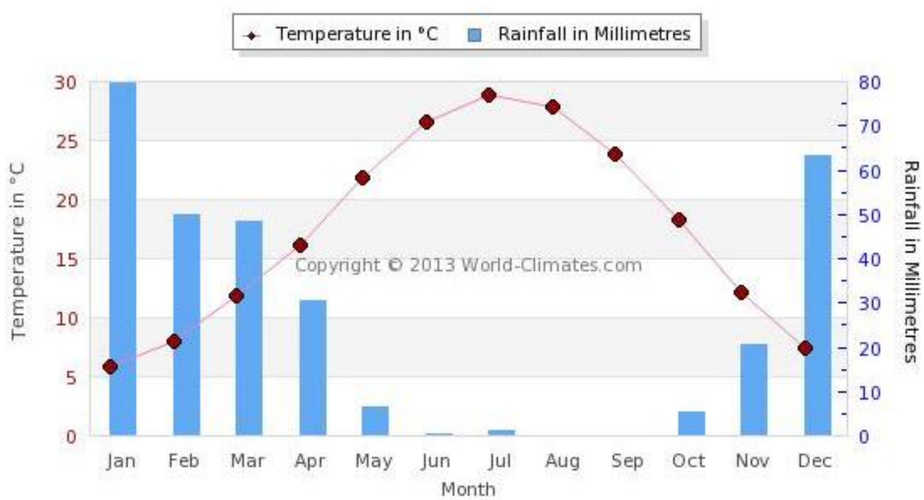


Fig.4. 33. Average rainfall and temperature in Shiraz (world-climate.com)

Table: 4.2. Shiraz monthly rainfall (world-climate.com)

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total rainfall in MM	79.8	49.8	48.4	30.6	6.6	0.2	1	0.1	0	5.2	20.7	63.2
Total rainfall in Inches	3.1	2.0	1.9	1.2	0.3	0.0	0.0	0.0	0.0	0.2	0.8	2.5
Total number of rainy days	6.6	6	5.9	4.2	1.2	0	0.2	0.1	0	0.6	2.5	5.5
Chances of rain	21.3%	21.4%	19.0%	14.0%	3.9%	0.0%	0.6%	0.3%	0.0%	1.9%	8.3%	17.7%

4-5-Environmental energy

This project significantly tends to overcome high energy consumption of fossil fuel in residential and commercial sectors from local scale to district scale. For this aim, climatic analysis and data show the high potential in utilization of environmental energy in Iran especially in the city of Shiraz is applicable. Therefore, the section below shows all of necessary and appropriate facility use, such as solar devices and natural elements, and also the architectural design regulations according to the climatic conditions and site situation.

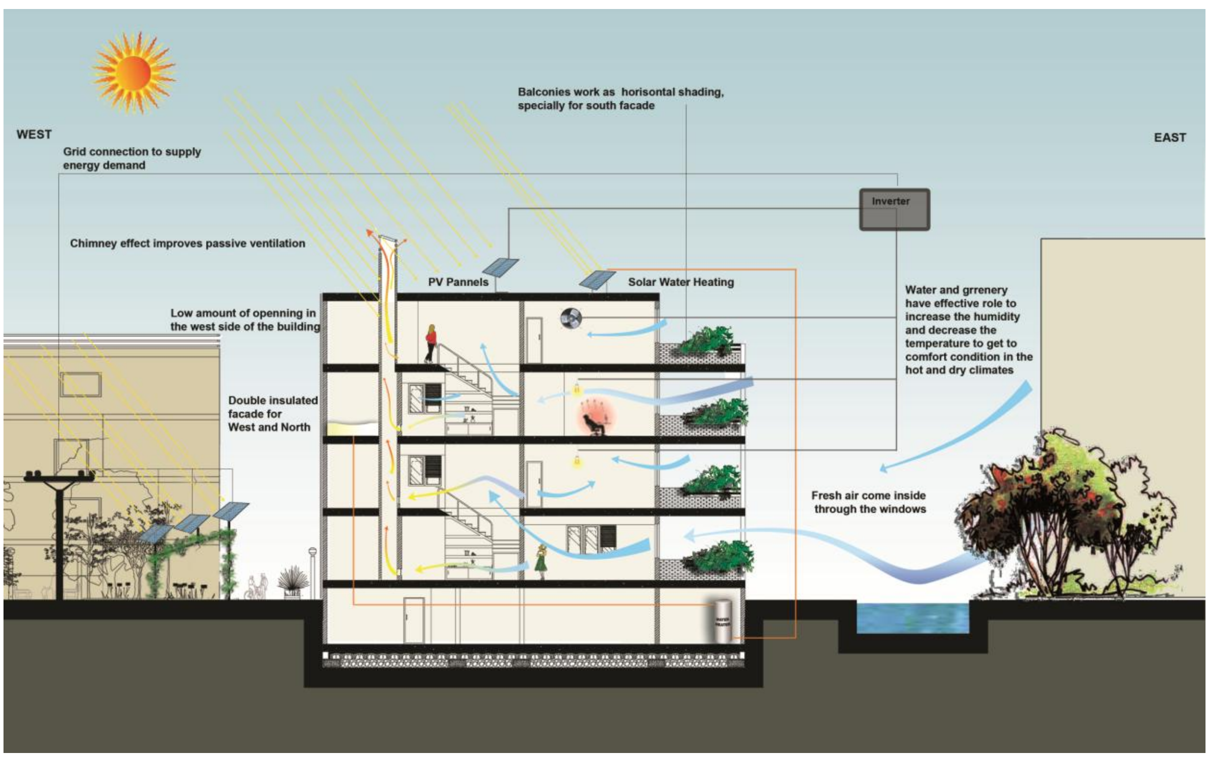


Fig.4. 34. Schematic sketch of residential building in the site

The solar energy is suggested to provide energy demand through PV panels both on rooftops and inside the district, and also for hot water the solar water heater system is suggested. Also, to pull fresh air inside and to reduce the air temperature at the same time, passive ventilation by means of chimney effect inside the building and employment of water pool and greenery part for outside the building is proposed. Moreover, for west and north side double insulated façade and less openings is considered to prevent energy loss in winter and cold weather. There is no doubt that these solutions have the high potential to improve the concept of energy saving district in the city. In the next session the proposed technological solutions are provided.

4-6-Proposed Technological Solutions for the Envelope

The materials and the layers of the external walls and the roof have direct effect on energy efficiency of the building, where, by removing or doubling a layer of insulation the amount of U-Value will change dramatically. In the residential buildings energy saving is highlighted to decrease the costs and keeping spaces in the optimum comfort condition. Another important issue is condensation in the walls and roof. This problem happens in cold walls and floors, and it affects the materials. To avoid this phenomenon, vapor barrier has been used in all the external walls and cold surfaces. In the proposal materials, there was a significant attention to availability and costs issues. However there are lots of different facade materials for residential building in Iran, but most common ones are brick, stone and fiber cement. As the concept is to have a ventilated facade, hanging bricks on a suspended structure, is a good solution for this aim.

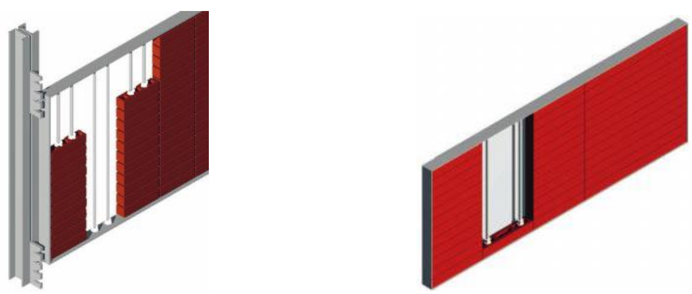


Fig.4. 35. Proposed hanging bricks façade [10]

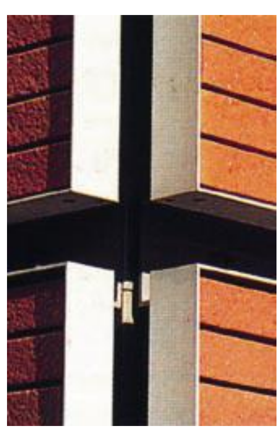
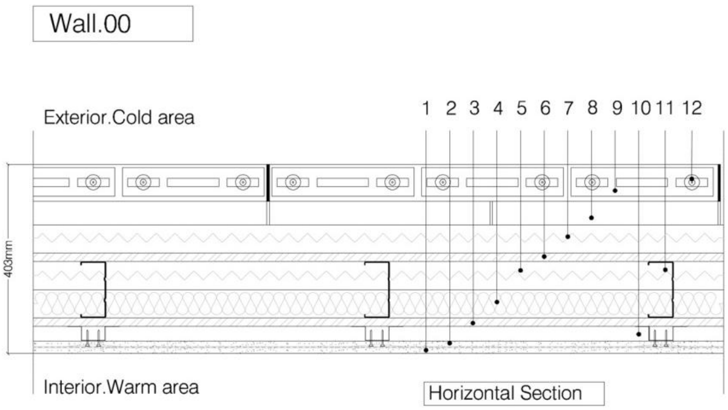


Fig.4. 36. External façade [10]

4-6-1-External wall solutions



Exterior Wall - TYPE 00		
Number	Layer	Thickness
1	"Knauf" PlasterBoard with vapor barrier	12.5 mm
2	"Knauf" PlasterBoard	12.5 mm
3	OSB Board (support)	18 mm
4	"Knauf" Mineral Wool	60 mm
5	Polystyrene Board- 45kg/m3	60 mm
6	OSB Board(suppport & rigidity)	18 mm
7	Polyurethane Foam coated with embossed Aluminium sheet	60 mm
8	Air Cavity	50 mm
9	Brick	
10	Cable Duct	
11	Steel Stud	
12	Steel Bar	

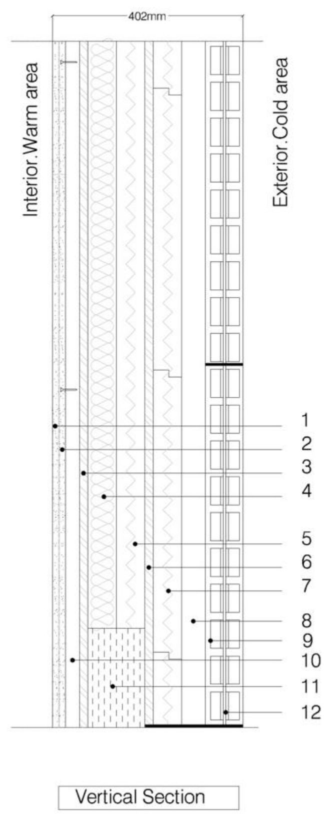
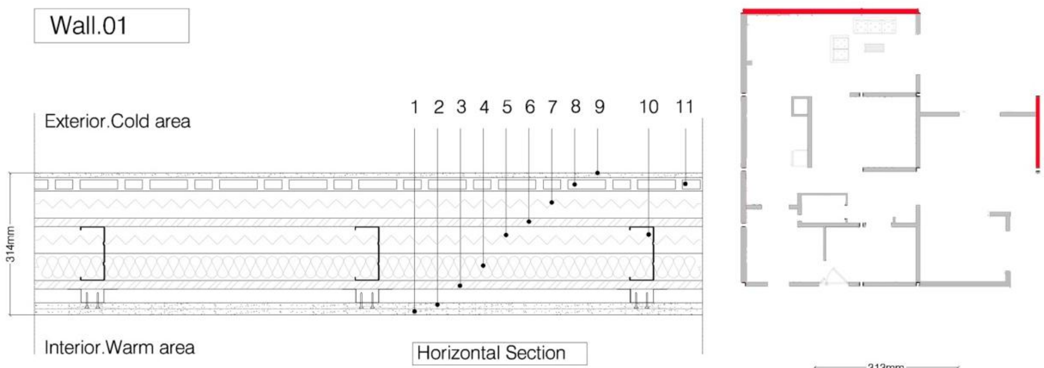


Fig.4. 37. External wall solution for wall type 00



Exterior Wall - TYPE 01		
Number	**Layer**	**Thickness**
1	"Knauf" PlasterBoard with vapor barrier	12.5 mm
2	"Knauf" PlasterBoard	12.5 mm
3	OSB Board (support)	18 mm
4	"Knauf" Mineral Wool	60 mm
5	Polystyrene Board- 45kg/m3	60 mm
6	OSB Board(suppport & rigidity)	18 mm
7	"Isotec Parete" Polyurethane Foam coated with embossed Aluminium sheet	60 mm
8	Pierce Steel Profile	
9	Cladding system	20 mm
10	Cable Duct	
11	Steel Stud	
12	Ventilation Gap	

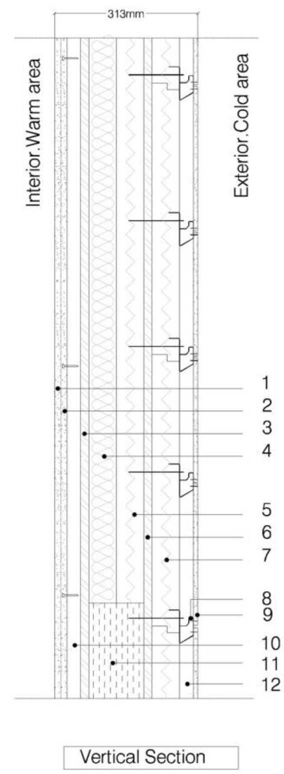


Fig.4. 38. External wall solution for wall type 01

Also, fiber cement board is used as facade material, which has advantages in long-term performance, and highly resistant to absorb moisture in its life cycle.

Fig.4. 39. External fiber cement board façade

Table: 4.4. Proposed material details and U-Value

Layer	Material	Thickness	Thermal conductivity	Resistance	Transmittance	ΔT*U*Ri	Ti
		s (m)	λ(W/m.k)	R (m².k/W)	u(w/m².k)		˚C
	Inside						23.9
	internal surface			0.13	7.69	0.52	23.38
1	knauf Plaster board	0.0125	0.16	0.08	12.80	0.31	23.06
2	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.0006	0.27	0.00			23.06
3	Knauf plaster board	0.0125	0.16	0.08	12.80	0.31	22.75
4	OSB Board	0.018	0.13	0.14	7.22	0.56	22.19
5	Mineral wool	0.06	0.044	1.36	0.73	5.49	16.70
6	Polystryene Board 45Kg/m3	0.06	0.031	1.94	0.52	7.79	8.91
7	OSB Board	0.018	0.13	0.14	7.22	0.56	8.35
8	"Isotec Parete" Polyurethane Foam	0.06	0.022	2.73	0.37	10.98	-2.63
	external surface			0.04	25.00	0.16	-2.79
	Outside						-2.8
	Total	0.2416		6.63	**0.15**		
	ΔT	26.7					

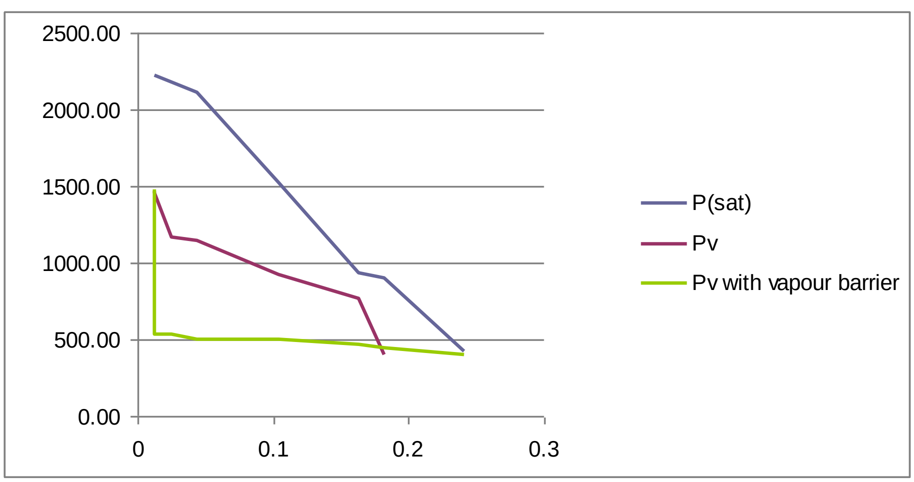
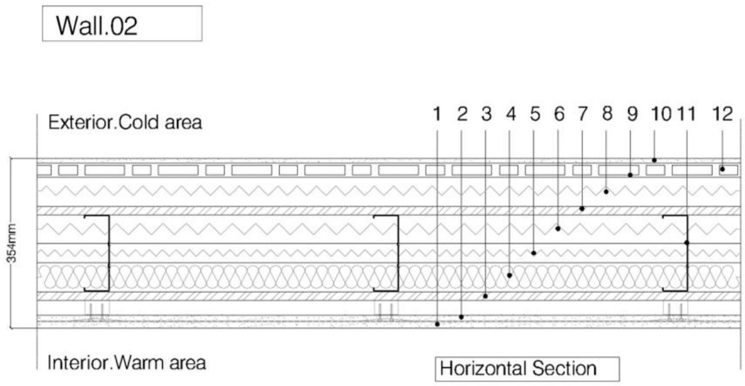
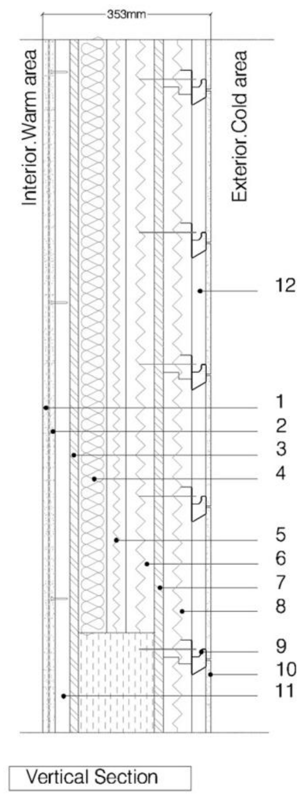


Fig.4. 40. Condensation graph for wall type 01

Table: 4.3. Details of condensation analysis for wall type 01

Interior	Pi(sat)@23.9˚C	2957.30	Pi(50%)	1478.65						
Exterior	Pe(sat)@-2.8˚C	496.06	Pe(80%)	396.85						
	ΔP (Pa)	1081.80			**Wall 01**					
	ΔT (˚C)	26.7								
Layer	Material	Thickness	Vapour permeability	Vapour Ressistance	Ti	P(sat)	ΔP*ρi/ρtot	Pv	ΔP*ρi/ρ'tot	Pv'
		s (m)	δ (kg/msPa)	ρ(m²sPa/kg)	˚C	Pa		Pa	vapour barrier	Pa
	Inside				23.9	2957.30				
	internal surface				19.51	2261.4				
1	knauf Plaster board	0.0125	23	0.0005	19.22	2220.9	12.879	1465.7	1.70	1476.9
2	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.0006	0.002	0.3000	19.22	2220.9			938.93	538.02
3	Knauf plaster board	0.0125	23	0.0005	18.93	2181.1	12.879	1452.8	1.70	536.32
4	OSB Board	0.018	1.5	0.0120	18.40	2110.0	284.38	1168.50	37.56	498.76
5	Mineral wool	0.06	63	0.0010	13.26	1518.7	22.570	1145.9	2.98	495.78
6	Polystryene Board 45Kg/m3	0.06	6.3	0.0095	5.97	930.54	225.70	920.23	29.81	465.97
7	OSB Board	0.018	1.5	0.0067	5.44	896.97	158.78	761.45	20.97	445.00
8	"Isotec Parete" Polyurethane Foam	0.06	3.9	0.0154	-4.84	425.69	364.59	396.85	48.15	396.85
	external surface				-4.99	420.89				
	Outside				-2.8	496.06				
	Total	0.241		0.05						
	Total with vapour barrier	0.2416		0.3456						





Exterior Wall - TYPE 02		
Number	Layer	Thickness
1	"Knauf" PlasterBoard with vapor barrier	12.5 mm
2	"Knauf" PlasterBoard	12.5 mm
3	OSB Board (support)	18 mm
4	"Knauf" Mineral Wool	60 mm
5	Polystyrene Board- 45kg/m3	40 mm
6	Polystyrene Board- 45kg/m3	60 mm
7	OSB Board(suppport & rigidity)	18 mm
8	"Isotec Parete"Polyurethane Foam coated with embossed Aluminium sheet	60 mm
9	Pierce Steel Profile	
10	Cladding system	20 mm
11	Steel Stud	
12	Ventilation Gap	

Fig.4. 41. External wall solution for wall type 02

For some of critical sides like west and north direction, two layers of polystyrene considered to improve U-Values.

Table: 4.5. Proposed material details and U-Value in west direction

Layer	Material	Thickness	Thermal conductivity	Ressistance	Transmittance	ΔT*U*Ri	Ti
		s (m)	λ(W/m.k)	R (m².k/W)	u(w/m².k)		˚C
	Inside						23.9
	internal surface			0.13	7.69	0.52	23.38
1	knauf Plaster board	0.0125	0.16	0.08	12.80	0.31	23.07
2	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.0006	0.27	0.00			23.07
3	Knauf plaster board	0.0125	0.16	0.08	12.80	0.31	22.76
4	OSB Board	0.018	0.13	0.14	7.22	0.55	22.21
5	Mineral Wool	0.06	0.38	0.16	6.33	0.63	21.58
6	Polystryene Board 45Kg/m3	0.06	0.031	1.94	0.52	7.69	13.89
7	Polystryene Board 45Kg/m3	0.04	0.031	1.29	0.78	5.13	8.76
8	OSB Board	0.018	0.13	0.14	7.22	0.55	8.21
9	ISOTEC Parete	0.06	0.022	2.73	0.37	10.84	-2.63
	external surface			0.04	25.00	0.16	-2.79
	Outside						-2.8
	Total	0.2816		6.72	**0.15**		
	ΔT	26.7					

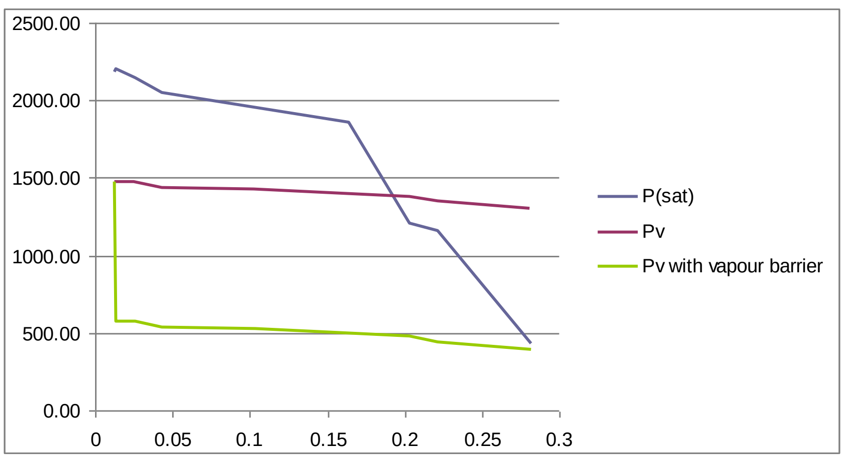
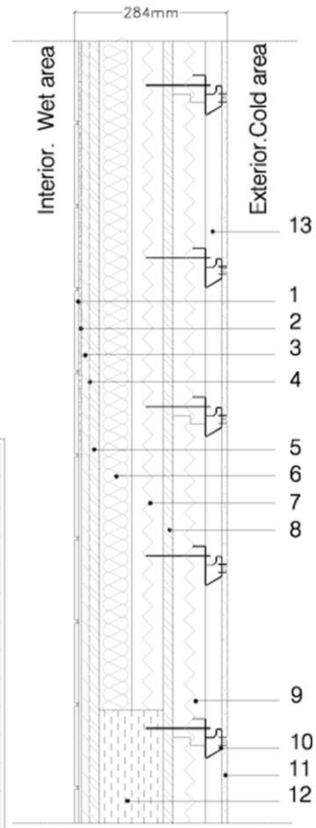


Fig.4. 42. Condensation graph for wall type 02

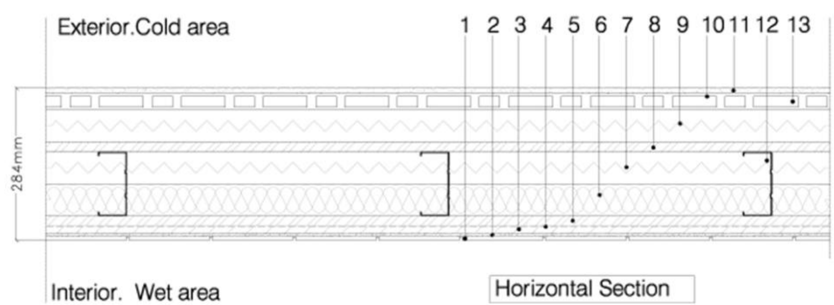
Table: 4.6. Details of condensation analysis for wall type 02

Interior	Pi(sat)@23.9˚C	2957.30	Pi(50%)	1478.65	Wall 02					
Exterior	Pe(sat)@-2.8˚C	496.06	Pe(80%)	396.85						
	ΔP (Pa)	1081.80								
	ΔT (˚C)	26.7								
Layer	Material	Thickness	Vapour permeability	Vapour Ressistance	Ti	P(sat)	ΔP* ρi/ρtot	Pv	ΔP*ρi/ ρ'tot	Pv'
		s (m)	δ (kg/msPa)	ρ(m²sPa/kg)	˚C	Pa		Pa	vapour barrier	Pa
	inside				23.9	2957.3				
	internal surface				19.3	2237.6				
1	knauf Plaster board	0.0125	23	0.0005	18.9	2183.9	1.63	1477.0	1.64	1477.0
2	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.0006	0.002	0.3000	19.0	2200.3			904.13	572.8
3	Knauf plaster board	0.0125	23	0.0005	18.6	2146.0	1.63	1475.3	1.64	571.2
4	OSB Board	0.018	1.5	0.0120	17.9	2053.8	36.1	1439.2	36.17	535.0
5	Mineral Wool	0.06	23	0.0026	17.1	1952.7	7.86	1431.3	7.86	527.2
6	Polystryene Board 45Kg/m3	0.06	6.3	0.0095	16.3	1857.2	28.7	1402.6	28.70	498.5
7	Polystryene Board 45Kg/m3	0.04	6.3	0.0063	9.84	1211.2	19.1	1383.5	19.13	479.3
8	OSB Board	0.018	1.5	0.0120	9.14	1155.5	36.1	1347.3	36.17	443.2
9	ISOTEC Parete	0.06	3.9	0.0154	-4.66	431.52	46.3	1300.9	46.37	396.8
	external surface				-4.87	424.73				
	outside				-2.8	496.06				
	Total	0.281		0.36						
	Total with vapour barrier	0.2816		0.3590						

Exterior Wall - TYPE 03		
Number	**Layer**	**Thickness**
1	Ceramic Tile 15*15cm	8 mm
2	Ceramic Adhesive	5 mm
3	"Knauf" Aquapanel	12.5 mm
4	"Dupont TYVEK" Vapour Barrier	2 mm
5	OSB Board (support)	18 mm
6	"Knauf" Mineral Wool	60 mm
7	Polystyrene Board- 45kg/m3	60 mm
8	OSB Board(suppport & rigidity)	18 mm
9	"Isotec Parete" Polyurethane Foam coated with embossed Aluminium sheet	60 mm
10	Pierce Steel Profile	
11	Cladding system	20 mm
12	Steel Stud	
13	Ventilation Gap	



Vertical Section



Horizontal Section

Fig.4. 43. External wall solution for wall type 03

Table: 4.7. Proposed material details and U-Value in north direction

Layer	Material	Thickness	Thermal conductivity	Resistance	Transmittance	ΔT*U*Ri	Ti
		s (m)	λ(W/m.k)	R (m².k/W)	u(w/m².k)		˚C
	Inside						23.9
	internal surface			0.13	7.69	0.59	23.31
1	Ceramic Tile 15*15 cm	0.0125	0.02	0.63	1.60	2.82	20.50
2	Ceramic Adhesive	0.0125	1.5	0.01			20.50
3	Knauf Aquapanel	0.0125	0.79	0.02	63.20	0.07	20.43
4	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.002	0.27	0.01			20.43
5	OSB Board	0.018	0.13	0.14	7.22	0.62	19.80
6	Mineral Wool	0.06	0.38	0.16	6.33	0.71	19.09
7	Polystryene Board 45Kg/m3	0.06	0.031	1.94	0.52	8.72	10.37
9	OSB Board	0.018	0.13	0.14	7.22	0.62	9.74
10	ISOTEC Parete	0.06	0.022	2.73	0.37	12.29	-2.55
	external surface			0.04	25.00	0.18	-2.73
	Outside						-2.8
	Total	0.2555		5.92	**0.17**		
	ΔT	26.7					

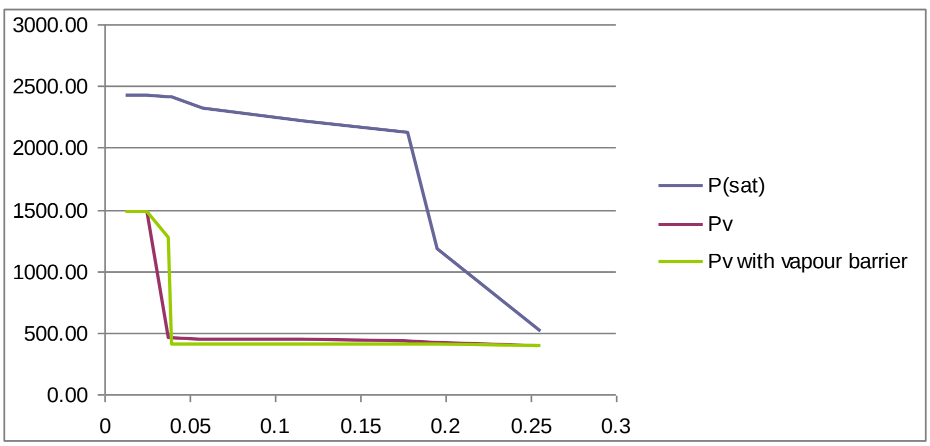
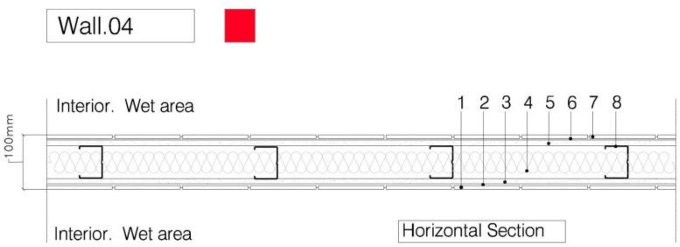


Fig.4. 44. Condensation graph for wall type 03

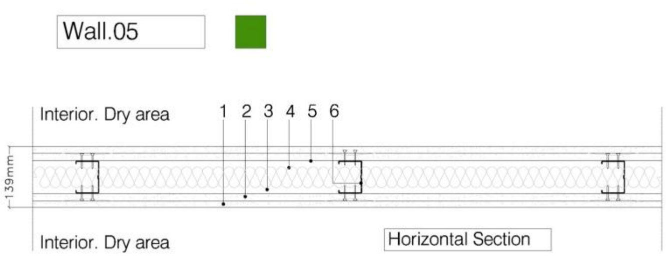
Table: 4.8. Details of condensation analysis for wall type 03

Interior	Pi(sat)@23.9˚C	2957.30	Pi(50%)	1478.65	**Wall 03**					
Exterior	Pe(sat)@-2.8˚C	496.06	Pe(80%)	396.85						
	ΔP (Pa)	1081.80								
	ΔT (˚C)	26.7								
Layer	Material	Thickness	Vapour permeability	Vapour Resistance	Ti	P(sat)	ΔP*ρi/ρtot	Pv	ΔP*ρi/ρ'tot	Pv'
		s (m)	δ (kg/msPa)	ρ(m²sPa/kg)	˚C	Pa		Pa	vapour barrier	Pa
	inside				23.90	2957.30				
	internal surface				23.33	2857.39				
1	Ceramic Tile 15*15 cm	0.0125	20	0.0006	20.59	2417.09	0.763572	1477.89	0.16	1478.49
2	Ceramic Adhesive	0.0125	0	0.0000	20.59	2417.09	0	1477.89	0.00	1478.49
3	Knauf Aquapanel	0.0125	0.015	0.8333	20.52	2406.76	1018.095	459.79	213.69	1264.80
4	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.002	0.0006	3.3333	20.52	2406.76			854.74	410.06
5	OSB Board	0.018	1.5	0.0120	19.91	2318.01	14.66057	445.13	3.08	406.99
6	Mineral Wool	0.06	23	0.0026	19.22	2220.30	3.187081	441.94	0.67	406.32
7	Polystyrene Board 45Kg/m3	0.06	6.3	0.0095	18.52	2126.22	11.63538	430.31	2.44	403.87
8	OSB Board	0.018	1.5	0.0120	9.42	1177.33	14.66057	415.65	3.08	400.80
9	ISOTEC Parete	0.06	3.9	0.0154	-2.56	505.16	18.79561	396.85	3.94	396.85
	external surface				-2.73	498.62				
	outside				-2.80	496.06				
	Total	0.2535		0.89						
	Total with vapour barrier	0.2555		4.2188						

4-6-2-Partition solutions



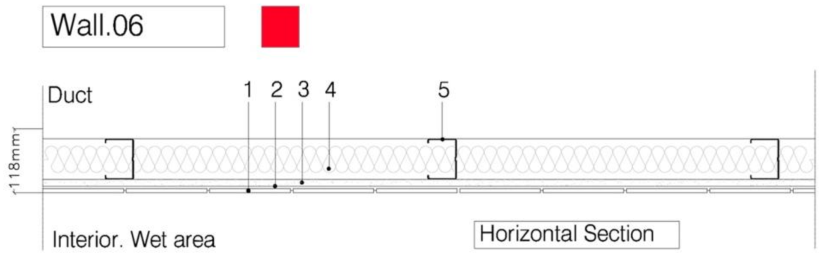
Interior Wall - TYPE 04		
Number	Layer	Thickness
1	Ceramic Tile 15*15cm	8 mm
2	Ceramic Adhesive	4 mm
3	"Knauf" Aquapanel	12.5 mm
4	"Knauf" Mineral Wool	75mm
5	"Knauf" Aquapanel	12.5 mm
6	Ceramic Adhesive	4 mm
7	Ceramic Tile 15*15cm	8 mm
8	Metal C Stud (@40cm)	



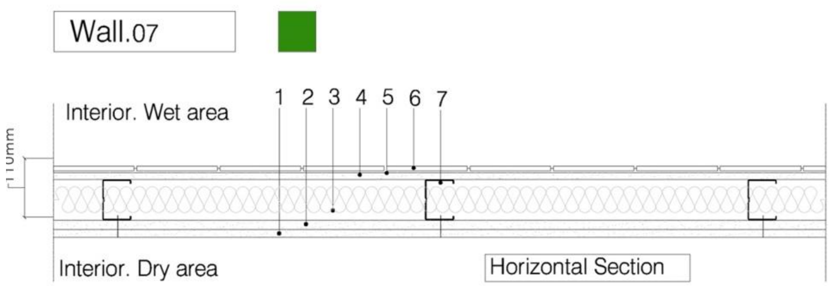
Interior Wall - TYPE 05		
Number	Layer	Thickness
1	"Knauf" PlasterBoard	12.5 mm
2	"Knauf" PlasterBoard	12.5 mm
3	"Knauf" Mineral Wool	75mm
4	"Knauf" PlasterBoard	12.5 mm
5	"Knauf" PlasterBoard	12.5 mm
6	Metal C Stud (@60cm)	

Fig.4. 45. Internal wall solution for wall type 04 and 05

Sound insulation is the most important layer in the internal partitions, while the thermal insulation is not necessary regarding to any thermal gains and losses in internal spaces. Whereas, in some cases such as bath room, water proof membrane and vapor barrier is applied to prevent damages by infiltration and condensation.



