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Design and Construction of a 16-unit Residential Complex Based on Maximizing Energy Efficiency

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Abstract

The house is the most inseparable space around humans, from which human daily activities directly originate or affect it. The house is a concept that encompasses housing and encompasses a set of rich meanings such as cultural, social, psychological, demographic, . . . and is constantly changing and evolving. Although the house is a symbol of society for most people, it must continue to live independently. That is, it must be both a member of society and act independently, which in itself creates a major problem in the construction of apartments and high-rise residential complexes. Therefore, it should be noted that the construction of any apartment should not interfere with the personal independence of a house. Due to the extreme cold of Hamedan city, forms whose northern and southern sides are longer than their eastern and western sides are not suitable as a base for the construction and design of the residential complex in the winter season. It is better to have a compact building form and a cubic plan. Two-story buildings whose form resembles a cube are the best type of building in terms of controlling indoor air heat in winter. Low air temperatures in winter are more critical than high air temperatures in summer. As a result, the need to heat indoor spaces is much greater than cooling them. Paying attention to the direction of the wind in the cold months is very important. Considering the direction of sunlight in different seasons and considering the cold and winter winds that blow from northwest to southeast, the direction of the building was considered to be south to 30 degrees to the west. Therefore, it can be said that by considering the direction of sunlight and wind, as well as paying attention to the orientation of the building relative to these natural factors, the building can be largely insulated against the heat and cold of the outside environment and the lack of heat exchange. Therefore, in addition to how to use natural resources and clean energy, attention should also be paid to the use of materials. For example, in Hamedan, which is considered a cold and dry region, it is better to use heavy materials to minimize heat exchange.

Keywords: Energy, Residential Building, Construction, Hamedan, Energy Efficiency

1. Introduction

The house is the center from which we start everything and it is a small world compared to the big world around it. After knowing the world around him, a man tries to build the world around him based on his perceptions of it (Arash Sohrabi, S. 2024). He transfers the outside world to the inside and tries to build a house with the features and materials available in the surroundings (Dizaji, A. A. 2024). This only stems from introversion and the inherent need of man to have shelter. The house is the center of the world for its inhabitants and is considered the most significant building in consolidating the place for the place where it is located. A person is first placed in the cradle of the house, a house where the world around him is simply given (Samami, H. *et al*., 2024).

The house is the center of the world for its inhabitants, and the reason for this goes back to childhood when the child's world in the first years of his life is the house (Abbaszadeh, M., *et al*., 2015) [1]. This is a small world that later becomes intertwined with the big world around it and shapes social interactions. Therefore, it can be said that although there are various cultures and religions throughout the world, each of them affects the customs and social behavior of the people of those lands in its own way. However, the concept of a house, considering the various perceptions that can be gained from it, is common in all societies in having a shelter to protect humans from environmental damage (Niloofar Akbarzadeh *et al*., 2016) [34].

We return home after daily social activities to regain our identity, and it can be said that individual identity is continuous in private residence because the personality and identity of each person are formed in the first social institution, which is the family, and in the house where that family lives (Khanian, M. *et al*., 2013) [21]. The house symbolically manifests the feelings of individuals about themselves and is closely related to the individual and collective personality of the family. The house is an institution of social growth and development: The house is primarily an institution, not a structure, and since it is a cultural phenomenon, its shape and spatial organization are influenced by the culture to which it belongs (Mohammad Mehdi Norouzian *et al*., 2024) [30].

The house and the creation of a favorable environment for family life are considered as a structure and social unit. One of the cultural characteristics of each ethnic group is the way residential units are placed together, and these cultural characteristics are adapted from traditional beliefs and culture (Mahmoud Zahiri *et al*., 2023) [23]. People prefer separate, independent, private, and unique houses to living in apartments. A house can only be imagined independently and on the ground. Apartments disrupt the old image that people have of a house (Arash Sohrabi, S. 2024).

The category of housing is vast and complex and has various dimensions. Today, it is considered a physical place and shelter that provides basic human needs such as sleep, food, rest, and protection from weather conditions (Gheitarani, N., *et al*., 2024). Psychologically, it also creates inner security in a person. With the lifestyle change, the concept and example of a residential unit have replaced home and residence. A house is a place where its inhabitants do not feel uncomfortable. The interior of the house or the place where women and children live should have a lot of variety so that they do not feel tired. The concept of housing is nothing more than a shelter and nothing more than a protector of humans and their activities from the harm of natural elements (Saba Sultan Qurraie, 2024) [42].

It is very difficult to answer the question of what are the shortcomings of this definition and what is more. The amount of income that should be allocated to housing costs varies depending on factors such as location, climate, religion, and ethnic group, as well as an individual's history about housing and their individual preferences and insights. It should be noted here that the terms housing and housing. Given the similarities and the fact that they are often used interchangeably, they have different meanings. Housing is more quantitative, in other words, it relies more on being a shelter for a place that protects humans from external damage and does not describe the space qualitatively. However, the house contains rich qualitative concepts (Norouzian, M. M. *et al*., 2024).

Concepts that give quality to life and, in addition to meeting the basic need for shelter, provide a positive response to human internal needs such as the need for peace and comfort. The term residence has a broader meaning than housing and refers to a set of household biological activities (Naghibi Iravani, S. *et al*., 2024). Household biological activities include individual and collective activities on the one hand and socio-economic activities on the other. The concept of residence, in contrast to housing, is a place that provides all the necessary services and facilities for the well-being of the family, such as health, education, culture, and social relations, regardless of the importance and extent of these services (Norouzian, M. M. 2024; MM Norouzian; N Gheitarani., 2025-a, b).

