Studying the Climate-Compatible Architectural Elements in Iran Warm & Dry Region

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ABSTRACT

Nowadays, paying attention to climatic conditions in designing and constructing all buildings is important and necessary. Climate-compatible buildings are of better quality from the point of view of Human’s thermal comfort. In such buildings, diversity of daily and seasonal light, heat and air flow creates diverse spaces. Construction in different regions should be proportionate to and affected by the climate and, also, it should be in conformity with the traditional architecture of the region. Accordingly, by recognizing the climate more and more, the climatologists must present appropriate guidance and instructions for achieving more comfort in the life environment. In designing buildings, climate of the location shall be taken into consideration, and an appropriate design should be presented in regard with geographical latitudes, topographic status, and slope of the ground in geographical directions, rate or receiving solar energy in summer and coldness in winter. Climate of warm and dry regions has specifications and features including little rainfall, little air humidity, little vegetation and plant cover, and high temperature difference between day and night, and winds with dust. Thus, the urban and rural context in these regions includes high compressed context, completely enclosed and surrounded urban spaces, narrow, irregular and sometimes arched alleys, buildings connected together, and establishment of biological sets based on sunlight and wind direction. Generally, all residential spaces of these regions have been protected against atmospheric factors and especially undesired winds, and desired wind and sunlight have been applied with especial strategies. In addition, total form of the building in these regions has especial characteristics. For instance, buildings are completely introverted and surrounded, most buildings have central yard, basement, porch and wind tower (wind catcher), buildings’ floor, and especially yard’s floor is lower than the passages level, rooms’ height is relatively high, vaults are often arched and domical and walls are thick. As another instance of climatic designing we can name introverted houses of warm and dry regions, known as four-season house. However, this kind of climatic-compatible architecture has been forgotten in modern urban planning resulting in increased use of mechanical heating and cooling in contrast to little use of natural energies.

Key words: Kerman, Regulation, Regeneration, Texture.

Introduction

Nowadays, the necessity of considering climatic conditions in designing and constructing all buildings, and especially buildings used by human beings and animals, is important from two points of view. On one hand, climate-consistent buildings, or climatically-designed buildings, are of higher quality in regard with human’s thermal comfort, have better environmental conditions, and daily and seasonal diversity and variation of light, temperature and air flow create diverse and desired spaces in these buildings. On the other hand, building’s consistency with climatic conditions results in saving in energy required for controlling the environmental condition (energy conservation). In some climates, the internal conditions of climate-consistent buildings may be regulated at human’s comfort level naturally and without need to mechanical heat systems throughout the year. Applying comfort-supply strategies in buildings is the most important factor for achieving comfort conditions. For continuity of protection against environment, some conditions and strategies must be observed in constructing buildings including designing the building.
in conformity with the environment and selecting environment-consistent materials. Construction in different regions should be proportionate to the climate and in conformity with the traditional architecture of the related region. Thus, by recognizing the climate more and better, the climatologists shall present appropriate instructions for achieving comfort in buildings and natural environments of life. A new design should be presented by boarder recognition of the specifications and characteristics of the ancient architecture, and the current existing status should be organized considering past, present and future. In designing urban, rural and industrial buildings, the climate of the location must be thoroughly taken into consideration, and an appropriate design should be presented in regard with geographical latitudes, topographic status, and slope of the ground in geographical directions, rate or receiving solar energy in summer and coldness in winter [1].

Methodology:

Climatic conditions:

Plateau plains, which are considered to be a main part of the area of our Country, are mainly located at the central and eastern regions of the State. Dasht-e-Kavir and Dasht-e-Lut are located at the center of Iran and are generally barren or have little rainfall. These two deserts approximately constitute one seventh of Iran area. Desert fringe areas and mountainous areas have more temperate weather and more rainfall, but however, these regions also have warm and dry climate.

General characteristics of climatic conditions in plateau plains are as follows:

- Warm and dry climate in summer and cold and dry climate in winter
- Little rainfall
- Little humidity
- Little plant cover (vegetation)
- High temperature difference between day and night hours
- Winds with dust in desert and desert fringe areas

In shall be noted that shortage of water for agricultural use and residents’ daily use, and also desert storms which distribute the desert sand and soil strongly throughout the residential regions, does not provide a desired environment for human’s hesitancy. In addition, trees and, as the result, woods are scarce in areas and, accordingly, residents cannot easily construct roofs and shelters. However, in regard with the above-mentioned climatic difficulties, our traditional architecture, with its experiences of several thousand years, has provided logical solutions for having a more desired life in these regions.