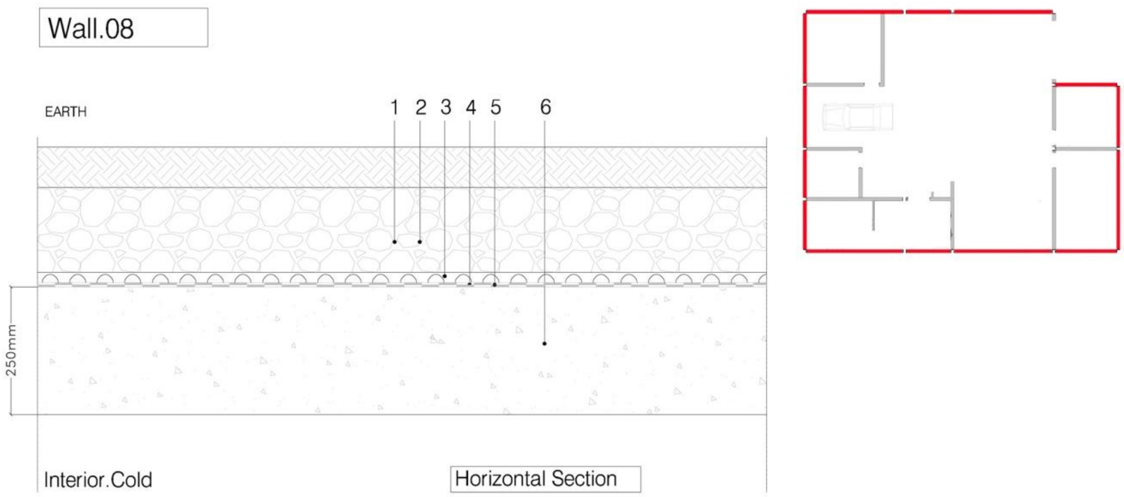
Duct Wall - TYPE 06		
Number	Layer	Thickness
1	Ceramic Tile 15*15cm	8 mm
2	Ceramic Adhesive	2 mm
3	"Knauf" Aquapanel	12.5 mm
4	"Knauf" Mineral Wool	75mm
5	Metal C Stud (@60cm)	



Interior Wall - TYPE 07		
Number	Layer	Thickness
1	"Knauf" PlasterBoard	12.5mm
2	"Knauf" PlasterBoard	12.5mm
3	"Knauf" Mineral Wool	75mm
4	"Knauf" Aquapanel	12.5mm
5	Ceramic Adhesive	2mm
6	Ceramic Tile 15*15cm	8mm
7	Metal C Stud (@60cm)	

Fig.4. 46. Internal wall solution for wall type 06 and 07

4-6-3-Retaining Wall solution

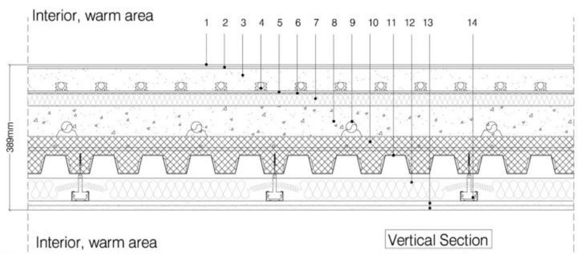


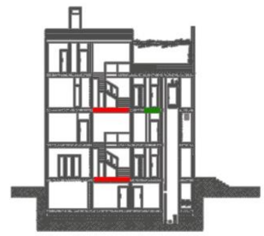
Exterior Wall- TYPE 08		
Number	Layer	Thickness
1	Earth	
2	Gravel	
3	Convex shield	20 mm
4	Bitumen Membrane	4 mm
5	Bitumen Membrane	4 mm
6	Concrete wall	250 mm
7	Polystyrene Board-60kg/m3	40 mm
8	"Knauf" PlasterBoard	12.5mm
9	"Knauf" PlasterBoard with vapor barrier	12.5mm

Fig.4. 47. Retaining wall solution for wall type 08

4-6-4-Floor solutions

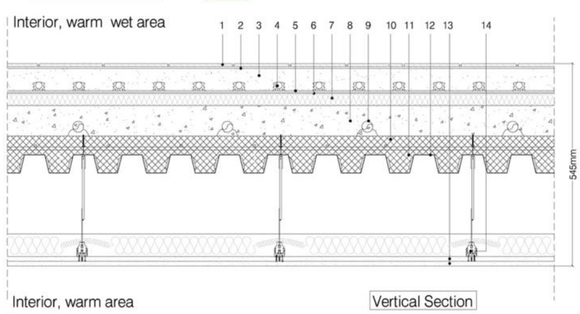
Floor A





Intermediate Floor- Type A		
Number	Layer	Thickness
1	Strip Parquet With Sound-absorbing cushion	5 mm
2	Parquet adhesive	5 mm
3	Sand cement screed	60 mm
4	"Velta" PE-Xa 17mm*2mm Pipe	
5	"velta" fixing grid	2 mm
6	"velta" PE 200 Slip membrane	4 mm
7	Knauf insulation board	30 mm
8	Light concrete	80 mm
9	Water plumps	
10	Reinforced concrete	
11	Metal Deck	
12	"Knauf" mineral wool	60 mm
13	2 Layer of " Knauf" Gypsumboard	12.5 mm
14	Knauf False cieling clips	

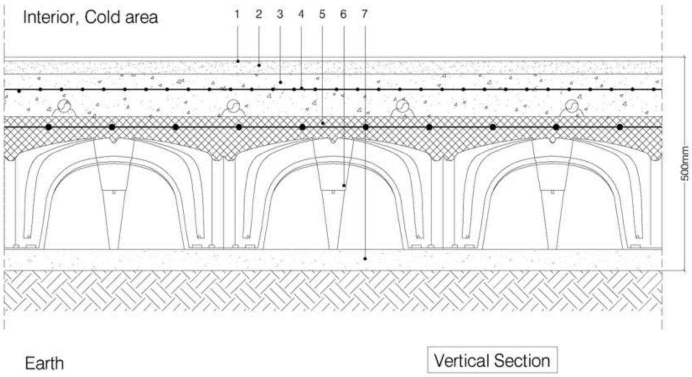
Floor A1

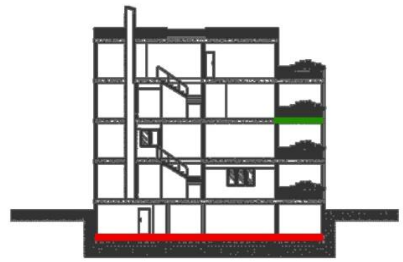


Intermediate Floor- Type A1		
Number	Layer	Thickness
1	ceramic 30 * 30 cm	5 mm
2	Ceramic Glue	5 mm
3	Sand cement screed	50 mm
4	"Velta" PE-Xa 17mm*2mm Pipe	
5	"velta" fixing grid	2 mm
6	"velta" PE 200 Slip membrane	4 mm
7	Knauf insulation board	30 mm
8	Light concrete	80 mm
9	Water plumps	
10	Reinforced concrete	
11	Metal Deck	
12	"Knauf" mineral wool	
13	2 Layer of " Knauf" Gypsumboard	
14	Knauf False cieling clips	

Fig.4. 48. Floor solution for type A and A1

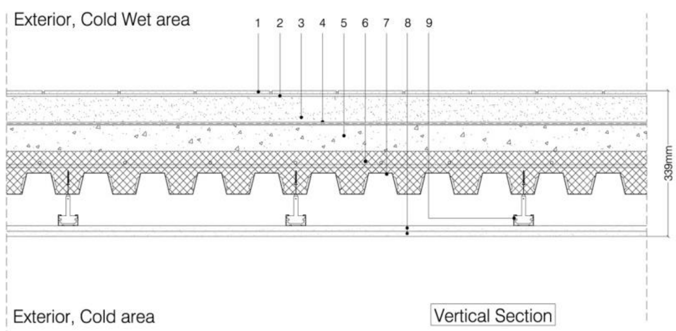
Floor B





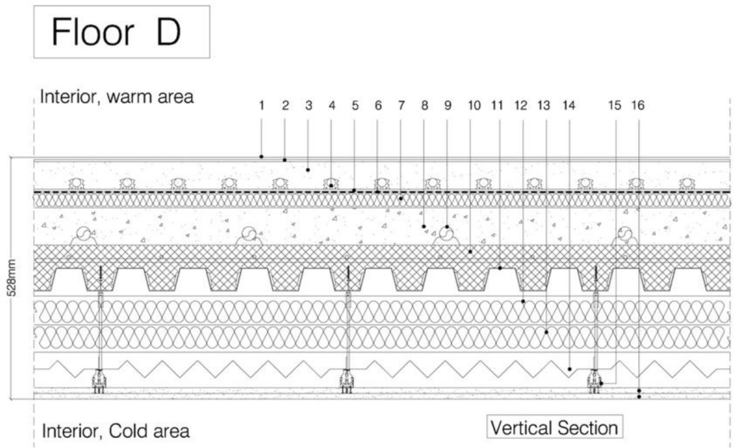
Floor- Type D		
Number	Layer	Thickness
1	Flooring mat	10 mm
2	screed	30 mm
3	Light concrete	100 mm
4	Thermal bar	
5	Reinforced concrete	50mm
6	Cupolex	135 mm
7	Lean concrete	50

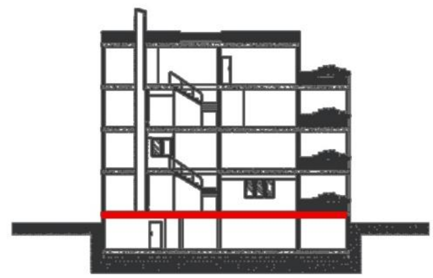
Floor C



Intermediate Floor- Type C		
Number	Layer	Thickness
1	ceramic 30 * 30 cm	5 mm
2	Ceramic Glue	5 mm
3	Sand cement screed	30 mm
4	2 layers of "Index" bitumen sheet membrane	2*2 mm
5	Light concrete with 1.5% slope	
6	Reinforced concrete	
7	Metal Deck	
8	2 Layer of " Knauf" Aqua panels	
9	Knauf False cieling clips	

Fig.4. 49. Floor solution for type B and C



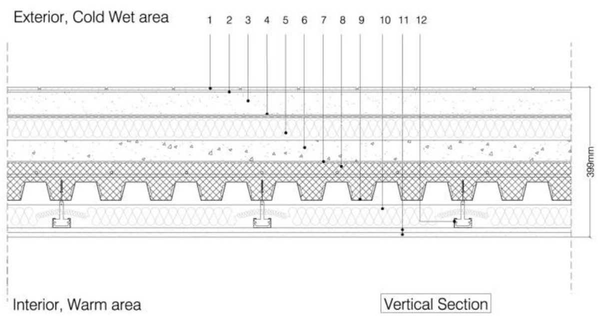


Intermediate Floor- Type D		
Number	Layer	Thickness
1	Strip Parquet With Sound-absorbing cushion	5 mm
2	Parquet adhesive	5 mm
3	Sand cement screed	60 mm
4	"Velta" PE-Xa 17mm*2mm Pipe	
5	"velta" fixing grid	2 mm
6	"velta" PE 200 Slip membrane	4 mm
7	Knauf insulation board	30 mm
8	Light concrete	80 mm
9	Water plumps	
10	Reinforced concrete	
11	Metal Deck	
12	"Knauf" Mineral wool Sound Insulation- 30kg/m²	60 mm
13	polystyrene board- kg/m²	60 mm
14	polystyrene board-45 kg/m²	80 mm
15	Knauf False cieling clips	
16	2 Layer of " Knauf" Gypsumboard with vapour barrier	12.5 mm

Fig.4. 50. Floor solution for type D

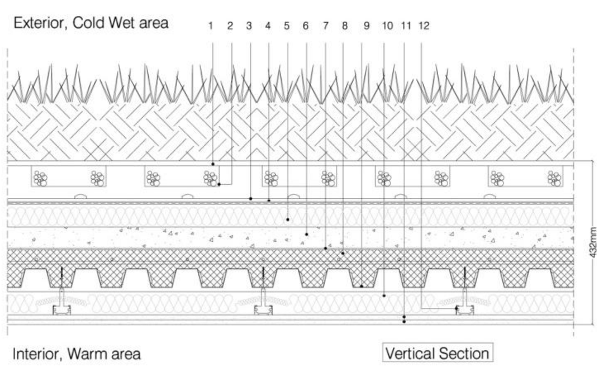
4-6-5-Roof and Green Roof

ROOF



ROOF		
Number	Layer	Thickness
1	ceramic 30 * 30 cm	5 mm
2	Ceramic Glue	5 mm
3	Sand cement screed	50 mm
4	2 layers of "Index" bitumen sheet membrane	2*2 mm
5	"Knauf" mineral wool	60 mm
6	Light concrete with 1.5% slope	
7	1 layer of "Index" bitumen sheet membrane	
8	Reinforced concrete	
9	Metal Deck	60 mm
10	Knauf insulation board	
11	2 Layer of " Knauf" Gypsumboard with vapour barrier	
12	Knauf False cieling clips	

GREEN ROOF



GREEN ROOF		
Number	Layer	Thickness
1	Filter	
2	Rainwater storage	
3	Separating mat	
4	2 layers of "Index" bitumen sheet membrane	2*2 mm
5	"Knauf" mineral wool	60 mm
6	Light concrete with 1.5% slope	
7	1 layer of "Index" bitumen sheet membrane	
8	Reinforced concrete	
9	Metal Deck	60 mm
10	Knauf insulation board	
11	2 Layer of " Knauf" Gypsumboard with vapour barrier	
12	Knauf False cieling clips	

Fig.4. 51. Green roof and rooftop

Table: 4.9. Proposed material details and U-Value for roof

Layer	Material	Thickness	Thermal conductivity	Ressistance	Transmittance	∆T*U*Ri	Ti
		s (m)	λ(W/m.k)	R (m².k/W)	u(w/m².k)		˚C
	Inside						23.9
	internal surface			0.17	5.88	1.49	22.41
1	knauf Plaster board	0.0125	0.16	0.08	12.80	0.69	21.72
2	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.0006	0.27	0.002	450.00	0.02	21.70
3	Knauf plaster board	0.0125	0.16	0.08	12.80	0.69	21.02
4	Knauf insulation board	0.06	0.23	0.26	3.83	2.29	18.73
5	Metal Deck	0.003	43	0.00	14333.33	0.00	18.73
6	Reinforced concrete	0.1	0.3	0.33	3.00	2.92	15.81
7	Light concrete	0.06	0.4	0.15	6.67	1.32	14.49
	1 layer of "Index" bitumen sheet membrane	0.004	0.5	0.01	125.00	0.07	14.42
8	Knauf mineral wool	0.06	0.038	1.58	0.63	13.85	0.57
9	2 layers of "Index" bitumen sheet membrane	0.008	0.5	0.02	62.50	0.14	0.43
10	Sand cement screed	0.06	0.8	0.08	13.33	0.66	-0.23
11	Ceramic Glue	0.005	0.02	0.25	4.00	2.19	-2.42
12	ceramic	0.005	1.5	0.003	300.00	0.03	-2.45
	external surface			0.04	25.00	0.35	-2.80
	Outside						-2.80
	Total	0.3906		3.04	**0.33**		
	∆T	26.70					

Table: 4.10. Details of condensation analysis for roof

Interior	Pi(sat)@23.9˚C	2957.30	Pi(50%)	1478.65	**Roof**					
Exterior	Pe(sat)@-2.8˚C	496.06	Pe(80%)	396.85						
	ΔP (Pa)	1081.80								
	ΔT (˚C)	26.70								
Layer	Material	Thickness	Vapour permeability	Vapour Resistance	Ti	P(sat)	ΔP*ρi/ρtot	Pv	ΔP*ρi/ρ'tot	Pv'
		s (m)	δ (kg/msPa)	ρ(m²sPa/kg)	˚C	Pa		Pa	vapour barrier	Pa
	Inside				23.9	2957.30				
	internal surface				22.41	2702.47				
1	knauf Plaster board	0.0125	23	0.001	21.72	2591.94	0.089221069	1478.56	0.085336053	1478.56
2	"DuPont™ Tyvek® VCL SD2 " Vapour Barrier	0.0006	0.002	0.300	21.70	2588.85	49.25003007	347.60	47.10550141	1431.46
3	Knauf plaster board	0.0125	23	0.001	21.02	2482.41	0.089221069	347.51	0.085336053	1431.37
4	Knauf insulation board	0.06	63	0.001	18.73	2154.18	0.156349302	347.36	0.149541274	1431.22
5	Metal Deck	0.003	0.000875	3.428571	18.73	2154.10	562.8574865	-215.50	538.3485875	892.88
6	Reinforced concrete	0.1	1.25	0.080	15.81	1790.42	13.13334135	-228.63	12.56146704	880.31
7	Light concrete	0.06	1.95	0.031	14.49	1645.17	5.051285135	-233.69	4.831333478	875.48
	1 layer of "Index" bitumen sheet membrane	0.004	0.5	0.008	14.42	1637.73	1.313334135	-235.00	1.256146704	874.23
8	Knauf mineral wool	0.06	0.02	3.000	0.57	635.17	492.5003007	-727.50	471.0550141	403.17
9	2 layers of "Index" bitumen sheet membrane	0.008	0.5	0.016	0.43	628.76	2.62666827	-730.13	2.512293408	400.66
10	Sand cement screed	0.06	2.5	0.024	-0.23	599.44	3.940002406	-734.07	3.768440112	396.89
11	Ceramic Glue	0.005	0		-2.42	510.26	0	-734.07	0	396.89
12	ceramic	0.005	20	0.0003	-2.45	509.16	0.041041692	-734.11	0.039254585	396.85
	external surface				-2.80	496.06				
	Outside				-2.80	496.06				
	Total	0.39		6.590						
	Total with vapour barrier	0.3906		6.890						

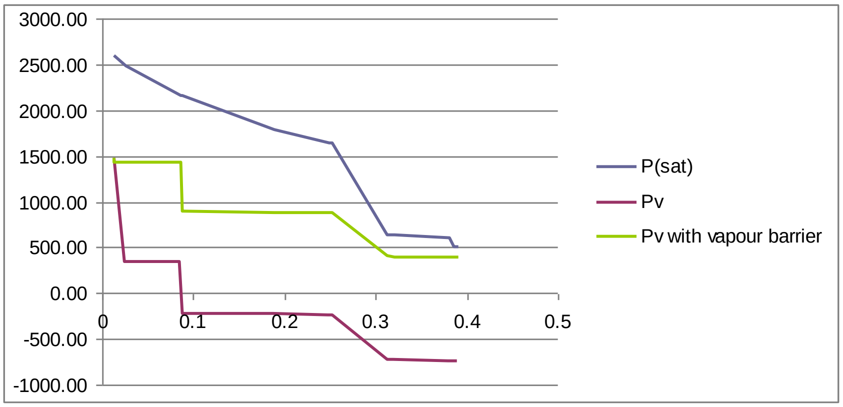


Fig.4. 52. Condensation graph for roof

4-7-Thermal Analysis

4-7-1-Introduction

Energy efficiency is a crucial issue in the building construction, where from the first step of designing to the last steps of materials selection and in construction period it should be considered. In this regard, to decrease energy demand of a building there is several highlights to be checked such as well-insulated envelope, double glazed diagrams, passive heating and ventilation and etc.

For most people home is the place of relaxation and comfort, also from the thermal point of view the indoor condition should be located in the comfort zone, such that each individual feels comfort temperature and humidity in the spaces.

In this project, two conditions are compared for reaching to the optimum condition and reduction in both energy consumption and energy cost of a building. First condition consists: the average U-Values of 1 W/m²K for external walls, window surface areas of 82 m^2, and the building is facing North-South direction. And in second condition (Proposed Condition): the average U-Values of 0.17 W/m²K, window surface areas of 67 m^2, and the building is 19 degree oriented from the North.

It should be mentioned that in both condition the HVAC system works from 6:00 am to 10:00 pm through a whole year. Another time we had comparison by playing with characteristics of windows and u values to find out which u value of windows or walls is more effective to decrease the building loads.

The following graphs show the comparison between these two conditions in terms of Hourly/Annual Temperature Distribution, Comfort, Losses/Gains through the envelope, HVAC loads and etc., which are extracted from the Ecotect software.

The simplified volume:

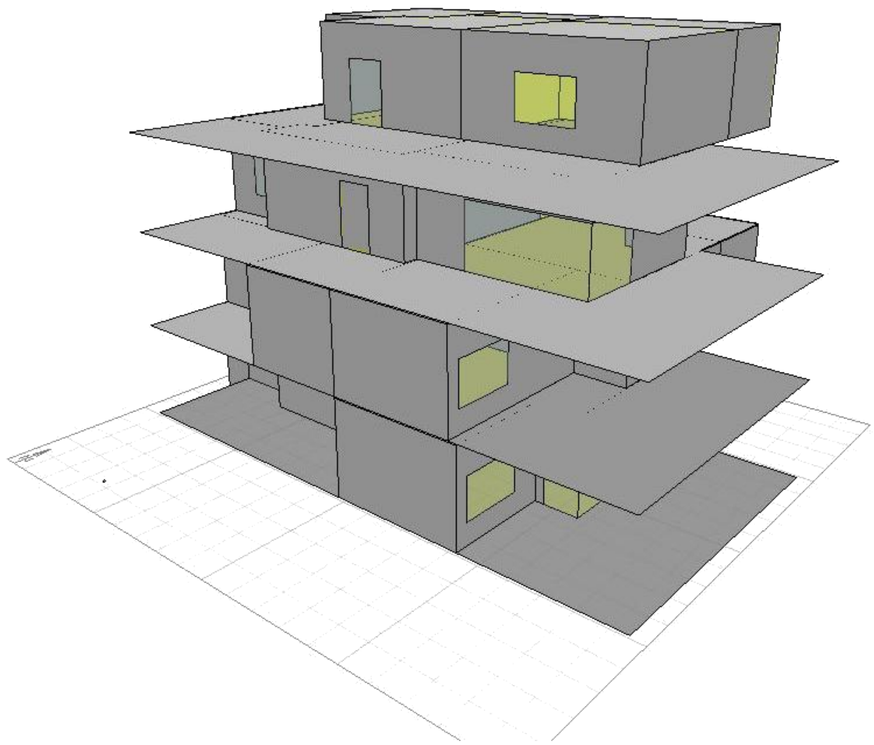


Fig.4. 53. Simplified volume of the building

The building Characteristics:

Length	18.5 m
Width	13.8 m
Height	12.5 m
Total Floor area	584.173 m^2
Volume	3191.25 m^3

4-7-2-Thermal Zones

In the followings for simplicity of the analysis the building has been divided into different zones by various surface areas to show the different functions and diverse volumes more accurately.

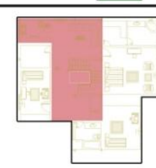
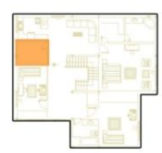
Zone	Surface Area m2	Volume m3		
Groound Floor Family Room	139	133		
Ground Floor Kitchwn	58	51		
Ground Floor Entrance	103	122		
Ground Floor Living Room	163	151		
First Floor Family Room	172	216		
First Floor Store	28	31		
First Floor Room1	66	60		
First Floor Bath	30	36		

Fig.4. 54. Different zoning and function of the building

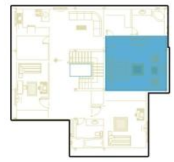
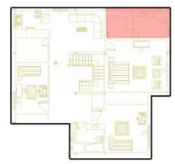
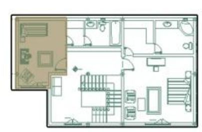
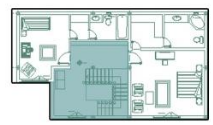
Zone	Surface Area m2	Volume m3		
First Floor Room 2	80	78		
First Floor Master Room	101	103		
First Floor Master Bath	61	53		
Second Floor Family Room	129	133		
Second Floor KItchen	55	50		
Second Floor Entrance	123	122		
Second Floor Living Room	172	166		
Third Floor Room 1	102	69		

Fig.4. 55. Different zoning and function of the building

Zone	Surface Area m2	Volume m3		
Third Floor Bath	49	33		
Third Floor Master Bath	76	59		
Third Floor Master Room	99	103		
Third Floor Family Room	93	102		

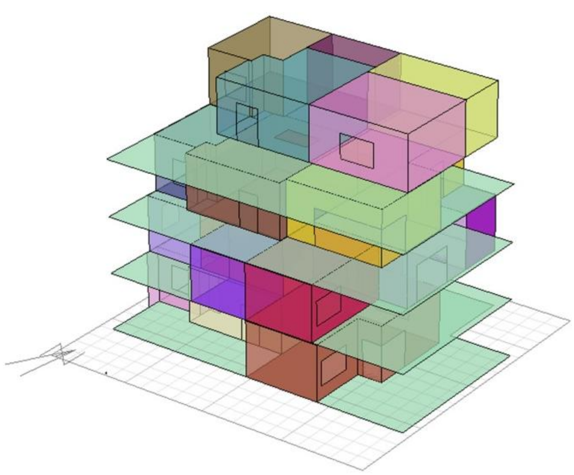


Fig.4. 56. Different zoning and function of the building

4-7-3-Results comparison

4-7-3-1-Temperature Hourly Profile

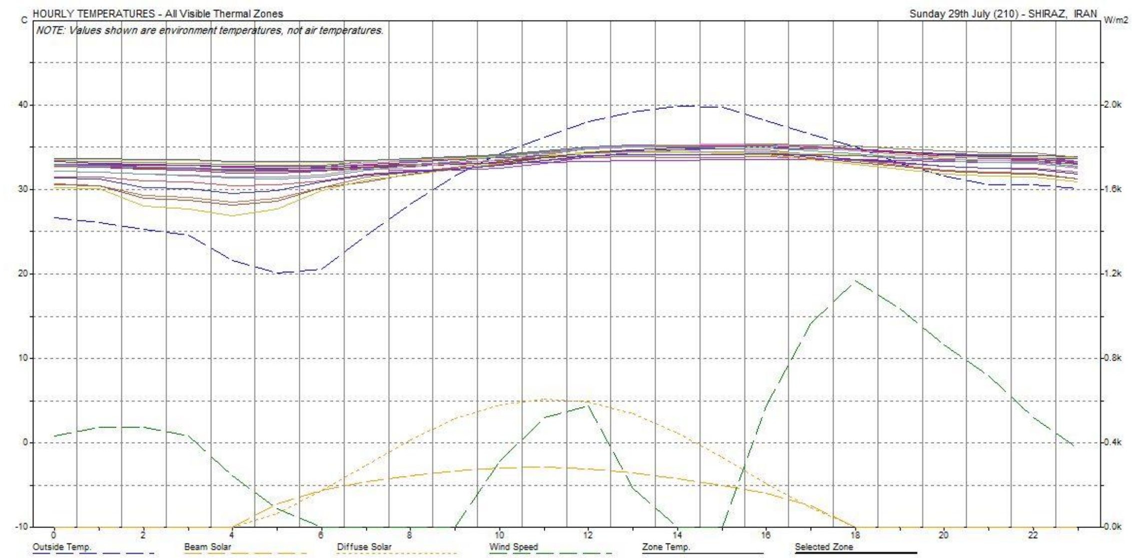


Fig.4. 57. Hottest temperature Hourly Profile in the condition 1

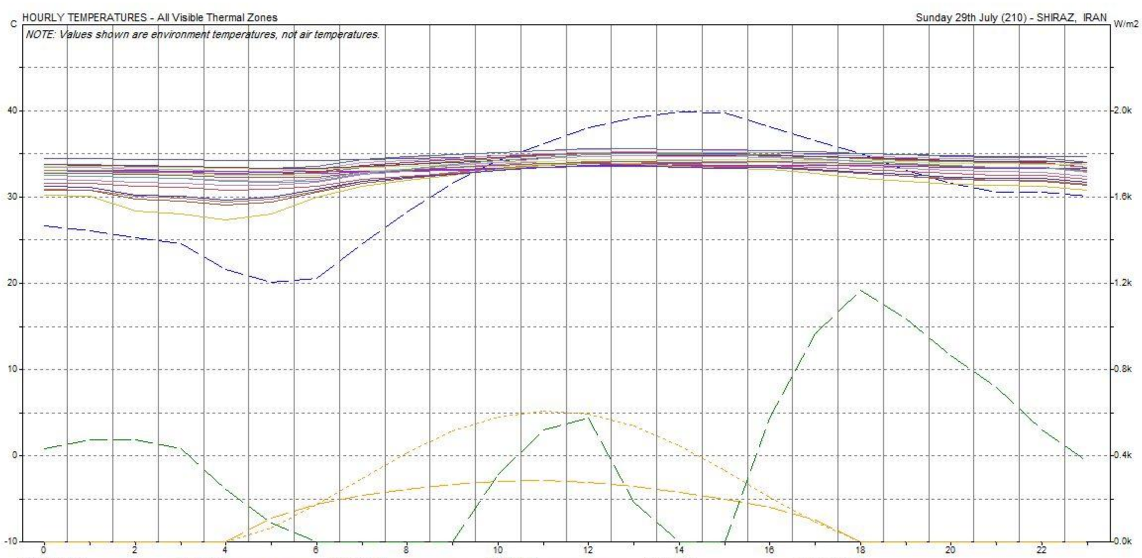


Fig.4. 58. Hottest temperature Hourly Profile in the Proposed Condition

The graphs show fluctuation of temperature during the hottest day in the year. In both conditions the reaction of the systems are similar. It can be concluded, the behavior of the system and insulation are not as relevant as in the cold situation.

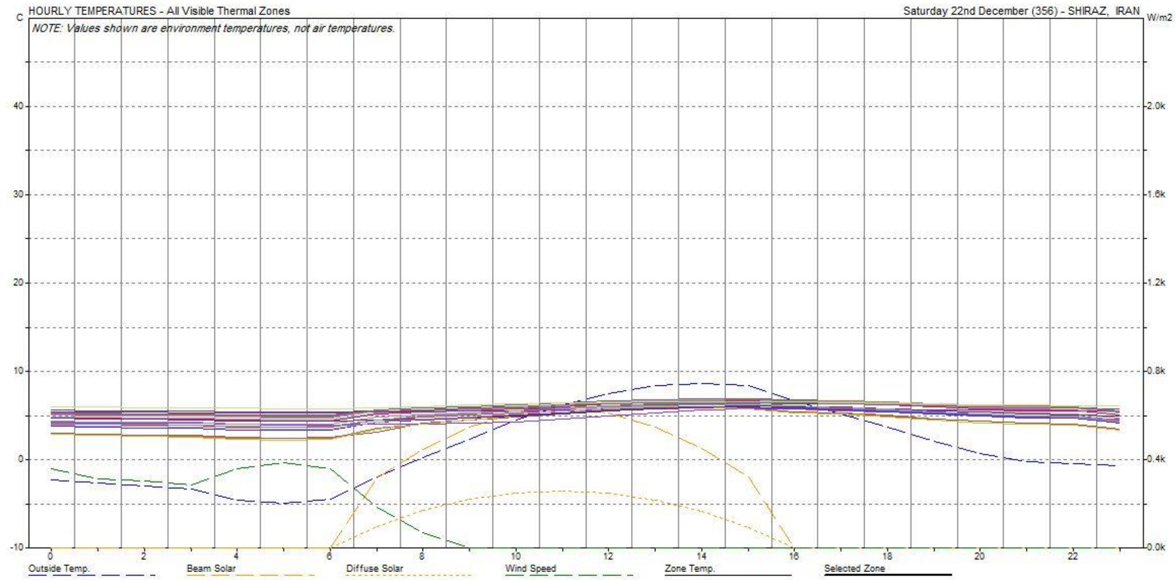


Fig.4. 59. Coldest temperature Hourly Profile in the condition 1

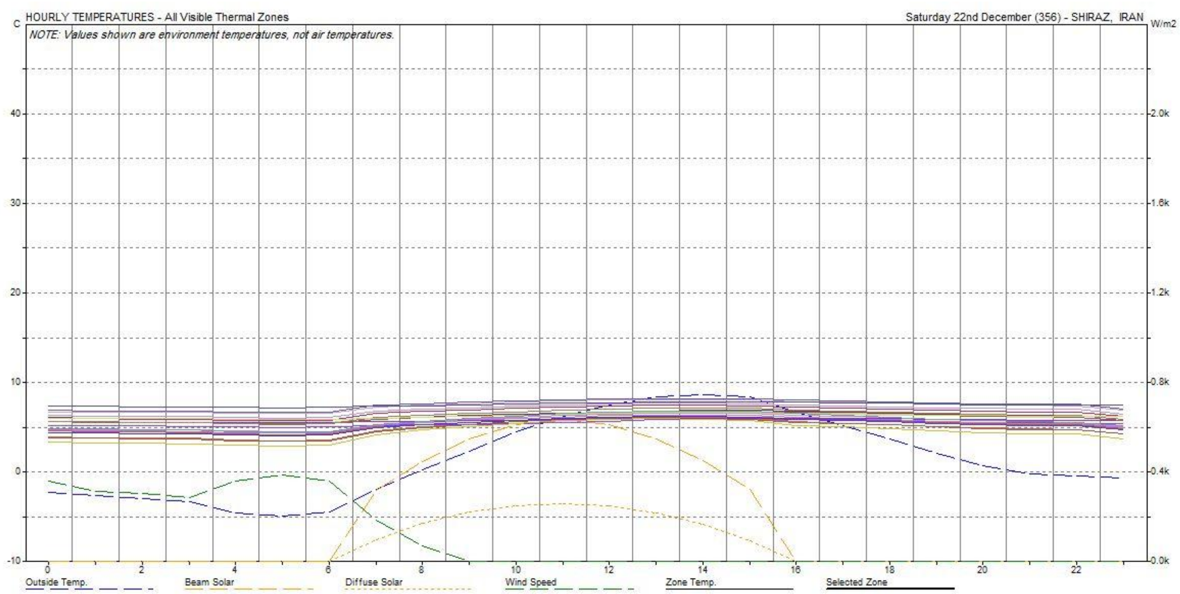


Fig.4. 60. Coldest temperature Hourly Profile in the Proposed Condition

As the graphs show, in the proposed condition temperature of the zones are higher (around 2-5 degree), because the system saves heat inside the building by well implemented insulation.

