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Full Length Research Paper

Analysis of the status of traditional knowledge and technology in energy improvement: The case of Sistan Region, Iran

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Environments have fascinated humans throughout the ages. Covering approximately one-third of the Earth's land surface, these arid (dry) landscapes receive less than 10 inches (25 centimeters) of rain per year and they support only limited plant and animal life. Sistan, in the southern east of Iran, is a big plain with high, hot and low rainfall per year. Apparently, humans controlled most of the natural forces. Environmental varieties comprise climate, land cover, topography, water and other effective factors on rural dwellings in Sistan. The annual precipitation in the lower Sistan basin is about 50 mm. The last drought was exceptionally long, transforming the lakebeds into barren desert. The infamous '120-day wind' characterizes the summers in the region; as such, by the end of the season, the wind blown sand originating from the lakebeds covers the surrounding villages. On the basis of witnesses and studies about rural dwellings, rural architectures and fruitions of simplicity of the rural dwellings units, without ornament of visual patterns, conformity of the natural environment and harmonization of the revenue of living and livelihood, local affairs and knowledge are used as valuable experiments for the population of each region.

Key words: Sistan, ventilators, energy control, traditional knowledge.

INTRODUCTION

Sistan is an arid region in the southeast of Iran which has a long history of civilization in the memory of humankind in the world. From previous periods, the people of this region dealt with atmospheric and climatic phenomena. This was followed with an experience based on traditional approaches. From many of the prior periods in Sistan, indigenous variety was used windward; of course, this ventilation has different kinds, ranging from size and architecture to color. As it is obviously unsaid, to design such ventilations, advance levels of technology and high knowledge of humans about their surrounding environment are required. This has been the reason why the environment, in different seasons, showed different features to the natives and indigenes of Sistan region, and why it prepared the people of Sistan for the great confrontation with environments. The design of an energy conscious rural complex requires a careful analysis and evaluation of different design alternatives throughout the different design stages, taking into account different design strategies for improving the thermal comfort inside the buildings and in the open spaces among them. Moreover, in open spaces, the aim of the design is to provide comfort conditions through the selection of correct passive design strategies. The selection of the possible strategies relies on the knowledge and deep understanding of the climatic conditions at the site, including solar radiation, temperature, relative humidity and the site’s wind regime.

Wind energy, like most terrestrial energy sources, comes from solar energy. Solar radiation emitted by the sun travels through space and strikes the Earth, causing regions of unequal heating over landmasses and oceans. This unequal heating produces regions of high and low pressure, creating pressure gradients between these regions (Reeves 2006:10; Ljunggren, 2007). On the basis of witnesses and studies about rural dwellings, rural architectures and the fruitions of simplicity of rural

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dwellings units, without ornament of visual patterns, conformity of the natural environment and harmonization of the revenue of living and livelihood, local affairs and knowledge are used as valuable experiments for the population of each region. Moreover, those dwelling there respond to the live needs of the villagers. The rural dwellings of different regions have different characteristics, depending on the climate type, the kind of livelihood, and the existence of local traditions and cultures. The architecture of rural dwellings of each region with the different sights are the simple borrowing of nature and geography of these regions which respond to the basic needs of such people who have different economical and livelihood activities accommodating in these regions.

The way of life and the kind of rural dwellings affect the natural factors. Social, economical, ecological and rural houses are the symbols of culture of rural life, providing site impression and rural backgrounds in an economical frame in effect of internal or external factors that are the subject obtained during these times. In summary, those factors that are effective in the kind and foundation of rural life depend on the following parameters: disharmony of environmental factors, climate and the sense of dispersion of water resources, besides, social, economical and political factors. Other parameters affecting the rural life are the historical and cultural antecedents, the kind of livelihood and economical jobs, as well as the efficiency of public services availability at each region (Saeedi, 1996).

