

ROLE OF WIND IN VERNACULAR ARCHITECTURE OF HOT AND HUMID REGION OF IRAN

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ABSTRACT

One of the main reasons that make vernacular architecture of various regions look different is variation in climate. The strategies used in vernacular architecture to respond to climate often define the total framework which underlies architecture. Vernacular architecture in hot and humid regions of Iran has strong bonds with local climate. Shenasil, Taremi and Wind towers are the features that have developed according to climatic considerations.

The key objective of this paper is to scrutinize the role of wind in development of vernacular architecture of hot and humid region of Iran. For this purpose, we first study the climatic character of the region and will consider the influence of different climatic elements on the vernacular architecture with a focus on humidity and air currents. Then, natural ventilation and the architectural elements involving it will be discussed. Finally, the wind towers of the region and their characteristics will be studied.

HOT AND HUMID REGION OF IRAN AND THE CLIMATIC CHARACTER

Hot and humid region of Iran is located in vicinity of long and thin coastline of Persian Gulf which is more than 1250 miles long and begins from the estuary of Arvandrood in southwestern Khuzestan province of Iran and ends in the southeastern Sistan and Baluchestan province. This coast region has hot and humid summers and mild, short winters. In summer, the maximum of temperature is between 95 to 105°F (35 to 40°C) and the maximum of relative humidity is 70 percent. The humidity is high in all seasons and thus, the diurnal and annual temperature ranges are small. The temperature differences between land and water create sea and land breezes in summer. However, the breezes are confined to the coastline and the speed of wind is low in internal regions.

Although the humidity is high, the vegetation level is too low due to the lack of rain. Since the soil contains great amounts of limestone and due to the lack of vegetation, the rain does not readily absorb into the earth and floods happen even with a low amount of rain. Moving away the coast toward high mountains, humidity is reduced. Here, we confront hot and arid climate in a distance of nearly 13 miles (21 kilometers) away the coast.

Although the sun is not as strong as in dry climate of central parts of Iran, the high humidity makes any additional heating from the sun very objectionable. The general characteristics of the region in terms of climate include:

- humidity in all seasons is high
- annual precipitation is low (most of which is in fall and specially in winter)
- diurnal temperature range is small
- sub-ground waters are saline in much of the region
- vegetation level is low

URBAN CONTEXT AND ARCHITECTURAL FORM

Urban context

The urban and rural contexts in the region are mainly a function of climate and location relative to the sea. One aspect that should be noted is that the urban context, due to population growth, economical issues and the price of land is usually more compact than rural one (Ghobadian, 1996). In general, the main traits of the urban and rural contexts of the region include:

- urban context is semi-compact. In some cities like Bushehr, the urban setting is compact
- rural areas have relatively low density
- urban spaces are semi-enclosed
- streets and paths are usually exposed to the sea

- cities and towns are scattered across the coastline and exposed to the sea

Influence of wind

The context of cities and villages of the region has characteristics of both the southern coasts of Caspian Sea with humid, temperate climate and the central parts of Iran with hot and arid climate. Therefore, the urban settings allow air currents to circulate in physical structure of cities and at the same time, use the nearby buildings and the existing plants to reduce the heat. Another characteristic of the coastal cities of the region is large waterways that run through the city. However, except for a few days, these waterways are dry much of the year.

The general orientation of the urban setting is based on state of coastline and wind directions (figure 1). The internal streets and routes are arranged so that they can direct the pleasant winds inside the city. Regarding the role of wind in developing the form of cities, three different kinds of urban context exist in the ports of the region:

- Ports like Bushehr and Siraf have a completely compact setting. The limited access to the coastline creates narrow routes inside these ports.
- Ports like Lenge have a mix of the compact and open settings.
- Ports like BandarAbbas have a completely light setting. Every building in these cities has routes in all of its four sides.



Figure 1- State of coastline and wind directions are the main determining factors in developing the form of cities of hot and humid region of Iran.

Influence of humidity

Resulting from the nearby sea, the high humidity in the region as well as high altitude angles of solar radiation make the thermal conditions uncomfortable in summer. Consequently, as seen in the temperate, humid region of southern coast of Caspian Sea, the urban and rural settings have been developed with low density. But, since the length of the coastline in some parts is too short to accept the whole area of the cities next to it and due to the great

tendency of the cities to have access to the sea, the urban setting in these parts are dense and curved, narrow streets and routes have been created to make the access to the sea possible. Here, instead of affecting the urban and rural circumstances, architectural strategies are applied in the form of buildings to solve the problem of high humidity.

Architectural form

Two critical aspects of the region's climate which affect the architecture are solar radiation and humidity. So, the best way vernacular architecture helps the severe climate of the region is shading and using the air currents. In other words, natural ventilation when combined with shading can result in thermal comfort in architecture.