4-7-3-2-Temperature Hourly profile for Proposed Condition with mixed use ventilation

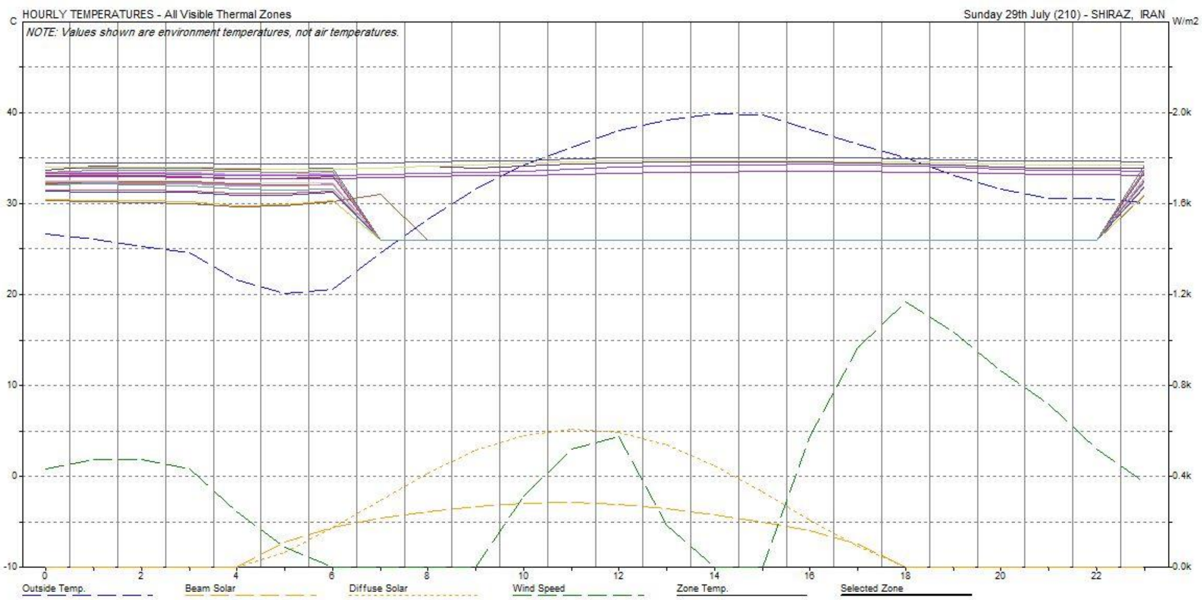


Fig.4. 61. Coldest temperature Hourly Profile

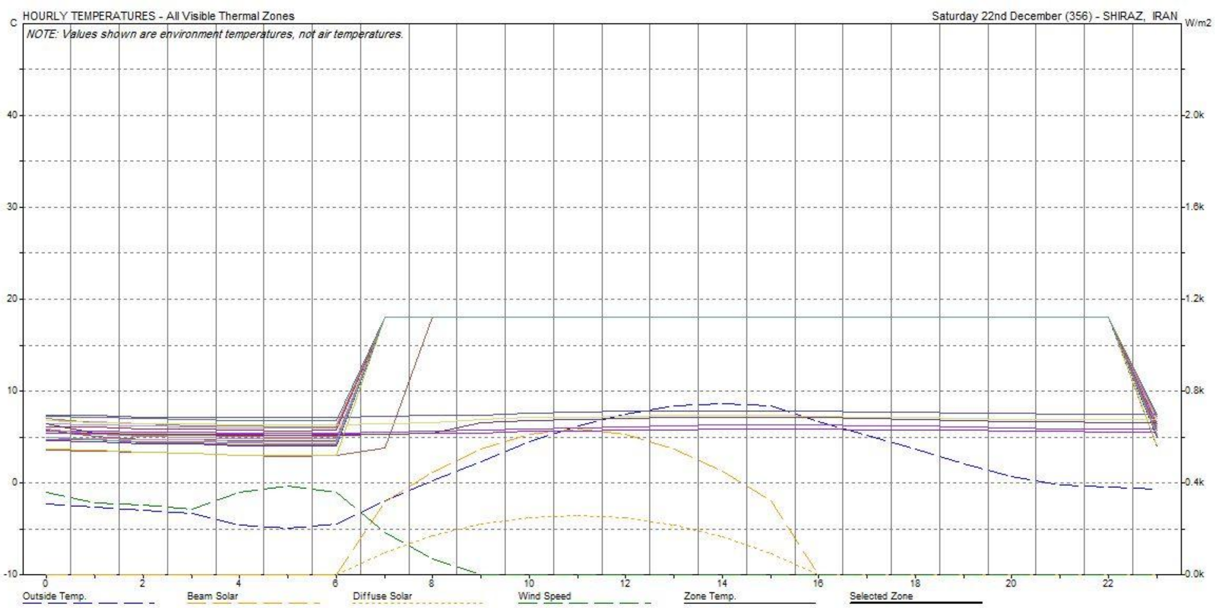


Fig.4. 62. Coldest temperature Hourly Profile

In both graphs the role of HVAC system is considerable, which should compensate the gains and losses of the system, to remain in the comfort condition.

4-7-3-3-Hourly Gains/Losses

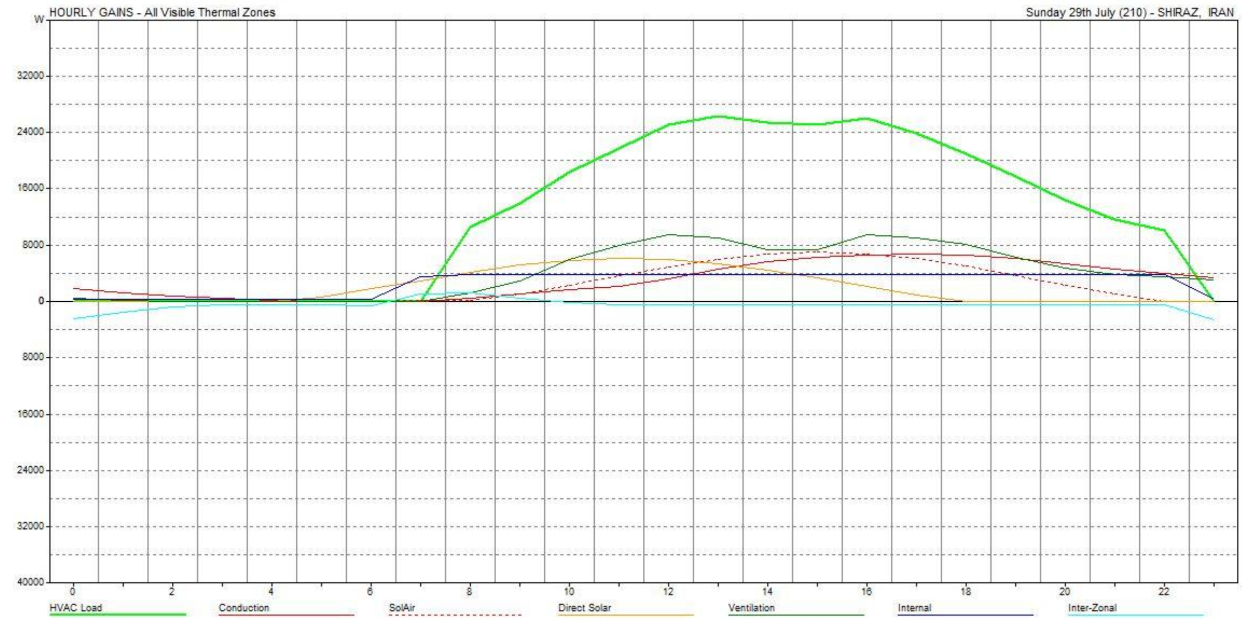


Fig.4. 63. Hottest Day Gains/Losses (Condition 1)

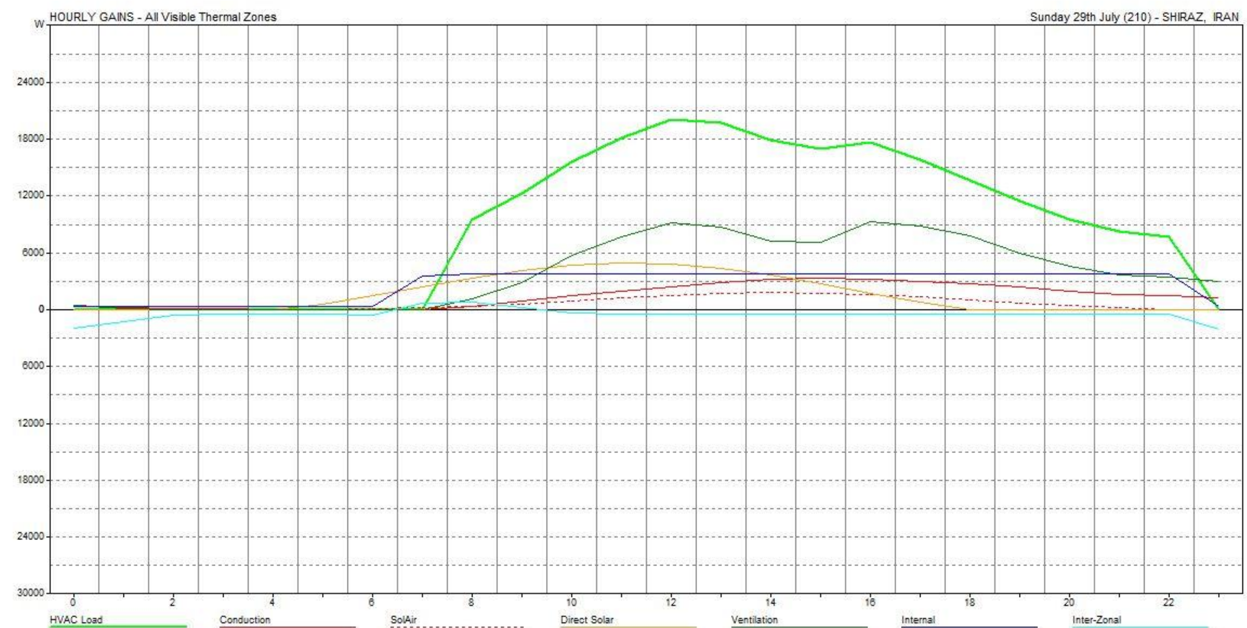


Fig.4. 64. Hottest Day Gains/Losses (Proposed Condition)

The higher gains in the condition 1 is recognizable, regardless of HVAC load, conduction and ventilation are so significant.

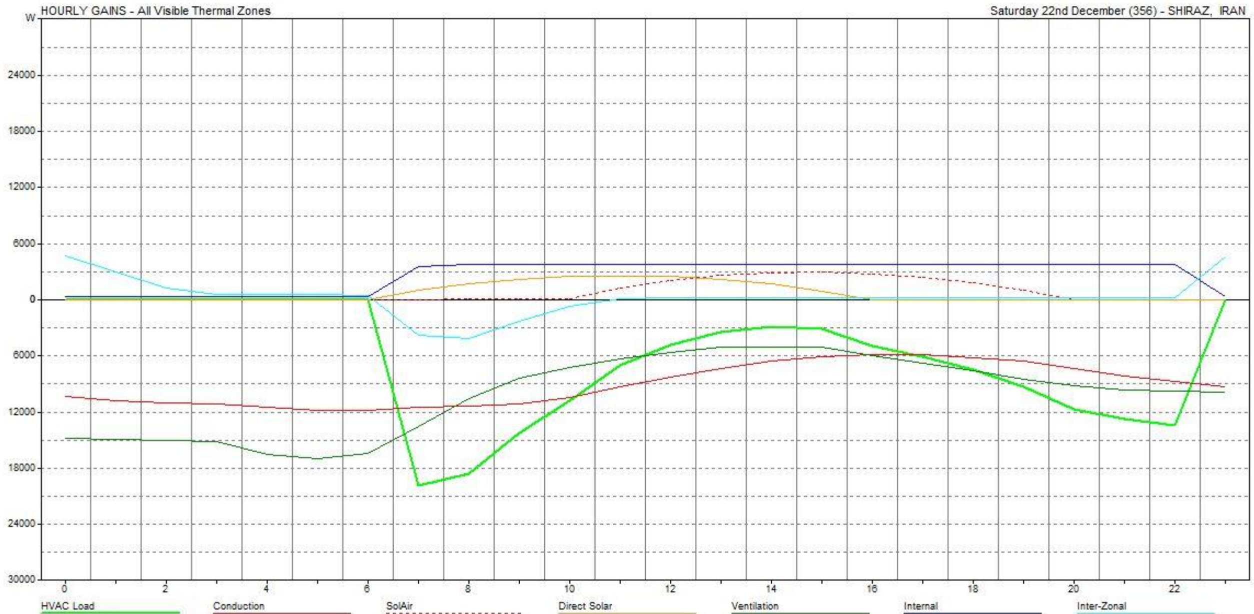


Fig.4. 65. Coldest Day Gains/Losses (Condition 1)

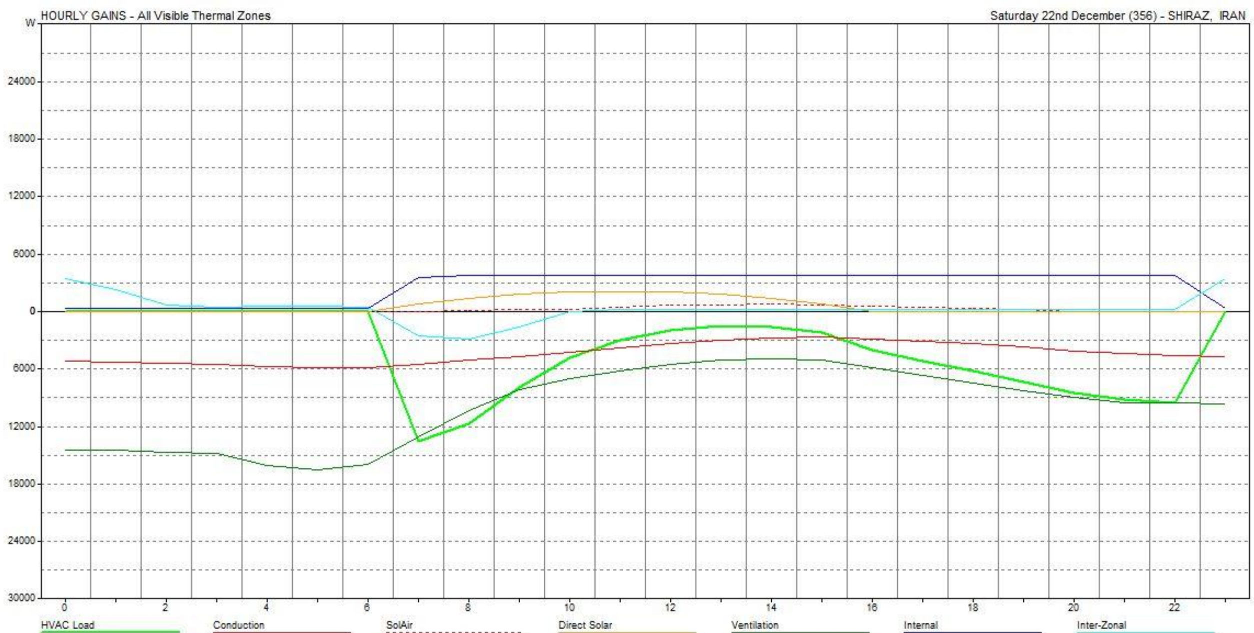


Fig.4. 66. Coldest Day Gains/Losses (Proposed Condition)

In the coldest day of the year also the importance of conduction, ventilation and HVAC system are tangible. Where the conduction losses are 12kW in the condition 1, and it has been decreased to 6kW in the proposed condition. Also the HVAC load is lower around 5kW in proposed condition. So it has direct effect on the costs, where the comfort condition is a fixed point.

4-7-3-4-Fabric Gains/Losses

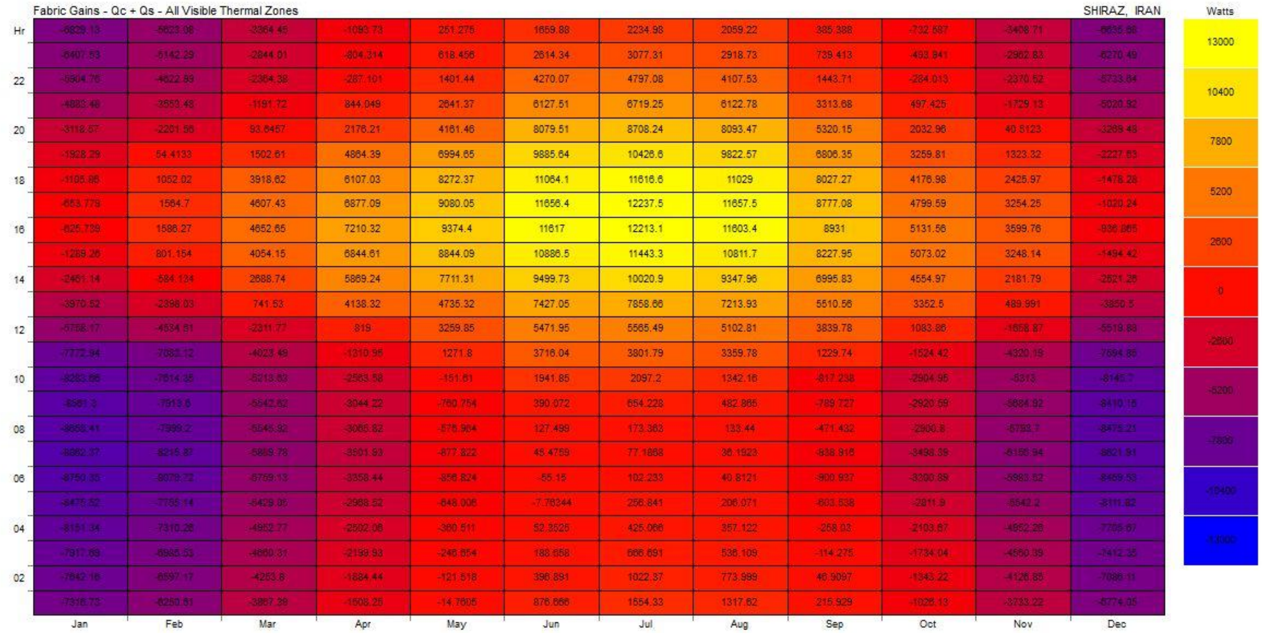


Fig.4. 67. Annual Fabric Gains/Losses (Condition 1)

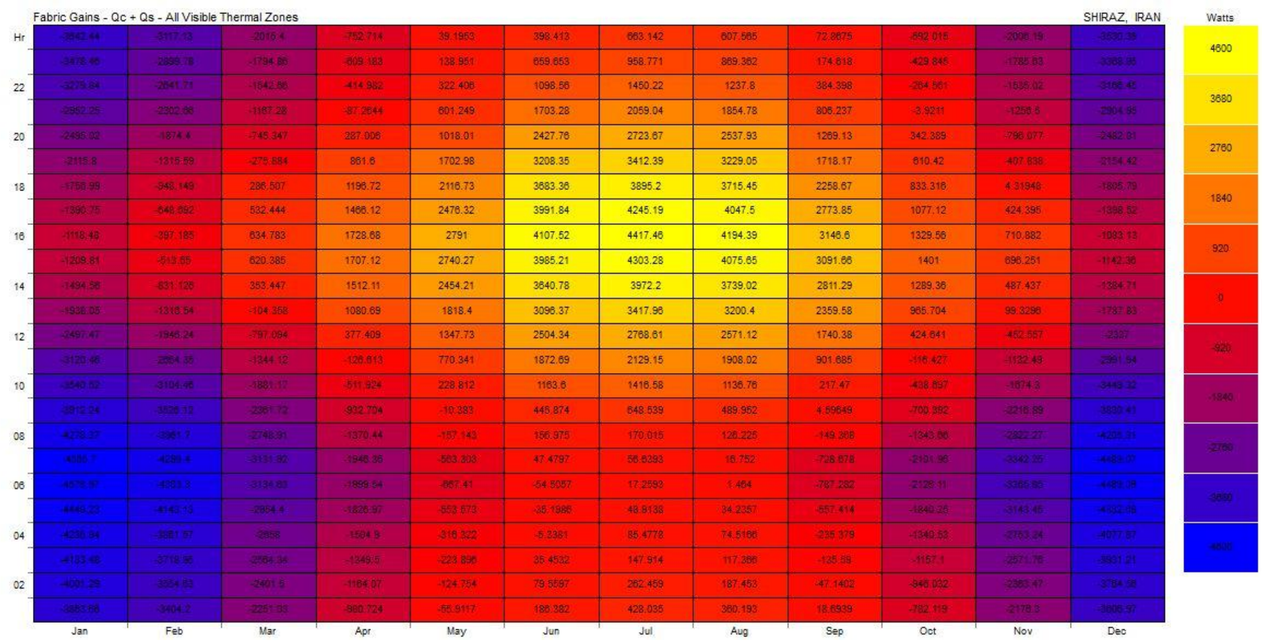


Fig.4. 68. Annual Fabric Gains/Losses (Proposed Condition)

The graph above shows overall gain of the building during the year, which shows the maximum gain is in July especially in the afternoon, and the minimum is in January. The results are usable for selection of the materials as well as the U-values of the envelope. Since there is a difference between U-Values of two conditions the gains and losses in the condition 1 is higher with no doubt.

4-7-3-5-Passive Gains Breakdown

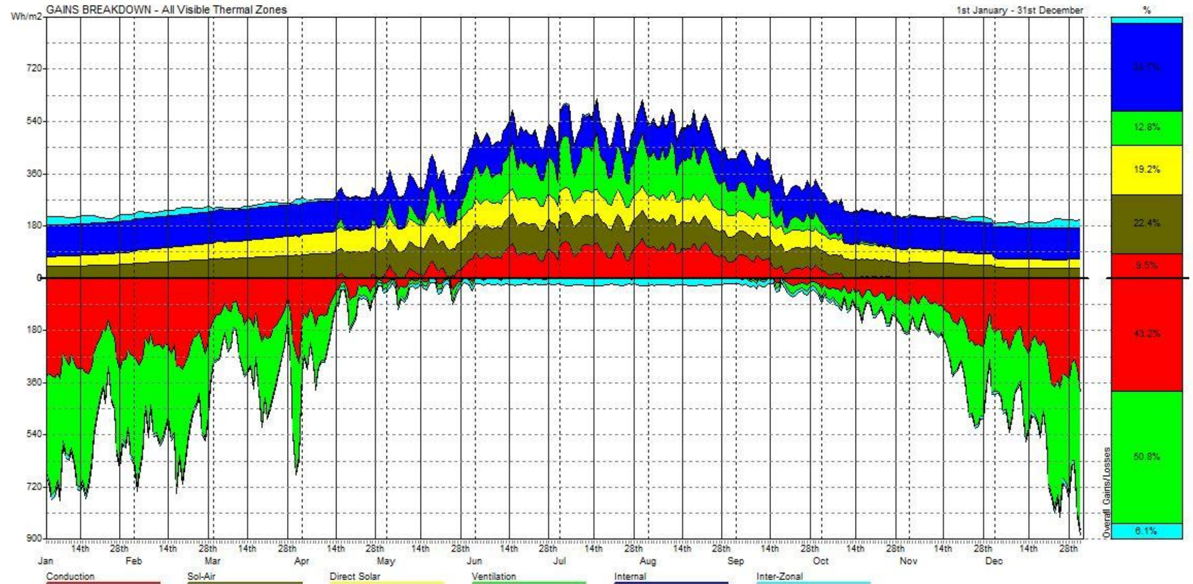


Fig.4. 69. Passive Gains Breakdown (Condition 1)

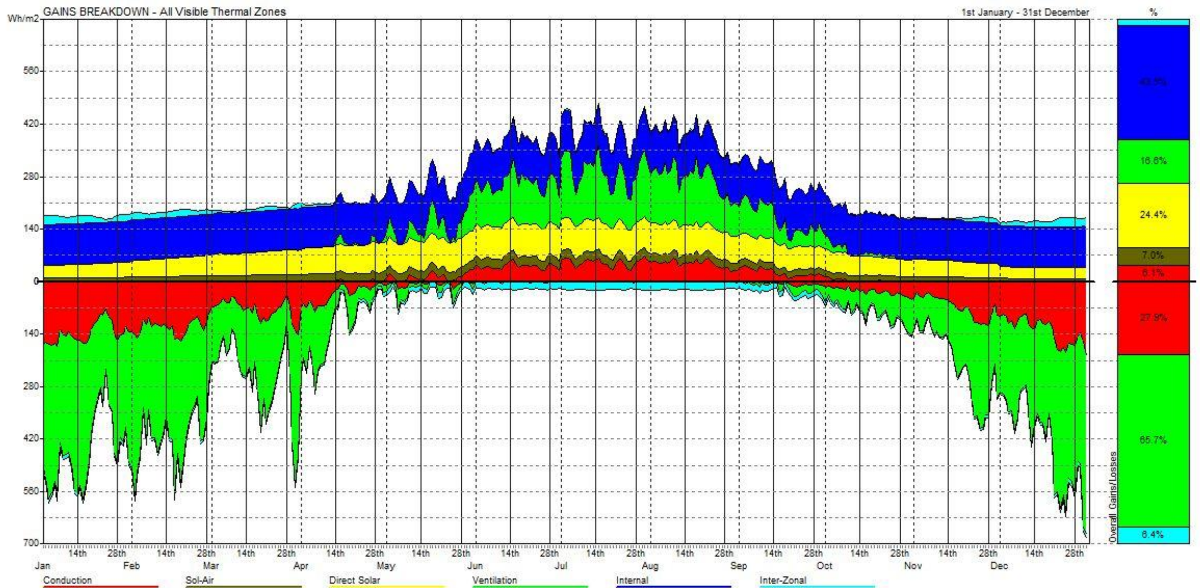


Fig.4. 70. Passive Gains Breakdown (Proposed Condition)

Again conduction shows itself as a major point in the condition 1. As the graph shows, during May to October the building is more close to its passive condition, the critical issue for the building is ventilation, which illustrates the high amount of losses, and it should be taken into account in the choice of the HVAC system.

4-7-3-6-Heating/Cooling Loads

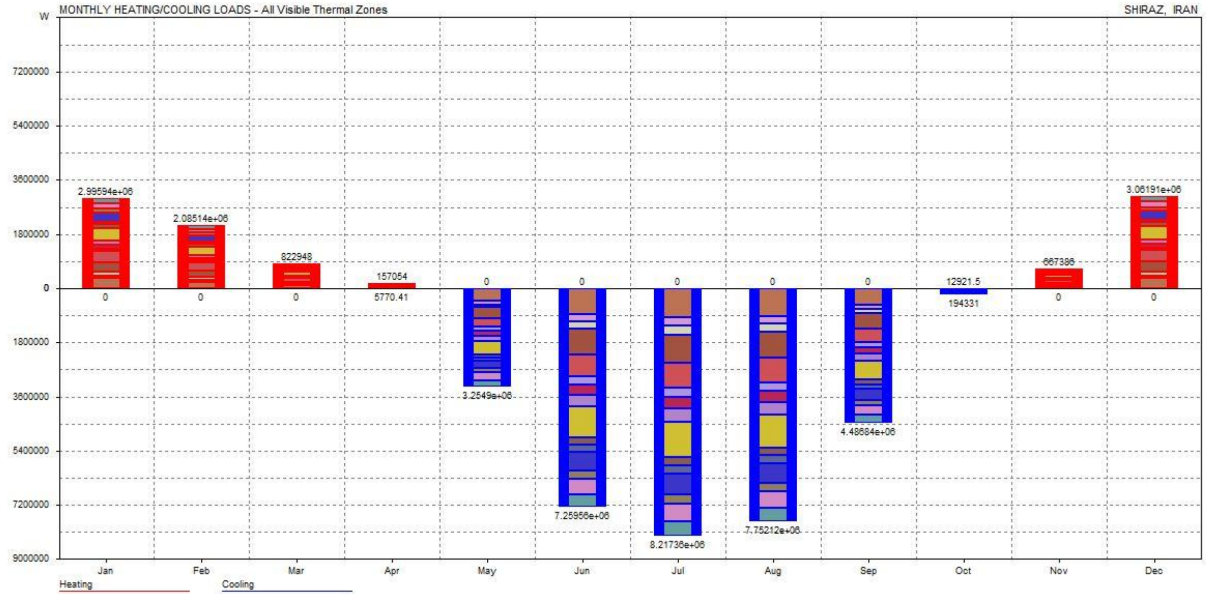


Fig.4. 71. Heating/Cooling Loads (Condition 1)

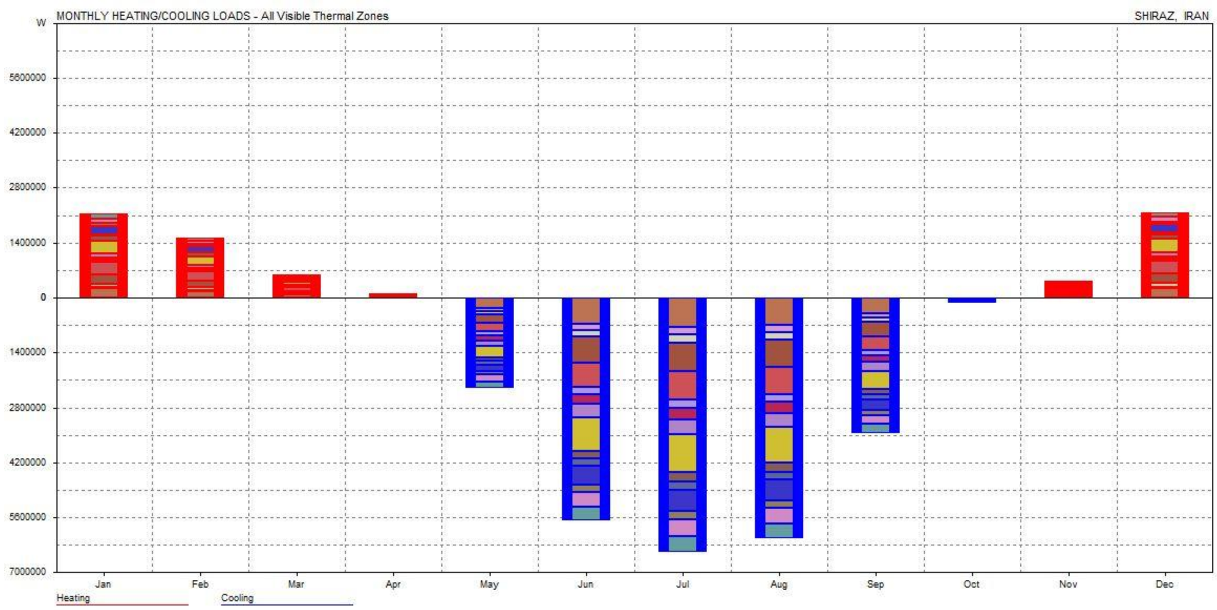


Fig.4. 72. Heating/Cooling Loads (Proposed Condition)

The above graphs are illustrated the heating and cooling loads, which obvious that the cooling load is more critical in the Shiraz climate. As the results extracted from all visible zones, by changing the materials, dimension of windows, and working time of the system, it is possible to decrease the loads. To achieve this goal, in the proposed condition the total load of the building is decreased from 79kWh/m^2 to 49kWh/m^2 through 11554Wh/m^2 heating load and 37863Wh/m^2 cooling load. And consequently numbers show that the cooling load is a critical point to drop dawn the total load in this section.

