

Environmental impacts and compatible urban design: Case study of Bam Citadel

N. Mohajeri

Department of Art and Architecture, Azad University (Jonoob), Ahan Blvd, Tehran, Iran

ABSTRACT

Bam citadel is the greatest and oldest mud-brick construction of the world. It includes three parts of residential, military and citadel with covering an area of sq.ms 200,000. This article explores the skills of design used in urban spaces of Bam citadel with considering of environmental characteristics such as temperature, wind, sunshine, water, and vegetations and analyzes them. This paper discusses the role of such factors as the orientation of ways and buildings, the relation of height to cross passages, using local materials, the relation between urban form and environment, ...in the structure of spatial of Bam citadel. Finally, it will present compatible urban design strategies regarding the topic of the research.

1. INTRODUCTION

The factor of climate plays the main role in giving a logical shape to the urban structure and architectural complex of cities in hot-arid areas of Iran and the major problems people of these areas have with climatic issues, have led them to find some solutions which reduces the bothering aspects of climate amazingly. Traditional houses which exist in hot-arid areas of Iran are one of the most evident examples of adaptability of architecture with climate.

They have developed some interesting creativities to cope with severe hot weather and environmental conditions like creating some spaces under the ground, using local construction materials and etc. In this article, some aspects of these creativities done in old Bam city are to be presented. Also, the strategies used for adaptability with the climate and environmental

conditions in residential buildings will be introduced.

2. ENVIRONMENTAL AND CLIMATIC CONDITIONS IN HOT-ARID AREAS OF IRAN

Wind, raining, high temperature, humidity and sunshine are some important climatic factors which shape the landscapes and make people adapt with them. The peacefulness of human and in some cases his survival depends on the skills which are used to construct buildings and spaces.

Alborz range in north and Zagros range in east block the way of clouds to the central part of Iran plateau. Thus, in this area, rainfall is very low and about 70 mm during the year. Due to the dry weather, the sky is clear and this leads to severer sunshine. Hot days and cold nights are resulted from these conditions. During the day, the earth will get hot severely and after the sunset, due to the dry and clear weather, will lose its heat quickly and gets cold. In this situation, the air near the ground is cold and because of that the temperature tolerance is high between days and nights.

Since the evaporation is high the soil is salty. Shortage of water and salty soil has led to poor plant coverage and this poverty contributes to flow of sandstorms and high-speed hot dry dusty winds. The deficiency of relative humidity makes hot sizzling summers and cold dry winters and the annual and daily difference of the temperature is very high.

3. LOCATION, ENVIRONMENTAL AND REGIONAL CONDITIONS OF THE CONSIDERED ZONE (BAM)

Bam city is located in southeastern part of Iran and east of Kerman province. Its area is 21381/1 square kilometer at longitude 57 degrees 42 minutes east and latitude 29 degrees and 34 minutes north.

This city is considered as a part of Loot central desert, which is located at the center of Iran like a triangle.

Loot desert whose southern part is located in Bam city is a part of Loot central desert.

According to the latest statistics in 1380 the climate situation of this zone is as below:

4. THE URBAN STRUCTURE ACCORDING TO ENVIRONMENTAL CONDITIONS OF THE ZONE

Covered passageways and narrow alleys with long walls are cool ways during summer and most of the times especially in summer afternoons there is shadow in the mentioned areas. The whole village or city seems like a concentrated colony in order to have the minimum amount of sunshine exposed areas. The direction of main alleys and passageways are in a way to avoid hot sunshine of summer afternoons and hot and stormy winds, and is based on the field location to make the best use of existing water. Narrow passageways with long walls



make shadow in summer afternoons. Concentrated and compressed urban structure especially in residential parts helps in avoiding heat into the complex. Most of the houses are faced to the back of complex and their walls in relation with passageways, gain more height which lead to more shadow in passageways.

Flexibility of urban structure and application of lifestyle to natural causes and providing a suitable environment to live in these zones are of the main achievements of Iranian traditional architecture.

Urban structure in these areas is concentrated and the buildings are linked to each other. Narrow alleys with long walls are continued on a broken line.

Open areas in these zones could rarely be seen because protecting an open area against bad condition of climate is impossible. Long walls beside passageways for making shadows and also protecting the passages against hot and stormy desert winds, are really useful. The helical alleys and passages avoid desert wind streams to flow in those areas because the winds can rapidly move in vast, straight areas and make life difficult.

The network of the ways is made with an organic order and according to the slope of the ground and the direction of the Ghanats flow. The segmentation of the ground is irregular and



the buildings have been constructed with geometrical symmetry. Surrounding, the hierarchy and the limits in social sites, residential buildings and neighboring units are taken into consideration.

