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The Principles and Platform of Climatic Design of the Bushehr Architecture, Iran

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Abstract

The port of Bushehr had been among the most important ways of communication between Iran and other countries. The thriving market of exchange of merchants had been the host to traders from India, Africa and Arabs of the Persian Gulf, who visited the port to sell and buy goods. The commercial and geographic positions of the port have played an important in the architecture and formation of the city. They have been, in fact, the factors driving the city toward growth and development. Hence, the development of Bushehr necessitates the development, design and construction of new buildings with various functions. As a result of the approach adopted to give purpose to the resources and energy, considering the climatic knowledge and configuration of the island shall be the first priority in making policies and decisions aimed at optimizing energy consumption. The present manuscript tries to propose solutions to reduce energy consumption and replace current sources of energy with renewable resources by considering the environmental and climatic platforms of Bushehr as well as its precious indigenous architectural elements and factors. Hence, the analytic-documentary research method is employ to conduct field studies on this issue. Results of this research can be widely applied to planning, design and construction of buildings by experts, enforcers and administrators.

Keywords: Climatic architecture, Hot and Humid, Targeted energy, Bushehr, Vernacular architecture.

Introduction

The port of Bushehr had been among the most important ways of communication between Iran and other countries. The thriving market of exchange of merchants had been the host to traders from India, Africa and Arabs of the Persian Gulf, who visited the port to sell and buy goods. The oldest remains of the Bushehr peninsula are spotted 12 km to the current city of Bushehr. The remains, which include Elamite brick posts dating back to the third millennium BC, indicate that the current Reyshahr City had been substituted with the ancient city of Lian. The Elamites used the Bushehr peninsula as their naval base. After coming to power, Nader Shah Afshar decided to a navy. Since there was a bay near the current Bushehr city, which protected ships during storm and war, it was superior to Reyshahr. Hence, it was selected for establishment of the Naderieh Castle. In fact, the primary core of the current City of Bushehr (Iran) was formed by then. Following the death of Nader Shah, the Iranian navy gradually lost its function and the name of the Naderieh Port was changed to Abushahr. Old residential neighborhoods were formed and Busher was turned from a military region into a residential, touristic and commercial region. It shall be noted that organized introduction of precious places such as old precious contexts, ecologic regions (e.g. the Hora Jungle in Siraf, Bushehr) requires development of buildings with various functions.

Methodology

Hence, in order to create the infrastructure for utilization of commercial, industrial and touristic areas vast construction measures have been taken, especially in the housing and purchase sectors. Field studies and various other studies have indicated that most of the contemporary buildings do not comply with rich native experiences with environment-friendly architecture and climatic characteristics of Bushehr. Therefore, these buildings have added to the use of fossil energies and environmental destruction.

The Climatic Architecture of Bushehr

The current context of Bushehr is the result of the special climate of this city. "Since Bushehr Province is situated in an extra-tropical region, its most important climatic phenomenon and process is heat. This region is affected by high pressures imposed by average widths and lacks considerable rainfall. However, it experiences intense evaporation due to the elongation of hot seasons. In winter, as a result of the attack and expansion of Northern and Mediterranean cold weather fronts to the East, a pleasant rainy and cloudy weather is dominant. In general, the weather of that part of Bushehr located on the shoreline is hot and humid"[1-2]. Frosting never occurs to Bushehr because even in the coldest moths of the year the temperature in this province rarely reaches zero degree. "Local winds in Bushehr originate from storms blowing in the Persian Gulf, which are caused in different seasons by the pressure difference between the Arabian Desert and the heights in South Iran"[1]. These winds blow in all shores of the Persian Gulf and are called by different names depending on the region they below in: Lahimer wind, Lachizeb wind, Kush wind, Barard wind, Soheili wind, Qoyoub wind, etc. The aforementioned winds along with the prevailing and pleasant winds have formed the architectural form of Bushehr. As we know, air heat capacity is very low and therefore it is only capable of preserving little heat. However, humid air is more capable of preserving heat due to the presence of water vapor particles. Hence, in humid areas the difference between the temperature degrees in day and night is less than arid areas.