GEOGRAPHICAL SITUATION OF SISTAN REGION

Sistan is located in the east of Iran and north of Sistan and Baluchestan, between pivot 30 and 18 min till 31 and 20 min in the northern region and 61 and 10 min till 61 and 50 min in the eastern region. The height of Sistan in average is between 475 and 500 m from the sea, and Zabol is the center of Sistan with the height of approximately 487 m up the sea. The only natural item of Sistan is the mountain of Kuh-e-Khajeh with the height of 612 m located in the south western region of Zabol. The Sistan is approximately 15200 km^2, that is, 8% of the total territory of Sistan and Baluchestan. Sistan, from the north and east, is a neighbor of Afghanistan and is limited from the west and northwest to the dry deserts.

On the basis of different studies, Sistan is located in dry and desert areas. The average temperature is maximum at 22 to 49 and minimum at -8, which has been reported for a 20 year period. The average annual rain in Sistan is reported at around 59ml and the average humidity at approximately 40%. In Sistan region, with attention to climate, the important winds are blown by the most famous 120 days wind that usually starts by the end of Ordibehesht (approximately 21st of May) and continue till half of Mehr (approximately 9th of October). The basic water resources of Sistan are Hirrnand river that is sourced from Hedukesh mountains in Afghanistan, and also the seasonal lake of Hamoon.

The hot and dry climate of Iran's deserts is located on the central and eastern sides of Iran, the Alborz Mountains from a side and Zagros Mountains from the other side. Also, the height of southern and eastern mountains made this area hot and dry. The rain is very little with very visible temperature difference and sand storms. As regard the mentioned climate, such architecture is structured in a way that it is different from the other climates (Iran architecture, 2006).

Dust storms are natural recurrent events common in desert regions. The vast distribution of sandy, clayey and solonchak deserts of natural and anthropogenic origin, long summer drought periods, scarcity of vegetation cover and strong winds create conditions favorable to dust storms in Sistan. In spite of the fact that dust storms occur here all the year round, this phenomenon has still been insufficiently explored. The buildings in a desert climate like that of Sistan are subject not only to high ambient air temperatures, averaging 45.8°C, but also to strong solar radiation, which strikes each part of the building in turn as the sun moves around an unclear sky. The solar intensities on horizontal surfaces are the greatest at mid-July, reaching 940 W/m^2, affecting roof surfaces under high intensity solar radiation. This may draw designer's and architect's attention to consider very carefully the horizontal building components, that is, roof surface, in order to minimize heat gain into buildings. However, other considerations affecting the energy requirements of buildings may comprise the following factors:

1. Building location (altitude, latitude, longitude and orientation).
2. Local weather conditions.
3. Heat transfer and storage characteristics of the building's elements, which depend on the various thermo physical properties of the building's components.
4. Windows, doors and other openings.
5. Shading of the exterior surface.
6. Building dimensions.
7. Indoor temperature, number of occupants, lighting and building usage.
8. Primary and secondary air-conditioning systems.
9. Ventilation and infiltration.

Each of these factors could influence the cooling load of the building. The degree of influence of each factor will vary from one building to another depending on the variation in architectural design, function of the building and materials used in the construction.

Wind

For the planners, the wind is a basic factor used in designing and planning changes in air; although an effect of wind in the building can be "temperature comforting". Better knowledge of the wind, especially on how it affects the building, is the main and basic factor used in determining climate changes. The local situations are the main factors used in determining the speed and temperature of the wind. If we want to have nice actions, we must collect the information regarding the seasonal changes from the appropriate places of the world. Although the wind blows, it does not mean that this condition continues the whole year round. For example, Mistral winds, in the south of France, and Sirocco, in the south of Italy, are just blowing at the determined time of the year (Betley Mc Cartey, translated by Ahmadi, 2005: 13).