5. ARCHITECTURAL ELEMENTS OF THE HOUSES ACCORDING TO THE ENVIRONMENTAL STATUS OF THE AREA

5.1 *The form of the structure*

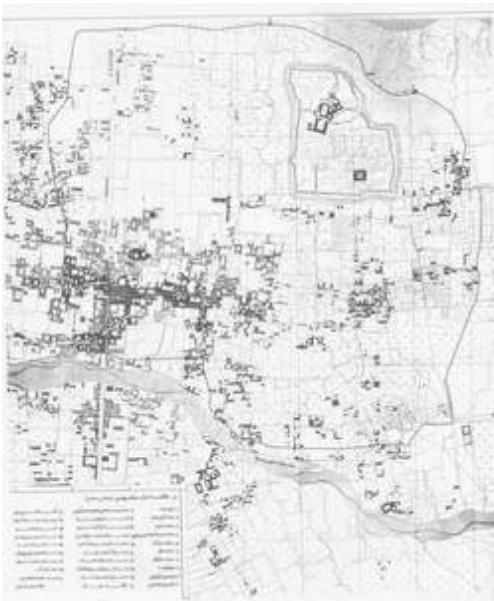
- All the residential buildings are completely introvert and surrounded.
- All the residential buildings have central yards and majority of them have basements, porches and wind towers.
- The floor of the buildings and the yards are lower than the level of the passageway.
- The height of the rooms is relatively high.
- The arches are arc-shaped and the ceilings are usually dome-shaped.
- The walls are usually thick.

5.2 *The shape and frame of the structures*

The shape of the structure can contribute to the decreasing of the heat of the weather. The best state is that the building takes the least heat in summer and holds the most heat in winter.

In hot-arid zones, the features of the winter necessitate the long shape of the building (in east-west direction) but because of the heat wave of summer, the rectangular shape of the buildings is more suitable for the comfort of the residents.

Thus, the local residents of this zone have adopted their structures with the environmental conditions, in a way that there is a yard in the center in which the shadow stretches.



Thus, the basis of the structures shape in this zone is related to the internal combination and design, which is Square rather than a non-geometric shape.

Central Yard

The cold weather at nights occupies the whole deep yard. During the day, the weather of the yard is cold for a while especially at the side back to the sun. The tolerance of temperature in the area is very high and the moisture ratio is more than the normal. So building a yard in the centre of the house and creating a pond and a small garden, lead to the raising of the moisture in internal space. Plant coverage makes the weather soft besides creating shadows. In some houses the level of the yard is lower than the normal level of the ground and the passageways which has four benefits:

The water for watering the garden and plants flow easily and if there is a water reservoir, it will be filled.

The excavated soil will be used for making mud bricks to construct buildings.

Having a part of the structure inside the ground, transferring of the temperature will be low from inside to outside and the temperature tolerance will be reduced.

In the case of earthquakes the foundation and relatively, the whole structure will show more resistance.

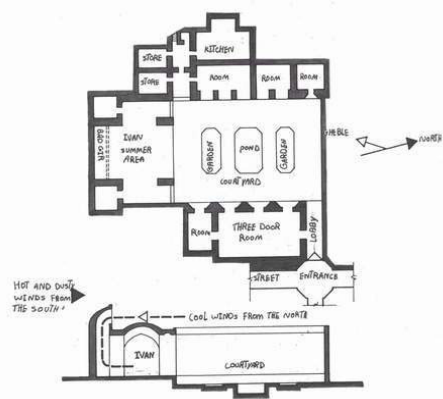
Sardab or Basement

In height difference between the floor and the yard, cellar air conditioners used to be built under summer living area. Sardabs have been located in the middle of the porches and five-doored rooms where, are the most suitable resting place for summer afternoons.

Porch

Normally the place of porch or summer salon is in northeastern corner, which makes shadow in this part, which is called Nesar or bower, and normally Sardab is built in this part. The height of summer salon in these houses is high to let the warm weather go up and replace the cold weather in lower part of the rooms.

Opposite this part, in the other side of the yard where winter salon is located, the structure benefits from the sunlight. In summer salon, the porch makes a semi-open area. The floor of the



porch is elevated with few steps in a way that the porch is imminent to the yard.

Type of materials

The most important materials are mud brick, clay and brick. These kinds of materials get warm late during the day and lose the warmth very late at nights and contribute to the temperature adjustment during the day. In addition, the light color of clay reflexes the heat. The temperature of the yard floor in the type of the houses, which are covered by brick instead of mosaic, is lower and at nights when the weather gets cold, they will keep the heat and the yard will not get cold.

Parapet

Parapet is one factor as fence to keep the privacy of the house. Also, it is a good obstacle against the unwanted wind. It provides shadow in alleys and roofs. Besides, it makes the passageways and the yards deeper. All these result in less contact with environmental heat.

