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Sustainable Traditional Architecture and Urban Planning in Hot-Humid Climate of Iran

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***Abstract*—**This paper concentrates on the sustainable traditional architecture and urban planning in hot-humid regions of Iran. In a vast country such as Iran with different climatic zones traditional builders have presented series of logical solutions for human comfort. The aim of this paper is to demonstrate traditional architecture in hot-humid climate of Iran as a sample of sustainable architecture. Iranian traditional architecture has been able to response to environmental problems for a long period of time. Its features are based on climatic factors, local construction materials of hot-humid regions and culture. This paper concludes that Iranian traditional architecture can be addressed as a sustainable architecture.

***Keywords*—**Hot-humid climate, Iran, Sustainable Traditional architecture, Urban planning

I. Introduction

THERE are different geographical locations in Iran and this provides various climates and every climate has its special characteristics. Some Iranian researchers worked on climatic division of Iran but the method of Dr. H. Ganjee that is based on Koppen's method is considered suitable for this research. Koppen divided the world based on the growing of plants. Microclimates have affected urban planning and architecture. In a vast country such as Iran with different climatic zones, traditional builders in the past have presented series of logical solutions for human comfort. Here, we just describe Hot – humid climate of Iran [1].

II. Hot-humid Climate

This region lies along a narrow and relatively lengthy littoral strip of Persian Gulf coast. Its length exceeds more than two thousand (2000) kilometers. The different zones of this strip are considered as those with hot and humid climate. They have rather long summers and winters with short days. In fact, there is normally rather cold weather only during two mouths, Jan. and Feb. In this area, there are very high levels of evaporation and air humidity because of its proximity to the sea and vertical solar radiation in both spring and summer on the one hand and because of the existence of typical soil of this area which is physically calicoes and because of very hot weather, the grass and plant covering is very meager on the other hand. Too much humidity of air across the sea coast and much heat of air in hot seasons create sweltering weather that develops very troublesome living condition [1], [2]. In general, this region has the following climatic conditions:

1) Scanty level of annual Rainfall with the most rainfall occurring during autumn (fall) and particularly winter.
2) Overwhelmingly high humidity in air in all seasons of the year.
3) It has a very hot and humid weather in summer and moderate one in winter.
4) Salty or briny ground water in most areas.
5) Scanty level of grass and plant covering [2].

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III. Urban Texture

Urban texture has taken a semi-consolidated form and is bound to the south and south east. Urban spaces are half-circled so that cities develop towards the coast line and have seaward directions. The more the cities are away from the sea coast, the more the spaces are closed and encircled. A semi-consolidated urban texture allows air to flow easily across the city. The air flow and shade are two important factors to make a suitable urban texture and structural form for life in this climate. The urban texture is dense and the lanes and alleys have narrow widths that they would be around 1-1.5 Meters wide. The proportion of walls height to the width of a lane or alley is about 10/1 so that they may create suitable shade in hot seasons and decrease the surrounding temperature. Other important characteristics of littoral cities located in the southern parts of Iran are the existence of long flood canals. Since the soil in this territory is of calicoes type and the earth is not covered with grass completely, rain water does not penetrate into the soil and so even a little rain that falls can make flood. For that reason, it is very imperative to construct and dig up long canals to conduct the rain water away in such cities. These flood canals are, however, in need almost all days of year except a few days [2], [3].

IV. Central Courtyard

The courtyard (Hayat-e-Markazi) in hot dry and hot humid climates are the heart of the dwelling spatially, socially, and environmentally. The average size of the courtyard is generally determined according to the latitude. They are narrow enough to maintain a shaded area during the hot days of summer, but wide enough to receive solar radiation in winter. A courtyard can provide security, privacy, and a comfortable place in the house [1].