Urban Planning and the Overall Framework of the Old Context of Bushehr

Due to climatic reasons, the context of Bushehr is considered among the dense contexts of Iran. The need to access the coast and the confinement of the point of the peninsula by the sea have led to the formation of a dense context with narrow paths. The dense context is a result of the reduction in the width of passages and the increase in the height of buildings. The streets in the region lie perpendicular to the shoreline in order to induce draft by drawing wind into their narrow aisles. The pressure difference is also used to induce wind. That is to say, the narrow and round about aisles end to small squares that present unexpectedly vast areas. These squares have cultural significance to the context of the city. Moreover, they had been used to host religious and traditional rituals. Evidently, as a result of the narrow allies and the need for accessing houses in this context, numerous crossways have been created which form an intermeshed architectural network. "One of prominent solutions proposed for this context is the use of a venturi system to organize buildings, passages and allies. The aforementioned system is used in industry and fluid mechanics to accelerate the flow of fluids. Allies in the old context of Bushehr are among the tightest allies included in the Iranian architecture. Although the width of allies is small, buildings on both sides of them gradually become closer and form gorges. At some point the distance between the buildings increases and a venturi system is created in each ally"[3]. Shade is necessary to this climate. Therefore, the need for shade is easily met by designing a special type of context which is dense and contains tall walls. The whole context is formed of blocks of residential units with the minimum in common with neighborhoods. The success of this context can be ascribed to draft. Walls contained in each context can be used as samples to analyze the context. One unit of block is formed of walls. The orientation of the block defines the orientation of the context as well. In the context of Bushehr structures are in the direction to receive the wind known as the North wind. "It moderates the warmth of summer. Therefore, the majority of openings embedded in walls face North and Northwest"[1]. Sustainable architecture seeks to restore the balance between human and the environment. This goal is only achieved by using sustainable forces as natural resources to meet human needs. The problems associated with the use of nonrenewable fossil energies have widely attracted the attention of construction practitioners, as the biggest consumers of energy. The design based on renewable energies has progressed in the last three decades in the construction industries of developing countries. The notion of sustainable architecture has also drawn a considerable amount of attention recently.

The Climatology of Bushehr

The southern coasts of Iran, which are separated from the central plateau by the Zagros Mountain Range, form the hot and humid climate of the country. This climate gives very hot and humid summers as well as mild winters. The maximum temperature in summer is between 35 to 40 degrees while the maximum relative humidity is 70%. In this climate, humidity is high in all seasons and the difference between the temperatures at day and night is small in all seasons[4] (Table-1). In such areas, the difference between the temperature of dry surface forces and the sea level leads to the creation of breeze but the breezes are not limited to the narrow shoreline, the local areas have mild weather and the speed of wind is low[5]. Radiation intensity is high and causes daze and eye irritation. However, the intensity of radiation depends on weather conditions. When it is cloudy and the sky is milky, the intensity of radiation of transmitted ray of light is maximized and too much light hurts the eye. The amount of the transmitted ray of light which is reflected by the Earth depends on the clouds in the sky and land coverage. When it is cloudy or when the Earth is covered with vegetation, the radiation is minimized. However, when the sky is clear or the land is arid, radiation is maximized[6] (Table-1).

Radiation

According to the ten-year statistics of the weather station of Bushehr City, the maximum average daytime radiation (24.37 MJ/m^2) occurs from September 23 to October 22 while the minimum average daytime radiation (20.63 MJ/m^2) occurs from December 22 to January 20 (Figure-1).

Temperature

According to the ten-year statistics of the weather station of Bushehr City, the maximum average temperature (34.02^0C) is obtained from July 23 to August 22 while the minimum average temperature (15.12^0C) is obtained from December 22 to January 20. Moreover, the maximum average maximum temperature (36.62^0C) is obtained from June 22 to July 22 while the minimum average minimum temperature (11.5^0C) is obtained from December 22 to January 20. The absolute maximum and minimum temperature are 41.4^0C and 9.5^0C which belong to June 22-July 22 and December 22-January 20, respectively (Figure-1).