Windows and openings

Opening all the windows and entrances to the

humid and mild yard weather and also blocking all external walls (Except the entrance), will reduce the contact between inside and outside environments and makes the house, a small and suitable place to live and rest.

Wind tower

Wind towers and air conditioners used to be in southern part of the house for a better conditioning. Wind towers are normally connected to the main room in the ground floor or in some houses, to Sardab in summer salon.

They collect the desirable wind and canalize it to different places like main rooms, water storages or Sardabs. Also, when there is no flow of wind, the warm weather rises through this tower and develops a weaker flow of wind.

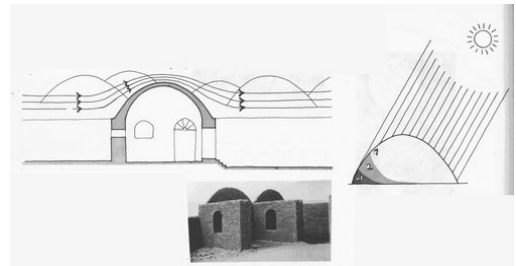
Construction direction

Developing of the buildings is in east to west direction in order to reduce the intensity of sunlight in the summer afternoons in houses. The direction of the house is defined in a way that it causes to pass sunlight in summer afternoon completely. In this area the best direction is 25 degrees east.

Roof

The dome shape of roof has a logical reason and is a very economical coverage for the roofs in this area where wood is rarely found. Vast domes used to be covered easily with the skill of builders and in hot-arid zones, could desirably answer the climatic problems of the region.

The thick dome roof prevents the entrance of sunlight to the building. This kind of roof is



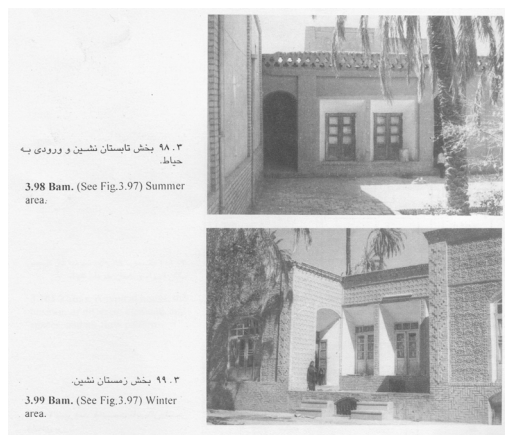
normally placed in the stream of the wind due to its shape and this is effective in reducing the heat, which is raised from the sunlight. Also, during the night it will get cold soon. Due to the shape, all part of the roof doesn't receive equal light. The part 3 always receives less heat than the part 1 and it is useful in reducing the heat especially when the dome has stem.

One of the especial benefits of domes is that the height in internal environment is more which causes a natural vertical flow of air. Since the warm air is light and goes up and the cool air substitutes it. Installing several small windows in the sides or top of the roof lets the heat exit and a natural flow of air is created from bottom to top, which is suitable for resting in warm seasons. In summer, flat roofs attract more heat than other roofs because the radiation angle is straight but the dome-shaped roof has a diagonal angle with the sunlight line and also because of the shape and design, always some parts of roof are located in shadow, which causes the roof to attract less warmth. In addition, wind blow very smoothly on surface of this kind of roofs and it causes less erosion and destruction.

In the end, since the dome roof has three-dimensional structure, it has a better resistance against lateral forces like wind and earthquake. However, the lighter the dome and the lower the gravity center is, the more resistance of construction will be resulted.

Thick walls

A thick wall keeps the house away from the effect of the sunlight. Being close to each other, the houses are protected in the group. It makes shadow inside the yard, and in the deep part develops cool weather. These walls are built thick enough to bear the heavy load of the domes and decrease the temperature tolerance during the days and nights.



6. CONCLUSION

Recognition of potentials, skills and rules which are governing area and its architecture, results in a suitable method to reconstruct, recovery and any kind of development or change in their framework which should be taken into consideration.

In fact any kind of change should be executed according to the Ecologic capacity of the natural background of the area and with regard to the applied solution for the construction of these residential units.

The residential space construction of Bam city is a typical example of conformity with the climate and an obvious sample of ecologic architecture which includes the sketching of variety of full and empty spaces like central yard with high walls and shadows, covered space like porches, rooms in different directions, corner room with wind tower, pond, basement and roof which each of them is made proper for especial hours of days and nights and warm and cool seasons.

APPENDIX

Badgir (Wind Tower)

A climatologically responsive element interconnected with several other main element including: Talar; Panjdari, Zirzamin, also a distinguished symbolic element of the towns and cities in the hot arid zone.

Passageway

Narrow Vaulted roof and shaded crossed by mud buttresses, which are cool in summer.

Ivan

The summer areas of the houses including Ivan and Talar look to the north east to avoid the heat of the afternoon sun.

Dome

Domed roof shape responsive to climate factors.

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