4-7-3-7-Material characteristics and efficiency

This section shows another comparison between different characteristics of materials, in which to find out which aspect of material is more effective in decreasing of heating and especially cooling loads. For this aim, once the window U-Value and the surface area is fixed with the amount of 2 W/m^2K and 67 m^2, respectively, but for the comparison evaluation the U-Value of walls has been increased from 0.17W/m^2K to 1 W/m^2K. In the next step the U-Value of walls is fixed by the average of 0.17W/m^2K, but the U-Value of Windows increased to 5.1W/m^2K, meanwhile, the calculation has been done for windows with U-Value of about 2W/m^2K and changing the visible transmittance from 0.639 to 0.45. The results are as follows:

- **Heating/Cooling Loads**

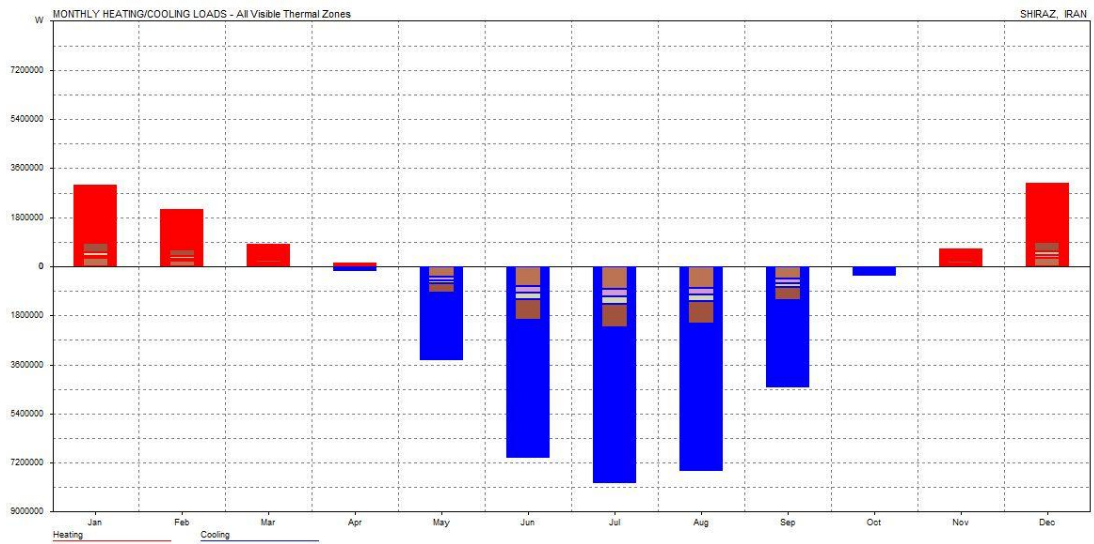


Fig.4. 73. Heating/Cooling Loads (windows characteristics are fixed, walls U-Value is 1W/m²K)

Table: 4.11. Total heating and cooling for above condition

MONTH	(Wh)	(Wh)	(Wh)
------------	--------	---------	---------
Jan	2994368	0	2994368
Feb	2106117	0	2106117
Mar	819675	0	819675
Apr	154836	180928	335764
May	0	3428002	3428002
Jun	0	7009554	7009554
Jul	0	7945089	7945089
Aug	0	7497344	7497344
Sep	0	4446608	4446608
Oct	6819	352039	358858
Nov	658191	0	658191
Dec	3050043	0	3050043
------------	--------	---------	---------
TOTAL	9790049	30859564	40649612
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PER M²	16759	52826	69585

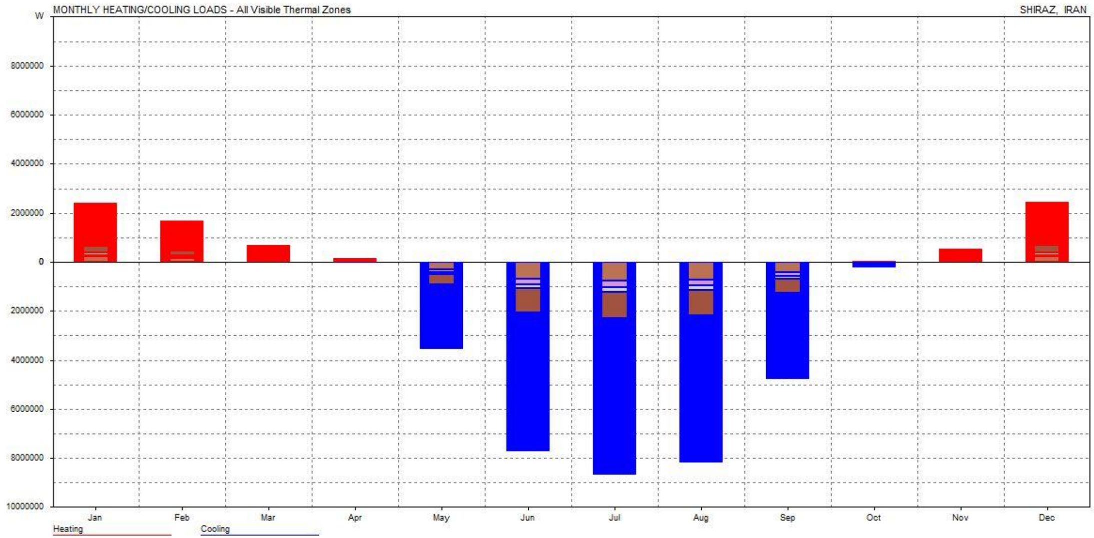


Fig.4. 74. Heating/Cooling Loads (walls characteristics are fixed, windows U-Value is 5.1W/m²K)

Table: 4.12. Total heating and cooling for above condition

MONTH	(Wh)	(Wh)	(Wh)
Jan	2392307	0	2392307
Feb	1696313	0	1696313
Mar	696610	0	696610
Apr	134026	36131	170158
May	0	3566808	3566808
Jun	0	7711542	7711542
Jul	0	8684670	8684670
Aug	0	8181401	8181401
Sep	0	4782633	4782633
Oct	19934	244236	264170
Nov	544309	0	544309
Dec	2447275	0	2447275
TOTAL	7930775	33207420	41138196
PER M²	13576	56845	70421

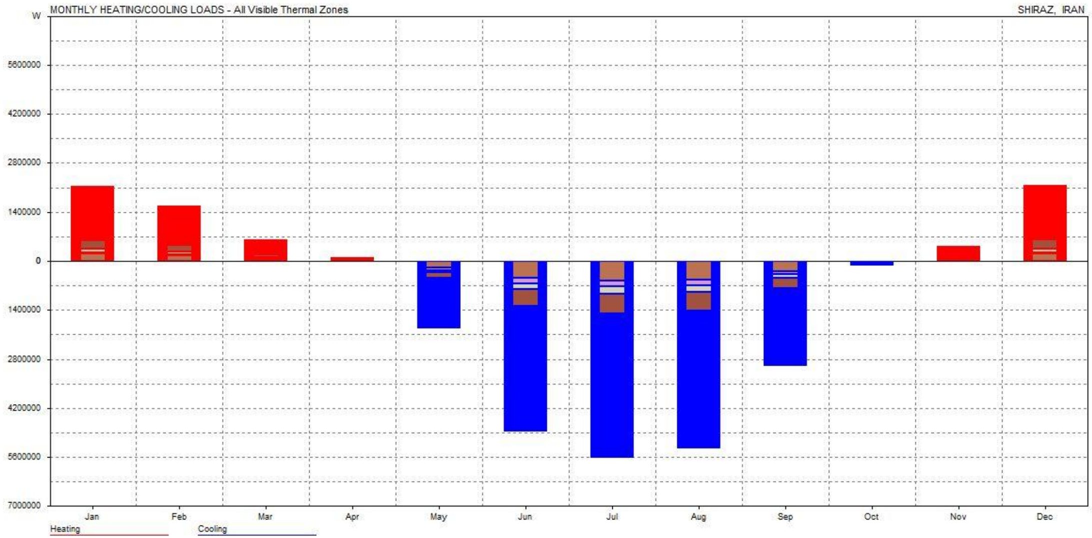


Fig.4. 75. Heating/Cooling Loads
(walls characteristics are fixed, windows U-Value: 2W/m²K, visible transmittance 0.45)

Table: 4.13. Total heating and cooling for above condition

MONTH	(Wh)	(Wh)	(Wh)
Jan	2154812	0	2154812
Feb	1587657	0	1587657
Mar	624910	0	624910
Apr	109680	1152	110832
May	0	1927134	1927134
Jun	0	4881882	4881882
Jul	0	5629526	5629526
Aug	0	5344930	5344930
Sep	0	3000557	3000557
Oct	7154	120925	128079
Nov	436784	0	436784
Dec	2168485	0	2168485
TOTAL	7089481	20906104	27995584
PER M²	12136	35788	47923

Analysis and data shows that the characteristics of materials and shading system are most effective aspects in reducing energy demand in buildings. Therefore, as results show in the diagrams above, while the window characteristics are fixed, the other parameters such as U-value and shading systems are dramatically play the effective proficiency in energy saving in hot and/or cold weather conditions of summer and winter thru decrease in energy demand of the residents.

4-7-3-8-Light and Shadow

Sun is playing a significant role in the building design. This section illustrates shading analysis in the building, which can affect the yearly gains and losses. As in the winter, the sun height is lower than summer so the sun light can pass trough openings, whereas in the summer the height is higher and it helps to have more shadows on building, since direct light is disturbing. Regardless of sun height, balconies and vertical blinds are the major elements to avoid direct light.

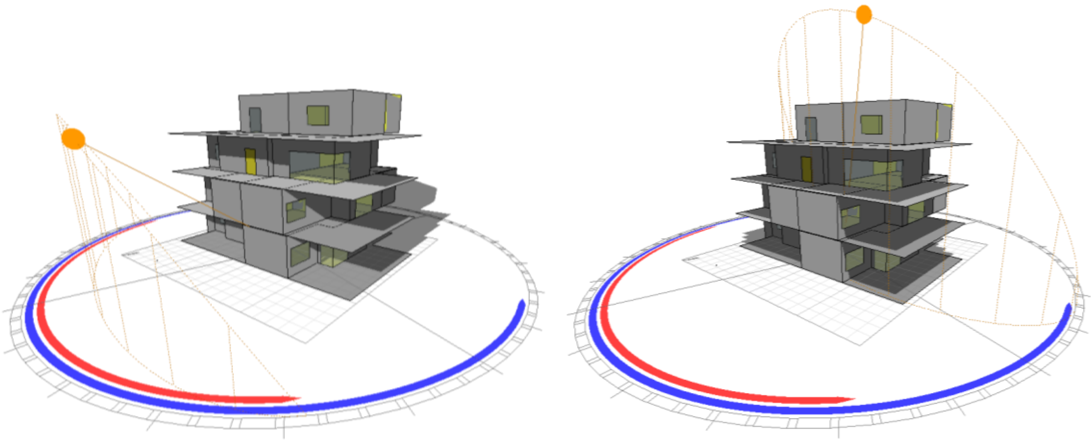


Fig.4. 76. Shadows on building at 10:00 am,
Left: in winter, Right: in summer

These figures show sun path during the day in two season of the year. In winter direct light is required much more during the day, to have more gains and increasing passive heating, whereas, in summer shadows are the main solutions of decreasing the gains.

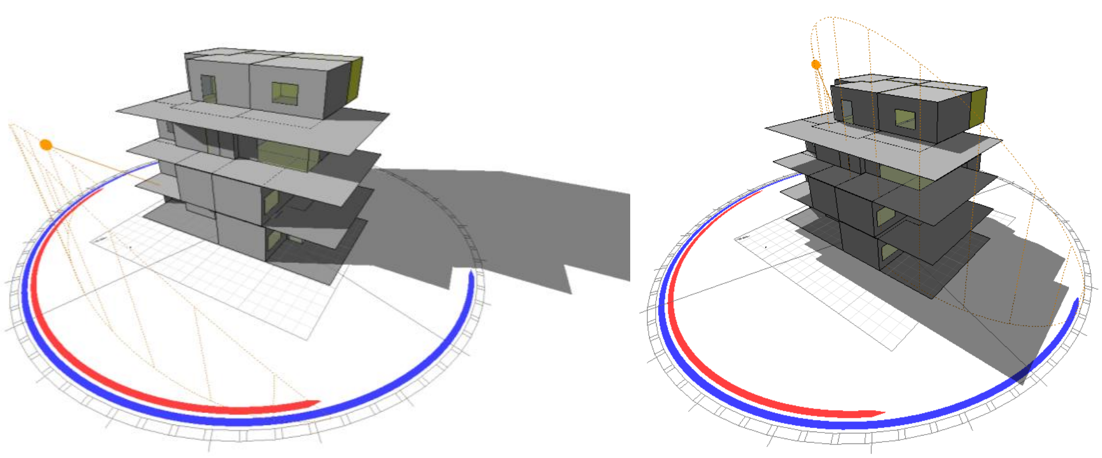


Fig.4. 77. Shadows on building at 15:00 pm,
Left: in winter, Right: in summer

Since horizontal surfaces make deep shadows on the facade, vertical blinds should be designed to stop direct light to access to inside of the building. Windows in the west and east façade have been located into a frame for this aim.

Also same analysis has been done for the spring and the fall season, and results are as below.

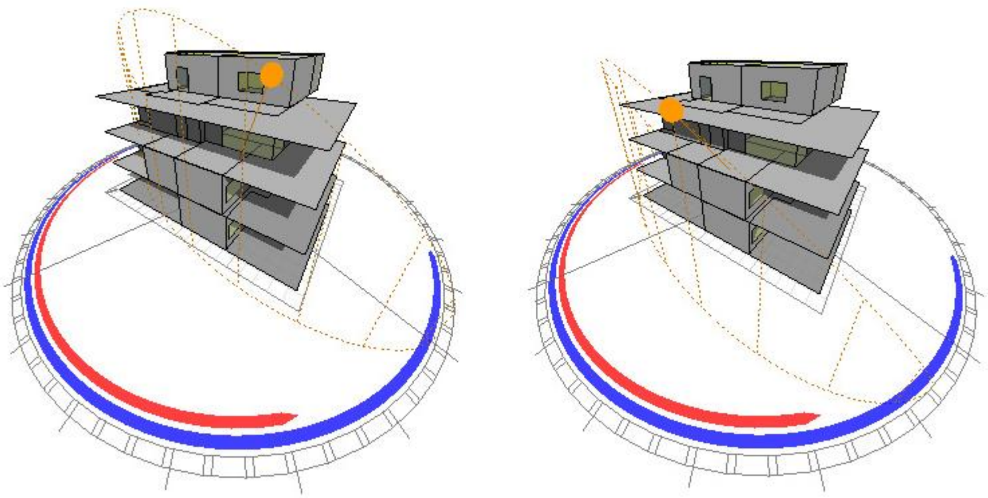


Fig.4. 78. Shadows on building at 10:00 am,
Left: in spring, Right: in fall

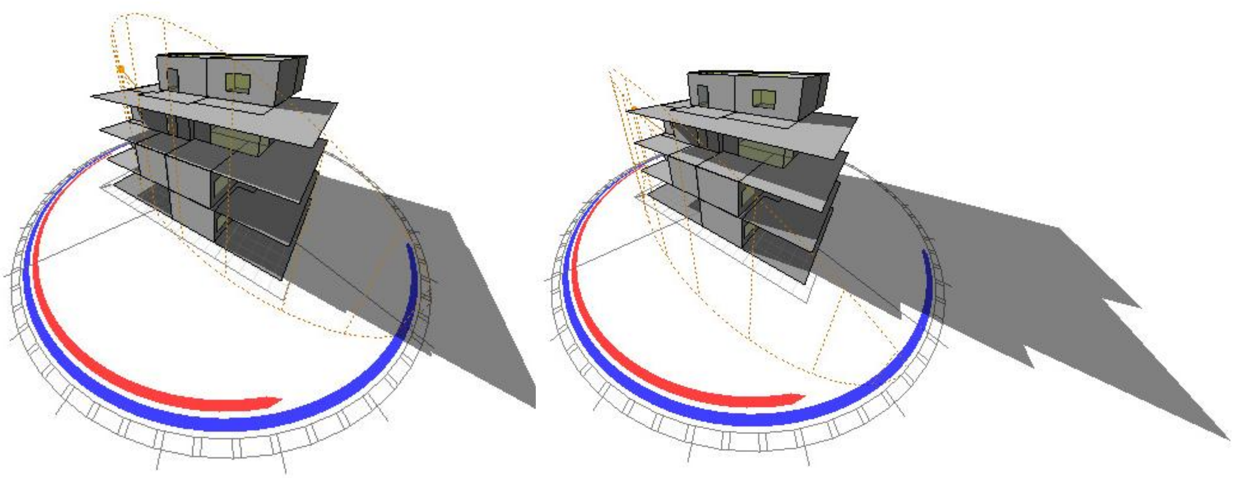


Fig.4. 79. Shadows on building at 15:00 pm,
Left: in spring, Right: in fall

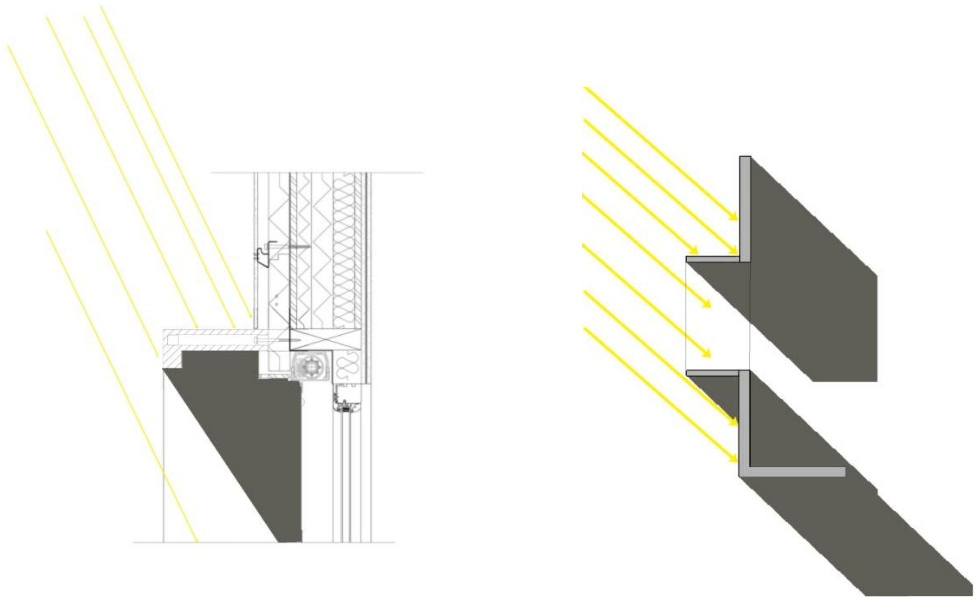


Fig.4. 80. Left: shadows in vertical section, Right: shadows in horizontal section

4-7-3-9-Incident solar radiation analyses for roof top

Incident solar radiation on roof top shows total solar radiation value between 210kWh (blue) to 1800kWh (yellow). The grid is 1m higher than the roof top. As the figure shows, the roof receives the high amount of total average of solar radiation during a year for a period of 8am to 18pm, because there is no major obstacle in front of the light.

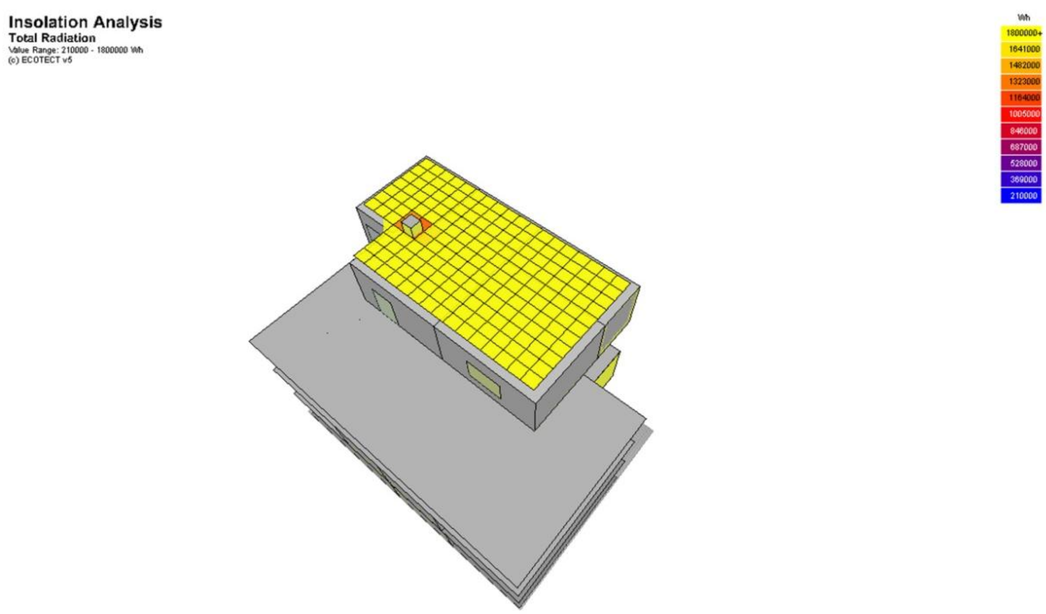


Fig.4. 81. Solar radiation analysis on rooftop

4-7-3-10-Daylight Factor

Natural light is more desirable in the building instead of artificial light resources. The building which uses more natural light is more high-grad in terms of saving electricity and costs and pollution. Daylight factor shows if the lighting level is sufficient for the occupants or not.

Standards for Daylight factor:

Table.4.14. Standards for Daylight factor

Average	**DF**	**Appearance Energy implications**
<2%	Room looks gloomy	Electric lighting needed most of the day.
2% to 5%	Predominantly daylight appearance, but supplementary artificial lighting is needed	Good balance between lighting and thermal aspects.
> 6%	Room appears strongly daylight	Daytime electric lighting rarely needed, but potential for thermal problems due to overheating in summer and heat losses in winter.

The fallowing graphs show lighting analysis for different levels of the building. These results are extracted at the height of 0.8m from the floor surface of each level.

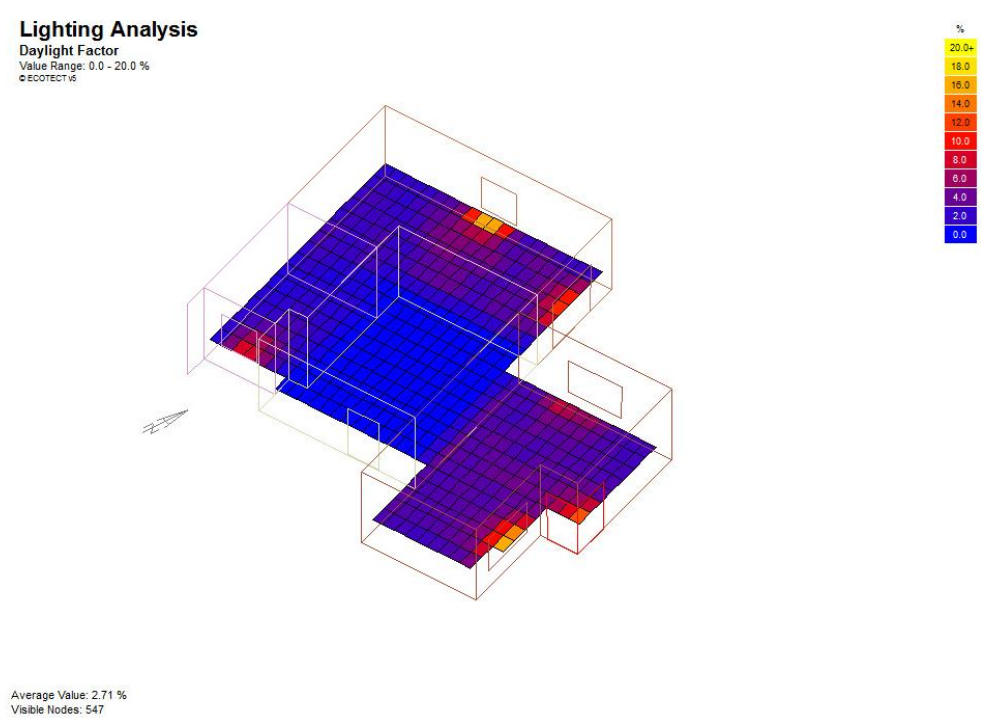


Fig.4. 82. Ground Floor Lighting analysis

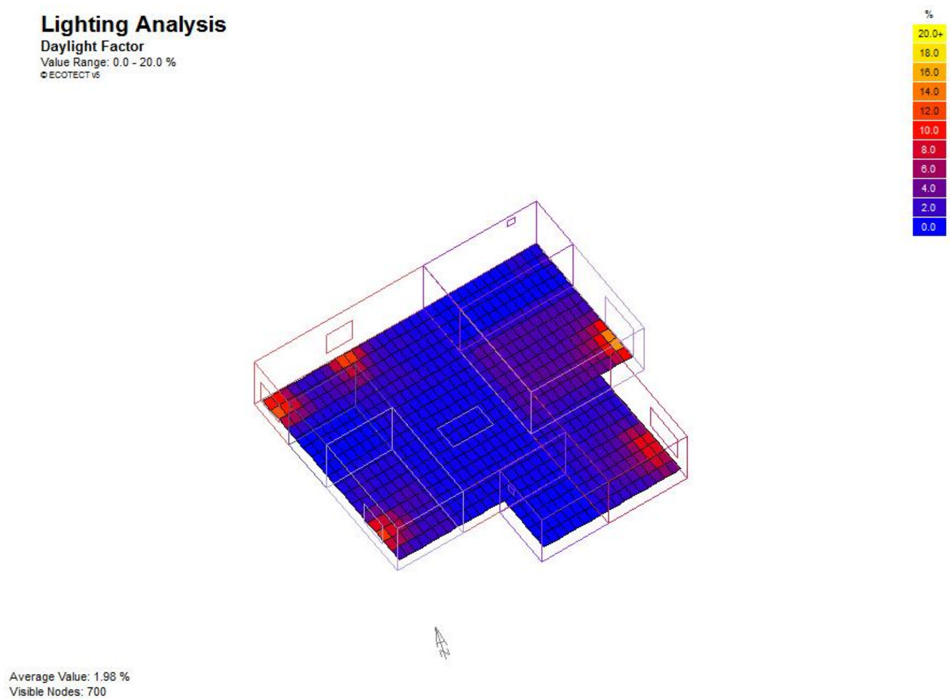


Fig.4. 83. First Floor Lighting analysis

The average value in this graph is the average amount of the total zones in the first floor, since zones like bath and corridor are not used permanently, then artificial light is needed for short times. The figure below shows, first floor master room average DLF=3.06%.

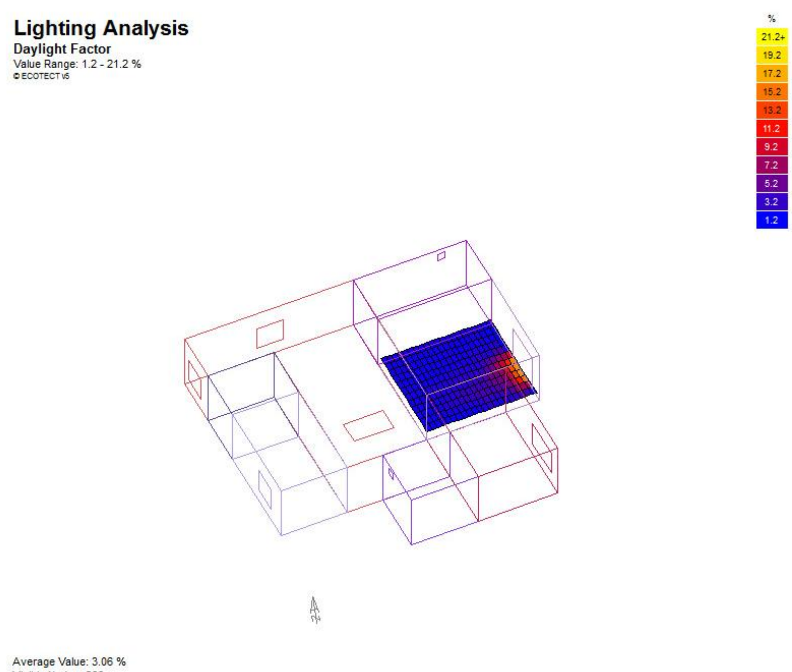


Fig.4. 84. First floor master room lighting analysis

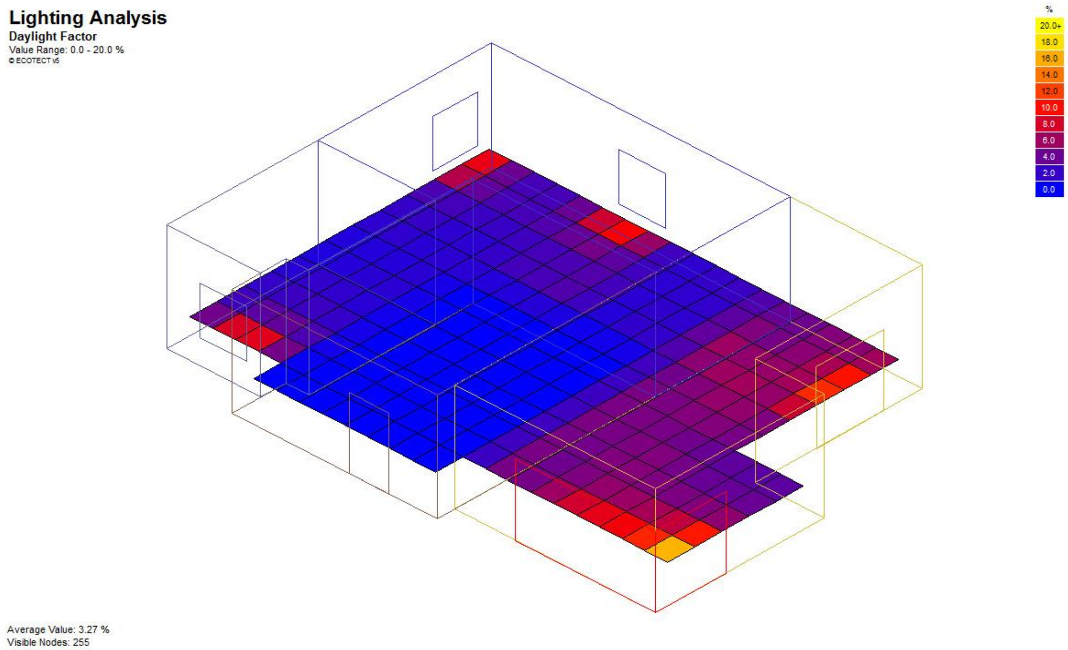


Fig.4. 85. Second floor lighting analysis

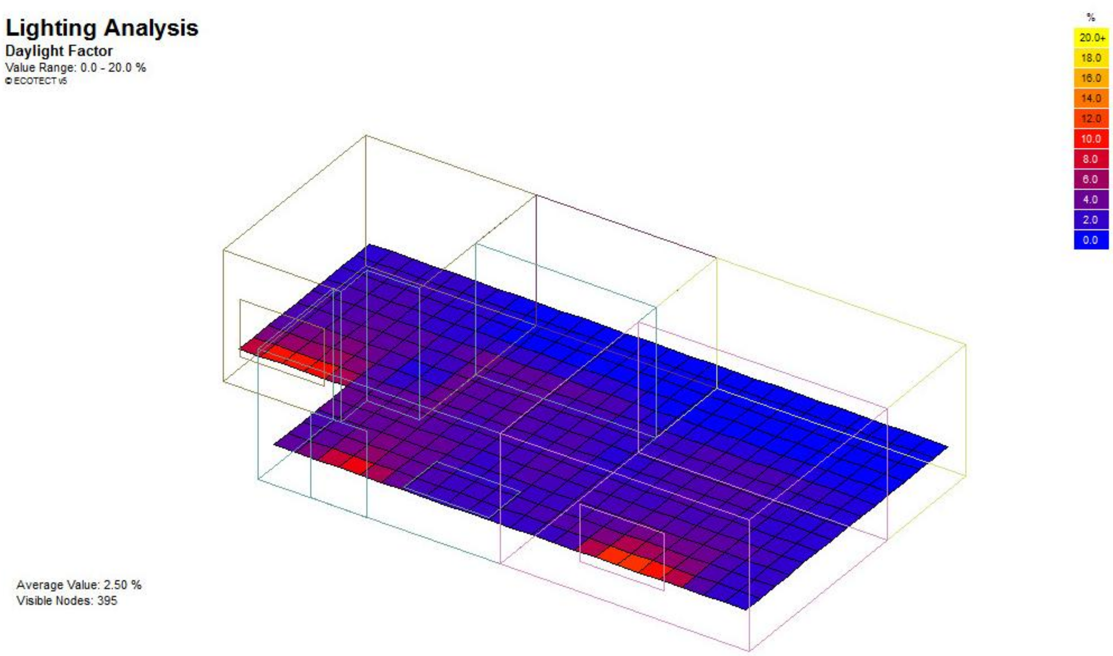


Fig.4. 86. Third floor lighting analysis

4-8-Solar power energy for the district 6th of Shiraz

This project collects and analyzes the energy consumption data of six different residential buildings with approximately 40 inhabitants each in 6th district of Shiraz and employing of a solar power as a water heating system and PV panel instead of natural gas and electricity. As explained before, solar energy is sustainable form of energy that recently has an attractive attention because of its advantages. Shiraz solar power plant is first power plant in Iran. The plant is designed to produce 250kWh electricity thru sunny days, which Shiraz at least has 300 sunny days in the country. In addition, when for a family of four (one household), the temperature of the water in the storage tank of solar water heating device is about the same as the outside temperature, under solar radiation a typical solar collector system delivers 4kWh of electrical equivalent thermal power. As a mean value 0.6MWh/m^2/year would be chosen for Shiraz city which has more or less similar climatic situation as city of Barcelona. Nevertheless, photovoltaic panels would produce 0.18MWh/m^2/year under the same climatic situation of Shiraz [11, 12].

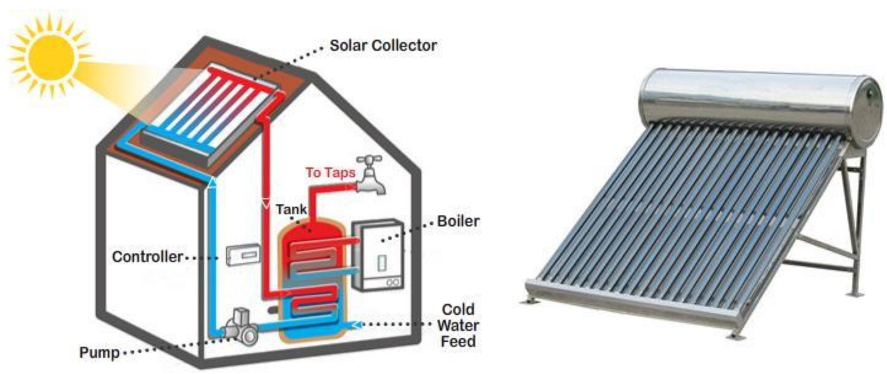


Fig.4. 87. Solar water heating system (SWHS) [14, 15]

But to increase and improve this amount of energy, this design needs to be applied also for the city or districts in neighborhood scale. Regarding to the energy demand, total final energy consumption in Iran was about 995.7 million boe, or 13.72 boe per capita (23MWh per capita) in 2008. This amount of utilization due to the low cost of energy in Iran is estimated to be 3.5 times bigger than that of Turkey, 14.5 times greater than that of Japan and 5 times higher than that of the global average (EIA, 2011). In this regard, the monthly average energy consumption for electricity is around 200kWh/household, and it is about 2.4MWh/ household/year. And yearly average for space cooling amounts is 0.72MWh/household. Relatively, the monthly average of gas consumption is 284M^3/household, which is around 36MWh/household/year. And finally, the monthly average energy utilization of central space heating is 80M^3/household, which is 10MWh/household/year [9, 13]. On the other hand, according to the CEERS, Wuppertal Institute; the average consumption energy for heat up the water with the assumption of one household approximately is 4.5MWh/year [16].

According to these data and analysis on one randomly selected building in the 6th district, and the same calculation on the neighborhood scale of around this building has done. For the concept of NZE building, 70% of rooftop is assumed to be used for the solar power collector devices and the results are as follow:

Table: 4.15. Total energy demand

	Energy demand	Total area	Total energy demand	Total energy demand for water heating
One residential building	0.049MWh/m^2/year	584 m^2	29 MWh/year	9 MWh/year
Neighborhood scale (6 different residential buildings)	0.049MWh/m^2/year	2936 m^2	144 MWh/year	54 MWh/year

Table: 4.16. Total energy generation

	Total rooftop area	70% of rooftop area	Portion of PV panel	Portion of SWHS	PV panel energy generation	SWHS energy generation	Total energy generated by PV panels	Total energy generated by SWHS
One residential building	114 m^2	80 m^2	65 m^2 (80%)	15 m^2 (20%)	0.18 MWh/m^2/year	0.6 MWh/m^2/year	12 MWh/year	9 MWh/year
Neighborhood scale (6 different residential buildings)	840 m^2	588 m^2	476 m^2 (80%)	112 m^2 (20%)	0.18 MWh/m^2/year	0.6 MWh/m^2/year	86 MWh/year	67 MWh/year

As the tables show, the energy demand for electricity and water heating are provided mostly throughout the solar power systems, and it is obvious that the energy for water heating is totally provided by solar water heating system. The chart below shows the total result.