Local weather conditions

A local weather condition in the region of Sistan is quite different from other regions of Iran. For example, most of the rainfall seasons were between July to November, in which the highest level of rainfall was in November with 0.35 cm and the lowest level was in the months of August and September with 0.01 cm. Also, a small percentage of rainfall is distributed in other seasons. In most places of the world, the wind blows, but it does not mean that this condition continued the whole year round. For example, Mistral winds, in the south of France, and Sirocco, in the south of Italy, are just blowing in the determined time of the year. Recognition of the act and pressure of the wind on the building for architects and planners that want to use the wind energy is a non-removable affair. The different pressure between input and output points has provided the airflow in the building, for the air ventilation of a combined building. In the complex climate, the size and place of entrances and exits should be carefully chosen. The building that was located in the wind path makes such speed of wind to regularly decrease quickly. Creation of such decreases in the dynamic pressure of the wind can increase the static nature and vice versa. If we suppose that the atmosphere pressure is zero, the mentioned pressure will be 1.

Natural ventilation of air

The purpose of using winds for natural ventilation as a strategy for improving the human comfort is in three fold:

1. To provide comfort ventilation, improving the comfort sensation exposes the body to moving air.
2. To provide quality ventilation moving away undesirable smells, gases and residual air humidity.
3. To assure thermal mass ventilation as a means of reducing the maximum indoor temperature of buildings in summer (Shaviv et al., 2001; Capeluto et al., 2004).

The criterion for determining the need of winds as a passive cooling strategy is based on the concept of desirability or undesirability of the prevailing winds. The determination of the winds that would help people to feel comfortable (desirable winds) or those that will produce uncomfortable conditions (undesirable winds) is done based on the bio-climatic chart.

This ventilation has conformed to exploitation of the pressure difference around the building by wind and on the basis of ventilation. The natural ventilation is founded on three climate factors: 1) speed of the wind, 2) direction of the wind, and 3) temperature difference (Betley Mc Cartey, translated by Ahmadi, 2005).

Local architecture of hot and dry climate

In such climate, the buildings and structures are complex with thick walls made from sun-dried bricks. In rejecting the hot sun shine and cooling of the house, the roof is structured in such a way that it has a navy and low height.

For the outward appearance, white and light colors are mostly used. However, the windows have decreased and are mostly wooden-made (Zomarshidy and Hosein, 2006) (Figure 1).

Ventilators

Ventilators are an Iranian innovation method for creation of cool atmosphere inside the house of hot and dry regions. This air condition device (ventilator) was made at old times for the comfort life of Iranians. Ventilators usually are the small towers (4 or more lateral) that have never been seen in triangle shapes. Generally, the ventilators are made on the part of the building named Hovz-Khaneh. The summer room created large rooms with 5 doors that are located at the end of each building. The "hovz-khaneh" (small pool) was the connection joint between courtyard and summer rooms. In that place, there was a small pool (hovz) and the ventilators were located upon the pool that directed the airflow on the pool. The ventilators were made from the sun-dried bricks, while sands were used as wooden bars for their resistance. The ventilators were designed with decoration and decorative bricks. The action of past ventilators is used today as air conditions. Some of the rooms that were for rich persons had corridors that air passed through to the rooms, bringing the cool flow to the rooms, such as coolers that are used today (Figure 1). The other means of using ventilators was for keeping cool the food and water sources. We can see most of these ventilators in very hot and dry fields, such as Kashan, Yazd, Tabas, Jahrom, Sistan and the shores of Persian Gulf (Almerind, 2002). The most natural method to be used as ventilator is designed on the basis of speed and direction of the

