

Architectural Strategies in Cold Regions to Create Sustainability in Residential Spaces

Mansour Nikpour¹, Farhad Kazemian², Nasim Bahmani³
^{1,2,3}(Architecture Department, Islamic Azad University, Bam Branch, Iran)

ABSTRACT

Disregarding the excessive consumption of energy to provide comfort in the residential units, especially in cold and mountainous regions, is one of the problems of residential complexes in Iran. Although a lot of researches have been done in this field, the inattention to this matter not only causes energy crisis in the future but makes the residential complexes as the biggest environment polluter sources. On the other hand, the traditional architects of Iran have provided the residential areas, especially by considering the hard conditions of cold regions, with comfort by applying simple and available techniques and by the minimum use of fossil fuels.

Therefore at the first of this research there's a review on the regional specifics and climatic properties of cold and mountainous regions and then through the observation and former researches the specifics and strategies of residential areas architecture are discussed and reviewed from the viewpoint of providing comfort conditions by minimum amount of fossil energy, so that the effect of each feature in reducing the energy consumption could be evident. As a result, the possibility of creating sustainable residential areas are provided in the future by applying the traditional architecture strategies

Keywords - Sustainable Architecture, Residential Areas, Comfort Conditions, Architectural Techniques

I. INTRODUCTION

Mountains and High Plateau Region is one of the four climatic divisions of Iran [1].

Alborz and Zagros mountain chains separate the central areas of Iran from the Caspian Sea in the north and Mesopotamia in the west. There are also single mountains in the center and east of Iran including Taftan Mountain, Shirkooh. The western highlands, that surround the western highlands, that surround the western slopes of Iranian central plateau mountain chains and all the Zagros mountains, are considered as cold regions of the country. The climatic generalities of this region are as follows: Severe chill in winter and temperate weather in summer;

Extreme difference between day and night temperatures;
Heavy Snows;
Low humidity of weather.

The average weather temperature in the warmest month of year is more than 10 degree Centigrade and less than 3 degree Centigrade below zero in the coldest month of year. The temperature fluctuation during day and night is more in the mountainous regions. The valleys in this region are very warm in summer and temperate in winter. Rate of sunshine in this region is high in summer and very low in winter. The winters are long, cold and severe, and the earth is covered by ice for several months of year; the spring that separates the winter and summer stays for a short time. The cold weather starts from the first of October and continues nearly to the end of April. All over this region, from Azarbayejan to Fars Province, is severely cold in winters. In these regions the amount of precipitation is low in summer and high in winter and it's mostly snowfall. The continuous snowfalls cover most of tops. There's always snow in the heights higher than 3000 m and these highlands are the source of rivers and aqueducts of the country.

Snowfall in the north and northwestern areas of this region is more than western south areas. Despite the great deal of precipitations, the humidity of this region is low. The western mountain ranges also prevent the penetration of humid Mediterranean weather to Iranian plateau and keep the moisture in their own slopes. Despite the heavy weather of the northern regions of Iran and the coasts of the Caspian Sea, which is because of the low altitude and much precipitation, the weather in the cold region is lighter and this fact decreases the use of natural air conditioning [2].

II. METHODOLOGY

This research engaged in reviewing any of the traditional residential areas of Iran via observation and evaluation of former studies and demonstrated the role of any obvious effective factor in establishing the comfort conditions with minimum energy consumption including residential areas positioning in relation with each other (city texture), orientation, general form and pattern of buildings, elements, materials, openings, dimensions and proportions; so as to create sustainable residential areas by help of traditional architects' strategies in design and construction.

III. FINDING AND DISCUSSION

3.1 CITY CONTEXT CHARACTERISTICS

The city texture of the cold and mountainous region has been developed in order to cope with extreme cold. Specifics of urban and rural texture in this region are as follows:

1. Compact and intensive texture
2. Small and enclosed areas
3. Taking advantage of the sun and earth directions (As determining factors for establishment and expansion of the city and its appearance)
4. Narrow passages along the ground level[1].

Considering the cold and mountainous region in Iran, the buildings are constructed compact and joined together to decrease the contact surface between

warm residential areas and outer cold environment, so that the heat dissipation and draught is prevented. The buildings are also located side by side in a way that enclose each other and the urban spaces become as small as possible to reduce the cold wind penetration into urban spaces and let the heat reflection from the outer surface of warm walls of the buildings decreases and moderates the coldness of weather in small and enclosed urban areas "Fig." 1.