In 1961, the World Health Organization defined housing as a residential environment, neighborhood, small area, or physical structure used by humans as shelter. Along with the accessories of this structure such as huts, services, facilities, and necessary tools and equipment needed, or designed for the physical and mental health and social well-being of the family and the individual. Based on this definition, it can be stated that the differences between cultures affect the definition of housing, and the definition of home has a common meaning in all cultures, nations, and religions (Karimimansoob, V. *et al*., 2024).

Simply means shelter, but housing emphasizes the necessary needs, facilities, tools, and life services for the mental and physical health of the residents, and these themselves are also affected by culture (Aghazadeh Dizaji, A. 2017). Considering Dr. Pirnia's definition of home, it can be recalled again that in the design of a house, the indigenous culture of the region has the first place. In ancient Iran, houses had internal and external parts, and non-mahrams were not allowed to enter the private parts of the house, and women rarely left the house. Diversity in the home environment was the main thing, of course, now, considering that women are more present in society and the culture has changed to some extent, it cannot be denied (Qurraie, Saba Sultan, *et al*., 2023) [41].

Since family members spend most of their rest time at home, diversity must be created in the home environment that will cure the feeling of disgust and fatigue from the outside environment. But of course, this diversity does not exist in today's apartments, which have an area of about 80-90 meters and emphasize only the concept of a house being a shelter (Farrokhirad, E., & Gheitarani, N. 2024). A house of any type, whether it is a villa or a unit in a multi-unit residential complex, must, in addition to providing the feeling of need for shelter, also respond to the diversity of humans and create different spaces with different functions. As mentioned, whatever the house, whether it is a villa or an apartment, it must meet the needs of its users (Aydin, A. C. *et al*., 2020).

As we know, the needs of each person have a direct and undeniable connection with their culture. Therefore, here I consider it necessary to express the principles of Iranian architecture, which are not only necessary but also obligatory to observe in the design of a residential complex (Norouzian, M. M., & Gheitarani, N. 2023).

2. Theoretical

Principles of Iranian Architecture. The principles that exist in Iranian art, and especially in the riddle, can be divided into five principles.

1. Humanism
2. Avoidance of futility
3. Demand
4. Self-sufficiency
5. Introversion

Humanism: This means having a human scale, in other words, observing the proportion between the structural parts and the human parts. This principle is evident in Iranian buildings, especially houses. None of the houses in ancient Iran were high enough to exceed the human scale because the house is a refuge and shelter for an individual.

Therefore, a person should feel comfortable in it, and therefore if the height is too high. It creates a feeling of inferiority in a person and destroys the real peace that reigns in the house. In addition, a human scale was observed in every component of a house (Sarabi, M. S. *et al*., 2023). For example, if we consider the three doors that are the same as the bedroom, their size is considered according to the different needs of a man and a woman, their child or children, the necessary equipment, etc. So that the function of the room and the placement of elements such as doors, openings, etc. . . are also carefully selected on this basis (Norouzian M. M., Talebian, M. H. 2023).

Avoiding Futility: This principle was in pre-Islamic architecture and has been emphasized and used after Islam. This principle has been emphasized a lot because futile work, in addition to capital, damages time and even the eye; our artists have always been aware of this. And they have avoided it. Installing statues, which is common in most buildings in other lands, does not exist in Iranian architecture because there is no use for it. But it should be noted that this principle only means avoiding waste and not thrift, as in some regions of Iran, the walls were built in two layers, or the diameter of the foundations was increased to protect the people of the house from the intense heat. The best example of these houses can be found in Yazd (Naghibi Iravani, S. *et al*., 2024).

Niyarash: It is a correction in architecture and refers to all works. Which is done for the stability and stability of the building. In other words, Niyarash is a set of calculations and statistics, including material science and the selection and use of the most appropriate and minimal materials (MM Norouzian; N Gheitarani. 2025). In the past, architects relied more on engineering, and a building was beautiful when it also showed its stability in terms of statistics (Maleki, M. *et al*., 2024). Ancient Iranian architects used a tool called paimon to facilitate work and to give direction to all sizes. Paimon was one of the criteria that was observed to determine the proportion between the components of the building. Using Niarash and Paimon, the three important stages of design, calculation, and execution were carried out in the best way so that in a beautiful design, correct calculations and execution were also simplified (Norouzian, M. M., & Sarabi, M. S. 2023).

Self-sufficiency: Another principle in Iranian architecture is self-sufficiency, meaning that the builders have tried to obtain the required materials from the nearest places and at the cheapest price. In this way, the work was done more quickly and the materials were more in harmony with the surrounding nature. Similarly, buildings that had to be repaired over time were able to be repaired at those times by having access to the original materials on site (Dizaji, A. A. *et al*., 2023).

Introversion: Introversion is another principle of Iranian architecture. By introversion and placing architectural elements and building external walls, the architect enables a direct connection of the building with the outside space within itself with an element called the courtyard. Within this space, throughout the history of Iranian architecture, architects have built a paradise in the heart of the land (Mehdi Norouzian, M., & Gheitarani, N. 2024- a, b). Considering the principles mentioned, it can be said that although these principles have been important in the past architecture of Iran and are inseparable parts of the design of a unit, they are not used much at present. For example, we can mention the principle of self-sufficiency. In today's urban designs, not only are the materials available around the site not used to make a complex stand out, but these materials are imported from other countries at high costs (Karimimansoob, V. *et al*., 2024).

