

An Analysis to Historic Roots of Climatic Design in Ancient Architecture of Central Zone of Iran

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Abstract. Human life has been affected by climate and its influence on the earth and built environment for a long time. The first humans lived in caves and constructed shelters to protect themselves from the rough climatic elements and it can be claimed that the first architects well knew the impacts of climate on the built environment, since the first documentation of design with climatic interests in mind dates back to ancient times. Iranian traditional architects were no exception and they had obtained admirable approaches and techniques to create climate-responsive designs or buildings which were constructed with designs and materials that make use of the surrounding climate and its natural effects in order to keep occupants comfortable. Mentioned climatic impacts are much stronger in Iran because with the country's struggling economy and varying climate zones, and in this paper, techniques of climatic design in ancient architecture of central region of Iran are introduced and analyzed.

Keywords: architecture, climate, design

1. Introduction

Each region of the world, due to its unique climate and environmental conditions, employs its own construction techniques, materials and designs in its buildings that are best suited to that particular region and that encompass the region's cultural patterns too. As a matter of fact, many of the same techniques were employed in different zones, but it is the way they are used in each respective climate that makes them unique. Besides, the formation of new attitudes towards architecture, design, construction and environment with the aim of promoting the quality of human life by the help of green and sustainable strategies, as well as reducing the reliance on fossil energies and minimizing the consumption of energy has led to identification of the passive cooling and heating strategies used for creating a condition of comfort for man along recent decades, and it is now being taken into consideration more precisely and comprehensively in different steps of an urban or architectural project.

On the other hand, over the twentieth century building design and construction in advanced nations became increasingly regulated and in the 1990s, post the Rio Earth Summit, ESD (Ecologically Sustainable Development) got added onto other planning and design requirements. The combination of pressure from regulators, directions over the last two decades within architecture, as well as increased public concern about environmental degradation and climate change, has meant that more things are designed and constructed today with the claim of being environment friendly or climate-responsive.

2. Climatic Challenges of Architecture in Iran

Iran enjoys a considerable climatic diversity, experiencing various seasons in different parts of the country, in a way that in some areas, the coldness of winter and the warmth of summer can be simultaneous. According to scientific statistics, Iran reveals considerable climatic changes due to its latitude. For example, the average annual temperature increases from northwest to southeast of the country and varies from 10 degrees Centigrade in northwest to 25-35 degrees Centigrade in the south and southeast. The northern and southern shores of Iran, in different seasons, have diverse climates, compared with central and mountainous

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regions. The difference of average annual rainfall is also very high in different parts of the country and due to statistics these changes vary from 2000 mm in Gilan to less than 100 mm in central parts of Iran. Therefore, climatic conditions of Iran are very complicated and the issue of climate and the associated aspects must be judged regionally. Among different parts of the country, central parts of Iran have a very hot and dry climate and most important is the existence of the two deserts of Kavir-e-Loot and Kavir-e-Namak (Dasht-e-Kavir), as well as scanty rainfall which resulted in having a semi-dry and dry arid climate with hot summers and cold winters. In many historic city centers of each region, the urban and architectural features indicate the particular life style in which the adaptation with the specific climatic situation of the relevant areas has been an initial principle of architectural and urban planning and design process. In fact, this situation made it necessary to adopt a particular architectural style and construction method in which the old parts of cities such as Yazd, Kashan, Isfahan, Tabriz, Shiraz, Kerman and Hamadan were mostly built of [1].

Iranian traditional architects were well aware of this fact and had obtained admirable approaches and techniques to create climatic architecture or construct climatic buildings with designs that make use of the surrounding climate and its natural effects in order to keep occupants comfortable. Iran has a diverse climate and vernacular builders have presented a series of logical solutions for human comfort. Nowadays, the knowledge of building ecology focuses on its capacity to integrate environmental and climatic parameters into design and thus enhances space qualities such as comfort ability [3].

3. Climatic Design in Traditional Architecture of Central Zone of Iran

Although some studies have been carried out to identify different vernacular strategies in architecture and urban design of hot and arid climate of Iran but there exists no enough understanding of conscious designing based on the all patterns at hand. In central Iran, in order to create harmony with its hot and arid climate, vernacular architects have contrived and applied some strategies as a response to desert conditions so that they can meet the demands of the inhabitants, while the designs and constructions are based on environmental concerns and sustainable interaction between human and environment [4].

This climate that consist of the most parts of the central Iranian plateau, receives almost no rain for at least six month of the year, hence it is very dry and hot. In this climate the summer is very hot – arid and the winter is very cold and hard. In this area, sky in the most of months of year is without cloud and the weather hasn't nay humidity. Thus temperature variety in the past has presented a series of logical solutions for human comfort. A principle for the existence of building is the need for better environmental conditions. Early men constructed houses to keep out the elements – rain, wind, sun and snow. Their purpose was to produce an environment favorable to their comfort and even to their survival [2]. Its features are based on climatic factors as well as local construction materials of hot-arid and hot-humid regions and natural cooling systems are one of these feature. There are various natural cooling systems in vernacular architecture of Iran Like: Qanats, Showdan, Cellar Shabestan, Khishkhan, Courtyard, Sabat, domes with air vent and Badgir (wind catcher). Furthermore, the desert buildings are equipped with arched roofed, water reservoirs with arched domes, ice stores for the preservation of ice, and urban texture in these areas is harmonized with conditions of life and natural factors. Therefore, vernacular buildings and materials are normally well adapted to the climate and result of this approach is harmony with nature [3].