Wind

The maximum wind speed (6.35 knots) occurs from March 21 to April 20 while the minimum wind speed (3.7 knots) is observed from September 23 to October 22 (Figure-1).

Relative Humidity: According to the ten-year statistics of the weather station of Bushehr City, the maximum relative humidity of air (87.1%) in the city occurs at 3 in the morning from December 22 to January 20 while the minimum relative humidity of (65.9%) occurs at 9 in the morning from April 21 to May 21 (Figure-1).

Precipitation

According to the ten-year statistics of the weather station of Bushehr City, the maximum monthly value of precipitation in the city (242.6 mm) occurs from December 22 to January 20 while the minimum monthly precipitation (no precipitation) occurs from May 22-June 21 and August 23-September 22 (Figure-1).

Analysis of the Human Comfort Range Table (Olgi Table)

In the Olgi table, the range of human comfort is between 20 and 28^0C with relative humidity of 30-60. In hot and humid climate the ambient temperature rarely falls in this range. Therefore, provision and preservation of comfort temperature necessitates the use of suitable outer walls and utilization of heating, cooling and dehumidifying systems.

Study of the building ecological table for subdivisions of Bushehr reveals that due to high temperature and air humidity, it is often impossible to create comfort zones in critical conditions through natural ventilation or some characteristics of construction materials[7]. Evidently, in such conditions the entrance of hot air into the indoor space must be prevented. In any case, it is preferred to use natural ventilation to control and reduce room temperature (Figure-2).

According to the Olgi table of comfort range, different conditions at day and night can be predicted for different months of the year: January (month Dey): From 7 A.M. to 13 P.M., the required solar energy varies from 12.5 to 30 kilocalories per hour. From 18 P.M. to 7 A.M. there is the need for mechanic heating devices to achieve human comfort. Other times of the day naturally fall in the comfort range. February (month Bahman): From 13:30 to 16:45 comfort is achieved naturally. From 6:44 A.M. to 11 A.M. human comfort is achieved by 12.5 to 25 kilocalories per hour of solar energy. From 20 to 6:44 A.M. mechanical heating devices are useful to provide human comfort (Figure-2).

March (month Esfand): The time spans between 9 and 13:15 and between 17 and 21 fall in the comfort range. From 6:15 to 6:45 a total of 12.5 kilocalories per hour of solar energy is used to provide comfort. From 23:30 to 6:16 A.M. mechanical heating devices are used to provide comfort (Table-2).

April (month Farvardin): The time span between 23:30 and 6:30 falls in the comfort range. From 10:30 t0 19:50 temperature exceeds the comfort range and wind power of 100-600 feet per minute is required to feel comfortable without the need for cooling devices (Table-2).

May (month Ordibehesht): The time span between 20:30 and 3:50 falls in the human comfort range. From 4:30 to 10 A.M. a total of 100-700 feet per minute of wind power is used while from 20 to 20:30 a total of 100-700 feet per minute of wind power along with air flow are used to achieve comfort. At other times the boundary of comfort wind and humidity of air is exceeded and consequently only mechanical cooling devices are useful to create comfort (Table-2).

Table-1
The 9-fold climatic divisions in Iran[6,4]

Type of climate	Climate characteristic	Average maximum temperature in summer	Average minimum temperature in winter	Sample cities
1	Hot and very humid summers and no winter	35-40	10-15	Jask, Chabahar, Bandar Lengeh, Bandar Abbas, Bushehr
2	Very hot and humid summers and no winter	45-50	5-10	Abadan, Ahwaz
3	Hot and humid summers with mild winters	35-40	0-5	Kazeroon
4	Very hot summers with no winter	40-45	5-10	Iranshahr
5	Very hot and arid summers with mild winters	40-45	0-5	Tabas, Kashan
6	Mild and humid summers with mild winters	25-30	0-5	Babolsar, Bandar Anzali, Rasht, Gorgan
7	Hot and arid summers with mild winters	35-40	0-5	Zabol, Zahedan, Fasa, Bam
8	Hot and arid summers with cold winters	35-40	0 to -5	Tehran, Shiraz, Mashhad
9	Hot and arid summers with very cold winters	35-40	-5 to -10	Arak, Hamedan, Zanjan, Tabriz

