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The Role of Climate in Bandar Abbas Architecture

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ABSTRACT

Climatic conditions are important and effective parameters in bio-comfort in human environments. Given the climatic conditions, the architecture of the building has long been paid much attention since it can provide humans with more comfort. For example, vernacular and traditional architecture in different countries and regions of the world, especially in our country, is rich in experiences and samples that represent precise solutions for adapting the physical spaces to the climatic conditions. These solutions led to buildings and living spaces which have been quite successful in adapting to the natural environment, exploiting the natural energies, and dealing with the adverse and very hard climate conditions. The southern coasts of Iran, which are separated from the central plateau by the Zagros Mountains, form the hot and humid climate of Iran. This climate is characterized by very hot and humid summers and temperate winters. The cities of Bandar Abbas are considered some of the big cities which are subjected to this climate. Accordingly, the city's climatic characteristics have significantly affected its formation. Therefore, the present research has aimed to investigate the climate impacts on the architecture of Bandar Abbas, using the methods of Algi, Givani and Mahani. Finally, some appropriate solutions were provided for the compatibility of the climate and architecture in the city.

Keywords: *Comfort level, Climatic Architecture, Bandar Abbas.*

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1. INTRODUCTION

Creating a comfortable and ideal living environment and meeting the security of the residents of the building against adverse environmental and climatic conditions are among the fundamental principles of architecture and building. Since the early times, when early man took shelter in caves in order to avoid inappropriate environmental conditions and created ancient civilizations next to the big rivers, the above-mentioned principles have always been the source of life and survival. Besides, the man still seeks to create intelligent architecture in order to provide comfort for the residents and exploit natural energy. Interestingly, the man also explores the living conditions on other planets other than Earth, using the above-mentioned principles (Moradi, 2007, p.1). Understanding the environment, architecture, and the interaction between these two, as well as creating an architecture compatible with the environment will be investigated in this study. Bandar Abbas, which is located on the southern coast of the country, is characterized by extreme humidity, high temperature, the sea breeze blowing to the land, and local winds (Saligheh., 2004, p.1), Each of which somehow affect the architectural aspects and the formation of a residential environment. Because of their simplicity of operation and small scale, residential buildings are the most vulnerable buildings against the climatic conditions (Kasmaei, 1987, p.57). Moreover, throughout the year and all day long, residential buildings are being used by the inhabitants. The factors influencing the climatic conditions in Bandar Abbas include latitude, proximity to the sea, low altitude, the role of sea in high humidity, Mediterranean winds and two distinct regimes of precipitation, which affect the architectural aspects and the formation of residential buildings. These factors are of great importance. (Dalman, 1990: 174). Therefore, it is also of particular importance to consider the climatic characteristics in the design of residential environments in this city.

2. LITERATURE AND RESEARCH BACKGROUND

1. Geographic characteristics

1.1. Geographical characteristics of hot and humid regions of Iran

The coastal zone of southern Iran is approximately 1480 km long, adjacent to the Oman Sea and Persian Gulf. Strait of Hormuz, which is 8 km from Bandar Abbas, is located between the two seas.

The coastal zones of southern Iran were once under the water as scattered morasses. Then, the morasses dried due to low water surface and extreme heat. As a result, the morass lands emerged as current coasts and islands. Most of the coastal zones are dry, arid and low in water. The humidity appearing in the sky is scattered by the hot winds of Saudi Arabia, and that is why this area does not witness significant rain. Because of high evaporation, there is less flowing water in these areas. In addition, the rivers are often low in water, temporary, and saline (Tahbaz and Jalalian, 1998: 5).