Urban context:

Flexibility of urban context, adaptation of life styles with natural factors, and also applying these factors at a very undesired climatic conditions in these regions are remarkable; to the extent that one of the main achievements of our traditional architecture is in this adaptation and providing a proper life environment in these anhydrous and arid regions.

Total features of urban and rural context are as follows:

- High compressed urban and rural context
- Completely enclosed urban space
- Narrow, irregular and sometimes arched alleys
- Connected buildings
- Establishment of residential sets based on sunlight and wind direction

Generally, all residential spaces of these regions, including urban spaces, passages, yards and buildings, have been protected against atmospheric factors and especially undesired winds; and desired sunlight and wind have been applied by especial strategies. The urban context of these regions is compressed and buildings are connected to each other. Alleys are narrow, have relatively high walls, and are located along a cursive. Basically there is no non-enclosed urban space in these regions, since protecting non-enclosed spaces against undesired climatic conditions is impossible. One of the reasons why alleys are narrow, and sometimes just wide enough for two individuals’ passing beside each other, is to provide better climatic conditions in the passages. High wall at passages sides play effective role in providing shadow against solar radiation and also protecting the passages against the desert winds. It shall be noted that the winding form of the alleys is considered to be a bioclimatic advantage in desert warm and dry regions, since desert winds can blow strongly in direct and wide routes and disturb the routine life.

Form of the Building:

Total features of the form of building in these regions are as follows:

- All buildings are completely introverted and enclosed
- All buildings, except from bathroom, have central yard, all most of them have basement, porch and wind tower
- Floor of the building and especially yard is lower than the passage level
- Rooms are relatively high
- Vaults are mostly arched and domical
- Walls are relatively thick

As urban spaces are enclosed and completely protected against undesired natural conditions, buildings and their yards are also surrounded and have a controlled bioclimatic environment. This is true about all building of these regions, including commercial, religious, service and residential buildings. As it was mentioned, temperature variation is so high in these regions, and the air humidity is less than human’s comfort level. Furthermore, sunlight radiation and its heat in summer create a warm and hot environment, and desert dust winds, which blow in most days of the year, disturb the comfort. Thus, creating a central yard at the middle of the building and constructing a water pond and garden in it increases the humidity in the biological environment, and also mud and brick walls, which are built with a relatively high thickness so that they can endure the heavy load of arched and domical vaults, decrease the temperature variations during day and night as a heat capacitor. Finally, locating all openings faced to the relatively humid and moderate space of the yard, and closing the external walls of the building except from the entrance door, the internal biological space is disconnected from the external spaces as much as possible and a small climate desired for human’s comfort in the warm and dry climate of the region is created [2].

Four-season houses:

Adapting the life styles with the climatic conditions is one of the main features of these regions. An evident instance of this adaptation may be observed in the introverted houses of these regions known as four-season houses. At these buildings, the rooms around the yard are used depending on a distinct season of the year. The northern side of the yard to which the inclined sunlight of the winter radiates and receives more heat is winter-stay part which is known as “Panah” (Shelter) and the most part of the residents’ activities is done in this part. In contrast, in summer the family members reside at the rooms at southern side the yard which are located at shadow and are cooler. This part is called “Nesar” (shadow catcher and cool) and cellar or basement is commonly located at this part. In warm seasons, temperature of cellar, due to being placed at the basement, is less than the temperature in other parts. When temperature is so high, family members used to go to the cellar and enjoy its cooler weather. In some houses, which subterranean canal (Kanat) branches pass beneath them in their path, an access way from cellar to the subterranean canal existed. Even in some cases, in these houses, the subterranean water entered a small pond from one side and exited from another side. The chamber containing this pond was called “Hozkhaneh” (pond chamber or spring house). Existence of water pond and the entrance canals of wind tower in this space resulted in increased coolness and humidity. Usually the height of summer-stay part in these houses is higher so that the warm air may rise upward and the cooler air may replace it at the lower level of the room. In addition, wind towers and air-conditioners are often located at the southern side of the building so that the air conditioning may take place better. Eight-way wind towers cross the main room of the house -that is the hall in the ground floor- and basement below it in summer stay. Holes on dome of the hall act as a wind tower in direction of wind flow and act as a ventilator in opposite direction. It helps comfort of residents in warm seasons effectively. The kitchen and storehouse are placed in corners and in parts of the house that have no direct relation with the yard so that there is low light and ventilation. The fuel used for cooking has been firewood. In order to ventilate the kitchen, the ceiling of this space has been tall and there has been a circular opening with 0.5 m diameter at the top of the kitchen’s dome or vault. The light required for the kitchen has been provided by this opening or ceiling openings. Presence of pond and plants compensates lack of air humidity and tender air is increased in addition to shading. All openings and room entries are led to the yard or the space led to it and the yard acts as the relational space among all parts of the house. Approximately, no window is opened to outside the house and only the entry door relates to outside the house that connects to the yard by a rather long corridor and vestibule. In these regions, the surface of house yard is lower than natural surface of alley and land. Low surface of yard has four advantages compared to alley surface:

1- Water of aqueduct or dike that flows in gutters co- surface with the alley, goes through garden inside the yard or water tank if there is water storage in the basement.
2- Adobe will be made from excavated soil if the soil is rather appropriate and will be used for construction.
3- Heat exchange between inside and outside of the structure is reduced by placing some part of the building inside the land and temperature fluctuation is decreased.
4- Building foundations show better resistance against earthquake

Depth of some yards has been more than usual threshold in order to access water of aqueduct crossing below the yard for irrigation of gardens. These yards have been called hole of garden. This architecture is greatly represented in Yazd.

Dome and vault:

Brick and adobe were used in ceiling in form of
dome or vault due to lack of wood in central plateau in Iran. The main difference between dome and vault is that vault is like a semi-cylinder in a continuous line and dome is a hemisphere meaning that arc has been circled around a point in its circumference. Form of all vaults and domes are not based on above definitions.

Features of vaults and domes:

Of climatic characteristics of arc and dome vaults in warm and arid regions is that the height of the room is long from floor to below the vault. Therefore, vertical natural ventilation is provided in the room. Since warm air is lighter and goes to the top and cooler air is replaced, warm air exits from windows placed in sides or in tip of the room and a bottom-up air flow is provided that is appropriate in warm seasons in order to provide comfort. It should be noted that in cold regions, the height of hall under the dome is lower than that in warm and arid regions in order to keep heat. Also, openings towards walls are low around the hall. In summer when there is no need for heat, flat vault or ceiling obtains the highest heat from radiation compared other surfaces because in this season, radiation is vertical but surface of arc vault and dome is diagonal to radiation. In addition, due to curvature of vault surface, some part of it is shaded that helps reduce heat absorption. If there is a two-shelled vault or dome, the effect of temperature fluctuations on the lowest shell will be less resulting in more balanced air temperature in the hall under dome or vault. Another advantage of arc vault and dome is that wind crosses convex surface more easily thus lower erosion and destruction. Finally, since arc vault or dome is a three dimensional structure, it resists well against lateral forces such as wind and earthquake. The less the weight of the vault and the lower the gravity center of the building, the more the building resistance against lateral forces.

Wind tower:

Using wind tower is an old tradition in Iran. Wind towers have been made in different shapes in central and southern cities of Iran. Wind tower has been used in different residential, religious and servicing structures. These wind towers can still be seen in warm and arid climates in central regions such as Kerman, Naeen, Yazd, Tabas, Kashan, Semnan, and Isfahan and even in southern regions of Tehran and in warm and humid climates in southern cities such as Bandar Abbas, Bandar Lengeh, Gheshm and Booshehr.

Performance Manner of Wind Tower:

Wind tower performance is that it gets ideal wind and leads it inside main rooms of the building, water storage or cellar. In some mosques in desert margin such as old masque of Ardakan and Jame mosque of Firoozabad in Yazd, valve of wind tower has been placed at the top of the altar. Thereby, ideal wind enters different parts of the building and provides coolness and ventilation. Historical city of Yazd is known as city of wind towers and it has more wind towers than other central cities of Iran. In this city, there is the highest wind tower in the world - Dolatabad wind tower - that is 34 meters high. The height of upper opening of wind tower is 11 meters. This eight-way wind tower leads wind into the building from any direction. Here it is noteworthy that some wind towers cool inside the building by only air displacement and others by either air displacement or evaporation. Cooling system of Dolatabad wind tower is done by the second method so air flow crosses a small stone pond and fountain after entering inside the building then it goes into other rooms. The room under wind tower where the pond and fountain are placed is octagonal and there are several doors. When a certain room is required to be cold, the door between that room and vestibule room under wind tower is opened. In order to reinforce cooling performance of wind tower and use evaporative cooling, other methods have been used. For example, there is a wind tower in Bam that is 50 meters far from the building and it connects to the building by an underground channel. Above the channel, there is a garden. After irrigating garden, humidity penetrates walls of relational channel and makes air from wind tower to the building cooler. In some cases, thorn-bush, pan tile or straw have been placed on opening of wind tower and water was sprinkled on it in a way that humidity and outside air cooling were increased. Wind tower and ventilator on the dome or roof were essential parts of water storages in central regions of Iran. Humid environment of water storage makes stored water cool using air flow. It should be noted that in central warm and arid regions of Iran, water is evaporated rapidly due to dry air. Therefore, relative humidity is increased in addition to cooling the environment resulting in reduction of extreme air warmness and dryness and provides residents a favorable environment. But it is impossible to use these wind towers in south of the country where there is a warm and humid climate. Because firstly due to increased relative humidity and air saturated by vapor, water evaporation is not done easily. Secondly, addition of damp air to an environment in which the weather is extremely humid and wet, makes life more difficult for residents. Thereby, southern wind towers decrease temperature only by using air displacement inside the building.

Architecture of different wind towers:
Wind towers are two-way, four-way and eight-way. In Yazd, all wind towers are tall and they are four or eight-way. Conversely, in Meybod located 50 kilometers to west of Yazd, wind towers are short and one way. The reason is that in Meybod, desert winds with dust blow from desert and residents have to make their wind towers in opposite direction of this wind and in an optimal direction. But in Yazd, desert winds blow less because the city has been placed between two mountain ranges and tall, multi-way wind towers can be made. In cities where optimal wind accompaniments with dust including Gonabad in Khorasan, weir space is provided under wind tower. Channel section of wind tower is wider than its upper section in order to decrease wind velocity and dust is placed there. After entering opening of wind tower and crossing weir space, wind becomes smoother and enters the room. One-way wind towers are generally short and they cannot be made where there is much dust. But four and eight-way wind towers are relatively higher. In particular, very high wind towers are constructed in eight-way form in order to resist against wind pressure and shape of wind tower body makes cross of wind flow with less pressure. In four-season residential houses that have central yards, wind tower is constructed in summer stay and this wind tower connects to the main room or hall and cellar. A considerable example is seen in Boroojerdi houses in Kashan. In this part of building, ventilators placed on the dome of hall help ventilation of inside environment in addition to wind tower. In this building, cooling performance of wind tower is done only by air displacement. In case of cellar, evaporative cooling affects slightly cooling of cellar space because body of wind tower channel is placed in the cellar and it is to some extent wet. Chimney effect is one of features of wind tower. Whenever wind does not blow, warm air inside the building ascends and is transferred outside the building by wind tower thereby air flow continues inside the building although its intensity is less than when wind blows in outside. The best wind towers can be seen in south of the country in Bandar-e Lengeh and Bandar-e Kang. Huge four-way wind towers are still the main ones in these two ports. Performance of wind towers of this region is similar to that of central parts of Iran but as mentioned, cooling performance of these wind towers is done by air displacement. Another point is that air breeze between land and sea and general local winds in this region are less intense than that in central parts of Iran. Therefore, wind towers should be huge in order to transfer more air flow inside the room. In some cases, sectional area of wind tower reaches more than 8 m² and it is placed on entire roof of room. In Bandar-e Lengeh, number of wind towers is higher near the beach and their dimensions are more as well. But the farther from the beach, the less the number of wind towers and their dimensions so that in northern part of Bandar-e Lengeh, there are lower wind towers.

Results and Discussion

Climatic design is a method to reduce energy consumption of a building and it is the first defense against climatic factors outside the building. In all climates, buildings built based on principles of climatic design reduce necessity of mechanical cooling and heating and use natural energy. Climatic design means a design that can provide users an appropriate natural environment by using natural force present in the region and coordinating with natural environment in its surrounding. Climatic design is said to be a particular building method that its goal is to reduce costs of heating and cooling using natural energy flows for making comfort in buildings. In order to realize this goal, climatic condition of the region should be considered in terms of human comfort and physical design of building such as building dimensions and its area, type of walls, size of windows. Of climatic designs, Iranian traditional architecture can be referred to. A considerable example is introverted houses of warm and arid regions that are known as four-season houses. Of elements of climatic design, vault, dome and wind tower can be referred that in modern urbanism and architecture, climatic architecture has been forgotten.

References