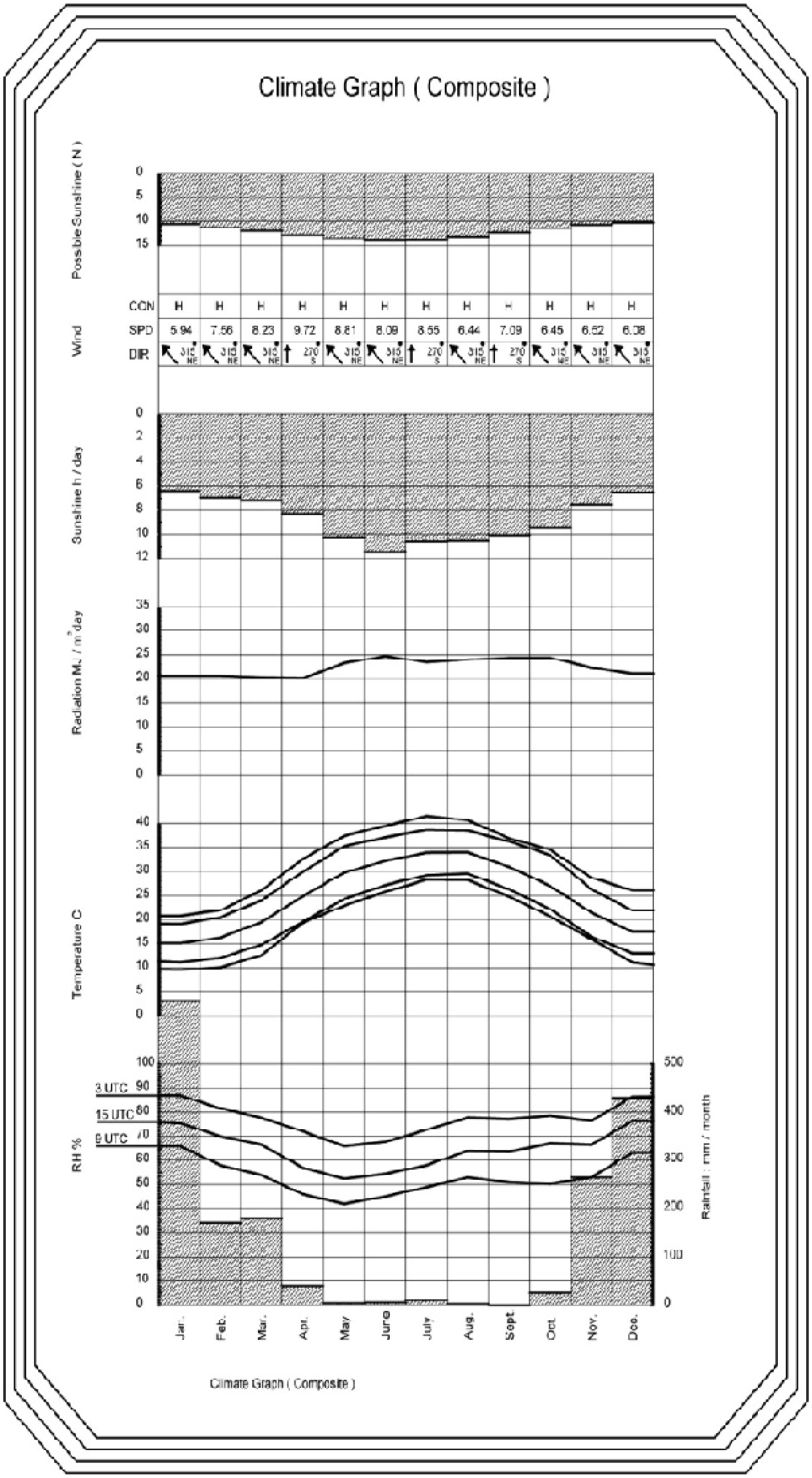

Figure-1
The diagram of climate information composite for a ten-year period in Bushehr