Influence of wind

The main strategy used by vernacular architecture to reduce heat and humidity is to use natural ventilation. While lightweight construction makes natural ventilation work better in buildings, the lack of vegetation and wood in the region – which is a result of soil type – makes adobe the prominent building material of architecture and thus, the buildings are usually massive.

To use cross ventilation inside spaces and to reduce the heat, the lane windows and the windows of courtyard walls are often built opposed to each other. These windows are usually large enough to maximize natural ventilation. Moreover, the rooms usually have openings on sides with positive and negative pressure. Where using windows on two walls is impossible, for example when the room is only in the windward side of a building, large openings connect the room to the spaces on the reverse side – in this case, the leeward side. This makes open plan and inter-connected spaces popular in this region (figure 2).

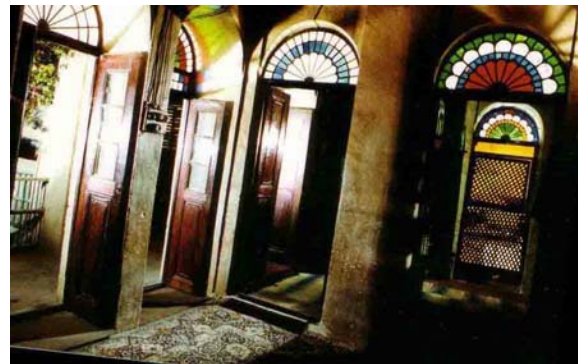


Figure 2- Each room of building usually has several large openings in different directions that sometimes connect spaces of building.

Besides, constructing buildings in two or three stories not only allows more ventilation between the stories but it makes easier to achieve the high winds, while keeping humidity in the lower stories. While these stories are usually used for storing goods, the upper stories are utilized as living spaces. Using the upper stories as living space provides women with privacy which is a religious, cultural necessity in this region as well as offering pleasant, wind-catching spaces during the severe days of summer. At summer nights, local people usually sleep on the flat roof of buildings due to the cool weather on the roof and heat radiation toward the night sky. *Taremis*, which are perforated screens usually used in porticos, provide not only privacy but also least obstacles against the night breezes (figure 3).



Figure 3- Taremi is perforated screen used in portico

Wind towers are the other strategy to bring the cool sea breezes inside the building (figure 4). These wind towers have the greatest size near the sea. But, as the distance to the sea increases and thus, the influence of wind decreases, their size and height diminishes and they are sometimes eliminated. The characteristics of these wind scoops will be discussed in following sections.

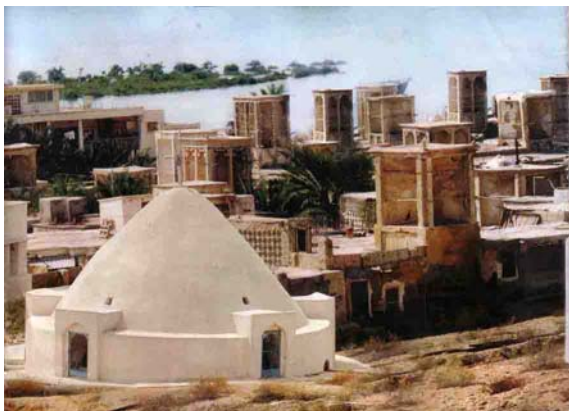


Figure 4- Wind towers of this village catch the pleasant breezes of the sea. The wind towers of hot and humid region of Iran are usually four-sided.

Influence of humidity, solar radiation and temperature

Since the region is located near the sea and level of sub-ground water is near the surface, buildings are usually constructed without basement and the ground floor of the building is used as kitchen and storage area. The first and second floors are usually allocated to living spaces.

Due to the intense solar radiation in west and east, the buildings usually have their shortest facades in these orientations and have a long façade across the east-west axis.

Because using large windows for natural ventilation can also admit great amounts of sunlight and thus, can increase discomfort, using large overhangs that are supported on columns is popular to resolve this problem. These porticos which are called *Shenasil* in the region are another solution to protect the building against solar radiations (figure 5). The porticos in hot and humid region of Iran have the greatest size relative to the ones in hot and arid or temperate regions. Many of the outdoor activities are carried out inside these porticos.



Figure 5- Shenasil is a local portico that shades the windows and walls of building. Many of outdoor activities are carried out in this space.

To reduce the effect of high temperatures of the region, it is common in vernacular architecture to use materials with low thermal capacity. Even in some parts like Bushehr, the local materials such as limestone are utilized. Because the limestone of the region is porous, its insulating effect is improved. The light colored limestone also has high solar reflectance which aides cooling (Akbari et al., 1990). Reducing surface to volume ratio also decreases the influence of climatic elements and thus, the temperature inside the building.