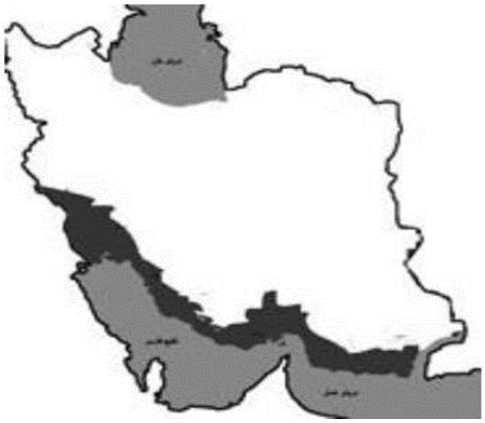

Figure 1. The vastness of the hot and humid climate of Iran

1.2. Geographical characteristics of Bandar Abbas

Bandar Abbas is the center of Hormozgan province in southern Iran. This city is characterized by a semi-arid and sultry climate, and being very hot in the summer. Bandar Abbas is located on a sandy plain. It is limited to Hajiabad from the north, Rudan and Minab from the east, Bandar Lengeh and Lar from the west, and the Persian Gulf, Oman Sea and Qeshm Island from the south. Although this city has a very hot climate (average annual temperature = 26.8 °C), with high air humidity (average humidity = 64%), and hot-sultry summers. Given the topographic conditions, it is almost moderate at high altitude (Tavernier, p. 689). Bandar Abbas is located on latitude 27 degrees and 13 minutes north and longitude 56 degrees and 18 minutes east, and 16 meters above sea level (Anonymous, 2008: 217).

2. Climatic characteristics

2.1. Climate divisions in Iran

Basically, in many parts of the world, the climate is determined by latitude and altitude from sea level. Iran is located in the warm zone between latitude of 25 and 40 degrees north. In terms of latitude, it is a high plateau with a total surface of less than 475 meters above sea level, which accounts for a very small percentage of the total surface area.

However, Iran has two large water areas (the Caspian Sea and the Persian Gulf), that their effects are limited to areas very close to them due to the Alborz and Zagros mountains. Accordingly, these areas rarely have any effect on the adjustment of temperature in internal parts.

Undoubtedly, in a mountainous country like Iran, there are never two climatically similar areas. However, the best way to achieve a foundation for determining the country's climatic zones is to use the Koppen Principles. Therefore, the divisions of Iran proposed by Dr. Hassan Konji can be used. He proposed the Koppen climate classification with a slight change, considering the geographical implications of the country, as follows:

1. Moderate and humid climate (Southern Coasts of the Caspian Sea)
2. Cold climate (Western Mountains)
3. Warm Dry climate (Central Plateau)
4. Warm humid climate (Southern Coasts)

2.2. Characteristics of warm humid climates

This climatic zone dominates along a narrow, relatively long coastal strip which is more than two thousand kilometers long. It begins at the Arvand River in the southwest of Khuzestan province, and ends in the Goatr Bay in the southeast of Sistan and Baluchestan province. In terms of climate, these coastal zones are regarded as warm and humid areas (Ghobadian, 2003: 68), which has hot and humid weather in the summer and moderate in the winter. Therefore, it is very important to investigate the climatic characteristics of this region in order to present an appropriate plan, which agrees well with the region's climate (Kasmaei, 1988: 85). The effective climatic factors in warm and humid areas, which also applies to Bandar Abbas, are as follows:

2.2.1. The sunlight

Sunlight provides the light and the heat for the building simultaneously. The intensity of the solar energy received by the earth depends on the latitude and clearness of the sky in each region. Since sunlight is almost vertical in warm and humid areas in the spring and summer, buildings are exposed to maximum heat absorption. Thus, it is necessary to control and reduce the level of radiation (Watson & Labs, 2011: 43).

2.2.2. Wind

Among the winds blowing in this area are seasonal winds such as the northern winds in the summer, which cover Bushehr and Bandar Abbas (Memarian, 1996: 4). The breeze blowing from the sea level is another important factor which has a significant effect on air conditioning. In fact, it can be argued that the optimal use of air flow is the only way to improve the extreme climatic conditions in these areas.

2.2.3. The level of humidity and precipitation

The relative humidity of hot and humid areas is about 70% due to the proximity to the sea and the high evaporation of water. This level of humidity leads to a sultry weather on the coasts along with very high temperatures, resulting very difficult and tough living conditions (Ghobadian, 2005: 62). Owing to low precipitation during about seven months of the year, the surface is dry and easily reflects the radiation, which increases the temperature of the air and disrupts the living conditions. Therefore, during seven months of the year, many activities are carried out under very hot conditions, which leads to several consequences. There is a need for continued air flow in order to evaporate the sweat and cool the body. Accordingly, this low and sporadic precipitation causes the vegetation of these areas to be limited only to date fields and the small fields.

In fact, many of the procedures that offer sustainable architecture, are based on a climatic attitude. With a climatic attitude, humans need to be provided with appropriate water and climate. The climatic conditions are one of the important foundations of Iranian architecture, so that humans can feel a relaxing space (Memarian1996: 13).