Therefore, not using these 5 important principles of architecture in Iran has caused the disintegration of the urban fabric. And each building tries to make its existence stand out. In Iranian architecture, different methods, including the Parthian-Persian-Khorasani-Razi-Azari-Isfahani methods, have been used in different architectural periods. However, it should be noted that each of these methods has a common feature (Gheitarani, N. *et al*., 2024). One of the characteristics of Iranians, from the Aryans to the later immigrant tribes, and especially Iranian artists, has been the belief in good imitation, which they considered better than bad innovation. In Iranian architecture, if we use good imitation, we can better show the characteristics and principles that the people of this country depend on. Imitation can even be used according to the culture of the region (MM Norouzian; N Gheitarani. 2023).

However, if an innovation is made solely for the sake of modernity and lack of imitation, it can ignore the aforementioned principles and destroy the intended function that is in line with the culture of the people. Classification of Iranian houses into historical and contemporary houses. Iranian houses can be studied and analyzed in two categories: historical houses and contemporary houses. The title of historical houses refers to those Iranian houses that were built until 1300 AH. And a number of them remain in the historical contexts of cities. Contemporary houses are houses that have been built since 1340 as residential units, whether single units or apartments. The architecture of the Qajar period can be mentioned as the closest period of historical architecture in Iran.

The residential buildings of the peasants of the Qajar period, although they had a very simple appearance, However, they had a strong foundation and skeleton. In their exterior and interior buildings, open designs are seen along with observing the principles of communication and privacy, paying attention to the technical issues of sewage, water supply, foundation, resistant and earthquake-resistant skeletons, facades with resistant artistic phenomena connected to the building, and finally, values of art related to architecture. From the Qajar period onwards, the construction of residential buildings has been very different according to the class status of the people.

During that period, ordinary people used simple buildings made of brick and mud materials and with vaulted or skylight ceilings, and the wealthy classes lived in resistant brick buildings with extensive designs, especially exterior and interior, and with elements of traditional Iranian architecture. Therefore, it can be said that from the Qajar period onwards, the principles of Iranian architecture, which have been mentioned as the 5 important principles of Iranian architectural design, have been established.

Unfortunately, it was only observed in the houses of the wealthy, and the houses of peasants and ordinary people, like the houses currently existing, were deprived of these 5 principles. Houses built from 1340 onwards are referred to as contemporary houses. With the change in lifestyle in the past half-century, the concept and meaning of house and residence gave way to residential units and accommodation. The lifestyle change has included almost all aspects of

ritual, politics, society, economy, and of course food, clothing, and living habits. Here, it can be said that architecture reflects the language of spatial concepts and lifestyles in different eras.

Therefore, by comparing historical houses and contemporary houses, it can be stated that people's lifestyles have changed now. The architecture of houses has also changed, but it should not be forgotten that the 5 important principles of Iranian architecture have permeated our culture. And culture is still fixed, and these contemporary houses do not respond appropriately to these principles. There are clear differences between the language used in the architecture of historical houses and the language used in contemporary houses. In the first, there is a conversation with space, and volume, and the point to the increase in the age of marriage, the tendency towards families with few children, and the growth of individualistic values. These changes have left their mark on the structure of the population. It is due to these changes that contemporary architecture is a conversation with the body, materials, and surface. Because attention has been focused on building a house in the shortest possible time, several families no longer live together in one house like in the past, so the design of the house is based on the relationship between family members. Contemporary houses are very legible and functional (Dehghan, S., *et al*., 2024).

In some contemporary houses, especially examples attributed to modern architecture, where space is defined and combined as the essential material of architecture, spatial feelings and experiences similar to the architecture of historical houses are noticeable. However, non-architectural language has dominated the vast majority of contemporary houses. In the middle of the first Pahlavi era and especially the second Pahlavi era, the construction of the country, especially residential buildings, suddenly became devoid of identity (Zakerhaghighi, K. *et al*., 2015). The Westernization of the country's top officials and their tendency towards Western life and thoughts, as well as pushing people's thoughts towards it, led to the spread of Westernization among the people (Gheitarani, N., *et al*., 2013).

This Westernization had a direct impact on construction, especially residential buildings, to the extent that the principle of design and privacy of external and internal spaces was forgotten and replaced by Western-friendly criteria. Finally, the design of residential spaces was drawn towards ignoring the inner desires and views of the people and generally towards identitylessness. What happened in our cities was replacement instead of restoration. There was no timely intervention in historical textures to harmonize them with new industrial phenomena, and as a result, old houses in the old texture fell victim to new urban manifestations, such as streets, asphalt, and electric lights (Khanian, M. *et al*., 2019) [22].

In short, this abnormal process caused the loss of the very original identity of the unique traditional Iranian architecture, which was always of global interest. To the extent that in a very short time, our people and even many engineers and students of architecture and civil engineering, many valuable phenomena of Iranian architectural art and its spirituality in terms of philosophy and the principle of introversion and extroversion methods and moral characteristics and many perfections were rightly forgotten. Therefore, Iranian architecture became confused and irrational. Spatial differences between historical and contemporary houses.

In the spaces of contemporary houses, when we enter, we do not get lost, but we cannot find ourselves and our space. Almost all of the things that shape the spaces of contemporary houses become apparent at once. Everything is predictable. In contrast, in old houses in Iran, until around 1340 and before the emergence of contemporary houses, everything was not so obvious to the visitor of a house. In ancient times, to reach the internal and inner parts, a hierarchy had to be followed. The philosophy of creating a vestibule in the space before the entrance was also because not everyone could see the space inside (Naghibi Iravani, S., *et al*., 2024).