Providing optimum cooling and heating in residential buildings of hot and dry regions in Iran so far has been according to the relations of ecology, so that using designs based on climate, local materials and also culture has damaged the environment as little as possible. Iran's traditional architecture has been generated from a climate and the situation which it has grown on it, so that all existing spaces of these regions such as urban spaces, passages, yards, and buildings are protected against the atmospheric factors especially undesirable winds, and desirable winds and the sun radiation are exploited according to some special arrangements. In order to escape sun light and heat, outer parts of building walls of these regions are condensed to each other and the houses are thickly joined to each other. The public passages are narrow with organic geometry and sometimes they are enclosed with quite high walls or covered. It is believed that while these situations create a shadow against the sun's radiation they control the speed of Kavir (desert) winds. Another unique feature is the courtyard. The idea of courtyard in the houses of these regions has been formed according to the climatic factors, so that construction of courtyard houses with other elements such as thick walls of porches, basements, wind catchers, arches and domes show that architects had an explicit concept of environmental conditions. Moreover, seasonal usage of spaces, concentration and attention to courtyard and making suitable use of roof are the very functional ways of planning which is in accordance with hot-arid regions [5]. It can be concluded that the buildings in central Iran which is almost a desert region were designed and constructed according to the specific climatic and environmental conditions and differ with those built in other climates. The buildings of this area were equipped with features such as Badgir (wind

catcher), domes with air vent, water reservoirs and ice stores for the preservation of ice for hot seasons [6]. These features along with some characteristics of urban structure create a climatic environment in which human comfort can be obtained. Among the most obvious characteristics of architecture and urban design in this area, factors such as direction of buildings, organic geometry of urban structure, buildings with climatic functions and special elements of building are worth mentioning.



Fig. 1: Covered alleyways called Sabat in central zone of Iran.

In this area, design and construction of residential buildings was exactly according to the climatic conditions especially considering the direction of prevailing wind. In other words the residential quarters are such that the winter sun deposits its maximum heat over the building and in summer a pleasant wind blows in the passages which have been designed due to the direction of desirable wind of the area. Of course other factors were involved such as compact texture of the city and the construction over underground water reservoirs and exploiting the water by means of underground water channels or aqueducts called Qanat. The Qanat was connected to several water reservoirs in its route and supplied the necessary water for houses and other buildings such as mosques, public baths and caravansaries and bazaar. In order to benefit the existence of Qanat, most of the important and prestigious buildings of the city were built along its route or adjacent to it. Another important factor in the architecture of the region making it climate-responsive was the materials used in the construction of buildings. The common material for constructing huge walls in hot and dry regions includes mud, mud brick, stone, clay mortar, lime and wood. The thermo-physical specifications of these materials are the important factors in hot and dry regions. These materials have thermal resistance, high heat capacity and they absorb the sun radiation by their external surfaces. The microscopic pores of the mentioned material, which are filled with air, change them to a material similar to thermal insulator [5].



Fig. 2: An overview of Yazd, a city in central zone of Iran.

Besides, air vents were employed in domes and curved roofs, which was another creative approach in traditional convective cooling systems. The hot air that gathers under a curved roof is above the living area of the room. So, the room is kept more comfortable and heat transfer from the ceiling to inside is limited. A curved roof is most effective when it is incorporated into an air vent. The operation of an air vent depends on the fact that when air flows over a cylindrical or spherical object, the velocity at the apex decreases. If there

is a hole at the apex of a domed or cylindrical roof, the difference in pressure collects the hot air under the roof to flow out through the vent [7]. From the above mentioned examples as a few examples not all of the climatic concepts employed in the traditional architecture of central Iran, it can be concluded that traditional architecture of Iran can be perceived to be climate-responsive construction for having climatic features. It was able to respond to environmental problems from a long period because its features were based on climatic factors, local construction materials and human-environment interaction.