3. Determining the shape of the building in relation to the climate

Given the formation and composition of the vernacular architecture of different regions, we realize that the different characteristics of each climate have a great influence on the formation and composition of the cities. Therefore, it is very

important to determine the accurate climatic zones in the country and specify the climatic characteristics of different regions, in order to come up with appropriate plans which are in good agreement with the climate of each region. Efficient heat and air conditioning in the interior part of the building is another architectural issue which requires huge attention. It is directly associated with the comfort of humans. Accordingly, the concepts of heat or cold are more likely to result from the natural sensation of man and his/her physiological conditions. In general, humans use different ways to cope with the environment and weather conditions in order to balance the heat and thermal comfort. For example, humans use food, clothing, heating devices and housing to control his/her body temperature. (2011: 2). Further in this section, the climatic characteristics of the architecture in warm and humid areas, including Bandar Abbas, have been addressed.

3.1 The specific characteristics of warm and humid climate architecture

1) Buildings density

Owing to the high humidity of the air and the individuality, the air can easily flow around the buildings. The buildings are built at higher altitudes, with two or three floors. The high density of houses and narrow streets allows the passage of air through the houses. Given the heat and humidity of the air, an appropriate route is provided for the flow of wind by creating multiple stomata in the exterior of the house and connecting them with the courtyard. In total, there are three types of contexts on the coasts of the Persian Gulf which are known as dense, semi-dense, and open contexts (Memarian, 1996: 249). The direction of the whole buildings is directly associated with the direction of wind. Building the houses at higher altitudes to reach the proper wind direction has led to the fact that most summer rooms are located in the upper floors, while the winter rooms are located on the ground floor or just below the courtyard. Buildings in the eastern part of Bandar Abbas are in a limited space, which are also smaller in size, and each building has a garden (Babak Rad, 1974: 61). In Khorramshahr, the central courtyard wall is taller than usual and can provide more shadows. Moreover, a lot of trees are planted in the interior (Masaeli, 2011: 64). Light is usually provided by the porch from the courtyard. Roofs are suitable for sleep since it does not rain much. The bump of the roof is usually very tall, often with a height the same as a man. They aim to provide a shadow on the roof (cooling the ceiling), create more shadow over the alley and the courtyard, prevent the view of the alley to the roof and two adjacent houses, allow the air passage and cool the roof surface through bump networks. Due to the warm and humid climatic conditions, these areas have hot climates for several months. Thus, the buildings should be expanded in the east-west axis, in order to increase the view exposure to the winter sunlight. However, the eastern and western views, that only receive sunlight during the summer decrease.

2) Rooms

The room is regarded as the most private space. In terms of the hierarchy of establishment, room is classified after the porch, which is also in connection with the courtyard. The coherence of the rooms in some cases is so wide that it can be reached from one side to the other without having to cross the yard. The rooms are connected to the outside through doors and windows. The whole spaces of the house are organized based on its division into winter and summer spaces. The winter room has a small number of doors and sometimes only a single door. The small size of these rooms with a small number of openings, their depth on the ground, and the fact that they are closed from several directions, play an important role in the rapid warming of the rooms. However, there are windows and doors in different directions of summer rooms. The summer rooms are also built with three, four, five, six, seven, eight, ten, twelve or sixteen doors (Varjavand, 1972: 62).

3) Openings

The doors and windows are made of wood. These doors are half-closed or open. The openings which face the central courtyard are in the ground floor and are usually made of wood, while the same doors have a glass-fiber-reinforced woodwork with higher-level balusters. The openings are usually made up of two sections: a movable section and a static (fixed) section. The fixed section usually appears in the form of a half circle, and sometimes in the form of a rectangle or a combination of these two. This section is covered with colored glasses and a variety of designs, woods, and glass compositions (Pirnia, 1968: 79). The movable section of the openings is made of two or four leaves. The type of openings is different depending on the space used and how space interacts with the outside. Part of the openings of the outer walls of the buildings are equipped with retractable shades, which make it possible to control the light and air flow. About two thirds of the doors are made up of wood and the rest is glass. The windows also have two parts. The lower part has two wooden openings, while the upper part has two glass openings. As a result of these doors and windows, part of the sunlight is refracted and the rooms are cooled.