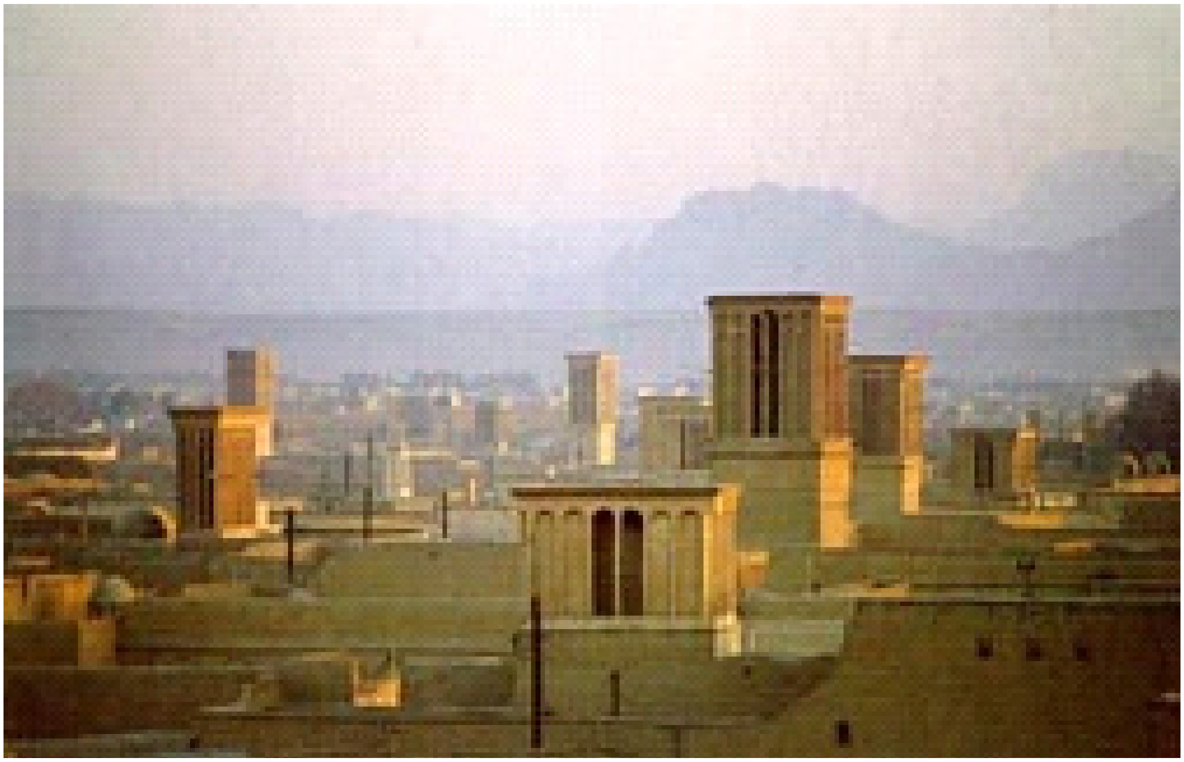

Figure 1. A view of the four sides' ventilator.

wind.

The movement of air is named wind. The wind on the earth is an important factor for temperature changes and humidity. This action plays an important role in the comfort or discomfort of human life. The movement of air is so effective on increasing the level of action of physical decreases. The importance of wind was attended to by the designing and construction of a living environment. "Aristae" 4 centuries B.C. and "Vitreous" a Russian architect 1 century B.C. were discussed about architecture and city constructions.

In Iran, during the many centuries, all the buildings were constructed on the basis of climate and environment conditions. Sun, wind, humidity, cold, hot and, generally, all conditions of climate and geographical conditions had direct effect on Iran traditional architectures. Moreover, most of them are ventilators, such as the ventilator of Dovlat abad Yazd national garden, which is one ventilator that made a cool interior weather on rooms (such as, ventilators of the southern parts of Iran). Nonetheless, the old and historical names are: Vatfer, Badhanj, Batkhan, Khishood, Khishkhan, Khishoor, Masooreh and havakod (National Census Organization, 1997).

Kinds of ventilators

(1) First kind: The four sides' ventilators are completely made than other kinds. Usually, some of the inside parts of the channels are separated with woods or bricks, and in some cases, a large and beautiful pool that converts the hot and dry weather to a nice and cool weather is made below. These places (Sard-Abha) were the place of gathering in summer afternoons, such as Yazd, Kerman and Bushier and in Yazd and also in some central areas of Iran, the regular ventilators (8 sides) are named the fifth kind of ventilators. However, the ventilator of Chopoqi is the sixth kind that was made from some pipes of the external part that can be seen in Sirjan.