In hot–humid climate, surrounding rooms overlook the central yard. The difference between the central yard in this climate and in hot and dry climate is that there is no entirely closed connection between internal spaces of building and those of external in hot and dry climate. These courtyards with

high and long windows have broad verandas overlook the lanes in second floors and especially in third floors. These buildings have bilateral ventilation. In hot days if the windows toward the yard are open and those toward the lanes are open too, it will make the natural bilateral air current to flow freely. This will slump down the intensely high temperature in interior spaces. Another difference is that in hot and humid regions, the courtyard is designed as more compact and of less size. One reason for it is to facilitate a way for tree irrigation and permanent predominance of shade in hot seasons [2], [3].

The courtyard where it is usually planted with trees, flowers and shrubs, not only provides comfortable condition and beautiful place, but also supplies some shade and increase the relative humidity in the courtyard space. "Even without modern, mechanical heating or cooling systems, the courtyard provides a comfortable living environment through seasonal usage of sections of the house. The thermal performance of courtyards has been studied by many researchers [3]. An appropriate explanation however, can be provided by considering the thermal properties of the air and the material of the courtyard .As the thermal capacity of air is very low, the temperature of the courtyard air follows very closely the temperature of the surrounding surface at night, the mass of the walls and floor of the courtyard is cooled by outgoing long wave radiation, and therefore, the surface of the courtyard floor and walls will remain cool by the following morning. In this way, the mass of the walls and floor of the courtyard (and not the air deposited in the courtyard) serves as a reservoir of coolness, if it is not too large and well shaded [1], [4].

In houses where rich people live there are two courtyards. One is a private quarter where close family members such as kinsfolk live and the other is an external one where guests are allowed to come in. In a larger house, there is another courtyard which is called service and facility room. This is simpler and smaller in size than private quarters and special to the living of servants and breeding the chicken, and domestic animals [1].

V. Roof

In hot-humid region, most buildings have flat roofs. In hot seasons people are used to sleeping on roofs because of cool weather. The shelters on and around the roofs are often made in the form of grid so that the residents would be kept safe from the looking of outsiders and at the same time residents use the current of air on the roof. Flat clay plastered arch is used to cover the roof. Lengthy wood beams are laid on to the opposite wall within 30 centimeters away from each other and then mats are laid on these beams and finally the surface on these beams and finally the surface of roof is covered with one layer of clay plaster. In most cases *Rhizophora mucronata*, an Indian wood, is used as hat for roof. This lumber is smooth, long and is kept safe against pests such as termite as well as humidity. One disadvantage of such roofs is that there is no rigid link between beams and walls and are, thus, affected by earthquake [2].

VI. Materials

Wood is considered to serve as a good material. However, since in hot-humid region, there is little grass covering, wood was merely used for roof framing and windows or door woodworking. And in making other parts of building uses are made of native and local materials existing in any region there such adobe, baked brick, brick and alluvial rocks, marine coral stone and reed. As these kinds of stones (rocks) are porous and they can be used as good thermal and acoustic insulators [2], [5].

VII. Color

Colors painted on walls and roofs of a building in hot and humid climate where the sun radiates in a rather intense ray will play the best part in controlling the absorption of sun's rays and radiation. A typical color also plays a very important and controlling part in controlling the solar radiation on walls and particularly on roof with its maximum potentiality in absorbing solar energy depending on different orientations of a building. The temperature difference between a white-colored roof and a black-colored one is 40 k. Of course, the amount of heat the internal space of a building takes in depends largely on thermo physical features of layers. A typical color plays a very important part. Light colors painted on external surfaces of a building also play an effective role to decrease the daily level of temperature caused by reflected sun's radiations, increase the thermal stability [6].

VIII. Ornaments

Because cities with hot and humid climate in Iran are located along the Persian Gulf coastline, there are business and commercial relationships between such cities and those lying in Arab nations and India. This, in turn brought as the same formal ornaments such as arches and semi- circular arches on the openers of building as popular in architectures of those countries [2], [7].

IX. Spaces

In cities and towns lying along Persian Gulf coastline with their hot and humid climates, spaces are organized around central courtyards and there is a limitation of at least two stories of building. No basement has been designed for houses in this region because of their proximity to the sea, higher levels of ground water and immense humidity of air. Ground floors, were used as spaces such as kitchen, foodstuff room and probably rooms to store provisions. First and second floors were living spaces such as living room, bedroom and etc. [3].