The spatial organization in historical houses guides those entering different spaces according to their relationship with the family. The entrance spaces in historical houses provide the possibility for activities such as negotiation, quick and informal meetings, and rejection. It is possible to carry out necessities and the like in it. However, in contemporary houses, most entrance spaces are not prepared for use upon entry. Even for shoes and clothes, which in most contemporary houses have a place allocated for them at the entrance of the house, the spatial organization does not offer a special suggestion for moving inside the house. And there is no sense of territory and entering a private space distinct from the public space. Apart from service and health spaces and day and night spaces, it is rare to find distinctive and different spaces in today's residences (Dizaji, A. A. 2024- a, b).

Apartment building: Given the Westernization of country officials and their tendency towards Western ideas and the changes that occurred in building construction and caused Iranian architecture to lose its identity, the house construction system in the country has shifted more towards apartment buildings. Apartments with completely imported Western designs and without logical facades have seriously endangered the country's urban architecture. The hated trend of apartment building, with completely wrong methods, is advancing day by day in the country. Open-plan projects, without considering the privacy and dignity of spaces for family members, influenced by Western culture, have confused these people with ancient culture (Kahvand, M. *et al*., 2015).

Definition of housing in the form of general social goals: The general social goals that are raised in national development planning are mainly based on the resources and values of each society and are a reflection of social ideals. For example, raising living standards is one of the main goals within society and is influenced by the ideals of social growth. Article 31 of the Constitution states that access to suitable housing is the right of every Iranian family. Housing is considered one of the important social goals here. For this reason, the importance of housing and the need to examine and provide access to it are among the issues that the government has reflected in its programs and relation to social goals, and a special place has been assigned to it (Gheitarani, N. *et al*., 2020).

In a more complete statement of the general needs and goals of housing, we come across the following concepts. Shelter - Housing and Family - Participation - Residential Environment. Quality of Life: General social goals in national development plans refer to the needs and demands that improve the quality of life and social well-being of

people. Although the definition of quality of life is different in different countries and even in the same country, it is included as a main general goal in all development plans. Factors affecting the improvement of quality of life. Improving the quality of life is a main general goal in development plans, it is included as a main general goal (GHADARJANI, R., & GHEITARANI, N. 2013).

Factors affecting the improvement of quality of life:

1. In improving the quality of life as a main general goal in development plans, individual and collective needs are also relied on.
2. Basic biological needs: Including food, clothing, shelter, protection from weather conditions, proper hygiene, and a suitable environment
3. Economic needs: Including suitable job opportunities, the opportunity to improve living standards, access to the following facilities Buildings, and facilities necessary for daily activities
4. Social needs: include mutual security between the individual and the state, having opportunities and social solidarity, having opportunities to develop one's mind and obtain an education, satisfying spiritual needs, access to nature, opportunities for participation, social interactions, and access to sufficient facilities to support the family (Ghadarjani, R. *et al*., 2013).

Criteria for desirable housing:

1. Housing is a place of peace.
2. Identity -Definition and distinction of boundaries and territories.
3. Possibility of human life -Preserving and strengthening neighborhood relations.
4. Prevision of appropriate public spaces.

As mentioned, one of the criteria for improving the quality of life is to respond to basic needs, which can be called the need for shelter, a suitable environment, protection against weather conditions, and... Therefore, here it is necessary to address the physical characteristics of the city of Hamedan as the context of the desired project. And the climatic and social factors existing in this city, which certainly affect the design process, should be examined (Gheitarany, N. *et al*., 2013).

Table 1: Comparison of indicators in different years

Master Plan 2006	Status quo	Master Plan Approved in 1991	Indicators
4300000	1788000	1464000	Population
270	185	1716	Area
168	96	85	Gross Density

3. Methodology

Site Survey/Field Studies

Site Introduction:

- The site in question is located on Upper Saeidieh Boulevard in Hamedan City.
- The site is rectangular with dimensions 5×100^{m} whose area is 5000m2.
- The site is located on the east-west axis.
- The site has three axes with access for vehicles and pedestrians: the northern, southern, and western sides, and there is a neighboring unit on the eastern side.
- The uses around the site are mainly residential.

Fig 1: Conceptual View and Plan of the Building

Reasons for choosing this site: It was chosen due to the uncontrolled expansion of high-rise buildings located on Saeidieh Boulevard.

In response to the fact that high-rise buildings are not the only way to create housing for the people of the community. Therefore, in this project, an attempt was made to maintain uniformity and uniformity with the regional texture and not to damage the regional skyline. Review and determination of the number of bedrooms: Based on the website of the Statistical Center of Iran, the number of housing required was calculated according to the number of bedrooms required according to the information obtained, and the results are remarkable.

Table 2: Details of residential units according to existing facilities and facilities and number of rooms (Hamedan- 2022)

	Plural	1 room	2 rooms	3 rooms	4 rooms	5 rooms	6 rooms and more
Apartment Residential Unit	399837	13338	114472	168444	76607	18648	5359
Non-apartment Residential Unit	465689	30549	203934	125175	64550	23165	13889

Two Rooms $\frac{114472}{399837} = 0/28 \rightarrow 28\%$

Three Rooms $\frac{168444}{399837} = 0/42 \rightarrow 42\%$

Four Rooms $\frac{76607}{399837} = 0/19 \rightarrow 19\%$

Other (5 rooms, 6 rooms and not stated) $\rightarrow 11\%$

Since we are only considering 2, 3, and 4-room apartments, we divide 11% among the other percentages.

about 32% ← Two Rooms
about 42% ← Three Rooms
about 23% ← Four Rooms

The residential complex we are looking for has 40 units.