(2) Second kind: It comprises 3 sides' ventilators, having 2 kinds (jointed and unjointed), but these are so rare (Mahdavi, 2000) (Figure 2).

(3) Third kind: It comprises 2 sides' ventilators opposite each other with tall and narrow windows without any guard and has 1 or 2 holes in the internal part. It can be seen in Sirjan, but seldom in Kerman.

(4) Fourth kind: It is the simplest ventilator with 1 side, and is very small. It has a hole on the top of it and is made against the storm. The size of this ventilator is smaller when compared with other kinds. However, such ventilators can be seen in Sistan region and part of the cities of Barn (Kardovcani, 2000).

IMPORTANCE AND ACTION OF VENTILATORS

The existence of ventilator in each house is introduced as

Figure 2. A view of the ventilator of Sistan.

a characteristic of owners in the same house. The size of ventilator is related to the economical situation of landlords (Saeedi, 2004). As can be seen, the ventilator is known about the economical and financial position of the family. The ventilator is a suitable device used for ventilation of the house in the heart of the desert; as such, houses can breathe with ventilation of the cool air. For this reason, the ventilators have been made in the most suitable direction of the air. For example, in the world as a whole, the ventilators have been made at the north direction of Ardekan, and "Qibleh" is located behind them. The main job of ventilators is in two fold: (1) ventilating of cool air and directing it downwards, and (2) throwing out the hot and dirty weather, such as suctioning.

In the path of some of the ventilators that find a way to "sardab", a section is installed in the wall and a wood is put on it to control the wind. At winter, they almost work as a refrigerator. Meat, yogurt, cheese and food are placed on the shelf and the door is closed to be safe from hot weather and pets. It is made for the food not to be spoilt and there is another method also (Tit, 1982). The size of ventilators can show the economical situation of the owners of the house, because poor houses were made without ventilators. Some of them that have ventilators which have been made with sun-dried bricks and with fewer channels, but rich houses have been made with better material and bricks with design and special decorations. Most of the ventilators have bridled 1 floor, while 2 floors ventilator needs a special art of architecture. For the fact that at first, it has 8 literals and secondly, the form of the second floor is found on top of the first stone, the 2nd floor is a suitable facility for breathe in the 1st floor.

Ventilator also plays the role of protecting the water sources from getting spoilt. For this reason, the ventilator should be built very carefully and it depends on the scale and experience of the builder (Bazi, 2004).

DISCUSSION

Method used to build the ventilator

In building a ventilator, the local architects make use of the housetop and the place exposed to the ventilator that is built with sun-dried bricks or bricks, after which, at the top of it, they install two wooden bars as "X" shape, in which both sides of it make an X corner and then the eastern-western and southern wall is built 2 to 5 m. Subsequently, in the north side that is in the direction of "Isfahani" wind, with half bricks of 6 cm, they put up the tandir (40 cm) named "Payeh" (Range and Water, 2002). For example, they make it look nice outward, and as well make the building firm. Thus, the width between the two partition walls is named "Cheshmeh", and is 40 to 60 cm. The quantity of each spring depends on the width of the room. For example, the room whose width is 3 to 5 and 7 m has installed 5, 7 and 11 springs. At that area, the springs are not in pairs, because they can bring bad luck to the owner of the house. However, the depth of each ventilator is 1 to 2.5 m and sometimes, for a firm installation of each 0.5 m, a wooden bar is constructed between the walls.

The housetop of the ventilator has been made as a ridge to help suction the nice weather and the flowing out of the hot and dirty weather (Z N M, 2006). Then the top of the ventilator was made by 3 cm, with 2 or 3 bricks. These bricks were made to be attractive and the ventilators were made to be more firm, but sometimes, they covered the roof of the top house with a plaster of clay and straw, as well as a row of bricks (Hanna, 2007). The distances between bricks were filled with plaster and sands. Some of these persons with better financial position also covered the walls with plasters. The quantity of the springs has direct relation with the size of the ventilator (CCI, 1995-2008).