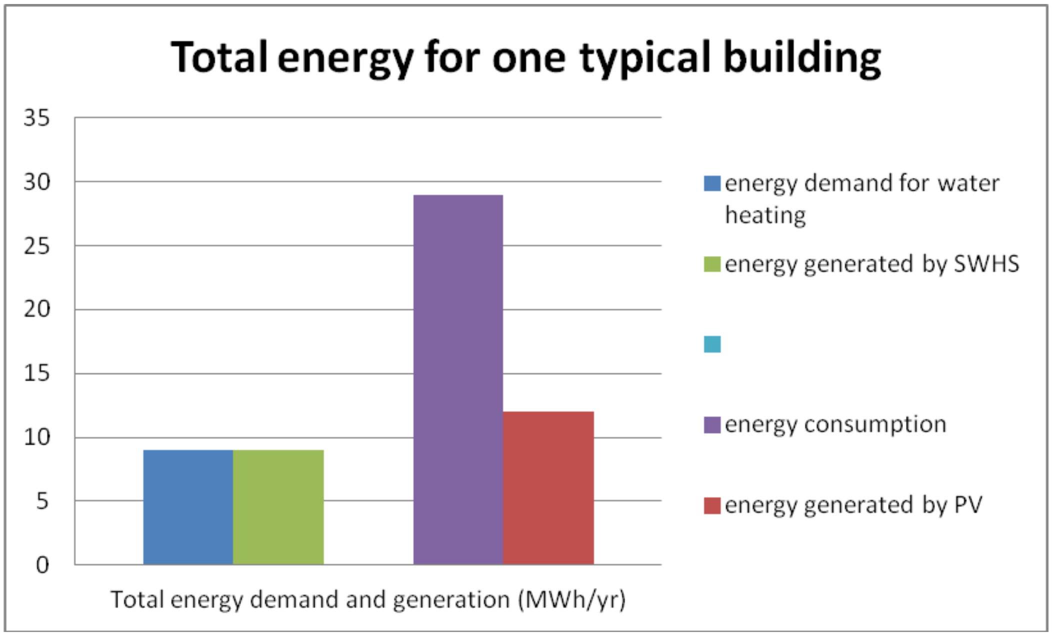


Fig.4. 88. Total energy demand for randomly selected residential building, And energy generated thru solar power devices installed on this building rooftop

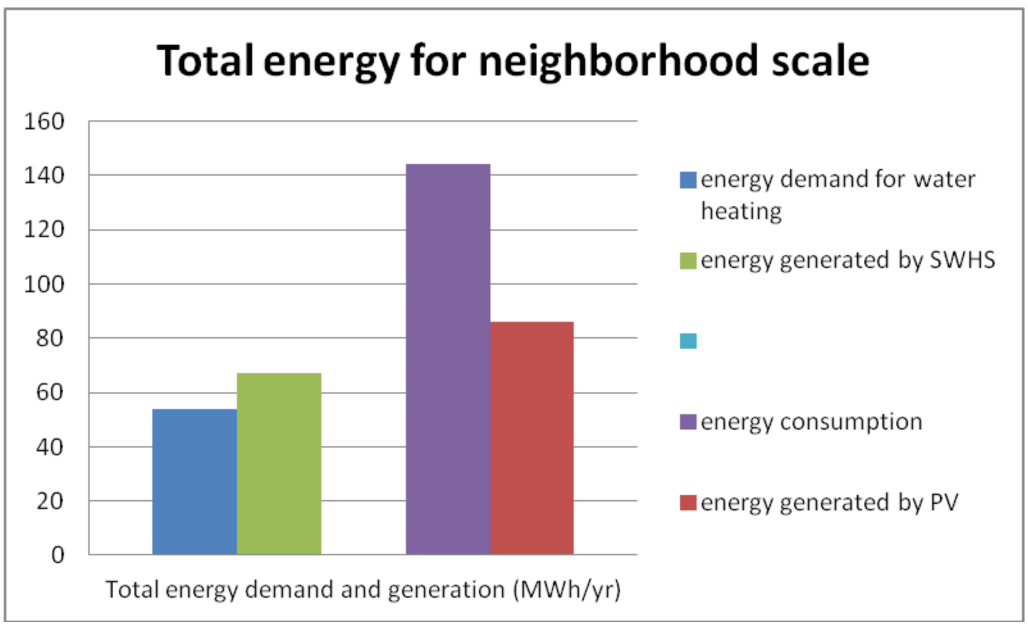


Fig.4. 89. Total energy demand for neighborhood scale, And energy generated thru solar power systems installed on building rooftops in this neighborhood.

Although, the energy generation thru PV panels are not sufficient to generate enough energy to cover all required electricity consumption in the selected building or in the neighborhood scale, but by installing the PV panel plants in smaller scale in the 6th region by some distances it is possible to produce demanded energy for all residential buildings in the mentioned area. The chart below shows the mentioned result.

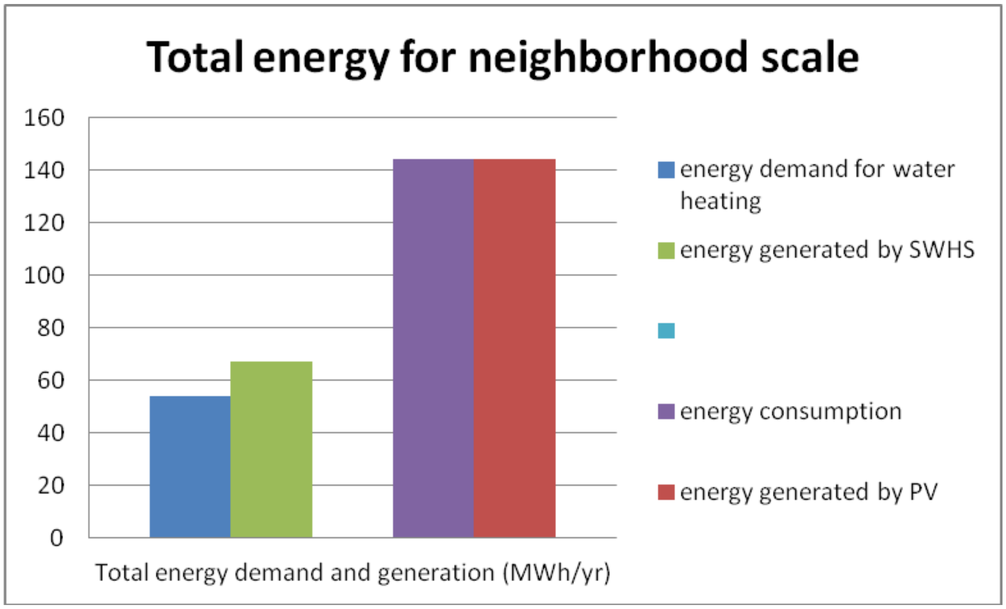


Fig.4. 90. Total energy demand and energy generated by installed solar power systems in the whole region to cover neighborhoods consumption.

4-9-Conclusion

It is conceivable to conserve great amounts of energy only by optimization of architectural design as well as the potential in energy saving of architectural design is significantly high. Moreover, the energy productivity might also be cost neutral. This technique of energy conservation that related to the architectural energy efficiency can be applied to all buildings and also to all climatic conditions worldwide. The improved instructions (Iran national building provisions thread No.19 on Architectural Energy Saving) for architectural design in residential buildings that leads to energy saving have the potential to be utilized as official instructions for all residential in Iran. Subsequently, providing same improved instructions for all kind of building and for all type of climatic conditions, and moreover, as discussed before, employing of solar power energy instead of natural gas and fossil fuels will help more and more in reduction of the energy consumption rate in Shiraz and consequently in Iran.

Chapter 5
Structural Design

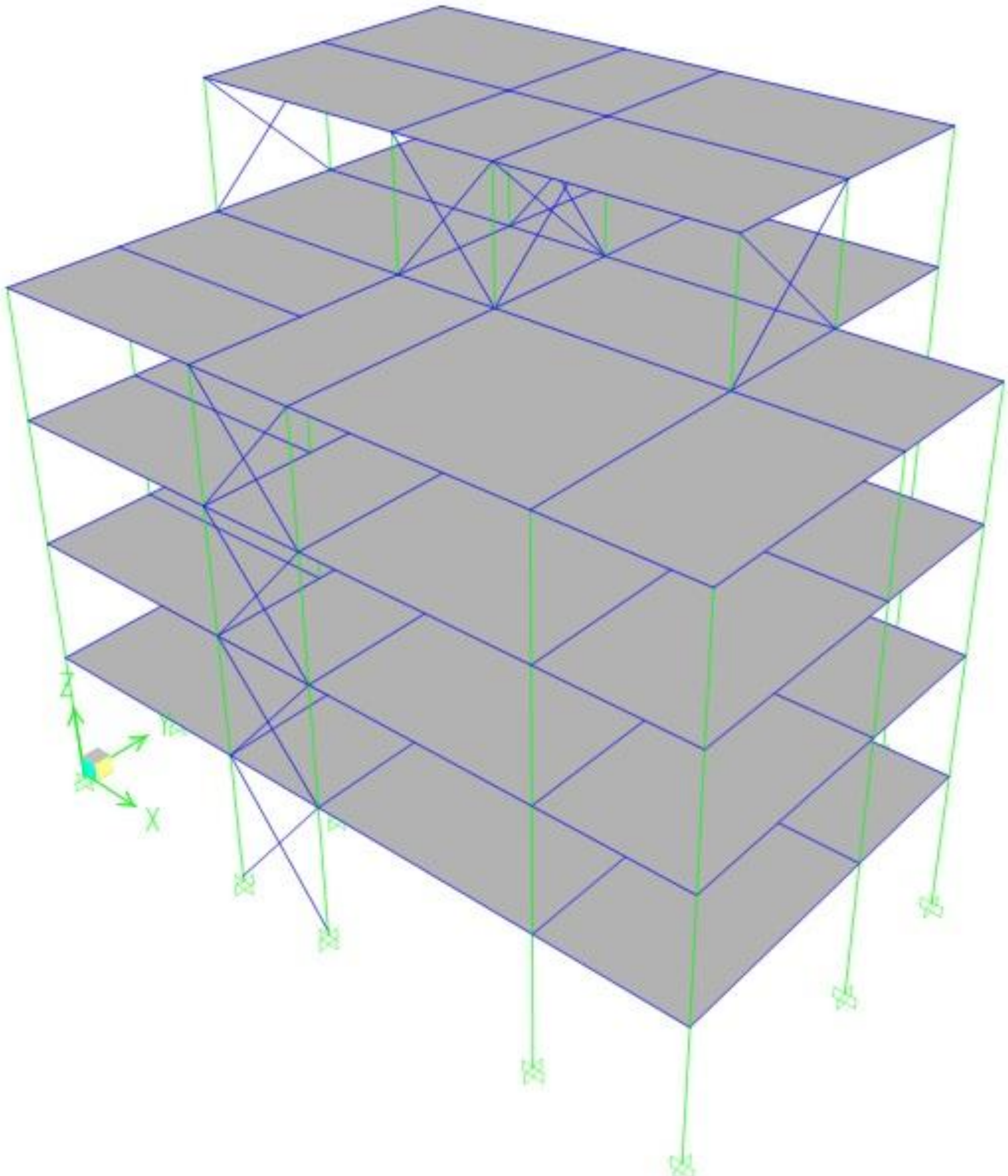


Fig.5. 1.Structural 3D of Residential Building

Introduction

In this chapter the necessary design and analysis related to the structural integrity of the residential buildings project in the 6th region which belongs to the 6th municipality of Shiraz is presented. From architectural point of view and structural simplicity, the residential buildings in this neighborhood have similarity in plan, design, shape and height; in this regard for structural design and analysis we chose one 5 storey building as a sample case to indicate that the same method could be used for other buildings in the 6th area.

This building is located in one of the west-north part of the typical neighborhood plan which shown in the figure 5.2. Moreover, in this 5 storey residential building the floor area in the top floor level is about one half with a comparison to the 4 other remaining floor areas in lower levels. Next figures show the foundation plan and typical plans for basement, ground, first, second and third floor with secondary beam directions. North and west façade of this building is faced with the local street, south walls are faced with the neighbor building and east part is with its own courtyard.

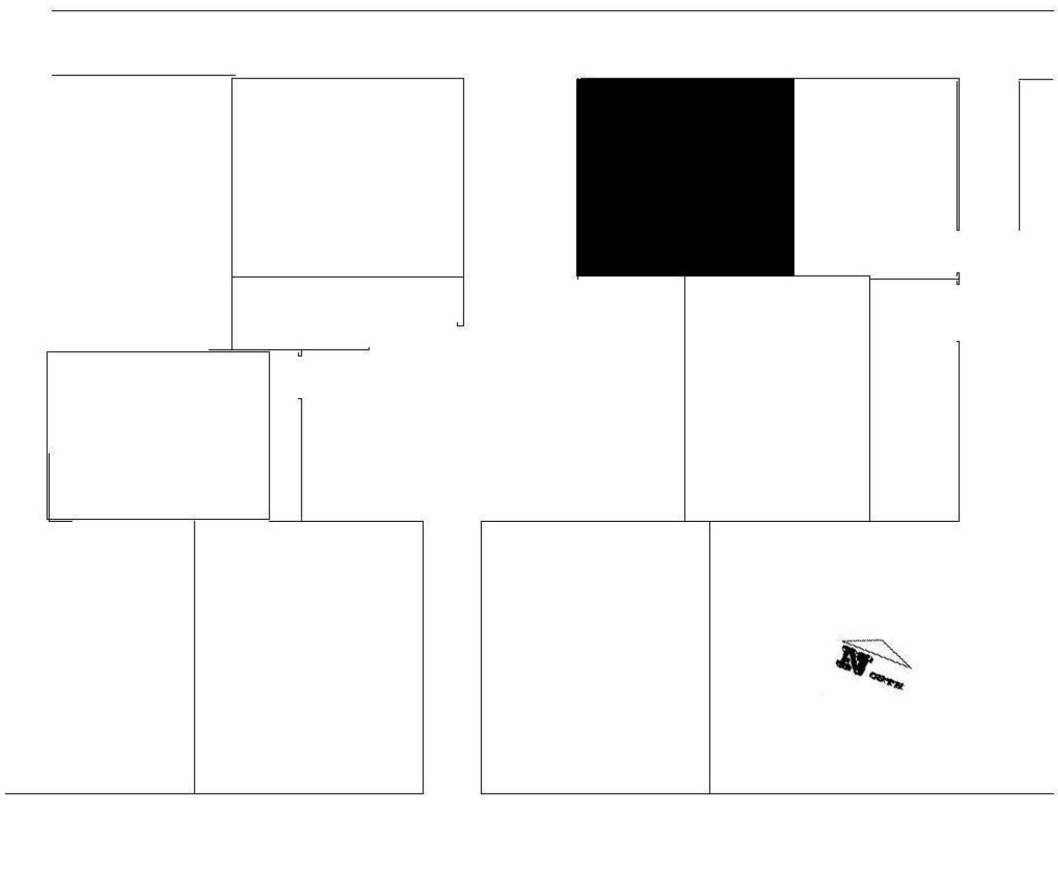


Fig.5. 2.Location of the selected building

From structural point of view, the building is simple supported steel structure; means the structural frame is non-bending moment resistant in which lateral (earthquake, wind) loads are expected to be carried out by the bracing systems which is installed in both X and Y directions of structural frames. Thus, it means the columns and the beams are not able to resist the bending moments that arisen by earthquake or wind action.

It is worthwhile to mention that it is better to make the orientation of the secondary beams towards the main beams which is installed in the bracing frames; so that when bracings are resisting the lateral loads the beam is totally able to cover and carry the gravitational load simultaneously.

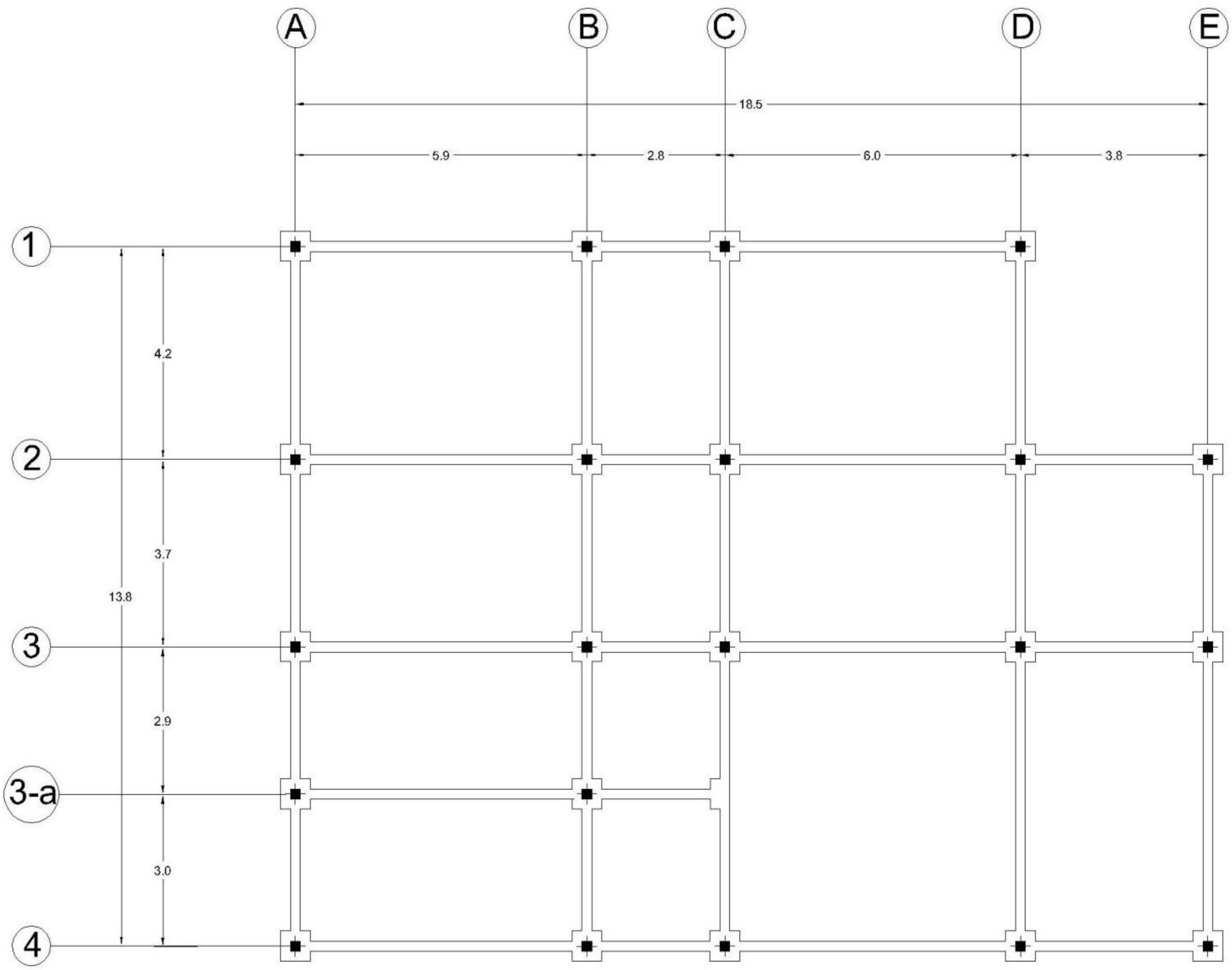


Fig.5. 3.Foundation plan of the selected residential building

The only difference of the fig.5.3 and fig.5.4 is that in third floor in between the (3-a) and (4) axis the stairs way does not exist in the third floor, and it has been filled up with the floor materials as a third floor area. On the other hand, in the third floor no roof for the area between (3-a) and (4) axis, as well as the area between (D) and (E) axis exist, and also instead of external walls they all have parapet, thus for this reason, in (B-C) frame of third floor there is no bracings to support earthquake loads for structural analysis point of view in 4 axis. Yet the structure is still completely capable of bearing the earthquake or wind load actions.

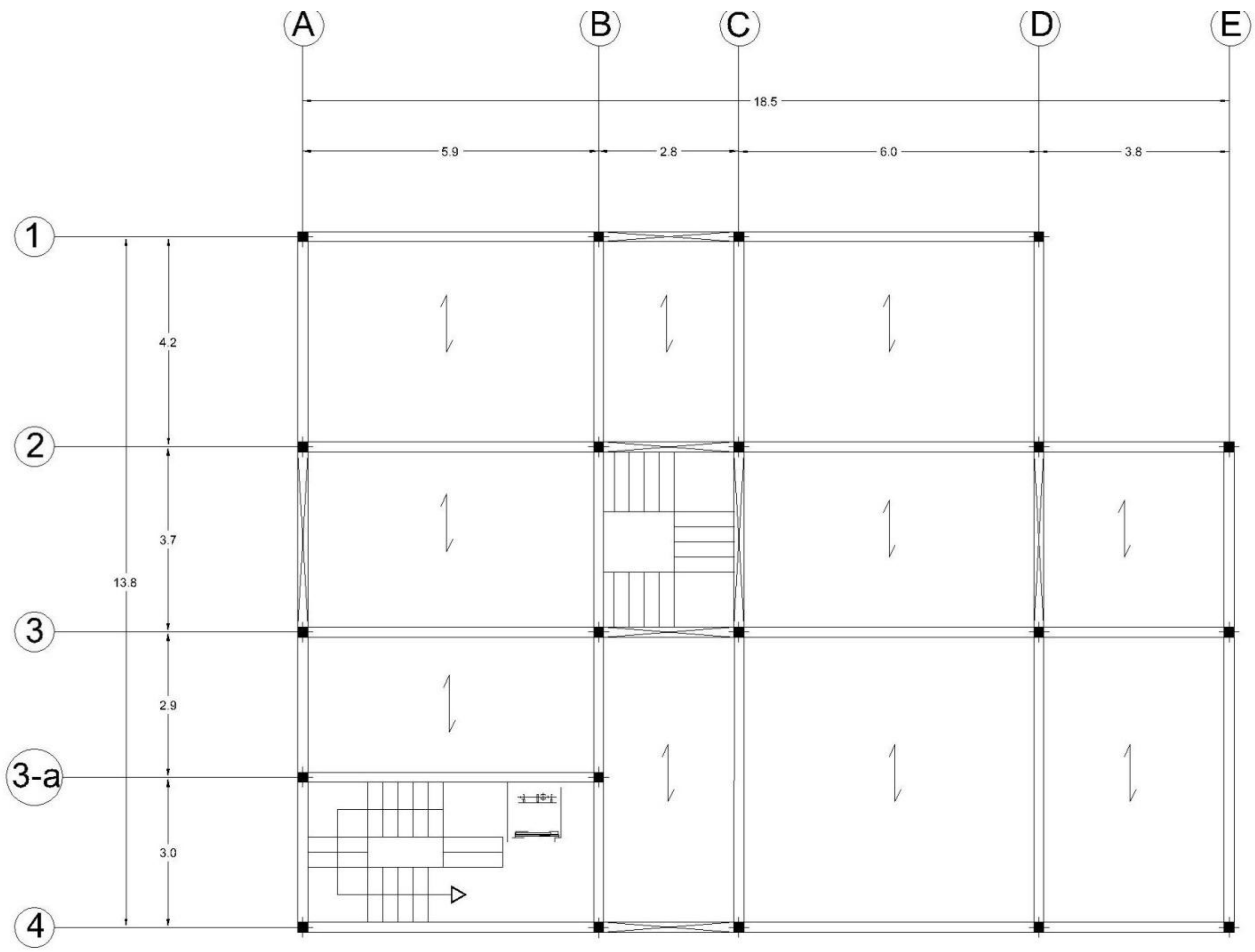


Fig.5. 4.Typical plan of ground, first and second floor with secondary beam directions

The roof plan with the secondary beam directions has shown in the figure 5.5. And it is easier to understand the previous explanation about the floor area of third floor and the mentioned bracing system. Thus, according to the roof plan, in direction X there are three bracing frames that support lateral loads and same happens for the direction Y in the top floor of this residential building. But in other floors in X direction we have 4 bracing frames and in Y direction for all levels it is same as top floor with 3 bracing frames to resistant bending moment.

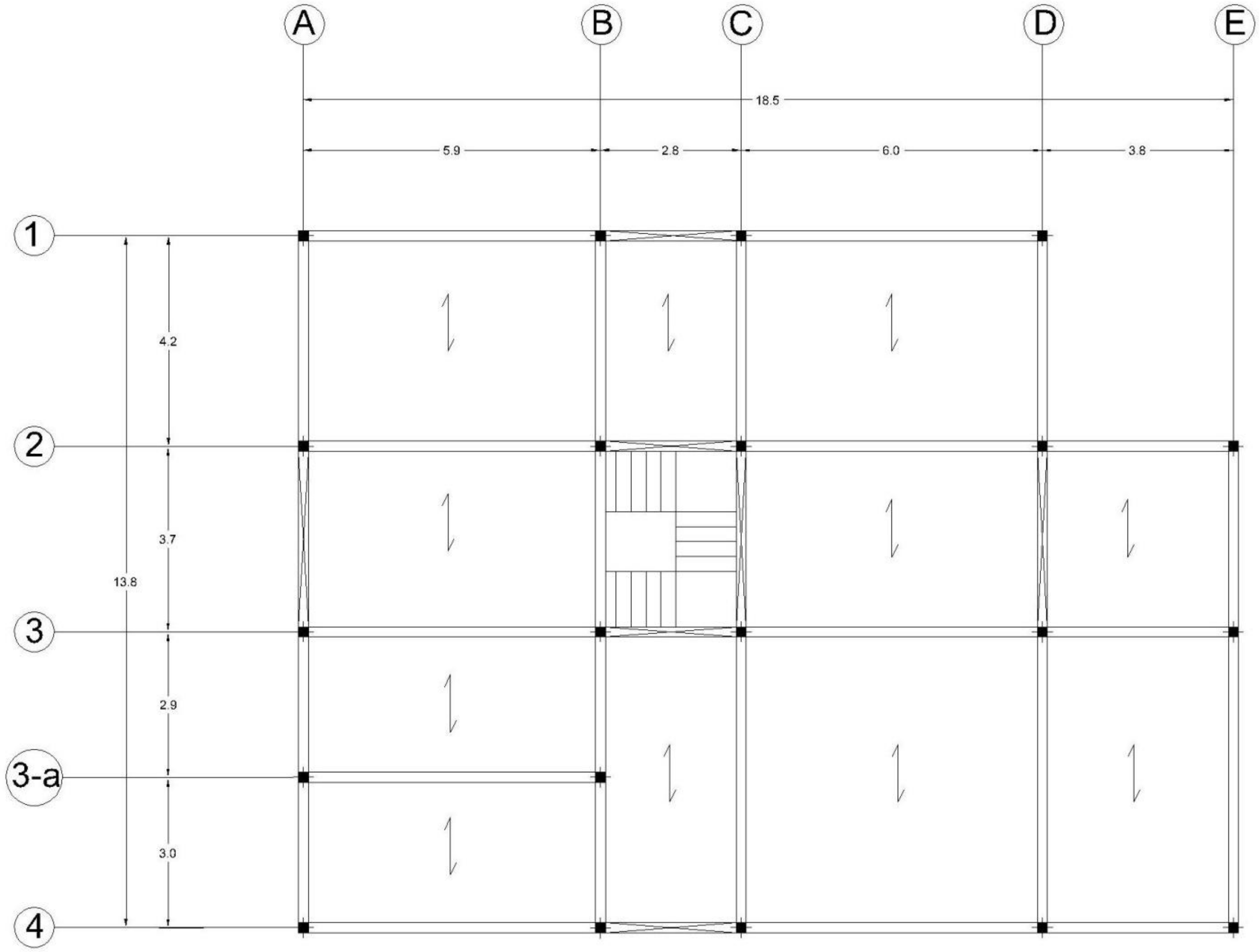


Fig.5. 5.Third floor plan with secondary beam directions

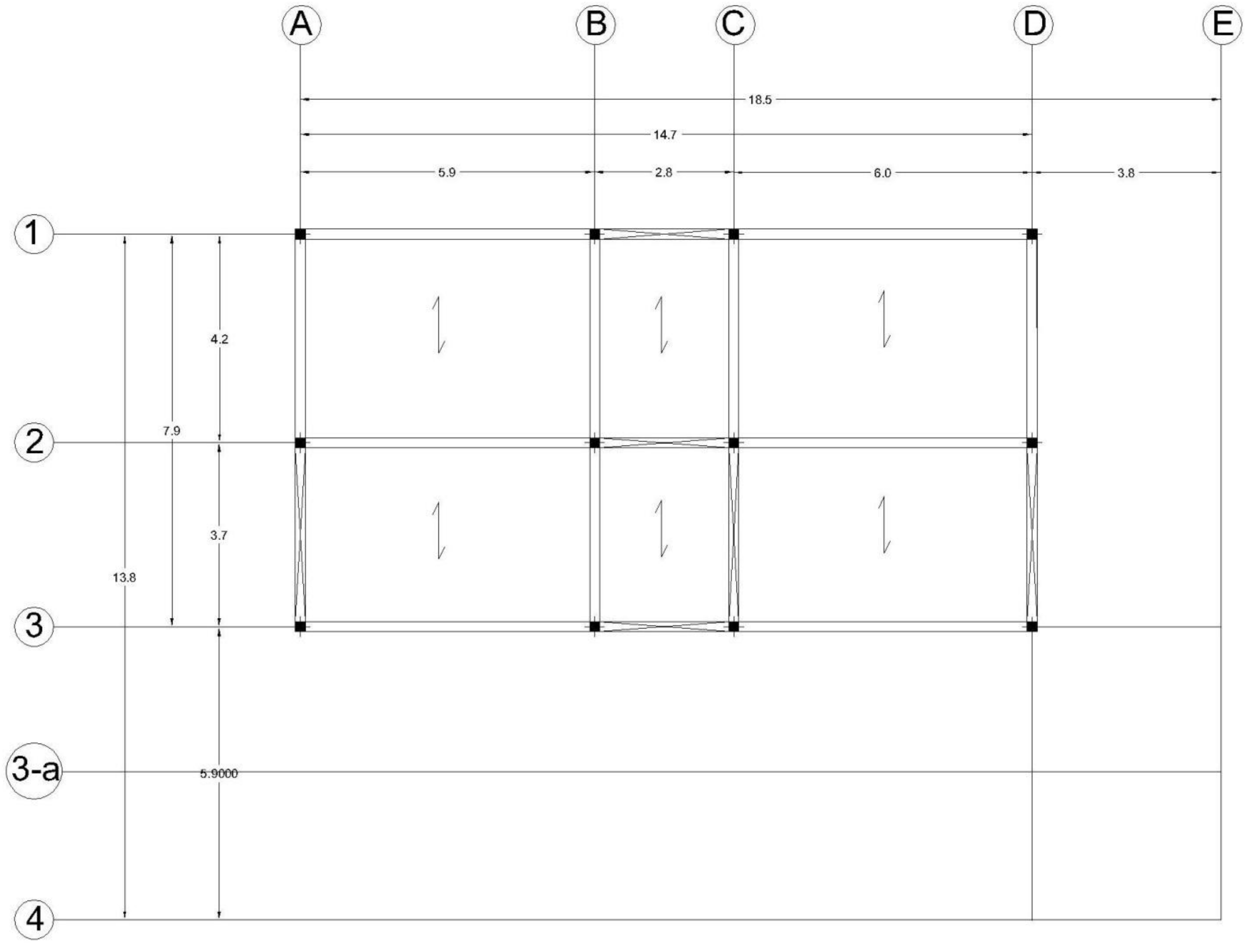


Fig.5. 6.Rooftop plan with secondary beam directions

5-1-Loading actions

As this project is located in the city of Shiraz in Iran, for standards, load calculations and structural analysis and design, the 6th and 10th Threads of Iran National Building Regulations, and for buildings against earthquake loading, the Iran Earthquake bylaw 2800 has been considered.

5-1-1-Gravitational loads

Gravitational loads produce axial, flexural and shear loads by arriving to the main beams and columns from the slab, it means that the axial and flexural loads are for columns, and shear and flexural loads are for the beams. But as mentioned before columns of this building are not able to resist the flexural loads.

Gravitational loads mainly are:

1- Dead Load (external and internal walls, partitions, parapets, floors, roof)

2- Live Load (floors, roof, stairs)

3- Snow Load on rooftop

4- Elevators' live and dead loads

5-1-1-1- Floors and rooftop dead loads

Floors is consist of dead loads of a firm shell of concrete slab, technological members and building materials where is supported by the main and secondary beams, meanwhile, secondary beams are installed with the distance of 2.5 meters consecutively.

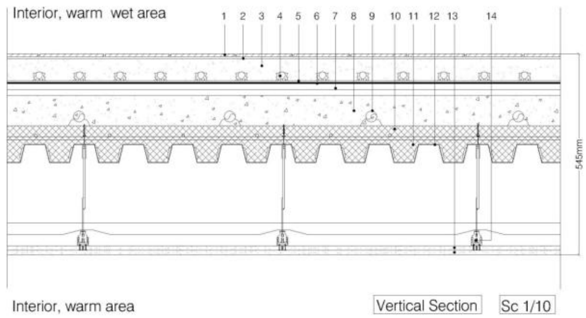


Fig.5. 7.Typical floor section and technological details

Intermediate Floor- Type D			
Number	Layer	Thickness	Weight
1	ceramic 30 * 30 cm	5 mm	15(kg/m2)
2	Ceramic Glue	5 mm	-
3	Sand cement screed	50 mm	42 (kg/m2)
4	2 layers of "Index" bitumen sheet membrane	2*2 mm	15 (kg/m2)
5	Knauf insulation board	30 mm	15 (kg/m2)
6	Light concrete with 1.5% slope		72 (kg/m2)
7	Reinforced concrete		250 (kg/m2)
8	Metal Deck		15 (kg/m2)
9	"Knauf" mineral wool		16 (kg/m2)
10	2 Layer of " Knauf" Gypsumboard with vapour barrier		60 (kg/m2)
11	Knauf False cieling clips		-
			500 (kg/m2)

Fig.5. 8.Dead load of ground, first, second and third floors

Generally, dead load for rooftop and typical floor type is different from one another; the reason is that the rooftop due to its location between inside and outside ambient should be have more thickness and insulation to prevent the heat lost and penetration of humidity. Therefore, it has more weight and thickness than other ceilings.

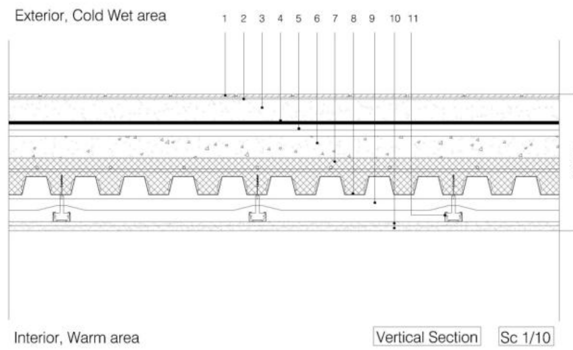


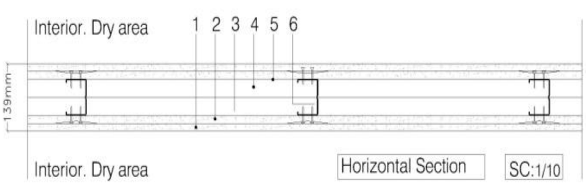
Fig.5. 9.Rooftop section and technological details

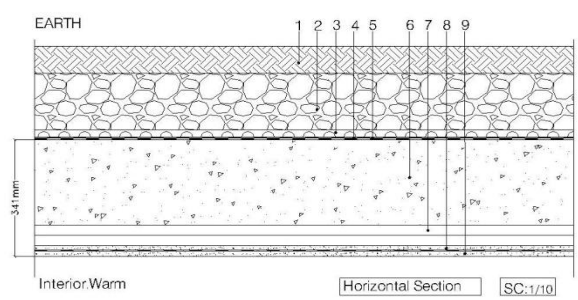
Intermediate Floor- Type A1			
Number	Layer	Thickness	Weight
1	ceramic 30 * 30 cm	5 mm	20 (kg/m2)
2	Ceramic Glue	5 mm	-
3	Sand cement screed	50 mm	42 (kg/m2)
4	"Velta" PE-Xa 17mm*2mm Pipe		40 (kg/m2)
5	"velta" fixing grid	2 mm	16 (kg/m2)
6	"velta" PE 200 Slip membrane	4 mm	15 (kg/m2)
7	Knauf insulation board	30 mm	15 (kg/m2)
8	Light concrete	80 mm	15 (kg/m2)
9	Water plumps		72 (kg/m2)
10	Reinforced concrete		270 (kg/m2)
11	Metal Deck		15 (kg/m2)
12	"Knauf" mineral wool		20 (kg/m2)
13	2 Layer of " Knauf" Gypsumboard		60 (kg/m2)
14	Knauf False cieling clips		-
			600 (kg/m2)

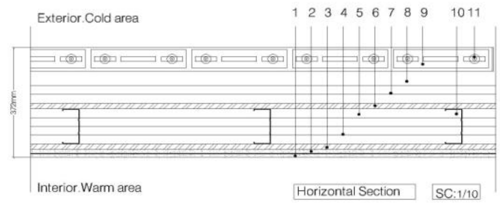
Fig.5. 10.Dead load of rooftop

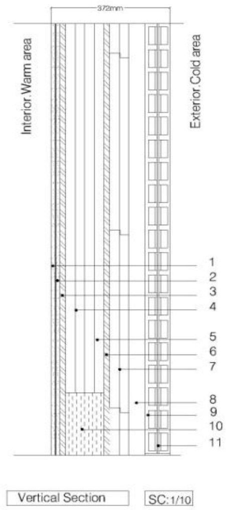
5-1-1-2- Dead loads of walls

Generally walls of this building are built with the composition of metal studs and Plasterboards to make building lighter and more efficient for technological aspects. A void space that provided between the studs is used for placement of thermal insulations. Figures and Table below show the properties and specification of walls.