The vernacular architecture in the region is usually developed by arranging the spaces around a courtyard and creates semi-closed buildings. This strategy decreases the contact of buildings with the outdoor hot air. At the same time, the height of buildings as well as smaller courtyards – relative to the courtyards in hot and arid region – allow walls to shade the courtyards and cool the buildings and thus, support convective air currents between the courtyard and the spaces around it and reduce the high temperatures.

The difference between the courtyards of this region and the ones in hot and arid region of Iran concerns the courtyard's size and location of windows and porticos in relation. While the courtyards in hot and arid region are vast and include different elements like fountains and trees to help the building make hot, dry winds cool and humid, the ones in hot and humid region are usually smaller and are surrounded with higher walls. The other difference refers to location of windows and porticos. In hot and arid region, all of the windows and porticos, because of severe climate of the outdoor environment, are oriented toward the courtyard. You can see no window or portico from the streets. In other words, the volume of building is solid from these views. On the other hand, the buildings in the hot and humid region have porticos and windows toward the street to catch wind and remove the heat.

VERNACULAR ARCHITECTURE OF THE REGION AND ITS CHARACTERISTICS

In general, the characteristics of vernacular architecture in hot and humid regions of Iran include:

- Buildings have small courtyards with high walls around them
- Large windows and high spaces are used for increasing ventilation
- Vast porticos – *Shenasil* - are used for shading and outdoor activities

- In coastal cities, wind towers are a dominant feature. The size and height of each varies with distance to the sea
- Due to the compact setting, in some cities like Bushehr, multistory buildings are constructed for catching high winds (figure 6)
- The upper stories of buildings are used for living spaces
- The lower stories of buildings are used as kitchen and for storing goods
- Due to high humidity, there is no basement in buildings
- Roofs which are usually flat are used as sleeping area during summer nights
- Limestone and adobe are the local materials used in buildings. The limestone is of a light color and has good solar reflectance.



Figure 6- multistory buildings are constructed in compact cities of the region to achieve high winds.

NATURAL VENTILATION

Vernacular architecture uses natural ventilation in form of cross or vertical ventilation to overcome the problems of high temperature. The buildings' features varies with the ventilation chosen. Besides, the ventilation approach differs from place to place. In general, the cities in the region are classified in two categories in terms of the ventilation approach they have chosen in vernacular architecture.

Most cities and ports like BandarAbbas and Lenge use a mix of cross and vertical ventilation. In these cities, the non-dense urban setting allows the main orientation of buildings to be toward the coast. The large windows on this side admit the sea breezes as much as possible. Moreover, four-sided wind towers – which have four distinct openings in four directions – bring northern winds and other possible breezes inside the building and intensify the cooling effect of cross ventilation.

On the other hand, the climatic character of vernacular architecture in cities like Bushehr is mainly based on multistory buildings that rise into the sky to catch high winds. In this city, the short coastline and the great tendency of the city to grow along the coast create a compact urban context which is too dense to allow every building face toward the sea. Thus, the buildings were constructed in two or three stories to achieve the pleasant breezes. Since the great density of houses and narrow routes and streets keep air currents from passing the built environment and entering the houses and due to high amount of humidity and heat inside the city, using openings in external envelope of buildings and connecting these openings to the small courtyard of buildings through mediums like *Shenasil* define a suitable way for circulating winds inside the layers of architecture. The courtyard acts as a chimney as well as organizing various spaces of building. This strategy would also provide a beautiful view to the coast of Persian Gulf.

Finally, the different architectural elements involving in ventilation in vernacular architecture of hot and humid region include:

- *Taremi* – perforated screens used in porticos and on roofs to minimize the obstacles blocking air currents
- *Shenasil* – special porticos of this region which much of the daily activities are carried out in them. Since warm seasons contain half of the year, *Shenasils* are usually very large (they have the largest size among the porticos usually used in vernacular architecture of Iran) to provide a large outdoor living area. They also shade the envelope of buildings and thus, reduce the internal temperatures
- *Window* – the windows usually used in buildings are large and tall. The size of windows increases with height of the building. Upper stories have the largest windows.
- *Wind tower* – which their size and height varies with the distance to the sea

- *Goljam* – which is a high opening on the top of doors and windows and contains a perforated screen (with abstract geometric patterns) inside it. *Goljams* allow calm currents of convection inside space (figure 6).
- *Courtyard* – which has small size and when combined with high walls around it, acts as a chimney

WIND TOWER

Wind towers that rise to sky are a dominant feature in much of the hot regions of Iran. When combined with the calm broad sea, these vertical elements create beautiful scenery in hot and humid regions. The wind towers of these parts provide the required air current by suction.