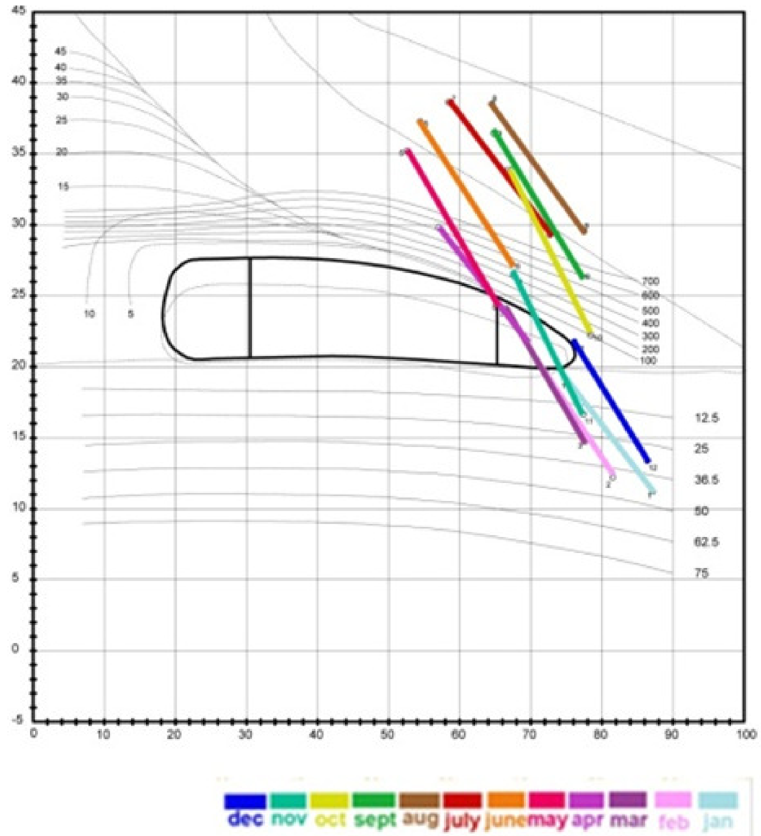

Figure-2
The Olgi diagram for Bushehr

June (month Khordad): From 00:20 to 5:50 it is useful to use 500-700 feet per minute of wind power to provide comfort. At other times of the day mechanical cooling devices are necessary (Table-2).

July (month Tir) and August (month Mordad): At 24 hours of the day humidity exceeds the range of comfort against wind. Consequently, in these months mechanical cooling devices are required 24 hours of the day (Table-2).

September (month Shahrivar): From 1:55 to 4:15 a total of 600-700 feet per minute of wind power and air flow are required. However, at other times of the day it is necessary to use mechanical cooling devices (Table-2).

October (month Mehr): At 24 hours of the day temperature exceeds the comfort range. From 21 to 9:15 A.M. it is necessary to use 100-700 feet per minute of wind power (Table-2).

November (month Aban): From 17:50 to 23 P.M. comfort is achieved naturally. From 12 to 17:50 a total of 100-350 feet per minute of wind power is required (Table-2).

December (month Azar): From 6:45 to 8:45 the use of 12.5 kilocalories per hour of solar energy is necessary to reach comfort. From 21:45 to 6:45 A.M. mechanical heating devices shall be used to confront coldness and achieve comfort (Table-2).

Manifests of Application of Energy Management to the Details of Single Buildings in Bushehr

In this region energy is only limited to radiation and wind. Proper utilization of materials can considerably contribute to energy management. Since this city has a hot and humid climate, efforts shall be made to use wind power for natural ventilation and draft purposes in houses. In addition, summertime radiation should also be controlled.

Wind

All of the houses in the old context of Bushehr lie in the direction of the prevailing wind. Moreover, houses in Bushehr are defined at heights. The elevation of houses from the ground not only helps to skip the ground humidity but also makes it possible to utilize wind power in all stories. Hence, the everyday life of habitants of Bushehr used to be divided in different stories. That is to say, the lower stories were used to provide service and the upper stories served as living spaces. Therefore, in this architecture, elements such as porch, veranda, and balcony are embedded in the interior design of stories to be used during day and night[8] (Figure-3).