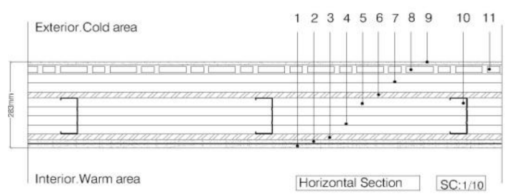


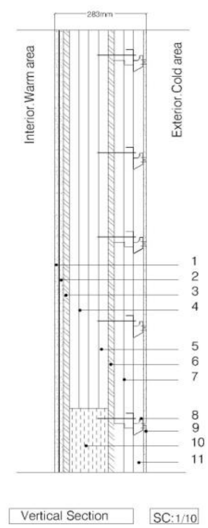






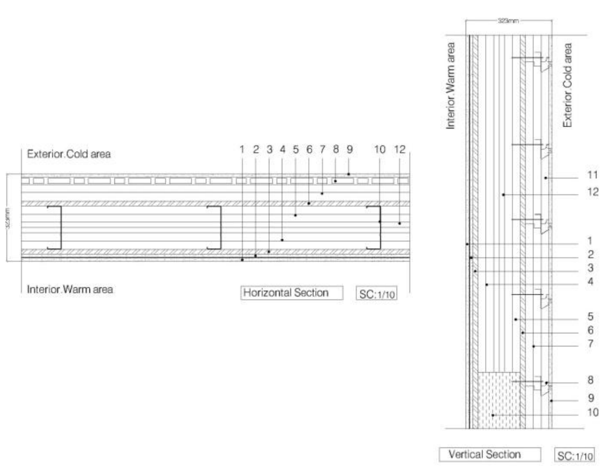
Exterior Wall - TYPE 00		
Number	Layer	Thickness
1	"Knauf" PlasterBoard with vapor barrier	12.5 mm
2	"Knauf" PlasterBoard	12.5 mm
3	OSB Board (support)	18 mm
4	"Knauf" Mineral Wool	60 mm
5	Polystyrene Board- 45kg/m3	60 mm
6	OSB Board(suppport & rigidity)	18 mm
7	Polyurethane Foam coated with embossed Aluminium sheet	60 mm
8	Air Cavity	50 mm
9	Brick	
10	Steel Stud	
11	Steel Bar	





Exterior Wall - TYPE 01		
Number	Layer	Thickness
1	"Knauf" PlasterBoard with vapor barrier	12.5 mm
2	"Knauf" PlasterBoard	12.5 mm
3	OSB Board (support)	18 mm
4	"Knauf" Mineral Wool	60 mm
5	Polystyrene Board- 45kg/m3	60 mm
6	OSB Board(suppport & rigidity)	18 mm
7	"Isotec Parete" Polyurethane Foam coated with embossed Aluminium sheet	60 mm
8	Pierce Steel Profile	
9	Cladding system *	20 mm
10	Steel Stud	
11	Ventilation Gap	

* Thermo Wood
Fibre Cement Board



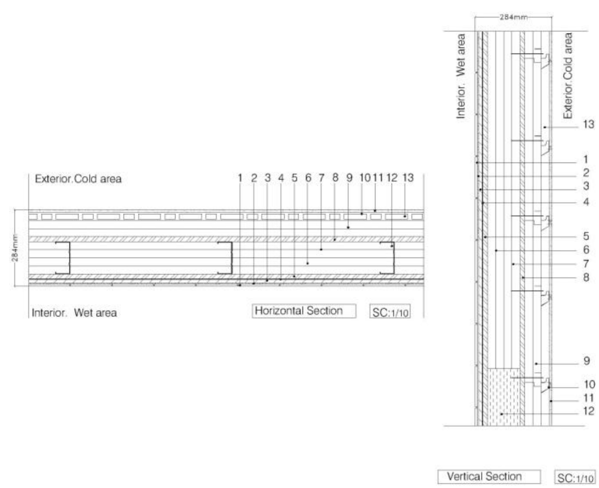


Fig.5. 11.Interior and exterior wall sections

Table: 5. 1.The weight of walls

Walls	weight		
	height (m)	kg/m^2	kg/m
façade walls	3.2	300	725
Non-facade walls	3.2	260	585
Partitions	3.2	170	363
Parapets	0.9	300	270

5-1-1-3- Live load action in floors and rooftop

According to the Iran Earthquake bylaw 2800 category of occupancy, the value of 200 kg/m^2 live load is announced to be considered for the residential buildings. By applying this value for the whole building the live load for the roof is considered as 150 kg/m^2 and because the snow load is lower than this value the live load of the roof is selected to remain as 150 Kg/m^2.

The live and dead load actions for floors, roof and stairs, and also dead load action of different walls are categorized in the table 5.2. The snow load action is calculated in the next following topic.

Table: 5. 2.Dead load and live load of building members

Live load (kg/m^2)	**Dead load (kg/m^2)**	
150	600	**Roof**
200	500	**Floors**
350	730	**Stairs**
-	300	**Wall(fd)**
-	260	**Wall(n.fd)**
-	170	**Partition**

5-1-1-4- Snow load action

According to the Iran Earthquake bylaw 2800, different shape and angle (slope) of a roof can make the snow load equation's factors variable. In this stage, when the snow load action is stronger (heavier) than the live load that applied to the rooftop, snow load should be replaced with the live load action. However, in this project live load action is stronger than the calculated snow load action, so no substitution of loads required.

$P_r = C_s * P_s$

C_s : Slope effect coefficient
P_s : Basis snow load
P_r : Snow load on roofs

No slope for the roof: $C_s = 1$

Building is located in Shiraz city, so from the table in 2800 bylaw:

$P_s = 100$ kg/m^2

So: $P_r = 100 \times 1 = 100$ kg/m^2 and

100 (Snow Load) $\leq$ 150 (Roof Live Load)

Thus, we consider the live load of the roof as a live load for the roof.

5-2- Dead load on main beams

Now that we have obtained the live and dead loads applied to the building structure, these amount need to be calculated for each main beams and columns one by one.

As an example the calculation for the distributed load on beam A-B-1 is shown below:

Floor dead load: 500 x 2.1 = 1050 (kg/m)

Non-façade wall dead load:

260 (kg/m^2) < 275 (kg/m^2) so, it will considered as partition distributed load on floors.
260*20(m)*2.7/240(m^2) = 58 (kg/m^2)

Partition wall:

170 (kg/m^2) < 275 (kg/m^2) so, it will considered as partition distributed load on floors.
170*30(m)*2.7/240(m^2) = 52 (kg/m^2)

52 + 58 = 110 (kg/m^2)

Partition dead load: 110 x 2.1 = 231 (kg/m)

North Façade dead load: 810 (kg/m)

Total load on Beam A-B-1: 2091 (kg/m)

Dead load of stair case in B-C-2:

Stair load: 730 x 1.3= 950 kg/m

Roof dead load on beam A-B-1:

Roof dead load: 600 x 2.1= 1260 kg/m

Roof parapet dead load: 270 kg/m

Total load on beam A-B-1: 1530 kg/m

And followings are the calculated dead loads for main beams in the table:

Table: 5. 3.Dead load for main beams to withstand (kg)

	A-B-1	B-C-1	C-D-1	D-E-1	A-B-2	B-C-2	C-D-2	D-E-2
loading width (m)	2.1	2.1	2.1	-	3.95	3.4	3.95	1.85
Gr&1&2 (kg/m)	2091	2091	2091	-	2410	2230	2410	1129
3rd Floor (kg/m)	2091	2091	2091	-	2410	2230	2410	1399
Roof (kg/m)	1530	1530	1530	-	2370	2327	2370	-

	A-B-3	B-C-3	C-D-3	D-E-3	A-B-3a	B-C-3a	C-D-3a	D-E-3a
loading width (m)	3.3	4.25	3.3	3.3	2.75	-	-	-
Gr&1&2 (kg/m)	2013	1834	2013	2013	1834	-	-	-
3rd Floor (kg/m)	2013	1834	2013	2013	1800	-	-	-
Roof (kg/m)	1110	1940	1110	-	-	-	-	-

	A-B-4	B-C-4	C-D-4	D-E-4
loading width (m)	1.5	2.95	2.95	2.95
Gr&1&2 (kg/m)	1013	2576	2576	2070
3rd Floor (kg/m)	1185	2070	2070	2070
Roof (kg/m)	-	-	-	-

5-3- Dead load for columns

After calculation of gravitational loads on main beams, next step is the calculation for dead loads which columns have to receive, withstand and transfer these gravitational forces to the ground. For this purpose, first we have to assume an approximate amount of weight for each column. Therefore, in this case, we assumed that we use IPE 270 for each column.

Table: 5. 4.An approximate weight for columns

Ton	h(m)	IPE270(kg/m)	no.	column
0.13	3.5	36.1	21	**Bst**
0.12	3.2	36.1	21	**Grd**
0.12	3.2	36.1	21	**1st**
0.12	3.2	36.1	21	**2nd**
0.12	3.2	36.1	18	**3rd fl**
-	16.3	-	102	**total**

Now below is the calculation for the column A-1 computed to withstand the building dead load:

(Loading area) x (roof dead load) = (dead load to A-1 column in 3rd floor)
6.2 x 0.600= 3720 kg

[(0.5(is floor DL) + 0.11(is partitions DL)) x 6.2] + 0.2(is one clmn weight) + 3.72= 7702 kg (DL to A-1 clmn in 2nd fl)

[(0.5(floor dl) + 0.11(partitions dl)) x 6.2] + 0.2(one clmn weight) + 7.702= 11684 kg (dl to A-1 clmn in 1st fl)

[(0.5(floor dl) + 0.11(partitions dl)) x 6.2] + 0.2(one clmn weight) + 11.684= 15666 kg (dl to A-1 clmn in Grd fl)

[(0.5(floor dl) + 0.11(partitions dl)) x 6.2] + 0.2(one clmn weight) + 15.666= 19648 kg (dl to A-1 clmn in Bsmt)

Now same method is used for other columns and the results are indicated in the following tables:

Table: 5. 5.Dead loads that withstand by columns (kg)

	A-1	A-2	A-3	A-3a	A-4	B-1	B-2	B-3	B-3a
loading area (m^2)	6.2	11.65	9.7&5.46	8.7	4.4	9.12	17.2	14.35&8	12.8
3rd floor clmn	3720	6990	3276	0	0	5472	10320	4800	0
2nd floor clmn	7702	14297	9393	5507	2884	11235	21012	13754	8008
1st floor clmn	11684	21603	15510	11014	5768	16998	31704	22707	16016
Grand floor clmn	15666	28910	21627	16521	8652	22762	42396	31661	24024
Basement clmn	19648	36216	27744	22028	11536	28525	53088	40614	32032

	B-4	C-1	C-2	C-3	C-4	D-1	D-2	D-3	D-4
loading area (m^2)	6.5	9.24	17.4	14.5&8.14	6.6	6.3	15.37&9.3	16.17&5.5	7.35
3rd floor clmn	0	5544	10440	4884	0	3780	5580	3300	0
2nd floor clmn	4165	11380	21254	13929	4226	7823	15156	13364	4684
1st floor clmn	8330	17217	32068	22974	8452	11866	24731	23427	9367
Grand floor clmn	12495	23053	42882	32019	12678	15909	34307	33491	14051
Basement clmn	16660	28890	53696	41064	16904	19952	43883	43555	18734

	E-1	E-2	E-3	E-4
loading area (m^2)	-	3.52	6.27	2.85
3rd floor clmn	-	-	-	-
2nd floor clmn	-	2347	4025	1939
1st floor clmn	-	4694	8049	3877
Grand floor clmn	-	7042	12074	5816
Basement clmn	-	9389	16099	7754

5-4- Live load for beams

According to the earthquake bylaw for live loads it is considered that the reduction factor has to be included in the calculation for both beams and columns in analysis. Based on the mentioned criteria we only have reduction of loads for number of beams who exceed the criteria, so this means there is no live load reduction for columns.

Live load reduction factor is considered by:

$R= 100\ (0.7 - 3/\sqrt{A}) \leq 50\%$

A: loading area for beams and columns

Live load for beam A-B-1:

2.1(is loading width) x 150(is rooftop live load) = 315 kg/m (rooftop live load on beam A-B-1)

2.1(is loading width) x 200(is floors live load) = 420 kg/m (floors live load to beam A-B-1)

Reduction of live load for beam A-B-2:

3.95(is loading width) x 200(is floors live load) = 790 kg/m (floors live load for beam A-B-2)

790 x (1- 0.05) (is reduction factor) = 750.5 kg/m (reduced live load for beam A-B-2)

And here are the tables contain the live load for the beams:

Table: 5. 6.Live load for beams including reduction factor

Beam no.	loading width (m)	loading area (m^2)	Live load(kg/m)	Rd.Ll (%)	effective Ll (kg/m)	Roof Ll (150kg/m^2)
A-B-1	2.1	12.4	424	0%	424	315 (kg/m)
B-C-1	2.1	5.88	424	0	424	315
C-D-1	2.1	12.6	424	0	424	315
D-E-1	-	-	-	-	-	-
A-B-2	3.95	23	798	5%	758	593
B-C-2	3.4	9.5	687	0	687	510
C-D-2	3.95	23.7	798	8.38%	731	593

Beam no.	loading width (m)	loading area (m^2)	Live load(kg/m)	Rd.Ll (%)	effective Ll (kg/m)	Roof Ll (150kg/m^2)
D-E-2	1.85	7.03	374	0	374	0 (kg/m)
A-B-3	3.3	19.5	667	2.10%	653	278
B-C-3	4.25	11.9	859	0	859	278
C-D-3	3.3	28.8	667	14.10%	573	278
D-E-3	3.3	18.24	667	0	667	-
A-B-3a	2.75	16.22	556	0	556	0
B-C-3a	-	-	-	-	-	-

Beam no.	loading width (m)	loading area (m^2)	Live load(kg/m)	Rd.Ll (%)	effective Ll (kg/m)	Roof Ll (150kg/m^2)
C-D-3a	-	-	-	-	-	-
D-E-3a	-	-	-	-	-	-
A-B-4	1.5	8.85	303	0	303	0(kg/m)
B-C-4	2.95	8.26	596	0	596	0
C-D-4	2.95	17.7	596	0	596	0
D-E-4	2.95	11.21	596	0	596	-

5-5- Live load for columns

As motioned in the previous part for live load it is mandatory to control the reduction factor for both columns and beams. But, as there are no loading areas for columns to exceed the criteria, thus, no reduction factors for columns are considered.

Live load reduction factor is considered by:

$R = 100\ (0.7 - 3/\sqrt{A}) \leq 50\%$

A: loading area for columns and beams

Table: 5. 7.Live load for columns including reduction factor

	A-1	A-2	A-3	A-3a	A-4	B-1	B-2	B-3
loading Area (m^2)	6.2	11.65	9.7&5.46	8.7	4.4	9.12	17.2	14.35&8
live load of 3rd fl (kg)	930	1748	819	0	0	1368	2580	1200
Reduction %	0%	0%	0%	0%	0%	0%	0%	0%
2nd fl	2170	4078	2759	1740	880	3192	6020	4070
1st fl	3410	6408	4699	3480	1760	5016	9460	6940
Grd fl	4650	8738	6639	5220	2640	6840	12900	9810
Bsm fl	5890	11068	8579	6960	3520	8664	16340	12680

	B-3a	B-4	C-1	C-2	C-3	C-4	D-1
loading Area (m2)	12.8	6.5	9.24	17.4	14.5&8.14	6.6	6.3
live load of 3rd fl (kg)	0	0	1386	2610	1221	0	945
Reduction %	0%	0%	0%	0%	0%	0%	0%
2nd fl	2560	1300	3234	6090	4121	1320	2205
1st fl	5120	2600	5082	9570	7021	2640	3465
Grd fl	7680	3900	6930	13050	9921	3960	4725
Bsm fl	10240	5200	8778	16530	12821	5280	5985

	D-2	D-3	D-4	E-1	E-2	E-3	E-4
loading Area (m2)	15.37&9.3	16.17&5.5	7.35	-	3.52	6.27	2.85
live load of 3rd fl (kg)	1395	825	0	-	0	0	0
Reduction %	0%	0%	0%	-	0%	0%	0%
2nd fl	4469	4059	1470	-	704	1254	570
1st fl	7543	7293	2940	-	1408	2508	1140
Grd fl	10617	10527	4410	-	2112	3762	1710
Bsm fl	13691	13761	5880	-	2816	5016	2280

5-6- Wind load action

Wind load is considered as a lateral force for building structure, thus again referring to the 2800 bylaw it is necessary to consider one of the strongest load between the wind load and earthquake load in which it is significantly related to the building location on a map, wind velocity and also the property of building itself such as the height, weight of the building and façade area that has faced to the wind.

For wind load analysis:
$F = P * A$
$P = C_e * C_q * q$

$q = 0.005V^2$

In inner city areas and dense neighborhood:

$C_e = 1.6(Z/10)^{0.24}$ or 1.9 (for buildings between 10m to 20m height), $C_e > 1.6$

$C_q = 1.4$ (for buildings between 12m to 60m height)

F: wind force

A: building area faced to the wind

P: pressure or suction due to the wind
q: basis wind pressure (kg/m^2)

V: basis wind velocity (km/hr)

C_e: velocity variation coefficient

Z: building height faced to the wind

Building is located in Shiraz city:

V= 80 km/hr , q=32 kg/m^2 (from related table in 2800 bylaw)

$P = 1.9 * 1.4 * 32 = 85.12$ (kg/m^2)

$F = P * A = 85.12 * (18.5 * 12.8) = 20,156$ (kg)

$F = 20156$ (kg)

5-7- Earthquake load action

Earthquake and wind loads are the key load actions to the lateral forces that exerted to a structure. But, since the contingency of incidence of these tow loads at once is very rare, thus, firstly the analysis relate to the lateral forces that created by earthquake with the static force method is calculated, and then the strongest lateral force between wind and earthquake is taken in to account.

Static force method:

$V = C\,W$, $V > V_{min} = 0.1\,A\,I\,W$

V: shear force from basic level (starts from upper surface level of foundation)
W: building weight (DL + 20% LL)
C: earthquake coefficient $C = ABI/R$

A: radix acceleration design ratio (earthquake to gravity)
B: building reflections coefficient (T_0 , T_s , T , s)
I: building importance coefficient
R: structure behavior coefficient

(T_0 , T_s , T , s) are related to Land Type table and shown in the 2800 bylaw.
T_0: soil period
T_s: structure period
T: (period of first mode) structure original time period (sec)
s: parameter related to soil
H: height of building starts from upper level surface of foundation

for steel structures:

for moment resisting frame: $T = 0.08H^{3/4}$
and for bracing systems: $T = 0.05H^{3/4}$

and if:

$0 \le T \le T_0$ --> $B = 1 + s * (T / T_o)$
$T_0 \le T \le T_s$ --> $B = s + 1$
$T_s \le T$ --> $B = (s+1) * (T_s / T)^{2/3}$

Building weight:

W_{roof} = DL + 20% LL + half load of downstairs' wall + parapet load

W_{roof} = (116*0.6) + (0.2*0.15*116) + (0.5*45*3.2*0.3) + (0.9*48.6*0.3) = 107802 kg

W_{3rdfl} = (116*0.5) + (0.2*0.2*116) + (0.5*45*3.2*0.3) + (0.5*45*3.6*0.3) = 108540 kg

$W_{1st,2nd}$ = (239.34*0.5) + (0.2*0.2*239.34) + (0.5*45*3.5*0.3) + (0.5*45*3.2*0.3) + (0.9*17.2*0.3) = 179113 kg

W_{grd} = (239.34*0.5) + (0.2*0.2*239.34) + (0.5*45*3.2*0.3) + (0.5*45*3.5*0.3) + (0.9*17.2*0.3) = 179113 kg

W_{total} = 753681 kg
Tables below show the area or mass coordinate ob the building:

Table: 5. 8.Area /Mass coordinate

floors	-
239.34	**Ai**
2096.6	**total AiXi**
1574.84	**total AiYi**
8.76	**Xm=AiXi/Ai**
6.58	**Ym=AiYi/Ai**

roof,3rd fl	-
116	**Ai**
852.6	**total AiXi**
1146.6	**total AiYi**
7.35	**Xm=AiXi/Ai**
9.85	**Ym=AiYi/Ai**

final Cm	-
355.34	**Ai**
2949.2	**total AiXi**
2721.44	**total AiYi**
8.3	**Xm=AiXi/Ai**
7.66	**Ym=AiYi/Ai**

Earthquake in Y direction:
Land type: type 2 and H = 16.3m
thus,

T_0 = 0.1 , T_s = 0.5 , s = 1.5 and $T = 0.05\ H^{3/4} = 0.41$ sec

$T_0 \leq T \leq T_s$ --> B = (1.5 + 1) = 2.5

A = 30% = 0.3g = 300 cm/sec^2 , R = 6 , I = 1.0

C_y = (0.3*2.5*1.0) / 6 = 0.125

$V_y = C_y$*W = 0.125*753681 = 94210 kg

V_{min} = 0.1 A I W = 22.61 --> 23.62 < 94.2 o.k !

Distribution of earthquake shears force (Y direction):

shear force for different levels:

$F_i = [\ w_i h_i / \sum w_i h_i\ ]\ (\ V - F_t\ )$

flagellation force:

$F_t = 0.07\ V\ T$ --> if $T > 0.7$
$F_t = 0.0$ --> if $T \leq 0.7$

thus, $T = 0.34$ sec and $F_t = 0$

Table: 5. 9.Distribution of shear load due to earthquake in Y direction

Levels	hi	Wi	wihi	wihi/∑wihi	V_y	Fi	Fihi
5	16.3	107802	1757173	0.26	94210	24419	398033
4	13.1	108540	1421874	0.21	94210	19760	258851
3	9.9	179113	1773219	0.26	94210	24642	243958
2	6.7	179113	1200057	0.18	94210	16677	111736
1	3.5	179113	626896	0.09	94210	8712	30492
Sum	-	753681	6779218	1.00	-	94210	1043070

Overturning and resisting moment:

$M_o = \sum Fi\ hi\ ,\ M_R = \sum wi\ (\ d / 2\ )$

d: building length

$M_R / M_o > 1.75$ -------> $9.97 > 1.75$ o.k !

Table: 5. 10.Overturning and resisting moment

W	B	M_R	M_o
753681	13.8	10400798	1043070

Accidental torsion in Y direction:

Ti = 0.05 Fi B

Ti: accidental torsion for i level

B: building length perpendicular to earthquake force

Fi: earthquake force for i level

level	Fi	B	Ti
5	24419	18.5	22587.78
4	19760	18.5	18277.65
3	24642	18.5	22794.05
2	16677	18.5	15426.27
1	8712	18.5	8058.50

Earthquake in X direction:

Land type: type 2 and H = 16.3m

thus,

$T_0 = 0.1$, $T_s = 0.5$, s = 1.5 and $T = 0.05\ H^{3/4} = 0.41$ sec

$T_0 \leq T \leq T_s$ --> B = (1.5 + 1) = 2.5

A = 30% = 0.3g = 300 cm/sec^2 , R = 6 , I = 1.0

$C_x = (0.3*2.5*1.0) / 6 = 0.125$

$V_x = C_x*W = 0.125*753681 = 94210$ kg

$V_{min} = 0.1\ A\ I\ W = 22.61$ --> 23.62 < 94.2 o.k !

Distribution of earthquake shears force (X direction):

shear force for different levels:

$F_i = [\ w_i h_i / \sum w_i h_i\ ]\ (\ V - F_t\ )$

flagellation force:

$F_t = 0.07\ V\ T$ --> if T > 0.7

$F_t = 0.0$ --> if $T \leq 0.7$

thus, T = 0.34 sec and $F_t = 0$

Table: 5. 11.Distribution of shear load due to earthquake in X direction

Levels	hi	wi	wihi	wihi/∑wihi	V_x	Fi	Fihi
5	16.3	107802	1757173	0.26	94210	24419	398033
4	13.1	108540	1421874	0.21	94210	19760	258851
3	9.9	179113	1773219	0.26	94210	24642	243958
2	6.7	179113	1200057	0.18	94210	16677	111736
1	3.5	179113	626896	0.09	94210	8712	30492
Sum	-	753681	6779218	1	-	94210	1043070

Overturning and resisting moment:

$M_o = \sum Fi\ hi$, $M_R = \sum Wi\ (d / 2)$

d: building length

$M_R / M_o > 1.75$ -------> 13.37 > 1.75 o.k !

Table: 5. 12.Overturning and resisting moment

W	B	M_R	M_o
753681	18.5	13943099	1043070

Accidental torsion in X direction:

Ti = 0.05 Fi B
Ti: accidental torsion for i level
B: building length perpendicular to earthquake force
Fi: earthquake force for i level

level	Fi	B	Ti
5	24419	13.8	16849.26
4	19760	13.8	13634.14
3	24642	13.8	17003.13
2	16677	13.8	11507.17
1	8712	13.8	6011.21

Earthquake force and shear force distribution diagrams Figure:

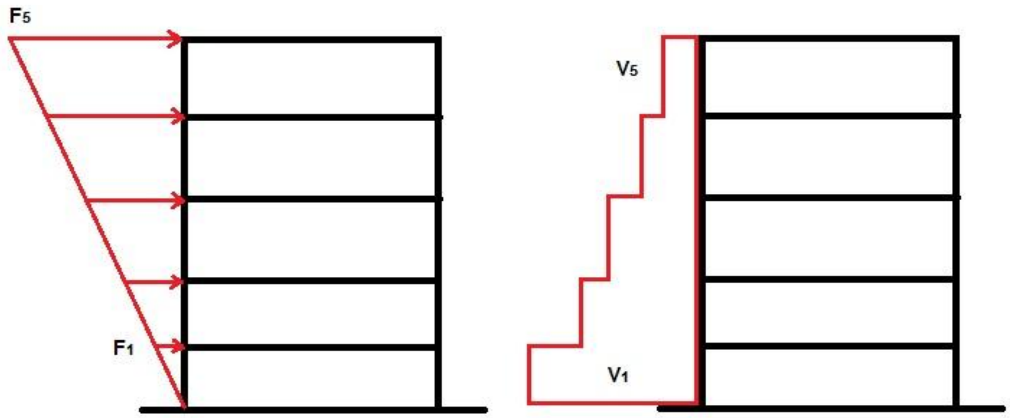


Fig.5. 12.Earthquake force and shear force distribution diagrams

5-8- Basement concrete wall resistance

Since in this building there is a basement for parking function in which surrounded by reinforcement concrete walls in four directions, it is possible to consider the up top level of these walls as a basic level for earthquake shear force instead of upper level of foundation. With this solution significant reduction of the basic shear force applied by the earthquake load action is considerable. But for this aim the resistant analysis of walls are required. And in addition it is necessary to fulfill back of the walls with local soil properly.

$R = 1 / 2 * P_p * (Q)$

$R > V$ (earthquake shear force)

$P_p = k_p * 8h$

$K_p = (1 + \sin Ø) / (1 - \sin Ø)$

P_p: soil force
K_p: soil inset coefficient
Ø: soil friction angle
R: wall resistance if properly filled by soil
h: wall hight
8: soil density
Q: effective dimension

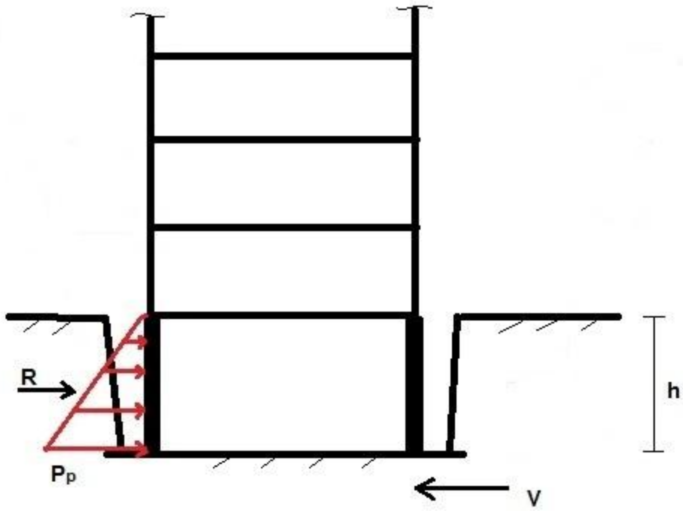


Fig.5. 13.Concrete wall and soil force resistance against earthquake shear force

$Ø = 35°$, $ɣ = 1.8\ (t / m^3)$, $h = 3.5$ m
$K_p = (1 + \sin Ø) / (1 - \sin Ø) = (1 + \sin 35) / (1 - \sin 35) = 3.69$
$P_p = k_p * ɣh = 3.69 * 1.8 * 3.5 = 23.31\ (t/m^2)$

Y direction:
$R_x = 1 / 2P_p (Q) = 1 / 2 * 23.31*(3.5 * 13.8) = 562937$ kg , $V_x = 94210$ kg
$R_x >> V_x$ ok !
And

Y direction:

$R_y = 1 / 2P_p (Q) = 1 / 2 * 23.31*(3.5 * 18.5) = 754661$ kg , $V_y = 94210$ kg
$R_y >> V_y$ ok !

Thus, it is possible to take H (hight of building) from ground level, if basement walls properly filled by surrounding soil.
And now, we again start the earthquake analysis by taking to account the recent calculations to see the difference in distribution shear forces for each level.
For Y direction:
Same computing and analysis done in the earthquake load action is used for this session.

Thus,
H=12.8(m) , W= 574568 (kg)
$T= 0.05H^{3/4} = 0.34$ sec
$T_s \leq T$ --> $B= (1.5+1)= 2.5$

C_y= 0.125
V_y= C_y*W = 0.125*574568= 71821 kg
V_{min} = 0.1 AIW = 17.23 --> 17.23 < 72 o.k !
and:
(new V_y) 71,821 < 94,210

Table: 5. 13.Shear loads due to earthquake in Y direction

Levels	hi	wi	wihi	wihi/∑wihi	V_y	Fi	Fihi
5	12.8	107802	1379866	0.33	71821	23930	306308
4	9.6	108540	1041984	0.25	71821	18071	173478
3	6.4	179113	1146323	0.28	71821	19880	127233
2	3.2	179113	573162	0.14	71821	9940	31808
1	0	0	0.00	0.00	0	0.00	0.00
Sum	-	-	4141334	1.00	-	71821	638826

It is obvious that in the second floor the amount reduced from 16677 (kg) to 9940 (kg), and this is happening for all other floors and levels.
Overturning and resisting moment:

Table: 5. 14.Overturning and resisting moment

W	B	M_R	M_o
574568	13.8	7929038	638826

M_o= ∑ Fi hi , M_R = ∑ Wi (d/2)
d: building length
M_R/M_o > 1.75 -------> 12.4 > 1.75 o.k !

Also, it has reduced the overturning moment from 1043070 (kg.m) to 638826 (kg.m) in Y direction.

Accidental torsion:

Level	Fi	B	Ti
5	23930	18.5	22136
4	18071	18.5	16715
3	19880	18.5	18389
2	9940	18.5	9195
1	0.00	0	0.00

Same calculation and result for direction X:

Table: 5. 15.Shear loads due to earthquake in X direction

Levels	hi	wi	wihi	wihi/∑wihi	V_x	Fi	Fihi
5	12.8	107802	1379866	0.33	71821	23930	306308
4	9.6	108540	1041984	0.25	71821	18071	173478
3	6.4	179113	1146323	0.28	71821	19880	127233
2	3.2	179113	573162	0.14	71821	9940	31808
1	0	0	0.00	0.00	0	0.00	0.00
Sum	-	-	4141334	1	-	71821	638826

Overturning and resisting moment in X direction:

$M_o = \sum F_i h_i$, $M_R = \sum W_i (d/2)$
d: building length
$M_R/M_o > 1.75$ -------> 16.64 > 1.75 o.k !

Table: 5. 16.Overturning and resisting moment

W	B	M_R	Mo
574568	18.5	10629508	638826

Accidental torsion in X direction:

Level	Fi	B	Ti
5	23930	13.8	16512
4	18071	13.8	12469
3	19880	13.8	13717
2	9940	13.8	6859
1	0.00	0	0.00

In the end of calculation of applied loads to the structure by obtained wind load action and earthquake load action, in fact, we can see that in this project according to every property related to the building location, building material and structure the wind force is much lower than the forces that generated from earthquake action, therefore, we consider the seismic load action instead of the wind action for this specific project. And, next step is to find the load combinations for structure analysis and design.

5-9- Load combination

For structural design and analysis, the effects of the different loads should be defined from the combination of the loads that might happen for structure simultaneously. Whereas, in a very rare status, all of the supposed load actions may happen simultaneously, thus, it is obligatory for an engineer to select load combinations correctly, in this project, part of the load actions based on their probability of occurrence is considered. Commonly, the combination load for steel structure buildings in Iran is selected as following table 5.17.

Table: 5. 17.Load combinations

Code	Combination
COMB1	D
COMB2	D+L
COMB3	0.75(D+L+Ex)
COMB4	0.75(D+L-Ex)
COMB5	0.75(D+L+Ey)
COMB6	0.75(D+L-Ey)
COMB7	0.75(D+Ex)
COMB8	0.75(D-Ex)
COMB9	0.75(D+Ey)
COMB10	0.75(D-Ey)

5-10- Manual calculation for the simple supported frames

The approximate method for structure analysis makes it possible for engineer to grasp an appropriate understanding of structural loading status in order to have a preliminary design. For the purpose of approximate analysis two methods of 1) frame method and 2) 0.1L method are considered. Meantime, for the aim of perceptual design of sections in simply supported frames, none of these methods are possible to use, but mid-span moment calculation method by $qL^2/8$. The load combination of (D+0.2L) is considered for this purpose and was applied in the form of a linear distributed force on the beams.

As you can see from the figures and calculation, no bending moments due to the gravitational load will happen because of the simple supported joint at the both sides of the beams. Thus, bending moment and shear force due to the vertical load is negligible for columns of the simple supported frame.

As a sample this calculation is done for frame 3(in X direction):

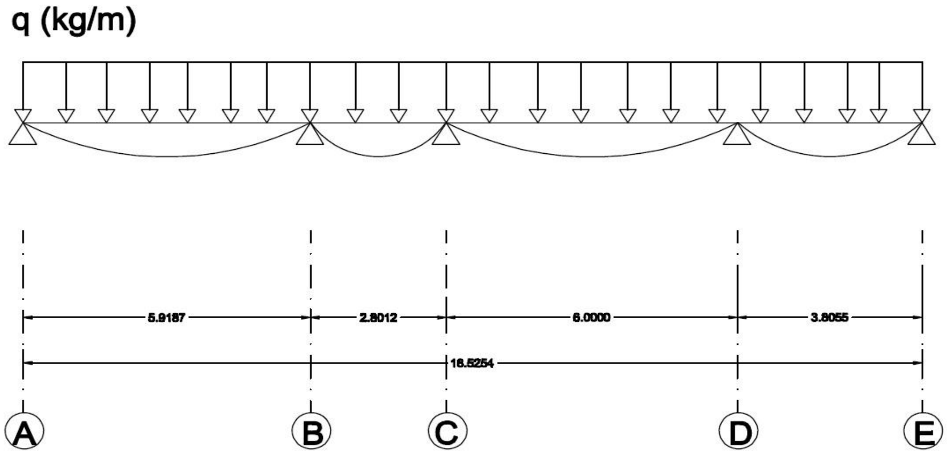


Fig.5. 14.Bending moment diagram under the vertical loading for simple support frame 3

By $qL^2/8$ moment method in the middle of the beam.