Form of wind towers

The form of wind towers consists of a tall structure with vertical openings in all directions, with internal walls arranged diagonally so that any breeze is forced downwards and up again before it can escape. This creates a circulation of air in rooms used in summer. Rooms used in winter were not provided with wind-towers.

Wind-towers were square in plan, showing an X configuration of interior planes. They were built around an armature of wooden poles, which stabilize and reinforce the structure, and whose projecting ends were usually left to serve as scaffolding for cleaning and maintenance (figure 7).

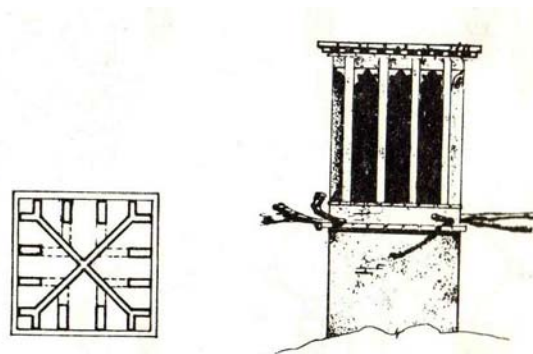


Figure 7- Plan of wind tower shows an X configuration.

Wind towers are often classified by the number of directions from which they draw air currents. In this point of view, wind towers of hot and humid region are classified to one-sided, two-sided, three-sided and four-sided. However, in hot and arid region of Iran, cities like Kashan and Yazd sometimes have wind towers with 6 to 8 faces. On

the other hand, since sea and land breezes and local winds of hot and humid region usually have less intensity than the winds of hot and arid region, the wind towers in those parts are often larger than the ones in hot and arid climate to catch more layers of air currents. Sometimes, the area of the tower's plan exceeds 86 square feet (8 square meters). As mentioned before, the wind towers near the sea are the largest in area (figure 8).

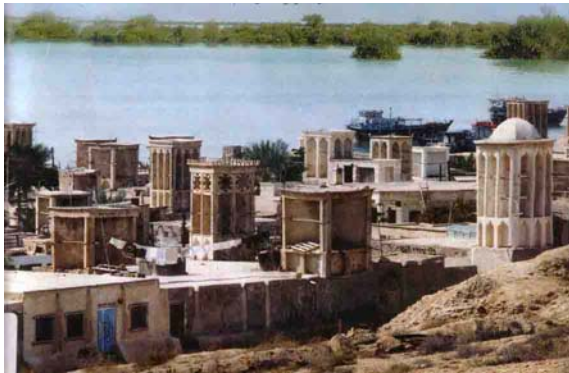


Figure 8- Wind towers of hot and humid region are usually larger than the ones in hot and arid region.

The height of wind towers is determined by distance to the sea and prosperity of house's owner. While coastal cities usually have wind towers with largest size and height, cities which are far from the sea usually have no or low wind towers. Besides, tall wind towers usually denote that the owner of building is wealthy (Tavassoli, 2002).

Function of wind towers

In general, the thermal function of Iranian wind towers is based on two methods of heat transfer: convection and evaporation.

The wind towers of hot and arid region use both convection and evaporation to achieve the thermal comfort. In this region, the wind tower takes hot dry winds of different directions. The winds pass over a small pond and fountain below the tower to get wet and cool. Thus, the unpleasant winds of outdoor environment turn into pleasant breezes inside living spaces.

In hot and humid region, On the other hand, wind towers use convection because of high humidity. The wind towers are usually large enough to use calm, local winds and mild pleasant breezes. They create air currents which remove saturated humidity around the body and make comfort condition achievable.

Unlike the wind towers of hot and arid regions which aim to create breezes that increase the humidity of space, the wind towers of hot and humid region create intense currents of air inside the space to reduce the high humidity of environment.

The most important problem with wind towers is that the volume of air current and the level of humidity and cooling can not be completely controlled. Birds, vermin and insects and dust and particulate entering the tower are another problem.

CONCLUSION

Vernacular architecture has always found its course through response to climate as one of the main factors which affects physical comfort. The unique elements that vernacular architecture of hot and humid region of Iran has created show the result of tactful strategies which had been capable to overcome the severe conditions of the region. High humidity with intense solar radiation is the most problematic feature of the climate. Indigenous, limestone building materials typically have a high solar reflectance. Which is helpful Thus; natural ventilation in combination with shading and reflectance has been the simple answer of the architecture. Taremi, Shenasil, wind tower, etc. are the elements that help architecture overcome this process.

While contemporary architecture applies modern technologies to develop new solutions in architecture, it should consider vernacular architecture of the past as a main source of inspiration.

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