Table-2
Analysis of the Olgi diagram for Bushehr

Month	OHP	CZ	UHP
January	-	-	From 7 A.M. to 13 P.M. a total of 12.5 to 30 kilocalories per hour of solar energy is used. From 18 to 7 A.M. mechanical heating devices are employed.
February	-	From 13:30 to 16:45	From 6:44 A.M. to 11 A.M a total of 12.5 to 25 kilocalories per hour of solar energy is used while from 20 P.M. to 6:44 A.M. mechanical heating devices are employed.
March	-	From 9 A.M. to 13:15 and from 17 P.M. to 21 P.M.	From 6:15 to 6:45 a total of 12.5 kilocalories per hour of solar energy are used. From 22 22:30 to 6:16 A.M. mechanical heating devices are used.
April	From 10:30 to 19:50 a total of 100-600 feet per minute energy is used	23:30- 6:30	-
May	From 4:30 to 10 A.M. a total of 100-700 feet per minute of wind power is used. From 20 to 2:30, 100-700 feet per minute of wind power is used. At other time of the day mechanical cooling devices are employed.	20:30-3:50	-
June	From 00:20 to 5:50 A.M., 500-700 feet per minute of wind power is used. At other times of the day mechanical cooling devices are employed.	-	-
July	Mechanical cooling devices are used at all times.	-	-
August	Mechanical cooling devices are used at all times.	-	-
September	From 1:55 to 4:15 A.M. a total of 600-700 feet per minute of energy power is used. At other times mechanical cooling devices are employed.	-	-
October	From 21 P.M. to 9:15 A.M. a total of 100-700 feet per minute of wind power is used. At other times mechanical cooling devices are employed.	-	-
November	From 12 to 17:50, 100-350 feet per minute of energy is used.	17:50-23	-
December	-	-	From 6:45 to 8:45 a total of 12.5 kilocalories per hour of solar energy is used. From 21:45 to 6:45 A.M. mechanical heating devices are employed.

Wind finds its way to the houses through the outer walls of buildings. Sometimes it enters from openings embedded in the outer walls, in which case the openings in two adjacent walls conduct wind through the rooms and provide for natural ventilation and cooling. Next, wind is drawn into the opening facing the central courtyard, which acts as a central duct and allows wind to flow in the central courtyard. Sometimes through the vast porches facing wind and provide 45-degree vertical sheds, wind enters into the building. This case is mostly seen in upper class houses facing the sea or coast. The vast areas of porches conduct wind to the indoor space through several openings (Figure 4). As a result draft is induced in the building. In another case, verandas are built that are equipped with wooden sheds. These spaces, which are attached to the main walls, are often seen in houses with one front in the street. These small architectural elements directly draw wind into rooms (Figure-5).

Figure-3
Veranda in the street

On top of most houses there is an arch which is usually constructed with bars. The arch draws in wind through a gorge that acts as a filter and brings it to the central yard[9]. Another manifest of the architecture is the use and construction of circular staircases which are added to corners (Figure-6). These staircases directly connect the yard to the roof of the house and other examples of louvers in the architecture of Bushehr (Figure-7, 8).

Figure-4
Vast porches along with openings facing the sea

Figure-5
Openings in lateral walls and openings facing the sea

Figure-6
Circular staircase

Figure-7
Filtering space between the entrance and the central yard

Since the roof space had also been considered a living place, shelters used to be built high. They were sometimes as high as the buildings. In this region shelters with wooden shutters were used along with openings to utilize wind power and create privacy (Figure-9).

Figure-8
Entrance facade

Radiation

The tightness of Bushehr implies that they are properly designed to prevent direct radiation. These aisles create shade on one another's walls and lead to comfort (Figure-10, 11). Openings have vertical wooden shutters that conduct light to the indoor space but cannot prevent direct radiation (Figure-12, 13). Sheds are installed on top of entrances, porches and verandas. Vertical shutters at an angle of 45 degree have added to the beauty of this climatic architecture. Sometimes radiation is avoided by closed aisles (Figure-14).