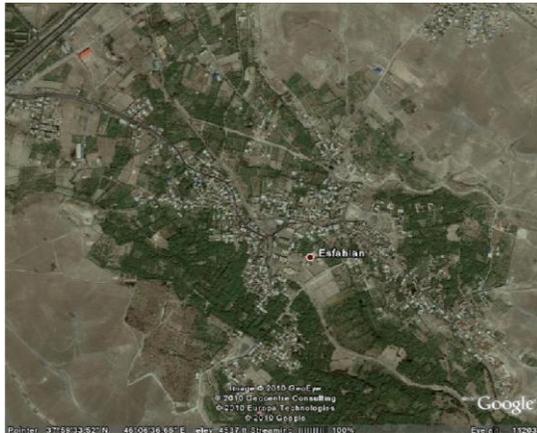


"Fig. "1. View from Mountain toward residential context

The other obvious point in this type of cities is design of narrow passages to take more advantage from heat and prevent cold and heat exchange. In this type of region the residential areas are usually established in the middle of heights slope toward the south and in or on the ground. This is done for the following reasons: first, to enhance the heat capacity of northern walls and increase the interior volume in relation to exterior surface. Secondly, penetration of the heavy cold weather to the valleys increases the chill severity during night. Thirdly, the northern front of the mountain is usually under shadow and is cold, while the cities should be built toward the valley and in the sun to make the maximum use of sunshine. Fourthly, because of the excess roughness and severe winds on the height of mountain, and on the other hand, the availability of water resources and running rivers in the bottom of heights, it's not correct to establish the urban texture on the height of mountain "Fig." 2 [2, 3, 4].

Also for preventing cold wind, cities are located in the middle of hillside In this area the central yard is

smaller than central yard of buildings which are located in central plateau. In this region wood is used for roofs and stone is used for walls because these materials are available in these regions and have low thermal conductivity [2].



"Fig."2. Texture of Esfahan(a city in the high plateau region)

3.2 BUILDING CHARACTERISTICS

The extreme cold weather during the greater part of year in cold and mountainous regions makes necessary for residential areas to take advantage from maximum sunshine, daily temperature fluctuation, heat protection and prevention from winter cold wind. So the form of building is designed and constructed to cope with extreme chill [3].

3.2.1 BUILDING'S FORM

The traditional houses in cold region such as central regions of Iranian plateau have a central yard and the other parts are set around this yard. The rooms located in the northern direction of yard are larger than other parts and hall or the main sitting room is also located in this direction of yard to make use of heat and direct sunshine in the cold season of winter. The southern part of building is not used much because of the short and temperate summer. So the southern rooms, eastern and western rooms, if available, are used as store room or Service areas like servants' room or bathrooms. Unlike the temperate and humid regions of southern coasts of the Capital Sea, the houses of these regions often have basement with short cellar beneath the winter room that is used

because of its cool for residence and comfort of home habitants in summer [5, 6, and 7].

3.2.2 BUILDING'S SPACES AND ELEMENTS

Since most days of year are cold or extremely cold in mountainous regions, most of daily activities are done inside the rooms. So the size of yards in these regions is slightly smaller than those of central Iranian plateau regions. Buildings in these regions have verandas but their depth is far lesser than the verandas in southern regions of country, and they don't have sitting room usage as those of the Caspian region and they're only used for snow and rain protection of building entrance. The other point is that the floor of building yards in cold region is 1 to 1.5 m below the sidewalks level to direct the current water of creeks or brook toward yard garden or water reservoir in the cellar, and on the other hand, the ground as a heat insulation surrounds the building, prevents thermal exchange between the building and environment and preserved the heat inside the building [2, 7].

3.2.3 BUILDING'S PLAN AND DIRECTION

The buildings in the cold and mountainous region have a compact plan and texture. The building formation should be in a way that reduces the contact surface with outer chill so that less heat may transfer from inside to outside. So the shapes such as cube or cubic rectangle are used to reduce the outer surface of building in relation to its inner volume and keep it in possible minimum. The buildings are established between 20 degrees to the west and 45 degrees to the east, in the wind shade of each other, out of sun shade of each other and along the north-south axis [2, 8].