4. Challenges of Climatic Design in Contemporary Architecture of Iran

Currently, energy constraints and global warming are the biggest challenges confronting the planet. Energy is a vital part of every aspect of life in the modern world and demand for energy is rising rapidly. The analysis carried out by the US Energy Information Administration (EIA) estimates that, by 2030, global energy consumption will have grown by over. The world population, which has increased more rapidly than ever before over the last 50 years, indicates huge future demand for houses and the energy to run them. The building sector is one of the major energy consumers in the world. The proportion of total energy use attributable to buildings generally ranges from 10 - 15% in undeveloped countries to more than 40% in the developed countries. In the UK, building use currently accounts for 46% of total energy consumption and it has been calculated that this energy could be almost halved if the existing building stock were adequately insulated [8]. In Iran statistics show that buildings account for about 39% of total energy consumption. According to a report in "The 2nd conference of Fuel Conservation in Buildings" in Tehran (2003), the amount of energy consumed in buildings in Iran is equal to 30% of its annual oil income (equivalent to US\$15 Billion in 2005), with 50% of this being wasted. Using and wasting energy, air-conditioned energy-dependent buildings result in more emissions of green-house gases that drive global warming. Global warming is one of the most critical components of environmental degradation. Global temperature which has risen by over 0.7°C in the last 300 years is predicted to rise by up to 8°C by 2050 in the worst global warming scenario [9]. What is certain is that one of major and unresolved difficulties is the question of the relation between contemporary architecture of Iran with traditional architecture. The ambiguity about the ability of contemporary architecture of Iran to keep connection with the past is obvious in different aspects such as identity, culture, construction materials, economy and climate among which the latter is related to our research. Most of 20th century buildings are not constructed suitable for present conditions being dependent on air-conditioning systems and electricity, reliant on fossil fuels and increasingly unable to adapt to a warming climate. A large proportion of these modern buildings are poorly designed for the prevailing climatic characteristics of each region, leading to extreme use of electrical equipment and energy to maintain desired indoor conditions. These buildings, without enough insulation, un-shaded, over-glazed and tight-skinned and with inefficient air conditioning, are using vast amounts of energy to provide thermal comfort, especially when the weather conditions are harsh and extreme. Developments in many parts of hot climate of Iran, is badly hindered by the crippling high cost of energy. At a time when brown-outs and black-outs are predicted due to high consumption levels, problems in production of electricity and the increasing summer temperatures, people will not be able to stay in many buildings if the electricity fails particularly during the day. In hot climates, if the air-conditioning goes off, buildings, very quickly become uncomfortable, and in a short time such structures will have soaring internal temperatures in summer.

5. Conclusion

In contrast to modern buildings, vernacular architecture in any region is more adaptable to the environment in many ways. Traditionally, builders used knowledge passed from generation to generation to ensure that their buildings could modify the impact of a hostile outdoor environment. Vernacular buildings in the desert are equipped with thick high walls, wind catchers, courtyards, ponds, fountains, rich gardens and vaulted chambers, according to principles evolved over many generations. These design and construction principles include physical functionality, beauty, low-energy use, comfort, durability and affordability. Such buildings used local construction materials, passive cooling and heating, and renewable energies. Vernacular resource technologies and forms are generally seen to be well adapted to local climate conditions and are often considered an appropriate base for environmental design.

In spite of its importance, traditional architecture and its construction methods and strategies, especially those of the hot-arid climate of Iran, are undervalued and unused in new constructions. Younger generation of architects are less experienced in the traditional architecture and construction methods of warm and dry climates, and most of the limited research in this field is not engaged in utilization and revival of traditional solutions and techniques in new constructions and modern buildings. It has been suggested that these

solutions are for all environments and cultures, not just for architecture in hot arid zones. Recognition and use of this traditional knowledge will enhance human thought and culture. Although some basic facts and figures are available, not many studies have identified general principles and concepts of vernacular architecture, particularly in Iran. Many of the early studies failed to pay much explicit attention to the way in which traditional construction methods might contribute to the creation of future built environments. Even in developed countries, the way in which vernacular knowledge and experience may be used to respond to 21st century challenges has so far not been the subject of many discussions. Research projects that explicitly address the application and use of vernacular knowledge and skills in contemporary architectural practice are rare. Most of the existing literature in this field does not deal with vernacular traditions in terms of their application in modern designs.

Some intellectuals have conducted studies on vernacular architecture in Iran but these studies are mostly history-oriented and descriptive, introducing and describing how this kind of architecture worked in the past. The difficulties in using traditional technologies, and the opportunities they could offer to today's architecture, have not been addressed. Except for a small quantity of research, the way traditional architecture works now, and can work in the future, in relation to energy and thermal performance, is a neglected area. Moreover, there is no comprehensive study on the relationship between temperature increase resulted from global warming and the effectiveness of passive-cooling systems. The extent to which traditional systems could provide comfort conditions in the buildings, has not been subject of much studies and the way buildings can withstand extremely hot summer temperatures has not been well addressed.

In this regard, the key challenge in the 21st century is to learn fundamental lessons and principles of vernacular architecture, and to find ways of integrating those principles into development programs to upgrade existing settlements and to plan new ones. The challenge is to find out how the achieved knowledge, skills and experience of the world's vernacular builders maybe fruitfully applied in a modern context. What is required is a method that enables us to scientifically test the actual performance of vernacular traditions and generate an understanding of how they may be upgraded to provide truly sustainable constructions and buildings for the future.

6. References

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