4) Construction materials

The most important construction materials are sponge rocks, which are extracted from the coast. These rocks are derived from marine corals, fossils, fish ears, and bones of fish that have been deposited on the coast. These rocks are extremely resistant and have vents that are resistant to heat and moisture. The grout is also used to build storage, water storage, foundation and high floors. The ceiling is also made of wooden beams. The exterior facade of the rooms is made of brick, while the interior facade is made up of plaster. Roofs are mostly made of mud. These materials prevent sunlight from penetrating into the building during the summer. Heavy construction materials on the outer walls of the building reduces the heat transfer of external air to the interior (Dalman, 1992: 26). Wood is the best type of materials in these areas because the wood transmits heat slowly. In addition, the heat accumulated during the day remains on the surface of the wood and loses its heat with a relatively cold breeze during the night. (Keiss, 1992: 217-219).

5) Patio and porch

Patio is the main communication and semi-open space in the private realm of the house which is built in two types, as follows.

A. Deep/Wooden porches

The porches are built in front of the rooms and along the length of the courtyard and connect with the different parts of the house. In many houses near the sea, instead of the patio, porches are used. Porches have a number of important functions, being an appropriate place for pleasant wind. In the

houses next to the southern coast, porches can be used to enjoy the beautiful scenery of the sea. The interior patios built in one or more directions are either ceilinged or ceiling-less. In the ceilinged patios, the cover relies on the low-pitched columns of four terraces.

B. Longitudinal porches

These porches are located on the axis to the north and east of the courtyard. Patio is a space between the rooms, and is open from one or more sides that connects open spaces to its adjacent space through the window or door. Patio is used as temporary hallway (Tavassoli, 1975: 90). The patio (taarmeh) is usually made in many shapes, the simplest type of which is represented by four square or extended rectangular corners. These simple shapes can be combined into L and U forms.

6) Water reservoirs

In these areas, private water reservoirs were located on the ground floor, while the water of these reservoirs had been provided by the rain falling on the roof and courtyard of the house. Water had been removed directly by buckets. All of the water reservoirs had been used to have ventilation valves (Ayatollah Zadeh Shirazi, 1968: 31). Although ventilation makes the air move inside the reservoir, it does not cause water to cool just like hot and dry areas, which is an advantage. Owing to the fact that the openings are built in lower heights, they do not contaminate the water inside the reservoir (Holod, 1982).

7) Windcatchers

In the coastal hot regions, the windcatchers were used in vernacular architecture for balancing the air inside the building. The windcatchers were facing the sea and used sea breeze to cool the building. In four season residences with a central courtyard, usually a wind catcher is built in those areas of the building, which are more often used in summer. Moreover, this wind catcher is linked to the main room, the hall and the cellar or the underground of the building (Semsar, 2004: 128). The windcatchers in the eastern part of Bandar Abbas do not have a major role, and therefore, the windcatchers are short in these areas and cover the openings. Perhaps one of the reasons why the windcatchers were not paid much attention was the fact that the water was abundant in this region (Varjavand, 1973: 93).

4. Research Background

Many scientific activities have been conducted in this field. One of the most prominent researches was carried out by Victor and Aldar Olgi (1953) who scientifically introduced moisture and heat conditions in relation to human needs and climate design. Ultimately, they plotted bioclimatic tables.

Carmona (1971) investigated the construction of the building according to the climatic conditions in warm and dry areas. Grishifield (1979) emphasized on the selection of the building site, and believed that, optimal usage of the maximum local climate conditions in comfort.

Riazi (1976) proposed a map of the existing climatic divisions in relation to construction work. This division was based on a method proposed by Aldar Olgi and Giounim. It was put into operation by using the statistics and information of 43 synoptic stations in the country. It aimed to study the weather conditions of different cities with respect to the performance of building elements, and to provide some information on climate design for architects and building engineers.

Alijani (1994) investigated the role of climate in housing design. In this study, he examined the different methods of studying houses compatible with climate. For this to happen, he investigated the angle of sunlight.

Jahanbakhsh (1998) studied the thermal needs of building in Tabriz. In this paper, he examined the impact of climate on living conditions by calculating the amount of day heating and cooling.

Saligheh (2004) studied and designed housings compatible with climate in Chabahar in a paper entitled "Modeling the housings compatible with climate in Chabahar using climatic elements of Chabahar Synoptic Station" from 1963 to 1995.

In his MSc thesis, Bahmani (2007) investigated the degree of comfort and characteristics of climatological architecture in Sanandaj.

Kamalvand et al. (2010) studied climate impacts on the vernacular architecture of southern coasts of Bandar Abbas. Naghipour Chenari et al. (2013) used the traditional model in order to solve the warm and humid climate problem. Fanaei and Ataei (2013) reviewed the role of climatic elements in the design of urban settlements.