3.2.4 BUILDING'S ROOM CHARACTERISTICS

In the cold and snowy regions construction of large rooms and areas inside the building should be avoided because this increases the contact surface with cold outer area and it's hard to warm this large room. So the ceiling of rooms in these regions are considered lower than the similar rooms in the other regions to decrease the room volume and the outer surface gets minimum in relation to the building volume. The low height of ceiling in halls, important

rooms, arch roofed passages and bazaar chambers are famous in these regions [2, 7 and 8].

3.2.5 BUILDING'S OPENING

Small openings in low numbers are used to prevent the thermal exchange between outside and inside of the building in these regions. If the windows are large, it's necessary to apply a shade. The openings used in the south side are larger and longer to take maximum advantage of sunshine. Also it should be prevented from settling the openings in the direction of cold winds. Double walled windows are also proper to minimize the thermal exchange. Meanwhile, the rate of internal air exchange and natural ventilation should be minimized as much as possible to prevent from breeze in the building and inner heat exit to out. In comparison with warm and dry regions, the dimensions of openings in this region are increased to make use of heat energy of sunshine [2, 5].

3.2.6 BUILDING'S WALLS

High thickness of walls, in turn, also prevents heat exchange between inner area of building and outer environment. The standards of architecture in cold and mountainous regions are nearly similar to those of warm and dry regions; and the only difference is in heat producing sources. In warm and dry regions this source is from out of building but in cold region is from inside. In these regions the wall thickness should be increased by constructional materials so that this wall may act as heat saving resource for internal area of the building. The thick walls save the heat of daily sunshine during the night and help in warming the inner space.

In local architecture of these areas, it's tried to warm the building by natural methods or by use of heater and the warmth resulted from house habitats and cookery [2, 4].

3.2.7 BUILDING'S ROOF

Traditional buildings in the northern mountain side of Alborz mountain chain have steep roofs but ones in the mountainous regions often have flat roofs. The steep roofs, if covered well, are much better than flat roofs because the rainwater is easily directed away from the roof. But if it is covered by cob (clay and

straw), its resistance toward moisture, rain and specially snow is far decreased. Therefore, when there's a precipitation, the snow is shoveled from the roof at once and the roof should be rolled by a small stony roller so that the cob cover gets compact again and the holes made by water infiltration get blocked. Applying flat roofs in cold region makes no problem because keeping snow on the roof can be used as a thermal insulation against the severe chill of outer environment that is several degrees lower than snow temperature. Also the space beneath the truss, which is used as store room, is a proper insulation between inner and outer area of the building. So a double walled roof for the buildings in this region is of high importance in keeping the building heat [2].

3.2.8 BUILDING'S MATERIALS

The materials used in traditional buildings in cold and mountainous regions, like in other regions, are from the available materials there. These materials should have a good thermal capacity and resistance to keep the building warmth in its inner area. So the body of these buildings is from stone (or wood, cob mortar, adobe and bricks) and the roofing is from timber and cob. Stone and heavy resistant materials are used for building foundation, and in some parts the heavy materials are used for base course to prevent moisture. However, the buildings of these regions are generally built on the ground [5, 9, 10].

3.3 DESIGN STRATEGIES

The principles that have been thought for adaptation to climatic conditions of these regions are very important; and they are as follows:

Using common walls as much as possible and creating a heaped and compacted texture in complexes;

Preparing compressed and compact planes;

Forming the building to create shade in summer and receive proper heat in winter;

Placing heat generating spaces like kitchen in the center of building plane;

Considering non important spaces like store as heat insulator in sides or cold parts of building;

Using appropriate heat insulator in outer walls and especially in roof;

Using stony bed below the rooms to reserve extra heat in floor and release this saved heat in night or cold times[2,10].

IV. CONCLUSION

The traditional architects of Iran provide residential areas with comfort conditions by applying simple techniques. Using compact plans, minimizing the outer surface against the covered volume, applying materials with good thermal insulation and capacity and minimizing the inner air exchange and natural ventilation are among the techniques that were used by traditional Iranian architects to create comfort conditions and this case was performed with minimum use of fossil energy. Applying nature - returnable materials and minimizing the use of fossil fuels are among the aim points of sustainable architecture. Therefore, the strategies applied in Iranian traditional architecture have a great effect in creating a sustainable architecture. These techniques can also be used in the design of residential complexes in cold regions to minimize the energy consumption for providing comfort conditions. In this case, by taking advantage of these techniques the aim of sustainable architecture is achieved.

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