Two Rooms $\frac{32}{100} = \frac{}{40} \rightarrow 12.8$ Units $\rightarrow 13$ Units

Three Rooms $\frac{45}{100} = \frac{}{40} \rightarrow 18$ Units

Four Rooms $\frac{23}{100} = \frac{}{40} \rightarrow 9.2$ Units $\rightarrow 9$ Units

9+18+13=40

So in total, we can say that in this residential complex, according to the results obtained from the Statistical Center of Iran website and the relevant table, we need 13 2-bedroom units, 18 3-bedroom units, and 9 4-bedroom units.

(35% of the approved occupancy level of the residential complex)

Residential occupation of the land surface $\frac{5000\times35}{100} = 1750$

Average number of floors $\frac{9000}{1750} = 5/14 \simeq 5$

Therefore, we can have a maximum of 5 floors of residential complex with an occupancy level of 35%, and the approximate height of the building, considering each m3 unit, will be about 15 meters. Number of parking spaces:

Documented parking - covered 75% of the number of residential units

$$\frac{75}{100} = \frac{}{40} \rightarrow 30$$

Guest parking – without a document – can be uncovered at 15% of the number of units.

$$\frac{15}{100} = \frac{}{4} \rightarrow 10$$

So we need 40 car parking spaces. 30 permanent and 10 for guests.

Table 3: Physical plan

Number of spaces	Percentage	area	Space Name
40	35	m2 1750	Residential Floors
1	40	1200 m2	Parking Space
	15	2000 m2	Open Space
	10	750 m2	Roads
		500 m2	Service Space

Basement rule in Hamedan Municipality Area 1: If 70% or more of the basement volume is in the basement, it is not considered as a density, considering the following conditions:

If parking, facilities, and storage can be provided in the pilot, basement construction is not allowed. In the basement, the swimming pool and jacuzzi are not considered as part of the infrastructure. The maximum height from the table to the basement ceiling is 1.20 meters (meaning the basement should not be buried in the ground and openings to the outside should be created in it).

Level 0. 00 Basement Land

Residential Complex Rules and Regulations on the Site

- Building Density: Medium (180%)
- Residential Occupancy Rule: 35%
- Open Space: 40%
- Walkways: 15% (Includes pedestrians, bicycles, wheelchairs, strollers, and wheeled vehicles, and essential service walkways such as ambulances and garbage trucks.)
- Services: 10% (50% open and 50% closed)
- Parking Rule: 75% of all units covered parking for residents and 25% of all units open parking for guests.

Table 4: Floor and Unit Specifications

Explanations	Area	Space Name
5000*%180=9000m2	9000m2	Total Infrastructure Area
5000*%35=1750m2	1750m2	Residential Occupancy Area
5000*%40=2000m2	2000m2	Open Space
5000*%15=750m2	750m2	Passageways
5000*%10=500m2	500m2	Services
40%*75 =30 Number of parking spaces (depending on the amount of car movement on the site, the area of the parking space varies between 15m2 and 30m2). 30*15=450m2 30*30=900m2)(	450-900m2	Covered Parking
40*%25=10 10*15=150 10*30=300	150-300m2	Open Parking

Area of spaces required in the residential complex:

Number of floors allowed: Floor $\frac{9000}{1750} = 5/1 \simeq 5$

Suggested percentage for performance levels of a residential unit

Table 5: Floor and Unit Specifications

Percentage	Space
2-3%	Entrance
10-15%	Corridor
10%	Walls
10-12%	Kitchen
2-4%	Bathroom
4-5%	Bathroom
25-30%	Bedroom
15%	Living Room
15%	Dining + Reception
93%	Total
7%	Additional Factor
100%	Total Total

Table 6: Floor and Unit Specifications

Percentage	Area
25%	Sleeps
25%	Living-Reception
25%	Services
25%	Yard
100%	Assembly

4. Results

Natural ventilation or the use of mechanical thermal or cooling systems in different months in Hamedan. Here we can examine the need for natural ventilation or the use of mechanical thermal or cooling systems in different months in Hamedan as follows:

- In late July and early August, we need heavy materials and internal heat acquisition.
- In late August and early September, we need natural ventilation.
- In late September and early October, we need natural ventilation, internal heat acquisition, and passive solar systems.
- In late October and early November, we need internal heat acquisition and active and passive solar systems.
- In late November and early December, we need internal heat acquisition solar systems and conventional thermal systems.
- In late December and late January, we need active and passive solar systems and conventional thermal systems.
- In late February and early February, we need conventional active and thermal solar systems.
- In late February and early March, We need active and conventional thermal solar systems.
- In late March and early April, we need internal heat and active and passive solar systems.
- In late April and early May, we need internal heat and passive solar systems.
- In late May and early June, we need internal heat and passive solar systems".