Shear for Roof beam A to E:

V_{AB} = 0.5*q*L_{AB} = 0.5*1388(kg/m)*5.9(m) = 4095 (kg)
V_{BC} = 0.5*q*L_{BC} = 0.5*1388(kg/m)*2.8(m) = 1943 (kg)
V_{CD} = 0.5*q*L_{CD} = 0.5*1388(kg/m)*6(m) = 4146 (kg)
V_{DE} = 0.5*q*L_{DE} = 0.5*0(kg/m)*3.8(m) = 0 (kg)

Moment for Roof beam A to E:

$M_{AB} = qL^2_{AB}/8 = 1388*(5.9)^2/8 = 6040$ (kg.m)
$M_{BC} = qL^2_{BC}/8 = 1388*(2.8)^2/8 = 1360$ (kg.m)
$M_{CD} = qL^2_{CD}/8 = 1388*(6)^2/8 = 6246$ (kg.m)
$M_{DE} = qL^2_{DE}/8 = 0*(3.8)^2/8 = 0$ (kg.m)

Moment for Floor beams A-E:

$M_{AB} = qL^2_{AB}/8 = 2666*(5.9)^2/8 = 11600$ (kg.m)
$M_{BC} = qL^2_{BC}/8 = 2693*(2.8)^2/8 = 2639$ (kg.m)
$M_{CD} = qL^2_{CD}/8 = 2586*(6)^2/8 = 11637$ (kg.m)
$M_{DE} = qL^2_{DE}/8 = 2680*(3.8)^2/8 = 4837$ (kg.m)

Roof, main beams in frame 3 (X direction) in table 13:

Table: 5. 18.Shear and moment of AE roof main beam in frame 3

Beam	Shear(kg)		
	start	middle	end
AB	4095	0	4095
BC	1943	0	1943
CD	4164	0	4164
DE	0	0	0

Beam	Moment(kg.m)		
	start	middle	end
AB	0	6040	0
BC	0	1360	0
CD	0	6246	0
DE	0	0	0

Floors, AE main beams in frame 3 (X direction):

Table: 5. 19. Shear and moment of AE floor main beam in frame 3

Beam	Shear(kg)		
	start	middle	end
AB	7865	0	7865
BC	3770	0	3770
CD	7758	0	7758
DE	5092	0	5092

Beam	Moment(kg.m)		
	start	middle	end
AB	0	11600	0
BC	0	2639	0
CD	0	11637	0
DE	0	4837	0

The same method for the frame A in direction Y:

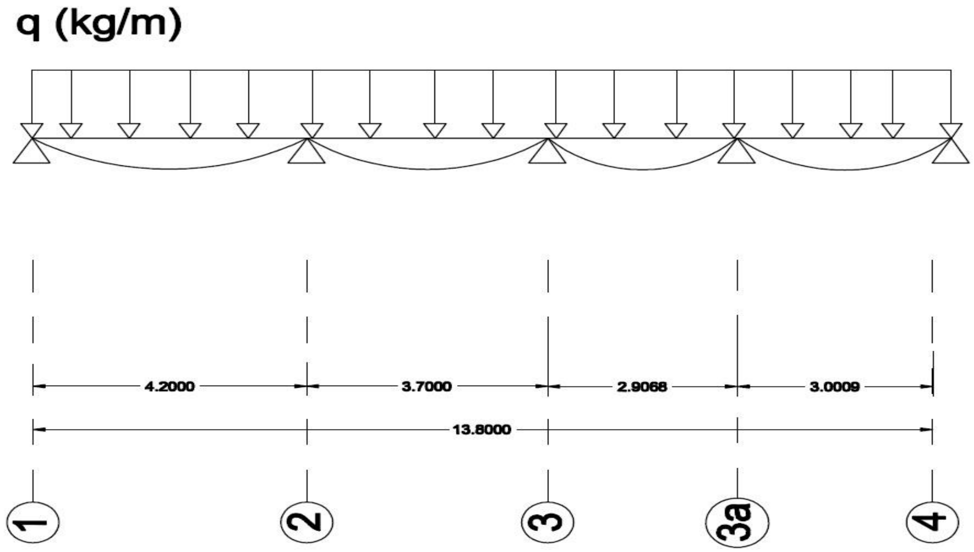


Fig.5. 15.Bending moment diagram under the vertical loading for simple support frame A

By $qL^2/8$ moment method in the middle of the beam.

Shear for Roof beam 1- 4:

$V_{12} = 0.5*q*L_{12} = 0.5*200$ (kg/m)*4.2 (m) = 420 (kg)

$V_{23} = 0.5*q*L_{23} = 0.5*200$ (kg/m)*3.7 (m) = 370 (kg)

$V_{33a} = 0.5*q*L_{33a} = 0.5*0$ (kg/m)*2.9 (m) = 0 (kg)

$V_{3a4} = 0.5*q*L_{3a4} = 0.5*0$ (kg/m)*3 (m) = 0 (kg)

Moment for Roof beam 1- 4:

$M_{12} = qL^2_{12}/8 = 200*(4.2)^2/8 = 441$ (kg.m)

$M_{23} = qL^2_{23}/8 = 200*(3.7)^2/8 = 342$ (kg.m)

$M_{33a} = qL^2_{33a}/8 = 0*(2.9)^2/8 = 0$ (kg.m)

$M_{3a4} = qL^2_{3a4}/8 = 0*(3)^2/8 = 0$ (kg.m)

By $qL^2/8$ moment method in the middle of the beam.

Shear for Floor beams 1- 4:

$V_{12} = 0.5*q*L_{12} = 0.5*200(kg/m)*4.2(m) = 420$ (kg)

$V_{23} = 0.5*q*L_{23} = 0.5*200(kg/m)*3.7(m) = 370$ (kg)

$V_{33a} = 0.5*q*L_{33a} = 0.5*200(kg/m)*2.9(m) = 290$ (kg)

$V_{3a4} = 0.5*q*L_{3a4} = 0.5*200(kg/m)*3(m) = 300$ (kg)

Moment for Floor beams 1- 4:

$M_{12} = qL^2_{12}/8 = 200*(4.2)^2/8 = 441$ (kg.m)

$M_{23} = qL^2_{23}/8 = 200*(3.7)^2/8 = 342$ (kg.m)

$M_{33a} = qL^2_{33a}/8 = 200*(2.9)^2/8 = 210$ (kg.m)

$M_{3a4} = qL^2_{3a4}/8 = 200*(3)^2/8 = 225$ (kg.m)

Roof, 1 to 4 beams in frame A (Y direction):

Table: 5. 20.Shear and moment of 1-4 roof main beam in frame A

Beam	**Shear(kg)**		
	start	**middle**	**end**
12	420	0	420
23	370	0	370
33a	0	0	0
3a4	0	0	0

Beam	**Moment(kg.m)**		
	start	**middle**	**end**
12	0	441	0
23	0	342	0
33a	0	0	0
3a4	0	0	0

Floors, 1-4 beams in frame A (Y direction):

Table: 5. 21. Shear and moment of 1-4 floor beam in frame A

Beam	Shear(kg)		
	start	middle	end
12	420	0	420
23	370	0	370
33a	290	0	290
3a4	300	0	300

Beam	Moment(kg.m)		
	start	middle	end
12	0	441	0
23	0	342	0
33a	0	210	0
3a4	0	225	0

5-11- Hand analysis for C-D main beam in frame 3 (X direction):

Assumption for the beam:

Compact member and laterally supported,

if :

$L' \leq L_c$ --> no lateral buckling $C_b = 1$

$L' > L_c$ --> lateral buckling occur so, check: $C_b = 1.75+1.05M_1/M_2+0.3(M_1/M_2)^2 \leq 2.3$ and $M_1 \leq M_2$

L' = length of lateral support to the main support

L_c = laterally unsupported length

L' = 0 --> because the beam flange is filled(covered) by concrete.
Which says it might be compact or non-compact member, we first hypothesize it is and then we control this state.

Lc --> is the minimum amount of:

$(635/\sqrt{F_y})*b_f$ = (cm) and $(14*10^5)/(d/t_f*b_f)*F_y$= (cm)

M_1 is lower moment amount and M_2 is higher moment amount in both side of laterally unsupported beam toward stronger axial section.

F_a= existing compressive stress (kg/cm^2)

F_y= steel yield strength (kg/cm^2)

F_b= bending allowable stress (kg/cm^2)
b_f= total width (flange width) (cm)
t_f= flange thickness (cm)
h= web height (flange to flange)
d= beam height (cm)
A_f= cross section area of flange in compression (cm^2)

As it is considered as compact member, calculation for the bending allowable stress;

$F_b = 0.66*F_y = 0.66*2400= 1584$ (kg/cm^2) ---> $W_x= M_{max}/ F_b = 11637*100/1584= 735$ (cm^3)
=> 904 cm^3 > 735 cm^3
=> Use IPE 360

Compact control:

Due to the lack of axial load in beam (P=0) there is no need for compact control, But better to be controlled. And also due to the continuous connection between the web and flange use the following equation:

A=72.7 (cm2) , d= 36(cm) , b_f= 17 (cm) , t_s= 0.8 (cm) , t_f= 1.27 , W_x= 904 (cm^3) , I_x= 16270 (cm^4)
$A_w= d*t_s= 36*0.8= 28.8$ (cm)
M_{max}= maximum moment in the C-D beam
W_x= section modulus (cm^3)
A= section area (cm^2)
$t_s=t_w$= web thickness
I_x= moment of inertia about the axis x-x (cm^4)
A_w= web section area (cm^2)
P= axial load (kg)

$b_f/2t_f \le 545/\sqrt{F_y}$ => $17/2*1.27 \le 545/\sqrt{2400}$ => $6.7 \le 11.12$ OK !

If : $F_a/F_y \le 0.16$ --> $d/t_w \le (5365/\sqrt{F_y})*(1-3.74*F_a/F_y)$
$F_a/F_y > 0.16$ --> $d/t_w \le (2155/\sqrt{F_y})$
As : P = 0 , $F_a= P/A = 0/A = 0$, $F_a/F_y = 0$ ----> so, $d/t_w \le (5365/\sqrt{F_y})*(1-0)$
=> $36/0.8 \le 109.5$ => $45 \le 109.5$ OK !

Lateral support control:

Due to the perch of beam in the floor concrete there is lateral support through beam length.
As beam is a compact member and laterally supported, compressive flange allowable stress is:

F_b= 0.66F_y --> F_b= 1584 (kg/cm^2)

the answer is equal to the considered initial stress, so the member is able to withstand the bending stress. OK !

Shear control:

if:

$h/t_w \leq 3185/\sqrt{F_y}$ --> diagonal buckling does not occur in the beam's web --> $T \leq F_v$= 0.4Fy

$h/t_w > 3185/\sqrt{F_y}$ --> diagonal buckling happens in the beam's web --> $T \leq F_v$ = calculate

=>

$45 \leq 65$ OK ! (no diagonal buckling)

$T = V/A_w$ ---> 7758/28.8 = 269.4 (kg/cm^2)

$T \leq F_v$= 0.4F_y => 269.4 (kg/cm^2) $\leq$ 960 (kg/cm^2) OK !

Deflection control:

The beam is simple supported (non-moment resistant) so:

Δ_{max}= L/240= 600/240 = 2.5 (cm)

Δ= 5ML^2/48EI = (5*10937*100*$(600)^2$)/(48*2.1*10^6*16270)= 1.20 (cm) OK !

=> Use IPE 360

T=existing shear stress (kg/cm^2)

V=shear force (kg)

F_v=shear allowable stress (kg/cm^2)

Δ=beam deflection (cm)

L=beam length (cm)

E=elastic modulus (Gpa)

I=area moment of inertia (cm^4)

5-12- Manual analysis of bracings

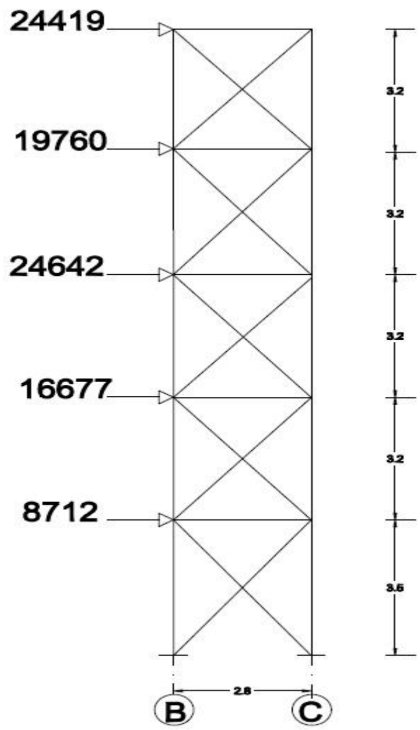


Fig.5. 16.Bracings in the frame B-C

Hand calculation for bracings in frame BC is analyzed. First the total shear force that applied to the structure obtained then calculations and controlling will be checked.

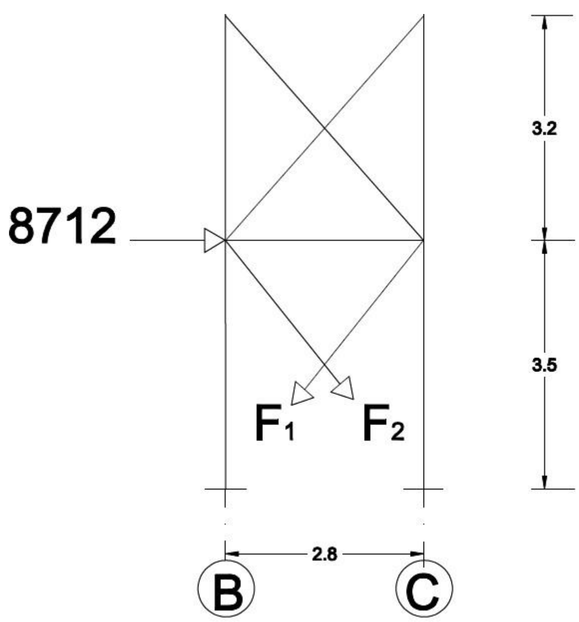


Fig.5. 17.Axial load of bracings

For this aim, definitions are as follows:

T=F= total shear base (kg)
F_i= shear force of each level (kg)
P=F_1,F_2= axial load in bracings (kg)
α= the angle between the bracing and the beam
σ = compressive stress (kg/cm^2)
A= cross section area of the member (cm^2)
A_g= gross cross section area of the member (cm^2)
K= effective length coefficient
KL= effective length
L= unsupported length of member (cm)
r = radius of gyration
λ= slenderness ratio
F_a= allowable compressive stress (kg/cm^2)
f_a= existing compressive stress (kg/cm^2)
B= allowable stress reduction factor
T= tensile strength, force (kg)
F_t= allowable tensile stress (kg/cm^2)
β= safety factor coefficient
F.S.= safety factor

Determination of total shear:

$T = \sum Fi = 24419+19760+24642+16677+8712= 94210$ (kg)
$P*\cos\alpha = F$, $F_1= F_2$ => $2F_1*\cos\alpha = 94210$, $\sqrt{[(2.8)^2+(3.5)^2]} = 4.5$ (m)
$\cos\alpha = (2.8/4.5)= 0.6$
=> $F_1= F_2 = 78508$ (kg)
And due to the 4 bracings in every level:
78508/4 = 19627 (kg)

Assumption: $\sigma = 1000\ kg/cm^2$, $A_{(need)}= F/\sigma = 78508/1000= 78.51$ (cm^2)
=> Use 2 UNP 260 D=10 mm A= 96.6 (cm^2)
Buckling control:
$K_x= 0.7$, $k_y= 0.5$, $r_x= 9.99$ (cm) , $r_y= 7.12$ (cm)

choose maximum of slenderness ratio,

$\lambda_x= K_x*L/r_x = 0.7*450/9.99= 31.53$
$\lambda_y= K_y*L/r_y = 0.5*450/7.12= 31.6$

$C_c = \sqrt{[2\pi^2 E/F_y]} = 6440/\sqrt{F_y} = 131$

=> $\lambda_x = 31.6 < C_c = 131$

if: $\lambda < C_c$ --> $F_a = ([1-(kL/r)^2/2]Fy) / (5/3+3/8*(kL/r)/C_c-1/8[(KL/r)/C_c]^3)$

or

$F_a = (1 - 0.5\beta^2)\ Fy/F.S.$, $\beta = [KL/r]/C_c$, $F.S. = 1.67+0.375\beta - 0.125\beta^3$

$\lambda > C_c$ --> $F_a = 12\pi^2 E/23[KL/r]^2 = 105*10^5/[KL/r]^2$

Thus, $F_a = 1040\ (kg/cm^2)$

And with consideration of 33% enhancement in allowable stress due to existence of lateral forces in combination loads:

$F_a = 1.33 * 1040 = 1383.2\ (kg/cm^2)$

reduction of allowable stress,

$F_{as} = BF_a$, $B = 1/[(1+\lambda_{max})/2C_c] = 1/[(1+80.6/2*131)] = 0.76$

$F_{as} = 0.76*1383.2 = 1051\ (kg/cm^2)$

Existing stress in bracings (according to 2800 bylaw),

$f_a = F/A = 78508/108.6 = 723\ (kg/cm^2)$

--> 723 < 1051 OK !

Tensile control:

$T_{max} = 78508\ (kg)$, $F_t = T_{max}/ Ag$, $F_t = 0.6(F_y)1.33$

$0.75A_g = 78508/[0.6(F_y)]$ => $A_g = 72.69\ (cm^2)$ OK !

$(KL/r)_{max} < 300$ => $31.6 < 300$ OK !

=> Use 2UNP 260 D=10 mm

Same calculation for the 2-3 frame:

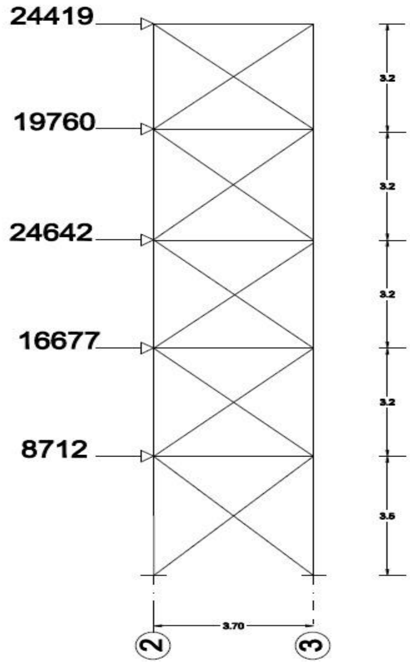


Fig.5. 18.Bracings in the frame 2-3

Determination of total shear:

T = ∑Fi = 24419+19760+24642+16677+8712= 94210 (kg)

P*cosα = F , F_1= F_2 => $2F_1$*cosα = 94210 , $\sqrt{[(3.7)^2+(3.5)^2]}$= 5.1 (m)
cosα = (3.7/5.1)= 0.73
=> F_1= F_2 = 64527 (kg)

And due to the 4 bracings in every level:
64527/4 = 16132 (kg)
Assumption: σ = 1000 kg/cm^2 , $A_{(need)}$= F/σ = 64527/1000= 64.53 (cm^2)
= > Use 2 UNP 260 D=10 mm A= 96.6 (cm2)
Buckling control:

K_x= 0.7 , k_y= 0.5 , r_x= 9.99 (cm) , r_y= 7.12 (cm)

choose maximum of slenderness ratio,

λ_x= K_x*L/r_x = 0.7*510/9.99= 35.74
λ_y= K_y*L/r_y = 0.5*510/7.12= 35.8
C_c = $\sqrt{[2\pi^2 E/F_y]}$= 6440/$\sqrt{F_y}$= 131

=> λ_x=35.8 < C_c =131

If: $\lambda < C_c$ --> F_a= ([1-(kL/r)^2/2]Fy)/(5/3+3/8*(kL/r)/C_c-1/8[(KL/r)/C_c]^3)
or
F_a= (1-0.5β^2)Fy/F.S. , β= [KL/r]/C_c , F.S.=1.67+0.375β-0.125β^3
$\lambda > C_c$ --> F_a=12π^2E/23[KL/r]^2= 105*10^5/[KL/r]^2

Thus, F_a= 968 (kg/cm^2)
And with consideration of 33% enhancement in allowable stress due to existence of lateral forces in combination loads:
F_a= 1.33 * 968 = 1287 (kg/cm^2)
reduction of allowable stress,
F_{as}= BF_a , B= 1/[(1+λ_{max})/2C_c] = 1/[(1+91.3/2*131)]= 0.74
F_{as}= 0.74*1287 = 952.4 (kg/cm^2)

Existing stress in bracings (according to 2800 bylaw),
f_a= F/A= 64527/108.6 = 594 (kg/cm^2)
--> 594 < 952 OK !
Tensile control:

T_{max}= 64527 (kg) , F_t= T_{max}/ Ag , F_t= 0.6(F_y)1.33
0.75A_g= 64527/[0.6(F_y)] => A_g= 59.75 (cm^2) OK !
$(KL/r)_{max}$ < 300 => 35.8 < 300 OK !

=> Use 2UNP 260 D=10 mm

5-13- Manual analysis of column

Axial load due to the lateral forces in columns adjacent to bracings:

In column B = compression with (-) sign due to the earthquake load and in column C = tension with (+) sign due to the same load.

For analysis of axial load in columns, first there is a need to find bending moment on each floor column due to the lateral earthquake forces:

M = $\sum$ Fi(ri)
Fi= shear load for i level (kg)
ri= distance from Fi load to the middle of selected column (m)

for basement column we have:

M=24419(4*3.2+3.5/2)+19760(3*3.2+3.5/2)+24642(2*3.2+3.5/2)+16677(3.2+3.5/2)+8712(3.5/2)
= 878202 (kg.m)
P= (+,-) 878202/2.8= (+,-) 313644 (kg) axial load of basement column

B and C columns adjacent to the bracings (kg):

Table: 5. 22.Axial loads in bracings and columns in frame BC

Levels	earthq. Shear	axial forces in bracings		axial forces in columns
3rd	24419	(+)18499	(-)18499	13954
2nd	19760	(+)33469	(-)33469	53153
1st	24642	(+)52137	(-)52137	117724
Gr	16677	(+)16192	(-)16192	205906
Bsm	8712	(+)19627	(-)19627	313644

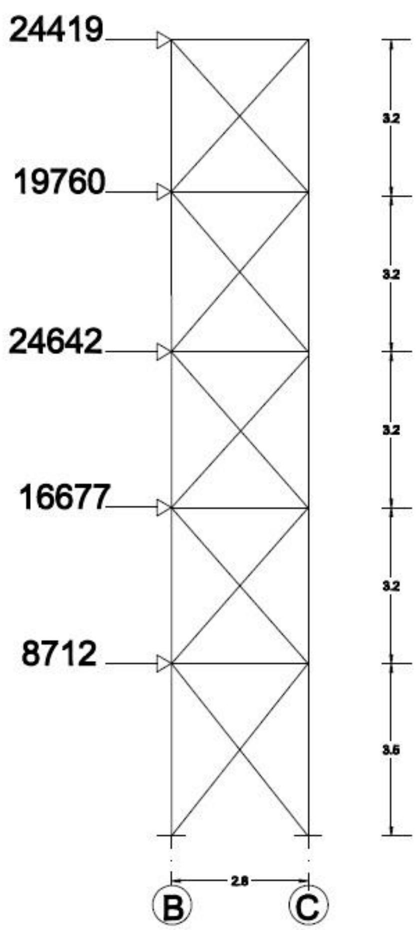


Fig.5. 19.Bracings and columns of frame B-C

Axial loads of A to D columns in frame 3:

Table: 5. 23.Axial loads in A to D columns of axis 3

	Levels	Axial load (D+L)	Axial load (E)	0.75(D+L+E)
A column in frame 3	3^{rd}	4095	0	3071.3
	2^{nd}	12152	0	9114
	1^{st}	20209	0	15157
	Gr	28266	0	21199.5
	Bsm	36323	0	27242.3
B column in frame 3	3^{rd}	6000	13954	14965.5
	2^{nd}	17824	53153	53233
	1^{st}	29647	117724	110528.3
	Gr	41471	205906	185532.8
	Bsm	53294	313644	275203.5
C column in frame 3	3^{rd}	6105	13954	15044.3
	2^{nd}	18050	53153	53402.3
	1^{st}	29995	117724	110789.3
	Gr	41940	205906	185884.5
	Bsm	53885	313644	275646.8
D column in frame 3	3^{rd}	4125	0	3093.8
	2^{nd}	17423	0	13067.3
	1^{st}	30720	0	23040
	Gr	44018	0	33013.5
	Bsm	57316	0	42987

Design for C column of frame 3 in first floor:

Axial load in this column is:

P= 110789.3 (kg)

Assumption: F_a= 1000 kg/cm^2 , $A_{(need)}$= P/F_a = 110789.3/1000= 110.8 (cm^2)

=> Use 2 IPE 180 + 2PL 250x10 (mm) D= 100(mm) A= 97.8 (cm^2)

Buckling control:

K_x= k_y = 1.0 , r_x= 8.55 (cm) , r_y= 6.4 (cm) , I_x= 7160 (cm^4) , I_y= 4000 (cm^4)

choose maximum of slenderness ratio,
$\lambda_x = K_x*L/r_x = 1.0*320/8.55 = 37.4$
$\lambda_y = K_y*L/r_y = 1.0*320/6.4 = 50$

$C_c = \sqrt{[2\pi^2 E/F_y]} = 6440/\sqrt{F_y} = 131$
=> $\lambda_y=50 < C_c = 131$ OK !

if: $\lambda < C_c$ --> $F_a = ([1-(kL/r)^2/2]F_y)/(5/3+3/8*(kL/r)/C_c-1/8[(KL/r)/C_c]^3)$
or
$F_a = (1-0.5\beta^2)F_y/F.S.$, $\beta = [KL/r]/C_c$, $F.S. = 1.67+0.375\beta-0.125\beta^3$
$\lambda > C_c$ --> $F_a = 12\pi^2 E/23[KL/r]^2 = 105*10^5/[KL/r]^2$

Thus, $\beta = 50/131 = 0.38$

allowable stress:

=> $F_a = [(1-0.5*(0.38)^2)*2400]/[1.67+0.375*(0.38)-0.125*(0.38)^3]$
$F_a = 1233$ (kg/cm^2)

Cross section control:

$P = A*F_a = 97.8*1233 = 120587.4$ (kg)
$P_{column} = 120587.4$ (kg) > $P_{existing} = 110789.3$ OK !

=> Use 2 IPE 180 + 2PL 250x10 (mm) D= 100(mm)

5-14- Simple support connection between the beam and column

Determination of N(depth of L):
IPE 360

$N = (R/0.66*F_y*t_w)-2.5k \geq k$

$f_b \leq F_b$

$(wl^2/8)/903 \leq 0.66*2400$ (compact condition) => w= 31.8 (kg/cm)

V= R= wl/2= 31.8*600/2= 9540 (kg)

N= 9540/(0.66*2400*0.8)-2.5*2.25= 1.9 => N $\geq$ k= 2.25 => so, N= 3(cm)

=> use L100*100*10

Determination of moment arm e and e_f:

$e= e_f-t-1$, $e_f= ms+(N/2)$

considering L 100*100*10,

e= 3.5-1.0-1= 1.5 cm , ef= 2+(3/2)= 3.5

length and thikness of L:

M= R*e

$S= b*t^2/6$

$f_b= M/S= (6Re/bt^2) \leq 0.75F_y$ => $t^2= (8Re/F_yb)$ (thickness)

$b \geq b_f+2*2$ cm (length)

=> $b \geq$ 18+2*2 cm= 22cm b= 22(cm)

$t^2= (8*9540*1.5)/(2400*22)$ => t= 2.17 N.G ! => L 120*120*12

control:

e= 3.5-1.2-1= 1.3cm

$f_b= (9540*0.5)/22*(1.2^2/6)= 903 \leq 1800$ ok !

=> use L 120*120*12

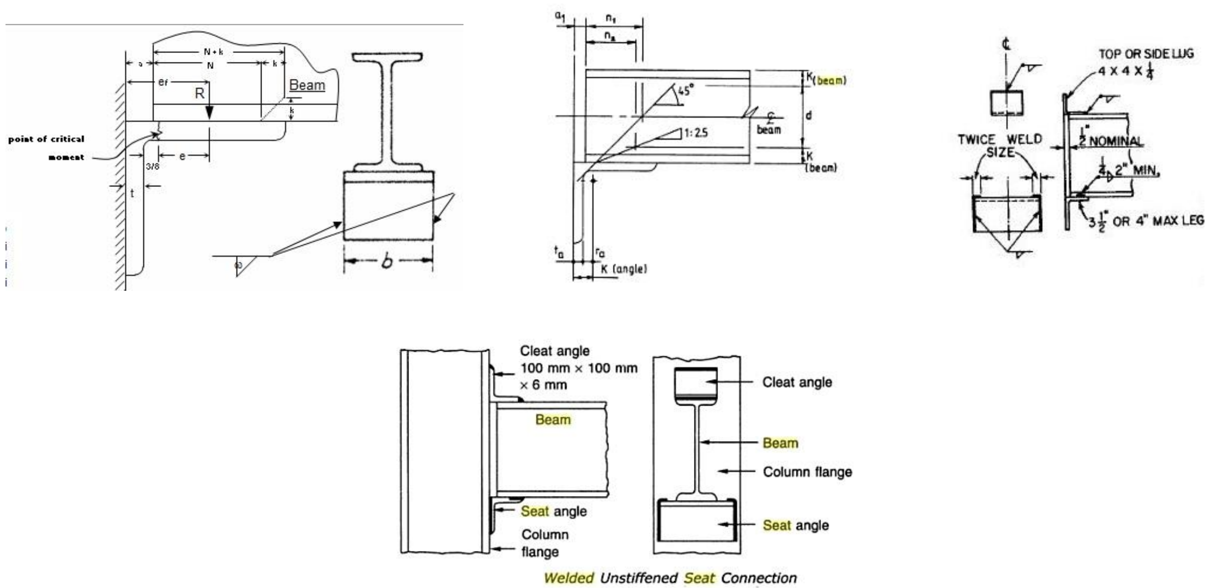


Fig.5. 20.Simple support connections of beam and column in steel structure

welding capacity control:

shear: $fy= R/(2l_w t)= 9540/2*1*12= 397.5$

moment: $f'x= (Re_f)*(l_w/2)/(2tl_w^3/12)= 3Re_f/l_w^2= 3*9540*3.5/(12)^2= 695.6$

$fr= \sqrt{f'x^2+fy^2}= \sqrt{397.5^2+695.6^2}= 801 \ \leq \ R_w= 650D$

=> $D= 801/650= 1.2cm= 12mm$

N= depth of L
R=V= shear force in the support
t_w= web thickness of IPE(beam)
K=C= neutral axis of the beam cross section
f_b= existing moment of inertia
F_b=allowable moment of inertia
w= maximum resistant load of the beam
l= beam length
e= space between resistant load and center of coordination of L
ef= space in between resistant load and column flange
ms= montage space (assembly)
M= moment of inertia by resistant load
S= section modulus
b= length of L

t= thickness of L
fy= welding shear stress in y axis
f'x= welding moment stress in x axis
fr= stress combination
D= welding dimention
R_w= welding value
l_w= welding length

5-15- Connections between bracings, beam and column in the structure

column: 2IPE 200 , beam: IPE 180 , brace: 2UNP 260

design of UNP welding to the plate:
D_{min}= 7mm
D_{max}= $1.52f_y t/\mu f_u$= 1.52*2400*0.85/0.75*4200= 0.98
=>   D= 7mm

connection force= 0.4R*F= 0.4*6*16677= 40025 (kg)
allowable tensile capacity= Af_y= 96.6*2400= 231840 (kg)

so, selecting of first amount(minimum force), P_1= 40025 (kg) and   n= 4
1.7*0.75*0.3*4200*√2/2*0.7*4L= 40025 =>   L= 12.58 (cm), we select   L= 20 (cm) welding length

connection of plate to beam and column:
P_x= 40025 cos31=34308 (kg)
P_y= 40025 sin31= 20614 (kg)
D= 7mm

1136*0.7*2L= 34308 => L= 21.57 => L= 25 (cm) length of plate to the beam
1136*0.7*2L= 20614 => L= 12.96 => L= 15 (cm) length of plate to the column

by kiss method:
welding design for shear and bending moment,

f_v= P_x/2L= 34308/(2*25)= 686 (kg/m)
f_b= M/W , W= $L^2/3$

f_b= 3000*100/(25^2/3)= 1440 (kg/cm)
f_r= $\sqrt{f_v^2+f_b^2}$= $\sqrt{(686)^2+(1440)^2}$= 1595 (kg/cm)
1136D= 1595 => D= 1.4 cm > Dmax => so, length between beam and plate should be reselected,

new L= 35 (cm)
f_v= 490 (kg/cm)
f_b= 735 (kg/cm)
=> fr= 883 (kg/cm) , 1136D= 883 => D= 0.77 cm => D= 8 (mm)
connection of plate to the column:

same calculation has done and L= 30 (cm) is selected
f_v= 20614/(2*30)= 343.6 (kg/cm)
f_b= 2000*100/$(30)^2$/3= 666.7 (kg/cm)
=> f_r= $\sqrt{343.7^2+666.7^2}$= 750 (kg/cm)
1136D= 750 => D= 0.66 => D= 7(mm)
controling of dimension of the plate:
according to effective length of whitmore,
ΔCC'C'': cos31= 5/h_1 => h1= 5.83 cm
ΔABC': tg31= h/35 => h= 21 cm

F= earthquake shear load
P_y= vertical component force in the plate
P_x= horizontal component force in the plate
f_b= welding moment stress
f_v= welding shear stress
A_t= net cross section area due to tensile
F_t=allowable tensile stress
P_{st}= tensile strength of middle plate
P_{sc}= compressive strength of plate in between beam and column
W= effective length of whitmore (length of the plate in the middle of frame)
t= thickness of the plate in the middle of the frame
t_{xy}= vertical shear stress
σ_x= vertical stress in X axis
σ_y= vertical stress in Y axis
σ_h= comparison stress
A_v= net cross section due to shear
F_v= allowable shear stress
P_1= design force

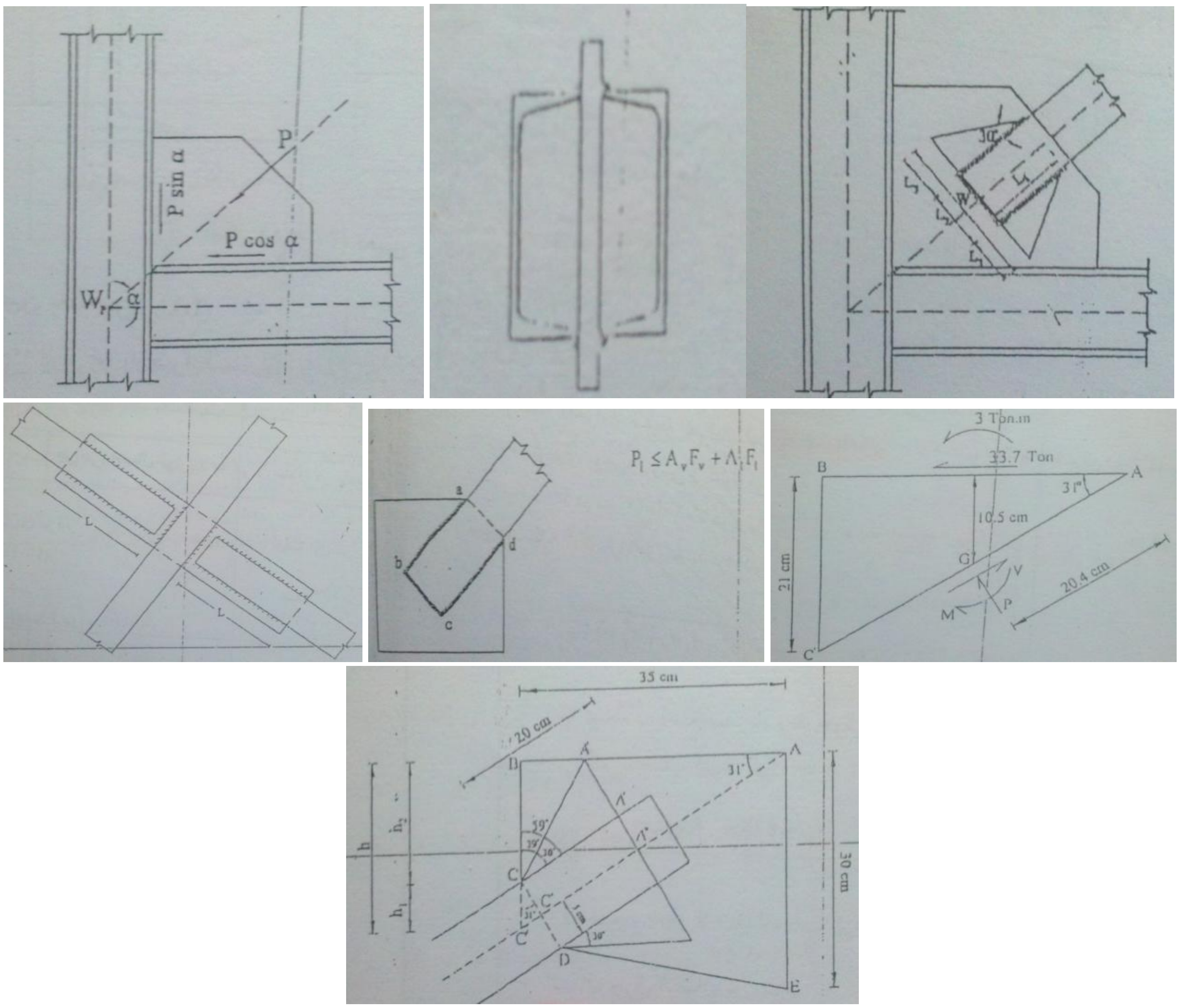


Fig.5. 21.Related details of connections between beam and column to the bracings

=> h2= h- h1 = 21- 5.83 = 15.17 (cm)

ΔA'BC: cos 29= h2/CA' => CA'= 17.34 (cm)

ΔA'CA'': sin30= AA''/CA' => AA''= 8.67 (cm)

W= AA''*2+10= 27.34 (cm)

P_{st}= F_yWt= 2400*27.34*1.5= 98280 (kg) > P_1 OK !