5. Proposed characteristics of Mahani architecture in Bandar Abbas

1) The direction of the buildings

Owing to the warm and humid climate during the year, Bandar Abbas is characterized by hot weather. For this purpose, the buildings should be expanded to the east-west axis. As a result, the southern facade is provided with more surface. However, the eastern and western facades that receive sunlight only in the summer have less surface. Of course, it should be noted that forms are preferable that eastern and western walls have lower surface area (Omidvar et al., 2010: 14).

2) Using double-covered roofs

In the hot areas, roof is the main cause of heat in the interior, which can be attributed to the type of roof design. In the vernacular architecture, roofs are mostly made of clay and mud. These materials prevent sunlight from penetrating into the building during the hot season (ibid.)

3) Thickness of the walls

Internal and external walls in Bandar Abbas are heavy. The heavy construction materials in the outer walls of the buildings reduce the transfer of outside heat into the interior. The heavy construction materials keep absorbed heat in a specific time. During this time, if the outside air cools out, some of the heat absorbed in the material is transferred to the outside air. Accordingly, such materials will improve the relative humidity of indoor air. Meanwhile, these principles have been applied in the old architecture of Bandar Abbas (ibid: p. 15).

4) The dimensions of the windows in Bandar Abbas are small and between 20-40%

Windows are the weakest part of the outer walls of the building, which do not play a significant role in preventing the transfer of external heat to the inside. Given the hot and humid climate of Bandar Abbas, the lesser the number of windows located on the outer surfaces of the building, the lesser the amount of heat transferred from them to the interior (ibid).

5) The role of the wind catchers in balancing the weather of buildings

In Bandar Abbas, a wind catcher is used in the vernacular architecture in order to moderate the flow of air inside the building. It is usually located in the direction of the sea and uses sea breeze to cool the building.

6) The height of buildings from the ground

In warm and humid climates, living spaces are generally built above the surface of the earth to prevent more moisture penetration (ibid: p. 16).

Research objectives

1- Investigating the weather conditions of the area in terms of comfort.
2- Getting familiar with urban construction based on climatic design factors.
3- Investigating the climate impact on Bandar Abbas architecture.

3. METHODS

In this research, the role of climate on the architecture of residences in Bandar Abbas was investigated. Since this is a descriptive-analytic research, most of the information is collected through library studies. In this regard, first various climates in Iran was briefly introduced, and then the warm and humid climate of Bandar Abbas was investigated. Then, the specific characteristics of the warm and humid climate architecture were discussed. Finally, according to the Mahani index, appropriate suggestions on the architecture of Bandar Abbas were provided with regard to its climate.

4. CONCLUSION

The warm and humid climate in Bandar Abbas, the change in temperature overnight, and high relative humidity, have made the traditional architecture of this city be special. Some of the factors influencing the comfort in this city are necessary to maintain. Considering the slight changes in temperature overnight, the temperature of the air in closed environments is always higher than the outside environment. Moreover, the establishment of a heat balance between the human body and the environment is one of the basic needs for comfort. To maintain this balance, body temperature should be fixed or undergo small change. This balance depends on several factors, the most important of which are climatic factors including air temperature, sunlight, relative humidity and air flow. In the traditional architecture, buildings are built in the north-south direction, which can exploit the sea breeze. Accordingly, the living and dressing rooms, as well as the rooms that are most used are located in this part, or are located in four sides of the building with a ceilinged-porch in the front and a courtyard in the middle, in which the main spaces face the south and north, and the storages and other parts of the building face the east and west. The ceilinged-porch in this part of the building is the best way to protect from the heat. By creating a shadow, they protect the inside of the building from direct sunlight, and provide some kind of comfort zone by directing the sea breeze to the interior.

According to the climatic requirements of Bandar Abbas, buildings with insulated walls, ceilings, and facades reflecting the sunlight require that shields that are used to prevent direct sunlight, create shadows, and conduct the airflow. In this case, the building should have the following features:

- To use open air in the buildings, large spaces should be designed creatively.
- The continuous air flow should be considered for all rooms.
- Buildings should be built on the western-east axis with views facing the north and south, so that they are less exposed to the sunlight.
- Thickened interior and exterior walls and their materials should pass through heat for more than 8 hours.
- The openings must be placed in the northern and southern walls in the direction of wind, so that the body is exposed to the wind, and protected from direct sunlight.
- The openings should be between 25% and 40% of the surface of the northern or southern wall in terms of size.
- Ceilings should be light and have a thermal insulation.

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