Developing living spaces in upper stories was to both create much better air current to cool the internal spaces and augment privacy by installing top window in upper stories. Rooms rise to 4 meters and sometimes more because convection decreases the air temperature in internal spaces at lower levels. Furthermore, air in the room is ventilated by windows on both sides of room. Ivan is one important space in houses in a hot and humid region. Broad and high verandas with big pillars

(Ivan) around courtyard are used as living spaced during half period of year. The reason is that it has both air current with good ventilation and suitable shade. Furthermore, these verandas do not allow the sunray to beam directly into the building [8].

X. Wind Catcher

Wind Catcher as its name implies is a ventilation structure for natural cooling. It has been needed for centuries in several countries with hot – arid and hot-humid climate, particularly in the Middle East countries. Typical wind catchers consist of a tower and a head above the roof of the building.

The tower head may have vents on only one side facing the direction of the cooler prevailing wind [1], [9]. However, two or four sides of the tower might be open to accommodate wind in all directions. Fig. 1 shows wind catchers with more than one side facing the prevailing wind. The tower would be subdivided, respectively, into two or more groups of shafts. This subdivision allows air to move separately up and down the tower at the same time and provides more surface area in contact with the air. Consequently, the breeze is drawn and is diverted to the summer living zone. Air caught in the vent is channeled down through a shaft in the building into the rooms below which are cooled and ventilated [1], [2]. Fig. 2 shows how a wind catcher ventilated different rooms in a house.

Fig.1 Wind catchers that have more than one side facing the prevailing wind

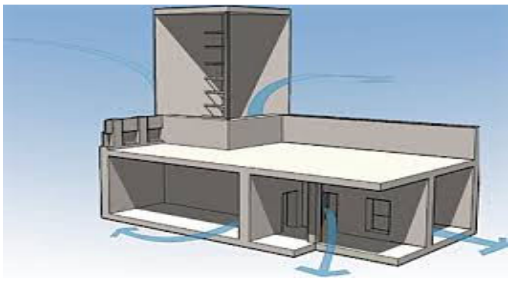

Fig. 2 The flow of air in different rooms

XI. Walls

Constructing huge walls for houses was one of the important elements in traditional architecture of hot–humid climate in Iran. Thick walls do not allow too much heat to enter to the building. Furthermore these walls were resistant against flood because in this region a lot of rain followed by flood usually happens [5], [10].

XII. Doors and Corridors

There are some grid windows on top of the doors. Directing cool winds into the building and rooms is one of the functions of these windows. The buildings' doors and the rooms' doors are often made of wood and woodwork. This wood is usually obtained from Prosopis. Prosopis is a kind of tree and its wood is resistant against the high humidity and temperature.

There are usually six grids on the doors. Just two out of six grids are covered with glass and four others are covered with wood, because fewer sunrays can beam into the rooms by this way. After the entrance door of the building there is a corridor. This corridor is sharply curved. This sharply curved corridor avoids the sunray to beam to the rooms directly. There are rooms on both sides of the corridor. These rooms have grids on their doors. By opening these grids the cool wind of corridor can enter to the rooms. On both sides of the corridor there are wide platforms that residents use them in hot seasons because of existence of cool wind in the corridor [10].

XIII. Outdoor Spaces

All of the houses and shops are on a platform that its height is one meter or more. The reason is avoiding the rain and flood entering to the buildings.

In front of each big building there is a wide platform that is used during hot seasons in the evenings [7].

XIV. Water Reservoir (Ab Anbar)

There are some differences in accessing to water resources in the south of Iran. In some cities like Abas port, Lenge port and other cities located in the western part of Abas port, rain was the most important source in providing water for people, so people had to build big water reservoirs to save water. The water reservoir includes a storage tank, stairs and elliptical arch, platform and wind catchers around it. Fig. 3 shows a water reservoir in the western part of Abas port. However, in cities and villages located in the eastern part of Abas port, because of freshwater and big rivers, people do not need to build water reservoirs. Just in some high parts that people do not have access to the rivers, they built some small water reservoirs [4], [6].