As can be seen here, Hamedan, with its cold climate, requires heating systems in most months of the year. These cold months start in early October and continue until about mid-spring (i.e., about 3.4 years or 8 months). To reduce the cost of using fossil fuels to heat the building in the cold months, solar energy can be used. Conditions for using maximum solar energy in architecture:

- Best orientation angle
- Use of glass
- Orientation of the building and stretching in the east and west directions
- Roof windows facing south
- Dark wall color
- Dense texture
- Light profile thickness
- Light color of the environment
- Suitable materials
- Window floor"

Direction of the Building. Given the energy radiated on vertical surfaces and also the direction of the wind, especially in cold seasons, the best direction of 45 degrees of rotation of the building from south to west has been selected. Utilization of solar energy in building heating:

- Choosing south-facing slopes for building construction.
- On south-facing slopes, if possible, the building should be built in the upper part of the area.
- Placing the building in the direction of maximum solar energy radiation in cold weather.
- Opening the southern facade of the building to at least an angle of 30 degrees on each side (in geographical areas of 30 degrees and below, this angle increases to 40 degrees.
- Expanding and stretching the plan in the direction of the east-west axis.
- Allocation of spaces facing south to the living area and placement of less important spaces in the eastern and western parts of the building.

Organizing the plan in such a way that sunlight can penetrate the interior spaces.

- The depth of the building and the location of the windows on the facade should be such that adequate sunlight can penetrate the interior spaces in winter.
- Using vertical windows on southern facades or roof windows and skylights
- Predicting suitable shades for windows that, while directing winter sunlight to the interior spaces, prevent summer sunlight from reaching these spaces.
- Predicting reflective surfaces in Floors facing sunny windows
- The use of greenhouses connected to interior spaces on the southern side of the building should be foreseen to prevent such spaces from heating up in the summer.
- The use of building materials with high thermal capacity and dark surfaces in the sunny parts of the interior spaces
- The use of walls with heavy building materials on the southern facades of the building
- The use of dark colors and rough textures for exterior surfaces
- The use of Iran with sunny and wind-protected exterior spaces, for use when the weather is suitable outside.

5. Findings

Climate study. Given that the average temperature in the warmest month of the year is more than 10 and the average minimum temperature in the coldest month is less than -3

degrees Celsius, it is considered one of the cold regions of the country. The western mountain range acts as a barrier preventing the penetration of humid Mediterranean air into the Iranian plateau and keeps the air humidity in its region. Among the characteristics of this climate are the intense heat of the valleys in the summer and their moderation in the winter. The amount and intensity of sunlight in these areas are high in the summer and very low in the winter. The winters are long, cold, and harsh, and the ground is covered with ice for several months of the year. Winter is cold throughout this region, and the cold starts in early December and continues more or less until the end of April. The amount of precipitation is low in summer and high in winter, and it mostly falls in the form of snow. Snow covers most of the peaks, and at altitudes above 3,000 meters, it always snows. So in this region, spring is short and separates winter and summer".

"The direction and speed of the prevailing winds in Hamedan in different months show that the percentage and speed of the winds that blow in the summer season are higher than other winds. Although autumn and winter winds have a low percentage and speed, respectively, due to the coldness of the region and considering the importance of heating indoor spaces over cooling these spaces, the direction of these winds should be fully considered because these winds, in addition to increasing the heat loss of the building and increasing the consumption of building heating systems, are significantly effective in reducing the perceived temperature, that is, in lowering the air temperature about the feeling of cold".

Number of frost days

The average number of days of sunshine at the weather station is 3.100 during the year. It can be said that in this region, low air temperatures in the cold months of the year are more important than high air temperatures in the warm months. It can be said that in this city, due to the cold climate, the main problem is heating the air inside the building in most months of the year. The maximum summer air temperature in this city is so high that by choosing materials appropriate to the climate, it is easy to create a comfort zone inside the building. However, due to the low air temperature in most months of the year, the use of mechanical heating devices is necessary to create a comfort zone inside the building during these months.

- The average maximum monthly temperature is 23.9
- Average minimum monthly temperature -4.7 degrees
- Absolute minimum temperature -28
- Absolute maximum temperature 43 degrees

In summer, the air is a little dry, but during the rest of the year, the air humidity is sufficient.

Features of Native Architecture in Cold Regions: Although the degree of cold and its duration vary in cold regions, in general, the principles that prevent heat loss in buildings are the same and are similar to those that have been considered in the architecture of hot and dry regions. The difference is that in cold regions, the source of heat is inside the building. Also, in these regions, efforts have been made to heat the building naturally or by using large heaters, heat from people, cooking, or even animals. In Hamedan, the need to heat indoor spaces is more than 6 times the need to cool them, and in summer, the temperature can be adjusted to a comfortable level by increasing the humidity in the air.

However, in winter, it is not possible to heat the air naturally, that is, by using sunlight". The general and main principles of architecture in cold regions: which are observed in the native architecture of these regions are:

- Using dense and compact plans
- Minimizing the external surface compared to the volume to be covered
- Using materials with good thermal capacity and insulation
- Minimizing the amount of internal air exchange and internal ventilation, and consequently preventing combustion inside and the escape of internal heat from the building.
- Choosing flat roofs and keeping snow on the roof as thermal insulation, the only difference between these regions and hot and dry regions is the desire and necessity to use the heat from the sun inside the building in the winter.
- Of course, this need is usually overshadowed by the effect of wind and cold caused by it blowing on the building. And overall, an attempt has been made to keep the external surface as small as possible. However, in any case, to utilize the thermal energy from sunlight, the external surface covering has been chosen to be dark in color and the dimensions of the windows have been increased compared to hot and dry regions.