Types of ventilators

Paying attention to the following aspects of a natural ventilation system will help insure effectiveness of Sistan ventilators: Roof slope is important to good ventilation; and as a rule, the steeper the slope, the better the ventilation. If possible, slopes that are less than 3/12 inches (3 inches of its rise per foot) should be avoided. Generally, the wider the building, the steeper the roof slope should be. Obstructions protruding from the underside of the roof, such as deep purlins, can trap moist air and increase metal corrosion and wood deterioration. Therefore, wide truss spacing, which requires deep exposed purling, should be avoided. Never use purloins deeper than 6 inches (4 inches is preferable), if the building is to be ventilated naturally. Sidewall height can also affect natural ventilation. For instance, if walls are not high enough, mechanical bunks can disrupt proper air flow through the building in summer. Also, winter sun cannot penetrate open-front buildings adequately if wall height is insufficient (HA, 1914: 30). There are 3 types of ventilators: Ardekani, Kermani and Yazdi. The Ardekani's ventilator can be seen more in Ardekan area and is located in the direction of Isfahani's wind. However, there is no pore at the West, East and South side, though the main material is a sun-dried brick that is also called twin ventilators. They work more ideally and exactly, because wind pressures, on one side, support the process of flow of the hot and dirty air.

Most ventilators of the water source were made by Kermani to ventilate the cool and hot weather. The Yazdi's ventilators are bigger than others and they have 4 laterals. For this reason, they were also called "char-su", but they have more complex architecture and were usually made tall.

Future perspective (view)

With the coming of new and modern architecture, the use of mechanical installations has gradually removed the role of climate in constructions, but from the last century, the use of architecture with natural environment, industrial salvage and the use of the clean energies, such as wind, sun and water are more important.

Today, ventilators can be used as a complementary means of ventilation and cooling of buildings. With the use of the ventilator, the condition of ventilations can be made more comfortable and in case it did not, mechanical installations can be used. In Egypt, so many efforts have been tried to combine modern and traditional architecture. From a pump bringing water inside the building, a fountain was made so that in hot and dusty days, dust and temperature could be decreased. Moreover, in other countries, architects have planned and designed the constructions with natural ventilation. For example, in a shopping center (Blue water) in England, the fresh air flow in the ventilators was installed on top of the house to direct the cool air inside it. They were placed 15 m away from each other. Also, the Amory Tower of China used it in hotels, offices and buildings. At summer, it directs the fresh air from a channel to interior parts. Another sample is the Lister of England, where the quantity of the energy used in building the Queens of Mont Front University is half of the regular used energy.

CONCLUSION

Natural ventilation systems rely on natural driving forces, such as: wind and temperature, between a building and its environment, to drive the flow of fresh air through a building. Both wind and temperature work on the principle of air moving from a high pressure zone to a low pressure zone. The ventilators that are made depend on the kind of climate and direction of the wind, especially when the movement of the wind is in 2, 3 or 4 directions. In the climate with hot weather and hot storms in the desert, it is better to make one side ventilator. The action is that the ventilator suctions the hot air and makes it cool (Zomarshidi and Hosien, 2006). With the use of the ventilator, the condition of ventilations can be comfortably made, and just in case it can not be made, mechanical installations can be used. Many efforts have been made on modern and traditional architecture in the many areas of the world. The main job of ventilators is to: (1) ventilate cool air and direct it downwards, and (2) throw out the hot and dirty weather such as suctioning. Sistan, as referred to earlier, is located in the hot and dry region, with 120 days wind of Sistan that makes a special position of these areas. The direction of "Kolak" is to the north, because the main wind blows from the north. It is made by sun-dried bricks and sands. The average height is between 70 and 80 cm. In the year that Hamun's lake is full of water, it worked as a cooler air conditioner. However, the use of modern technologies, such as coolers and air conditioners, today has made the role of this old device gone into extinction.

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