Buckling control of the plate:

AA'''= AC'- C'C''- C''A''

ΔABC':cos31= 35/AC' => AC'= 40.8 (cm)

ΔCC'C'':sin31= C'C''/h_1 => C'C''= 3 (cm)

ΔCA'A'': cos30= C''A''/CA' => C''A''= 15.02 (cm)

AA'''= 40.8-3-15.02= 22.78 (cm)

KL/r= 1.2*22.78/0.48= 60.78 , r= 0.3t= 0.3*1.5= 0.45 => F_a= 1162 (kg/cm^2)

P_{sc}= 1.7F_aWt= 1.7*1162*27.34*1.5= 81011 (kg) > P_1 OK !

Casted shear control:

$P_1 \leq A_vF_v+A_tF_t$
A_v= 2*20*1.5= 60 (cm^2) , F_v= 0.3*3600= 1080n(kg/cm^2)
A_t= 10*1.5= 15 (cm^2) , F_t= 0.5*3600= 1800 (kg/cm^2)

$A_vF_v+A_tF_t$= 91800 (kg) > P_1 OK !

buckling control of free edge in plate:
due to the higher length of DE, this control only goes for DE,

DE= 31 cm , BC= 15.17
31/1.5= 20.66
$0.75\sqrt{(2.1*10^6/2400)}$= 22.18

$L/t \leq 0.75\sqrt{(E/F_y)}$ => 20.66 < 22.18 OK !

stress combination control:
in connection of the plate to the beam,

t_{xy}= 34308/(35*1.5)= 653 (kg/cm^2)
σ_y= MC/I= (3000*100*35/2)/[(1/12)*1.5*35]= 979 (kg/cm^2)
σ_x= 0

σ_h= $\sqrt{979^2+3*642^2}$= 1482 (kg/cm2) < F_y OK !

plate for connection of column, beam and bracings,

=> use PL 350*300*310*152 t=150mm

plate for the middle space of the frame,

=> use PL 700*274*150

5-16- Software analysis

Following the hand calculation of beam, column and bracings in the frame of the structure, an appropriate perception for the amount of loads and forces in the structural members were obtained. These achievements are beneficial in obtaining of cross sections from software output and also checking/comparing the software final result. Since the project is residential building and located in Iran, therefore, the initial assumptions and input data and even the typical beam and columns cross sections are all considered for this aim. For the analysis and design of this structure Etabs software is used.

By analysis of the structure, results are as follows:

Selected beam sections in X direction:

Table: 5. 24.Selected beam sections in direction X

		X direction				
Level	**Beam**	**1**	**2**	**3**	**3a**	**4**
roof	AB	IPE 360	IPE 450	IPE 360	-	-
	BC	IPE 200	IPE 240	IPE 200	-	-
	CD	IPE 360	IPE 450	IPE 360	-	-
3rd	AB	IPE 450	IPE 450	IPE 450	IPE 450	IPE 360
	BC	IPE 200	IPE 240	IPE 300	-	IPE 240
	CD	IPE 450	IPE 450	IPE 450	-	IPE 450
	DE	-	IPE 240	IPE 360	-	IPE 300
2nd	AB	IPE 360	IPE 450	IPE 450	IPE 450	IPE 360
	BC	IPE 200	IPE 240	IPE 240	-	IPE 240
	CD	IPE 450	IPE 450	IPE 450	-	IPE 450
	DE	-	IPE 240	IPE 360	-	IPE 300
1st	AB	IPE 360	IPE 450	IPE 450	IPE 450	IPE 360
	BC	IPE 200	IPE 240	IPE 240	-	IPE 240
	CD	IPE 450	IPE 450	IPE 450	-	IPE 450
	DE	-	IPE 240	IPE 360	-	IPE 300
grd	AB	IPE 360	IPE 450	IPE 450	IPE 450	IPE 360
	BC	IPE 200	IPE 240	IPE 240	-	IPE 240
	CD	IPE 450	IPE 450	IPE 450	-	IPE 450
	DE	-	IPE 240	IPE 360	-	IPE 300

Beam typical sections in Y direction:

Table: 5. 25.Selected beam sections in direction Y

		Y direction				
Level	**Beam**	**A**	**B**	**C**	**D**	**E**
roof	12	IPE 200	IPE 100	IPE 100	IPE 200	-
	23	IPE 200	IPE 100	IPE 100	IPE 200	-
	33a	-	-	-	-	-
	3a4	-	-	-	-	-
	34	-	-	-	-	-
3rd	12	IPE 200	IPE 100	IPE 100	IPE 200	-
	23	IPE 200	IPE 100	IPE 100	IPE 200	IPE 200
	33a	IPE 100	IPE 100	-	-	-
	3a4	IPE 100	IPE 100	-	-	-
	34	-	-	IPE 100	IPE 100	IPE 200
2nd	12	IPE 200	IPE 100	IPE 100	IPE 200	-
	23	IPE 200	IPE 100	IPE 100	IPE 200	IPE 200
	33a	IPE 200	IPE 100	-	-	-
	3a4	IPE 200	IPE 100	-	-	-
	34	-	-	IPE 100	IPE 240	IPE 200
1st	12	IPE 200	IPE 100	IPE 100	IPE 200	-
	23	IPE 200	IPE 100	IPE 100	IPE 200	IPE 200
	33a	IPE 200	IPE 100	-	-	-
	3a4	IPE 200	IPE 100	-	-	-
	34	-	-	IPE 100	IPE 240	IPE 200
grd	12	IPE 200	IPE 100	IPE 100	IPE 200	-
	23	IPE 200	IPE 100	IPE 100	IPE 200	IPE 200
	33a	IPE 200	IPE 100	-	-	-
	3a4	IPE 200	IPE 100	-	-	-
	34	-	-	IPE 100	IPE 240	IPE 200

Typical beam sections:

Table: 5. 26.Typical steel beam sections

	IPE	n.	(kg/m)	(m)	(kg)
1	450	31	77.6	185	14356
2	360	15	57.1	81	4625.1
3	300	5	42.2	17	717.4
4	240	19	30.7	67	2056.9
5	200	41	22.4	146	3270.4
6	100	35	8.1	133	1077.3
				629	26103

Selected beam cross sections:

Fig.5. 22.Cross section areas of selected beams

Column sections:

Table: 5. 27.Selected column sections for each levels by codes

Level	1A	1B	1C	1D	1E
3rd	C1	C1	C1	C1	-
2nd	C1	C1	C1	C1	-
1st	C1	C5	C5	C1	-
grd	C2	C7	C7	C2	-
bsm	C4	C7	C7	C4	-
Level	**2A**	**2B**	**2C**	**2D**	**2E**
3rd	C1	C1	C1	C1	-
2nd	C1	C2	C1	C1	C1
1st	C4	C6	C5	C3	C1
grd	C6	C7	C7	C6	C1
bsm	C7	C7	C7	C7	C1
Level	**3A**	**3B**	**3C**	**3D**	**3E**
3rd	C1	C1	C1	C1	-
2nd	C1	C2	C1	C1	C1
1st	C4	C5	C5	C4	C1
grd	C6	C7	C7	C6	C2
bsm	C7	C7	C7	C7	C3
Level	**3aA**	**3aB**	**3aC**	**3aD**	**3aE**
3rd	-	-	-	-	-
2nd	C1	C1	-	-	-
1st	C1	C1	-	-	-
grd	C2	C1	-	-	-
bsm	C3	C2	-	-	-
Level	**4A**	**4B**	**4C**	**4D**	**4E**
3rd	-	-	-	-	-
2nd	C1	C1	C1	C1	C1
1st	C1	C4	C4	C2	C1
grd	C1	C6	C6	C4	C1
bsm	C1	C7	C7	C5	C1

Column typical sections correction:

Table: 5. 28.Cross section area of selected columns, properties and codes

no.	type	code	def.	A (cm^2)	I_x (cm^4)	I_y (cm^4)	W_x (cm^3)	W_y (cm^3)	m	kg/m	kg
1	2I14C/C14	C1	2IPE140+2PL170*10mm,D =140mm	66.8	2997	2515	374	236	149	65	9685
2	2I16C/C16	C2	2IPE160+2PL200*10mm,D =160mm	80.2	4631	4042	514	334	23	70.8	1628.4
3	2I18C/C18	C3	2IPE180+2PL230*10mm,D =180mm	93.8	6795	6101	679	450	11	90	990
4	2I20C/C20	C4	2IPE200+2PL260*10mm,D =200mm	109	9617	8913	874	594	27	99.7	2691.9
5	2I24C/C24	C5	2IPE240+2PL320*10mm,D =240mm	142.2	17785	17290	1368	960	21	120	2520
6	2I30C/C30	C6	2IPE300+2PL410*10mm,D =300mm	189.2	36427	36814	2276	1636	24	163	3912
7	2I30C45FB1	C7	2IPE300+2PL560*8mm,D= 450mm	196.8	37974	78893	2403	2619	62	170	10540
									317		31967.3

Column cross section areas:

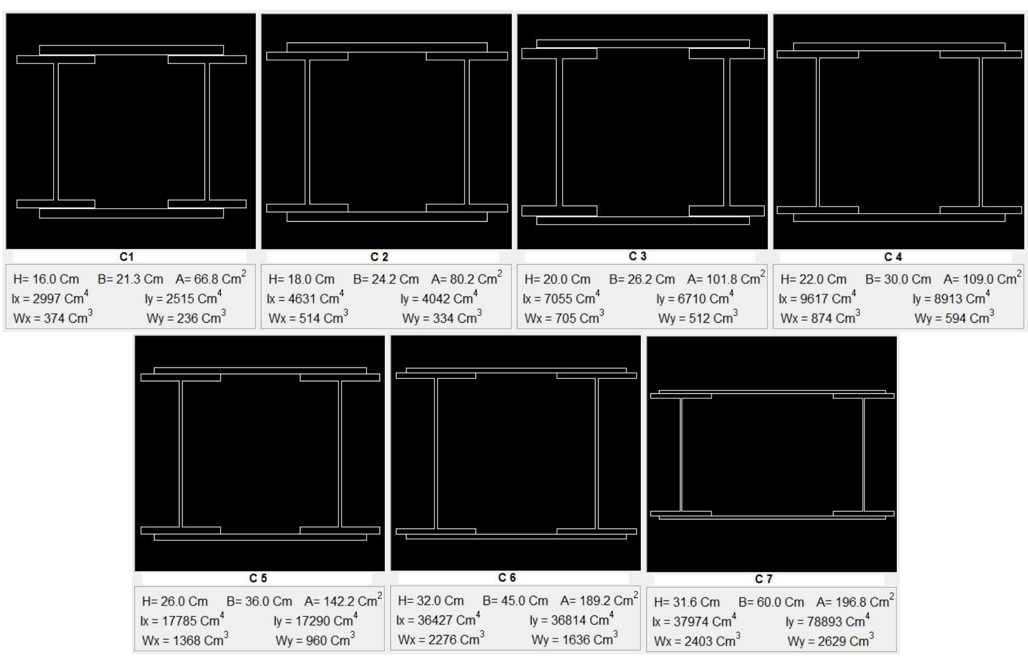


Fig.5. 23.Cross section of selected columns for the structure

Bracings typical sections:

Table: 5. 29.Cross section of selected bracings and properties

direction	B-C	2-3	A(m^2)	I_x(cm^4)	I_y(cm^4)	(m)	(kg)
1	2UNP260 D=10mm	2UNP260 D=10mm	96.6	9640	5560		
2	2UNP260 D=10mm	2UNP260 D=10mm	96.6	9640	5560		
3	2UNP260 D=10mm	2UNP260 D=10mm	96.6	9640	5560		
4	2UNP260 D=10mm	2UNP260 D=10mm	96.6	9640	5560	321	24332
A	2UNP260 D=10mm	2UNP260 D=10mm	96.6	9640	5560		
C	2UNP260 D=10mm	2UNP260 D=10mm	96.6	9640	5560		
D	2UNP260 D=10mm	2UNP260 D=10mm	96.6	9640	5560		

Brace cross section area:

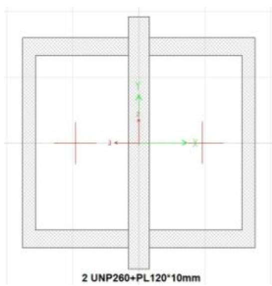


Fig.5. 24.Cross section area of selected bracings of the structure

Software outputs:

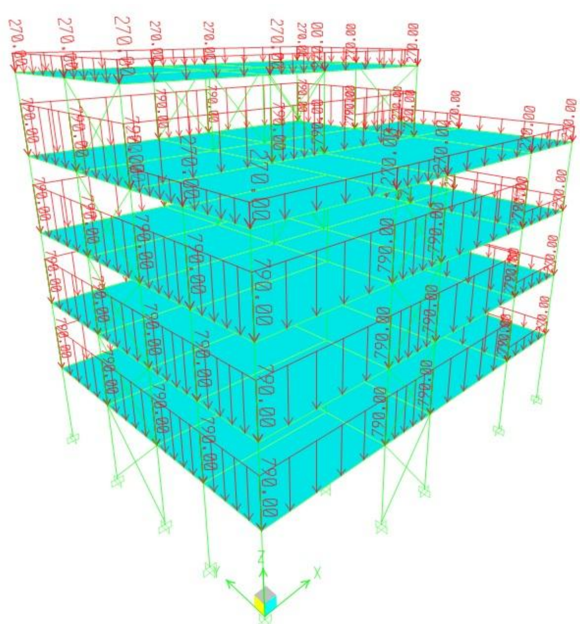


Fig.5. 25.Exterior wall loading on Structure

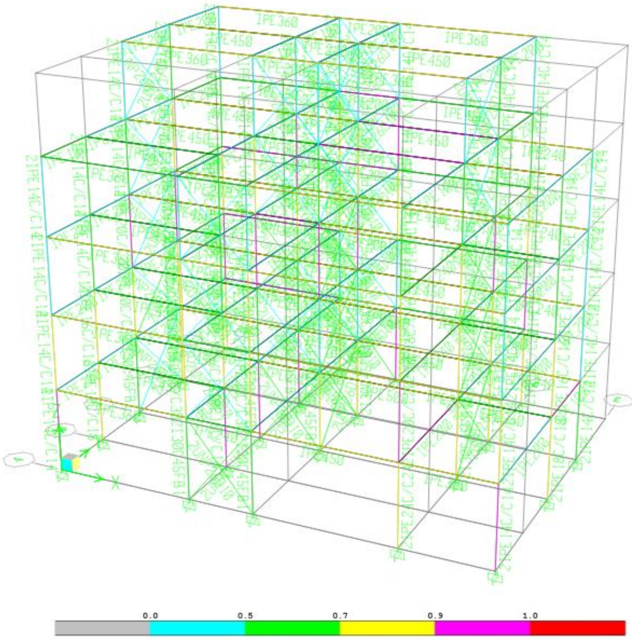


Fig.5. 26.Software output of Designed structures' members and stress ratio

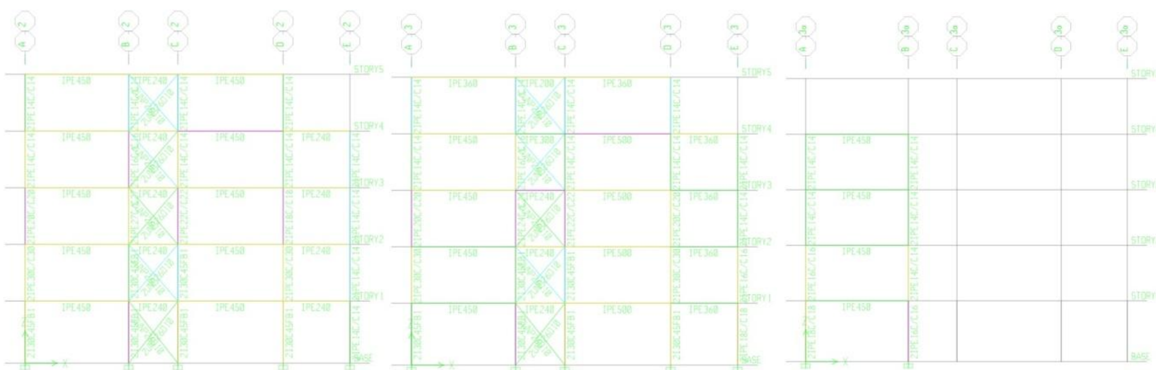


Fig.5. 27.Designed structures' members in three different frames

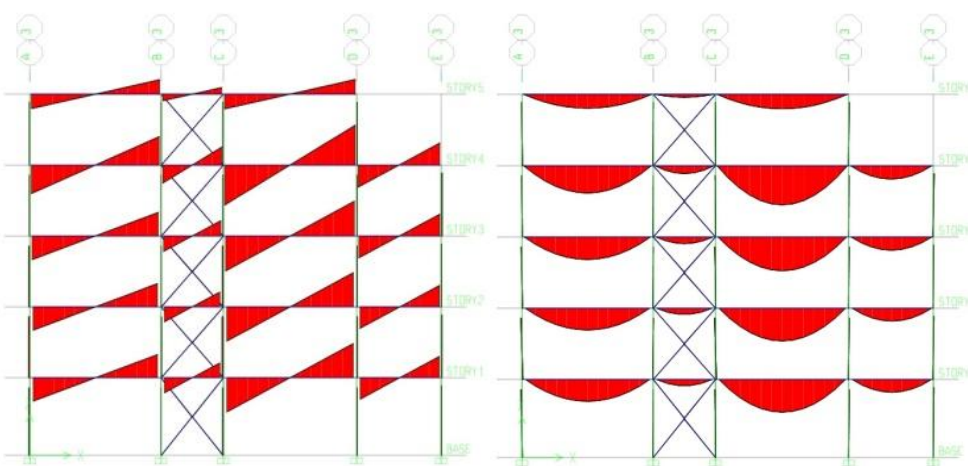


Fig.5. 28.Shear and moment diagram by software

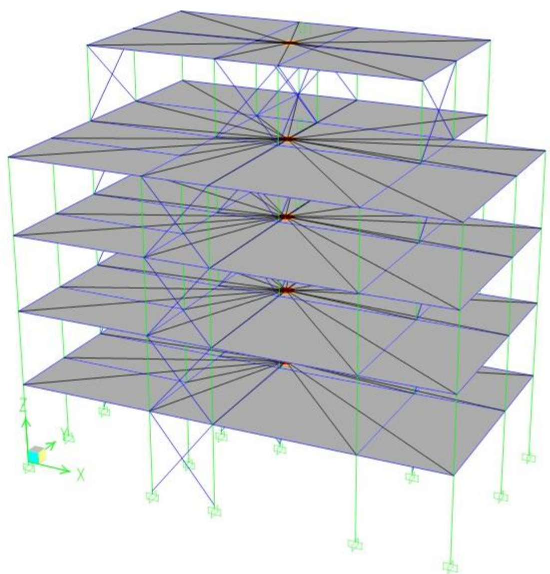


Fig.5. 29.Floor diaphragm of structure in 3D

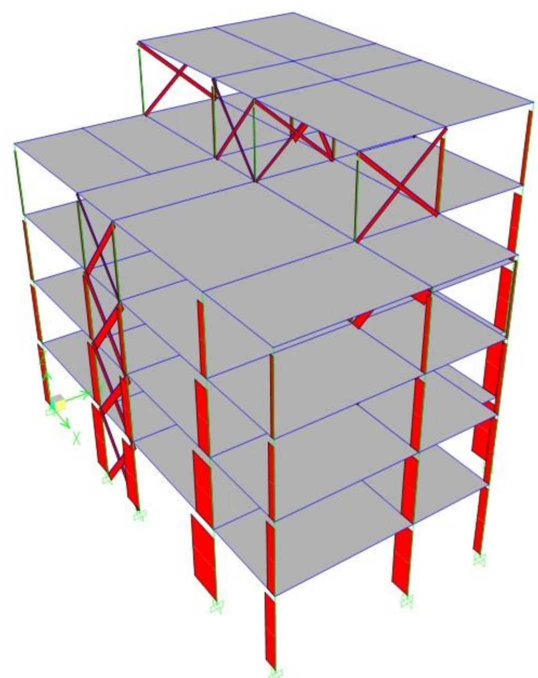


Fig.5. 30.Axial load in structures' members in 3D

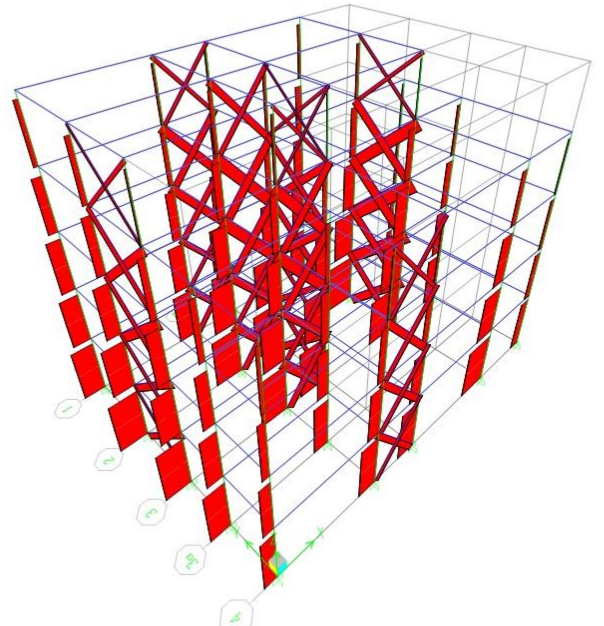


Fig.5. 31.Axial load diagram in structure 3D

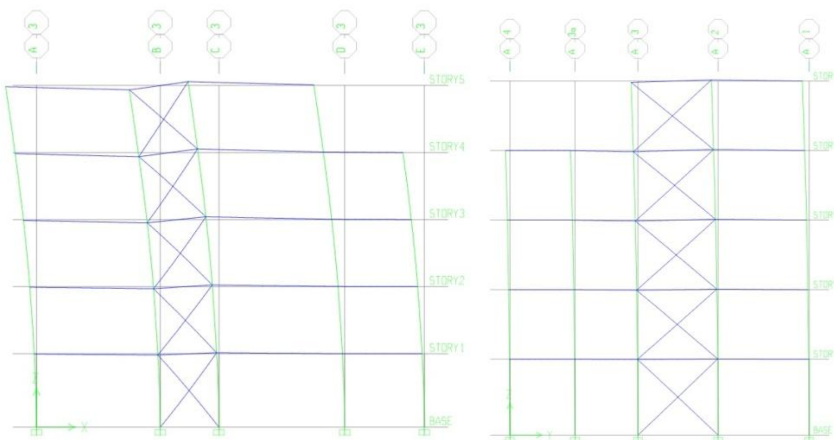


Fig.5. 32.Drift in the structure due to the lateral forces

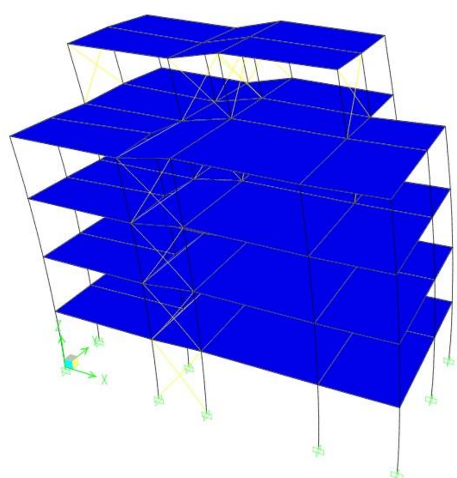


Fig.5. 33.Drift in the structure due to the lateral forces in 3D

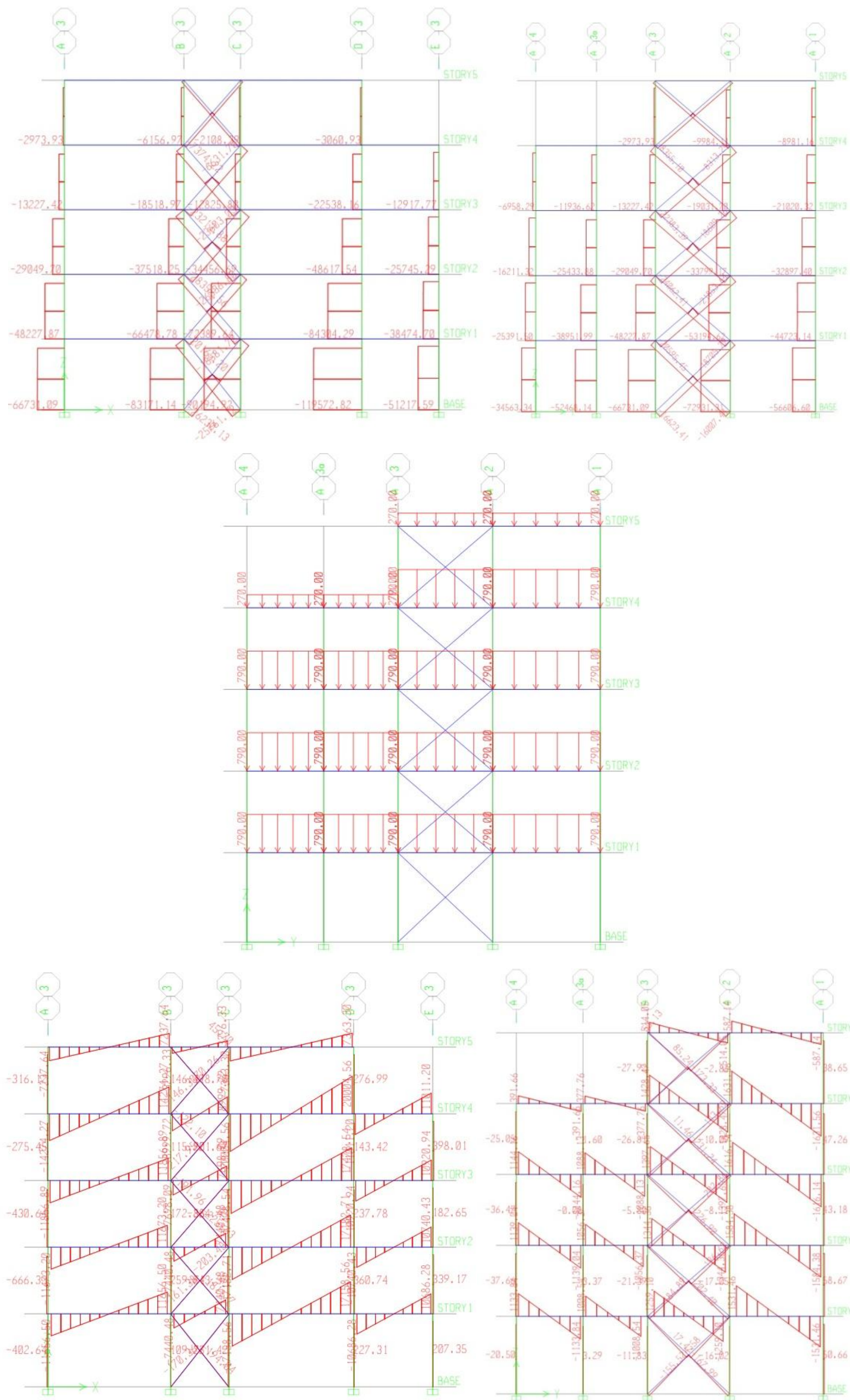


Fig.5. 34.Axial and shear forces and external walls loading in structure

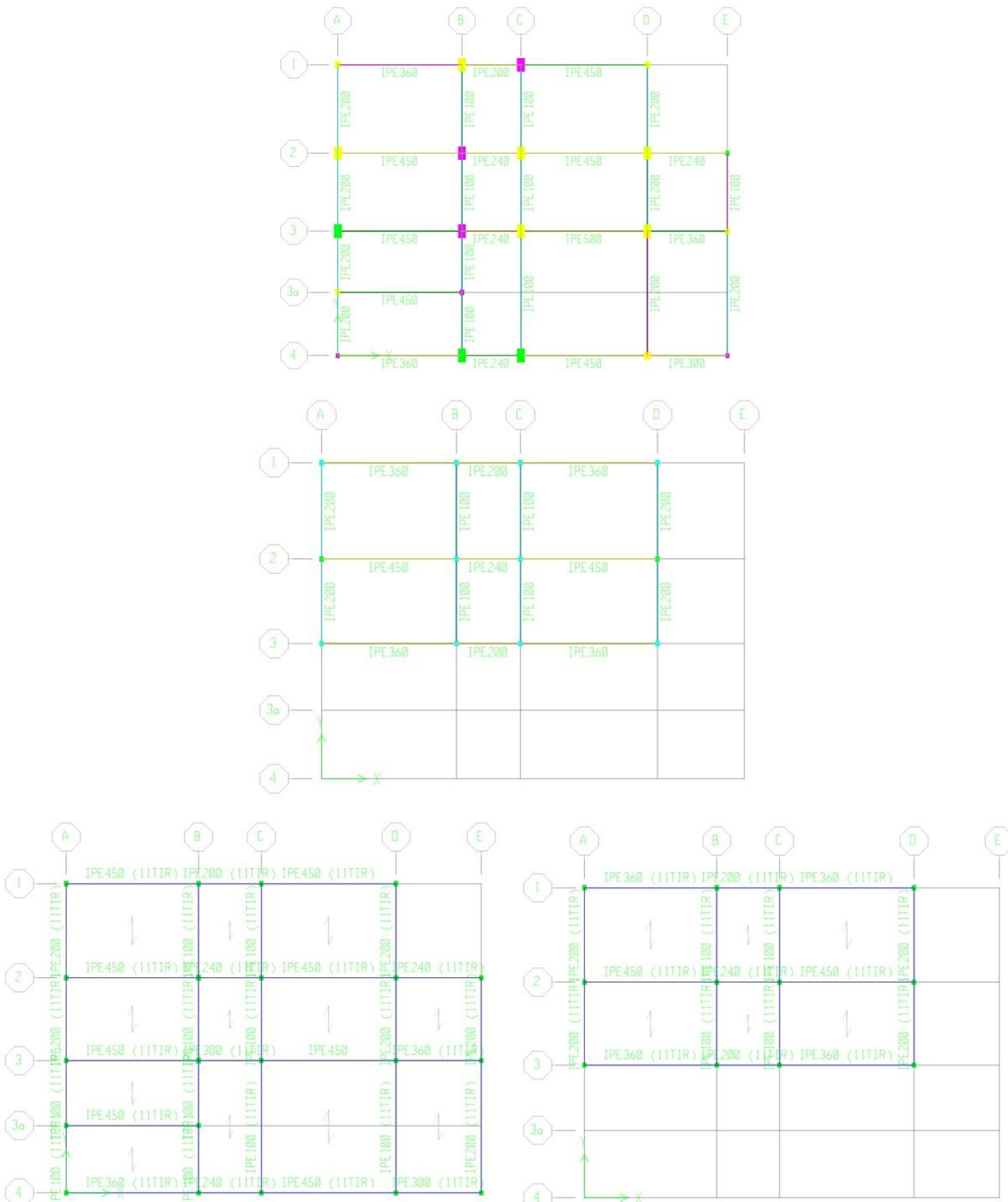


Fig.5. 35.Selected beams and secondary beams direction in roof and floor plans

5-17- Conclusion

In this project the results of structural design and analysis indicated an appropriate correlation between both manual calculations and Etabs software. In fact, using of simply supported structure in which the lateral forces withstand by bracing systems showed that again it would be a good solution for a residential or any kind of buildings with similar properties such as weight, height and more importantly the location of construction from the point of view of lateral load actions. However, the small changes would be needed to make structure to be more assured against all load actions, but the software output in the latest part of the report shows that the reliability of structural design and calculations for this project is sufficient.

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Chapter 3

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