Principles used in the architecture of cold regions:

- Type of materials = high thermal capacity and resistance
- Type of plan = compact
- Type of roof = flat
- Orientation = 45 degrees southwest
- Surface and number of windows = low

The way the building connects to the ground = on the ground. In cold climates, in other words, cold and dry climates like Hamedan, to maintain the desired space inside the building maintain the temperature within the comfort temperature range, and create relative desirability, the thermal resistance of building materials must be increased. To achieve this, heavy materials such as brick and concrete must be used in the interior and western walls of the building. Main goals of climate design:

- Reducing the heat loss of the building
- Reducing the effect of the load on the heat loss of the building
- Using solar energy in heating the building
- Protecting the building from sunlight 5-Using the daily temperature fluctuation.

"In building design and its technical issues, human thermal comfort refers to a situation where a person is mentally and intellectually in a state of thermal comfort. Many researchers believe that thermal neutrality is a more accurate interpretation of thermal comfort. Because in such an environment, the human body does not feel cold or hot, nor does it feel local discomfort due to asymmetric radiation, air pollution, room humidity, inappropriate clothing, etc. By stating this issue, the importance of studying the climate becomes clear. If we act according to the climate of the region to create thermal comfort, it will certainly have a significant impact on reducing the costs imposed for heating or cooling the building.

6. Discussion and Conclusion

Reason for selection: In terms of floors form of blocks and number of bedrooms in each unit, it is similar to the design of the site in question. Examination of the physical and spatial characteristics of the complex:

This complex was built between 1988 and 1993 by the Housing Investment Company in partnership with the National Bank of Iran on a triangular-shaped land located on Water and Electricity Boulevard - at the end of Tajrish Alley with an area of 76,483 square meters with an infrastructure of about 52,000 square meters. Since mid-1973, it has been assigned to the owners of the investment deposits of the Housing Bank on a concession basis. The Valiasr complex consists of 312 residential units, which are formed into 52 blocks of 6 units. Both blocks are located adjacent to each other. In better words, it can be said that this complex consists of 26 blocks, each block consisting of 6 units from June 2. These units are built on a pilot at a height of 3 floors, and the uses located in the surrounding context of the complex are:

- Residential
- Commercial
- Educational
- Administrative
- Cultural
- Religious
- Green space

Review of the floor plan. The plan of all units is designed in two types, two-bedroom with an area of 100 square meters and three-bedroom with an area of 130 square meters. Each floor has 2 units, including a two-bedroom unit and a three-bedroom unit. Which is repeated in all blocks and therefore there is no variation in the complex. All blocks are located in different parts of the site in the same direction. Mine also does not change.

Most of the interior spaces have good lighting, with the kitchen and one bedroom facing north and the living room and the other bedroom facing south. Special attention has also been paid to separating public and private spaces in the design of the units. The following are some of the weaknesses of the plan. The location of the terrace (which is mainly used for drying clothes. In the vicinity of the reception, the lack of connection between the terrace and the kitchen, the distance of the bathroom from the bedrooms, inappropriate kitchen furniture, the length of the entrance corridor to the bedrooms, and the lack of proper lighting, especially in three-bedroom units, and the proximity of the facilities to the warehouses were also mentioned in the pilot plan. Due to the presence of facilities in the vicinity of the warehouses, the warehouse space becomes humid and cannot be used for long-term storage of food.

Survey of the complex site. The views and landscapes of the blocks are not the same so the units overlooking Saeidieh Boulevard have a view of the natural scenery (surrounding heights). However, the units located in the center of the complex have a view of the interior spaces of the complex and the blocks opposite them. Regardless of this issue, it can be said that all units have a good view and landscape. The following points can be mentioned about the complex site.

Positive points. Semi-private walking path through the green space With different paving and narrow widths, which gives it a private aspect. Planting evergreen trees in front of the pilots to prevent undesirable views from the units opposite the parking area. Having two entrances to the complex and controlling it by security. Having a complex management and a multi-purpose hall in the central open space of the complex Planting green trees and a dense mass of plants to separate the riding and pedestrian areas from the semi-private space in front of the block. The orientation of the blocks is based on north and south, which makes it possible to use the best light (south and north light). Also, the distance between the blocks has been observed in terms of shading, as the shadow of the blocks falls on the riding path and the open space of the block. Forming the riding path and the access path to the parking lot of the blocks on the northern side of the block and allocating the southern side (which benefits from sunlight) to green space and the pedestrian access path to the residential units. Also, direct riding access to each block is possible.

Negative points: In the center of the residential complex, where there is a large open space, two main access routes for vehicles are connected. The lack of a large green space that can be used by residents, as well as the lack of defined and separated pedestrian paths on the site (interference between pedestrian and vehicle movement), and the absolute dominance of cars and vehicle paths throughout the complex are among the reasons for residents' dissatisfaction with the open space of the complex. The terraces open to the public open space, which creates a sense of superiority over it (view of the terrace from the public space).

The open space between the blocks is used both as a parking space for guests and a children's play space. However, there is no green space and suitable vegetation for recreation sitting, etc .The semi-public open space of the complex, which is dedicated to games and entertainment and has a chess table, basketball court, etc. . . , is mostly usable in the evenings and is not used due to the intense sunlight during the day and the lack of desirable shade from trees. In other words, in this complex, the lack of organized communal spaces, whether at the block or complex scale, has reduced the social connections of residents and the lack of participation of individuals in improving the quality of the complex's environment. Also, the lack of an entrance to the block, the interference of open spaces between blocks, the lack of sufficient privacy between them, and the lack of a suitable play area for children are other problems of the complex.