Materials

"In the port of Bushehr coral and sedimentary rocks form a large part of walls used in the traditional buildings because there are large layers of such rocks several meters down the ground. Hence, sedimentary rocks are easily accessed and used as building materials"[10]. As we know, sustainable architecture and optimal energy management are not separate from the choice of use of suitable materials. Since the architecture of Bushehr had been based on a climatic design, it employed materials to manage energy. Materials such as local rocks (tesk), local plaster (lime), wood (mangrove and teak), planks, matting, cast iron, glass, etc. were employed. Local rocks were used in yards for their high resistance to impact and humidity and wood was used for its resistance against termite. Wood has been employed a lot in the architecture of this region due to climatic reasons. "In hot and humid regions, the use of materials with low thermal mass and no heat capacity is preferred because with respect to climatology, the major problem with this area is extreme heat and therefore it is not recommended to save daytime heat for night use. Therefore, wood is the best material for his region because it slowly transfers heat. As a result the heat absorbed by wood remains on the surface during the day and is lost at night by a relatively cold breeze"[10].

Climatic Design Solutions for Bushehr

Shades can be increased by expanding buildings in the East-West direction. Building density leads to decreased temperature and development of shade in this climate. Design and construction of a central courtyard (which acts as a central and facilitating duct) as well as design of openings to the central yard (which causes draft and natural ventilation) lead to comfort. Incorporating solar panels instead of wooden shutters into building roofs to minimize the consumption of other energies. Creating shades on facades to cool the walls by sheds, shitters, and trees. Trees are specific to the region and do not produce humidity include mesquite, silk flowers, etc. Construction of twin walls with thermal insulation in between as well as inner walls made up of materials with low heat capacity. Construction of facades out of light color materials and sedimentary rocks. Use of materials with low heat capacity (such as wood) in sheds. Draft leads to a reduction in humidity. Absorption of maximum coastal winds at depths of buildings. Providing for the rapid evaporation of humidity of body surface and preventing the influence of solar energy on the inhabitants. Windows are installed in the direction of constant flow of air and sea breeze is utilized to the possible extent. Service rooms are in the ground floors and living rooms are designed to be in upper stories.

Figure-9
A view of shelters and roof spaces

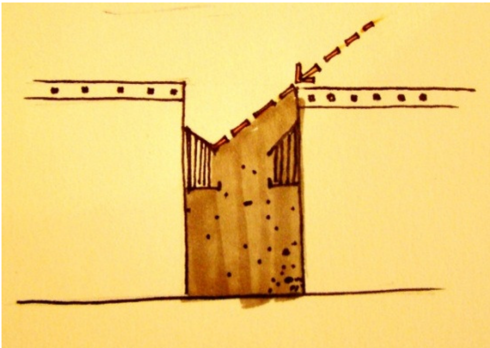

Figure-10
Shade in the central yard in the context of Bushehr

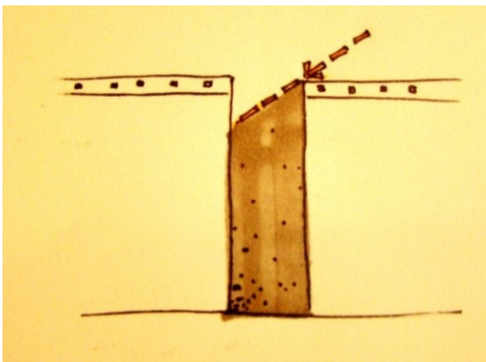

Figure-11
Shade of the walls in the old context of Bushehr on passages

Figure-12
Closed passageway

Figure-13
Shed on top of the entrance

Figure-14
Vertical wooden shutters

Finally, maximum environmental potential can be used to achieve consumer comfort and minimize unfavorable living conditions.

Conclusion

An inductive analysis of the buildings in Bushehr revealed that the architecture of this city is environment-friendly and has been sustainable as a result of using natural and non-fossil energies. The choice of suitable materials, orientation and building form, incorporation of the native culture, beautiful and eye-catching design of the urban scenery (which is obtained by logical ups and downs in the skyline), passageways, etc. are all proofs of the claim.

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