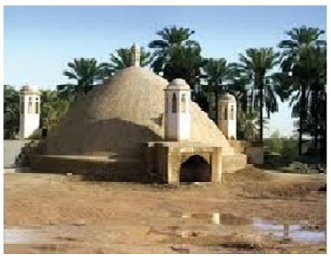

Fig. 3 A water reservoir in the western part of Abas port

XV. Sabat

One of the important elements of urban planning in cities with hot climate is Sabat. Sabat is the linked arches between two walls of an alley or it can be defined as the roofed lane. A

Sabat is designed in order to keep human safe in hot from direct radiation of sunlight in shade for some moments and makes the hot temperature of the city more tolerable. In fact these linked arches have been multifunctional structures, particularly over the long days of the hot summer, these structures together with narrow alleys and tall walls of residential buildings wildly create shade and prevent sunlight falling directly on pedestrians and make air to be cooled. It is such a way that any pedestrian under it is positioned in shade and light repeatedly. These structures also protect pedestrians from the cold wind in winter and make the weather warmer. Therefore one of the main intentions behind the construction of Sabats has been the creation of a bracing system for the linked structures. These structures have also enriched the sense of neighborhood and local correlation among the citizens. Fig. 4 shows Sabat in a hot-humid city in Iran. As it can be seen, Sabats do not cover the alley completely [5].

Iranian architects in some instances built houses up to somewhere lying on the lane and began to build one or more protruded rooms with same eaves above the passage all commuting was made under these rooms called Sabat. In some cases they are as single rooms over the narrow alleys. Sabats improve the stability of the houses and make neighbors more close to each other [3], [10].

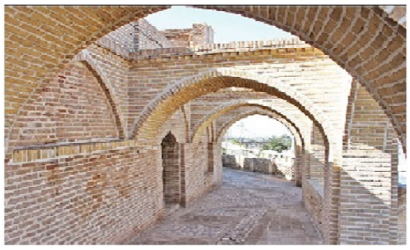

Fig. 4 Sabat in a hot-humid city in Iran

XVI. Conclusion

Many traditional societies in cities with hot seasons were thermally adapted and often lived comfortably for centuries. The solutions substantially relied on creative architectural structures that we developed to make use of natural energy, available locally in the environment.

Iranian traditional architecture and urban planning in hot-humid climate is a sample of logical planning for providing human comfort.

Planning narrowly binding or spiral-shaped lanes with high walls to provide shade in hot seasons , a structure of compact clusters of courtyard houses in the form of dense mass of cells, common and thick walls, broad verandas (Ivan) with high canopies, wind catchers to remove humidity and provide cooling in internal spaces, planning upper windows to increase passing ventilation and use of locally made materials indicates how the designers who planned such buildings good understood the environmental conditions. Focusing on how to plan the central courtyard and appropriate use of roofs at night, though appears so simple, are efficient solutions for planning in hot and humid climate. These buildings have been designed in such a fashion to take in maximum sun light in winter and maximum shade in summer for better natural ventilation and good comfort.

In conclusion, Iranian traditional architecture in hot and humid climate is considered sustainable and can be used as a model for contemporary architecture.

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She began her job as a lecturer in several universities in Iran from 2006 to 2013. As a part of her experiences she taught English language in two foreign language institutes. She had a miniature (Persian painting) exhibition in 2007. In 2009 her paper entitled "Evaluation of Priorities and Potential of Recycling of Municipal Solid Waste in Shahreza" was published in the Iranian Journal of Natural Resources. She has done some design projects such as: Land evaluation in Oroumieh in 2003, Design of an urban park in Tehran city in 2014, Urban Park Design in the North West of Tehran city in 2015, Landscape design in Islamic Azad University of Shahreza in 2015. Now she is working on her thesis that is about designing a theme park. Her interests include subjects that are related to design of a site from the regional and national scales to the urban park scales.