Residents are generally satisfied with the floor plan. In terms of income level, residents are in the middle position. The type of property ownership of most households is 4 or 5 people and the level of education of the head of the household is high. The ownership period is often more than 3 years, and residents have their own vehicles. The complex is not homogeneous with its surrounding context. The complex is deprived of having an efficient and quality commercial center to meet the daily needs of people, so most residents purchase their consumables from the city and the water and electricity boulevard. The type of communication between residents is generally limited to greetings, but the social communication of individuals in a block and two adjacent blocks is assessed as good, therefore the need to create organized and block-scale communal spaces is felt.

Also, the location of the formation of social communication between individuals makes it necessary to create 2 types of spaces: Spaces in the stairwell and near the entrance door of the units with multiple functions that strengthen and enable

social communication between neighbors. Other suitable, prepared, and equipped open spaces make it possible to strengthen the collective spirit of residents at the scale of the complex and the block and are useful in increasing the sociality of individuals and the feeling of social solidarity. Also, the place where residents spend their leisure time emphasizes this, that is, creating spaces for social communication between individuals at 4 levels is necessary.

- Residential unit.
- Several residential units are organized around a stairwell (one block or one block).
- On the scale of several neighboring blocks.
- On the scale of the entire complex.

Also, emphasis on the role of pedestrian paths and routes and efforts to diversify and organize them (which creates the possibility of confrontation between people and increases social relations) can be considered in this regard.

The results of examining the status of this complex will be used in the field studies in the design of the project site. Because of the number of floors and the form of placement of masses, The number of units in each block and the plan of the units (number of bedrooms) have a similar composition. Minimum required height of spaces:

- The minimum height of the living space must be 2.40 meters.
- This minimum must be observed throughout the required area.
- In a sloping roof, the height of its shortest part must not be less than 2.05 meters.
- The minimum height in spaces where there is no stopping for a long time, such as storage and small car parks, is 2.20 meters.
- The minimum height of sanitary spaces in residential occupancy must be 2.20 meters in 80% of the required area.
- In a sloping roof, the height of its shortest part must not be less than 2.05 meters.

Physical plan:

Table 7: Floor and Unit Physical Plans Details

Percentage	Area	Number	Space Name	Unit Type	
11.5%	15	1	Kitchen	Two Bedroom	Residential
11.5%	15	1	Living Room		
11.5%	15	1	Parents' Bedroom		
9%	12	1	Children's Bedroom		
30%	40	1	Reception + Dining Room		
2%	M3	1	Bathroom		
7%	M 9	1	Bathroom		
3%	M 4	2	Entrance - Filter		
2%	M 3	1	Storage Room		
3%	M 4	1	Trucks		
5.7%	M 10	1	Corridor		
100%	130	1	Total		
10%	M 15	1	Kitchen	Three-bedrooms	
10%	15	1	Living Room		
10%	15	2	Parents' Bedroom		
5.15%	24=12	Number	Children's Bedroom		

Table 8: Floor and Unit Standards Proposed Areas

Area	Area	Number	Space Name	Unit type
M 50	M 50	1	Reception + Dining Room	
M3	M3	1	Bathroom	
M9	M9	2	Bathroom	
M4	M4	1	Entrance - Filter	
M3	M3	1	Storage Room	
M5	M5	1	Terrace	
M10	M10	1	Corridor	
M155	M155	1	Total	
18	18	1	Kitchen	
20	20	1	Living Room	
17	17	3	Parents' Bedroom	
36	36	1	Children's Bedroom	
55	55	1	Reception + Dining Room	4 bedrooms
M3	M3	2	Bathroom	
M9	M9	1	Bathroom	
M4	M4	Number	Entrance	

Table 9: Floor and Unit Specifications

Percentage	Area	Number	Space Name	Unit type
1.5%	M 3	1	Warehouse	
3%	M5	1	Terrace	
5.5%	M10	1	Corridor	
100%	M180		Total	
31%	$5 \times \frac{2}{5} = \frac{12}{5}$ $\frac{12}{5} \times 30 = 375$	30	Permanent Parking Space	
10.5%	$5 \times \frac{2}{5} = \frac{12}{5}$ $\frac{12}{5} \times 10 = 125$	10	Guest Parking Space	
58.5%	M700		Roads	
	M1200		Total	
50%	M1000	2	Public Courtyard	
25%	M500		Yard of Each Unit	
12.5%	M250		Gathering Space	
5%	100M		Children's Play Space	

Desired area for two bedrooms:
Total area $13 \times 130 = 1690$
M 130 Substructure
units, number of two bedrooms
Desired area for three bedrooms:
Total Area: $18 \times 155 = 2790$
M 155 Substructure
units, number of three bedrooms
Desired area for four bedrooms:
Total Area $9 \times 180 = 1620$
M 180 under construction
units with four bedrooms
Total area of residential units: 6100
Total area required:
M 9920 = (janitor) 120 + (open space) M 2000+ (services) 500+ (parking) 1200+ (residential infrastructure) 6100

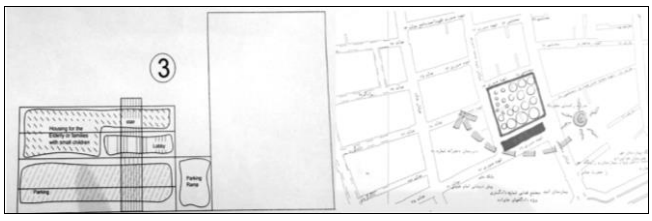

Fig 2: Spatial Organization of the building (right) as well as the sun's orbiting angle

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